Measurement Basics

ANGA Engineering and Operation

Spring Conference

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MarieCo, Inc.

Overview

- Importance of Measurement
- Terminology
- Compressibility (Press & Temp)
  - Boyles and Charles law
  - Ideal and Real Gas
  - Supercompressibility

Importance of Accurate Measurement

- Billing
  - Gas System is Billing the End User
  - Gas Supplier is Billing the Gas System
- Lost and Unaccountable
- Flow control
- Odorization injection rate

Common Industry Units

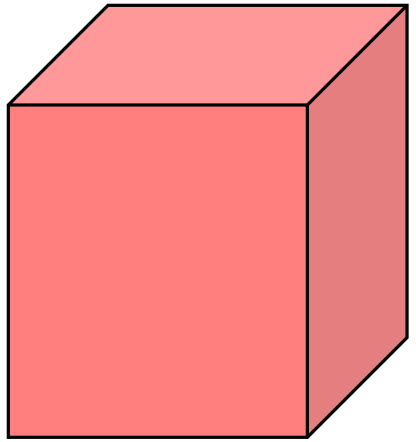
- Volume
  - Cubic foot: CF
  - One hundred cubic feet: CCF
  - One thousand cubic feet: MCF
  - One million cubic feet: MMCF
  - One billion cubic feet: BCF
  - One trillion cubic feet: TCF
  - Standard cubic foot: SCF
  - Actual cubic foot: ACF
  - One million BTU: MMBTU

Common Industry Units (cont)

- Pressure
  - Gauge (Pounds Per Square Inch Gauge…PSIG)
  - Absolute (Pounds Per Square Inch Absolute…PSIA)
- Temperature
  - Fahrenheit
  - Celsius (centigrade)
  - Absolute
    - Rankine
      - Fahrenheit
    - Kelvin
      - Celsius

Standard Cubic Foot

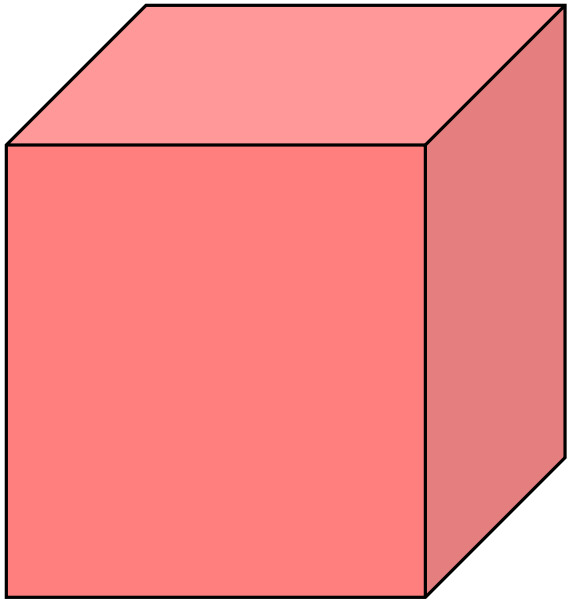
- Fixed parameters or Standard Conditions
  - Volume = one cubic foot
  - Temperature = 60^{o} F
  - Pressure = 14.73 psi Base Pressure
    - 14.73 is atmospheric pressure at sea level



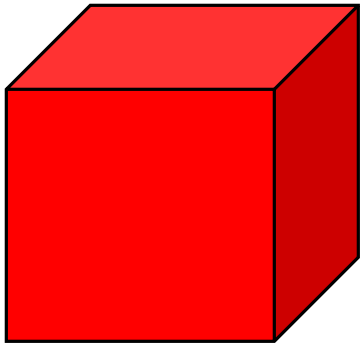
Actual Cubic Foot

- Usually variable parameters/ pipeline conditions
  - Volume of the container, one cubic foot
    - Volume/capacity of meter
  - Temperature of gas in container (meter)
  - Pressure within container (meter), psig
  - Atmospheric pressure, psia (at meter location)

Actual Cubic Foot



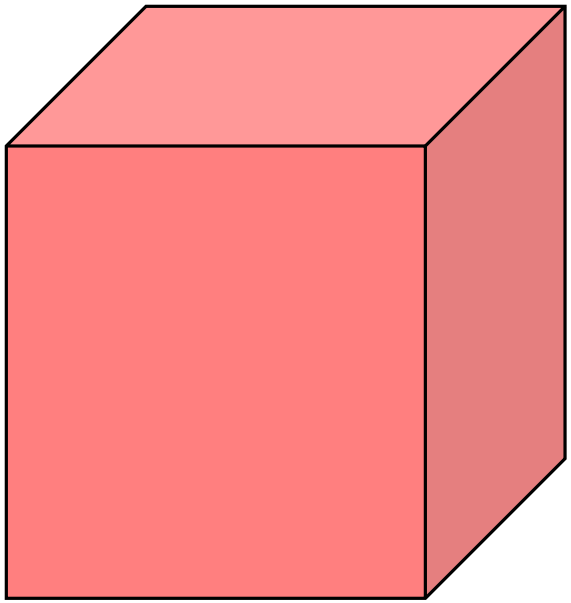
Actual cubic foot at;
Atmospheric pressure 14.73, &
Standard temperature, 60^{o} F



Actual cubic foot at;
Higher pressure, and/or
Lower temperature.

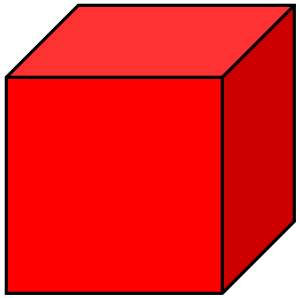
More molecules (gas) compacted into the same volume.

Actual Cubic Foot to Standard Cubic Foot Conversion



15,000 cubic feet at;
Atmospheric pressure, & 60^{o} F

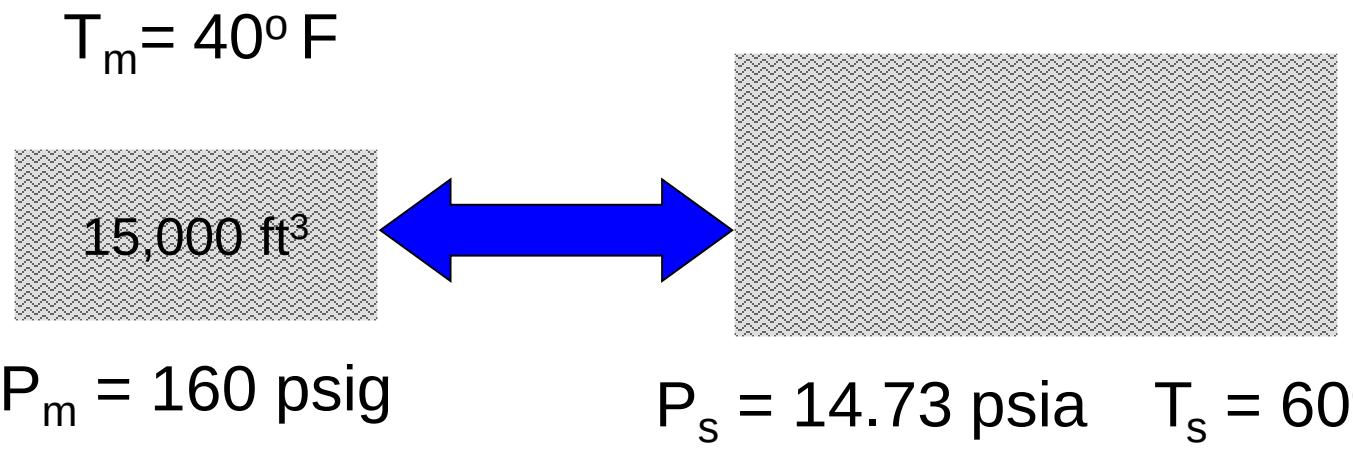
What is the equivalent volume in standard cubic feet?



15,000 cubic feet at;
160 psig, & 40^{o} F

What is the equivalent volume in standard cubic feet?

Correcting to the Standard



15,000 ft^3 of gas is metered at 160 psig and 40^0 F. What is the volume at a pressure of 14.73 psia and a temperature of 60^0 F? Local atmospheric pressure is 14.5 psia.

Correcting to the Standard

$V_s = (P_m/P_s) \times V_m \times (T_s/T_m)$

$P_m = 160 + 14.5 = 174.5$ psia

$P_s = 14.73$ psia

$T_m = 40 + 460 = 500^o$ R

$T_s = 60 + 460 = 520^o$ R

$V_m = 15{,}000$ ft^3

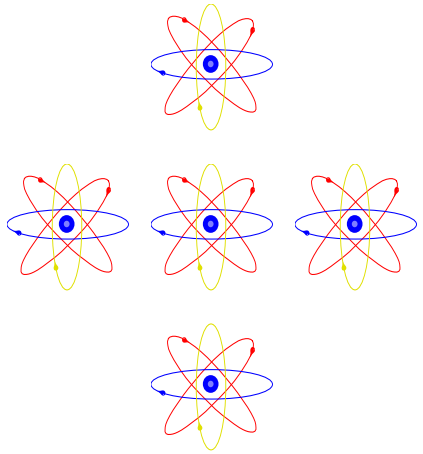
$V_s = (174.5/14.73) \times 15{,}000 \times (520/500)$

$V_s = 11.85 \times 15{,}000 \times 1.04 = 184{,}860$ ft^3

Correcting to the Standard

Supercompressibility

At pressures up to about 2000 psig, attractive forces bring the molecules closer together than that from just the pressure, therefore the gas occupies an even smaller volume



Supercompressibility Factor, F_{pv}

0.6 Specific Gravity Hydrocarbon Gas

Pressure (psig)	Temperature (°F)					
	40	45	50	55	60	65
0	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
20	1.0018	1.0017	1.0016	1.0016	1.0016	1.0015
40	1.0037	1.0036	1.0034	1.0033	1.0032	1.0031
60	1.0054	1.0053	1.0051	1.0049	1.0047	1.0046
80	1.0073	1.0070	1.0068	1.0066	1.0064	1.0062
100	1.0091	1.0088	1.0085	1.0083	1.0080	1.0078
120	1.0110	1.0106	1.0103	1.0100	1.0097	1.0094
140	1.0128	1.0124	1.0120	1.0116	1.0112	1.0109
160	1.0147	1.0142	1.0138	1.0133	1.0129	1.0125

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Supercompressibility

$V_s = 11.85 \times 15{,}000 \times 1.04 \times F_{pv}^{\,2}$

$V_s = 184{,}860\ ft^3 \times F_{pv}^{\,2}$

$F_{pv}^{\,2} = (1.0147)^2 = 1.0296$

$V_s = 184{,}860\ ft^3 \times 1.0296 = 190{,}335\ ft^3$

Results of Correction Factor

Uncorrected Volume = 15,000 cf

Press factor (11.846) = 177,690 scf

Press &Temp factor (11.846 x1.04 = 12.324) = 184,860 scf

Pressure, Temp and Supercompressibility

(11.846 x 1.04 x 1.0296) = 190,335 scf

Billing Basics

- Today's billing typically accounts for BTU quantity in “therm”
  - BTU = British Thermal Unit
  - Therm = 100,000 BTU
  - Dekatherm = 1,000,000 BTU
  - 1,000,000 BTU= 1000 CF

Energy or Therm Billing

$7.00 per 15,000 CF (15 MCF)

190,335 SCF Corrected Volume

BTU value 1025

190,335 x 7 $/MCF = 190.335 X 7= $ 1,332.35

$1,332.35 x 1025 BTU = 1,332.35 x 1.025 = $1,365.66

Pressure, Temperature and BTU

- Pressure
  - Pressure is always the same (Fixed Factor by hand or Index)
  - Pressure is not always the same (Live Pressure Correction Required)
- Temperature
  - Temp always at 60° F (no factor required)
  - Temp varies from 60° F (Live Temp Correction is required)
  - Temp stable but < or > 60° F (Fixed Factor by hand or index)
- BTU content
  - Constant/Repeatable (BTU fixed factor or factored in)
  - Gas sampling & analysis (Live, Composite or Spot)
- Billing typically in Therms/Dekatherms

Back to the Basics

Thank You