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U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS
Washington

Letter
Circular
LC-469

(May 26, 1936)

PUBLICATIONS ON TEMPERATURE MEASUREMENTS
by Members of the Staff of the National Bureau of Standards.

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GENERAL INFORMATION

This Letter Circular is a list of selected publications on temperature measurements by members of the staff of the National Bureau of Standards, and, in addition, contains a list of standard samples available and schedules of test fees. Some of the papers were printed in the regular series of publications of the Bureau and others in the various scientific and technical journals. Copies can usually be consulted at the leading libraries of the larger cities.

For ready reference and convenience in ordering the separate papers of the Bureau, these have been listed with the serial letter and number in one column, and the price in the second column. "O.P." indicates that the paper is out of print, but may be consulted in libraries as stated in the first paragraph. See also paragraph on "Scientific Papers" below. A complete list of our publications (Circular No. C24 and Supplement) is also generally available at such libraries.

Where the price is noted, the publication may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. The prices quoted are for delivery to addresses in the United States and its possessions, and to Canada, Cuba,

Mexico, Newfoundland, the Philippines, and the Republic of Panama. When remitting for delivery to other countries than those, include in your remittance one-third of the total cost of the publications to cover postage. Remittances should be made payable to the "Superintendent of Documents, Government Printing Office, Washington, D. C." and sent to him with the order.

Serial letters are used to designate Bureau publications:

S = "Scientific Paper" of the National Bureau of Standards. From S1 to S329, inclusive, the separate papers of this series were known as reprints from the "Bulletin of the Bureau of Standards" (Bul. BS). Subsequently, from S330 to S572, the separates were known as reprints from the "Scientific Papers of the Bureau of Standards" (Sci. Pap. BS). This series was superseded by the "Bureau of Standards Journal of Research" in 1928. Each volume of the Bulletin was published in four parts called the Quarterly of the Bulletin of the Bureau of Standards. Most of the Scientific Papers, S1 to S329, which are no longer obtainable as separates, may still be secured by purchasing the Quarterly of the Bulletin which contains the paper or papers desired. The Quarterly of the Bulletin sells at 25 cents per number.

T = "Technologic Paper" of the National Bureau of Standards. T1 to T202 were issued each independent of the other with individual pagination. Later they were assembled to make the first 15 volumes of this series, and subsequent separates were given volume pagination (Tech. Pap. BS). This series was superseded by the "Bureau of Standards Journal of Research" in 1928.

RP = "Research Paper". These are reprints of articles appearing in the "Bureau of Standards Journal of Research" (BS J. Research) and the "Journal of Research of the National Bureau of Standards" (J. Research NBS), the latter being the title of this periodical since July 1934 (volume 13, number 1).

C = "Circular" of the National Bureau of Standards.

CS = "Commercial Standard" of the National Bureau of Standards.

For papers in other scientific or technical journals, the name of the journal or of the organization publishing the article is given in abbreviated form, with address in parentheses, together with the volume number (underscored), page, and year of publication, in the order named. The Bureau can not supply copies of these journals, or reprints from them, and it is unable to furnish information as to their availability or price.

THERMOMETRY

Liquid-in-glass Thermometry

<u>Series</u>	<u>Price</u>	<u>Title</u>
S13	O.P.	The testing of clinical thermometers. C. W. Waidner and L. A. Fischer. Bul. BS <u>1</u> , 275 (1904-05).
S32	O.P.	Heat treatment of high-temperature mercurial thermometers. Hobert C. Dickinson. Bul. BS <u>2</u> , 189 (1906).
S69	O.P.	On the standard scale of temperature in the interval 0° to 100°. C. W. Waidner and H. C. Dickinson. Bul. BS <u>3</u> , 663 (1907).
S170	O.P.	The correction for "emergent stem" of the mercurial thermometer. Edgar Buckingham. Bul. BS <u>8</u> , 239 (1912).
C8	10¢	Testing of thermometers. (Contains general information of interest to those who desire to submit thermometers to the Bureau for test.) Cir. BS, C8 (4th ed.) (1926).
CS1	5¢	Clinical thermometers. Com. Std. BS, CS1 (1932).

Resistance Thermometry

S68	O.P.	Calorimetric resistance thermometers and the transition temperature of sodium sulphate. H. C. Dickinson and E. F. Mueller. Bul. BS <u>3</u> , 641 (1907).
S124	O.P.	Platinum resistance thermometry at high temperatures. C. W. Waidner and G. K. Burgess. Bul. BS <u>6</u> , 149 (1909-10).
S200	O.P.	New calorimetric resistance thermometers. H. C. Dickinson and E. F. Mueller. Bul. BS <u>9</u> , 483 (1913).
S288	O.P.	Wheatstone bridges and some accessory apparatus for resistance thermometry. E. F. Mueller. Bul. BS <u>13</u> , 547 (1916-17).
S407	5¢	Recent modifications in the construction of platinum resistance thermometers. T. S. Sligh, Jr. Sci. Pap. BS <u>17</u> , 49 (1922).
RP508	5¢	Coiled-filament resistance thermometers. C. H. Meyers. BS J. Research <u>9</u> , 807 (1932).

Low temperature specific heats. II. The calibration of the thermometer and the resistance of platinum, platinum-10% rhodium and constantan between -259 and -190°. J. C. Southard and R. T. Milner. J. Am. Chem. Soc. (Mills Bldg., Washington, D. C.), 55, 4384 (1933).

Miscellaneous

<u>Series</u>	<u>Price</u>	<u>Title</u>
S57	15¢	On the establishment of the thermodynamic scale of temperature by means of the constant-pressure gas thermometer. Edgar Buckingham. Bul. BS <u>3</u> , 237 (1907).
S185	O.P.	Thermometric lag. D. R. Harper 3d. Bul. BS <u>8</u> , 659 (1912).
S210	O.P.	Observations on ocean temperatures in the vicinity of the icebergs and in other parts of the ocean. C. W. Waidner, H. C. Dickinson, and J. J. Crowe. Bul. BS <u>10</u> , 267 (1914).
S520	10¢	Nonflammable liquids for cryostats. C. W. Kanolt. Sci. Pap. BS <u>20</u> , 619 (1924-26).
RP22	5¢	The international temperature scale. George K. Burgess. BS J. Research <u>1</u> , 635 (1928).
RP222	10¢	Thermometric lag of aircraft thermometers, thermographs, and barographs. H. B. Henrickson. BS J. Research <u>5</u> , 695 (1930).
RP284	5¢	A precision cryostat with automatic temperature regulation. R. B. Scott and F. G. Brickwedde. BS J. Research <u>6</u> , 401 (1931).
RP452	5¢	An optical method for measuring temperature distribution and convective heat transfer. R. B. Kennard. BS J. Research <u>8</u> , 787 (1932).
RP658	5¢	Reproducibility of the ice point. James L. Thomas. BS J. Research <u>12</u> , 323 (1934).

Note on platinum resistance thermometry at low temperatures. M. S. Van Dusen. J. Am. Chem. Soc. (Mills Bldg., Washington, D. C.), 47, 326 (1925).

PYROMETRY

Thermoelectric pyrometry

<u>Series</u>	<u>Price</u>	<u>Title</u>
RP99	5¢	Thermoelectric temperature scales. W. F. Roeser. BS J. Research <u>3</u> , 343 (1929).
RP354	5¢	The passage of gas through the walls of pyrometer protection tubes at high temperatures. W. F. Roeser. BS J. Research <u>7</u> , 485 (1931).
RP530	5¢	Reference tables for platinum to platinum-rhodium thermocouples. W. F. Roeser and H. T. Wensel. BS J. Research <u>10</u> , 275 (1933).
RP537.	5¢	Thermoelectric properties of platinum-rhodium alloys. Frank R. Caldwell. BS J. Research <u>10</u> , 373 (1933).
RP573	5¢	An international comparison of temperature scales between 660° and 1,063° C. W. F. Roeser, F. H. Schofield, and H. A. Moser. BS J. Research <u>11</u> , 1 (1933).
RP767	5¢	Standard tables for chromel-alumel thermocouples. W. F. Roeser, A. I. Dahl, and G. J. Gowens. J. Research NBS <u>14</u> , 239 (1935).
RP768	5¢	Methods of testing thermocouples and thermocouple materials. W. F. Roeser and H. T. Wensel. J. Research NBS <u>14</u> , 247 (1935).

Optical and Radiation Pyrometry

S8	O.P.	On the temperature of the arc. C. W. Waidner and G. K. Burgess. Bul. BS <u>1</u> , 109 (1904-05).
S198	O.P.	A micropyrometer. G. K. Burgess. Bul. BS <u>9</u> , 475 (1913).
S224	O.P.	The emissivity of metals and oxides. I. Nickel oxide (NiO) in the range 600° to 1,300° C. G. K. Burgess and P. D. Foote. Bul. BS <u>11</u> , 41 (1915).
S242	O.P.	The emissivity of metals and oxides. II. Measurements with the micropyrometer. G. K. Burgess and R. G. Waltenberg. Bul. BS <u>11</u> , 591 (1915).

<u>Series</u>	<u>Price</u>	<u>Title</u>
S243	O.P.	The emissivity of metals and oxides. III. The total emissivity of platinum and the relation between total emissivity and resistivity. Paul D. Foote. Bul. BS <u>11</u> , 607 (1915).
S249	5¢	The emissivity of metals and oxides. IV. Iron oxide. George K. Burgess and Paul D. Foote. Bul. BS <u>12</u> , 83 (1915-16).
S250	O.P.	Characteristics of radiation pyrometers. George K. Burgess and Paul D. Foote. Bul. BS <u>12</u> , 91 (1915-16).
S260	O.P.	"Center of gravity" and "effective wave length" of transmission of pyrometer color screens, and the extrapolation of the high temperature scale. Paul D. Foote. Bul. BS <u>12</u> , 483 (1915-16).
The proper type of an absorption glass for an optical pyrometer. Paul D. Foote, F. L. Mohler, and C. O. Fairchild. J. Wash. Acad. Sci. (450 Ahnapp St., Menasha, Wis.), <u>7</u> , 545 (1917).		
Disappearance of the filament and diffraction effects in improved forms of an optical pyrometer. C. O. Fairchild and W. H. Hoover. J. Opt. Soc. Am. & Rev. Sci. Insts. (Cornell Univ., Ithaca, N. Y.), <u>7</u> , 543 (1923).		
Pyrometry of molten brass. W. F. Roeser and C. O. Fairchild. Trans. Am. Foundrymen's Assn. (222 W. Adams St., Chicago, Ill.), <u>34</u> , 675 (1926).		
Characteristics of pyrometric cones. C. O. Fairchild and M. F. Peters. J. Am. Ceram. Soc. (2525 N. High St., Columbus, Ohio), <u>9</u> , 701 (1926).		
A comparison of the softening points of some foreign and American pyrometric cones. R. F. Geller and E. E. Presler. J. Am. Ceram. Soc. (2525 N. High St., Columbus, Ohio), <u>9</u> , 744 (1926).		
Temperature measurements of molten cast iron. H. T. Wensel and W. F. Roeser. Trans. Am. Foundrymen's Assn. (222 W. Adams St., Chicago, Ill.), <u>36</u> , 191 (1928).		

Miscellaneous

<u>Series</u>	<u>Price</u>	<u>Title</u>
S406	10¢	Present status of the constants and verification of the laws of thermal radiation of a uniformly heated inclosure. W. W. Coblentz. Sci. Pap. BS <u>17</u> , 7 (1922).

<u>Series</u>	<u>Price</u>	<u>Title</u>
T170	60¢	Pyrometric practice. Paul D. Foote, C. O. Fairchild, and T. R. Harrison. Tech. Pap. BS, T170 (1921).
RP22	5¢	The international temperature scale. George K. Burgess. BS J. Research <u>1</u> , 635 (1928).
RP231	10¢	Measurement of surface temperatures. W. F. Roeser and E. F. Mueller. BS J. Research <u>5</u> , 793 (1930).
RP325	5¢	The Waidner-Burgess standard of light. H. T. Wensel, W. F. Roeser, L. E. Barrow, and F. R. Caldwell. BS J. Research <u>6</u> , 1103 (1931).
RP327	10¢	Special refractories for use at high temperatures. Wm. H. Swanger and Frank R. Caldwell. BS J. Research <u>6</u> , 1131 (1931).
RP506	5¢	A multirange potentiometer and its application to the measurement of small temperature differences. H. B. Brooks and A. W. Spinks. BS J. Research <u>9</u> , 781 (1932).
RP677	5¢	Establishment of a scale of color temperature. H. T. Wensel, D. B. Judd, and W. F. Roeser. BS J. Research <u>12</u> , 527 (1934).

THERMOMETRIC FIXED POINTS

S62	O.P.	Melting points of the iron-group elements by a new radiation method. G. K. Burgess. Bul. BS <u>3</u> , 345 (1907).
S143	O.P.	Note on the temperature scale between 100° and 500°C. C. W. Waidner and G. K. Burgess. Bul. BS <u>7</u> , 1 (1911).
S149	O.P.	On the constancy of the sulphur boiling point. C. W. Waidner and G. K. Burgess. Bul. BS <u>7</u> , 127 (1911).
S205	5¢	Melting points of the refractory elements. I. Elements of atomic weight from 48 to 59. G. K. Burgess and R. G. Waltenberg. Bul. BS <u>10</u> , 79 (1914).
S212	O.P.	Melting points of some refractory oxides. C. W. Kanolt. Bul. BS <u>10</u> , 295 (1914).

Series	Price	Title
S294	5¢	Freezing point of mercury. R. M. Wilhelm. Bul. BS <u>13</u> , 655 (1916-17).
S339	5¢	Standardization of the sulphur boiling point. E. F. Mueller and H. A. Burgess. Sci. Pap. BS <u>15</u> , 163 (1919-20).
S340	O.P.	A standardized method for the determination of solidification points, especially of naphthalene and paraffin. R. M. Wilhelm and J. L. Finkelstein. Sci. Pap. BS <u>15</u> , 185 (1919-20).
T10	O.P.	The melting points of fire brick. C. W. Kanolt. Tech. Pap. BS, T10 (1912).
RP65	10¢	A new determination of the melting point of palladium. C. O. Fairchild, W. H. Hoover, and M. F. Peters. BS J. Research <u>2</u> , 931 (1929).
RP258	5¢	The freezing point of nickel as a fixed point on the international temperature scale. H. T. Wensel and W. F. Roeser. BS J. Research <u>5</u> , 1309 (1930).
RP326	5¢	The freezing point of platinum. W. F. Roeser, F. R. Caldwell, and H. T. Wensel. BS J. Research <u>6</u> , 1119 (1931).
RP557	5¢	Conditions affecting the freezing temperature of silver. W. F. Roeser and A. I. Dahl. BS J. Research <u>10</u> , 661 (1933).
RP568	5¢	The freezing point of iridium. F. Henning and H. T. Wensel. BS J. Research <u>10</u> , 809 (1933).
RP676	5¢	The freezing point of rhodium. W. F. Roeser and H. T. Wensel. BS J. Research <u>12</u> , 519 (1934).
RP735	5¢	The freezing point of gallium. W. F. Roeser and James I. Hoffman. J. Research NBS, <u>13</u> , 673 (1934).

STANDARD SAMPLES AVAILABLE

The following melting-point standards are obtainable from the Bureau at the prices indicated. Remittance must accompany order. Money orders, etc. should be payable to the "National Bureau of Standards".

Standard Sample Number.	Material.	Freezing temperature	Approximate weight	Price per sample
		°C	Grams	
44c	Aluminum	660.15	200	\$2.00
45a	Copper	1083	450	2.00
49a	Lead	327.35	1650	2.00
42b	Tin	231.90	350	2.00
43c	Zinc	419.48	350	2.00

A copy of Circular C398, which contains general information concerning the above and other standard samples, and a copy of the Supplement to C398, which is a list of the standard samples obtainable from the Bureau, may be had free on request to the Bureau. The temperatures given above apply only for the standard samples being issued on July 1, 1936.

TEST FEE SCHEDULES

Instruments are accepted for test as outlined in the accompanying fee schedules. A letter should be addressed to the Bureau describing the instrument and tests desired.

DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

Test Fee Schedule 311 - Laboratory Thermometers

Effective March 1, 1936, superseding all previous schedules for the items covered.

Item	Description	Fee
311a	Thermometers, testing at points in the interval 0 to 100°C (32 to 212°F) for each point tested	\$0.50*
311b	Thermometers, testing at points above 100 and up to 300°C or above 212 and up to 600°F, for each point tested	0.75*
311c	Thermometers, testing at points above 300°C or above 600°F, for each point tested	2.00
311d	Thermometers, testing at points in the interval 0 to -35°C or 32 to -35°F, for each point tested	2.50
Items (a) to (d) inclusive, apply particularly to the types of thermometers listed in Tables 1, 2, 3, and 4 of Bureau Circular No. 8, 3rd or 4th Edition.		
311e	Calorimetric thermometers, testing at intervals of 2°C or 5°F	5.00
311f	Beckmann thermometers, with 5° or 6°C scale, testing at 1° intervals by comparison with precision standards	6.00
311ff	Beckmann thermometers, calibration by means of mercury threads and comparison with precision standards, with the highest accuracy warranted by the construction and action of the thermometer	12.00

Unless the request for test of a Beckmann thermometer specifies test under 311ff, the instrument will be tested under item 311f. Thermometers so constructed that unusual difficulty is encountered in

separating mercury threads for calibration will be eligible for test only under item 311f. There is somewhat greater danger of breakage in tests under 311ff than in tests under 311f. Beckmann thermometers with scales longer than 6° will be subject to special fees.

Items (e), (f), and (ff) apply particularly to the types of thermometers listed in table 5 of Circular 8.

311g	Platinum resistance thermometers - standardization at the ice, steam, and sulphur-boiling points	30.00
311h	Platinum resistance thermometers - standardization under 311g and at the oxygen boiling point	40.00
311i	Calorimetric platinum resistance thermometers - standardization	25.00
311j	Thermocouples for temperatures between -40 and 500°C - minimum charge each	10.00
311k	Thermocouples for range -40 to 500°C, calibration per point	3.00

Items (j) and (k) do not cover tests of multiple junction assemblies.

Items (g) to (k) inclusive refer to tests described in Bureau of Standards Circular No. 8.

311m	When instruments submitted are found by preliminary tests to be unsuitable for test, a charge will be made to cover the cost of the preliminary work. Minimum fee	1.00
311x	Copies of certificates or reports previously issued or reissue of certificates or reports returned - each	.25*
311y*	Minimum fee in any test or transaction	1.00
311z	If a test, not covered by any schedule item, is undertaken, it will be subject to a special fee depending upon the nature and cost of the test.	

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Test Fee Schedule 312 - Clinical Thermometers.

Effective August 1, 1932, superseding all previous schedules for the items covered.

Item	Description	Fee
312a	For any number of thermometers tested, not exceeding ten, total fee.....	\$1.00
312b	For any number of thermometers greater than ten, for each thermometer tested.....	.10
312z	If thermometers submitted are of a form such that they cannot be tested in the usual manner, a fee will be charged depending upon the cost of making the test.	

Note - Clinical thermometers marked "Government Tested" or its equivalent will not be accepted for test.

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Test Fee Schedule 313 - Certain Types of Industrial Thermometers - Effective August 1, 1932.

Item	Description	Fee
313a	Industrial thermometers, testing at points in the interval 0 to 100°C (32 to 212°F), for each point tested, or minimum fee for each thermometer submitted.....	\$1.00
313b	Industrial thermometers, testing at points above 100°C and up to 300°C or above 212°F and up to 600°F, for each point tested.....	1.50
	(Thermometers will not be tested at less than 2 points nor more than 5 points on the scale)	
313z	If a test, not covered by the above schedule items is undertaken, it will be subject to a special fee depending upon the nature and cost of the test.	

Notes on the testing of industrial thermometers.

1. For the present, thermometers having a depth of immersion of not less than six inches above the top of the bulb and not more than twenty-four inches immersion will be accepted for test. The test will be made in an oil bath of the type now in use in the laboratory. Tests are limited to the types of thermometers specified because it is considered reasonably certain, if the immersion is as much as 6 inches, that the indications will be sensibly the same under the conditions of test and of use. The limit of 24 inches is determined by the equipment now available.

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Test Fee Schedule 321 - Thermocouples and Pyrometer
Indicators.

Effective August 1, 1932, superseding all previous schedules
for the items covered.

Item	Description	Fee
321a	Standard rare metal thermocouples - calibration at standard fixed points.....	\$40.00
321b	High temperature thermocouples - temperature - emf test at not more than 15 points at integral millivolt values (intervals of approximately 100°C).....	10.00
321c	High temperature thermocouples, testing at additional points, per point.....	1.00
321d	Platinum or platinum-10% rhodium wire - thermoelectric comparison against laboratory reference standards (at 1200°C unless otherwise specified).....	2.00
Note.- Used base metal thermocouples will be tested only when, in the opinion of the Bureau, such tests would be warranted by special circumstances.		
321e	Pyrometer indicator alone - single range.....	4.00
321f	Pyrometer indicator alone - additional range.....	3.50
321g	Thermocouple and indicator as unit - test includes 321b and 321c.....	17.50
321h	Computed values - interpolated values computed and certified, each 50 points or fraction thereof.....	5.00

(Over)

321x Copies of certificates or reports previously
issued or reissue of certificates or reports
returned - each.....\$1.00

The above schedule refers to tests described in
Bureau of Standards Circulars No.07 and No.08.

321z If a test not covered by any schedule item, is
undertaken it will be subject to a special fee
depending upon the nature and cost of the test.

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Test Fee Schedule 322 - Optical Pyrometers.

Effective August 1, 1932, superseding all previous schedules for the items covered.

Item	Description	Fee
322a	Optical Pyrometer - Telescope and Lamp. Calibration to 1400°C, 25 or fewer certified values.....	\$15.00
322b	Optical Pyrometer Lamp (Single Contact, Standard Bayonet type base with pins removed) - Calibration as per 322a.....	15.00
322c	Direct Reading Pyrometer - Calibration as per 322a.....	17.50
322d	Absorption Screen - Calibration for extrapolation to 2000°C.....	10.00
322e	Absorption Screen - Calibration for extrapolation above 2000°C.....	15.00
322f	Red Glass Filter - Determination of effective wave length.....	10.00
322g	Additional Interpolated Values - Interpolated values computed and certified, each 50 points or fraction thereof.....	5.00
322h	Optical Pyrometer Indicator.....	2.50
322x	Copies of certificates or reports previously issued, or reissue of certificates or reports returned, each.....	1.00
322z	If a test not covered by any schedule item is undertaken, it will be subject to a special fee depending upon the nature and the cost of the test.	

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Test Fee Schedule 351 - Low Temperature Thermometers.

Effective August 1, 1932, superseding all previous schedules for the items covered.

Item	Description	Fee
351a	Fundamental calibration of a resistance thermometer against primary standards at the oxygen point (-183°C).....	\$10.00
351b	Calibration of liquid in glass, thermo-electric and resistance thermometers, in the range extending from -35° to -70°C , per point.....	4.00
351c	Calibration of liquid in glass, thermo-electric and resistance thermometers in the range extending from -70° to -140°C , per point.....	5.00
351d	Calibration of liquid in glass, thermo-electric and resistance thermometers in liquid air (-188°C to -191°C).....	5.00
351x	Copies of certificates or reports previously issued, or reissue of certificates or reports returned, each.....	1.00
351z	If a test not covered by any schedule item, is undertaken it will be subject to a special fee depending upon the nature and cost of the test.	