

A BIBLIOGRAPHY OF THERMODYNAMIC NETWORKS OF
PURE SUBSTANCES

A THESIS

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the Faculty of the Graduate Division

By

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SUMMARY

Man's insatiable quest for knowledge is reflected in the prodigious amount of material that is published every month. However, this wealth of information is of little value if one cannot find it. Among the wide variety of data in the published literature are those concerning the thermodynamic properties of pure substances. Knowledge of these data is becoming increasingly important in our technology. Efforts are underway by many groups to collect and systematize these data and to publish annual bibliographies.

One particular facet of the area of thermodynamic properties was chosen for a systematic study. Specifically, a literature survey was made to compile a set of references containing enthalpy or entropy data for pure substances over a pressure and temperature range. Of especial interest was the existence of thermodynamic charts as diagrams. The major literature was reviewed from 1918 to February 1958. Chemical Abstracts was used for the primary source of references and whenever possible the original publications were examined, both for the range in temperature and pressure and for further references.

Data for 91 substances from 212 references were collected for this bibliography. It gives, in addition to the reference, information as to the type of chart published, whether tabular data were presented, and the range of pressure and temperature covered by the article.

CHAPTER I

INTRODUCTION

The purpose of this study was to prepare a bibliography of enthalpy or entropy data for pure substances at varying pressures and temperatures. Such a bibliography can be useful in the fields of science and engineering. In recent times it has become more costly and time-consuming to find information in the published literature on the thermodynamic properties of substances. This is due to the steadily increasing amount of literature being published.

Beginning with R. Regnault (1) in the middle of the nineteenth century, succeeding investigators have been determining data of the thermodynamic properties of substances at an ever increasing rate. Among the first to suggest a way of presenting this data was Belpaire (2) who, in 1872, proposed a plot of temperature versus entropy. Subsequently, J. W. Gibbs (3) in 1873 not only worked out the characteristics of the temperature-entropy diagram but also suggested other thermodynamic surfaces. The first temperature-entropy diagram based on detailed experimental data was constructed by J. M. Gray (4), who in 1889 prepared such a diagram for steam. A few years later, in 1904, R. Mollier (5) was the first investigator to use the available data for the construction of an enthalpy versus entropy diagram and an enthalpy versus pressure diagram. Today the enthalpy-entropy plot and the enthalpy-logarithm pressure plot are known as Mollier diagrams. As more and more data were

published in the literature, little attempt was made to keep track of it by means of bibliographies. Since Regnault's time and especially after World War II, the volume of published literature in all fields of science and engineering has increased many-fold, with the result that at the present time obtaining information from the literature has become a major task.

The ultimate objective of this bibliography is to provide in one place convenient references to the published literature. References are made to articles containing data on the thermodynamic properties of enthalpy or entropy for pure substances over some pressure and temperature range. The references that were reviewed contained the data either in diagrammatic or tabular form.

An evaluation of the published data was not made, since this would have entailed a critical examination of every article. A comment has been made, however, in cases where the data given were obtained entirely by estimation procedures. Recently there have been many papers on methods of predicting thermodynamic properties (6, 7, 8, 9, 10) and on the construction of thermodynamic charts for pure substances (6, 7, 11).

Excluded from this research were references to the following thermodynamic data:

1. Pressure - Volume - Temperature relations.
2. Ideal thermodynamic functions, i.e., functions obtained from spectroscopic measurements.
3. Properties at a point, i.e., triple point data, entropy of vaporization at some temperature, etc.

4. Properties of substances in the solid state.
5. Heat capacity data for any substance.
6. Thermodynamic properties of mixtures of pure substances, except for air and Dowtherm A (which is a mixture of 75% Diphenyl oxide and 25% Diphenyl).

In general the minimum amount of data included were the enthalpy or entropy of a substance at saturation pressures and temperatures. Certain exceptions were made to this generalization. Papers were reviewed for properties of substances in the critical region where the properties change rapidly. Another exception is ozone, for which data are included because of the increased industrial use of this substance.

CHAPTER II

PROCEDURE

An exhaustive search of the literature for all substances was not made in the preparation of this paper for several reasons. Ordinary substances such as air, water, carbon dioxide, etc. were the first to be investigated and their thermodynamic properties are continually being reinvestigated. All the references to these substances were not sought out because the earlier works would be more of a historical interest rather than of a practical interest. Only the more recent references are included in this report. Secondly, time was not available for an exhaustive survey as the author did not have access to an unlimited number of different publications.

Abstracting services such as Chemical Abstracts, Dissertation Abstracts, and Nuclear Science Abstracts were heavily relied on as primary sources of information. Thus European literature was not covered as extensively as it might have been. This is at least true for the period prior to World War II.

The abstracts in Chemical Abstracts were systematically reviewed from December 1957 back to January 1918. It was assumed that any reference to the thermodynamic properties of substances prior to this time would be only for the ordinary substances such as air, water, carbon dioxide, etc. and that the recent data available for these substances would be more accurate. There are several reasons for this heavy reliance on Chemical

Abstracts. One, a high percentage of published data pertinent to this search would be abstracted by Chemical Abstracts (12). Secondly, the editors of Chemical Abstracts also scan the British Abstracts and Chemisches Zentralblatt and publish any references that were missed (12). Thus it was felt that the time involved in searching through British Abstracts and Chemisches Zentralblatt would not compensate for the possibility of finding one or two abstracts that were missed by Chemical Abstracts.

It was found necessary to use a painstaking procedure for this search because the indexes of Chemical Abstracts did not list the terms: "Charts," "Thermodynamic Property Charts," "Tables," etc. All of the abstracts under the heading of "Thermodynamic properties of ..." were examined and notes were made of references that appeared promising. At times it was difficult to ascertain from the abstract whether a particular reference contained the requisite data. Generally an abstract would note that the thermodynamic properties of a substance were given. Upon examination of several articles, it was found that the phrase "thermodynamic properties" inferred many different concepts, these ranging from the vapor pressure at the triple point to the free energy of reaction for some substances. Thus the fact that the substances were indexed by subject headings only in a general sense made the search long and detailed. Approximately 1500 abstracts have been checked and 500 articles read in obtaining the present list of 212 references for 91 substances.

Company literature that was not found in Chemical Abstracts was not extensively surveyed. American theses abstracted in Dissertation

Abstracts were reviewed, but the original theses were not examined. A large majority of American and practically all of the European theses which were not abstracted were not reviewed. Nuclear Science Abstracts (1947 to the present) was checked because this publication represents the best key to the tremendous quantity of government publications from the United States Atomic Energy program.

When a large majority of the abstracts had been obtained, the next step was to seek out all the references in their original publications. While it is true that an abstract may or may not give the requisite information, it is always best to check the original source to insure accuracy. Occasionally abstracts have been found to be in error. A more important reason for checking is that the original article may lead to further references, thus becoming an invaluable secondary source of information. For checking the original publications, the facilities of the Price Gilbert Library of the Georgia Institute of Technology in Atlanta, Georgia were used. In a few instances, the original publications could not be found. In these cases the abstract was given as the source of information.

This search was brought up to date by reviewing the individual issues of Chemical Abstracts after December 1955, the last year for which a subject index was available. The 1956 and 1957 annual indexes of many of the publications which had previously presented thermodynamic data were also scanned. Since many publications are not abstracted by Chemical Abstracts until a considerable period of time has elapsed from the date of publication, this bibliography may not

be as complete for the period after 1955 as it is for the period prior to 1955. During this period only the abstracts in the second section, entitled "General and Physical Chemistry," of the individual issues of Chemical Abstracts were reviewed.

CHAPTER III

PRESENTATION OF THE TABLES

The thermodynamic data found for 91 substances are presented in Table 3. The arrangement of the substances in this table is alphabetical, using the Chemical Abstracts system of nomenclature. Table 1 gives a listing of the substances arranged according to this alphabetical system, and Table 2 gives a listing of the substances by chemical formula using the system employed by Chemical Abstracts. Following Table 3 is a complete list of references by alphabetical listing of the last name of the first author listed on the publication. The abbreviations used in the list of references are the same as those used in the 1956 List of Periodicals Abstracted by Chemical Abstracts and the 1957 supplement.

The data is presented in a columnar arrangement in Table 3. An explanation of the columns (left to right) is given below.

Column 1. Column heading: References. In this column there appears a number which corresponds to a publication listed in the list of references immediately following Table 3. The references for each substance are listed in reverse chronological order.

Column 2. Column heading: Type of Table. The following symbols are used in this column to denote whether tabular enthalpy or entropy data appeared in the publication.

- denotes the fact that no tables appeared in the article.

Sa denotes that tables of the saturated properties only appeared in the reference.

Su denotes that tables for the properties of the superheated region only appeared in the reference.

B denotes that tables of the properties of the saturated and superheated region appeared in the publication.

Column 3. Column heading: Type of Chart. This column describes the types of charts which appeared in the publication by coordinates only. The following symbols will be used in this column.

- denotes that no chart was given in the article.

H-P denotes a chart of enthalpy vs. pressure as the coordinates. This chart is plotted on arithmetic coordinates and will contain lines of constant temperature. These charts may also contain lines of constant entropy or volume.

H- log P denotes a chart of enthalpy vs. pressure plotted on semi-log paper. This chart is generally known as a Mollier diagram in Europe, with enthalpy usually denoted by the symbols, i or w .

T-S denotes a chart of temperature vs. entropy plotted on arithmetic coordinates.

H-S denotes a chart of enthalpy vs. entropy plotted on arithmetic coordinates. This chart is generally called the Mollier chart.

P-T denotes a chart of pressure vs. temperature and contains lines of constant enthalpy plotted on arithmetic coordinates.

Column 4. Column heading: Temperature Range. This column gives the range of temperatures covered by the charts in preference to the tables if there is a difference between the two. Usually the range

covered by the tables and the charts are the same. The chart range is preferred since many references give a chart of both the saturated and superheat regions, while only a table of the saturated properties may be included. This can be deduced from the information in the columns.

Column 5. Column heading: Pressure Range. This column gives the range of pressures covered by the charts. The procedure here is the same as for column 4.

Column 6. Column heading: Comments. This column contains the following type of information presented as footnotes at the bottom of each page.

1. Articles that extend or employ the data of another reference will be noted.
2. The units of energy will be given if they are other than Btu's or calories.
3. A comment will be made whenever the data were obtained by only using estimation procedures. Since many investigators employ some estimation methods in presenting their data, there will be no comment made as to the amount of estimation used. It is beyond the scope of this work to determine precisely how the data were obtained when several methods were used.
4. A note will be made when several charts are presented in the reference covering the same range of temperatures and pressures.
5. A publication which gives a large number of references will be noted.

General Note.--From the units of pressure and the temperature scale used, one can determine whether the English or the metric system of units are used. (e.g., psia-°R usually means English units). If the units are different from the commonly used units, this fact is noted as a comment in Column 6.

During the search several references were found which gave enthalpy-entropy data for many substances. Since these works may serve as "source-books" in many fields of application, they are listed separately in Table 4 of the Appendix.

Table 1. Alphabetical Arrangement of Substances
Used in Table 3

-
1. Acetaldehyde
 2. Acetic acid
 3. Acetone
 4. Acetylene
 5. Air
 6. Ammonia
 7. Aniline
 8. Argon
 9. Benzene
 10. Benzene, ethyl-
 11. Benzene, o-dichloro-
 12. 1,3-Butadiene
 13. n-Butane
 14. Butane, decafluoro-
 15. 1-Butene
 16. 2-Butene
 17. tert-Butyl alcohol
 18. Carbon dioxide
 19. Carbon disulfide
 20. Carbon monoxide
 21. Carbon tetrachloride
 22. Chlorine

(continued)

Table 1. Alphabetical Arrangement of Substances
Used in Table 3 (continued)

-
23. Chloroform
 24. Cyclobutane, octafluoro-
 25. Deuterium
 26. Dimethylamine
 27. Diphenyl
 28. Diphenyl oxide 75%- Diphenyl 25%
 29. Ethane
 30. Ethane, bromo-
 31. Ethane, chloro-
 32. Ethane, 1-chloro-1, 1-difluoro- (Freon 142)
 33. Ethane, 1,1-dichloro-1,2,2,2-tetrafluoro- (Freon 114)
 34. Ethane, 1,1-difluoro-
 35. Ethane, trichlorotrifluoro-
 36. Ethyl acetate
 37. Ethyl alcohol
 38. Ethylamine
 39. Ethylene
 40. Ethylene, 2-chloro-1,1-difluoro- (Genetron 160)
 41. Ethylene, 1,1-dichloro-
 42. Ethylene, 1,1-difluoro-
 43. Ethylene oxide

(continued)

Table 1. Alphabetical Arrangement of Substances
Used in Table 3 (continued)

-
44. Ethylene, trichloro-
 45. Ethyl ether
 46. Formic acid, methyl ester
 47. Helium
 48. n-Heptane
 49. n-Hexane
 50. Hydrochloric acid
 51. Hydrogen
 52. Hydrogen sulfide
 53. Isobutane
 54. Isobutylene
 55. Isopentane
 56. Isopropyl alcohol
 57. Mercury
 58. Methane
 59. Methane, bromo-
 60. Methane, bromotrifluoro-
 61. Methane, chloro-
 62. Methane, chlorodifluoro-
 63. Methane, chlorotrifluoro-
 64. Methane, dichloro-
 65. Methane, dichlorodifluoro- (Freon 12)

(continued)

Table 1. Alphabetical Arrangement of Substances
Used in Table 3 (continued)

-
66. Methane, dichlorofluoro- (Freon 21)
 67. Methane, fluoro-
 68. Methane, trichlorofluoro- (Freon 11)
 69. Methanol
 70. Methylamine
 71. Methyl ether
 72. Neon
 73. Nitric oxide
 74. Nitrogen
 75. Nitrous oxide
 76. n-Octane
 77. Oxygen
 78. Ozone
 79. n-Pentane
 80. Propane
 81. Propane, 1,2-dichlorohexafluoro-
 82. Propene
 83. Propionic acid, ethyl ester
 84. Propyl alcohol
 85. Sodium
 86. Sulfur

(continued)

Table 1. Alphabetical Arrangement of Substances
Used in Table 3 (continued)

-
- | | |
|-----|----------------------|
| 87. | Sulfur dioxide |
| 88. | Toluene |
| 89. | Uranium hexafluoride |
| 90. | Water |
| 91. | Xenon |
-

Table 2. Formula Listing of the Substances in Table 3
Using the Chemical Abstracts System
(The name given is the same as that used in Tables
1 and 3).

Formula	Name
A	8. Argon
CBrF_3	60. Methane, bromotrifluoro-
CClF_3	63. Methane, chlorotrifluoro-
CCl_2F_2	65. Methane, dichlorodifluoro-
CCl_3F	68. Methane, trichlorofluoro-
CCl_4	21. Carbon tetrachloride
CHClF_2	62. Methane, chlorodifluoro-
CHCl_2F	66. Methane, dichlorofluoro-
CHCl_3	23. Chloroform
CH_2Cl_2	64. Methane, dichloro-
CH_3Br	59. Methane, bromo-
CH_3Cl	61. Methane, chloro-
CH_3F	67. Methane, fluoro-
CH_4	58. Methane
CH_4O	69. Methanol
CH_5N	70. Methylamine
CO	20. Carbon monoxide
CO_2	18. Carbon dioxide
CS_2	19. Carbon disulfide
$\text{C}_2\text{Cl}_2\text{F}_4$	33. Ethane, 1,1-dichloro-1,2,2,2-tetrafluoro-

(continued)

Table 2. Formula Listing of the Substances in Table 3
Using the Chemical Abstracts System
(The name given is the same as that used in Tables
1 and 3). (continued)

Formula	Name
$C_2Cl_3F_3$	35. Ethane, trichlorotrifluoro-
C_2HClF_2	40. Ethylene, 2-chloro-1,1-difluoro-
C_2HCl_3	44. Ethylene, trichloro-
C_2H_2	4. Acetylene
$C_2H_2Cl_2$	41. Ethylene, 1,1-dichloro-
$C_2H_2F_2$	42. Ethylene, 1,1-difluoro-
$C_2H_3ClF_2$	32. Ethane, 1-chloro-1,1-difluoro-
C_2H_4	39. Ethylene
$C_2H_4F_2$	34. Ethane, 1,1-difluoro-
C_2H_4O	1. Acetaldehyde; 42. Ethylene oxide
$C_2H_4O_2$	46. Formic acid, methyl ester; 2. Acetic Acid
C_2H_5Br	30. Ethane, bromo-
C_2H_5Cl	31. Ethane, chloro-
C_2H_6	29. Ethane
C_2H_6O	37. Ethyl alcohol; 70. Methyl ether
C_2H_7N	38. Ethylamine; 26. Dimethylamine
$C_3Cl_2F_6$	81. Propane, 1,2-dichlorohexafluoro-
C_3H_6	82. Propene
C_3H_6O	3. Acetone

(continued)

Table 2. Formula Listing of the Substances in Table 3
 Using the Chemical Abstracts System
 (The name given is the same as that used in Tables
 1 and 3). (continued)

Formula	Name
C_3H_8	80. Propane
C_3H_8O	84. Propyl alcohol; 55. Isopropyl alcohol
C_4F_8	24. Cyclobutane, octafluoro-
C_4F_{10}	14. Butane, decafluoro-
C_4H_6	12. 1,3-Butadiene
C_4H_8	15. 1-Butene; 16. 2-Butene; 53. Isobutylene
C_4H_{10}	13. n-Butane; 52. Isobutane
$C_4H_{10}O$	17. tert-Butyl alcohol; 44. Ethyl ether
$C_5H_{10}O_2$	83. Propionic acid, ethyl ester
C_5H_{12}	79. n-Pentane; 54. Isopentane
$C_6H_4Cl_2$	11. Benzene, dichloro-
C_6H_6	9. Benzene
C_6H_7N	7. Aniline
C_6H_{14}	49. n-Hexane
C_7H_8	88. Toluene
C_7H_{16}	48. n-Heptane
C_8H_{10}	10. Benzene, ethyl-
C_8H_{18}	76. n-Octane
ClH	50. Hydrochloric acid

(continued)

Table 2. Formula Listing of the Substances in Table 3
 Using the Chemical Abstracts System
 (The name given is the same as that used in Tables
 1 and 3). (continued)

Formula	Name
Cl ₂	22. Chlorine
D ₂	25. Deuterium
F ₆ U	89. Uranium hexafluoride
H ₂	57. Hydrogen
H ₂ O	90. Water
H ₂ S	52. Hydrogen sulfide
H ₃ N	6. Ammonia
He	47. Helium
Hg	57. Mercury
N ₂	74. Nitrogen
NO	73. Nitric oxide
N ₂ O	75. Nitrous oxide
Na	85. Sodium
Ne	72. Neon
O ₂	77. Oxygen
O ₃	78. Ozone
O ₂ S	87. Sulfur dioxide
S	86. Sulfur
Xe	91. Xenon

Table 3. Summary of Enthalpy or Entropy Data for Pure Substances

Refer- ences (1)	Type of Table (2)	Type of Chart (3)	Temperature Range (4)	Pressure Range (5)	Comments (6)
<u>1. Acetaldehyde</u>					
24	B	H-S	-80 to 300°F	15 to 700 psia	See note a
<u>2. Acetic acid</u>					
44	Sa	T-S	0 to 321.6°C	Not given	See note b
<u>3. Acetone</u>					
136	B	H-P	96 to 800°F	1 to 2500 psia	
<u>4. Acetylene</u>					
49	Sa	H-log P	-10 to 36.3°C	20 to 61.6 atm	
<u>5. Air</u>					
70	-	T-S, H-S	79 to 300°K	1 to 200 atm	
95	Su	T-S	300 to 675°R	1 to 50 atm	See note c
129	B	T-S	-170 to 75°C	1 to 1100 atm	
195	B	-	90 to 5400°R	0.01 to 100 atm	
61	B	-	100 to 5000°R	0.055 to 1346 atm	See note d
30	-	T-S	-320 to 80°F	0 to 180 psia	See note e
169	-	T-S	-320 to 300°F	1 to 3500 psia	
5	-	H-S	0 to 2800°C	0.1 to 200 atm	
178	-	H-S	0 to 500°C	0 to 300 atm	
207	B	-	125 to 500°R	1 to 220 atm	See note f
75, 76	B	-	300 to 6500°R	0.36 to 60310	See note g
52	-	T-S	0 to 600°F	15 to 3500 psia	
43	-	T-S	500 to 5500°R	1 to 2048 psia	
182	-	T-S	60 to 500°C	0.1 to 1000 kg/cm ²	
		H-log P	80 to 500°C	1 to 1000 kg/cm ²	

Note a. Chart contains lines of constant entropy

Note b. Chart contains a saturation line for entropy only

Note c. This reference extends the data of reference 207

Note d. Data given as $(H-H^0)_T$ and as $(S-S^0) + R \ln P$; 44 references

Note e. Gives 36 references

Note f. H-log P chart reproduced in Refrigerating Data Book, 1953

Note g. Pressures given as relative pressures, Tables give enthalpy in Btu's per pound

(continued)

Table 3. Summary of Enthalpy or Entropy Data for Pure Substances
(continued)

Refer- ences (1)	Type of Table (2)	Type of Chart (3)	Temperature Range (4)	Pressure Range (5)	Comments (6)
<u>6. Ammonia</u>					
58	-	H-T	-100 to 700°F	0 to 16,000 psia	
8	-	H-S	-60 to 270°C	0.2 to 20 atm	See note a
185	Sa	H-log P	-76 to 150°C	0.07 to 20 atm	See note b
		H-log P	0 to 150°C	4 to 120 atm	
112	Sa	H-P	-107.8 to 250°F	0.8 to 5 psia	
50	B	H-log P	-10 to 150°C	4 to 120 atm	
73	Su	-	150 to 300°C	20 to 1000 atm	
140	-	H-log P	-60 to 400°C	5 to 300 psia	
94	-	H-log P	-77 to 140°C	0.07 to 20 atm	
194	B	H-log P	-60 to 400°F	5.5 to 300 psia	See note c
54, 55	-	H-S	-110 to 475°F	0.75 to 700 psia	
89	B	H-S	-100 to 200°F	1.1 to 700 psia	
<u>7. Aniline</u>					
99	B	-	20 to 2000°F	0 to 10,000 psia	See note d
<u>8. Argon</u>					
195	Su	-	180 to 5400°R	0.01 to 100 atm	See note e
206	B	-	0 to 600°C	0 to 80 atm	See note f
121	B	T-S, H-S	0 to 150°C	0 to 2000 atm	
		H-log P	0 to 150°C	0 to 2000 atm	
122	B	-	0 to 150°C	0 to 2000 atm	
100	-	H-T	-460 to 290°F	15 to 3000 psia	

Note a. Data of reference 94 are used

Note b. Data of references 50, 94, and 194 are used

Note c. Data reproduced in Refrigerating Data Book, 1953

Note d. Estimation procedures used

Note e. Data given as $(H-H_0^0)/RT_0$ and S/R where $T_0 = 273.16^\circ\text{K}(491.688^\circ\text{R})$ Note f. Data given as $(H-H_0)/RT_0$ and $(S-S_0)/R$ where $T_0 = 273.16^\circ\text{K}$

(continued)

Table 3. Summary of Enthalpy or Entropy Data for Pure Substances
(continued)

Refer- ences (1)	Type of Table (2)	Type of Chart (3)	Temperature Range (4)	Pressure Range (5)	Comments (6)
<u>9. Benzene</u>					
142	B	H-P	100 to 1800°F	10 to 3000 psia	See note a
168	-	H-S	5.4 to 210°C	0.06 to 16 atm	
	B	-	0 to 288.6°C	0.04 to 50 atm	
45	Sa	-	0 to 130°C	0.03 to 3.8 kg/cm ²	
105	-	H-P	0 to 1200°F	1 to 150 atm	
44	Sa	T-S	0 to 288.5°F	0.04 to 50 atm	See note b
<u>10. Benzene, ethyl</u>					
64	Su	H-P	280 to 1280°F	14.7 to 560 psia	
<u>11. Benzene, o-dichloro-</u>					
193	-	H-log P, H-T	100 to 900°F	0 to 500 psia	
<u>12. 1,3-Butadiene</u>					
113	Sa	H-log P	-164 to 288°F	3 to 3000 psia	
180	Sa	-	-108.9 to 152°C	0.5 to 32,400 mm Hg	
<u>13. n-Butane</u>					
156	B	H-P	31.1 to 540°F	1 to 300 atm	
172	B	T-S	60 to 250°F	15 to 3000 psia	
105	-	H-S	20 to 580°F	0.5 to 60 atm	
34	Sa	-	0 to 140°F	7.3 to 92.6 psia	
40	Sa	-	0 to 120°F	8 to 69.5 psia	
<u>14. Butane, decafluoro- (Perfluorobutane)</u>					
150	Sa	T-S	-40 to 30°C	0.16 to 3.15 atm	See note c

Note a. See also reference 4, document number 2535

Note b. Chart contains a saturation line for entropy only

Note c. Based on data of reference 10

(continued)

Table 3. Summary of Enthalpy or Entropy Data for Pure Substances
(continued)

Refer- ences (1)	Type of Table (2)	Type of Chart (3)	Temperature Range (4)	Pressure Range (5)	Comments (6)
<u>15. 1-Butene</u>					
201	B	H-log P	32 to 480°F	15 to 1000 psia	
105	-	H-P	-200 to 1200°F	1 to 150 atm	
<u>16. 2-Butene</u>					
105	-	H-P	-200 to 1200°F	1 to 150 atm	
<u>17. tert-Butyl alcohol</u>					
93	B	T-S	78 to 500°F	14.7 to 700 psia	
<u>18. Carbon dioxide</u>					
33	B	T-S	-100 to 1000°C	0.01 to 12,000 atm	See note a
		H-log P	-50 to 175°C	0 to 3000 atm	
195	B	-	200 to 1500°K	.01 to 100 atm	
157,158	B	-	100 to 1000°C	50 to 1400 bars	
101	Su	-	0 to 600°C	1 to 50 atm	
185	B	H-log P	-80 to 130°C	0 to 110 atm	See note b
115	B	-	25 to 150°C	0 to 2000 atm	
190	B	H-P	-75 to 1800°F	0.15 to 3000 psia	See note c
114	B	-	25 to 150°C	0 to 3000 atm	See note d
152,153	-	T-S	0 to 300°F	15 to 1700 psia	
<u>19. Carbon disulfide</u>					
139	B	H-P	32 to 1500°F	2.46 to 1000 psia	See note e

Note a. Gives 44 references

Note b. Based on data of references 152 and 153

Note c. Chart contains lines of constant entropy

Note d. Only entropy data given

Note e. Used empirical equation of state

(continued)

Table 3. Summary of Enthalpy or Entropy Data for Pure Substances
(continued)

Refer- ences (1)	Type of Table (2)	Type of Chart (3)	Temperature Range (4)	Pressure Range (5)	Comments (6)
<u>20. Carbon monoxide</u>					
82	B	H-P	-205 to 200°C	0.15 to 300 atm	
119,120	B	H-P,H-S, T-S	0 to 150°C	0 to 3000 atm	
59	-	H-S	0 to 600°C	1 to 1000 atm	
43	-	T-S	500 to 5500°R	1 to 2048 psia	
<u>21. Carbon tetrachloride</u>					
29	Sa	-	0 to 140°F	0.22 to 8.6 psia	
26	Sa	-	0 to 140°F	11.5 to 445 mm Hg	
<u>22. Chlorine</u>					
35	-	H-log P	-40 to 500°F	10 to 1500 psia	
72	B	H-S	-130 to 540°F	.03 to 1400 psia	
212	Sa	H-log P	-70 to 140°F	.15 to 100 atm	
67	B	-	-40 to 520°F	15 to 1100 psia	
68	Sa	H-T	-40 to 520°F	15 to 1100 psia	
<u>23. Chloroform (Methane, trichloro-)</u>					
29	Sa	-	0 to 150°F	0.74 to 17.4 psia	
<u>24. Cyclobutane, octafluoro- (Perfluorocyclobutane)</u>					
11	Sa	H-log P	-40 to 115°C	0.2 to 28.6 kg/cm ²	
<u>25. Deuterium</u>					
118	Su	-	0 to 150°C	40 to 700 amagats	See note a
<u>26. Dimethylamine</u>					
111	Sa	-	-30 to 40°C	0.16 to 3.5 atm	See note b

Note a. Data given are internal energy and entropy

Note b. Data also reproduced in Refrigerating Data Book, 1953

(continued)

Table 3. Summary of Enthalpy or Entropy Data for Pure Substances
(continued)

Refer- ences (1)	Type of Table (2)	Type of Chart (3)	Temperature Range (4)	Pressure Range (5)	Comments (6)
<u>27. Diphenyl</u>					
3	Sa	H-S,T-S	156 to 980°F	0.015 to 607 psia	See note a
<u>28. Diphenyl oxide-75%,Diphenyl-25% (Dowtherm A)</u>					
9	Sa	-	53.6 to 750°F	0.14 to 150 psia	
<u>29. Ethane</u>					
176	Su	H-P,T-S	100 to 460°F	0 to 10,000 psia	
185	B	H-log P	-100 to 150°C	0.5 to 70 atm	See note b
126	B	-	0 to 150°C	0 to 200 atm	See note c
12	B	H-log P	-150 to 500°F	10 to 1500 psia	See note d
171	B	H-P	70 to 250°C	1 to 3500 psia	
151	Sa	H-log P	-100 to 150°C	0.5 to 80 atm	
138	Sa	-	-148 to 90°C	7.6 to 70.7 psia	
105	-	H-S	-140 to 400°F	0.5 to 60 atm	
		H-T	-200 to 1200°F	0 to 150 atm	
<u>30. Ethane,bromo- (Ethyl bromide)</u>					
143	B	T-S	-30 to 150°C	.05 to 1.09 atm	
17,18	Sa	-	-30 to 40°C	.05 to 1.09 atm	
<u>31. Ethane,chloro- (Ethyl chloride)</u>					
143	Sa	-	-40 to 40°C	.065 to 2.6 Kg/cm ²	See note e
71	Sa	T-S	-30 to 110°C	0.15 to 4 atm	

Note a. Only enthalpy data given

Note b. Data of reference 151 used

Note c. Data given in joules/mole

Note d. Compares data with references 151 and 152

Note e. Data from reference 71 used

(continued)

Table 3. Summary of Enthalpy or Entropy Data for Pure Substances
(continued)

Refer- ences (1)	Type of Table (2)	Type of Chart (3)	Temperature Range (4)	Pressure Range (5)	Comments (6)
<u>32. Ethane,1-chloro-1,1-difluoro-</u>					
106	Sa	-	-40 to 120°C	15 to 600 psia	See note a
163	Sa	-	-60 to 30°C	.07 to 4 atm	
<u>33. Ethane,1-1-dichloro-1,2,2,2-tetrafluoro- (Freon 114)</u>					
48	-	H-log P	-40 to 100°C	0.15 to 6 kg/cm ²	
107	Sa	-	-40 to 145.5°F	20 to 479 psia	
160	B	H-log P	-40 to 140°F	2 to 75 psia	
<u>34. Ethane,1-1-difluoro- (Freon 152)</u>					
107	Sa	-	-40 to 113.5°F	5 to 652 psia	
<u>35. Ethane,trichlorotrifluoro-</u>					
166	Sa	H-log P	-30 to 80°C	.03 to 2.7 kg/cm ²	
<u>36. Ethyl acetate</u>					
44	Sa	-	70 to 240°C	Not given	See note b
<u>37. Ethyl alcohol</u>					
144	B	H-P	0 to 480°C	.016 to 56 atm	See note c
161	-	H-P	32 to 470°C	0.3 to 1000 psia	See note d
45	Sa	-	0 to 130°C	.01 to 5.8 kg/cm ²	
44	Sa	T-S	0 to 240°C	Not given	See note e

Note a. See also reference 4, Document No. 4502

Note b. Entropy data given for saturation temperature only

Note c. Chart contains lines of constant entropy

Note d. See also reference 4, Document No. 3316

Note e. Chart contains a saturation line for entropy only

(continued)

Table 3. Summary of Enthalpy or Entropy Data for Pure Substances
(continued)

Refer- ences (1)	Type of Table (2)	Type of Chart (3)	Temperature Range (4)	Pressure Range (5)	Comments (6)
<u>38. Ethylamine</u>					
109,110	Sa	H-log P	-50 to 110°C	.03 to 3.5 atm	
160	Sa	-	-58 to 113°F	.35 to 41 psia	
<u>39. Ethylene</u>					
15	B	H-log P	-150 to 400°C	1 to 10,000 kg/cm ²	
32	Sa	T-S	-160 to 200°C	.02 to 3000 atm	
79	-	H-log P	-150 to 200°C	.02 to 300 atm	
115,117	B	-	25 to 150°C	0 to 2500 atm	
210	B	H-log P	-140 to 520°F	1 to 300 atm	
83	-	T-S, H-S	-100 to 100°C	1 to 80 atm	
<u>40. Ethylene, 2 chloro-1,1-difluoro- (Genetron 160)</u>					
107	Sa	-	-40 to 120°C	10 to 647 psia	
<u>41. Ethylene, 1,1-dichloro-</u>					
200	Sa	-	-40 to 130°F	.175 to 17 psia	
189	B	H-log P	-26 to 80°C	.02 to 1.5 kg/cm ²	
29	Sa	-	-40 to 130°F	.175 to 17 psia	
66	Sa	-	-30 to 60°C	.027 to 1.5 kg/cm ²	See note a
6,58	-	T-S	-40 to 40°C	0.1 to 2.5 psia	
<u>42. Ethylene, 1,1-difluoro- (Genetron 150)</u>					
107	Sa	-	-40 to 25°C	100 to 643 psia	
<u>43. Ethylene oxide</u>					
199	B	-	70 to 384°F	0 to 1043 psia	
134	B	H-P	120 to 300°F	0 to 540 psia	See note b

Note a. Data given for both cis- and trans- isomers

Note b. Chart contains lines of constant entropy

(continued)

Table 3. Summary of Enthalpy or Entropy Data for Pure Substances
(continued)

Refer- ences (1)	Type of Table (2)	Type of Chart (3)	Temperature Range (4)	Pressure Range (5)	Comments (6)
<u>44. Ethylene, trichloro-</u>					
29	Sa	-	0 to 150°F	0.15 to 7.7 psia	
6	-	T-S	-40 to 40°C	0.1 to 2.5 psia	
<u>45. Ethyl ether</u>					
179	B	H-log P	50 to 600°F	4 to 1000 psia	
5,58	-	T-S	-40 to 40°C	0.5 to 15 psia	
<u>46. Formic acid, methyl ester (Methyl formate)</u>					
29	Sa	-	0 to 170°F	1.5 to 63 psia	
98	Sa	-	-40 to 60°C	.025 to 2.7 kg/cm ²	
<u>47. Helium</u>					
183	B		-440 to 600°F	15 to 6000 psia	See note a
81	-	H-log P	1 to 500°K	0 to 300 atm	
1	B	T-S	-440 to 600°F	15 to 6000 psia	
211	B	T-S	3 to 20°K	0.5 to 60 atm	
78	B	T-S	1.25 to 4.5°K	1.4x10 ⁻³ to 30 atm	
86	-	T-S	1 to 4.5°K	1 to 30 atm	
83	-	T-S	2 to 300°K	0.6 to 60 atm	
<u>48. n-Heptane</u>					
187	-	H-log P	209 to 1800°F	1 to 300 atm	
105	-	H-P	0 to 1200°F	1 to 150 atm	
<u>49. n-Hexane</u>					
202	B	H-log P	160 to 540°F	0.8 to 600 psia	
105	-	H-P	-100 to 1200°F	1 to 150 atm	

Note a. Tables and charts compiled from previously published data

(continued)

Table 3. Summary of Enthalpy or Entropy Data for Pure Substances
(continued)

Refer- ences (1)	Type of Table (2)	Type of Chart (3)	Temperature Range (4)	Pressure Range (5)	Comments (6)
<u>50. Hydrochloric acid</u>					
35	-	H-log P	-120 to 500°F	10 to 1500 psia	See note a
<u>51. Hydrogen</u>					
91	-	T-S, H-T	20 to 85°K	1 to 120 atm	See note b
195	Su	S/R-T	60 to 600°K	.01 to 100 atm	
208	B	T-S	16 to 600°K	6 to 160 atm	
118	Su	-	0 to 150°C	40 to 700 amagats	
85	-	T-S	14 to 300°K	0.1 to 50 atm	
83	-	T-S	15 to 300°K	0.4 to 50 atm	
<u>52. Hydrogen sulfide</u>					
203	B	H-log P	100 to 1200°F	1 to 100 atm	See note c
<u>53. Isobutane</u>					
176	B	H-P, H-S			
		T-S	100 to 460°F	0 to 5000 psia	
173	B	T-S	60 to 280°F	15 to 3000 psia	
62	Sa	-	-20 to 275°F	7 to 528 psia	
34	Sa	-	-20 to 140°F	7.5 to 127 psia	
105	-	H-P	-200 to 1200°F	1 to 150 atm	
<u>54. Isobutylene</u>					
62	Sa	-	-20 to 293°F	5.7 to 580 psia	
105	-	H-P	-200 to 1200°F	1 to 150 atm	
<u>55. Isopentane</u>					
105	-	H-P	-100 to 1200°F	1 to 150 atm	
14	Sa	-	28 to 178°C	Not given	

Note a. Data obtained by using generalized correlations

Note b. A chart of $(H-E_0)/RT_0$ vs. T is included where $T_0 = 273.16^\circ\text{K}$ Note c. The tables give the data from -76.4°F

(continued)

Table 3. Summary of Enthalpy or Entropy Data for Pure Substances
(continued)

Refer- ences (1)	Type of Table (2)	Type of Chart (3)	Temperature Range (4)	Pressure Range (5)	Comments (6)
<u>56. Isopropyl alcohol</u>					
53	Sa	-	54 to 200°C	.01 to 27.7 atm	
<u>57. Mercury</u>					
36	Sa	-	-38.8 to 500°C	2×10^{-6} to 6145 mm Hg	See note a
88,108	Sa	-	400 to 1000°F	0.4 to 180 psia	
38	Sa	H-S H-log P	100 to 700°C 200 to 700°C	10^{-4} to 50 kg/cm ² 10^{-3} to 50 kg/cm ²	
<u>58. Methane</u>					
79	-	H-log P	-100 to 475°C	.01 to 300 atm	
176	B	H-P,T-S	70 to 460°F	0 to 10,000 psia	
103	B	H-log P	-260 to 500°F	10 to 1500 psia	
31	-	T-S	-230 to 70°F	15 to 1400 psia	
97	B	-	-70 to 200°C	10 to 1000 atm	
39	Sa	-	-70 to 200°C	1 to 120 atm	
125	Sa	-	0 to 150°C	1 to 225 amagats	
42	B	H-T	110 to 290°K	0 to 150 kg/cm ²	
83	-	T-S	100 to 270°K	1 to 40 atm	
105	-	H-S H-T	-260 to 480°F -200 to 1200°F	0.5 to 60 atm 0 to 150 atm	
<u>59. Methane,bromo- (Methyl bromide)</u>					
188	B	-	-50 to 50°C	0.08 to 5 atm	
65	Sa	H-log P	-50 to 50°C	0.08 to 5 atm	
<u>60. Methane,bromotrifluoro-</u>					
148	Sa	-	-40 to 60°C	2.3 to 35 atm	See note b

Note a. Data also given in reference 146

Note b. H-log P diagram available from Eston Chemicals, Inc.

Table 3. Summary of Enthalpy or Entropy Data for Pure Substances
(continued)

Refer- ences (1)	Type of Table (2)	Type of Chart (3)	Temperature Range (4)	Pressure Range (5)	Comments (6)
<u>61. Methane, chloro- (Methyl chloride)</u>					
8,197	-	H-S	-60 to 100°C	0.2 to 11 atm	See note a
185	B	H-log P	-60 to 130°C	1.5 to 12 atm	See note a
191	B	-	-40 to 280°F	6.8 to 200 psia	
27,28	Sa	-	-40 to 260°F	7 to 300 psia	
198	Sa	T-S	-30 to 110°C	0.8 to 9 atm	
<u>62. Methane, chlorodifluoro- (Freon 22)</u>					
46	Sa	H-log P	-100 to 180°C	.02 to 20 kg/cm ²	See note b
8,197	-	H-S	-100 to 150°C	.03 to 20 atm	See note c
56	Sa	H-log P	-100 to 150°C	.03 to 20 atm	
167	Sa	H-log P	-120 to 20°C	.06 to 50 atm	
<u>63. Methane, chlorotrifluoro- (Freon 13)</u>					
2	B	H-log P	-160 to 500°F	1 to 1000 psia	
8,197	Sa	H-S	-120 to 25°C	.08 to 40 atm	
164	Sa	-	-140 to 28.8°C	.0087 to 39 atm	
165	Sa	H-log P	-120 to 25°C	.06 to 40 kg/cm ²	
<u>64. Methane, dichloro- (Methylene chloride)</u>					
185	Sa	-	-20 to 40°C	.065 to 1.02 atm	See note d
143	Sa	-	-30 to 40°C	.03 to 1.02 atm	
29	Sa	-	-10 to 140°F	0.7 to 2.7 psia	
13	-	T-S	-30 to 150°C	0 to 1.4 kg/cm ²	
<u>65. Methane, dichlorodifluoro- (Freon 12)</u>					
87	B	H-log P	-140 to 700°F	0.1 to 5000 psia	
136	-	H-log P	-80 to 100°C	.06 to 500 atm	
106	B	H-log P, H-S	-150 to 410°F	0.15 to 300 psia	

Note a. Data of reference 191 is used.

Note b. Data of reference 56 converted to metric units

Note c. Data is based on references 46 and 56

Note d. Data from Brown Boveri Company

(continued)

Table 3. Summary of Enthalpy or Entropy Data for Pure Substances
(continued)

Refer- ences (1)	Type of Table (2)	Type of Chart (3)	Temperature Range (4)	Pressure Range (5)	Comments (6)
<u>65. Methane, dichlorodifluoro- (Freon 12) (continued)</u>					
7	-	H-S	-80 to 40°C	.08 to 12 atm	
196	Sa	H-log P	-80 to 100°C	.06 to 40 atm	
149	Sa	H-log P	-40 to 56°C	0.6 to 15 atm	
20	B	-	-40 to 135°F	8 to 220 psia	
<u>66. Methane, dichlorofluoro- (Freon 21)</u>					
8,197	-	H-S	-40 to 140°C	0.1 to 8 atm	See note a
47	Sa	H-log P	-40 to 140°C	0.1 to 9 kg/cm ²	
<u>67. Methane, fluoro- (Methyl fluoride)</u>					
132	Sa	-	0 to 150°C	1 to 150 atm	
<u>68. Methane, trichlorofluoro- (Freon 11)</u>					
145	Sa	-	-40 to 50°C	.05 to 2 kg/cm ²	
136	Sa	H-log P	-40 to 150°C	.05 to 4 kg/cm ²	
	B	-	-40 to 460°F	.74 to 60 psia	
<u>69. Methanol (Methyl alcohol)</u>					
184	B	H-log P	50 to 460°F	1 to 1500 psia	
	-	T-S	30 to 460°F	1 to 900 psia	
<u>70. Methylamine</u>					
109	Sa	H-log P	-50 to 140°C	0.4 to 8 kg/cm ²	
<u>71. Methyl ether</u>					
185	B	H-log P	-40 to 80°C	0.5 to 9 atm	
48	-	H-log P	-40 to 80°C	0.5 to 9 atm	

Note a. Data of reference 47 is used

(continued)

Table 3. Summary of Enthalpy or Entropy Data for Pure Substances
(continued)

Refer- ences (1)	Type of Table (2)	Type of Chart (3)	Temperature Range (4)	Pressure Range (5)	Comments (6)
<u>72. Neon</u>					
90	-	H-log P	27 to 130°K	6 to 120 atm	
<u>73. Nitric Oxide</u>					
141	Su	H-S, T-S	-80 to 220°F	10 to 3000 psia	
<u>74. Nitrogen</u>					
70	-	T-S, H-S	78 to 300°K	1 to 50 atm	
123	-	T-S, H-log P	-125 to 150°C	0 to 6000 atm	
124	Su	-	-125 to 150°C	0 to 760 amagats	
61	B	-	100 to 5000°R	.057 to 1224 atm	See note a
22	-	T-S	-200 to 650°C	0.1 to 1200 atm	
176	B	H-P, T-S, H-S	0 to 800°F	0 to 15,000 psia	
100	-	H-T	-400 to 700°F	14.7 to 3000 psia	
	-	P-T	-320 to 1200°F	14.7 to 10,000 psia	See note b
	-	T-S	-320 to 300°F	14.7 to 3500 psia	
81	-	H-log P	-200 to 200°C	0.1 to 3000 atm	
60	-	H-log P	80 to 300°K	1 to 200 atm	
131	B	-	0 to 150°C	0 to 3000 atm	
133	B	H-log P	77 to 300°K	1 to 60 atm	
83, 84	B	T-S, H-S	-210 to 0°C	0.2 to 60 atm	
43	-	H-S	500 to 5500°R	1 to 2048 psia	See note c
<u>75. Nitrous oxide</u>					
104	-	H-log P	-120 to 200°F	15 to 700 psia	

Note a. Data given as $(H-H^0)_T$ or $S-S_P^* = 1 + R \ln P$

Note b. P-T chart contains lines of constant entropy

Note c. Data for several gases given on one plot with extrapolation factors

(continued)

Table 3. Summary of Enthalpy or Entropy Data for Pure Substances
(continued)

Refer- ences (1)	Type of Table (2)	Type of Chart (3)	Temperature Range (4)	Pressure Range (5)	Comments (6)
<u>76. n-Octane</u>					
105	-	H-P	0 to 1200°F	1 to 150 atm	
<u>77. Oxygen</u>					
82	-	H-log P	-200 to 200°C	.11 to 300 atm	
61	B	-	100 to 5000°R	.06 to 1173 atm	See note a
133	Sa	H-log P	90 to 300°K	1 to 60 atm	
43	-	T-S	500 to 5500°R	1 to 2048 psia	See note b
<u>78. Ozone</u>					
16	Su	-	200 to 350°K	1 to 10 atm	See note c
<u>79. n-Pentane</u>					
19	B	H-log P	100 to 570°F	10 to 3000 psia	
176	B	H-P, T-S	100 to 460°F	15 to 10,000 psia	
174	B	-	100 to 460°F	15 to 10,000 psia	
175	Sa	T-S	80 to 220°F	10 to 3000 psia	
92	-	P-T	0 to 900°F	0 to 500 psia	See note d
<u>80. Propane</u>					
176	B	H-S, T-S	100 to 460°F	15 to 10,000 psia	
105	-	H-S	-60 to 540°F	0.5 to 60 atm	
		H-T	-200 to 1200°F	0 to 150 atm	
25	B	T-S	100 to 460°F	15 to 10,000 psia	
51	Su	-	60 to 200°F	130 to 250 psia	See note e
186	B	H-P	-50 to 200°F	150 to 600 psia	See note f
		T-S	-50 to 200°F	15"Hg to 300 psia	

Note a. Data given as $(H-H^0)_T$ or $S-S_P^* = 1 + R \ln P$

Note b. Data for several gases given on one plot with extrapolation factors

Note c. Enthalpy data given as $(H-H_0)/T$

Note d. Chart contains lines of constant enthalpy

Note e. This is a correction to the data of reference 186

Note f. Data in tables are given from -80°F

(continued)

Table 3. Summary of Enthalpy or Entropy Data for Pure Substances
(continued)

Refer- ences (1)	Type of Table (2)	Type of Chart (3)	Temperature Range (4)	Pressure Range (5)	Comments (6)
<u>80. Propane (continued)</u>					
155	Sa	T-S	-90 to 160°C	0.1 to 200 atm	See note a
21	Sa	T-S	-50 to 200°C	1 to 200 atm	
177	B	T-S	60 to 220°F	25 to 3000 psia	
34	Sa	-	-75 to 125°F	6.4 to 254 psia	
<u>81. Propane, dichlorohexafluoro-</u>					
150	Sa	-	-20 to 40°C	.09 to 1.24 kg/cm ²	See note b
<u>82. Propene (Propylene)</u>					
128	Su	-	25 to 150°C	1 to 2800 atm	
127	Su	-	25 to 150°C	6 to 340 amagats	
23	B	H-log P	-50 to 480°F	1 to 200 atm	
105	-	H-S	-60 to 560°F	0.5 to 60 atm	
		H-T	-200 to 1200°F	1 to 50 atm	
<u>83. Propionic acid, ethyl ester</u>					
44	Sa	T-S	0 to 273°C	Not given	See note c
<u>84. n-Propyl alcohol</u>					
44	Sa	T-S	40 to 263.7°C	Not given	See note c
<u>85. Sodium</u>					
69	B	T-S	500 to 5000°R	.006 to 103 atm	See note d
192	Sa	-	25 to 1125°C	9x10 ⁻⁸ to 4604 mm Hg	See note e

Note a. This reference added to the data of reference 21

Note b. This data is a digest of a chapter of reference 10

Note c. Chart contains a saturation line for entropy only

Note d. Ideal gas laws assumed

Note e. Only enthalpy data given

(continued)

Table 3. Summary of Enthalpy or Entropy Data for Pure Substances
(continued)

Refer- ences (1)	Type of Table (2)	Type of Chart (3)	Temperature Range (4)	Pressure Range (5)	Comments (6)
<u>86. Sulfur</u>					
204	-	H-log P	500 to 1040°C	1 to 10 atm	See note a
<u>87. Sulfur dioxide</u>					
205	-	H-log P	-100 to 2000°F	10 to 1000 psia	See note b
170	B	H-log P	20 to 500°F	10 to 1000 psia	
181	B	H-log P	-50 to 150°C	0.1 to 10 atm	
162	B	H-log P	-50 to 150°C	0.1 to 5 kg/cm ²	
<u>88. Toluene</u>					
105	-	H-P	0 to 1200°F	1 to 150 atm	
137	-	T-S	110 to 320°C	1 to 40 atm	
<u>89. Uranium hexafluoride</u>					
63	-	T-S	-5 to 375°C	.001 to 100 atm	
<u>90. Water</u>					
159	B	-	32 to 1600°F	5500 to 10,000 psia	See note c
37	Sa	H-S	0 to 800°C	.006 to 500 Bars	See note d
41	-	H-V	32 to 1280°F	0.2"Hg to 5000 psia	See note c
96	Su	H-T	800 to 1700°F	1000 to 21,000 psia	See note e
209	B	H-log P	0 to 700°C	.006 to 300 kg/cm ²	
77	B	H-S,T-S	32 to 1600°F	.08 to 5500 psia	

Note a. Ideal gas laws assumed for S₂, S₆ and S₈ at equilibrium

Note b. See also reference 4, Document number 2708

Note c. This data is an extension of reference 77

Note d. Units are given as kilojoules/kilogram

Note e. Only enthalpy data given; gives 32 references

(continued)

Table 3. Summary of Enthalpy or Entropy Data for Pure Substances
(continued)

Refer- ences (1)	Type of Table (2)	Type of Chart (3)	Temperature Range (4)	Pressure Range (5)	Comments (6)
<u>90. Water (continued)</u>					
102	-	H-S	32 to 115°F	0.2 to 3.0"Hg	
147	-	H-S	400 to 2800°C	1 to 200 atm	
<u>91. Xenon</u>					
130	Su	-	0 to 150°C	1 to 2800 atm	

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APPENDIX

Table 4. List of Sourcebooks to Thermodynamic Data

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