MIL-STD-735A(SHIPS)
6 May 1965
SUPERSEDING
MIL-STD-735(SHIPS)
16 July 1962
(See Sec. 6)

MILITARY STANDARD

TEST METHODS AND TEST EQUIPMENT FOR THERMOMETERS USED IN MACHINERY AND PIPING SYSTEMS

C 6685

DEPARTMENT OF THE NAVY
BUREAU OF SHIPS
WASHINGTON, D. C. 20360

Test Methods and Test Equipment for Thermometers used in Machinery and Piping Systems
MIL-STD-735A (SHIPS)

1. This standard has been approved by the Bureau of Ships and is published to insure uniformity in the requirements for the test methods and test equipment and to obtain reproducibility in test results by setting forth methods of testing and designs of test equipment that are sound and appropriate for the intended measurement.

2. When referencing this standard in a contract or specification, the applicable tests, sequence of performance and the parameters for each test as indicated in the summary paragraphs shall be furnished.

3. When using this standard for evaluating facilities and operating personnel. Form A shall be certified by the Government inspector or reviewing activity.

4. When this standard is referenced in specifications for purposes of inspection testing, the testing activity shall furnish copies of Form B, as required.

5. Use of this standard by activities under cognizance of the Bureau of Ships shall be mandatory and effective on 6 May 1965.

6. Recommended corrections, additions or deletions should be addressed to Chief, Bureau of Ships, Department of the Navy, Washington, D. C. 20360.

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TABLES

1. SCOPE

1.1 This standard describes methods and equipment for testing of thermometers used in machinery and piping systems.

2. REFERENCED DOCUMENTS

2.1 The following documents of the issue in effect on date of invitation for bids form a part of this standard to the extent specified herein:

SPECIFICATIONS

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

STANDARDS

MILITARY
MIL-STD-167 - Mechanical Vibrations of Shipboard Equipment.

2.2 Other publications.- The following documents form a part of this standard to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids shall apply.

AMERICAN INSURANCE ASSOCIATION
Research Report No. 2 - Potential Hazards in Molten Salt Baths for Heat Treatment of Metals.

(Application for copies should be addressed to the American Insurance Association, 85 John Street, New York, N. Y. 10038.)

AMERICAN STANDARDS ASSOCIATION (ASA)
C 96.1-1964 - Temperature Measurement Thermocouples.

(Application for copies should be addressed to the American Standards Association, 10 East 40th Street, New York, N. Y. 10016.)

3. DEFINITIONS

3.1 Indicator.- An indicator is a measuring instrument that includes a sensing element to detect the variable parameter being measured and generates an output signal that varies with the measured parameter; a translation mechanism that converts the output signal of the sensing element to a readout signal; and a readout display which converts the readout signal to an indicated or recorded value.

3.2 Master test standard.- A master test standard is an indicator whose accuracy is periodically compared with an indicator of higher level of accuracy through various traceable steps or levels to the National Bureau of Standards. Each master test indicator shall be furnished with a dated calibration curve which shows the limit of errors of the indicator.

3.3 Accuracy.- The accuracy of an indicated or recorded value is a number or quantity which defines the limit of error, where the error is the difference between the indicated and the true value of the parameter being measured, expressed either in scale units, in percent of scale span, in percent of top scale value, or in percent of actual reading.

3.4 Response time.- Response time is the time interval under specified test conditions for the output or indication of an instrument or component having a substantially exponential response characteristic to achieve 63.2 percent of the total change that it will make in response to a step change in the measured or input quantity.

3.5 Dead band.- The range of values through which the measured parameter can be varied without initiating instrument response.

3.6 Insertion length.- The insertion length of the protective tube, well or thermal element is the length from the free end to, but not including, the external threads or other means of attachment to a pressure vessel.

3.7 True value.- True value is the value of the parameter being measured as determined by an acceptable standard or master indicator after all corrections have been made.

3.8 Calibration.- Within the scope of this standard, calibration means the determination for error by comparing the instrument under investigation with a standard.

3.9 Thermometer systems.- Thermometer systems made up of complete assemblies include the following:

(a) Liquid-in-glass.
(b) Bimetallic.
(c) Filled system (adjustable angle, direct reading).
(d) Filled system (remote reading).

4. TEST CONDITIONS AND REPORTS

4.1 Requirements.- The requirements which shall be met by the thermometers or temperature actuated devices subjected to the tests described herein are specified in the individual equipment specification, as applicable, and the tests shall be applied as specified herein. Whenever this standard conflicts with the individual equipment specification, the latter shall govern.

4.2 Environmental conditions.- Unless otherwise specified herein, or in the individual specifications, all measurements and tests shall be made at room ambient temperature, atmospheric pressure, and relative humidity. Whenever these conditions must be closely controlled in order to obtain reproducible results environmental conditions shall be as follows:

(a) The pressure shall be barometric pressure.
(b) The ambient temperature shall be 74° ± 5°F.
(c) The relative humidity shall not exceed 50 percent.

4.3 Power supply.- The supply voltage and frequency shall be the normal operating voltage and frequency.

4.4 Personnel and facilities.- Form A is for use in evaluating personnel and facilities to determine conformance to this standard.

4.5 Product test reports.- Form B is to be used for maintaining a record of equipment performance.

TO: BUREAU OF SHIPS (CODE 648), WASHINGTON, D. C. 20360

MANUFACTURER
LOCATION OF PLANT

GOVERNMENT INSPECTOR
MAKING SURVEY

A. PERSONNEL (Dept. Head, Chief Inspector, Section Heads, Inspectors - A short resume to establish the order of responsibility, qualifications, and stability of the group).

NAME AND POSITION	EDUCATION AND TRAINING	EXPERIENCE	TIME IN PRESENT POSITION

B. TEMPERATURE STANDARDS (Include associated equipment, e.g. resistance thermometer and resistance bridge).
1. REFERENCE STANDARDS

DESCRIPTION	MANUFACTURER	MODEL NR.	SERIAL NR.	CERTIFICATION	
				BY WHOM	LAST DATE

FORM A - Report on contractor's personnel and facilities for testing thermometers.

Sheet 1 of 3

B. TEMPERATURE STANDARDS
2. WORKING STANDARDS

DESCRIPTION	MANUFACTURER	MODEL NR.	QUANTITY	RANGE	ACCURACY	CALIB. PERIOD (MONTHS)

C. CALIBRATION BATHS AND FURNACES

DESCRIPTION	TEMPERATURE RANGE	DIMENSIONS OF WORKING SPACE	METHODS OF HEATING OR COOLING	TYPE OF CONTROL	METHOD OF AGITATING

Sheet 2 of 3

D. QUESTION LIST

1. Does manufacturer have a Navy lightweight high impact shock testing machine? Yes___No___. If he does not have a machine where will he have the shock test performed when such tests are required?

2. Does manufacturer have a vibration table capable of performing the environmental vibration test of MIL-STD-167? Yes___No___. If he does not where will he have the vibration test performed when such tests are required?

3. Does manufacturer have a standard cylinder and a suitable millivolt pyrometer or potentiometer for use in conjunction with the thermal response (LAG) test? Yes___No___.

4. Does manufacturer have a means for determining the effects of variations in ambient temperature on the capillary of a remote-reading thermometer? Yes___No___; on the indicator? Yes___No___. On the indicator of a direct-reading thermometer? Yes___No___.

5. Does the manufacturer have suitable equipment for performing the thermal cycling test? Yes___No___, is the rate of cycling adjustable? Maximum___°F, Minimum___°F.

Sheet 3 of 3

PRODUCT	For use with MIL-STD-735 and applicable individual Military Specifications on thermometers	DATE	TEST NR.
CLASSIFICATION OF THERMOMETER TESTED		RANGE AND SERVICE	
MANUFACTURER	LOCATION OF PLANT		CONTRACT NR.
TYPE OF TEST	____QUALIFICATION	____VERIFICATION	____INSPECTION
APPLICABLE MILITARY SPECIFICATION MIL-			

TEST DESCRIPTION	APPLICABLE PARAGRAPH		PERFORMANCE		PASSED	FAILED
	MIL-STD-735	INDIVIDUAL SPEC.	REQUIRED	TEST		
CALIBRATION	6.1					
THERMAL RESPONSE (LAG)	6.2					
OVER TEMPERATURE	6.3					
INDICATOR AND CAPILLARY COMPENSATION	6.4					
THERMAL CYCLING	6.5					
VIBRATION	6.6					
SHOCK (HI IMPACT)	6.7					
THERMAL AND MECHANICAL STABILITY	6.8					
INCLINATION	6.9					
LOAD	6.10					
LEAK	6.11					
FOG	6.12					
OTHER						
REMARKS			REMARKS			

SIGNATURE OF FACTORY QUALITY CONTROL SUPERVISOR	SIGNATURE OF GOVERNMENT INSPECTOR

FORM B - Product Test Record.

5. TEST EQUIPMENT

(Information specified herein is to guide the user in the selection, arrangement and method of operation of the test equipment. Equipment is described that has been found suitable or has been designed for the tests of this standard. Unless a particular device or apparatus is specified, any equipment that can provide the conditions required for the tests and is not objectionable to the bureau or agency concerned may be used.)

5.1 Bath comparator.- The bath comparator shall be a stirred liquid bath in which the temperature sensing element under test and that of a master test standard may both be immersed for accuracy comparison. Suggested fluids and approximate temperature ranges for liquid baths are:

Liquid	Temperature range (°F)
Ethyl alcohol	-150 to 0
Ethylene glycol + water	- 20 to 140
Water	32 to 212
Oil	150 to 500
Salt	400 to 1500

Note: Other liquids may be used where the liquid will not damage the element being immersed and other conditions required herein are met.

5.1.1 General design.- Baths may be of various types or designs. However, all baths shall include one or more pots or tanks, a stirrer, means of heating or cooling and controls. The tank shall be designed so that the temperature will not be excessively lowered when an element is immersed and to accommodate the types of sensing elements most frequently used.

5.1.1.1 Controls.- The controls shall be suitable for maintaining the temperature either constant or uniformly increasing or decreasing while the bath is being stirred. Stirring shall be sufficient to insure that the temperature gradient throughout the test portion of the bath does not exceed 1/2°F. under steady state load conditions.

5.1.2 Alcohol, glycol, water and oil baths.- Figure 1 shows one design of bath used with water, oil or other liquids that do not solidify at ambient temperature. This bath consists of two tubes of different diameters in a common framework with connecting passages at the top and bottom. The heating coil, cooling coil and stirrer are located in the smaller tube, the larger tube being left clear for immersion of the master test standard and the test element. Other designs are equally suitable provided they do not conflict with other requirements of this standard.

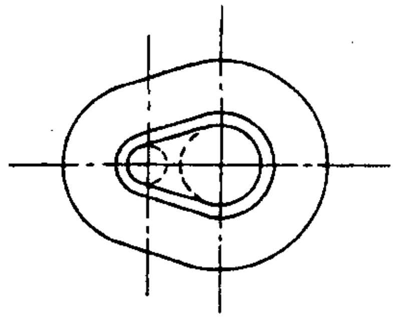
5.1.2.1 Stirrer.- Any method of stirring may be used provided temperature gradients throughout the working space of the bath do not exceed 1/2°F. under steady state conditions.

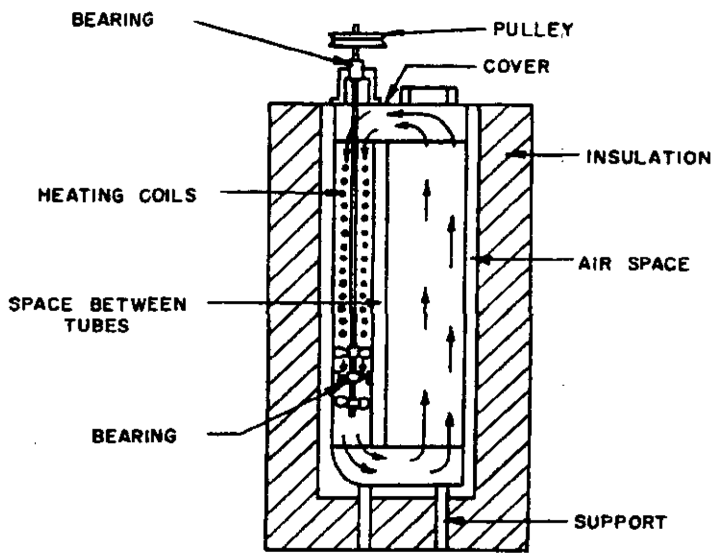
5.1.2.2 Liquids.- Tap (fresh water) shall be used for water baths, a suitable high-flash-point-oil shall be used for oil baths. An overflow tube and reservoir shall be provided to maintain the bath level as the liquid expands or contracts. At the higher temperatures (above 400°F) great care shall be taken to avoid dangerous flash fires. When not in use the container should be covered.

5.1.3 Salt bath.- Figure 2 shows one design of salt bath. Salt baths may be of the type frequently used for heat treating purposes, converted to calibration and test work by the addition of a stirrer for uniform temperature distribution and a controller for heat input regulation and temperature control. Heat may be supplied externally, internally, or both, provided the conditions of 5.1.2.1 are met.

5.1.3.1 Salt.- Information on the best salt to use for specific temperature ranges and areas of application can be obtained from companies supplying materials to industry for the heat treating of metals. The Bellis Heat Treating Company and E. F. Houghton and Company are two examples of such companies. It is recommended that every user or potential user of these baths obtain a copy of American Insurance Association Research Report Number 2.

5.2 Master test standards.- Master test standards shall be reference standards, liquid-in-glass mercury actuated, etched stem thermometers; reference or primary level thermocouples or resistance type elements.





NOTE: Care shall be taken to insure that both temperatures do not approach oil flash point used in the bath.

Figure 1 - Liquid bath comparator (alcohol, glycol, water and oil).

5.2.1 Reference standards liquid-in-glass thermometers.- Test thermometers shall consist of a set of nine thermometers in overlapping ranges for a temperature coverage of minus 38°F. to plus 760°F. The set of liquid-in-glass thermometers shown in table I manufactured in strict accordance with American Society of Testing and Materials Precision Specifications is recommended.

The set of thermometers should be standardized for total immersion. With the exception of the first two, each thermometer is provided with an auxiliary scale which includes 32°F, thus each of the thermometers in this series is provided with a means for checking the ice point, which shall be done from time to time when the thermometer is used. From these ice point tests, the effect of changes in bulb volume on the thermometer indication may be followed throughout the life of the thermometer and the resulting correction applied to subsequent readings.

5.2.2 Reference or primary standard thermocouples.- Thermocouples are dissimilar types of wire joined at the "measuring junction" with a second junction in an "ice bottle". The EMF output from these

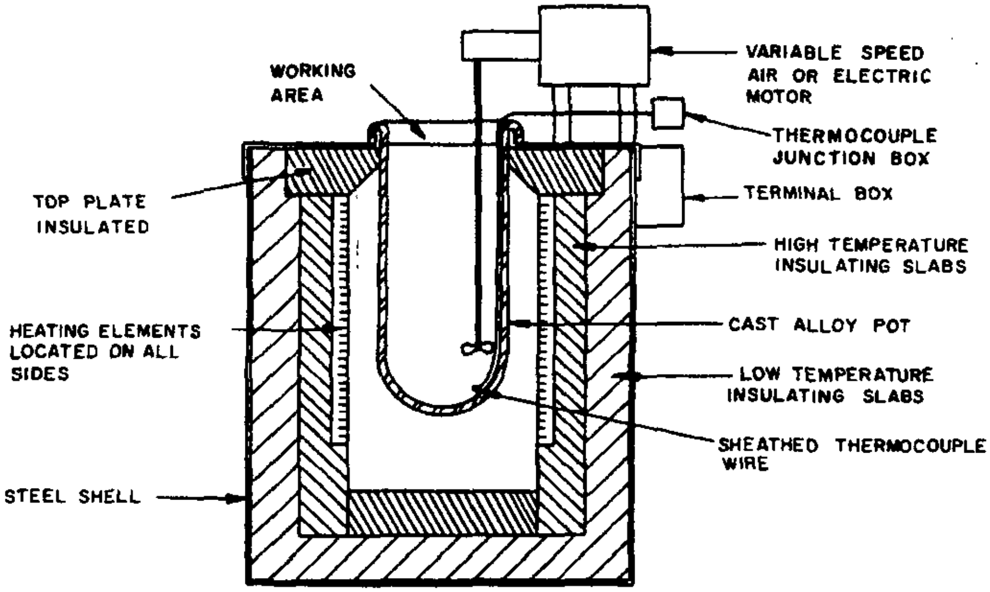


Figure 2 - Salt bath comparator.

Table I - Reference standards liquid-in-glass thermometers.

ASTM No. (°F.)	Range (°F.)	Divisions (°F.)	Length (mm)
62	-36 to +35	0.2	380
63	18 to 89	0.2	380
64	77 to 131	0.2	380
65	122 to 176	0.2	380
66	167 to 221	0.2	380
67	203 to 311	0.5	380
68	293 to 401	0.5	380
69	383 to 581	1.0	380
70	563 to 761	1.0	380

junctions depend on the change in temperature at the measuring junction if the ice bottle junction is maintained constant. For details of thermocouples, materials and fabrication see ASA Standard C 96.1-1964. Figures 3 and 4 show two types of master standard thermocouple assemblies. Figure 5 shows a recommended ice bath for reference junctions.

5.2.3 Primary or working standard resistance thermometer.- A resistance temperature indicator consists of a resistance element for sensing the temperature connected to a resistance thermometer bridge indicator. A change in temperature at the resistance element causes a deflection of the bridge indicator proportional to the temperature change.

5.2.3.1 Resistance thermometer bridge.- The resistance thermometer bridge shall have the following minimum characteristics:

Range: 0 to 100 ohms. Limit of error: 0.1 percent plus 0.01 ohms.

NOTES	INSTALLATION
1	Install a checking thermocouple in each bottle used.
2	Run all thermocouple wires from check thermocouples to individual tubes in the master bottle. Connect thermocouples in series by piece no. 2.
3	Make up reference junctions as shown on figure 3 and observe all precautions listed.
4	Connect (4) to point 50 in (5). If no connection box is used run (4) directly to last point on indicator.
5	Cross connect last two points in indicator or points 40 and 50 in connection box with piece no. 2 as shown.
6	For over 8 check thermocouples, repeat 1 through 5 above using an additional master bottle and points 47 and 48 in connection box.

OPERATION

7	Close switch 50, indicator should read zero.
8	Close switch 49, indicator should read zero.
9	If indicator shows a reading, one or more ice bottles or the master ice bottle are not at 32°F and must be re-iced.
10	When the master ice bottle is connected to an indicator reading in degrees; 1 and 2 above should read 32°F or 0°C, if bottles are functioning properly.

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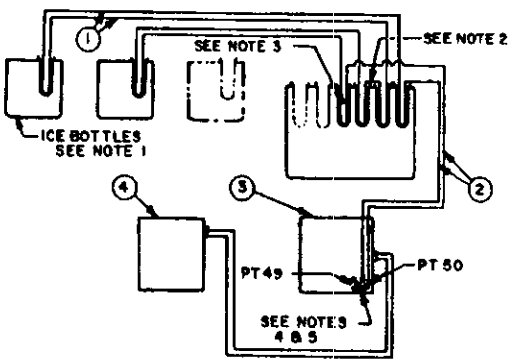

BILL OF MATERIAL

PC. NO.	DESCRIPTION
1	WIRE, 20 GAGE IRON-CONSTANTAN ASBESTOS AND GLASS
2	WIRE, 24 GA. COPPER ENAMEL AND GLASS
3	CONNECTION BOX FOR 50 POINT INDICATOR
4	INDICATOR MILLIVOLT, 50 POINT RACK MOUNTED COMPLETE WITH CONNECTING CABLE

Figure 3 - Thermocouple-indicator assembly, non-movable.

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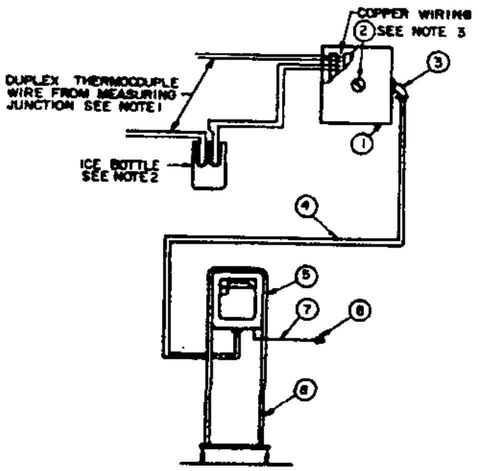

BILL OF MATERIAL

PC. NO.	DESCRIPTION	MATERIAL
1	CONNECTION BOX (50 POINT)	
2	THERMOMETER, WESTON DIAL 20-240°F.	MODEL NO. 122-D
3	CONNECTOR, CANNON SHELL SIZE 48 100 PINS	CAT. NO. 2106-16
4	CABLE, 60 TWISTED PAIR TELE. HEAT AND FLAME ARMOR	
5	INDICATOR, LEEDS & NORTHRUP 50 PT. 0-40.1 MV	CAT. NO. 60899-SP
6	RACK, MOVABLE LEEDS & NORTHRUP	CAT. NO. 8655-P1-P2
7	CABLE, 3 COND. TOOP 1-1/2 RUBBER COV.	
8	PLUG, 3 WIRE GROUNDED	

NOTES:
1 Thermocouples can be connected either directly into the connection box or through ice bottles as desired. Connection through ice bottles should always be made when readings better than ±2°F. are desired.
2 When thermocouples are connected through ice bottles a master ice bottle check installation as shown in figure 3 shall be installed and provisions made to log indicator points 49 and 50.
3 Thermometer Pc. No. 2 is to be used to determine cold junction temperature when thermocouples are connected directly into connection box.

Figure 4 - Thermocouple-indicator assembly movable installation.

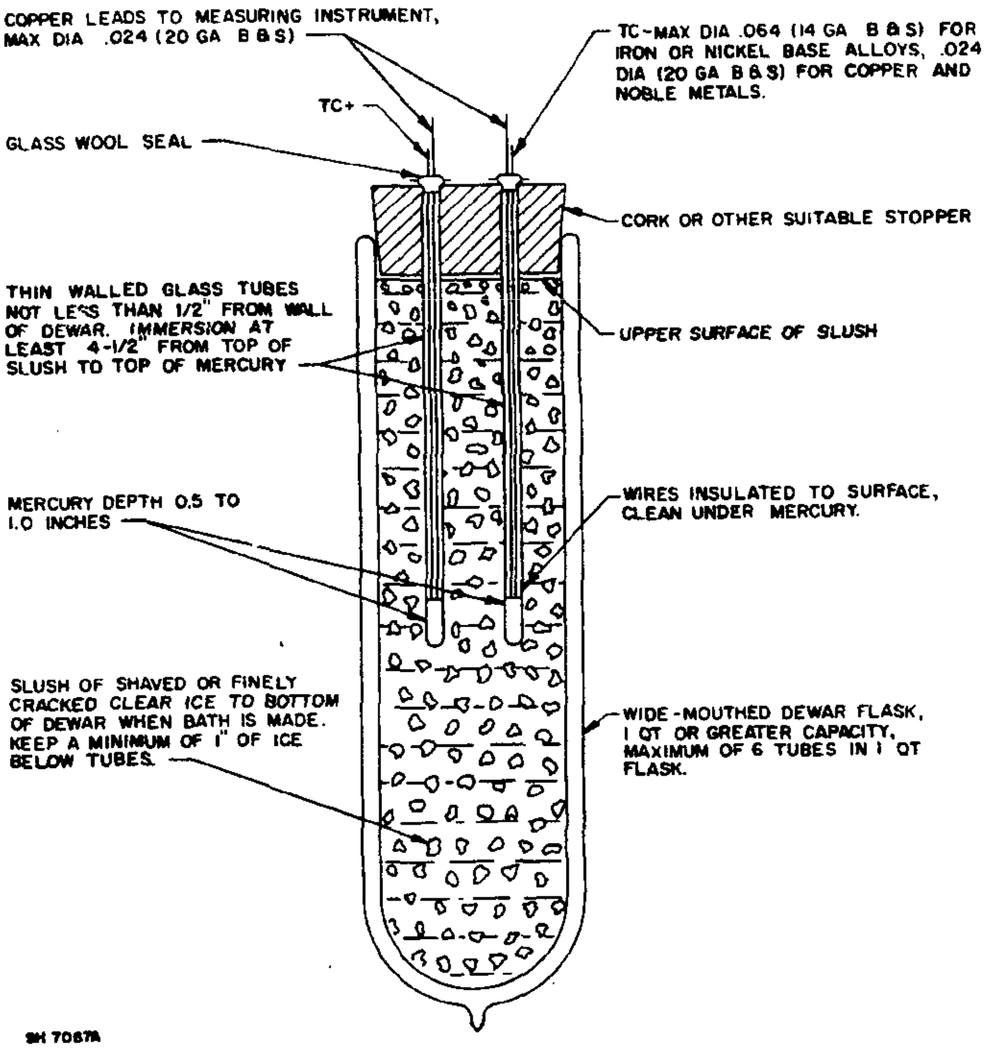

Figure 5 - Reference junction ice bath.

5.2.3.2 Primary standard resistance element.- Primary standard resistance elements shall be as follows:

Range - -310°F to 932°F.
Limit of error - ±0.005°F.
Element - Platinum wire resistor in Pyrex tube (see note) of 0.7 cm. diameter.
Resistance - 25.5 ohms at 32°F, changing 0.05 ohms per degree F.
Length - Element 2 cm.; tube 46 cm.
Connections - Four-lead potential wired.
Note: For temperatures above 932°F., the tube shall be quartz material.

A certificate of calibration should be obtained from the National Bureau of Standards for either ice, steam and sulfur points for use above 32°F. or the ice, steam, sulfur and oxygen points for use both above and below 32°F.

5.2.3.3 Working standard resistance element.- The working standard resistance element shall have the following minimum requirements.

Range: 0 to 1000°F.
Limit of error: ±1.5°F. from 0 to 1000°F.

6. TESTS

6.1 Calibration.-

6.1.1 Purpose.- This test is made to determine the condition and accuracy of the thermometer throughout its operating range. An initial calibration is made to establish the condition of the thermometer as received from the manufacturer or before being used or tested. No corrections or adjustments to the thermometer shall be made. Additional calibrations are made as required to determine the condition and any changes that may have occurred in the thermometer after it has been used or subjected to a test condition.

6.1.2 Equipment.- The calibration shall be performed in a liquid bath or baths, where one bath will not cover the entire range. Baths shall be in accordance with 5.1. The master standard used shall conform to 5.2 as applicable, of higher accuracy than the thermometer being calibrated and shall be capable of giving results within 1/4 of the tolerance specified for the thermometer being tested.

6.1.3 Methods.- The entire insertion length of the thermometer being tested shall be immersed in a suitably stirred liquid bath. Readings shall be taken at not less than five points spaced at nearly equal intervals over the operating range of the thermometer. At each point the bath temperature shall be leveled out in such a manner as to eliminate lag between the thermometer and the master standard. A temperature rise or fall of one or two degrees in 5 minutes is satisfactory for the purpose.

6.1.4 Special methods.-

6.1.4.1 Remote reading filled systems.- During the calibration test, the indicator and capillary tubing shall be at normal room temperature, approximately 75°F.

6.1.4.2 Filled system and bimetallic.- The indicator shall be tapped near the center of the dial before each reading. In the event that tapping causes a pointer shift greater than one subdivision, an additional test shall be made to determine the "dead band" of the thermometer as follows:

Select a temperature within the middle third of the range and slowly bring the bath temperature to this value first from one direction then the other. When approaching the selected temperature from either direction there must be no reversal in the direction of the temperature change. The dead band is the average difference between the thermometer readings at which the indicator comes to rest when the bath temperature, as indicated by the master standard, reaches the selected value from the opposite direction. The change in bath temperature for this test should not exceed ±10 percent or be less than ±5 percent of the full scale value.

NOTE: The thermometer shall not be tapped, jarred or vibrated during this test.

6.1.4.3 Liquid-in-glass industrial.- Industrial type liquid-in-glass thermometers are in effect partial immersion thermometers. When used at any immersion other than that for calibrated, they will not give a true indication of bulb temperature. Generally, the depth of immersion is fixed by the thread or the flange of the well. However, even when inserted to the proper depth in the bath, differences in indication can still be caused by differences in heat transferred to or lost from the well, flange or other parts of the thermometer not immersed in the bath liquid. Unless otherwise specified, the thermometer shall be tested without a well when the well is removable. The bulb shall be immersed to the same depth in the bath without a well as it would be if in a well. The case shall be insulated from radiant and convection heating or cooling from the bath by a suitable thermal shield. When a flange is an integral part of the thermometer and cannot be detached, the insulating shield shall be placed between the flange and the case.

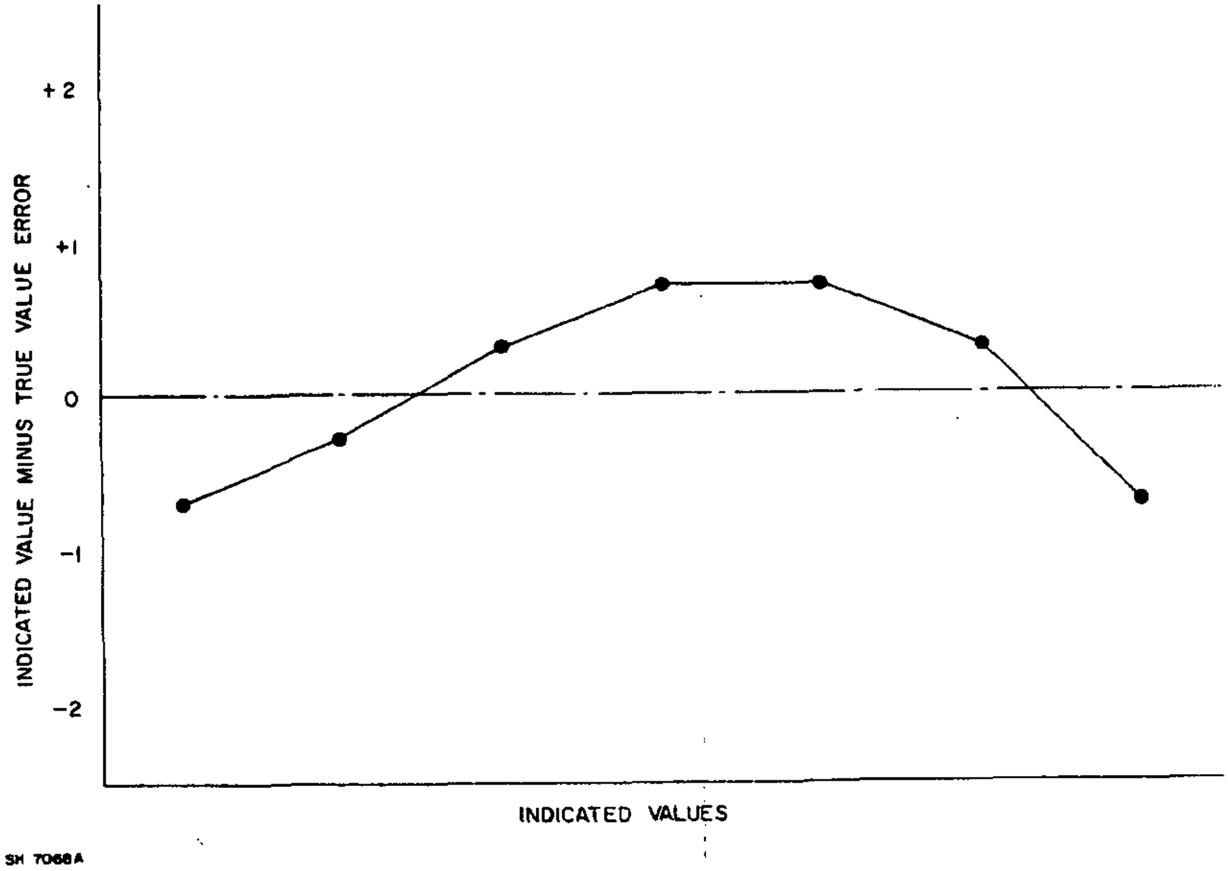

Figure 6 - Typical calibration curve.

6.1.5 Calibration curve.- The calibration curve shall be drawn as shown on figure 6. Drawn this way it is easily used and there is little possibility of error in its use. It should be noted, however, that the calibration curve obtained in the way indicated shows only the average amount by which the indication of the thermometer may be expected to vary from true temperature.

NOTE: For filled system and bimetallic thermometers the dead band is a supplementary measurement representing the amount by which the readings of the thermometer vary in successive indications of the same temperature.

6.1.6 Summary.- The following details shall be specified in the individual specification:

(a) The operating range of the thermometer, if less than the dial range.
(b) The portion of the thermometer to be put in the bath if other than the insertion length.
(c) Acceptable limit of errors.
(d) Master standard accuracy shall be better than 1/4 the specified accuracy of the thermometer being tested.

6.2 Thermal response (lag).-

6.2.1 Purpose.- This test is a means of comparing the dynamic performance of the thermometers. The results of the test is expressed as a time lapse called the response time. This time is indicative of the speed at which a thermometer responds to changes in temperature of the medium being measured or the amount the indicated temperature lags behind the temperature of the medium.

6.2.2 Equipment.- A continuously stirred liquid bath in accordance with 5.1 capable of temperatures in the upper quarter of the scale of the thermometer to be tested is required. The bath shall be sufficiently large so that it will not be cooled more than 1/2 of one percent of the scale span when the thermometer bulb is dipped into it. The standard cylinder shown on figure 7 shall be used to set the stirring speed of the bath

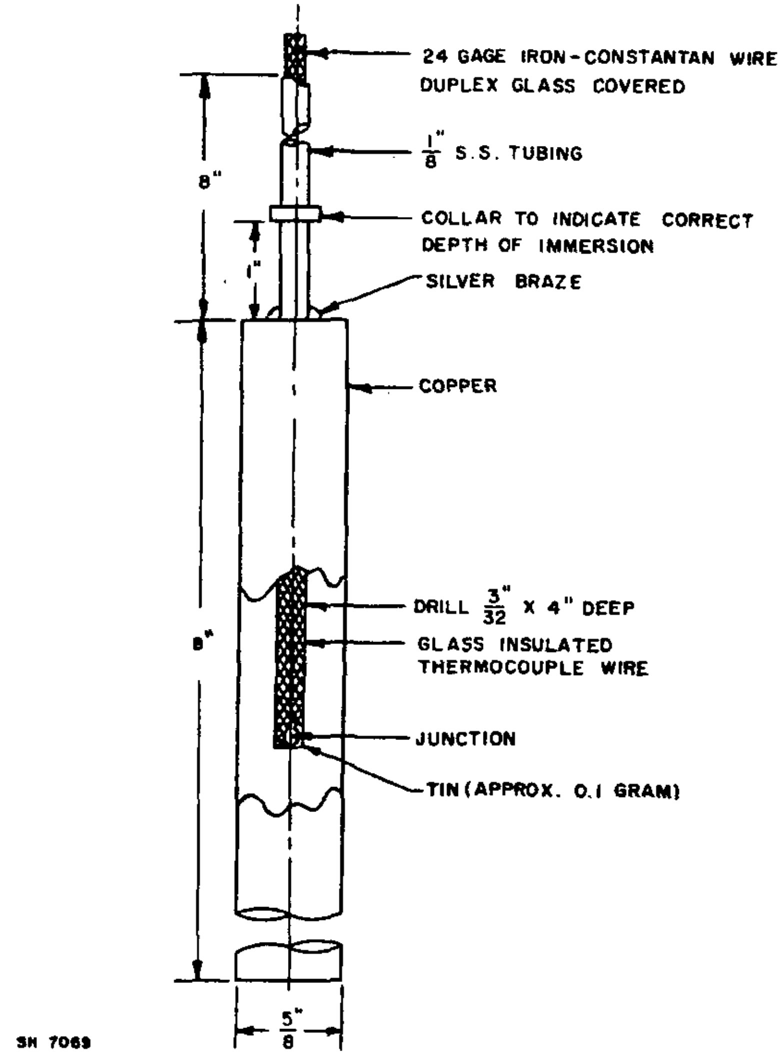

Figure 7 - Standard cylinder.

or as a comparison standard, whichever may apply. Timing shall be by stop watch or other method capable of timing to 0.2 second or better. A millivolt pyrometer or potentiometer having a response time at least two times faster than the response time of the standard cylinder, (see table II), will be needed to measure the temperature rise of the cylinder.

Table II - Response time for standard cylinder.

Bath medium	Test temperature Range (°F.)	Response time (Seconds)
Glycol 1/	-20 to 140	15 ± 1
Water	32 to 212	6 ± 0.2
Oil	180 to 500	40 ± 2
Salt 2/	400 to 1500	8 ± 0.2

1/ Fifty percent glycol, 50 percent water.
2/ Noncorrosive low melting point mixture of nitrates and nitrites of sodium and potassium. The liquid shall be stable at all operating temperatures.

6.2.3 Methods.- The test shall be performed in a liquid bath having either a variable or a fixed rate of stirring. When the stirring rate is variable (type A test) the stirring rate shall be set to give the response time of table II or as specified for the standard cylinder. The setting is determined by performing the test described in this method using the standard cylinder instead of a thermometer and adjusting the stirring rate to give the required response time. When the bath is not equipped with a variable speed stirrer (type B test), the response time of the test cylinder is determined by the fixed stirring rate. The response time shall be the average of at least six trials not counting those performed in determining the stirring speed required to give eight seconds. Response times determined by the type B test can be put on the same basis as the type A test by use of the following ratio:

$$\frac{\text{Thermometer time, type A test}}{\text{Thermometer time, type B test}} = \frac{\text{Specified time for standard cylinder}}{\text{Type B test time for standard cylinder}}$$

6.2.3.1 Temperatures.- The temperature listed below shall be as specified or shall be selected to give a step change of at least 25 percent of the scale span of the thermometer being tested.

(a) Bath temperature.
(b) Initial temperature; T_1 minus 10 percent of scale span.
(c) Temperature at which timing is to begin, T_1.
(d) Temperature at which timing is to stop, T_2.

6.2.3.2 Lag determination.- The bath shall be adjusted to hold a constant temperature and the stirring speed set as described above. The thermometer bulb shall be immersed in the bath at the same location at which the test was performed with the standard cylinder and shall be allowed to soak until the indicator shows no further rise. The bulb shall be removed from the bath and shall be cooled in air or in a second bath to a temperature 10 percent of the dial span of the thermometer below the temperature at which timing is started. When a second bath is used, the bulb shall be held in this bath until its temperature becomes constant. The bulb shall be transferred back into the first bath where the bulb shall be immersed to its full insertion length at the same location in the bath it originally occupied. Timing shall be started when the indicator passes the T_1 mark and stopped when it passes the T_2 mark. The time lapse between T_1 and T_2 is the response time. The response time shall be the average of 4 trials. T_1 and T_2 shall be true, not indicated temperatures.

6.2.3.3 Summary.- The following details shall be specified in the individual specification:

(a) The bath medium.
(b) The bath temperature.

(c) The initial temperature.
(d) The temperature at which timing is to begin, T_1.
(e) The temperature at which timing is to stop, T_2.
(f) Response time of the thermometer in the bath medium.
(g) Type of well to be used for the test if other than bare bulb.

6.3 Over temperature.-

6.3.1 Purpose.- In the over or excess temperature test the bulb or sensitive portion of the thermometer is subjected for a specified time to a temperature above its normal range of operation. The test is used to prove that the thermometer system can be used at the top of its operating range and that it will withstand short periods of higher temperatures without failure. Weaknesses in the system will be indicated by physical damage or loss of accuracy. The effects of over temperature include heat damage to the materials, overstressing of the pressure system, leakage of the filling medium and changes in electrical or mechanical characteristics.

6.3.2 Equipment.- The test shall be performed in a bath in accordance with 5.1. The bath shall be of sufficient size for complete immersion of the insertion length of the thermometer bulb.

6.3.3 Methods.- The insertion length of the bulb shall be subjected to a temperature equal or slightly greater than the maximum dial indication for 5 minutes. The bulb shall then be allowed to cool to ambient temperature in air. After cooling, the thermometer shall be calibrated for accuracy.

6.3.4 Summary.- The following details shall be specified in the individual specification:

(a) The temperature if other than maximum dial indication.
(b) The time if other than 5 minutes.

6.4 Indicator and capillary compensation (filled systems type only).-

6.4.1 Purpose.- This test is performed to determine the effectiveness of the provisions made in the thermometer system to compensate for temperature changes around the indicator and along the capillary. Without compensation or with inadequate compensation the temperature variations around these elements may have a substantial influence on the indication.

6.4.2 Equipment.- A stirred liquid bath and a cabinet or oven capable of being heated or cooled are required for this test. The first of these is for bulb temperatures. The second is for ambient temperatures around the capillary and indicator. The cabinet shall have a suitable opening for enclosing either the capillary or the indicator while the bulb is in the liquid bath. A cabinet for heating or cooling the indicator of direct connected thermometers is shown on figure 8. An alternate method for testing the capillary is to immerse it in a water bath at the specified temperature.

6.4.3 Methods.- The bulb shall be immersed in a stirred liquid bath. Bulb, indicator and capillary temperature shall be obtained as shown in table III. In each test the indicator or capillary shall be held at the required temperature for not less than one hour before taking a reading. The results of the test shall be plotted as shown on figure 9 and the effectiveness of the compensation determined therefrom as illustrated.

6.4.4 Summary.- The following details shall be specified in the individual specification:

(a) The base temperature or temperatures if other than 110°F. and the temperature changes from 110°F. if different from those specified in table III.
(b) The maximum change in indication allowable for the indicator and the capillary if other than one scale division each.

6.5 Thermal cycling.-

6.5.1 Purpose.- This test is made to determine the resistance of the thermometer system to cyclic changes in temperature and to expose weaknesses in materials or construction that may cause premature failure. Such failure may include leakage of the filling medium, clogging or plugging of the capillary, changes in operating characteristics, and physical damage or distortion.

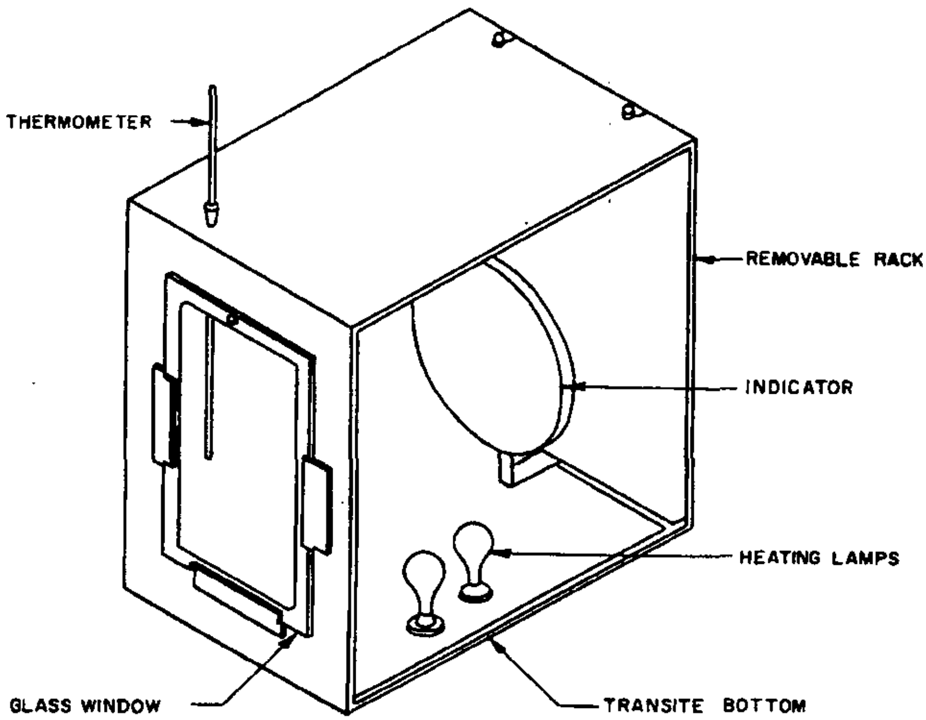

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Figure 8 - Oven for case compensation test.

Table III - Bulb, indicator and capillary temperatures.

Temperatures		
Bulb	Indicator[1] (°F.)	Capillary[1] (°F.)
75% of range	60	80
75% of range + 10°	60	80
75% of range + 10°	110	80
75% of range	110	80
75% of range	160	80
75% of range + 10°	160	80
75% of range + 10°	80	60
75% of range	80	60
75% of range	80	110
75% of range + 10°	80	110
75% of range + 10°	80	160
75% of range	80	160

[1] ±5°F. NOTE: At least 75 percent of capillary shall be exposed to the required temperature.

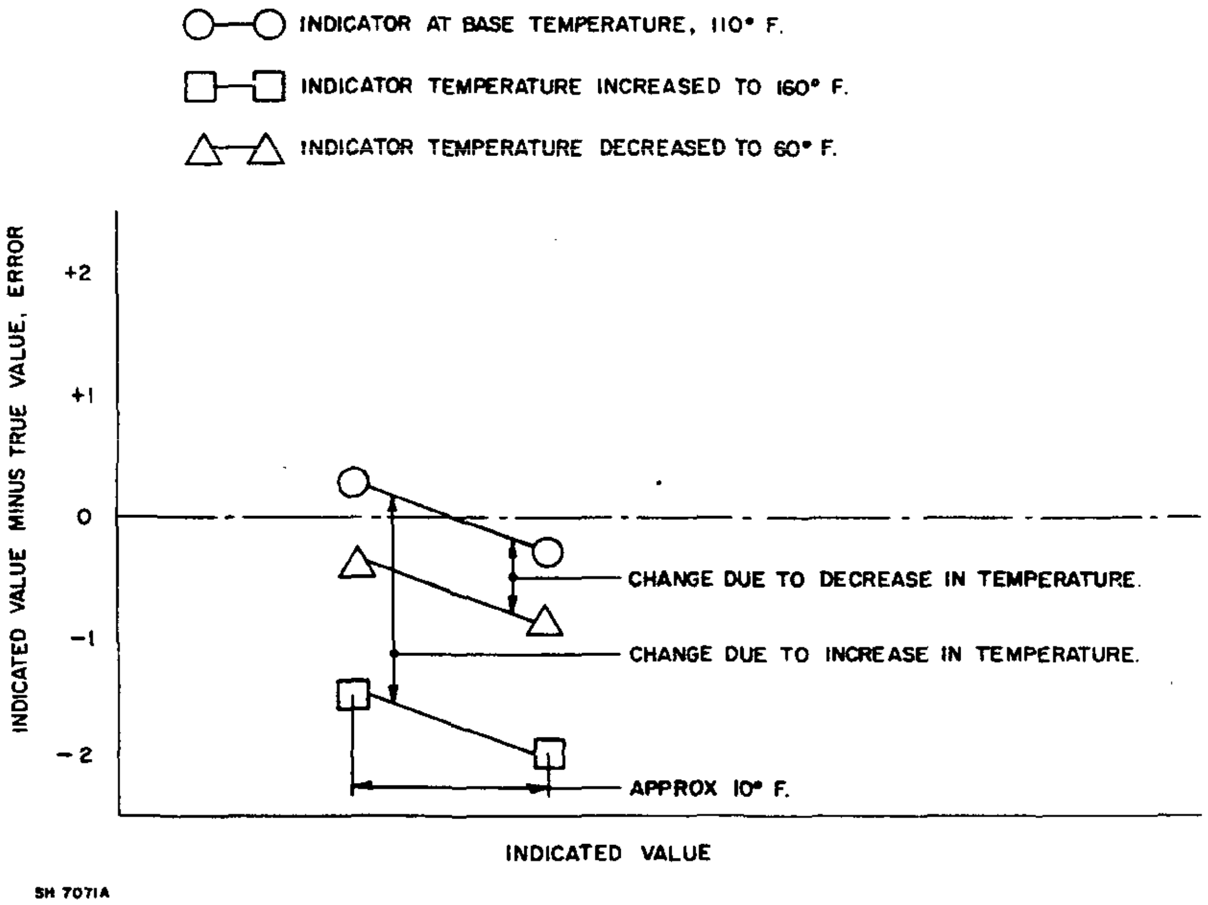

Figure 9 - Indicator compensation.

6.5.2 Equipment.- The change in temperature required for this test may be obtained by using two liquid baths, induction heating or other means that will reproduce the desired range of temperature. The cycling can be performed by mechanical apparatus such as that shown on figure 10 or by any suitable method. Where two baths are used the heat transfer medium should generally be the same in both baths. Some high temperature salts are not compatible and the dragging of liquid from one bath 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.

6.5.3 Methods.- The thermometer bulb shall be successively heated and cooled at a convenient rate.

6.5.4 Summary.- The following details shall be specified in the individual specification:

(a) Cycling rate if a specific rate is desired.
(b) Number of cycles if other than 1500.

6.6 Vibration.-

6.6.1 Purpose.- The vibration test is used to determine the effects on component parts of vibration within the predominant frequency ranges and magnitudes that may be encountered during field service. Most vibration encountered in field service is not a simple harmonic nature, but tests based on vibrations of this type have proven satisfactory for determining critical frequencies, modes of vibration, and other data necessary for planning protective steps against the effects of undue vibration. Vibration, by causing the loosening of parts or relative movement between parts in the specimen can produce objectionable operating characteristics, noise, wear, and physical distortion, and often results in fatigue and failure of mechanical parts.

6.6.2 Methods.- This test shall be conducted in accordance with MIL-STD-167. Prior to vibration the specified tests or measurements shall be made. The equipment shall be mounted as specified using suitable mounting apparatus to assure that the mounting is free from resonance over the test frequency range. Thermal elements shall normally be heated to a temperature within the operating range of the thermometer unless otherwise specified. If applicable, electric powered equipment shall be energized.

6.6.2.1 Special methods.- Certain thermometers, such as the bimetallic, are mounted directly in piping or on machinery and subjected to higher frequencies than the 5 to 33 cps range covered in MIL-STD-167. The

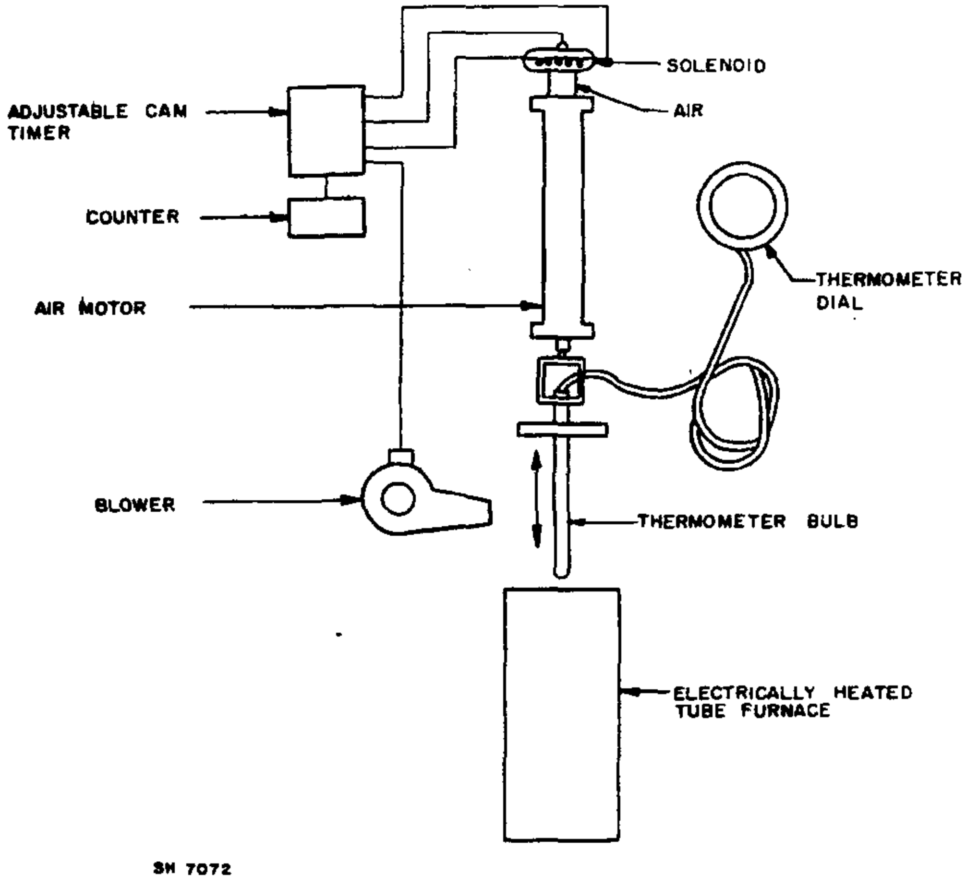

Figure 10 - Test arrangement for thermal cycling.

thermometer shall be secured to the mounting bracket in the same manner that it will be installed in service. In some instances, the thermometer may be installed in a number of different positions, in which case the test engineer shall use his judgment as to the proper installation. The thermometer shall be tested in accordance with the procedures of MIL-STD-167 except that the range shall be from 5 to 100 c.p.s. at the amplitudes specified below. At each frequency the vibration shall be maintained for 2 minutes. If no resonance is observed, the endurance test shall be performed at 100 c.p.s.

Frequency range, c.p.s.	Table amplitude, inches
5 to 20	0.030
21 to 50	0.020
51 to 100	0.010

As a result of the test no part of the thermometer shall become loosened, dislodged or broken and parts shall show no signs of wear. Without adjustment, a calibration check shall meet the specified requirements. In addition, pointer oscillation shall not exceed 5 percent of the range span and the center of oscillation shall be within ± 1 percent of the reading obtained under static conditions.

6.6.3 Measurements.- The specified measurements shall be made during and after vibration tests.

6.6.4 Summary.- The following details shall be specified in the individual specification:

(a) Tests and measurements prior to vibration (see 6.6.2).
(b) Method of mounting (see 6.6.2).
(c) Thermal element temperature (see 6.6.2).
(d) Electrical-load condition, if applicable (see 6.6.2).
(e) Tests and measurements during and after vibration (see 6.6.3).
(f) Allowable change in indication or output during vibration.

6.7 Shock (high-impact).-

6.7.1 Purpose.- The shock test is intended to determine the suitability of equipment that is intended for installation on naval ships. The shock originates generally from a large force that is suddenly applied to the structure or housing which supports the equipment. The equipment generally sees only the motion of the structure, and shock is thought of in terms of the motion of the support for the equipment. A shock motion usually embodies a significant displacement and a sudden change in velocity, in most instances, it is oscillatory in nature and includes several apparent frequencies. These characteristics are reproduced in shock-testing machines by mounting the equipment under test to a structure that experience a sudden change in velocity. The machine originally developed for shock testing was required to satisfy the sole criterion that it caused damage to the equipment similar to that experienced during conditions of warfare. The U. S. Navy has adapted this machine with but relatively minor changes in design and is using the same criterion in establishing shock testing specifications. The acceptability of equipment is contingent upon its withstanding the shock resulting from the test specified when tested on a standard shock testing machine. During and subsequent to the test the equipment shall not fail to perform its principle function.

6.7.2 Methods.- This test shall be conducted in accordance with MIL-S-901. Prior to shock the specified tests and measurements shall be made. The equipment shall be secured to the mounting bracket of the shock machine in the same manner that it will be secured on shipboard. Thermal elements shall normally be heated to a temperature within the operating range of the thermometer unless otherwise specified. If applicable, electrical powered equipment shall be energized.

6.7.3 Measurements.- The specified measurements shall be made upon completion of the required number of blows and between blows, where applicable.

6.7.4 Summary.- The following details shall be specified in the individual specification:

(a) Mounting method.
(b) Electrical-load conditions, if applicable.
(c) Measurements after shock.
(d) Allowable change in indication or output from the shock test.
(e) Thermal element temperature if other than as specified in 6.7.2.

6.8 Thermal and mechanical stability.-

6.8.1 Purpose.- This test is performed to determine the suitability of materials and thermal systems for sustained service. It is intended to reveal permanent changes in operating characteristics resulting from physical changes and material instability. These include such things as bulb growth or distortion from sustained high temperature or from rapid temperature changes. leakage of filling fluids, changes in the properties of bimetals owing to continued metallurgical changes with time, failure because of unsuitable soldering or welding materials or techniques, and other material, structural. or design weaknesses.

6.8.2 Method.- Tests performed on any one of the various types of thermal systems shall be designed to reveal weaknesses inherent to the system being tested. They will generally consist of steady state tests to indicate drift or variation with time, and cyclic tests to indicate mechanical or physical weaknesses. In some instances it may be expeditious to break down the system and test component parts, for example, the indicator of a filled system thermometer may be tested as a pressure gage.

6.8.3 Special tests.-

6.8.3.1 Thermal stability for glass, filled systems and bimetallic thermometers.- The insertion length of the bulb shall be subjected to a temperature within the upper 10 percent of the range for an accumulated total of not less than 96 hours. A single point calibration check within this temperature range shall be made at the beginning of the test and after each 24 hours at this temperature. Any drift in indication shall be shown by plotting the calibration error as shown on figure 6, except that time shall be substituted for indicated value. The thermometer shall be acceptable if at the end of 96 hours the drift is less than 1/4 percent of the range. If the drift is more than 1/4 percent but less than one percent of the range, the test shall be extended 288 hours for a total of 384 hours. The test shall be terminated and the thermometer rejected if the drift exceeds one percent of the range at any time before the completion of the 384 hours.

6.8.3.2 Mechanical reliability test for filled system indicators.- In this test the indicator shall be treated as a pressure gage. If possible it should be obtained as a component prior to its assembly in a finished thermal system since cutting it out of a finished system will destroy the system. The indicator shall be subjected to 100,000 pressure cycles at a rate of approximately 1000 cycles per hour. The pressure during each cycle shall vary from less than 20 percent to over 80 percent of the dial span. The pressure shall be applied to the indicator by connecting to a short length of the capillary tubing. Fully compensated systems shall only have pressure applied to the main thermal system with the compensating system pressurized as in the normal assembly of the system.

6.9 Inclination.-

6.9.1 Purpose.- The purpose of this test is to determine the effect on the thermometer indication when the thermometer is inclined from its normal position.

6.9.2 Equipment.- The test may be performed at ambient conditions unless the pointer indicates off scale, in which case the thermal element may be heated by any suitable means to bring it within range.

6.9.3 Methods.- With the pointer at any point within the scale range and the thermometer held so as to face the dial, and with the pointer in a vertical position, the thermometer shall be rotated to place the pointer 60 degrees to the right, left, forward and backward. No change in indication greater than ±1 percent of the range shall occur.

6.9.4 Summary.- The following details shall be specified in the individual specification:

(a) The number of degrees of inclination if other than 60.
(b) The allowable change in indication if different than ±1 percent of range.

6.10 Load.-

6.10.1 Purpose.- This test is performed to determine the ability of the thermometer to resist damage when bumped or otherwise subjected to an external force.

6.10.2 Equipment.- Any suitable means may be used to hold the thermometer and apply the load.

6.10.3 Methods.- The thermometer, while mounted in its well, shall be securely held in place. A load of 150 pounds, applied in any convenient manner, shall be applied to the case at any point, in any direction, without permanently distorting the alignment of the case with the bulb, or damaging the thermometer in any way.

6.10.4 Summary.- The following detail shall be specified in the individual specification:

(a) The load if different than 150 pounds.

6.11 Leak.-

6.11.1 Purpose.- Certain types of thermometers, for example the bimetallic, must operate in environments that are injurious to thermometer parts causing corrosion and a reduction in accuracy. Hence, they must be hermetically sealed. This test determines the effectiveness of the seal.

6.11.2 Equipment.- Water baths with means of obtaining the desired temperatures are required for this test. Fresh water shall be used.

6.11.3 Methods.- The entire thermometer without its well shall be submerged in a water bath at room temperature for 30 minutes. It shall then be submerged in a second bath between 150 and 160°F. for 15 minutes. This shall be followed by submergence in a cold water bath between 40 and 50°F. for 15 minutes. The entire procedure shall be repeated once. Transfer from one bath to another shall be accomplished as rapidly as practicable. There shall be no evidence of leakage during the test.

6.11.4 Summary.- The following details shall be specified in the individual specification.

(a) Bath temperatures if other than specified.
(b) Time in the baths if other than specified.

6.12 Fog.-

6.12.1 Purpose.- This test is a continuation of the test specified in 6.11. A small amount of leakage may be unobserved during the leak test but should be detected during this test.

6.12.2 Equipment.- A refrigerator or cooling cabinet capable of maintaining a temperature of 35 to 45°F. is required for this test.

6.12.3 Methods.- After completion of the leak test (see 6.11) the thermometer shall be placed immediately in the cooling cabinet and held for one hour between 35 and 45°F. The thermometer shall then be removed and visually inspected for evidence of moisture in the case.

6.12.4 Summary.- The following detail shall be specified in the individual specification:

(a) Cooling cabinet temperature if other than 35 to 45°F.

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