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Report of

Tests on Mercury-in-Glass Thermostats

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AUTHORIZATION

1. This problem was authorized by reference (a), and the governing specifications are listed as reference (b). Reference (c) is a previous report which is pertinent to this problem.

Reference (a) Bu.Eng. let. S67/40(10-25-W8) of 27 Oct. 1934.
(b) Specifications RE 13A 486B.
(c) N.R.L. Report R-1074 of 21 Sept. 1934.

OBJECT OF TESTS

2. The object of the tests is to determine if thermostats as supplied by the Collins Instrument Company (types 139-503 and -40008), and the H. B. Instrument Company (type -40009) comply with specifications reference (b), and if they are suitable for Naval use.

ABSTRACT OF TESTS

3. The thermostats were tested for accuracy of calibration at the operating temperatures, sensitivity, the effect of shock, accuracy of dimensions, degree of recession of the mercury column at -10°C, the degree of extension of the column at 100°C, and all other requirements (where possible) under specifications reference (b).

CONCLUSIONS

(a) All of the three samples submitted as Product A passed the tests as outlined in reference (b).

(b) Two of the three samples submitted as Product B failed in the accuracy of calibration.

(c) Should the manufacturers of Product B improve the accuracy of calibration, then on the basis of the tests on these samples, same would be suitable for Naval use.

RECOMMENDATIONS

(a) It is recommended that the H. B. Instrument Company be not granted approval on type No. -40009 because of failures in two of the samples to comply with specifications for operating temperature.

(b) It is recommended that the Collins Instrument Company be granted approval on both types -40008 and -40004, and also on the diminutive type 139-503 in so far as it passed all requirements of operation but is not listed as for size in reference (b).

Key to Manufacturers.

Product "A" - Collins Instrument Company.

Product "B" - H. B. Instrument Company.

MATERIAL UNDER TEST

4. The material under test consists of two mercury-in-glass thermostats of the straight type detailed on page 13B of reference (b) having operating temperatures of 50° C and 60° C, and one of the same type but of diminutive dimensions as follows:

	Length	Width	Diameter
Mercury reservoir or bulb	13/16 inch		1/5 inch
Tip of bulb to first contact ring	2-9/16 inch		
Tip of bulb to second contact ring	3 inch		
Overall dimensions of stem	4-1/4 inch		15/64 inch approx.
Contact rings		1/8 inch	17/64 inch approx.
Distance between contact rings	9/32 inch		

The operating temperature of this thermostat is 45° C.
The above three thermostats have been referred to as Product A.

5. There are also three mercury-in-glass thermostats of the right angled type detailed on page 14B of reference (b), all having an operating temperature of 50° C. The latter three thermostats have been referred to as Product B.

METHOD OF TESTS

6. (a). The operating temperatures and sensitivity were determined by comparison with precision standard thermometers calibrated in hundredths of a degree Centigrade. Each thermometer and thermostat were tightly coupled together in a relatively small beaker into which pure mercury was placed and the bulbs completely immersed therein. The excess of applied heat over and above that necessary to reach the operating point was held to a minimum in each case.

(b). The life test was performed on but five of the six samples submitted as shown in the tabulation of data at the end of this report. The method used was to excite the bulb of the thermostat by heat rays generated by a 500 watt projection lamp. These rays were collected and reflected by a parabolic mirror of medium focal length through a lens system and thence to the thermostat bulb. Interposed between the thermostat an the converging lens was an electro-magnetic light shutter of sufficient aperture to admit the necessary heat rays, the thermostat operating the shutter synchronistically as the thermostat passed through one complete cycle of "on" and "off"

positions, the period of which was governed by the degree to which the bulb was coupled to the focal point of the rays, and the rate of cooling of the bulb during eclipse. The period was held around two to three complete cycles per second although five or six cycles are possible. Over 300,000 complete cycles were recorded for each thermostat tested. One each of the submitted samples was tested at 70 volts R.M.S., 60 cycles and 20 milliamperes as per specifications reference (b), paragraph 4-6. One of Product B and two of Product A units were tested at 12 volts direct potential and 12 milliamperes as per specifications reference (b).

(c). The effect of shock was determined by testing the instruments in a centrifuge.

DATA RECORDED DURING TESTS.

7. The data recorded during tests are shown in Table I.

PROBABLE ERRORS IN RESULTS.

8. The precision thermometers used are of the Beckmann type, and according to the Bureau of Standards calibration are accurate to 0.°01C.

9. Errors in the measurement of acceleration by the hand centrifuge are not greater than 10%.

RESULTS OF TESTS.

10. These thermostats were tested and inspected (where possible) to determine compliance with every applicable paragraph of specifications reference (b), with the following exception: Thermostat of type 139-503 No. 2114 operating at 44.°94C is not contained in above referred to specification, consequently physical measurements against specifications measurements are not applicable. However, all specifications relating to its operational characteristics were measured in the usual manner, and appear in Table I.

11. From Table I it will be noted that a shifting of the point of operation of the thermostats resulted after 300,000 cycles of test. The direction of shift is, in most cases, to a lower operating temperature except one of Product A, #2039; the mean point of operation of this sample shifted from 59.°95C to 61.°0C. The on-and-off period of operation showed a period retardation of from 3 to 4 cycles per second to about 0.5 cycle per second, indicating an increase in linear travel of the mercury column before contact was made or broken. One Product B unit #2085 began operating at about 2 to 3 cycles per second on its life test, but considerable trouble was

experienced after a count of 218,000 cycles had been reached due to the mercury running past the last platinum point or operating contact. Its ability to make and break the circuit under this condition gave no little concern, the period being irregular and led to the conclusion that the column had been separated by the presence of mercury or water vapors due to some arcing at the break; assisted possibly by tiny particles of carbon deposit lying between the platinum point and the column. This carbon deposit is now plainly visible together with some condensed mercury which has failed to adhere to the receding column upon cooling.

12. An acceleration exceeding those of specifications by 6.4 g were given two samples of Product A, Nos. 2038 and 2039, No. 2039 separated while No. 2038 remained intact. No. 2039 was accidentally broken in an effort to reunite the column. Both Nos. 2038 and 2039 had previously successfully withstood the acceleration test of 50g in accordance with specifications.

13. Two thermostats of Product B, Nos. 2083 and 2085, failed the subject tests of paragraph 4-3, of specifications, reference (b), by 0.°01 C and 0.°03 C, respectively.

CONCLUSIONS

14. All of the three samples submitted as Product A passed the tests as outlined in reference (b).

15. Two of the three samples submitted as Product B failed in the accuracy of calibration.

16. Should the manufacturers of Product B improve the accuracy of calibration, then on the basis of the tests on these samples, same would be suitable for Naval use.

TABLE I

TABULATION OF DATA ON THERMOSTAT TESTS

Make	No.	Initial Operating Temperature	Initial Sensitivity	Life test* in cycles	Final Sensitivity	Final Operating Temperature	Source	Frequency of Operation
Product A	2038	49.°96C	0.°01C	304,000	0.°01C	49.°89C	A.C.	2-3 cycles/sec
Product A	2039	59.°95C	0.°004C	314,566	variable	61.°0 C	D.C.	3-4 cycles/sec slowing to .5 cycles/sec
Product A	2114	44.°94C	0.°01C	400,000	0.°002C	44.°92	D.C.	4-5 cycles/sec
Product B	2083	49.°93C	0.°002C	306,125	0.°009C	49.°91C	D.C.	4-5 cycles/sec
Product B	2085	49.°91C	0.°002C	309,000	0.°006C	49.°90C	A.C.	2-3 cycles/sec
Product B	2093	49.°94C	0.°02C	-	-	-	-	Life test omitted.

* Note: Test discontinued, maximum life not indicated.

Make	No.	Recession at - 10°C	Expansion at 100°C	Centrifuge	Remarks
Product A	2038	0.87 in. #	Satisfactory	Satisfactory	Mercury capillary tube appears clean - operation good.
Product A	2039	0.31 in.	"	"	Capillary clean - operation good up to 303,526 afterward was sluggish.
Product A	2114	1.06 in.	"	"	Capillary clean - operation good.
Product B	2083	1.73 in.	"	"	Capillary blackened - Residual globules of mercury around contact point.
Product B	2085	1.77 in.	"	"	Capillary clean but carbon deposit on upper contact.
Product B	2093	1.18 in.	"	"	Life test omitted - Capillary clean - contact clean.

Figures indicate height above mercury reservoir.