Bailey

SECTION
G99-2

PRODUCT INSTRUCTIONS

FLOW CORRECTION FACTORS
FOR BAILEY RECORDERS AND/INDICATORS

INDEX

The Primary Element used with the flow or differential measuring mechanism is designed to give direct results under only one set of fluid conditions. These conditions are listed on the *Specification Sheet* for the particular instrument and on the instrument nameplate. When the average conditions of fluid vary from those specified, the chart or scale and integrator readings must be compensated for such variations. If the Recorder or Indicator is not equipped with a means of flow compensation, correction factors, as described in this Instruction Section, must be applied to the chart or scale and integrator readings to compensate for such variations.

CROSS - REFERENCES

Instrument or Equipment	Instruction Section
Bailey Recorders and Indicators	M11-1
Type KM or WM Recorder or Indicator	E12-3
Type W Recorder	E12-2

BAILEY METER COMPANY • WICKLIFFE, OHIO 44092

FORM A 905 1162
LITHO IN U S A

APPLY NG CORRECTION FACTORS

For Bailey flow measuring instruments.

(1) *The rate of flow* at any given time may be determined by means of the chart or scale reading times the chart or scale multiplying factor;

2) *The total flow* for any given period of time may be determined by means of the integrator multiplying factor times the difference in integrator readings at the beginning and end of the time period

The chart or scale and integrator multiplying factors are listed on the instrument *Specification Sheet* in the front of this Instruction Book and on the nameplate attached to the door of the instrument.

To apply the correction factors, as determined below, multiply the rate of flow chart or scale reading) and total flow (integrator reading) by the correction factor or factors Thus, if two or more conditions vary simultaneously, the total correction factor to apply to the instrument readings is the product of these two or more factors.

STEAM OR LIQUID FLOW CORRECTION FACTORS

STEAM FLOW

For steam flow, calculate the correction factors as follows·

$$C \sqrt{\frac{Vd}{Va}}$$

Where. C correction factor for a variation in conditions of pressure and temperature

Va specific volume of steam at actual existing conditions

Vd specific volume of steam at design conditions

To simplify the determination of correction factors, curves from which the necessary factors may be obtained are shown in Figures 1 thru 5 Refer to the "Index of Correction Factor Curves" on page 4 for the number of the curve applicable to the conditions of the metered steam

An example of the application of the correction factor curve is given in each Figure Apply the factor or factors to both the chart or scale and integrator readings, as explained above

If the design pressure is maintained in actual operation, a correction factor based on temperature (or per cent moisture) alone may be sufficient, and will be more easily used than the complete pressure and temperature correction factor curves of Figures 1 thru 5. Figure 6 shows this temperature correction factor

WATER FLOW

For water flow, it is usually sufficient to consider only variations from design temperature as changes in specific weight due to ordinary changes in pressure are insignificant This temperature correction factor is determined as follows

$$Ct \sqrt{\frac{\gamma ta}{\gamma td}}$$

Where: Ct correction factor for a variation in temperature

γ ta specific weight of water at actual existing temperature

γ td specific weight of water at design temperature

Figure 7 shows curves from which correction factors for variations in water temperature may be obtained directly

For pressure changes of 200 psi or more, the changes in specific weight become significant and should be taken into account in the determination of correction factors Figure 8 shows correction factors for variations of both pressure and temperature of water

Note that the correction factors calculated by the formula above or determined from Figures 7 and 8 apply to meters measuring water flow in units of weight, as pounds per hour. If the measurement is made in terms of volume, as gallons per minute, the correction factor to be applied will be the *reciprocal* of the factor calculated above.

PETROLEUM OILS

Petroleum oils do not expand with increases in temperature in the same manner as does water, thus Figures 7 and 8 are not applicable. Figure 9 shows curves for determining the change in specific gravity for a change in temperature, and the correction factor required to correct for that change in specific gravity. Note that the change in specific weight of the oil on a change in temperature is referred to as a change in specific gravity, referred to water at a base temperature of 60° F, in accordance with regular practice of the petroleum industry. Also note that, the correction factor determined from the curve is applied directly to meters reading in terms of units of weight and for meters reading in units of volume at a standard or base temperature.

AIR OR GAS FLOW CORRECTION FACTORS

STANDARD CONDITIONS

Many air or gas flow measuring instruments read in terms of cubic feet or volume referred to Standard Conditions of pressure and temperature. Standard Conditions are necessary in order to form a uniform, equitable rate basis for billing, accounting, or comparison of gas or air consumption.

While Standard Conditions frequently are taken as 30 inches of mercury absolute pressure, and 60° F temperature, other Standard Conditions may be selected for use with any individual instrument, as the specific application dictates. These conditions are fixed for any one installation and are not subject to operational changes.

The Standard Conditions selected for the particular instrument are given on the instrument *Specification Sheet* in the front of this Instruction Book.

OPERATING CONDITIONS

Usually the operating conditions of pressure and temperature, for which the instrument was designed, are different from the Standard Conditions, since these are dependent upon the equipment used in generating and moving the gas or air thru the pipe lines, the use to which the gas or air is put, and other factors.

The average operating conditions, however, are known and must be specified in designing the Primary Element used with the particular instrument. These operating conditions are stamped on the instrument nameplate and are listed on the instrument *Specification Sheet* in the front of this Instruction Book.

When these average operating conditions actually exist, the instrument reads correctly. When either the pressure, temperature, or specific gravity are different from the average used in the design, correction factors must be applied to the instrument readings to compensate for such variations. These factors are obtained from the correction factor curves described below.

PRESSURE CORRECTION FACTORS

Since the designed average pressure may be expressed either in pounds or inches of mercury, three pressure correction factor curves are included: Figure 10 for inches of mercury absolute, and Figures 11 and 12 for pounds gage. An example of the application of the curves is given in each Figure.

If the design pressure lies between any two adjacent diagonal pressure lines on these curves, draw in a new curve parallel to the printed curves and spaced between them in proportion to the relation of the actual design pressure with these two pressures. Apply the new curve in the same manner as the printed curves.

TEMPERATURE CORRECTION FACTORS

Figure 13 shows correction factors for variations from the average temperature used in the design of the Primary Element. Note, however, that Figure 13 applies to dry air or gas only.

If the air or gas is saturated, and if the actual temperature of the mixture varies widely from the designed average, do not use the correction factor curves shown in Figure 13. Special combined temperature-moisture correction factor curves must be prepared to show the corrections due to variations in temperature and moisture.

Interpolation for intermediate temperatures between diagonal temperature lines shown in Figure

13 should be made as described above for pressure correction curves.

SPECIFIC GRAVITY CORRECTION FACTORS

A correction for specific gravity may be necessary if the measured gas consists of a mixture of gases having different specific gravities, in which the proportions of the mixture may change in normal operation. Figure 14 shows the correction factors necessary for variations in specific gravity from the designed value.

COMPRESSIBLE FLUID CORRECTION FACTORS

For a compressible fluid, the relation of flow to differential across a Primary Element deviates slightly from the square root relationship because of the different specific weights or volumes applying at the different pressures at inlet and outlet. The amount of the error which results from this deviation for different differential meters and different Primary Elements at maximum flow rate can be determined from Figure 15 This curve may be used for flow nozzles and concentric orifices with steam and gases which have a specific heat ratio of 1 3 For air and other diatomic gases with a specific heat ratio of 1 4, multiply the indicated span by 93.

Example To illustrate the use of the curve, assume an installation measuring steam at 100 psig (115 psia) with a 80 ratio flow nozzle and a maximum meter differential of 53 inches For these conditions, Figure 15 shows that the maximum meter error or span of the meter correction factor for compressibility is 1 8 per cent

Since the error diminishes at rates of flow less than maximum, and is a linear function of the differential pressure drop between inlet and outlet, the standard Bailey procedure is to minimize the maximum error by including in the Primary Element design the correction factor for the midrange value of the differential pressures applied to the meter *i e, for about 70 per cent of maximum* flow At this flow rate, therefore, the meter reads correctly. The correction factors which apply at other rates of flow can then be determined by plotting a line *on the grid* shown in Figure 16. The line is drawn thru two points as follows.

1 Point Ⓐ fixed point for all meters

2 Point Ⓑ correction factor at 0% flow, calculated as follows for the particular meter:

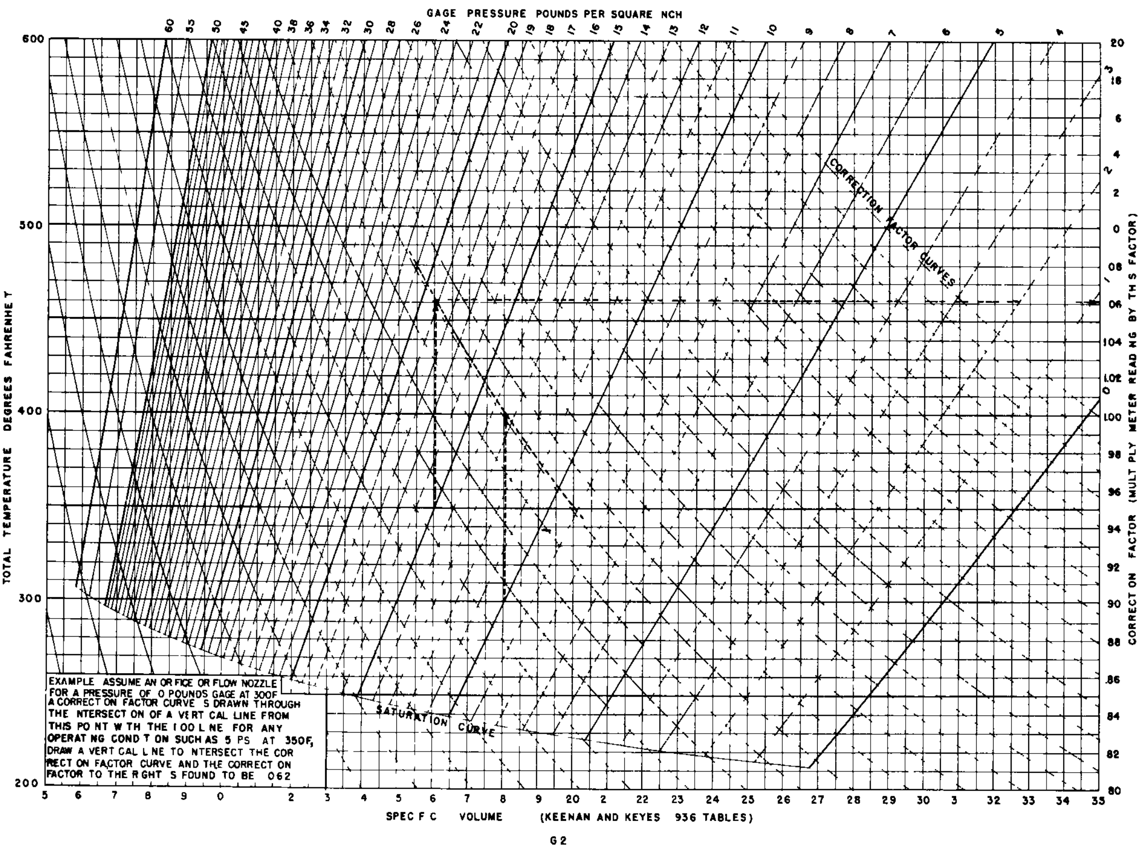
$$1\,000 + \frac{\text{correction factor span (\%) from Figure 15}}{200}$$

PIPE INTERNAL DIAMETER CORRECTION FACTORS

The fundamental flow formula used in the design of Primary Elements is based on a specified internal pipe diameter If the actual internal pipe diameter differs from the value specified for the Primary Element design, there is a change in diameter ratio with a consequent effect on the approach factor, F, in the flow formula. Figure 17 shows a curve from which correction factors for variations in pipe diameter may be determined.

Example. To illustrate the use of the curve, assume an orifice designed for six-inch Schedule 40 pipe (6 065" I D.) and a diameter ratio β of 635, but actually installed in Schedule 80 pipe (5 761" I D.) The ratio of 5 761 to 6.065 is .95, and the curve shows that a correction factor of 1 024 should be used for these conditions.

INDEX OF CORRECTION FACTOR CURVES



F GURE 1 Temperature and Pressure Correction Factors for Steam F ow, 0 to 60 ps , 200 to 600F

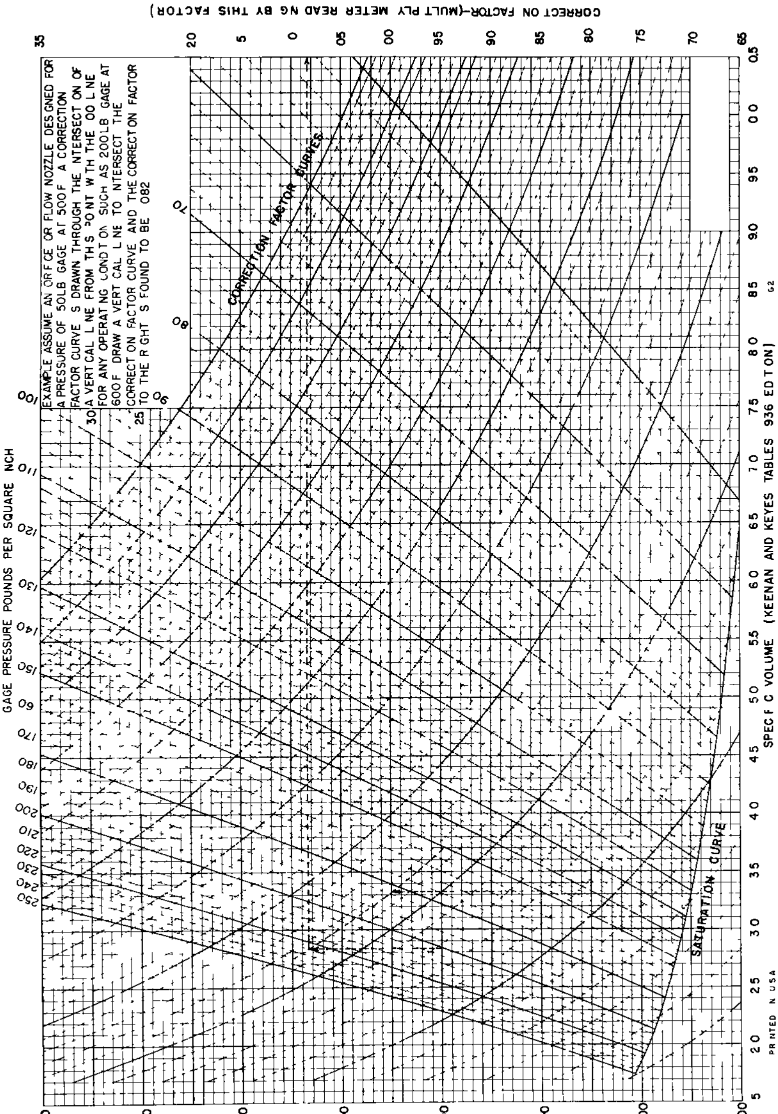
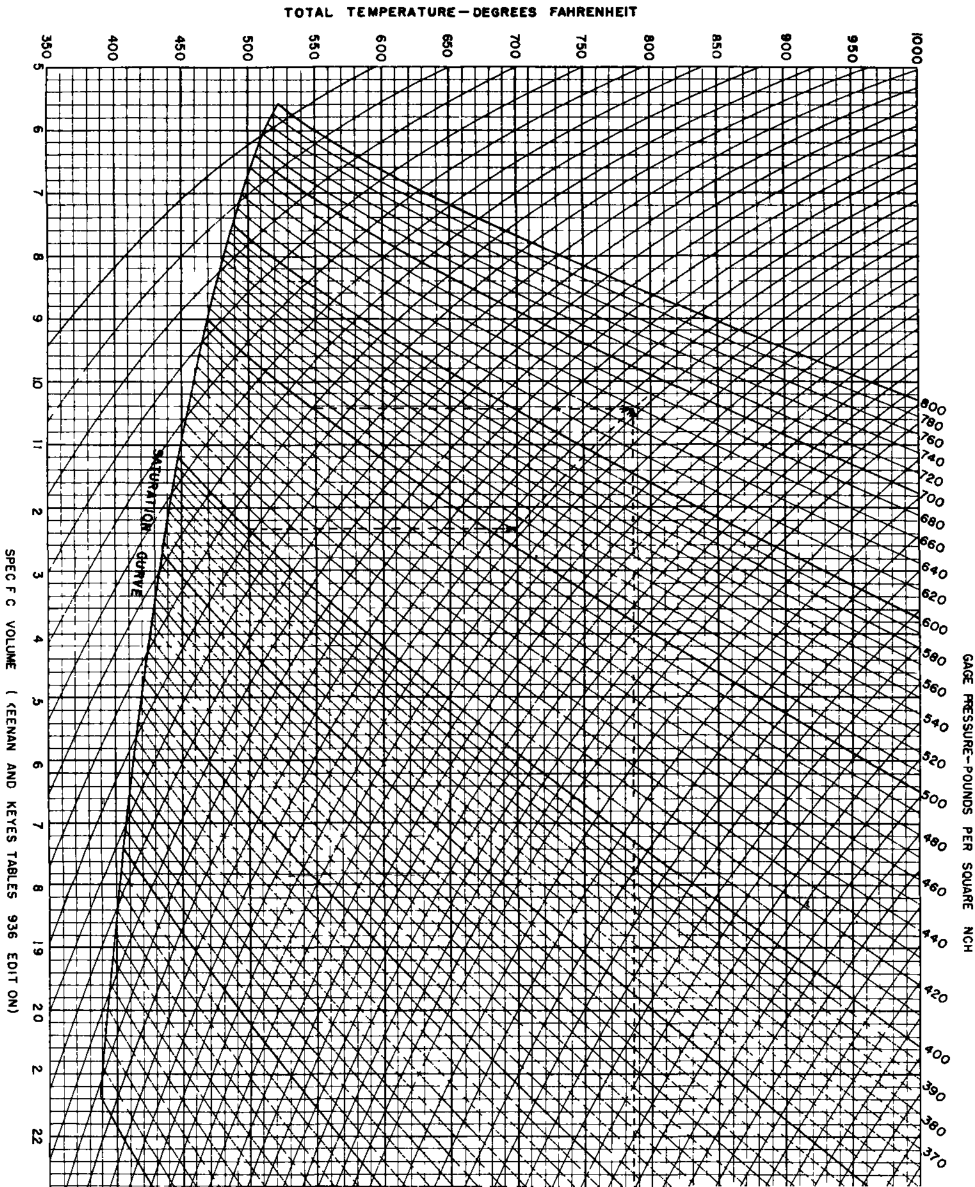
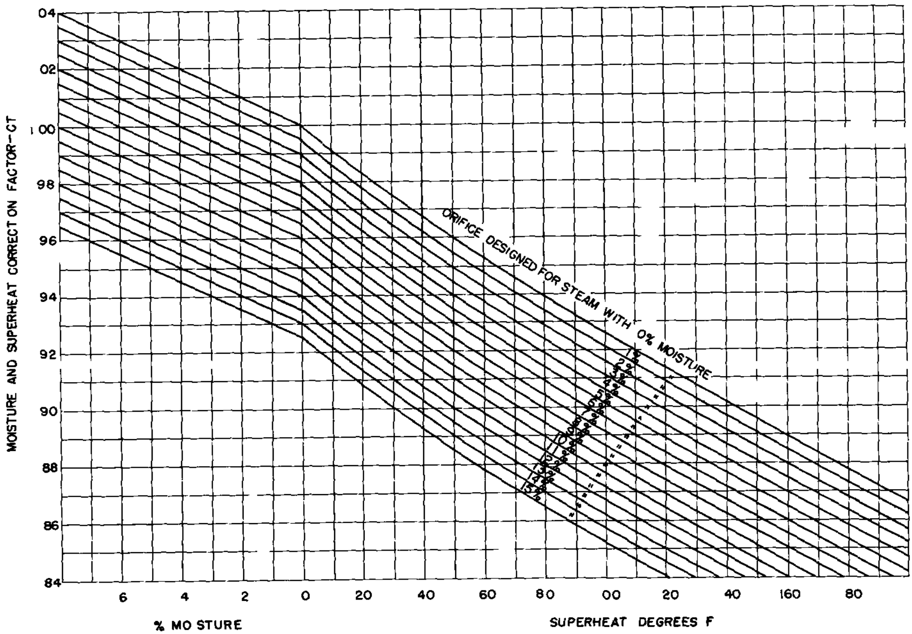


FIGURE 2 Temperature and Pressure Correct on Factors for Steam F ow, 50 to 250 ps , 300 to 1000F

00 48 02 04 11 07



00 48 02 04/11/07



Read actual conditions of steam at the bottom of chart, project up to curve showing design conditions read correction factor at left.

Example 1. Steam is found to be 96% quality (contains 4% moisture) and the orifice is designed for steam containing 2% moisture Projecting up on 4% moisture (actual) conditions to curve labeled 2% moisture (design) conditions the correction factor at left is found to be 1.01

Example 2. *Actual steam is superheated 50F, but orifice is designed for steam containing 2%* moisture. Projecting up on 50F superheat (actual) conditions to curve labeled 2% moisture, the correct factor at left is found to be .95.

FIGURE 6—Moisture and Temperature Correction Factors for Steam Flow, 0 to 15% Moisture, 0 to 200F Superheat

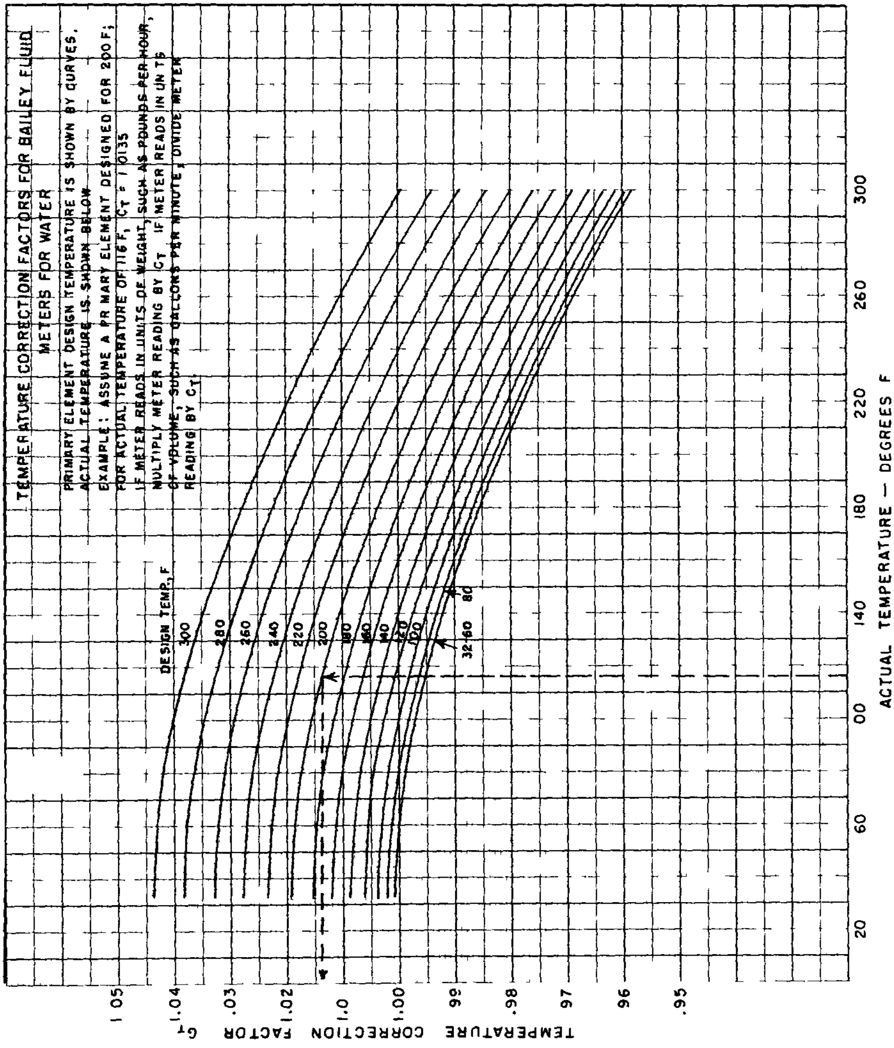


FIGURE 7—Temperature Correction Factor for Water, 32 to 300F

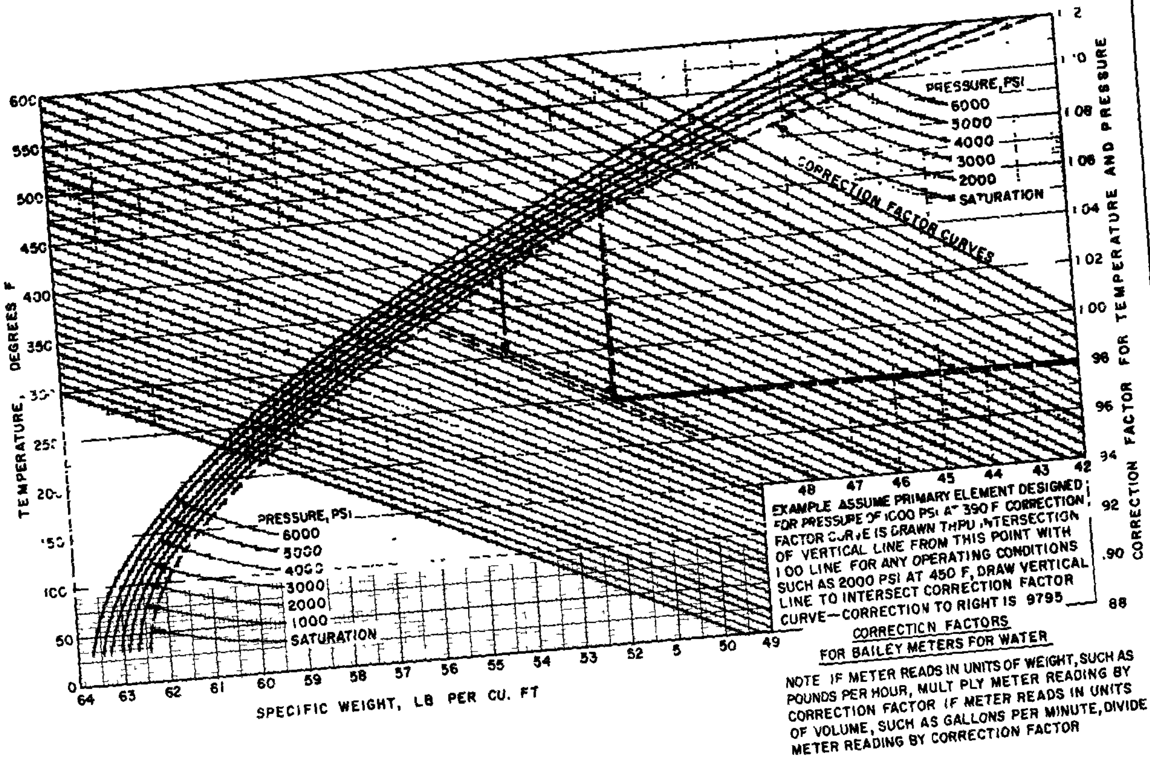
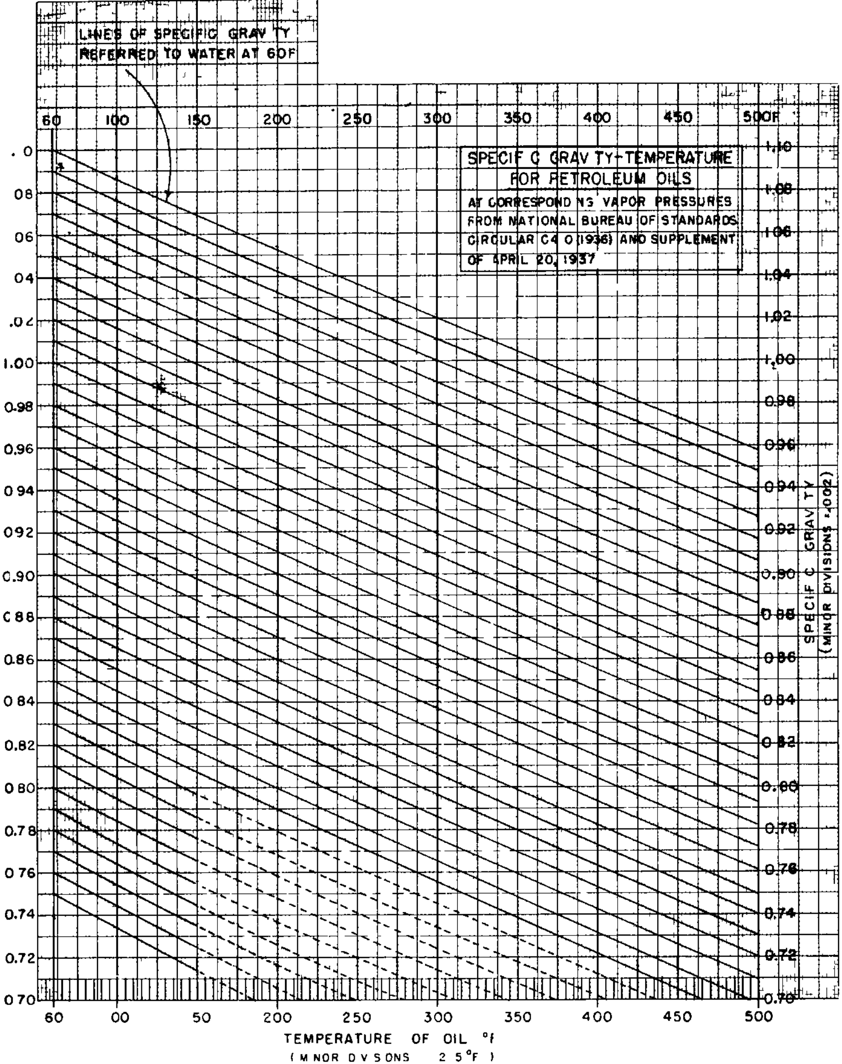
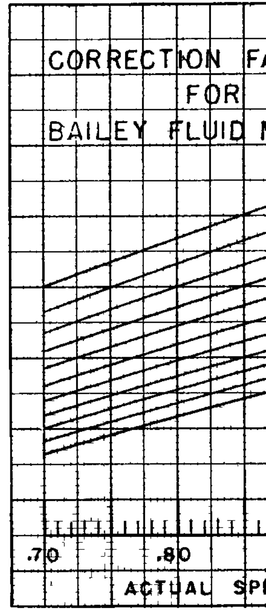


FIGURE 8 Temperature and Pressure Correct on Factors for Water 0 to 6000 ps, 32 to 600F



LINES OF SPECIFIC GRAVITY
REFERRED TO WATER AT 60F
SPECIFIC GRAVITY-TEMPERATURE
FOR PETROLEUM OILS
AT CORRESPONDING VAPOR PRESSURES
FROM NATIONAL BUREAU OF STANDARDS
CIRCULAR C4 O (1936) AND SUPPLEMENT
OF APRIL 20, 1937
SPECIFIC GRAVITY
(MINOR DIVISIONS =.002)
TEMPERATURE OF OIL °F
(MINOR DIVISIONS 2.5°F)



CORRECTION FA
FOR
BAILEY FLUID M
.70
.80
ACTUAL SP

00 48 38 04 11 07

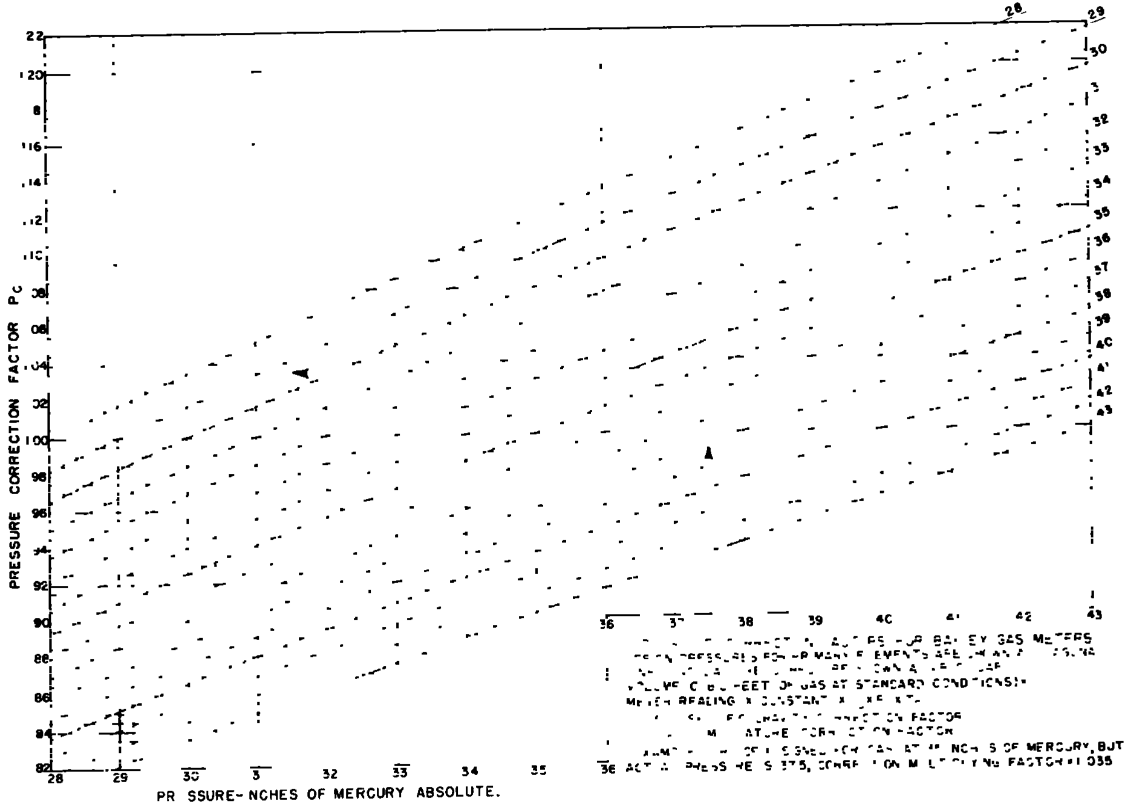
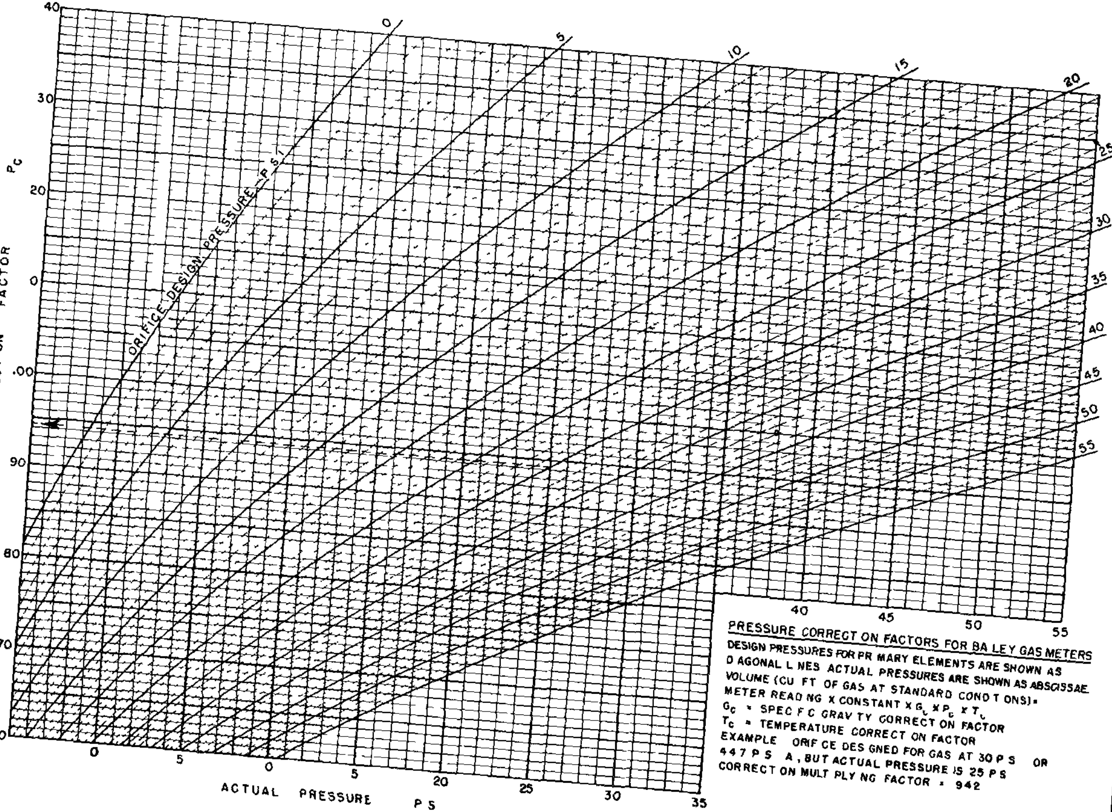


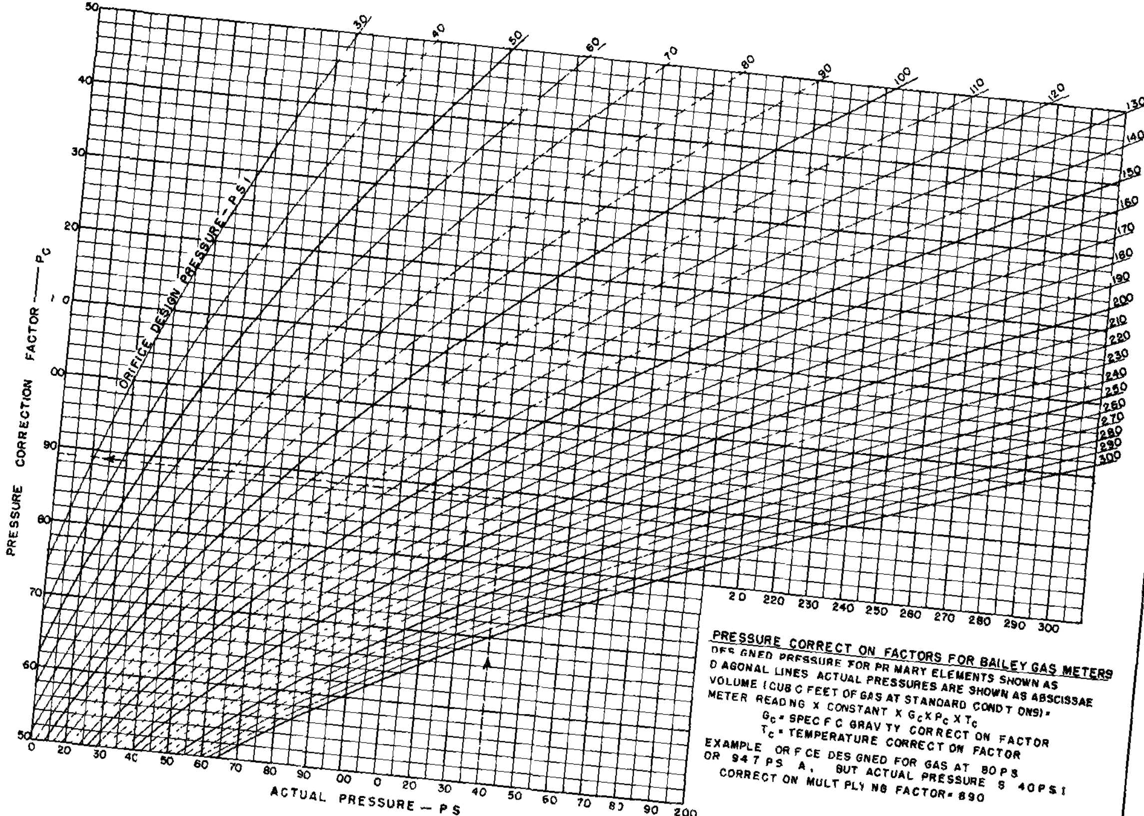
FIGURE 10 Pressure Correction Factors for Air or Gas Flow, 28 to 43 Inches of Mercury



PRESSURE CORRECT ON FACTORS FOR BA LEY GAS METERS

DESIGN PRESSURES FOR PR MARY ELEMENTS ARE SHOWN AS D AGONAL L NES ACTUAL PRESSURES ARE SHOWN AS ABSCISSAE
VOLUME (CU FT OF GAS AT STANDARD COND T ONS) = METER READ NG X CONSTANT X G_c X P_c X T_c
G_C = SPEC F C GRAV TY CORRECT ON FACTOR
T_C = TEMPERATURE CORRECT ON FACTOR
EXAMPLE ORIF CE DES GNED FOR GAS AT 30 P S OR 44 7 P S A, BUT ACTUAL PRESSURE IS 25 P S CORRECT ON MULT PLY NG FACTOR = 942

FIGURE 11 Pressure Correction Factors for Air or Gas Flow, 5 to 55 psig



PRESSURE CORRECT ON FACTORS FOR BAILEY GAS METERS

DES GNED PRESSURE FOR PR MARY ELEMENTS SHOWN AS D AGONAL LINES ACTUAL PRESSURES ARE SHOWN AS ABSCISSAE

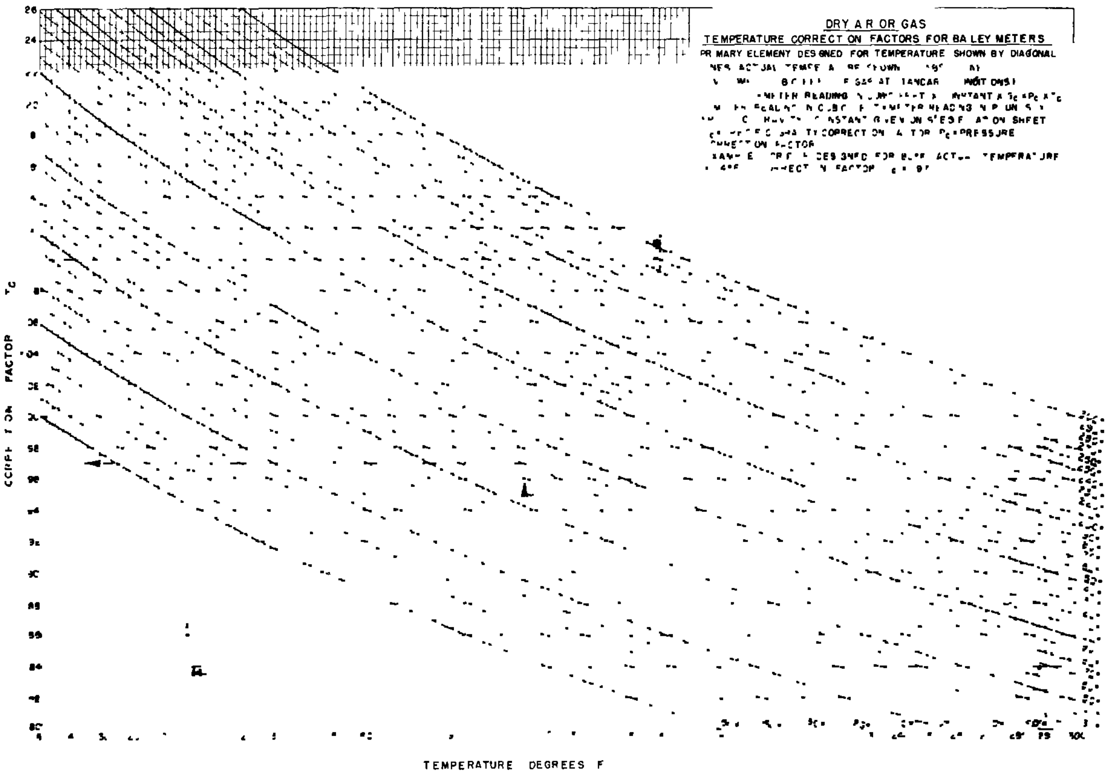
VOLUME (CUB C FEET OF GAS AT STANDARD COND T ONS) = METER READ NG X CONSTANT X G_C X P_C X T_C

G_C = SPEC F C GRAV TY CORRECT ON FACTOR

T_C = TEMPERATURE CORRECT ON FACTOR

EXAMPLE OR F CE DES GNED FOR GAS AT 80 P S OR 94 7 PS A, BUT ACTUAL PRESSURE S 40 PSI CORRECT ON MULT PLY NG FACTOR = 890

FIGURE 12 Pressure Correct on Factors for A r or Gas F ow, 10 to 310 ps g



F GURE 13 Dry A r or Gas Temperature Correct on Factors for A r or Gas F ow

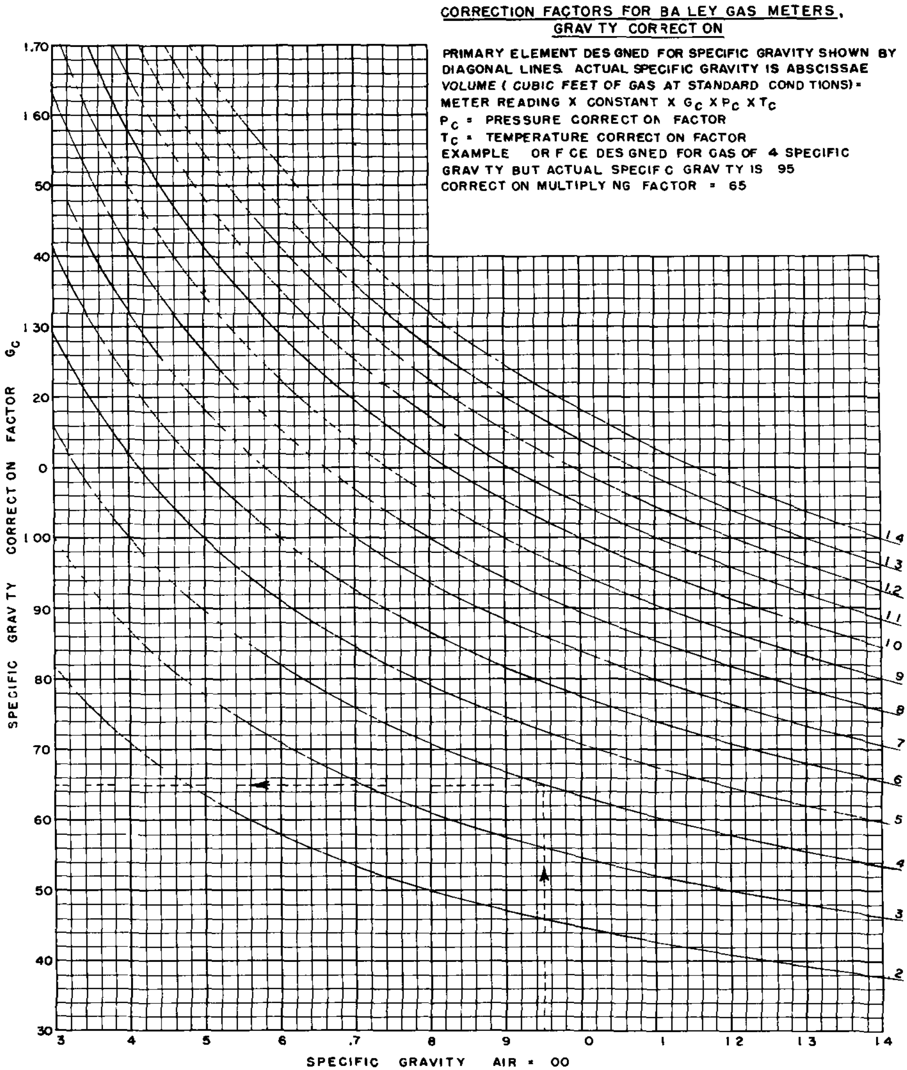


FIGURE 14—Gravity Correction Factors for Air or Gas Fow

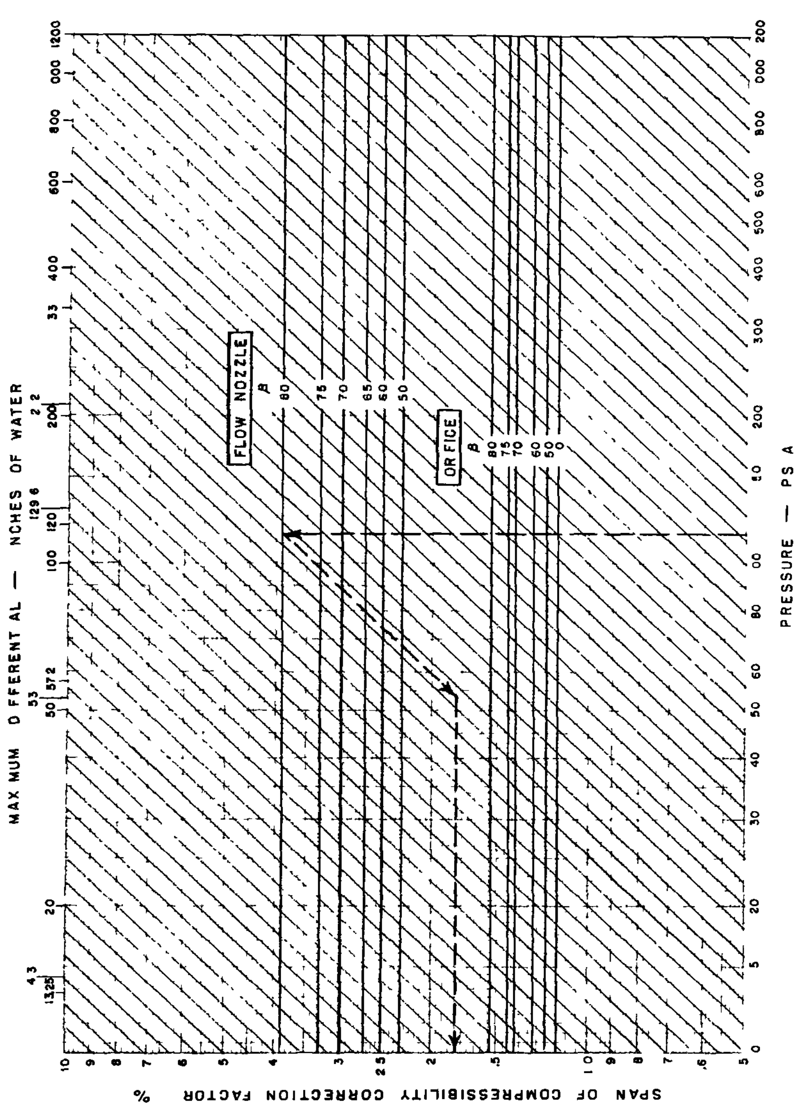


FIGURE 15 Span of Compressibility Correction Factors for Steam and Gases with a Specific Heat Ratio of 1.3
(For Air and Other Diatomic Gases with a Specific Heat Ratio of 1.4, Multiply Indicated Span by .931)

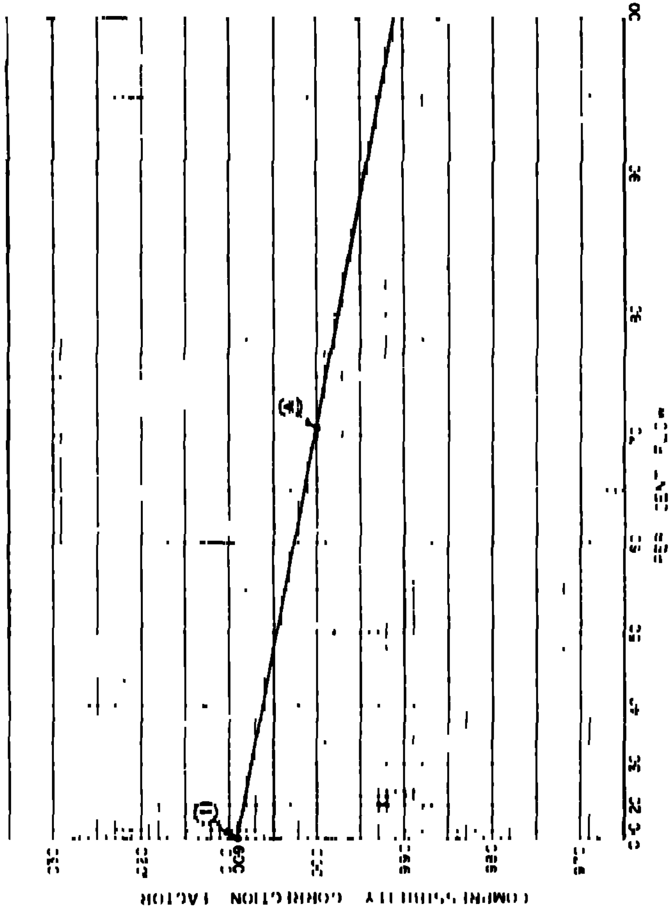


FIGURE 16—Grid for Plotting Meter Correction Factors Due To Compressibility
(Example Shows Correction Factors for C F Span of 1 8 Per Cent)

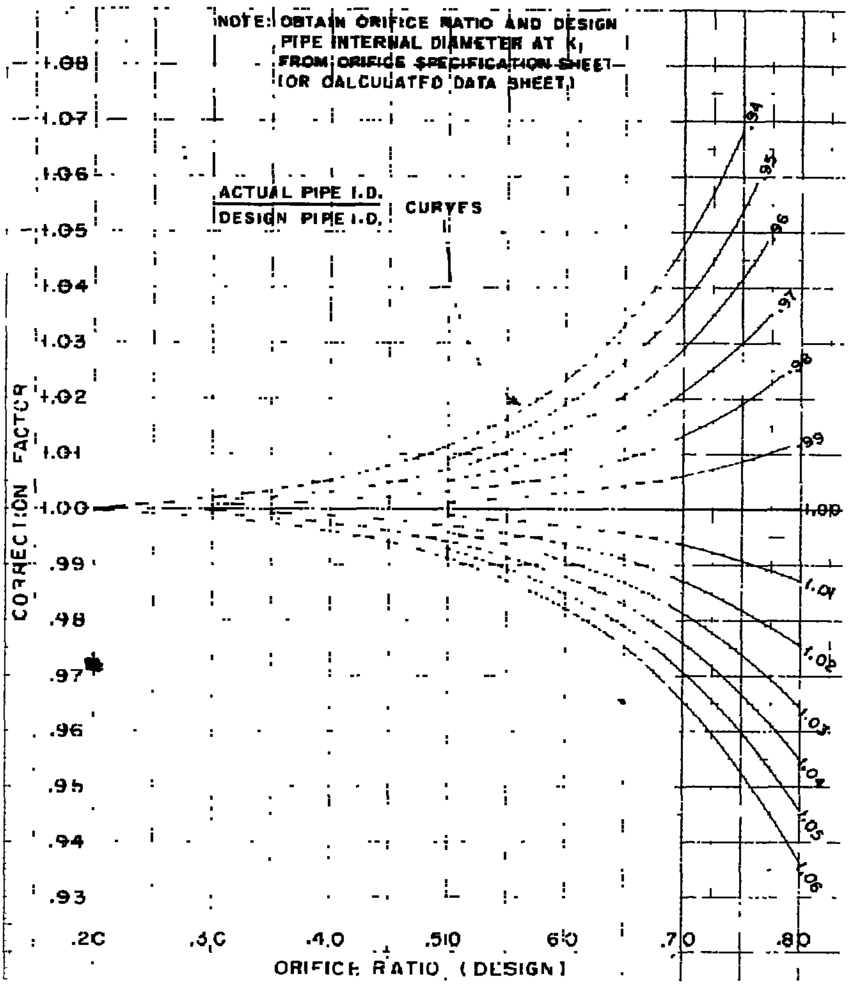


FIGURE 17—Correction Factors for Variations in Pipe Internal Diameter