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NAVY DEPARTMENT

Report of

Test of Thermometers and Thermostats

Submitted by

The Philadelphia Thermometer Company

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D.C.

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BuEng.ltr. S67(T)L5(7-25-~~R6~~) of 5 Aug. 1939 to Philadelphia Thermometer Company (Copy to NRL).

Date of Test: 1 - 21 September 1939.

Prepared by: _____
R. B. Owens, Associate Radio Engineer, Chief of Section.

Reviewed by: _____
A. Hoyt Taylor, Head Physicist, Superintendent, Radio Division.

Approved by: _____
H. G. Bowen, Rear Admiral, USN, Director.

Distribution:

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APPENDICES

AUTHORIZATION

1. The work reported herein was authorized by Bureau of Engineering letters, references (a) and (b).

Reference: (a) BuEng. ltr. S67/40 (10-25-W8) of 27 October 1934.
(b) BuEng. ltr. S67(T)L5(7-25-R6) of 5 August 1939 to Philadelphia Thermometer Co. (Copy to NRL).
(c) Specification RE 13A 486C.

OBJECT OF TEST

2. The object of the test was to determine whether the thermometers and thermostats submitted by the Philadelphia Thermometer Company comply with specifications, reference (c), and are suitable for Naval use.

ABSTRACT OF TEST

3. The thermometers were tested for accuracy of calibration and the thermostats for accuracy of operating temperature and for sensitivity. Both thermometers and thermostats were tested to determine whether the expansion chamber provides protection to a temperature of 100° C, to determine whether mercury is trapped in the bulbs at a temperature of -10° C when the bulb is lying in a horizontal position, and to determine the effect of shock. The thermostats were made to operate 500,000 times in a life test.

Conclusions

(a) These thermometers and thermostats conform to all applicable requirements of specifications, reference (c).

(b) Both the thermometers and thermostats are considered suitable for Naval use.

Recommendations

(a) It is recommended that these thermometers and thermostats be considered suitable for Naval use.

DESCRIPTION OF MATERIAL UNDER TEST

4. The following mercury-in-glass thermal devices were delivered to this Laboratory by the Philadelphia Thermometer Company on 28 August 1939.

(a) Three right angle thermometers, Navy Style #1, Type 40011 (range 48-52° C. with 0.1° graduations and a horizontal length of 4-11/16 inches).

(b) Three right angle thermometers, Navy Style #2, Type 40014 (range 58-62° C. with 0.1° graduations and a horizontal length of 7 inches).

(c) Three straight thermostats, Navy Type 40008 (operating temperature 50° C; overall length 6 inches).

(d) Three right angle thermostats, Navy Type 40010 (operating temperature 60° C; length of each leg 3-1/4 inches).

METHOD OF TEST

5. The thermometer scale readings were compared with those of a standard precision thermometer while the bulbs of the two instruments were in contact and immersed in water to within 1 inch of the bend of the instrument under test. The rate of change of temperature of the circulating water was very slow, and precautions were taken to avoid introducing errors into the readings.

6. The operating temperature of the thermostats was determined with the instrument under test totally immersed in a heat-insulated chamber provided with air circulation. The thermostat bulb was held in contact with that of the standard thermometer. The thermostat was used to control the temperature of the compartment, which temperature was allowed to change very slowly. The temperature of the standard thermometer was noted at the make and break of the thermostat circuit repeatedly. The difference in temperature between the make and the break is the measured sensitivity of the thermostat.

7. Two thermostats of each group of three were subjected to a life test consisting of more than 500,000 electrical contacts in the thermostat. In the life test a 500 watt projection lamp with reflector supplied heat to the thermostat bulb through a narrow slit in a metal plate. When contact was made and broken in the thermostat an electrically operated shutter closed and opened the aperture in the plate, thus controlling the application of heat to the thermostat bulb. A fan was used to assist in the dissipation of heat from the bulb to expedite cooling after the shutter was closed. The number of contacts made was indicated on a Veeder counter. This system operated at speeds up to 200 contacts per minute. The current through the thermostat was approximately 10 milliamperes.

8. Both the thermometers and the thermostats were heated to 100° C. to ascertain whether the expansion chamber provides protection from breakage at that temperature. They were also chilled to a temperature of -10° C to determine whether gas would be trapped in the bulb at this temperature when the bulb portion of the device was in a horizontal position.

9. All samples were subjected to an acceleration of 50 g in a hand-operated centrifuge to determine the ability of the instruments to withstand shock without separation of the mercury column.

DATA RECORDED DURING TEST

10. The data recorded during the test are given in the results of test and Tables 1 and 2, appended.

DISCUSSION OF PROBABLE ERRORS

11. The errors involved in the observed values are not greater than the following.

(a) Determination of the accuracy of the thermometers and of the operating temperature of the thermostats, ±0.03° C.

(b) Temperature of the -10 and +100° C. test, ±2° C.

(c) Acceleration applied in the shock test, ±10 per cent.

RESULTS OF TEST

12. The results of tests are given below, with the number of the applicable paragraph of the governing specification, reference (c), given at the end of the paragraph in parentheses.

Accuracy

13. The thermometer calibrations are accurate to well within the allowed tolerance of 0.10° C at all points on the scale, as shown in Table 1, appended. (Par. 3-3.)

14. All three of the 50° thermostats operate within 0.05° C of 50° C when the probable error of the measurement is taken into consideration. (The tolerance allowed in the specifications is 0.05° All three of the 60° thermostats operate within 0.02° C of 60° C. (Par. 4-4.)

Sensitivity of the Thermostats

15. The difference in temperature when the electric circuit was made and broken through the thermostats was not greater than 0.01°

for any sample. The specifications allow 0.03° C. (Par. 4-5.)

Test at -10° C

16. No gas was trapped in the bulbs of any of the thermometers or thermostats as a result of chilling them to a temperature of -10° C while the bulb was in the horizontal position. (Par. 2-8).

Test at 100° C

17. All of the thermometers and thermostats were operated at a temperature of 100° C without damage. (Par. 2-7.)

Shock Test

18. All of the thermometers and five of the six thermostats withstood an acceleration of 52 g without separation of the mercury column. Thermostat #TS114 withstood an acceleration of 48.8 g, but mercury was thrown into the expansion chamber at 52 g. Since a probable error of 10 per cent is assigned to the measured values of acceleration, and since this thermostat is known to have satisfactorily withstood an acceleration within 2.4 per cent of the required 50 g, it is considered to have complied with this specification. (Par. 2-9.)

Life Test of Thermostats

19. The four thermostats which were subjected to a life test completed in excess of 500,000 contacts without any failure or evidence of deterioration. One of these was operated 667,000 times before the test was discontinued, as shown in Table 2. (Par. 4-8.)

Dimensions and Markings

20. The 50° C thermometers conform to the dimensions for Style #1, and the 60° C thermometers to those for Style #2 thermometers.

21. The 50° thermostats comply with the dimensional requirements for the straight type, and the 60° thermostats comply with the dimensional requirements for the angle type, as detailed on Pages 14c and 15c of the specifications. Scale graduations on the thermometers and the lettering on both the thermometers and the thermostats comply with specification requirements. The thermostats are provided with six-inch long rubber-covered flexible leads, with terminal lugs.

22. These thermometers and thermostats comply with all other items of the specifications, reference (c), so far as could be determined.

CONCLUSIONS

23. These thermometers and thermostats conform to all applicable requirements of specifications, reference (c).

24. Both the thermometers and thermostats are considered suitable for Naval use.

Table 1

Thermometer Test Data

Thermometer Scale Readings			
Standard	T29911	T29913	T29914
48.23	48.20	48.20	48.20
48.51	48.50	48.50	48.49
49.02	49.00	49.00	49.00
49.50	49.50	49.50	49.50
50.02	50.00	50.00	50.00
50.45	50.45	50.48	50.45
50.87	50.90	50.90	50.90
51.35	51.40	51.40	51.40
51.85	51.90	51.90	51.90
	T29906	T29908	T29909
58.03	58.00	58.00	58.07
58.79	58.75	58.76	58.80
59.45	59.48	59.47	59.50
60.09	60.12	60.12	60.12
60.79	60.80	60.80	60.80
61.58	61.62	61.59	61.60

Table 2

Thermostat Test Data

Sample		Operating Temperature	Number of Contacts in
Type Number	Serial Number	° C *	Life Test #
40008	TS114	50.08	-
40008	TS115	50.06	667,000
40008	TS116	50.05	505,000
40010	TS109	60.00	-
40010	TS111	60.00	501,000
40010	TS112	60.02	502,000

* ±0.03° C.

All thermostats in good condition when life tests were discontinued after number of contacts given in column 4.

No life test run on TS114 and TS109.