CODING FORMS FOR SRC INDEXING

Microfiche No.	
OTS0001044	

New Doc ID	Old Doc ID
FYI-OTS-0794-1044	84940000144

Date Produced	Date Received	TSCA Section
01/17/84	07/26/94	FYI

Submitting Organization
E I DUPONT DE NEMOURS & CO

Contractor

Document Title
INITIAL SUBMISSION: LETTER FROM DUPONT CHEM TO USEPA RESPONDING TO AN ITC 5TH SCORING EXERCISE FOR BROMOTRIFLUOROMETHANE WITH ATTACHMENTS, DATED 1/17/84

Chemical Category
BROMOTRIFLUOROMETHANE

FORM LO-4878

FYI-0794-001044 Perry

#012484(3)

E. I. DU PONT DE NEMOURS & COMPANY
INCORPORATED
WILMINGTON, DELAWARE 19898

LEGAL DEPARTMENT

FYI-94-001044
INIT 07/26/94

January 17, 1984

Mr. Martin Greif
Executive Secretary
TSCA Interagency Testing Committee
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, DC 20460

Contains No CBI

04940000144

Dear Mr. Greif:

IR-401

Du Pont Comments
ITC 5th Scoring Exercise
48 FR 51519 (1983)

On behalf of E. I. du Pont de Nemours and Company (Du Pont), I am pleased to submit comments on the ITC 5th Scoring Exercise for the chemical substance: bromotrifluoromethane (CAS 75-63-8). In addition, Du Pont notes that it ceased manufacture of the following chemicals by 1980:

IR-417 N,N-Dimethylcyclohexylamine (CAS 98-94-2)
IR-420A 1,1'-Methylenebis(4-isocyanotobenzene) (CAS 101-68-8)
IR-423 2,6-Di-tert-butylphenol (CAS 128-39-2)
IR-407 1,8-Dihydroxy-4,5-dinitroanthraquinone (CAS 81-55-0)
IR-408 Anthraquinone (CAS 84-65-1)
IR-428 Anthraquinone, 1-amino-2-bromo-4-hydroxy (CAS 116-82-5)

Does not produce

Finally, Du Pont will submit additional comments on several other chemical candidates selected by the ITC. See K. D. Dastur to M. Greif, 1/13/84 (attached).

Should the Committee have questions or desire further assistance with this Du Pont submission, please contact me at 302-774-6443.

Very truly yours,

Mark H. Christman

MHC:mdm
Attachments

RECEIVED
OPPT CBIC
94 JUL 26 PM 3:45

BROMOTRIFLUOROMETHANE

IR-401

(CAS No. 75-63-8)

INITIAL DISCUSSION

The Du Pont Company provides the enclosed information and comments concerning the listing of bromotrifluoromethane in the 1983 List of Chemicals Selected for Review by the TSCA Interagency Testing Committee. Du Pont has been a producer of bromotrifluoromethane since the early 1940's and has been a leader in developing the toxicological and technical data upon which current uses of the compound are based.

Du Pont recommends that bromotrifluoromethane be deleted from the 1983 List of Chemicals Selected for Review. The basis for our recommendation is that the compound exhibits an extremely low order of toxicity, that occupational exposure is infrequent and is limited to a small number of people and that occupational exposures, other than in fire extinguishant use, are low compared with accepted long-term exposure standards such as the TLV.

Although concentrations exceeding the TLV are encountered in fire extinguishant use, exposure is, in such cases, for a short period of time while the fire is extinguished and occupants are evacuated. The exposure levels are, as a result of system engineering design, kept at or below levels recommended by the National Fire Protection Association for short-term exposure. Fire extinguishant releases expose a very small number of people annually to bromotrifluoromethane who would otherwise be at a much more severe risk from the fire or from the need to evacuate during the fire episode before alternative vapor systems (such as carbon dioxide) could be actuated. Consideration of a few uses (See Applications section in Attachment 3) immediately indicates that the life and property protection value of such systems is very large.

To support our recommendation we have provided information in the Technical Data section on the seven topics listed in the subject Federal Register Notice, based on our estimates of the total use of bromotrifluoromethane in the U.S. We believe such information is of greater value to the Committee than limiting our comments to Du Pont's sales of bromotrifluoromethane, which would require us to designate these comments as "Confidential Business Information." We would be pleased to provide ITC with any further information, descriptions, or references that the Committee may need and which are available to us.

Virtually all bromotrifluoromethane utilized in the U.S. is used for fire extinguishing purposes in enclosed, occupied areas and/or where high value equipment is installed. Carefully engineered total flooding systems permit automatic release of the agent as soon as a fire is detected. The extreme efficiency of this compound as a fire extinguishant, combined with its extremely low toxicity, permits rapid fire extinguishing action (ten seconds or less) without mandatory evacuation of occupants prior to extinguishant release. Maximum protection of the occupants from fire and minimal property damage is achieved simultaneously by use of this unique compound. Bromotrifluoromethane is also used to a much lesser extent in portable fire extinguishers.

When utilized as a fire extinguishant, exposure concentrations of 7 percent for up to 15 minutes have been shown to be safe, permitting the fire to be extinguished immediately and a subsequent orderly evacuation of the area. If personnel cannot be evacuated prior to agent discharge, the prompt extinguishment of the fire insures that people are evacuated in the absence of smoke and other toxic combustion products.

A small amount (one percent or less of total U.S. use) of bromotrifluoromethane is used as a special refrigerant, for example, in reciprocating units designed to produce medium-low temperatures ranging down to -70°F or lower with one or two stages of compression.

Except when released as a fire extinguishant, emissions are carefully minimized and exposure concentrations are typically well below the 1000 ppm TLV for 8-hour/day, 40-hour/week exposure. The very limited use of bromotrifluoromethane as a refrigerant insures that a minimal number of workers are exposed.

TECHNICAL DATA SECTION AND ATTACHMENTS - CONTENTS

Part I Synonyms and Trademark Information for Bromotrifluoromethane.

Part II Information Categories Requested in 48 Federal Register 51519.

1. Technical Bulletins

   1.1 Bromotrifluoromethane Fire Extinguishant

   1.2 Bromotrifluoromethane Refrigerant

2. Material Safety Data Sheets

3. Current Annual Production Data and Trends

4. Numbers of Workers Exposed, Concentrations, Controls, Use of Open Versus Closed Systems, Etc.

5. Use Data

6. Environmental Impact Data

7. Toxicological Data

Attachments

1. Bulletin NFPA 12A: "Halon 1301 Fire Extinguishing Systems"

2. Bulletin G-1: "Freon® Fluorocarbons, Properties and Applications"

3. Bulletin B-29E "Du Pont Halon 1301 Fire Extinguishant" (Technical Bulletin)

4. Bulletin E-43977 "Du Pont Halon 1301 Fire Extinguishant"

5. Bulletin T-13B1 "Thermodynamic Properties of Freon® 13B1 Refrigerant"

6. MSDS - Halon 1301 Fire Extinguishant

7. MSDS - Freon® 13B1 Refrigerant

8. "TLVs® Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment...." American Conference of Governmental Industrial Hygienists (1983-84).

9. "Haskell Laboratory Toxicity Review: Halon 1301."

PART I

SYNONYMS AND TRADEMARK INFORMATION FOR BROMOTRIFLUOROMETHANE

Bromotrifluoromethane ($CBrF_3$), when utilized as a fire extinguishant is named HALON 1301. The name Halon is not a trademark and does not indicate the producer. Bromotrifluoromethane, when utilized as a refrigerant is known as refrigerant 13B1 (or R-13B1). The refrigerant is generally sold under the producer's trademark, e.g., Du Pont sells Freon® 13b1 refrigerant.

Freon® 13B1 refrigerant is not, therefore, a generic synonym for bromotrifluoromethane.

Additionally, the compound may generically be referred to as fluorocarbon 13B1 (FC-13B1 or F-13B1).

PART II

INFORMATION CATEGORIES REQUESTED IN 48 FEDERAL REGISTER 51519

1. Technical Bulletins

1.1 Bromotrifluoromethane Fire Extinguishant (Halon 1301)

NFPA 12A: Halon 1301 Fire Extinguishing Systems

This booklet, prepared by the Technical Committee on Halogenated Fire Extinguishing Systems of the National Fire Protection Association, Inc., defines standards for the design, installation, maintenance, and operation of Halon 1301 fire

extinguishing systems. It is the basis on which such systems are designed and operated in the U.S. (Attachment 1).

G-1: Freon® Fluorocarbons, Properties and Applications

This is a general bulletin on the Freon® fluorocarbons including bromotrifluoromethane. The bulletin discusses safety, physical and chemical properties, applications, and other information (Attachment 2).

B-29E: Du Pont Halon 1301 Fire Extinguishant (Technical Bulletin)

This bulletin presents technical details on applications, mode of fire extinguishing action, toxicological properties, safety, and container information (Attachment 3).

E-43977: Du Pont Halon 1301 Fire Extinguishant

The bulletin discusses the chemical mechanism by which Halon 1301 extinguishes fires, as well as its safety, effectiveness, toxicology, and system design factors. This bulletin is similar in coverage to Bulletin 29-E (above) but less technical (Attachment 4).

1.2 Bromotrifluoromethane Refrigerant (Refrigerant 13B1)

G-1: Freon® Fluorocarbons, Properties and Applications

(See paragraph 1.1 under fire extinguishant use).

T-13B1: Thermodynamic Properties of Freon® 13B1 Refrigerant

The bulletin provides detailed thermodynamic data and physical properties for the design of refrigeration equipment utilizing Freon® 13B1 (Attachment 5).

2. Material Safety Data Sheets

Two MSDS are provided: Attachment 6 is the MSDS for Halon 1301 Fire Extinguishant, Attachment 7 is the MSDS for Freon® 13B1 refrigerant. The contents of the two MSDS are essentially identical.

3. Current Annual Production Data and Trends

For the reasons given in the initial discussion, we have provided Du Pont's estimates of total bromotrifluoromethane use in the U.S. rather than specific Du Pont sales figures for bromotrifluoromethane.

There are two companies producing bromotrifluoromethane in the U.S.: Du Pont and Great Lakes Chemical Corporation. Additionally, material is imported into the U.S. from Japan, Germany, and France. We expect Korea and the U.K. to start importing in 1984. The current total market in the U.S. is about 7 million pounds annually, and is growing annually at an average rate of about 9 percent. This includes material for both fire extinguishant and refrigerant use (See Section 5 for use distribution).

4. Number of Workers Exposed, Concentrations, Controls, Use of Open Versus Closed Systems, Etc.

4.1 Fire Extinguishant - Production, Shipment, and Storage

Bromotrifluoromethane is manufactured in a closed system, shipped in compressed gas cylinders, and sold in high pressure storage containers. Product transfers and handling operations are carefully controlled to minimize losses. Since even a small leak would ultimately empty a cylinder or render a fire protection system inoperative, maintenance programs are designed to keep leaks to an absolute minimum.

Due to the high cost of Halon 1301 ($6 to $10 per pound for the end-user), a strong economic incentive exists to prevent leakage, apart from the maintenance of effective fire protection.

4.2 Fire Extinguishant - End Use (discharge)

We estimate about 700,000 pounds per year are discharged in the U.S. This is for all purposes - accidental discharges, tests, and actual fire extinguishments. The number of individuals exposed during these discharges is estimated to be less than 100.

Salesmen demonstrating the product (100 to 200 salespeople) may discharge Halon 1301 to produce a 5 percent concentration into a manned demonstration "booth" to demonstrate the rapid fire extinguishing properties and the safety of bromotrifluoromethane. The number of times per year per salesperson is impossible to estimate with confidence. Based on our experience we would guess 4 to 6 exposures per salesman per year.

4.3 Refrigerant Use

Production, shipment, and storage are essentially identical to the use as Halon 1301 Fire Extinguishant (See section 4.1 above). The quantities used as a refrigerant are small (See section 5).

FC-13B1 refrigerant is used in sealed equipment designed for use with the specific refrigerant. Equipment operation is entirely dependent on maintaining the refrigerant charge in a sealed system. Venting of refrigerant during maintenance is infrequent and is kept to a practical minimum and field service procedures require any venting to be to the outside.

4.4 Open Versus Closed Systems

Due to the low boiling point of FC-13B1 (-72°F), all uses of FC-13B1 (Halon 1301) are in closed systems.

4.5 Concentrations

With the exception of actual fire events or accidental release of Halon 1301 into occupied spaces, or for demonstration of the safety and effectiveness of Halon 1301, worker exposures are typically very low, ~ 1 below the ACGIH Threshold Limit Value of 1000 ppm (6100 mg/m^3). In Attachment 8, page 33, FC-13B1 (Halon 1301) is listed as "trifluorobromomethane".

Fire extinguishant uses can result in brief exposures (less than 15 minutes) to concentrations in the range 5-7 percent. Tests on human volunteers have indicated such exposures are safe and can produce, in the most susceptible subjects, effects indicating the onset of mild anesthesia. The effects are sufficiently minor that subjects remain fully capable of exiting the fire location in an orderly and safe fashion without assistance. All the minor effects are transient and disappear rapidly and within about an hour. The chemical is rapidly eliminated from the body in expired air.

5. Use Data

5.1 Use Breakdown

Use Breakdown	U.S. Use, Lb/Yr*	Percent of Total
Refrigerant	< 100,000	~ 1
Fire Extinguishant	7,000,000	99
Total	7,100,000	100

*Du Pont Company estimates.

5.2 Use Descriptions

FC-13B1 is used as a low temperature refrigerant. This use is extremely small (less than 100,000 lbs).

A small proportion of Halon 1301 is used for portable fire extinguishers, most of which are used in military applications.

The balance is used in fixed extinguishing systems (total flooding systems) to protect high value areas, critical equipment or irreplaceable objects where other extinguishants cannot be used. Examples are computer rooms, U.S. Navy ships, F-14 fighter plane fuel tanks, museums, and telephone exchanges (See Attachment 3 for more detail).

Since the product extinguishes fire so quickly (less than 10 seconds) and is "people-compatible" at fire extinguishing concentrations, it can be used in areas where other extinguishants (e.g., CO_2) would be fatal or could potentially cause as much damage (e.g., water) as the fire itself.

6. Environmental Impact Data

6.1 Waste Control

For economic reasons (for the end-user, bromotrifluoromethane costs $6 - $10 per pound) wastage is carefully minimized during manufacture, shipment, storage, and use as a refrigerant. Use as a fire extinguishant involves discharge to the fire location, followed by venting of the extinguishant and any combustion products.

6.2 Pollution Potential and Ecotoxicity

Ambient concentrations of bromotrifluoromethane are extremely low ($\sim 1 \times 10^{-12}$ or 1 part per trillion*) and many orders of magnitude below levels at which adverse health effects are found. The inertness of bromotrifluoromethane results in no significant degradation in the troposphere and thus the compound is of negligible photochemical reactivity. Due to the compound's low solubility in water (300 mg/l at 25°C and 1 atm. vapor pressure, corresponding to an equilibrium water concentration of 0.3 pg/l at a 1 ppt atmospheric concentration), no significant removal in rainfall occurs. No significant tropospheric removal processes for the compound are known. For instance, by analogy with compounds of similar chemical inertness, the reaction rate with hydroxyl radical (the primary tropospheric scavenging reaction for such compounds) is estimated to be $<1 \times 10^{-16}$ cm^3 $molecule^{-1}s^{-1}$, suggesting a tropospheric half life >75 years.

6.3 Fraction Released to the Environment and Route of Environmental Entry

There are no significant destruction processes for bromotrifluoromethane in its use and thus essentially all material is eventually released. Most releases occur as fire extinguishant releases. The material may be stored for many years before release, and release rates are currently much less than production rates for this reason. Due to the low boiling point (-72°F) and high vapor pressure, all releases to the environment occur as vapor releases to the atmosphere. The gas is essentially insoluble in water and does not contaminate rainfall.

---

*Reference: Table 1-2 in "The Stratosphere 1981: Theory and Measurements". World Meteorological Organization/National Aeronautics and Space Administration, January 1982.

6.4 Environmental Reactions

The only known removal process for bromotrifluoromethane is photochemical degradation in the stratosphere. Although stratospheric bromine is expected, on the basis of computer calculations, to enter into reactions with stratospheric ozone, the amount of bromine involved and its effect on stratospheric ozone are insignificant opposite the various calculated effects from chlorine, nitrogen oxides, nitrous oxide, carbon dioxide, and methane.*

7. Toxicological Data

Bromotrifluoromethane is an inert, nonflammable gas of extremely low toxicity. The LC_{50} for rats, 4-hour exposure, is approximately 800,000 ppm. The National Fire Protection Association recommends that human exposure to the compound, when used as a fire extinguishant, should be limited to 15 percent (150,000 ppm) and exposure times be controlled as shown (data from Attachment 1, page 12A-50).

7% or less	(70,000 ppm)**	15 minutes
7-10%	(70,000-100,000 ppm)	1 minute
10-15%	(100,000-150,000 ppm)	30 seconds

No evidence of carcinogenic, mutagenic or teratogenic potential for bromotrifluoromethane has been found in tests.

---

*For instance, see "Protection Against Depletion of Stratospheric Ozone by Chlorofluorocarbons" pp. 195-6. Committee on Alternatives for the Reduction of Chlorofluorocarbon Emissions, NAS, Washington, D.C., 1979. Calculations of future ozone depletion have been substantially reduced since 1979.

**Normal design criteria for total flooding systems to extinguish most combustible materials - See Attachments 3 and 4).

The published and unpublished toxicological literature on bromotrifluoromethane has been reviewed and listed in our "Haskell Laboratory Toxicity Review: Halon 1301" (Attachment 9) which contains 55 references. We can provide copies of any available reference needed by the Toxic Substances Control Act Interagency Testing Committee upon request.

FREON PRODUCT INFORMATION

G-1

"FREON" FLUOROCARBONS
Properties and Applications

Attachment 2

TABLE OF CONTENTS

I. Table of "Freon" Compounds 2

II. Safety 2

A. Flammability
B. Toxicity
i. Relative Toxicity and the TLV
ii. Dermal
iii. Oral
iv. CNS Effects
v. Cardiac Sensitization
C. Thermal Decomposition
D. Major Spills and Vapor Releases

III. Physical and Chemical Properties 4

A. Physical Properties*
B. Chemical Properties
i. Thermal Stability
ii. Reactions with Other Materials
a. Air
b. Water (Hydrolysis)
c. Lubricating Oils (Hydrocarbons)
d. Metals
e. Plastics
f. Elastomers
C. Solubility Properties

IV. Applications 8

V. Pressure Temperature Relationships 10

VI. Miscellaneous 11

VII. References 11

*see also Table VII, p. 9

U.S. Pat. Off. for Du Pont's fluorocarbon products.

DUPONT REGISTERED

Better things for better living...through chemistry

I. TABLE OF "FREON" COMPOUNDS

TABLE I

Product	C/D*	Formula	Molecular Weight	Boiling Point °F	Boiling Point °C
"Freon" 14	D	CF_4	88.0	−198.3	−127.9
"Freon" 23	D	CHF_3	70.0	−115.7	−82.1
"Freon" 13	C	$CClF_3$	104.5	−114.6	−81.4
"Freon" 116	D	CF_3-CF_3	138.0	−108.8	−78.2
"Freon" 13B1(1)	C	$CBrF_3$	148.9	−72.0	−57.8
"Freon" 22	C	$CHClF_2$	86.5	−41.4	−40.8
"Freon" 115	C	$CClF_2$-CF_3	154.5	−37.7	−38.7
"Freon" 12	C	CCl_2F_2	120.9	−21.6	−29.8
"Freon" 114	C	$CClF_2$-$CClF_2$	170.9	38.8	3.8
"Freon" 21	D	$CHCl_2F$	102.9	48.1	8.9
"Freon" 11(2)	C	CCl_3F	137.4	74.9	23.8
"Freon" 113(3)	C	CCl_2F-$CClF_2$	187.4	117.6	47.6

*C—Fully Commercial Products
D—Developmental Compound

(1) HALON 1301
(2) "FREON" MF Solvent
(3) "FREON" TF Solvent

The "Freon" products are organic compounds containing one or more carbon atoms and fluorine. Chlorine, bromine and hydrogen atoms also may be present. Their principal characteristics include nonflammability, low toxicity, excellent thermal and chemical stability, high density coupled with low boiling point, low viscosity and low surface tension. A brief discussion of their properties and applications is given on the following pages. Further information on specific subjects is available from the "Freon" Products Division.

II. SAFETY

Although the "Freon" compounds have relatively low toxicities compared with most chemicals, users should be familiar with Section II.

A. Flammability

None of the "Freon" compounds is flammable or explosive. However, mixtures with flammable liquids or gases may be flammable and should be handled with caution.

B. Toxicity

Potential hazards of fluorocarbons are summarized in Table II. Specific hazards are discussed below.

i. Relative Toxicity and the Threshold Limit Value

A Threshold Limit Value (TLV) has been established by the American Conference of Governmental Industrial Hygienists (ACGIH) for a number of compounds in common use. These values are "airborne concentrations of substances (representing) conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse effect . . . TLV's refer to time-weighted concentrations for a 7- or 8-hour work day and 40-hour work week". Based on both experiment and experience, TLV's provide a quantitative assessment of the relative toxicity of compounds. The TLV is customarily expressed in parts per million by volume, abbreviated ppm.

With the exceptions of "simple asphyxiants" (such as nitrogen) and also carbon dioxide (TLV 5000 ppm, a unique compound since it is a normal product of respiration), the range of TLV's extends from 0.001 ppm (most toxic) to 1000 ppm (least toxic). Where TLV's have been assigned to individual "Freon" fluorocarbons, all are 1000 ppm. (See Table VIII on page 9).

Exposure to chemicals should be minimized and should not exceed the TLV. Since the TLV is a time-weighted concentration, some provision is made for temporary excursions above the TLV. Details of the TLV, permissible excursions and the TLV for mixtures of compounds are more fully explained in Reference 9.

ii. Dermal Effects (Skin Contact) Including Eye Contact

Liquid fluorocarbons with boiling points below 0°C (32°F) may freeze the skin on contact causing frost-bite. Suitable protective gloves

TABLE II Potential Hazards of Fluorocarbons		
Condition	**Potential Hazard**	**Safeguard**
Vapors may decompose in flames or in contact with hot surfaces.	Inhalation of toxic decomposition products.	Good ventilation. Irritant decomposition products serve as warning agents.
Vapors are 4 to 5 times heavier than air. High concentrations may tend to accumulate in low places.	Inhalation of concentrated vapors can be fatal.	Avoid misuse. Forced-air ventilation at the level of vapor. Use breathing devices with air supply.
Deliberate inhalation to produce intoxication.	Can be fatal.	Use lifelines when entering tanks or other confined areas. Do not administer epinephrine or other similar drugs.
Some fluorocarbon liquids tend to remove natural oils from the skin.	Irritation of skin.	Use gloves and protective clothing.
Lower boiling liquids may be splashed on skin.	Freezing.	Use gloves and protective clothing.
Liquids may be splashed into eyes.	Lower boiling liquids may cause freezing. Higher boiling liquids may cause temporary irritation and if other chemicals are dissolved, may cause serious damage.	Wear eye protection. Get medical attention. Flush eyes for several minutes with running water.
Contact with highly reactive metals.	Violent explosion may occur.	Test the proposed system and take appropriate safety precautions.

and clothing give insulation protection. Eye protection should be used. In the event of frost-bite, warm the affected area quickly to body temperature. Eyes should be flushed with water copiously. Hands may be held under armpits or immersed in warm water. Get medical attention promptly.

Fluorocarbons with boiling points at or above ambient temperature tend to dissolve protective fat from the skin, leading to skin dryness and irritation, particularly after prolonged or repeated contact. Such contact should be avoided by using rubber or plastic gloves. Eye protection and face shields should be used if splashing is possible. If irritation occurs following accidental contact, seek medical attention.

iii. **Oral Toxicity**

Fluorocarbons have low oral toxicity as judged by single dose administration or repeated dosing over long periods of time. When "Freon" 11 and 114 were fed to rats and dogs for 90 days, there were no adverse effects relative to nutritional, biochemical, hematological, urineanalytical, or histopathological indices, even at the highest dose levels tested. A two-year feeding study on "Freon" 12 resulted in similar findings. In addition, there were no adverse effects of "Freon" 12 on mutagenic, teratogenic, or three-generation reproductive indices.

However, direct contact of liquid fluorocarbons with lung tissue (aspiration) can result in chemical pneumonitis, pulmonary edema, and hemorrhage. "Freon" 11 (B.P. 23.8°C) and 113 (B.P. 47.6°C), like many petroleum distillates, are fat solvents and can produce such an effect. If products containing these fluorocarbons were accidentally or purposely ingested, induction of vomiting would be contraindicated.

iv. **Central Nervous System (CNS) Effects**

Inhalation of concentrated vapors of the fluorocarbons can lead to CNS effects comparable with the effects of general anesthesia. Symptoms, as the extent of exposure increases, are initially a feeling of intoxication, followed by loss of coordination and unconsciousness. Under severe conditions, death can result. If these symptoms are felt, the exposed individual should immediately go or be moved to fresh air. Medical attention should be sought promptly. See also II.b.v.—Cardiac Sensitization (below). Individuals exposed to fluorocarbons must not be treated with adrenalin (epinephrine).

v. **Cardiac Sensitization**

In common with a number of volatile, water-insoluble organic liquids, fluorocarbons can, in sufficient vapor concentration, produce cardiac sensitization. Cardiac sensitization is a sensitization of the heart to adrenaline brought about by exposure to high concentrations of organic vapors. Under conditions of sufficiently severe exposure, cardiac arrhythmias may result from sensitization of the heart to the body's own levels of adrenaline, particularly under conditions of emotional or

physical stress, fright, panic, etc. (Reference 10) Such cardiac arrhythmias may result in ventricular fibrillation and death. As indicated in II.b.iv. above, exposed individuals should go or be removed to fresh air promptly (where the hazard of cardiac effects will rapidly decrease). Prompt medical examination and observation should be provided following accidental exposures. A worker adversely affected by fluorocarbon vapors should *not* be treated with adrenalin (epinephrine) or similar heart stimulants since these would increase the risk of cardiac arrhythmias.

C. Thermal Decomposition Products

Fluorocarbons decompose when exposed directly to high temperatures. Flames and electrical resistance heaters, for example, will cause pyrolysis of fluorocarbon vapors. Products of this decomposition in air include halogens and halogen acids (hydrochloric, hydrofluoric and hydrobromic), as well as other irritating compounds. Although much more toxic than the parent fluorocarbon, these decomposition products tend to irritate the nose, eyes and upper respiratory system, thereby providing a warning of their presence. The practical hazard is relatively slight since it is difficult for a person to remain voluntarily in the presence of decomposition products at concentrations where physiological damage occurs.

When such irritating decomposition products are detected, the area should be evacuated, ventilated, and the source of the problem corrected.

Such thermal decomposition products can be formed when vapors are drawn through lighted tobacco. Smoking should not be permitted in the presence of fluorocarbon vapors.

D. Major Spills and Vapor Releases

Although the toxicity of fluorocarbons is low, the possibility of serious injury or death exists under unusual or uncontrolled exposures or in deliberate abuse by inhalation of concentrated vapors. Since fluorocarbon vapors are more dense than air, high concentrations may form in low-lying areas and persist under poorly ventilated or still air conditions. Personnel should be immediately evacuated from enclosed areas in the event of a large spill or leak, and not return until the contaminated area has been well ventilated. For "Freon" 12, the Threshold Limit Value (TLV) corresponds to approximately one-third of a pound of "Freon" 12 vapor per 1000 cu. ft. of air (about 5 grams/cubic meter).

Emergency access to areas containing high concentrations of fluorocarbons (e.g., into a vapor-filled storage tank) requires the use of self-contained breathing apparatus and experienced supervision.

III. PHYSICAL AND CHEMICAL PROPERTIES

A. Physical Properties

The unusual combination of physical properties found in the "Freon" compounds is the basis for their application and usefulness. Uses and a summary of physical properties are given in Tables VII and VIII (pages 8 & 9). Typically, the compounds have high molecular weight in relation to the boiling point, low viscosity, low surface tension, and low latent heats of freezing and vaporization. Low conductivity and good dielectric properties are also found. Additional details on thermodynamic properties of individual "Freon" compounds are available on request.

B. Chemical Properties

i. Thermal Stability

The hazards from the thermal decomposition of fluorocarbons are discussed in Section II.C, page 4.

The "Freon" fluorocarbons will not decompose by the application of heat alone except at very high temperatures. Table III lists the temperatures to which various compounds were heated to obtain measureable decomposition rates. Shown also are the temperatures at which decomposition rates are calculated to be 1% per year. The latter can be considered to be the temperature limits imposed by the inherent stability of the molecules.

TABLE III
Fluorocarbon Decomposition Temperatures

Fluorocarbon	Decomposition Temperature*	
	Lab Test**	1%/year†
"Freon" 11	590°C (1100°F)	>300°C (>570°F)
"Freon" 12	760°C (1400°F)	>480°C (>900°F)
"Freon" 13	840°C (1550°F)	>535°C (>1000°F)
"Freon" 22	425°C (800°F)	250°C (480°F)
"Freon" 114	590°C (1100°F)	375°C (710°F)
"Freon" 115	625°C (1160°F)	390°C (740°F)

*For the pure compound (in the absence of air)

**The decomposition rate at this temperature is of the order of 1%/minute. Tests were run in platinum tubes and, except for "Freon" 11, represent homogeneous decomposition rates (no wall effect).

†These temperatures were computed by extrapolating the high temperature rate data.

ii. Reactions with Other Materials

When fluorocarbons are heated to high temperatures in contact with other materials (such as

air, moisture, metallic and plastic construction materials, lubricating oils, etc.), chemical reactions may occur between the fluorocarbon and the other material. These proceed at temperatures lower than the values shown in Table III. Also, the products of reaction are different. The temperatures at which significant reaction occurs and the reaction products will be different for each material; therefore, no simple generalization can be made regarding the stability of "Freon" fluorocarbons in combination with other materials. Some important specific cases are considered below.

a. Air

No evidence for interaction of fluorocarbons with air has been found in the wide variety of uses that fluorocarbons have been put to in the past several decades. The only exception is exposure of fluorocarbon-air mixtures to extreme temperatures such as flames (where temperatures are upwards from 1650°C [3000°F]) or electric resistance heaters (where temperatures will be over 700°C [1300°F] if the wire is red hot). The reactions that occur here were discussed in Section II.C.

b. Water (Hydrolysis)

The perhalogenated "Freon" compounds do not hydrolyze in the normal sense to carbonic acid derivatives. Rates of hydrolysis in pure water are too low to be measurable, being less than 0.1 grams/liter of water/year at 25°C (77°F). The presence of oxidizable materials can enhance the apparent hydrolysis.

Hydrogen-containing "Freon" 21, "Freon" 22 and "Freon" 23 hydrolyze at rates proportional to the concentration in solution and the hydroxyl ion concentration. Table IV gives the measured hydrolysis rates in sodium hydroxide solution and extrapolated values in pure water.

c. Lubricating Oils (Hydrocarbons)

The stability of "Freon" fluorocarbons with lubricating oils has been amply demonstrated by their successful use for many years in refrigeration systems. In small hermetic systems where "Freon" 12, "Freon" 22, and "Freon" 502* are used, oil-fluorocarbon mixtures are exposed to electric motors operating as high as 107°C (225°F). At the discharge valve of the compressor, mixtures of fluorocarbon gas and oil mist may be at temperatures of 177°C (350°F) and higher, but the exposure time is brief. Table V lists the suggested maximum temperatures for continuous exposure of various "Freon" fluorocarbons in contact with oil and metals.

If the stability limits are exceeded, a chemical reaction occurs between the refrigerant and the oil. For some fluorocarbons, such as "Freon" 12 and 22, the reaction is believed to involve the interchange of a chlorine atom from the fluorocarbon with a hydrogen atom from the oil. The resulting chlorinated oil may break down to hydrochloric acid and unsaturated oil which, in turn, may polymerize to a degraded oil and ultimately a sludge.

*Azeotropic mixture of "Freon" 22 and "Freon" 115.

TABLE IV
Hydrolysis Rate in Grams/Liter of Water/Hour
Saturated Conditions at 25°C (77°F)

Compound	in Water Only	in 10% Sodium Hydroxide Solution
"Freon" 21	1.92×10^{-8}	4.3×10^{-3}
"Freon" 22	1.40×10^{-6}	2.2×10^{-1}
"Freon" 23	3×10^{-10}	1.6×10^{-4}

TABLE V
Thermal Stabilities of "Freon" Compounds

Compound	Formula	Maximum Temperature for Continuous Exposure in the Presence of Oil, Steel and Copper, °C (°F)	Decomposition Rate at 204°C (400°F) in Steel, Percent/Year (a)
"Freon" 11	CCl_3F	107 (225)	2
"Freon" 113	$CCl_2F\text{-}CClF_2$	107 (225)	6
"Freon" 12	CCl_2F_2	121 (250)	<1
"Freon" 114	$CClF_2\text{-}CClF_2$	121 (250)	1
"Freon" 22	$CHClF_2$	149 (300)	(b)
"Freon" 13	$CClF_3$	>149 (>300)	(b)

(a) no oil present
(b) not measured

d. Metals

Most of the commonly-used construction metals—such as steel, cast iron, brass, copper, tin, lead, aluminum—can be used satisfactorily with the "Freon" compounds under normal conditions of use. At high temperatures, some of the metals may act as catalysts for the breakdown of the compound. The tendency of metals to promote thermal decomposition of the "Freon" compounds is in the following general order:

Least decomposition: Inconel <18-8 stainless steel <nickel <1340 steel <aluminum <copper <bronze <brass <silver: Most decomposition

This order is only approximate and exceptions may be found for individual "Freon" compounds or for special conditions of use.

Magnesium alloys and aluminum containing more than 2 percent magnesium are not recommended for use in systems containing "Freon" compounds where water may be present.

Zinc is not recommended for use with "Freon" 11 or "Freon" 113. Experience with zinc and the other "Freon" compounds has been limited and no unusual reactivity has been observed. However, it is somewhat more chemically reactive than other common construction metals, and it would seem wise to avoid its use with the "Freon" compounds unless adequate testing is carried out.

Metals which may be questionable for use in applications requiring contact with the "Freon" compounds for long periods of time or unusual conditions of exposure, however, can be cleaned safely with "Freon" solvents. Cleaning applications are usually for short exposures at moderate temperatures.

Halocarbons may react violently with highly reactive materials such as the alkali and alkaline earth metals, sodium, potassium, and barium, etc., in their free metallic form. Materials become more reactive when finely ground or powdered, and in this state magnesium and aluminum may react with fluorocarbons, especially at higher temperatures. Highly reactive materials should not be brought into contact with fluorocarbons until a careful study is made and appropriate safety precautions are taken.

e. Compatibility with Plastics

A brief summary is given below. Differences in polymer structure, molecular weight, plasticizer type and content and temperature may result in significant changes in the resistance of plastics to "Freon" compounds. Thus, compatibility tests should be made for specific applications.

ABS Plastics—Considerable variation in resistance with specific formulations is found. Careful testing is required.

Acetal Resins—Suitable for use with "Freon" compounds under most conditions.

Acrylic Fiber (polyacrylonitrile)—Generally suitable for use with "Freon" compounds.

Acrylic Resin (methacrylate polymers)—May be dissolved by "Freon" 22, but is generally suitable for use with "Freon" 12 and "Freon" 114, particularly for short exposures. On long exposure, cracking and crazing may occur, and the plastic may become cloudy. Use with "Freon" 113 and "Freon" 11 is questionable and should be carefully tested.

Cast resins are usually significantly more resistant than extruded resin.

Cellulose Acetate and Cellulose Nitrate—Generally suitable for use with "Freon" compounds.

Epoxy Resins—Highly resistant when cured and normally completely suitable for use with "Freon" compounds.

Nylon—Generally suitable but may tend to embrittle at high temperatures in the presence of air or water. Tests at 121°C (250°F) with "Freon" 12 and "Freon" 22 indicated the presence of water or alcohol to be undesirable. Testing required, particularly for high temperature service.

Phenolic Resins—Usually unaffected by "Freon" compounds. Resins of this type encompass a wide range of compositions, and testing is recommended.

Polycarbonate Resin—Usually undergoes considerable swelling and extraction. Not recommended.

Polychlorotrifluoroethylene—Slight swelling, but generally suitable for use with the "Freon" compounds.

Polyethylene and Polypropylene—Usually suitable for room temperature applications. Resistance to "Freon" compounds becomes more variable as temperatures are increased.

Polystyrene—Considerable variation in resistance is found. Some applications with "Freon" 114 may be satisfactory. Generally use with "Freon" compounds is not satisfactory. Careful testing is required. Generally less suitable for use with fluorocarbons than ABS plastics.

Polyvinyl Alcohol—Not affected by "Freon" compounds, but highly sensitive to water. Used in tubing for fluorocarbon service with an outer protective covering.

Polyvinyl Chloride and Other Vinyl Plastics—Resistance to "Freon" compounds depends on the vinyl type and the amount and type of plasticizer. Testing required.

Silicone Resin—Generally extensively swollen. Not recommended.

TFE-Fluorocarbon Resin—No swelling observed in "Freon" liquids, but diffusion through the resin occurs with "Freon" 12 and "Freon" 22.

f. Compatibility with Elastomers

Considerable variation is found in the effect of the "Freon" compounds on elastomers depending on the particular compound and elastomer type. In nearly all cases, a satisfactory combination can be found. In some instances, the presence of other materials such as oils may give unexpected results, so preliminary testing of the system is recommended.

Comparison of the linear swelling of elastomers often provides an indication of their suitability for use with the "Freon" compounds. Such a comparison is given in Table VI.

Swelling tests were conducted by immersing the elastomers in the liquid until equilibrium or maximum swelling was reached. Elastomers which swell excessively are not recommended for applications requiring long exposure. In many cases, however, parts containing such elastomers can be cleaned safely with "Freon" solvents when the exposure is relatively short.

Additional data are available in our Bulletin B-12A.

C. Solubility Properties

The solvent power of the "Freon" compounds varies from poor for "Freon" 115, "Freon" 114 and "Freon" 12 to fairly good for "Freon" 11, "Freon" 21, "Freon" 22, and "Freon" 113. Typical non-polar liquids, the fluorocarbons are good solvents for other non-polar materials and poor solvents for polar compounds. The solubilities of water in "Freon" compounds and of "Freon" compounds in water are low. Lubricating oils are generally miscible with "Freon" compounds at room temperature, although separation may occur at low temperatures. Water solubility, Kauri-Butanol (KB) values and solubility parameters (δ) are shown in Table VIII.

TABLE VI
Swelling of Elastomers by "Freon" Fluorocarbons and Other Compounds

Product	Percent Increase in Length at Room Temperature					
	Neoprene GN	Buna N (butadiene/ acrylonitrile)	Buna S (butadiene/ styrene)	Butyl (isoprene/ isobutylene)	Polysulfide Type	Natural Rubber
"Freon" 11	17	6	21	41	2	23
"Freon" 12	0	2	3	6	1	6
"Freon" 13	0	1	1	0	0	1
"Freon" 21	28	48	49	24	28	34
"Freon" 22	2	26	4	1	4	6
"Freon" 113	3	1	9	21	1	17
"Freon" 114	0	0	2	2	0	2
"Freon" 115	0	0	0	0	0.2	0
"Freon" 502	1	7	3	1.6	1.6	4
"Freon" 13B1	2	1	1	2	0	1
Methyl chloride	22	35	20	16	11	26
Methylene chloride	37	52	26	23	59	34
Methyl chloroform (1,1,1-trichloroethane)	54	24	44	35	12	59

IV. APPLICATIONS OF "FREON" FLUOROCARBON COMPOUNDS

TABLE VII

The table below is intended to provide a general view of the range of applications and is not all-inclusive. For specialized applications or more detail, please make specific request.

Fluorocarbon	Refrigerants	Aerosol Propellants(b)	Solvents, Blowing Agents, Fire Extinguishants, Dielectric Fluids and Other Uses
"Freon" 14	—	—	—
"Freon" 23	Component of "Freon" 503 azeotrope(a)	—	—
"Freon" 13	Specialty low temperature applications, usually in "cascade" systems.	—	—
"Freon" 116	—	—	Dielectric fluid
"Freon" 13B1	Intermediate between "Freon" 13 and "Freon" 22 for medium to low temperature applications. Not extensively used.	—	Efficient fire extinguishant (Halon® 1301) especially suited for automatic protection of materials subject to water damage and of areas occupied by personnel.
"Freon" 22	Household and commercial refrigeration and air conditioning applications. Permits use of smaller equipment. Component of azeotropes(a).	—	—
"Freon" 115	Used as an azeotrope component in "Freon" 502(a).	Accepted as a food propellant by the FDA, this material is well suited for food aerosols and finds use in fat emulsion food whips. Good foam stability with absence of odor or taste.	Dielectric fluid, an economic replacement for "Freon" 116 in most dielectric applications.
"Freon" 12	Most widely used refrigerant in household, automotive and commercial refrigeration and air conditioning systems. Also as a component of azeotropes(a) and, in high purity form ("Freon" freezant) approved as a direct contact freezing agent for foods.	Most widely used high-pressure propellant for non-food use. Blends with "Freon" 11 and "Freon" 114 are widely used.	Blowing agent for foamed plastics applications(d). Dielectric gas.
"Freon" 114	In large industrial process cooling and air conditioning systems using multi-stage centrifugal compressors.	Low pressure propellant, alternative to "Freon" 11, having poorer solubility properties and less odor. Especially used in personal products.	Blowing agent for foamed plastics.
"Freon" 21	—	—	Heat transfer fluid.
"Freon" 11	Widely used in centrifugal compressors for industrial and commercial air conditioning systems and for industrial cooling of process water or brine. Low viscosity and freezing point permit use as a low-temperature cooling liquid.	Most widely used low pressure propellant for non-food use. Does not provide adequate pressure alone, so is almost entirely used in blends with "Freon" 12(c).	Occasionally used as a solvent ("Freon" MF). Blowing agent for foamed plastics(d).
"Freon" 113	In commercial and industrial air conditioning and process water or brine chilling using centrifugal compressors, particularly in small tonnage applications.	Solvent in some aerosol formulations, usually propelled with "Freon" 12	Extensively as a solvent ("Freon" TF) alone and in special purpose formulations for a wide range of critical cleaning needs. In cutting fluid formulations, Valclene dry-cleaning, etc.

(a) A number of azeotropes ("Freon" 500, "Freon" 502, etc.) are available for refrigeration use. Bulletins describing the composition, properties and uses of these mixtures are available on request.

(b) Normally aerosol propellants are blended to give the required vapor pressure and solubility requirements.

(c) "Freon" 11 S is a stabilized grade frequently used in formulations containing alcohols or water.

(d) "Freon" 12 and "Freon" 11 are widely used as blowing agents for a range of foamed plastics, in which they provide excellent cell structure, and the trapped fluorocarbon in closed-cell foams significantly improves insulation and recovery properties of the foam.

TA

PHYSICAL PROPERTIES OF FREON*

Manufactured by E. I. DU PONT DE NEMOURS
Wilmington, De

	"FREON" 11	"FREON" 12	"FREON" 13	"FREON" 13B1	"FREON" 14
Chemical Formula	CCl_3F	CCl_2F_2	$CClF_3$	$CBrF_3$	CF_4
Molecular Weight	137.37	120.92	104.46	148.92	88.00
Boiling Point at 1 atm °C °F	23.82 74.87	−29.79 −21.62	−81.4 −114.6	−57.75 −71.95	−127.86 −198.32
Freezing Point °C °F	−111 −168	−158 −252	−181' −294	−168 −270	−184* −299
Critical Temperature °C °F	198.0 388.4	112.0 233.6	28.9 83.9	67.0 152.6	−45.67 −50.2
Critical Pressure atm lbs/sq in abs	43.5 639.5	40.6 596.9	38.2 561	39.1 575	36.96 543.2
Critical volume cc/mol cu ft/lb	247 0.0289	217 0.0287	181 0.0277	200 0.0215	141 0.0256
Critical Density g/cc lbs/cu ft	0.554 34.6	0.558 34.8	0.578 36.1	0.745 46.5	0.626 39.06
Density, Liquid g/cc at 25°C (77°F) lbs/cu ft at 54.5°C (130°F) g/cc lbs/cu ft	1.476 92.14 1.40 87.40	1.311 81.84 1.19 74.28	1.298 @ −30°C 81.05 (−22°F)	1.538 96.01 1.24 77.41	1.317 @ −80°C 82.21 (−112°F)
Density, Sat'd Vapor g/l at Boiling Point lbs/cu ft	5.86 0.367	6.33 0.395	7.01 0.438	8.71 0.544	7.62 0.476
Specific Heat, Liquid (Heat Capacity) cal/(g) (°C) at 25°C (77°F) Btu/(lb) (°F)	0.208	0.232	0.247 @ −30°C (−22°F)	0.208	0.294 @ −80°C (−112°F)
Specific Heat, Vapor, at Const Pressure (1 atm) cal/(g) (°C) at 25°C (77°F) Btu/(lb) (°F)	0.142 @ 38°C (100°F)	0.145	0.158	0.112	0.169
Specific Heat Ratio of Vapor at 25°C and 1 atm Cp/Cv	1.137 @ 38°C (100°F)	1.137	1.145	1.144	1.159
Heat of Vaporization cal/g at Boiling Point Btu/lb	43.10 77.51	39.47 71.04	35.47 63.85	28.38 51.08	32.49 58.48
Thermal Conductivity at 25°C (77°F) Btu/(hr) (ft) (°F) Liquid* Vapor (1 atm) (Data from ASHRAE in most cases)	0.0506 0.00451	0.0405 0.00576	0.0183 0.00698	0.0234 0.00534	0.033 @ −73°C (−100°F) 0.00912
Viscosity at 25°C (77°F) Liquid centipoise Vapor (1 atm) centipoise (Data from ASHRAE in most cases)	0.430 0.0107	0.214 0.0123	0.195 @ −46°C (−50°F) 0.0145	0.157 0.0154	0.09 @ −73°C (−100°F) 0.0172
Surface Tension at 25°C (77°F) dynes/cm	18	9	14 @ −73°C (−100°F)	4	4 @ −73°C (−100°F)
Refractive Index of Liquid at 25°C (77°F)	1.374	1.287	1.199 @ −73°C (−100°F)	1.238	1.151 @ −73°C (−100°F)
Relative Dielectric Strength[5] of Vapor at 1 atm and 25°C (77°F) (nitrogen = 1)	3.71	2.46	1.65	1.83	1.06
Dielectric Constant Liquid Vapor (1 atm)*a	2.28 @ 29°C 1.0036 @ 24°C*b	2.13 @ 29°C 1.0032	1.0024 @ 29°C		1.0012 @ 24.5°C
Solubility of "Freon" in Water at 1 atm and 25°C (77°F) wt %	0.11	0.028	0.009	0.03	0.0015
Solubility of Water in "Freon" at 25°C (77°F) wt %	0.011	0.009		0.0035 @ 21°C (70°F)	
Solubility Parameter ( ) Kauri-Butanol Value (KB)	7.5 60	6.1 18			
Toxicity* ppm (v/v) Threshold Limit Value (TLV) mg/m³	1000 5600	1000 4950	Less toxic than "Freon" 12	1000 6100	Less toxic than "Freon" 12

*FREON is Du Pont's registered trademark for its fluorocarbon products. (a) Intended addition, 1974

LE VIII

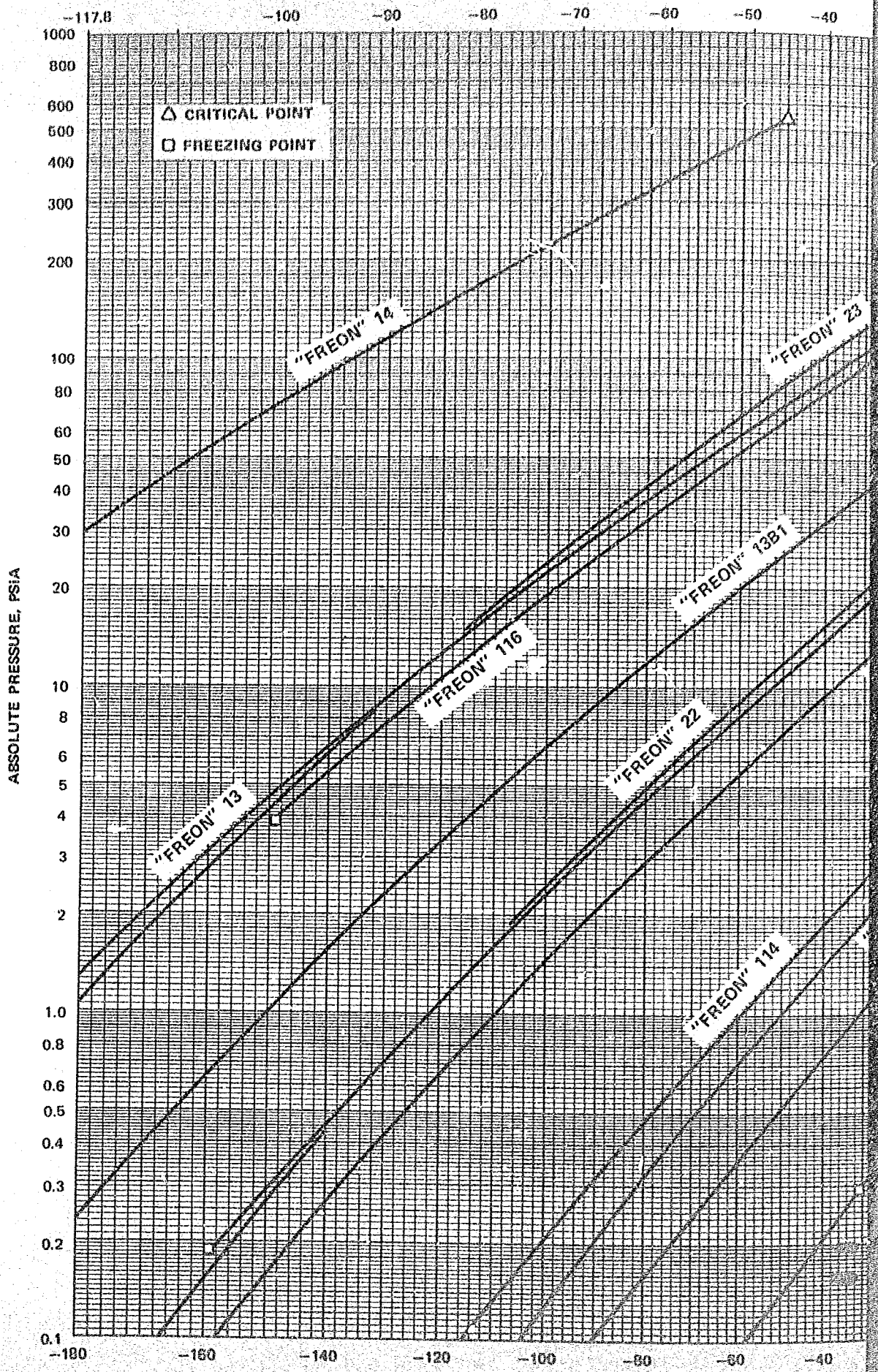
FLUOROCARBON COMPOUNDS**

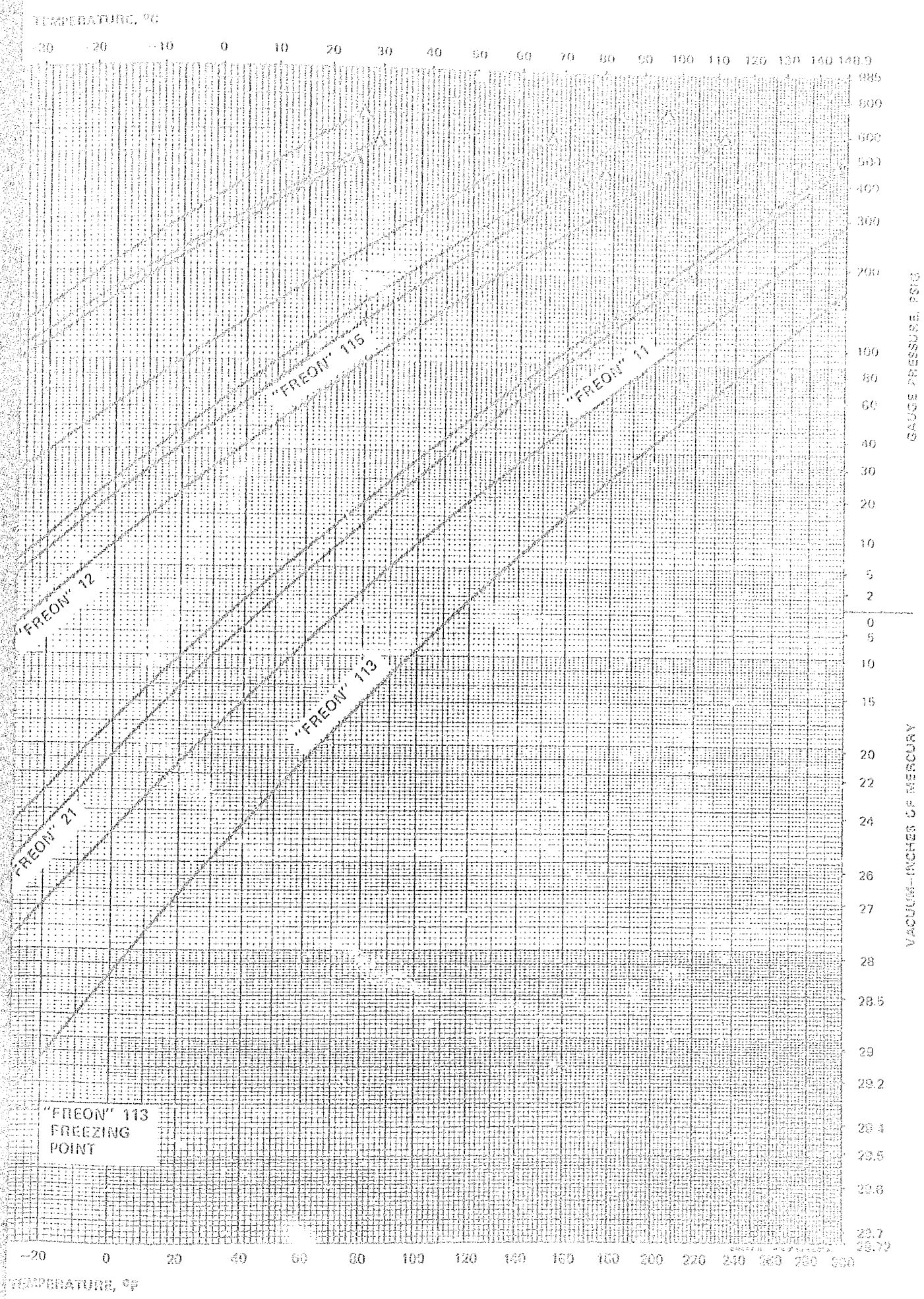
& CO. (INC.), "FREON" PRODUCTS DIVISION
aware 19898

"FREON" 21	"FREON" 22	"FREON" 23	"FREON" 113	"FREON" 114	"FREON" 115	"FREON" 116
$CHCl_2F$	$CHClF_2$	CHF_3	$CCl_2F\text{-}CClF_2$	$CClF_2\text{-}CClF_2$	$CClF_2\text{-}CF_3$	CF_3CF_3
102.93	86.47	70.01	187.38	170.93	154.47	138.01
8.92 48.06	−40.75 −41.36	−82.03 −115.66	47.57 117.63	3.77 38.78	−39.1 −38.4	−78.2 −108.8
−135 −211	−160 −256	−155.2 −247.4	−35 −31	−94 −137	−106' −159	−100.6 −149.1
178.5 353.3	96.0 204.8	25.9 78.6	214.1 417.4	145.7 294.3	80.0 175.9	19.7' 67.5
51.0 750	49.12 721.9	47.7 701.4	33.7 495	32.2 473.2	30.8 453	29.4' 432
197 0.0307	165 0.0305	133 0.0305	325 0.0278	293 0.0275	259 0.0269	225 0.0262
0.522 32.6	0.525 32.76	0.525 32.78	0.576 36.0	0.582 36.32	0.596 37.2	0.612 38.21
1.366 85.28 1.29 80.53	1.194 74.53 1.06 66.17	0.670 41.82	1.565 97.69 1.49 93.01	1.456 90.91 1.36 84.90	1.291 80.60 1.11 69.29	1.587' 99.03 @ −73°C (−100°F)
4.57 0.285	4.72 0.295	4.66 0.291	7.38 0.461	7.83 0.489	8.37 0.522	9.01' 0.562
0.256	0.300	1.553	0.218	0.243	0.285	0.232 @ −73°C (−100°F)
0.140	0.157	0.176	0.161 @ 60°C (140°F)	0.170	0.164	0.182' @ 0 pressure
1.175	1.184	1.191 @ 0 pressure	1.080 @ 60°C (140°F)	1.084	1.091	1.085 (est) @ 0 pressure
57.86 104.15	55.81 100.45	57.23 103.02	35.07 63.12	32.51 58.53	30.11 54.20	27.97 50.35
0.0592 0.00506	0.0507 0.00609	0.022 0.00851	0.0434 0.0044 (0.5 atm)	0.0372 0.0060	0.0302 0.00724	0.045 @ −73°C (−100°F)).0098 (est)
0.313 0.0114	0.198 0.0127	0.034 0.0146	0.68 0.010 (0.1 atm)	0.36 0.0112	0.193 0.0125	0.30 0.0148
18	8	15 @ −73°C (−100°F)	17.3	12	5	16 @ −73°C (−100°F)
1.354	1.256	1.215 @ −73°C (−100°F)	1.354	1.288	1.214	1.206 @ −73°C (−100°F)
1.85	1.27	1.04	3.9 (0.44 atm)	3.34	2.54	2.02
.34 @ 28°C 0070 @ 30°C	6.11 @ 24°C 1.0071 @ 25.4°C	1.0073 @ 25°C	2.41 @ 25°C	2.26 @ 25°C 1.0043 @ 26.8°C	1.0035 @ 27.4°C	1.0021 @ 23°C
0.95	0.30	0.10	0.017 (Sat'n Pres)	0.013	0.006	
0.13	0.13		0.011	0.009		
8.0 102	6.5 25		7.2 32	6.2 12	5.7 7	
10 40	1000 (s) 3500 (s)	Less toxic than "Freon" 22	1000 7800	1000 7000	Less toxic than "Freon" 114	Less toxic than "Freon" 114

**See page 11 for reference to data sources.

V. PRESSURE TEMPERATURE RELATIONSHIPS




TEMPERATURE, °C
-30 -20 -10 0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 148.9
"FREON" 12
"FREON" 21
"FREON" 113
"FREON" 115
"FREON" 11
"FREON" 113 FREEZING POINT
GAUGE PRESSURE, PSIG
800 700 600 500 400 300 200 100 80 60 40 30 20 10 5 2 0
VACUUM—INCHES OF MERCURY
5 10 15 20 22 24 26 27 28 28.5 29 29.2 29.4 29.5 29.6 29.7 29.70
-20 0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300
TEMPERATURE, °F

VI. MISCELLANEOUS

Additional information and technical bulletins on individual products and specific uses are available from the "Freon" Products Division of the Du Pont Company. This additional information includes information on shipping containers, bulk shipments, safe material handling, principles and practice of use, comparative performance of compounds, extensive thermodynamic and physical properties, and toxicological properties. You are invited to write or call the nearest sales office or Du Pont Product Information Center listed on the back cover.

VII. REFERENCES

Physical Properties Chart

Unless noted otherwise, data in the charts were developed by the Du Pont Company in its laboratories or under contract with other laboratories.

Other References

1. "Freon" 13 freezing point from Ruff and Keim, z. anorg. allgem. Chem. 201, 245 (1931).
2. "Freon" 14 freezing point from Ruff and Bretschneider, z. anorg. allgem. Chem. 210, 173 (1933).
3. "Freon" 116 data from Pace and Aston, J. Am. Chem. Soc. 70, 566 (1948).
4. W. Tauscher, Kaaltetechnik-Klimatisierung 19, 288, (No. 9, 1967).
5. Data from Du Pont at one atmosphere, 0.1 inch gap and ¾ inch sphere-to-plane gap.

6a. Vapor dielectric constants from Fuoss, J. Am. Chem. Soc. 60, 1633 (1938).

6b. Table of Dielectric Constants and Electric Dipole Moments of Substances in the Gaseous State, NBS Circular 537, 1953.

7. "Freon" 115 freezing point from Calfee, Fukushara, Young and Bigelow, J. Amer. Chem. Soc. 62, 267 (1940).
8. Cleveland et al, J. Mol Spec. 7, 209 (1961).
9. Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes for 1974, ACGIH and subsequent editions. Where a compound has not been given a TLV, relative toxicity is indicated based on available toxicological data.
10. Mullin, Azar, Reinhardt, Smith, and Fabryka, Am. Ind. Hygiene Assoc. J., 389, June 1972, and Reinhardt, Azar, Maxfield, Smith and Mullin, Arch. Environ. Health, 22, 265 (1971).

E.I. DU PONT DE NEMOURS & CO. (INC.)
"FREON" PRODUCTS DIVISION
WILMINGTON, DELAWARE 19898

For further information, please contact one of the following offices:

Wilmington, Delaware 19898
Phone: 774-8346
(Area Code 302)

701 Welch Road
Palo Alto, California 94304
Phone: 326-2840
(Area Code 415)

The information contained herein is based on technical data and tests which we believe to be reliable and is intended for use by persons having technical skill, at their own discretion and risk. Since conditions of use are outside of Du Pont's control, we can assume no liability for results obtained or damages incurred through the application of the data presented.

Publication of the information in this bulletin should not be understood as permission or recommendation for the use of "Freon" compounds in violation of any patents.

DU PONT
REG. U.S. PAT. OFF.

Better things for better living . . . through chemistry

E-03528 6/75

PRINTED IN U.S.A.

I INTRODUCTION

Du Pont Halon 1301 Fire Extinguishant is monobromotrifluoromethane, $CBrF_3$. It offers unusual advantages as a fire extinguishing agent against Class A (cellulosic materials), Class B (flammable liquid), and Class C (electrical) fires.

On a weight basis, Halon 1301 is the most effective gaseous extinguishing agent available. It is up to three times more effective than carbon dioxide and some other halogenated agents. It is approximately equivalent to sodium-base dry powder, although somewhat less effective than potassium-base powder.

Halon 1301 may be applied to fires by hand portable extinguishers, total flooding systems, and local applications systems. Each method is effective and offers certain advantages for a particular hazard. Total flooding systems using Halon 1301 are especially attractive due to the combination of compact storage volumes, low vision obscuration, lack of particulate residue, rapid mixing with air, ready access to blocked or baffled spaces, and low toxicity of the extinguishing atmosphere.

Du Pont Halon 1301 has been used as a fire extinguishing agent since 1948 when its combination of effectiveness and low toxicity was recognized. Medical data and a growing body of experience indicate that Halon 1301 may be safely used in a wide variety of fire extinguishing situations if recommended application procedures are followed.

The properties of Halon 1301 are described in more detail on the following pages.

II APPLICATIONS

Du Pont Halon 1301 is now being used commercially for the protection of:

- computers and data processing equipment
- electrical and electronic equipment
- file rooms
- libraries, museums and historic buildings
- chemical and physical laboratories, hoods and glove boxes
- aircraft engines, cargo compartments, and passenger cabins
- military vehicles, such as tanks, trucks, and personnel carriers
- coventional and nuclear power plants
- radioactive "caves" and hot cells
- marine engines and engine rooms
- racing cars and boats
- flammable liquids and vapors
- telephone exchanges
- and many others

III EFFECTIVENESS — Portable Extinguishers

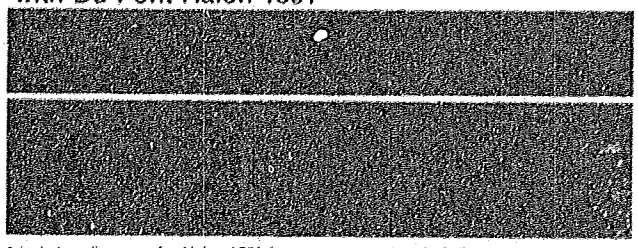
Du Pont Halon 1301 has proven to be a very effective agent in portable extinguishers for use against Class B (flammable liquid) and Class C (electrical) fires. The U. S. military uses a large quantity of a portable extinguisher containing Halon 1301.

The primary variable affecting the rating of a portable extinguisher is the rate of agent discharge. The shape of the discharge horn is also important, since the discharge pattern must allow the agent to reach the far side of the fire pan, yet be broad enough to cover the entire area sufficiently and not splash the fuel from the pan. Testing by Du Pont using optimum nozzle designs has determined the minimum discharge rates of Halon 1301 necessary to extinguish various standard U.L. fires. These rates are shown in Table I. Complete test data of these experiments are available upon request.

U. L. requirements for portable extinguishers can be obtained from Underwriters' Laboratories.*

Table I

Portable Extinguisher Performance with Du Pont Halon 1301



* includes allowance for Halon 1301 in vapor space at end of discharge, which is ineffective in extinguishing the fire

( ) interpolation of data for U.L. Size 5; other data determined experimentally

Underwriters' Laboratories
333 Pfingsten road
Northbrook, Illinois 60062

IV EFFECTIVENESS — Total Flooding Systems

Du Pont Halon 1301 is particularly suited for use in total flooding extinguishing systems. Fires involving most fuels can be extinguished by concentrations of Halon 1301 to which personnel can be exposed for limited times with low risk of harm. In addition, vision obscuration and chilling of the atmosphere are minimal in most applications. The high dielectric strength of Halon 1301 and lack of particulate residue enhance its use where electrical or electronic equipment is involved. The low volumetric discharge is attractive where overpressurization of the enclosure may be a concern. And the cost of a Halon 1301 total flooding system may be lower than systems based on competitive agents.

Total flooding extinguishing systems are based on the release of a predetermined amount of agent into an enclosure to develop a uniform extinguishing concentration throughout. The amount of agent required is based upon the size of the enclosure and the concentration required to extinguish or inert the particular fuels involved.

In determining the agent concentrations required, consideration must be given to the specific fuels involved. A 5% concentration of Halon 1301 extinguishes flaming combustion of most fuels, but test evaluations must be made to define necessary concentrations for specific fuels.

NFPA Standard 12A, "Halogenated Fire Extinguishing Agent Systems — Halon 1301,"* provides many design principles and procedures for Halon 1301 systems.

The amount of Halon 1301 required to attain a total flooding concentration may be determined using the following formula:

$$W = \frac{1}{S}\left(\frac{C}{100-C}\right)V$$

where W = weight of Halon 1301 required, pounds
S = specific volume superheated Halon 1301 vapor, cu.ft./lb. (at 70°F, S= 2.5605 cu.ft./lb.)
C = concentration of agent required, percent by volume
V = enclosure volume, cubic feet

As a rule of thumb, one pound of Halon 1301 discharged per 50 cubic feet of enclosed volume will produce a 5% concentration.

Flammable Liquids and Gases — Class B

Fires involving most flammable liquids and gases are extinguished quickly when the atmosphere surrounding the flame is flooded with relatively low concentrations of Halon 1301. Two levels of Halon

*Available from:
National Fire Protection Association, Inc.
Batterymarch Park
Quincy, MA 02269

1301 concentrations may be considered — one is adequate for flame extinguishment while the other (higher) level will inert flammable mixtures of the fuel and air.

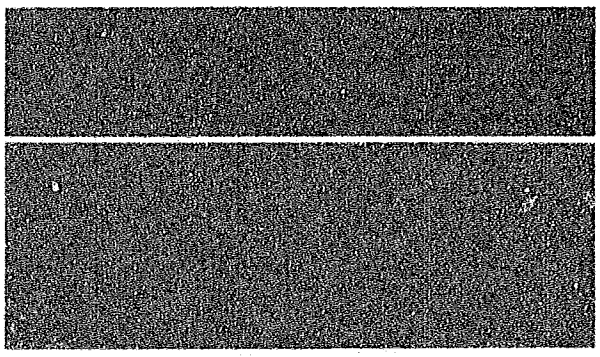
Flame extinguishment concentrations apply to diffusion flames and should not be used when an explosive mixture of fuel and air can occur. An explosive mixture is improbable if either an insufficient quantity of fuel is available or the volatility of liquid fuels is sufficiently low at temperatures involved both before and after a fire.

Inerting requirements should be used when flame extinguishment limitations are exceeded, or where it is considered possible that an explosive atmosphere would develop before or after ignition. Highly volatile, gaseous or atomized fuels generally carry high explosion potentials. an inerting concentration makes ignition of any concentration of fuel vapor in the enclosure impossible.

Halon 1301 design concentrations for flame extinguishment and inerting of several fuels are listed in Table II.

Table II

Du Pont HALON 1301 Concentrations Required for Flame Extinguishment and Inerting for Various Fuels in Air at 1 ATM., 25°C



*Includes 20% safety factor on experimental determination, 5% minimum
**Includes 10% safety factor on experimental determination, 5% minimum
Source: NFPA-12A.

Combustible Materials — Class A

Fires involving ordinary combustible materials (such as wood, cloth, paper, rubber, and plastics) usually consist of both flaming combustion of gases vaporized from the solid and also surface combustion. For most Class A fuels, the flaming combustion is readily extinguished by 5% concentrations of Halon 1301.

For many fuels including most plastics, the surface combustion will be extinguished shortly after flame extinguishment during "soaking" in the Halon 1301/air mixture. When the radiant heat feedback from the flame to the solid is stopped in these fuels, the surface combustion dies out.

For some fuels, smoldering combustion in the solid will continue even after extended soaking times. NFPA-12A defines fires as "deep-seated" if smoldering combustion continues after 10 minutes soaking with 5% Halon 1301. The deep-seated tendency is dependent not only on the specific fuel but also its geometric configuration and burning time before Halon 1301 application. The deep-seated combustion characteristic appears to be related to the preservation of heat from smoldering combustion which becomes well insulated from heat loss.

Such solid fuels as corrugated cardboard or shredded paper can quickly become deep-seated while others such as some plastics show no tendency to become deep-seated.

In any Halon 1301 application with potential deep-seated combustion, two related effects must be considered and appropriate provisions made, i.e., 1) decomposition of agent and 2) rekindling of fire after dissipation of agent. Decomposition can be controlled by limiting the quantities of fuels with deep-seated combustion potential in any protected enclosure. Rekindling hazards can be controlled with appropriate secondary extinguishment — either automatic or manual.

Live Electrical Equipment — Class C

Halon 1301 fire extinguishing effectiveness has been demonstrated on several types of electrical equipment especially electronic computer and data processing equipment. Tests have shown fires of fuels commonly present in computer rooms are extinguished by 5% concentration of Halon 1301 without detrimental side effects on computer equipment.

Limitations

Halon 1301 is not effective in preventing the combustion or reaction of the following:

1. Chemicals capable of oxidation without air: e.g., cellulose nitrate, gunpowder.
2. Reactive metals e.g., sodium, potassium, magnesium, ti[illegible]
3. Metal hydride
4. Chemicals capable of autothermal decomposition: e.g., organic peroxides, hydrazine.

V THEORY of FIRE EXTINGUISHMENT

In the past, the effectiveness of fire extinguishing agents has been attributed to one of the following actions: cooling (water), oxygen exclusion or smothering (carbon dioxide), or mechanical separation of fuel from the oxidizer (foam). The well-known "fire triangle" is based upon these three mechanisms.

None of these actions satisfactorily explains the action of Du Pont Halon 1301.

It is thought that Halon 1301 extinguishes by a chemical action. The halogen compound reacts with the transient combustion products which are responsible for rapid and violent flame propagation. This reaction terminates the combustion chain reaction and thereby stops the flame propagation. There are two different theories to explain the extinguishment process, one based on a free radical process, the other based on ionic activiation of oxygen during combustion.

In the free radical theory, a bromine radical is first formed through thermal decomposition of Halon 1301:

$$CBrF_3 \qquad CF_3 + Br$$

The bromine radical reacts with hydrogen in the fuel to give hydrogen bromide:

$$R\text{-}H + Br \qquad R + HBr$$

The hydrogen bromide then reacts with active hydroxyl radicals:

$$HBr + OH \qquad H_2O + Br$$

The bromine radical may now react with more fuel to repeat the process to remove more active radicals from the fire.

According to the ionic theory, elemental oxygen must be activated by absorbing free electrons before it can react with the fuel. The bromine atom on Halon 1301 provides a much larger target for the capture of electrons than does oxygen, and thus reduces the probability of oxygen activation.

In both theories, the chain reaction of the fire is broken with relatively small quantities of extinguishing agent.

VI PHYSICAL PROPERTIES

Du Pont Halon 1301 is a low-boiling, colorless liquified compressed gas having high density and low viscosity. Its physical properties are outlined in Table IV; more detailed values of those properties of most interest in fire extinguishment applications are given in Tables III and V. Information on other physical properties is available upon request.

The vapor pressure, liquid and vapor densities, liquid viscosity and liquid heat capacity values are based on direct measurements. The vapor viscosity and liquid thermal conductivity values have been estimated from generalized relationships.

Table III
Heat Capacity and Thermal Conductivity of Liquid Du Pont Halon 1301

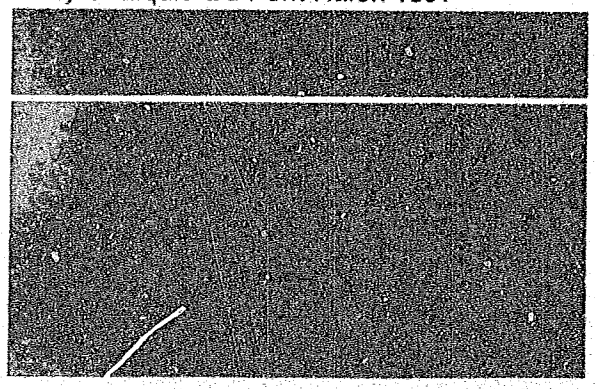
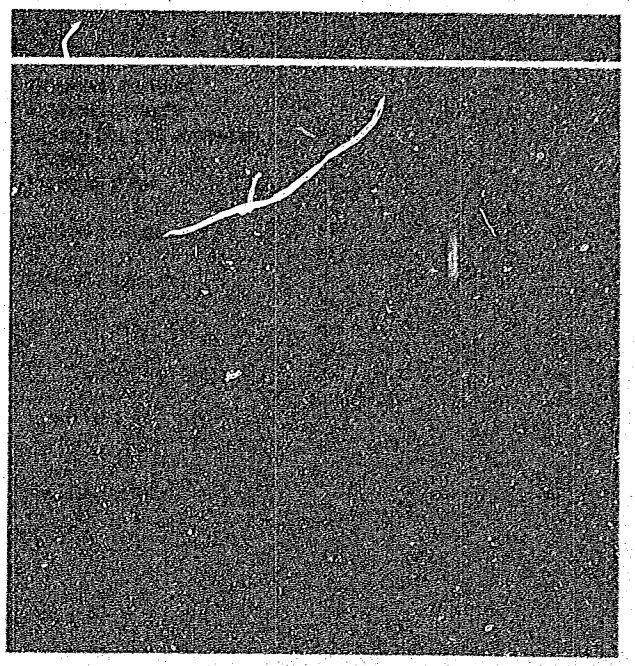


Table IV
Physical Properties of Du Pont Halon 1301



VII TOXICITY

The inhalation toxicity of Du Pont Halon 1301 is low. This, plus a high degree of extinguishing effectiveness and excellent thermal stability, makes Halon 1301 the safest gaseous extinguishing agent available, when properly applied. But Du Pont Halon 1301, as with all other chemicals, cannot be considered non-toxic under all circumstances. This section will discuss the inhalation toxicity of Halon 1301 from four aspects:

1. Equipment design.
2. Toxicity of natural (undecomposed) Halon 1301.
3. Toxicity of Halon 1301 decomposition products.
4. Toxicity of common fire combustion products.

Equipment Design

Any consideration of the safety of Halon 1301 must begin with a discussion of the equipment in which the agent is used. When considering either hand portable extinguishers or automatic extinguishing systems, the agent is safer to use if it is applied to a fire at an early stage of combustion. At this stage, the fire is generally smaller, has not become deeply involved (and is thus easier to extinguish), and has not created extensive quantities of toxic combustion products.

For a hand portable extinguisher, the size and weight of the extinguisher influence to some extent the ease and promptness with which the extinguisher may be applied. A small light extinguishant may be used more quickly than a large bulky one. In this regard, Du Pont Halon 1301 offers advantages in weight savings and compactness which can save precious seconds in the time normally required to begin attack on a fire.

In automatic extinguishing systems, the detectors determine at what stage the fire is attacked. Optimum rapid sensing of the fire by suitable detectors is necessary to obtain agent discharge at an early combustion stage.

Finally, the agent discharge should be as rapid as possible. In total flooding systems, the more quickly an extinguishing concentration is achieved, the lower will be the extent of agent decomposition by the fire. By extinguishing the fire more quickly, fire damage and the quantity of toxic combustion products will also be reduced. Typical discharge times range from less than one second in the case of flammable gases or highly volatile liquids, up to perhaps 30 seconds for slower burning fuels.

Selection of the proper combination of detectors and agent discharge rate should be coordinated with a qualified fire protection engineer after a thorough study of all aspects of the individual situation.

Natural (Undecomposed) Du Pont HALON 1301

The safety of Halon 1301 has been established not only through practical experience but through more than 30 years of research including toxicological testing. Based on results of these tests, the National Fire Protection Association has set up the following guidelines for the use of Halon 1301 in occupied areas:

Concentration by Volume	Length of Time of Human Exposure
7% or lower	15 minutes
7-10%	1 minute
10-15%	30 seconds
Above 15%	Prevent exposure

Since fires of most combustible materials can be quickly extinguished with Halon 1301 at concentrations of 7% or less by volume, the vapor presents little or no danger to personnel. Tests also show that people may inhale these concentration levels up to 15 minutes without risk of cardiac or harmful central nervous system effects.

It has only recently become known that many common and frequently encountered materials can have an unusual effect upon the animal or human heart. Things like chloroform, gasoline, paint thinner, various volatile solvents, if inhaled in sufficient quantity, can make the heart very sensitive to a major upset in rhythm (called "arrhythmia"). Excitement and stress in a human or animal can cause a heart arrhythmia or irregular heart action. The combination of exposure to high concentrations of one of these vapors PLUS high levels of adrenaline, seems to be a much more serious hazard than either of these situations separately.

Halon 1301 has been studied extensively for cardiac sensitization. From animal experiments involving exposure to Halon 1301 and high levels of injected adrenaline, plus studies of humans exposed to Halon 1301 without injected adrenaline, we conclude that exposure to concentrations for the time shown above should not increase risk of cardiac arrythmia. However, at high Halon 1301 concentrations, if combined with extreme blood adrenaline levels, cardiac rhythms in humans may be affected. A few animals exposed to 7.5% Halon 1301 or greater, with injected adrenaline, had serious cardiac arrhythmias; at levels of 10% or more, irreversible arrhythmias occurred with some.

Decomposition Products Du Pont HALON 1301

Upon exposure to flames or hot surfaces above about 950°F, Halon 1301 decomposes to form primarily hydrogen bromide (HBr) and hydrogen fluoride (HF). Trace quantities of bromine (Br_2), carbonyl halides (carbonyl fluoride, COF_2, and carbonyl bromide, $COBr_2$) have been observed, but their quantities are generally too small to be of concern. Phosgene is not formed from Halon 1301; there is no chlorine available in Halon 1301 from which to form phosgene.

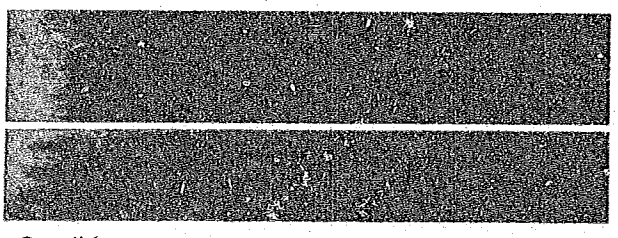
In most fire situations where Halon 1301 automatic protection systems are used, the concentrations of HF and HBr have been found to be below 20 parts per million (ppm) — often barely detectable to the nose. Severe fire tests indicate larger amounts of HF (200 to 300 ppm) and HBr (40 to 50 ppm) are produced when Halon 1301 decomposes while extinguishing a large, hot fire. Such concentrations are noxious and irritating and may be harmful if exposure is prolonged.

The primary effect of the decomposition products is irritation. They have a characteristic sharp, acrid odor, even in very low concentrations, which provides a built-in warning system for the agent. The irritation becomes severe well in advance of really hazardous levels. Test animals exposed to sub-lethal concentrations of decomposed Halon 1301 appear to recover completely following exposure. The effects of exposure are not believed to be cumulative.

The amount of Halon 1301 which will decompose in any given fire is dependent upon the fire size and fuel type, the enclosure size, and the agent discharge time. Some representative test results are listed in Tables VI and VII. From the standpoint of equipment design, prompt detection and rapid extinguishment of the fire will produce the safest post-extinguishment atmosphere.

Table VI

n-Heptane fire tests showed only moderate levels of decomposition products, except when fire area is very large compared to enclosure size



Conditions:
- n-heptane pool in fire pan
- 1695 cu. ft. enclosure volume
- 4% Halon 1301 concentration (vol.)
- 30 second preburn
- 6 second Halon 1301 discharge time

Common Products of Combustion of the Fire

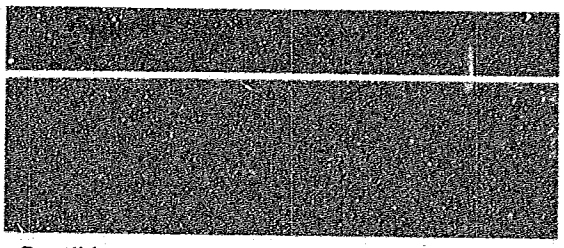
A study of fire toxicology raises the following question: which is more hazardous, the toxicity attributable to the fire combustion products, or the toxicity attributable to decomposition of the extinguishing agent? The level and hazards of the combustion products depend on several factors including the fuel type and location, the amount of air available, and the length of time personnel are exposed to the fire. A toxic material formed in most fires is carbon monoxide, an odorless and colorless gas which is fatal to humans in concentrations higher than 15,000 ppm (1.5%) by volume in air. It is present in every fire, with the amount varying according to the completeness of combustion. Large quantities are generally formed under conditions of incomplete combustion evidenced by smoke and acrid fumes. Generally, decomposition products from the fire itself, especially carbon monoxide, smoke, heat and oxygen depletion, create a greater hazard than the thermal decomposition products of Halon 1301.

The foregoing discussion should not be construed to minimize the hazards associated with the decomposition products of Halon 1301. Rather, it is intended to point out that one should choose an extinguishing agent with the lowest possible toxicity in relationship to its fire fighting effectiveness, ease in handling, and reliability.

Additional toxicity information is available upon request.

Table VII

Deep-seated test fire showed only moderate levels of decomposition products using trashbasket-size fire in average room.



Conditions:
- 5 lbs. mixed paper (sheets, cards and tape) in 18" x 30" open wire basket
- 50% by weight preburn
- 1729 cu. ft. enclosure volume
- 5.1% Halon 1301 concentration
- 2-second discharge time
- Sampling times are minutes after completion of discharge

VIII SAFETY

Pressure

At normal temperatures, Halon 1301 is under considerable pressure. All containers and transfer equipment used must be of strength adequate to withstand the maximum expected service pressure and to meet Department of Transportation shipping regulations. Considering Halon 1301 fill density and temperature, suitable relief devices should be installed. For additional information, contact Du Pont at address shown on back page.

Effect on Skin and Eyes

Liquid Halon 1301 (including the spray in the immediate vicinity of a discharge) may freeze the skin (frostbite) on contact. Such contact should be avoided by wearing protective clothing and eye protection. In the event of frostbite, warm the affected area quickly to body temperature. Eyes should be flushed copiously with water. Hands may be held under armpits or immersed in warm water. Get medical attention promptly.

Personnel Training

In addition to normal good safety practices (emergency lighting, directional signs, continuous alarms, etc.), personnel in a Halon 1301 protected area should be familiar with the operating characteristics of the system. These instructions should detail the necessary safeguards unique to each location. Personnel should be warned that, if a system discharges, they should not smoke until the atmosphere has been completely purged of Halon 1301. Occupants of a Halon protected area should be warned that the noise of discharging superpressurized Halon 1301 may be startling. We strongly recommend that maintenance and construction personnel be similarly trained.

IX EFFECT on CONSTRUCTION MATERIALS

Metals

Extensive laboratory tests indicate that Du Pont Halon 1301 fire extinguishing agent has no serious adverse effects on any of the metals commonly considered for use in fire extinguishers or fixed fire extinguishing systems. This is not surprising from a chemical standpoint because the presence of the fluorine atom in a molecule generally reduces its chemical reactivity and corrosive properties and increases its stability.

Ten different types of metals including aluminum, magnesium, stainless steel, titanium, and brass have been exposed to Du Pont Halon 1301 for periods up to 44 months under controlled laboratory conditions. The liquid extinguishing agent and test strips of the various metals were sealed in glass tubes and stored at temperatures of 250°F and 130°F, as well as at ordinary room temperature. Samples of the extinguishing agent containing 2 parts per million moisture were representative of commercial material. Samples containing 72 parts per million moisture represented about a 75% saturation level in Du Pont Halon 1301.

In evaluating the tests, corrosion of the metal and appearance of the liquid were examined since both of these effects are considered significant and related. Results are summarized in Table VIII.

The sealed-tube corrosion tests indicate that all of the metals tested are suitable for use with Halon 1301.

Separate tests conducted by the Aerojet Engineering Corporation indicate that copper immersed in equivalent moisture level samples of Halon 1301 for seven days at room temperature is unaffected by the extinguishing agent.

The presence of free water in systems containing Halon 1301 should be avoided. In long term exposures, localized corrosion can be significant, particularly at the Halon 1301 liquid-vapor interface where the water floats on the liquid Halon 1301.

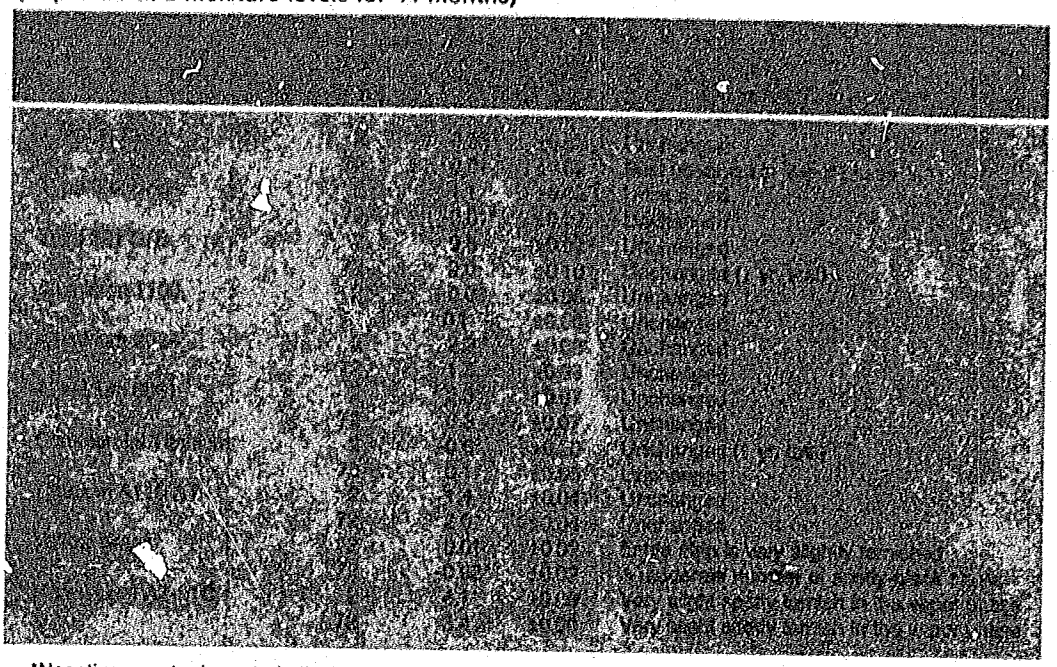
Stability Tests at High Temperatures

To determine its stability and effect on metals under high temperature as might be encountered in aircraft engine fire protection systems, Du Pont Halon 1301 was exposed to three different types of steel in sealed tubes at temperatures of 600°F for 25 hours. Results of the tests, summarized in Table IX, are helpful in determining the best types of metal to be used in extinguisher equipment construction. Inconel, for example, was found to be the safest for use with Halon 1301, from the standpoint both of minimum decomposition of extinguishing agent and corrosion of metal. It was followed by stainless steel 316 and mild steel.

Most halocarbons may react violently with highly reactive materials, such as the alkali and alkaline

Table VIII

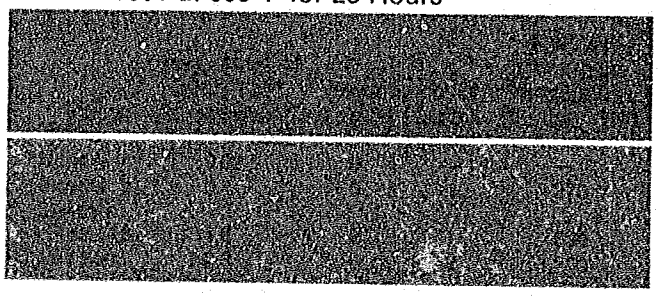
Common Metals Show Negligible Corrosion by HALON 1301
(Exposure at 2 moisture levels for 44 months)



*Negative penetration rate indicates a weight gain of test strip.

Table IX

Sealed-Tube stability tests of Du Pont HALON 1301 at 600°F for 25 Hours

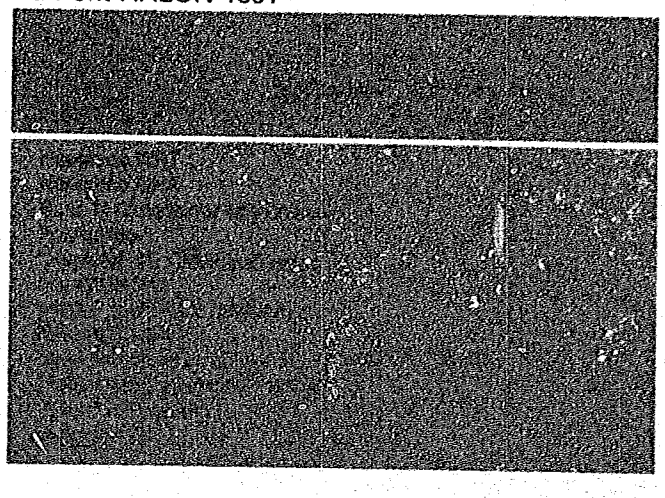


*Appearance key:

Rating	Liquid	Metal
0	No change	No change
1	Sl. darkening	Tarnish
2	Mod. darkening	Sl. corrosion
3	Very dark	Mod. corrosion
4	Very dark and deposits	Severe corrosion

Table X

Linear Swell of Elastomers by Du Pont HALON 1301



earth metals, sodium, potassium, and barium, etc., in their free metallic form. Materials become more reactive when finely ground or powdered and in this state magnesium and aluminum may react with fluorocarbons especially at higher temperatures. Highly reactive materials should not be brought into contact with fluorocarbons until a careful study is made and appropriate safety precautions are taken.

Under some circumstances when Du Pont Halon 1301 is exposed to high temperatures, the products of decomposition will include certain acids which may have a slight corrosive effect on metals.

Elastomers and Plastics

Du Pont Halon 1301 is inert toward most elastomers and plastics. Suitable materials for gasketing, insulation, tubing, etc., for nearly any application can be found readily. The effect of Halon 1301 on elastomers is shown in Table X and on plastic materials in Table XI.

Test strips of the elastomer or plastic were sealed in glass tubes with the liquid agent and stored at room temperature for a period of two weeks. The maximum linear swelling of the test piece was measured and the general condition of the material and liquid observed. The change in weight of the test piece was measured at the end of the test and again after drying for two weeks.

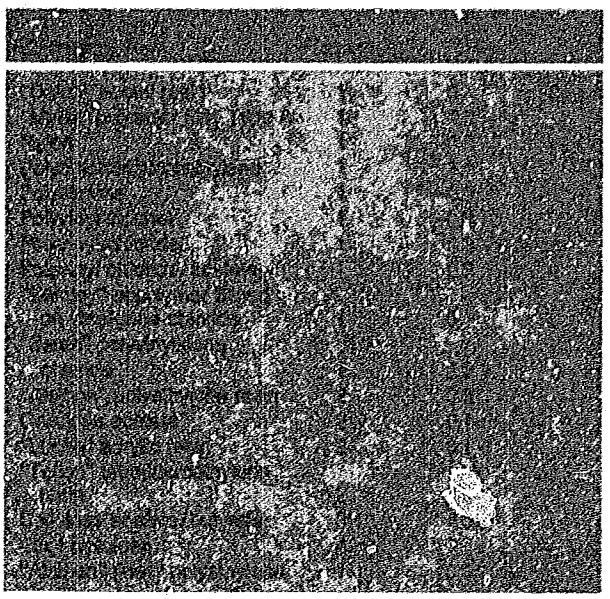
All of the elastomers tested except silicone rubber are suitable for use with Halon 1301.

Most of the commonly used plastics undergo little, if any, swelling in the presence of Halon 1301 with the exception of ethyl cellulose and possibly cellulose acetate/butyrate.

Table XI
Effect of Du Pont HALON 1301 on Plastic Materials at Room Temperature

The rating system is based on linear swell, change in weight and physical changes in the plastic test piece. The following interpretation can be given to the ratings.

1. Unchanged and suitable for use with the agent.
2. Slightly changed but probably suitable for use with the agent.
3. Moderately changed and probably not suited for use with the agent.
4. Severely changed and not suitable for use with the agent.
5. Sample disintegrated.



Condition of Test Sample
a — crazed slightly after removal from the liquid.
b — Softened and warped.

X SOLUBILITY PROPERTIES

In its liquid state, Du Pont Halon 1301 is miscible in all proportions in many organic solvents. Its solubility is usually greatest in compounds with similar chemical structures and least in those with different structures and properties. The solubility of Halon 1301 vapor in a number of solvents at 77°F and atmospheric pressure is shown in Table XII. Solubility varies, of course, with both temperature and pressure changes.

The solubility relationships of Du Pont Halon 1301 with water, carbon dioxide and nitrogen have been determined and are described in the following sections. In each case the solubility is a function of the pressure as well as the temperature.

Water

The solubility of Du Pont Halon 1301 in water has been measured at various temperatures and pressures. The results are given in Figure 1 in terms of pounds per gallon. The solubility at 77°F and a total pressure of 100 psia is 0.0017 gram of Halon 1301 per cc of water.

The solubility of water in liquid Halon 1301 is 95 ppm (0.0095 percent by weight) at 70°F.

Table XII

Solubility of Du Pont HALON 1301 in Various Liquids at Atmospheric Pressure and 77°F

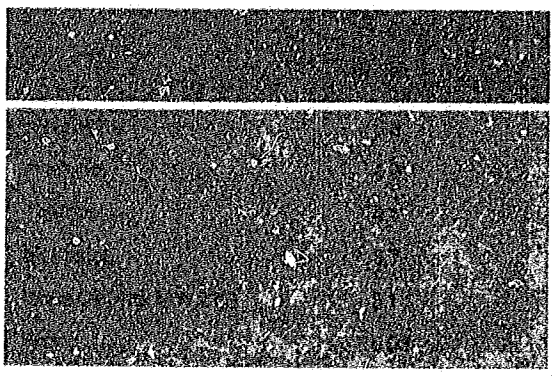
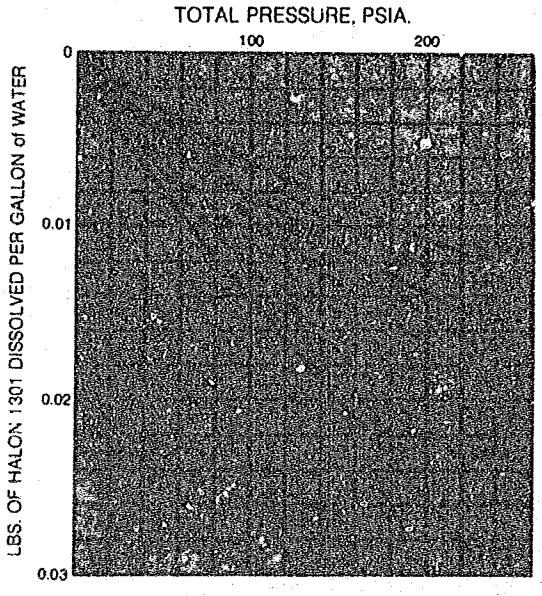


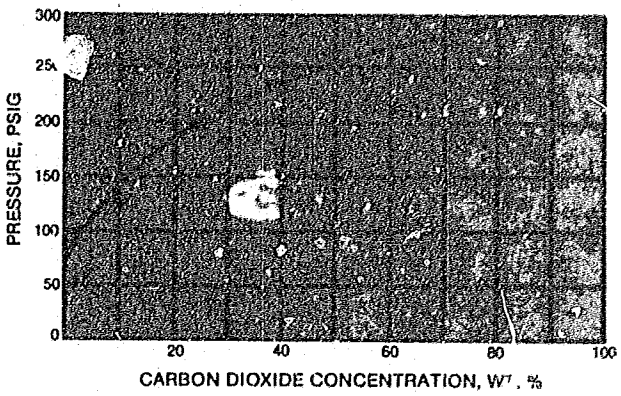
Figure 1
Solubility of Du Pont HALON 1301 in Water



Carbon Dioxide

The solubility of carbon dioxide in liquid Du Pont Halon 1301 is approximately that which is calculated from Raoult's Law. Measurement at room temperature and a total pressure of 300 psig showed the solubility to be about 30±5 mole percent. In Figure 2, the solubility of carbon dioxide in terms of weight percent in Halon 1301 at 0°F is shown. The curve is based on calculations using Raoult's Law.

Figure 2
Calculated Solubility of Carbon Dioxide at 0°F in Du Pont HALON 1301



Nitrogen

The solubility of nitrogen in the liquid phase of Du Pont Halon 1301 is low. However, when nitrogen is used as a pressuring gas for Halon 1301, the solubility characteristics will markedly affect the total container pressure obtained at a given temperature. As is usual for gases, the solubility in the liquid phase increases with increasing pressure. It decreases with increasing temperature to about 40°F, then increases again as the critical temperature (152°F) is approached.

Figure 3 shows the Henry's Law Constant, H_x, for solubility of nitrogen in liquid Halon 1301 at various temperatures, based on experimental data. Henry's Law Constant is defined as:

$$H_x = \frac{\bar{P}_n}{x_n}$$

Where H_x = Henry's Law constant, psi per mole fraction

$\bar{P}_n$ = Partial pressure of nitrogen in vapor phase, psia

x_n = Composition of nitrogen in liquid phase, mole fraction

When the temperature and total system pressure are known, the nitrogen partial pressure may be calculated as follows:

$$\bar{P}_n = P_T - (1 - x_n)\, P_{1301}$$

Where P_T = total system pressure, psia

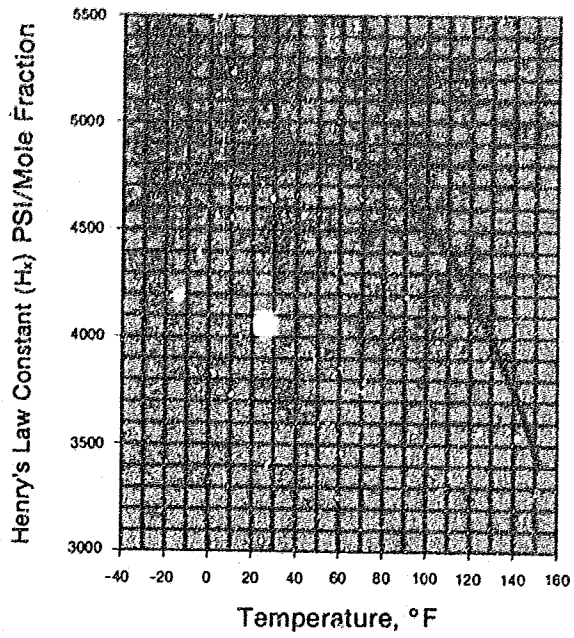
P_{1301} = Vapor pressure of Halon 1301, psia

These two relationships may be combined to permit direct solution for x_n:

$$x_n = \frac{P_T - P_{1301}}{H_x - P_{1301}}$$

Values of vapor pressure for Halon 1301 are given in Table V. These values must be converted to absolute pressure (psig + 14.7) before applying them in the above formulas.

Figure 3
Henry's Law Constant for Nitrogen Solubility in Liquid for Du Pont Halon 1301



XI CONTAINERS

Du Pont Halon 1301 is shipped in containers meeting DOT regulations. Table XIII gives information on volumes and dimensions.

Table XIII
Domestic Shipping Containers for Du Pont Halon 1301

Description	Contents Lbs. Halon 1301	Total Volume Cu.Ft.	Dimensions Length, In.	Dimensions O.D., In.	D.O.T Specification
Small Cylinder*	150	[illegible]	[illegible]	10.2	4BA400
Tank*	[illegible]	[illegible]	[illegible]	30.0	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]**	[illegible]
Tank*	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Tank*	[illegible]	2071.000		Varies	[illegible]

*Dimensions will vary slightly
**Outside width of frame.

XII ADDITIONAL BULLETINS

Additional technical bulletins on Du Pont Halon 1301 are available on request.

Du Pont HALON 1301... A Fast, Safe, Clean Way To Put Out Fire

Halon 1301 is a colorless, odorless, electrically non-conductive vapor that puts out fire differently than any other extinguishing agent. Most other extinguishants — CO_2, water or foam — work physically. They attack fire by smothering, cooling or separating fuel from oxygen.

Halon 1301 works chemically to halt fire. It actually stops the combustion process itself — breaks the chain reactions which propagate from one fuel molecule to another. That's why Halon 1301 puts out fire faster. And it prevents rekindling or reflash as long as the initial concentration of Halon in the area's atmosphere is maintained. Furthermore, Du Pont Halon 1301 is low in toxicity, does no damage to property and leaves no residue behind to clean up.

Consider The Effect Of Other Extinguishants On What You're Protecting

If your responsibility is to protect buildings or equipment of high value or high risk, you'd probably choose an automatic extinguishing system. Up till now, choosing the right system has depended on your willingness to compromise with the problems and limitations inherent in the available extinguishing agents. With water, for example, you'd have to determine whether the value of what you're protecting would change if it got wet. If not, and if there's no water supply problem, then a sprinkler system would probably suffice. Or perhaps the small amount of water associated with a high expansion foam system wouldn't harm your equipment or material, so foam could be your answer.

Dry chemical systems are good for particular applications, also. But they do leave quite a mess to clean up, and sometimes the chemical powder causes damage to machines or materials.

Carbon dioxide systems suppress fire by displacing air in the room. So there is a life hazard — people must exit before the system can operate, because oxygen levels would be reduced below life-support levels. It takes time for people to get out — time that allows fire to grow to damaging proportions before it can be extinguished. And, although CO_2 leaves no residue, it can cause a "fog" which obscures vision in the fire area.

If you refuse to compromise protection with the limitation of these extinguishants, and thus you've delayed installing automatic fire extinguishing systems, consider Halon 1301. It doesn't harm property, and it extinguishes fire faster than any other method — *it can even stop fire while people are getting out!*

Even A Small Delay Can Have A Serious Impact On Sensitive Equipment

Heat can threaten computer tapes.

After fire is out, records may be lost even though building is saved.

Ask Yourself These Questions About Your Own Hazard Area

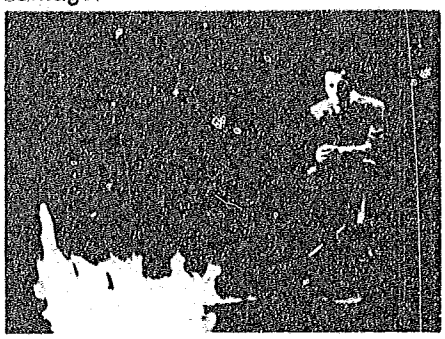
1. Does the hazard area represent a high concentration of value?
2. If you are depending on human detection of a fire, are there times when no one is there?
3. Would loss of equipment or operations in the area result in a substantial economic burden or jeopardize safety?
4. Would loss of the operation in the hazard area cause significant interruptions in business?
5. Does risk analysis indicate high potential loss?
6. Does the area contain a combustible material or configuration in which fire would tend to spread rapidly?
7. Does the hazard area contain sensitive materials or equipment which might be damaged by extinguishing agents?
8. Are there cabinets or barriers that would keep most agents from reaching the fire?

If Your Answer To Any Of These Questions Is Yes, You Should Look Further Into An Automatic Total Flooding System Using Du Pont Halon 1301

Important Facts You Should Know About Du Pont HALON 1301

Stops Fire Faster Than Any Other Method

Halon 1301 works differently than other fire extinguishants. It doesn't "fight" fire. It stops it chemically in seconds — actually breaks the "chain" of the combustion process. What's more, Halon 1301 systems can be discharged as soon as fire is detected, even while people are in the fire area. By releasing extinguishant while people are clearing the area, the fire is put out sooner, before it can do much damage.



Purposely set fire demonstrates effectiveness of total flooding system using Halon 1301.

Within seconds, fire is completely out and man has time to leave the area.

National Fire Protection Association Standard

Halon 1301 is effective against a wide range of different types of fires. National Fire Protection Association's Standard 12A gives specifications for systems using Halon 1301 which are effective for Class A (paper, wood or other cellulous materials), Class B (paint, solvent, gasoline and other flammable liquids) and Class C (electrical) fires.

Simpler Design of Systems Using Halon 1301 Gives You Installation Advantages

Design of systems using Halon 1301 extinguishant is simpler, because less extinguishant has to be moved from storage to nozzles.

Since Halon 1301 is a liquid in the storage container and changes to a vapor only after it leaves the nozzle, small diameter piping can be used. And, because fewer nozzles are required, less piping has to be installed. To simplify design even further, time delays and pre-discharge alarms can be eliminated — personnel can be leaving the fire area while the extinguishant is being released, because of the low toxicity of Halon 1301.

With fewer pipes and nozzles needed and less storage space required, systems using Halon 1301 are more easily concealed, and less apt to interfere with the esthetics of building and room decor. And more valuable floor space can be devoted to other preferred uses.

The variables involved in systems for different applications actually determine the costs. The costs of total flooding systems using Halon 1301 will depend on the size of the area, the amount and type of detection, piping, and distribution systems required, and the concentrations of 1301 needed.

The degree of sophistication in detection, piping and discharge systems can affect the system cost. Also, the amount of Halon 1301 needed will vary with the materials protected. Fires that feed on most hydrocarbon fuels (kerosene, methane or propane) are easily extinguished with 5% Halon 1301 by volume. A five percent concentration will also provide a high degree of control in wood or paper fires. Since fires involving some fuels or configurations may require concentrations higher than 5%, a reputable fire equipment distributor should be consulted.

Compared to water sprinkler systems, generally, total flooding systems using Halon are more expensive, but they put out the fire faster and *eliminate the extinguishing agent damage problem.* You have to decide how much those advantages are worth.

Compared to systems using other gaseous agents, the systems using Halon 1301 are usually less expensive. Although the agents, themselves, cost less per pound, the installation costs of these other systems may be substantially higher, which results in a higher total cost than for systems using Halon 1301. For example, the average labor and hardware cost for systems using Halon 1301 is about 40% of the cost for a carbon dioxide system for the same application. (The system with Halon requires less piping and about one-fifth the number of cylinders.) Also, systems using Halon 1301 can be discharged immediately upon detection of fire — so while people are leaving the area, Halon is already putting out the fire. The other gaseous systems require that all personnel vacate the area before the agent is released; this gives the fire time to build, and then it's harder to extinguish. Another significant point, Halon doesn't cause moisture condensation in the protected area to the degree that some other gaseous agents do. *So in comparing Halon versus other gaseous agent systems, you can consider both cost and performance advantages of Halon 1301.*

Actually, your concern is probably not the costs for individual components of various systems, but the best total fire protection system for your particular application at the lowest total cost. And, since systems using Du Pont Halon 1301 offer you unique advantages at competitive prices, you really ought to take another look at automatic Halon 1301 fire protection. It might change your whole life — or even save it.

Only Du Pont HALON 1301 Puts Out Fire Fast Without Harming Life or Property

Is Halon 1301 safe? Will it hurt people? Can you breathe it? Why is it safe to breathe? Just what *is* the effect on people?

Halon 1301 is a vapor that works chemically to stop the combustion process itself. Total flooding systems charged with 1301 will extinguish most fires within seconds after they are detected by automatic devices. Only a 5% concentration by volume is needed to stop most fires, leaving plenty of oxygen in the air for people to breathe while they leave the fire area. These systems are carefully engineered so that the amount of 1301 put into the system cannot

(cont'd., pg. 4)

Animal vs. Human Studies

It has only recently become known that many common and frequently encountered materials can have an unusual effect upon the animal or human heart. Things like chloroform, gasoline, paint thinner, various volatile solvents, if inhaled in sufficient quantity, can make the heart very sensitive to a major upset in rhythm (called "arrhythmia"). Excitement and stress in a human or animal can cause high adrenaline levels, which can also cause a heart arrhythmia or irregular heart action. The combination of exposure to high

concentrations of one of these various vapors *PLUS* high levels of adrenaline, seems to be a much more serious hazard than either of these situations separately.

Since some of the fluorcarbon materials have been shown to be "sensitizers" in this sense, Halon 1301 was studied for this effect by several investigators.

- **A Haskell Laboratory** study with dogs (which is the species used widely to study this effect) showed no irregularities in heart action when the animals were exposed to concentrations of Halon 1301 up to 20% in air and without administering *injections* of adrenaline. However, large injections of adrenaline plus a 10% concentration of Halon 1301 in these same dogs produced arrhythmias. In addition, one dog (out of 18) responded at 7½% and five minutes' exposure.
- **The Hine Laboratories** were unable to produce ventricular fibrillation (rapid uncoordinated arrhythmias) in the hearts of dogs exposed to concentrations up to 40% Halon 1301, when the dogs were frightened to produce high levels of *natural* adrenaline. Convulsions and tremors were observed at higher Halon concentrations.
- **Aerospace Medical Laboratories** used 40% or more Halon 1301 to demonstrate spontaneous cardiac arrhythmias in dogs and monkeys.

Although these studies and others vary somewhat as to the extent of effect of high concentrations upon various animals, they all agree that the low concentration levels and exposure times shown in the previous section will not result in the hazard of heart sensitization to arrhythmias.

Human Studies Prove Degree of Safety

Encouraged by the relatively low acute toxicity of Halon 1301 as determined in animal tests, several laboratories have conducted exposures with humans.

Haskell Laboratory exposed three persons to Halon 1301 concentrations up to 10% for three to four minutes. At concentrations below 7% by volume, no effects were observed. Higher concentrations produced lightheadedness and slight difficulty in mental concentration with a suggestion of a slight disturbance in equilibrium and reaction time. Electrocardiograms recorded throughout these exposures did not reveal any disturbance in cardiac rhythm.

Hine Laboratories exposed 10 people to Halon 1301 concentrations up to 17% and for times up to 20 minutes. Subjects exposed to higher than 7% Halon 1301 experienced feelings of lightheadedness and reduced dexterity, which increased in intensity with increasing Halon concentration. At concentrations below 10%, the effects were not considered serious.

In an extensive study at Medical College in Wisconsin, three subjects were exposed to Halon 1301 at airborne levels of 0.1 to 7.1% for up to 30 minutes. Subjects' health was monitored before, during and after exposure. Monitoring included a physical examination, electrocardiograms, electroencephalograms, clinical blood chemistry, mood evaluation, tests of eye-hand coordination, short-term memory, reaction time, depth perception, balance, walking, writing and speaking. A brief reduction in one subject's coordination was observed at 4.5 and 7.1% during exposure but this was not considered serious enough to prevent the subject from exiting a protected area; response was normal within an hour after exposure. All other monitoring results were within normal limits.

Conclusions

Based on over 20 years of practical use experience, Halon 1301 fire extinguishant has not proven harmful to people when discharged in their presence.

Exposures to concentrations greater than 10% carry a degree of risk to personnel and should be avoided in normally occupied spaces.

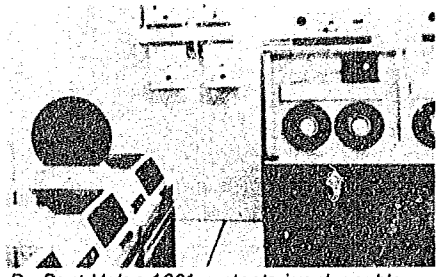
Furthermore, over 25 years of medical research on both test animals and humans has proven that Halon 1301 in concentrations up to 7% by volume can be used with a high degree of safety.

(cont'd. from pg. 3)

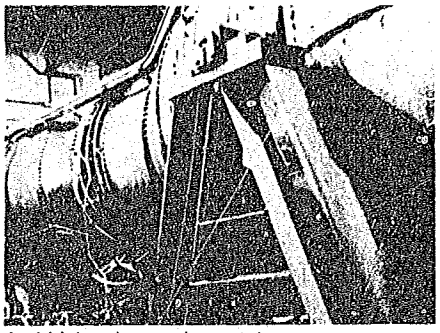
exceed the design concentration when released in the volume of the area to be protected. Halon is clean, too. It doesn't damage equipment because it leaves no water, foam, powder or other residue behind.

Du Pont Halon 1301 has been used in combating fires for over 30 years without a single reported injury resulting from exposure to its vapor. In fact, thousands of demonstrations have occured across the U.S. with people purposely experiencing exposure to proper concentrations of Halon 1301 without harmful effects.

The proven low toxicity of Halon 1301 is the major reason why the National Fire Protection Association recognizes Halon 1301 as the only



Du Pont Halon 1301 protects irreplaceable business data —



And high value equipment, too.

gaseous agent accepted for use in occupied areas. Also, Underwriters' Laboratories, Inc., classifies Halon 1301 in toxicity group 6 — the group of lowest toxicity of the six defined. And Halon 1301 is the *only* gaseous extinguishing agent in group 6.

Moreover, the speed with which Halon 1301 extinguishes fires provides the greatest safety factor of all. Smoke, heat, carbon monoxide and oxygen depletion — all present in every fire — create hazards to personnel which are often recognized too late. Fast extinguishment of fire at its inception greatly reduces these hazards.

Animal Studies Prove Low Toxicity

The low toxcity of Halon 1301 vapor when inhaled has been determined by many nationally recognized U.S. medical laboratories and one French investigator through studies with animals. These investigators include:

- **U.S. Army Chemical Center,** in 1950, determined the approximate lethal concentration of Halon 1301 vapor to rats to be 83.2% by volume in air for a 15-minute exposure.
- **Underwriters' Laboratories, Inc.,** in 1955, confirmed with guinea pigs the low toxicity of Halon 1301. Results of these tests showed no effect with exposures up to 20% Halon 1301 in air for two hours.
- **Kettering Laboratory** exposed animals to Halon 1301 concentrations up to 32% for seven hours without harm.
- **Haskell Laboratory** evaluated the teratogenic potential of Halon 1301 in rats. Pregnant rats were exposed to airborne levels of up to 5% Halon 1301 during the organ development or critical stages of gestation. Results of this test showed Halon 1301 was not embryotoxic or teratogenic.
- **G. Paulet of France** went even further. He exposed rabbits, mice, guinea pigs and rats to Halon concentrations up to 80%. (20% oxygen) for two hours a day for 15 consecutive days without producing death. No signs of toxic effect were found when the animals were exposed to 50% Halon 1301 (maintaining 20% oxygen) for two hours a day for 15 consecutive days.
- **Hazelton Laboratories** exposed animals, including monkeys, to concentrations up to 20% Halon 1301 in air for two hours with no observable changes in blood chemistry during or after exposure.

  In addition, Halon 1301 was not mutagenic when tested in the
- **Salmonella**/microsome assay (Ames test).

30 Years Medical Research

The safety of Halon 1301 has been established not ony through practical experience but also through more than 30 years of medical research involving both test animals and humans. Based on results of these tests, the National Fire Protection Association has set up the following guidelines for the use of Halon 1301 in occupied areas.

Concentration by Volume	Length of Time for Human Exposure
7% or lower	15 minutes
7-10%	1 minute
10-15%	30 seconds
Above 15%	Prevent exposure

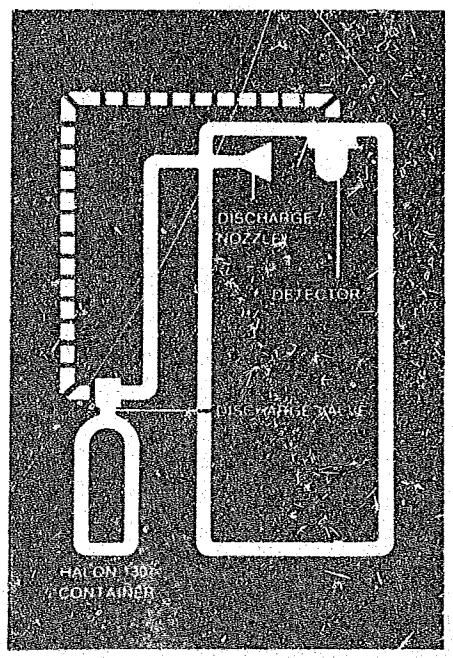
Since fires of most combustible materials can be quickly extinguished with Halon 1301 at concentrations of 7% or less by volume, the vapor presents little or no danger to personnel. Tests also show that people may inhale these concentration levels up to 15 minutes without risk of cardiac or harmful central nervous system effects.

But what happens if Halon 1301 is released during a very hot fire? Does it decompose into harmful by-products? Research has determined the answer to that as well.

As Halon 1301 ($CBrF_3$) extinguishes a fire, it produces primarily hydrogen bromide (HBr) and hydrogen fluoride (HF). In most fire situations where Halon 1301 automatic protection systems are used, the concentrations of HF and HBr have been found to be below 20 parts per million (ppm) — often barely detectable to the nose. Severe fire tests indicate larger amounts of HF (200 to 300 ppm) and HBr (40 to 50 ppm) are produced when Halon 1301 decomposes while extinguishing a large, hot fire. Such concentrations are noxious and irritating and may be harmful if exposure is prolonged.

Generally, decomposition products from the fire itself, especially carbon monoxide, smoke, heat and oxygen depletion, create a greater hazard than the thermal decomposition products of Halon. Fortunately, the irritating nature of Halon decomposition products provides a built-in alarm to warn personnel well in advance of toxic levels.

Typical Layout of Total Flooding System Using Halon 1301



Detectors

The thermal detector is triggered by a combination of fixed temperature and rate of temperature rise. The ionization detector senses smoldering fires long before substantial quantities of smoke or heat are produced. Also available are optical detectors that "see" flames or detect smoke concentrations.

Containers

Pressure vessels are used to store Du Pont Halon 1301. Since so little Halon is required to extinguish fires, these containers use very little storage space. These containers may be cylinders, spheres or tanks.

Distribution

This consists of piping, valves and discharge nozzles. There are various nozzle designs available, all engineered to mix Halon 1301 quickly and thoroughly with air.

Only One Fire Extinguishant Stops Fire Fast Without Harming People or Property*...

Du Pont Halon

1301

FIRE EXTINGUISHANT

For more information on Halon 1301, write:

Du Pont Company
Fire Extinguishants
Canby Mill Building
Barley Mill Plaza
Wilmington, Delaware 19898

or call
toll free (800) 441-9450
ask for extension 47381

*When used in accordance with NFPA Standard 12A

DU PONT

REG. U.S. PAT. & TM. OFF.

Printed in U.S.A.

E-43977

DU PONT

Better Things for Better Living Through Chemistry

FREON

REG. U.S. PAT. OFF.

T-13B1

Technical Bulletin

Attachment 5

THERMODYNAMIC PROPERTIES OF FREON-13B1® REFRIGERANT

REFRIGERANT

(BROMOTRIFLUOROMETHANE)

DU PONT

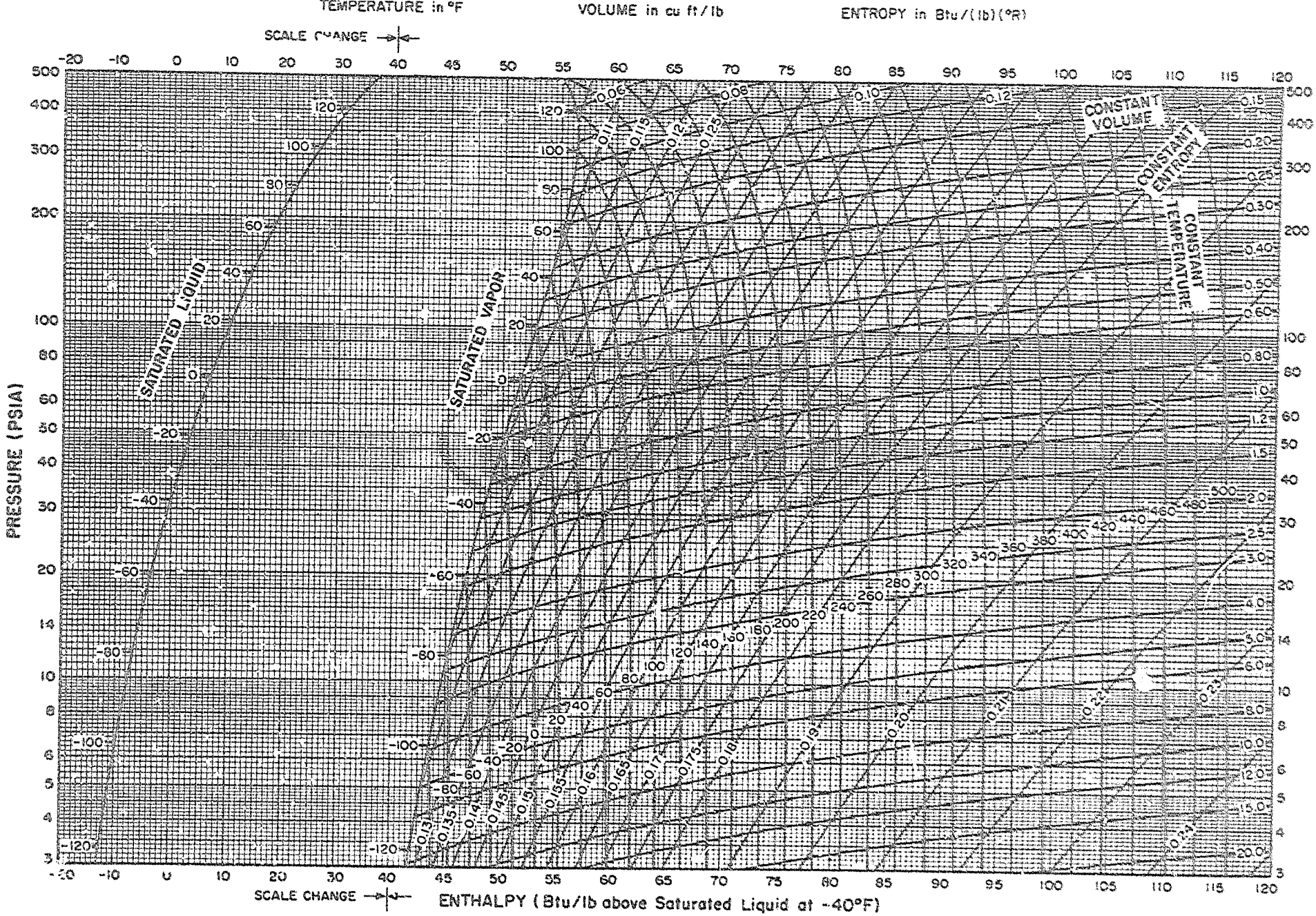
BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

COPYRIGHT 1963
E. I. du Pont de Nemours & Co. (Inc.), Wilmington, Delaware 19898

Not to be reprinted in whole or in part without permission of the copyright owner.

"FREON" PRODUCTS DIVISION
ORGANIC CHEMICALS DEPARTMENT

E. I. DU PONT DE NEMOURS & COMPANY (INC.)
WILMINGTON, DELAWARE 19898



"FREON" PRODUCTS DIVISION

Copyright 1963, E. I. du Pont de Nemours & Company (Inc.)

TABLE 1 "FREON-13B1" - SATURATION PROPERTIES

TEMP. °F	PRESSURE		VOLUME cu ft/lb		DENSITY lb/cu ft		ENTHALPY Btu/lb			ENTROPY Btu/(lb)(°R)		TEMP. °F
	PSIA	PSIG	LIQUID V_f	VAPOR V_g	LIQUID $1/V_f$	VAPOR $1/V_g$	LIQUID h_f	LATENT h_{fg}	VAPOR h_g	LIQUID S_f	VAPOR S_g	
-160	0.6380	28.62*	0.00731	33.748	136.73	0.0296	-18.51	57.11	38.60	-0.0516	0.1389	-160
-159	0.6691	28.56*	0.00732	32.281	136.59	0.0310	-18.36	57.04	38.68	-0.0511	0.1386	-159
-158	0.7015	28.49*	0.00733	30.889	136.46	0.0324	-18.22	56.97	38.76	-0.0507	0.1382	-158
-157	0.7353	28.42*	0.00734	29.567	136.33	0.0338	-18.07	56.91	38.84	-0.0502	0.1378	-157
-156	0.7703	28.35*	0.00734	28.312	136.20	0.0353	-17.93	56.84	38.92	-0.0497	0.1375	-156
-155	0.8067	28.28*	0.00735	27.119	136.07	0.0369	-17.78	56.78	39.00	-0.0492	0.1371	-155
-154	0.8446	28.20*	0.00736	25.985	135.94	0.0385	-17.63	56.71	39.08	-0.0487	0.1368	-154
-153	0.8839	28.12*	0.00736	24.906	135.80	0.0402	-17.49	56.65	39.16	-0.0482	0.1364	-153
-152	0.9248	28.04*	0.00737	23.881	135.67	0.0419	-17.34	56.58	39.24	-0.0478	0.1361	-152
-151	0.9672	27.95*	0.00738	22.904	135.54	0.0437	-17.19	56.52	39.32	-0.0473	0.1358	-151
-150	1.011	27.86*	0.00739	21.975	135.41	0.0455	-17.05	56.45	39.40	-0.0468	0.1355	-150
-149	1.057	27.77*	0.00739	21.090	135.27	0.0474	-16.90	56.38	39.48	-0.0464	0.1351	-149
-148	1.104	27.67*	0.00740	20.247	135.14	0.0494	-16.75	56.32	39.57	-0.0459	0.1348	-148
-147	1.153	27.57*	0.00741	19.444	135.01	0.0514	-16.61	56.25	39.65	-0.0454	0.1345	-147
-146	1.204	27.47*	0.00741	18.678	134.87	0.0535	-16.46	56.19	39.73	-0.0449	0.1342	-146
-145	1.257	27.36*	0.00742	17.948	134.74	0.0557	-16.31	56.12	39.81	-0.0445	0.1339	-145
-144	1.312	27.25*	0.00743	17.252	134.61	0.0580	-16.17	56.06	39.89	-0.0440	0.1336	-144
-143	1.368	27.13*	0.00744	16.587	134.47	0.0603	-16.02	55.99	39.97	-0.0435	0.1335	-143
-142	1.427	27.01*	0.00744	15.953	134.34	0.0627	-15.87	55.93	40.06	-0.0431	0.1330	-142
-141	1.488	26.89*	0.00745	15.348	134.20	0.0652	-15.73	55.86	40.14	-0.0426	0.1327	-141
-140	1.551	26.76*	0.00746	14.769	134.07	0.0677	-15.58	55.80	40.22	-0.0422	0.1324	-140
-139	1.616	26.63*	0.00747	14.217	133.93	0.0703	-15.43	55.73	40.30	-0.0417	0.1321	-139
-138	1.683	26.49*	0.00747	13.689	133.80	0.0731	-15.28	55.67	40.38	-0.0412	0.1318	-138
-137	1.752	26.35*	0.00748	13.184	133.66	0.0758	-15.14	55.60	40.47	-0.0408	0.1315	-137
-136	1.824	26.21*	0.00749	12.701	133.53	0.0787	-14.99	55.53	40.55	-0.0403	0.1312	-136
-135	1.898	26.06*	0.00750	12.239	133.39	0.0817	-14.84	55.47	40.63	-0.0399	0.1310	-135
-134	1.975	25.90*	0.00750	11.797	133.26	0.0848	-14.69	55.40	40.71	-0.0394	0.1307	-134
-133	2.054	25.74*	0.00751	11.375	133.12	0.0879	-14.54	55.34	40.79	-0.0390	0.1304	-133
-132	2.136	25.57*	0.00752	10.970	132.98	0.0912	-14.40	55.27	40.88	-0.0385	0.1302	-132
-131	2.221	25.40*	0.00753	10.582	132.85	0.0945	-14.25	55.21	40.96	-0.0381	0.1299	-131
-130	2.308	25.22*	0.00754	10.211	132.71	0.0979	-14.10	55.14	41.04	-0.0376	0.1296	-130
-129	2.398	25.04*	0.00754	9.8550	132.57	0.1015	-13.95	55.08	41.12	-0.0372	0.1294	-129
-128	2.491	24.85*	0.00755	9.5140	132.44	0.1051	-13.80	55.01	41.21	-0.0367	0.1291	-128
-127	2.586	24.65*	0.00756	9.1870	132.30	0.1088	-13.65	54.94	41.29	-0.0363	0.1289	-127
-126	2.685	24.45*	0.00757	8.8735	132.16	0.1127	-13.50	54.88	41.37	-0.0358	0.1286	-126
-125	2.787	24.25*	0.00757	8.5727	132.02	0.1166	-13.36	54.81	41.46	-0.0354	0.1284	-125
-124	2.892	24.03*	0.00758	8.2841	131.89	0.1207	-13.21	54.75	41.54	-0.0349	0.1282	-124
-123	3.000	23.81*	0.00759	8.0072	131.75	0.1249	-13.06	54.68	41.62	-0.0345	0.1279	-123
-122	3.111	23.59*	0.00760	7.7413	131.61	0.1292	-12.91	54.61	41.70	-0.0340	0.1277	-122
-121	3.226	23.35*	0.00761	7.4859	131.47	0.1336	-12.76	54.55	41.79	-0.0336	0.1274	-121
-120	3.344	23.11*	0.00761	7.2407	131.33	0.1381	-12.61	54.48	41.87	-0.0332	0.1272	-120
-119	3.465	22.86*	0.00762	7.0051	131.19	0.1428	-12.46	54.41	41.95	-0.0327	0.1270	-119
-118	3.591	22.61*	0.00763	6.7787	131.05	0.1475	-12.31	54.35	42.04	-0.0323	0.1268	-118
-117	3.719	22.35*	0.00764	6.5610	130.91	0.1524	-12.16	54.28	42.12	-0.0318	0.1265	-117
-116	3.852	22.08*	0.00765	6.3518	130.77	0.1574	-12.01	54.21	42.20	-0.0314	0.1263	-116
-115	3.988	21.80*	0.00765	6.1505	130.63	0.1626	-11.86	54.14	42.29	-0.0310	0.1261	-115
-114	4.128	21.52*	0.00766	5.9570	130.49	0.1679	-11.71	54.08	42.37	0.0305	0.1259	-114
-113	4.272	21.22*	0.00767	5.7707	130.35	0.1733	-11.56	54.01	42.45	0.0301	0.1257	-113
-112	4.420	20.92*	0.00768	5.5915	130.21	0.1788	-11.41	53.94	42.54	0.0297	0.1255	-112
-111	4.573	20.61*	0.00769	5.4189	130.07	0.1845	-11.25	53.87	42.62	0.0292	0.1253	-111
-110	4.729	20.29*	0.00770	5.2528	129.93	0.1904	-11.10	53.81	42.70	0.0288	0.1251	-110
-109	4.890	19.96*	0.00770	5.0928	129.79	0.1964	-10.95	53.74	42.79	0.0284	0.1249	-109
-108	5.055	19.63*	0.00771	4.9386	129.65	0.2025	-10.80	53.67	42.87	0.0279	0.1247	-108
-107	5.224	19.28*	0.00772	4.7901	129.51	0.2088	-10.65	53.60	42.95	0.0275	0.1245	-107
-106	5.398	18.93*	0.00773	4.6470	129.36	0.2152	-10.50	53.53	43.04	0.0271	0.1243	-106

*Inches of mercury below one atmosphere

TABLE 1 "FREON-13B1" - SATURATION PROPERTIES

TEMP. °F	PRESSURE PSIA	PRESSURE PSIG	VOLUME cu ft/lb LIQUID V_f	VOLUME cu ft/lb VAPOR V_g	DENSITY lb/cu ft LIQUID $1/V_f$	DENSITY lb/cu ft VAPOR $1/V_g$	ENTHALPY Btu/lb LIQUID h_f	ENTHALPY Btu/lb LATENT h_{fg}	ENTHALPY Btu/lb VAPOR h_g	ENTROPY Btu/(lb×°F) LIQUID s_f	ENTROPY Btu/(lb×°F) VAPOR s_g	TEMP. °F
-105	5.577	18.57*	0.00774	4.5090	129.22	0.2218	-10.34	53.46	43.12	0.0266	0.1241	-105
-104	5.760	18.19*	0.00775	4.3760	129.08	0.2285	-10.19	53.40	43.20	0.0262	0.1239	-104
-103	5.948	17.81*	0.00776	4.2477	128.94	0.2354	-10.04	53.33	43.29	0.0258	0.1237	-103
-102	6.141	17.42*	0.00776	4.1240	128.79	0.2425	-9.89	53.26	43.37	0.0254	0.1235	-102
-101	6.339	17.01*	0.00777	4.0046	128.65	0.2497	-9.73	53.19	43.46	0.0249	0.1233	-101
-100	6.542	16.60*	0.00778	3.8894	128.51	0.2571	-9.58	53.12	43.54	0.0245	0.1232	-100
-99	6.750	16.18*	0.00779	3.7782	128.36	0.2647	-9.43	53.05	43.62	0.0241	0.1230	-99
-98	6.964	15.74*	0.00780	3.6709	128.22	0.2724	-9.27	52.98	43.71	0.0237	0.1228	-98
-97	7.183	15.30*	0.00781	3.5672	128.07	0.2803	-9.12	52.91	43.79	0.0232	0.1226	-97
-96	7.407	14.84*	0.00782	3.4671	127.93	0.2884	-8.97	52.84	43.87	0.0228	0.1225	-96
-95	7.637	14.37*	0.00783	3.3704	127.78	0.2967	-8.81	52.77	43.96	0.0224	0.1223	-95
-94	7.872	13.89*	0.00783	3.2770	127.64	0.3052	-8.66	52.70	44.04	0.0220	0.1221	-94
-93	8.113	13.40*	0.00784	3.1867	127.49	0.3138	-8.50	52.62	44.12	0.0216	0.1220	-93
-92	8.360	12.90*	0.00785	3.0994	127.35	0.3226	-8.35	52.55	44.20	0.0211	0.1218	-92
-91	8.613	12.39*	0.00786	3.0150	127.20	0.3317	-8.19	52.48	44.29	0.0207	0.1216	-91
-90	8.871	11.86*	0.00787	2.9335	127.06	0.3409	-8.04	52.41	44.37	0.0203	0.1215	-90
-89	9.136	11.32*	0.00788	2.8546	126.91	0.3503	-7.88	52.34	44.46	0.0199	0.1213	-89
-88	9.408	10.77*	0.00789	2.7782	126.76	0.3599	-7.73	52.27	44.54	0.0195	0.1212	-88
-87	9.685	10.20*	0.00790	2.7044	126.61	0.3698	-7.57	52.19	44.62	0.0190	0.1210	-87
-86	9.969	9.62*	0.00791	2.6329	126.47	0.3798	-7.42	52.12	44.70	0.0186	0.1209	-86
-85	10.26	9.03*	0.00792	2.5638	126.32	0.3900	-7.26	52.05	44.79	0.0182	0.1207	-85
-84	10.56	8.43*	0.00793	2.4968	126.17	0.4005	-7.10	51.97	44.87	0.0178	0.1206	-84
-83	10.86	7.81*	0.00794	2.4320	126.02	0.4112	-6.95	51.90	44.95	0.0174	0.1204	-83
-82	11.17	7.18*	0.00794	2.3692	125.88	0.4221	-6.79	51.83	45.04	0.0170	0.1203	-82
-81	11.49	6.53*	0.00795	2.3084	125.73	0.4332	-6.63	51.75	45.12	0.0165	0.1201	-81
-80	11.81	5.87*	0.00796	2.2495	125.58	0.4445	-6.48	51.68	45.20	0.0161	0.1200	-80
-79	12.14	5.19*	0.00797	2.1925	125.43	0.4561	-6.32	51.61	45.29	0.0157	0.1198	-79
-78	12.48	4.50*	0.00798	2.1372	125.28	0.4679	-6.16	51.53	45.37	0.0153	0.1197	-78
-77	12.83	3.80*	0.00799	2.0835	125.13	0.4800	-6.00	51.45	45.45	0.0149	0.1196	-77
-76	13.18	3.08*	0.00800	2.0316	124.98	0.4922	-5.85	51.38	45.54	0.0145	0.1194	-76
-75	13.55	2.34*	0.00801	1.9812	124.83	0.5047	-5.69	51.31	45.62	0.0141	0.1193	-75
-74	13.91	1.59*	0.00802	1.9323	124.68	0.5175	-5.53	51.23	45.70	0.0137	0.1192	-74
-73	14.29	0.82*	0.00803	1.8849	124.53	0.5305	-5.37	51.16	45.79	0.0133	0.1190	-73
-72	14.68	0.04*	0.00804	1.8390	124.37	0.5438	-5.21	51.08	45.87	0.0128	0.1189	-72
-71	15.07	0.37	0.00805	1.7944	124.22	0.5573	-5.05	51.00	45.95	0.0124	0.1188	-71
-70	15.47	0.77	0.00806	1.7511	124.07	0.5711	-4.89	50.93	46.03	0.0120	0.1187	-70
-69	15.88	1.18	0.00807	1.7091	123.92	0.5851	-4.73	50.85	46.12	0.0116	0.1185	-69
-68	16.30	1.60	0.00808	1.6683	123.77	0.5994	-4.57	50.77	46.20	0.0112	0.1184	-68
-67	16.72	2.03	0.00809	1.6287	123.61	0.6140	-4.41	50.69	46.28	-0.0108	0.1183	-67
-66	17.16	2.46	0.00810	1.5903	123.46	0.6288	-4.25	50.61	46.36	-0.0104	0.1182	-66
-65	17.60	2.91	0.00811	1.5529	123.31	0.6439	-4.09	50.54	46.45	-0.0100	0.1180	-65
-64	18.05	3.36	0.00812	1.5167	123.15	0.6593	-3.93	50.46	46.53	-0.0096	0.1179	-64
-63	18.51	3.82	0.00813	1.4814	123.00	0.6750	-3.77	50.38	46.61	-0.0092	0.1178	-63
-62	18.99	4.29	0.00814	1.4472	122.84	0.6910	-3.61	50.30	46.69	-0.0088	0.1177	-62
-61	19.46	4.77	0.00815	1.4139	122.69	0.7072	-3.45	50.22	46.77	-0.0084	0.1176	-61
-60	19.95	5.26	0.00816	1.3816	122.53	0.7238	-3.29	50.14	46.85	-0.0080	0.1175	-60
-59	20.45	5.76	0.00817	1.3502	122.38	0.7406	-3.12	50.06	46.94	-0.0076	0.1174	-59
-58	20.96	6.26	0.00818	1.3196	122.22	0.7578	-2.96	49.98	47.02	-0.0072	0.1173	-58
-57	21.48	6.78	0.00819	1.2899	122.06	0.7752	-2.80	49.90	47.10	-0.0068	0.1171	-57
-56	22.00	7.31	0.00820	1.2611	121.91	0.7930	-2.64	49.82	47.18	-0.0064	0.1170	-56
-55	22.54	7.85	0.00821	1.2330	121.75	0.8111	-2.47	49.73	47.26	-0.0060	0.1169	-55
-54	23.09	8.39	0.00822	1.2056	121.59	0.8294	-2.31	49.65	47.34	-0.0056	0.1168	-54
-53	23.65	8.95	0.00823	1.1790	121.44	0.8482	-2.15	49.57	47.42	-0.0052	0.1167	-53
-52	24.21	9.52	0.00825	1.1532	121.28	0.8672	-1.98	49.49	47.51	-0.0048	0.1166	-52
-51	24.79	10.10	0.00826	1.1280	121.12	0.8865	-1.82	49.41	47.59	-0.0044	0.1165	-51

*Inches of mercury below one atmosphere

TABLE 1 "FREON-1331" - SATURATION PROPERTIES

TEMP. °F	PRESSURE		VOLUME cu ft/lb		DENSITY lb/cu ft		ENTHALPY Btu/lb			ENTROPY Btu/(lb)(°R)		TEMP. °F
	PSIA	PSIG	LIQUID V_f	VAPOR V_g	LIQUID $1/V_f$	VAPOR $1/V_g$	LIQUID h_f	LATENT h_{fg}	VAPOR h_g	LIQUID S_f	VAPOR S_g	
-50	25.38	10.69	0.00827	1.1035	120.96	0.9062	-1.65	49.32	47.67	-0.0040	0.1164	-50
-49	25.98	11.28	0.00828	1.0796	120.80	0.9263	-1.49	49.24	47.75	-0.0036	0.1163	-49
-48	26.59	11.89	0.00829	1.0564	120.64	0.9466	-1.33	49.16	47.83	-0.0032	0.1162	-48
-47	27.21	12.52	0.00830	1.0338	120.48	0.9673	-1.16	49.07	47.91	-0.0028	0.1161	-47
-46	27.84	13.15	0.00831	1.0118	120.32	0.9884	-1.00	48.99	47.99	-0.0024	0.1160	-46
-45	28.49	13.79	0.00832	0.9903	120.16	1.0098	-0.83	48.90	48.07	-0.0020	0.1159	-45
-44	29.14	14.45	0.00833	0.9694	120.00	1.0315	-0.66	48.81	48.15	-0.0016	0.1158	-44
-43	29.81	15.11	0.00834	0.9491	119.84	1.0537	-0.50	48.73	48.23	-0.0012	0.1158	-43
-42	30.49	15.79	0.00836	0.9292	119.68	1.0762	-0.33	48.64	48.31	-0.0008	0.1157	-42
-41	31.17	16.48	0.00837	0.9099	119.51	1.0990	-0.17	48.56	48.39	-0.0004	0.1156	-41
-40	31.88	17.18	0.00838	0.8911	119.35	1.1222	0.00	48.47	48.47	0.0000	0.1155	-40
-39	32.59	17.89	0.00839	0.8727	119.19	1.1459	0.17	48.38	48.55	0.0004	0.1154	-39
-38	33.31	18.62	0.00840	0.8548	119.02	1.1698	0.33	48.30	48.63	0.0008	0.1153	-38
-37	34.05	19.36	0.00841	0.8374	118.86	1.1942	0.50	48.21	48.71	0.0012	0.1152	-37
-36	34.80	20.11	0.00842	0.8203	118.70	1.2190	0.67	48.12	48.79	0.0016	0.1151	-36
-35	35.56	20.87	0.00844	0.8038	118.53	1.2442	0.84	48.03	48.87	0.0020	0.1151	-35
-34	36.34	21.64	0.00845	0.7876	118.37	1.2697	1.00	47.94	48.95	0.0024	0.1150	-34
-33	37.13	22.43	0.00846	0.7718	118.20	1.2957	1.17	47.85	49.02	0.0028	0.1149	-33
-32	37.93	23.23	0.00847	0.7564	118.04	1.3221	1.34	47.76	49.10	0.0031	0.1148	-32
-31	38.74	24.04	0.00848	0.7414	117.87	1.3489	1.51	47.67	49.18	0.0035	0.1147	-31
-30	39.57	24.87	0.00850	0.7267	117.70	1.3761	1.68	47.58	49.26	0.0039	0.1147	-30
-29	40.41	25.71	0.00851	0.7124	117.54	1.4037	1.85	47.49	49.34	0.0043	0.1146	-29
-28	41.26	26.56	0.00852	0.6984	117.37	1.4318	2.02	47.40	49.41	0.0047	0.1145	-28
-27	42.13	27.43	0.00853	0.6848	117.20	1.4603	2.19	47.30	49.49	0.0051	0.1144	-27
-26	43.01	28.31	0.00854	0.6715	117.03	1.4892	2.36	47.21	49.57	0.0055	0.1143	-26
-25	43.90	29.20	0.00856	0.6585	116.86	1.5186	2.53	47.12	49.65	0.0059	0.1143	-25
-24	44.81	30.11	0.00857	0.6458	116.69	1.5485	2.70	47.02	49.72	0.0063	0.1142	-24
-23	45.73	31.03	0.00858	0.6334	116.52	1.5787	2.87	46.93	49.80	0.0067	0.1141	-23
-22	46.67	31.97	0.00859	0.6213	116.35	1.6095	3.04	46.84	49.88	0.0070	0.1140	-22
-21	47.62	32.92	0.00861	0.6095	116.18	1.6407	3.21	46.74	49.95	0.0074	0.1140	-21
-20	48.58	33.89	0.00862	0.5979	116.01	1.6724	3.38	46.64	50.03	0.0078	0.1139	-20
-19	49.56	34.87	0.00863	0.5867	115.84	1.7046	3.56	46.55	50.11	0.0082	0.1138	-19
-18	50.56	35.86	0.00865	0.5756	115.67	1.7372	3.73	46.45	50.18	0.0086	0.1138	-18
-17	51.57	36.87	0.00866	0.5649	115.49	1.7703	3.90	46.36	50.26	0.0090	0.1137	-17
-16	52.59	37.90	0.00867	0.5543	115.32	1.8039	4.07	46.26	50.33	0.0094	0.1136	-16
-15	53.63	38.94	0.00868	0.5440	115.15	1.8381	4.25	46.16	50.41	0.0097	0.1135	-15
-14	54.69	39.99	0.00870	0.5340	114.97	1.8727	4.42	46.06	50.48	0.0101	0.1135	-14
-13	55.76	41.06	0.00871	0.5242	114.80	1.9078	4.59	45.96	50.56	0.0105	0.1134	-13
-12	56.85	42.15	0.00872	0.5145	114.62	1.9435	4.77	45.87	50.63	0.0109	0.1133	-12
-11	57.95	43.25	0.00874	0.5051	114.45	1.9797	4.94	45.77	50.71	0.0113	0.1133	-11
-10	59.07	44.37	0.00875	0.4959	114.27	2.0164	5.12	45.67	50.78	0.0117	0.1132	-10
-9	60.20	45.51	0.00876	0.4869	114.10	2.0536	5.29	45.56	50.85	0.0121	0.1132	-9
-8	61.35	46.66	0.00878	0.4782	113.92	2.0914	5.47	45.46	50.93	0.0124	0.1131	-8
-7	62.52	47.82	0.00879	0.4695	113.74	2.1297	5.64	45.36	51.00	0.0128	0.1130	-7
-6	63.70	49.01	0.00881	0.4611	113.56	2.1686	5.81	45.26	51.07	0.0132	0.1130	-6
-5	64.90	50.21	0.00882	0.4529	113.38	2.2080	5.99	45.16	51.15	0.0136	0.1129	-5
-4	66.12	51.42	0.00883	0.4448	113.20	2.2480	6.17	45.05	51.22	0.0140	0.1128	-4
-3	67.35	52.66	0.00885	0.4369	113.02	2.2886	6.34	44.95	51.29	0.0143	0.1128	-3
-2	68.60	53.91	0.00886	0.4292	112.84	2.3298	6.52	44.85	51.36	0.0147	0.1127	-2
-1	69.87	55.18	0.00888	0.4217	112.66	2.3715	6.70	44.74	51.44	0.0151	0.1126	-1
0	71.16	56.46	0.00889	0.4143	112.48	2.4139	6.87	44.64	51.51	0.0155	0.1126	0
1	72.46	57.77	0.00890	0.4070	112.30	2.4568	7.05	44.53	51.58	0.0159	0.1125	1
2	73.78	59.09	0.00892	0.3999	112.11	2.5004	7.23	44.42	51.65	0.0163	0.1125	2
3	75.12	60.42	0.00893	0.3930	111.93	2.5445	7.40	44.32	51.72	0.0166	0.1124	3
4	76.48	61.78	0.00895	0.3862	111.75	2.5893	7.58	44.21	51.79	0.0170	0.1124	4

TABLE 1 "FREON-13B1" . SATURATION PROPERTIES

TEMP. °F	PRESSURE		VOLUME cu ft/lb		DENSITY lb/cu ft		ENTHALPY Btu/lb			ENTROPY Btu/(lb)(°R)		TEMP. °F
	PSIA	PSIG	LIQUID V_f	VAPOR V_g	LIQUID $1/V_f$	VAPOR $1/V_g$	LIQUID h_f	LATENT h_{fg}	VAPOR h_g	LIQUID S_f	VAPOR S_g	
5	77.85	63.10	0.00896	0.3795	111.56	2.6347	7.76	44.10	51.86	0.0174	0.1123	5
6	79.25	64.55	0.00898	0.3730	111.38	2.6808	7.94	43.99	51.93	0.0178	0.1122	6
7	80.66	65.96	0.00899	0.3666	111.19	2.7275	8.12	43.88	52.00	0.0181	0.1122	7
8	82.09	67.39	0.00901	0.3604	111.00	2.7749	8.30	43.77	52.07	0.0185	0.1121	8
9	83.54	68.84	0.00902	0.3542	110.82	2.8229	8.48	43.66	52.14	0.0189	0.1121	9
10	85.00	70.31	0.00904	0.3482	110.63	2.8716	8.66	43.55	52.21	0.0193	0.1120	10
11	86.49	71.79	0.00905	0.3424	110.44	2.9210	8.84	43.44	52.28	0.0197	0.1119	11
12	88.00	73.30	0.00907	0.3366	110.25	2.9710	9.02	43.33	52.35	0.0200	0.1119	12
13	89.52	74.83	0.00909	0.3309	110.06	3.0218	9.20	43.22	52.41	0.0204	0.1118	13
14	91.07	76.37	0.00910	0.3254	109.87	3.0732	9.38	43.10	52.48	0.0208	0.1118	14
15	92.63	77.93	0.00912	0.3200	109.68	3.1254	9.56	42.99	52.55	0.0212	0.1117	15
16	94.21	79.52	0.00913	0.3146	109.49	3.1783	9.74	42.87	52.62	0.0215	0.1117	16
17	95.82	81.12	0.00915	0.3094	109.30	3.2319	9.92	42.76	52.68	0.0219	0.1116	17
18	97.44	82.75	0.00917	0.3043	109.10	3.2863	10.11	42.64	52.75	0.0223	0.1116	18
19	99.09	84.39	0.00918	0.2993	108.91	3.3414	10.29	42.53	52.81	0.0227	0.1115	19
20	100.8	86.06	0.00920	0.2944	108.71	3.3973	10.47	42.41	52.88	0.0230	0.1115	20
21	102.4	87.74	0.00921	0.2895	108.52	3.4539	10.65	42.29	52.94	0.0234	0.1114	21
22	104.1	89.45	0.00923	0.2848	108.32	3.5113	10.84	42.17	53.01	0.0238	0.1113	22
23	105.9	91.18	0.00925	0.2801	108.13	3.5695	11.02	42.05	53.07	0.0242	0.1113	23
24	107.6	92.93	0.00927	0.2756	107.93	3.6285	11.20	41.93	53.14	0.0245	0.1112	24
25	109.4	94.69	0.00928	0.2711	107.73	3.6883	11.39	41.81	53.20	0.0249	0.1112	25
26	111.2	96.5	0.00930	0.2667	107.53	3.7490	11.57	41.69	53.27	0.0253	0.1111	26
27	113.0	98.3	0.00932	0.2624	107.33	3.8105	11.76	41.57	53.33	0.0257	0.1111	27
28	114.8	100.1	0.00933	0.2582	107.13	3.8728	11.94	41.45	53.39	0.0260	0.1110	28
29	116.7	102.0	0.00935	0.2541	106.93	3.9359	12.13	41.32	53.45	0.0264	0.1110	29
30	118.6	103.9	0.00937	0.2500	106.73	4.0000	12.32	41.20	53.51	0.0268	0.1109	30
31	120.5	105.8	0.00939	0.2460	106.52	4.0649	12.50	41.07	53.58	0.0272	0.1109	31
32	122.4	107.7	0.00941	0.2421	106.32	4.1307	12.69	40.95	53.64	0.0275	0.1108	32
33	124.3	109.6	0.00942	0.2382	106.11	4.1974	12.88	40.82	53.70	0.0279	0.1108	33
34	126.3	111.6	0.00944	0.2345	105.91	4.2650	13.06	40.69	53.76	0.0283	0.1107	34
35	128.3	113.6	0.00946	0.2308	105.70	4.3335	13.25	40.57	53.82	0.0287	0.1107	35
36	130.3	115.6	0.00948	0.2271	105.49	4.4030	13.44	40.44	53.88	0.0290	0.1106	36
37	132.3	117.6	0.00950	0.2235	105.28	4.4734	13.63	40.31	53.93	0.0294	0.1106	37
38	134.4	119.7	0.00952	0.2200	105.08	4.5448	13.82	40.18	53.99	0.0298	0.1105	38
39	136.5	121.8	0.00954	0.2166	104.86	4.6172	14.01	40.05	54.05	0.0301	0.1104	39
40	138.6	123.9	0.00956	0.2132	104.65	4.6906	14.19	39.91	54.11	0.0305	0.1104	40
41	140.7	126.0	0.00957	0.2099	104.44	4.7649	14.38	39.78	54.16	0.0309	0.1103	41
42	142.9	128.2	0.00959	0.2066	104.23	4.8403	14.57	39.65	54.22	0.0313	0.1103	42
43	145.1	130.4	0.00961	0.2034	104.01	4.9168	14.77	39.51	54.28	0.0316	0.1102	43
44	147.3	132.6	0.00963	0.2002	103.80	4.9943	14.96	39.38	54.33	0.0320	0.1102	44
45	149.5	134.8	0.00965	0.1971	103.58	5.0728	15.15	39.24	54.39	0.0324	0.1101	45
46	151.7	137.1	0.00967	0.1941	103.36	5.1525	15.34	39.10	54.44	0.0327	0.1101	46
47	154.0	139.3	0.00969	0.1911	103.15	5.2332	15.53	38.96	54.50	0.0331	0.1100	47
48	156.3	141.6	0.00972	0.1881	102.93	5.3151	15.72	38.82	54.55	0.0335	0.1100	48
49	158.7	144.0	0.00974	0.1853	102.71	5.3981	15.92	38.68	54.60	0.0339	0.1099	49
50	161.0	146.3	0.00976	0.1824	102.49	5.4822	16.11	38.54	54.65	0.0342	0.1099	50
51	163.4	148.7	0.00978	0.1796	102.26	5.5676	16.31	38.40	54.71	0.0346	0.1098	51
52	165.8	151.1	0.00980	0.1769	102.04	5.6541	16.50	38.26	54.76	0.0350	0.1097	52
53	168.2	153.5	0.00982	0.1742	101.81	5.7418	16.69	38.11	54.81	0.0354	0.1097	53
54	170.7	156.0	0.00984	0.1715	101.59	5.8306	16.89	37.97	54.86	0.0357	0.1096	54
55	173.2	158.5	0.00987	0.1689	101.36	5.9210	17.08	37.82	54.91	0.0361	0.1096	55
56	175.7	161.0	0.00989	0.1663	101.13	6.0124	17.29	37.67	54.96	0.0365	0.1095	56
57	178.2	163.5	0.00991	0.1638	100.90	6.1052	17.48	37.53	55.00	0.0368	0.1095	57
58	180.8	166.1	0.00993	0.1613	100.67	6.1992	17.68	37.38	55.05	0.0372	0.1094	58
59	183.4	168.7	0.00996	0.1589	100.44	6.2946	17.87	37.23	55.10	0.0376	0.1094	59

TABLE 1 "FREON-13B1" - SATURATION PROPERTIES

TEMP. °F	PRESSURE		VOLUME cu ft/lb		DENSITY lb/cu ft		ENTHALPY Btu/lb			ENTROPY Btu/(lb)(°R)		TEMP. °F
	PSIA	PSIG	LIQUID v_f	VAPOR v_g	LIQUID $1/v_f$	VAPOR $1/v_g$	LIQUID h_f	LATENT h_{fg}	VAPOR h_g	LIQUID s_f	VAPOR s_g	
60	186.0	171.3	0.00998	0.1565	100.20	6.3914	18.08	37.07	55.15	0.0380	0.1093	60
61	188.6	173.9	0.01000	0.1541	99.97	6.4895	18.27	36.92	55.19	0.0383	0.1092	61
62	191.3	176.6	0.01003	0.1518	99.73	6.5890	18.47	36.77	55.24	0.0387	0.1092	62
63	194.0	179.3	0.01005	0.1495	99.50	6.6900	18.67	36.61	55.28	0.0391	0.1091	63
64	196.7	182.0	0.01007	0.1472	99.26	6.7924	18.87	36.46	55.32	0.0394	0.1091	64
65	199.5	184.8	0.01010	0.1450	99.02	6.8962	19.07	36.30	55.37	0.0398	0.1090	65
66	202.3	187.6	0.01012	0.1428	98.77	7.0016	19.27	36.14	55.41	0.0402	0.1089	66
67	205.1	190.4	0.01015	0.1407	98.53	7.1085	19.47	35.98	55.45	0.0406	0.1089	67
68	207.9	193.2	0.01017	0.1386	98.29	7.2170	19.67	35.82	55.49	0.0409	0.1088	68
69	210.8	196.1	0.01020	0.1365	98.04	7.3270	19.88	35.66	55.53	0.0413	0.1088	69
70	213.7	199.0	0.01023	0.1344	97.79	7.4387	20.08	35.49	55.57	0.0417	0.1087	70
71	216.6	201.9	0.01025	0.1324	97.54	7.5520	20.28	35.33	55.61	0.0421	0.1086	71
72	219.6	204.9	0.01028	0.1304	97.29	7.6670	20.49	35.16	55.65	0.0424	0.1086	72
73	222.6	207.9	0.01031	0.1285	97.04	7.7837	20.69	34.99	55.68	0.0428	0.1085	73
74	225.6	210.9	0.01033	0.1265	96.78	7.9021	20.90	34.82	55.72	0.0432	0.1084	74
75	228.7	214.0	0.01036	0.1247	96.53	8.0223	21.11	34.65	55.76	0.0436	0.1084	75
76	231.7	217.0	0.01039	0.1228	96.27	8.1443	21.31	34.48	55.79	0.0439	0.1083	76
77	234.8	220.1	0.01042	0.1209	96.01	8.2682	21.52	34.30	55.83	0.0443	0.1082	77
78	238.0	223.3	0.01044	0.1191	95.75	8.3940	21.73	34.13	55.86	0.0447	0.1082	78
79	241.2	226.5	0.01047	0.1173	95.48	8.5216	21.94	33.95	55.89	0.0451	0.1081	79
80	244.4	229.7	0.01050	0.1156	95.22	8.6513	22.15	33.77	55.92	0.0454	0.1080	80
81	247.6	232.9	0.01053	0.1139	94.95	8.7829	22.36	33.59	55.95	0.0458	0.1080	81
82	250.9	236.2	0.01056	0.1121	94.68	8.9166	22.57	33.41	55.98	0.0462	0.1079	82
83	254.2	239.5	0.01059	0.1105	94.41	9.0524	22.78	33.23	56.01	0.0466	0.1078	83
84	257.5	242.8	0.01062	0.1088	94.14	9.1904	23.00	33.04	56.04	0.0470	0.1077	84
85	260.8	246.1	0.01065	0.1072	93.86	9.3305	23.21	32.85	56.06	0.0473	0.1077	85
86	264.2	249.5	0.01069	0.1056	93.58	9.4728	23.42	32.66	56.09	0.0477	0.1076	86
87	267.7	253.0	0.01072	0.1040	93.30	9.6175	23.64	32.47	56.11	0.0481	0.1075	87
88	271.1	256.4	0.01075	0.1024	93.02	9.7645	23.86	32.28	56.14	0.0485	0.1074	88
89	274.6	259.9	0.01078	0.1009	92.74	9.9138	24.07	32.09	56.16	0.0489	0.1073	89
90	278.1	263.4	0.01082	0.0993	92.45	10.0657	24.29	31.89	56.18	0.0493	0.1073	90
91	281.7	267.0	0.01085	0.0978	92.16	10.2200	24.51	31.69	56.20	0.0496	0.1072	91
92	285.3	270.6	0.01089	0.0964	91.87	10.377	24.73	31.49	56.22	0.0500	0.1071	92
93	288.9	274.2	0.01092	0.0949	91.57	10.536	24.95	31.29	56.24	0.0504	0.1070	93
94	292.6	277.9	0.01096	0.0935	91.27	10.699	25.17	31.08	56.25	0.0508	0.1069	94
95	296.3	281.6	0.01099	0.0920	90.97	10.864	25.39	30.87	56.27	0.0512	0.1068	95
96	300.0	285.3	0.01103	0.0906	90.67	11.032	25.62	30.66	56.28	0.0516	0.1068	96
97	303.7	289.0	0.01107	0.0893	90.36	11.202	25.84	30.45	56.29	0.0520	0.1067	97
98	307.5	292.9	0.01110	0.0879	90.05	11.376	26.07	30.24	56.30	0.0524	0.1066	98
99	311.4	296.7	0.01114	0.0866	89.74	11.553	26.29	30.02	56.31	0.0527	0.1065	99
100	315.2	300.6	0.01118	0.0852	89.42	11.733	26.52	29.80	56.32	0.0531	0.1064	100
101	319.2	304.5	0.01122	0.0839	89.10	11.917	26.75	29.58	56.33	0.0535	0.1063	101
102	323.1	308.4	0.01126	0.0826	88.78	12.103	26.98	29.35	56.34	0.0539	0.1062	102
103	327.1	312.4	0.01131	0.0813	88.46	12.293	27.21	29.13	56.34	0.0543	0.1061	103
104	331.1	316.4	0.01135	0.0801	88.13	12.487	27.45	28.90	56.34	0.0547	0.1060	104
105	335.1	320.4	0.01139	0.0788	87.79	12.684	27.68	28.66	56.34	0.0551	0.1059	105
106	339.2	324.5	0.01143	0.0776	87.45	12.886	27.91	28.43	56.34	0.0555	0.1058	106
107	343.3	328.6	0.01148	0.0764	87.11	13.090	28.15	28.19	56.34	0.0559	0.1057	107
108	347.5	332.8	0.01153	0.0752	86.77	13.300	28.39	27.94	56.33	0.0563	0.1056	108
109	351.7	337.0	0.01157	0.0740	86.42	13.513	28.63	27.70	56.33	0.0567	0.1054	109
110	355.9	341.2	0.01162	0.0728	86.06	13.731	28.87	27.45	56.32	0.0571	0.1053	110
111	360.2	345.5	0.01167	0.0717	85.70	13.953	29.11	27.20	56.31	0.0575	0.1052	111
112	364.5	349.8	0.01172	0.0705	85.34	14.179	29.35	26.94	56.30	0.0580	0.1051	112
113	368.9	354.2	0.01177	0.0694	84.97	14.411	29.60	26.68	56.28	0.0584	0.1050	113
114	373.2	358.5	0.01182	0.0683	84.59	14.647	29.85	26.41	56.27	0.0588	0.1048	114

TABLE 1 "FREON-13B1" - SATURATION PROPERTIES

TEMP. °F	PRESSURE		VOLUME cu ft/lb		DENSITY lb/cu ft		ENTHALPY Btu/lb			ENTROPY Btu/(lb)(°R)		TEMP. °F
	PSIA	PSIG	LIQUID V_f	VAPOR V_g	LIQUID $1/V_f$	VAPOR $1/V_g$	LIQUID h_f	LATENT h_{fg}	VAPOR h_g	LIQUID s_f	VAPOR s_g	
115	377.7	363.0	0.01187	0.0672	84.21	14.888	30.10	26.15	56.25	0.0592	0.1047	115
116	382.1	367.4	0.01193	0.0661	83.83	15.135	30.35	25.87	56.23	0.0596	0.1046	116
117	386.6	371.9	0.01199	0.0650	83.43	15.388	30.61	25.60	56.20	0.0601	0.1044	117
118	391.2	376.5	0.01204	0.0639	83.03	15.646	30.85	25.32	56.18	0.0605	0.1043	118
119	395.8	381.1	0.01210	0.0629	82.63	15.910	31.12	25.03	56.15	0.0609	0.1042	119
120	400.4	385.7	0.01216	0.0618	82.22	16.181	31.38	24.74	56.12	0.0613	0.1040	120
121	405.1	390.4	0.01223	0.0608	81.80	16.456	31.64	24.44	56.08	0.0618	0.1039	121
122	409.9	395.1	0.01229	0.0597	81.37	16.742	31.91	24.14	56.05	0.0622	0.1037	122
123	414.5	399.8	0.01236	0.0587	80.93	17.033	32.17	23.83	56.01	0.0627	0.1036	123
124	419.3	404.6	0.01242	0.0577	80.49	17.332	32.44	23.52	55.97	0.0631	0.1034	124
125	424.1	409.4	0.01249	0.0567	80.04	17.639	32.72	23.20	55.92	0.0635	0.1032	125
126	429.0	414.3	0.01257	0.0557	79.57	17.954	32.99	22.88	55.87	0.0640	0.1031	126
127	433.9	419.2	0.01264	0.0547	79.10	18.278	33.27	22.54	55.82	0.0645	0.1029	127
128	438.9	424.2	0.01272	0.0537	78.62	18.611	33.55	22.20	55.76	0.0649	0.1027	128
129	443.9	429.2	0.01280	0.0528	78.12	18.954	33.84	21.86	55.70	0.0654	0.1025	129
130	448.9	434.2	0.01288	0.0518	77.61	19.307	34.13	21.50	55.63	0.0659	0.1023	130
131	454.0	439.3	0.01297	0.0508	77.09	19.672	34.42	21.14	55.56	0.0663	0.1021	131
132	459.1	444.4	0.01306	0.0499	76.56	20.048	34.72	20.77	55.49	0.0668	0.1019	132
133	464.3	449.6	0.01316	0.0489	76.01	20.437	35.02	20.38	55.41	0.0673	0.1017	133
134	469.5	454.8	0.01326	0.0480	75.44	20.840	35.33	19.99	55.32	0.0678	0.1015	134
135	474.8	460.1	0.01336	0.0470	74.85	21.257	35.64	19.59	55.23	0.0683	0.1012	135
136	480.1	465.4	0.01347	0.0461	74.24	21.690	35.96	19.17	55.13	0.0688	0.1010	136
137	485.4	470.7	0.01358	0.0452	73.61	22.140	36.28	18.74	55.02	0.0693	0.1007	137
138	490.8	476.1	0.01371	0.0442	72.96	22.608	36.62	18.30	54.91	0.0699	0.1005	138
139	496.3	481.6	0.01384	0.0433	72.28	23.097	36.95	17.84	54.79	0.0704	0.1002	139
140	501.8	487.1	0.01397	0.0424	71.57	23.608	37.30	17.36	54.66	0.0710	0.0999	140
141	507.3	492.6	0.01412	0.0414	70.82	24.144	37.66	16.86	54.52	0.0715	0.0996	141
142	512.9	498.2	0.01428	0.0405	70.03	24.707	38.03	16.34	54.37	0.0721	0.0993	142
143	518.5	503.8	0.01445	0.0395	69.20	25.301	38.41	15.80	54.21	0.0727	0.0989	143
144	524.2	509.5	0.01464	0.0386	68.31	25.931	38.80	15.23	54.03	0.0734	0.0986	144
145	529.9	515.2	0.01485	0.0376	67.36	26.601	39.22	14.62	53.84	0.0740	0.0982	145
146	535.7	521.0	0.01508	0.0366	66.32	27.318	39.65	13.98	53.63	0.0747	0.0978	146
147	541.5	526.8	0.01534	0.0356	65.18	28.091	40.11	13.29	53.40	0.07[illegible]	0.0973	147
148	547.4	532.7	0.01565	0.0346	63.91	28.931	40.61	12.53	53.14	0.076[illegible]	0.0969	148
149	553.3	538.6	0.01601	0.0335	62.45	29.857	41.15	11.70	52.85	0.0771	0.0963	149
150	559.2	544.5	0.01647	0.0324	60.71	30.891	41.77	10.74	52.51	0.0781	0.0957	150
151	565.2	550.6	0.01711	0.0312	58.46	32.07	42.52	9.61	52.12	0.0793	0.0950	151
152	571.3	556.6	0.01815	0.0299	54.96	33.48	43.59	8.05	51.65	0.0810	0.0942	152
152.6 (Critical)	574.9	560.2	0.0215	0.0215	46.5	46.5						

"FREON-13B1" – SUPERHEATED VAPOR

V=volume in cu ft/lb; H=enthalpy in Btu/lb; S=entropy in Btu/(lb)(°R) (saturation properties in parentheses)

ABSOLUTE PRESSURE, lb/sq in

TEMP. °F	3.0			3.5			4.0			4.5			TEMP. °F
	23.81* (–123.00°F.)			22.80* (–118.72°F.)			21.78* (–114.91°F.)			20.76* (–111.47°F.)			
	V	H	S	V	H	S	V	H	S	V	H	S	
	(8.0067)	(41.62)	(0.1279)	(6.9411)	(41.98)	(0.1269)	(6.1336)	(42.29)	(0.1261)	(5.4998)	(42.58)	(0.1254)	
-120	8.0798	41.88	0.1287	–	–	–	–	–	–	–	–	–	-120
-110	8.3237	42.77	0.1313	7.1238	42.75	0.1292	6.2239	42.73	0.1273	5.5239	42.71	0.1257	-110
-100	8.5673	43.66	0.1338	7.3331	43.65	0.1317	6.4075	43.63	0.1299	5.6875	43.61	0.1283	-100
-90	8.8106	44.57	0.1363	7.5422	44.56	0.1342	6.5908	44.54	0.1324	5.8508	44.52	0.1308	-90
-80	9.0537	45.49	0.1387	7.7510	45.48	0.1366	6.7739	45.46	0.1348	6.0139	45.45	0.1332	-80
-70	9.2967	46.43	0.1412	7.9596	46.41	0.1391	6.9568	46.40	0.1373	6.1768	46.38	0.1357	-70
-60	9.5394	47.38	0.1436	8.1681	47.36	0.1415	7.1395	47.35	0.1397	6.3396	47.33	0.1381	-60
-50	9.7820	48.34	0.1459	8.3764	48.32	0.1439	7.3221	48.31	0.1421	6.5021	48.29	0.1405	-50
-40	10.0245	49.31	0.1483	8.5845	49.30	0.1462	7.5046	49.28	0.1444	6.6646	49.27	0.1428	-40
-30	10.2668	50.29	0.1506	8.7926	50.28	0.1485	7.6869	50.27	0.1467	6.8269	50.25	0.1451	-30
-20	10.5090	51.29	0.1529	9.0005	51.28	0.1508	7.8691	51.26	0.1490	6.9890	51.25	0.1474	-20
-10	10.7512	52.30	0.1552	9.2083	52.29	0.1531	8.0511	52.27	0.1513	7.1511	52.26	0.1497	-10
0	10.9932	53.32	0.1574	9.4160	53.31	0.1553	8.2331	53.29	0.1535	7.3131	53.28	0.1519	0
10	11.2351	54.35	0.1596	9.6236	54.34	0.1575	8.4150	54.33	0.1558	7.4750	54.32	0.1542	10
20	11.4769	55.39	0.1618	9.8312	55.38	0.1597	8.5968	55.37	0.1580	7.6368	55.36	0.1564	20
30	11.7187	56.45	0.1640	10.0386	56.44	0.1619	8.7786	56.43	0.1601	7.7985	56.41	0.1585	30
40	11.9604	57.51	0.1661	10.2460	57.50	0.1641	8.9602	57.49	0.1623	7.9601	57.48	0.1607	40
50	12.2020	58.59	0.1683	10.4533	58.58	0.1662	9.1418	58.57	0.1644	8.1217	58.56	0.1628	50
60	12.4436	59.68	0.1704	10.6606	59.67	0.1683	9.3233	59.66	0.1665	8.2832	59.65	0.1649	60
70	12.6851	60.78	0.1725	10.8678	60.77	0.1704	9.5048	60.76	0.1686	8.4447	60.75	0.1670	70
80	12.9265	61.88	0.1746	11.0749	61.87	0.1725	9.6862	61.86	0.1707	8.6061	61.86	0.1691	80
90	13.1679	63.00	0.1766	11.2870	62.99	0.1745	9.8676	62.98	0.1728	8.7674	62.97	0.1712	90
100	13.4093	64.13	0.1786	11.4891	64.12	0.1766	10.0489	64.11	0.1748	8.9287	64.10	0.1732	100
110	13.6506	65.27	0.1807	11.6961	65.26	0.1786	10.2301	65.25	0.1768	9.0900	65.24	0.1752	110
120	13.8919	66.42	0.1827	11.9030	66.41	0.1806	10.4114	66.40	0.1788	9.2512	66.39	0.1772	120
130	14.1331	67.58	0.1846	12.1099	67.57	0.1826	10.5926	67.56	0.1808	9.4124	67.55	0.1792	130
140	14.3743	68.75	0.1866	12.3168	68.74	0.1845	10.7737	68.73	0.1828	9.5735	68.72	0.1812	140
150	14.6154	69.92	0.1886	12.5236	69.91	0.1865	10.9548	69.91	0.1847	9.7346	69.90	0.1831	150
160	14.8565	71.11	0.1905	12.7304	71.10	0.1884	11.1359	71.09	0.1866	9.8957	71.09	0.1851	160
170	15.0976	72.30	0.1924	12.9372	72.30	0.1903	11.3169	72.29	0.1885	10.0567	72.28	0.1870	170
180	15.3387	73.51	0.1943	13.1440	73.50	0.1922	11.4979	73.49	0.1904	10.2177	73.49	0.1889	180
190	–	–	–	13.3507	74.71	0.1941	11.6789	74.71	0.1923	10.3787	74.70	0.1907	190

TEMP. °F	5.0			5.5			6.0			6.5			TEMP. °F
	19.74* (–108.33°F.)			18.72* (–105.43°F.)			17.71* (–102.73°F.)			16.69* (–100.21°F.)			
	V	H	S	V	H	S	V	H	S	V	H	S	
	(4.9886)	(42.84)	(0.1247)	(4.5673)	(43.08)	(0.1242)	(4.2138)	(43.31)	(0.1237)	(3.9128)	(43.52)	(0.1232)	
-100	5.1115	43.59	0.1268	4.6402	43.58	0.1255	4.2475	43.56	0.1244	3.9152	43.54	0.1233	-100
-90	5.2589	44.51	0.1293	4.7745	44.49	0.1280	4.3708	44.47	0.1269	4.0293	44.45	0.1258	-90
-80	5.4059	45.43	0.1318	4.9085	45.41	0.1305	4.4939	45.40	0.1293	4.1431	45.38	0.1282	-80
-70	5.5528	46.37	0.1343	5.0423	46.35	0.1330	4.6168	46.34	0.1318	4.2568	46.32	0.1307	-70
-60	5.6996	47.32	0.1367	5.1759	47.30	0.1354	4.7396	47.29	0.1342	4.3703	47.27	0.1331	-60
-50	5.8461	48.28	0.1390	5.3094	48.26	0.1377	4.8621	48.25	0.1366	4.4836	48.24	0.1355	-50
-40	5.9926	49.25	0.1414	5.4427	49.24	0.1401	4.9845	49.23	0.1389	4.5968	49.21	0.1378	-40
-30	6.1389	50.24	0.1437	5.5759	50.23	0.1424	5.1068	50.21	0.1412	4.7099	50.20	0.1401	-30
-20	6.2850	51.24	0.1460	5.7090	51.23	0.1447	5.2290	51.21	0.1435	4.8228	51.20	0.1424	-20
-10	6.4311	52.25	0.1483	5.8420	52.24	0.1470	5.3511	52.22	0.1458	4.9356	52.21	0.1447	-10
0	6.5771	53.27	0.1505	5.9749	53.26	0.1492	5.4730	53.25	0.1481	5.0484	53.23	0.1470	0
10	6.7229	54.30	0.1527	6.1076	54.29	0.1515	5.5949	54.28	0.1503	5.1610	54.27	0.1492	10
20	6.8687	55.35	0.1549	6.2403	55.34	0.1537	5.7167	55.33	0.1525	5.2735	55.31	0.1514	20
30	7.0144	56.40	0.1571	6.3729	56.39	0.1558	5.8384	56.38	0.1547	5.3860	56.37	0.1536	30
40	7.1601	57.47	0.1593	6.5055	57.46	0.1580	5.9600	57.45	0.1568	5.4984	57.44	0.1557	40
50	7.3056	58.55	0.1614	6.6380	58.54	0.1601	6.0815	58.53	0.1590	5.6107	58.52	0.1579	50
60	7.4512	59.64	0.1635	6.7704	59.63	0.1622	6.2030	59.62	0.1611	5.7230	59.61	0.1600	60
70	7.5965	60.74	0.1656	6.9027	60.73	0.1643	6.3245	60.72	0.1632	5.8352	60.71	0.1621	70
80	7.7420	61.85	0.1677	7.0350	61.84	0.1664	6.4458	61.83	0.1652	5.9473	61.82	0.1642	80
90	7.8873	62.97	0.1698	7.1672	62.96	0.1685	6.5672	62.95	0.1673	6.0594	62.94	0.1662	90
100	8.0326	64.10	0.1718	7.2994	64.09	0.1705	6.6885	64.08	0.1693	6.1715	64.07	0.1683	100
110	8.1779	65.24	0.1738	7.4316	65.23	0.1725	6.8097	65.22	0.1714	6.2835	65.21	0.1703	110
120	8.3231	66.38	0.1758	7.5637	66.38	0.1745	6.9309	66.37	0.1734	6.3954	66.36	0.1723	120
130	8.4682	67.54	0.1778	7.6958	67.54	0.1765	7.0520	67.53	0.1753	6.5073	67.52	0.1743	130
140	8.6134	68.71	0.1798	7.8278	68.70	0.1785	7.1731	68.70	0.1773	6.6192	68.69	0.1762	140
150	8.7584	69.89	0.1817	7.9598	69.88	0.1804	7.2942	[illegible]	0.1793	6.7310	69.87	[illegible]	150
160	8.9035	71.08	0.1836	8.0917	71.07	0.1824	7.415[illegible]	[illegible]	0.1812	6.8428	71.05	0.1801	160
170	9.0485	72.27	0.1856	8.2236	72.27	0.1843	7.53[illegible]	[illegible]	[illegible].1831	6.9546	72.25	0.1820	170
180	9.1935	73.48	0.1875	8.3555	73.47	0.1862	[illegible]	[illegible]	[illegible]1850	7.0663	73.46	0.1839	180
190	9.3385	74.69	0.1893	8.4874	74.69	0.1881	[illegible]	[illegible]	[illegible]1869	7.1780	74.67	0.1858	190
200	9.4834	75.92	0.1912	8.6192	75.91	0.1899	[illegible]	[illegible]	[illegible]888	7.2897	75.89	0.1877	200

*Inches of Mercury below one atmosphere.

"FREON-13B1" – SUPERHEATED VAPOR

V=volume in cu ft/lb; H=enthalpy in Btu/lb; S=entropy in Btu/(lb)(°R) (saturation properties in parentheses)

ABSOLUTE PRESSURE, lb/sq in

TEMP. °F	7.0			7.5			8.0			8.5			TEMP. °F
	15.67* (–97.83°F.)			14.65* (–95.53°F.)			13.63* (–93.47°F.)			12.62* (–91.44°F.)			
	V	H	S	V	H	S	V	H	S	V	H	S	
	(3.6533)	(43.72)	(0.1228)	(3.4272)	(43.91)	(0.1224)	(3.2284)	(44.08)	(0.1220)	(3.0521)	(44.25)	(0.1217)	
-90	3.7365	44.44	0.1247	3.4827	44.42	0.1238	3.2607	44.40	0.1229	3.0647	44.39	0.1221	-90
-80	3.8424	45.36	0.1272	3.5818	45.35	0.1263	3.3538	45.33	0.1254	3.1525	45.32	0.1245	-80
-70	3.9402	46.30	0.1297	3.6807	46.29	0.1287	3.4467	46.27	0.1278	3.2402	46.26	0.1270	-70
-60	4.0338	47.26	0.1321	3.7795	47.24	0.1311	3.5394	47.23	0.1302	3.3275	47.21	0.1294	-60
-50	4.1592	48.22	0.1345	3.8780	48.21	0.1335	3.6320	48.19	0.1325	3.4149	48.18	0.1318	-50
-40	4.2645	49.20	0.1368	3.9765	49.18	0.1359	3.7244	49.17	0.1350	3.5021	49.16	0.1342	-40
-30	4.3696	50.19	0.1391	4.0748	50.17	0.1382	3.8167	50.16	0.1373	3.5890	50.15	0.1365	-30
-20	4.4747	51.19	0.1414	4.1729	51.17	0.1405	3.9089	51.16	0.1395	3.6759	51.15	0.1388	-20
-10	4.5796	52.20	0.1437	4.2710	52.19	0.1428	4.0009	52.17	0.1419	3.7627	52.16	0.1411	-10
0	4.6844	53.22	0.1460	4.3689	53.21	0.1450	4.0929	53.20	0.1442	3.8493	53.19	0.1433	0
10	4.7891	54.26	0.1482	4.4668	54.24	0.1473	4.1848	54.23	0.1464	3.9359	54.22	0.1455	10
20	4.8937	55.30	0.1504	4.5646	55.29	0.1495	4.2765	55.28	0.1486	4.0224	55.27	0.1478	20
30	4.9983	56.36	0.1526	4.6622	56.35	0.1516	4.3682	56.34	0.1508	4.1088	56.33	0.1499	30
40	5.1028	57.43	0.1547	4.7599	57.42	0.1538	4.4598	57.41	0.1529	4.1951	57.40	0.1521	40
50	5.2072	58.51	0.1569	4.8574	58.50	0.1559	4.5514	58.49	0.1551	4.2813	58.48	0.1542	50
60	5.3115	59.60	0.1590	4.9549	59.59	0.1581	4.6429	59.58	0.1572	4.3675	59.57	0.1564	60
70	5.4158	60.70	0.1611	5.0523	60.69	0.1602	4.7343	60.68	0.1593	4.4537	60.67	0.1585	70
80	5.5200	61.81	0.1632	5.1497	61.80	0.1622	4.8256	61.79	0.1614	4.5397	61.78	0.1605	80
90	5.6242	62.93	0.1652	5.2470	62.92	0.1643	4.9170	62.91	0.1634	4.6257	62.90	0.1625	90
100	5.7283	64.06	0.1673	5.3443	64.05	0.1663	5.0082	64.04	0.1655	4.7117	64.03	0.1646	100
110	5.8324	65.20	0.1693	5.4415	65.19	0.1684	5.0994	65.18	0.1675	4.7974	65.17	0.1667	110
120	5.9364	66.35	0.1713	5.5387	66.34	0.1704	5.1906	66.33	0.1695	4.8831	66.32	0.1687	120
130	6.0404	67.51	0.1733	5.6358	67.50	0.1723	5.2817	67.49	0.1715	4.9593	67.49	0.1707	130
140	6.1444	68.68	0.1752	5.7329	68.67	0.1743	5.3728	68.66	0.1734	5.0551	68.65	0.1725	140
150	6.2483	69.86	0.1772	5.8299	69.85	0.1763	5.4639	69.84	0.1754	5.1409	69.83	0.1745	150
160	6.3522	71.05	0.1791	5.9270	71.04	0.1782	5.5549	71.03	0.1773	5.2265	71.02	0.1765	160
170	6.4560	72.24	0.1810	6.0240	72.24	0.1801	5.6459	72.23	0.1792	5.3120	72.22	0.1784	170
180	6.5599	73.45	0.1829	6.1209	73.44	0.1820	5.7369	73.43	0.1811	5.3980	73.43	0.1803	180
190	6.6637	74.66	0.1848	6.2179	74.66	0.1839	5.8278	74.65	0.1830	5.4835	74.64	0.1822	190
200	6.7674	75.89	0.1867	6.3148	75.88	0.1858	5.9187	75.87	0.1849	5.5692	75.87	0.1841	200
210	6.8712	77.12	0.1885	6.4116	77.11	0.1876	6.0096	77.10	0.1867	5.5548	77.10	0.1859	210

TEMP. °F	9.0			9.5			10			11			TEMP. °F
	11.60* (–89.51°F.)			10.58* (–87.66°F.)			9.56* (–85.89°F.)			7.53* (–82.55°F.)			
	V	H	S	V	H	S	V	H	S	V	H	S	
	(2.8946)	(44.41)	(0.1214)	(2.7532)	(44.57)	(0.1211)	(2.6254)	(44.72)	(0.1208)	(2.4033)	(44.99)	(0.1203)	
-80	2.9737	45.30	0.1238	2.8136	45.28	0.1230	2.6696	45.27	0.1223	2.4208	45.23	0.1210	-80
-70	3.0566	46.24	0.1262	2.8924	46.23	0.1255	2.7445	46.21	0.1248	2.4892	46.18	0.1234	-70
-60	3.1394	47.20	0.1286	2.9709	47.18	0.1279	2.8193	47.17	0.1272	2.5574	47.14	0.1259	-60
-50	3.2219	48.16	0.1310	3.0493	48.15	0.1303	2.8939	48.13	0.1296	2.6254	48.10	0.1283	-50
-40	3.3044	49.14	0.1334	3.1275	49.13	0.1326	2.9683	49.11	0.1319	2.6933	49.09	0.1306	-40
-30	3.3867	50.13	0.1357	3.2056	50.12	0.1350	3.0426	50.10	0.1343	2.7611	50.08	0.1330	-30
-20	3.4688	51.13	0.1380	3.2835	51.12	0.1373	3.1168	51.11	0.1366	2.8287	51.08	0.1353	-20
-10	3.5509	52.15	0.1403	3.3614	52.13	0.1396	3.1908	52.12	0.1389	2.8962	52.10	0.1375	-10
0	3.6328	53.17	0.1425	3.4391	53.16	0.1418	3.2648	53.15	0.1411	2.9636	53.12	0.1398	0
10	3.7147	54.21	0.1448	3.5168	54.20	0.1440	3.3386	54.19	0.1433	3.0310	54.16	0.1420	10
20	3.7965	55.26	0.1470	3.5943	55.25	0.1463	3.4124	55.23	0.1456	3.0982	55.21	0.1442	20
30	3.8782	56.32	0.1492	3.6718	56.30	0.1484	3.4861	56.29	0.1477	3.1653	56.27	0.1464	30
40	3.9598	57.38	0.1513	3.7492	57.37	0.1506	3.5597	57.36	0.1499	3.2324	57.34	0.1486	40
50	4.0413	58.46	0.1535	3.8265	58.45	0.1527	3.6333	58.44	0.1520	3.2994	58.42	0.1507	50
60	4.1228	59.56	0.1556	3.9038	59.55	0.1549	3.7067	59.54	0.1542	3.3663	59.51	0.1529	60
70	4.2042	60.66	0.1577	3.9810	60.65	0.1570	3.7801	60.64	0.1563	3.4332	60.62	0.1550	70
80	4.2856	61.77	0.1598	4.0582	61.76	0.1590	3.8535	61.75	0.1583	3.5000	61.73	0.1570	80
90	4.3669	62.89	0.1618	4.1353	62.88	0.1611	3.9268	62.87	0.1604	3.5667	62.85	0.1591	90
100	4.4481	64.02	0.1639	4.2123	64.01	0.1631	4.0001	64.00	0.1624	3.6335	63.99	0.1612	100
110	4.5293	65.16	0.1659	4.2893	65.16	0.1652	4.0733	65.15	0.1645	3.7001	65.13	0.1632	110
120	4.6105	66.32	0.1679	4.3663	66.31	0.1672	4.1464	66.30	0.1665	3.7667	66.28	0.1652	120
130	4.6916	67.48	0.1699	4.4432	67.47	0.1692	4.2196	67.46	0.1685	3.8333	67.44	0.1672	130
140	4.7727	68.65	0.1718	4.5200	68.64	0.1711	4.2926	68.63	0.1704	3.8998	68.61	0.1693	140
150	4.8538	69.83	0.1738	4.5969	69.82	0.1731	4.3657	69.81	0.1724	3.9663	69.79	0.1711	150
160	4.9348	71.02	0.1757	4.6737	71.01	0.1750	4.4387	71.00	0.1743	4.0328	70.98	0.1730	160
170	5.0158	72.21	0.1777	4.7505	72.21	0.1769	4.5117	72.20	0.1762	4.0992	72.18	0.1749	170
180	5.0967	73.42	0.1796	4.8272	73.41	0.1788	4.5846	73.40	0.1781	4.1656	73.39	0.1768	180
190	5.1776	74.63	0.1814	4.9039	74.63	0.1807	4.6575	74.62	0.1800	4.2320	74.61	0.1787	190
200	5.2585	75.86	0.1833	4.9806	75.85	0.1826	4.7304	75.84	0.1819	4.2983	75.83	0.1806	200
210	5.3394	77.09	0.1852	5.0572	77.08	0.1844	4.8033	77.08	0.1837	4.3647	77.06	0.1825	210
220	5.4203	78.33	0.1870	5.1339	78.32	0.1863	4.8761	78.32	0.1856	4.4309	78.30	0.1843	220

*Inches of Mercury below one atmosphere.

"FREON-13B1" – SUPERHEATED VAPOR

V=volume in cu ft/lb; H=enthalpy in Btu/lb; S=entropy in Btu/(lb)(°R) (saturation properties in parentheses)

ABSOLUTE PRESSURE, lb/sq in

TEMP. °F	12			13			14			14.696			TEMP. °F
	5.49* (−79.43°F.)			3.45* (−76.52°F.)			1.42* (−73.77°F.)			0 (−71.95°F.)			
	V	H	S	V	H	S	V	H	S	V	H	S	
	(2.2170)	(45.25)	(0.1199)	(2.0582)	(45.49)	(0.1195)	(1.9213)	(45.72)	(0.1191)	(1.8366)	(45.87)	(0.1189)	
−70	2.2763	46.15	0.1222	2.0962	46.11	0.1211	1.9410	46.08	0.1201	1.8468	46.06	0.1194	−70
−60	2.3391	47.10	0.1246	2.1544	47.07	0.1235	1.9961	47.04	0.1225	1.8986	47.02	0.1218	−60
−50	2.4017	48.07	0.1270	2.2124	48.05	0.1259	2.0501	48.02	0.1249	1.9502	47.99	0.1242	−50
−40	2.4642	49.06	0.1294	2.2702	49.03	0.1283	2.1040	49.00	0.1273	2.0016	48.98	0.1266	−40
−30	2.5265	50.05	0.1318	2.3279	50.02	0.1306	2.1577	50.00	0.1296	2.0530	49.98	0.1289	−30
−20	2.5886	51.06	0.1341	2.3855	51.03	0.1330	[illegible]	51.00	0.1319	2.1042	50.98	0.1313	−20
−10	2.6507	52.07	0.1364	[illegible]	[illegible]	0.1352	2.2649	52.02	0.1342	2.1552	52.00	0.1335	−10
0	2.7127	53.10	0.1386	[illegible]	[illegible]	0.1375	[illegible]	53.05	0.1365	2.2062	53.03	0.1358	0
10	2.7745	54.14	0.1409	[illegible]	[illegible]	0.1397	[illegible]	54.09	0.1387	2.2571	54.07	0.1381	10
20	2.8363	55.19	0.1431	[illegible]	[illegible]	0.1420	[illegible]	[illegible]	0.1409	2.3078	55.13	0.1403	20
30	2.8980	56.25	0.1452	[illegible]	56.23	0.1441	[illegible]	[illegible]	0.1431	2.3585	56.19	0.1425	30
40	2.9596	57.32	0.14[illegible]	[illegible]	7.30	0.1463	[illegible]	57.28	0.1453	2.4091	57.26	0.1446	40
50	3.0211	58.40	0.1496	2.7857	58.38	0.1485	2.5839	58.36	0.1474	2.4597	58.34	0.1468	50
60	3.0826	59.49	0.1517	2.8426	59.47	0.1508	2.6348	59.45	0.1496	2.5101	59.44	0.1489	60
70	3.1440	60.60	0.1538	2.8994	60.58	0.1527	2.6896	60.56	0.1517	2.5605	60.54	0.1510	70
80	3.2054	61.71	0.1559	2.9561	61.69	0.1548	2.7424	61.67	0.1538	2.6109	61.66	0.1531	80
90	3.2667	62.83	0.1579	3.0128	62.82	0.1568	2.7952	62.80	0.1559	2.6612	62.78	0.1552	90
100	3.3279	63.97	0.1600	3.0694	63.95	0.1589	2.8479	63.93	0.1579	2.7114	63.92	0.1572	100
110	3.3892	65.11	0.1620	3.1260	65.09	0.1609	2.9005	65.08	0.1599	2.7616	65.06	0.1592	110
120	3.4503	66.26	0.1640	3.1826	66.25	0.1629	2.9531	66.23	0.1619	2.8118	66.22	0.1612	120
130	3.5114	67.43	0.1660	3.2391	67.41	0.1649	3.0056	67.39	[illegible]	2.8619	67.38	0.1632	130
140	3.5725	68.60	0.1680	3.2955	68.58	0.1669	3.0581	68.56	0.1659	2.9119	68.55	0.1652	140
150	3.6335	69.78	0.1699	3.3520	69.76	0.1688	3.1106	69.75	0.1678	2.9620	69.73	0.1672	150
160	3.6946	70.97	0.1718	3.4083	70.95	0.1708	3.1630	70.94	0.1698	3.0120	70.93	0.1691	160
170	3.7555	72.17	0.1738	3.4647	72.15	0.1727	3.2154	72.14	0.1717	3.0619	72.13	0.1710	170
180	3.8165	73.37	0.1757	3.5210	73.36	0.1746	3.2678	73.34	0.1736	3.1119	[illegible]	0.1729	180
190	3.8774	74.59	0.1776	3.5773	74.58	0.1765	3.3201	74.56	0.1755	3.1618	[illegible]	0.1748	190
200	3.9383	75.82	0.1794	3.6336	75.80	0.1783	3.3724	75.79	0.1773	3.2116	75.78	0.1767	200
210	3.9991	77.05	0.1813	3.6898	77.03	0.1802	3.4247	77.02	0.1792	3.2615	77.01	0.1785	210
220	4.0599	78.29	0.1831	3.7460	78.28	0.1820	3.4770	78.26	0.1810	3.3113	78.25	0.1804	220
230	4.1208	79.54	0.1849	3.8022	79.52	0.1839	3.5292	79.51	0.1829	3.3611	79.[illegible]	0.1822	230

TEMP. °F	15			16			17			18			TEMP. °F
	0.3 psig (−71.17°F.)			1.3 psig (−68.71°F.)			2.3 psig (−66.36°F.)			3.3 psig (−64.12°F.)			
	V	H	S	V	H	S	V	H	S	V	H	S	
	(1.8020)	(45.94)	(0.1188)	(1.6971)	(46.14)	(0.1185)	(1.6040)	(46.33)	(0.1182)	(1.5209)	(46.52)	(0.1179)	
−70	1.8080	46.05	0.1191	–	–	–	–	–	–	–	–	–	−70
−60	1.8588	47.01	0.1215	1.7387	46.96	0.1206	1.6327	46.95	0.1198	1.5385	46.92	0.1189	−60
−50	1.9094	47.99	0.1239	1.7864	47.96	0.1230	1.6777	47.93	0.1222	1.5812	47.90	0.1214	−50
−40	1.9599	48.97	0.1263	1.8338	48.94	0.1254	1.7226	48.91	0.1246	1.6237	48.88	0.1237	−40
−30	2.0102	49.97	0.1287	1.8812	49.94	0.1278	1.7673	49.91	0.1269	1.6660	49.88	0.1261	−30
−20	2.0604	50.98	0.1310	1.9284	50.95	0.1301	1.8118	50.92	0.1292	1.7082	50.90	0.1284	−20
−10	2.1105	51.99	0.1333	1.9755	51.97	0.1324	1.8563	51.94	0.1315	1.7503	51.92	0.1307	−10
0	2.1605	53.02	0.1355	2.0224	53.00	0.1346	1.9006	52.97	0.1338	1.7923	52.95	0.1330	0
10	2.2104	54.07	0.1378	2.0693	54.04	0.1369	1.9449	54.02	0.1360	1.8342	53.99	0.1352	10
20	2.2602	55.12	0.1400	2.1161	55.09	0.1391	1.9890	55.07	0.1383	1.8760	55.05	0.1375	20
30	2.3098	56.18	0.1422	2.1628	56.16	0.1413	2.0330	56.14	0.14[illegible]	1.9177	56.11	0.1397	30
40	2.3595	57.25	0.1444	2.2094	57.23	0.1435	2.0770	57.21	0.1426	1.9593	57.19	0.1418	40
50	2.4090	58.34	0.1465	2.2560	58.32	0.1456	2.1209	58.30	0.1448	2.0009	58.27	0.1440	50
60	2.4585	59.43	0.1486	2.3024	59.41	0.1477	2.1648	59.39	0.1469	2.0424	59.37	0.1461	60
70	2.5079	60.54	0.1507	2.3489	60.52	0.1498	2.2085	60.50	0.1490	2.0838	60.48	0.1482	70
80	2.5573	61.65	0.1528	2.3952	61.63	0.1519	2.2522	61.61	0.1511	2.1251	61.59	0.1503	80
90	2.6066	62.78	0.1549	2.4415	62.76	0.1540	2.2959	62.74	0.1532	2.1664	62.72	0.1524	90
100	2.6558	63.91	0.1569	2.4878	63.89	0.1560	2.3395	63.88	0.1552	2.2077	63.86	0.1544	100
110	2.7050	65.06	0.1590	2.5340	65.04	0.1581	2.3830	65.02	0.1572	2.2489	65.00	0.1565	110
120	2.7542	66.21	0.1610	2.5801	66.19	0.1601	2.4266	66.18	0.1593	2.2901	66.16	0.1585	120
130	2.8033	67.38	0.1630	2.6262	67.36	0.1621	2.4700	67.34	0.1612	2.3312	67.32	0.1605	130
140	2.8524	68.55	0.1649	2.6723	68.53	0.1640	2.5135	68.51	0.1632	2.3722	68.50	0.1624	140
150	2.9014	69.73	0.1669	2.7184	69.71	0.1660	2.5568	69.70	0.1652	2.4133	69.68	0.1644	150
160	2.9504	70.92	0.1688	2.7644	70.91	0.1679	2.6002	70.89	0.1671	2.4543	70.87	0.1663	160
170	2.9994	72.12	0.1707	2.8103	72.11	0.1699	2.6435	72.09	0.1690	2.4952	72.07	0.1683	170
180	3.0483	73.33	0.1726	2.8563	73.31	0.1718	2.6868	73.30	0.1709	2.5362	73.28	0.1702	180
190	3.0972	74.55	0.1745	2.9022	74.53	0.1737	2.7301	74.52	0.1728	2.5771	74.50	0.1721	190
200	3.1461	75.77	0.1764	2.9480	75.76	0.1755	2.7733	75.74	0.1747	2.6180	75.73	0.1739	200
210	3.1949	77.01	0.1783	2.9939	76.99	0.1774	2.8165	76.98	0.1766	2.6588	76.96	0.1758	210
220	3.2438	78.25	0.1801	3.0397	78.23	0.1792	2.8597	78.22	0.1784	2.6996	78.21	0.1776	220
230	3.2926	79.50	0.1819	3.0855	79.48	0.1811	2.9028	79.47	0.1802	2.7404	79.46	0.17[illegible]	230
240	–	–	–	3.1313	80.74	0.1829	2.9459	80.73	0.1820	2.7812	80.72	0.1813	240

*Inches of Mercury below one atmosphere.

"FREON-13B1" – SUPERHEATED VAPOR

V=volume in cu ft/lb; H=enthalpy in Btu/lb; S=entropy in Btu/(lb)(°R) (saturation properties in parentheses)

ABSOLUTE PRESSURE, lb/sq in

TEMP. °F	19			20			21			22			TEMP. °F
	4.3 psig (−61.97°F.)			5.3 psig (−59.91°F.)			6.3 psig (−57.92°F.)			7.3 psig (−56.01°F.)			
	V	H	S	V	H	S	V	H	S	V	H	S	
	(1.4462)	(46.69)	(0.1177)	(1.3786)	(46.86)	(0.1175)	(1.3173)	(47.03)	(0.1172)	(1.2613)	(47.18)	(0.1170)	
−60	1.4542	46.89	0.1182	–	–	–	–	–	–	–	–	–	−60
−50	1.4948	47.87	0.1206	1.4170	47.83	0.1199	1.3466	47.80	0.1192	1.2826	47.77	0.1185	−50
−40	1.5352	48.86	0.1230	1.4555	48.83	0.1223	1.3834	48.80	0.1216	1.3179	48.77	0.1209	−40
−30	1.5754	49.86	0.1253	1.4939	49.83	0.1246	1.4201	49.80	0.1239	1.3530	49.77	0.1233	−30
−20	1.6155	50.87	0.1277	1.5321	50.84	0.1269	1.4566	50.81	0.1263	1.3880	50.79	0.1256	−20
−10	1.6555	51.89	0.1300	1.5702	51.86	0.1292	1.4930	51.84	0.1286	1.4228	51.81	0.1279	−10
0	1.6954	52.92	0.1322	1.6082	52.90	0.1315	1.5293	52.87	0.1308	1.4576	52.85	0.1302	0
10	1.7352	53.97	0.1345	1.6461	53.94	0.1338	1.5655	53.92	0.1331	1.4922	53.90	0.1324	10
20	1.7749	55.02	0.1367	1.6839	55.00	0.1360	1.6016	54.98	0.1353	1.5267	54.95	0.1347	20
30	1.8145	56.09	0.1389	1.7216	56.07	0.1382	1.6376	56.04	0.1375	1.5612	56.02	0.1369	30
40	1.8540	57.17	0.1411	1.7592	57.14	0.1404	1.6735	57.12	0.1397	1.5955	57.10	0.1390	40
50	1.8935	58.25	0.1432	1.7968	58.23	0.1425	1.7093	58.21	0.1418	1.6298	58.19	0.1412	50
60	1.9329	59.35	0.1454	1.8343	59.33	0.1447	1.7451	59.31	0.1440	1.6640	59.29	0.1433	60
70	1.9722	60.46	0.1475	1.8717	60.44	0.1468	1.7808	60.42	0.1461	1.6982	60.40	0.1454	70
80	2.0114	61.57	0.1496	1.9091	61.56	0.1489	1.8165	61.54	0.1482	1.7323	61.52	0.1475	80
90	2.0506	62.70	0.1516	1.9464	62.68	0.1509	1.8521	62.66	0.1503	1.7663	62.64	0.1496	90
100	2.0898	63.84	0.1537	1.9836	63.82	0.1530	1.8876	63.80	0.1523	1.8003	63.78	0.1517	100
110	2.1289	64.99	0.1557	2.0208	64.97	0.1550	1.9231	64.95	0.1543	1.8342	64.93	0.1537	110
120	2.1679	66.14	0.1577	2.0580	66.12	0.1570	1.9585	66.11	0.1564	1.8681	66.09	0.1557	120
130	2.2069	67.31	0.1597	2.0951	67.29	0.1590	1.9939	67.27	0.1583	1.9020	67.26	0.1577	130
140	2.2459	68.48	0.1617	2.1322	68.46	0.1610	2.0293	68.45	0.1603	1.9358	68.43	0.1597	140
150	2.2848	69.67	0.1637	2.1692	69.65	0.1630	2.0646	69.63	0.1623	1.9695	69.62	0.1616	150
160	2.3237	70.86	0.1656	2.2062	70.84	0.1649	2.0999	70.83	0.1642	2.0033	70.81	0.1636	160
170	2.3626	72.06	0.1675	2.2432	72.04	0.1668	2.1352	72.03	0.1662	2.0369	72.01	0.1655	170
180	2.4014	73.27	0.1694	2.2801	73.25	0.1687	2.1704	73.24	0.1681	2.0706	73.22	0.1674	180
190	2.4402	74.49	0.1713	2.3170	74.47	0.1706	2.2056	74.46	0.1699	2.1042	74.44	0.1693	190
200	2.4790	75.71	0.1732	2.3539	75.70	0.1725	2.2407	75.69	0.1718	2.1378	75.67	0.1712	200
210	2.5177	76.95	0.1750	2.3907	76.94	0.1743	2.2759	76.92	0.1737	2.1714	76.91	0.1730	210
220	2.5564	78.19	0.1769	2.4276	78.18	0.1762	2.3110	78.17	0.1755	2.2050	78.15	0.1749	220
230	2.5951	79.44	0.1787	2.4644	79.43	0.1780	2.3460	79.42	0.1774	2.2385	79.40	0.1767	230
240	2.6338	80.70	0.1805	2.5011	80.69	0.1798	2.3811	80.68	0.1792	2.2720	80.68	0.1785	240
250	–	–	–	2.5379	81.96	0.1816	2.4161	81.94	0.1810	2.3055	81.93	0.1803	250

TEMP. °F	23			24			25			26			TEMP. °F
	8.3 psig (−54.16°F.)			9.3 psig (−52.38°F.)			10.3 psig (−50.65°F.)			11.3 psig (−48.97°F.)			
	V	H	S	V	H	S	V	H	S	V	H	S	
	(1.2100)	(47.33)	(0.1168)	(1.1628)	(47.48)	(0.1167)	(1.1192)	(47.62)	(0.1165)	(1.0789)	(47.75)	(0.1163)	
−50	1.2241	47.74	0.1179	1.1706	47.71	0.1172	1.1213	47.68	0.1166	–	–	–	−50
−40	1.2580	48.74	0.1203	1.2031	48.71	0.1196	1.1526	48.68	0.1190	1.1060	48.65	0.1185	−40
−30	1.2917	49.74	0.1226	1.2356	49.71	0.1220	1.1839	49.69	0.1214	1.1362	49.66	0.1209	−30
−20	1.3253	50.76	0.1250	1.2678	50.73	0.1244	1.2149	50.70	0.1238	1.1661	50.68	0.1232	−20
−10	1.3587	51.79	0.1273	1.3000	51.76	0.1267	1.2459	51.73	0.1261	1.1960	51.71	0.1255	−10
0	1.3920	52.82	0.1295	1.3320	52.80	0.1289	1.2767	52.77	0.1284	1.2257	52.75	0.1278	0
10	1.4253	53.87	0.1318	1.3639	53.85	0.1312	1.3074	53.82	0.1306	1.2553	53.80	0.1301	10
20	1.4584	54.93	0.1340	1.3957	54.91	0.1334	1.3381	54.88	0.1329	1.2849	54.86	0.1323	20
30	1.4914	56.00	0.1362	1.4274	55.98	0.1356	1.3686	55.95	0.1351	1.3143	55.93	0.1345	30
40	1.5243	57.08	0.1384	1.4591	57.06	0.1378	1.3991	57.03	0.1373	1.3436	57.01	0.1367	40
50	1.5572	58.17	0.1406	1.4907	58.15	0.1400	1.4294	58.12	0.1394	1.3729	58.10	0.1389	50
60	1.5900	59.27	0.1427	1.5222	59.25	0.1421	1.4597	59.23	0.1416	1.4021	59.20	0.1410	60
70	1.6227	60.38	0.1448	1.5536	60.36	0.1442	1.4900	60.34	0.1437	1.4312	60.32	0.1431	70
80	1.6554	61.50	0.1469	1.5849	61.48	0.1463	1.5201	61.46	0.1458	1.4603	61.44	0.1452	80
90	1.6880	62.63	0.1490	1.6163	62.61	0.1484	1.5502	62.59	0.1478	1.4893	62.57	0.1473	90
100	1.7206	63.76	0.1511	1.6475	63.75	0.1505	1.5803	63.73	0.1499	1.5182	63.71	0.1493	100
110	1.7531	64.91	0.1531	1.6787	64.90	0.1525	1.6103	64.88	0.1519	1.5471	64.86	0.1514	110
120	1.7856	66.07	0.1551	1.7099	66.05	0.1545	1.6403	66.04	0.1539	1.5760	66.02	0.1534	120
130	1.8180	67.24	0.1571	1.7410	67.22	0.1565	1.6702	67.20	0.1559	1.6048	67.19	0.1554	130
140	1.8504	68.41	0.1591	1.7721	68.40	0.1585	1.7001	68.38	0.1579	1.6336	68.36	0.1574	140
150	1.8827	69.60	0.1610	1.8031	69.58	0.1604	1.7299	69.57	0.1599	1.6623	69.55	0.1593	150
160	1.9150	70.79	0.1630	1.8341	70.78	0.1624	1.7597	70.76	0.1618	1.6910	70.75	0.1613	160
170	1.9473	72.00	0.1649	1.8651	71.98	0.1643	1.7895	71.97	0.1638	1.7197	71.95	0.1632	170
180	1.9795	73.21	0.1668	1.8960	73.19	0.1662	1.8192	73.18	0.1657	1.7483	73.16	0.1651	180
190	2.0117	74.43	0.1687	1.9269	74.41	0.1681	1.8489	74.40	0.1676	1.7769	74.38	0.1670	190
200	2.0439	75.66	0.1706	1.9578	75.64	0.1700	1.8786	75.63	0.1694	1.8054	75.61	0.1689	200
210	2.0760	76.89	0.1724	1.9886	76.88	0.1719	1.9082	76.87	0.1713	1.8340	76.85	0.1708	210
220	2.1082	78.14	0.1743	2.0195	78.12	0.1737	1.9378	78.11	0.1731	1.8625	78.10	0.1726	220
230	2.1403	79.39	0.1761	2.0502	79.38	0.1755	1.9674	79.36	0.1750	1.8910	79.35	0.1744	230
240	2.1723	80.65	0.1779	2.0810	80.64	0.1773	1.9970	80.62	0.1768	1.9194	80.61	0.1763	240
250	2.2044	81.92	0.1797	2.1118	81.90	0.1791	2.0265	81.89	0.1786	1.9479	81.88	0.1781	250
260	–	–	–	–	–	–	–	–	–	1.9763	83.15	0.1798	260

"FREON-13B1" – SUPERHEATED VAPOR

V=volume in cu ft/lb; H=enthalpy in Btu/lb; S=entropy in Btu/(lb)(°R) (saturation properties in parentheses)

ABSOLUTE PRESSURE, lb/sq in

TEMP. °F	27			28			29			30			TEMP. °F
	12.3 psia (−47.34°F.)			13.3 psia (−45.76°F.)			14.3 psia (−44.22°F.)			15.3 psia (−42.71°F.)			
	V	H	S	V	H	S	V	H	S	V	H	S	
	(1.0414)	(47.88)	(0.1162)	(1.0065)	(48.01)	(0.1160)	(0.9739)	(48.13)	(0.1159)	(0.9434)	(48.25)	(0.1157)	
−40	1.0629	48.62	0.1179	1.0228	48.59	0.1174	0.9854	48.56	0.1169	0.9506	48.53	0.1164	−40
−30	1.0920	49.63	0.1203	1.0509	49.60	0.1198	1.0127	49.57	0.1193	0.9771	49.54	0.1188	−30
−20	1.1209	50.65	0.1227	1.0790	50.62	0.1221	1.0399	50.59	0.1216	1.0034	50.57	0.1211	−20
−10	1.1498	51.68	0.1250	1.1068	51.65	0.1245	1.0669	51.63	0.1239	1.0296	51.60	0.1235	−10
0	1.1785	52.72	0.1273	1.1346	52.70	0.1267	1.0938	52.67	0.1262	1.0556	52.64	0.1258	0
10	1.2071	53.77	0.1295	1.1623	53.75	0.1290	1.1205	53.72	0.1285	1.0816	53.70	0.1280	10
20	1.2356	54.83	0.1318	1.1898	54.81	0.1312	1.1472	54.79	0.1307	1.1074	54.76	0.1303	20
30	1.2640	55.91	0.1340	1.2173	55.88	0.1335	1.1738	55.86	0.1330	1.1332	55.84	0.1325	30
40	1.2923	56.99	0.1362	1.2446	56.97	0.1357	1.2003	56.94	0.1352	1.1589	56.92	0.1347	40
50	1.3205	58.08	0.1383	1.2719	58.06	0.1378	1.2267	58.04	0.1373	1.1844	58.02	0.1368	50
60	1.3487	59.18	0.1405	1.2992	59.16	0.1400	1.2530	59.14	0.1395	1.2100	59.12	0.1390	60
70	1.3768	60.30	0.1426	1.3263	60.28	0.1421	1.2793	60.25	0.1416	1.2354	60.23	0.1411	70
80	1.4049	61.42	0.1447	1.3534	61.40	0.1442	1.3055	61.38	0.1437	1.2608	61.36	0.1432	80
90	1.4328	62.55	0.1468	1.3804	62.53	0.1463	1.3316	62.51	0.1458	1.2861	62.49	0.1453	90
100	1.4608	63.69	0.1488	1.4074	63.67	0.1483	1.3577	63.65	0.1478	1.3114	63.63	0.1474	100
110	1.4887	64.84	0.1509	1.4343	64.82	0.1504	1.3838	64.80	0.1499	1.3366	64.79	0.1494	110
120	1.5165	66.00	0.1529	1.4612	65.98	0.1524	1.4098	65.97	0.1519	1.3618	65.95	0.1514	120
130	1.5443	67.17	0.1549	1.4881	67.15	0.1544	1.4357	67.14	0.1539	1.3869	67.12	0.1534	130
140	1.5720	68.35	0.1569	1.5149	68.33	0.1564	1.4616	68.31	0.1559	1.4120	68.30	0.1554	140
150	1.5997	69.54	0.1588	1.5416	69.52	0.1583	1.4875	69.50	0.1578	1.4370	69.49	0.1574	150
160	1.6274	70.73	0.1608	1.5683	70.71	0.1603	1.5133	70.70	0.1598	1.4620	70.68	0.1593	160
170	1.6550	71.94	0.1627	1.5950	71.92	0.1622	1.5391	71.90	0.1617	1.4870	71.89	0.1612	170
180	1.6826	73.15	0.1646	1.6217	73.13	0.1641	1.5649	73.12	0.1636	1.5119	73.10	0.1632	180
190	1.7102	74.37	0.1665	1.6483	74.36	0.1661	1.5906	74.34	0.1655	1.5368	74.33	0.1650	190
200	1.7377	75.60	0.1684	1.6749	75.59	0.1679	1.6163	75.57	0.1674	1.5617	75.56	0.1669	200
210	1.7652	76.84	0.1702	1.7014	76.82	0.1697	1.6420	76.81	0.1693	1.5865	76.79	0.1688	210
220	1.7927	78.08	0.1721	1.7279	78.07	0.1716	1.6676	78.06	0.1711	1.6113	78.04	0.1706	220
230	1.8201	79.34	0.1739	1.7545	79.32	0.1734	1.6933	79.31	0.1729	1.6361	79.30	0.1725	230
240	1.8475	80.60	0.1757	1.7809	80.58	0.1752	1.7188	80.57	0.1748	1.6609	80.55	0.1743	240
250	1.8750	81.87	0.1775	1.8074	81.85	0.1770	1.7444	81.84	0.1766	1.6856	81.83	0.1761	250
260	1.9024	83.14	0.1793	1.8338	83.13	0.1768	1.7700	83.12	0.1783	1.7104	83.10	0.1779	260

TEMP. °F	31			32			33			34			TEMP. °F
	16.3 psia (−41.25°F.)			17.3 psia (−39.82°F.)			18.3 psia (−38.43°F.)			19.3 psia (−37.07°F.)			
	V	H	S	V	H	S	V	H	S	V	H	S	
	(0.9147)	(48.37)	(0.1156)	(0.8878)	(48.48)	(0.1155)	(0.8625)	(48.60)	(0.1154)	(0.8386)	(48.70)	(0.1152)	
−40	0.9180	48.50	0.1159	–	–	–	–	–	–	–	–		−40
−30	0.9437	49.51	0.1183	0.9124	49.48	0.1178	0.8830	49.45	0.1174	0.8553	49.42	0.1169	−30
−20	0.9692	50.54	0.1207	0.9372	50.51	0.1202	0.9071	50.48	0.1197	0.8788	50.45	0.1193	−20
−10	0.9947	51.57	0.1230	0.9619	51.55	0.1225	0.9312	51.52	0.1221	0.9022	51.49	0.1215	−10
0	1.0200	52.62	0.1253	0.9865	52.59	0.1249	0.9551	52.57	0.1244	0.9255	52.54	0.1239	0
10	1.0451	53.67	0.1275	1.0110	53.65	0.1271	0.9789	53.62	0.1266	0.9487	53.60	0.1262	10
20	1.0702	54.74	0.1298	1.0353	54.71	0.1293	1.0026	54.69	0.1289	0.9717	54.67	0.1285	20
30	1.0952	55.81	0.1320	1.0596	55.79	0.1316	1.0261	55.77	0.1311	0.9947	55.74	0.1307	30
40	1.1201	56.90	0.1342	1.0838	56.88	0.1338	1.0496	56.85	0.1333	1.0175	56.83	0.1329	40
50	1.1449	57.99	0.1364	1.1079	57.97	0.1359	1.0731	57.95	0.1355	1.0403	57.93	0.1351	50
60	1.1697	59.10	0.1385	1.1319	59.08	0.1381	1.0966	59.06	0.1375	1.0630	59.04	0.1372	60
70	1.1943	60.21	0.1406	1.1558	60.19	0.1402	1.1197	60.17	0.1398	1.0855	60.15	0.1393	70
80	1.2189	61.34	0.1427	1.1797	61.32	0.1423	1.1429	61.30	0.1419	1.1082	61.28	0.1414	80
90	1.2435	62.47	0.1448	1.2035	62.45	0.1444	1.1660	62.43	0.1439	1.1307	62.41	0.1435	90
100	1.2680	63.62	0.1469	1.2273	63.60	0.1464	1.1891	63.58	0.1460	1.1532	63.55	0.1456	100
110	1.2924	64.77	0.1489	1.2510	64.75	0.1485	1.2122	64.73	0.1481	1.1756	64.71	0.1475	110
120	1.3168	65.93	0.1510	1.2747	65.91	0.1505	1.2351	65.89	0.1501	1.1979	65.88	0.1497	120
130	1.3412	67.10	0.1530	1.2983	67.08	0.1525	1.2581	67.07	0.1521	1.2202	67.05	0.1517	130
140	1.3655	68.28	0.1549	1.3219	68.26	0.1545	1.2810	68.25	0.1541	1.2425	68.23	0.1537	140
150	1.3897	69.47	0.1569	1.3455	69.45	0.1565	1.3039	69.44	0.1560	1.2647	69.42	0.1556	150
160	1.4140	70.67	0.1588	1.3690	70.65	0.1584	1.3267	70.64	0.1580	1.2869	70.62	0.1576	160
170	1.4382	71.87	0.1608	1.3924	71.86	0.1603	1.3495	71.84	0.1599	1.3090	71.83	0.1595	170
180	1.4623	73.09	0.1627	1.4159	73.07	0.1623	1.3722	73.06	0.1618	1.3311	73.04	0.1614	180
190	1.4865	74.31	0.1646	1.4393	74.30	0.1642	1.3949	74.28	0.1637	1.3532	74.27	0.1633	190
200	1.5106	75.54	0.1665	1.4625	75.53	0.1660	1.4176	75.51	0.1656	1.3753	75.50	0.1652	200
210	1.5346	76.78	0.1683	1.4860	76.77	0.1679	1.4403	76.75	0.1675	1.3973	76.74	0.1671	210
220	1.5587	78.03	0.1702	1.5093	78.01	0.1698	1.4629	78.00	0.1693	1.4193	77.99	0.1689	220
230	1.5827	79.28	0.1720	1.5326	79.27	0.1716	1.4855	79.26	0.1712	1.4413	79.24	0.1707	230
240	1.6067	80.54	0.1738	1.5559	80.53	0.1734	1.5081	80.52	0.1730	1.4632	80.50	0.1726	240
250	1.6307	81.81	0.1756	1.5791	81.80	0.1752	1.5307	81.79	0.1748	1.4851	81.78	0.1744	250
260	1.6546	83.09	0.1774	1.6023	83.08	0.1770	1.5532	83.07	0.1766	1.5070	83.05	0.1762	260
270	–	–	–	1.6255	84.36	0.1788	1.5758	84.35	0.1783	1.5289	84.34	0.1779	270

"FREON-13B1" – SUPERHEATED VAPOR

V=volume in cu ft/lb; H=enthalpy in Btu/lb; S=entropy in Btu/(lb)(°R) (saturation properties in parentheses)

ABSOLUTE PRESSURE, lb/sq in

TEMP. °F	35			36			37			38			TEMP. °F
	20.3 psig (–35.74°F.)			21.3 psig (–34.43°F.)			22.3 psig (–33.16°F.)			23.3 psig (–31.91°F.)			
	V	H	S	V	H	S	V	H	S	V	H	S	
	(0.8159)	(49.31)	(0.1151)	(0.7945)	(48.91)	(0.1150)	(0.7743)	(49.01)	(0.1149)	(0.7550)	(49.11)	(0.1148)	
–30	0.8292	49.39	0.1163	0.8045	49.37	0.1161	0.7812	49.34	0.1157	0.7591	49.33	0.1153	–30
–20	0.8521	50.43	0.1189	0.8269	50.40	0.1184	0.8031	50.37	0.1180	0.7804	50.34	0.1176	–20
–10	0.8749	51.46	0.1212	0.8492	51.44	0.1208	0.8248	51.41	0.1204	0.8016	51.38	0.1200	–10
0	0.8976	52.51	0.1235	0.8713	52.49	0.1231	0.8463	52.46	0.1227	0.8227	52.43	0.1223	0
10	0.9202	53.57	0.1258	0.8933	53.55	0.1254	0.8678	53.52	0.1250	0.8437	53.50	0.1246	10
20	0.9426	54.64	0.1280	0.9151	54.62	0.1276	0.8891	54.59	0.1272	0.8645	54.57	0.1268	20
30	0.9650	55.72	0.1303	0.9369	55.70	0.1299	0.9104	55.67	0.1295	0.8853	55.65	0.1291	30
40	0.9872	56.81	0.1325	0.9586	56.79	0.1321	0.9315	56.76	0.1317	0.9059	56.74	0.1313	40
50	1.0094	57.91	0.1346	0.9802	57.88	0.1342	0.9526	57.86	0.1338	0.9265	57.84	0.1335	50
60	1.0315	59.01	0.1368	1.0018	58.99	0.1364	0.9737	58.97	0.1360	0.9470	58.95	0.1356	60
70	1.0535	60.13	0.1389	1.0232	60.11	0.1385	0.9945	60.09	0.1381	0.9674	60.07	0.1377	70
80	1.0755	61.26	0.1410	1.0446	61.24	0.1406	1.0154	61.22	0.1402	0.9877	61.20	0.1399	80
90	1.0974	62.39	0.1431	1.0659	62.37	0.1427	1.0362	62.36	0.1423	1.0080	62.34	0.1419	90
100	1.1193	63.54	0.1452	1.0872	63.52	0.1448	1.0569	63.50	0.1444	1.0282	63.48	0.1440	100
110	1.1410	64.69	0.1472	1.1085	64.68	0.1468	1.0776	64.66	0.1464	1.0484	64.64	0.1461	110
120	1.1628	65.86	0.1493	1.1298	65.84	0.1489	1.0982	65.82	0.1485	1.0685	65.80	0.1481	120
130	1.1845	67.03	0.1513	1.1508	67.01	0.1509	1.1188	67.00	0.1505	1.0886	66.98	0.1501	130
140	1.2061	68.21	0.1532	1.1718	68.20	0.1529	1.1394	68.18	0.1525	1.1087	68.16	0.1521	140
150	1.2278	69.40	0.1552	1.1929	69.39	0.1548	1.1599	69.37	0.1544	1.1286	69.35	0.1541	150
160	1.2493	70.60	0.1572	1.2139	70.59	0.1568	1.1804	70.57	0.1564	1.1486	70.55	0.1560	160
170	1.2709	71.81	0.1591	1.2349	71.80	0.1587	1.2008	71.78	0.1583	1.1685	71.76	0.1579	170
180	1.2924	73.03	0.1610	1.2558	73.01	0.1606	1.2212	73.00	0.1602	1.1884	72.98	0.1599	180
190	1.3139	74.25	0.1629	1.2767	74.24	0.1625	1.2416	74.22	0.1621	1.2083	74.21	0.1618	190
200	1.3353	75.48	0.1648	1.2976	75.47	0.1644	1.2619	75.45	0.1640	1.2281	75.44	0.1637	200
210	1.3567	76.72	0.1667	1.3184	76.71	0.1663	1.2822	76.70	0.1659	1.2479	76.68	0.1655	210
220	1.3781	77.97	0.1685	1.3393	77.96	0.1681	1.3025	77.94	0.1677	1.2677	77.93	0.1674	220
230	1.3995	79.23	0.1703	1.3600	79.21	0.1700	1.3227	79.20	0.1696	1.2874	79.19	0.1692	230
240	1.4208	80.49	0.1722	1.3808	80.48	0.1718	1.3430	80.46	0.1714	1.3071	80.45	0.1710	240
250	1.4421	81.76	0.1740	1.4016	81.75	0.1736	1.3632	81.74	0.1732	1.3268	81.72	0.1728	250
260	1.4634	83.04	0.1758	1.4223	83.03	0.1754	1.3834	83.01	0.1750	1.3465	83.00	0.1746	260
270	1.4847	84.33	0.1775	1.4430	84.31	0.1771	1.4035	84.30	0.1768	1.3661	84.29	0.1764	270

TEMP. °F	39			40			42			44			TEMP. °F
	24.3 psig (–30.68 F.)			25.3 psig (–29.48 F.)			27.3 psig (–27.14 F.)			29.3 psig (–24.89 F.)			
	V	H	S	V	H	S	V	H	S	V	H	S	
	(0.7367)	(49.21)	(0.1147)	(0.7192)	(49.30)	(0.1146)	(0.6867)	(49.48)	(0.1144)	(0.6571)	(49.65)	(0.1143)	
–30	0.7381	49.28	0.1149	–	–	–	–	–	–	–	–	–	–30
–20	0.7590	50.31	0.1173	0.7386	50.28	0.1169	0.7007	50.22	0.1161	0.6663	50.16	0.1154	–20
–10	0.7797	51.35	0.1196	0.7589	51.33	0.1192	0.7202	51.27	0.1185	0.6869	51.22	0.1178	–10
0	0.8003	52.41	0.1219	0.7790	52.38	0.1215	0.7395	52.33	0.1208	0.7035	52.27	0.1201	0
10	0.8207	53.47	0.1242	0.7990	53.45	0.1238	0.7586	53.39	0.1231	0.7219	53.34	0.1224	10
20	0.8411	54.54	0.1265	0.8189	54.52	0.1261	0.7777	54.47	0.1254	0.7402	54.42	0.1247	20
30	0.8614	55.63	0.1287	0.8387	55.60	0.1283	0.7967	55.55	0.1276	0.7584	55.51	0.1269	30
40	0.8816	56.72	0.1309	0.8585	56.69	0.1305	0.8155	56.65	0.1298	0.7765	56.60	0.1291	40
50	0.9017	57.82	0.1331	0.8781	57.82	0.1327	0.8343	57.75	0.1320	0.7945	57.71	0.1313	50
60	0.9217	58.93	0.1352	0.8976	58.91	0.1349	0.8530	58.86	0.1342	0.8124	58.82	0.1335	60
70	0.9416	60.05	0.1374	0.9171	60.03	0.1370	0.8716	59.99	0.1363	0.8303	59.94	0.1356	70
80	0.9615	61.18	0.1395	0.9365	61.16	0.1391	0.8902	61.12	0.1384	0.8480	61.08	0.1378	80
90	0.9813	62.32	0.1416	0.9559	62.30	0.1412	0.9087	62.26	0.1405	0.8658	62.22	0.1398	90
100	1.0010	63.46	0.1436	0.9751	63.45	0.1433	0.9271	63.41	0.1426	0.8834	63.37	0.1419	100
110	1.0207	64.62	0.1457	0.9944	64.60	0.1453	0.9455	64.57	0.1446	0.9010	64.53	0.1440	110
120	1.0403	65.79	0.1477	1.0136	65.77	0.1474	0.9638	65.73	0.1467	0.9186	65.70	0.1460	120
130	1.0599	66.96	0.1497	1.0327	66.94	0.1494	0.9822	66.91	0.1487	0.9361	66.87	0.1480	130
140	1.0795	68.15	0.1517	1.0518	68.13	0.1514	1.0003	68.09	0.1507	0.9535	68.06	0.1500	140
150	1.0990	69.34	0.1537	1.0708	69.32	0.1533	1.0185	69.29	0.1527	0.9710	69.25	0.1520	150
160	1.1185	70.54	0.1556	1.0898	70.52	0.1553	1.0367	70.49	0.1546	0.9885	70.46	0.1540	160
170	1.1379	71.75	0.1576	1.1088	71.73	0.1572	1.0548	71.70	0.1565	1.0057	71.67	0.1559	170
180	1.1573	72.97	0.1595	1.1278	72.95	0.1591	1.0729	72.92	0.1585	1.0230	72.89	0.1578	180
190	1.1767	74.19	0.1614	1.1467	74.18	0.1611	1.0909	74.15	0.1604	1.0403	74.12	0.1597	190
200	1.1960	75.43	0.1633	1.1655	75.41	0.1629	1.1089	75.38	0.1623	1.0575	75.35	0.1616	200
210	1.2153	76.67	0.1652	1.1844	76.65	0.1648	1.1269	76.62	0.1641	1.0747	76.60	0.1635	210
220	1.2346	77.92	0.1670	1.2032	77.90	0.1667	1.1449	77.87	0.1660	1.0919	77.85	0.1653	220
230	1.2539	79.17	0.1688	1.2220	79.16	0.1685	1.1628	79.13	0.1678	1.1091	79.11	0.1672	230
240	1.2731	80.44	0.1707	1.2408	80.43	0.1703	1.1808	80.40	0.1696	1.1262	80.37	0.1690	240
250	1.2923	81.71	0.1725	1.2595	81.70	0.1721	1.1986	81.67	0.1714	1.1433	81.65	0.1708	250
260	1.3115	82.99	0.1743	1.2782	82.98	0.1739	1.2165	82.95	0.1732	1.1604	82.93	0.1726	260
270	1.3306	84.28	0.1760	1.2969	84.26	0.1757	1.2344	84.24	0.1750	1.1775	84.21	0.1744	270
280	–	–	–	1.3156	85.56	0.1774	1.2522	85.53	0.1768	1.1945	85.51	0.1761	280

"FREON-13B1" – SUPERHEATED VAPOR

V=volume in cu ft/lb; H=enthalpy in Btu/lb; S=entropy in Btu/(lb)(°R) (saturation properties in parentheses)

ABSOLUTE PRESSURE, lb/sq in

TEMP. °F	46			48			50			52			TEMP. °F
	31.3 psig (–22.71°F.)			33.3 psig (–20.60°F.)			35.3 psig (–18.56°F.)			37.3 psig (–16.58°F.)			
	V	H	S	V	H	S	V	H	S	V	H	S	
	(0.6299)	(49.82)	(0.1141)	(0.6049)	(49.98)	(0.1139)	(0.5818)	(50.14)	(0.1138)	(0.5604)	(50.29)	(0.1137)	
–20	0.6348	50.11	0.1147	0.6059	50.05	0.1141	–	–	–	–	–	–	–20
–10	0.6528	51.16	0.1171	0.6233	51.10	0.1165	0.5961	51.04	0.1158	0.5711	50.99	0.1152	–10
0	0.6706	52.22	0.1194	0.6405	52.17	0.1188	0.6128	52.11	0.1182	0.5871	52.06	0.1176	0
10	0.6883	53.29	0.1217	0.6576	53.24	0.1211	0.6293	53.19	0.1205	0.6031	53.13	0.1199	10
20	0.7059	54.37	0.1240	0.6745	54.32	0.1234	0.6456	54.27	0.1228	0.6189	54.22	0.1222	20
30	0.7234	55.46	0.1263	0.6914	55.41	0.1256	0.6619	55.36	0.1250	0.6347	55.31	0.1244	30
40	0.7409	56.56	0.1285	0.7081	56.51	0.1279	0.6780	56.46	0.1272	0.6503	56.41	0.1267	40
50	0.7581	57.66	0.1307	0.7248	57.62	0.1301	0.6941	57.57	0.1294	0.6658	57.53	0.1289	50
60	0.7753	58.78	0.1328	0.7414	58.73	0.1322	0.7101	58.69	0.1316	0.6812	58.65	0.1310	60
70	0.7925	59.90	0.1350	0.7579	59.86	0.1344	0.7260	59.82	0.1336	0.6966	59.77	0.1332	70
80	0.8096	61.04	0.1371	0.7743	60.99	0.1365	0.7418	60.95	[illegible]	0.7119	60.91	0.1353	80
90	0.8266	62.18	0.1392	0.7907	62.14	0.1386	0.7576	62.10	[illegible]	0.7271	62.06	0.1374	90
100	0.8435	63.33	0.1413	0.8070	63.29	0.1407	0.7733	63.25	0.1401	0.7423	63.21	0.1395	100
110	0.8604	64.49	0.1433	0.8232	64.45	0.1427	0.7890	64.42	0.1421	0.7574	64.38	0.1416	110
120	0.8773	65.66	0.1454	0.8394	65.62	0.1448	0.8046	65.59	0.1442	0.7724	65.55	0.1436	120
130	0.8941	66.84	0.1474	0.8556	66.80	0.1468	0.8201	66.77	0.1462	0.7874	66.73	0.1456	130
140	0.9108	68.03	0.1494	0.8717	67.99	0.1488	0.8356	67.96	0.1482	0.8024	67.92	0.1476	140
150	0.9275	69.22	0.1514	0.8877	69.19	0.1508	0.8511	69.15	0.1502	0.8173	69.12	0.1496	150
160	0.9442	70.43	0.1533	0.9037	70.39	0.1527	0.8665	70.36	0.1521	0.8321	70.33	0.1516	160
170	0.9608	71.64	0.1553	0.9197	71.61	0.1547	0.8819	71.57	0.1541	0.8470	71.54	0.1535	170
180	0.9774	72.86	0.1572	0.9357	72.83	0.1566	0.8972	72.80	0.1560	0.8618	72.77	0.1554	180
190	0.9940	74.09	0.1591	0.9516	74.06	0.1585	0.9125	74.03	0.1579	0.8765	74.00	0.1574	190
200	1.0105	75.32	0.1610	0.9675	75.29	0.1604	0.9278	75.26	0.1598	0.8913	75.24	0.1592	200
210	1.0270	76.57	0.1629	0.9833	76.54	0.1623	0.9431	76.51	0.1617	0.9060	76.48	0.1611	210
220	1.0435	77.82	0.1647	0.9991	77.79	0.1641	0.9583	77.76	0.1635	0.9206	77.74	0.1630	220
230	1.0599	79.08	0.1665	1.0149	79.05	0.1659	0.9735	79.02	0.1654	0.9353	79.00	0.1648	230
240	1.0764	80.35	0.1684	1.0307	80.32	0.1678	0.9887	80.29	0.1672	0.9499	80.27	0.1667	240
250	1.0928	81.62	0.1702	1.0464	81.59	0.1696	1.0038	81.57	0.1690	0.9645	81.54	0.1685	250
260	1.1091	82.90	0.1720	1.0622	82.88	0.1714	1.0190	82.85	0.1708	0.9791	82.82	0.1703	260
270	1.1255	84.19	0.1737	1.0779	84.16	0.1732	1.0341	84.14	0.1726	0.9936	84.11	0.1720	270
280	1.1418	85.48	0.1755	1.0936	85.46	0.1749	1.0491	85.44	0.1743	1.0081	85.41	0.1738	280
290	–	–	–	–	–	–	1.0642	86.74	0.1761	1.0226	86.71	0.1756	290

TEMP. °F	54			56			58			60			TEMP. °F
	39.3 psig (–14.65°F.)			41.3 psig (–12.78°F.)			43.3 psig (–10.95°F.)			45.3 psig (–9.18°F.)			
	V	H	S	V	H	S	V	H	S	V	H	S	
	(0.5405)	(50.43)	(0.1135)	(0.5220)	(50.57)	(0.1134)	(0.5047)	(50.71)	(0.1133)	(0.4885)	(50.84)	(0.1132)	
–10	0.5478	50.93	0.1146	0.5262	50.87	0.1141	0.5061	50.81	0.1135	–	–	–	–10
0	0.5634	52.00	0.1170	0.5414	51.94	0.1164	0.5208	51.89	0.1159	0.5017	51.83	0.1153	0
10	0.5789	53.08	0.1193	0.5564	53.03	0.1188	0.5356	52.97	0.1182	0.5158	52.92	0.1177	10
20	0.5942	54.17	0.1216	0.5713	54.12	0.1210	0.5499	54.06	0.1205	0.5299	54.01	0.1200	20
30	0.6094	55.26	0.1239	0.5860	55.21	0.1233	0.5642	55.16	0.1228	0.5438	55.11	0.1223	30
40	0.6245	56.37	0.1261	0.6007	56.32	0.1255	0.5784	56.27	0.1250	0.5576	56.22	0.1245	40
50	0.6396	57.48	0.1283	0.6152	57.43	0.1278	0.5925	57.39	0.1272	0.5713	57.34	0.1267	50
60	0.6545	58.60	0.1305	0.6297	58.56	0.1299	0.6065	58.51	0.1294	0.5850	58.47	0.1289	60
70	0.6694	59.73	0.1326	0.6441	59.69	0.1321	0.6205	59.65	0.1316	0.5985	59.60	0.1311	70
80	0.6841	60.87	0.1348	0.6584	60.83	0.1342	0.6344	60.79	0.1337	0.6120	60.75	0.1332	80
90	0.6988	62.02	0.1369	0.6726	61.98	0.1363	0.6482	61.94	0.1358	0.6254	61.90	0.1353	90
100	0.7135	63.18	0.1390	0.6868	63.14	0.1384	0.6619	63.10	0.1379	0.6387	63.06	0.1374	100
110	0.7281	64.34	0.1410	0.7009	64.30	0.1405	0.6756	64.27	0.1400	0.6520	64.23	0.1395	110
120	0.7426	65.52	0.1431	0.7150	65.48	0.1425	0.6892	65.44	0.1420	0.6652	65.41	0.1415	120
130	0.7571	66.70	0.1451	0.7290	66.66	0.1446	0.7028	66.63	0.1441	0.6784	66.59	0.1436	130
140	0.7716	67.89	0.1471	0.7430	67.85	0.1466	0.7163	67.82	0.1461	0.6915	67.78	0.1456	140
150	0.7860	69.09	0.1491	0.7569	69.05	0.1485	0.7298	69.02	0.1480	0.7045	68.99	0.1476	150
160	0.8003	70.30	0.1510	0.7708	70.26	0.1505	0.7432	70.23	0.1500	0.7176	70.20	0.1495	160
170	0.8146	71.51	0.1530	0.7846	71.48	0.1525	0.7567	71.45	0.1520	0.7306	71.42	0.1515	170
180	0.8289	72.73	0.1549	0.7984	72.70	0.1544	0.7700	72.67	0.1539	0.7435	72.64	0.1534	180
190	0.8432	73.97	0.1568	0.8122	73.94	0.1563	0.7834	73.91	0.1558	0.7565	73.88	0.1553	190
200	0.8574	75.21	0.1587	0.8259	75.18	0.1582	0.7967	75.15	0.1577	0.7693	75.12	0.1572	200
210	0.8716	76.45	0.1606	0.8397	76.42	0.1601	0.8099	76.40	0.1596	0.7822	76.37	0.1591	210
220	0.8857	77.71	0.1624	0.8533	77.68	0.1619	0.8232	77.65	0.1614	0.7950	77.62	0.1610	220
230	0.8999	78.97	0.1643	0.8670	78.94	0.1638	0.8364	78.91	0.1633	0.8078	78.89	0.1628	230
240	0.9140	80.24	0.1661	0.8806	80.21	0.1656	0.8496	80.19	0.1651	0.8206	80.16	0.1646	240
250	0.9281	81.52	0.1679	0.8942	81.49	0.1674	0.8627	81.46	0.1669	0.8334	81.44	0.1664	250
260	0.9421	82.80	0.1697	0.9078	82.77	0.1692	0.8759	82.75	0.1687	0.8461	82.72	0.1682	260
270	0.9562	84.09	0.1715	0.9214	84.06	0.1710	0.8890	84.04	0.1705	0.8588	84.01	0.1700	270
280	0.9702	85.39	0.1733	0.9349	85.36	0.1728	0.9021	85.34	0.1723	0.8715	85.31	0.1718	280
290	0.9842	86.69	0.1750	0.9484	86.67	0.1745	0.9152	86.64	0.1740	0.8841	86.62	0.1735	290
300	–	–	–	–	–	–	–	–	–	0.8968	87.93	0.1753	300

"FREON-13B1" – SUPERHEATED VAPOR

V=volume in cu ft/lb; H=enthalpy in Btu/lb; S=entropy in Btu/(lb)(°R) (saturation properties in parentheses)

ABSOLUTE PRESSURE, lb/sq in

TEMP. °F	62			64			66			68			TEMP. °F
	47.3 psig (–7.44°F.)			49.3 psig (–5.75°F.)			51.3 psig (–4.10°F.)			53.3 psig (–2.48°F.)			
	V	H	S	V	H	S	V	H	S	V	H	S	
	(0.4733)	(50.97)	(0.1131)	(0.4591)	(51.09)	(0.1129)	(0.4456)	(51.21)	(0.1128)	(0.4329)	(51.33)	(0.1127)	
0	0.4837	51.77	0.1148	0.4669	51.72	0.1143	0.4510	51.66	0.1136	0.4361	51.60	0.1133	0
10	0.4975	52.86	0.1172	0.4803	52.81	0.1167	0.4642	52.75	0.1162	0.4490	52.70	0.1157	10
20	0.5112	53.96	0.1195	0.4937	53.91	0.1190	0.4772	53.85	0.1185	0.4617	53.80	0.1180	20
30	0.5247	55.06	0.1217	0.5069	55.01	0.1213	0.4901	54.96	0.1208	0.4742	54.91	0.1203	30
40	0.5382	56.18	0.1240	0.5200	56.13	0.1235	0.5028	56.08	0.1230	0.4867	56.03	0.1226	40
50	0.5515	57.30	0.1262	0.5329	57.25	0.1257	0.5155	57.20	0.1253	0.4990	57.15	0.1248	50
60	0.5648	58.42	0.1284	0.5458	58.38	0.1279	0.5280	58.33	0.1275	0.5113	58.29	0.1270	60
70	0.5779	59.56	0.1306	0.5586	59.52	0.1301	0.5405	59.47	0.1296	0.5234	59.43	0.1292	70
80	0.5910	60.70	0.1327	0.5714	60.66	0.1322	0.5529	60.62	0.1318	0.5355	60.58	0.1313	80
90	0.6040	61.86	0.1348	0.5840	61.82	0.1344	0.5652	61.78	0.1339	0.5475	61.74	0.1334	90
100	0.6170	63.02	0.1369	0.5966	62.98	0.1365	0.5775	62.94	0.1360	0.5595	62.90	0.1355	100
110	0.6299	64.19	0.1390	0.6091	64.15	0.1385	0.5897	64.11	0.1381	0.5713	64.08	0.1376	110
120	0.6427	65.37	0.1410	0.6216	65.33	0.1406	0.6018	65.29	0.1401	0.5832	65.26	0.1397	120
130	0.6555	66.56	0.1431	0.6340	66.52	0.1426	0.6139	66.48	0.1422	0.5949	66.45	0.1417	130
140	0.6682	67.75	0.1451	0.6464	67.72	0.1446	0.6259	67.68	0.1442	0.6067	67.65	0.1437	140
150	0.6809	68.95	0.1471	0.6587	68.92	0.1466	0.6379	68.89	0.1462	0.6183	68.85	0.1457	150
160	0.6936	70.16	0.1490	0.6710	70.13	0.1486	0.6499	70.10	0.1481	0.6300	70.06	0.1477	160
170	0.7062	71.38	0.1510	0.6833	71.35	0.1505	0.6618	71.32	0.1501	0.6415	71.29	0.1497	170
180	0.7187	72.61	0.1529	0.6955	72.58	0.1525	0.6737	72.55	0.1520	0.6531	72.52	0.1516	180
190	0.7313	73.84	0.1549	0.7077	73.81	0.1544	0.6855	73.78	0.1539	0.6646	73.75	0.1535	190
200	0.7438	75.09	0.1567	0.7198	75.06	0.1563	0.6973	75.03	0.1558	0.6761	75.00	0.1554	200
210	0.7562	76.34	0.1586	0.7319	76.31	0.1582	0.7091	76.28	0.1577	0.6875	76.25	0.1573	210
220	0.7687	77.59	0.1605	0.7440	77.57	0.1600	0.7208	77.54	0.1596	0.6990	77.51	0.1592	220
230	0.7811	78.86	0.1623	0.7561	78.83	0.1619	0.7325	78.80	0.1614	0.7104	78.78	0.1610	230
240	0.7935	80.13	0.1642	0.7681	80.10	0.1637	0.7442	80.08	0.1633	0.7217	80.05	0.1629	240
250	0.8059	81.41	0.1660	0.7801	81.38	0.1655	0.7559	81.36	0.1651	0.7331	81.33	0.1647	250
260	0.8182	82.70	0.1678	0.7921	82.67	0.1673	0.7675	82.65	0.1669	0.7444	82.62	0.1665	260
270	0.8305	83.99	0.1696	0.8040	83.96	0.1691	0.7791	83.94	0.1687	0.7557	83.91	0.1683	270
280	0.8428	85.29	0.1713	0.8160	85.26	0.1709	0.7907	85.24	0.1705	0.7670	85.22	0.1700	280
290	0.8551	86.59	0.1731	0.8279	86.57	0.1726	0.8023	86.55	0.1722	0.7782	86.52	0.1718	290
300	0.8674	87.91	0.1748	0.8398	87.88	0.1744	0.8138	87.86	0.1739	0.7895	87.84	0.1735	300

TEMP. °F	70			72			74			76			TEMP. °F
	55.3 psig (–0.90°F.)			57.3 psig (–0.65°F.)			59.3 psig (2.16°F.)			61.3 psig (3.65°F.)			
	V	H	S	V	H	S	V	H	S	V	H	S	
	(0.4209)	(51.44)	(0.1126)	(0.4095)	(51.55)	(0.1126)	(0.3988)	(51.66)	(0.1125)	(0.3886)	(51.77)	(0.1124)	
0	0.4221	51.54	0.1129	–	–	–	–	–	–	–	–	–	0
10	0.4346	52.64	0.1152	0.4211	52.58	0.1148	0.4082	52.53	0.1143	0.3960	52.47	0.1139	10
20	0.4470	53.75	0.1176	0.4332	53.69	0.1171	0.4201	53.64	0.1167	0.4077	53.58	0.1162	20
30	0.4593	54.86	0.1198	0.4452	54.81	0.1194	0.4319	54.76	0.1190	0.4192	54.70	0.1185	30
40	0.4715	55.98	0.1221	0.4571	55.93	0.1217	0.4435	55.88	0.1212	0.4306	55.83	0.1208	40
50	0.4835	57.11	0.1243	0.4689	57.06	0.1239	0.4550	57.01	0.1235	0.4419	56.96	0.1231	50
60	0.4955	58.24	0.1266	0.4805	58.20	0.1261	0.4664	58.15	0.1257	0.4530	58.10	0.1253	60
70	0.5073	59.39	0.1287	0.4921	59.34	0.1283	0.4777	59.30	0.1279	0.4641	59.25	0.1275	70
80	0.5191	60.54	0.1309	0.5036	60.49	0.1305	0.4890	60.45	0.1300	0.4751	60.41	0.1296	80
90	0.5308	61.69	0.1330	0.5151	61.65	0.1326	0.5002	61.61	0.1322	0.4860	61.57	0.1318	90
100	0.5425	62.86	0.1351	0.5264	62.82	0.1347	0.5113	62.78	0.1343	0.4969	62.74	0.1339	100
110	0.5541	64.04	0.1372	0.5377	64.00	0.1368	0.5223	63.96	0.1364	0.5077	63.92	0.1360	110
120	0.5656	65.22	0.1393	0.5490	65.18	0.1388	0.5333	65.14	0.1384	0.5184	65.11	0.1380	120
130	0.5771	66.41	0.1413	0.5602	66.37	0.1409	0.5442	66.34	0.1405	0.5290	66.30	0.1401	130
140	0.5885	67.61	0.1433	0.5713	67.57	0.1429	0.5551	67.54	0.1425	0.5397	67.50	0.1421	140
150	0.5998	68.82	0.1453	0.5824	68.78	0.1449	0.5659	68.75	0.1445	0.5502	68.71	0.1441	150
160	0.6112	70.03	0.1473	0.5934	70.00	0.1469	0.5767	69.97	0.1465	0.5608	69.93	0.1461	160
170	0.6225	71.25	0.1492	0.6044	71.22	0.1488	0.5874	71.19	0.1484	0.5712	71.16	0.1480	170
180	0.6337	72.48	0.1512	0.6154	72.45	0.1508	0.5981	72.42	0.1504	0.5817	72.39	0.1500	180
190	0.6449	73.72	0.1531	0.6263	73.69	0.1527	0.6088	73.66	0.1523	0.5921	73.63	0.1519	190
200	0.6561	74.97	0.1550	0.6372	74.94	0.1546	0.6194	74.91	0.1542	0.6025	74.88	0.1538	200
210	0.6673	76.22	0.1569	0.6481	76.19	0.1565	0.6300	76.16	0.1561	0.6128	76.13	0.1557	210
220	0.6784	77.48	0.1588	0.6589	77.45	0.1583	0.6405	77.42	0.1579	0.6231	77.40	0.1576	220
230	0.6895	78.75	0.1606	0.6697	78.72	0.1602	0.6511	78.69	0.1598	0.6334	78.67	0.1594	230
240	0.7005	80.02	0.1624	0.6805	80.00	0.1620	0.6616	79.97	0.1616	0.6437	79.94	0.1613	240
250	0.7116	81.31	0.1643	0.6913	81.28	0.1639	0.6721	81.25	0.1635	0.6539	81.23	0.1631	250
260	0.7226	82.59	0.1661	0.7020	82.57	0.1657	0.6825	82.54	0.1653	0.6641	82.52	0.1649	260
270	0.7336	83.89	0.1678	0.7127	83.86	0.1674	0.6930	83.84	0.1671	0.6743	83.81	0.1667	270
280	0.7446	85.19	0.1696	0.7234	85.17	0.1692	0.7034	85.14	0.1688	0.6844	85.12	0.1684	280
290	0.7555	86.50	0.1714	0.7341	86.47	0.1710	0.7138	86.45	0.1706	0.6946	86.43	0.1702	290
300	0.7665	87.81	0.1731	0.7447	87.79	0.1727	0.7242	87.77	0.1723	0.7047	87.74	0.1719	300
310	–	–	–	0.7554	89.11	0.1744	0.7345	89.09	0.1741	0.7148	89.06	0.1737	310

"FREON-13B1" – SUPERHEATED VAPOR

V=volume in cu ft/lb; H=enthalpy in Btu/lb; S=entropy in Btu/(lb)(°R) (saturation properties in parentheses)

ABSOLUTE PRESSURE, lb/sq in

TEMP. °F	78			80			82			84			TEMP. °F
	63.3 psig (5.11°F.)			65.3 psig (6.54°F.)			67.3 psig (7.94°F.)			69.3 psig (9.32°F.)			
	V	H	S	V	H	S	V	H	S	V	H	S	
	(0.3788)	(51.87)	(0.1123)	(0.3696)	(51.97)	(0.1122)	(0.3608)	(52.07)	(0.1121)	(0.3523)	(52.16)	(0.1120)	
10	0.3845	52.41	0.1135	0.3735	52.36	0.1130	0.3630	52.30	0.1126	0.3531	52.24	0.1122	10
20	0.3959	53.53	0.1158	0.3847	53.47	0.1154	0.3741	53.42	0.1150	0.3639	53.36	0.1145	20
30	0.4072	54.65	0.1181	0.3958	54.60	0.1177	0.3849	54.55	0.1173	0.3745	54.49	0.1169	30
40	0.4184	55.78	0.1204	0.4067	55.73	0.1200	0.3957	55.68	0.1196	0.3851	55.63	0.1192	40
50	0.4294	56.92	0.1226	0.4175	56.87	0.1222	0.4063	56.82	0.1219	0.3955	56.77	0.1215	50
60	0.4403	58.06	0.1249	0.4283	58.01	0.1245	0.4168	57.96	0.1241	0.4058	57.92	0.1237	60
70	0.4512	59.21	0.1271	0.4389	59.16	0.1267	0.4272	59.12	0.1263	0.4160	59.07	0.1259	70
80	0.4619	60.36	0.1292	0.4494	60.32	0.1288	0.4375	60.28	0.1284	0.4262	60.23	0.1281	80
90	0.4726	61.53	0.1314	0.4599	61.49	0.1310	0.4477	61.45	0.1306	0.4362	61.40	0.1302	90
100	0.4832	62.70	0.1335	0.4703	62.66	0.1331	0.4579	62.62	0.1327	0.4462	62.58	0.1323	100
110	0.4938	63.88	0.1356	0.4806	63.84	0.1352	0.4680	63.80	0.1348	0.4561	63.76	0.1344	110
120	0.5043	65.07	0.1376	0.4908	65.03	0.1372	0.4781	64.99	0.1368	0.4659	64.96	0.1365	120
130	0.5147	66.27	0.1397	0.5010	66.23	0.1393	0.4881	66.19	0.1389	0.4757	66.16	0.1385	130
140	0.5251	67.47	0.1417	0.5112	67.43	0.1413	0.4980	67.40	0.1409	0.4854	67.35	0.1405	140
150	0.5354	68.68	0.1437	0.5213	68.65	0.1433	0.5079	68.61	0.1430	0.4951	68.[illegible]	0.1425	150
160	0.5457	69.90	0.1457	0.5313	69.87	0.1453	0.5177	69.83	0.1449	0.5047	69.80	0.1445	160
170	0.5559	71.12	0.1476	0.5414	71.09	0.1473	0.5275	71.06	0.1469	0.5143	71.03	0.1465	170
180	0.5661	72.36	0.1496	0.5513	72.33	0.1492	0.5373	72.30	0.1489	0.5239	72.25	0.1485	180
190	0.5763	73.60	0.1515	0.5613	73.57	0.1511	0.5470	73.54	0.1508	0.5334	73.51	0.1504	190
200	0.5864	74.85	0.1534	0.5712	74.82	0.1531	0.5567	74.79	0.1527	0.5429	74.76	0.1523	200
210	0.5965	76.10	0.1553	0.5810	76.08	0.1549	0.5663	76.05	0.1546	0.5523	76.02	0.1542	210
220	0.6066	77.37	0.1572	0.5909	77.34	0.1568	0.5759	77.31	0.1565	0.5617	77.28	0.1561	220
230	0.6166	78.64	0.1590	0.6007	78.61	0.1587	0.5855	78.58	0.1583	0.5711	78.56	0.1580	230
240	0.6267	79.92	0.1609	0.6105	79.89	0.1605	0.5951	79.86	0.1602	0.5805	79.83	0.1598	240
250	0.6366	81.20	0.1627	0.6202	81.17	0.1623	0.6046	81.15	0.1620	0.5898	81.12	0.1616	250
260	0.6466	82.49	0.1645	0.6300	82.46	0.1641	0.6142	82.44	0.1638	0.5991	82.41	0.1634	260
270	0.6565	83.79	0.1663	0.6397	83.76	0.1659	0.6237	83.74	0.1656	0.6084	83.71	0.1652	270
280	0.6665	85.09	0.1681	0.6494	85.07	0.1677	0.6331	85.04	0.1674	0.6175	85.02	0.1670	280
290	0.6764	86.40	0.1698	0.6590	86.38	0.1695	0.6426	86.35	0.1691	0.6269	86.33	0.1688	290
300	0.6862	87.72	0.1716	0.6687	87.70	0.1712	0.6520	87.67	0.1709	0.6361	87.65	0.1705	300
310	0.6961	89.04	0.1733	0.6783	89.02	0.1729	0.6614	89.00	0.1726	0.6453	88.97	0.1723	310

TEMP. °F	86			88			90			92			TEMP. °F
	71.3 psig (10.67°F.)			73.3 psig (12.00°F.)			75.3 psig (13.31°F.)			77.3 psig (14.60°F.)			
	V	H	S	V	H	S	V	H	S	V	H	S	
	(0.3443)	(52.25)	(0.1120)	(0.3366)	(52.35)	(0.1119)	(0.3292)	(52.43)	(0.1118)	(0.3221)	(52.52)	(0.1117)	
20	0.3542	53.31	0.1142	0.3449	53.25	0.1138	0.3361	53.19	0.1134	0.3276	53.14	0.1130	20
30	0.3647	54.44	0.1165	0.3553	54.38	0.1161	0.3462	54.33	0.1158	0.3376	54.28	0.1154	30
40	0.3750	55.58	0.1188	0.3654	55.52	0.1184	0.3562	55.47	0.1181	0.3474	55.42	0.1177	40
50	0.3853	56.72	0.1211	0.3755	56.67	0.1207	0.3661	56.62	0.1203	0.3572	56.57	0.1200	50
60	0.3954	57.87	0.1233	0.3854	57.82	0.1229	0.3759	57.77	0.1226	0.3668	57.73	0.1222	60
70	0.4054	59.03	0.1255	0.3953	58.98	0.1252	0.3856	58.94	0.1248	0.3763	58.89	0.1244	70
80	0.4153	60.19	0.1277	0.4050	60.15	0.1273	0.3951	60.10	0.1270	0.3857	60.06	0.1266	80
90	0.4252	61.36	0.1298	0.4147	61.32	0.1295	0.4046	61.28	0.1291	0.3950	61.23	0.1288	90
100	0.4350	62.54	0.1320	0.4243	62.50	0.1316	0.4140	62.46	0.1313	0.4042	62.42	0.1309	100
110	0.4447	63.73	0.1341	0.4338	63.69	0.1337	0.4234	63.65	0.1334	0.4134	63.61	0.1330	110
120	0.4543	64.92	0.1361	0.4432	64.88	0.1358	0.4327	64.84	0.1354	0.4225	64.80	0.1351	120
130	0.4639	66.12	0.1382	0.4526	66.08	0.1379	0.4419	66.04	0.1375	0.4316	66.01	0.1372	130
140	0.4734	67.33	0.1402	0.4620	67.29	0.1399	0.4510	67.25	0.1395	0.4406	67.22	0.1392	140
150	0.4829	68.54	0.1422	0.4713	68.51	0.1419	0.4602	68.47	0.1416	0.4495	68.44	0.1412	150
160	0.4923	69.76	0.1442	0.4805	69.73	0.1439	0.4692	69.70	0.1435	0.4584	69.66	0.1432	160
170	0.5017	70.99	0.1462	0.4897	70.96	0.1459	0.4783	70.93	0.1455	0.4673	70.90	0.1452	170
180	0.5111	72.23	0.1481	0.4989	72.20	0.1478	0.4872	72.17	0.1475	0.4761	72.14	0.1471	180
190	0.5204	73.48	0.1501	0.5080	73.45	0.1497	0.4962	73.41	0.1494	0.4849	73.38	0.1491	190
200	0.5297	74.73	0.1520	0.5171	74.70	0.1517	0.5051	74.67	0.1513	0.4936	74.64	0.1510	200
210	0.5389	75.99	0.1539	0.5262	75.96	0.1535	0.5140	75.93	0.1532	0.5023	75.90	0.1529	210
220	0.5482	77.25	0.1558	0.5352	77.23	0.1554	0.5228	77.20	0.1551	0.5110	77.17	0.1548	220
230	0.5573	78.53	0.1576	0.5442	78.50	0.1573	0.5316	78.47	0.1570	0.5196	78.44	0.1566	230
240	0.5665	79.81	0.1595	0.5532	79.78	0.1591	0.5404	79.75	0.1588	0.5282	79.73	0.1585	240
250	0.5756	81.09	0.1613	0.5621	81.07	0.1610	0.5492	81.04	0.1606	0.5368	81.01	0.1603	250
260	0.5847	82.39	0.1631	0.5710	82.36	0.1628	0.5579	82.34	0.1624	0.5454	82.31	0.1621	260
270	0.5938	83.69	0.1649	0.5799	83.66	0.1646	0.5666	83.64	0.1642	0.5539	83.61	0.1639	270
280	0.6029	84.99	0.1667	0.5888	84.97	0.1663	0.5753	84.94	0.1660	0.5625	84.92	0.1657	280
290	0.6119	86.31	0.1684	0.5977	86.28	0.1681	0.5840	86.26	0.1678	0.5710	86.23	0.1675	290
300	0.6210	87.63	0.1702	0.6065	87.60	0.1699	0.5927	87.58	0.1695	0.5794	87.55	0.1692	300
310	0.6300	88.95	0.1719	0.6153	88.93	0.1716	0.6013	88.90	0.1713	0.5879	88.88	0.1709	310
320	0.6389	90.28	0.1736	0.6241	90.26	0.1733	0.6099	90.24	0.1730	0.5963	90.21	0.1727	320

"FREON-13B1" – SUPERHEATED VAPOR

V=volume in cu ft/lb; H=enthalpy in Btu/lb; S=entropy in Btu/(lb)(°R) (saturation properties in parentheses)

ABSOLUTE PRESSURE, lb/sq in

TEMP. °F	94			96			98			100			TEMP. °F
	79.3 psig (15.87°F.)			81.3 psig (17.11°F.)			83.3 psig (18.34°F.)			85.3 psig (19.55°F.)			
	V	H	S	V	H	S	V	H	S	V	H	S	
	(0.3153)	(52.61)	(0.1117)	(0.3088)	(52.69)	(0.1116)	(0.3026)	(52.77)	(0.1115)	(0.2966)	(52.85)	(0.1115)	
20	0.3195	53.08	0.1127	0.3117	53.02	0.1123	0.3042	52.96	0.1119	0.2970	52.90	0.1116	20
30	0.3293	54.22	0.1150	0.3214	54.16	0.1147	0.3138	54.11	0.1143	0.3064	54.05	0.1140	30
40	0.3390	55.37	0.1173	0.3309	55.31	0.1170	0.3232	55.26	0.1166	0.3157	55.21	0.1163	40
50	0.3486	56.52	0.1196	0.3404	56.47	0.1193	0.3325	56.42	0.1189	0.3249	56.37	0.1186	50
60	0.3580	57.68	0.1219	0.3497	57.63	0.1215	0.3416	57.58	0.1212	0.3339	57.53	0.1209	60
70	0.3674	58.84	0.1241	0.3589	58.80	0.1238	0.3507	58.75	0.1234	0.3428	58.70	0.1231	70
80	0.3766	60.01	0.1263	0.3679	59.97	0.1259	0.3596	59.92	0.1256	0.3516	59.88	0.1253	80
90	0.3858	61.19	0.1284	0.3770	61.15	0.1281	0.3685	61.11	0.1278	0.3604	61.06	0.1275	90
100	0.3949	62.38	0.1306	0.3859	62.33	0.1303	0.3773	62.29	0.1299	0.3690	62.25	0.1296	100
110	0.4039	63.57	0.1327	0.3948	63.53	0.1324	0.3860	63.49	0.1320	0.3776	63.45	0.1317	110
120	0.4128	64.76	0.1348	0.4035	64.73	0.1345	0.3946	64.69	0.1341	0.3861	64.65	0.1338	120
130	0.4217	65.97	0.1368	0.4123	65.93	0.1365	0.4032	65.89	0.1362	0.3945	65.86	0.1359	130
140	0.4306	67.18	0.1389	0.4210	67.15	0.1386	0.4117	67.11	0.1382	0.4029	67.07	0.1379	140
150	0.4393	68.40	0.1409	0.4296	68.37	0.1406	0.4202	68.33	0.1403	0.4112	68.30	0.1399	150
160	0.4481	69.63	0.1429	0.4382	69.59	0.1426	0.4286	69.56	0.1423	0.4195	69.53	0.1419	160
170	0.4568	70.86	0.1449	0.4467	70.83	0.1445	0.4370	70.80	0.1442	0.4278	70.76	0.1439	170
180	0.4654	72.10	0.1468	0.4552	72.07	0.1465	0.4454	72.04	0.1462	0.4359	72.01	0.1459	180
190	0.4740	73.35	0.1488	0.4636	73.32	0.1484	0.4537	73.29	0.1481	0.4441	73.26	0.1478	190
200	0.4826	74.61	0.1507	0.4721	74.58	0.1504	0.4619	74.55	0.1501	0.4522	74.52	0.1498	200
210	0.4911	75.87	0.1526	0.4804	75.84	0.1523	0.4702	75.81	0.1520	0.4603	75.78	0.1517	210
220	0.4997	77.14	0.1545	0.4888	77.11	0.1541	0.4784	77.08	0.1538	0.4684	77.05	0.1535	220
230	0.5081	78.42	0.1563	0.4971	78.39	0.1560	0.4865	78.36	0.1557	0.4764	78.33	0.1554	230
240	0.5166	79.70	0.1582	0.5054	79.67	0.1579	0.4947	79.64	0.1576	0.4844	79.62	0.1573	240
250	0.5250	80.99	0.1600	0.5137	80.96	0.1597	0.5028	80.93	0.1594	0.4924	80.91	0.1591	250
260	0.5334	82.28	0.1618	0.5219	82.26	0.1615	0.5109	82.23	0.1612	0.5003	82.21	0.1609	260
270	0.5418	83.59	0.1636	0.5301	83.56	0.1633	0.5189	83.54	0.1630	0.5082	83.51	0.1627	270
280	0.5501	84.89	0.1654	0.5383	84.87	0.1651	0.5270	84.84	0.1648	0.5161	84.82	0.1645	280
290	0.5585	86.21	0.1672	0.5465	86.19	0.1668	0.5350	86.16	0.1665	0.5240	86.14	0.1663	290
300	0.5668	87.53	0.1689	0.5546	87.51	0.1686	0.5430	87.48	0.1683	0.5318	87.46	0.1680	300
310	0.5751	88.86	0.1706	0.5628	88.83	0.1703	0.5510	88.81	0.1700	0.5397	88.79	0.1697	310
320	0.5833	90.19	0.1724	0.5709	90.17	0.1721	0.5589	90.14	0.1718	0.5475	90.12	0.1715	320

TEMP. °F	105			110			115			120			TEMP. °F
	90.3 psig (22.50°F.)			95.3 psig (25.34°F.)			100.3 psig (28.09°F.)			105.3 psig (30.76°F.)			
	V	H	S	V	H	S	V	H	S	V	H	S	
	(0.2825)	(53.04)	(0.1113)	(0.2696)	(53.22)	(0.1112)	(0.2578)	(53.39)	(0.1110)	(0.2470)	(53.56)	(0.1109)	
30	0.2893	53.91	0.1131	0.2737	53.77	0.1123	0.2595	53.62	0.1115	–	–	–	30
40	0.2983	55.07	0.1155	0.2825	54.94	0.1146	0.2679	54.80	0.1139	0.2546	54.65	0.1131	40
50	0.3072	56.24	0.1178	0.2910	56.11	0.1170	0.2763	55.98	0.1162	0.2627	55.86	0.1154	50
60	0.3159	57.41	0.1200	0.2995	57.29	0.1193	0.2844	57.16	0.1185	0.2707	57.03	0.1178	60
70	0.3245	58.59	0.1223	0.3078	58.47	0.1215	0.2925	58.35	0.1208	0.2785	58.22	0.1200	70
80	0.3330	59.77	0.1245	0.3160	59.65	0.1237	0.3004	59.54	0.1230	0.2862	59.42	0.1223	80
90	0.3414	60.95	0.1267	0.3241	60.84	0.1259	0.3083	60.73	0.1252	0.2938	60.62	0.1245	90
100	0.3497	62.15	0.1288	0.3321	62.04	0.1281	0.3160	61.93	0.1273	0.3013	61.83	0.1266	100
110	0.3579	63.34	0.1309	0.3400	63.24	0.1302	0.3237	63.14	0.1295	0.3087	63.04	0.1288	110
120	0.3661	64.55	0.1330	0.3479	64.45	0.1323	0.3313	64.35	0.1316	0.3161	64.25	0.1309	120
130	0.3742	65.76	0.1351	0.3557	65.67	0.1344	0.3389	65.57	0.1337	0.3234	65.48	0.1330	130
140	0.3823	66.98	0.1372	0.3635	66.89	0.1364	0.3463	66.80	0.1357	0.3306	66.70	0.1351	140
150	0.3903	68.21	0.1392	0.3712	68.12	0.1385	0.3537	68.03	0.1378	0.3378	67.94	0.1371	150
160	0.3982	69.44	0.1412	0.3788	69.35	0.1405	0.3611	69.27	0.1398	0.3449	69.18	0.1391	160
170	0.4061	70.68	0.1432	0.3864	70.60	0.1425	0.3684	70.51	0.1418	0.3519	70.43	0.1411	170
180	0.4140	71.93	0.1451	0.3940	71.85	0.1444	0.3757	71.76	0.1438	0.3590	71.68	0.1431	180
190	0.4218	73.18	0.1471	0.4015	73.10	0.1464	0.3829	73.02	0.1457	0.3659	72.94	0.1450	190
200	0.4296	74.44	0.1490	0.4090	74.36	0.1483	0.3901	74.29	0.1476	0.3729	74.21	0.1470	200
210	0.4373	75.71	0.1509	0.4164	75.63	0.1502	0.3973	75.56	0.1495	0.3798	75.48	0.1489	210
220	0.4450	76.98	0.1528	0.4238	76.91	0.1521	0.4044	76.83	0.1514	0.3866	76.76	0.1508	220
230	0.4527	78.26	0.1547	0.4312	78.19	0.1540	0.4115	78.12	0.1533	0.3935	78.05	0.1527	230
240	0.4604	79.55	0.1565	0.4385	79.48	0.1558	0.4186	79.41	0.1552	0.4003	79.34	0.1545	240
250	0.4680	80.84	0.1584	0.4458	80.77	0.1577	0.4256	80.71	0.1570	0.4071	80.64	0.1564	250
260	0.4756	82.14	0.1602	0.4531	82.07	0.1595	0.4326	82.01	0.1588	0.4138	81.94	0.1582	260
270	0.4832	83.45	0.1620	0.4604	83.38	0.1613	0.4396	83.32	0.1606	0.4205	83.25	0.1600	270
280	0.4907	84.76	0.1638	0.4676	84.70	0.1631	0.4466	84.63	0.1624	0.4272	84.57	0.1618	280
290	0.4983	86.08	0.1655	0.4749	86.02	0.1649	0.4535	85.95	0.1642	0.4339	85.89	0.1636	290
300	0.5058	87.40	0.1673	0.4821	87.34	0.1666	0.4604	87.28	0.1660	0.4406	87.22	0.1653	300
310	0.5133	88.73	0.1690	0.4892	88.67	0.1684	0.4673	88.61	0.1677	0.4472	88.56	0.1671	310
320	0.5207	90.07	0.1708	0.4964	90.01	0.1701	0.4742	89.95	0.1694	0.4538	89.90	0.1688	320
330	0.5282	91.41	0.1725	0.5035	91.35	0.1718	0.4811	91.30	0.1711	0.4604	91.24	0.1705	330
340	–	–	–	–	–		–	–	–	0.4670	92.59	0.1722	340

"FREON-13B1" – SUPERHEATED VAPOR

V=volume in cu ft/lb; H=enthalpy in Btu/lb; S=entropy in Btu/(lb)(°R) (saturation properties in parentheses)

ABSOLUTE PRESSURE, lb/sq in

TEMP. °F	125			130			135			140			TEMP. °F
	110.3 psig (33.34°F.)			115.3 psig (35.85°F.)			120.3 psig (38.29°F.)			125.3 psig (40.65°F.)			
	V	H	S	V	H	S	V	H	S	V	H	S	
	(0.2369)	(53.71)	(0.1107)	(0.2277)	(53.86)	(0.1106)	(0.2190)	(54.01)	(0.1105)	(0.2110)	(54.14)	(0.1104)	
40	0.2423	54.51	0.1123	0.2309	54.36	0.1116	0.2203	54.21	0.1109	–	–	–	40
50	0.2502	55.70	0.1147	0.2387	55.57	0.1140	0.2279	55.42	0.1133	0.2179	55.28	0.1126	50
60	0.2580	56.90	0.1170	0.2462	56.77	0.1163	0.2353	56.64	0.1156	0.2252	56.50	0.1150	60
70	0.2656	58.10	0.1193	0.2536	57.97	0.1186	0.2426	57.85	0.1180	0.2323	57.72	0.1173	70
80	0.2731	59.30	0.1216	0.2609	59.18	0.1209	0.2497	59.06	0.1202	0.2392	58.94	0.1196	80
90	0.2805	60.51	0.1238	0.2681	60.39	0.1231	0.2567	60.28	0.1225	0.2461	60.16	0.1218	90
100	0.2877	61.72	0.1260	0.2752	61.61	0.1253	0.2636	61.50	0.1247	0.2528	61.38	0.1240	100
110	0.2949	62.93	0.1281	0.2822	62.83	0.1275	0.2704	62.72	0.1268	0.2594	62.61	0.1262	110
120	0.3021	64.15	0.1302	0.2891	64.05	0.1296	0.2771	63.95	0.1290	0.2660	63.85	0.1284	120
130	0.3091	65.38	0.1323	0.2960	65.28	0.1317	0.2838	65.18	0.1311	0.2725	65.08	0.1305	130
140	0.3161	66.61	0.1344	0.3028	66.52	0.1338	0.2904	66.42	0.1332	0.2789	66.33	0.1326	140
150	0.3231	67.85	0.1365	0.3095	67.76	0.1358	0.2969	67.67	0.1352	0.2852	67.57	0.1346	150
160	0.3299	69.09	0.1385	0.3161	69.00	0.1379	0.3034	68.92	0.1372	0.2915	68.83	0.1367	160
170	0.3368	70.34	0.1405	0.3228	70.26	0.1399	0.3098	70.17	0.1393	0.2977	70.09	0.1387	170
180	0.3436	71.60	0.1425	0.3293	71.52	0.1418	0.3162	71.43	0.1412	0.3039	71.35	0.1407	180
190	0.3503	72.86	0.1444	0.3359	72.78	0.1438	0.3225	72.70	0.1432	0.3101	72.62	0.1426	190
200	0.3570	74.13	0.1464	0.3423	74.05	0.1457	0.3288	73.97	0.1452	0.3162	73.90	0.1446	200
210	0.3637	75.41	0.1483	0.3488	75.33	0.1477	0.3350	75.25	0.1471	0.3222	75.18	0.1465	210
220	0.3703	76.69	0.1502	0.3552	76.61	0.1496	0.3412	76.54	0.1490	0.3282	76.47	0.1484	220
230	0.3769	77.98	0.1521	0.3616	77.90	0.1515	0.3474	77.83	0.1509	0.3342	77.76	0.1503	230
240	0.3835	79.27	0.1539	0.3679	79.20	0.1533	0.3536	79.13	0.1527	0.3402	79.06	0.1522	240
250	0.3900	80.57	0.1558	0.3743	80.50	0.1552	0.3597	80.43	0.1546	0.3461	80.37	0.1540	250
260	0.3965	81.88	0.1576	0.3805	81.81	0.1570	0.3658	81.74	0.1564	0.3520	81.68	0.1559	260
270	0.4030	83.19	0.1594	0.3868	83.12	0.1588	0.3718	83.06	0.1582	0.3579	83.00	0.1577	270
280	0.4095	84.51	0.1612	0.3931	84.44	0.1606	0.3779	84.38	0.1600	0.3638	84.32	0.1595	280
290	0.4159	85.83	0.1630	0.3993	85.77	0.1624	0.3839	85.71	0.1618	0.3696	85.65	0.1613	290
300	0.4223	87.16	0.1647	0.4055	87.10	0.1642	0.3899	87.04	0.1636	0.3754	86.98	0.1630	300
310	0.4287	88.50	0.1665	0.4117	88.44	0.1659	0.3959	88.38	0.1653	0.3812	88.32	0.1648	310
320	0.4351	89.84	0.1682	0.4178	89.78	0.1676	0.4018	89.72	0.1671	0.3869	89.67	0.1665	320
330	0.4415	91.18	0.1699	0.4240	91.13	0.1694	0.4077	91.07	0.1688	0.3927	91.02	0.1683	330
340	0.4478	92.54	0.1716	0.4301	92.48	0.1711	0.4137	92.43	0.1705	0.3984	92.37	0.1700	340
350	–	–	–	–	–	–	–	–	–	0.4041	93.73	0.1716	350

TEMP. °F	145			150			155			160			TEMP. °F
	130.3 psig (42.97°F.)			135.3 psig (45.23°F.)			140.3 psig (47.42°F.)			145.3 psig (49.57°F.)			
	V	H	S	V	H	S	V	H	S	V	H	S	
	(0.2035)	(54.27)	(0.1102)	(0.1964)	(54.39)	(0.1101)	(0.1898)	(54.51)	(0.1100)	(0.1836)	(54.63)	(0.1099)	
50	0.2086	55.13	0.1119	0.1998	54.99	0.1113	0.1916	54.83	0.1106	0.1839	54.68	0.1100	50
60	0.2157	56.36	0.1143	0.2068	56.22	0.1137	0.1985	56.08	0.1130	0.1907	55.93	0.1124	60
70	0.2227	57.59	0.1167	0.2137	57.45	0.1160	0.2052	57.32	0.1154	0.1973	57.18	0.1148	70
80	0.2295	58.81	0.1190	0.2203	58.69	0.1183	0.2118	58.56	0.1177	0.2038	58.43	0.1171	80
90	0.2361	60.04	0.1212	0.2269	59.92	0.1206	0.2182	59.80	0.1200	0.2101	59.68	0.1194	90
100	0.2427	61.27	0.1234	0.2333	61.16	0.1228	0.2245	61.04	0.1222	0.2162	60.92	0.1217	100
110	0.2492	62.50	0.1256	0.2396	62.39	0.1250	0.2307	62.28	0.1244	0.2223	62.17	0.1239	110
120	0.2556	63.74	0.1278	0.2459	63.64	0.1272	0.2368	63.53	0.1266	0.2283	63.42	0.1261	120
130	0.2619	64.98	0.1299	0.2521	64.88	0.1293	0.2428	64.78	0.1287	0.2342	64.68	0.1282	130
140	0.2681	66.23	0.1320	0.2581	66.13	0.1314	0.2488	66.03	0.1309	0.2400	65.94	0.1303	140
150	0.2743	67.48	0.1340	0.2642	67.39	0.1335	0.2546	67.29	0.1329	0.2457	67.20	0.1324	150
160	0.2804	68.74	0.1361	0.2701	68.65	0.1355	0.2605	68.56	0.1350	0.2514	68.46	0.1345	160
170	0.2865	70.00	0.1381	0.2760	69.91	0.1378	0.2662	69.82	0.1370	0.2570	69.74	0.1365	170
180	0.2925	71.27	0.1401	0.2819	71.18	0.1396	0.2719	71.10	0.1390	0.2626	71.01	0.1385	180
190	0.2985	72.54	0.1421	0.2877	72.46	0.1416	0.2776	72.37	0.1410	0.2681	72.29	0.1405	190
200	0.3044	73.82	0.1440	0.2935	73.74	0.1435	0.2832	73.66	0.1430	0.2736	73.58	0.1425	200
210	0.3103	75.10	0.1460	0.2992	75.03	0.1454	0.2888	74.95	0.1449	0.2790	74.87	0.1444	210
220	0.3162	76.39	0.1479	0.3049	76.32	0.1473	0.2943	76.24	0.1468	0.2844	76.17	0.1463	220
230	0.3220	77.69	0.1498	0.3105	77.62	0.1492	0.2998	77.54	0.1487	0.2898	77.47	0.1482	230
240	0.3278	78.99	0.1516	0.3162	78.92	0.1511	0.3053	78.85	0.1506	0.2951	78.78	0.1501	240
250	0.3335	80.30	0.1535	0.3217	80.23	0.1530	0.3107	80.16	0.1525	0.3004	80.09	0.1520	250
260	0.3392	81.61	0.1553	0.3273	81.54	0.1548	0.3161	81.48	0.1543	0.3057	81.41	0.1538	260
270	0.3449	82.93	0.1572	0.3328	82.87	0.1566	0.3215	82.80	0.1561	0.3109	82.73	0.1556	270
280	0.3506	84.26	0.1590	0.3384	84.19	0.1584	0.3269	84.13	0.1579	0.3161	84.06	0.1575	280
290	0.3563	85.59	0.1607	0.3438	85.52	0.1602	0.3322	85.46	0.1597	0.3213	85.40	0.1592	290
300	0.3619	86.92	0.1625	0.3493	86.86	0.1620	0.3375	86.80	0.1615	0.3265	86.74	0.1610	300
310	0.3675	88.26	0.1643	0.3548	88.20	0.1638	0.3428	88.14	0.1633	0.3316	88.09	0.1628	310
320	0.3731	89.61	0.1660	0.3602	89.55	0.1655	0.3481	89.49	0.1650	0.3368	89.44	0.1645	320
330	0.3787	90.96	0.1677	0.3656	90.90	0.1672	0.3534	90.85	0.1667	0.3419	90.79	0.1663	330
340	0.3842	92.32	0.1694	0.3710	92.26	0.1689	0.3586	92.21	0.1684	0.3470	92.15	0.1680	340
350	0.3898	93.68	0.1711	0.3763	93.63	0.1706	0.3638	93.57	0.1701	0.3520	93.52	0.1697	350

"FREON-13B1" – SUPERHEATED VAPOR

V=volume in cu ft/lb; H=enthalpy in Btu/lb; S=entropy in Btu/(lb)(°R) (saturation properties in parentheses)

ABSOLUTE PRESSURE, lb/sq in

TEMP. °F	165			170			175			180			TEMP. °F
	150.3 psig (51.67°F.)			155.3 psig (53.72°F.)			160.3 psig (55.73°F.)			165.3 psig (57.70°F.)			
	V	H	S	V	H	S	V	H	S	V	H	S	
	(0.1778)	(54.74)	(0.1098)	(0.1722)	(54.84)	(0.1096)	(0.1670)	(54.94)	(0.1095)	(0.1621)	(55.04)	(0.1094)	
60	0.1833	55.79	0.1118	0.1764	55.64	0.1112	0.1698	55.49	0.1106	0.1635	55.34	0.1100	60
70	0.1899	57.05	0.1142	0.1828	56.91	0.1136	0.1762	56.77	0.1130	0.1698	56.62	0.1125	70
80	0.1962	58.31	0.1165	0.1891	58.17	0.1160	0.1823	58.04	0.1154	0.1759	57.90	0.1148	80
90	0.2024	59.56	0.1188	0.1952	59.43	0.1183	0.1883	59.31	0.1177	0.1819	59.18	0.1172	90
100	0.2085	60.81	0.1211	0.2011	60.69	0.1206	0.1942	60.57	0.1200	0.1876	60.45	0.1195	100
110	0.2144	62.06	0.1233	0.2070	61.95	0.1228	0.1999	61.84	0.1223	0.1933	61.72	0.1217	110
120	0.2203	63.32	0.1255	0.2127	63.21	0.1250	0.2056	63.10	0.1245	0.1988	62.99	0.1239	120
130	0.2260	64.58	0.1277	0.2184	64.48	0.1271	0.2111	64.37	0.1266	0.2043	64.27	0.1261	130
140	0.2317	65.84	0.1298	0.2239	65.74	0.1293	0.2166	65.64	0.1288	0.2096	65.54	0.1283	140
150	0.2373	67.11	0.1319	0.2294	67.01	0.1314	0.2220	66.91	0.1309	0.2149	66.82	0.1304	150
160	0.2429	68.38	0.1339	0.2349	68.28	0.1334	0.2273	68.19	0.1329	0.2201	68.10	0.1325	160
170	0.2484	69.65	0.1360	0.2402	69.56	0.1355	0.2326	69.47	0.1350	0.2253	69.38	0.1345	170
180	0.2538	70.93	0.1380	0.2456	70.84	0.1375	0.2378	70.76	0.1370	0.2304	70.67	0.1365	180
190	0.2592	72.21	0.1400	0.2508	72.13	0.1395	0.2429	72.05	0.1390	0.2354	71.96	0.1385	190
200	0.2646	73.50	0.1420	0.2560	73.42	0.1415	0.2480	73.34	0.1410	0.2404	73.26	0.1405	200
210	0.2699	74.80	0.1439	0.2612	74.72	0.1434	0.2531	74.64	0.1430	0.2454	74.56	0.1425	210
220	0.2751	76.09	0.1458	0.2664	76.02	0.1454	0.2581	75.94	0.1449	0.2503	75.87	0.1444	220
230	0.2803	77.40	0.1477	0.2715	77.33	0.1473	0.2631	77.25	0.1468	0.2552	77.18	0.1463	230
240	0.2855	78.71	0.1496	0.2765	78.64	0.1491	0.2680	78.57	0.1487	0.2600	78.49	0.1482	240
250	0.2907	80.02	0.1515	0.2816	79.96	0.1510	0.2730	79.89	0.1506	0.2648	79.82	0.1501	250
260	0.2958	81.35	0.1533	0.2866	81.28	0.1529	0.2779	81.21	0.1524	0.2696	81.14	0.1520	260
270	0.3009	82.67	0.1552	0.2916	82.61	0.1547	0.2827	82.54	0.1542	0.2744	82.47	0.1538	270
280	0.3060	84.00	0.1570	0.2965	83.94	0.1565	0.2876	83.88	0.1561	0.2791	83.81	0.1556	280
290	0.3111	85.34	0.1588	0.3015	85.28	0.1583	0.2924	85.21	0.1579	0.2838	85.15	0.1574	290
300	0.3161	86.68	0.1606	0.3064	86.62	0.1601	0.2972	86.56	0.1596	0.2885	86.50	0.1592	300
310	0.3211	88.03	0.1623	0.3112	87.97	0.1619	0.3019	87.91	0.1614	0.2931	87.85	0.1610	310
320	0.3261	89.38	0.1641	0.3161	89.32	0.1636	0.3067	89.26	0.1632	0.2977	89.21	0.1627	320
330	0.3311	90.74	0.1658	0.3210	90.68	0.1653	0.3114	90.62	0.1649	0.3024	90.57	0.1645	330
340	0.3360	92.10	0.1675	0.3258	92.04	0.1671	0.3161	91.99	0.1666	0.3069	91.93	0.1662	340
350	0.3410	93.47	0.1692	0.3306	93.41	0.1688	0.3208	93.36	0.1683	0.3115	93.30	0.1679	350
360	0.3459	94.84	0.1709	0.3354	94.78	0.1704	0.3254	94.73	0.1700	0.3161	94.68	0.1696	360

TEMP. °F	185			190			195			200			TEMP. °F
	170.3 psig (59.62°F.)			175.3 psig (61.51°F.)			180.3 psig (63.36°F.)			185.3 psig (65.18°F.)			
	V	H	S	V	H	S	V	H	S	V	H	S	
	(0.1574)	(55.13)	(0.1093)	(0.1529)	(55.21)	(0.1092)	(0.1487)	(55.30)	(0.1091)	(0.1446)	(55.38)	(0.1090)	
60	0.1576	55.18	0.1094	–	–	–	–	–	–	–	–	–	60
70	0.1638	56.48	0.1119	0.1581	56.33	0.1113	0.1527	56.17	0.1108	0.1475	56.02	0.1102	70
80	0.1699	57.77	0.1143	0.1641	57.63	0.1138	0.1586	57.48	0.1132	0.1534	57.34	0.1127	80
90	0.1757	59.05	0.1167	0.1699	58.92	0.1161	0.1644	58.78	0.1156	0.1591	58.65	0.1151	90
100	0.1814	60.33	0.1190	0.1755	60.20	0.1184	0.1699	60.08	0.1179	0.1646	59.95	0.1174	100
110	0.1870	61.60	0.1212	0.1810	61.49	0.1207	0.1753	61.37	0.1202	0.1699	61.25	0.1197	110
120	0.1924	62.88	0.1234	0.1864	62.77	0.1229	0.1806	62.66	0.1225	0.1752	62.54	0.1220	120
130	0.1978	64.16	0.1256	0.1917	64.05	0.1251	0.1858	63.94	0.1247	0.1803	63.83	0.1242	130
140	0.2031	65.44	0.1278	0.1968	65.34	0.1273	0.1909	65.23	0.1268	0.1853	65.13	0.1264	140
150	0.2083	66.72	0.1299	0.2019	66.62	0.1294	0.1959	66.52	0.1290	0.1902	66.42	0.1285	150
160	0.2134	68.00	0.1320	0.2070	67.91	0.1315	0.2009	67.81	0.1311	0.1951	67.72	0.1306	160
170	0.2184	69.29	0.1340	0.2119	69.20	0.1336	0.2057	69.11	0.1331	0.1999	69.02	0.1327	170
180	0.2234	70.58	0.1361	0.2168	70.49	0.1356	0.2106	70.41	0.1352	0.2046	70.32	0.1347	180
190	0.2284	71.88	0.1381	0.2217	71.79	0.1376	0.2153	71.71	0.1372	0.2093	71.62	0.1368	190
200	0.2333	73.18	0.1401	0.2265	73.10	0.1396	0.2200	73.01	0.1392	0.2139	72.93	0.1388	200
210	0.2381	74.48	0.1420	0.2312	74.40	0.1416	0.2247	74.32	0.1412	0.2185	74.24	0.1407	210
220	0.2429	75.79	0.1440	0.2359	75.71	0.1435	0.2293	75.64	0.1431	0.2230	75.56	0.1427	220
230	0.2477	77.10	0.1459	0.2406	77.03	0.1435	0.2339	76.96	0.1450	0.2275	76.88	0.1446	230
240	0.2524	78.42	0.1478	0.2452	78.35	0.1474	0.2384	78.28	0.1469	0.2319	78.21	0.1465	240
250	0.2571	79.75	0.1497	0.2498	79.68	0.1492	0.2429	79.61	0.1488	0.2364	79.54	0.1484	250
260	0.2618	81.07	0.1515	0.2544	81.01	0.1511	0.2474	80.94	0.1507	0.2407	80.87	0.1503	260
270	0.2665	82.41	0.1534	0.2590	82.34	0.1529	0.2519	82.28	0.1525	0.2451	82.21	0.1521	270
280	0.2711	83.75	0.1552	0.2635	83.68	0.1548	0.2563	83.62	0.1544	0.2494	83.55	0.1540	280
290	0.2757	85.09	0.1570	0.2680	85.03	0.1566	0.2607	84.96	0.1562	0.2537	84.90	0.1558	290
300	0.2802	86.44	0.1588	0.2724	86.38	0.1584	0.2650	86.32	0.1580	0.2580	86.25	0.1576	300
310	0.2848	87.79	0.1606	0.2769	87.73	0.1601	0.2694	87.67	0.1597	0.2623	87.61	0.1593	310
320	0.2893	89.15	0.1623	0.2813	89.09	0.1619	0.2737	89.03	0.1615	0.2665	88.97	0.1611	320
330	0.2938	90.51	0.1640	0.2857	90.46	0.1636	0.2780	90.40	0.1632	0.2707	90.34	0.1628	330
340	0.2983	91.88	0.1658	0.2901	91.82	0.1654	0.2823	91.77	0.1650	0.2749	91.71	0.1646	340
350	0.3028	93.25	0.1675	0.2945	93.20	0.1671	0.2866	93.14	0.1667	0.2791	93.09	0.1663	350
360	0.3072	94.63	0.1692	0.2988	94.57	0.1687	0.2908	94.52	0.1684	0.2833	94.47	0.1680	360
370	–	–	–	0.3031	95.96	0.1704	0.2951	95.90	0.1700	0.2874	95.85	0.1696	370

"FREON-13B1" – SUPERHEATED VAPOR

V=volume in cu ft/lb; H=enthalpy in Btu/lb; S=entropy in Btu/(lb)(°R) (saturation properties in parentheses)

ABSOLUTE PRESSURE, lb/sq in

TEMP. °F	205			210			215			220			TEMP. °F
	190.2 psig (66.97°F.)			195.3 psig (68.72°F.)			200.3 psig (70.44°F.)			205.3 psig (72.14°F.)			
	V	H	S	V	H	S	V	H	S	V	H	S	
	(0.1407)	(55.45)	(0.1089)	(0.1371)	(55.52)	(0.1088)	(0.1335)	(55.59)	(0.1087)	(0.1302)	(55.65)	(0.1086)	
70	0.1426	55.86	0.1096	0.1378	55.70	0.1091	–	–	–	–	–	–	70
80	0.1484	57.19	0.1121	0.1436	57.04	0.1116	0.1391	56.89	0.1111	0.1347	56.73	0.1106	80
90	0.1540	58.51	0.1146	0.1492	58.37	0.1141	0.1446	58.23	0.1135	0.1402	58.08	0.1130	90
100	0.1595	59.82	0.1169	0.1546	59.69	0.1164	0.1500	59.56	0.1159	0.1455	59.42	0.1155	100
110	0.1648	61.12	0.1192	0.1599	61.00	0.1188	0.1552	60.88	0.1183	0.1507	60.75	0.1178	110
120	0.1699	62.43	0.1215	0.1650	62.31	0.1210	0.1602	62.19	0.1206	0.1557	62.07	0.1201	120
130	0.1750	63.72	0.1237	0.1699	63.61	0.1233	0.1651	63.50	0.1228	0.1605	63.39	0.1224	130
140	0.1799	65.02	0.1259	0.1748	64.92	0.1255	0.1699	64.81	0.1250	0.1653	64.70	0.1246	140
150	0.1848	66.32	0.1281	0.1796	66.22	0.1276	0.1747	66.12	0.1272	0.1699	66.02	0.1267	150
160	0.1896	67.62	0.1302	0.1843	67.52	0.1297	0.1793	67.43	0.1293	0.1745	67.33	0.1289	160
170	0.1943	68.92	0.1323	0.1890	68.83	0.1318	0.1839	68.74	0.1314	0.1790	68.64	0.1310	170
180	0.1989	70.23	0.1343	0.1935	70.14	0.1339	0.1884	70.05	0.1335	0.1834	69.96	0.1331	180
190	0.2035	71.54	0.1363	0.1980	71.45	0.1359	0.1928	71.36	0.1355	0.1878	71.28	0.1351	190
200	0.2081	72.85	0.1383	0.2025	72.77	0.1379	0.1972	72.68	0.1375	0.1921	72.60	0.1371	200
210	0.2125	74.16	0.1403	0.2069	74.08	0.1399	0.2015	74.00	0.1395	0.1964	73.92	0.1391	210
220	0.2170	75.48	0.1423	0.2113	75.40	0.1419	0.2058	75.33	0.1415	0.2006	75.25	0.1411	220
230	0.2214	76.81	0.1442	0.2156	76.73	0.1438	0.2101	76.66	0.1434	0.2048	76.58	0.1430	230
240	0.2258	78.13	0.1461	0.2199	78.06	0.1457	0.2143	77.99	0.1453	0.2089	77.91	0.1449	240
250	0.2301	79.47	0.1480	0.2241	79.39	0.1476	0.2185	79.32	0.1472	0.2130	79.25	0.1468	250
260	0.2344	80.80	0.1499	0.2284	80.73	0.1495	0.2226	80.66	0.1491	0.2171	80.60	0.1487	260
270	0.2387	82.14	0.1517	0.2326	82.08	0.1513	0.2267	82.01	0.1510	0.2212	81.94	0.1506	270
280	0.2429	83.49	0.1536	0.2367	83.42	0.1532	0.2308	83.36	0.1528	0.2252	83.29	0.1524	280
290	0.2471	84.84	0.1554	0.2409	84.78	0.1550	0.2349	84.71	0.1546	0.2292	84.65	0.1542	290
300	0.2513	86.19	0.1572	0.2450	86.13	0.1568	0.2389	86.07	0.1564	0.2331	86.01	0.1560	300
310	0.2555	87.55	0.1589	0.2491	87.49	0.1586	0.2429	87.43	0.1582	0.2370	87.37	0.1578	310
320	0.2597	88.93	0.1607	0.2531	88.86	0.1603	0.2469	88.80	0.1600	0.2410	88.74	0.1596	320
330	0.2638	90.28	0.1625	0.2572	90.23	0.1621	0.2509	90.17	0.1617	0.2449	90.11	0.1613	330
340	0.2679	91.66	0.1642	0.2612	91.60	0.1638	0.2548	91.55	0.1634	0.2487	91.49	0.1631	340
350	0.2720	93.03	0.1659	0.2652	92.98	0.1655	0.2587	92.93	0.1651	0.2526	92.87	0.1648	350
360	0.2761	94.42	0.1676	0.2692	94.36	0.1672	0.2627	94.31	0.1668	0.2564	94.26	0.1665	360
370	0.2801	95.80	0.1693	0.2732	95.75	0.1689	0.2665	95.70	0.1685	0.2602	95.65	0.1682	370
380	–	–	–	–	–	–	0.2704	97.09	0.1702	0.2640	97.04	0.1698	380

TEMP. °F	225			230			235			240			TEMP. °F
	210.3 psig (73.80°F.)			215.3 psig (75.44°F.)			220.3 psig (77.05°F.)			225.3 psig (78.64°F.)			
	V	H	S	V	H	S	V	H	S	V	H	S	
	(0.1269)	(55.72)	(0.1084)	(0.1238)	(55.77)	(0.1083)	(0.1209)	(55.83)	(0.1082)	(0.1180)	(55.88)	(0.1081)	
80	0.1305	56.57	0.1100	0.1264	56.41	0.1095	0.1225	56.24	0.1090	0.1188	56.07	0.1085	80
90	0.1360	57.94	0.1125	0.1319	57.79	0.1120	0.1280	57.64	0.1116	0.1242	57.48	0.1111	90
100	0.1413	59.29	0.1150	0.1372	59.15	0.1145	0.1332	59.01	0.1140	0.1295	58.86	0.1136	100
110	0.1464	60.62	0.1173	0.1422	60.49	0.1169	0.1383	60.36	0.1164	0.1345	60.23	0.1160	110
120	0.1513	61.95	0.1197	0.1471	61.83	0.1192	0.1431	61.70	0.1188	0.1393	61.58	0.1183	120
130	0.1561	63.27	0.1219	0.1519	63.16	0.1215	0.1479	63.04	0.1210	0.1440	62.92	0.1206	130
140	0.1608	64.59	0.1241	0.1565	64.48	0.1237	0.1525	64.37	0.1233	0.1485	64.26	0.1229	140
150	0.1654	65.91	0.1263	0.1611	65.81	0.1259	0.1569	65.70	0.1255	0.1530	65.60	0.1251	150
160	0.1699	67.23	0.1285	0.1655	67.13	0.1281	0.1613	67.03	0.1276	0.1573	66.93	0.1272	160
170	0.1744	68.55	0.1306	0.1699	68.45	0.1302	0.1657	68.36	0.1298	0.1616	68.26	0.1294	170
180	0.1787	69.87	0.1327	0.1742	69.78	0.1323	0.1699	69.68	0.1319	0.1658	69.59	0.1315	180
190	0.1830	71.19	0.1347	0.1785	71.10	0.1343	0.1741	71.01	0.1339	0.1699	70.92	0.1335	190
200	0.1873	72.51	0.1367	0.1827	72.43	0.1363	0.1782	72.34	0.1360	0.1740	72.26	0.1356	200
210	0.1915	73.84	0.1387	0.1868	73.76	0.1383	0.1823	73.68	0.1380	0.1780	73.59	0.1376	210
220	0.1956	75.17	0.1407	0.1909	75.09	0.1403	0.1863	75.01	0.1399	0.1820	74.93	0.1396	220
230	0.1998	76.50	0.1426	0.1949	76.43	0.1423	0.1903	76.35	0.1419	0.1859	76.27	0.1415	230
240	0.2038	77.84	0.1446	0.1989	77.77	0.1442	0.1943	77.69	0.1438	0.1898	77.62	0.1435	240
250	0.2079	79.18	0.1465	0.2029	79.11	0.1461	0.1982	79.04	0.1457	0.1936	78.97	0.1454	250
260	0.2119	80.53	0.1483	0.2068	80.46	0.1480	0.2020	80.39	0.1476	0.1974	80.32	0.1473	260
270	0.2158	81.87	0.1502	0.2107	81.81	0.1498	0.2059	81.74	0.1495	0.2012	81.67	0.1491	270
280	0.2198	83.23	0.1521	0.2146	83.16	0.1517	0.2097	83.10	0.1513	0.2049	83.03	0.1510	280
290	0.2237	84.59	0.1539	0.2185	84.52	0.1535	0.2135	84.46	0.1532	0.2087	84.39	0.1528	290
300	0.2276	85.95	0.1557	0.2223	85.89	0.1553	0.2172	85.82	0.1550	0.2124	85.76	0.1546	300
310	0.2314	87.31	0.1575	0.2261	87.25	0.1571	0.2209	87.19	0.1568	0.2160	87.13	0.1564	310
320	0.2353	88.68	0.1592	0.2298	88.62	0.1589	0.2246	88.57	0.1585	0.2197	88.51	0.1582	320
330	0.2391	90.06	0.1610	0.2336	90.00	0.1606	0.2283	89.94	0.1603	0.2233	89.89	0.1600	330
340	0.2429	91.44	0.1627	0.2373	91.38	0.1624	0.2320	91.32	0.1620	0.2269	91.27	0.1617	340
350	0.2467	92.82	0.1644	0.2410	92.76	0.1641	0.2356	92.71	0.1638	0.2305	92.65	0.1634	350
360	0.2504	94.20	0.1661	0.2447	94.15	0.1658	0.2393	94.10	0.1655	0.2340	94.05	0.1651	360
370	0.2542	95.59	0.1678	0.2484	95.54	0.1675	0.2429	95.49	0.1671	0.2376	95.44	0.1668	370
380	0.2579	96.99	0.1695	0.2521	96.94	0.1692	0.2465	96.89	0.1688	0.2411	96.84	0.1685	380

"FREON-13B1" – SUPERHEATED VAPOR

V=volume in cu ft/lb; H=enthalpy in Btu/lb; S=entropy in Btu/(lb)(°R) (saturation properties in parentheses)

ABSOLUTE PRESSURE, lb/sq in

TEMP. °F	245			250			260			270			TEMP. °F
	230.3 psig (80.20°F.)			235.3 psig (81.74°F.)			245.3 psig (84.75°F.)			255.3 psig (87.68°F.)			
	V	H	S	V	H	S	V	H	S	V	H	S	
	(0.1152)	(55.93)	(0.1080)	(0.1126)	(55.97)	(0.1079)	(0.1076)	(56.06)	(0.1077)	(0.1029)	(56.13)	(0.1075)	
90	0.1206	57.32	0.1106	0.1171	57.16	0.1101	0.1104	56.83	0.1091	0.1042	56.48	0.1081	90
100	0.1253	58.72	0.1131	0.1223	58.57	0.1126	0.1156	58.26	0.1117	0.1094	57.95	0.1107	100
110	0.1308	60.09	0.1155	0.1273	59.95	0.1151	0.1206	59.67	0.1142	0.1143	59.38	0.1133	110
120	0.1356	61.45	0.1179	0.1320	61.33	0.1175	0.1253	61.06	0.1166	0.1190	60.80	0.1157	120
130	0.1402	62.80	0.1202	0.1366	62.68	0.1198	0.1298	62.44	0.1189	0.1235	62.19	0.1181	130
140	0.1447	64.15	0.1225	0.1411	64.04	0.1220	0.1343	63.81	0.1212	0.1279	63.57	0.1204	140
150	0.1491	65.49	0.1247	0.1455	65.38	0.1243	0.1385	65.16	0.1235	0.1321	64.94	0.1227	150
160	0.1534	66.83	0.1268	0.1497	66.72	0.1265	0.1427	66.52	0.1257	0.1362	66.31	0.1249	160
170	0.1577	68.16	0.1290	0.1539	68.07	0.1286	0.1468	67.87	0.1278	0.1402	67.67	0.1271	170
180	0.1618	69.50	0.1311	0.1580	69.40	0.1307	0.1508	69.22	0.1300	0.1441	69.02	0.1292	180
190	0.1659	70.83	0.1332	0.1620	70.74	0.1328	0.1547	70.56	0.1321	0.1480	70.38	0.1314	190
200	0.1699	72.17	0.1352	0.1660	72.09	0.1348	0.1586	71.91	0.1341	0.1517	71.74	0.1334	200
210	0.1739	73.51	0.1372	0.1699	73.43	0.1369	0.1624	73.26	0.1362	0.1554	73.09	0.1355	210
220	0.1778	74.85	0.1392	0.1737	74.77	0.1389	0.1661	74.61	0.1382	0.1591	74.45	0.1375	220
230	0.1816	76.20	0.1412	0.1776	76.12	0.1408	0.1699	76.96	0.1401	0.1627	75.81	0.1395	230
240	0.1855	77.54	0.1431	0.1813	77.47	0.1428	0.1735	77.32	0.1421	0.1663	77.17	0.1414	240
250	0.1892	78.89	0.1450	0.1851	78.82	0.1447	0.1771	78.68	0.1440	0.1698	78.53	0.1433	250
260	0.1930	80.25	0.1469	0.1887	80.18	0.1466	0.1807	80.04	0.1459	0.1733	79.89	0.1453	260
270	0.1967	81.60	0.1488	0.1924	81.54	0.1485	0.1843	81.40	0.1478	0.1768	81.26	0.1471	270
280	0.2004	82.97	0.1506	0.1960	82.90	0.1503	0.1878	82.77	0.1497	0.1802	82.63	0.1490	280
290	0.2041	84.33	0.1525	0.1996	84.27	0.1521	0.1913	84.14	0.1515	0.1836	84.01	0.1509	290
300	0.2077	85.70	0.1543	0.2032	85.64	0.1540	0.1948	85.51	0.1533	0.1870	85.39	0.1527	300
310	0.2113	87.07	0.1561	0.2068	87.01	0.1558	0.1982	86.89	0.1551	0.1903	86.77	0.1545	310
320	0.2149	88.45	0.1579	0.2103	88.39	0.1575	0.2016	88.27	0.1569	0.1936	88.15	0.1563	320
330	0.2184	89.83	0.1596	0.2138	89.77	0.1593	0.2050	89.66	0.1587	0.1969	89.54	0.1580	330
340	0.2220	91.21	0.1614	0.2173	91.16	0.1610	0.2084	91.04	0.1604	0.2002	90.93	0.1598	340
350	0.2255	92.60	0.1631	0.2207	92.55	0.1628	0.2118	92.44	0.1621	0.2035	92.33	0.1615	350
360	0.2290	93.99	0.1648	0.2242	93.94	0.1645	0.2151	93.83	0.1639	0.2067	93.73	0.1632	360
370	0.2325	95.39	0.1665	0.2276	95.34	0.1662	0.2184	95.23	0.1655	0.2099	95.13	0.1649	370
380	0.2360	96.79	0.1682	0.2310	96.74	0.1679	0.2217	96.63	0.1672	0.2131	96.53	0.1666	380
390	0.2394	98.19	0.1698	0.2344	98.14	0.1695	0.2250	98.04	0.1689	0.2163	97.94	0.1683	390

TEMP. °F	280			290			300			310			TEMP. °F
	265.3 psig (90.53°F.)			275.3 psig (93.30°F.)			285.3 psig (96.00°F.)			295.3 psig (98.64°F.)			
	V	H	S	V	H	S	V	H	S	V	H	S	
	(0.0986)	(56.19)	(0.1072)	(0.0945)	(56.24)	(0.1070)	(0.0906)	(56.28)	(0.1068)	(0.0870)	(56.31)	(0.1065)	
100	0.1036	57.62	0.1098	0.0980	57.28	0.1089	0.0928	56.91	0.1079	0.0878	56.53	0.1069	100
110	0.1085	59.09	0.1124	0.1030	58.77	0.1115	0.0978	58.45	0.1106	0.0929	58.12	0.1097	110
120	0.1132	60.52	0.1149	0.1077	60.24	0.1140	0.1025	59.94	0.1132	0.0976	59.64	0.1124	120
130	0.1176	61.93	0.1173	0.1121	61.67	0.1165	0.1069	61.40	0.1157	0.1020	61.12	0.1149	130
140	0.1219	63.33	0.1197	0.1164	63.08	0.1189	0.1112	62.83	0.1181	0.1063	62.58	0.1173	140
150	0.1261	64.72	0.1219	0.1205	64.48	0.1212	0.1152	64.25	0.1205	0.1103	64.01	0.1197	150
160	0.1301	66.09	0.1242	0.1245	65.87	0.1235	0.1192	65.65	0.1227	0.1142	65.43	0.1220	160
170	0.1341	67.46	0.1264	0.1283	67.26	0.1257	0.1230	67.05	0.1250	0.1179	66.83	0.1243	170
180	0.1379	68.83	0.1285	0.1321	68.63	0.1278	0.1267	68.44	0.1272	0.1216	68.23	0.1265	180
190	0.1417	70.20	0.1307	0.1358	70.01	0.1300	0.1303	69.82	0.1293	0.1252	69.63	0.1286	190
200	0.1454	71.56	0.1327	0.1394	71.38	0.1321	0.1339	71.20	0.1314	0.1287	71.01	0.1308	200
210	0.1490	72.92	0.1348	0.1430	72.75	0.1341	0.1374	72.58	0.1335	0.1321	72.40	0.1328	210
220	0.1526	74.28	0.1368	0.1465	74.12	0.1362	0.1408	73.95	0.1355	0.1355	73.78	0.1349	220
230	0.1561	75.65	0.1388	0.1499	75.49	0.1382	0.1442	75.33	0.1375	0.1388	75.17	0.1369	230
240	0.1596	77.01	0.1408	0.1533	76.86	0.1401	0.1475	76.71	0.1395	0.1420	76.55	0.1389	240
250	0.1630	78.38	0.1427	0.1567	78.23	0.1421	0.1508	78.09	0.1415	0.1452	77.94	0.1409	250
260	0.1664	79.75	0.1446	0.1600	79.61	0.1440	0.1540	79.47	0.1434	0.1484	79.32	0.1428	260
270	0.1698	81.12	0.1465	0.1633	80.99	0.1459	0.1572	80.85	0.1453	0.1516	80.71	0.1447	270
280	0.1731	82.50	0.1484	0.1666	82.37	0.1478	0.1604	82.23	0.1472	0.1547	82.10	0.1466	280
290	0.1764	83.88	0.1502	0.1698	83.75	0.1496	0.1635	83.62	0.1491	0.1577	83.49	0.1485	290
300	0.1797	85.26	0.1521	0.1730	85.13	0.1515	0.1667	85.01	0.1509	0.1608	84.88	0.1503	300
310	0.1830	86.64	0.1539	0.1761	86.52	0.1533	0.1697	86.40	0.1527	0.1638	86.28	0.1522	310
320	0.1862	88.03	0.1557	0.1793	87.91	0.1551	0.1728	87.79	0.1545	0.1668	87.67	0.1540	320
330	0.1894	89.42	0.1574	0.1824	89.31	0.1569	0.1758	89.19	0.1563	0.1697	89.07	0.1557	330
340	0.1926	90.82	0.1592	0.1855	90.71	0.1586	0.1788	90.59	0.1581	0.1726	90.48	0.1575	340
350	0.1957	92.22	0.1609	0.1885	92.11	0.1604	0.1818	92.00	0.1598	0.1756	91.89	0.1593	350
360	0.1989	93.62	0.1627	0.1916	93.51	0.1621	0.1848	93.40	0.1615	0.1785	93.30	0.1610	360
370	0.2020	95.02	0.1644	0.1946	94.92	0.1638	0.1878	94.81	0.1632	0.1813	94.71	0.1627	370
380	0.2051	96.43	0.1660	0.1977	96.33	0.1655	0.1907	96.23	0.1649	0.1842	96.12	0.1644	380
390	0.2082	97.84	0.1677	0.2007	97.74	0.1672	0.1936	97.64	0.1666	0.1870	97.54	0.1661	390
400	0.2113	99.26	0.1694	0.2036	99.16	0.1688	0.1965	99.06	0.1683	0.1899	98.97	0.1677	400

"FREON-13B1" – SUPERHEATED VAPOR

V=volume in cu ft/lb; H=enthalpy in Btu/lb; S=entropy in Btu/(lb)(°R) (saturation properties in parentheses)

ABSOLUTE PRESSURE, lb/sq in

TEMP. °F	320			330			340			350			TEMP. °F
	305.3 psig (101.22°F.)			315.3 psig (103.73°F.)			325.3 psig (106.19°F.)			335.3 psig (108.60°F.)			
	V	H	S	V	H	S	V	H	S	V	H	S	
	(0.0836)	(56.33)	(0.1063)	(0.0804)	(56.34)	(0.1060)	(0.0774)	(56.34)	(0.1058)	(0.0745)	(56.33)	(0.1055)	
110	0.0882	57.76	0.1080	0.0837	57.39	0.1079	0.0794	57.00	0.1069	0.0752	56.58	0.1059	110
120	0.0930	59.32	0.1115	0.0886	59.00	0.1107	0.0844	58.65	0.1098	0.0803	58.30	0.1089	120
130	0.0974	60.84	0.1141	0.0931	60.54	0.1133	0.0889	60.23	0.1125	0.0849	59.92	0.1117	130
140	0.1016	62.31	0.1166	0.0973	62.04	0.1158	0.0931	61.76	0.1151	0.0892	61.48	0.1143	140
150	0.1056	63.76	0.1190	0.1013	63.51	0.1183	0.0971	63.26	0.1175	0.0932	62.99	0.1168	150
160	0.1095	65.20	0.1213	0.1051	64.96	0.1206	0.1009	64.73	0.1199	0.0970	64.48	0.1192	160
170	0.1132	66.62	0.1236	0.1088	66.40	0.1229	0.1046	66.18	0.1222	0.1006	65.95	0.1216	170
180	0.1168	68.03	0.1258	0.1123	67.82	0.1252	0.1081	67.61	0.1245	0.1041	67.40	0.1239	180
190	0.1204	69.43	0.1280	0.1158	69.24	0.1274	0.1115	69.04	0.1267	0.1075	68.83	0.1261	190
200	0.1238	70.83	0.1301	0.1192	70.64	0.1295	0.1149	70.45	0.1289	0.1108	70.26	0.1283	200
210	0.1272	72.22	0.1322	0.1225	72.04	0.1316	0.1181	71.86	0.1310	0.1140	71.68	0.1304	210
220	0.1305	73.61	0.1343	0.1258	73.44	0.1337	0.1213	73.27	0.1331	0.1172	73.10	0.1325	220
230	0.1337	75.00	0.1363	0.1290	74.84	0.1357	0.1245	74.68	0.1351	0.1202	74.51	0.1346	230
240	0.1369	76.39	0.1383	0.1321	76.24	0.1377	0.1276	76.08	0.1372	0.1233	75.92	0.1366	240
250	0.1401	77.78	0.1403	0.1352	77.63	0.1397	0.1306	77.48	0.1392	0.1262	77.33	0.1386	250
260	0.1432	79.17	0.1422	0.1382	79.03	0.1417	0.1336	78.88	0.1411	0.1292	78.73	0.1406	260
270	0.1462	80.57	0.1442	0.1412	80.42	0.1436	0.1365	80.28	0.1430	0.1321	80.14	0.1425	270
280	0.1493	81.96	0.1460	0.1442	81.82	0.1455	0.1394	81.69	0.1450	0.1349	81.55	0.1444	280
290	0.1523	83.35	0.1479	0.1471	83.22	0.1474	0.1423	83.09	0.1468	0.1377	82.96	0.1463	290
300	0.1552	84.75	0.1498	0.1500	84.62	0.1492	0.1451	84.49	0.1487	0.1405	84.37	0.1482	300
310	0.1582	86.15	0.1516	0.1529	86.03	0.1511	0.1479	85.90	0.1505	0.1433	85.78	0.1500	310
320	0.1611	87.55	0.1534	0.1558	87.43	0.1529	0.1507	87.31	0.1524	0.1460	87.19	0.1519	320
330	0.1640	88.96	0.1552	0.1586	88.84	0.1547	0.1535	88.72	0.1542	0.1487	88.60	0.1537	330
340	0.1668	90.37	0.1570	0.1614	90.25	0.1565	0.1562	90.14	0.1559	0.1514	90.02	0.1554	340
350	0.1697	91.78	0.1587	0.1642	91.66	0.1582	0.1590	91.55	0.1577	0.1540	91.44	0.1572	350
360	0.1725	93.19	0.1605	0.1669	93.08	0.1599	0.1616	92.97	0.1594	0.1567	92.86	0.1590	360
370	0.1753	94.60	0.1622	0.1697	94.50	0.1617	0.1643	94.39	0.1612	0.1593	94.29	0.1607	370
380	0.1781	96.02	0.1639	0.1724	95.92	0.1634	0.1670	95.82	0.1629	0.1619	95.71	0.1624	380
390	0.1809	97.44	0.1656	0.1751	97.34	0.1651	0.1696	97.24	0.1646	0.1645	97.14	0.1641	390
400	0.1836	98.87	0.1672	0.1778	98.77	0.1667	0.1723	98.67	0.1662	0.1670	98.58	0.1658	400
410	0.1864	100.30	0.1689	0.1804	100.20	0.1684	0.1749	100.11	0.1679	0.1696	100.01	0.1674	410

TEMP. °F	360			370			380			390			TEMP. °F
	345.3 psig (110.95°F.)			355.3 psig (113.26°F.)			365.3 psig (115.52°F.)			375.3 psig (117.74°F.)			
	V	H	S	V	H	S	V	H	S	V	H	S	
	(0.0717)	(56.31)	(0.1052)	(0.0691)	(56.28)	(0.1049)	(0.0666)	(56.24)	(0.1046)	(0.0642)	(56.18)	(0.1043)	
120	0.0765	57.92	0.1080	0.0727	57.52	0.1071	0.0691	57.10	0.1061	0.0655	56.64	0.1051	120
130	0.0811	59.59	0.1109	0.0775	59.24	0.1100	0.0740	58.88	0.1092	0.0706	58.51	0.1083	130
140	0.0854	61.18	0.1135	0.0818	60.88	0.1128	0.0784	60.56	0.1120	0.0751	60.23	0.1112	140
150	0.0894	62.73	0.1161	0.0859	62.45	0.1154	0.0825	62.16	0.1147	0.0792	61.87	0.1139	150
160	0.0932	64.23	0.1186	0.0896	63.98	0.1179	0.0862	63.72	0.1172	0.0830	63.45	0.1165	160
170	0.0968	65.72	0.1209	0.0932	65.48	0.1203	0.0898	65.24	0.1196	0.0866	65.00	0.1190	170
180	0.1003	67.18	0.1232	0.0967	66.96	0.1226	0.0933	66.74	0.1220	0.0900	66.51	0.1214	180
190	0.1037	68.63	0.1255	0.1000	68.42	0.1249	0.0966	68.21	0.1243	0.0933	68.00	0.1237	190
200	0.1069	70.07	0.1277	0.1033	69.87	0.1271	0.0998	69.67	0.1265	0.0965	69.47	0.1259	200
210	0.1101	71.50	0.1298	0.1064	71.31	0.1293	0.1029	71.12	0.1287	0.0995	70.93	0.1281	210
220	0.1132	72.92	0.1319	0.1095	72.74	0.1314	0.1059	72.57	0.1308	0.1025	72.38	0.1303	220
230	0.1162	74.34	0.1340	0.1125	74.17	0.1335	0.1089	74.00	0.1329	0.1055	73.83	0.1324	230
240	0.1192	75.76	0.1361	0.1154	75.59	0.1355	0.1118	75.43	0.1350	0.1083	75.27	0.1345	240
250	0.1222	77.17	0.1381	0.1183	77.02	0.1375	0.1146	76.86	0.1370	0.1111	76.70	0.1365	250
260	0.1250	78.58	0.1400	0.1211	78.43	0.1395	0.1174	78.28	0.1390	0.1139	78.13	0.1385	260
270	0.1279	80.00	0.1420	0.1239	79.85	0.1415	0.1201	79.71	0.1410	0.1166	79.56	0.1405	270
280	0.1307	81.41	0.1439	0.1266	81.27	0.1434	0.1228	81.13	0.1429	0.1192	80.99	0.1424	280
290	0.1334	82.82	0.1458	0.1294	82.69	0.1453	0.1255	82.55	0.1448	0.1218	82.42	0.1443	290
300	0.1362	84.24	0.1477	0.1320	84.11	0.1472	0.1281	83.98	0.1467	0.1244	83.84	0.1462	300
310	0.1389	85.65	0.1495	0.1347	85.53	0.1490	0.1307	85.40	0.1486	0.1270	85.27	0.1481	310
320	0.1415	87.07	0.1514	0.1373	86.95	0.1509	0.1333	86.82	0.1504	0.1295	86.70	0.1499	320
330	0.1442	88.49	0.1532	0.1399	88.37	0.1527	0.1359	88.25	0.1522	0.1320	88.13	0.1517	330
340	0.1468	89.91	0.1550	0.1425	89.79	0.1545	0.1384	89.68	0.1540	0.1345	89.56	0.1535	340
350	0.1494	91.33	0.1567	0.1450	91.22	0.1562	0.1409	91.11	0.1558	0.1369	90.99	0.1553	350
360	0.1520	92.75	0.1585	0.1476	92.65	0.1580	0.1434	92.54	0.1575	0.1394	92.43	0.1571	360
370	0.1546	94.18	0.1602	0.1501	94.08	0.1597	0.1458	93.97	0.1593	0.1418	93.86	0.1588	370
380	0.1571	95.61	0.1619	0.1526	95.51	0.1615	0.1483	95.41	0.1610	0.1442	95.30	0.1606	380
390	0.1596	97.04	0.1636	0.1550	96.94	0.1631	0.1507	96.84	0.1627	0.1466	96.74	0.1623	390
400	0.1621	98.48	0.1653	0.1575	98.38	0.1648	0.1531	98.28	0.1644	0.1489	98.18	0.1639	400
410	0.1646	99.91	0.1669	0.1599	99.82	0.1665	0.1555	99.72	0.1660	0.1513	99.63	0.1656	410
420	0.1671	101.35	0.1686	0.1624	101.26	0.1681	0.1578	101.17	0.1677	0.1536	101.07	0.1673	420

"FREON-13B1" – SUPERHEATED VAPOR

V=volume in cu ft/lb; H=enthalpy in Btu/lb; S=entropy in Btu/(lb)(°R) (saturation properties in parentheses)

ABSOLUTE PRESSURE, lb/sq in

TEMP. °F	400			410			420			430			TEMP. °F
	385.3 psig (119.91°F.)			395.3 psig (122.05°F.)			405.3 psig (124.14°F.)			415.3 psig (126.20°F.)			
	V	H	S	V	H	S	V	H	S	V	H	S	
	(0.0619)	(56.12)	(0.1040)	(0.0597)	(56.05)	(0.1037)	(0.0576)	(55.96)	(0.1034)	(0.0555)	(55.86)	(0.1030)	
120	0.0619	56.14	0.1041	–	–	–	–	–	–	–	–	–	120
130	0.0673	58.11	0.1074	0.0641	57.68	0.1065	0.0609	57.22	0.1055	0.0578	56.73	0.1045	130
140	0.0719	59.89	0.1104	0.0689	59.53	0.1096	0.0659	59.16	0.1088	0.0630	58.76	0.1079	140
150	0.0761	61.57	0.1132	0.0731	61.26	0.1125	0.0702	60.93	0.1117	0.0674	60.60	0.1110	150
160	0.0799	63.18	0.1158	0.0769	62.90	0.1151	0.0741	62.61	0.1144	0.0713	62.31	0.1137	160
170	0.0835	64.74	0.1183	0.0805	64.49	0.1177	0.0777	64.23	0.1170	0.0750	63.96	0.1164	170
180	0.0869	66.28	0.1207	0.0839	66.04	0.1201	0.0811	65.80	0.1195	0.0784	65.55	0.1189	180
190	0.0902	67.78	0.1231	0.0872	67.56	0.1225	0.0843	67.34	0.1219	0.0816	67.11	0.1213	190
200	0.0933	69.27	0.1253	0.0903	69.06	0.1248	0.0875	68.85	0.1242	0.0847	68.64	0.1236	200
210	0.0964	70.74	0.1276	0.0933	70.55	0.1270	0.0905	70.35	0.1265	0.0877	70.15	0.1259	210
220	0.0993	72.20	0.1297	0.0963	72.02	0.1292	0.0935	71.83	0.1287	0.0906	71.64	0.1281	220
230	0.1022	73.65	0.1318	0.0991	73.48	0.1313	0.0962	73.30	0.1308	0.0934	73.12	0.1303	230
240	0.1050	75.10	0.1339	0.1019	74.93	0.1334	0.0989	74.76	0.1329	0.0961	74.59	0.1324	240
250	0.1078	76.54	0.1360	0.1046	76.38	0.1355	0.1016	76.22	0.1350	0.0988	76.06	0.1345	250
260	0.1105	77.98	0.1380	0.1073	77.83	0.1375	0.1043	77.67	0.1370	0.1014	77.52	0.1365	260
270	0.1132	79.41	0.1400	0.1099	79.27	0.1395	0.1069	79.12	0.1390	0.1039	78.97	0.1385	270
280	0.1158	80.85	0.1419	0.1125	80.71	0.1414	0.1094	80.56	0.1410	0.1064	80.42	0.1405	280
290	0.1184	82.28	0.1438	0.1151	82.14	0.1434	0.1119	82.01	0.1429	0.1089	81.87	0.1425	290
300	0.1209	83.71	0.1457	0.1176	83.58	0.1453	0.1144	83.45	0.1448	0.1113	83.31	0.1444	300
310	0.1234	85.14	0.1476	0.1200	85.02	0.1472	0.1168	84.89	0.1467	0.1137	84.76	0.1463	310
320	0.1259	86.58	0.1495	0.1225	86.45	0.1490	0.1192	86.33	0.1486	0.1161	86.21	0.1481	320
330	0.1284	88.01	0.1513	0.1249	87.89	0.1508	0.1216	87.77	0.1504	0.1184	87.65	0.1500	330
340	0.1308	[illegible].45	0.1531	0.1273	89.33	0.1527	0.1239	89.21	0.1522	0.1207	89.10	0.1518	340
350	0.1332	90.88	0.1549	0.1296	90.77	0.1544	0.1263	90.66	0.1540	0.1230	90.54	0.1536	350
360	0.1356	92.32	0.1566	0.1320	92.21	0.1562	0.1286	92.10	0.1558	0.1253	91.99	0.1554	360
370	0.1380	93.76	0.1584	0.1343	93.65	0.1580	0.1308	93.54	0.1575	0.1275	93.44	0.1571	370
380	0.1403	95.20	0.1601	0.1366	95.09	0.1597	0.1331	94.99	0.1593	0.1298	94.89	0.1589	380
390	0.1426	96.64	0.1618	0.1389	96.54	0.1614	0.1353	96.44	0.1610	0.1320	96.34	0.1606	390
400	0.1449	98.09	0.1635	0.1412	97.99	0.1631	0.1376	97.89	0.1627	0.1341	97.79	0.1623	400
410	0.1472	99.53	0.1652	0.1434	99.44	0.1648	0.1398	99.34	0.1644	0.1363	99.24	0.1640	410
420	0.1495	100.98	0.1668	0.1457	100.89	0.1664	0.1420	100.79	0.1660	0.1385	100.70	0.1656	420
430	–	–	–	0.1479	102.34	0.1681	0.1442	102.25	0.1677	0.1406	102.16	0.1673	430

TEMP. °F	440			450			460			470			TEMP. °F
	425.3 psig (128.22°F.)			435.3 psig (130.21°F.)			445.3 psig (132.17°F.)			455.3 psig (134.09°F.)			
	V	H	S	V	H	S	V	H	S	V	H	S	
	(0.0535)	(55.75)	(0.1027)	(0.0516)	(55.62)	(0.1023)	(0.0497)	(55.47)	(0.1015)	(0.0479)	(55.31)	(0.1014)	
130	0.0547	56.18	0.1034	–	–	–	–	–	–	–	–	–	130
140	0.0601	58.34	0.1070	0.0573	57.90	0.1061	0.0546	57.41	0.1051	0.0518	56.88	0.1041	140
150	0.0647	60.25	0.1102	0.0620	59.88	0.1094	0.0595	59.49	0.1086	0.0570	59.09	0.1077	150
160	0.0687	62.01	0.1130	0.0661	61.69	0.1123	0.0637	61.36	0.1116	0.0613	61.02	0.1109	160
170	0.0724	63.68	0.1157	0.0698	63.40	0.1151	0.0674	63.11	0.1144	0.0651	62.82	0.1137	170
180	0.0758	65.30	0.1183	0.0733	65.05	0.1177	0.0709	64.79	0.1170	0.0685	64.52	0.1164	180
190	0.0790	66.88	0.1207	0.0765	66.64	0.1201	0.0741	66.41	0.1196	0.0718	66.16	0.1190	190
200	0.0821	68.43	0.1231	0.0796	68.21	0.1225	0.0772	67.99	0.1220	0.0749	67.76	0.1214	200
210	0.0851	69.95	0.1254	0.0825	69.74	0.1248	0.0801	69.54	0.1243	0.0778	69.33	0.1238	210
220	0.0879	71.45	0.1276	0.0854	71.26	0.1271	0.0829	71.07	0.1266	0.0806	70.87	0.1261	220
230	0.0907	72.94	0.1298	0.0881	72.76	0.1293	0.0857	72.58	0.1288	0.0833	72.39	0.1283	230
240	0.0934	74.42	0.1319	0.0908	74.25	0.1314	0.0883	74.08	0.1309	0.0859	73.90	0.1305	240
250	0.0960	75.89	0.1340	0.0934	75.73	0.1335	0.0909	75.56	0.1331	0.0885	75.40	0.1326	250
260	0.0986	77.36	0.1361	0.0959	77.20	0.1356	0.0934	77.04	0.1351	0.0910	76.89	0.1347	260
270	0.1011	78.82	0.1381	0.0984	78.67	0.1376	0.0959	78.52	0.1372	0.0934	78.37	0.1367	270
280	0.1036	80.26	0.1401	0.1009	80.13	0.1396	0.0983	79.99	0.1392	0.0958	79.84	0.1387	280
290	0.1060	81.73	0.1420	0.1033	81.59	0.1416	0.1007	81.45	0.1411	0.0981	81.31	0.1407	290
300	0.1084	83.18	0.1439	0.1056	83.05	0.1435	0.1030	82.91	0.1431	0.1004	82.78	0.1426	300
310	0.1108	84.63	0.1458	0.1080	84.50	0.1454	0.1053	84.37	0.1450	0.1027	84.24	0.1445	310
320	0.1131	86.08	0.1477	0.1103	85.95	0.1473	0.1075	85.83	0.1468	0.1049	85.70	0.1464	320
330	0.1154	87.53	0.1495	0.1125	87.41	0.1491	0.1098	87.29	0.1487	0.1071	87.17	0.1483	330
340	0.1177	88.98	0.1514	0.1148	88.86	0.1509	0.1120	88.74	0.1505	0.1093	88.63	0.1501	340
350	0.1199	90.43	0.1532	0.1170	90.32	0.1528	0.1142	90.20	0.1523	0.1115	90.09	0.1520	350
360	0.1222	91.88	0.1549	0.1192	91.77	0.1545	0.1163	91.66	0.1541	0.1136	91.55	0.1537	360
370	0.1244	93.33	0.1567	0.1214	93.22	0.1563	0.1185	93.12	0.1559	0.1157	93.01	0.1555	370
380	0.1266	94.78	0.1584	0.1235	94.68	0.1580	0.1206	94.57	0.1577	0.1178	94.47	0.1573	380
390	0.1287	96.24	0.1602	0.1256	96.14	0.1598	0.1227	96.03	0.1594	0.1199	95.93	0.1590	390
400	0.1309	97.69	0.1619	0.1278	97.59	0.1615	0.1248	97.49	0.1611	0.1219	97.40	0.1607	400
410	0.1330	99.15	0.1636	0.1299	99.05	0.1632	0.1268	98.96	0.1628	0.1239	98.86	0.1624	410
420	0.1351	100.61	0.1652	0.1319	100.51	0.1648	0.1289	100.42	0.1645	0.1260	100.33	0.1641	420
430	0.1372	102.07	0.1669	0.1340	101.98	0.1665	0.1309	101.88	0.1661	0.1280	101.79	0.1657	430
440	–	–	–	0.1361	103.44	0.1681	0.1329	103.35	0.1677	0.1299	103.26	0.1674	440

"FREON-13B1" – SUPERHEATED VAPOR

V=volume in cu ft/lb; H=enthalpy in Btu/lb; S=entropy in Btu/(lb)(°R) (saturation properties in parentheses)

ABSOLUTE PRESSURE, lb/sq in

TEMP. °F	480			490			500			510			TEMP. °F
	465.3 psig (135.98°F.)			475.3 psig (137.84°F.)			485.3 psig (139.68°F.)			495.3 psig (141.46°F.)			
	V	H	S	V	H	S	V	H	S	V	H	S	
	(0.0461)	(55.13)	(0.1010)	(0.0444)	(54.93)	(0.1005)	(0.0427)	(54.70)	(0.1000)	(0.0410)	(54.45)	(0.0995)	
140	0.0490	56.30	0.1029	0.0461	55.63	0.1017	0.0429	54.82	0.1002	-	-	-	140
150	0.0545	58.66	0.1068	0.0520	58.20	0.1059	0.0496	57.70	0.1050	0.0472	57.16	0.1039	150
160	0.0589	60.67	0.1101	0.0566	60.30	0.1094	0.0544	59.91	0.1086	0.0522	59.50	0.1077	160
170	0.0628	62.51	0.1131	0.0606	62.19	0.1124	0.0585	61.87	0.1117	0.0564	61.52	0.1110	170
180	0.0663	64.25	0.1158	0.0641	63.97	0.1152	0.0621	63.68	0.1145	0.0600	63.38	0.1139	180
190	0.0696	65.91	0.1184	0.0674	65.66	0.1178	0.0653	65.40	0.1172	0.0633	65.14	0.1166	190
200	0.0726	67.53	0.1209	0.0705	67.30	0.1203	0.0684	67.06	0.1198	0.0664	66.83	0.1192	200
210	0.0755	69.12	0.1232	0.0734	68.90	0.1227	0.0713	68.68	0.1222	0.0693	68.46	0.1217	210
220	0.0783	70.67	0.1256	0.0762	70.47	0.1250	0.0741	70.27	0.1245	0.0721	70.06	0.1240	220
230	0.0810	72.21	0.1278	0.0789	72.02	0.1273	0.0768	71.83	0.1268	0.0748	71.63	0.1263	230
240	0.0836	73.72	0.1300	0.0814	73.55	0.1295	0.0793	73.37	0.1290	0.0773	73.18	0.1286	240
250	0.0862	75.23	0.1321	0.0840	75.06	0.1317	0.0818	74.89	0.1312	0.0798	74.72	0.1307	250
260	0.0886	76.73	0.1342	0.0864	76.56	0.1338	0.0843	76.40	0.1333	0.0822	76.24	0.1329	260
270	0.0911	78.21	0.1363	0.0888	78.06	0.1358	0.0866	77.90	0.1354	0.0845	77.75	0.1350	270
280	0.0934	79.69	0.1383	0.0911	79.55	0.1378	0.0889	79.40	0.1374	0.0868	79.25	0.1370	280
290	0.0957	81.17	0.1403	0.0934	81.03	0.1398	0.0912	80.89	0.1394	0.0891	80.74	0.1390	290
300	0.0980	32.64	0.1422	0.0957	82.51	0.1418	0.0934	82.37	0.1414	0.0913	82.23	0.1410	300
310	0.1002	84.11	0.1441	0.0979	83.98	0.1437	0.0956	83.85	0.1433	0.0934	83.72	0.1429	310
320	0.1024	85.58	0.1460	0.1001	85.45	0.1456	0.0978	85.32	0.1452	0.0955	85.20	0.1448	320
330	0.1046	87.04	0.1479	0.1022	86.92	0.1475	0.0999	86.80	0.1471	0.0976	86.68	0.1467	330
340	0.1068	88.51	0.1497	0.1043	88.39	0.1493	0.1020	88.27	0.1490	0.0997	88.15	0.1486	340
350	0.1089	89.97	0.1516	0.1064	89.86	0.1512	0.1040	89.74	0.1508	0.1017	89.63	0.1504	350
360	0.1110	91.44	0.1534	0.1085	91.33	0.1530	0.1061	91.21	0.1526	0.1038	91.10	0.1522	360
370	0.1131	92.90	0.1551	0.1105	92.79	0.1548	0.1081	92.69	0.1544	0.1057	92.58	0.1540	370
380	0.1151	94.37	0.1569	0.1125	94.26	0.1565	0.1101	94.16	0.1561	0.1077	94.05	0.1558	380
390	0.1171	95.83	0.1586	0.1145	95.73	0.1582	0.1121	95.63	0.1579	0.1097	95.53	0.1575	390
400	0.1192	97.30	0.1603	0.1165	97.20	0.1600	0.1140	97.10	0.1596	0.1116	97.00	0.1592	400
410	0.1212	98.76	0.1620	0.1185	98.67	0.1617	0.1160	98.57	0.1613	0.1135	98.48	0.1610	410
420	0.1231	100.23	0.1637	0.1205	100.14	0.1633	0.1179	100.04	0.1630	0.1154	99.95	0.1626	420
430	0.1251	101.70	0.1654	0.1224	101.61	0.1650	0.1198	101.52	0.1647	0.1173	101.43	0.1643	430
440	0.1271	103.17	0.1670	0.1243	103.08	0.1667	0.1217	102.99	0.1663	0.1191	102.90	0.1660	440
450	-	-	-	-	-	-	-	-	-	0.1210	104.38	0.1676	450

TEMP. °F	520			530			540			550			TEMP. °F
	505.3 psig (143.26°F.)			515.3 psig (145.02°F.)			525.3 psig (146.74°F.)			535.3 psig (148.45°F.)			
	V	H	S	V	H	S	V	H	S	V	H	S	
	(0.0393)	(54.16)	(0.0989)	(0.0376)	(53.84)	(0.0982)	(0.0359)	(53.46)	(0.0975)	(0.0341)	(53.01)	(0.0966)	
150	0.0447	56.55	0.1028	0.0421	55.86	0.1015	0.0393	55.05	0.1001	0.0362	54.00	0.0982	150
160	0.0501	59.07	0.1069	0.0479	58.61	0.1060	0.0458	58.11	0.1051	0.0437	57.58	0.1041	160
170	0.0544	61.17	0.1103	0.0524	60.81	0.1095	0.0504	60.42	0.1088	0.0485	60.02	0.1080	170
180	0.0581	63.08	0.1133	0.0562	62.77	0.1126	0.0543	62.45	0.1120	0.0525	62.11	0.1113	180
190	0.0614	64.87	0.1160	0.0595	64.59	0.1154	0.0577	64.31	0.1148	0.0560	64.02	0.1142	190
200	0.0645	66.58	0.1187	0.0627	66.33	0.1181	0.0609	66.08	0.1175	0.0591	65.82	0.1170	200
210	0.0674	68.24	0.1211	0.0656	68.01	0.1206	0.0638	67.78	0.1201	0.0620	67.54	0.1196	210
220	0.0702	69.85	0.1235	0.0683	69.64	0.1230	0.0665	69.43	0.1225	0.0648	69.21	0.1221	220
230	0.0728	71.44	0.1259	0.0709	71.24	0.1254	0.0691	71.04	0.1249	0.0674	70.84	0.1244	230
240	0.0754	73.00	0.1281	0.0735	72.82	0.1276	0.0717	72.63	0.1272	0.0699	72.44	0.1267	240
250	0.0778	74.55	0.1303	0.0759	74.37	0.1299	0.0741	74.19	0.1294	0.0723	74.02	0.1290	250
260	0.0802	76.07	0.1324	0.0783	75.91	0.1320	0.0764	75.74	0.1316	0.0747	75.57	0.1311	260
270	0.0825	77.59	0.1345	0.0806	77.43	0.1341	0.0787	77.28	0.1337	0.0769	77.12	0.1333	270
280	0.0848	79.10	0.1366	0.0828	78.95	0.1362	0.0810	78.80	0.1358	0.0791	78.65	0.1354	280
290	0.0870	80.60	0.1386	0.0850	80.46	0.1382	0.0831	80.31	0.1378	0.0813	80.17	0.1374	290
300	0.0892	82.09	0.1406	0.0872	81.96	0.1402	0.0853	81.82	0.1398	0.0834	81.68	0.1394	300
310	0.0913	83.58	0.1425	0.0893	83.45	0.1421	0.0874	83.32	0.1418	0.0855	83.18	0.1414	310
320	0.0934	85.07	0.1444	0.0914	84.94	0.1441	0.0894	84.81	0.1437	0.0875	84.68	0.1433	320
330	0.0955	86.55	0.1463	0.0934	86.43	0.1460	0.0914	86.31	0.1456	0.0895	86.18	0.1452	330
340	0.0975	88.03	0.1482	0.0954	87.91	0.1478	0.0934	87.80	0.1475	0.0915	87.68	0.1471	340
350	0.0995	89.51	0.1500	0.0974	89.40	0.1497	0.0954	89.28	0.1493	0.0934	89.17	0.1489	350
360	0.1015	90.99	0.1519	0.0994	90.88	0.1515	0.0973	90.77	0.1511	0.0953	90.66	0.1508	360
370	0.1035	92.47	0.1536	0.1013	92.36	0.1533	0.0992	92.25	0.1529	0.0972	92.14	0.1526	370
380	0.1054	93.95	0.1554	0.1032	93.84	0.1551	0.1011	93.74	0.1547	0.0991	93.63	0.1544	380
390	0.1074	95.42	0.1572	0.1051	95.32	0.1568	0.1030	95.22	0.1565	0.1009	95.12	0.1561	390
400	0.1093	96.90	0.1589	0.1070	96.80	0.1586	0.1049	96.70	0.1582	0.1028	96.60	0.1579	400
410	0.1111	98.38	0.1606	0.1089	98.28	0.1603	0.1067	98.19	0.1599	0.1046	98.09	0.1596	410
420	0.1130	99.86	0.1623	0.1107	99.76	0.1619	0.1085	99.67	0.1616	0.1064	99.58	0.1613	420
430	0.1149	101.34	0.1640	0.1125	101.24	0.1636	0.1103	101.15	0.1633	0.1082	101.06	0.1630	430
440	0.1167	102.82	0.1656	0.1144	102.73	0.1653	0.1121	102.64	0.1649	0.1099	102.55	0.1646	440
450	0.1185	104.30	0.1673	0.1162	104.21	0.1669	0.1139	104.12	0.1666	0.1117	104.04	0.1663	450

"FREON-13B1" – SUPERHEATED VAPOR

V=volume in cu ft/lb; H=enthalpy in Btu/lb; S=entropy in Btu/(lb)(°R) (saturation properties in parentheses)

ABSOLUTE PRESSURE, lb/sq in

TEMP. °F	560			570			580			590			TEMP. °F
	545.3 psig (150.13°F.)			555.3 psig (151.78°F.)			565.3 psig			575.3 psig			
	V	H	S	V	H	S	V	H	S	V	H	S	
	(0.0322)	(52.47)	(0.0956)	(0.0302)	(51.76)	(0.0944)	–	–	–	–	–	–	
160	0.0415	56.99	0.1030	0.0393	56.33	0.1018	0.0370	55.58	0.1005	0.0345	54.68	0.0989	160
170	0.0467	59.60	0.1072	0.0448	59.15	0.1063	0.0430	58.68	0.1054	0.0411	58.17	0.1045	170
180	0.0507	61.77	0.1106	0.0490	61.41	0.1099	0.0473	61.04	0.1092	0.0457	60.66	0.1084	180
190	0.0542	63.73	0.1136	0.0526	63.42	0.1130	0.0510	63.11	0.1124	0.0494	62.79	0.1117	190
200	0.0574	65.56	0.1164	0.0558	65.29	0.1159	0.0542	65.02	0.1153	0.0527	64.74	0.1147	200
210	0.0604	67.31	0.1191	0.0587	67.07	0.1185	0.0572	66.82	0.1180	0.0556	66.57	0.1175	210
220	0.0631	69.00	0.1216	0.0615	68.77	0.1211	0.0599	68.55	0.1206	0.0584	68.32	0.1201	220
230	0.0657	70.64	0.1240	0.0641	70.44	0.1235	0.0625	70.23	0.1230	0.0610	70.02	0.1225	230
240	0.0682	72.25	0.1263	0.0666	72.06	0.1258	0.0650	71.87	0.1254	0.0635	71.67	0.1249	240
250	0.0706	73.84	0.1285	0.0690	73.66	0.1281	0.0674	73.48	0.1277	0.0659	73.30	0.1272	250
260	0.0729	75.41	0.1307	0.0713	75.24	0.1303	0.0697	75.06	0.1299	0.0681	74.89	0.1295	260
270	0.0752	76.96	0.1329	0.0735	76.79	0.1325	0.0719	76.63	0.1320	0.0704	76.47	0.1316	270
280	0.0774	78.49	0.1350	0.0757	78.34	0.1346	0.0741	78.19	0.1342	0.0725	78.03	0.1338	280
290	0.0795	80.02	0.1370	0.0778	79.87	0.1366	0.0762	79.73	0.1362	0.0746	79.58	0.1358	290
300	0.0816	81.54	0.1390	0.0799	81.40	0.138[illegible]	0.0782	81.26	0.1383	0.0766	81.12	0.1379	300
310	0.0837	83.05	0.1410	0.0819	82.92	0.1406	0.0802	82.78	0.1402	0.0786	82.64	0.1399	310
320	0.0857	84.56	0.1429	0.0839	84.43	0.1426	0.0822	84.30	0.1422	0.0806	84.17	0.1418	320
330	0.0877	86.06	0.1449	0.0859	85.93	0.1445	0.0842	85.81	0.1441	0.0825	85.68	0.1438	330
340	0.0896	87.56	0.1467	0.0878	87.44	0.1464	0.0861	87.31	0.1460	0.0844	87.19	0.1457	340
350	0.0915	89.05	0.1486	0.0897	88.93	0.1482	0.0879	88.82	0.1479	0.0862	88.70	0.1476	350
360	0.0934	90.54	0.1504	0.0916	90.43	0.1501	0.0898	90.32	0.1497	0.0881	90.21	0.1494	360
370	0.0953	92.04	0.1522	0.0934	91.93	0.1519	0.0916	91.82	0.1516	0.0899	91.71	0.1512	370
380	0.0971	93.53	0.1540	0.0952	93.42	0.1537	0.0934	93.31	0.1534	0.0917	93.21	0.1530	380
390	0.0990	95.02	0.1558	0.0970	94.91	0.1555	0.0952	94.81	0.1551	0.0934	94.71	0.1548	390
400	0.1008	96.50	0.1575	0.0988	96.40	0.1572	0.0970	96.31	0.1569	0.0952	96.21	0.1565	400
410	0.1026	97.99	0.1592	0.1006	97.90	0.1589	0.0987	97.80	0.1586	0.0969	97.70	0.1583	410
420	0.1043	99.48	0.1610	0.1023	99.39	0.1606	0.1004	99.29	0.1603	0.0986	99.20	0.1600	420
430	0.1061	100.97	0.1626	0.1041	100.88	0.1623	0.1021	100.79	0.1620	0.1003	100.70	0.1617	430
440	0.1078	102.46	0.1643	0.1058	102.37	0.1640	0.1030	102.28	0.1637	0.1020	102.19	0.1634	440
450	0.1095	103.95	0.1659	0.1075	103.86	0.1656	0.1055	103.78	[illegible]	0.1036	103.69	0.1650	450
460	0.1113	105.44	0.1676	0.1092	105.35	0.1673	0.1072	105.27	[illegible]	0.1053	105.18	0.1666	460

TEMP. °F	600												TEMP. °F
	585.3 psig												
	V	H	S	V	H	S	V	H	S	V	H	S	
	–	–	–										
160	0.0317	53.54	0.0970										
170	0.0393	57.63	0.1035										
180	0.0440	60.26	0.1077										
190	0.0478	62.46	0.1111										
200	0.0512	64.45	0.1141										
210	0.0542	66.32	0.1169										
220	0.0569	68.09	0.1196										
230	0.0595	69.81	0.1221										
240	0.0620	71.48	0.1245										
250	0.0644	73.11	0.1268										
260	0.0666	74.72	0.1291										
270	0.0688	76.31	0.1312										
280	0.0710	77.88	0.1334										
290	0.0730	79.43	0.1355										
300	0.0751	80.97	0.1375										
310	0.0770	82.51	0.1395										
320	0.0790	84.04	0.1415										
330	0.0809	85.56	0.1434										
340	0.0828	87.07	0.1453										
350	0.0846	88.58	0.1472										
360	0.0864	90.09	0.1491										
370	0.0882	91.60	0.1509										
380	0.0900	93.10	0.1527										
390	0.0917	94.61	0.1545										
400	0.0934	96.11	0.1562										
410	0.0951	97.61	0.1580										
420	0.0968	99.11	0.1597										
430	0.0985	100.60	0.1614										
440	0.1001	102.10	0.1630										
450	0.1018	103.60	0.1647										
460	0.1034	105.10	0.1663										

The information contained herein is based on technical data and tests which we believe to be reliable and is intended for use by persons having technical skill, at their own discretion and risk. Since conditions of use are outside of Du Pont's control, we can assume no liability for results obtained or damages incurred through the application of the data presented.

Publication of the information in this bulletin should not be understood as permission or recommendation for the use of "Freon" compounds in violation of any patents.

U.S. DEPARTMENT OF LABOR

Occupational Safety & Health Administration

MATERIAL SAFETY DATA SHEET

Attachment 6

SECTION I

MANUFACTURER'S NAME: E. I. DuPont de Nemours and Company	EMERGENCY TELEPHONE NO.: (302) 774-1000
ADDRESS (Number, Street, City, State, and ZIP Code): Freon® Products Division, Wilmington, Delaware 19898	
CHEMICAL NAME AND SYNONYMS: Bromotrifluoromethane	TRADE NAME AND SYNONYMS: Halon 1301 Fire Extinguishant
CHEMICAL FAMILY: Halogenated Hydrocarbon	FORMULA: $CBrF_3$

SECTION II HAZARDOUS INGREDIENTS

PAINTS, PRESERVATIVES, & SOLVENTS	%	TLV (Units)	ALLOYS AND METALLIC COATINGS	%	TLV (Units)
PIGMENTS	--		BASE METAL	--	
CATALYST	--		ALLOYS	--	
VEHICLE	--		METALLIC COATINGS	--	
SOLVENTS	--		FILLER METAL PLUS COATING OR CORE FLUX	--	
ADDITIVES	--		OTHERS	--	
OTHERS	--			--	

HAZARDOUS MIXTURES OF OTHER LIQUIDS, SOLIDS, OR GASES	%	TLV (Units)

SECTION III PHYSICAL DATA

BOILING POINT (°F.)	-71.95	SPECIFIC GRAVITY (H_2O=1) at 77°F g/1	1.538
VAPOR PRESSURE (mm Hg.) at 77°F	12.152	PERCENT VOLATILE BY VOLUME (%)	100
VAPOR DENSITY (AIR=1) at B.P. g/1	8.71	EVAPORATION RATE (Ether=1)	Rapid
SOLUBILITY IN WATER at 77°F - wt. %	0.03		

APPEARANCE AND ODOR: Colorless liquid - slight ethereal odor

SECTION IV FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (Method used): Nonflammable	FLAMMABLE LIMITS	Lel	Uel

EXTINGUISHING MEDIA

SPECIAL FIRE FIGHTING PROCEDURES

UNUSUAL FIRE AND EXPLOSION HAZARDS

NOTICE FROM DU PONT

[illegible] in this Material Safety Data Sheet relates only [illegible] specific material designated herein and does not

SECTION V HEALTH HAZARD DATA

THRESHOLD LIMIT VALUE
1000 ppm

EFFECTS OF OVEREXPOSURE Light-headedness, giddiness, shortness of breath, possible cardiac arrhythmias at concentrations of 10% by volume and higher

EMERGENCY AND FIRST AID PROCEDURES

Inhalation: Remove to fresh air, call a physician. Do not give epinephrine or similar drugs.

Skin or Eye Contact: Flush with water.

SECTION VI REACTIVITY DATA

STABILITY			CONDITIONS TO AVOID
	UNSTABLE		Extended contact with open flames or temperatures >1000°F
	STABLE	X	

INCOMPATABILITY (Materials to avoid) Liquid contact with alkali and alkaline earth metals-powdered Al, Zn, Be, etc.

HAZARDOUS DECOMPOSITION PRODUCTS Hydrogen fluorides, hydrogen bromide, free bromine, possibly carbonyl halides.

HAZARDOUS POLYMERIZATION			CONDITIONS TO AVOID
	MAY OCCUR		
	WILL NOT OCCUR	X	

SECTION VII SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED
Ventilate area--especially low places where heavy vapor might collect. Remove open flames.

WASTE DISPOSAL METHOD

SECTION VIII SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION (Specify type)
Use air mask in concentrations above 10% by volume.

VENTILATION		
	LOCAL EXHAUST: When large amounts are released	SPECIAL
	MECHANICAL (General): Especially in low places	OTHER

PROTECTIVE GLOVES	EYE PROTECTION
When handling liquid	When handling liquid

OTHER PROTECTIVE EQUIPMENT

SECTION IX SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING
Store containers in a clean, dry area. Do not heat above 125°F.

OTHER PRECAUTIONS
For further information, see latest edition of Halon Bulletin B29.

U.S. DEPARTMENT OF LABOR

Occupational Safety & Health Administration

MATERIAL SAFETY DATA SHEET

Attachment 7

SECTION I

MANUFACTURER'S NAME: E. I. DuPont de Nemours and Company	EMERGENCY TELEPHONE NO.: (302) 774-2421
ADDRESS (Number, Street, City, State, and ZIP Code): Freon® Products Division, Wilmington, Delaware 19898	
CHEMICAL NAME AND SYNONYMS: Bromotrifluoromethane	TRADE NAME AND SYNONYMS: Freon® 13B1; Halon 1301
CHEMICAL FAMILY: Halogenated Hydrocarbon	FORMULA: $CBrF_3$

SECTION II HAZARDOUS INGREDIENTS

PAINTS, PRESERVATIVES, & SOLVENTS	%	TLV (Units)	ALLOYS AND METALLIC COATINGS	%	TLV (Units)
PIGMENTS	--		BASE METAL	--	
CATALYST	--		ALLOYS	--	
VEHICLE	--		METALLIC COATINGS	--	
SOLVENTS	--		FILLER METAL PLUS COATING OR CORE FLUX	--	
ADDITIVES	--		OTHERS	--	
OTHERS	--			--	

HAZARDOUS MIXTURES OF OTHER LIQUIDS, SOLIDS, OR GASES	%	TLV (Units)

SECTION III PHYSICAL DATA

BOILING POINT (°F.)	-71.95	SPECIFIC GRAVITY (H_2O=1) at 77°F g/l	1.538
VAPOR PRESSURE (mm Hg.) at 77°F	12,152	PERCENT VOLATILE BY VOLUME (%)	100
VAPOR DENSITY (AIR=1) at B.P. g/1	8.71	EVAPORATION RATE (_____=1)	Rapid
SOLUBILITY IN WATER at 77°F - wt. %	0.03		
APPEARANCE AND ODOR	Colorless liquid - slight ethereal odor		

SECTION IV FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (Method used): Nonflammable	FLAMMABLE LIMITS	Lel	Uel

EXTINGUISHING MEDIA

SPECIAL FIRE FIGHTING PROCEDURES

UNUSUAL FIRE AND EXPLOSION HAZARDS

NOTICE FROM DU PONT

The data in this Material Safety Data Sheet relates only to the specific material designated herein and does not relate to use in combination with any other material or in any process.

SECTION V HEALTH HAZARD DATA

THRESHOLD LIMIT VALUE: 1000 ppm

EFFECTS OF OVEREXPOSURE: Light-headedness, giddiness, shortness of breath, possible cardiac arrhythmias at concentrations of 10% by volume and higher

EMERGENCY AND FIRST AID PROCEDURES

Inhalation: Remove to fresh air, call a physician. Do not give epinephrine or similar drugs.

Skin or Eye Contact: Flush with water.

SECTION VI REACTIVITY DATA

STABILITY			CONDITIONS TO AVOID
	UNSTABLE		Extended contact with open flames or temperatures >1000°F
	STABLE	X	

INCOMPATABILITY (Materials to avoid): Liquid contact with alkali and alkaline earth metals-powdered Al, Zn, Be, etc.

HAZARDOUS DECOMPOSITION PRODUCTS: Hydrogen fluorides, hydrogen bromide, free bromine, possibly carbonyl halides.

HAZARDOUS POLYMERIZATION			CONDITIONS TO AVOID
	MAY OCCUR		
	WILL NOT OCCUR	X	

SECTION VII SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED

Ventilate area--especially low places where heavy vapor might collect. Remove open flames.

WASTE DISPOSAL METHOD

SECTION VIII SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION (Specify type): Use air mask in concentrations above 10% by volume.

VENTILATION		
	LOCAL EXHAUST: When large amounts are released	SPECIAL
	MECHANICAL (General): Especially in low places	OTHER

PROTECTIVE GLOVES: When handling liquid

EYE PROTECTION: When handling liquid

OTHER PROTECTIVE EQUIPMENT

SECTION IX SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING

Store containers in a clean, dry area. Do not heat above 125°F.

OTHER PRECAUTIONS

For further information, see Freon± Bulletins S-35A, B-29C.

Revised 8-15-79

TOXICITY REVIEW

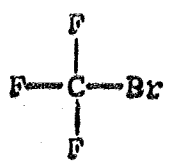
HALON 1301

HASKELL LABORATORY

LIMITED DISTRIBUTION

This review reflects the available toxicity literature, both published and unpublished. Studies have not been evaluated for scientific merit.

Common Name: Halon 1301
Chemical Name: Methane, bromotrifluoro-
Synonyms: Freon® 13B1, FC-13B1
CAS Registry No.: 75-63-8
Chemical Structure:



Physical and Chemical Properties:

Description:	Colorless gas
Molecular Weight:	148.9
Boiling Point:	-57.8°C @ 760 mm Hg
Melting Point:	-168°C
Density/Specific Gravity:	1.57 g/cc (liquid at 70°F)
Vapor Pressure:	56.5 psig @ 0°F / -18°C
	199 psig @ 70°F / 21°C
	300 psig @ 100°F / 38°C
Flash Point/Flammability:	Nonflammable
Solubility:	300 ppm in water @ 77°F / 25°C
Conversion Factors:	1 mg/L - 164 ppm
	1 ppm = 6.1 mg/m^3

Exposure Standards:

TLV® = 1000 ppm; STEL = 1200 ppm (1).
OSHA 8-hour TWA = 1000 ppm (2).
See Related Reference 52 for additional information.

DOT Classification:

Nonflammable gas; DOT shipping name monobromotrifluoromethane (44).

EPA RCRA Status

None.

FDA Status:

None.

TSCA Inventory:

Yes.

TOXICITY

A. Acute

1. Oral

- Not applicable.

2. Skin and Eyes

- Liquid Halon 1301 may freeze the skin (frostbite) on contact. Such contact should be avoided by wearing protective clothing and eye protection (3).

3. Inhalation

a) Animal Studies

Concentration (ppm)	Duration of Exposure	Animal Species	Effect(s)	Reference
850,000	2 hours	Mice Guinea pigs	Lethal	4
832,000	15 minutes	Rats	Lethal	5
800,000	4 hours	Rats	3/70 deaths	40
800,000	2 hours	Rats Rabbits Mice Guinea pigs	No deaths Toxic effects: drowsiness, tremors, ataxia and convulsions	4

Concentration (ppm)	Duration of Exposure	Animal Species	Effect(s)	Reference
800,000	30 minutes	Rats, Mice	Lethal	10
770,000	1 hour	Rats	No deaths	6
600,000	2 hours	Mice, Rats, Guinea Pigs, Rabbits	No deaths Hypoactivity Slow and deep respiration	4
560,000	1 hour	Rats	No deaths	6
500,000	2 hours	Rats, Mice, Guinea Pigs, Rabbits	Slight initial CNS, depression Normal behavior thereafter	4
500,000	26 minutes	Rats	Drowsiness	7
400,000	2 hours	Mice, Rats, Guinea Pigs, Rabbits	No effect	4
370,000	7 hours	Cats Guinea Pigs Mice Rats Rabbits	Lethal (1/1) Lethal (6/6) Survived Survived Survived	8
370,000	7 hours	Guinea Pigs	No deaths	11
360,000	3.5 hours	Cats Guinea Pigs Mice Rats Rabbits	Survived Lethal (5/6) Survived Survived Survived	8
360,000	1.33 hours	Cats Guinea Pigs Mice Rats Rabbits	Survived Survived Survived Survived Survived	8
300,000	2 hours	Mice, Rats Guinea Pigs Rabbits	No effect	4

Concentration (ppm)	Duration of Exposure	Animal Species	Effect(s)	Reference
300,000	40 minutes	Rats	No effect Pathology normal	40
200,000	2 hours	Monkeys Rabbits Guinea Pigs Rats	Glassy eyes (1/2) Restlessness (4/4) Lacrimation (1/6) Restlessness (10/10) Normal recovery	40
200,000	2 hours	Guinea Pigs	No effect Normal Pathology	9
200,000	2 hours	Rats	No effects Normal Pathology	40
180,000	7 hours	Rabbits Cats Mice Rats Guinea Pigs	Lethal (1/4) Survived Survived Survived Survived	8
150,000	2 hours	Monkeys Rabbits Guinea Pigs Rats	Glassy eyes (1/2) No effect No effect No effect	40
90,000	7 hours	Cats, Mice Rats, Rabbits, Guinea Pigs	No effect	8
46,000-50,000	2 hours	Guinea Pigs	No effect	9
44,000	2 hours	Guinea Pigs	No effect	8
24,000-28,000	2 hours	Guinea Pigs	No effect	9
9,000-13,000	2 hours	Guinea Pigs	No effect	9

- Pathological examination of animals killed by Halon 1301 exposure revealed edema and hemorrhage in the lungs, severe pneumonitis and tracheitis and congestion of the liver, spleen and kidneys. No cellular changes were seen in these organs (5). Examination of other animals which survived Halon 1301 exposures failed to reveal any significant changes (40).

- Hematological examination of the monkeys exposed to 10 or 20% Halon 1301 failed to reveal any significant changes (40).

- Seven monkeys trained on continuous and discrete avoidance performance tasks were exposed to Halon 1301 concentrations ranging from 10.5 to 42%. Significant performance decrements were observed in all monkeys during 20-25% exposures. Higher concentrations resulted in impaired performance to the point of complete disruption of operant behavior in some monkeys. No visible signs of CNS depression or analgesia accompanied this loss of ability to perform conditioned performance tasks (12).

- See Related References 45, 47, 49 and 50 for more information.

b) Human Exposures

Concentration (percent)	Duration of Exposure	Effect(s)	Reference
15	1 minute	Severe dizziness and marked paresthesia. Increased heart rate and T-wave depression (EKG). Recovery was rapid and complete within 5 minutes.	13
12	1 minute	Severe dizziness and mild paresthesia in 1/2 subjects. T-wave depression and increased heart rate.	13
10	1 minute	No effect for the first 30 second followed by slight dizziness and paresthesia (1/2). Heart rate increased and T-wave was depressed in 1/2 subjects.	13
10	3-3.5 minutes	Light headedness increasing to near unconsciousness. Slight disturbance tests (balance and reaction time). No EKG changes were observed.	40

10	20 minutes	Euphoria (2/6) Light-headedness (3/6) Paresthesia (1/6) Tinnitus (1/6) Slight to moderate eye/ nose irritation (2/6) Pulmonary discomfort (2/6)	14
9	2 minutes	After 1 minute of exposure dizziness was felt which increased in intensity. Increased heart rate, no EKG changes.	13
7	3 minutes	Exposure was during flight at 5,000-20,000 feet. No adverse subjective biomedical or EKG effects were reported.	16
7	3 minutes	Dizziness, faintness and drowsiness (6/8). Different altitudes had no effect on subjective symptoms. No compound-related EKG changes.	15
7	3-3.5 minutes	Light-headedness. No EKG changes.	40
6	3 minutes	Slight paresthesia, dizziness. No EKG changes. Increased heart rate.	13
5	3-3.5 minutes	No effects observed. EKGs normal.	40
5	20 minutes	Euphoria (2/4) Light headedness (2/4) Pressure in the ears (1/4) or in the head (1/4) Slight eye and nose irritation (1/4) Slight pulmonary discomfort (1/4)	14

4	3 minutes	Dizziness, faintness and drowsiness (3/8). Changes in altitude had no effect on symptoms. No compound-related EKG changes.	15
4	3 minutes	Exposure was during flight at 5,000-20,000 feet. No adverse subjective biomedical or EKG effects were reported.	16
3	3-3.5 minutes	No effects observed. EKGs normal.	40
1	3-3.5 minutes	No effects observed EKGs normal.	40

- Ten volunteers were exposed to inhalation of $CBrF_3$ from an anesthesia machine. These experiments consisted of a series of relatively short exposures to different concentrations of $CBrF_3$. Heart rate, blood pressure and electrocardiographic tracings were monitored. Cardiac arrhythmias were not observed to develop during exposure of 5 subjects for a total of 10 to 17 minutes to 4-6.7% nor during the additional exposures of 5 subjects to 7-9.6% for 5 to 7 minutes. These subjects reported reactions including dizziness, tingling of extremities, light-headedness and a fear of imminent loss of consciousness. Five subjects were exposed to 8.2-15.7% for total exposure times of 10-31 minutes. Only one of these subjects developed a serious cardiac arrhythmia. The subjective sensations which were reported to have developed during these serial exposures to $CBrF_3$ were on the central nervous system. These sensations ranged from an increased awareness of sound, visual disturbances (e.g. flashing before eyes), tingling of extremeties and numbness of body to the sensation of the room rocking back and forth or spinning, drowsiness, and the fear of impending unconsciousness (14).

- Three volunteers, one visually handicapped, were exposed to 0.1, 4.3, 4.5 and 7.1% of Halon 1301 for up to 30 minutes. The subjects' health and feelings were monitored before, during, and up to 2 hours after exposure. Included before each exposure were

a complete physical examination (blood pressure, body temperature, electrocardiogram [ECG], pulmonary function, urinalysis, clinical blood chemistry & symptoms) and mood evaluation. During and after each exposure, the subjects performed various tasks to measure effects of exposure on eye-hand coordination, short-term memory, reaction time, depth perception, balance, ability to walk on a treadmill, write, and speak. Finally, spontaneous electroencephalograms (EEGs) were made immediately after exposure on each subject. At 0.1% Halon 1301, no significant deviations from normal were detected in any of the subjects. At 4.3 and 4.5%, subjects experienced sensations of light-headedness, dizziness, and euphoria 2 minutes into exposure. At 9 minutes into exposure at 4.5%, only the visually handicapped subject showed signs of imparied balance; at 30 minutes after exposure, his response was normal. A second subject showed mild impairment in balance at 30 minutes. At 7.1%, one subject showed mild changes in tests of balance during exposure, while the visually handicapped subject performed unsatisfactorily in the balance and eye-hand coordination tests. Sensations of light-headedness, dizziness, and euphoria also were noted, persisting up to 60 minutes after exposure. Analysis of ECG tracings did not show any abnormalities caused by the exposures. One of the subjects showed slight changes in brain wave activity (EEG) at 7.1%, with a pattern representative of slight anesthesia. All untoward physiological and subjective responses were reversible shortly after exposure. Results of the other health tests were within normal limits (40)

B. Extended Inhalation Studies

- A single cat survived two 7-hour exposures to 18% Halon 1301. Guinea pigs exposed to the same concentration died after 2 exposures as did 1/4 rabbits. All of the 10 rats and 10 mice similarly exposed survived. Five 7-hour exposures to 8.72% killed 4/6 guinea pigs. Mice, rats, cats and rabbits were not killed except for 2 natural deaths. Five 7-hour exposures to 4.44% was responsible for the death of 1/10 mice, but no other deaths were attributable to the Halon 1301 exposure. Dogs exposed to either 9 or 18% for 7 hours on each of 2 consecutive days developed no signs of intoxication. Acute hemorrhagic pneumonitis and degeneration of

the liver and kidneys were found among animals that died as the result of exposure (8).

- Exposure of groups of 3 rats, 3 guinea pigs, 1 dog and 3 cats to 20-60% Halon 1301 for up to 70 hours did not produce symptoms of toxicity (17).

- A group of 20 rats and 20 guinea pigs was exposed to 5.1% Halon 1301 continuously for 10 days. No toxic effects or pathologic or histopathologic changes were observed. Hematologic determinations also failed to reveal any adverse compound-related changes (6).

- A group of 20 mice, 10 rats and 10 guinea pigs was exposed to 50% of Halon 1301 in air, 2 hours daily for 15 days. No significant effects were observed (4).

- Rats were exposed to 5% of Halon 1301, 23 hours daily for 30 days. Studies of blood did not reveal any accumulation of Halon 1301. There was no elevation in the rate of excretion of fluoride ion in the urine. No gross pathological changes were found (1[illegible]).

- Rats and dogs were exposed to 2.3% of Halon 1301 in air for 6 hours daily, 5 days per week for up to 18 weeks. At no time did the animals show any signs of intoxication. Upon autopsy the animals showed no evidence of pulmonary edema or necrosis as had been seen in acute lethal studies. There was a moderate diffuse congestion of the entire respiratory tract but no other significant changes. All other organs appeared normal (19).

Halon 1301 Blood Levels

- Beagle dogs with cannulas surgically implanted in the common carotid artery and external jugular vein were exposed to 5%, 7.5%, and 10% Halon 1301 for 60 minutes. Blood samples were withdrawn from the cannulas before, during, and after exposure and analyzed for the Halon 1301 concentration. Blood levels of Halon 1301 increased rapidly during the first ten minutes of exposure, plateaued within twenty minutes, and declined rapidly after exposure. The mean blood concentrations at equilibrium were directly proportional to inspired levels: at an inspired concentration of 5% - arterial 19.2 ug/mL,

venous 14.6 ug/mL; at an inspired concentration of 7.5% - arterial 30.6 ug/mL, venous 26.4 ug; and at an inspired concentration of 10% - arterial 40.2 ug/mL, venous 32.1 ug/mL. During exposure arterial concentration was greater than venous concentration, but after exposure the venous concentration slightly exceeded the arterial concentration (40, 41).

- Anesthetized rats were exposed to 5% of Halon 1301 for 30 minutes and blood levels of Halon 1301 determined. The following blood levels were found at the indicated post-exposure times:

Time	Level
0	5.6 ug/g
15 minutes	0.62 ug/g
1 hour	0.35 ug/g
2 hour	0.05 ug/g
4 hour	0.07 ug/g

(18)

- Groups of 15 rats were exposed for 1-5 minutes to 70% Halon 1301. Rats were removed at various times for collection of brain tissue, heart and intracardiac blood samples. During the first minutes of exposure, the Halon 1301 concentration in the brain and heart rose rapidly. Following the end of exposure, the concentrations in brain and heart fell rapidly. The Halon 1301 concentrations in the samples of intracardiac blood were similar to those of the hearts obtained at the corresponding time intervals (20).

Cardiac Studies

a) Cardiac Arrhythmias

- It has been known for some time that inhalation of vapors from certain organic materials, which include such compounds as carbon tetrachloride and gasoline, can make the heart muscle abnormally reactive to elevated adrenalin levels with resulting cardiac arrhythmias. These arrhythmias are frequently ventricular in origin and may result in sudden death. This phenomenon is commonly referred to as cardiac sensitization. Since Halon 1301 is used as a fire extinguishing agent and fire is a life-threatening emergency which can be expected to result in high circulating levels of adrenalin in persons attempting to extinguish the fire or those

whose escape may be blocked, several investigators have studied the effects of adrenalin plus Halon 1301 exposure on the cardiovascular system.

- EC50* (dogs) = 200,000 ppm (23).

- Development of spontaneous cardiac arrhythmias were not observed in the electrocardiographic tracings obtained during exposure of 1 dog to 10% (100,000 ppm) $CBrF_3$ for 20 minutes, exposure of 4 dogs to 20% (200,000 ppm) for 15 minutes, and exposure of 5 dogs to 30% (300,000 ppm) for 15 minutes. Salivation and whole body trembling occurred during exposures to 30% and to a lesser extent during exposures to 20%. Weakness and inability to stand was reported only for those dogs exposed to 20%. Recovery following exposure to 30% occurred within 1-2 minutes after exposure was ended. The author does not report whether the $CBrF_3$ was mixed with air or with oxygen. Cardiac sensitization to intravenously injected epinephrine during 5-minute exposures to 10% or to 20% $CBrF_3$ was evidenced by increases in the number of ectopic beats in 2/2 exposed to 10% and in 1/2 exposed to 20% and by ventricular tachycardia in 1/2 exposed to 20% (13).

- Dogs were exposed to 5, 7.5 and 10% of Halon 1301 for 30-60 minutes. The test animals received an injection of epinephrine both before and after the exposure. None of the dogs exposed to 5.0% developed cardiac arrhythmias. Two of 12 dogs exposed to 7.5% showed a marked response after a 30-minute exposure. Following a 30-minute exposure to 10% Halon 1301 there was one definite and one questionable response in 12 dogs (40).

- A dog was exposed to 10% Halon 1301 for a few minutes following an injection of epinephrine. A challenge injection followed the exposure. Some effect on the heart was seen (40).

- Halon 1301 did not cause cardiac sensitization of the beagle heart below a concentration of 10% in air (40). Further experimentation showed that the minimum effect level is closer to 7.5% than 10% (40).

* EC50 is the concentration causing cardiac arrhythmias in 50% of the animals. Exposure was for 5 minutes followed by an exogenous dose of epinephrine.

- Groups of 8 dogs were exposed to 10, 20 or 40% Halon 1301 in air. Exposure times were 15, 27 and 55 minutes, respectively. During exposure the chambers were darkened and the dogs subject for 5 minutes to fright-inducing stimuli. Those dogs exposed to 10% Halon 1301 demonstrated increased alertness, those exposed to 20% developed tremors without increased alertness and those exposed to 40% howled, salivated and developed dyspnea and tremors (14).

- Spontaneous cardiac arrhythmias developed within 1-3 minutes of exposure to 40% Halon 1301. Arrhythmias could be produced in those animals not developing spontaneous arrhythmias by the intravenous injection of a pressor dose of epinephrine. Larger doses caused ventricular fibrillation with cardiac arrest in dogs and, commonly, spontaneous defibrillation in monkeys (21).

- Anesthetized guinea pigs, cats and dogs were exposed to 20% Halon 1301. This exposure increased the arrhythmogenic effect of i.v. infusion of epinephrine (24).

- Five anesthetized monkeys were exposed, successively, for 10 minutes each, to 10-80% Halon 1301. spontaneous ventricular arrhythmias developed during the first 5 minutes of exposure to 30% and higher. Cardiac arrhythmias spontaneously appearing in monkeys exposed to $CBrF_3$ required a minimal blood pressure threshold for their production. The blood pressure threshold varied as an inverse function of the log of the $CBrF_3$ concentration to which monkeys in acid-base balance were exposed. Acidosis decreased the threshold and alkalosis increased the threshold at concentrations of 10 and 20% $CBrF_3$ but were without effect at 30% or greater concentrations. Epinephrine decreased the blood pressure threshold required to trigger arrhythmias but was not necessary for their production as it is in the case of cyclopropane (25).

- No significant difference in the percentage of marked responses was seen when dogs with myocardial infractions were used instead of healthly dogs (40 , 42).

- Groups of rats were exposed to one of the following conditions:

  1) simulated altitude with added Halon 1301 (27 rats);

  2) simulated altitude without Halon 1301 (9 rats);

  3) simulated altitude with added Halon 1301 and injected epinephrine (27 rats);

  4) simulated altitude without Halon 1301 but with injected epinephrine (9 rats).

  No rats died during any chamber exposure. Three animals developed cardiac arrhythmias during inhalation of Halon 1301. One rat breathing 24 percent Halon 1301 at a simulated altitude of 5,000 feet, and one exposed to 16 percent $CBrF_3$ at 389 mm Hg, developed premature atrial contractions about one minute after the Halon 1301 was admitted to the chamber. Indications of bundle branch blocks appeared as the exposure continued. In both cases, these changes disappeared when the $CBrF_3$-air mixture was replaced with room air during the chamber descents. Premature atrial contractions were also noted in the electrocardiogram of one rat breathing 24 percent Halon 1301 at 632 mm Hg. This animal had received an epinephrine injection before the exposure. Normal EKG tracings reappeared when the rat was returned to ambient conditions. No other prolonged cardiac arrhythmias were noted on the electrocardiograms from any other rats. Histological examination of the lungs from rats sacrificed immediately after exposure showed no pathologic changes which could be directly related to breathing Halon 1301 or exposure to hypobaric conditions. In this experiment epinephrine was administered intramuscularly to rats rather than the usual intravenous route. The use of i.m. administration would be expected to produce much lower blood levels of epinephrine than i.v. injection. The observation of only 1/27 premature atrial contractions after exposure to 24% Halon 1301 at 632 mm Hg may reflect the low dose of epinephrine rather than any species different (22).

- Rats were subjected to 79% Halon 1301 plus 21% oxygen and challenged with subtoxic doses of epinephrine. CNS effects were the major

observations in rats, 17/20 showed respiratory arrest within 40 minutes and several exhibited erratic convulsive behavior prior to exhibiting respiratory difficulties (26).

b) Heart Rate And Blood Pressure

- Inhalation of 80% Halon 1301 caused blood pressure falls in many cases and a marked elevated diastolic pressure in rhesus monkeys. Inhalation of 70 percent Halon 1301 triggered cardiac arrhythmias. These arrhythmias were dependent on the maintenance of a minimum blood pressure. Halon 1301 (80%) inhalation in dogs which had undergone a left lumbar sympathectomy caused a large increase in right femoral artery blood flow. Concurrently, mean arterial blood pressure, peak systolic blood pressure fell while left ventricular and diastolic pressure rose (27).

- Dogs were exposed to 50 and 75% Halon 1301 for 10-minute periods. Recordings were made and arterial and coronary sinus blood samples were obtained before, during and after the exposures. A small decrease in the vigor of myocardial contraction, decreases in vasoconstrictor tone and mean arterial blood pressure, an increase in aortic blood flow, an increase in myocardial lactate utilization and a decrease in myocardial oxygen consumption were observed as functions of the Halon 1301 concentration. Conclusions were than under the conditions of this experiment (1), a decrease in pressure-volume work done by the left ventricular myocardium during Halon 1301 exposure resulted in a decrease in myocardial oxygen consumption; (2) myocardial metabolism was little affected; and (3) decreased peripheral vascular flow resistance was accompanied by increased cardiac output (28).

- To investigate the effect of Halon 1301 on blood pressure 10 anesthetized dogs were exposed to air or 70% Halon 1301 for 50 minutes. The blood pressure of the treated dogs was significantly lower than pre- and postexposure levels and also lower than for air treated controls. No significant differences were seen for cardiac output. Heart rate was significantly lower (29).

- Halon 1301 was administered to dogs and the following parameters recorded: pulmonary

resistance, pulmonary compliance, respiratory minute volume, heart rate and aortic blood pressure. Halon 1301 was shown to produce an increase in pulmonary resistance a decrease in compliance an increase in respiratory minute volume, very little effect on heart rate even at concentrations up to 20%, and a mild hypertensive effect (4% increase at 20% concentration). Heart-lung experiments in surgically prepared dogs showed little change in myocardial contraction even at high concentrations. Experiments with rats showed Halon 1301 capable of producing apnea with atrioventricular conduction blocks occurring during this period of apnea. Halon 1301 also produced a rise in pulmonary resistance and fall in compliance as it did in the dog experiments (40).

- Exposure of dogs and monkeys to 10-80% of Halon 1301 caused cardiovascular and CNS effects which increased in severity with increasing concentration. An initial fall in blood pressure of 10-20 mm Hg at the lower concentrations and 40-60 mm Hg at the higher concentrations was observed. Epileptiform convulsions were seen in about 50% of the dogs exposed to 50-80% Halon 1301 while conscious. Conscious monkeys, on the other hand, became lethargic, and no convulsions were seen (21).

- The mechanism of the decrease in mean arterial blood pressure in the dog during Halon 1301 exposure was a decrease vasomotor tone resulting from ganglionic blockade. No direct vascular smooth muscle effect of $CBrF_3$ was observed. When arterial blood from one dog was perfused through the hind leg at constant flow rate through a hind limb of another dog, exposure of the donor to 67-70% $CBrF_3$ was accompanied by a reversible decrease in the donor's mean arterial blood pressure, but the perfusion pressure was unaltered (30).

- When anesthetized dogs were exposed to Halon 1301 the animals myocardial contractility decreased inversely with the concentration of Halon 1301 (31).

- Halon 1301 significantly decreased total peripheral resistance and myocardial contractility in anesthetized open-chested dogs and monkeys resulting in a reversible hypotension during exposure (32).

- Groups of dogs were exposed to 27-75% Halon 1301 in oxygen or 27-75% mixture of O_2 and N_2. Exposure to Halon 1301 may result in disturbances of myocardial energy metabolism that are connected to myocardial performance. The exposure resulted in a progressive rise of plasma glucose concentrations that persisted for at least 30 minutes post exposure (33).

- Exposure of dogs to 27, 51 or 75% Halon 1301 produced no myocardial tissue hypoxia, slight metabolic acidosis, normal pyruvate, lactate, and coronary sinus blood glucose, decreased mean arterial blood pressure and myocardial contraction strength and elevated arterial blood glucose (34).

- Twelve anesthetized cats were subjected under hyperbarbic conditions to 5-minute inhalation of 5% Halon 1301. This exposure was associated with:

  1) Cardiac arrhythmias in 10/12 cats;

  2) Fall in systolic blood pressure (average decrease -18.4 mm Hg) in 10/10 cats and a fall in diastolic pressure (average decrease - 19 mm Hg) in 9/10 cats (35).

- A anesthetized cat was exposed to 80% Halon 1301 and 20% oxygen. This exposure did not materially modify the physiologic equilibrium of the cat. The following changes were observed:

  - Slight activation of respiration;

  - Decreased arterial blood pressure (1 mm Hg);

  - Slight decrease in oxygen consumption;

  - CNS depression (hypnotic). (4)

- Anesthetized dogs and monkeys were exposed to 70 or 80% of Halon 1301 and EEGs recorded. The most significant findings were (1) dominance of the EEGs by 6-9 Hz waves beginning 2-3 minutes after beginning exposure to $CBrF_3$ and (2) a nearly normal susceptibility of the EEG to activation by auditory and photic stimuli during exposure to $CBrF_3$. Several lines of evidence were explored which suggested that the central nervous system effects of $CBrF_3$ may be the result of the induction of functional changes at the rhinencephalic level (36).

- To determine if the negative inotropic effect of Halon 1301 was accompanied by altered myocardial metabolism, urethane anesthetized-guinea pigs were exposed for 30 minutes and myocardial ATP, ADP, AMP and creatine phosphate levels were determined. A concentration of 75% Halon 1301, produced a 34% decrease in contractibility. Blood levels stabilized within 2.5 minutes. Blood pressure and heart rate were decreased. High energy phosphate levels were not altered in a fashion commensurate with the theory that a block in energy metabolism was responsible for the production of the induced negative inotropic effect (43).

- See Related References 46, 48 and 51 for more information.

C. Carcinogenic Potential

- No evidence of a carcinogenic potential has been found. However, the longest study conducted was an 18-week inhalation study (19).

D. Mutagenic Potential

- Halon 1301 was tested in Salmonella typhimurium strains TA 1535, TA 1537, TA 1538, TA 98 and TA 100 at levels up to 40%. The gas was not mutagenic either in the presence or absence of a liver microsomal system (40).

E. Embryotoxic Potential

- Groups of 27 pregnant rats were exposed 6 hours a day on days 6-15 of gestation to 962 ± 57, 10,196 ± 1514 or 49,505 ± 4753 ppm of Halon 1301. No compound-related clinical signs of toxicity or changes in behavior were noted. The outcome of pregnancy, measured by the number of implantation sites, resorptions and live fetuses, were not adversely affected by the exposure. Exposure did not affect embryonal development as measured by weight and crown-rump length of the fetuses. Three fetuses were found with malformations. All three were from dams exposed at the intermediate level, however, these effects were not considered compound-related. Under the conditions of this test, Halon 1301 was not embryotoxic or teratogenic (40).

F. Other Reproduction Studies

- None.

G. Aquatic

- None.

H. Human Exposure

- See Section A.2.b. for details of controlled inhalation experiments in human volunteers.

I. Epidemilogy

- No information available.

J. Metabolism

- See Related References 53-55.

K. Pyrolysis Studies

- Halon 1301 decomposes upon contact with flames or hot surfaces above 1000°F. While this action appears necessary for the product to function effectively as a fire extinguishing agent, it also results in the formation of several new compounds whose properties are considerably different from Halon 1301. The common decomposition products of Halon 1301 are: HF, HBr, Br_2, carbonyl halides, consisting of carbonyl fluoride (COF_2) and carbonyl bromide ($COBr_2$). The quantities of these materials in the post-extinguishment atmosphere depend upon several factors, such as the size of the fire, type of fuel, enclosure size, degree of ventilation, and rapidity of flame extinguishment. In practical fire tests, the predominant decomposition products are HF and HBr. Free bromine and carbonyl halides have not been detected in significant quantities and post-extinguishment atmospheres.

- ALC (15-minute exposure, rats) = 14,000 ppm (5).

- The toxicity of pyrolyzed Halon 1301 appears to be due to the HF formed. The 15-minute LC50 for HF is 2700 ppm. At the LC50 determined for pyrolyzed Halon 1301 (2300 ppm), 2480 ppm of HF is formed. (37)

- The passage of Halon 1301 through an Inconel tube heated to 482°C did not result in any detectable decomposition of the compound, nor did the exposure of the animals to the effluent material result in any deviation in the mortality rates seen with undecomposed material. When the tube is heated to 593°C, some decomposition of the compound and an increase in mortality was seen. The incidence of mortality was dependent on the Halon 1301 concentration. Mild degrees of pneumonities were found in all exposed species, except rats, which were exposed to 482°C fumes. Acute chemical pneumonitis and degeneration of the liver, kidneys and brain were found in all species exposed to fumes generated at temperatures greater than 482°C (8).

- Deaths as the result of inhalation of pyrolysis products of Halon 1301 characteristically resulted from pulmonary hemorrhage and edema. The 15-minute LC50 value for pyrolyzed Halon 1301 calculated from these experiments was 2300 ppm. The pathologic response and delayed death patterns are similar to those seen from HF (38).

- Groups of animals were exposed for 30 minutes to atmospheres containing the pyrolysis products of Halon 1301. None of the animals died after being exposed at concentrations up to 80% of 800°C pyrolysis products. Signs of toxicity included dyspnea and prostration. When exposed to vapor products at 1000°C, all of the animals were killed at concentrations greater than 1%. At 0.75% approximately 20% of the exposed rats and 90% of the mice were killed. At 0.5%, none of the rats and 50% of the mice died (4).

- When Halon 1301 is applied to ordinary fires such as gasoline or wood, the resulting decomposition products may include HF, HBr, carbonyl halides and in some cases free bromine in concentrations depending on the quantity used. When applied in quantities of 2.3 pounds in a 720 cubic foot room for durations of the order of 5 to 30 minutes Halon 1301 caused some injury to guinea pigs, but was not lethal (9).

- With the exception of initial excitement, no symptoms indicative of a toxic action were observed during exposure of 20 mice and 40 rats to 1.07% Halon 1301 in air for 15 minutes. Very few deaths occurred during gasoline fires, however, the trachea and lungs were found to be congested (39).

REFERENCES

1. "ACGIH TLV® Booklet" (1981).
2. Code of Federal Regulations, Title 29 Section 1910.1000.
3. Du Pont Bulletin B-29D, "Du Pont Halon 1301 Fire Extinguishment" (1977) (C-1205).
4. Paulet, G., Arch. Mal. Prof., 23, 341-347 (1962) (J-2142).
5. Comstock, C. C. et al., Army Chemical Center, Report No. 23 (1950) (J-31).
6. Unpublished Data, Hazleton Laboratories, Reported by McHale, E. T., Atlantic Research Corporation, U. S. Army Res. Office Contract DAHC 19-71-C-0026 (J-1638).
7. Unpublished Data, ICI Ltd. (1954) (J-102).
8. Treon, J. F. et al., Unpublished Data, Kettering Laboratory (1957) (J-1868).
9. Dufour, R. E., Underwriters' Laboratories, Inc., Report NC 445 (J-1493).
10. Caujolle, F., Bull. Ins., Ind du Froid, 21 (1964) (J-1683).
11. Engibous, D. L. and T. R. Torkelson, Dow Chemical Company. Data reported in U.S.N.T.I.S. Report PB 161942.
12. Carter, V. L. Jr., et al., Tox. Appl. Pharmacol., 17(3), 648-655 (1970).
13. Clark, D. G., Unpublished Data, ICI Ltd. (1970) (J-4064).
14. Hine, C. H. et al., Proc. 4th Ann. Conf. Atmospheric Cont. Conf. Spaces, AMRL-TR-68-175, 127-144 (1968) (J-2418).
15. Call, D. W., Aerosp. Med., 44, 202-204 (1973) (J-2409).
16. Smith, D. G. and D. J. Harris, Ibid., 198-201 (J-2408).
17. Scholz, J. and W. Weigand, Z. Arbeitsmed. Arbeitsschutz, 14(6), 129-131 (1964) (CA 62:2166h). (J-2439).
18. Griffin, T. B. et al., Appr. Halogenated Fire Ext. Agents, Proc. Symp., 136-147 (1972) (J-2383).

REFERENCES (Cont'd.)

19. Comstock, C. C. et al., U. S. Army Chemical Corps, Med. Div. Report No. 5030-180 (1953) (J-476).

20. Van Stee, E. W. and K. C. Back, Aerosp. Res. Lab., Wright-Patterson Air Force Base, AMRL-TR-70-139 (1970) (CA 75:74289).

21. Van Stee, E. W. and K. C. Back, Tox. Appl. Pharmacol., 15, 164-174 (1969).

22. Call, D. W., Appr. Halogenated Fire Ext. Agents, Proc. Symp., 127-135 (1972) (J-2383).

23. Clark, D. G. and D. J. Tinston, Brit. J. Pharmacol., 49(2), 355-357 (1973).

24. Wills, J. H. et al., Tox. Appl. Pharmacol., 22, 305-306 (1972).

25. Van Stee, E. W. and K. C. Back, Aerospace Med. Res. Lab., AMRL-TR-68-188 (J-2370).

26. Rhoden, R. A. and K. L. Gabriel, Tox. Appl. Pharmacol., 25, 469 (1973).

27. Van Stee, E. W. et al., Proc. Annu. Conf. Environ. Toxicol., 5th, AMRL-TR-74-125, 155-167 (1974) (J-2836).

28. Back, K. C. and E. W. Van Stee, Tox. Appl. Pharmacol., 25, 469 (1973).

29. Van Stee, E. W. et al., Proc. 4th Ann. Conf. Atmos. Cont. Conf. Spaces, AMRL-TR-68-175, 113-126 (1968).

30. Van Stee, E. W. and K. C. Back, Tox. Appl. Pharmacol., 23(3), 428-442 (1972).

31. Van Stee, E. W. et al., Ibid., 26(4), 549-558 (1973).

32. Van Stee, E. W. and K. C. Back, Aerosp. Med. Res. Lab, Wright-Patterson Air Force Base, AMRL-TDR-68-182 (1971) (J-2369).

33. Van Stee, E. W. et al., Tox. Appl. Pharmacol., 34(1), 62-71 (1975).

34. Van Stee, E. W. et al., Proc. Annu. Conf. Environ. Toxicol., 4th, 65-83 (1973) (J-5247).

REFERENCES (Cont'd.)

35. Greenbaum, L. J. et al., Tox. Appl. Pharmacol., 21, 1-11 (1972).

36. Van Stee, E. W. et al., Ibid., 16(3), 779-785 (1970).

37. Huan, C. C. et al., Amer. Ind. Hyg. Assoc. J., 30, 551-558 (1969).

38. MacEwen, J. D., Appr. Halog. Fire Ext. Agents, Proc. Symp., 53-59 (1972) (J-2383).

39. Comstock, C. C. and F. W. Oberst, Arch. Ind. Hyg. Occup. Med., 7, 157-167 (1953).

40. Unpublished Haskell Laboratory Data

41. Mullin, L. S. et al., Amer. Ind. Hyg. Assoc., J., 40, 653-658 (1979) (CA 91:118115).

42. Trochimowicz, H. J., et al., J. Occ. Med., 18, 26-30 (1976).

43. Terpolilli, R. N. et al., Tox. Appl. Pharmacol., 48, A22 (1979).

44. Code of Federal Regulations, Title 49, Section 172.101.

RELATED REFERENCES

Inhalation

45. Dimov, D., Arh. Hig. Rada Toksikol., 23(2), 153-5 (1972) (CA 79:944).

"Toxicology of bromotrifluoromethane"

46. Back, K. C. and E. W. Van Stee, Wright-Patterson Air Force Base, AGARD Rep. R-599 (CA 78:132355) (J-5248).

"Cardiovascular and nervous system effects of bromotrifluoromethane" A review.

47. Van Stee, E. W., Wright-Patterson AFB, U.S.N.T.I.S. Report No. AD-A011538 (1974) (CA 84:26504).

"Review of the toxicology of halogenated fire extinguishing agents"

48. Toy, P. A. et al., Tox. Appl. Pharmacol., 38(1), 7-17 (1976).

"The effects of three halogenated alkanes on excitation and contraction in the isolated, perfused rabbit heart"

49. Kappus, H., et al., Funct. Glutathione Liver Kidney, [Pap. Konf. Ges. Biol. Chem], 25th, 176-182 (1978) (CA 91:118086).

"Lipid peroxidation induced by ethanol and halogenated hydrocarbons *in vivo* as measured by ethane exhalation"

50. Karpov, B. D., Tr. Leningr. Sanit.-Gig. Med. Inst., 111, 10-14 (1975) (CA 89:79501).

"Materials for the toxicology of some bromofluorohydrocarbons of the methane and ethane series"

51. Back, K. C. and E. W. Van Stee, Int. Encycl. Pharmacol. Ther., Section 102 (Pharmacol. Methods Toxicol.), 103-113 (1979) (CA 92:70440) (J-).

"Various techniques for evaluating cardiodynamic function using chronically instrumented canine models"

RELATED REFERENCES (Cont'd.)

Industrial Hygiene

52. Bales, R. E., NIOSH Pub. No. 79-101 (1978) (CA 90:209347) (J-).

"Fluorocarbons. An industrial hygiene survey of worker exposure in four facilities"

Metabolism/Biochemical

53. Wolf, C. R. et al., Mol. Pharmacol., 13(4), 698-705 (1977) (CA 87:63685).

"The reduction of polyhalogenated methanes by liver microsomal cytochrome P450"

54. Van Stee, E. W. et al., Wright-Patterson AFB, U.S.N.T.I.S. Report AD-751428 (1971) (CA 78:132421).

"Halogenated hydrocarbons and drug metabolism. Effect of fluorocarbons on hexobarbitol sleeping and zoxazolamine paralysis times in mice"

55. Young, W. and J. A. Parker, Combust. Toxicol., 2(4), 286-97 (1975) (CA 84:100431).

"Effect of fluorocarbon on acetylcholinesterase activity and some counter measures"

Richard C. Graham:md
March 6, 1978

Updated:
Richard C. Graham:jrg
November 18, 1981

R.C. Graham

THIS REPORT HAS BEEN MADE AVAILABLE TO YOU FREE OF CHARGE AND AT YOUR REQUEST. WE BELIEVE THE INFORMATION CONTAINED HEREIN IS RELIABLE. HOWEVER, WE MAKE NO WARRANTY, EXPRESSED OR IMPLIED, AND ASSUME NO LIABILITY IN CONNECTION WITH ANY USE OF THIS INFORMATION.