# KIRBY INLAND MARINE

## CARGO TRANSFER PROCEDURES FOR THE BARGE

## KIRBY 14803

***PLEASE NOTE:***

FOR PROPER VALVE ALIGNMENT AND SAFE CARGO TRANSFER GUIDANCE, PLEASE REFER TO KIRBY MARINE TRANSPORTATION'S CARGO HANDLING PROCEDURE MANUAL AND FOLLOW THE KIRBY TRANSFER PLAN.

IF YOU NEED A COPY OF THE PROCEDURE MANUAL, PLEASE CALL THE KIRBY DUTY LINE (713) 435-1618 OR (713) 435-1925 BEFORE CARGO OPERATION.

# TABLE OF CONTENTS

# SECTION 155.750 (a)(1):

# CHEMICAL INFORMATION

This section complies with 33 CFR 155.750 (a) with regard to the chemical information provided for the following liquefied gases:

BUTADIENE

BUTANE

ISOBUTANE

BUTYLENE (Butene)

BUTAYLENE MIXTURES

ISOBUTYLENE

The information in the following pages for each cargo is represented jointly in the following manner:

1. Data sheet from CHRIS Manual and Chemical Data Guide (CDG)
2. Descriptions of chemical form the Matheson Gas Data Book.
3. Tables of vapor pressure and temperature data from Matheson Gas Data Book.
4. Graph of vapor pressure vs. temperature from Matheson Gas Data Book.

The information in these procedures will assist the PIC in determining chemical properties for personal protection, response, etc. as well as to provide needed guidance on pressure/temperature relationships and load limits.

The Material Safety Data Sheet (MSDS) is the most accurate source of information for the particular cargo involved in the transfer. For example, all generic sources in CHRIS, CDG, etc. will state that butadiene must be inhibited, but only the specific MSDS for the butadiene involved in the transfer will state whether or not it actually is inhibited. This is critical, and mistakes have been made in the past when the PIC does not check the MSDS for specifics.

Under the “Right to Know” laws, the PIC has a right to ask the terminal to view the MSDS. Do so!

# BUTADIENE

**Synonyms**—Biethylene; Bivinyl; 1,3-Butadiene; alpha, gamma-Butadiene; Divinyl; Erythrene; Pyrrolylene; Vinyl ethylene

**Formula**—$C_4H_6$, or $CH_2 = CHCH = CH_2$

**Appearance-Odor**—Colorless gas or liquid; mild, aromatic odor

**Specific Gravity**—0.62 at 20°C (a liquid)

**Chemical Family**—Unsaturated hydrocarbon

**Pollution Category**—USEPA _____ IMO gas

**Applicable Bulk Reg. 46 CFR Subchapter** ..... O

**United Nations Number** ..... 1010

**CHRIS Code** ..... BDI

| | | |
|---|---|---|
| **Boiling Point** | −4°C | 24°F |
| | °C | °F |
| **Freezing Point** | −109°C | −164°F |
| | °C | °F |
| **Vapor Pressure 20°C (68°F) (mmHg)** | | 1799 |
| **Reid Vapor Pressure (psia)** | | 61 |
| **Vapor Pressure 46°C (115°F) (psia)** | | 75 |
| **Vapor Density (Air = 1.0)** | | 1.88 |
| **Solubility in Water** | | Negligible |

## FIRE & EXPLOSION HAZARD DATA

**Grade**—Liquefied Flammable Gas (LFG)
**Electrical Group**—B

**General**—Unless flow of gas can be stopped, extinguishing a butadiene fire may permit accumulation of an explosive concentration of vapor, and subsequent explosion or re-flash. Fire may cause violent rupture of tank.

**Flash Point (°F)** ..... −105
**Flammable Limits** ..... 2.0 to 11.5%
**Autoignition Temp. (°F)** ..... 842
**Extinguishing Agents** ..... Stop flow of gas; $CO_2$, dry chemical, water fog
**Special Fire Procedures** ..... Keep burning tank and adjacent tanks cool with a water spray. Wear full protective clothing and self-contained breathing apparatus.

## HEALTH HAZARD DATA

| Health Hazard Ratings | Odor Threshold (ppm) | PEL/TWA (ppm) | TLV/TWA (ppm) |
|---|---|---|---|
| 1,1,1 | above 1000 | unavailable | 1000 |

**General**—Suspected carcinogen. Liquid or cold gas may cause skin or eye injury similar to frostbite.

**Symptoms**—Inhalation: dizziness, headache. Skin contact: frostbitten areas will appear white. Irritating to eyes and respiratory tract.

**Short Exposure Tolerance**—8,000 ppm was found endurable for 8 hours with only slight irritation of the eyes and upper respiratory tract.

**Exposure Procedures**—Vapor—remove victim to fresh air; if breathing stops, apply artificial respiration. Skin or eye contact—remove contaminated clothing and gently flush affected areas with water for 15 minutes. Protect frostbitten areas from abrasions and mechanical damage. DO NOT RUB. Get medical advice or attention.

## REACTIVITY DATA

**Stability**—Must be inhibited to prevent polymerization. Forms unstable peroxides in presence of oxygen and/or iron rust.

**Compatibility**—**Material:** Unsafe in contact with acetylide-forming materials such as monel, copper or copper alloys.

**Cargo:** Group 30 of compatibility chart.

## SPILL OR LEAK PROCEDURE

Wear rubber gloves, face shield, protective clothing, and self-contained breathing apparatus. Secure ignition sources. The spilled liquid will boil away leaving no residue.

**If a spill occurs, call the National Response Center, 800-424-8802.**

**Remarks:**

## Table 1. THERMODYNAMIC PROPERTIES OF SATURATED 1,3-BUTADIENE[2]

| Temp., °F. | Pressure p.s.i.a. | Specific Volume Liquid cu. ft./lb. | Specific Volume Vapor cu. ft./lb. | Enthalpy Liquid BTU/lb. | Enthalpy Vapor BTU/lb. | Latent Heat BTU/lb. | Entropy Liquid BTU/lb. °R. | Entropy Vapor BTU/lb. °R. | Temp., °F. |
|---|---|---|---|---|---|---|---|---|---|
| –164.05 | 0.010 | 0.02097 | 5706 | 122.6 | 341.8 | 219.2 | 0.5904 | 1.3317 | –164.05 |
| –160 | .013 | .02104 | 4504 | 124.4 | 342.7 | 218.3 | .5973 | 1.3256 | –160 |
| –140 | .045 | .02136 | 1406 | 133.5 | 347.3 | 213.8 | .6267 | 1.2953 | –140 |
| –120 | .130 | .02170 | 516.5 | 142.7 | 352.0 | 209.3 | .6546 | 1.2707 | –120 |
| –100 | .329 | .02205 | 216.7 | 151.9 | 356.9 | 205.0 | .6810 | 1.2509 | –100 |
| –90 | .500 | .02224 | 146.4 | 156.6 | 359.5 | 202.9 | .6938 | 1.2425 | –90 |
| –80 | .740 | .02242 | 101.44 | 161.3 | 362.0 | 200.7 | .7062 | 1.2350 | –80 |
| –70 | 1.071 | .02261 | 71.88 | 166.0 | 364.7 | 198.7 | .7184 | 1.2283 | –70 |
| –60 | 1.076 | .02280 | 52.00 | 170.7 | 367.3 | 196.6 | .7304 | 1.2223 | –60 |
| –50 | 2.103 | .02300 | 38.33 | 175.5 | 370.0 | 194.5 | .7422 | 1.2170 | –50 |
| –40 | 2.867 | .02320 | 28.75 | 180.3 | 372.7 | 192.4 | .7538 | 1.2123 | –40 |
| –30 | 3.841 | .02341 | 21.91 | 185.1 | 375.5 | 190.4 | .7652 | 1.2081 | –30 |
| –20 | 5.068 | .02362 | 16.94 | 190.0 | 378.2 | 188.2 | .7764 | 1.2045 | –20 |
| –10 | 6.592 | .02384 | 13.27 | 194.9 | 381.0 | 186.1 | .7875 | 1.2013 | –10 |
| 0 | 8.461 | .02406 | 10.525 | 199.9 | 383.9 | 184.0 | .7984 | 1.1985 | 0 |
| 10 | 10.728 | .02429 | 8.441 | 205.0 | 386.7 | 181.7 | .8092 | 1.1962 | 10 |
| 20 | 13.45 | .02453 | 6.840 | 210.1 | 389.6 | 179.5 | .8199 | 1.1942 | 20 |
| 30 | 16.68 | .02478 | 5.595 | 215.2 | 392.4 | 177.2 | .8305 | 1.1925 | 30 |
| 40 | 20.49 | .02503 | 4.617 | 220.4 | 395.3 | 174.9 | .8410 | 1.1910 | 40 |
| 50 | 24.94 | .02529 | 3.840 | 225.7 | 398.2 | 172.5 | .8514 | 1.1899 | 50 |
| 60 | 30.11 | .02557 | 3.218 | 231.0 | 401.1 | 170.1 | .8617 | 1.1890 | 60 |
| 70 | 36.05 | .02585 | 2.715 | 236.4 | 404.0 | 167.6 | .8719 | 1.1883 | 70 |
| 80 | 42.84 | .02614 | 2.305 | 241.9 | 406.8 | 164.9 | .8821 | 1.1878 | 80 |
| 90 | 50.57 | .02645 | 1.968 | 247.4 | 409.7 | 162.3 | .8922 | 1.1874 | 90 |
| 100 | 59.30 | .02678 | 1.689 | 253.0 | 412.5 | 159.5 | .9023 | 1.1872 | 100 |
| 120 | 80.11 | .02747 | 1.262 | 264.6 | 418.2 | 153.6 | .9223 | 1.1873 | 120 |
| 140 | 105.93 | .02823 | 0.9576 | 276.4 | 423.6 | 147.2 | .9422 | 1.1877 | 140 |
| 160 | 137.4 | .02909 | .7362 | 288.6 | 428.9 | 140.3 | .9620 | 1.1883 | 160 |
| 180 | 175.4 | .03007 | .5715 | 301.3 | 433.9 | 132.6 | .9817 | 1.1891 | 180 |
| 200 | 220.5 | .03121 | .4465 | 315 | 439.0 | 124.0 | 1.001 | 1.190 | 200 |

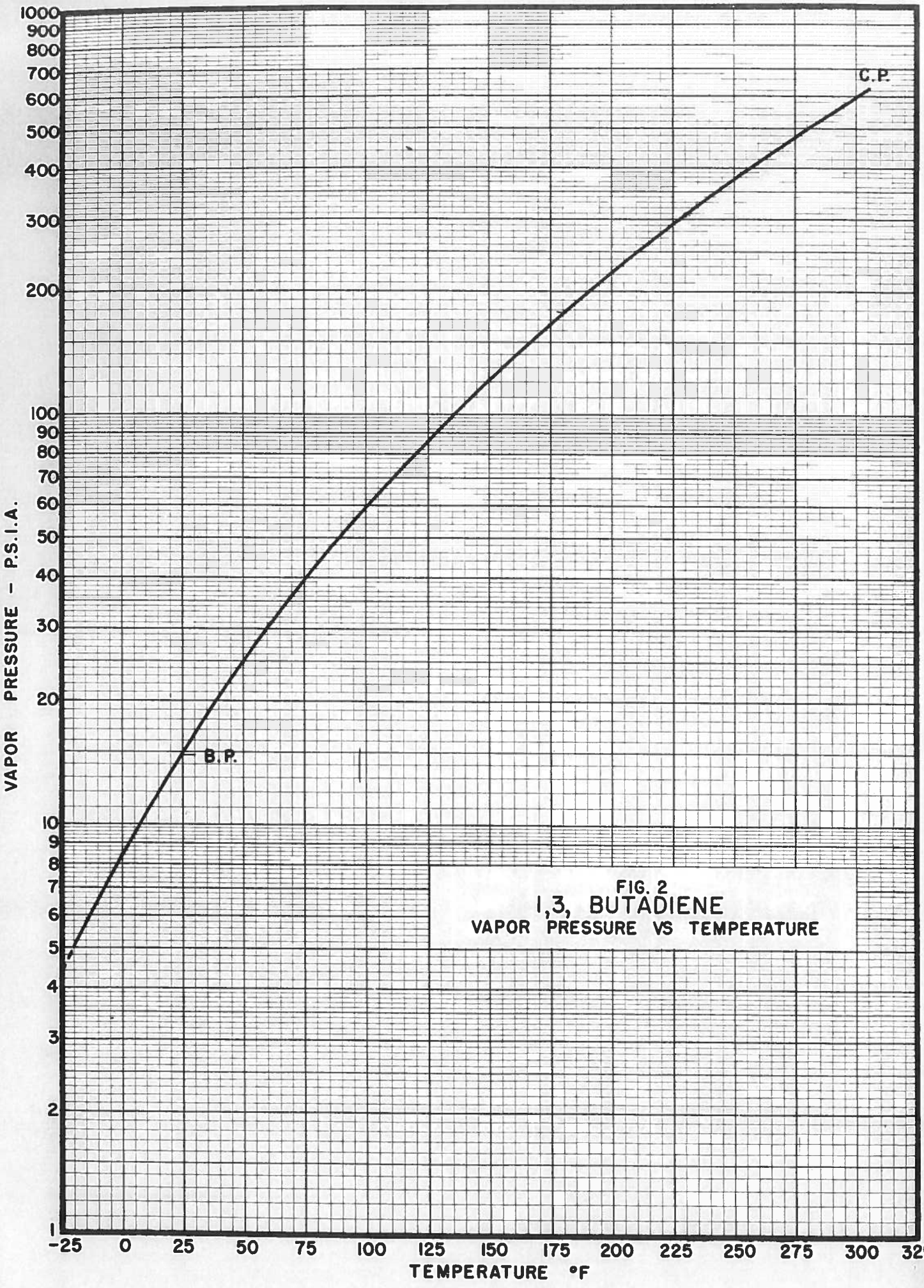



FIG. 2
1,3, BUTADIENE
VAPOR PRESSURE VS TEMPERATURE

# n-BUTANE

**Synonyms**—Butane; Diethyl; Methylethylmethane

**Formula**—$C_4H_{10}$

**Appearance-Odor**—Colorless; odorless gas

**Specific Gravity**—0.58 at 0°C (a liquid)

**Chemical Family**—Saturated hydrocarbon

**Pollution Category**—USEPA _____ IMO gas

**Applicable Bulk Reg. 46 CFR Subchapter** D, O

**United Nations Number** 1011

**CHRIS Code** BUT

"(iso-, n-)" BMX

| | | |
|---|---|---|
| **Boiling Point** | −0.5°C | 31°F |
| | °C | °F |
| **Freezing Point** | −138°C | −217°F |
| | °C | °F |
| **Vapor Pressure 20°C (68°F) (mmHg)** | 1530 | |
| **Reid Vapor Pressure (psia)** | 52.4 | |
| **Vapor Pressure 46°C (115°F) (psia)** | 66.0 | |
| **Vapor Density (Air = 1.0)** | 2.07 | |
| **Solubility in Water** | Insoluble | |

## FIRE & EXPLOSION HAZARD DATA

**Grade**—Liquefied Flammable Gas (LFG)
**Electrical Group**—D

**General**—Unless the flow of gas can be stopped, extinguishing a butane fire will permit accumulation of an explosive concentration of vapor, and subsequent explosion or re-flash.

**Flash Point (°F)** ..... −76
**Flammable Limits** ..... 1.9 to 8.5%
**Autoignition Temp. (°F)** ..... 761
**Extinguishing Agents** ..... Stop flow of gas; $CO_2$, dry chemical, water fog.
**Special Fire Procedures** ..... Keep burning tank and adjacent tanks cool with a water spray. Stop flow of gas.

## HEALTH HAZARD DATA

| Health Hazard Ratings | Odor Threshold (ppm) | PEL/TWA (ppm) | TLV/TWA (ppm) |
|---|---|---|---|
| 0, 0, 0 | 5000 | 800 | 800 |

**General**—Produces drowsiness. Simple asphyxiant. Liquid or cold gas may cause frostbite.

**Symptoms**—Dizziness and drowsiness.

**Short Exposure Tolerance**—10,000 ppm (1%) for 10 minutes will cause drowsiness.

**Exposure Procedures**—Remove victim to fresh air. If breathing has stopped, give artificial respiration. If the liquid has spilled onto the skin, points of contact may be frostbitten; handle gently and protect from mechanical damage. DO NOT RUB. Get medical attention.

## REACTIVITY DATA

**Stability**—Stable product.

**Compatibility—Material:** Non-corrosive to most materials of construction.

**Cargo:** Group 31 of compatibility chart.

## SPILL OR LEAK PROCEDURE

Wear rubber gloves, face shield, protective clothing. Have all-purpose canister mask available. Secure ignition sources. The spilled liquid will boil away rapidly, leaving no residue.

**If a spill occurs, call the National Response Center, 800-424-8802.**

**Remarks:**

**REFERENCES**

[1]Sage, Webster and Lacey, *Ind. Eng. Chem., 29,* 1188 (1937).

[2]Rodd, E. H., Editor, *Chemistry of Carbon Compounds,* Elsevier Publishing Co., New York, N. Y., 1951, *IA,* pp. 230-248.

[3]Lipkin, M. R., Davidson, J. A., and Kurtz, S. S., Jr., Ind. Eng. Chem. *34,* 978 (1942).

**FURTHER DATA REFERENCES**

Beattie, J., Stockmayer, W., and Ingersoll, H., *The Compressibilities of Gaseous Mixtures of Methane and Normal Butane,* J. Chem. Phys. *9,* 871 (1941).

## Table 1. THERMODYNAMIC PROPERTIES OF SATURATED n-BUTANE[1]

| Temp. °F. | Pressure p.s.i.a. | Specific Volume Liquid cu.ft./lb. | Specific Volume Vapor cu.ft./lb. | Enthalpy Liquid BTU/lb. | Enthalpy Vapor BTU/lb. | Latent Heat BTU/lb. | Entropy Liquid BTU/lb. °R. | Entropy Vapor BTU/lb. °R. | Temp. °F. |
|---|---|---|---|---|---|---|---|---|---|
| 67.6 | 30 | 0.02747 | 3.027 | 4.20 | 163.88 | 159.68 | 0.0106 | 0.3108 | 67.6 |
| 84.3 | 40 | .02802 | 2.301 | 13.80 | 169.11 | 155.31 | .0284 | .3116 | 84.3 |
| 98.0 | 50 | .02850 | 1.8568 | 22.09 | 173.51 | 151.42 | .0407 | .3124 | 98.0 |
| 109.7 | 60 | .02891 | 1.5556 | 29.29 | 177.22 | 147.93 | .0527 | .3132 | 109.7 |
| 120.1 | 70 | .02926 | 1.3377 | 35.65 | 180.49 | 144.84 | .0639 | .3142 | 120.1 |
| 129.3 | 80 | .02960 | 1.1728 | 41.50 | 183.38 | 141.88 | .0741 | .3152 | 129.3 |
| 137.7 | 90 | .02993 | 1.0433 | 46.80 | 186.00 | 139.20 | .0834 | .3161 | 137.7 |
| 145.5 | 100 | .03025 | 0.9393 | 51.89 | 188.42 | 136.53 | .0919 | .3172 | 145.5 |
| 162.6 | 125 | .03104 | .7492 | 63.70 | 193.77 | 130.07 | .1105 | .3196 | 162.6 |
| 177.3 | 150 | .03183 | .6203 | 74.30 | 198.33 | 124.03 | .1267 | .3218 | 177.3 |
| 190.3 | 175 | .03264 | .5259 | 83.17 | 202.14 | 118.97 | .1408 | .3237 | 190.3 |
| 202.0 | 200 | .03342 | .4536 | 91.55 | 205.29 | 113.74 | .1534 | .3252 | 202.0 |
| 212.7 | 225 | .03422 | .3959 | 99.40 | 207.88 | 108.48 | .1646 | .3261 | 212.7 |
| 222.5 | 250 | .03497 | .3489 | 106.68 | 209.97 | 103.29 | .1755 | .3267 | 222.5 |
| 231.7 | 275 | .03580 | .3095 | 113.63 | 211.68 | 98.05 | .1856 | .3270 | 231.7 |
| 240.2 | 300 | .03671 | .2761 | 120.37 | 212.97 | 92.60 | .1950 | .3270 | 240.2 |

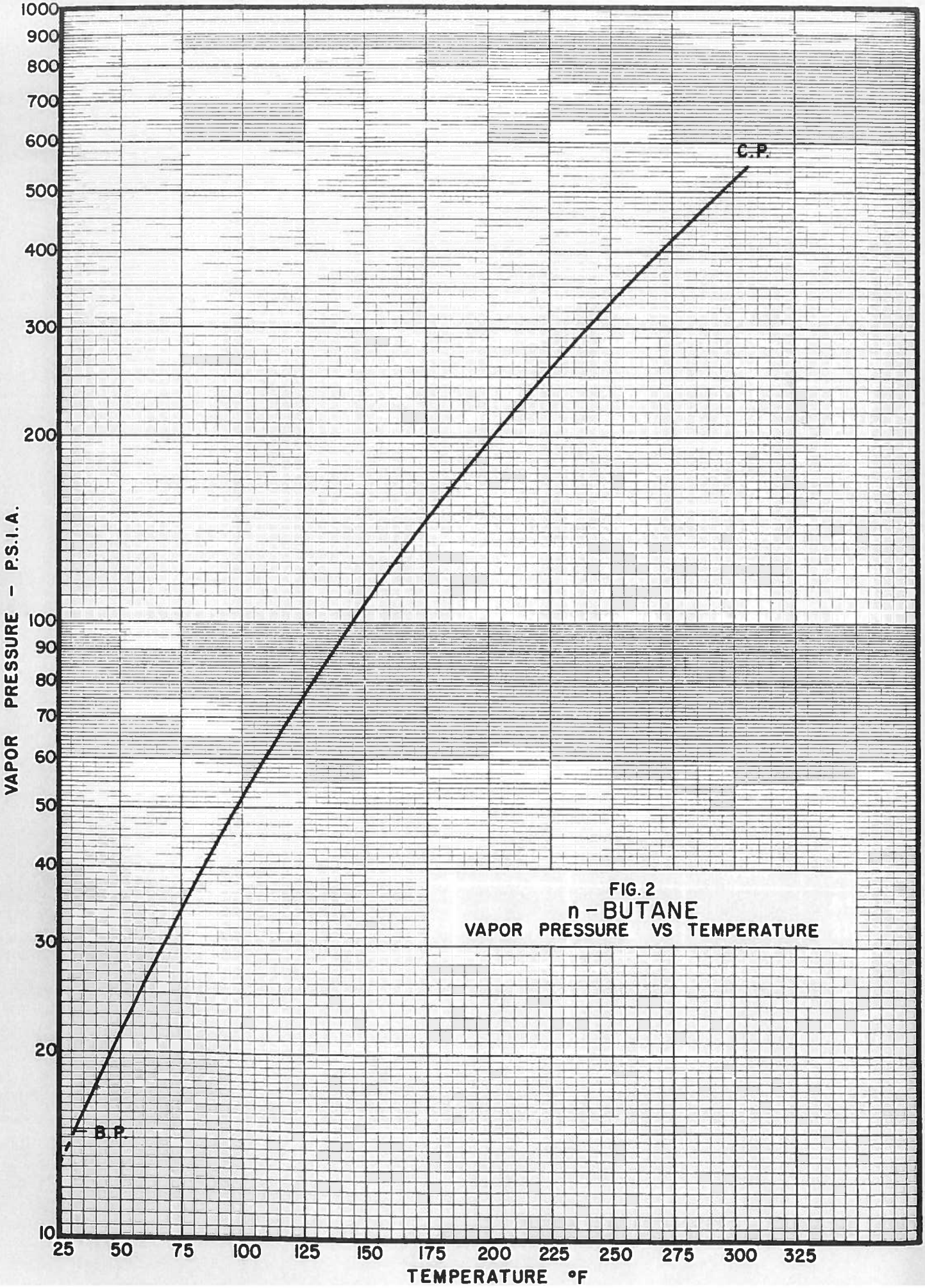



FIG. 2
n - BUTANE
VAPOR PRESSURE VS TEMPERATURE

## Table 1. THERMODYNAMIC PROPERTIES OF SATURATED ISOBUTANE[1]

| Temp. °F. | Pressure p.s.i.a. | Specific Volume Liquid cu. ft./lb. | Specific Volume Vapor cu. ft./lb. | Enthalpy Liquid BTU/lb. | Enthalpy Vapor BTU/lb. | Latent Heat BTU/lb. | Entropy Liquid BTU/lb. °R. | Entropy Vapor BTU/lb. °R. | Temp. °F. |
|---|---|---|---|---|---|---|---|---|---|
| 63.0 | 40 | 0.02838 | 2.210 | 1.64 | 146.4 | 144.76 | 0.0032 | 0.2803 | 63.0 |
| 76.5 | 50 | .02888 | 1.7813 | 9.30 | 151.11 | 141.81 | .0173 | .2818 | 76.5 |
| 88.1 | 60 | .02932 | 1.4904 | 16.01 | 154.82 | 138.81 | .02957 | .2831 | 88.1 |
| 98.2 | 70 | .02973 | 1.2796 | 21.96 | 157.97 | 136.01 | .0403 | .2841 | 98.2 |
| 107.3 | 80 | .03013 | 1.1198 | 27.34 | 160.81 | 133.47 | .0499 | .2852 | 107.3 |
| 115.5 | 90 | .03049 | 0.9947 | 32.37 | 163.33 | 130.96 | .0586 | .2862 | 115.5 |
| 123.8 | 100 | .03088 | .8949 | 37.57 | 165.73 | 128.16 | .0674 | .2871 | 123.8 |
| 139.8 | 125 | .03167 | .7103 | 47.89 | 170.44 | 122.55 | .0844 | .2889 | 139.8 |
| 154.2 | 150 | .03245 | .5864 | 57.36 | 174.49 | 117.13 | .0998 | .2906 | 154.2 |
| 167.0 | 175 | .03331 | .4979 | 66.06 | 178.03 | 111.97 | .1136 | .2923 | 167.0 |
| 178.3 | 200 | .03412 | .4305 | 73.94 | 181.0 | 107.06 | .1259 | .2938 | 178.3 |
| 188.7 | 225 | .03496 | .3769 | 81.42 | 183.8 | 102.38 | .1373 | .2951 | 188.7 |
| 198.3 | 250 | .03578 | .3327 | 88.51 | 185.8 | 97.29 | .1478 | .2957 | 198.3 |
| 207.3 | 275 | .03663 | .2954 | 95.26 | 187.3 | 92.04 | .1578 | .2959 | 207.3 |
| 215.6 | 300 | .03748 | .2633 | 101.7 | 188.7 | 87.0 | .1671 | .2959 | 215.6 |
| 223.5 | 325 | .03838 | .2325 | 108.0 | 189.6 | 81.6 | .1760 | .2954 | 223.5 |
| 231.0 | 350 | .03935 | .2110 | 114.1 | 189.6 | 75.5 | .1846 | .2941 | 231.0 |
| 238.1 | 375 | .04036 | .1888 | 120.1 | 189.5 | 69.4 | .1928 | .2920 | 238.1 |
| 244.9 | 400 | .04143 | .1686 | 126.1 | 189.7 | 63.6 | .2009 | .2897 | 244.9 |

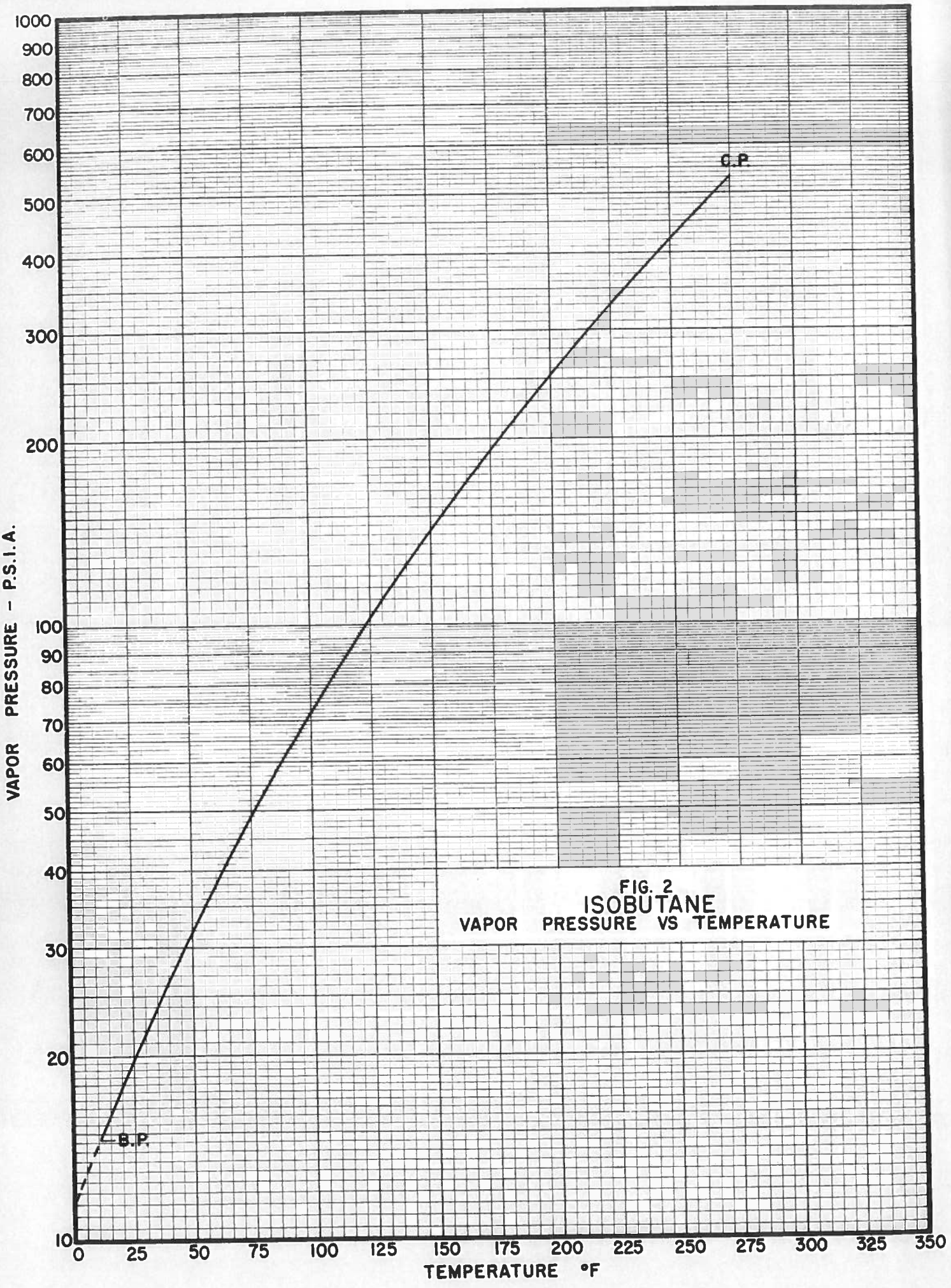



FIG. 2
ISOBUTANE
VAPOR PRESSURE VS TEMPERATURE

# BUTYLENE

**Synonyms**—Butene; 1-Butene; alpha-Butylene; Ethylethylene

**Formula**—$CH_2 = CHCH_2CH_3$

**Appearance-Odor**—Colorless gas; sweetish odor

**Specific Gravity**—0.60 at 20°C (a liquid)

**Chemical Family**—Olefin

**Pollution Category**—USEPA _____ IMO gas

**Applicable Bulk Reg. 46 CFR Subchapter** D, O

**United Nations Number** 1012

**CHRIS Code** BTN

| | | |
|---|---|---|
| **Boiling Point** | −6°C | 21°F |
| | °C | °F |
| **Freezing Point** | −185°C | −302°F |
| | °C | °F |
| **Vapor Pressure 20°C (68°F) (mmHg)** | 1030 | |
| **Reid Vapor Pressure (psia)** | 62.5 | |
| **Vapor Pressure 46°C (115°F) (psia)** | 76 | |
| **Vapor Density (Air = 1.0)** | 1.94 | |
| **Solubility in Water** | Insoluble | |

## FIRE & EXPLOSION HAZARD DATA

**Grade**—Liquefied Flammable Gas (LFG)
**Electrical Group**—D

**General**—Unless the flow of gas can be stopped, extinguishing a butene fire will permit accumulation of an explosive concentration of vapor, and subsequent explosion or re-flash.

| | |
|---|---|
| **Flash Point (°F)** | 110 (cc) |
| **Flammable Limits** | 1.6 to 9.3% |
| **Autoignition Temp. (°F)** | 723 |
| **Extinguishing Agents** | Stop flow of gas; $CO_2$, dry chemical, water fog. |
| **Special Fire Procedures** | Keep burning tank and adjacent tanks cool with a water spray. |

## HEALTH HAZARD DATA

| Health Hazard Ratings | Odor Threshold (ppm) | PEL/TWA (ppm) | TLV/TWA (ppm) |
|---|---|---|---|
| Unavailable | Unavailable | Unavailable | Unavailable |

**General**—May produce anesthetic effects on exposure to high vapor concentrations. Contact with liquid may produce a frostbite.

**Symptoms**—Breathing high concentrations of gas for some time may cause dizziness. Contact with liquid may cause skin and eye injury similar to frostbite.

**Short Exposure Tolerance**—Unavailable

**Exposure Procedures**—Remove to fresh air. If breathing has stopped, give artificial respiration. If the liquid has spilled onto the skin, points of contact may be frostbitten; handle gently and protect from mechanical damage. DO NOT RUB. Get medical attention.

## REACTIVITY DATA

**Stability**—Stable. Can react with oxidizing materials.

**Compatibility**—**Material:** Noncorrosive to most materials of construction.

**Cargo:** Group 30 of compatibility chart.

## SPILL OR LEAK PROCEDURE

Wear rubber gloves, face shield, protective clothing. Have all-purpose canister mask available. Secure ignition sources. The spilled liquid will boil away rapidly, leaving no residue.

**If a spill occurs, call the National Response Center, 800-424-8802.**

**Remarks:**

*Vapor Pressure*[1]

The vapor pressure of 1-butene up to 1 atm. is as follows:

| Temperature °C. | Pressure mm. Hg |
|---|---|
| –104.8 | 1 |
| –89.4 | 5 |
| –81.6 | 10 |
| –73.0 | 20 |
| –63.4 | 40 |
| –57.2 | 60 |
| –48.9 | 100 |
| –36.2 | 200 |
| –21.7 | 400 |
| –6.3 | 760 |

Vapor pressures above 1 atm. may be obtained from Table 1 on Thermodynamic Properties of Saturated 1-Butene or from the vapor pressure curve, Figure 2.


**REFERENCES**

[1]Perry, John H., Editor-in-Chief, *Chemical Engineers' Handbook, 3rd Edition*, McGraw-Hill Book Co., New York, N. Y., 1950 p. 154. Compiled from extended tables published by D. R. Stull in *Ind. Eng. Chem., 39*, 517 (1947).

[2]Weber, J., A.I.Ch.E. Journal *1*, 210 (1955).

**OTHER DATA**

Kilpatrick, J., and Pitzer, K., *Heat Content, Free Energy Function, Entropy, and Heat Capacity of Ethylene, Propylene, and the Four Butenes to 1500°K.*, Research Natl. Bur. Standards *37*, 163 (1946).

Wacker, P., Cheney, R., and Scott, R., *Heat Capacities of Gaseous Oxygen, Isobutane, and 1-Butene from –30 to 90°C.*, J. Research Natl. Bur. Standards *38*, 651 (1947).


## Table 1. THERMODYNAMIC PROPERTIES OF SATURATED 1-BUTENE[2]

| Temp., °F. | Pressure p.s.i.a. | Specific Volume Liquid cu. ft./lb. | Specific Volume Vapor cu. ft./lb. | Enthalpy Liquid BTU/lb. | Enthalpy Vapor BTU/lb. | Latent Heat BTU/lb. | Entropy Liquid BTU/lb.°R. | Entropy Vapor BTU/lb.°R. | Temp., °F. |
|---|---|---|---|---|---|---|---|---|---|
| 32 | 18.64 | 0.02588 | 4.79 | 0.0 | 166.1 | 166.1 | 0.0000 | 0.3378 | 32 |
| 40 | 21.91 | .02610 | 4.19 | 3.4 | 168.3 | 164.9 | .0068 | .3368 | 40 |
| 50 | 26.60 | .02638 | 3.52 | 8.4 | 171.4 | 163.0 | .0167 | .3365 | 50 |
| 60 | 32.0 | .02667 | 2.89 | 13.6 | 174.4 | 160.8 | .0268 | .3365 | 60 |
| 70 | 38.2 | .02698 | 2.41 | 19.2 | 177.5 | 158.3 | .0375 | .3365 | 70 |
| 80 | 45.2 | .02730 | 2.25 | 25.4 | 180.5 | 155.1 | .0491 | .3365 | 80 |
| 90 | 53.1 | .02770 | 1.76 | 31.2 | 183.7 | 152.5 | .0597 | .3371 | 90 |
| 100 | 62.5 | .02811 | 1.52 | 37.0 | 186.7 | 149.7 | .0702 | .3377 | 100 |
| 110 | 72.1 | .02852 | 1.33 | 42.9 | 189.6 | 146.7 | .0806 | .3381 | 110 |
| 120 | 83.5 | .02898 | 1.16 | 48.7 | 192.5 | 143.8 | .0907 | .3388 | 120 |
| 130 | 96.3 | .02943 | 1.01 | 54.4 | 195.2 | 140.8 | .1007 | .3395 | 130 |
| 140 | 110.2 | .02992 | 0.875 | 60.5 | 198.5 | 138.0 | .1107 | .3408 | 140 |
| 150 | 125.5 | .03042 | .768 | 66.6 | 201.5 | 134.9 | .1207 | .3420 | 150 |
| 160 | 142.4 | .03091 | .676 | 72.7 | 204.4 | 131.7 | .1307 | .3432 | 160 |
| 170 | 161.3 | .03145 | .595 | 79.0 | 207.5 | 128.5 | .1409 | .3450 | 170 |
| 180 | 182.0 | .03202 | .524 | 85.5 | 210.4 | 124.9 | .1511 | .3463 | 180 |
| 190 | 204.7 | .03261 | .463 | 92.2 | 213.1 | 120.9 | .1615 | .3476 | 190 |
| 200 | 228.6 | .03328 | .409 | 99.1 | 215.9 | 116.8 | .1721 | .3492 | 200 |
| 210 | 254.6 | .03399 | .364 | 106.4 | 218.6 | 112.2 | .1831 | .3506 | 210 |
| 220 | 282.8 | .03477 | .324 | 114.1 | 221.2 | 107.1 | .1944 | .3520 | 220 |
| 230 | 313.4 | .03567 | .286 | 122.0 | 223.4 | 101.4 | .2059 | .3529 | 230 |
| 240 | 346.4 | .03671 | .251 | 130.0 | 225.2 | 95.2 | .2174 | .3535 | 240 |
| 250 | 382.5 | .03800 | .219 | 138.4 | 226.7 | 88.3 | .2293 | .3537 | 250 |
| 260 | 421.3 | .03962 | .189 | 147.1 | 226.5 | 79.4 | .2415 | .3518 | 260 |
| 270 | 462.2 | .04180 | .161 | 158.5 | 226.4 | 67.9 | .2572 | .3503 | 270 |
| 280 | 505.0 | .04488 | .134 | 173.4 | 225.4 | 52.0 | .2748 | .3451 | 280 |

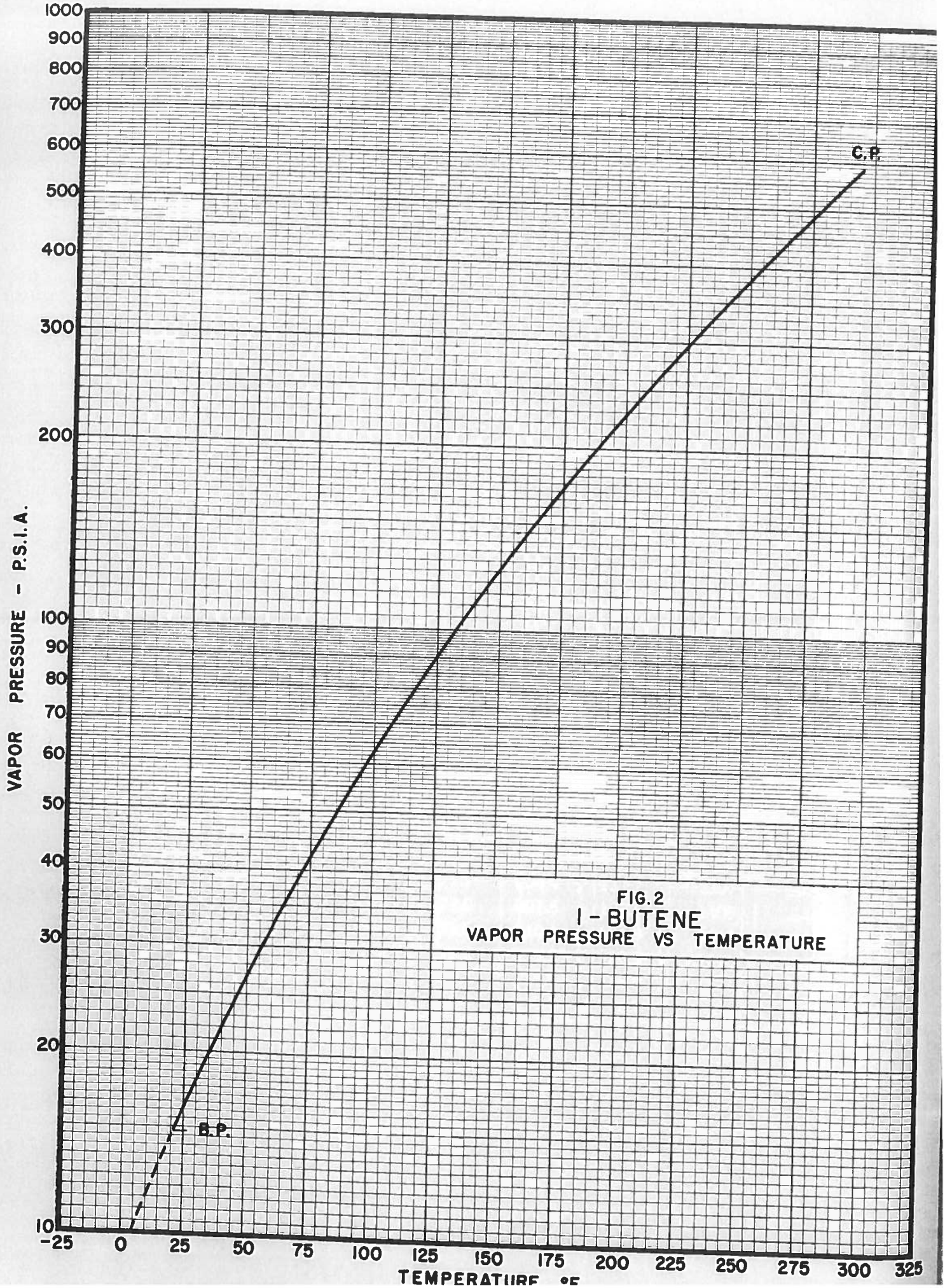



FIG. 2
I - BUTENE
VAPOR PRESSURE VS TEMPERATURE

# BUTYLENE MIXTURES*

**Synonyms**—No common synonyms.

**Formula**—$C_4H_8$

**Appearance-Odor**—Gas with gasoline-like odor.

**Specific Gravity**—Unavailable

**Chemical Family**—Olefins

**Pollution Category—USEPA** _____ **IMO** gas

**Applicable Bulk Reg. 46 CFR Subchapter** D, O

**United Nations Number** ‡

**CHRIS Code** ‡

| | | |
|---|---|---|
| **Boiling Point** | _____°C | _____°F |
| | _____°C | _____°F |
| **Freezing Point** | _____°C | _____°F |
| | _____°C | _____°F |

**Vapor Pressure 20°C (68°F) (mmHg)** _____
**Reid Vapor Pressure (psia)** _____
**Vapor Pressure 46°C (115°F) (psia)** _____
**Vapor Density (Air = 1.0)** 1.9
**Solubility in Water** Insoluble

## FIRE & EXPLOSION HAZARD DATA

**Grade**—A: Liquefied Flammable Gas (LFG)
**Electrical Group**—Unassigned

**General**—Unless the flow of gas can be stopped, extinguishing a fire will permit the accumulation of an explosive concentration of vapor, and subsequent explosion or re-flash.

**Flash Point (°F)** ..... −24 approximately
**Flammable Limits** ..... 1.0 to 10.0% (approx.)
**Autoignition Temp. (°F)** ..... 615 to 725 (approx.)
**Extinguishing Agents** ..... Stop flow of gas; $CO_2$, dry chemical, water spray
**Special Fire Procedures** ..... Use water to cool containers in order to reduce possibility of rupturing tank. Try to seal the gas leak. Use water spray to knock down water vapors. Flash back along vapor trail may occur.

## HEALTH HAZARD DATA

| Health Hazard Ratings | Odor Threshold (ppm) | PEL/TWA (ppm) | TLV/TWA (ppm) |
|---|---|---|---|
| 1, 4, 0 | Unavailable | Unavailable | Unavailable |

**General**—Essentially non-toxic at low concentrations. At higher concentrations, it can act as an anesthetic.

**Symptoms**—Causes dizziness and difficult breathing. Liquid will cause frostbite.

**Short Exposure Tolerance**—Unavailable

**Exposure Procedures**—Remove victim to fresh air. If breathing has stopped, administer artificial respiration. If breathing is difficult, give oxygen. If the liquid has spilled onto the skin, points of contact may be frostbitten; handle gently and protect from mechanical damage. DO NOT RUB. Get medical attention.

## REACTIVITY DATA

**Stability**—Will react with acids and alkyl halides.

**Compatibility**—**Material:** Usual materials of construction are suitable.

**Cargo:** Group 30 of compatibility chart.

## SPILL OR LEAK PROCEDURE

Wear rubber gloves, face shield and protective clothing. Have all purpose canister mask available. Keep concentration of leaking gas below explosive mixture range by ventilation. Secure ignition sources. Do not flush spill into confined spaces where flammable vapors can accumulate.

**If a spill occurs, call the National Response Center, 800-424-8802.**

**Remarks:** * Some data are undeterminable because this category considers mixture of butylenes.
‡ Unassigned

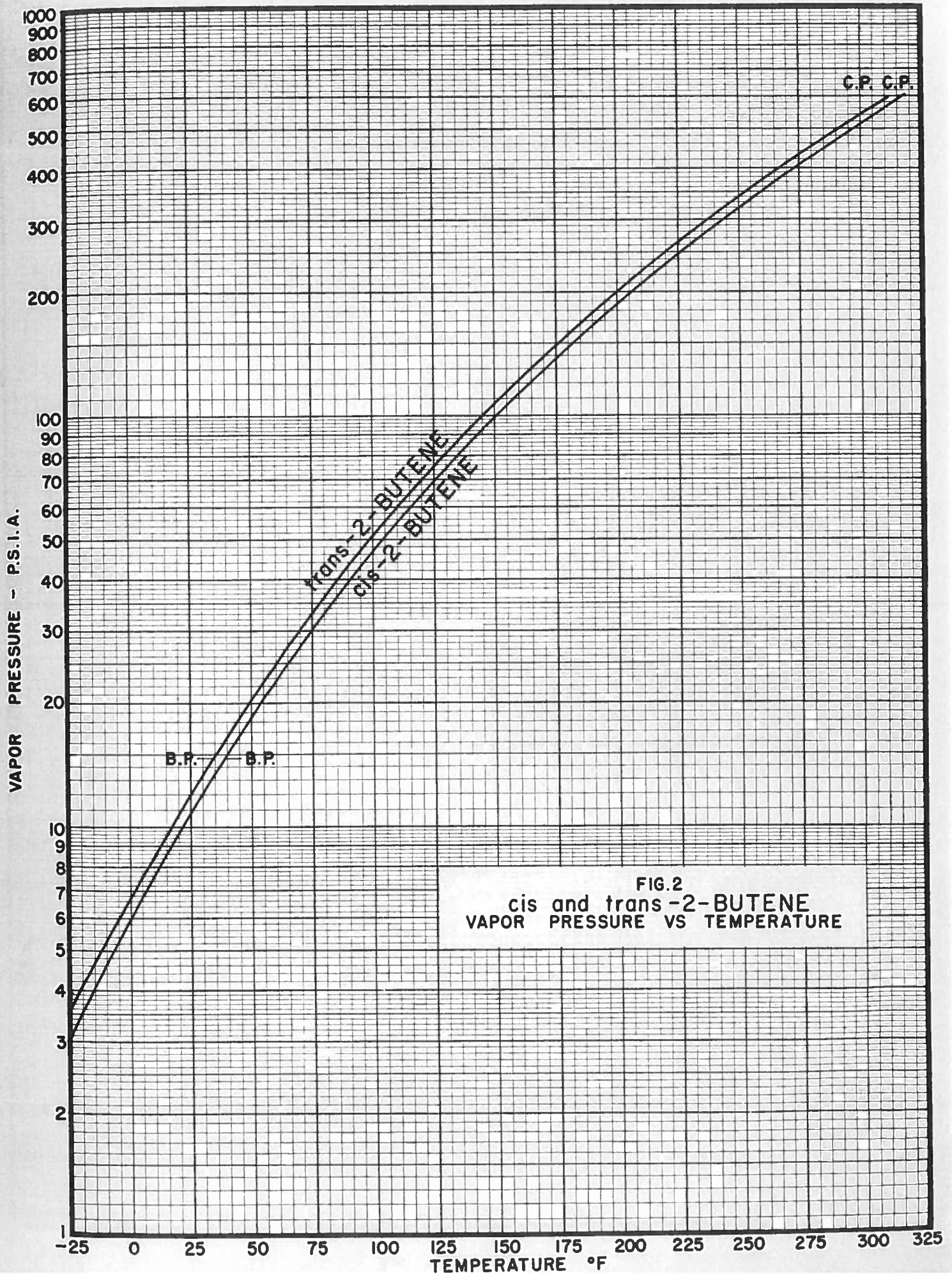



FIG.2
cis and trans-2-BUTENE
VAPOR PRESSURE VS TEMPERATURE

## Table 1. THERMODYNAMIC PROPERTIES OF SATURATED ISOBUTYLENE[1]

| Temp. °F. | Pressure P.S.I.A. | Specific Volume Liquid cu. ft./lb. | Specific Volume Vapor cu. ft./lb. | Enthalpy Liquid BTU/lb. | Enthalpy Vapor BTU/lb. | Latent Heat BTU/lb. | Entropy Liquid BTU/lb. °R. | Entropy Vapor BTU/lb. °R. |
|---|---|---|---|---|---|---|---|---|
| –20 | 5.68 | 0.02463 | 14.54 | 173.1 | 350.9 | 177.8 | 0.775 | 1.179 |
| –10 | 7.36 | .02486 | 11.46 | 178.2 | 354.0 | 175.8 | .791 | 1.182 |
| 0 | 9.40 | .02510 | 9.10 | 183.4 | 357.1 | 173.7 | .807 | 1.184 |
| 5 | 10.58 | .02522 | 7.32 | 186.0 | 358.6 | 172.6 | .815 | 1.186 |
| 10 | 11.88 | .02535 | 6.60 | 188.6 | 360.1 | 171.5 | .822 | 1.187 |
| 15 | 13.29 | .02547 | 5.96 | 191.2 | 361.7 | 170.5 | .829 | 1.188 |
| 20 | 14.83 | .02560 | 5.39 | 193.8 | 363.2 | 169.4 | .837 | 1.190 |
| 25 | 16.51 | .02573 | 4.39 | 196.4 | 364.8 | 168.4 | .844 | 1.191 |
| 30 | 18.33 | .02587 | 4.89 | 199.0 | 366.3 | 167.3 | .850 | 1.192 |
| 35 | 20.31 | .02600 | 4.45 | 201.6 | 367.9 | 166.3 | .857 | 1.193 |
| 40 | 22.43 | .02614 | 4.06 | 204.2 | 369.4 | 165.2 | .863 | 1.194 |
| 45 | 24.74 | .02628 | 3.70 | 206.9 | 370.9 | 164.0 | .870 | 1.195 |
| 50 | 27.22 | .02642 | 3.39 | 209.6 | 372.4 | 162.8 | .877 | 1.197 |
| 55 | 29.89 | .02657 | 3.10 | 212.3 | 373.9 | 161.6 | .884 | 1.198 |
| 60 | 32.74 | .02672 | 2.85 | 215.0 | 375.4 | 160.4 | .890 | 1.199 |
| 65 | 35.79 | .02687 | 2.62 | 217.7 | 376.9 | 159.2 | .897 | 1.200 |
| 70 | 39.05 | .02702 | 2.41 | 220.5 | 378.4 | 157.9 | .903 | 1.201 |
| 75 | 42.54 | .02718 | 2.22 | 223.3 | 379.9 | 156.6 | .909 | 1.202 |
| 80 | 46.25 | .02735 | 2.05 | 226.1 | 381.4 | 155.3 | .915 | 1.203 |
| 85 | 50.21 | .02751 | 1.90 | 228.9 | 382.9 | 154.0 | .921 | 1.204 |
| 90 | 54.42 | .02768 | 1.76 | 231.7 | 384.4 | 152.7 | .927 | 1.205 |
| 95 | 58.89 | .02785 | 1.63 | 234.5 | 385.9 | 151.4 | .933 | 1.206 |
| 100 | 63.64 | .02803 | 1.51 | 237.3 | 387.4 | 150.1 | .939 | 1.207 |
| 110 | 73.99 | .02840 | 1.30 | 243.1 | 390.4 | 147.3 | .950 | 1.208 |
| 120 | 85.58 | .02880 | 1.13 | 248.9 | 393.2 | 144.3 | .961 | 1.210 |
| 130 | 98.48 | .02921 | 0.980 | 255.0 | 396.0 | 141.0 | .972 | 1.211 |
| 140 | 112.8 | .02965 | .853 | 261.3 | 398.8 | 137.5 | .983 | 1.212 |
| 150 | 128.6 | .03011 | .744 | 267.8 | 401.4 | 133.6 | .994 | 1.213 |
| 170 | 165.1 | .03117 | .572 | 280.6 | 406.5 | 125.9 | 1.015 | 1.215 |
| 190 | 208.7 | .03245 | .444 | 293.7 | 411.2 | 117.5 | 1.034 | 1.215 |
| 210 | 260.1 | .03400 | .346 | 307.8 | 415.6 | 107.8 | 1.054 | 1.215 |
| 230 | 320.3 | .03587 | .268 | 323.0 | 419.4 | 96.4 | 1.074 | 1.214 |
| 250 | 390.4 | .0385 | .204 | 340.1 | 421.8 | 81.7 | 1.096 | 1.211 |
| 270 | 471.4 | .0430 | .145 | 358.9 | 420.2 | 61.3 | 1.123 | 1.207 |
| 292.5 | 580.2 | .0681 | .0681 | 404.6 | 404.6 | 0 | 1.188 | 1.188 |

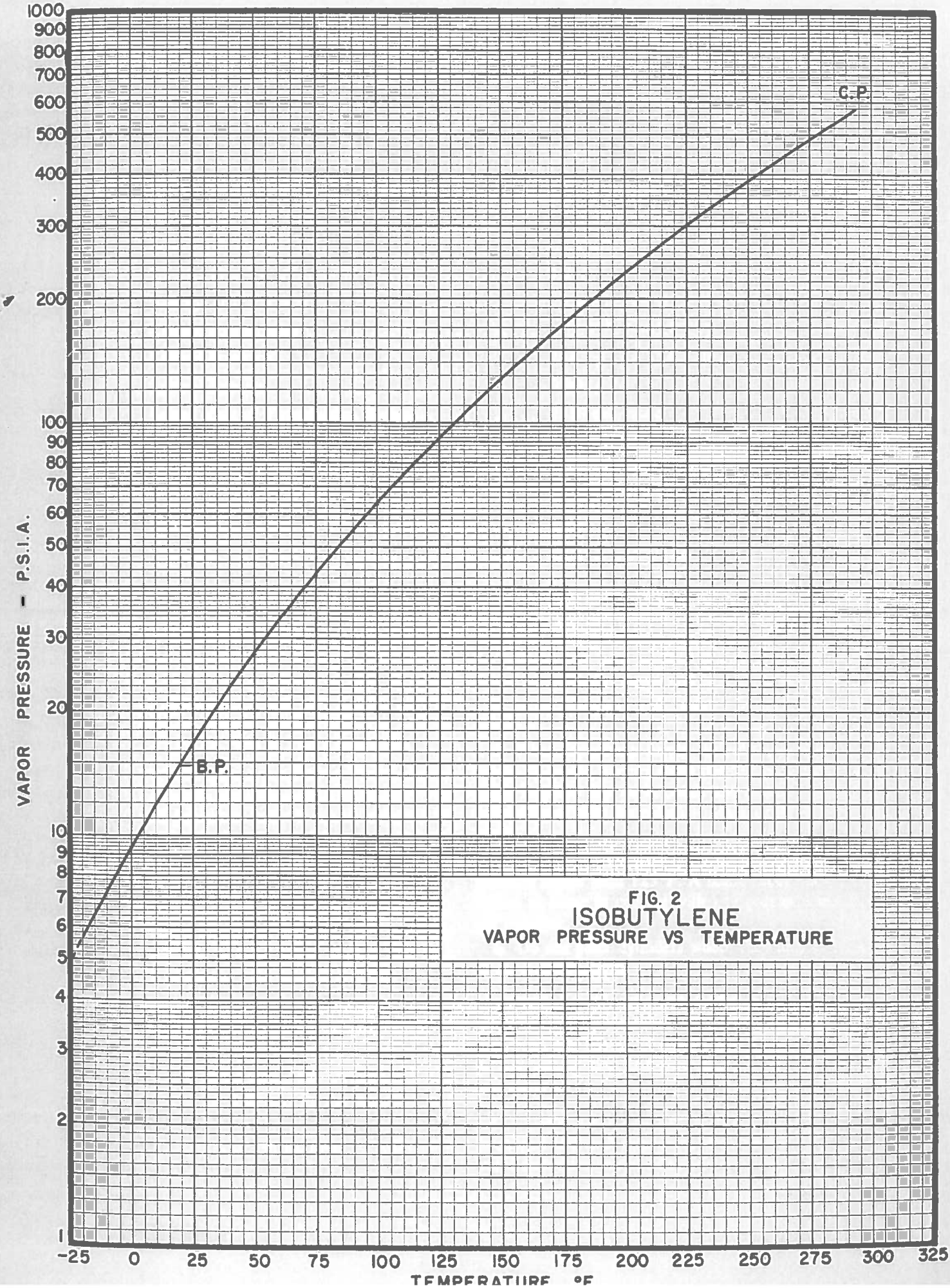



FIG. 2
ISOBUTYLENE
VAPOR PRESSURE VS TEMPERATURE

# PROPANE

**Synonyms**—Dimethylmethane; Propyl hydride

**Formula**—$C_3H_8$

**Appearance-Odor**—Colorless gas or liquid; natural-gas odor

**Specific Gravity**—0.53 (liquid)

**Chemical Family**—Saturated hydrocarbon

**Pollution Category—USEPA** _____ **IMO** gas

**Applicable Bulk Reg. 46 CFR Subchapter** D, O

**United Nations Number** 1978

**CHRIS Code** PRP

| | | |
|---|---|---|
| **Boiling Point** | −42°C | −44°F |
| | °C | °F |
| **Freezing Point** | −187°C | −305°F |
| | °C | °F |

**Vapor Pressure 20°C (68°F) (mmHg)** 6800
**Reid Vapor Pressure (psia)** 190
**Vapor Pressure 46°C (115°F) (psia)** 228
**Vapor Density (Air = 1.0)** 1.55
**Solubility in Water** Negligible

## FIRE & EXPLOSION HAZARD DATA

**Grade**—Liquefied Flammable Gas (LFG)
**Electrical Group**—D

**General**—Unless the flow of gas can be stopped, extinguishing a propane fire will permit the accumulation of an explosive concentration of vapor, and subsequent explosion or reflash.

**Flash Point (°F)** ..... less than −64
**Flammable Limits** ..... 2.2 to 9.5%
**Autoignition Temp. (°F)** ..... 842
**Extinguishing Agents** ..... Stop flow of gas; $CO_2$, dry chemical, water fog
**Special Fire Procedures** ..... Tanks exposed to fire should be kept cool with a continuous spray of water.

## HEALTH HAZARD DATA

| Health Hazard Ratings | Odor Threshold (ppm) | PEL/TWA (ppm) | TLV/TWA (ppm) |
|---|---|---|---|
| 0, 0, 0 | 5,000 to 20,000* | 1000 | Unavailable |

**General**—Liquid causes frostbite on skin contact. Cold vapor causes skin damage. Inhalation can lead to asphyxiation.

**Symptoms**—Headache, dizziness, drowsiness. Contact with the liquid will cause frostbite.

**Short Exposure Tolerance**—A vapor concentration of 10,000 ppm for brief periods has been reported as producing no symptoms.

**Exposure Procedures**—Remove victim to fresh air. Give artificial respiration if breathing stops. Get medical attention. If liquid has spilled onto the skin, points of contact may be frostbitten; handle gently and protect from mechanical damage. DO NOT RUB. Get medical attention. *NOTE: Exposure to potentially dangerous vapor concentrations can occur before the product can be detected by smell.

## REACTIVITY DATA

**Stability**—Stable

**Compatibility—Material:** Usual materials of construction are suitable.

**Cargo:** Group 31 of compatibility chart

## SPILL OR LEAK PROCEDURE

Wear rubber gloves, face shield, protective clothing. Have all-purpose canister mask available. Secure all possible sources of ignition and call the fire department. The spilled liquid will boil away rapidly, leaving no residue.

**If a spill occurs, call the National Response Center, 800-424-8802.**

**Remarks:**

## Table 1. THERMODYNAMIC PROPERTIES OF SATURATED PROPANE[1]

| Temp. °F. | Pressure p.s.i.a. | Specific Volume Liquid cu. ft./lb. | Specific Volume Vapor cu. ft./lb. | Enthalpy Liquid BTU/lb. | Enthalpy Vapor BTU/lb. | Latent Heat BTU/lb. | Entropy Liquid BTU/lb. °R. | Entropy Vapor BTU/lb. °R. | Temp. °F. |
|---|---|---|---|---|---|---|---|---|---|
| –80 | 5.65 | 0.0265 | 16.2 | 162.6 | 354.0 | 191.4 | 0.8794 | 1.3832 | –80 |
| –70 | 7.48 | .0268 | 12.5 | 167.6 | 357.0 | 189.4 | .8927 | 1.3781 | –70 |
| –60 | 9.78 | .02703 | 9.77 | 172.7 | 360.0 | 187.3 | .9060 | 1.3740 | –60 |
| –50 | 12.60 | .02733 | 7.73 | 177.8 | 362.8 | 185.0 | .9188 | 1.3702 | –50 |
| –40 | 16.00 | .02763 | 6.16 | 183.0 | 365.7 | 182.7 | .9315 | 1.3670 | –40 |
| –30 | 20.18 | .02794 | 5.02 | 188.4 | 368.6 | 180.2 | .9441 | 1.3640 | –30 |
| –20 | 25.05 | .02826 | 4.06 | 193.8 | 371.5 | 177.7 | .9568 | 1.3610 | –20 |
| –10 | 30.95 | .02859 | 3.33 | 199.4 | 374.4 | 175.0 | .9690 | 1.3582 | –10 |
| 0 | 37.81 | .02893 | 2.74 | 205.0 | 377.2 | 172.2 | .9812 | 1.3555 | 0 |
| 10 | 45.85 | .02930 | 2.30 | 210.7 | 380.0 | 169.3 | .9932 | 1.3531 | 10 |
| 20 | 55.00 | .02970 | 1.93 | 216.6 | 382.6 | 166.0 | 1.0050 | 1.3510 | 20 |
| 30 | 65.70 | .03011 | 1.60 | 222.3 | 385.1 | 162.8 | 1.0167 | 1.3491 | 30 |
| 40 | 77.80 | .03055 | 1.33 | 227.9 | 387.5 | 159.6 | 1.0283 | 1.3473 | 40 |
| 50 | 91.50 | .03101 | 1.14 | 233.8 | 389.9 | 156.1 | 1.0398 | 1.3456 | 50 |
| 60 | 106.9 | .03150 | 0.984 | 239.6 | 392.2 | 152.6 | 1.0511 | 1.3441 | 60 |
| 70 | 124.3 | .03209 | .854 | 245.7 | 394.4 | 148.7 | 1.0624 | 1.3427 | 70 |
| 80 | 143.6 | .03269 | .745 | 251.9 | 396.4 | 144.5 | 1.0737 | 1.3413 | 80 |
| 90 | 165.0 | .03329 | .643 | 258.2 | 398.3 | 140.1 | 1.0850 | 1.3400 | 90 |
| 100 | 188.7 | .03390 | .558 | 264.6 | 400.2 | 135.6 | 1.0963 | 1.3388 | 100 |
| 110 | 214.8 | .03452 | .487 | 271.1 | 401.9 | 130.8 | 1.1080 | 1.3378 | 110 |
| 120 | 243.4 | .03532 | .426 | 278.0 | 403.8 | 125.8 | 1.1195 | 1.3368 | 120 |
| 130 | 274.5 | .03612 | .370 | 285.2 | 405.4 | 120.2 | 1.1310 | 1.3356 | 130 |
| 140 | 308.4 | .03702 | .320 | 292.7 | 407.0 | 114.3 | 1.1430 | 1.3347 | 140 |
| 150 | 345.4 | .03817 | .278 | 300.2 | 408.2 | 108.0 | 1.1552 | 1.3326 | 150 |
| 160 | 385.0 | .03962 | .240 | 308.4 | 408.8 | 100.4 | 1.1680 | 1.3303 | 160 |
| 170 | 426.0 | .04132 | .208 | 317.5 | 408.6 | 91.1 | 1.1816 | 1.3272 | 170 |
| 180 | 473.2 | .04367 | .180 | 327.5 | 407.6 | 80.1 | 1.1970 | 1.3223 | 180 |
| 190 | 523.4 | .04712 | .149 | 339.2 | 404.6 | 65.4 | 1.2140 | 1.3156 | 190 |
| 200 | 575.0 | .0521 | .113 | 353.5 | 398.3 | 44.8 | 1.2360 | 1.3040 | 200 |

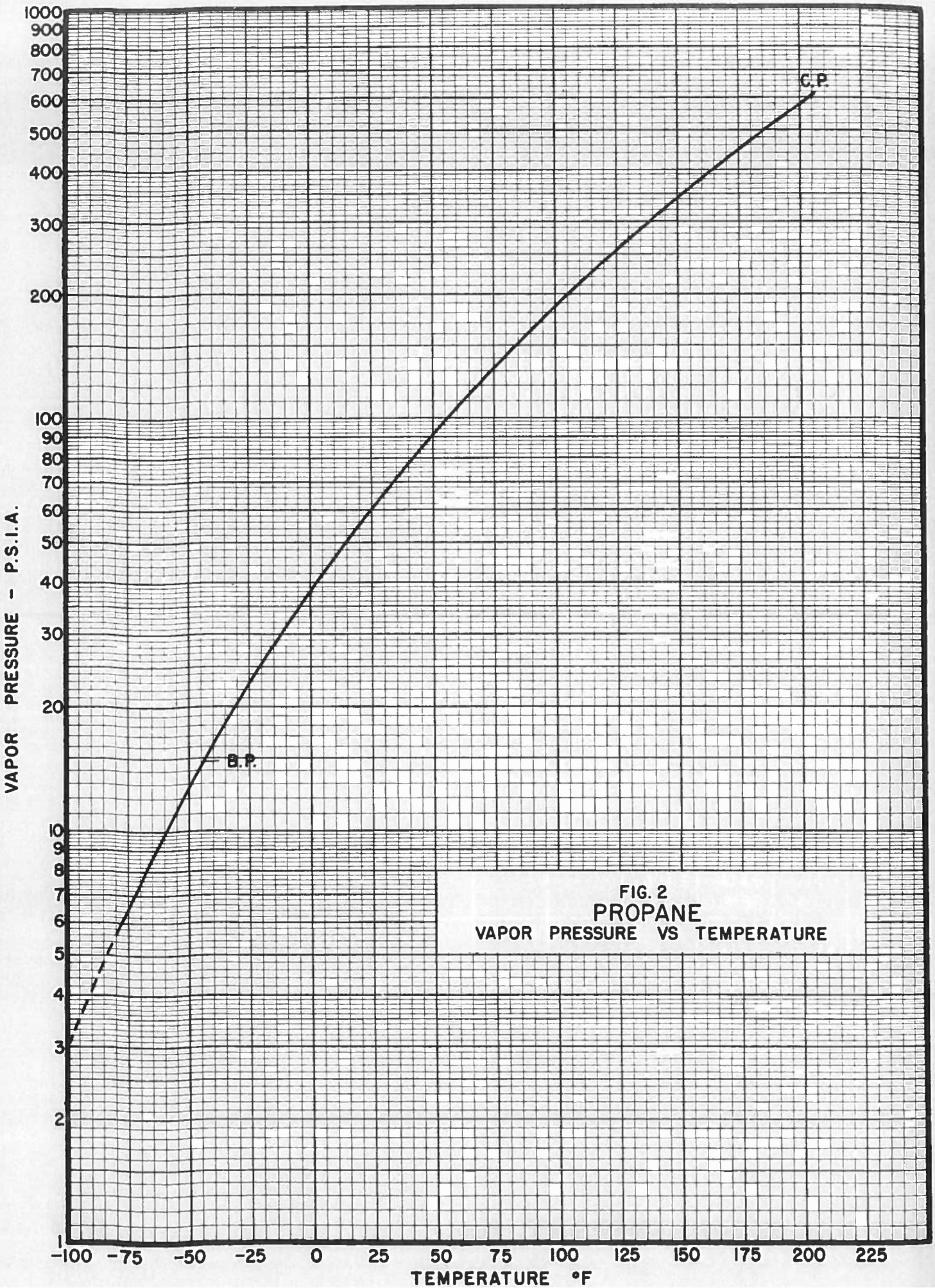



FIG. 2

PROPANE

VAPOR PRESSURE VS TEMPERATURE

# PROPYLENE

**Synonyms**—Methylethene; Methylethylene; Propene

**Formula**—$CH_3CH = CH_2$

**Appearance-Odor**—Colorless gas, liquid under pressure; characteristic olefin (gassy) odor

**Specific Gravity**—0.52 at 20°C

**Chemical Family**—Olefin

**Pollution Category**—USEPA _____ IMO gas

**Applicable Bulk Reg. 46 CFR Subchapter** ..... D, O

**United Nations Number** ..... 1077

**CHRIS Code** ..... PPL

| | | |
|---|---|---|
| **Boiling Point** ..... | −48°C | −54°F |
| | _____°C | _____°F |
| **Freezing Point** ..... | −185°C | −301°F |
| | _____°C | _____°F |

**Vapor Pressure 20°C (68°F) (mmHg)** ..... 7840
**Reid Vapor Pressure (psia)** ..... 227.2
**Vapor Pressure 46°C (115°F) (psia)** ..... 273.0
**Vapor Density (Air = 1.0)** ..... 1.48
**Solubility in Water** ..... 45 ml gas/100 ml water

## FIRE & EXPLOSION HAZARD DATA

**Grade**—Liquefied Flammable Gas (LFG)
**Electrical Group**—D

**General**—As with all gas fires, the only effective method of extinguishing is to shut off the fuel supply. Otherwise a more dangerous situation, the formation of an explosive mixture can result.

**Flash Point (°F)** ..... −162
**Flammable Limits** ..... 2.0 to 11.0%
**Autoignition Temp. (°F)** ..... 927
**Extinguishing Agents** ..... Stop flow of gas; water fog
**Special Fire Procedures** ..... Tanks exposed to fire should be kept cool with a water spray.

## HEALTH HAZARD DATA

| Health Hazard Ratings | Odor Threshold (ppm) | PEL/TWA (ppm) | TLV/TWA (ppm) |
|---|---|---|---|
| 0, 0, 1 | Unavailable | Unavailable | Unavailable |

**General**—Simple asphyxiant. Absence of adequate warning indications such as strong odor or pronounced irritation of mucous membranes of eyes and nose introduces possibility of exposure to hazardous concentrations. Contact with the liquid may cause frostbite.
**Symptoms**—Dizziness, sleepiness

**Short Exposure Tolerance**—Mixture of 6.4% propylene and 26% oxygen inhaled for 2 1/4 minutes produces mild intoxication, drowsiness, tingling of the skin, and inability to concentrate.

**Exposure Procedures**—Remove victim to fresh air. Apply artificial respiration if breathing stops. Contact with liquid may cause frostbite. If the liquid has spilled onto the skin, points of contact may be frostbitten; handle gently and protect from mechanical damage. DO NOT RUB. Get medical attention.

## REACTIVITY DATA

**Stability**—Stable at ordinary temperatures.

**Compatibility**—**Material:** Usual materials of construction may be used.

**Cargo:** Group 30 of compatibility chart.

## SPILL OR LEAK PROCEDURE

Have all-purpose canister mask available. Shut off ignition sources. Call the fire department. If product does not catch fire, it will soon boil off.

**If a spill occurs, call the National Response Center, 800-424-8802.**

**Remarks:**

## Table 1. THERMODYNAMIC PROPERTIES OF SATURATED PROPYLENE[2]

| Temp. °F. | Pressure atm. | Specific Volume Liquid cu. ft./lb. | Specific Volume Vapor cu. ft./lb. | Enthalpy Liquid BTU/lb. | Enthalpy Vapor BTU/lb. | Latent Heat BTU/lb. | Entropy Liquid BTU/lb. °R. | Entropy Vapor BTU/lb. °R. | Temp. °F. |
|---|---|---|---|---|---|---|---|---|---|
| –53.86 | 1.000 | 0.02610 | 6.774 | 265.81 | 454.0 | 188.19 | 0.9543 | 1.418 | –53.86 |
| –50 | 1.102 | 0.02627 | 6.194 | 268.20 | 455.4 | 187.20 | 0.9591 | 1.416 | –50 |
| –40 | 1.401 | 0.02659 | 4.936 | 273.48 | 458.04 | 184.56 | 0.9723 | 1.412 | –40 |
| –30 | 1.761 | 0.02691 | 4.015 | 278.66 | 460.49 | 181.83 | 0.9849 | 1.408 | –30 |
| –20 | 2.187 | 0.02723 | 3.284 | 283.89 | 462.89 | 179.00 | 0.9979 | 1.405 | –20 |
| –10 | 2.686 | 0.02771 | 2.713 | 289.08 | 465.13 | 176.05 | 1.0096 | 1.401 | –10 |
| 0 | 3.263 | 0.02803 | 2.255 | 294.50 | 467.47 | 172.97 | 1.0218 | 1.398 | 0 |
| 10 | 3.932 | 0.02835 | 1.885 | 300.01 | 469.76 | 169.75 | 1.0336 | 1.395 | 10 |
| 20 | 4.984 | 0.02883 | 1.586 | 305.56 | 471.94 | 166.38 | 1.0452 | 1.392 | 20 |
| 30 | 5.575 | 0.02915 | 1.343 | 311.18 | 474.02 | 162.84 | 1.0565 | 1.389 | 30 |
| 40 | 6.568 | 0.02963 | 1.142 | 316.84 | 476.95 | 159.11 | 1.0676 | 1.386 | 40 |
| 50 | 7.685 | 0.03011 | 0.976 | 322.81 | 478.97 | 156.16 | 1.0786 | 1.383 | 50 |
| 60 | 8.939 | 0.03075 | 0.838 | 328.46 | 479.44 | 150.98 | 1.0895 | 1.380 | 60 |
| 70 | 10.336 | 0.03124 | 0.722 | 334.40 | 481.96 | 147.56 | 1.1003 | 1.377 | 70 |
| 80 | 11.888 | 0.03172 | 0.624 | 340.30 | 482.21 | 141.91 | 1.1121 | 1.375 | 80 |
| 90 | 13.599 | 0.03236 | 0.543 | 346.46 | 483.48 | 137.02 | 1.1228 | 1.372 | 90 |
| 100 | 15.486 | 0.03300 | 0.472 | 352.66 | 484.56 | 131.90 | 1.1338 | 1.369 | 100 |
| 110 | 17.552 | 0.03380 | 0.412 | 358.81 | 485.35 | 126.54 | 1.1444 | 1.367 | 110 |
| 120 | 19.814 | 0.03460 | 0.360 | 365.11 | 485.99 | 120.88 | 1.1550 | 1.364 | 120 |
| 130 | 22.286 | 0.03572 | 0.314 | 371.19 | 486.39 | 115.20 | 1.1650 | 1.360 | 130 |
| 140 | 24.978 | 0.03700 | 0.274 | 377.88 | 486.62 | 108.74 | 1.1757 | 1.357 | 140 |
| 150 | 27.914 | 0.03844 | 0.237 | 385.06 | 486.06 | 101.00 | 1.1876 | 1.353 | 150 |
| 160 | 31.095 | 0.04021 | 0.203 | 393.55 | 485.04 | 91.49 | 1.2008 | 1.348 | 160 |
| 170 | 34.547 | 0.04197 | 0.170 | 403.72 | 483.47 | 79.75 | 1.2157 | 1.342 | 170 |
| 180 | 38.293 | 0.04469 | 0.138 | 415.22 | 480.53 | 65.31 | 1.2329 | 1.335 | 180 |
| 190 | 42.385 | 0.04982 | 0.106 | 430.14 | 473.73 | 43.59 | 1.2595 | 1.327 | 190 |
| 197.17 | 45,609 | 0.07271 | 0.07271 | 457.85 | 457.85 | 0 | 1.2962 | 1.2962 | 197.17 |

.03124 ft³/lb

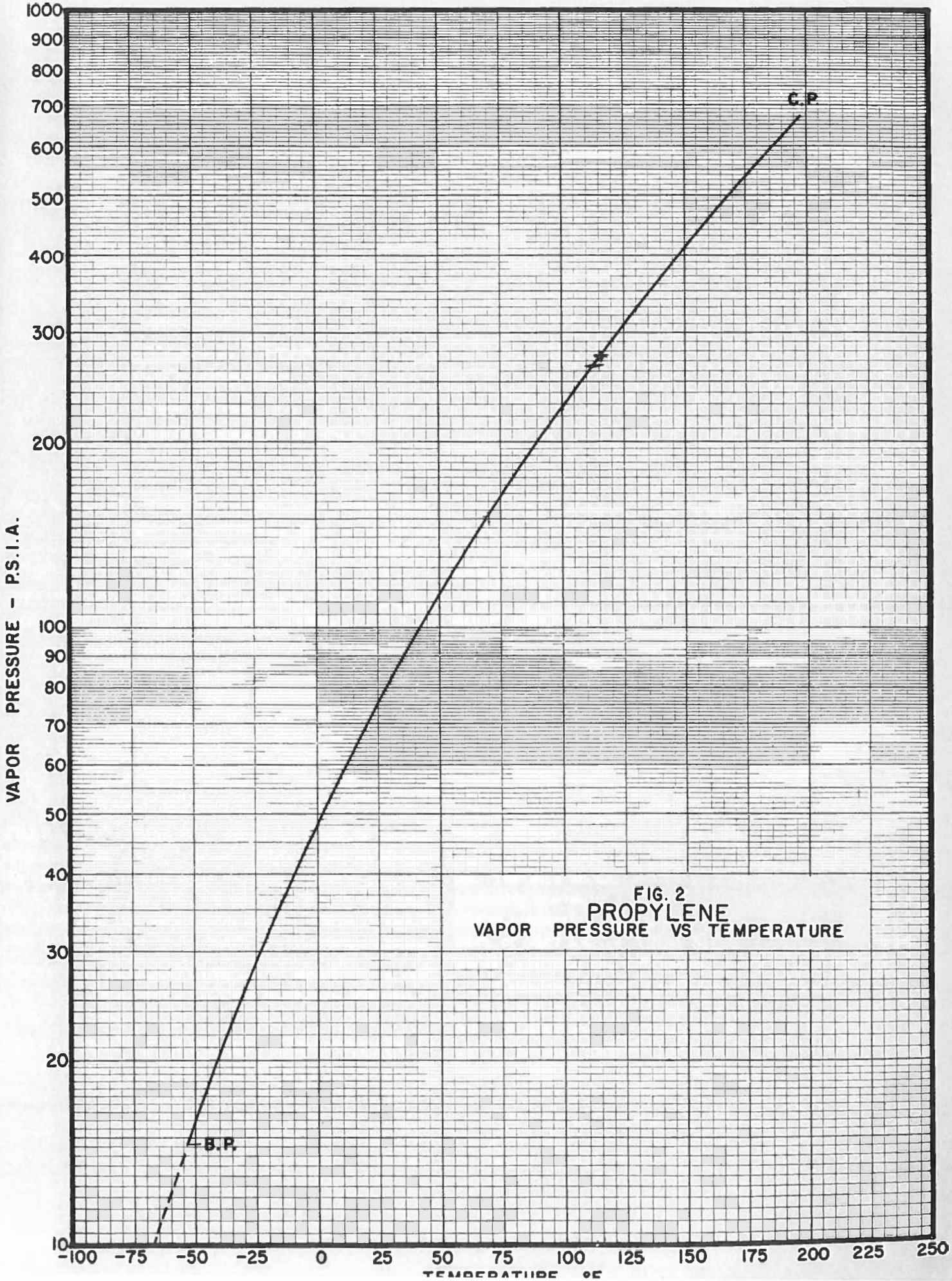


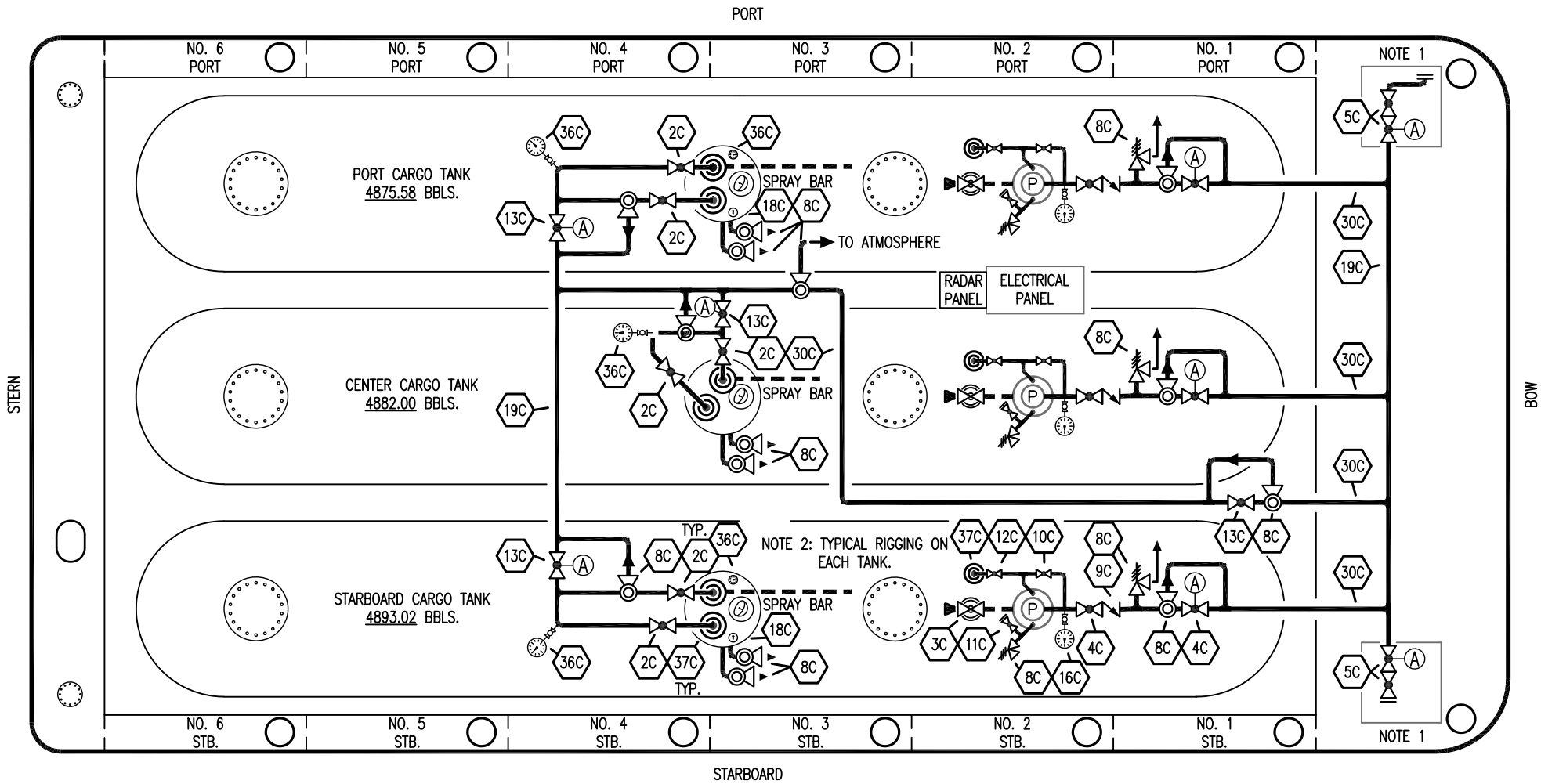

FIG. 2
PROPYLENE
VAPOR PRESSURE VS TEMPERATURE

# SECTION 155.750(a)(2):

# PIPING DIAGRAM

This section complies with 33 CFR 155.750 (a) (2) with regard to the piping diagram. It includes the following:

1. Piping diagram
2. Explanation of symbols to Piping Diagram




| NO | DESCRIPTION |
|---|---|
| 2C | LOAD VALVE (BOTTOM FILL) |
| 2C | LOAD VALVE (SPRAY BAR) |
| 3C | MASTER SUCTION VALVE |
| 4C | DISCHARGE VALVE |
| 5C | HEADER VALVE |
| 8C | RELIEF VALVE |
| 9C | CHECK VALVE |
| 10C | BURP VALVE |
| 11C | BLEED OFF VALVE |
| 12C | BURP VALVE RETURN TO CARGO TANK |
| 13C | CARGO PIPING BLOCK VALVE |

| NO | DESCRIPTION |
|---|---|
| 16C | DISCHARGE PRESSURE GAUGE |
| 18C | TEMPERATURE GAUGE |
| 19C | CARGO HEADER |
| 30C | CARGO PIPELINE |
| 32V | TEMPERATURE GAUGE |
| 36C | PRESSURE GAUGE |
| 37C | CARGO DROP |
| A | AUTOMATIC |
| ——— | ABOVE DECK PIPING |
| - - - | BELOW DECK PIPING |

NOTE 1: CONTAINMENT P&S

NOTE 2: TYPICAL RIGGING ON EACH TANK

MISENER SHIPYARD – EX: DC 530

| REV. | DATE | BY | CHK | APP | REVISION DESCRIPTION |
|---|---|---|---|---|---|
| 2 | 05/03/24 | AC | DDA | DAR | REVISED PER CLIENT COMMENTS |
| 1 | 02/14/14 | GP | GP | OF | REVISED PER CLIENT COMMENTS |
| 0 | 01/11/10 | RB | RB | OF | APPROVED |

KIRBY INLAND MARINE

**CARGO**

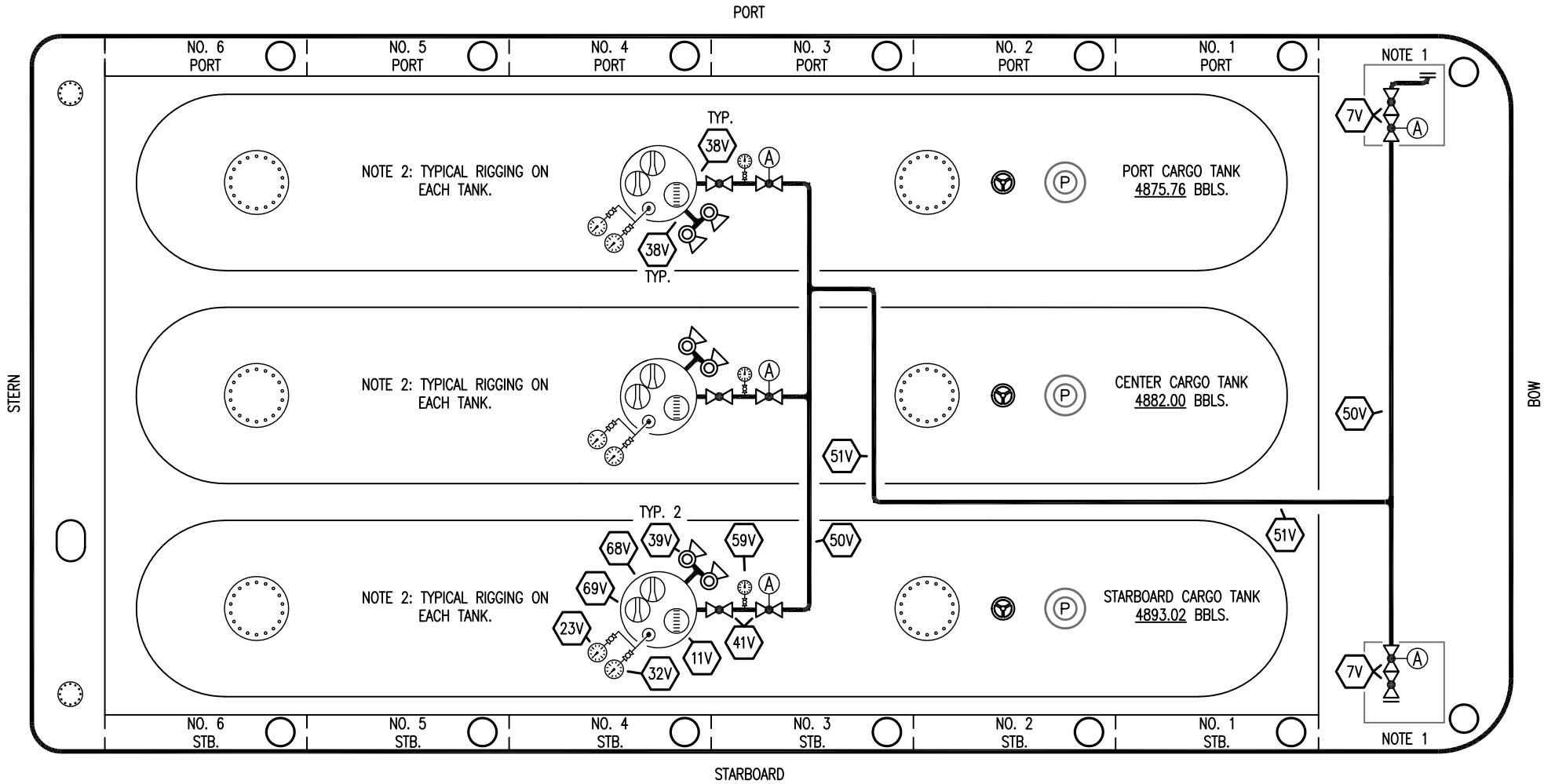
**PIPING FLOW DIAGRAM**

SCALE: NONE

PAGE: 1 OF 2

**KIRBY 14803**

REV. **2**




| NO | DESCRIPTION |
|---|---|
| 7V | HEADER VALVE |
| 11V | GAUGE STICK |
| 23V | PRESSURE GAUGE |
| 32V | TEMPERATURE GAUGE |
| 38V | VAPOR PENETRATION |
| 39V | PRESSURE/VACUUM VALVE |
| 41V | VAPOR TANK VALVE |
| 50V | VAPOR HEADER |

| NO | DESCRIPTION |
|---|---|
| 51V | VAPOR PIPELINE |
| 59V | PRESS/VAC GAUGE |
| 68V | LOW LEVEL SPRAY TUBE |
| 69V | HIGH LEVEL SPRAY TUBE |
| A | AUTOMATIC VALVE |
| ——— | ABOVE DECK PIPING |

NOTE 1: CONTAINMENT P&S

NOTE 2: TYPICAL RIGGING ON EACH TANK

MISENER SHIPYARD – EX: DC 530

| REV. | DATE | BY | CHK | APP | REVISION DESCRIPTION |
|---|---|---|---|---|---|
| 0 | 05/03/24 | AC | DDA | DAR | ISSUED FOR APPROVAL |

KIRBY INLAND MARINE

# VAPOR
# PIPING FLOW DIAGRAM

SCALE: NONE

PAGE: 2 OF 2

**KIRBY 14803**

REV. 0

# SECTION 155.750(a)(3):

# NUMBER OF PERSONS ON DUTY

No person shall act as the person in charge of transfer operations on more than one vessel at a time during transfers between vessels or between two or more vessels and a facility unless authorized by the Captain of the Port. This authorization will be in writing and made part of the transfer procedure. The person in charge shall be aboard the barge at all times unless he is properly relieved or transfer operations have stopped.

# SECTION 155.750(a)(4):

# DUTIES OF TANKERMAN (PERSON IN CHARGE)

The tankerman (person in charge) is responsible for transferring barge and carrying out related operations on board in an efficient, safe, and pollution free manner.

The tankerman (person in charge) shall:

1. Have on board a valid merchant mariners document endorsed as tankerman, certified to handle LFG.

2. Make a thorough inspection of the barge prior to the start of the transfer and check the following:

    a. Hull condition

    b. Pressure and Temperature Gauge accuracy

    c. Any valve or safety valve leakage

    d. Fire extinguisher condition and number

    e. Piping Diagram and Strappings for correctness and completeness

    f. Warning signs, flag, night warning light, shut down sign

    g. Condition of shutdowns and air control system valves and regulators

    h. Operability of closed stick gauges

3. In addition the tankerman shall ensure that:

    a. The vessel's moorings are strong enough to hold during all expected conditions of surge, current, and are long enough to allow for changes in draft, drift, and tide.

    b. The hoses are long enough to allow the vessels to move within the limits of its moorings without placing a strain on the hose loading arm or piping systems.

## SECTION 155.750(a)(4) continued:

c. Each hose is supported to prevent chaffing kinking, or other damages to the hose or hose couplings.

d. Each transfer system is aligned to allow the flow of cargo.

e. Each part of the transfer system not in use is securely blanked or shut off.

f. Each end of hose or loading arm that is not in use is securely blanked by using a bolt in every hole.

g. Each hose has no loose covers, kinks, bulges, soft spots, gouges, cuts, or slashes that penetrate the first layer of hose reinforcement.

h. All connections in the transfer system are leak free.

i. The communications required for the transfer system are leak free.

j. Tankerman is at the site of the transfer and immediately available.

k. Transfer is conducted in accordance with the vessel transfer procedure.

l. Thankerman has a copy of transfer procedure in possession.

m. Tankerman and dock person in charge both speak English.

n. A pre-transfer conference is held with the person in charge of the dock facility and the person understands the following details of the transfer:

   1) The identity of the product being transferred

   2) The sequence of transfer operations

   3) The transfer rate

   4) The name, or title, and location of each person involved in the transfer operations

5) Details of the transferring and receiving system

## SECTION 155.750(a)(4) continued:

6) Critical stages of the transfer operations

7) Federal, state, and local rules that apply to the transfer

8) Emergency procedure

9) Discharge mitigation and containment procedures

10) Discharge reporting procedures

11) Watch or shift change arrangements

12) Transfer shutdown procedures

o. The Persons in charge of transfer operations for the vessel and facility must agree on the transfer operations prior to transfer.

p. The transfer operation is lighted between sunset and sunrise.

# SECTION 155.750(a)(5):

# TENDING VESSEL MOORINGS DURING TRANSFER OPERATIONS

Proper mooring of the barge is essential for both safety and pollution prevention. You may not transfer cargo to or from a barge unless its moorings are strong enough to hold in all expected conditions of surge, current, and weather. The mooring lines must be long enough to allow for changes in draft, trim, surge, and tide during transfer operations.

All conditions at the dock must be considered to determine the adequate size, proper lead and the number of lines necessary. Surge of the barge, both at parallel to and at right angles to the dock, will be influenced by the proximity of traffic in the channel, the dock design, the state of the tide and the barge's draft. Be sure that all lines have the proper lead and are secure.

Be particularly mindful of docks with high and low mooring dolphins, etc. It may be necessary to shift from lower mooring supports to higher or visa versa, as the barge goes down or comes up from the water.

When mooring the barge, as a MINIMUM standard, the PIC should ensure that the number of mooring lines used is in accordance with the governing Standard Operating Procedures for the service of this barge. The lines are used in combination to fulfill the following functions:

(1) Towing lines
(2) Backing lines
(3) Spring lines

# SECTION 155.750(a)(6):

# EMERGENCY SHUTDOWN AND COMMUNICATIONS

The valving system contains air diaphragm control valves throughout, with the exception of a manual valve closest to the tank entrance for the liquid and vapor lines.

NOTE: These manual valves are adjacent to the air operated valves, thus each vapor and liquid line has two valves as close to the tank penetration as possible. The air diaphragm valves are opened by application of air pressure against their diaphragms.

The control valves throughout the barge can be opened by controlling a four way valve at each control station. Suitable block valves are located in the air control system in order to keep some valves closed if desired.

The air control system for this barge is designed with special dump valves at each control valve to ensure total closure time is within 10 seconds. By pulling the cable at the four way valve at any station, all control valves will close within 10 seconds.

The control system is also designed to allow local closure at a particular control valve without having to dump the entire system. This valving arrangement is located at the particular control valve.

Each vessel must have a means that enables continuous two way voice communications between the facility and vessel persons in charge. This means must be usable and effective in all phases of the transfer operation and in all conditions of weather.

The means of communication may be a two way radio or a loud hailer and must be intrinsically safe as defined in 46 CFR 110 and meet Class 1, Division 1, Group D.

# SECTION 155.750(a)(7):

# PROCEDURES FOR TOPPING OFF TANKS AND DISCHARGE OPERATIONS

The load limits for LG barges are based on authorized Type II draft limitations, or volumetric capacities based on filling densities, whichever comes first. It is anticipated that at all loading temperatures, the percentage based on filling density will be reaches before the authorized barge draft is obtained.

Filling density limits vary with temperature and pressure of the LG cargo when loaded. Well before the topping off stage, at about 75% to 80% full, the temperature of the LG cargo will stabilize. Take this temperature and refer to the chart in these procedures for the specific LG product. At the given temperature, take the load % and refer to the strappings to determine the correct amount in "topping off."

Remember, load to the designated FILLING PERCENTAGE of MEAN MIDSHIP DRAFT, whichever comes first. If the COI draft is obtained before the % of fill, then check to ensure that this is the mean midship draft and not the point at which one end of the barge first reaches the COI draft. Also check to see if water is in the hopper or voids.

Any unresolved situations where COI draft is reached before the loading % should be reported to the appropriate Kirby Inland Marine authorities, who hopefully will take measures to legally correct the problem with the USCG for the future.

Remember, any OPERATIONAL draft restriction placed upon you by the company due to the water depth will supersede the USCG loading % and mean draft requirements, if this draft is less than what the COI authorizes. In this case, you might have to terminate the load at the point where the barge first reaches the depth limit in order to avoid rubbing bottom. LG barges are hard to load to an even trim.

The remaining pages in this section of the procedures give the filling % as a function of topping off temperature.

## SECTION 155.750(a)(7) continued:

For discharge operations, since pumps are not installed on the barge, either an inert gas or cargo vapors must be provided from the terminal through the vapor line as the pressurizing medium to allow for cargo discharge. The safety relief valves on the pipelines are set much higher than the safety relief valves on the cargo tanks. This is USCG approved to ensure that venting of product trapped in the pipelines does not easily occur. PIC's should not mistake this higher pipeline pressure setting to allow more pressure on the system to help discharge the barge. PIC's are bound by the cargo tank relief valve setting of 100 psig, or better yet, about 90% of it or 235 psig. DO not exceed the tank design pressure, regardless of the higher pressure setting which applies for the pipelines.

# BUTADIENE

(FILLING DENSITY .59)

VOLUMETRIC TANK CAPACITIES
VS.
TEMPERATURE

| TEMP (F) | SEPCIFIC VOLUME ($H_2O$) $FT^3/LB$ | SPECIFIC VOLUME (LFG) $FT^3/LB$ | % VOLUME USING LIQUID FULL @ 115°F |
|---|---|---|---|
| 40 | .01602 | .02503 | 91.7 |
| 50 | .01602 | .02529 | 92.6 |
| 60 | .01603 | .02557 | 93.7 |
| 70 | .01605 | .02585 | 94.7 |
| 80 | .01607 | .02614 | 95.8 |
| 90 | .01610 | .02645 | 96.9 |
| 100 | .01613 | .02678 | 98.1 |
| 110 | .01617 | .02713 | 99.4 |
| 115 | .016185 | .02730 | 100.0 |

NOTE:

% volume by the liquid full at 115°F criteria is found by ensuring that the ratios of specific LFG volumes between successive temperature intervals equal the ratio of volumetric %, with the starting point assuming a liquid full tank at 115°F

# BUTANE

(FILLING DENSITY .54)

VOLUMETRIC TANK CAPACITIES
VS.
TEMPERATURE

| TEMP (F) | SEPCIFIC VOLUME ($H_2O$) $FT^3/LB$ | SPECIFIC VOLUME (LFG) $FT^3/LB$ | % VOLUME USING LIQUID FULL @ 115°F |
|---|---|---|---|
| 40 | .01602 | .02690 | 92.5 |
| 50 | .01602 | .02718 | 93.4 |
| 60 | .01603 | .02745 | 94.4 |
| 70 | .01605 | .02776 | 95.4 |
| 80 | .01607 | .02808 | 96.5 |
| 90 | .01610 | .02841 | 97.7 |
| 100 | .01613 | .02873 | 98.8 |
| 110 | .01617 | .02892 | 99.4 |
| 115 | .016185 | .02909 | 100.0 |

NOTE:

% volume by the liquid full at 115°F criteria is found by ensuring that the ratios of specific LFG volumes between successive temperature intervals equal the ratio of volumetric %, with the starting point assuming a liquid full tank at 115°F

# ISOBUTANE

(FILLING DENSITY .52)

VOLUMETRIC TANK CAPACITIES
VS.
TEMPERATURE

| TEMP (F) | SEPCIFIC VOLUME ($H_2O$) $FT^3/LB$ | SPECIFIC VOLUME (LFG) $FT^3/LB$ | % VOLUME USING LIQUID FULL @ 115°F |
|---|---|---|---|
| 40 | .01602 | .02778 | 91.2 |
| 50 | .01602 | .02810 | 92.2 |
| 60 | .01603 | .02843 | 93.3 |
| 70 | .01605 | .02876 | 94.4 |
| 80 | .01607 | .02909 | 95.5 |
| 90 | .01610 | .02947 | 96.7 |
| 100 | .01613 | .02986 | 98.0 |
| 110 | .01617 | .03006 | 98.6 |
| 115 | .016185 | .03047 | 100.0 |

NOTE:

% volume by the liquid full at 115°F criteria is found by ensuring that the ratios of specific LFG volumes between successive temperature intervals equal the ratio of volumetric %, with the starting point assuming a liquid full tank at 115°F

# BUTYLENE

(FILLING DENSITY .56)

VOLUMETRIC TANK CAPACITIES
VS.
TEMPERATURE

| TEMP (F) | SEPCIFIC VOLUME ($H_2O$) $FT^3/LB$ | SPECIFIC VOLUME (LFG) $FT^3/LB$ | % VOLUME USING LIQUID FULL @ 115°F |
|---|---|---|---|
| 40 | .01602 | .02610 | 90.8 |
| 50 | .01602 | .02638 | 91.8 |
| 60 | .01603 | .02667 | 92.8 |
| 70 | .01605 | .02698 | 93.8 |
| 80 | .01607 | .02730 | 95.1 |
| 90 | .01610 | .02770 | 96.3 |
| 100 | .01613 | .02811 | 97.8 |
| 110 | .01617 | .02852 | 99.2 |
| 115 | .016185 | .02875 | 100.0 |

NOTE:

% volume by the liquid full at 115°F criteria is found by ensuring that the ratios of specific LFG volumes between successive temperature intervals equal the ratio of volumetric %, with the starting point assuming a liquid full tank at 115°F

# ISOBUTYLENE

(FILLING DENSITY .56)

VOLUMETRIC TANK CAPACITIES
VS.
TEMPERATURE

| TEMP (F) | SEPCIFIC VOLUME ($H_2O$) $FT^3/LB$ | SPECIFIC VOLUME (LFG) $FT^3/LB$ | % VOLUME USING LIQUID FULL @ 115°F |
|---|---|---|---|
| 40 | .01602 | .02614 | 91.4 |
| 50 | .01602 | .02642 | 92.4 |
| 60 | .01603 | .02672 | 93.4 |
| 70 | .01605 | .02702 | 94.5 |
| 80 | .01607 | .02735 | 95.6 |
| 90 | .01610 | .02768 | 96.8 |
| 100 | .01613 | .02803 | 98.0 |
| 110 | .01617 | .02840 | 99.3 |
| 115 | .016185 | .02860 | 100.0 |

NOTE:

% volume by the liquid full at 115°F criteria is found by ensuring that the ratios of specific LFG volumes between successive temperature intervals equal the ratio of volumetric %, with the starting point assuming a liquid full tank at 115°F

# SECTION 155.750(a)(8):

# CONTROL VALVE OPERATION & CLOSURE

**To Open Control Valves:**

1. Connect shore air supply to control station.
2. Open manual air supply valve to air operated control valves.
3. Open the air valve in the system to each control valve desired for the operation.
4. In case of emergency pull the emergency shutdown cable at any control station.

**To Close Control Valves:**

1. Shut off and bleed the air pressure from the system.
2. Close all manual air supply valves in the system.
3. Close all cargo and vapor manual valves.

**Cargo Hose Connections:**

1. All flanges must be made up with bolts in every hole.
2. After discharge or loading, blinds are made up with bolts in every hole.

# SECTION 155.750(a)(9):

# PROCEDURES FOR REPORTING DISCHARGES

In the event of an LFG discharge during loading or discharging operations, the most important consideration is to locate the source and stop the discharge at the source. This will in almost all situations require the tankerman to activate the remote quick closing valve shutdowns to close off all potential flow to or discharge from the barge tanks. Notify the dock of this action in order to prevent excessive pressure buildup.

Also, since the discharge of LFG is most likely to exist in the vapor phase (since any liquid spilled will rapidly vaporize), an exclusion zone must immediately be established particularly in the downwind areas and the release is of high pressure. This means ensuring that potential ignition sources are kept away.

Once these immediate "first responder" initial actions have taken place (this should not take a great deal of time,) then proceed with the following steps:

1. Notify Kirby Inland Marine, Inc at 713-435-1195 (dispatch) who will make the reporting requirements as outlines in the spill report. Be prepared to provide the following information to the best of your ability.

   **NOTE: IF YOU DO NOT HAVE ALL THE INFORMATION, DON'T LET THAT DELAY YOU IN REPORTING TO THE COMPANY.**

   A. Name
   B. Company name
   C. Name of barge
   D. Incident location
   E. Type of product
   F. Estimated quantity discharge
   G. Weather, tide, and sea conditions
   H. Cause of the discharge
   I. Actions taken to mitigate the discharge

2. Remember, until Kirby Response Team personnel arrive, your best actions as the "first responder" are to stop the discharge and establish and enforce the exclusion zone.

## SECTION 155.750(a)(9) continued:

3. If possible, use boat equipment to rig a water spray system to knock down the vapor or at least disperse concentrations below flammable limits. This is important if the vapor cloud would be heading to areas of potential ignition sources and it is best to apply water perpendicular to the vapor flow (hit is broadside) as close to the discharge point as possible. However, if adequate personnel protection equipment is not available, then this shouldn't be done, without first checking with the Safety supervisor.

# SECTION 155.750(a)(10):

# PROCEDURES FOR CLOSING AND OPENING THE VESSEL OPENINGS

This is an LG barge with pressure vessel tanks at MAWP. The cargo tanks are not designed to allow any open or PV venting to the atmosphere during transfer operations in while transit. In fact, they are outfitted only with safety relief valves set at MAWP as the venting device. Any such venting needs to be reported to the appropriate Kirby Inland Marine authorities. Slip tubes in particular, are to remain closed and sealed off when not in use. Check for leaks in this area and report them.

Sometimes after a load residual product will be trapped in the pipelines. The safety relief valves on these pipelines have been set much higher than the cargo tank safety relief valve in order to minimize the transit venting of product. This is USCG approved. Nevertheless, be wary of these pipelines and their potential to vent. If they do vent, report this to the appropriate Kirby Inland Marine authorities.

The hull and hopper have voids, which could provide a great deal of space for the influx of rainwater, etc. which could compromise load limits and barge stability. Hatches over these void spaces should only be opened for inspection purposes. During the transfer, they need not be totally dogged down since the PIC will be conducting frequent inspections of the voids. After the transfer, and while in transit, they must be totally secured. If opened periodically for inspection during transit, they must be totally secured.

# SECTION 155.750(a)(11):

# HOSES

Cargo hoses for LG service whether provided by the barge/boat or terminal must be made of flexible metal and fabricated of seamless steel pipe and flexible joints of steel or bronze, or of other suitable material resistant to the action of the cargo.

The Maximum Allowable Working Pressure (MAWP) of the hose shall be marked on it. The pressure as marked shall be 150 psig for use with this barge. Most will be marked with a 150 psig MAWP rating.

In addition to the MAWP, the date of the manufacture and date of the annually required pressure test should be marked on the hose. If not, however, this information can be contained within the barge or facility paperwork records, and the hose must be marked to indicate this.

Further, the hose must be either marked for Liquefied Gas service, or for the specific liquefied gas, or reference a chart of approved LG products in the barge or facility paperwork, where appropriate.

Ensure that the pre transfer inspection procedures for hoses as outlined in Section 155.750 (a)(4) are met.