Demystifying Dispense Gas
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Sales Quality Specialist
Bell’s Brewery

Ken Smith
Beer Education
The Boston Beer Company
Purpose of Dispense Gas

1. Maintain carbonation of beer
2. Push beer from keg to faucet
Many lagers have between 2.5 – 2.7 vols of CO2

This means that each 16 oz glass of beer has nearly 2 ½ glasses of gas
Gas is an Ingredient

Perfect Carbonation

Under Carbonation

Over Carbonation

What the brewer intended
Gas Laws and Beer

Henry’s Law: At a constant temperature the amount of dissolved gas in a liquid is proportional to its partial pressure above the liquid.

Dissolved CO₂ in Beer is 2.6 v/v at 38 degrees F and 12 psi of applied pressure.
Gas Laws and Beer

- ↑Temperature = ↓Solubility
- ↓Temperature = ↑Solubility

Dissolved CO2 in beer is 2.38 v/v at 42 degrees F and 12 psi of applied pressure.
Gas Laws and Beer

- ↑Temperature = ↓Solubility
- ↓Temperature = ↑Solubility

Dissolved CO2 in beer is 2.82 v/v at 34 degrees F and 12 psi of applied pressure.
Dissolved CO2 in beer is 3.07 v/v at 38 degrees F and 16 psi of applied pressure.
Gas Laws and Beer

• ↑ Pressure = ↑ Solubility
• ↓ Pressure = ↓ Solubility

Dissolved CO2 in beer is 2.38 v/v at 38 degrees F and 8 psi of applied pressure.
CO2 breakout caused by decreased solubility

- High temperature
- Low pressure
Pressure vs. Temperature

As temperature **increases** so must pressure to maintain the same volumes of CO2 and vice versa
# Pressure vs. Temperature

<table>
<thead>
<tr>
<th>Volumes of CO2 in the beer</th>
<th>9 psi</th>
<th>11 psi</th>
<th>13 psi</th>
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<tbody>
<tr>
<td>34° F</td>
<td>2.5</td>
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<td>42° F</td>
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</table>
Pressure vs. Beer Carbonation

CO2 Pressure = ? psig

2.65 volumes CO2

- @ 40°F
- @ sea level
- 100% CO₂ Direct draw system
## CO₂ Gauge Pressure Reference Chart

**Determination of CO₂ Applied Gauge Pressure Given Volumes of CO₂ and Temperature**

<table>
<thead>
<tr>
<th>Vol. CO₂</th>
<th>2.1</th>
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* Chart assumes sea level as altitude. Add 1 psi for every 2,000 ft. above sea level.

**What do you need to know?**

1. Volumes of CO₂
2. Serving Temp
Pressure vs. Beer Carbonation

CO2 Pressure = 14 psig

2.65 volumes CO2

- @ 40°F
- @ sea level
- 100% CO₂ Direct draw system
Pressure vs. Beer Carbonation

CO2 Pressure = 14 psig
2.65 volumes CO2
• @ 40°F
• @ sea level
• 100% CO₂ Direct draw system

What if it’s Denver @ 5280 feet?
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<th>Vol. CO₂</th>
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What do you need to know?
1. Volumes of CO₂
2. Serving Temp
3. Altitude
Pressure vs. Beer Carbonation

What if it’s Denver @ 5280 feet?

- @ 40°F
- @ sea level
- 100% CO₂ Direct draw system

CO₂ Pressure = 17 psig

2.65 volumes CO₂
Push beer from keg to faucet

- Applied pressure
- Gravity and system restriction
RESISTANCE is the FRICTION beer encounters as it moves from the keg to the faucet.

APPLIED PRESSURE
The amount of PSI force to overcome resistance.
Flow rate of 128 oz per minute

Applied Pressure = Total restriction
Pressure vs. Resistance

Dynamic – all the components of a system

Static – effects of gravity
STATIC (Gravity)
<table>
<thead>
<tr>
<th>Type</th>
<th>Size</th>
<th>Restriction</th>
<th>Volume</th>
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<td>3/16” ID</td>
<td>3.00 lbs/ft</td>
<td>1/6 oz/ft</td>
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<td>Vinyl</td>
<td>1/4” ID</td>
<td>0.85 lbs/ft</td>
<td>1/3 oz/ft</td>
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<td>Vinyl</td>
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<td>Vinyl</td>
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<td>0.20 lbs/ft</td>
<td>3/4 oz/ft</td>
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<td>Vinyl</td>
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<td>0.025 lbs/ft</td>
<td>1-1/3 oz/ft</td>
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<td>Barrier</td>
<td>1/4” ID</td>
<td>0.30 lbs/ft</td>
<td>1/3 oz/ft</td>
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<td>Barrier</td>
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<td>1/2 oz/ft</td>
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<tr>
<td>Barrier</td>
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<td>0.06 lbs/ft</td>
<td>3/4 oz/ft</td>
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<td>Stainless</td>
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<td>1.20 lbs/ft</td>
<td>1/6 oz/ft</td>
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<td>Stainless</td>
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<td>0.30 lbs/ft</td>
<td>1/3 oz/ft</td>
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<tr>
<td>Stainless</td>
<td>3/8” OD</td>
<td>0.12 lbs/ft</td>
<td>1/2 oz/ft</td>
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</tbody>
</table>
Pressure vs. Resistance

Example System
- Direct draw system
- 40° F Serve
- Denver (5280')
- 2.65 vol CO²

14 psi + 3 (2000’) = 17psi

Need **17 lbs restriction** to balance (push pressure)
- Parts resistance = 3 lbs
- 3’ vertical rise = 1.5 lbs = 4½
- Need 12.5 lbs

Restriction to balance
- Vinyl 3/16 choker provides 3 lbs restriction per foot
- Need 12.5 ÷ 3 = 4.17 feet

3 X 4.17 = 12.5 + 4.5 = 17

**Cut 3/16 line at 4’2”**

17 psi – KEG = 17 lbs – RESISTANCE
(pours 1 gallon/ minute)
Pressure vs. Resistance

To achieve proper flow and beer quality, the pressure applied to the keg must equal the total resistance of the draft system.
Pressure vs. Resistance

40° F Serve

17 PSI Pressure to Keg

Carbonation Quality

Flow Rate

25 LBS Restriction

#CraftBrewersCon
Pressure vs. Resistance

40° F Serve

25 PSI Pressure to Keg

25 LBS Restriction

Carbonation Quality

Flow Rate
Pressure and Beer Carbonation

CO\textsubscript{2} Pressure = 17 psig (in Denver)

Total Pressure = 25 psig

N\textsubscript{2} is 74 times less soluble than CO\textsubscript{2} @ 0°C
Pressure vs. Resistance

80% CO₂
25 PSI Pressure to Keg

40° F Serve

25 LBS Restriction

Carbonation Quality

Flow Rate

#CraftBrewersCon
Appendix C:  Page 93

\[ C = \frac{b + 14.7}{a + 14.7} \]

a = gauge pressure of the blended gas
b = gauge pressure of pure CO$_2$
c = proportion of CO$_2$ in blended gas

14.7 = atmospheric pressure in pounds per square inch at sea level
\[ C = \frac{b + 14.7}{a + 14.7} \]

- \( a \) = gauge pressure of the blended gas
- \( b \) = gauge pressure of pure CO\(_2\)
- \( c \) = proportion of CO\(_2\) in blended gas

14.7 = atmospheric pressure in pounds per square inch at sea level
## Pressure vs. Resistance

### 30 PSI Pressure to Keg

<table>
<thead>
<tr>
<th>70% CO₂</th>
<th>30 PSI</th>
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**Carbonation Quality**

<table>
<thead>
<tr>
<th>Flow Rate</th>
<th>70% CO₂</th>
<th>40° F Serve</th>
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*If pressure is 2-3 psi over ideal gage pressure (at sea level), gas should be blended!*
What makes up the air we breathe?

- Nitrogen: 78%
- Oxygen: 21%
- Argon: 0.93%
- CO2: 0.04%
- Trace gases

100% CO2
Dalton’s Law:

\[ P_{\text{Total}} = P_{\text{gas } 1} + P_{\text{gas } 2} + P_{\text{gas } 3} \ldots \]

**Nitrogen:**
- Will push beer along with CO2
- Much less soluble than CO2
- Doesn’t help keep CO2 in solution
Thank you!

Please click HERE to take this brief survey.