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Standard Specification for Mercury-in-Glass, Maximum Self-Registering Clinical Thermometers[1]

This standard is issued under the fixed designation E 667; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This specification covers mercury-in-glass, reusable maximum self-registering clinical thermometers of the types commonly used for measuring body temperatures of humans and of animals. Requirements are given for bulb and stem glasses, mercury, legibility and permanency of markings, dimensions, temperature scale ranges, and graduations, as well as for thermometer stability, ease of resetting, retention of temperature indication, and for accuracy of scale reading. Appropriate methods of testing to determine compliance are provided. Also included is a glossary of terms used in the standard and an appendix with additional information on thermometer glasses and stability.

1.2 All values of temperature in this standard are with reference to the International Temperature Scale of 1990.

1.3 This specification was developed to provide nationally recognized marketing classifications and quality requirements for mercury-in-glass, maximum self-registering clinical thermometers. It is also intended to provide producers, distributors, and users with a common understanding of the characteristics of this product.

1.4 The following precautionary statement pertains only to the test method portion, Section 6 of this specification: *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications[2]

E 344 Terminology Relating to Thermometry and Hydrometry[3]

3. Terminology

3.1 *Definitions*—The definitions given in Terminology E 344 apply to this specification.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *bore, n*—hole or lumen in the stem.

3.2.2 *calibration date, n*—date on which the scale is affixed to a thermometer.

3.2.3 *ceramic marking, n*—marking produced by fusing a ceramic colorant onto the glass surface.

3.2.4 *constriction, n*—obstruction in the bore of a clinical thermometer which permits the passage of mercury from the bulb when the bulb is heated, but which restricts its passage back to the bulb when heat is removed.

3.2.5 *fire cracks, n*—cracks in glass caused by local temperature shock.

3.2.6 *flat magnifying lens, n*—thermometer stem glass in which the numerals, graduations, and lens lie on the same relative surface.

3.2.6.1 *Discussion*—It is so named for its approximately flat cross section (See Fig. 1.)

3.2.7 *fractures, n*—internal or external breaks or cracks in the glass.

3.2.7.1 *Discussion*—Internal fractures usually occur in the area between the bulb and the constriction.

3.2.8 *graduations, n*—series of lines on the stem of the thermometer that designate the temperature scale intervals.

3.2.9 *hard shaker thermometer, n*—thermometer in which the constriction is overly severe thereby restricting the passage of mercury back to the bulb causing the thermometer to fail the ease-of-resetting requirements.

3.2.10 *index, n*—upper point of the mercury column whose position, when noted with respect to the corresponding numerals and graduations, indicates the temperature of the mercury within the bulb.

3.2.11 *magnifying lens, n*—stem glass that, due to its configuration, results in a magnification of the mercury column.

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[1] This specification is under the jurisdiction of ASTM Committee E-20 on Temperature Measurement and is the direct responsibility of E20.08 on Medical Thermometry.

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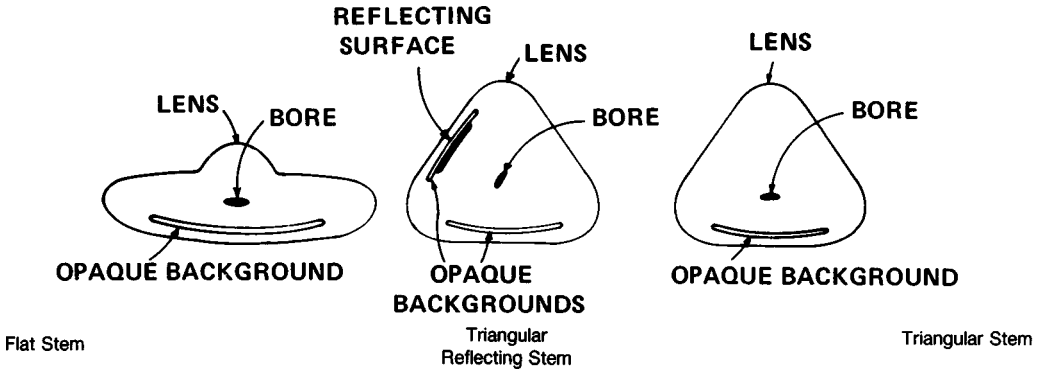
[2] *Annual Book of ASTM Standards,* Vol 14.02.

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



Cross section of magnifying lens stems.

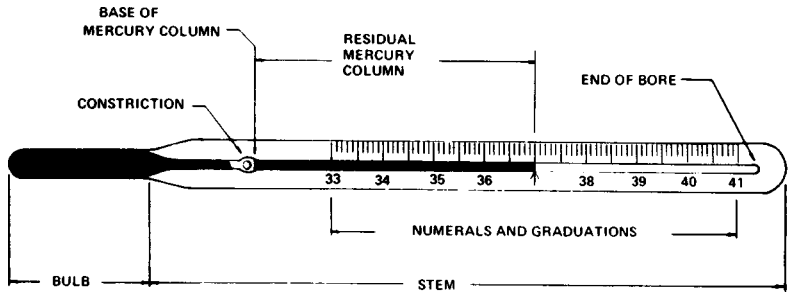


FIG. 1 Composite and Sectional Views of Clinical Thermometers (These sketches are for illustration only.)

3.2.12 *normal human temperature*, *n*—conventionally accepted average body temperature in healthy human beings (37 °C or 98.6 °F).

3.2.13 *ovulation thermometer*, *n*—thermometer specifically designed for obtaining body temperature for the purpose of determining the date of ovulation or the basal body temperature.

3.2.14 *reflecting stem*, *n*—stem glass containing a colored stripe along its length in a location that, when reflected on the mercury column, allows greater contrast and enables the column to appear tinted.

3.2.15 *residual mercury column*, *n*—mercury that lies in the bore of the stem above the constriction.

3.2.16 *retreating index thermometer*, *n*—thermometer in which the constriction is not sufficiently small to prevent the passage of mercury back to the bulb (or the mercury index from falling) without shaking when heat is removed from the bulb.

3.2.17 *scale range*, *n*—range of temperature through which a thermometer is usable.

3.2.18 *stained marking*, *n*—marking produced by diffusing colorant into the glass surface.

3.2.19 *triangular magnifying lens*, *n*—thermometer stem glass in which the numerals and graduations lie on surfaces that smoothly merge to form a lens.

3.2.19.1 *Discussion*—It is so named for its approximately triangular cross section. (See Fig. 1.)

3.2.20 *subnormal thermometer*, *n*—clinical thermometer specifically designed for obtaining lower than normal body temperatures.

3.2.20.1 *Discussion*—A subnormal thermometer is marked with a subnormal scale range. See 4.4.

4. Classification

4.1 Clinical thermometers covered by these specifications are generally available in the following classifications. Other designs and configurations of thermometers meeting the requirements specified herein shall also be considered as complying with this specification.

NOTE 1—The requirements of this specification shall not preclude the manufacture and sale of special thermometers having different temperature ranges and degrees of subdivision designed for specific medical uses. Packaging on any “special” thermometers shall state that the thermometer is a special one intended for a specific use and, therefore, is not necessarily in compliance with this specification. In addition, the special thermometer must be marked in such a way so as to identify it as “special.”

4.2 *Types*—Thermometers are classified by types as follows (see Fig. 2):

4.2.1 *Human*:

4.2.1.1 *Basal or Ovulation*, with large cylindrical bulb (ovulation scale).

4.2.1.2 *Multiuse (Oral or Rectal)*, with stubby bulb (regular scale).

4.2.1.3 *Oral*, with cylindrical bulb (regular scale).

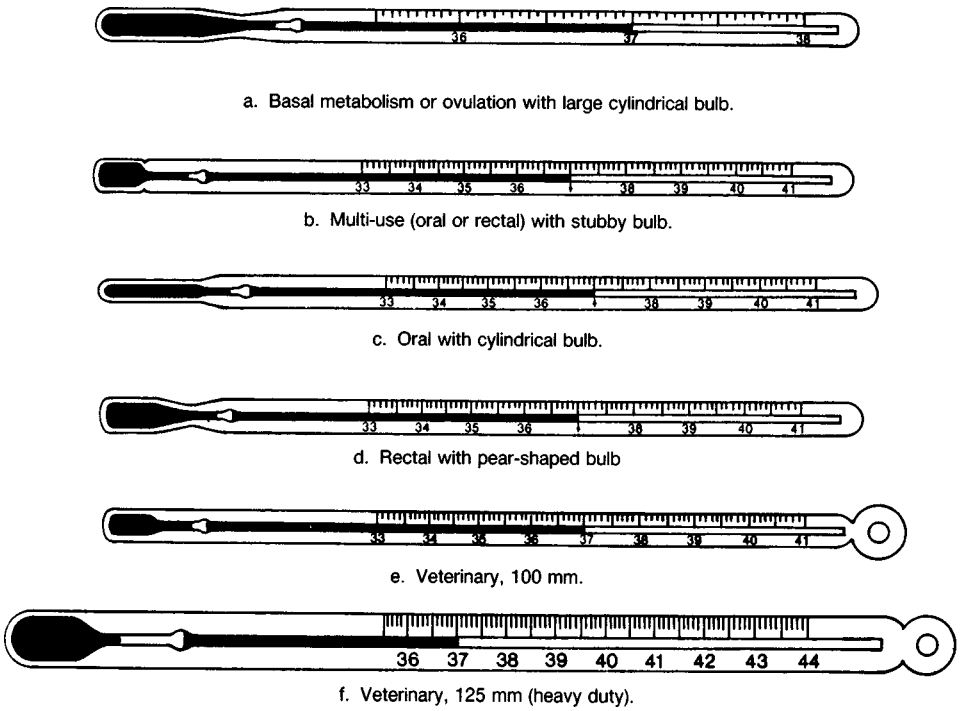
4.2.1.4 *Rectal*, with pear shaped bulb (regular scale).

4.2.1.5 *Subnormal*

4.2.2 *Veterinary*:

4.2.2.1 *Ring Top*, 100-mm (4 in.), with stubby bulb (regular scale).

4.2.2.2 *Heavy Duty Ring Top*, 125-mm (5 in.) with stubby bulb (extended scale).



a. Basal metabolism or ovulation with large cylindrical bulb.

b. Multi-use (oral or rectal) with stubby bulb.

c. Oral with cylindrical bulb.

d. Rectal with pear-shaped bulb

e. Veterinary, 100 mm.

f. Veterinary, 125 mm (heavy duty).

FIG. 2 Types of Clinical Thermometers (These sketches are for illustration only.)

4.3 *Stems*—Thermometer stems are classified as follows (see Fig. 2):

4.3.1 Flat magnifying lens.

4.3.2 Triangular reflecting magnifying lens.

4.3.3 Triangular magnifying lens.

4.4 *Scales*—Thermometer temperature scales and ranges are classified as follows:

4.4.1 Celsius (formerly known as Centigrade):

4.4.1.1 *Regular Scale*, at least 35.5 to 41 °C,

4.4.1.2 *Ovulation Scale*, at least 35.5 to 38 °C,

4.4.1.3 *Extended Scale*, at least 35.5 to 44 °C, and

4.4.1.4 *Subnormal Scale*, at least 21 to 38 °C.

4.4.2 Fahrenheit (Note 2):

4.4.2.1 *Regular Scale*, at least 96 to 106 °F,

4.4.2.2 *Ovulation Scale*, at least 96 to 100 °F,

4.4.2.3 *Extended Scale*, at least 96 to 110 °F,

4.4.2.4 *Subnormal Scale*, at least 70 to 100 °F.

NOTE 2—The Fahrenheit temperatures given in parentheses throughout this specification are not necessarily exact Celsius conversions but are the values to be used when testing thermometers with Fahrenheit scales for conformance with this specification.

4.5 *Marking*—Thermometer markings are classified as follows:

4.5.1 Etched and filled.

4.5.2 Stained.

4.5.3 Ceramic marked.

4.5.4 Marked in other ways that meet all of the requirements of this specification.

5. Requirements

5.1 *General*—All thermometers represented as complying with this specification shall meet all of the requirements specified herein. Terms shall be as defined in Section 4.

5.2 *Glass*—Thermometers shall be made from bulb glass and magnifying lens stem glass (glasses) having properties and characteristics that ensure stability, accuracy, and reliability in accordance with the requirements of this specification. (See Appendix X1.)

5.3 *Mercury*—Mercury used in the thermometers shall have the purity, properties, and characteristics that will enable the finished thermometers to comply with all the performance requirements of this specification. In addition, when finished thermometers are visually examined, the bulb and the mercury column shall be free of gas or other foreign material.

5.4 *Fabrication of Regular-Scale Thermometer for Human Use*:

5.4.1 *Length*—The overall length of the thermometers shall not be less than 98 mm (3⅞ in.).

5.4.2 *Thickness of Stem*—No dimension of the cross section of flat magnifying stems shall be greater than 7.6 mm (0.30 in.) nor less than 3.6 mm (0.14 in.). No dimension of the cross section of triangular stems shall be less than 3.6 mm (0.14 in.).

5.4.3 *Scale Range and Position*—There shall not be more than 5.0 °C (9.0 °F) per 25.4 mm (1 in.) of temperature scale. The range of scale shall be at least from 35.5 to 41 °C (96 to 106 °F). The 35.5 °C (96 °F) graduation mark shall not be less than 11 mm (7⁄16 in.) from the base of the mercury column. The 41 °C (106 °F) mark shall be at least 3 mm (⅛ in.) from the end of the bore.

5.4.4 *Celsius Graduations*—Celsius thermometers shall be graduated in 0.1 °C intervals. All full-degree and half-degree graduations shall be long lines, and all other graduations shall be short lines (see 5.4.6). Appropriate numerals shall be placed at every full-degree graduation. If an arrow or other mark designating normal is used, the numeral at 37 °C may be eliminated.

5.4.5 *Fahrenheit Graduations*—Fahrenheit thermometers shall be graduated in 0.2 °F intervals. All full-degree graduations shall be long lines, and the graduation for 98.6 °F may also be a long line or other suitable mark. All other graduations shall be short lines (see 5.4.6). Appropriate numerals shall be placed at every even-degree graduation.

5.4.6 *Temperature Scale Graduation Marks*—All short (0.1 and 0.2°) graduation lines shall not be less than 1.3 mm (0.05 in.) in length, and all long graduation lines shall be at least 25 % longer than the short lines. The graduation lines shall be substantially straight, uniformly spaced, of uniform width, and shall be perpendicular to the axis of the stem. They shall not be wider than the spaces between the graduations, nor wider than 0.46 mm (0.018 in.) and shall not be narrower than 0.10 mm (0.004 in.).

5.4.7 *Normal Human Temperature Marks*—The lines at 37 °C (98.6 °F) may be designated by an arrow or other suitable mark. If used, the mark shall be accurately positioned to within a tolerance of ±½of the minimum graduated interval.

5.4.8 *Legibility of Marks, Numbers, and Graduations*—All temperature scale graduations and numerals and all identification marks shall be made readily legible by the use of colorant. The cumulative absence of colorant from graduation lines shall not be more than the equivalent of one long graduation line, the cumulative absence of colorant from numbers shall not be more than the equivalent of one entire number, and the cumulative absence of colorant from letters shall not be more than the equivalent of one complete letter.

5.4.9 *Permanency of Marks, Numbers, and Graduations*—When tested in accordance with 6.2, all temperature scale graduations and numerals and all identification marks shall not fade or discolor in such a manner as to impair their legibility. The cumulative absence of colorant from graduation lines shall not be more than the equivalent of one long graduation line, the cumulative absence of colorant from numbers shall not be more than the equivalent of one entire number, and the cumulative absence of colorant from letters shall not be more than the equivalent of one complete letter.

5.4.10 *Stability*—Thermometers shall be stabilized by natural or artificial means to assure that the requirements of this specification will be maintained by the thermometers while in normal use (see Appendix X1).

5.4.11 *Accuracy*—No individual reading on any non-special scale thermometer shall be in error by more than the following in the ranges indicated:

Celsius Scale, °C		Fahrenheit Scale,° F	
Range	Maximum Error	Range	Maximum Error
Less than 35.8	0.3	Less than 96.4	0.4
35.8 to less than 37.0	0.2	96.4 to less than 98.0	0.3
37.0 to 39.0	0.1	98.0 to 102.0	0.2
Greater than 39.0 to 41.0	0.2	Greater than 102.0 to 106.0	0.3
Greater than 41.0	0.3	Greater than 106.0	0.4

Testing shall be in accordance with 6.3. Readings shall be rounded to one decimal place as provided in Recommended Practice E 29.

5.4.12 *Ease of Resetting*—The length of the residual mercury column shall not exceed 20.6 mm (13⁄16 in.), and the top of the column shall fall below 35.5 °C (96 °F) when tested in accordance with 6.4 (See description of *hard shaker thermometer* in 3.2.9.)

5.4.13 *Temperature Retention*—Each thermometer shall indicate 41.0 ± 0.2 °C (106.0 ± 0.3 °F) when tested in accordance with 6.5. If applicable, as provided in 6.3, the acceptable indication shall be 40.8 ± 0.2 °C (105.6 ± 0.3 °F). (See description of *retreating index thermometer* in 3.2.16.)

5.4.14 *Workmanship*—There shall be no constructional defects that would prevent the observations of temperature. The presence of unhealed fire cracks or fractures, when tested in accordance with 6.6, shall be considered evidence of discreditable workmanship.

5.5 *Fabrication of Ovulation-Scale Thermometers*—Thermometers designed for use in determining the date of ovulation or the basal body temperature shall meet the preceding requirements with the following exceptions:

5.5.1 *Scale Range and Position*—There shall not be more than 3 °C (4 °F) per 38 mm (1½ in.) of temperature scale. The range of the scale shall be at least from 35.5 to 38 °C (96 to 100 °F) as applicable. The 38 °C (100 °F) graduation mark shall be at least 3 mm (⅛ in.) from the end of the bore.

5.5.2 *Temperature Scale Graduations*—Thermometers shall be graduated in intervals no greater than 0.05 °C (0.1 °F). All full-degree and half-degree graduations shall be long lines, and all other graduations shall be short lines. The 0.05° and 0.1° graduation lines shall be clearly differentiable from one another (see 5.4.6). Numerals shall identify each full-degree mark on the scale.

5.5.3 *Accuracy*—No individual reading on any ovulation scale thermometer shall be in error by more than ± 0.1 °C (0.2 °F) at any point in the range 36.0 °C (97.0 °F) to 37.5 °C (99.0 °F) nor by more than ± 0.2 °C (0.3 °F) at other points in the thermometer's range.

5.5.4 *Ease of Resetting*—Thermometers shall meet the requirements specified in 5.4.12, except that when tested they shall be heated to 37 ± 0.3 °C (99 ± 0.5 °F) before centrifuging. (See description of *hard shaker thermometer* in 3.2.9.)

5.5.5 *Temperature Retention*—Each thermometer shall indicate 37.5 ± 0.1 °C (99.0 ± 0.2 °F) when tested in accordance with 6.5. (See description of *retreating index thermometer* in 3.2.16.)

5.6 *Fabrication of Veterinary Scale Thermometers*—Thermometers designed for use in veterinary application shall meet the preceding requirements in 5.1-5.4.14 with the following exceptions.

5.6.1 *Veterinary Thermometer*, 100-mm (4 in.):

5.6.1.1 *Ring Top*—Thermometers shall be constructed with a ring or loop at the end opposite the bulb.

5.6.1.2 *Length*—The overall length of the thermometer shall not be more than 120 mm (4¾ in.) including the ring.

5.6.2 *Heavy-Duty Veterinary Thermometer*, 125 mm (5 in.):

5.6.2.1 *Ring Top*—Thermometers shall be constructed with a ring or loop at the end opposite the bulb.

5.6.2.2 *Length*—The overall length shall not be less than 125 mm (4⅞ in.) nor more than 140 mm (5.5 in.) including the ring.

5.6.2.3 *Thickness of Stem*—No dimension of the cross

section of the stem shall be greater than 7 mm (0.276 in.) nor less than 5 mm (0.197 in.).

5.6.2.4 *Scale Range and Position*—The range of scale shall be at least from 35.5 to 44 °C (96 to 100 °F). The 44 °C (110 °F) mark shall be at least 3 mm (⅛ in.) from the end of the bore.

5.7 *Fabrication of Subnormal Thermometers*—Thermometers designed for use in subnormal applications shall meet the preceding requirements in 5.1-5.4.14 with the following exceptions.

5.7.1 *Scale Range and Position*—There shall be no more than 45 lines per 25 mm (1 in.) of temperature scale. The range of scale shall be at least from 21 to 38 °C (70 to 100 °F). The 21 °C (70 °F) graduation mark shall be not less than 11 mm (0.44 in.) from the base of the mercury column. The 38 °C (100 °F) mark shall be at least 3 mm (0.12 in.) from the end of the bore.

5.7.2 *Temperature Scale Graduation Marks*—Thermometers shall be graduated in intervals of 0.2 °C or 0.5 °F. Graduation lines shall be numbered at least every 5° (C or F).

5.7.3 *Accuracy*—No individual reading on any subnormal thermometer shall be in error by more than 0.3 °C (0.5 °F) in the range of 27 to 38 °C (80 to 100 °F) nor by more than 0.4 °C (0.7 °F) at any other points in the thermometers range.

5.7.4 *Ease of Resetting*—The length of the residual mercury column shall not exceed 21 mm (0.82 in.), and the top of the column shall fall below 21 °C (70 °F) when tested in accordance with 6.4, except that when tested they shall be heated to 37 ± 0.3 °C (99 ± 0.5 °F) before centrifuging.

NOTE 3—Exercise caution that ambient room temperature does not exceed 21 °C (70 °F) during test. False high reading may result.

5.7.5 *Temperature Retention*—Each thermometer shall indicate 38 ± 0.3 °C (100 ± 0.5 °F) when tested in accordance with 6.5.

5.8 *Marking*—Each thermometer represented as conforming to the requirements of this specification shall bear in legible characters the name or trademark of the manufacturer or distributor, country of origin, and a designation, either a serial number or a code, to indicate the specific period, not to exceed 90 days, in which the thermometer was calibrated. Additionally, each ovulation scale thermometer shall be appropriately marked to indicate clearly that it was designed specifically for obtaining temperatures to be used in determining the date of ovulation or the basal body temperature. Since ovulation temperature readings are only valuable in comparison with each other, the instructions or package should state that the same thermometer, site, and time of day must be used every time. Each subnormal thermometer shall be marked with the word “subnormal.”

6. Test Methods

6.1 *Significance and Use*—The inspection and test procedures contained in this section are to be used to determine the conformance of clinical thermometers to the requirements of this specification. Each producer or distributor who represents his products as conforming to this specification may utilize statistically based sampling plans that are appropriate for each particular manufacturing process but shall keep such essential records as are necessary to document with a high degree of assurance his claim that all of the requirements of this specification are met. Additional sampling and testing of the product, as may be agreed upon between purchaser and seller, is not precluded by this section.

6.1.1 In all tests where a temperature-controlled bath is used, immerse all thermometers being tested to cover at least the bulb and the constriction.

6.2 *Retention of Colorant*—Immerse thermometers in an aqueous solution of 5 weight % phenol for a period of 1 h at a temperature between 21 and 32 °C (70 and 90 °F).

6.3 *Accuracy Test*:

6.3.1 *Test Equipment Required*—The test equipment shall include constant-temperature water baths, the temperatures of which are uniform and known to be within ± 0.03 °C (± 0.05 °F), as measured by a thermometer or thermometry system for which the temperature calibration is traceable to the International Temperature Scale of 1990 (ITS-90) as maintained by NIST or other appropriate national standards laboratory. The volume of each bath shall be a minimum of 1 L.

6.3.2 *Procedure*—Test thermometers for accuracy at the temperatures listed in Table 1. Stabilize thermometers in a well-stirred temperature controlled bath, remove, and read.

6.4 *Ease of Resetting*—After heating to 41 ± 0.3 °C (106 ± 0.5 °F), centrifuge thermometers, bulb outward, to impart the equivalent centrifugal force of 51 ± 2 *g* at a point on the thermometer 33.9 mm (1 11⁄32 in.) from the end of the bulb. The centrifuging radius (from the center of rotation to 33.9 mm (1 11⁄32 in.) from the end of the bulb) shall be at least 127.0 mm (5 in.).

6.5 *Temperature Retention*—Test regular-scale and extended-scale thermometers for accuracy at 41 °C (106 °F) as described in 6.3, but allow to cool slowly to 40.5 °C (105 °F) or below at a uniform rate not exceeding 0.5 °C (1.0 °F) in 3 min while still in the temperature-controlled bath. Test ovulation-scale thermometers for accuracy at 37.5 °C (99 °F) as described in 6.3, but allow to cool slowly to 37 °C (98 °F) or below at a uniform rate not exceeding 0.5 °C (1.0 °F) in 3 min while still in the temperature-controlled bath. Test subnormal thermometers for accuracy at 38 °C (100 °F) as described in 6.3, but allow to cool slowly to 37 °C (98 °F) or below at a uniform rate not exceeding 0.5 °C (1 °F) for 3 min. While still in the temperature controlled bath. Remove the thermometers from the bath and read.

6.6 *Fire Cracks*—Inspect thermometers for the presence of fire cracks by examining them with the unaided eye.

TABLE 1 Temperatures for Accuracy Testing[A]

Regular and Extended scale		Ovulation scale		Sub-normal scale	
°C	°F	°C	°F	°C	°F
37	(98)	36.1	(97)	27	(80)
39	(102)	36.7	(98)	32	(90)
41[B]	(106)	37.2[B]	(99)	38[B]	(100)

[A] Exercise caution, especially with subnormal thermometers that ambient room temperature does not exceed test temperatures during test. False high readings may result.

[B] Tests at this temperature may be performed concurrently with the temperature-retention test described in 6.5. Thermometers not graduated above this temperature may be tested at the temperature two graduation lines lower.

6.7 *Precision and Bias*—All test equipment specified in 6.3 shall be sufficiently accurate so that test results produced with the equipment have an expanded uncertainty (k=3) not exceeding 0.045 °C.

7. Identification

7.1 In order that purchasers may identify products conforming to all requirements of this specification, producers and distributors may include a statement of compliance in conjunction with their name and address on product labels, invoices, sales literature, and the like. The following statement is suggested when sufficient space is available:

7.1.1 "This thermometer conforms to all of the requirements established in ASTM Standard E 667. Full responsibility for the conformance of this product to the specification is assumed by (name and address of producer or distributor)."

7.2 The following abbreviated statement is suggested when available space on labels is insufficient for the full statement:

7.2.1 "Conforms to ASTM E 667 (name and address of producer or distributor)."

8. Keywords

8.1 clinical thermometers; maximum self-registering clinical thermometers; mercury-in-glass

APPENDIX

(Nonmandatory Information)

X1. GLASS INFORMATION

X1.1 General

X1.1.1 The required thermometer stability and reliability have been achieved using glasses with the following characteristics in conjunction with the following stabilization procedures. References to specific characteristics of glass or specific stabilization procedures are solely for the purpose of description. Any glasses or stabilization procedures, or both, may be used provided that they produce thermometers that will meet all of the requirements of this specification throughout their life.

X1.2 Stem Glass

X1.2.1 Stem glass with a coefficient of expansion of 85 ± 4 × 10^{-7}°C^{-1}, a strain point of 418 ± 10 °C (784 ± 18 °F), and an annealing point of 459 ± 10 °C (858 ± 18 °F).

X1.3 Bulb Glass

X1.3.1 Bulb glass with a coefficient of expansion of 86 ± 4 × 10^{-7}°C^{-1}, a strain point of 494 ± 10 °C (921 ± 18 °F), and an annealing point of 533 ± 10 °C (991 ± 18 °F).

X1.3.2 Bulb glass with a coefficient of expansion of 93 ± 4 × 10^{-7}°C^{-1}, a strain point of 486 ± 10 °C (907 ± 18 °F), and an annealing point of 525 ± 10 °C (977 ± 18 °F).

X1.4 Stabilization Procedures

Glass	Natural	Artificial
Stem glass X1.2.1 and Bulb glass X1.3.1	4 months at room temperature	449 ± 5.6°C (840 ± 10°F) for at least 3 h. Cool to 260°C (500°F) or below at a rate not exceeding 55°C (100°F)/h
Stem glass X1.2.1 and Bulb glass X1.3.2	not effective	433 ± 5.6°C (830 ± 10°F) for at least 2 h. Cool to 260°C (500°F) or below at a rate not exceeding 55°C (100°F)/h