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ETHYLENE DENSITY MEASUREMENT MANUAL

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SECTION 1

INTRODUCTION

1.1

Application

This manual is intended to be the primary reference source for the calculation and determination of the quantity of ethylene delivered or purchased by [REDACTED]. It is assumed that the reader is familiar with measurement terminology and has had a general exposure to gas measurement theory and metering installations.

All procedures in this manual are based upon established [REDACTED] standards and other generally accepted industry practices. These standards are listed in the references section of this manual.

This manual covers the application of concentric orifice meter with flow computers or circular charts. Turbine meters and vortex meters are also addressed.

Care should be taken in all phases of handling the measurement equipment and associated records. For details of generally accepted practices, reference is made to the American Gas Association Gas Measurement Manual.

Operating conditions at the measurement site should be selected to insure that the flowing stream is always in the gas phase and free of pressure pulsations such as those associated with pumping. It is recommended that every effort be made to avoid operating at the critical conditions of ethylene. Specifically, this would preclude operating at conditions where the density of ethylene changes very rapidly thus making the measurement of pressure and temperature critical (see Figure 1).

Concentric Orifice Meter

1.2

The quantity of ethylene delivered shall be preferably measured by a concentric orifice meter with flange taps, located at the point of delivery. The meter tube shall be designed and installed in accordance with the recommendations of the American Gas Association Gas Measurement Committee Report No. 3. The calculation of the measured quantity will conform to the method as outlined in the AGA report. This manual includes physical property data which makes the calculations specific to ethylene.

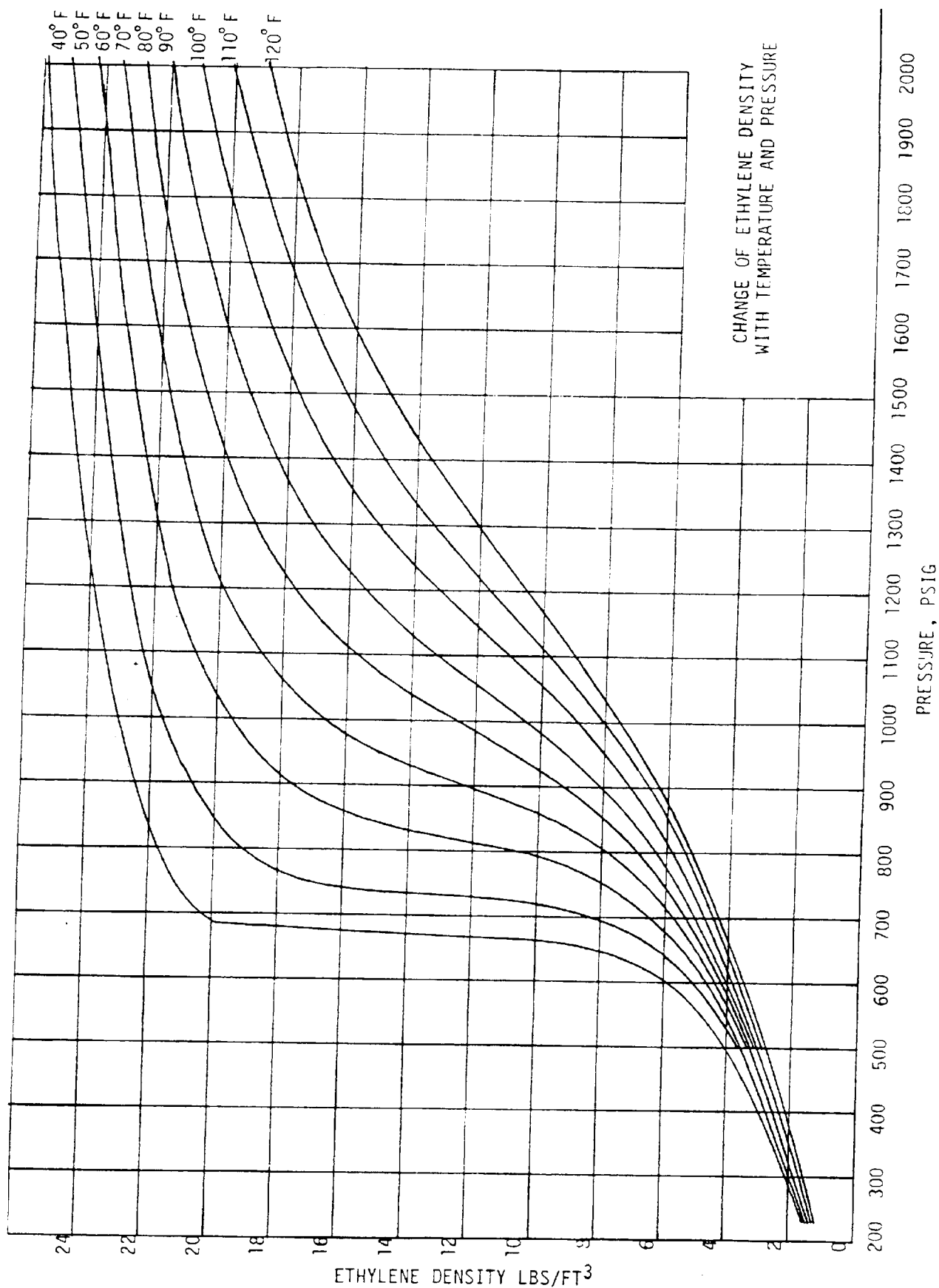


FIGURE 1

The ratio of the orifice diameter to the inside pipe diameter (β ratio) should be among those outlined in the AGA report and should be selected so that the normal readings of differential pressure should not be lower than 20 inches of water nor greater than 80 inches of water when using a recommended 100 inch full-scale range.

1.2.1 Flow Computer

A flow computer is preferred for use with the orifice meter. Electronic transmitters shall provide inputs to the flow computer which represent differential pressure, upstream static pressure and downstream temperature. The flow computer should continuously solve for density using the API-2565 algorithm unless a fluid density signal is provided as an input. A totalizer should be used to continuously integrate flow rate over the specified contract period.

The electronic transmitters shall be checked and calibrated at least once each month. These procedures should be witnessed by interested parties. Records of the calibration should be filed by the interested parties and retained on file for at least one year.

If upon testing the official flow measurement equipment, an inaccuracy sufficient to change the delivery by more than 1% is found, registrations of such equipment should be corrected for the period extending back to the time when such inaccuracy originated. If the time is not ascertainable, then the correction should be extended back one-half the total elapsed time since the last calibration.

1.2.2 Circular Chart Recorder

Optionally, a circular chart recorder may be used with an orifice meter tube. It should be of standard manufacture of either the mercury type or the dry type and should record in inches of water differential pressure. The orifice meter chart should be the 24-hour type unless a special arrangement for a longer period is made. In those cases in which this longer time period is used, the computations must reflect this time period in order to arrive at the correct volume.

Flowing ethylene pressure should be measured continuously and simultaneously with differential pressure on the high pressure side of the orifice and should be recorded continuously on the same chart as the differential pressure.

Flowing ethylene temperature should be measured continuously and simultaneously with the differential pressure on the low pressure side of the orifice and should be recorded continuously on a separate chart from the differential pressure and static pressure. However, it is permissible to use a three pen recorder where desired to record the differential pressure, static pressure and flowing temperature simultaneously.

The circular chart recorder shall be checked and calibrated at least once each month. These procedures should be witnessed by interested parties. Records of the calibration should be filed by the interested parties and retained on file for at least one year. If any inaccuracy is found the same procedure outlined in Section 1.2.1 should be followed.

The chart is to be interpreted by using a suitable chart analyzer which simultaneously traces differential and static pressures. These integrated values for differential and static pressure are used with the integrated value for temperature to calculate the weight of ethylene delivered per hour as described in Section 3.2.

Turbine Meter

1.3

A turbine meter may be used for ethylene gas flow measurement, provided the installation includes facilities for connecting a suitable prover to ensure the required accuracy. The meter is to be selected and proven for operation over the linear range of the meter.

The turbine meter measures volumetric flow rate and provides a pulse output in proportion to volume at stream conditions. The weight of ethylene delivered is determined by correcting the totalized volume to base conditions and multiplying by the base condition density. Procedures for these calculations are given in Section 3.3.

Vortex Meter

1.4

Vortex meters are used infrequently for ethylene gas flow measurement. In these cases the installation includes facilities for connecting a suitable prover to ensure the required accuracy. The meter is to be selected and proven for operation over the linear range of the meter.

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Vortex meters measure the volumetric flow rate and provide a pulse output in proportion to volume at stream conditions. The weight of ethylene delivered is determined by correcting the totalized volume to base conditions and multiplying by the base condition density of ethylene. Procedures for performing these calculations are given in Section 3.3.

SECTION 2 NOMENCLATURE

<u>Symbol</u>	<u>Units</u>
A Area of Orifice	Square Feet
B Constant for Reynolds Number Factor Determination	Dimensionless
C Constant for Expansion Factor Determination	Dimensionless
C' Orifice Flow Constant	Dimensionless
D Inside Diameter of Pipe	Inches
d Diameter of Orifice Bore	Inches
E Slope of Reynolds Number Factor	Dimensionless
F _a Orifice Thermal Expansion Factor	Dimensionless
F _b Basic Orifice Factor	Dimensionless
F _g Specific Gravity Factor	Dimensionless
F _l Gage Location Factor	Dimensionless
F _m Manometer Factor	Dimensionless
F _{pb} Pressure Base Factor	Dimensionless
F _{pv} Supercompressibility Factor	Dimensionless
F _r Reynolds Number Factor	Dimensionless
F _{tb} Temperature Base Factor	Dimensionless
F _{tf} Flowing Temperature Factor	Dimensionless
F _{tp} Prover Correction Factor	Dimensionless
g Acceleration Due to Gravity = 32.174	Feet per Second Squared
G Ideal Specific Gravity of Ethylene	Dimensionless
h Differential head in terms of the flowing fluid at the average specific weight at the orifice.	Feet

<u>Symbol</u>		<u>Units</u>
h_m	Differential Pressure, Maximum (Meter Range)	Inches of Water at 60°F
h_w	Differential Pressure, Working	Inches of Water at 60°F
k	Ratio of Specific Heats	Dimensionless
K	Coefficient of Discharge, Including Velocity of Approach	Dimensionless
K_t	Meter Manufacturer's Calibration Factor	Pulses per Actual Cubic Foot of Gas
K_o	Coefficient of Discharge at Infinite Reynolds Number	Dimensionless
M	Combined Coefficient for Ethylene Measurement Equal to $F_b \cdot F_{pb} \cdot F_{tb} \cdot F_g \cdot Y_b$	Dimensionless
N_t	Meter Pulses Accumulated	Dimensionless
P_b	Base Pressure	Pounds per Square Inch Absolute
P_f	Flowing Pressure at Upstream Pressure Connection	Pounds per Square Inch Absolute
P_m	Meter Flowing Pressure (Static Range)	Pounds per Square Inch Absolute
Q_f	Volume Rate of Flow at Flowing Conditions	Cubic Feet per Hour
Q_h	Volume Rate of Flow at Base Conditions	Cubic Feet per Hour
Q_s	Volume Rate of Flow at the Average Specific Weight of Measurement	Cubic Feet per Second
R_d	Reynolds Number at Plane of Orifice	Dimensionless
T_a	Ambient Temperature	Degrees Rankine
T_b	Base Temperature	Degrees Rankine

<u>Symbol</u>		<u>Units</u>
T_f	Flowing Temperature of Fluid	Degrees Rankine
U	Volume at Base Conditions Turbine or Vortex Meter	Cubic Feet
V_f	Mean Velocity of Fluid at Plane of Orifice	Feet per Second
W_h	Weight Rate of Flow	Pounds per Hour
W_t	Weight of Flow Delivered Over Time of Measurement	Pounds
x	Calculation Expedient Used in Expansion Factor Equation	-
Y_1	Expansion Factor, Based on Upstream Flowing Absolute Pressure	Dimensionless
Z_a	Compressibility of Ethylene at Ambient Conditions	Dimensionless
Z_f	Compressibility of Ethylene at Flowing Conditions	Dimensionless
Z_b	Compressibility of Ethylene at Base Conditions	Dimensionless
β	Ratio of Orifice Bore to Meter Tube Inside Diameter	Dimensionless
μ'	Absolute Viscosity of Flowing Fluid	Micropoise
μ	Absolute Viscosity of Flowing Fluid	Pounds per Second-Foot
γ_b	Ideal Specific Weight of Ethylene at Base Conditions	Pounds per Cubic Foot
γ_f	Specific Weight of Gas at Flowing Conditions	Pounds per Cubic Foot
γ_m	Specific Weight of Mercury at Ambient Temperature	Pounds per Cubic Foot
γ_w	Specific Weight of Water at 60°F	Pounds Per Cubic Foot

SECTION 3 EQUATIONS FOR WEIGHT OF ETHYLENE DELIVERED

Orifice Meter with Flow Computer

3.1

The following equations are based on the derivations developed in the American Gas Association Report No. 3, Appendix B, Section 17.

3.1.1 Introductory Equations

The basic flow rate equation for weight units is:

$$W_h = Q_f \cdot \gamma_f$$

where:

W_h = Weight rate of flow in pounds/hr.

Q_f = Volume rate of flow at flowing conditions in cu.ft./hr.

γ_f = Specific weight of gas at flowing conditions in lb./cu.ft.

The volume flow rate is given in the American Gas Association Report No. 3 as:

$$Q_f = (3600) \cdot Q_s$$

where

$$Q_s = K \cdot A \cdot (2 \cdot g \cdot h)^{1/2}$$

and

Q_s = Volume rate of flow at the average specific weight of measurement in cu.ft./second.

K = Coefficient of discharge, including velocity of approach factor.

$$A = \text{Area of orifice in sq.ft.} = \frac{\pi \cdot d^2}{(4 \cdot 144)}$$

g = Acceleration due to gravity in ft. per second per second (32.17 ft/sec²).

h = Differential head in feet of the fluid flowing and at the average specific weight at the orifice or

$$h = \frac{h_w \cdot \gamma_w}{12 \cdot \gamma_f}$$

where

h_w = Differential pressure in inches of water at 60°F.

γ_w = Specific weight of water at 60°F (62.37 lb/cu.ft.).

γ_f = Specific weight of gas at flowing conditions in lb/cu.ft.

Substituting these values into the equation for Q_f gives

$$Q_f = (3600) \cdot \left[\frac{\pi \cdot d^2}{(4 \cdot 144)} \right] \cdot K \cdot \left[\frac{(2) \cdot (32.17) \cdot h_w \cdot (62.37)}{12 \cdot \gamma_f} \right]^{1/2}$$

or

$$Q_f = 359.061 \cdot K \cdot d^2 \cdot \left[\frac{h_w}{\gamma_f} \right]^{1/2}$$

Substituting this into the equation for W_h and simplifying yields,

$$W_h = 359.061 \cdot K \cdot d^2 \cdot (h_w \cdot \gamma_f)^{1/2}$$

American Gas Association Report No. 3 equations 23 & 25 in the Appendix B show that

$$d^2 \cdot K = \left[\frac{F_b \cdot F_r}{338.17} \right]$$

where

F_b = Basic orifice factor (see Sec. 3.2.2).

F_r = Reynolds number factor (see Sec. 3.2.3).

Substituting again and simplifying yields the working equation with the expansion factor Y_1 added for compressible fluids (see Sec. 3.2.4).

$$W_h = 1.0618 \cdot F_b \cdot F_r \cdot Y_1 \cdot h_w \cdot \gamma_f^{1/2}$$

3.1.2 γ_f , Specific Weight of Ethylene at Flowing Conditions (See Table 6.6)

The specific weight of ethylene is to be determined using the API 2565 algorithm unless an optional on-line densitometer is used.

Orifice Meter with Circular Chart Recorder

3.2

The following calculations are based on equations developed in the American Gas Association Report No. 3. For more information, refer to Appendix B of that report. All base condition references are taken from the Gas Processors Suppliers Association's Engineering Data Book.

3.2.1 Introductory Equations

The basic flow rate equation is:

$$Q_h = C' \cdot [h_w \cdot P_f]^{1/2}$$

in which

Q_h = Volume rate of flow at base conditions,
cu.ft./hr.

C' = Orifice flow coefficient

h_w = Differential pressure in inches of water at 60°F

P_f = Flowing pressure, psi absolute

The weight of ethylene delivered during a given time is:

$$W_h = Q_h \cdot \frac{\gamma_b}{Z_b} = C' \cdot (h_w \cdot P_f)^{1/2} \cdot \frac{\gamma_b}{Z_b}$$

where

W_h = Weight Rate of Flow in pounds/hr.

γ_b = Ideal specific weight of ethylene in lb/cu.ft.
at base conditions

Z_b = Compressibility of ethylene at base conditions.

C' is composed of factors selected to reduce the flow rate to standard conditions of 60°F and 14.696 psia and may be defined as the rate of flow in cu.ft./hr. at base conditions when the extension $(h_w \cdot P_f)^{1/2}$ is equal to one. It is calculated by:

$$C' = F_b \cdot F_r \cdot Y_1 \cdot F_{pb} \cdot F_{tb} \cdot F_{tf} \cdot F_g \cdot F_{pv} \cdot F_m \cdot F_l \cdot F_a$$

where the individual factors as used for determining the weight of ethylene delivered are defined below.

3.2.2 F_b , Basic Orifice Factor

The basic orifice factor is a function of the meter tube inside diameter and the orifice bore. Values of F_b have been combined with other factors which are constant for this application and tabulated as the factor M in Table 6.5. For the definition of the factor M see Section 3.2.13.

3.2.3 F_r , Reynolds Number Factor

The Reynolds number factor corrects for the effects of viscous and frictional forces and is given by:

$$F_r = 1 + \frac{E}{R_d}$$

where

$$E = \left[d \cdot 830 - 50008 + 900082 - 420083 + \frac{530}{d^{1/2}} \right]$$

where

$$R_d = \left[\frac{V_f \cdot d \cdot \gamma_f}{12 \cdot \mu} \right]$$

and where

d = Orifice diameter in inches

D = Meter tube inside diameter in inches

β = Ratio of d to D

R_d = Reynolds number

V_f = Gas mean velocity at plane of orifice in ft/sec

γ_f = Specific weight of gas at flowing conditions in lb/cu.ft.

μ = Viscosity in lb/sec-ft

= $6.7197 \times 10^{-8} \mu'$, where μ' is the viscosity in micropoise

Now the velocity may be calculated from the volume flow rate by dividing by the area of the orifice. Thus:

$$V_f = \frac{Q_f}{3600 \cdot A}$$

where

Q_f = Volume flow rate at flowing conditions in cu.ft./hr.

A = Area of the orifice in sq.ft. = $\frac{\pi \cdot d^2}{(4 \cdot 144)}$

3600 = Number of seconds in one hour

The volume flow rate is given in the American Gas Association Report No. 3 as:

$$Q_f = 3600 \cdot Q_s$$

where

$$Q_s = K \cdot A \cdot (2 \cdot g \cdot h)^{1/2}$$

and

Q_s = Volume rate of flow at the average specific weight of measurement in cu.ft. per second.

K = Coefficient of discharge including velocity of approach factor.

g = Acceleration due to gravity in ft. per second per second (32.17 ft/sec²).

h = Differential head in feet of the fluid flowing and at the average specific weight at the orifice or

$$h = \left[\frac{h_w \cdot \gamma_w}{12 \cdot \gamma_f} \right]$$

where

γ_w = 62.37 lb/cu.ft. = specific weight of water at 60°F.

γ_f = Specific weight of gas at flowing conditions in lb/cu.ft.

h_w = Differential pressure in inches of water.

Substituting these values into the equation for Q_f gives

$$Q_f = 3600 \cdot A \cdot K \cdot \left[(2) \cdot (32.17) \cdot \left[\frac{h_w \cdot 62.37}{12 \cdot \gamma_f} \right] \right]^{\frac{1}{2}}$$

The specific weight of ethylene at flowing conditions may be defined as:

$$\gamma_f = \gamma_b \cdot \frac{P_f}{P_b} \cdot \frac{T_b}{T_f} \cdot \frac{Z_b}{Z_f}$$

where

γ_b = Ideal specific weight of ethylene at base conditions = .073926 lb/cu.ft.

P_f = Absolute static pressure in psia.

P_b = Absolute pressure at base conditions in psia = 14.696

T_f = Absolute flowing temperature in degrees Rankine.

T_b = Absolute temperature at base conditions in degrees Rankine = 520°R. (460° + 60°F = 520°R)

Z_b = Compressibility of ethylene at base conditions = 0.9938

Z_f = Compressibility of ethylene at flowing conditions.

Again, substitution yields

$$Q_f = 3600 \cdot A \cdot K \cdot \left[(2)(32.17) \cdot \frac{h_w}{12} \cdot \frac{62.37}{\gamma_b} \cdot \frac{P_b}{P_f} \cdot \frac{T_f}{T_b} \cdot \frac{Z_f}{Z_b} \right]^{\frac{1}{2}}$$

$$Q_f = 3600 \cdot A \cdot K \cdot \left[(2)(32.17) \cdot \frac{h_w}{12} \cdot \frac{62.37}{.073926} \cdot \frac{14.696}{P_f} \cdot \frac{T_f}{520} \cdot \frac{Z_f}{.9938} \right]^{\frac{1}{2}}$$

$$Q_f = 40,831 \cdot A \cdot K \cdot \left[\frac{h_w \cdot T_f \cdot Z_f}{P_f} \right]^{\frac{1}{2}}$$

Substituting the equation for volume flow rate into the equation for velocity gives:

$$V_f = \frac{Q_f}{(3600 \cdot A)}$$

$$V_f = 11.342 \cdot K \cdot \left[\frac{h_w \cdot T_f \cdot Z_f}{P_f} \right]^{\frac{1}{2}}$$

Again, the specific weight of ethylene at flowing conditions may be calculated from the ideal specific weight at base conditions by:

$$\begin{aligned} \gamma_f &= \gamma_b \cdot \frac{Z_b \cdot T_b}{P_b} \cdot \frac{P_f}{Z_f \cdot T_f} \\ &= (0.073926) \cdot \frac{520}{14.696} \cdot \frac{Z_b \cdot P_f}{Z_f \cdot T_f} \\ &= 2.6158 \cdot \frac{Z_b \cdot P_f}{Z_f \cdot T_f} \end{aligned}$$

Therefore, the Reynolds number equation may be restated using the relations derived above for velocity, specific weight and viscosity:

$$R_d = (3.6793 \times 10^7) \cdot \frac{K \cdot d}{\mu'} \cdot F_{pv} \cdot \left[\frac{P_f \cdot h_w}{T_f} \right]^{\frac{1}{2}}$$

where F_{pv} = supercompressibility for ethylene at flowing conditions. (See Sec. 3.2.9.)

This may be substituted into the Reynold number factor equation:

$$\begin{aligned} F_r &= 1 + \frac{E}{R_d} \\ &= 1 + \frac{E}{(3.6793 \times 10^7) \cdot K \cdot d} \cdot \frac{\mu'}{F_{pv}} \cdot \left[\frac{T_f}{h_w \cdot P_f} \right]^{\frac{1}{2}} \end{aligned}$$

K is defined as:

$$K = K_o \cdot \left(1 + \frac{E}{R_d} \right)$$

where K_o = The coefficient of discharge for infinite Reynolds number.

For large R_d we can assume $\left(1 + \frac{E}{R_d} \right)$ is equal to 1. Therefore $K = K_o$

Since E and K_o are functions only of the meter tube and orifice diameters, their values may be tabulated. Table 6.5 tabulates E and K_o combined with constants in the above equation as B , where:

$$B = \frac{E}{(3.6792 \times 10^7) \cdot K_o \cdot d}$$

Thus, the working equation for the Reynolds number factor is:

$$F_r = 1 + B \cdot \frac{\mu'}{F_{pv}} \cdot \left[\frac{T_f}{h_w \cdot P_f} \right]^{1/2}$$

3.2.4 Y_1 , Expansion Factor

The gas expansion factor based on the upstream tap pressure is:

$$Y_1 = 1 - (0.41 + 0.35 \cdot \beta^4) \cdot \frac{x}{k}$$

where

$$x = \frac{h_w}{27.70 \cdot P_f}$$

k = Ratio of specific heats (C_p/C_v) for ethylene at flowing conditions (Table 6.3).

so

$$Y_1 = 1 - \left[\frac{0.41 + 0.35 \cdot \beta^4}{27.70} \right] \cdot \left[\frac{h_w}{k \cdot P_f} \right]$$

The coefficient in the second term of the equation is a function only of the orifice and the meter tube inside diameter. Values of the coefficient are listed in Table 6.5 as C , where

$$C = \frac{0.41 + 0.35 \cdot \beta^4}{27.70}$$

Then the working equation for the expansion factor becomes:

$$Y_1 = 1 - C \cdot \left[\frac{h_w}{k \cdot P_f} \right]$$

3.2.5 F_{pb} , Pressure Base Factor

Since the AGA equations are based on 14.73 psia and the base pressure used in this manual is 14.696, the pressure base factor is:

$$F_{pb} = \frac{14.73}{14.696} = 1.0023$$

3.2.6 F_{tb} , Temperature Base Factor

Since the AGA equations are based on 60°F and the base temperature used in this manual is 60°F, the temperature base factor is unity.

3.2.7 F_{tf} , Flowing Temperature Factor

The flowing temperature factor corrects the flow to the base temperature, which in this manual is 60°F or approximately 520°R. Thus:

$$F_{tf} = \left[\frac{520}{T_f} \right]^{1/2}$$

Where T_f is the average flowing temperature in °R.

3.2.8 F_g , Specific Gravity Factor

The specific gravity factor is calculated by:

$$F_g = \left[\frac{1}{G} \right]^{1/2}$$

The ideal specific gravity of ethylene is 0.9686. Hence, for this manual:

$$F_g = \left[\frac{1}{0.9686} \right]^{1/2} = 1.0161$$

3.2.9 F_{pv} , Supercompressibility Factor

The supercompressibility factor corrects for deviations from Boyle's law when reducing the flow to base conditions. It is determined by:

$$F_{pv} = \frac{Z_b}{(Z_f)^{1/2}}$$

where

Z_b = Compressibility of ethylene at base conditions.
= 0.9938

Z_f = Compressibility of ethylene at flowing conditions.

Values of F_{pv} are in Table 6.1.

3.2.10 F_m , Mercury Manometer Factor

This factor is applied only when the meter station uses a mercury type manometer to measure the differential pressure. The mercury manometer factor corrects for the weight of ethylene over the mercury in the gas column. It is calculated as follows:

$$F_m = \left[1 - \frac{\gamma_f}{\gamma_m} \right]^{1/2}$$

Since the specific weight of mercury is 846.324 lb/cu.ft. and

$$\gamma_f = 2.5996 \cdot \left[\frac{P_f}{T_a \cdot Z_a} \right]$$

the working equation is:

$$F_m = \left[1 - \frac{P_f}{325.56 \cdot T_a \cdot Z_a} \right]^{1/2}$$

Values of F_m are given in Table 6.4.

Note: The ambient temperature is used since the gas above the mercury should be at ambient temperature. Z_a is based on the ambient temperature and the flowing pressure.

3.2.11 F_L , Gauge Location Factor

The gauge location factor is a correction to the mercury manometer factor which compensates for the difference in the force of gravity for a gauge location other than 45°N latitude and an elevation other than sea level. Refer to American Gas Association Report No. 3, Table 17A.

3.2.12 F_a , Orifice Thermal Expansion Factor

The orifice thermal expansion factor corrects for the difference in dimensions of the orifice at flowing and base temperatures. The value of this factor is very near unity at the flowing temperatures normally used when measuring ethylene. It is usually ignored by agreement between the contractual parties. The equations for calculating this factor are given in American Gas Association Report No. 3, Appendix B.

3.2.13 Final Equation

Since in this application the gas is ethylene and the base temperature and base pressure are fixed, certain factors in the orifice flow constant are constant for all meters. To facilitate calculation, those constant factors have been combined with the basic orifice factor and listed in Table 6.5 as the composite multiplier M , where:

$$\begin{aligned} M &= F_b \cdot F_{pb} \cdot F_{tb} \cdot F_g \cdot \frac{Y_b}{Z_b} \\ &= F_b \cdot (1.0023)(1)(1.0161) \frac{(0.073926)}{(0.9938)} \\ &= 0.075759 \cdot F_b \end{aligned}$$

Thus, the final equation for the weight of ethylene delivered becomes:

$$W_h = M \cdot F_r \cdot Y_1 \cdot F_{tf} \cdot F_{pv} \cdot (F_m \cdot F_L \cdot F_a) \cdot (h_w \cdot P_f)^{1/2}$$

where the factors in parentheses are calculated only if appropriate for the application. ($F_m \cdot F_L \cdot F_a$)

Turbine or Vortex Meter

A turbine meter or vortex meter measures volumetric flow rate at process conditions and produces a pulse output for totalizing. The pulse rate is linearly proportional to the volume of ethylene delivered. The totalized flow is corrected by the application of a calibration factor, provided by the manufacturer, and a prover correction factor. The weight of ethylene delivered is given by: 3.3

$$W_T = U \cdot \frac{\gamma_b}{Z_b}$$

where

U = Total delivered volume at base conditions of 60°F and 14.696 psia

γ_b = Ideal specific weight of ethylene at base conditions
= 0.073926 lb/cu.ft.

Z_b = Compressibility of ethylene at base conditions.
= 0.9938

The total volume delivered at base conditions is calculated by the following:

$$U = \frac{N_t}{K_t} \cdot \frac{P_f}{P_b} \cdot \frac{T_b}{T_f} \cdot \frac{Z_b}{Z_f} \cdot F_{tp}$$

where

N_t = Total pulses over the time of measurement

K_t = Calibration factor supplied by the meter manufacturer, actual pulse/cubic ft. of gas

F_{tp} = Prover correction factor

P_f = Flowing pressure, psia

T_f = Flowing temperature, °R

P_b = Base pressure = 14.696 psia

T_b = Base temperature = 520°R

Z_b = Compressibility of ethylene at base conditions

Z_f = Compressibility of ethylene at flowing conditions

Since there is a table of supercompressibility factors (F_{pv}) and

$$Z_f = \left[\frac{Z_b}{F_{pv}} \right]^2$$

Then,

$$U = \frac{N_t}{K_t} \cdot \frac{P_f}{P_b} \cdot \frac{T_b}{T_f} \cdot \frac{(F_{pv})^2}{Z_b} \cdot F_{tp}$$

Note: For Vortex Meter Applications, apply the necessary temperature correction factors for K_t . This factor is obtainable from the manufacturer.

Substituting in values for the constants and the specific weight of ethylene gives the working equation for the total weight in pounds of ethylene delivered as:

$$W_t = \frac{(520) \cdot (0.073926)}{(14.696) \cdot (0.9938)} \cdot \frac{P_f}{T_f} \cdot \frac{N_t}{K_t} \cdot \frac{(F_{pv})^2}{0.9938} \cdot F_{tp}$$

or

$$W_t = (2.6485) \cdot \frac{P_f}{T_f} \cdot \frac{N_t}{K_t} \cdot (F_{pv})^2 \cdot F_{tp}$$

SECTION 4 CALCULATION EXAMPLES

INTRODUCTION

4.1

It is important that the methods of performing calculations be standardized so that calculations may be repeated precisely. This may be accomplished by adhering to the following guidelines:

- . Perform calculations in the sequence used in the examples.
- . Use tabulated data exactly as given in the tables. Include the same number of digits in an interpolated number as is included in the table data.
- . Use linear interpolation of table data, except for coefficient M which includes the basic orifice factor which may not be interpolated.
- . Provide as many digits in field data as the instrument resolution justifies. This normally includes a last digit which must be estimated. Be consistent when recording the data.
- . Round each intermediate step result to five significant digits.
- . Round results for pounds of ethylene delivered to five significant digits. (Ex: 140,951.4 would be 140,950.)
- . Use calculation forms to minimize repetition and encourage method compliance.

ORIFICE METER WITH FLOW COMPUTER

4.2

The equation used by the flow computer as developed in section 3.1 is:

$$W_h = 1.0618 F_b \cdot F_r \cdot Y_1 \cdot (h_w \cdot \gamma_f)^{\frac{1}{2}}$$

where

W_h = Weight Rate of Flow

F_b = Basic orifice factor.

F_r = Reynolds number factor.

Y_1 = Expansion factor.

h_w = Differential pressure in inches of water.

γ_f = Specific weight of gas at flowing conditions in lb./cu.ft.

EXAMPLE 4.2.1

Meter Station

Tube inside diameter: 6.065 inches

Orifice diameter: 3.25 inches

Measured Quantities

T_f , flowing temperature: 95°F (555°R)

P_f , flowing pressure: 775 psig (789.7 psia)

h_w , differential pressure: 38 inches of water

Data Obtained from Tables

F_b is obtained from Table 6.5 by dividing the M coefficient by 0.075759:

$$\frac{170.516}{0.075759} = 2,250.77$$

B coefficient, Table 6.5: (1.312×10^{-5})

C coefficient, Table 6.5: (15.843×10^{-3})

μ' , viscosity, Table 6.2: 135 micropoise

k , C_p/C_v , Table 6.3: 2.0723

γ_f , flowing density, Table 6.6: 5.7360 lbs/cu.ft.

F_{pv} , supercompressibility factor, Table 6.1: 1.2339

Procedure

1. Calculate the Reynolds number factor

$$\begin{aligned} F_r &= 1 + B \cdot \left[\frac{\mu'}{F_{pv}} \right] \cdot \left[\frac{T_f^{1/2}}{(h_w \cdot P_f)^{1/2}} \right] \\ &= 1 + (1.312 \times 10^{-5}) \cdot \left[\frac{135}{1.2339} \right] \cdot \left[\frac{(555)^{1/2}}{(38 \cdot 789.7)^{1/2}} \right] \\ &= 1.0002 \end{aligned}$$

2. Calculate the expansion factor

$$\begin{aligned} Y_1 &= 1 - C \cdot \left[\frac{h_w}{k \cdot P_f} \right] \\ &= 1 - (15.843 \times 10^{-3}) \cdot \left[\frac{38}{(2.0723 \cdot 789.7)} \right] \\ &= 0.9996 \end{aligned}$$

3. Calculate the weight Flow Rate of ethylene delivered

$$\begin{aligned}
 W_h &= 1.0618 \cdot F_b \cdot F_r \cdot Y_1 \cdot (h_w \cdot \gamma_f)^{\frac{1}{2}} \\
 &= (1.0618) \cdot (2250.77) \cdot (1.0002) \cdot (0.9996) \cdot (38 \cdot 5.7360)^{\frac{1}{2}} \\
 &= 35,276 \text{ lbs/hr or } 846,624 \text{ lbs/day}
 \end{aligned}$$

ORIFICE METER WITH CHART RECORDER

The equation (developed in Section 3.2) for calculating the weight of ethylene delivered using a chart recorder is:

4.3

$$W_h = M \cdot F_r \cdot Y_1 \cdot F_{tf} \cdot F_{pv} \cdot (F_m \cdot F_l \cdot F_a) \cdot (h_w \cdot P_f)^{\frac{1}{2}}$$

where

W_h = Weight in pounds/hr. of ethylene delivered for the chart period

M = Combined factors, listed in Table 6.5

$$= F_b \cdot F_{pb} \cdot F_{tb} \cdot F_g \cdot \frac{Y_b}{Z_b}$$

F_r = Reynolds number factor

Y_1 = Expansion factor, based on upstream tap pressure

F_{tf} = Flowing temperature factor

F_{pv} = Supercompressibility factor

F_m = Mercury manometer factor

F_l = Gauge location factor

F_a = Orifice thermal expansion factor

h_w = Differential pressure in inches of water

P_f = Absolute static pressure in psia

EXAMPLE 4.3.1

Meter Station

Tube inside diameter: 4.026 inches

Orifice diameter: 1.250 inches

t , chart time: 24 hours

Manometer type: mercury

Location: 48°N latitude; 563 ft ASL

Agreements

The gauge location and orifice thermal expansion factors are assumed to be unity.

Measured Quantities

T_f , integrated flowing temperature: 103°F (563°R)

P_f , average flowing pressure for chart period: 454.4 psig
(469.1 psia)

Average ambient temperature for chart period: 73°F

h_w , average differential pressure: 45 in. H₂O

Data Obtained from Tables

M coefficient, Table 6.5: 24.049

B coefficient, Table 6.5: 1.283×10^{-5}

C coefficient, Table 6.5: 14.919×10^{-3}

F_{pv} , supercompressibility, Table 6.1: 1.0950

μ' , viscosity, Table 6.2: 117 micropoise.

k, C_p/C_v , Table 6.3: 1.4590

F_m , manometer factor, Table 6.4: 0.9983 (for 73°F ambient temperature and 454.4 psig flowing pressure)

Procedure

1. Determine the value of $(h_w \cdot P_f)^{1/2}$.

$$(h_w \cdot P_f)^{1/2} = (45 \cdot 469.1)^{1/2} \\ = 145.29$$

2. Calculate the Reynolds number factor.

$$F_r = 1 + B \cdot \left[\frac{\mu'}{F_{pv}} \right] \cdot \left[\frac{T_f^{1/2}}{(h_w \cdot P_f)^{1/2}} \right] \\ = 1 + (1.283 \times 10^{-5}) \cdot \left[\frac{117}{1.0950} \right] \cdot \left[\frac{(563)^{1/2}}{(145.29)} \right] \\ = 1.0002$$

3. Calculate the expansion factor.

$$Y_1 = 1 - C \cdot \left[\frac{h_w}{k \cdot P_f} \right]$$

$$= 1 - (14.919 \times 10^{-3}) \cdot \left[\frac{45}{(1.4590 \cdot 469.1)} \right]$$

$$= 0.9990$$

4. Calculate the flowing temperature factor.

$$F_{tf} = \left[\frac{520}{T_f} \right]^{1/2}$$

$$= \left[\frac{520}{563} \right]^{1/2}$$

$$= 0.9611$$

5. Finally, calculate the total weight of ethylene delivered using the factors computed above.

$$W_h = M \cdot F_r \cdot Y_1 \cdot F_{tf} \cdot F_{pv} \cdot (F_m \cdot F_L \cdot F_a) \cdot (h_w \cdot P_f)^{1/2}$$

$$= (24.049)(1.0002)(0.9990)(0.9611)(1.0950)(0.9983)(1.0)(1.0)(145.29)$$

$$= 3668.0 \text{ lbs/hr or } 88,032 \text{ lbs/day}$$

EXAMPLE 4.3.2

Meter Station

Tube inside diameter: 7.981 inches

Orifice diameter: 5.25 inches

t, chart time: 24 hours

Manometer type: bellows - DRI-FLO

Orifice plate material: Type 304 stainless steel

Agreements

The orifice thermal expansion factor is to be included in calculations.

Measured Quantities

T_f , integrated flowing temperature: 120°F (580°R)

P_f , average flowing pressure for chart period: 950.0
psig
(964.7 psia)

Average ambient temperature for chart period: 85°F

h_w , average differential pressure: 66.6 in. H₂O

Data Obtained from Tables

M coefficient, Table 6.5: 472.455
 B coefficient, Table 6.5: (1.737×10^{-5})
 C coefficient, Table 6.5: (17.167×10^{-3})
 F_{pv} , supercompressibility, Table 6.1: 1.2423
 μ' , viscosity, Table 6.2: 147 micropoise.
 k , C_p/C_v , Table 6.3: 2.0982
 F_m , manometer factor, Table 6.4: 1.0

Procedure

1. Determine the value $(h_w \cdot P_f)^{1/2}$.

$$\begin{aligned}(h_w \cdot P_f)^{1/2} &= (66.6 \cdot 964.7)^{1/2} \\ &= 253.47\end{aligned}$$

2. Calculate the Reynolds number factor.

$$\begin{aligned}F_R &= 1 + B \cdot \left[\frac{\mu'}{F_{pv}} \right] \cdot \left[\frac{T_f^{1/2}}{(h_w \cdot P_f)^{1/2}} \right] \\ &= 1 + (1.737 \times 10^{-5}) \cdot \left[\frac{(147)}{(1.2423)} \right] \cdot \left[\frac{(580)^{1/2}}{253.47} \right] \\ &= 1.0002\end{aligned}$$

3. Calculate the expansion factor.

$$\begin{aligned}Y_1 &= 1 - C \cdot \left[\frac{h_w}{k \cdot P_f} \right] \\ &= 1 - (17.167 \times 10^{-3}) \cdot \left[\frac{66.6}{(2.0982 \cdot 964.7)} \right] \\ &= 0.9994\end{aligned}$$

4. Calculate the flowing temperature factor.

$$\begin{aligned}F_{tf} &= \left[\frac{520}{T_f} \right]^{1/2} \\ &= \left[\frac{520}{580} \right]^{1/2} \\ &= 0.9469\end{aligned}$$

5. Calculate the orifice thermal expansion factor. (From AGA-3, Appendix B)

$$\begin{aligned} F_a &= 1 + 0.0000185 \cdot (^{\circ}\text{F} - 68) \\ &= 1 + 0.0000185 \cdot (120 - 68) \\ &= 1.0010 \end{aligned}$$

6. Finally, calculate the total weight of ethylene delivered.

$$\begin{aligned} W_h &= M \cdot F_r \cdot Y_1 \cdot F_{tf} \cdot F_{pv} \cdot (F_m \cdot F_l \cdot F_a) \cdot (h_w \cdot P_f)^{1/2} \\ &= (472.455)(1.0002)(0.9994)(0.9469)(1.2423)(1.0)(1.0)(1.0010)(253.47) \\ &= 140,950 \text{ lbs/hr or } 3,382,800 \text{ lbs/day} \end{aligned}$$

TURBINE OR VORTEX METER

4.4

The equation for calculating the weight of ethylene delivered for a turbine or vortex meter (developed in Section 3.3) is:

$$W_t = 2.6485 \cdot \frac{P_f}{T_f} \cdot \frac{N_t}{K_t} \cdot F_{pv}^2 \cdot F_{tp}$$

where

W_t = Weight in pounds of ethylene delivered during the time of measurement

P_f = Flowing pressure, psia

T_f = Flowing temperature, $^{\circ}\text{R}$

F_{pv} = Supercompressibility factor for ethylene at flowing conditions

F_{tp} = Prover correction factor

K_t = Calibration factor supplied by the meter manufacturer, actual pulses/cu. ft.

N_t = Total pulses over the time of measurement

EXAMPLE 4.4.1

Meter Data

K_t , manufacturer's calibration factor: 10.3961

F_{tp} , prover correction factor: 0.98934

N_t , total pulses: 631,490

Measured Quantities

P_f , flowing pressure: 646 psig (660.7 psia)

T_f , flowing temperature: 85°F (545°R)

Data Obtained from Tables

F_{pv} , supercompressibility, Table 6.1: 1.1911

Procedure

The weight of ethylene during the time period of measurement is calculated directly using the data above.

$$\begin{aligned}
 W_t &= 2.6485 \cdot \frac{P_f}{T_f} \cdot \frac{N_t}{K_t} \cdot F_{pv}^2 \cdot F_{tp} \\
 &= \frac{2.6485 \cdot 660.7 \cdot 631490}{545 \cdot 10.3961} \cdot (1.1911)^2 \cdot (0.98934) \\
 &= 273,750 \text{ pounds}
 \end{aligned}$$

SECTION 5

REFERENCES

1. Orifice Metering of Natural Gas, Report No. 3, American Gas Association.
2. API Manual of Petroleum Measurement, Chapter 11.3.2.1, "Ethylene Density", published as a Fortran IV computer card deck, Stock Number 852-25650, American Petroleum Institute. (Note: This is API Standard 2565)
3. Engineering Data Book, Gas Processors Suppliers Association (1981).
4. A.G.A. Gas Measurement Manual, American Gas Association (1964).

SECTION 6

DATA TABLES

Tables 6.1 through 6.4 include data for the temperature range 20 to 140°F and the pressure range 220 to 2000 psig. Data in Table 6.1 below 65°F is outside the range of the data provided by the American Petroleum Institute and was extrapolated from the API 2565 data using a least squares polynomial curve fitting technique.

TABLE 6.1 Ethylene Supercompressibility, F_{pv} .

TABLE 6.2 Ethylene Viscosity, μ' , micropoise.

TABLE 6.3 Ethylene Ratio of Specific Heats, k

TABLE 6.4 Mercury Manometer Factor, F_m

TABLE 6.5 Calculation Coefficients M , B & C (See Note)

TABLE 6.6 Ethylene Density

NOTE:

M is equal to $F_b \cdot F_{pb} \cdot F_{tb} \cdot F_g \cdot Y_b$, and is used in the equation for the weight of ethylene delivered (Section 3.2.13). (For Ethylene: $M = 0.075759 \cdot F_b$)

B is used in calculating the Reynolds number factor (Section 3.2.3). Note that entries must be multiplied by 10^{-5} .

C is used in calculating the expansion factor (Section 3.2.4). Note that entries must be multiplied by 10^{-3} .

TABLE 6.1 - ETHYLENE FLOW MEASUREMENT MANUAL

ETHYLENE SUPERCOMPRESSIBILITY

EXTRAPOLATED API STANDARD 2565

TEMP. F	PRESSURE, PSIG										TEMP. F	
	220	230	240	250	260	270	280	290	300	310		320
20	1.0756	1.0800	1.0846	1.0893	1.0941	1.0991	1.1043	1.1095	1.1149	1.1204	1.1262	20
25	1.0717	1.0760	1.0803	1.0847	1.0893	1.0940	1.0988	1.1038	1.1088	1.1141	1.1195	25
30	1.0681	1.0721	1.0762	1.0804	1.0848	1.0892	1.0938	1.0985	1.1033	1.1082	1.1133	30
35	1.0655	1.0693	1.0732	1.0772	1.0812	1.0854	1.0897	1.0941	1.0987	1.1033	1.1081	35
40	1.0636	1.0672	1.0708	1.0746	1.0784	1.0824	1.0864	1.0906	1.0948	1.0991	1.1036	40
45	1.0609	1.0644	1.0679	1.0714	1.0751	1.0789	1.0827	1.0866	1.0906	1.0946	1.0988	45
50	1.0584	1.0617	1.0651	1.0685	1.0720	1.0755	1.0792	1.0829	1.0866	1.0905	1.0944	50
55	1.0562	1.0593	1.0625	1.0658	1.0691	1.0724	1.0759	1.0794	1.0829	1.0866	1.0903	55
60	1.0542	1.0571	1.0601	1.0632	1.0663	1.0695	1.0728	1.0761	1.0795	1.0829	1.0864	60
65	1.0520	1.0549	1.0578	1.0608	1.0638	1.0669	1.0700	1.0731	1.0763	1.0796	1.0829	65
70	1.0500	1.0528	1.0556	1.0585	1.0614	1.0644	1.0674	1.0704	1.0734	1.0764	1.0795	70
75	1.0471	1.0498	1.0525	1.0552	1.0580	1.0608	1.0636	1.0665	1.0694	1.0724	1.0754	75
80	1.0464	1.0488	1.0513	1.0539	1.0565	1.0591	1.0618	1.0645	1.0673	1.0702	1.0730	80
85	1.0446	1.0470	1.0494	1.0519	1.0544	1.0569	1.0594	1.0621	1.0647	1.0674	1.0701	85
90	1.0430	1.0453	1.0476	1.0499	1.0523	1.0548	1.0572	1.0597	1.0622	1.0648	1.0674	90
95	1.0414	1.0436	1.0459	1.0481	1.0505	1.0528	1.0552	1.0575	1.0599	1.0624	1.0648	95
100	1.0399	1.0420	1.0442	1.0464	1.0487	1.0509	1.0532	1.0555	1.0578	1.0601	1.0624	100
105	1.0381	1.0402	1.0423	1.0444	1.0466	1.0487	1.0509	1.0531	1.0553	1.0575	1.0598	105
110	1.0364	1.0384	1.0404	1.0425	1.0445	1.0466	1.0487	1.0509	1.0530	1.0551	1.0573	110
115	1.0347	1.0367	1.0386	1.0406	1.0426	1.0446	1.0466	1.0487	1.0507	1.0528	1.0549	115
120	1.0331	1.0350	1.0369	1.0388	1.0407	1.0426	1.0446	1.0465	1.0485	1.0505	1.0526	120
125	1.0318	1.0336	1.0354	1.0372	1.0391	1.0409	1.0428	1.0447	1.0466	1.0486	1.0505	125
130	1.0306	1.0323	1.0341	1.0358	1.0376	1.0394	1.0412	1.0431	1.0449	1.0468	1.0486	130
135	1.0295	1.0311	1.0328	1.0345	1.0362	1.0380	1.0397	1.0415	1.0433	1.0451	1.0469	135
140	1.0284	1.0300	1.0316	1.0333	1.0349	1.0366	1.0383	1.0400	1.0417	1.0434	1.0452	140

PRESSURE, PSIG = 220 TO 320

TABLE 6.1 - ETHYLENE FLOW MEASUREMENT MANUAL

ETHYLENE SUPERCOMPRESSIBILITY

EXTRAPOLATED API STANDARD 2565

TEMP. F	PRESSURE, PSIG											TEMP. F
	320	330	340	350	360	370	380	390	400	410	420	
20	1.1262	1.1322	1.1384	1.1449	1.1517	1.1588	1.1663	1.1741	1.1823	1.1909	1.2001	20
25	1.1195	1.1251	1.1309	1.1369	1.1432	1.1497	1.1565	1.1636	1.1710	1.1788	1.1870	25
30	1.1133	1.1186	1.1240	1.1296	1.1354	1.1414	1.1477	1.1542	1.1611	1.1682	1.1756	30
35	1.1081	1.1130	1.1181	1.1233	1.1287	1.1342	1.1400	1.1459	1.1522	1.1587	1.1654	35
40	1.1036	1.1082	1.1129	1.1177	1.1227	1.1278	1.1331	1.1386	1.1443	1.1501	1.1562	40
45	1.0988	1.1031	1.1075	1.1120	1.1167	1.1214	1.1264	1.1314	1.1366	1.1420	1.1475	45
50	1.0944	1.0984	1.1026	1.1068	1.1111	1.1156	1.1201	1.1248	1.1296	1.1346	1.1397	50
55	1.0903	1.0941	1.0980	1.1019	1.1060	1.1102	1.1144	1.1188	1.1233	1.1279	1.1326	55
60	1.0864	1.0900	1.0937	1.0974	1.1013	1.1052	1.1092	1.1133	1.1175	1.1218	1.1262	60
65	1.0829	1.0862	1.0897	1.0932	1.0968	1.1005	1.1042	1.1081	1.1120	1.1160	1.1201	65
70	1.0795	1.0827	1.0860	1.0893	1.0927	1.0961	1.0996	1.1032	1.1069	1.1106	1.1145	70
75	1.0754	1.0785	1.0816	1.0848	1.0880	1.0913	1.0946	1.0980	1.1015	1.1051	1.1087	75
80	1.0730	1.0760	1.0789	1.0820	1.0850	1.0882	1.0913	1.0946	1.0978	1.1011	1.1045	80
85	1.0701	1.0729	1.0758	1.0786	1.0815	1.0845	1.0875	1.0906	1.0936	1.0968	1.1000	85
90	1.0674	1.0701	1.0727	1.0755	1.0782	1.0810	1.0839	1.0868	1.0897	1.0927	1.0957	90
95	1.0648	1.0674	1.0699	1.0725	1.0751	1.0777	1.0804	1.0832	1.0860	1.0888	1.0917	95
100	1.0624	1.0648	1.0672	1.0696	1.0721	1.0746	1.0772	1.0798	1.0824	1.0851	1.0879	100
105	1.0598	1.0621	1.0644	1.0667	1.0691	1.0715	1.0740	1.0764	1.0790	1.0815	1.0841	105
110	1.0573	1.0595	1.0617	1.0640	1.0662	1.0685	1.0709	1.0733	1.0757	1.0781	1.0806	110
115	1.0549	1.0570	1.0591	1.0613	1.0635	1.0657	1.0680	1.0702	1.0725	1.0749	1.0772	115
120	1.0526	1.0546	1.0567	1.0588	1.0609	1.0630	1.0652	1.0674	1.0696	1.0718	1.0740	120
125	1.0505	1.0525	1.0545	1.0565	1.0585	1.0606	1.0626	1.0647	1.0668	1.0689	1.0711	125
130	1.0486	1.0505	1.0525	1.0544	1.0563	1.0583	1.0603	1.0623	1.0643	1.0663	1.0684	130
135	1.0469	1.0487	1.0505	1.0524	1.0543	1.0561	1.0580	1.0600	1.0619	1.0638	1.0658	135
140	1.0452	1.0469	1.0487	1.0505	1.0523	1.0541	1.0559	1.0578	1.0596	1.0615	1.0634	140

PRESSURE, PSIG = 320 TO 420

STD-API/PETRO MPMS 11.3.2.1-ENGL 1974 0732290 0626074 721

TABLE 6.1 - ETHYLENE FLOW MEASUREMENT MANUAL

ETHYLENE SUPERCOMPRESSIBILITY

EXTRAPOLATED API STANDARD 2565

TEMP. F	PRESSURE, PSIG											TEMP. F
	420	430	440	450	460	470	480	490	500	510	520	
20	1.2001	1.2098	1.2202	1.2313	1.2432	1.2562	1.2704	1.2861	1.3036			20
25	1.1870	1.1956	1.2047	1.2143	1.2245	1.2354	1.2472	1.2597	1.2732	1.2881	1.3047	25
30	1.1756	1.1834	1.1915	1.2000	1.2090	1.2184	1.2284	1.2388	1.2497	1.2614	1.2742	30
35	1.1654	1.1724	1.1796	1.1872	1.1951	1.2034	1.2122	1.2212	1.2306	1.2405	1.2512	35
40	1.1562	1.1624	1.1690	1.1757	1.1828	1.1901	1.1978	1.2059	1.2146	1.2237	1.2332	40
45	1.1475	1.1533	1.1592	1.1653	1.1717	1.1782	1.1851	1.1923	1.1999	1.2078	1.2160	45
50	1.1397	1.1449	1.1504	1.1559	1.1617	1.1677	1.1738	1.1803	1.1869	1.1938	1.2010	50
55	1.1326	1.1375	1.1425	1.1476	1.1529	1.1584	1.1640	1.1698	1.1758	1.1820	1.1884	55
60	1.1262	1.1307	1.1353	1.1401	1.1450	1.1500	1.1552	1.1605	1.1659	1.1715	1.1773	60
65	1.1201	1.1243	1.1286	1.1330	1.1375	1.1421	1.1469	1.1517	1.1567	1.1618	1.1671	65
70	1.1145	1.1184	1.1224	1.1265	1.1306	1.1349	1.1393	1.1438	1.1484	1.1531	1.1579	70
75	1.1087	1.1123	1.1161	1.1199	1.1238	1.1278	1.1319	1.1361	1.1403	1.1447	1.1492	75
80	1.1045	1.1080	1.1115	1.1151	1.1187	1.1225	1.1263	1.1301	1.1341	1.1381	1.1422	80
85	1.1000	1.1032	1.1065	1.1099	1.1133	1.1168	1.1204	1.1240	1.1277	1.1314	1.1352	85
90	1.0957	1.0988	1.1019	1.1051	1.1083	1.1116	1.1149	1.1183	1.1218	1.1252	1.1288	90
95	1.0917	1.0946	1.0976	1.1006	1.1036	1.1067	1.1099	1.1131	1.1163	1.1196	1.1229	95
100	1.0879	1.0907	1.0935	1.0963	1.0992	1.1022	1.1051	1.1081	1.1112	1.1143	1.1174	100
105	1.0841	1.0868	1.0894	1.0921	1.0949	1.0977	1.1005	1.1033	1.1062	1.1091	1.1121	105
110	1.0806	1.0831	1.0856	1.0882	1.0908	1.0934	1.0961	1.0988	1.1015	1.1043	1.1071	110
115	1.0772	1.0796	1.0820	1.0845	1.0869	1.0894	1.0920	1.0945	1.0971	1.0997	1.1024	115
120	1.0740	1.0763	1.0786	1.0809	1.0833	1.0856	1.0880	1.0905	1.0929	1.0954	1.0979	120
125	1.0711	1.0733	1.0754	1.0777	1.0799	1.0822	1.0845	1.0868	1.0891	1.0915	1.0938	125
130	1.0684	1.0705	1.0725	1.0747	1.0768	1.0790	1.0811	1.0833	1.0856	1.0878	1.0901	130
135	1.0658	1.0678	1.0698	1.0718	1.0739	1.0759	1.0780	1.0801	1.0822	1.0843	1.0865	135
140	1.0634	1.0653	1.0672	1.0691	1.0711	1.0730	1.0750	1.0770	1.0790	1.0811	1.0831	140

PRESSURE, PSIG = 420 TO 520

TABLE 6.1 - ETHYLENE FLOW MEASUREMENT MANUAL

ETHYLENE SUPERCOMPRESSIBILITY

EXTRAPOLATED API STANDARD 2565

PRESSURE, PSIG												
TEMP. F	520	530	540	550	560	570	580	590	600	610	620	TEMP. F
20												20
25	1.3047	1.3236										25
30	1.2742	1.2883	1.3039	1.3215	1.3416	1.3654						30
35	1.2512	1.2627	1.2751	1.2887	1.3036	1.3201	1.3388	1.3601	1.3853	1.4170		35
40	1.2332	1.2433	1.2540	1.2655	1.2777	1.2908	1.3051	1.3202	1.3364	1.3548	1.3764	40
45	1.2160	1.2247	1.2337	1.2433	1.2534	1.2642	1.2757	1.2875	1.2997	1.3132	1.3282	45
50	1.2010	1.2086	1.2164	1.2246	1.2332	1.2422	1.2518	1.2615	1.2716	1.2823	1.2940	50
55	1.1884	1.1951	1.2020	1.2092	1.2167	1.2246	1.2328	1.2411	1.2495	1.2585	1.2680	55
60	1.1773	1.1832	1.1894	1.1958	1.2025	1.2093	1.2165	1.2237	1.2311	1.2388	1.2469	60
65	1.1671	1.1725	1.1781	1.1838	1.1898	1.1959	1.2023	1.2087	1.2152	1.2220	1.2291	65
70	1.1579	1.1628	1.1679	1.1731	1.1785	1.1841	1.1898	1.1956	1.2015	1.2076	1.2139	70
75	1.1492	1.1537	1.1584	1.1632	1.1681	1.1732	1.1784	1.1837	1.1891	1.1947	1.2005	75
80	1.1422	1.1464	1.1507	1.1551	1.1597	1.1643	1.1690	1.1738	1.1788	1.1838	1.1890	80
85	1.1352	1.1391	1.1431	1.1472	1.1514	1.1556	1.1599	1.1644	1.1689	1.1735	1.1782	85
90	1.1288	1.1324	1.1361	1.1399	1.1437	1.1477	1.1517	1.1557	1.1599	1.1641	1.1684	90
95	1.1229	1.1263	1.1298	1.1333	1.1369	1.1405	1.1442	1.1480	1.1518	1.1557	1.1596	95
100	1.1174	1.1206	1.1239	1.1272	1.1305	1.1339	1.1374	1.1409	1.1444	1.1480	1.1516	100
105	1.1121	1.1151	1.1181	1.1212	1.1244	1.1276	1.1308	1.1341	1.1374	1.1407	1.1441	105
110	1.1071	1.1099	1.1128	1.1157	1.1186	1.1216	1.1247	1.1278	1.1308	1.1340	1.1371	110
115	1.1024	1.1050	1.1078	1.1105	1.1133	1.1161	1.1190	1.1219	1.1248	1.1277	1.1307	115
120	1.0979	1.1005	1.1030	1.1056	1.1083	1.1109	1.1136	1.1164	1.1191	1.1219	1.1247	120
125	1.0938	1.0962	1.0987	1.1012	1.1036	1.1062	1.1087	1.1113	1.1139	1.1165	1.1192	125
130	1.0901	1.0924	1.0947	1.0970	1.0994	1.1018	1.1042	1.1066	1.1091	1.1115	1.1140	130
135	1.0865	1.0887	1.0909	1.0931	1.0953	1.0976	1.0999	1.1022	1.1045	1.1069	1.1092	135
140	1.0831	1.0852	1.0873	1.0894	1.0915	1.0937	1.0959	1.0981	1.1003	1.1025	1.1047	140

PRESSURE, PSIG = 520 TO 620

TABLE 6.1 - ETHYLENE FLOW MEASUREMENT MANUAL

ETHYLENE SUPERCOMPRESSIBILITY

EXTRAPOLATED API STANDARD 2565

TEMP. F	PRESSURE, PSIG											TEMP. F
	620	630	640	650	660	670	680	690	700	710	720	
20												20
25												25
30												30
35												35
40	1.3764	1.4023	1.4353	1.4822								40
45	1.3282	1.3449	1.3639	1.3860	1.4124	1.4455	1.4916	1.5822				45
50	1.2940	1.3066	1.3204	1.3355	1.3524	1.3715	1.3934	1.4193	1.4511	1.4929	1.5571	50
55	1.2680	1.2781	1.2890	1.3007	1.3133	1.3270	1.3420	1.3587	1.3774	1.3986	1.4230	55
60	1.2469	1.2554	1.2644	1.2740	1.2841	1.2949	1.3064	1.3190	1.3325	1.3473	1.3634	60
65	1.2291	1.2365	1.2442	1.2524	1.2609	1.2699	1.2793	1.2894	1.3001	1.3115	1.3237	65
70	1.2139	1.2205	1.2273	1.2344	1.2418	1.2495	1.2575	1.2660	1.2749	1.2842	1.2940	70
75	1.2005	1.2065	1.2126	1.2190	1.2255	1.2324	1.2394	1.2467	1.2543	1.2622	1.2705	75
80	1.1890	1.1943	1.1998	1.2055	1.2113	1.2173	1.2235	1.2299	1.2365	1.2434	1.2504	80
85	1.1782	1.1830	1.1880	1.1931	1.1983	1.2037	1.2092	1.2149	1.2207	1.2267	1.2330	85
90	1.1684	1.1728	1.1773	1.1820	1.1867	1.1916	1.1965	1.2016	1.2069	1.2122	1.2178	90
95	1.1596	1.1637	1.1678	1.1720	1.1763	1.1807	1.1852	1.1898	1.1946	1.1994	1.2044	95
100	1.1516	1.1553	1.1591	1.1630	1.1669	1.1709	1.1750	1.1792	1.1835	1.1879	1.1924	100
105	1.1441	1.1475	1.1511	1.1546	1.1583	1.1620	1.1658	1.1696	1.1736	1.1776	1.1817	105
110	1.1371	1.1404	1.1437	1.1470	1.1504	1.1538	1.1573	1.1609	1.1645	1.1682	1.1720	110
115	1.1307	1.1337	1.1368	1.1399	1.1431	1.1463	1.1496	1.1529	1.1562	1.1597	1.1631	115
120	1.1247	1.1276	1.1305	1.1334	1.1364	1.1394	1.1424	1.1455	1.1486	1.1518	1.1550	120
125	1.1192	1.1219	1.1246	1.1273	1.1301	1.1330	1.1358	1.1387	1.1416	1.1446	1.1476	125
130	1.1140	1.1166	1.1191	1.1217	1.1244	1.1270	1.1297	1.1324	1.1351	1.1379	1.1407	130
135	1.1092	1.1116	1.1141	1.1165	1.1190	1.1215	1.1240	1.1265	1.1291	1.1317	1.1343	135
140	1.1047	1.1070	1.1093	1.1116	1.1139	1.1163	1.1187	1.1211	1.1235	1.1259	1.1284	140

PRESSURE, PSIG = 620 TO 720

TABLE 6.1 - ETHYLENE FLOW MEASUREMENT MANUAL

ETHYLENE SUPERCOMPRESSIBILITY

EXTRAPOLATED API STANDARD 2565

TEMP. F	PRESSURE, PSIG											TEMP. F
	720	730	740	750	760	770	780	790	800	810	820	
20												20
25												25
30												30
35												35
40												40
45												45
50	1.5571	2.1294	2.1473	2.1560	2.1598	2.1608	2.1598	2.1576	2.1544	2.1505	2.1459	50
55	1.4230	1.4518	1.4874	1.5345	1.6068	1.8048	1.9699	2.0128	2.0346	2.0473	2.0548	55
60	1.3634	1.3811	1.4007	1.4229	1.4483	1.4779	1.5137	1.5585	1.6174	1.6968	1.7872	60
65	1.3237	1.3367	1.3506	1.3657	1.3821	1.4000	1.4198	1.4418	1.4665	1.4945	1.5267	65
70	1.2940	1.3043	1.3152	1.3268	1.3390	1.3521	1.3660	1.3810	1.3970	1.4144	1.4332	70
75	1.2705	1.2791	1.2880	1.2974	1.3072	1.3176	1.3284	1.3397	1.3516	1.3642	1.3775	75
80	1.2504	1.2578	1.2654	1.2733	1.2815	1.2900	1.2989	1.3081	1.3175	1.3274	1.3377	80
85	1.2330	1.2394	1.2460	1.2528	1.2598	1.2671	1.2746	1.2823	1.2901	1.2982	1.3067	85
90	1.2178	1.2234	1.2292	1.2352	1.2414	1.2477	1.2542	1.2608	1.2675	1.2744	1.2815	90
95	1.2044	1.2094	1.2146	1.2199	1.2254	1.2310	1.2367	1.2425	1.2483	1.2543	1.2605	95
100	1.1924	1.1970	1.2017	1.2065	1.2113	1.2163	1.2214	1.2266	1.2317	1.2370	1.2425	100
105	1.1817	1.1859	1.1901	1.1944	1.1989	1.2034	1.2080	1.2126	1.2172	1.2220	1.2268	105
110	1.1720	1.1758	1.1797	1.1836	1.1877	1.1918	1.1959	1.2001	1.2043	1.2086	1.2130	110
115	1.1631	1.1666	1.1702	1.1738	1.1775	1.1813	1.1851	1.1889	1.1928	1.1967	1.2007	115
120	1.1550	1.1583	1.1616	1.1649	1.1683	1.1718	1.1753	1.1788	1.1823	1.1859	1.1896	120
125	1.1476	1.1506	1.1536	1.1567	1.1599	1.1631	1.1663	1.1696	1.1728	1.1762	1.1795	125
130	1.1407	1.1435	1.1464	1.1492	1.1522	1.1551	1.1581	1.1611	1.1642	1.1673	1.1704	130
135	1.1343	1.1369	1.1396	1.1423	1.1450	1.1478	1.1506	1.1534	1.1562	1.1591	1.1620	135
140	1.1284	1.1308	1.1333	1.1359	1.1384	1.1410	1.1436	1.1462	1.1489	1.1515	1.1542	140

PRESSURE, PSIG = 720 TO 820

TABLE 6.1 - ETHYLENE FLOW MEASUREMENT MANUAL

ETHYLENE SUPERCOMPRESSIBILITY

EXTRAPOLATED API STANDARD 2565

TEMP. F	PRESSURE, PSIG											TEMP. F
	820	830	840	850	860	870	880	890	900	910	920	
20												20
25												25
30												30
35												35
40												40
45												45
50	2.1459	2.1408	2.1354	2.1296	2.1236	2.1174	2.1111	2.1046	2.0981	2.0916	2.0850	50
55	2.0548	2.0591	2.0611	2.0615	2.0607	2.0589	2.0563	2.0533	2.0498	2.0459	2.0417	55
60	1.7872	1.8562	1.8993	1.9266	1.9447	1.9570	1.9653	1.9710	1.9747	1.9769	1.9778	60
65	1.5267	1.5637	1.6063	1.6537	1.7028	1.7486	1.7871	1.8177	1.8414	1.8594	1.8730	65
70	1.4332	1.4537	1.4762	1.5007	1.5275	1.5565	1.5874	1.6197	1.6522	1.6834	1.7119	70
75	1.3775	1.3917	1.4068	1.4229	1.4401	1.4584	1.4778	1.4987	1.5209	1.5440	1.5676	75
80	1.3377	1.3485	1.3599	1.3718	1.3844	1.3976	1.4114	1.4262	1.4420	1.4584	1.4754	80
85	1.3067	1.3155	1.3246	1.3341	1.3440	1.3542	1.3649	1.3763	1.3884	1.4009	1.4138	85
90	1.2815	1.2889	1.2965	1.3044	1.3125	1.3209	1.3296	1.3388	1.3485	1.3585	1.3688	90
95	1.2605	1.2668	1.2734	1.2801	1.2870	1.2941	1.3014	1.3090	1.3171	1.3254	1.3339	95
100	1.2425	1.2480	1.2537	1.2596	1.2656	1.2717	1.2780	1.2845	1.2915	1.2985	1.3057	100
105	1.2268	1.2317	1.2368	1.2420	1.2472	1.2526	1.2581	1.2639	1.2698	1.2759	1.2821	105
110	1.2130	1.2174	1.2220	1.2266	1.2313	1.2361	1.2410	1.2460	1.2513	1.2566	1.2620	110
115	1.2007	1.2047	1.2088	1.2130	1.2173	1.2216	1.2260	1.2305	1.2351	1.2398	1.2446	115
120	1.1896	1.1933	1.1971	1.2009	1.2048	1.2087	1.2127	1.2167	1.2209	1.2250	1.2293	120
125	1.1795	1.1829	1.1864	1.1899	1.1935	1.1971	1.2007	1.2044	1.2081	1.2119	1.2157	125
130	1.1704	1.1735	1.1767	1.1799	1.1832	1.1865	1.1898	1.1932	1.1966	1.2000	1.2035	130
135	1.1620	1.1649	1.1678	1.1708	1.1738	1.1769	1.1800	1.1831	1.1862	1.1894	1.1925	135
140	1.1542	1.1569	1.1597	1.1625	1.1653	1.1681	1.1709	1.1738	1.1767	1.1796	1.1826	140

PRESSURE, PSIG = 820 TO 920

TABLE 6.1 - ETHYLENE FLOW MEASUREMENT MANUAL

ETHYLENE SUPERCOMPRESSIBILITY

EXTRAPOLATED API STANDARD 2565

TEMP. F	PRESSURE, PSIG										TEMP. F	
	920	930	940	950	960	970	980	990	1000	1010		1020
20												20
25												25
30												30
35												35
40												40
45												45
50	2.0850	2.0783	2.0716	2.0649	2.0581	2.0514	2.0447	2.0379	2.0312	2.0244	2.0177	50
55	2.0417	2.0372	2.0325	2.0276	2.0226	2.0174	2.0121	2.0067	2.0011	1.9955	1.9899	55
60	1.9778	1.9777	1.9769	1.9754	1.9734	1.9709	1.9681	1.9648	1.9613	1.9576	1.9536	60
65	1.8730	1.8834	1.8911	1.8969	1.9010	1.9038	1.9055	1.9064	1.9064	1.9059	1.9048	65
70	1.7119	1.7371	1.7587	1.7768	1.7919	1.8042	1.8142	1.8222	1.8286	1.8335	1.8373	70
75	1.5676	1.5914	1.6148	1.6373	1.6586	1.6781	1.6958	1.7115	1.7252	1.7371	1.7473	75
80	1.4754	1.4930	1.5109	1.5292	1.5475	1.5657	1.5834	1.6005	1.6167	1.6320	1.6461	80
85	1.4138	1.4271	1.4408	1.4548	1.4691	1.4836	1.4982	1.5128	1.5272	1.5414	1.5553	85
90	1.3688	1.3794	1.3902	1.4013	1.4127	1.4243	1.4360	1.4479	1.4598	1.4717	1.4837	90
95	1.3339	1.3426	1.3515	1.3606	1.3699	1.3794	1.3890	1.3987	1.4085	1.4184	1.4284	95
100	1.3057	1.3130	1.3205	1.3282	1.3360	1.3439	1.3519	1.3601	1.3683	1.3766	1.3850	100
105	1.2821	1.2885	1.2949	1.3014	1.3081	1.3148	1.3217	1.3286	1.3356	1.3427	1.3499	105
110	1.2620	1.2676	1.2731	1.2788	1.2846	1.2904	1.2964	1.3024	1.3084	1.3145	1.3207	110
115	1.2446	1.2494	1.2544	1.2593	1.2644	1.2695	1.2747	1.2799	1.2852	1.2906	1.2960	115
120	1.2293	1.2336	1.2379	1.2423	1.2468	1.2513	1.2559	1.2605	1.2651	1.2699	1.2746	120
125	1.2157	1.2195	1.2234	1.2274	1.2314	1.2354	1.2395	1.2437	1.2478	1.2520	1.2563	125
130	1.2035	1.2070	1.2106	1.2142	1.2178	1.2215	1.2252	1.2289	1.2327	1.2365	1.2404	130
135	1.1925	1.1958	1.1990	1.2023	1.2056	1.2090	1.2124	1.2158	1.2192	1.2227	1.2262	135
140	1.1826	1.1855	1.1885	1.1916	1.1946	1.1977	1.2008	1.2039	1.2071	1.2103	1.2134	140

PRESSURE, PSIG = 920 TO 1020

TABLE 6.1 - ETHYLENE FLOW MEASUREMENT MANUAL

ETHYLENE SUPERCOMPRESSIBILITY

EXTRAPOLATED API STANDARD 2565

TEMP. F	PRESSURE, PSIG											TEMP. F
	1020	1030	1040	1050	1060	1070	1080	1090	1100	1110	1120	
20												
25												20
30												25
35												30
40												35
												40
45												
50	2.0177	2.0111	2.0044	1.9978	1.9913	1.9847	1.9782	1.9717	1.9652	1.9586	1.9522	45
55	1.9899	1.9842	1.9785	1.9728	1.9671	1.9614	1.9556	1.9498	1.9439	1.9379	1.9320	50
60	1.9536	1.9495	1.9453	1.9409	1.9364	1.9318	1.9272	1.9224	1.9173	1.9123	1.9072	55
65	1.9048	1.9032	1.9013	1.8991	1.8965	1.8938	1.8908	1.8874	1.8838	1.8800	1.8761	60
												65
70	1.8373	1.8400	1.8420	1.8432	1.8437	1.8438	1.8433	1.8423	1.8408	1.8389	1.8367	70
75	1.7473	1.7560	1.7634	1.7695	1.7745	1.7786	1.7819	1.7842	1.7856	1.7865	1.7869	75
80	1.6461	1.6591	1.6708	1.6814	1.6908	1.6992	1.7065	1.7126	1.7177	1.7219	1.7255	80
85	1.5553	1.5687	1.5815	1.5937	1.6051	1.6158	1.6257	1.6346	1.6425	1.6496	1.6560	85
90	1.4837	1.4955	1.5072	1.5186	1.5298	1.5406	1.5509	1.5606	1.5697	1.5782	1.5862	90
95	1.4284	1.4385	1.4485	1.4585	1.4684	1.4782	1.4878	1.4970	1.5058	1.5144	1.5226	95
100	1.3850	1.3935	1.4020	1.4105	1.4191	1.4276	1.4361	1.4444	1.4525	1.4604	1.4682	100
105	1.3499	1.3571	1.3644	1.3717	1.3791	1.3865	1.3939	1.4012	1.4084	1.4155	1.4226	105
110	1.3207	1.3269	1.3332	1.3396	1.3460	1.3524	1.3589	1.3653	1.3717	1.3780	1.3843	110
115	1.2960	1.3014	1.3069	1.3125	1.3181	1.3237	1.3293	1.3350	1.3407	1.3464	1.3520	115
120	1.2746	1.2794	1.2843	1.2892	1.2941	1.2991	1.3041	1.3091	1.3142	1.3193	1.3244	120
125	1.2563	1.2606	1.2649	1.2693	1.2737	1.2781	1.2825	1.2871	1.2916	1.2962	1.3009	125
130	1.2404	1.2442	1.2481	1.2521	1.2560	1.2600	1.2640	1.2681	1.2722	1.2763	1.2805	130
135	1.2262	1.2297	1.2332	1.2368	1.2404	1.2440	1.2476	1.2513	1.2551	1.2588	1.2626	135
140	1.2134	1.2167	1.2199	1.2232	1.2264	1.2297	1.2330	1.2364	1.2398	1.2432	1.2466	140

PRESSURE, PSIG = 1020 TO 1120

TABLE 6.1 - ETHYLENE FLOW MEASUREMENT MANUAL

ETHYLENE SUPERCOMPRESSIBILITY

EXTRAPOLATED API STANDARD 2565

TEMP. F	PRESSURE, PSIG											TEMP. F
	1120	1130	1140	1150	1160	1170	1180	1190	1200	1210	1220	
20												20
25												25
30												30
35												35
40												40
45												45
50	1.9522	1.9458	1.9394	1.9331	1.9268	1.9206	1.9144	1.9083	1.9023	1.8963	1.8904	50
55	1.9320	1.9262	1.9203	1.9145	1.9087	1.9029	1.8972	1.8915	1.8859	1.8803	1.8747	55
60	1.9072	1.9021	1.8969	1.8918	1.8866	1.8815	1.8763	1.8712	1.8661	1.8611	1.8560	60
65	1.8761	1.8721	1.8680	1.8638	1.8596	1.8553	1.8509	1.8466	1.8422	1.8379	1.8335	65
70	1.8367	1.8343	1.8317	1.8290	1.8260	1.8229	1.8197	1.8164	1.8131	1.8097	1.8062	70
75	1.7869	1.7868	1.7863	1.7855	1.7844	1.7830	1.7813	1.7795	1.7776	1.7755	1.7732	75
80	1.7255	1.7284	1.7307	1.7324	1.7337	1.7345	1.7349	1.7351	1.7350	1.7346	1.7339	80
85	1.6560	1.6617	1.6667	1.6711	1.6749	1.6782	1.6810	1.6833	1.6853	1.6869	1.6881	85
90	1.5862	1.5936	1.6004	1.6067	1.6125	1.6177	1.6224	1.6267	1.6306	1.6341	1.6371	90
95	1.5226	1.5305	1.5381	1.5452	1.5519	1.5583	1.5642	1.5697	1.5750	1.5798	1.5843	95
100	1.4682	1.4758	1.4832	1.4903	1.4972	1.5039	1.5102	1.5163	1.5222	1.5278	1.5330	100
105	1.4226	1.4295	1.4364	1.4431	1.4497	1.4562	1.4624	1.4685	1.4745	1.4803	1.4858	105
110	1.3843	1.3906	1.3969	1.4031	1.4092	1.4152	1.4211	1.4269	1.4327	1.4383	1.4438	110
115	1.3520	1.3577	1.3634	1.3690	1.3745	1.3801	1.3855	1.3910	1.3964	1.4017	1.4070	115
120	1.3244	1.3295	1.3347	1.3398	1.3448	1.3499	1.3549	1.3599	1.3650	1.3700	1.3749	120
125	1.3009	1.3055	1.3101	1.3147	1.3193	1.3239	1.3285	1.3331	1.3377	1.3423	1.3468	125
130	1.2805	1.2847	1.2888	1.2930	1.2972	1.3013	1.3055	1.3096	1.3139	1.3181	1.3222	130
135	1.2626	1.2663	1.2701	1.2739	1.2777	1.2815	1.2852	1.2891	1.2929	1.2967	1.3006	135
140	1.2466	1.2501	1.2535	1.2570	1.2604	1.2639	1.2673	1.2708	1.2743	1.2778	1.2813	140

PRESSURE, PSIG = 1120 TO 1220

TABLE 6.1 - ETHYLENE FLOW MEASUREMENT MANUAL

ETHYLENE SUPERCOMPRESSIBILITY

EXTRAPOLATED API STANDARD 2565

PRESSURE, PSIG												
TEMP. F	1220	1230	1240	1250	1260	1270	1280	1290	1300	1310	1320	TEMP. F
20												20
25												25
30												30
35												35
40												40
45												45
50	1.8904	1.8845	1.8787	1.8729	1.8672	1.8615	1.8559	1.8503	1.8448	1.8393	1.8339	50
55	1.8747	1.8692	1.8637	1.8583	1.8529	1.8475	1.8422	1.8369	1.8317	1.8265	1.8214	55
60	1.8560	1.8510	1.8459	1.8409	1.8359	1.8310	1.8260	1.8211	1.8163	1.8115	1.8067	60
65	1.8335	1.8291	1.8246	1.8202	1.8158	1.8113	1.8068	1.8024	1.7981	1.7937	1.7894	65
70	1.8062	1.8027	1.7990	1.7954	1.7916	1.7879	1.7841	1.7803	1.7766	1.7728	1.7690	70
75	1.7732	1.7708	1.7683	1.7656	1.7628	1.7600	1.7570	1.7541	1.7511	1.7481	1.7450	75
80	1.7339	1.7330	1.7319	1.7305	1.7290	1.7273	1.7255	1.7236	1.7216	1.7196	1.7174	80
85	1.6881	1.6890	1.6895	1.6898	1.6898	1.6895	1.6891	1.6884	1.6877	1.6868	1.6857	85
90	1.6371	1.6398	1.6421	1.6440	1.6456	1.6468	1.6478	1.6486	1.6492	1.6496	1.6497	90
95	1.5843	1.5883	1.5920	1.5954	1.5983	1.6010	1.6034	1.6055	1.6074	1.6090	1.6103	95
100	1.5330	1.5380	1.5426	1.5469	1.5509	1.5546	1.5580	1.5611	1.5641	1.5668	1.5692	100
105	1.4858	1.4912	1.4962	1.5010	1.5056	1.5099	1.5140	1.5178	1.5215	1.5249	1.5281	105
110	1.4438	1.4491	1.4543	1.4592	1.4640	1.4686	1.4730	1.4772	1.4813	1.4852	1.4888	110
115	1.4070	1.4121	1.4171	1.4220	1.4267	1.4313	1.4358	1.4401	1.4444	1.4484	1.4523	115
120	1.3749	1.3797	1.3845	1.3891	1.3937	1.3982	1.4026	1.4068	1.4111	1.4151	1.4191	120
125	1.3468	1.3513	1.3558	1.3602	1.3645	1.3687	1.3729	1.3770	1.3810	1.3850	1.3889	125
130	1.3222	1.3264	1.3305	1.3345	1.3385	1.3425	1.3464	1.3503	1.3541	1.3579	1.3616	130
135	1.3006	1.3044	1.3081	1.3119	1.3156	1.3192	1.3228	1.3265	1.3300	1.3336	1.3371	135
140	1.2813	1.2848	1.2883	1.2917	1.2951	1.2985	1.3019	1.3052	1.3085	1.3118	1.3151	140

PRESSURE, PSIG = 1220 TO 1320

TABLE 6.1 - ETHYLENE FLOW MEASUREMENT MANUAL

ETHYLENE SUPERCOMPRESSIBILITY

EXTRAPOLATED API STANDARD 2565

TEMP. F	PRESSURE, PSIG											TEMP. F
	1320	1330	1340	1350	1360	1370	1380	1390	1400	1410	1420	
20												20
25												25
30												30
35												35
40												40
45												45
50	1.8339	1.8286	1.8232	1.8180	1.8127	1.8076	1.8024	1.7973	1.7923	1.7872	1.7823	50
55	1.8214	1.8163	1.8112	1.8062	1.8012	1.7963	1.7914	1.7865	1.7816	1.7768	1.7721	55
60	1.8067	1.8019	1.7972	1.7925	1.7878	1.7831	1.7785	1.7739	1.7693	1.7647	1.7602	60
65	1.7894	1.7850	1.7807	1.7764	1.7721	1.7678	1.7635	1.7592	1.7549	1.7507	1.7465	65
70	1.7690	1.7652	1.7614	1.7575	1.7537	1.7498	1.7460	1.7421	1.7383	1.7344	1.7306	70
75	1.7450	1.7418	1.7387	1.7355	1.7322	1.7289	1.7256	1.7223	1.7189	1.7155	1.7121	75
80	1.7174	1.7151	1.7128	1.7103	1.7078	1.7052	1.7026	1.6999	1.6972	1.6944	1.6916	80
85	1.6857	1.6845	1.6831	1.6816	1.6800	1.6783	1.6765	1.6746	1.6726	1.6706	1.6684	85
90	1.6497	1.6497	1.6494	1.6490	1.6485	1.6477	1.6469	1.6458	1.6447	1.6435	1.6421	90
95	1.6103	1.6115	1.6124	1.6131	1.6136	1.6139	1.6140	1.6139	1.6137	1.6133	1.6128	95
100	1.5692	1.5713	1.5733	1.5750	1.5765	1.5777	1.5788	1.5797	1.5804	1.5809	1.5812	100
105	1.5281	1.5311	1.5338	1.5363	1.5386	1.5407	1.5426	1.5443	1.5458	1.5471	1.5482	105
110	1.4888	1.4923	1.4956	1.4987	1.5015	1.5042	1.5067	1.5090	1.5111	1.5131	1.5148	110
115	1.4523	1.4561	1.4597	1.4631	1.4663	1.4694	1.4723	1.4750	1.4776	1.4800	1.4822	115
120	1.4191	1.4229	1.4266	1.4302	1.4336	1.4369	1.4401	1.4430	1.4459	1.4485	1.4511	120
125	1.3889	1.3926	1.3963	1.3999	1.4033	1.4067	1.4099	1.4130	1.4159	1.4187	1.4214	125
130	1.3616	1.3652	1.3687	1.3722	1.3755	1.3788	1.3820	1.3851	1.3880	1.3909	1.3936	130
135	1.3371	1.3405	1.3439	1.3472	1.3504	1.3535	1.3566	1.3596	1.3625	1.3654	1.3681	135
140	1.3151	1.3183	1.3215	1.3246	1.3277	1.3307	1.3336	1.3365	1.3393	1.3420	1.3447	140

PRESSURE, PSIG = 1320 TO 1420

TABLE 6.1 - ETHYLENE FLOW MEASUREMENT MANUAL

ETHYLENE SUPERCOMPRESSIBILITY

EXTRAPOLATED API STANDARD 2565

TEMP. F	PRESSURE, PSIG											TEMP. F
	1420	1430	1440	1450	1460	1470	1480	1490	1500	1510	1520	
20												20
25												25
30												30
35												35
40												40
45												45
50	1.7823	1.7773	1.7724	1.7676	1.7628	1.7580	1.7533	1.7486	1.7439	1.7393	1.7347	50
55	1.7721	1.7673	1.7626	1.7580	1.7533	1.7487	1.7442	1.7397	1.7352	1.7307	1.7263	55
60	1.7602	1.7557	1.7513	1.7468	1.7424	1.7380	1.7337	1.7293	1.7251	1.7208	1.7165	60
65	1.7465	1.7423	1.7381	1.7339	1.7298	1.7257	1.7216	1.7175	1.7134	1.7094	1.7054	65
70	1.7306	1.7267	1.7229	1.7191	1.7152	1.7114	1.7076	1.7038	1.7000	1.6963	1.6925	70
75	1.7121	1.7087	1.7053	1.7019	1.6985	1.6950	1.6916	1.6882	1.6847	1.6813	1.6779	75
80	1.6916	1.6887	1.6858	1.6829	1.6800	1.6770	1.6740	1.6710	1.6680	1.6649	1.6619	80
85	1.6684	1.6662	1.6639	1.6616	1.6593	1.6568	1.6544	1.6519	1.6493	1.6468	1.6442	85
90	1.6421	1.6407	1.6391	1.6375	1.6358	1.6340	1.6322	1.6303	1.6283	1.6262	1.6241	90
95	1.6128	1.6122	1.6115	1.6106	1.6096	1.6086	1.6074	1.6062	1.6048	1.6033	1.6018	95
100	1.5812	1.5814	1.5815	1.5814	1.5812	1.5809	1.5804	1.5798	1.5791	1.5783	1.5774	100
105	1.5482	1.5491	1.5499	1.5506	1.5511	1.5515	1.5517	1.5518	1.5517	1.5516	1.5513	105
110	1.5148	1.5164	1.5178	1.5191	1.5203	1.5213	1.5221	1.5228	1.5233	1.5237	1.5240	110
115	1.4822	1.4843	1.4862	1.4880	1.4896	1.4911	1.4925	1.4937	1.4947	1.4956	1.4964	115
120	1.4511	1.4535	1.4557	1.4579	1.4599	1.4618	1.4635	1.4651	1.4665	1.4678	1.4690	120
125	1.4214	1.4240	1.4265	1.4289	1.4311	1.4332	1.4353	1.4371	1.4388	1.4404	1.4419	125
130	1.3936	1.3963	1.3989	1.4014	1.4037	1.4060	1.4082	1.4102	1.4121	1.4139	1.4156	130
135	1.3681	1.3708	1.3733	1.3758	1.3783	1.3806	1.3829	1.3850	1.3870	1.3889	1.3907	135
140	1.3447	1.3473	1.3499	1.3523	1.3548	1.3571	1.3594	1.3615	1.3636	1.3655	1.3675	140

PRESSURE, PSIG = 1420 TO 1520

TABLE 6.1 - ETHYLENE FLOW MEASUREMENT MANUAL

ETHYLENE SUPERCOMPRESSIBILITY

EXTRAPOLATED API STANDARD 2565

TEMP. F	PRESSURE, PSIG											TEMP. F
	1520	1530	1540	1550	1560	1570	1580	1590	1600	1610	1620	
20												20
25												25
30												30
35												35
40												40
45												45
50	1.7347	1.7302	1.7257	1.7212	1.7168	1.7124	1.7080	1.7037	1.6994	1.6951	1.6909	50
55	1.7263	1.7219	1.7175	1.7132	1.7089	1.7046	1.7004	1.6962	1.6920	1.6879	1.6838	55
60	1.7165	1.7123	1.7081	1.7040	1.6999	1.6958	1.6917	1.6876	1.6836	1.6796	1.6757	60
65	1.7054	1.7014	1.6974	1.6934	1.6895	1.6856	1.6817	1.6778	1.6740	1.6702	1.6664	65
70	1.6925	1.6888	1.6851	1.6813	1.6777	1.6740	1.6703	1.6667	1.6630	1.6594	1.6558	70
75	1.6779	1.6744	1.6710	1.6676	1.6642	1.6607	1.6573	1.6540	1.6506	1.6472	1.6438	75
80	1.6619	1.6588	1.6557	1.6526	1.6496	1.6465	1.6434	1.6403	1.6372	1.6341	1.6310	80
85	1.6442	1.6415	1.6389	1.6362	1.6335	1.6308	1.6280	1.6253	1.6225	1.6197	1.6169	85
90	1.6241	1.6220	1.6198	1.6176	1.6154	1.6131	1.6108	1.6084	1.6060	1.6036	1.6012	90
95	1.6018	1.6003	1.5986	1.5969	1.5952	1.5934	1.5915	1.5896	1.5877	1.5857	1.5836	95
100	1.5774	1.5764	1.5754	1.5742	1.5730	1.5717	1.5704	1.5690	1.5675	1.5659	1.5643	100
105	1.5513	1.5509	1.5504	1.5498	1.5492	1.5484	1.5476	1.5467	1.5457	1.5446	1.5435	105
110	1.5240	1.5242	1.5243	1.5242	1.5241	1.5239	1.5236	1.5232	1.5226	1.5220	1.5213	110
115	1.4964	1.4970	1.4976	1.4981	1.4984	1.4987	1.4988	1.4988	1.4987	1.4986	1.4983	115
120	1.4690	1.4701	1.4710	1.4719	1.4726	1.4733	1.4738	1.4743	1.4746	1.4748	1.4749	120
125	1.4419	1.4432	1.4445	1.4457	1.4468	1.4478	1.4487	1.4494	1.4501	1.4506	1.4511	125
130	1.4156	1.4172	1.4187	1.4201	1.4214	1.4227	1.4239	1.4249	1.4258	1.4266	1.4274	130
135	1.3907	1.3925	1.3942	1.3957	1.3973	1.3987	1.4000	1.4013	1.4024	1.4035	1.4044	135
140	1.3675	1.3693	1.3711	1.3728	1.3744	1.3759	1.3774	1.3788	1.3801	1.3813	1.3825	140

PRESSURE, PSIG = 1520 TO 1620

TABLE 6.1 - ETHYLENE FLOW MEASUREMENT MANUAL

ETHYLENE SUPERCOMPRESSIBILITY

EXTRAPOLATED API STANDARD 2565

TEMP. F	PRESSURE, PSIG											TEMP. F
	1620	1630	1640	1650	1660	1670	1680	1690	1700	1710	1720	
20												20
25												25
30												30
35												35
40												40
45												45
50	1.6909	1.6867	1.6825	1.6784	1.6743	1.6702	1.6662	1.6622	1.6582	1.6542	1.6503	50
55	1.6838	1.6797	1.6757	1.6717	1.6677	1.6637	1.6598	1.6559	1.6520	1.6481	1.6443	55
60	1.6757	1.6717	1.6678	1.6639	1.6601	1.6562	1.6524	1.6487	1.6449	1.6412	1.6375	60
65	1.6664	1.6626	1.6589	1.6551	1.6514	1.6477	1.6441	1.6404	1.6368	1.6332	1.6296	65
70	1.6558	1.6522	1.6487	1.6451	1.6416	1.6381	1.6346	1.6311	1.6276	1.6242	1.6208	70
75	1.6438	1.6405	1.6371	1.6338	1.6305	1.6272	1.6239	1.6206	1.6173	1.6140	1.6108	75
80	1.6310	1.6279	1.6248	1.6217	1.6186	1.6155	1.6125	1.6094	1.6063	1.6033	1.6002	80
85	1.6169	1.6142	1.6113	1.6085	1.6057	1.6029	1.6001	1.5973	1.5944	1.5916	1.5888	85
90	1.6012	1.5987	1.5962	1.5938	1.5913	1.5887	1.5862	1.5837	1.5811	1.5786	1.5760	90
95	1.5836	1.5815	1.5795	1.5773	1.5752	1.5730	1.5708	1.5686	1.5663	1.5641	1.5618	95
100	1.5643	1.5627	1.5610	1.5593	1.5575	1.5557	1.5538	1.5520	1.5501	1.5481	1.5462	100
105	1.5435	1.5423	1.5410	1.5397	1.5383	1.5369	1.5355	1.5340	1.5324	1.5308	1.5292	105
110	1.5213	1.5206	1.5197	1.5188	1.5179	1.5169	1.5158	1.5147	1.5135	1.5123	1.5110	110
115	1.4983	1.4980	1.4975	1.4971	1.4965	1.4959	1.4952	1.4945	1.4937	1.4928	1.4919	115
120	1.4749	1.4749	1.4749	1.4748	1.4746	1.4743	1.4740	1.4736	1.4731	1.4726	1.4720	120
125	1.4511	1.4514	1.4517	1.4520	1.4521	1.4522	1.4522	1.4521	1.4520	1.4518	1.4515	125
130	1.4274	1.4280	1.4286	1.4292	1.4296	1.4300	1.4303	1.4306	1.4307	1.4308	1.4308	130
135	1.4044	1.4053	1.4062	1.4069	1.4076	1.4083	1.4088	1.4093	1.4097	1.4101	1.4104	135
140	1.3825	1.3835	1.3846	1.3855	1.3864	1.3872	1.3880	1.3887	1.3893	1.3899	1.3904	140

PRESSURE, PSIG = 1620 TO 1720

TABLE 6.1 - ETHYLENE FLOW MEASUREMENT MANUAL

ETHYLENE SUPERCOMPRESSIBILITY

EXTRAPOLATED API STANDARD 2565

TEMP. F	PRESSURE, PSIG											TEMP. F
	1720	1730	1740	1750	1760	1770	1780	1790	1800	1810	1820	
20												20
25												25
30												30
35												35
40												40
45												45
50	1.6503	1.6464	1.6426	1.6387	1.6349	1.6312	1.6274	1.6237	1.6200	1.6163	1.6127	50
55	1.6443	1.6405	1.6368	1.6330	1.6293	1.6256	1.6220	1.6183	1.6147	1.6111	1.6076	55
60	1.6375	1.6338	1.6301	1.6265	1.6229	1.6193	1.6157	1.6122	1.6087	1.6052	1.6017	60
65	1.6296	1.6261	1.6226	1.6190	1.6156	1.6121	1.6086	1.6052	1.6018	1.5984	1.5951	65
70	1.6208	1.6174	1.6140	1.6106	1.6073	1.6039	1.6006	1.5973	1.5941	1.5908	1.5876	70
75	1.6108	1.6076	1.6043	1.6011	1.5980	1.5948	1.5916	1.5885	1.5853	1.5822	1.5791	75
80	1.6002	1.5972	1.5942	1.5911	1.5881	1.5851	1.5821	1.5791	1.5762	1.5732	1.5703	80
85	1.5888	1.5860	1.5831	1.5803	1.5775	1.5747	1.5719	1.5691	1.5663	1.5635	1.5607	85
90	1.5760	1.5734	1.5708	1.5683	1.5657	1.5631	1.5605	1.5579	1.5553	1.5527	1.5501	90
95	1.5618	1.5595	1.5572	1.5549	1.5525	1.5502	1.5478	1.5455	1.5431	1.5408	1.5384	95
100	1.5462	1.5442	1.5422	1.5401	1.5381	1.5360	1.5339	1.5318	1.5297	1.5276	1.5255	100
105	1.5292	1.5275	1.5258	1.5241	1.5224	1.5206	1.5188	1.5170	1.5152	1.5133	1.5114	105
110	1.5110	1.5097	1.5083	1.5070	1.5055	1.5041	1.5026	1.5010	1.4995	1.4979	1.4963	110
115	1.4919	1.4909	1.4899	1.4888	1.4877	1.4865	1.4854	1.4841	1.4829	1.4816	1.4803	115
120	1.4720	1.4713	1.4707	1.4699	1.4691	1.4683	1.4674	1.4664	1.4655	1.4645	1.4634	120
125	1.4515	1.4512	1.4508	1.4504	1.4499	1.4494	1.4488	1.4481	1.4475	1.4467	1.4460	125
130	1.4308	1.4308	1.4307	1.4306	1.4304	1.4301	1.4298	1.4295	1.4291	1.4287	1.4282	130
135	1.4104	1.4106	1.4108	1.4109	1.4109	1.4110	1.4109	1.4108	1.4107	1.4105	1.4103	135
140	1.3904	1.3908	1.3912	1.3915	1.3918	1.3921	1.3922	1.3924	1.3924	1.3925	1.3925	140

PRESSURE, PSIG = 1720 TO 1820