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Department of Commerce
Bureau of Standards
Washington

Letter
Circular
L.C. 30
Revised
11-20-26

INFORMATION ON REFRIGERATION
November 20, 1926

The Bureau of Standards receives numerous requests for general information on refrigeration. The Bureau's work in this field has been confined largely to the determination of the fundamental constants of refrigerating engineering, and it has therefore no publications dealing with refrigeration in general and is not in a position to give consulting engineering service by correspondence.

The following list of books and papers has been compiled for the purpose of answering inquiries of the kind referred to. The number of pages given for each book is not the total number of pages but the number devoted explicitly to refrigeration. The list prices are given in some instances. A list of the Bureau's publications dealing with refrigeration and low temperature research is also included.

I - Books on Thermodynamics and Refrigeration

1. Principles of Thermodynamics, by C. A. Goodenough; Henry Holt and Co., New York, 1920; 19 pages, (College Textbook).
2. Thermodynamics for Engineers, by J.A. Ewing; Cambridge University Press, London, 1920; 53 pages \$12.00, (College Textbook).
3. Engineering Thermodynamics, by C. E. Lucke; McGraw-Hill Book Co., New York, 1912; 34 pages, \$2.00, (General Treatise).
4. Elements of Engineering Thermodynamics, by Moyer, Calderwood and Potter; John Wiley and Sons, New York, 1920; 16 pages, \$2.50, (College Text book).
5. The Mechanical Production of Cold, by J.A. Ewing; Cambridge University Press, London, 1908; 201 pages, (Scientific Lectures).
6. Mechanical Equipment of Buildings, Vol. 2, by Harding and Willard; John Wiley and Sons, New York, 1917; 109 pages, \$6.00, (General treatise).
7. The Elements of Refrigeration, by A. M. Greene; John Wiley and Sons, New York, 1919; 472 pages, \$4.50, (College Text book).
8. Principles of Refrigeration, by T. H. Motz; Nickerson and Collins Co., Chicago, 1926; 672 pages, \$5.00, (General Treatise).

9. Refrigeration, Cold Storage, and Ice Making, by A.J. Wallis-Taylor; Crosby Lockwood and Son, London, 3rd edition, 1912; 604 pages, (General Treatise).
10. Mechanical Refrigeration, by H. J. MacIntire; John Wiley and Sons, New York, 1914; 342 pages \$4.00, (Text book).
11. The Principles of Mechanical Refrigeration, by H.J. MacIntire; McGraw-Hill Book Co., New York, 1922, 248 pages, \$2.50, (for operating engineers).
12. Practical Refrigerating Engineers Pocketbook, by John E. Starr; Nickerson and Collins Co., Chicago, 1922; 186 pages, \$2.50, (for operating engineers).
13. Ammonia Compression Refrigerating System, by W. S. Doan; Nickerson and Collins Co., Chicago, 1921; 217 pages \$2.50, (for operating engineers).
14. Elementary Mechanical Refrigeration, by F.E. Matthews; McGraw-Hill Book Co., New York, 1912; 161 pages, \$2.50, (for operating engineers).
15. Compend of Mechanical Refrigeration and Engineering, by J.E. Siebel; Nickerson and Collins Co., Chicago, 9th edition; 1922; 550 pages, \$10.00, (for operating engineers).
16. The Absorption Refrigerating Machine - Elementary Theory and Practice, by Gardner T. Voorhees; Nickerson and Collins Co., Chicago, Ill. 158 pages.
17. Bibliography of American Literature Relating to Refrigeration, by The American Association of Ice and Refrigeration (3 volumes) Nickerson and Collins Co., Chicago.
18. Bibliography of Refrigeration, by Food Investigation Board of British Department of Scientific and Industrial Research, 16 Old Queen Street, Westminster, S.W. 1, London. So. Report No.2.
19. Ice and Refrigeration Blue Book and Buyers Guide, 5th edition, 1925, Nickerson and Collins, Co., Chicago, (mainly statistical) \$10.00.
20. Kent's Mechanical Engineers Handbook, 10th edition; John Wiley and Sons, New York, 1923; 34 pages, \$6.00.
21. Mechanical Engineers Handbook, Lionel S. Marks, 2nd edition; McGraw-Hill Book Co., Inc., New York, 1924; 46 pages.

II - Domestic Refrigeration

The Bureau has made no comparative tests of the various makes of domestic refrigerating machines, and has no detailed information on any machine. Even if such information were available the Bureau would not be in a position to make specific recommendations on competitive products. Considerable information may be found in the following publications:

1. "Household Refrigeration", by H. P. Hull, published by Nickerson and Collins Co., Chicago, 390 pages, \$3.50.
2. A series of articles entitled "The Domestic Refrigerating Machine" in four issues (July to October 1923) of Ice and Refrigeration, Nickerson and Collins Co., Chicago, Ill.
3. A report of the Electric Refrigeration Committee of the National Electric Light Association (1924-25) 29 West 39th Street, New York, N.Y. \$0.80.
4. A report of the Refrigeration-By-Gas Committee of the American Gas Association (1925), 342 Madison Avenue, New York, N.Y.

These publications contain illustrations of many types of small refrigerating machines and (3) contains data obtained in tests of various machines.

Numerous papers on this subject have been published in the past few years in the various refrigerating journals listed in Section IV.

III - Properties of Refrigerants

Data on the thermodynamic properties of some of the more important refrigerants have been made conveniently available in the form of tables or charts. Information on the effect on life or health, effect on various lubricants, flammability, explosion hazard, methods of testing purity, necessary precautions in handling, protective devices, etc. is also of interest. The publications listed below deal with properties of refrigerants.

1. Bureau of Standards Circular No. C 142. Tables of Thermodynamic Properties of Ammonia. 15¢ from Superintendent of Documents, Government Printing Office Washington, D.C. (Stamps not accepted)
2. Thermal properties of sulphur dioxide, by David L. Fiske. Ref. Eng. 11, p. 235; 1924. (Tables).
3. Properties of Refrigerants, by H. D. Edwards. Ref. Eng. 11, p. 95; 1924. (A general report giving data on many of the properties mentioned above. Printed separately and sold by the American Society of Refrigerating Engineers, 35 Warren St., New York, N.Y. at \$1.00 per copy.

4. Report on the Fire Hazard of Ethane, Propane, Butane and Ammonia as Refrigerants, published by Underwriters Laboratories, 207 E. Ohio Street, Chicago, 1925, 95 pages. May be purchased from Underwriters Laboratories, at \$1.00 per copy.
5. Thermodynamic properties of butane, isobutane and propane by L. I. Dine, A. C. Jenkins, J. M. Eurdick, and R. C. Tim. Ref. Eng. 12, p. 387; 1926. Also in three installments in Ice and Refrigeration in issues of June, July, and August 1926. Includes tables of properties of saturated liquid and vapor.

A list of charts of the properties of various refrigerants, with references to the publications in which they may be found, is given below.

Refrigerant	Coordinates of chart	Author	References
1 Ammonia	P-P	Bureau of Standards	Circular No. 142
2	P-P	" " "	Spec. Pub. No. 52 (ser. 1)
3	P-P	" " "	" " " No. 57 (ser. 2)
4 Carbon Dioxide	P-P	H. J. MacIntire	A.S.R.E. Jour. 8, 212, 1923
5	T-S	C. F. Jenkin & D. P. P.	Phil. Trans. 213, A, (Nov.) 1913.
6	P-S	Hollier	Z.V.D. Ing., 48, I, 27, 1904
7	P-P	Hollier	" " Ing. " " "
8 Sulphur Dioxide	P-P	D. L. Fiske	Ref. Eng. 10, 200, 1923
9 Methyl Chloride	T-S	D. W. Shorthose	Sp. Report Vol. 9, 1924
10	P-S		{ Reprint in Ref. Eng. 10, 76, 1924 (Aug.)
11 Ethyl Chloride	T-S	C. F. Jenkin and	{ Sp. Report, 14, 1925.
12	P-S	D. W. Shorthose	{ Reprint in Ref. Eng. 10, 316, 1924 (Feb.)

Notation

P = Absolute pressure T = temperature
 H = Heat content S = Entropy

A.S.R.E. Journ. = Journal of the American Society of Refrigerating Engineers.

Ref. Eng. = Refrigerating Engineering.

Sp. Report = Special Report of the Food Investigation Board of the Department of Scientific and Industrial Research of Great Britain, 13 Old Queen St., Westminster, S.W. 1, London.

Phil. Trans. = Philosophical Transactions of the Royal Society of London.

Z.V.D. Ing. = Zeitschrift des Vereins Deutscher Ingenieure.

IV - Insulation and Heat Transmission

Most of the books listed under I contain some reference to insulation. The literature of this subject is very extensive and reference may be made to the bibliography (up to 1920) included in the publication "Heat Transmission of Insulating Materials" published by the American Society of Refrigerating Engineers and obtainable from the office of the society, 35 Warren St., New York, N.Y. at \$2.00 per copy. A more complete bibliography, up to 1925 is included in Pennsylvania State College Engineering Experiment Station Bulletin No. 33, entitled "An Investigation of Certain Methods of Testing Heat Insulators" by E. F. Grundhofer, published June 1925 and purchasable from the Engineering Experiment Station, State College, Pa., at twenty-five cents per copy.

V - Journals and Periodicals

The following journals and periodicals are devoted to the refrigeration and allied industries.

<u>Name of Journal</u>	<u>Publisher</u>	<u>Address</u>
1. Refrigerating Engineering	American Society of Refrigerating Engrs.	35 Warren St., New York, N.Y.
2. Refrigerating World	The Ice Trade Journal Co.	Woolworth Bldg., New York, N.Y.
3. Ice & Refrigeration	Nickerson & Collins Co.	5707 W. Lake St., Chicago, Ill.
4. Refrigeration		Atlanta, Ga.
5. The Ice Cream Review	The Olson Publishing Co.	5th & Cherry Sts., Milwaukee, Wis.
6. The Ice Cream Trade Journal	Thomas D. Cutler	171 Madison Ave., New York, N.Y.

VI - Publications of the Bureau of Standards

A. Publications issued by the Government Printing Office and purchasable from the Superintendent of Documents, Government Printing Office, Washington, D.C. at the prices given. In ordering give title and serial number of publication desired. In case price is not given the publication is no longer available for distribution but may be consulted in the "Government Depository Reference Libraries" listed in the supplement to E.S. Circular No. 24.

1. Bureau of Standards Scientific Paper No. S 123. The Theory of the Hampson Liquefier, by Edgar Buckingham, B.S. Bull. 6, p.125; 1909. (out of print).
2. S135. Specific Heat of some Calcium Chloride Solutions between -35°C and $+20^{\circ}\text{C}$, by H.C. Dickinson, E. F. Mueller, and E. J. George. B.S. Bull. 6, p. 379; 1910. (out of print).
3. S209. Latent Heat of Fusion of Ice, by H.C. Dickinson, D.R. Harper, 3rd, and N.S. Osborne, B.S. Bull. 10, p. 235; 1914. (out of print).
4. S 247. An Android Calorimeter, by H.C. Dickinson and N.S. Osborne, B.S. Bull. 12, p. 23; 1915. 10¢
5. S248. Specific Heat and Heat of Fusion of Ice, by H.C. Dickinson and N.S. Osborne. B.S. Bull. 12, p. 49; 1915. 10¢
6. S294. Freezing Point of Mercury by R. M. Wilhelm, B.S. Scientific Papers 13, p. 655; 1917. 5¢
7. S301. An Android Calorimeter for Specific and Latent Heats, by N.S. Osborne, B.S. Bull. 14, p. 133; 1918. 10¢
8. S307. Note on Electrical Conduction in Metals at Low Temperatures, by Francis E. Silsbee. B.S. Bull, 14, p.301; 1918. (out of print).
9. S313. Specific Heat of Liquid Ammonia, by Nathan S. Osborne and Milton S. Van Dusen. B.S. Bull. 14, p. 397; 1918. 10¢
10. S314. Latent Heat of Pressure Variation of Liquid Ammonia, by Nathan S. Osborne and Milton S. Van Dusen. B.S. Bull. 14, p. 433; 1918. 5¢
11. S315. Latent Heat of Vaporization of Ammonia by Nathan S. Osborne and Milton S. Van Dusen. B.S. Bull. 14, p. 439; 1918. 5¢

12. S369. Vapor Pressure of Ammonia, by Carl S. Cragoe, Cyril W. Meyers, and Cyril S. Taylor. B.S. Scientific Papers 16, p.1; 1920. 10¢
13. S419. The Production of Liquid Air on a Laboratory Scale, by J.W. Cook, B.S. Scientific Papers 17, p.277; 1922. 5¢
14. S420. Specific Volume of Liquid Ammonia, by C.S. Cragoe and D.R. Harper, 3rd, B.S. Scientific Papers 17, p.287; 1922. (out of print).
15. S5. Composition, Purification, and Certain constants of Ammonia, by E.C. McKelvy and C.S. Taylor. B.S. Scientific Papers 18, p. 655; 1923. 10¢
16. S467. Specific Volume of Saturated Ammonia Vapor by C.S. Cragoe, E.C. McKelvy, and G.F. O'Connor, B.S. Scientific Papers 18, p. 707; 1923. 5¢
17. S501. Specific Heat of Superheated Ammonia Vapor by W.S. Osborne, F.F. Stimson, T.S. Sligh, Jr., and C.S. Cragoe, B.S. Scientific Papers 20, p. 65; 1925. 15¢
18. S503. A Flow Calorimeter for Specific Heats of Gases, by W.S. Osborne, F.F. Stimson, and T.S. Sligh, Jr., B.S. Scientific Papers 20, p. 119; 1925. 20¢
19. S520. Nonflammable Liquids for Cryostats, by C.W. Kenolt, B.S. Scientific Papers 20, p. 619; 1926. 10¢
20. B.S. Tech. Paper No. T 180. Causes and Prevention of the Formation of Noncondensable Gases in Ammonia Absorption Refrigeration Machines, by E.C. McKelvy and Aaron Isaacs. B.S. Tech. Papers. 5¢
21. B.S. Circular No. C 142. Tables of Thermodynamic Properties of Ammonia. Also contains Mollier Chart. 15¢
22. B.S. Miscellaneous Publication No. M 52. Mollier Chart of Properties of Ammonia. Same as chart in C 142 (9x23 inches)
23. M 57. Large Mollier Chart. Same as M 52 except for size. M 57 is 16 x 40 inches, 10¢.

B. Publications by members of the Bureau Staff, in scientific or technical journals.

1. The Latent Heat of Fusion of Ice, by H.C. Dickinson, D.R. Harper, 3rd, and N.S. Osborne; Presented at third Int. Cong. of Refrig., Chicago, Sept. 1913 and published in Ice and Refrigeration, 45, p. 287; 1913. (Same work as S 209).
2. An Aneroid Calorimeter, by H.C. Dickinson and N.S. Osborne, Am. Soc. Ref. Eng., Jour. 1, No. 3 p.5; 1915. (Same work as S 247).
3. The Specific Heat and Heat of Fusion of Ice by H.C. Dickinson and N.S. Osborne, Am. Soc. Ref. Eng. Jour. 1, No. 3 p. 32; 1915. (Same work as S 248).
4. The work of the Bureau of Standards on Constants of Refrigeration by H.C. Dickinson, Am. Soc. Ref. Eng. Jour. 2, No.5, p.46; 1916.
5. The Testing of Thermal Insulators, by H.C. Dickinson and M.S. Van Dusen, Am. Soc. Ref. Eng. Jour. 3, No.2, p. 5; 1916.
6. Composition and Testing of Commercial Liquid Ammonia, by E.C. McKelvy and C.S. Taylor. Am. Soc. Ref. Eng. Jour. 3, No. 5, p. 30; 1917.
7. An Aneroid Calorimeter for Specific and Latent Heats by Nathan S. Osborne. Am. Soc. Ref. Eng. Jour. 4, p. 103; 1917.
8. Specific Heat of Liquid Ammonia by Nathan S. Osborne and Milton S. Van Dusen, Am. Soc. Ref. Eng. Jour. 4 p. 134; 1917. (Same work as S 313).
9. Specific Heat of Liquid Ammonia by Nathan S. Osborne and Milton S. Van Dusen. Jour. Am. Chem. Soc. 40, n. 1; 1918. (Same work as S 313).
10. Latent Heat of Pressure Variation of Liquid Ammonia by Nathan S. Osborne and Milton S. Van Dusen. Am. Soc. Ref. Eng. Jour. 4, p. 167; 1917. (Same work as S 314).
11. Latent Heat of Vaporization of Ammonia, by Nathan S. Osborne and Milton S. Van Dusen. Am. Soc. Ref. Eng. Jour. 4, p. 122; 1917. (Same work as S 315).
12. Latent Heat of Vaporization of Ammonia by Nathan S. Osborne and Milton S. Van Dusen. Jour. Am. Chem. Soc. 40, p. 14; 1918. (Same work as S 315).

13. Gas Formation in Ammonia Absorption Refrigerating Machines, its Causes and Remedy, by E.C. McKelvy and A. Isaacs, Am. Soc. Ref. Eng. Jour. 4, p.447; 1918 (Same work as T 180).
14. Physical Properties of Brines, by E. F. Mueller. Am. Soc. Ref. Eng. Jour. 6, p. 25; 1919.
15. The Thermal Conductivity of Heat Insulators, by M.S. Van Dusen. Jour. Am. Soc. Heating and Ventilating Eng. 26, p. 625; 1920.
16. The Vapor Pressure of Ammonia by Carl S. Cragoe, Cyril H. Meyers and Cyril S. Taylor. Jour. Am. Chem. Soc. 42, p. 206; 1920. (Same work as S 369).
17. Vapor Pressure of Ammonia, by Carl S. Cragoe, Cyril H. Meyers and Cyril S. Taylor. Am. Soc. Ref. Eng. Jour. 6, p.307; 1920. (Same work as S 369).
18. Specific Volume of Anhydrous Liquid Ammonia, by C. S. Cragoe and D. R. Harper, 3rd. Am. Soc. Ref. Eng. Jour. 7, p. 113; 1920. (Same work as S 420).
19. The Thermal Conductivity of Heat Insulators by M.S. Van Dusen, Am. Soc. Ref. Eng. Jour. 7, p. 202; 1920.
20. Bureau of Standards Report of Progress in the Determination of the Fundamental Constants of Refrigeration Engineering, Am. Soc. Ref. Eng. Jour. 7, p. 338; 1921.
21. Pressure Relief Diaphragms, by H.F. Stimson, Am. Soc. Ref. Eng. Jour. 7, p. 380; 1921.
22. Total Heat Diagrams for Ammonia, by E. F. Mueller and C.H. Meyers. Am. Soc. Ref. Eng. Jour. 7, p. 419; 1921.
23. An Instrument for Measuring Clearance Volumes, by H.C. Dickinson, Am. Soc. Eng. Jour. 7, p. 460; 1921.
24. Gage Pressures by E. F. Mueller. Am. Soc. Ref. Eng. Jour. 8, p. 225; 1921.
25. Measurement of Specific Heat of Superheated Ammonia, by E.F. Mueller, Refrigerating Eng. 9, p. 1; 1922.
26. Composition, Purification and Certain Constants of Ammonia, by E.C. McKelvy and C.S. Taylor. Ref. Eng. 9, p. 213; 1923. (Same work as S 465).
27. Specific Volume of Saturated Ammonia Vapor, by C.S. Cragoe, E. C. McKelvy, and G. F. O'Connor. Ref. Eng. 9, p.239; 1923 (Same work as S 467).
28. Mollier Chart by E.F. Mueller and C.H. Meyers, Ref. Eng. 9, p.295, 1923.

39. Some Applications of the Mollier Chart, by C.H. Meyers, Ref. Eng. 10, p. 33; 1923.
40. The Principles of Heat transfer, by F.C. Dickinson, Ref. Eng. 10, p. 130; 1923.
41. Definitions, Nomenclature, and Symbols, by E.F. Mueller, Ref. Eng. 10, p. 133; 1923.
42. Plate method of testing insulating materials, by M.S. Van Dusen, Ref. Eng. 10, p. 140; 1923.
- 30, 31, and 32 are also issued by the American Society of Refrigerating Engineers as part of the publication "Heat Transmission of Insulating Materials" and sold by the Society at \$2.00 per copy.
43. Specific Heat of Superheated Ammonia Vapor, by W.S. Osborne, H. F. Stinson, T.S. Sligh, Jr., and C.S. Cragoe, Ref. Eng. 10, p. 145; 1923, (Same work as S 501).
44. Theoretical Calculations of Ammonia Compression by C.S. Cragoe. Ice and Refrigeration 66, p. 252; 1924.
45. Ammonia Tables versus $p v^n = \text{Constant}$, for Theoretical Calculations of Ammonia Compression by C.S. Cragoe, Ref. Eng. 11, p. 62; 1924.
46. Research in Heat Transmission, by Edgar Buckingham. Mech. Eng. 46, p. 386; 1924.
47. Research in Heat Transmission by Edgar Buckingham. Ref. Eng. 11, p. 91; 1924.
48. Specific Volume of Superheated Ammonia Vapor by C.H. Meyers and R.S. Jessup. Ref. Eng. 11, p. 345; 1925.
49. The Production of Cold, by C.W. Kanolt, Jour. Optical Soc. Am. 9, p. 411; 1924.
50. Calorimetry of Saturated Fluids, by Nathan S. Osborne, Jour. Optical Soc. Am. 8, p. 519; 1924.
51. Platinum Resistance Thermometry at Low Temperatures by M.S. Van Dusen, Jour. Am. Chem. Soc. 47, p. 326; 1925.
52. Production of Pure Hydrogen for Liquefaction, by C.W. Kanolt and J.W. Cook. Ind. & Eng. Chem. 17, p. 183; 1925.
53. Ratio of Specific Heats and the Joule-Thomson Effect for Ammonia, by C.S. Cragoe, Ref. Eng. 12, p. 131; 1925.
54. Antifreeze Solutions and Compounds by H.K. Cummings, Jour. Soc. Automotive Eng., 19, p. 93; 1926.
55. Properties of Refrigerating Brines, by R.S. Jessup, Ref. Eng. 12, p. 171; 1925.

