BREWERS ASSOCIATION FACTS ABOUT DRAUGHT BEER CARBONATION

Carbonation is an essential ingredient in beer. The amount of carbon dioxide in a beer is a key part of the beer's recipe and helps define the style. It influences the overall flavor of beer, having an impact on aroma, beer flavor, mouthfeel and appearance. Along with alcohol, carbon dioxide (CO_2) is a byproduct of fermentation. Additionally, brewers can force carbonate beer to create a variety of styles.

Kegged beer has the risk of being compromised at the retailer, due to unbalanced draught systems. In order to maintain the integrity of the beer's carbonation, temperature and applied pressure from the draught system must be considered.

PURPOSE OF DISPENSE GAS

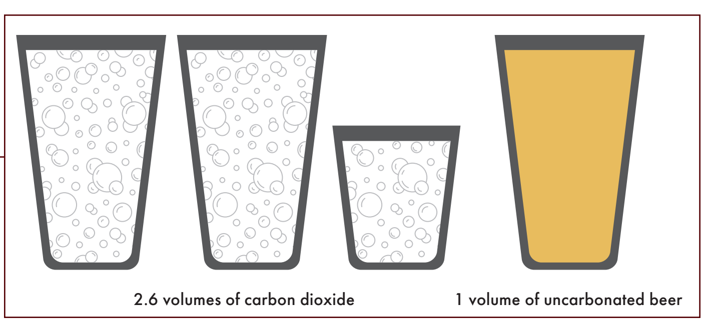
In a typical draught system, dispense gas serves two main functions.

1. Keep the beer carbonated to brewery specification.
2. Push the beer from the keg to the faucet.

Both functions are of equal importance, and mutually inclusive. The pressure required to keep the beer properly carbonated should equal the amount of pressure required to push the beer from the keg to the faucet. While the CO_2 volumes of beer are set by brewers, system design can be customized based on the target pressure. Installing a draught system without considering the CO_2 volumes of the beer being served will lead to major profit loss for the retailer.

CO_2 VOLUMES

Beer carbonation is measured in **CO_2 volumes** in the United States. CO_2 volumes are a ratio describing the amount of carbon dioxide dissolved in beer. For many lagers and ales, CO_2 volumes fall in a range between 2.3 to 2.8 v/v (volumes per volume). If a brewery describes their beer as having 2.6 v/v, it means there are 2.6 ounces of CO_2 in every 1.0 ounce of beer (if measuring volume in ounces). This is possible due to gas properties which allow gases to dissolve in liquids at specific temperatures and pressures.

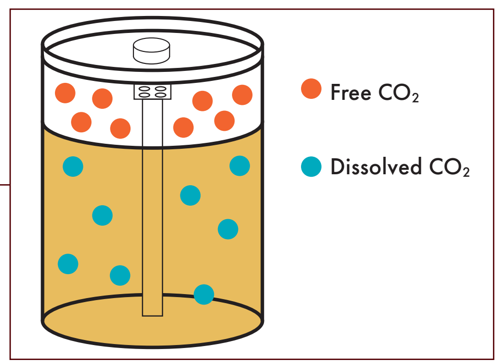


PROPERTIES OF CO_2 IN BEER

The most fundamental law that governs the way CO_2 behaves in liquids is Henry's law of gas solubility. Henry's law states that the amount of gas dissolved in a liquid is proportional to the partial pressure above the liquid. This balanced state is known as equilibrium. Equilibrium is impacted by both **temperature** and **pressure**.

PRESSURE

Consider a can of beer. In order to keep the beer carbonated, the space in the can above the beer contains carbon dioxide. Once the can is opened, gas in the headspace is released into the atmosphere. As the pressure above the beer drops, the carbon dioxide becomes less soluble in liquid, escaping to the headspace, and the beer eventually becomes flat.



Beer keg depicting dissolved CO_2 in the liquid and free CO_2 in the headspace.

Think of a keg as an oversized can. Similarly, the keg's headspace contains carbon dioxide which maintains the dissolved gas in the liquid. When beer is poured from the keg, it loses some carbon dioxide. In order to keep the beer properly carbonated, the carbon dioxide must be replaced at a specific pressure using a regulator attached to an external gas source, such as a CO_2 cylinder or bulk tank. If too much pressure is applied to the keg, the keg will become overcarbonated. If the keg doesn't receive enough pressure, the gas will escape to the headspace and through the keg valve. This can cause the beer to pour foam initially, and eventually become flat.

TEMPERATURE

Let's go back to that can of beer. If you open a beer from your refrigerator, it should pour easily, with an appropriate foam collar. If you open a beer that's been stored in a hot garage, it will be excessively foamy and *then* quickly become flat. This is due to the profound impact that temperature has on gas solubility.

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Most draught systems' target pressure is determined assuming the temperature of the beer is between 36˚–38˚. As temperature increases, gas solubility decreases forcing the gas to escape and beer to pour foamy. This will eventually result in flat beer. Conversely, if the temperature decreases, gas solubility increases. This will eventually result in over carbonation.

IDEAL PRESSURE

Determining the ideal amount of applied pressure for a keg first requires knowing the carbon dioxide volumes for that beer. That information is sometimes printed on the keg collar or dust cap. It could require asking the brewery or distributor representative. You can then use a CO_2 solubility chart to find the correct amount of pressure at a given temperature.

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).

Notes: Values assume sea-level altitude, beer specific gravity of 1.015, and beer alcohol content at 3.8% ABW or 4.8% ABV. Values shown are in psig, or gauge pressure.

It is important to remember that carbonation is proportional to absolute pressure, not gauge pressure. Atmospheric pressure drops as elevation goes up. Therefore, the gauge pressure needed to achieve proper carbonation at elevations above sea level must be increased. Add 1 psig for every 2000 ft. above sea level. For example, a retailer at sea level would use 11.3 psig to maintain 2.5 volumes CO_2 in beer served at 38°F. That same retailer at 4000 ft. above sea level would need 13.3 psig to maintain 2.5 volumes CO_2.

To use the chart above, first find the CO_2 volumes of the beer along the top axis. Along the left axis, find the row that equals the liquid temperature of the beer coming out of the faucet. The square that meets the CO_2 volume column and temperature row is the ideal applied pressure setting for that keg. For example, if a beer has 2.6 v/v of CO_2 and the temperature is 36˚, the ideal pressure is 11.3 psi (pounds per square inch). Slight adjustments should be made to compensate for high altitude locations. Longer draught systems requiring more pressure to push the beer to the faucet can utilize blended gas.

See the *Draught Beer Quality Manual* for more information on special adjustments and blended gas.