Thermometer Calibration Report

Traceable to NIST and DKD/PTB

Since 1903
ISO 9001:2000 Registered

Calibration Cert. # 2448.01

This laboratory is accredited in accordance with the recognized International Standard **ISO/IEC 17025:2005** General Requirements for the Competence of Testing and Calibration Laboratories. This laboratory also meets the requirements of **ANSI/NCSL Z540-1-1994** and any additional program requirements in the field of calibration. This accreditation also demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communique dated 18 June 2005).

The instrument described below has been examined and tested in H-B Instrument Company's Calibration Laboratory using controlled constant temperature equipment and NIST and DKD/PTB Traceable Reference Thermometers in accordance with our calibration procedure LAB-20 which is based in part on NBS Monograph 150, ASTM Method E-77, 3.1.2, 3.1.3, 3.1.4, and 7.2 only, NIST Special publication 819, and the International Temperature Scale ITS-90. Calibration is traceable to NIST and DKD/PTB. For a discussion of accuracy obtainable with such thermometers, see NIST SP 250-23. The results stated relate only to the instrument bearing the serial number identified.

This instrument is in good working order and is suitable for calibration. The capillary of the thermometer has been examined under magnification and no discernable capillary irregularities were noted. Strains in the glass revealed by examination under a polarized lens, if any, were judged to be minimal and of no detriment to the function of the instrument.

16-Mar-09

VWR International bvba/sprl

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Reference No: 4504355707/41H

Report No.	322837
Serial No	3357
Part No	82021-206
Distributor	VWR International
Manufacturer	H-B Instrument Company
Item	Thermometer, Total Immersion
Range	-1/101°C, 0.1°Div., SP, 610mm Lgth

N.I.S.T. Standard	Instrument Tested	Correction (ITS-90)*	Standard Serial No.	Traceability	Emer. Stem** Temperature
0.00 ° C	0.11 ° C	-0.11	5537C-01	CAL079226	°
50.00 ° C	50.28 ° C	-0.28	5537C-01	CAL079226	°
100.00 ° C	100.17 ° C	-0.17	5537C-01	CAL079226	°

Ambient Air Temperature: 23 ° C **Relative Humidity:** 36 %

* Observed instrument readings should be increased by positive numbers or reduced by negative numbers indicated by a minus (-) sign.
** Emergent Stem Temperature relates to PARTIAL IMMERSION thermometers ONLY.

The expanded measurement uncertainties associated with our calibration system are ±0.074°C from -80 to -1°C, ±0.041°C at the ice point in melting ice bath, ±0.045°C from 1 to 100°C, ±0.051°C from 101 to 200°C, ±0.047°C from 201 to 300°C, and ±0.052°C from 301 to 400°C. These uncertainties have been calculated using our Work Instruction WI-19 to 22 that utilizes methods found in NIST Technical Note 1297. The reported uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2.

Calibrated By James R Tubinson Title Vice President

Checked By Richard Jackson Title Production Manager

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If the thermometer is used under conditions which would cause the average temperatures of the emergent liquid column to differ markedly from those prevailing in H-B Instrument Company's calibration test, appreciable differences in the indications of the thermometer would result, as explained in the Emergent Stem Temperature Correction notes below. The column temperatures observed during the test are given in the "Instrument Tested" results for your comparison to actual conditions of use in your application.

U.S. DEPARTMENT OF COMMERCE
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
GAITHERSBURG, MD 20899

CORRECTION FOR EMERGENT STEM

EXPLANATORY NOTES ON THE EMERGENT STEM CORRECTION

Some thermometers are pointed and graduated by the maker to read correct, or approximately correct, temperatures when the bulb and the entire liquid index in the stem are exposed to the temperature to be measured, while other thermometers are so pointed and graduated that they will read correct, or approximately correct, temperatures when the bulb and only a short length of the stem of the thermometer are immersed in the bath, the temperature of which is to be measured. Thermometers of the former class are known as "total-immersion thermometers," and those of the latter class as "partial-immersion thermometers."

Total-immersion thermometers are tested under the condition of total immersion and the corrections resulting from such a test will serve to reduce the observed readings of the thermometer to true temperatures only if the thermometer is used as a total-immersion thermometer. If such a thermometer is actually used as a partial-immersion thermometer, i.e., with a part of the mercury column emergent into the space above the bath, and with the emergent stem therefore either colder (or warmer) than the bulb, the thermometer will obviously read lower (or higher) than it would under the condition of total immersion. Hence, if a total-immersion thermometer is so used, a so-called stem correction must be applied to the observed reading in addition to the correction taken from the accompanying table of corrections. This stem correction is very large if the number of degrees emergent and the difference of temperature between the bath and the space above it are large. It may amount to more than 20° C (36° F) for measurements made with a mercury thermometer at 400° C (750°F).

The coefficient k is different for different kinds of glass and, even for the same kind of glass, it differs for different temperature intervals, i.e., different values of $(t_1 - t)$. Values for k for two widely used thermometric glasses, for use in calculating stem corrections are tabulated as follows:

VALUES OF k FOR MERCURY-IN-GLASS THERMOMETERS

For Celsius thermometers			For Fahrenheit thermometers		
Mean temp. $\frac{t_1 + t}{2}$	k for "normal" glass	k for "borosilicate" glass	Mean temp. $\frac{t_1 + t}{2}$	k for "normal" glass	k for "borosilicate" glass
0°	0.000158	0.000164	0°	0.000088	0.00091
100	158	164	200	88	91
150	158	165	300	88	92
200	159	167	400	89	93
250	161	170	500	90	95
300	164	174	600	92	97
350	———	178	700	———	.000100
400	———	183	800	———	103
450	———	188			

If the kind of glass of which the thermometer is made is known, the value of k to be used in computing the stem correction may be taken from the above table. If the kind of glass is not known, use $k = 0.00016$ for Celsius or 0.00009 for Fahrenheit thermometers. High-grade thermometers are now generally made of "normal" or "borosilicate" glasses. If a thermometer is graduated only to about 450° C (850° F), it may be made of either of the above glasses; if it is graduated to 500° C (932° F) and is actually usable at that temperature, it is made of one of the borosilicate glasses or a similar glass.

The expansions of liquids such as alcohol, toluene, etc., vary quite rapidly with the temperature, so that k varies considerably for different temperature intervals. An approximate stem correction for such thermometers may be calculated by taking k in the above equation = 0.001 for Celsius thermometers or 0.0006 for Fahrenheit thermometers.

The value of t, the mean temperature of the emergent stem, is the most difficult of the terms in the above formula to estimate. It may be quite accurately measured by the use of special capillary thermometers. This is, however, very rarely done except in the testing laboratory, and then only when the stem correction *must* be determined with considerable precision (to 10 percent or better). In general, the value of t may be determined to a sufficient approximation by judgment or preferably by suspending an auxiliary thermometer close beside the emergent stem, with the bulb of the auxiliary thermometer somewhat nearer to the top of the bath than to the liquid meniscus.

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