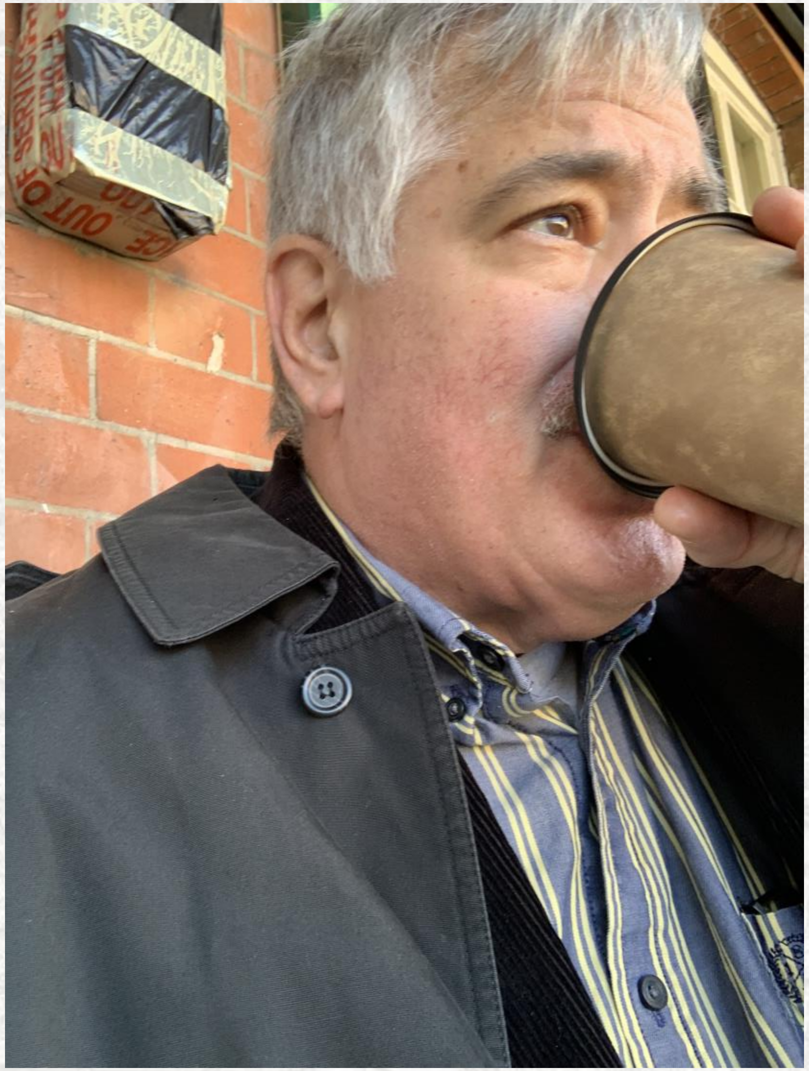
CRAFT BREWERS CONFERENCE & BrewExpo America

Draught Beer Quality Workshop: Calculating Proper Balance and Pours

BA Draught Beer Quality Manual

#CraftBrewersCon

BREWERS ASSOCIATION

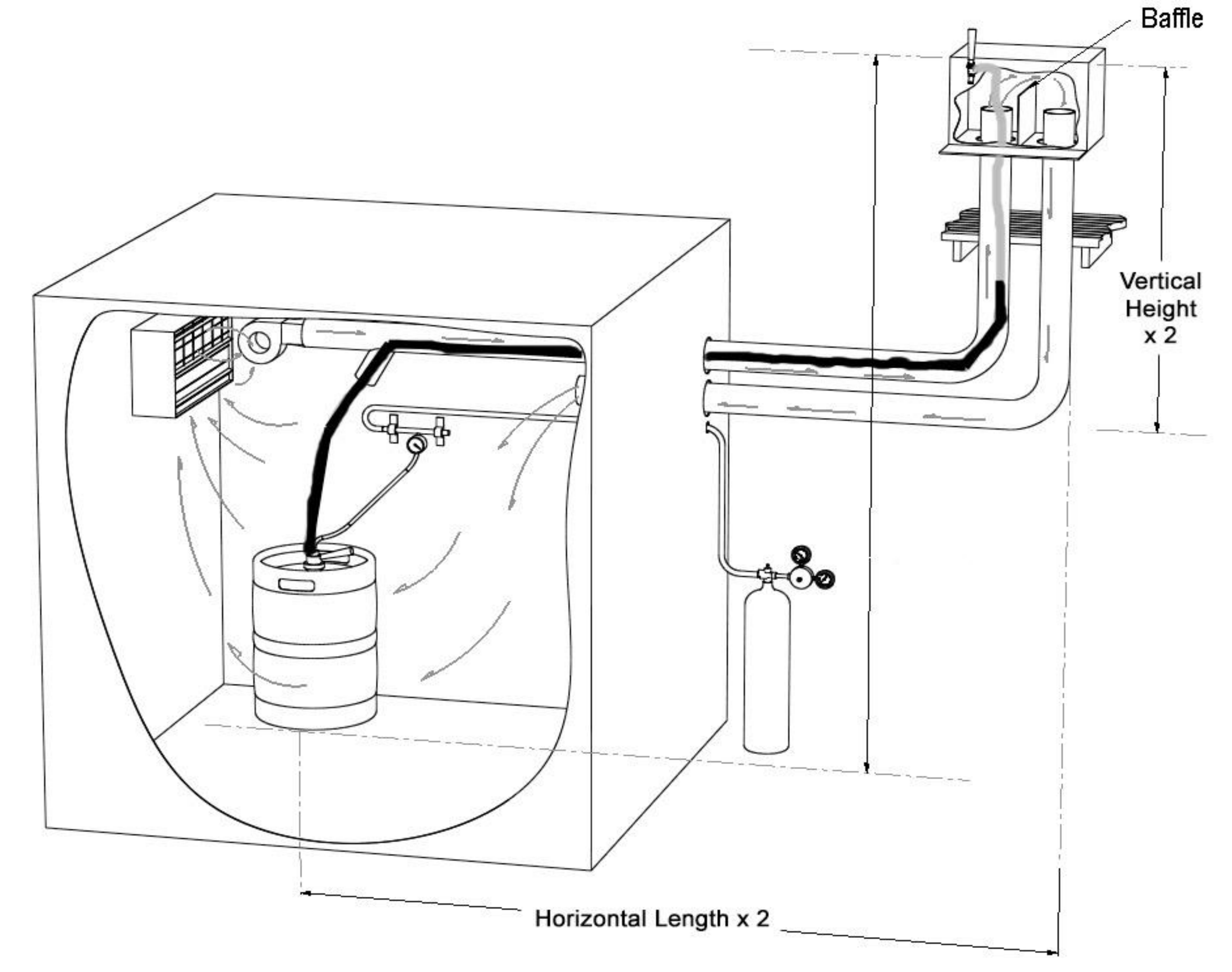


Jaime Jurado

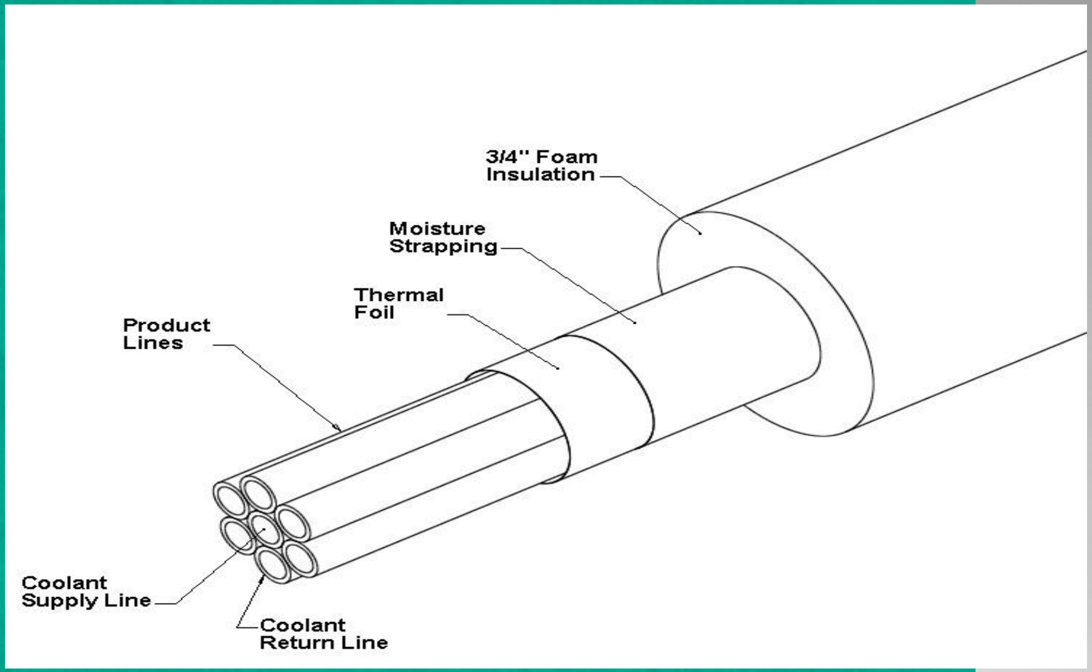
Vice President

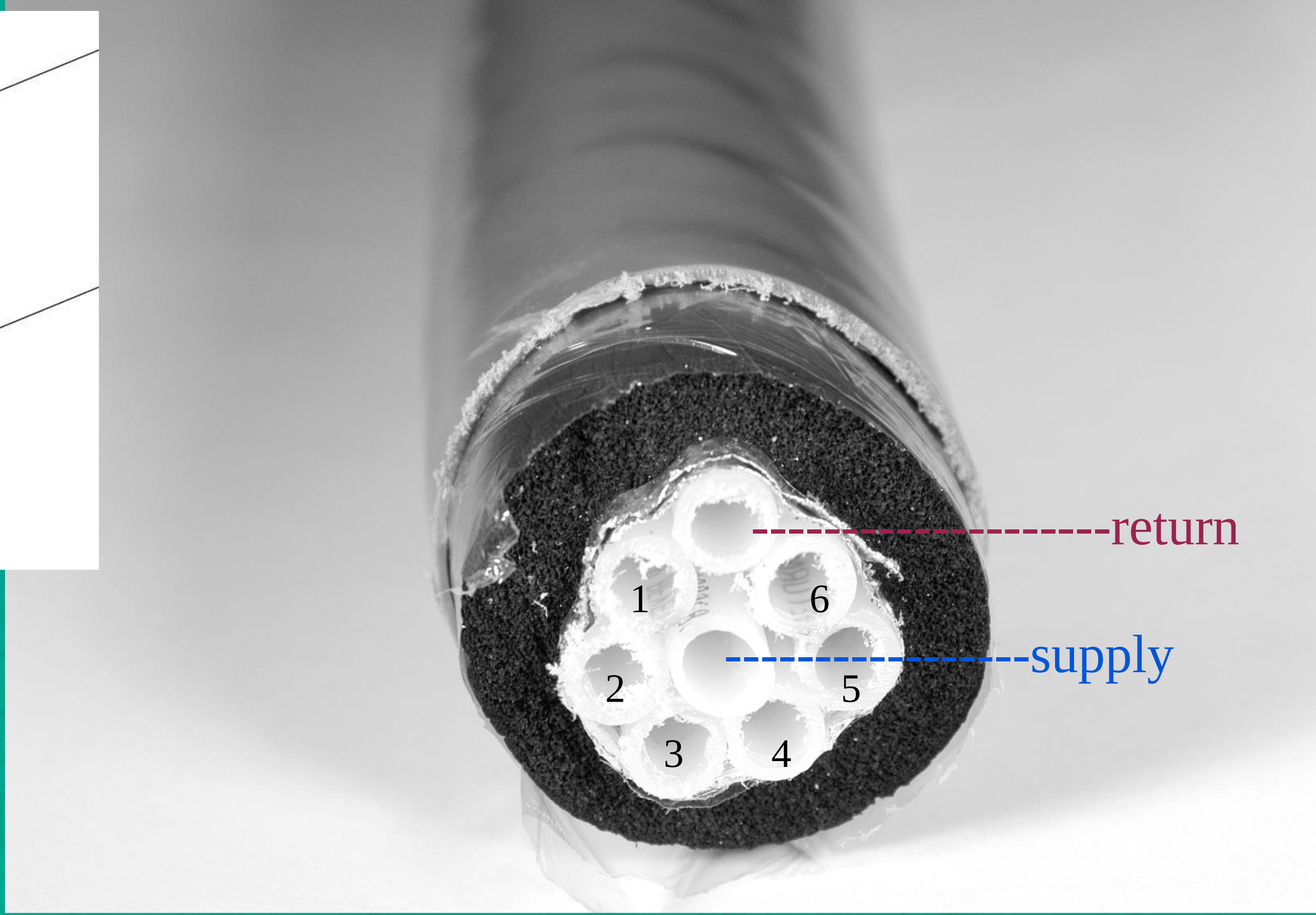
Ennoble Beverages, Inc

https://www.brewersassociation.org/resource-hub/draught-beer/



What was once world-class…


3/4" Foam Insulation
Moisture Strapping
Thermal Foil
Product Lines
Coolant Supply Line
Coolant Return Line


return
1
6
supply
2
5
3
4

…has evolved

The Facts About Draught Beer Carbonation

Are you using 60%CO2/40%N2 to dispense your beer? Chances are some if not all of your beers are slowly going flat and potentially falling out of the brewer's desired carbonation range.

Recently, the Brewer Association Technical Committee endorsed a beer industry-wide guideline that changes the default dispense gas blend from 60% CO2 to 70% CO2 for any systems that need CO2-rich blends (see back of page for criteria). Extensive market research indicates that when used as the sole gas blend, 70% CO2 keeps more beers within their respective carbonation specifications.

In a near-constant effort to maintain high-quality draught beer at retail, brewers have long battled gas systems which

When all the elements are in balance, the beer will stay properly carbonated. The problem is that the average draught system is pouring beers with differing levels of carbonation; with the three other elements remaining constant, this causes many beers to become flat.

The solution lies in making adjustments to either of the two elements we can readily adjust: CO2 percentage, and applied pressure. Let's look at these individually.

CO2 Percentage Adjustment

The adjustment of CO2 percentages for different beers has historically been difficult if not impossible. Gas blending panels usually have only one CO2-rich blend available, with dual

The BA offers a 'One-Pager' …

New Guidelines For the Use of Blended Gas for Draught Beer Dispense:

Prepared by the Brewers Association Technical Committee Draught Beer Quality Working Group

www.draughtquality.org

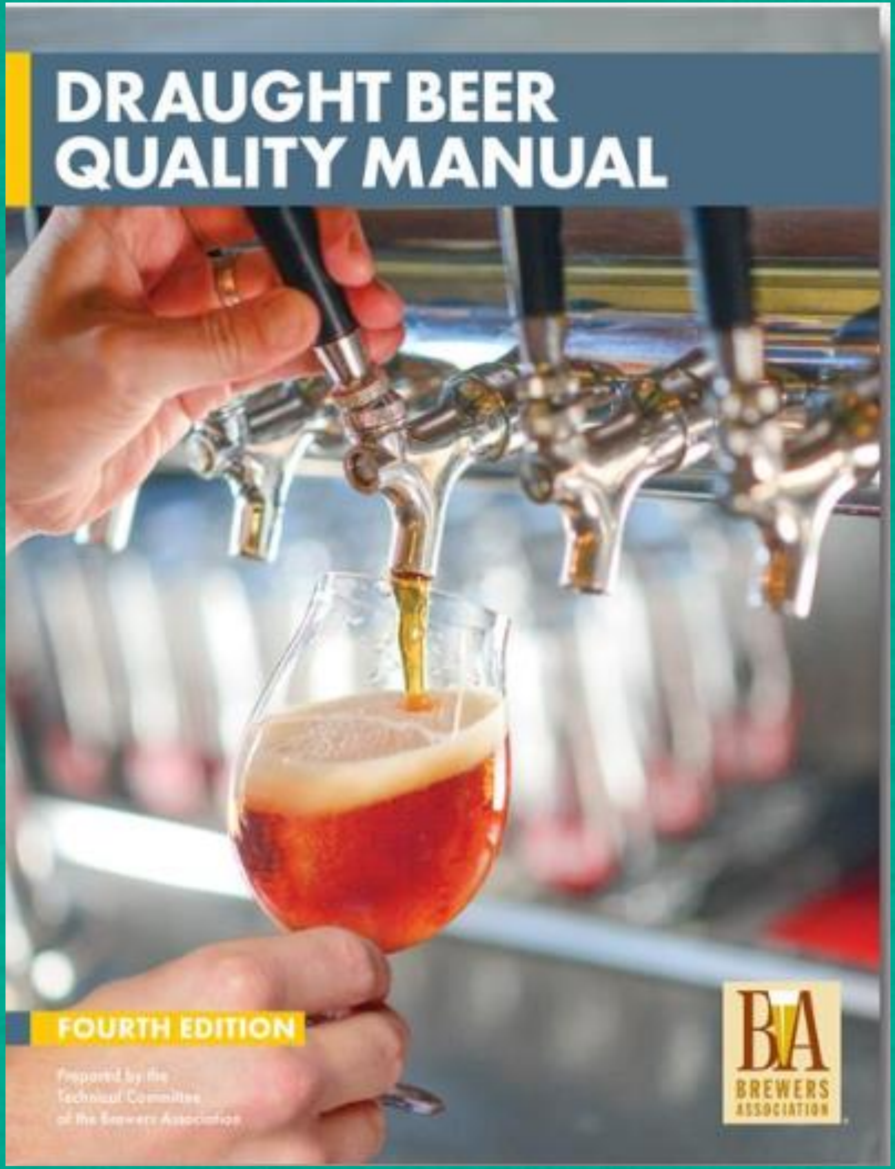
Excel Perfect Blend Program

Easy Blend Calclator	
Enter these values:	
Temperature (°F)	38
Pressure (psig)	18
CO_2 Content (vols/vol)	2.5
Perfect CO2 %	79%

Easy Blend Calclator	
Enter these values:	
Temperature (°F)	40
Pressure (psig)	22
CO_2 Content (vols/vol)	2.7
Perfect CO2 %	79%

Easy Blend Calclator	
Enter these values:	
Temperature (°F)	36
Pressure (psig)	26
CO_2 Content (vols/vol)	2.7
Perfect CO2 %	66%

www.draughtquality.org

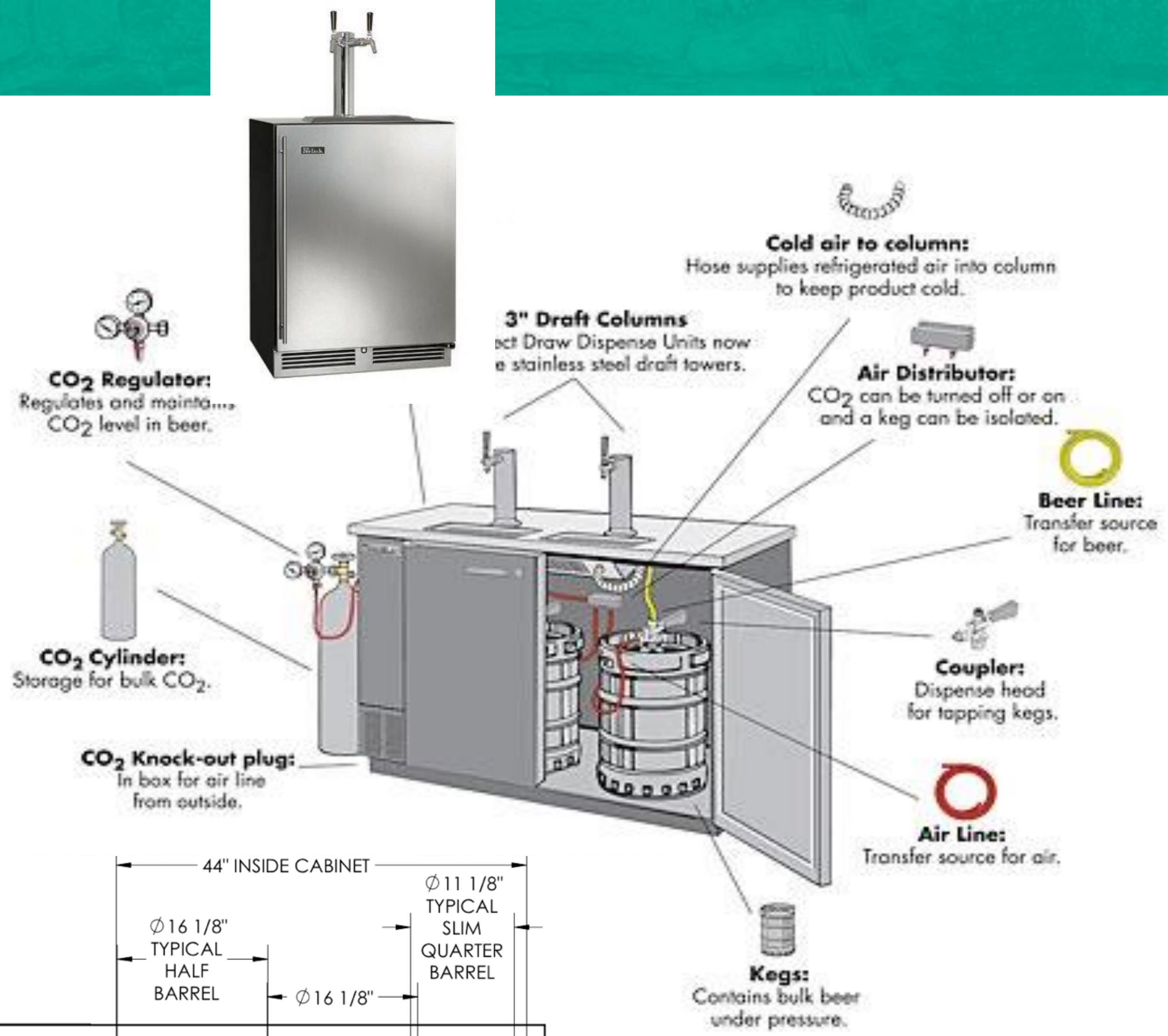


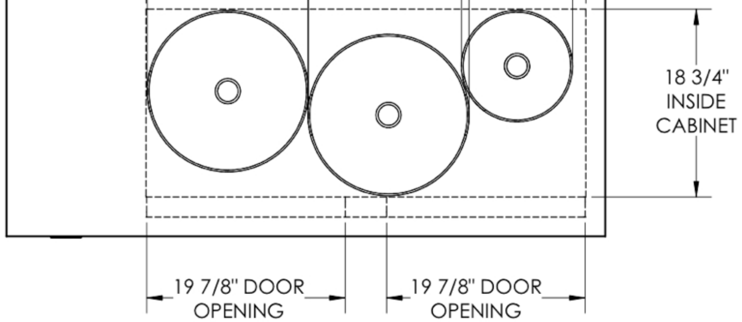
Our (free) State of Art Resource

- BA Draught Beer Quality Sub-Committee
- We'll use our unique and practical 'textbook' in guiding today's online presentation! Our framework is focused on attaining ***BALANCE to dispense perfect beer…***

  - Temperature
  - Pressure
  - Resistance & Components
  - Our options!

Social isolation in nature





#CraftBrewe

BREWERS ASSOCIATION

TABLE 3.3. DIRECT-DRAW DRAUGHT SYSTEM BALANCE AT 38°F

Carbonation (volumes CO_2)	2.3	2.4	2.5	2.6	2.7	2.8	2.9
Applied CO_2 (psig)	9.2	10.3	11.3	12.4	13.5	14.5	15.6
3⁄16" Vinyl beer line length	3'3"	3'5"	3'9"	4'2"	4'6"	4'10"	5'7"

Diverse tools are in the BA book for many situations

Today's focus is on longer systems and how we realize optimal dispense…

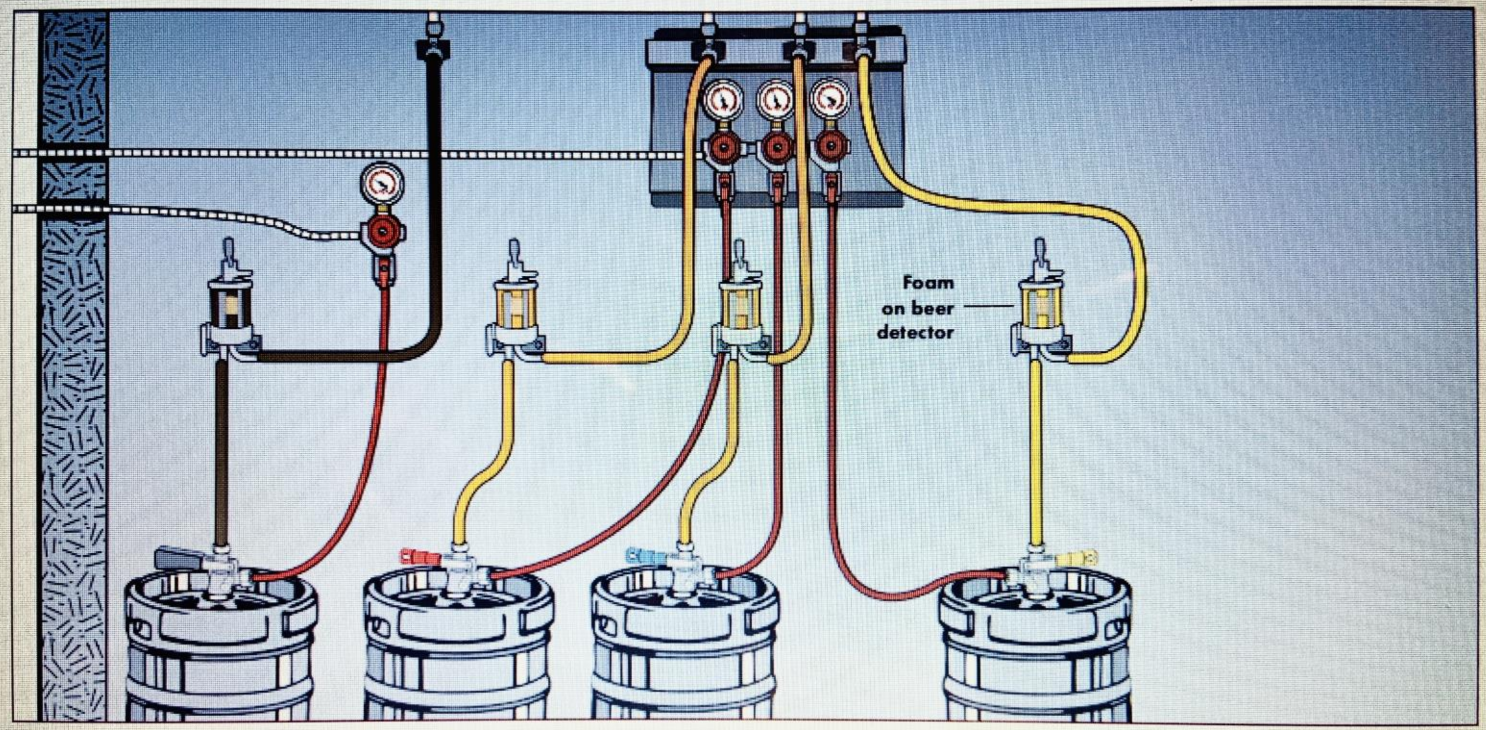
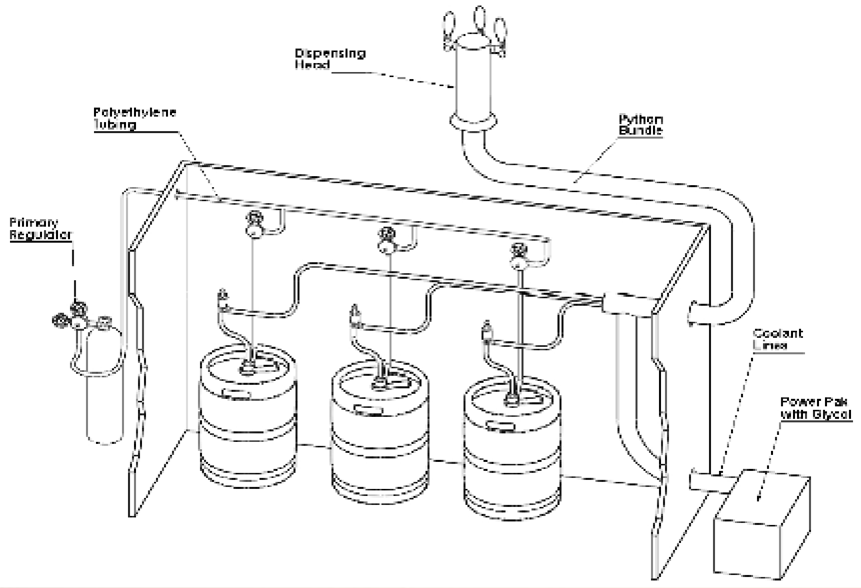


Figure 4.6. FOBs and wall brackets in walk-in cooler.

…including Calculations with examples

Ken Smith & Bridget Gauntner did the Prep work yesterday in their CBC talk!

Our goal….



Remember those times in learning where your Instructor/Professor illuminated solutions using approaches framed differently from the text?

No time to Spoon-Feed You

1. TEMPERATURE CHALLENGES REVIEW

1/2-bbl keg (36 F): if delivery van is at 90 deg F, rise in temp of 20 deg F in 2 hours. A keg at 50 deg F delivered into a 36 deg F cold room requires 3 days to equilibrate.

Temperature of many Lager Beers:
In cooler: 36^{o} F *(Jaime's ideal!)*
At faucet: 37^{o} F - 39^{o} F

- Consistent Quality
- Good Carbonation
- Palate - no off tastes
- Good head formation
- Lasting head retention

Heed Ken's (attemperation) comment………………24 hr min in cooler until tapping!

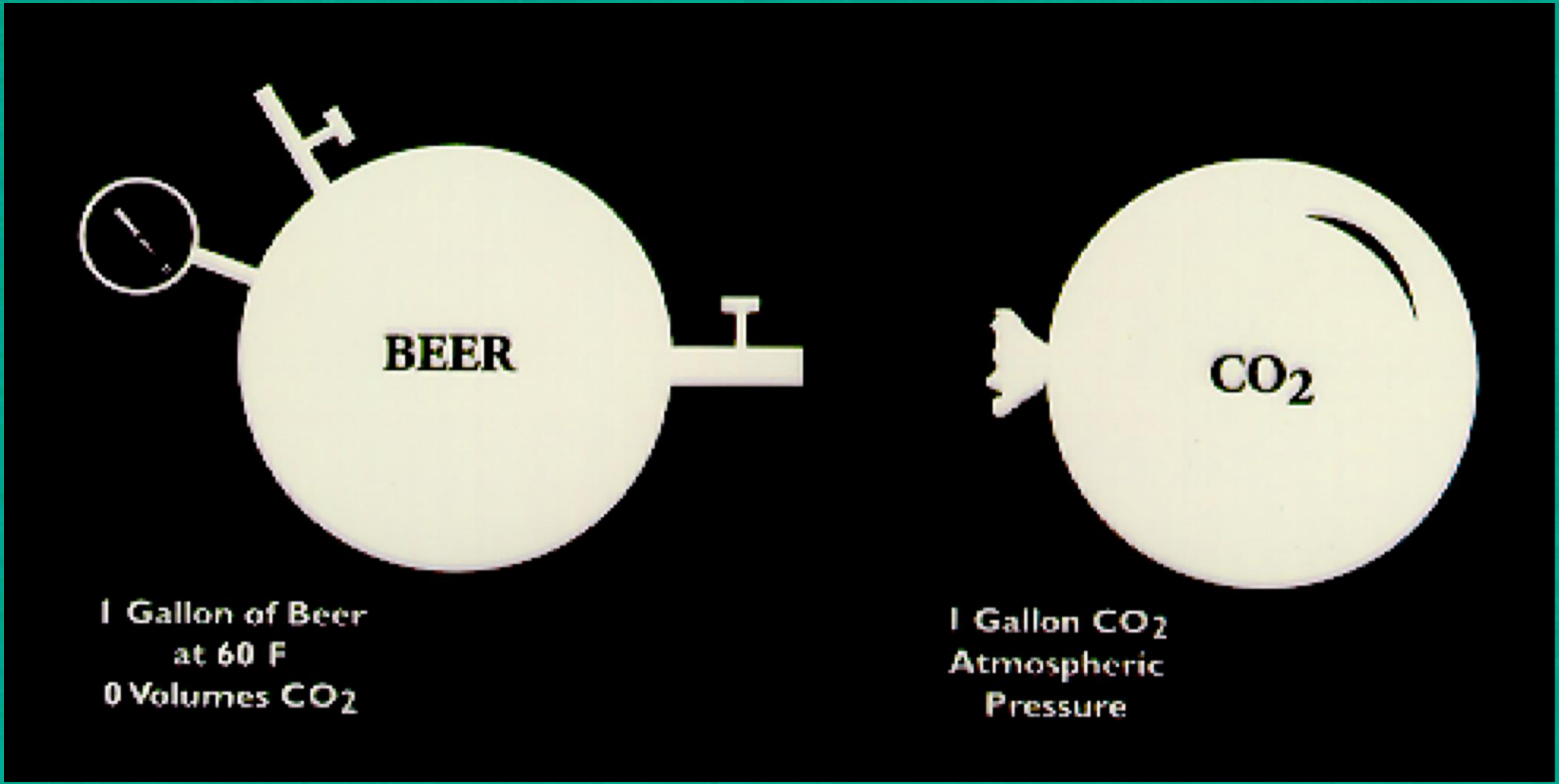
Gases Increase Solubility With Lowering Temperature

FOR EXAMPLE:

at 60º F - 1 gallon of CO_2 gas at atmospheric pressure will dissolve in 1 gallon of beer.

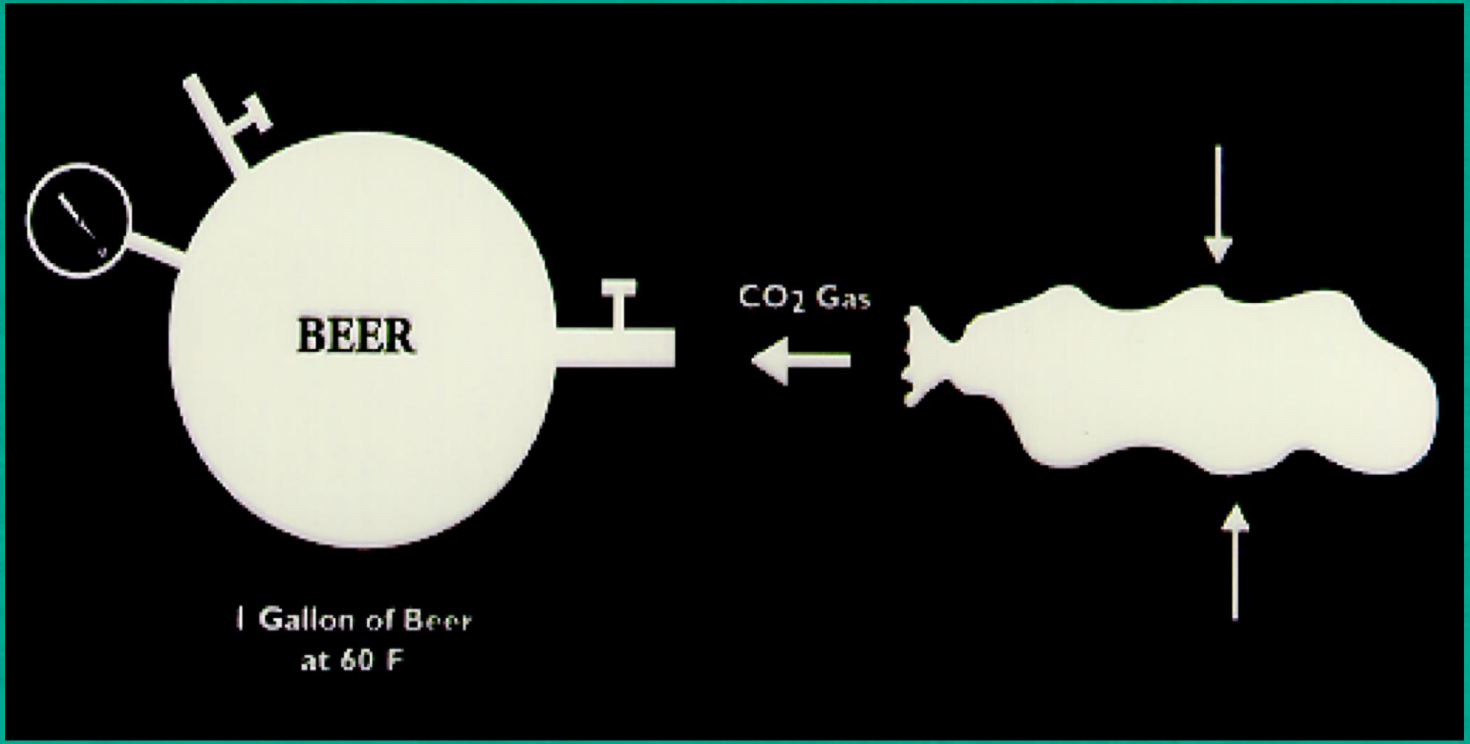
at 32º F - 1.71 gallons of CO_2 gas at atmospheric pressure will dissolve in 1 gallon of beer.

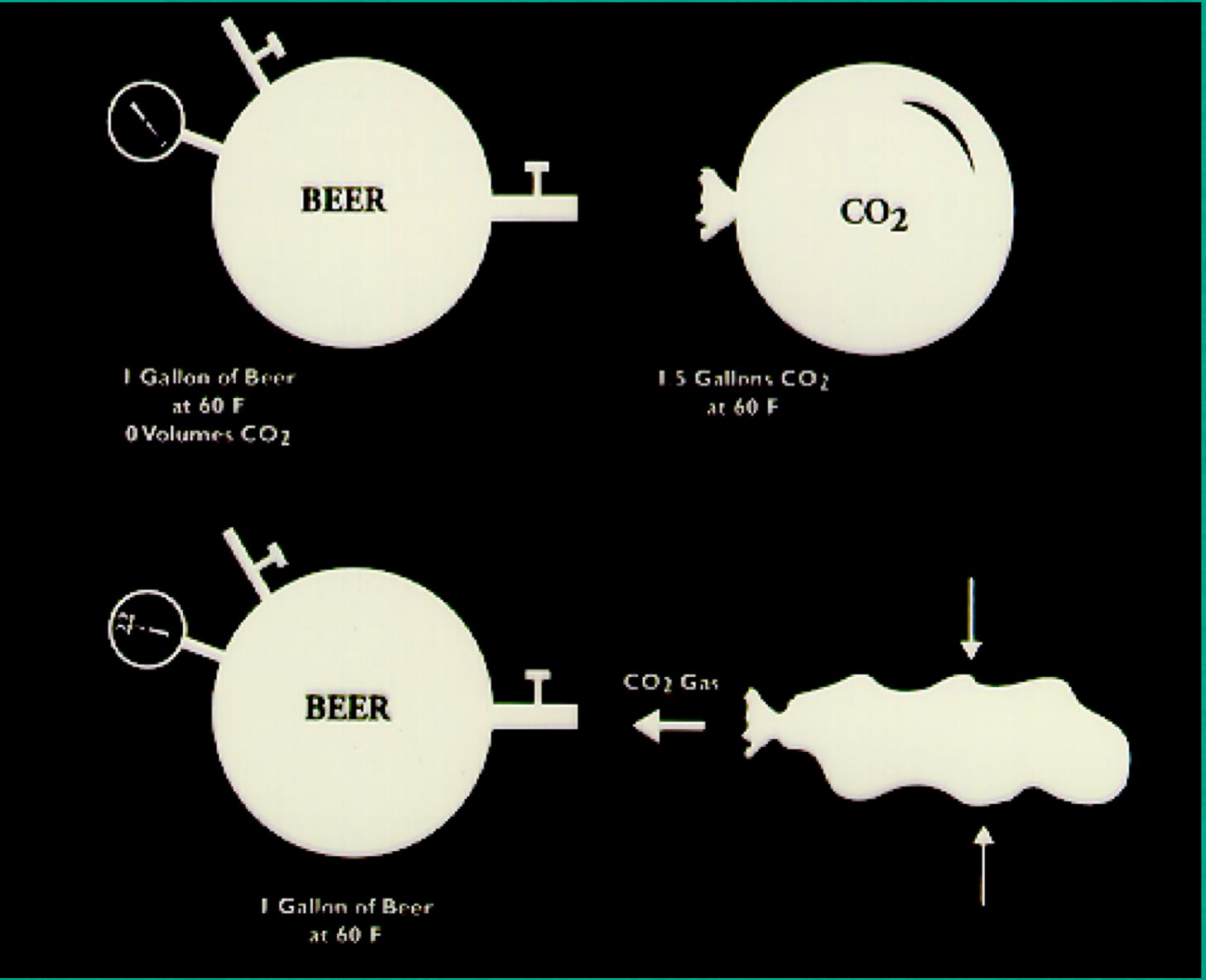
If we have 1 gallon of CO_2 in 1 gallon of beer, we say we have 1 volume of CO_2.


BEER
1 Gallon of Beer
at 60 F
0 Volumes CO_2
CO_2
1 Gallon CO_2
Atmospheric
Pressure

Beer now has 1 gallon of CO_2 dissolved in it.

The equilibrium condition is 1 volume CO_2 in solution at 0 PSI and 60^o F.





Add more gas (1.5 vols): CO_2 is now being restrained in solution by 22 PSI pressure.

The new equilibrium condition is 1 + 1.5 volume = 2.5 volume CO_2 at **22 PSI** and 60^o F.

Note: Allowing greater pressure on beer allows it to absorb more CO_2… and we'll see why this is a problem soon!

2. "BALANCE" is Differential Pressure Management in beer line

"Pressures produced when penguins pooh – calculations on avian defecation" by Victor Benno Meyer-Rochow and Jozsef Gal

$$z_1 + p_1/\rho g + v_1^2/2g = z_2 + p_2/\rho g + v_2^2/2g$$

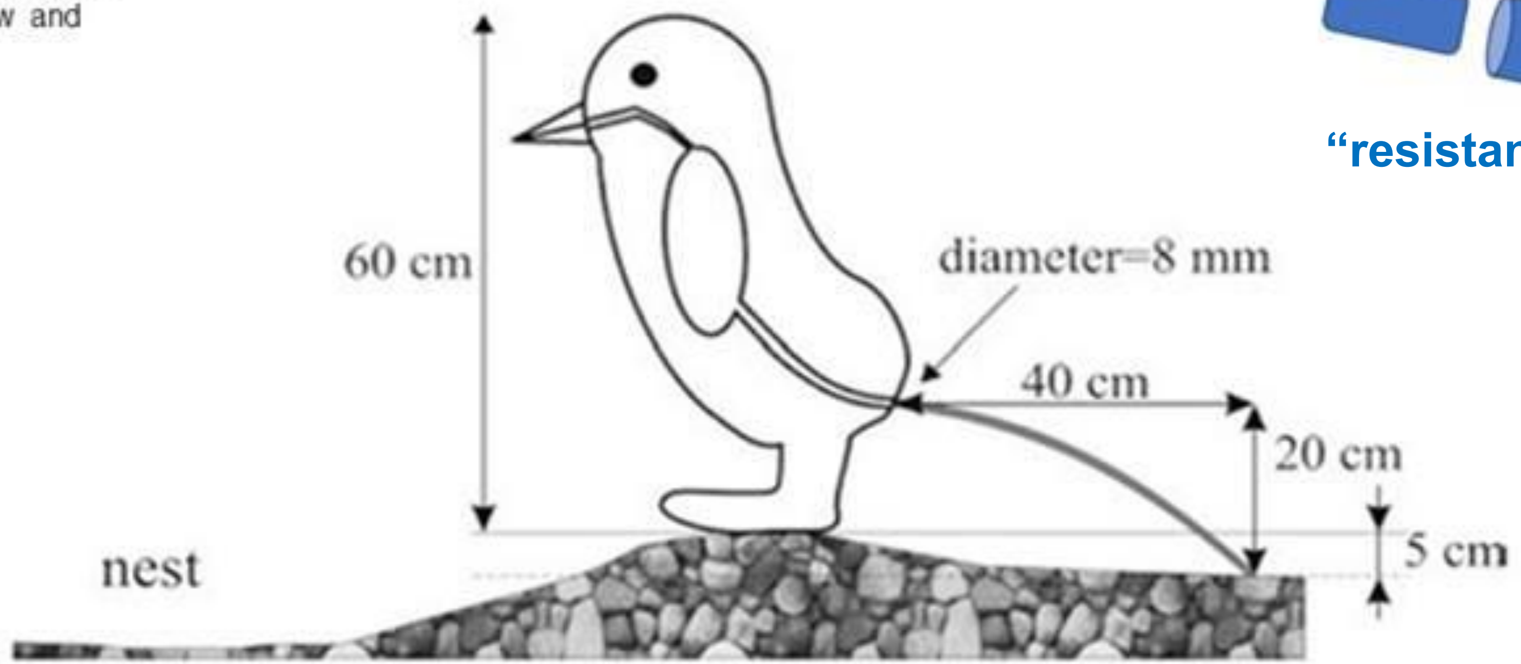


Fig. 1 Position of model penguin during defaecation and physical parameters used to calculate rectal pressure necessary to expel faecal material over a distance of 40 cm

American Institute of Chemical Engineers

Adopted by
J. Jurado

Hagen–Poiseuille equation: …a small increase in the internal diameter of the beer line yields a significant increase in flow rate of beer

TABLE 4.1. COMMON MATERIALS AND DIAMETERS USED FOR BEER LINE AND THEIR DYNAMIC RESISTANCE VALUES

Type	Size	Resistance (lb./ft.)*	Volume (fl. oz./ft.)
Vinyl/flexible	3⁄16" ID	3.00	1⁄6
Vinyl/flexible	1⁄4" ID	0.85	1⁄3
Vinyl/flexible	5⁄16" ID	0.40	1⁄2
Vinyl/flexible	3⁄8" ID	0.20	3⁄4
Vinyl/flexible	1⁄2" ID	0.025	1 1⁄3
Barrier	1⁄4" ID	0.30	1⁄3
Barrier	5⁄16" ID	0.10	1⁄2
Barrier	3⁄8" ID	0.06	3⁄4
Stainless	1⁄4" OD	1.20	1⁄6
Stainless	5⁄16" OD	0.30	1⁄3
Stainless	3⁄8" OD	0.12	1⁄2

Resistance decreases as beer line diameter increases

3. RESISTANCE

DRAUGHT SYSTEM BALANCE

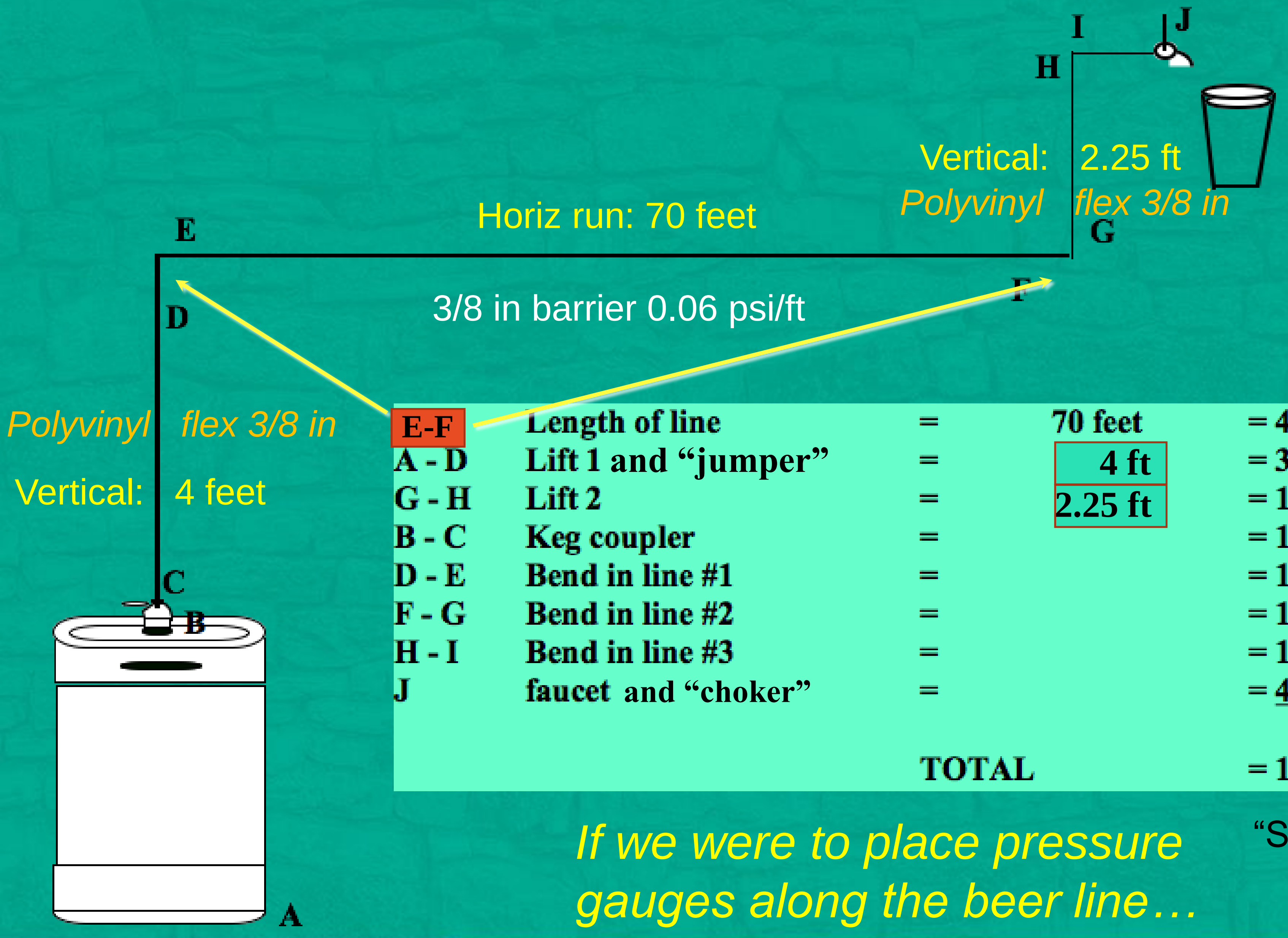
When applied pressure equals system resistance, a draught system will pour clear-flowing beer at the rate of 1 gal./min., or approximately 2 fl. oz./sec.

Page 37

Bridget discussed **Diffusion** yesterday

Think about our little penguin….

No time to Spoon-Feed You!



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Vinyl/flexible	3/8" ID	0.20	3/4
Vinyl/flexible	1/2" ID	0.025	1 1/3
Barrier	1/4" ID	0.30	1/3
Barrier	5/16" ID	0.10	1/2
Barrier	3/8" ID	0.06	3/4
Stainless	1/4" OD	1.20	1/6
Stainless	5/16" OD	0.30	1/3
Stainless	3/8" OD	0.12	1/2

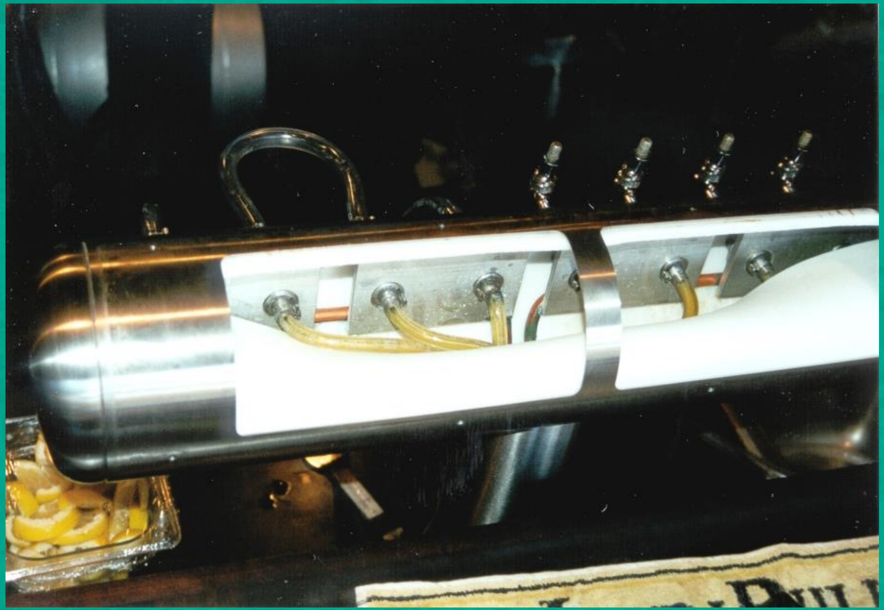
E-F	Length of line	=	70 feet	= 4.5 psi
A - D	Lift 1 and "jumper"	=	4 ft	= 3.0 psi
G - H	Lift 2	=	2.25 ft	= 1.5psi
B - C	Keg coupler	=		= 1.0 psi
D - E	Bend in line #1	=		= 1.0 psi
F - G	Bend in line #2	=		= 1.0 psi
H - I	Bend in line #3	=		= 1.0 psi
J	faucet and "choker"	=		= 4.0 psi
		TOTAL		= 17.0 psi

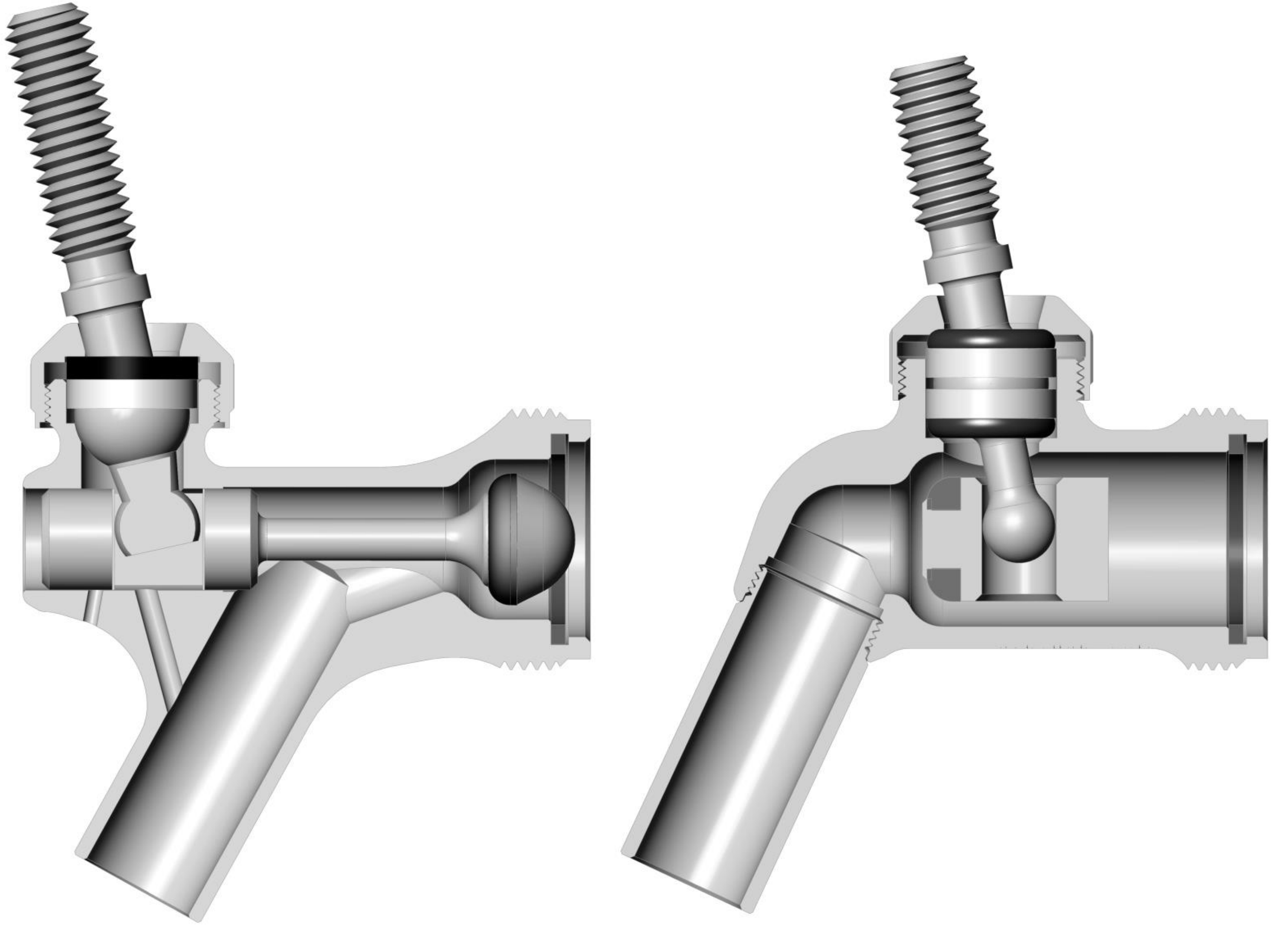
"System resistance"

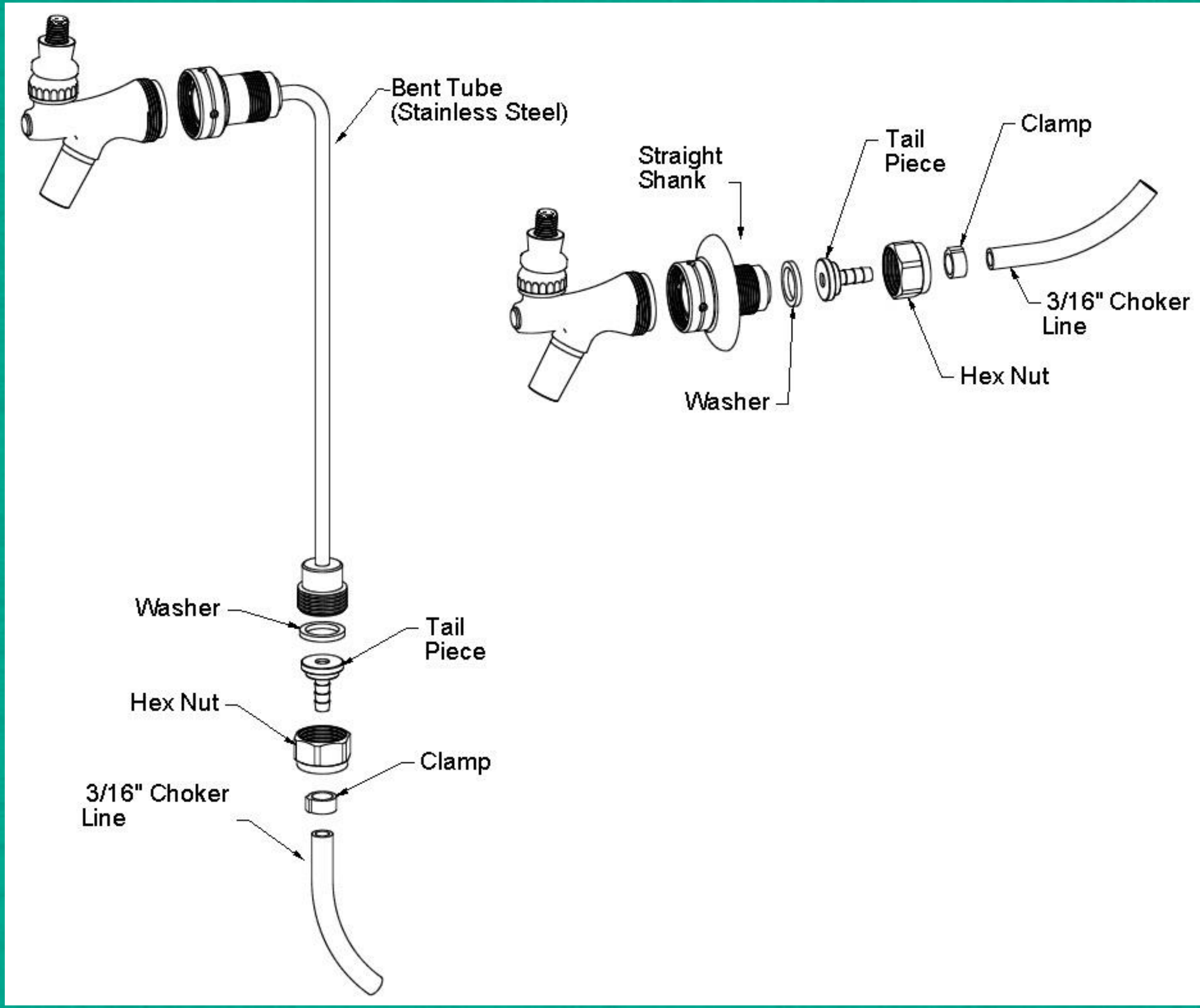
4 feet lift:
4 * 0.2 = 0.8 psig
4 * 0.45 = 1.8 psig
Total : 2.6 …*3 psig*

2.25 feet lift:
2.25 * 0.2 = 0.45 psig
2.25 * 0.45 =1.01 psig
Total : 1.46 …*1.5 psig*

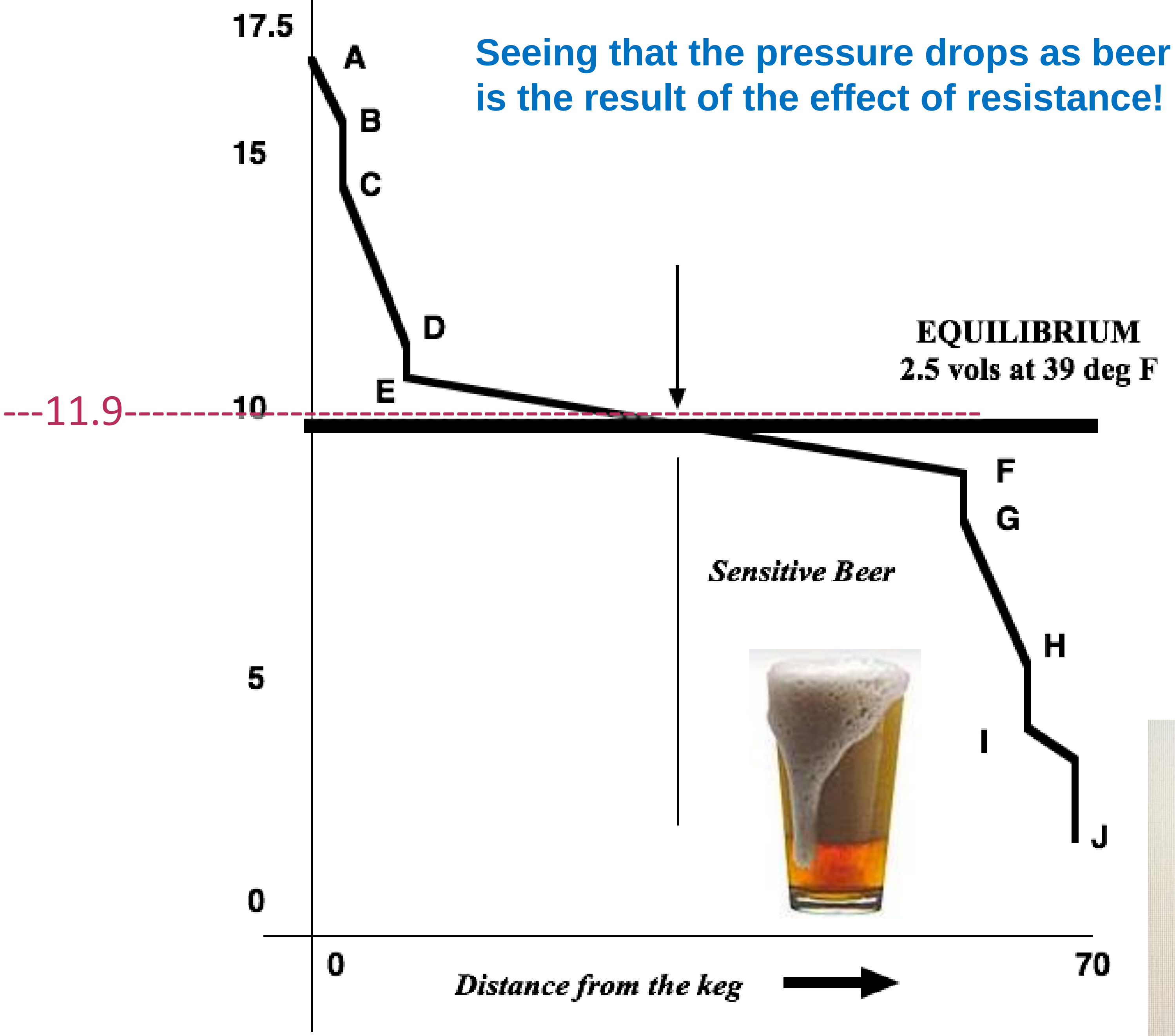
If we were to place pressure gauges along the beer line…






Bent Tube
(Stainless Steel)
Washer
Tail
Piece
Hex Nut
Clamp
3/16" Choker
Line
Straight
Shank
Tail
Piece
Clamp
3/16" Choker
Line
Hex Nut
Washer

Seeing that the pressure drops as beer progresses down the beerline is the result of the effect of resistance!



It's ok to interpolate!

TABLE 3.1. BEER CARBONATION AT SEA LEVEL IN VOLUMES CO_2 AS A FUNCTION OF SYSTEM TEMPERATURE AND CO_2 PRESSURE*

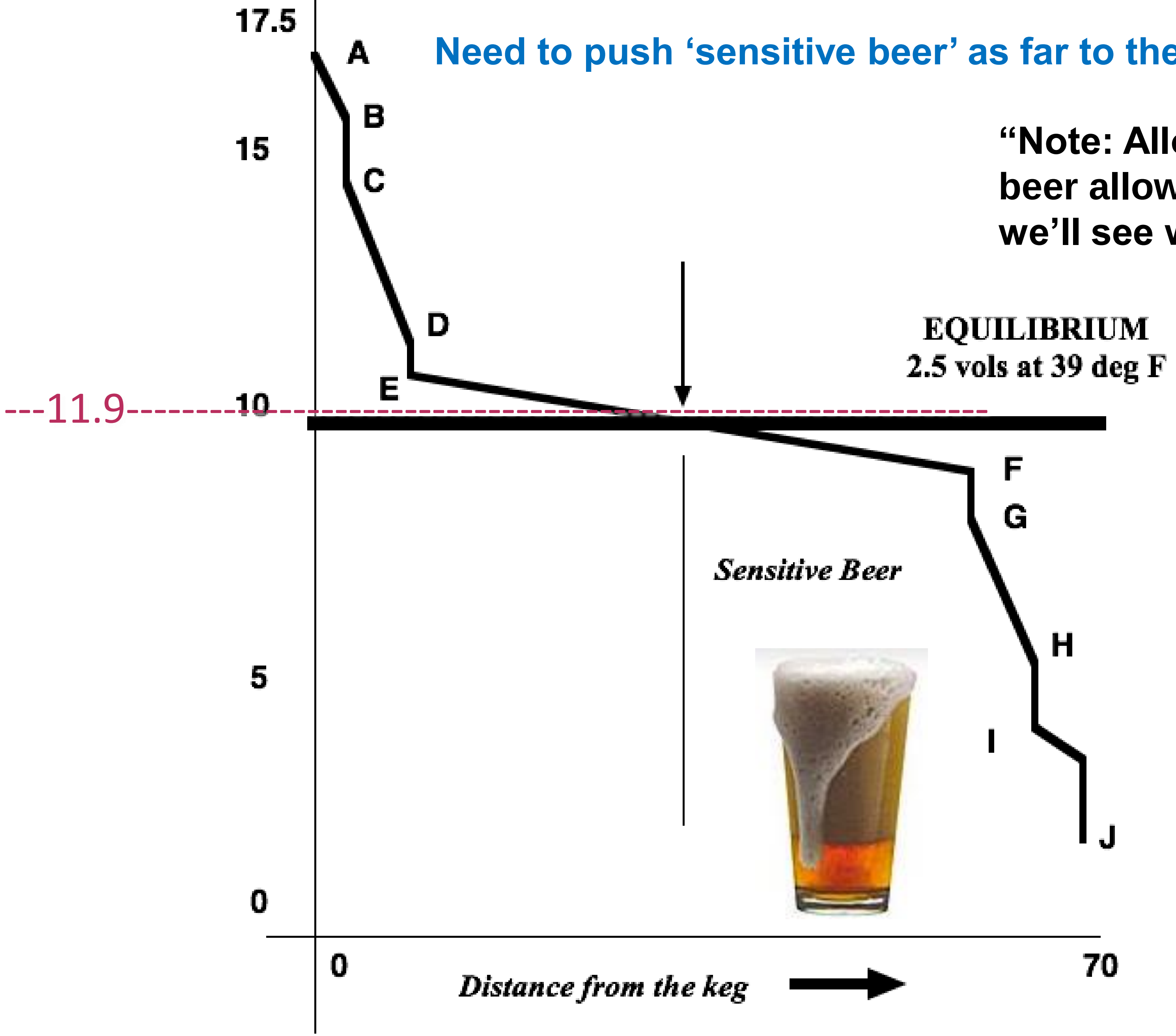
	CO_2 pressure (psi)		
Temp (°F)	9	11	13
34	2.5	2.7	2.9
38	2.3	2.5	2.7
42	2.1	2.3	2.5

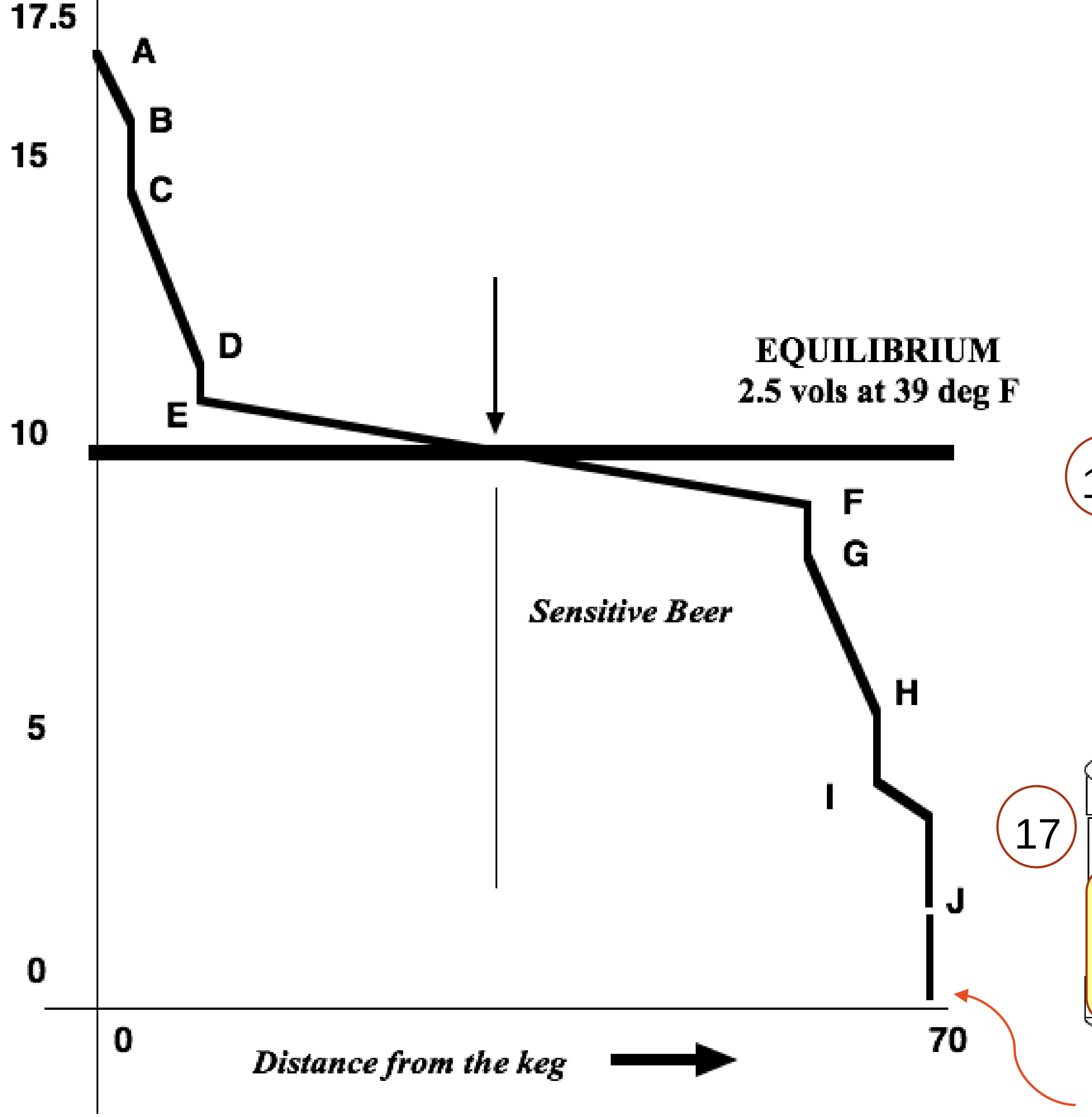
*Pressures rounded for purposes of illustration. Do not use this table for system adjustment.

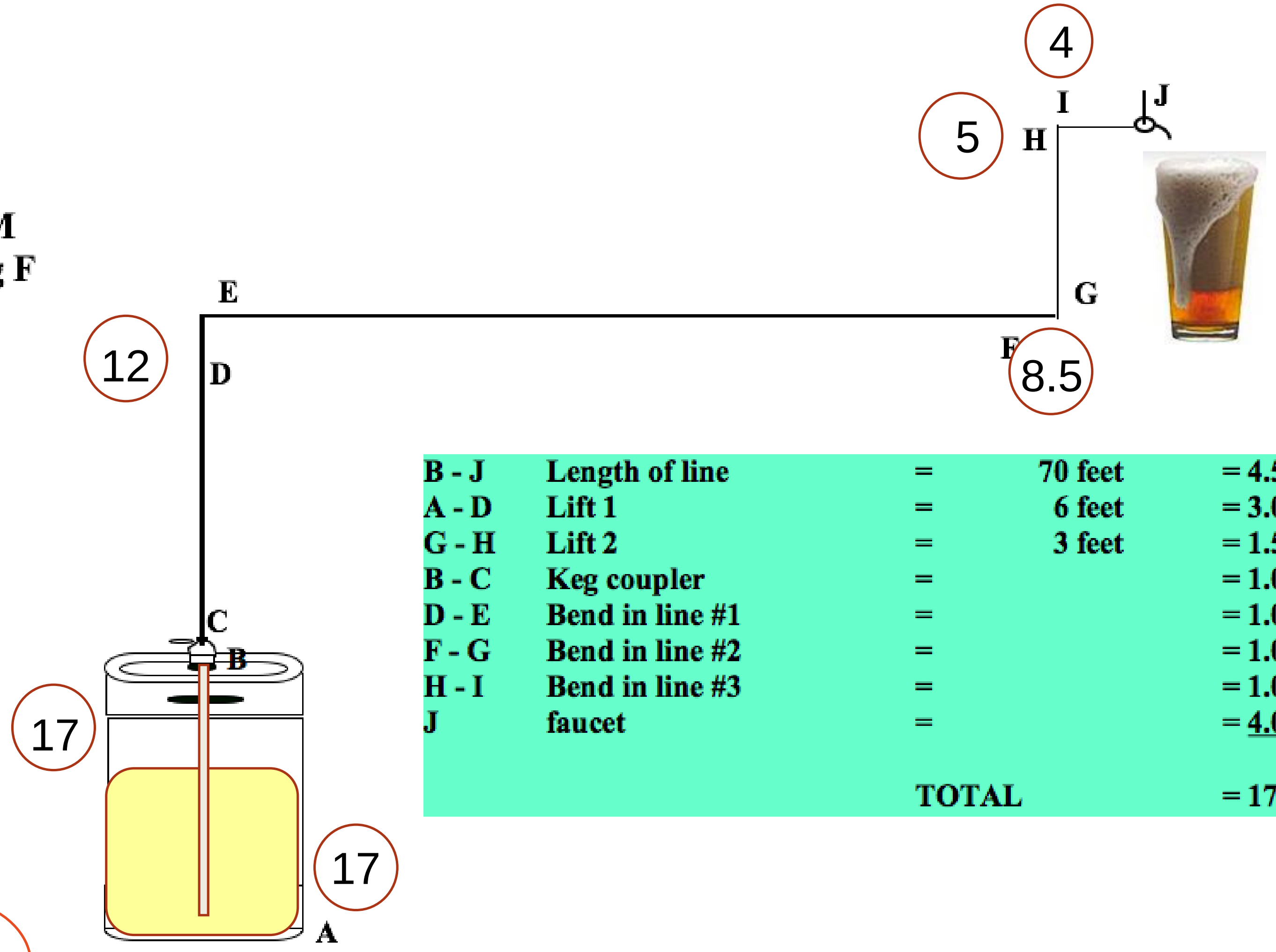
Need to push ‘sensitive beer’ as far to the dispense tap as we can!

“Note: Allowing greater pressure on beer allows it to adsorb more CO_2… and we’ll see why this is a problem soon!”

From Slide before penguin!







B - J	Length of line	=	70 feet	= 4.5 psi
A - D	Lift 1	=	6 feet	= 3.0 psi
G - H	Lift 2	=	3 feet	= 1.5psi
B - C	Keg coupler	=		= 1.0 psi
D - E	Bend in line #1	=		= 1.0 psi
F - G	Bend in line #2	=		= 1.0 psi
H - I	Bend in line #3	=		= 1.0 psi
J	faucet	=		= 4.0 psi
		TOTAL		= 17.0 ps

TABLE 3.2. DETERMINATION OF PURE CO_2 EQUILIBRIUM GAUGE PRESSURE (PSIG) FOR GIVEN VOLUMES OF CO_2 AND TEMPERATURE

	Volumes of CO_2										
Temp. (°F)	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1
33	5.0	6.0	6.9	7.9	8.8	9.8	10.7	11.7	12.6	13.6	14.5
34	5.2	6.2	7.2	8.1	9.1	10.1	11.1	12.0	13.0	14.0	15.0
35	5.6	6.6	7.6	8.6	9.7	10.7	11.7	12.7	13.7	14.8	15.8
36	6.1	7.1	8.2	9.2	10.2	11.3	12.3	13.4	14.4	15.5	16.5
37	6.6	7.6	8.7	9.8	10.8	11.9	12.9	14.0	15.1	16.1	17.2
38	7.0	8.1	9.2	10.3	11.3	12.4	13.5	14.5	15.6	16.7	17.8
39	7.6	8.7	9.8	10.8	11.9	13.0	14.1	15.2	16.3	17.4	18.5
40	8.0	9.1	10.2	11.3	12.4	13.5	14.6	15.7	16.8	17.9	19.0
41	8.3	9.4	10.6	11.7	12.8	13.9	15.1	16.2	17.3	18.4	19.5
42	8.8	9.9	11.0	12.2	13.3	14.4	15.6	16.7	17.8	19.0	20.1

Source: Data from *Methods of Analysis*, 5th ed. (Milwaukee, WI: American Society of Brewing Chemists, 1949).
Note: Values assume sea-level altitude. Add 1 psi for every 2000 ft. above sea level.

Table 3.2, page 38

“Atmospheric pressure decreases by about 1 psi per 2000 feet gained in elevation. To account for this loss of pressure, add 1 psi to the regulator setting for every 2000 feet gained in elevation”--*page 18*

SAME DATA…
DIFFERENT PRESENTATIONS38

PSI °F	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
32	2.15	2.27	2.38	2.48	2.59	2.70	2.80	2.90	3.00	3.11	3.21					
33	2.10	2.23	2.33	2.43	2.53	2.63	2.74	2.84	2.96	3.06	3.15	3.25				
34	2.06	2.18	2.28	2.38	2.48	2.58	2.69	2.79	2.90	3.00	3.09	3.19				
35	2.02	2.14	2.24	2.34	2.43	2.52	2.63	2.73	2.83	2.93	3.02	3.12	3.22			
36	1.98	2.09	2.19	2.29	2.38	2.47	2.57	2.67	2.77	2.86	2.96	3.05	3.15	3.24		
37	1.94	2.04	2.14	2.24	2.33	2.42	2.52	2.62	2.71	2.80	2.90	3.00	3.09	3.18	3.27	
38	1.90	2.00	2.10	2.20	2.29	2.38	2.48	2.57	2.66	2.75	2.85	2.94	3.03	3.12	3.21	
39	1.86	1.96	2.06	2.15	2.25	2.34	2.43	2.52	2.61	2.70	2.80	2.89	2.98	3.07	3.16	3.25
40	1.83	1.92	2.01	2.10	2.20	2.30	2.39	2.47	2.56	2.65	2.75	2.84	2.93	3.01	3.10	3.19
41	1.79	1.88	1.97	2.06	2.16	2.25	2.34	2.43	2.52	2.60	2.70	2.79	2.88	2.96	3.05	3.14
42	1.75	1.85	1.94	2.02	2.12	2.21	2.30	2.39	2.48	2.56	2.65	2.74	2.83	2.91	3.00	3.09
43	1.72	1.81	1.90	1.99	2.08	2.17	2.26	2.34	2.43	2.52	2.61	2.69	2.78	2.86	2.95	3.04
44	1.69	1.78	1.87	1.95	2.04	2.13	2.22	2.30	2.39	2.47	2.56	2.64	2.73	2.81	2.90	2.99
45	1.66	1.75	1.84	1.91	2.00	2.08	2.17	2.26	2.34	2.42	2.51	2.60	2.69	2.77	2.86	2.94

sea level” CO_2 chart

TABLE 1.2. ABSOLUTE PRESSURE DECREASES AS ELEVATION INCREASES WHEN DISPENSING PRESSURE IS HELD AT THE SAME PSIG.

Elevation (ft. above sea level)	Atmospheric pressure (psi)	Dispensing pressure (psig)	Absolute pressure (psia)
0	14.7	15	29.7
2,000	13.7	15	28.7
4,000	12.7	15	27.7
5,000	12.2	15	27.2
8,000	10.7	15	25.7
10,000	9.7	15	24.7

TABLE 1.3. DISPENSING PRESSURE MUST BE INCREASED AS ELEVATION INCREASES TO MAINTAIN ABSOLUTE PRESSURE, PSIA.

Elevation (ft. above sea level)	Atmospheric pressure (psi)	Dispensing pressure (psig)	Absolute pressure (psia)
0	14.7	15	29.7
2,000	13.7	16	29.7
4,000	12.7	17	29.7
5,000	12.2	17.5	29.7
8,000	10.7	19	29.7
10,000	9.7	20	29.7

See pages 28 &29
Discussion on
Absolute Pressure

MIXED GAS OPTION!

MIXED GAS….

Nitrogen is sparingly soluble

Provides motive force without increasing carbonation

Appendix C:
CARBONATION, BLENDED GAS, GAS LAWS, AND PARTIAL PRESSURES

- CO_2 = 100% CO_2
- …so 10 psig applied = 10 psig CO2
  - 40% N_2 + 60% CO_2 = 60% CO_2
  - …so 10 psig applied = 6 psig CO2

Determination of needed Mixed Gas Composition: calculation

1. Determine equilibrium *absolute* pressure[a] to maintain proper level of CO_2.

TABLE 3.2. DETERMINATION OF PURE CO_2 EQUILIBRIUM GAUGE PRESSURE (PSIG) FOR GIVEN VOLUMES OF CO_2 AND TEMPERATURE

	Volumes of CO_2										
Temp. (°F)	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1
33	5.0	6.0	6.9	7.9	8.8	9.8	10.7	11.7	12.6	13.6	14.5
34	5.2	6.2	7.2	8.1	9.1	10.1	11.1	12.0	13.0	14.0	15.0
35	5.6	6.6	7.6	8.6	9.7	10.7	11.7	12.7	13.7	14.8	15.8
36	6.1	7.1	8.2	9.2	10.2	11.3	12.3	13.4	14.4	15.5	16.5
37	6.6	7.6	8.7	9.8	10.8	11.9	12.9	14.0	15.1	16.1	17.2
38	7.0	8.1	9.2	10.3	11.3	12.4	13.5	14.5	15.6	16.7	17.8
39	7.6	8.7	9.8	10.8	11.9	13.0	14.1	15.2	16.3	17.4	18.5
40	8.0	9.1	10.2	11.3	12.4	13.5	14.6	15.7	16.8	17.9	19.0
41	8.3	9.4	10.6	11.7	12.8	13.9	15.1	16.2	17.3	18.4	19.5
42	8.8	9.9	11.0	12.2	13.3	14.4	15.6	16.7	17.8	19.0	20.1

Source: Data from Methods of Analysis, 5th ed. (Milwaukee, WI: American Society of Brewing Chemists, 1969).
Note: Values assume sea-level altitude. Add 1 psi for every 2000 ft. above sea level.

2. Determine the total *absolute* gas pressure to move the beer to the tap.

3. Divide the equilibrium absolute CO_2 pressure (Chart) by the total absolute gas pressure (Penguin) to obtain the CO_2 portion of the gas.

[a]***absolute pressure = gauge pressure + atmospheric pressure (i.e. 14.7 psi @ sea level; 12.1 psi in Denver; 9.7 psi @ 10,000 ft)***

EXAMPLE 1: LONG-DRAW, CLOSED-REMOTE SYSTEM

This example for a long-draw, closed-remote system assumes that the dispensing gas blend mixture is already fixed; there is a vertical lift of 12 feet; and the beer trunk line total run is 120 feet. Find the operating pressure of the system, and then determine the appropriate tubing size for the trunks and choker-line tubing length.

Beer Conditions

Beer temperature: 35°F
Beer carbonation: 2.6 volumes CO_2
Dispensing gas: 70% CO_2/30% N_2 blend

First, you must determine the gauge pressure of the blended gas required to maintain the correct level of carbonation. From Appendix C, this calculation is:

$$a = \left(\frac{b + 14.7}{c}\right) - 14.7$$

where a is the gauge pressure of the blended gas, b is the ideal gauge pressure of pure CO_2 for this situation (in this case, 10.7 psi; see table B.1 in appendix B), c is the proportion of CO_2 in the blended gas, and atmospheric pressure is assumed to be 14.7 psi (i.e., sea level).

$$a = \left(\frac{10.7 + 14.7}{0.70}\right) - 14.7$$
$$= (25.4/0.70) - 14.7$$
$$= 36.3 - 14.7$$
$$= 21.6 \text{ psi (round to 22 psi)}$$

Static Resistance

Vertical lift (faucet height above center of keg): 12 ft.

Static resistance = 12 ft. × 0.5 lb./ft.
= 6.0 lb.

EXAMPLE 2: FORCED-AIR 10-FOOT RUN

In this example of a forced-air system, the beer cooler is directly over the bar. There is a 10 ft. fall from the center of the kegs to the faucet height, and the total run length is also exactly 10 ft.

Beer Conditions

Beer temperature: 33°F
Beer carbonation: 2.8 volumes CO_2
Dispensing gas: 100% CO_2

We know the gauge pressure needed to maintain carbonation is 11.7 psig (see table B.1 in Appendix B).

Static Resistance

Vertical fall: 10 ft. (faucet is 10 ft. below the center of the keg)

Static resistance = 10 ft. × –0.5 lb./ft.
= –5.0 lb.

Note that the resistance here is negative. Because there is a drop between the keg and the faucet, the static resistance is contributing to the pressure applied by the gas to the beer.

Balance

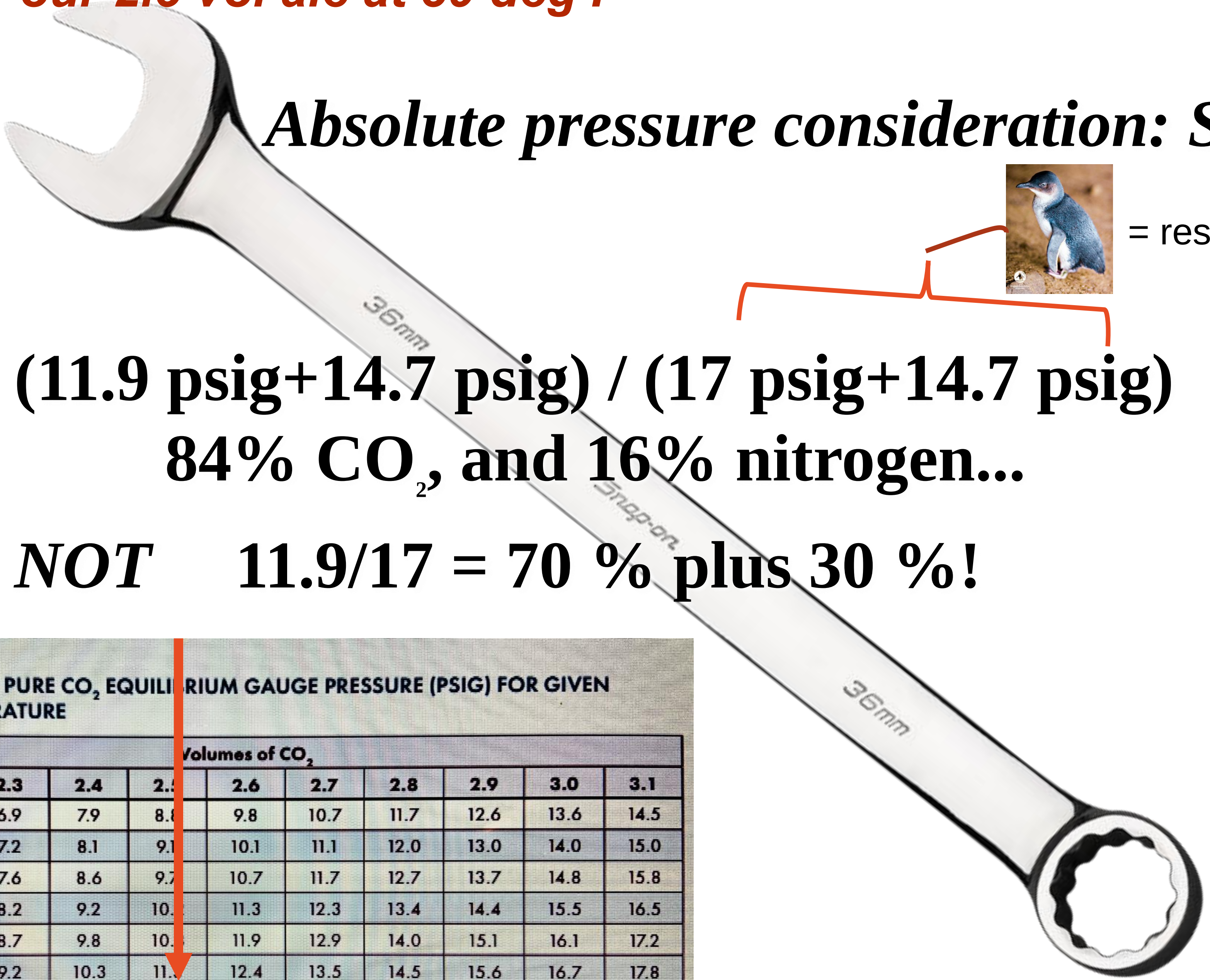
The applied dispensing pressure of 11.7 psi combined with the 5 psi of static pressure (i.e., negative 5 lb. static resistance) must be balanced by the total system resistance. This balancing has to come from dynamic resistance imparted by the beer line restriction of 16.7 lbs.

Dynamic resistance required = 11.7 + 5
= 16.7 lb.

Beer Line Restriction

Examples on Pages 41 and 42

Example 1…   our 2.5 vol ale at 39 deg F



Absolute pressure consideration: SEA LEVEL

= resistance

(11.9 psig+14.7 psig) / (17 psig+14.7 psig) =

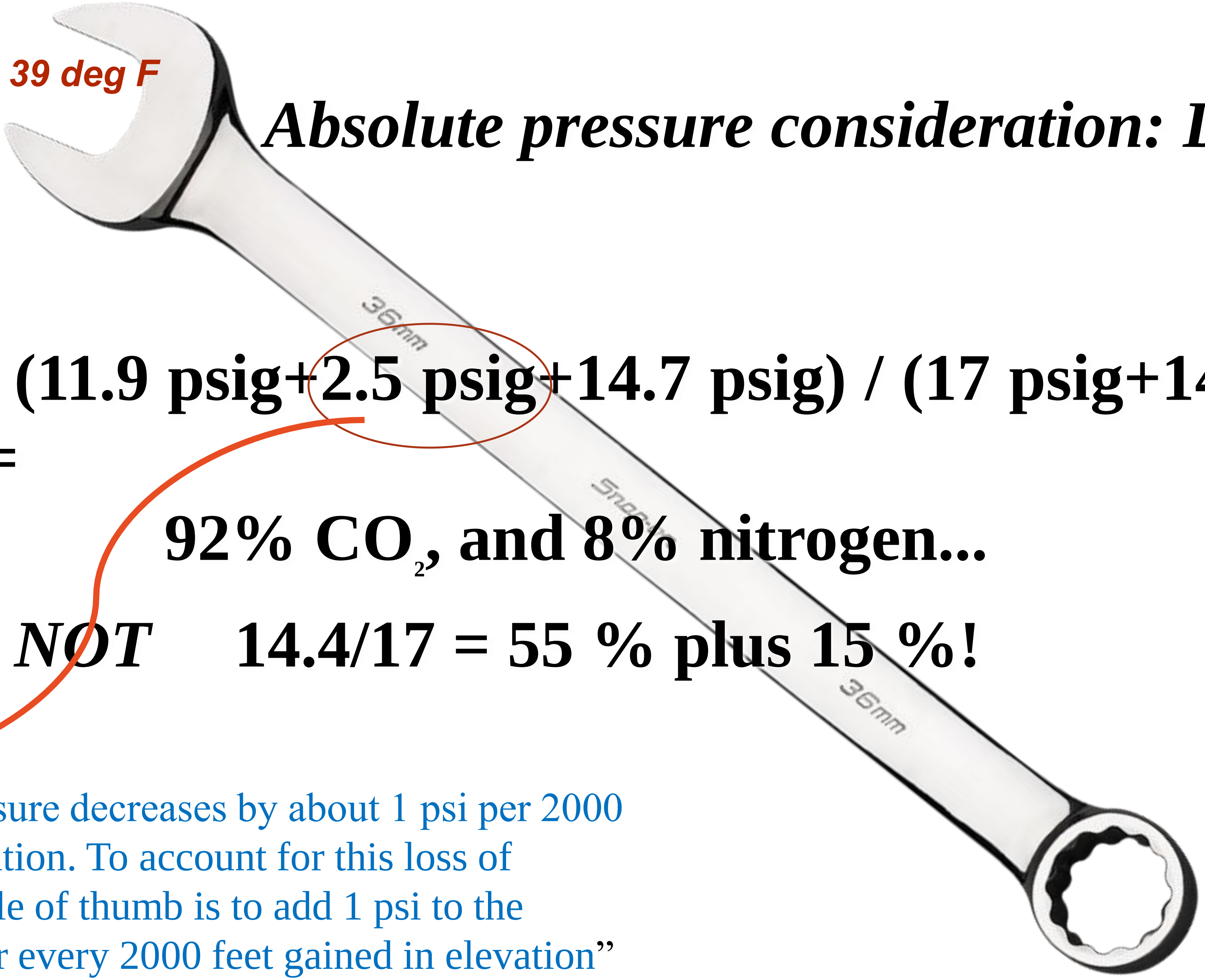
84% CO_2, and 16% nitrogen...

NOT **11.9/17 = 70 % plus 30 %!**

TABLE 3.2. DETERMINATION OF PURE CO_2 EQUILI[illegible]RIUM GAUGE PRESSURE (PSIG) FOR GIVEN VOLUMES OF CO_2 AND TEMPERATURE

	[illegible]olumes of CO_2										
Temp. (°F)	**2.1**	**2.2**	**2.3**	**2.4**	**2.[illegible]**	**2.6**	**2.7**	**2.8**	**2.9**	**3.0**	**3.1**
33	5.0	6.0	6.9	7.9	8.[illegible]	9.8	10.7	11.7	12.6	13.6	14.5
34	5.2	6.2	7.2	8.1	9.[illegible]	10.1	11.1	12.0	13.0	14.0	15.0
35	5.6	6.6	7.6	8.6	9.[illegible]	10.7	11.7	12.7	13.7	14.8	15.8
36	6.1	7.1	8.2	9.2	10.[illegible]	11.3	12.3	13.4	14.4	15.5	16.5
37	6.6	7.6	8.7	9.8	10.[illegible]	11.9	12.9	14.0	15.1	16.1	17.2
38	7.0	8.1	9.2	10.3	11.[illegible]	12.4	13.5	14.5	15.6	16.7	17.8
39	7.6	8.7	9.8	10.8	11.9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
40	8.0	9.1	10.2	11.3	12.4	13.5	14.6	15.7	16.8	17.9	19.0

Example 1
…our 2.5 vol ale at 39 deg F



Absolute pressure consideration: DENVER

(11.9 psig+2.5 psig+14.7 psig) / (17 psig+14.7 psig)

=

92% CO_2, and 8% nitrogen...

NOT **14.4/17 = 55 % plus 15 %!**

"Atmospheric pressure decreases by about 1 psi per 2000 feet gained in elevation. To account for this loss of pressure, a good rule of thumb is to add 1 psi to the regulator setting for every 2000 feet gained in elevation"

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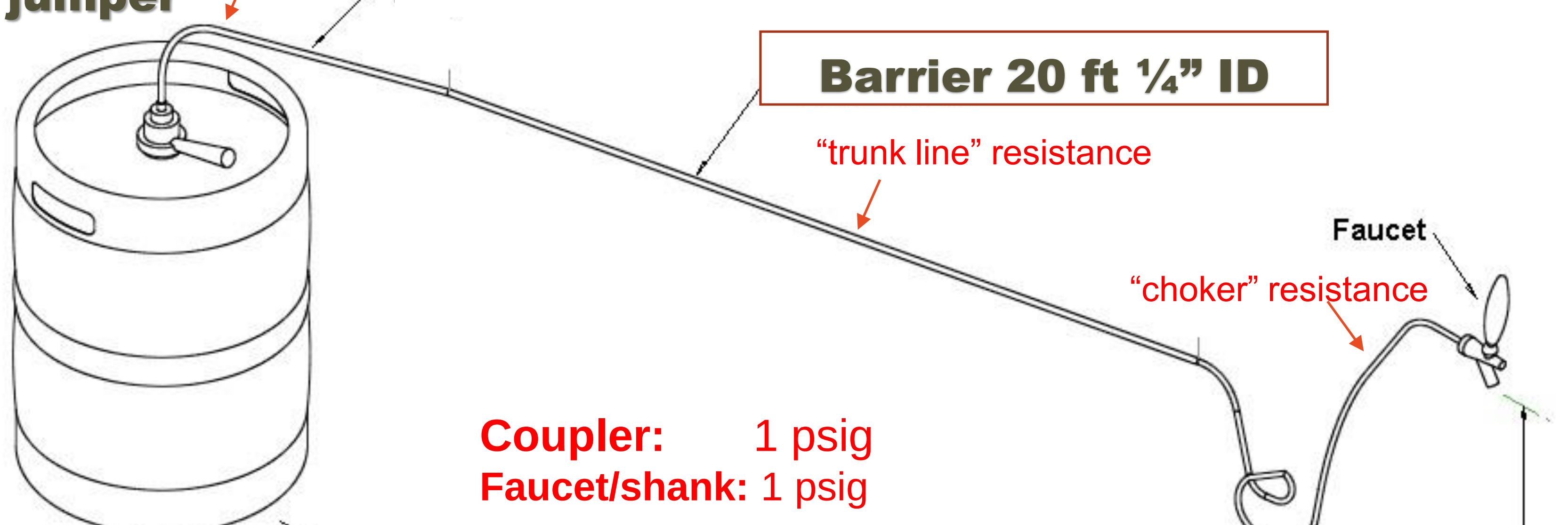
Example 2

Beer at 39 deg F ; 2.65 vol CO_2

36 in of 1/4 in vinyl*line

+ 2 ft 3/16 vinyl**

+ 20 ft ¼ in. barrier beer line.***



Coupler: 1 psig
Faucet/shank: 1 psig

Hydrostatic head
= 5 ft * 0.45 psig/ft
= 2.25 psig

Absolute pressure consideration:

Beer at 39 deg F in keg...2.65 vol CO_2

36 in of 1/4 in vinyl*line + 2 ft 3/16 vinyl** +20 ft of ¼ in. barrier beer line.***

TABLE 3.2. DETERMINATION OF PURE CO_2 EQUILIBRIUM GAUGE PRESSURE (PSIG) FOR GIVEN VOLUMES OF CO_2 AND TEMPERATURE

	Volumes of CO_2										
Temp. (°F)	**2.1**	**2.2**	**2.3**	**2.4**	**2.5**	**2.6**	**2.7**	**2.8**	**2.9**	**3.0**	**3.1**
33	5.0	6.0	6.9	7.9	8.8	9.8	10.7	11.7	12.6	13.6	14.5
34	5.2	6.2	7.2	8.1	9.1	10.1	11.1	12.0	13.0	14.0	15.0
35	5.6	6.6	7.6	8.6	9.7	10.7	11.7	12.7	13.7	14.8	15.8
36	6.1	7.1	8.2	9.2	10.2	11.3	12.3	13.4	14.4	15.5	16.5
37	6.6	7.6	8.7	9.8	10.8	11.9	12.9	14.0	15.1	16.1	17.2
38	7.0	8.1	9.2	10.3	11.3	12.4	13.5	14.5	15.6	16.7	17.8
39	7.6	8.7	9.8	10.8	11.9	13.0	14.1	15.2	16.3	17.4	18.5
40	8.0	9.1	10.2	11.3	12.4	13.5	14.6	15.7	16.8	17.9	19.0
41	8.3	9.4	10.6	11.7	12.8	13.9	15.1	16.2	17.3	18.4	19.5
42	8.8	9.9	11.0	12.2	13.3	14.4	15.6	16.7	17.8	19.0	20.1

Source: Data from *Methods of Analysis*, 5th ed. (Milwaukee, WI: American Society of Brewing Chemists, 1949).
Note: Values assume sea-level altitude. Add 1 psi for every 2000 ft. above sea level.

13.5 psig by interpolation

Absolute pressure consideration:

Beer at 39 deg F in keg...2.65 vol CO_2

36 in of 1/4 in vinyl*line + 2 ft 3/16 vinyl** +20 ft of ¼ in. barrier beer line.***

Resistance in dispense:

a) **Hydrostatic head** = 0.45 psi/ft vertical

b) The combined friction of beer line.

(13.5 psig+14.7 psig) / ([14.55+2.25+2] psig + 14.7 psig)

= 83% CO_2, and 17% nitrogen...

NOT 13.5/19.1 = 71 % plus 29 %!

jumper	* (3 ft)(0.85 psi/ft) = 2.55 psig
choker	**(2 ft)(3 psi/ft) = 6.0
trunk	***(20ft)(0.3 psi/ft) = 6.0 psig
	= 14.55 psig

TABLE 4.1. COMMON MATERIALS AND DIAMETERS USED FOR BEER LINE AND THEIR DYNAMIC RESISTANCE VALUES

Type	Size	Resistance (lb./ft.)*	Volume (fl. oz./ft
Vinyl/flexible	3/16" ID	3.00	⅙
Vinyl/flexible	¼" ID	0.85	⅓
Vinyl/flexible	5/16" ID	0.40	½
Vinyl/flexible	⅜" ID	0.20	¾
Vinyl/flexible	½" ID	0.025	1⅓
Barrier	¼" ID	0.30	⅓
Barrier	5/16" ID	0.10	½
Barrier	⅜" ID	0.06	¾
Stainless	¼" OD	1.20	⅙
Stainless	5/16" OD	0.30	⅓
Stainless	⅜" OD	0.12	½

GAS BLENDERS

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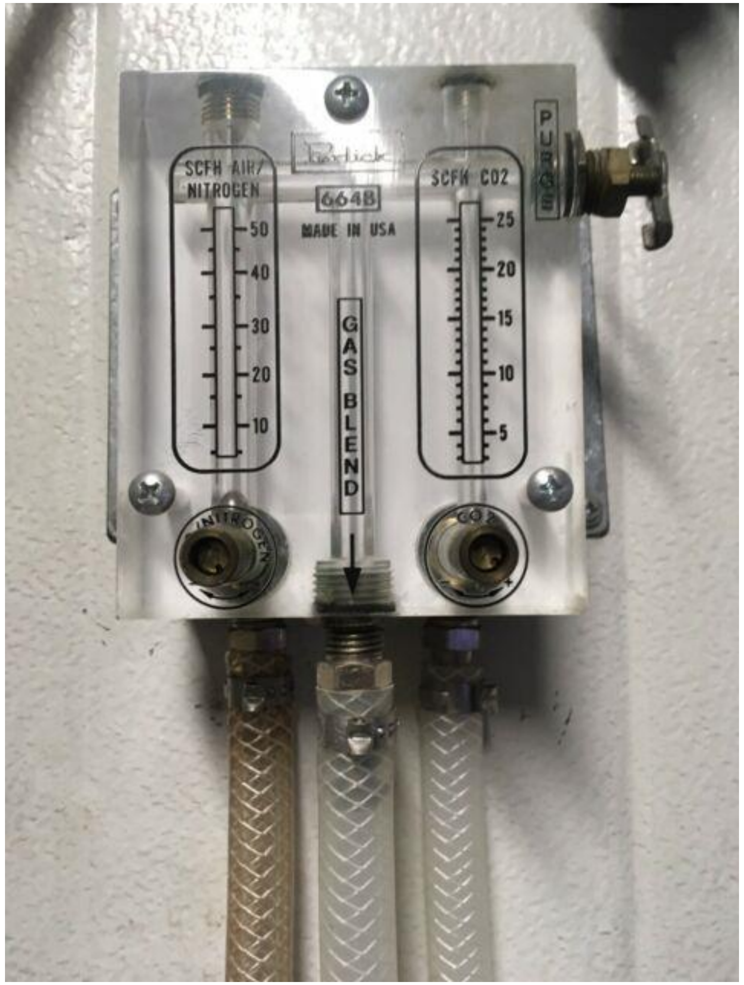


#CraftBrewersCon

On-site nitrogen generators

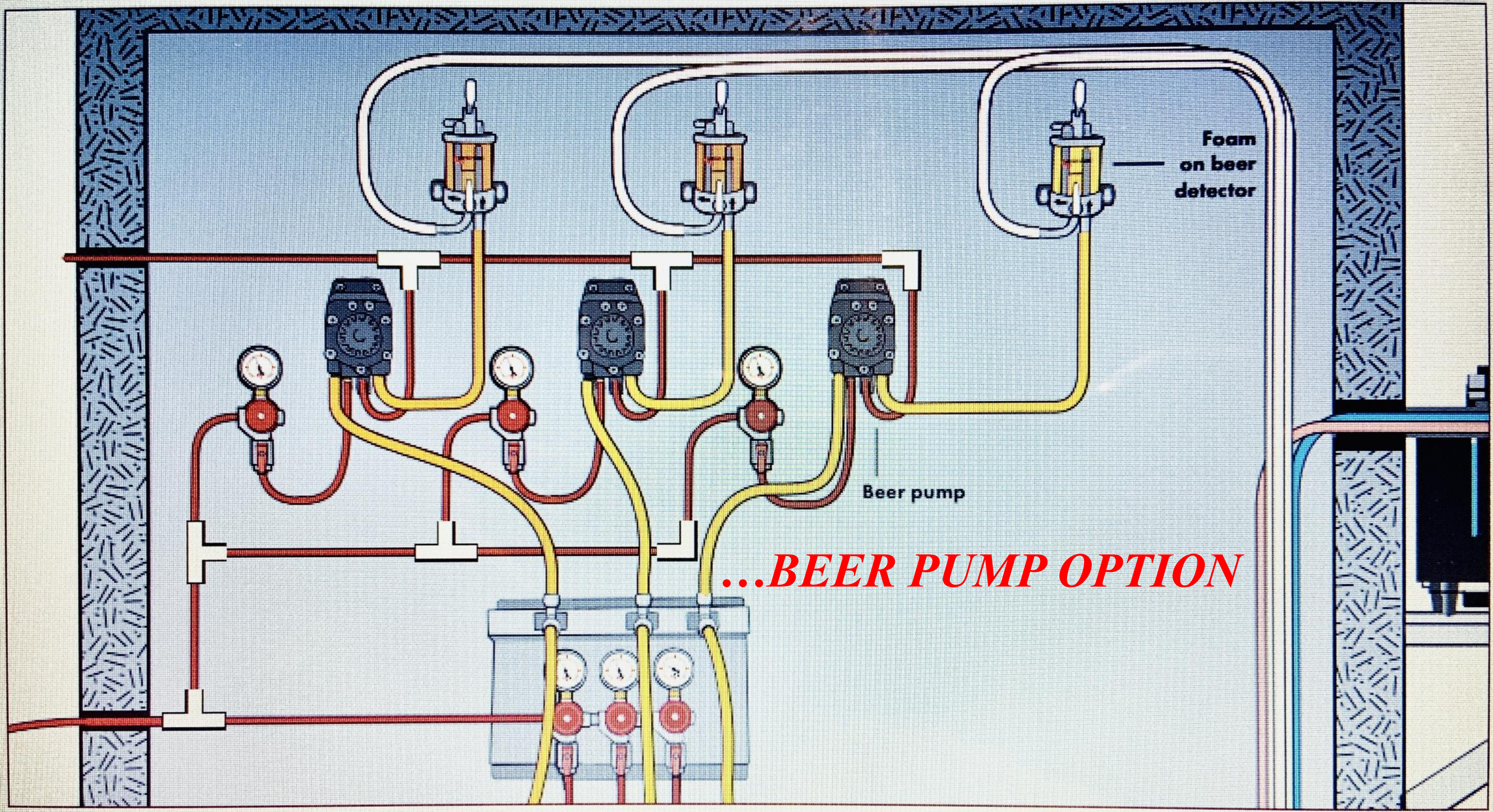
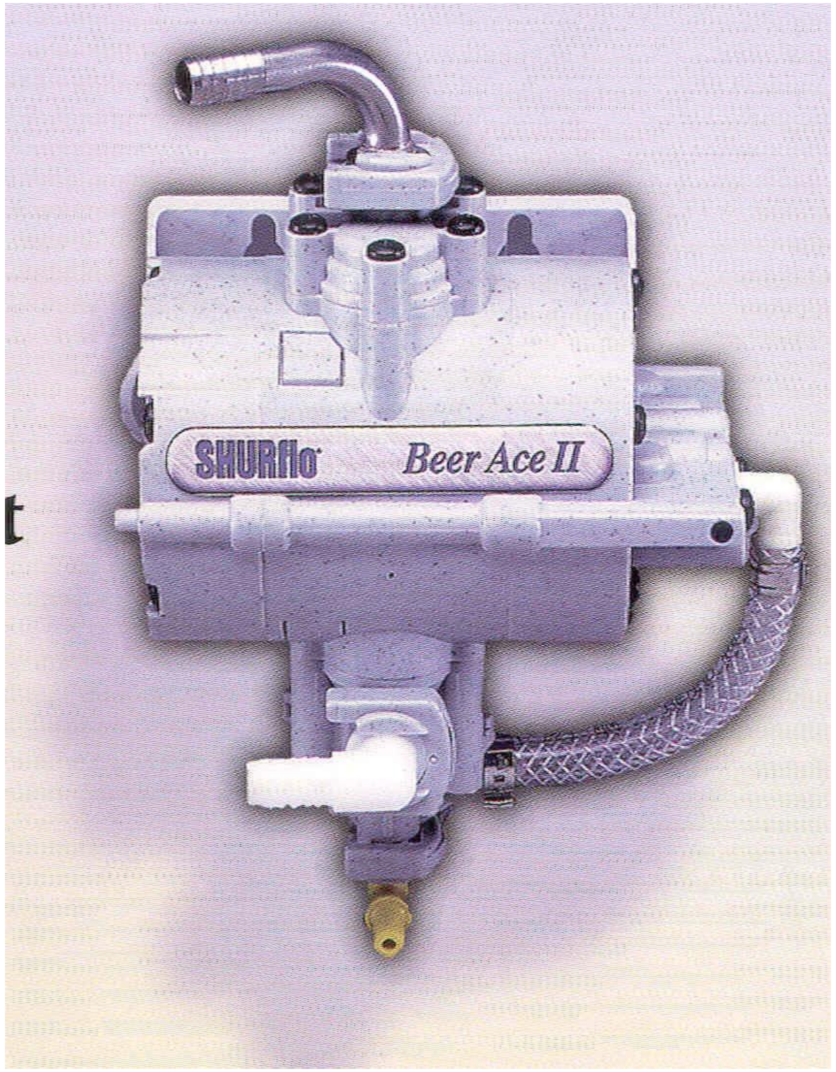
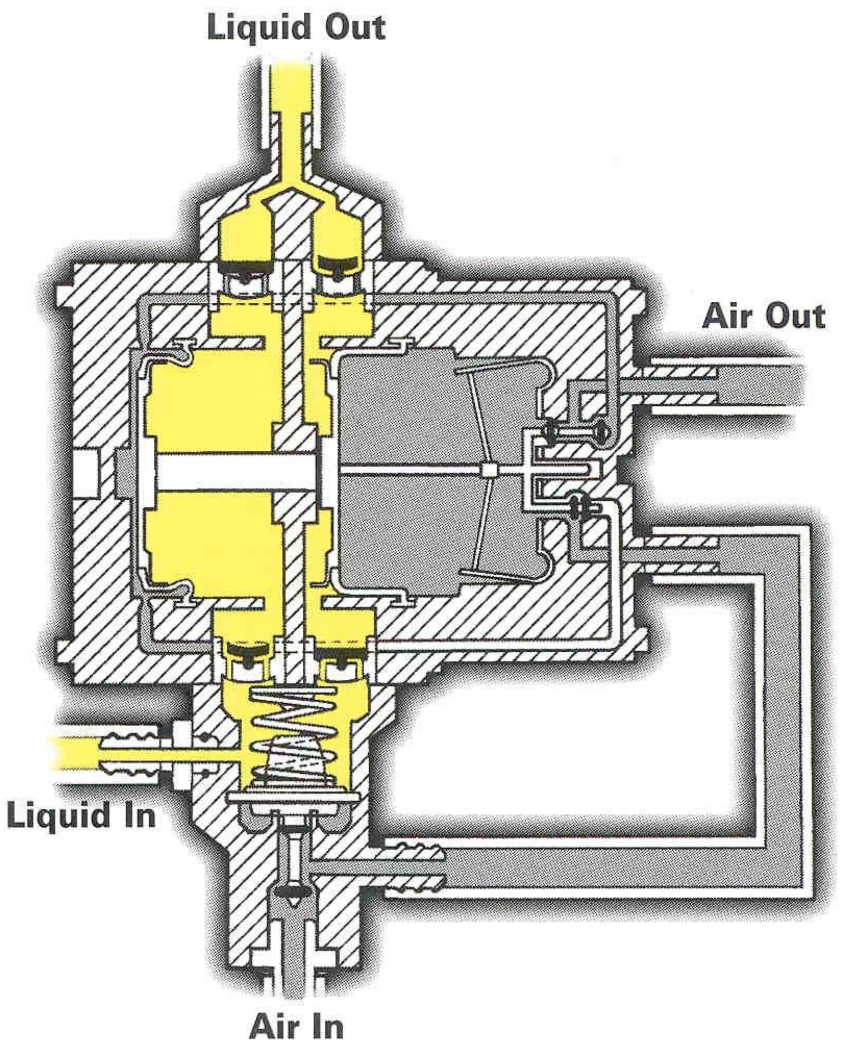
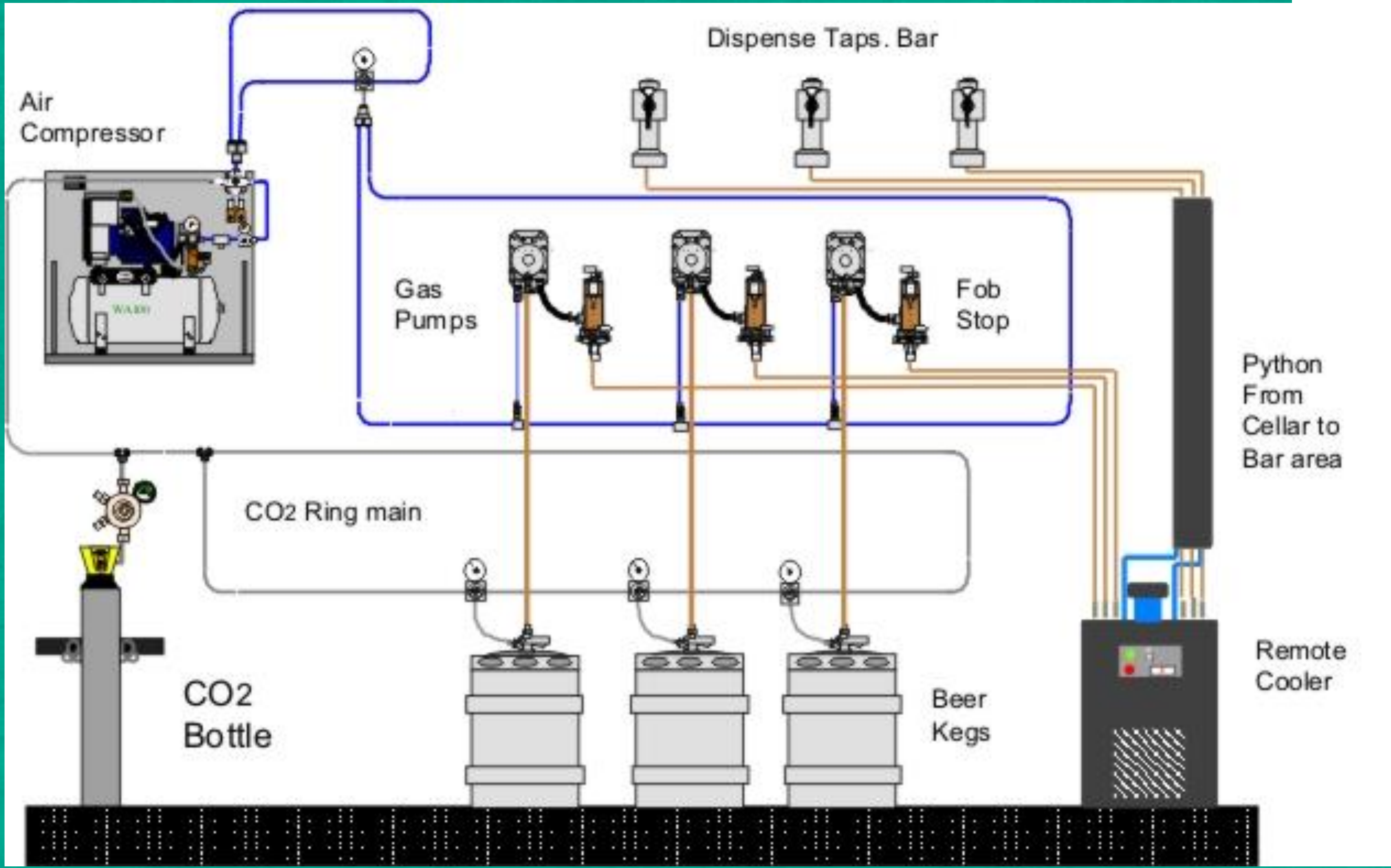


Figure 4.8. Beer pumps and FOBs in walk-in cooler.

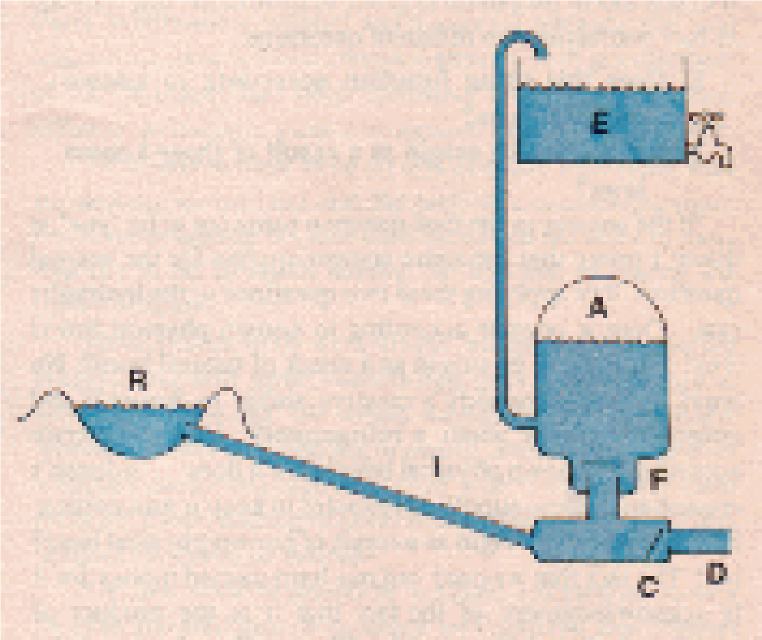
8.50 x 11.00 in


SHURflo
Beer Ace II


Liquid Out
Air Out
Liquid In
Air In


Dispense Taps. Bar
Air Compressor
Gas Pumps
Fob Stop
Python From Cellar to Bar area
CO2 Ring main
Remote Cooler
CO2 Bottle
Beer Kegs


FLOJET
FLOJET



QUESTION FROM BRIDGET & KEN TALK….

“If the serving lines rise 6 feet above the keg, travel to the tap location, and then drop 6 feet to the taps, is the static resistance zero?

All of the line is identical all the way to the taps and the trunk line is maintained at the same temp as the cold room and glycol chilled all the way to the taps. distance is 33 feet.”

Thank you & hoping everyone progresses back to pre-covid-19 business ASAP!

ENNOBLE

BEVERAGES

- Jaime.Jurado@ennoblebeverages.com

BREWERS ASSOCIATION