

brewers association

draught beer quality manual

Prepared by the
Technical Committee of
the Brewers Association

THIRD EDITION

BA
BREWERS
ASSOCIATION

®



preface

The Draught Beer Quality working group was formed in March 2007 under the direction of the Brewers Association Technical Committee. Our overriding mission was to improve the quality of draught beer dispensed to our customers. We seek to preserve the great flavor and aroma of beer created by the brewer, and to deliver it to the consumer at retail. Great beer must be handled conscientiously to arrive in the glass in perfect condition.

Distributors, wholesalers, retailers, or draught installation teams may install a draught system. But once in place, each system commonly pours a wide range of brewers' and suppliers' products. We have sought to bring the industry together to agree upon guidelines that present everyone's beer in an optimal condition.

When handled properly from brewery to bar to glass, draught beer delivers what many consider to be the freshest, most flavorful beer available to the customer. But the job does not end once the keg is tapped and the beer begins to flow. Good beer quality depends on proper alignment of the dispense variables and consistent housekeeping practices. As one industry insider quipped, "Even the Mona Lisa would look terrible in a museum with lousy lighting."

The draught quality group focused on these and other areas to develop a clear and well-researched resource of best practices for draught beer. Of course, individual brewers may have additional quality requirements or recommendations for various brands beyond these commonly agreed upon guidelines.

our mission

To improve the quality of draught beer for all beer drinkers.

our goal

To make our resources available to as many beverage industry members and consumers as possible, and work toward being the definitive draught quality resource for the U.S.

www.draughtquality.org

This third version of the Draught Beer Quality Manual includes several updates and revisions, and we will continue to refine it in the future. Our goal is to provide useful and current information for all industry members, manufacturers, distributors, retailers, and consumers.

This manual and excerpts from it are available at www.draughtquality.org. This website is in wiki form, and also contains far more information than this manual, in the form of downloadable forms and links to technical and supplier resources. For example, the website contains beer line cleaning logs you can download, print, and post on your walk-in coolers to encourage routine cleaning every 14 days. We encourage all industry members and affiliated groups to link to the website. ■



acknowledgments

We would like to thank our industry colleagues whose continued input allowed for the significant updates included in this edition of this manual. We appreciate their expertise and commitment to consistently deliver the highest possible quality draught beer to the consumer. If we overlooked anyone who contributed, we sincerely apologize.

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introduction

Walk into nearly any establishment that serves beer these days and you are likely to find draught beer for sale. But these days you will also see fancy options like nitro beers, effervescent German weissbier, and lightly carbonated English-style “cask” ales. Glassware also varies from run-of-the-mill pints to shapely half-liters and diminutive snifters with every possible shape and size in between.

We find draught taps so often that we assume it must be relatively simple to keep and serve beer this way. But behind the simple flick of a handle that sends beer streaming into our glass at the bar, you will find systems that require precise design, exact operating conditions, and careful, regular maintenance to ensure the proper flow of high-quality beer.

In this guide, we consider the equipment and anatomy of draught systems, then look at their operation and maintenance. We included a brief discussion of temporary systems such as picnic taps and jockey boxes, but the majority of our attention is given to systems usually seen in permanent installations: direct-draw and long-draw draught equipment.

While equipment and system layout drive the initial performance of a draught system, other factors play an equal role in the consumer’s experience. To help you understand and operate your draught system, we look at the balance equation that can keep perfect beer flowing from the taps. We also review pouring and glassware cleaning and show you how to check to see if a glass is “beer clean.” Finally, we focus on the cleaning and maintenance of your draught system. Without regular—and proper—maintenance, your investment in draught technology won’t bring you the dividends you expect. We conclude this manual by telling you what to look for in proper system maintenance, whether doing it yourself or supervising the work of a supplier.

To present this information, we have divided this manual into two sections. Section I focuses on draught system components and complete system layouts. From a simple party tap to a complex long-draw draught system, we review all the options.

Section II of this manual covers all the operation and maintenance issues for draught systems. It begins with a look at the details of pouring, glass cleaning, and other essentials of the perfect pint before finishing with cleaning and maintenance. ■



section I

draught equipment and system configurations

Among draught systems, we find three general types based on equipment and design: temporary systems, direct-draw systems, and long-draw systems. In the course of this manual, we look closely at the layout, operation, and maintenance for each system. In Section I of this manual, we present four chapters that focus on system components from faucets to tubing connectors and explore how they are assembled to create different systems. Along the way, we review important features of each component that can help prevent operating problems or beer quality issues in your system.

Before we jump into the components themselves, let's review some key concepts by looking briefly at the three sub-systems for draught: gas, beer, and cooling.

Gas

Draught systems use carbon dioxide (CO_2) alone or mixed with nitrogen (N_2) in varying proportions depending on the requirements of the system and the beers being served. When properly selected and set, dispense gas maintains the correct carbonation in the beer and helps to preserve its flavor. In most draught systems, the dispense gas also propels beer from the

keg to the faucet. Because the dispense gas comes into direct contact with the beer, it must meet strict criteria for purity. Because of the damage it does, ***compressed air should never be used to dispense draught beer.*** For the purposes of this manual, as a convention in discussions involving mixed gas, the proportion of CO_2 will always be shown first, followed by the proportion of N_2 .

Beer

Most draught systems use the gases mentioned above to drive beer from the keg, through tubing to the faucet where it will flow into the customer's glass. During the journey from keg to glass, we want to protect the beer from anything that would compromise its flavor or alter the carbonation established by the brewery. The beer should flow through well-maintained proper beer lines and avoid any contact with brass parts that would impart a metallic flavor. We also want the beer to flow at a specific rate and arrive with the ideal carbonation level. The key to getting this right is balance between the applied gas pressure and the resistance provided by the tubing and fixtures the beer passes through during its journey to the bar.

Cooling

The cooling system should hold beer at a constant temperature from keg to glass. Any increase in beer temperature between the cooler and the faucet can lead to dispense problems such as foaming. In a simple direct-draw system, a refrigerated cabinet maintains the temperature of the keg and provides cooling to the beer as it travels the short distance to the faucet. Many long-draw systems use a walk-in refrigerator to cool the kegs, plus chilled glycol that circulates in tubes next to the beer lines all the way to the faucet, to ensure that the beer stays close to the temperature in the cooler all the way to the glass.

For each draught dispense system, suitable equipment and designs must be chosen for each of these three components—gas, beer, and cooling. In Section I of this manual, we examine the equipment used in draught systems and the various system designs commonly employed.

Chapter 1 examines nine components common to nearly all draught systems, such as couplers, faucets, and beer line. Understanding these basic elements will help you operate the draught systems you encounter. Of course, additional components play a role in sophisticated systems—we introduce and discuss those, as well as look at the dynamics of carbonation, pressure, and system resistance, as we encounter them in **Chapters 3 and 4**. By understanding these concepts and their relationship with each other, you'll be much better equipped for successful draught system operation. Once we have reviewed the common draught components, we will be ready to see how they get used in various system designs.

The simplest draught systems serve a temporary need. We find these systems at picnics, beer festivals, and other short-term events. In **Chapter 2**, we

Draught Beer Dispense Systems

temporary systems

- Picnic Tap
- Jockey Box

direct-draw

- Keg Box
- Walk-in Cooler
- Special Event Trailer

long-draw

- Beer Pump
- Mixed Gas Dispense
- Forced Air-Cooled
- Glycol-Cooled

cover the design, setup, use, and maintenance of the two main systems: picnic taps and jockey boxes.

Moving to permanent draught installations, direct-draw systems offer the simplest approach. In **Chapter 3**, we talk about the anatomy of a keg box or “kegerator” and discuss how this basic approach is implemented in a walk-in cooler design. Both here and in **Chapter 4**, we find some new components beyond the nine “guidelines” from **Chapter 1**. In each chapter, we learn about the new components before looking at the anatomy of the overall system.

Permanent installations where the kegs cannot be located near the serving bar require long-draw draught systems. **Chapter 4** delves into the anatomy and operation of air-cooled and glycol-cooled long-draw systems, and also looks at beer pumps and mixed gas dispense solutions to moving beer through long-draw dispense systems. ■



chapter 1

essential draught system components

as a prelude to studying different draught system designs, let's review the equipment commonly found in all draught dispense setups, from the backyard hand tap to the ballpark beer vendor. Here we cover nine components:

Refrigeration/Cooling	Gas Source
Keg	Gas Line
Coupler	Regulator
Beer Line	Tail Pieces and Connectors
Faucet	

Refrigeration/Cooling

Consistent and controlled beer dispense requires that the beer traveling from keg to glass be maintained at a temperature of 34° to 38°F. While temporary service may employ ice for cooling, most permanent installations employ refrigeration systems.

Cold box refrigeration systems can provide cooling for a small direct-draw box cooler or a large walk-in. The refrigeration itself can either be self-contained with the compressor and condenser mounted on the unit or with a remotely mounted compressor and condenser. Remotely mounting the compressor can ben-

efit the installation by removing the source of heat from inside a room or building; however, this requires additional refrigerant piping and possibly higher installation costs.

Condenser cooling can utilize either air or water; both methods have their strengths and weaknesses. In warm climates, air-cooled compressors can lose significant cooling capacity on a hot day when it is needed most. Water-cooled systems operate more efficiently, but require more maintenance and investment. Proper preventive care for either system is imperative, such as regularly cleaning condenser fins for air-cooled systems, and cooling water treatment for water-cooled equipment to prevent condenser fouling, which diminishes cooling capacity. Acid cleaning or "roding" out the heat exchanger may be required to remedy this. Many draught system problems are revealed on the first hot day of the season due to a lack of preventive maintenance. Although R22 refrigerant is still in use, most new installations will utilize a more environmentally friendly substitute such as 404a.

Glycol systems are also used, as we will see when we examine long-draw systems.

⚠ Draught Safety ⚠

Kegs are pressurized vessels and can be dangerous if mishandled. Drop-in valve lock rings should never be removed in the field. A threaded valve can inadvertently loosen or become unseated when disengaging a coupler, creating a potentially dangerous situation. Keg valves should never be removed in the field. Kegs should only be serviced by trained personnel.

Keg

Kegs enable beer transport in bulk and dispense by the glass while maintaining its quality and integrity. Their design protects beer from both air and light while enabling easy and rapid dispense. Most brewers use kegs made of stainless steel, but you also see rubber-coated, aluminum, steel and single-use kegs manufactured from various materials and utilizing differing technologies.

When tapped, the keg's valve admits gas to the head space where it applies the pressure needed to push beer up through the spear or down tube and out of the keg through the coupler, while maintaining correct carbonation in the remaining beer.

Visit the Brewers Association website for a complete discussion on performance of both refillable and single use beer kegs:

brewersassociation.org/tag/keg-guidelines/

Keg Valve

Kegs are pressurized vessels and can be dangerous if mishandled. Nearly all modern kegs use some form of Sankey valve and stem. There are two main types of Sankey valves and corresponding keg necks: "drop-in" and threaded. From a user standpoint, the valves function identically; from above, they appear nearly indistinguishable to the untrained eye. Drop-in Sankey valves are



held in place by a lock ring or circlip. **The lock ring and valve should never be removed** in the field because keg pressure could cause the value and downtube to rocket upward with high velocity. Very rarely, a lock ring can fail, possibly loosening the valve, creating a potentially dangerous situation. Threaded Sankey valves screw into the neck of the keg. Very rarely, a threaded valve can inadvertently loosen or become unseated when disengaging a coupler, creating a potentially dangerous situation. Keg valves should never be removed in the field. Kegs should only be serviced by trained personnel. New o-rings and lock-rings should always be installed when replacing a keg valve. All new parts should be supplied by, or approved by, the keg valve manufacturer.

Older keg designs, although rarely encountered, utilize different tapping methods not covered here. Keg sizes vary from approximately 5 to 15.5 gallons.

Sankey Valves and Keg Necks





Capacity	1/6 Barrel or Cylinder	Pony Keg (1/4 Barrel)	1/4 Barrel	Full-Size Keg (1/2 Barrel)	Euro Keg
Gallons	5- 5.16	7.75	7.75	15.50	13.2
Ounces	661	992	992	1984	1690
# of 12 oz. beers	55	82	82	165	140
Weight (Full)	58 pounds	87 pounds	87 pounds	161 pounds	137 pounds

Coupler

Gas flows in and beer flows out of a keg through the coupler. While this device has many casual names in beer cellars around the country, the industry adopted the term “coupler” as the standard term for the device.

When you attach a coupler to a keg to tap it, a probe depresses a ball, or poppet, in the keg valve, allowing CO₂ or mixed gas to enter the keg, thereby applying pressure to the beer. This forces the beer to travel up the down tube (spear) and drive the beer to the faucet.

The coupler is typically attached to a flexible vinyl beer line (referred to as a jumper line) using a washer, tail piece, and hex nut. In the U.S., the threads on beer nuts and couplers are standard sized with the “Cleveland thread,” which is 29/32” diameter, and 14 threads per inch pitch. Be aware that some couplers from other countries may use different sized threads. Check for leaks after installing a beer nut onto any coupler.

Couplers include two types of one-way valves:

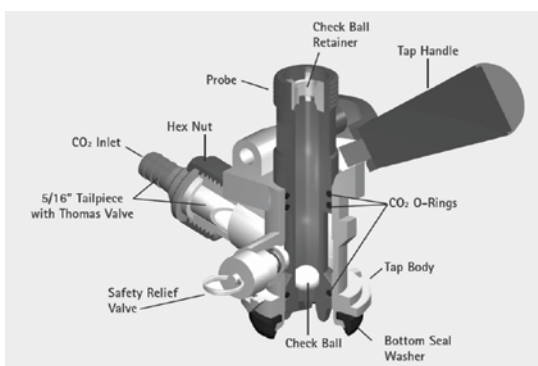
- **Thomas valve** – This valve allows CO₂ to flow into the keg but prevents the beer from backing up into the gas line if gas pressure drops. This protects the gas regulators from damage. (Thomas valves are removed when kegs are dispensed in series; see page 48)
- **Check valve** – When the coupler is disconnected from the keg, this valve prevents beer from the beer line flowing out through the coupler. This prevents beer spillage in keg tapping areas.

A keg coupler should also contain an integral pressure relief valve. If excessive gas pressure were applied to a keg, this valve should open to prevent injury and damage to the keg and coupler. The valve can also be opened manually. This should be done periodically to test the safety relief valve. The manual release usually looks like a small metal pin fitted with a wire ring. To test the valve, pull on the ring to slide the pin a short distance out of the coupler and release a small amount of gas.

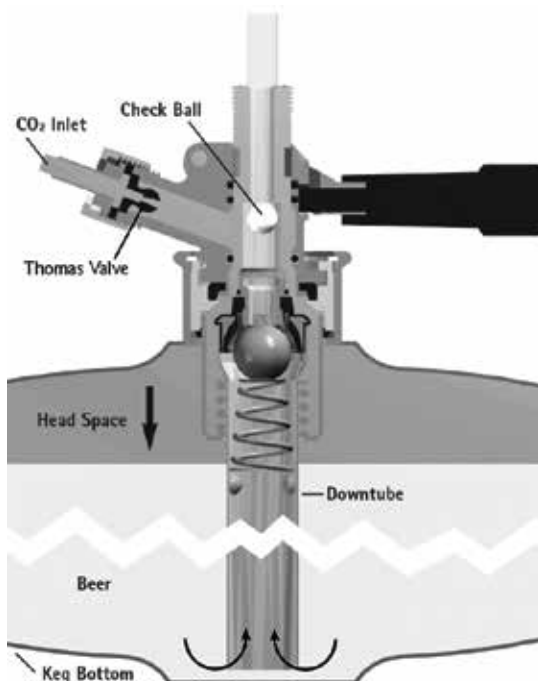


The diagram below shows all the features of a coupler

Cut-away of Sankey "D" Coupler



How Coupler Interacts with Keg to Draw Beer



At the time of this writing, most breweries worldwide use keg valves compatible with one of six variations of the Sankey-type coupler (see images above). Most U.S. breweries use the Sankey "D" coupler, unless otherwise noted. A few U.S. breweries still use the twin probe Hoff-Stevens valve and coupler system.

Tail Pieces and Connectors

Tail pieces connect couplers, wall brackets, shanks—or any other piece of equipment—to vinyl tubing or other types of beer line. Tail pieces come in several sizes to match common tubing diameters. They are held in place with a hex nut and sealing washer. A clamp secures the tubing to the tail piece on the barbed side. A wing or hex nut and sealing washer attach the tail piece to the coupler or other equipment on its flat side. In the U.S., hex nut and coupler threads are one standard size, the so-called "Cleveland thread," which is 29/32" diameter with 14 threads per inch.



A Few Words about Metal Parts & Hygienic Design

For many years, suppliers made metal parts for draught systems with chrome-plated brass. While chrome has no negative effect on beer quality, beer that has any contact with brass reacts and picks up a metallic off-taste. Exposed brass is also difficult to clean. While the chrome coating on these parts rarely wears away on the outside, cleaning and beer flow eventually expose the brass on the inside, bringing the beer in contact with the brass.

To avoid brass contact, brewers recommend stainless steel parts for draught dispense. In addition to being inert in contact with beer, they are easier to clean and help to maintain high quality draught dispense.

Manufacturers offer all faucets, shanks, tail pieces, splicers, wall brackets, and probes mentioned in this manual in stainless steel. If your system already contains chrome-plated brass components, inspect the beer contact surfaces regularly and replace those components as soon as any brass is exposed.

All system components should be designed to facilitate cleaning and to preclude contamination, particularly due to microbial growth. Indentations, recesses, dead space, and gaps should be avoided. If dead spaces cannot be avoided at the junction between tubing and fittings, their depth should be smaller than the smallest dimension of their cross section to facilitate cleaning. Edges at protrusions, transitions, and extensions should be rounded. Chosen components should be designed so they permit an unobstructed flow of liquids and are easy to drain.

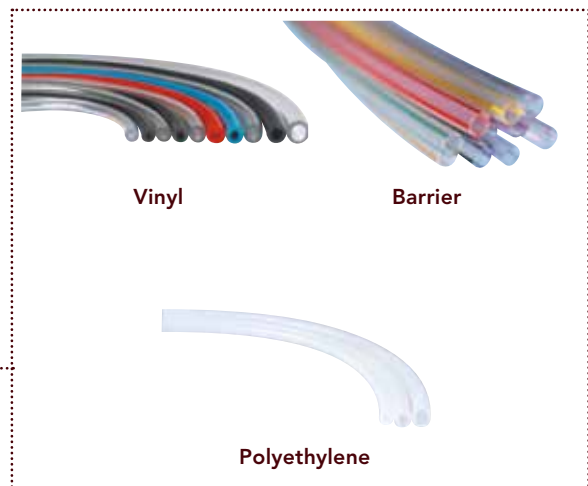
Beer Line

Between coupler and faucet, beer travels through beer line selected to fit the needs of the specific draught application. Options range from vinyl to specialized barrier tubing and even stainless steel.

Most draught systems use clear vinyl tubing for all or part of the beer line. In hand-pump and direct-draw systems, beer often runs most or the entire route from coupler to faucet in vinyl tubing. In long-draw systems, beer commonly passes through two different sections of vinyl hose but travels most of the way through special barrier tubing (See Chapter 4). While vinyl tubing is highly flexible, it is best used where lines are not secured in place and where it can easily be replaced.

In later pages, we will discuss other types of tubing as the topics for their use present themselves. They include:

- Colored vinyl and braided vinyl used for CO₂ gas
- Stainless steel tubing found in jockey boxes and tap towers
- Barrier tubing; a low-resistance, easy-to-clean beer line for long-draw systems
- Polyethylene tubing used to carry glycol coolant



Faucet

Faucets dispense beer to the glass. They often hold the tap marker to identify the type of beer being dispensed. The most common faucets are generally suitable for dispensing both ales and lagers. The most common or “standard” U.S. faucet is rear-sealing and

has vent holes that need to be carefully cleaned and inspected during routine cleanings. The holes, or vents, provide backpressure that allows for smooth beer flow and permits the faucet to drain between pours. Ventless, or forward-sealing faucets, are easy to clean and are available in stainless steel. Several other designs are widely available and are used either for their aesthetic appeal or for serving a specific style of beer. Nitro-Beer faucets are used for nitrogenized beers, such as certain stouts. These faucets use a diaphragm and restrictor plate to “cream” the beer.

In the U.S., all faucets attach to shanks with a standard thread size of 1-1/8” diameter, and 18 threads per inch pitch. Be aware that some faucets from other countries may use different thread sizes, and may require adapters or special shanks. For example, the flow control faucet in the chart below is shown with an adapter to allow it to be used on a standard U.S. shank and tower.

At retail, most faucets are fitted with tap markers that clearly display the brand being dispensed; in many states this is required. The tap marker must be aligned properly in order to be read easily by the consumer and sales staff. The tap marker is fitted with a standard-sized threaded sleeve for easy installation onto the faucet lever; in many cases, however, the tap marker may not be aligned properly when seated fully on the lever. For this reason, nearly all faucets are also fitted with a lever collar or handle jacket on the lever (see image on page 15). These allow the tap marker to be aligned properly, as well as installed securely. When installing the tap marker on the faucet lever, check to make sure it’s aligned appropriately. If not, unscrew the marker just enough to align it correctly, then back the lever collar up under the marker, and tighten the tap marker snugly onto the lever collar or handle jacket.



Standard



European



Ventless With Shaft



Ventless Without Shaft



Nitro



**Spring-Loaded
Cam-Actuated**



Flow Control

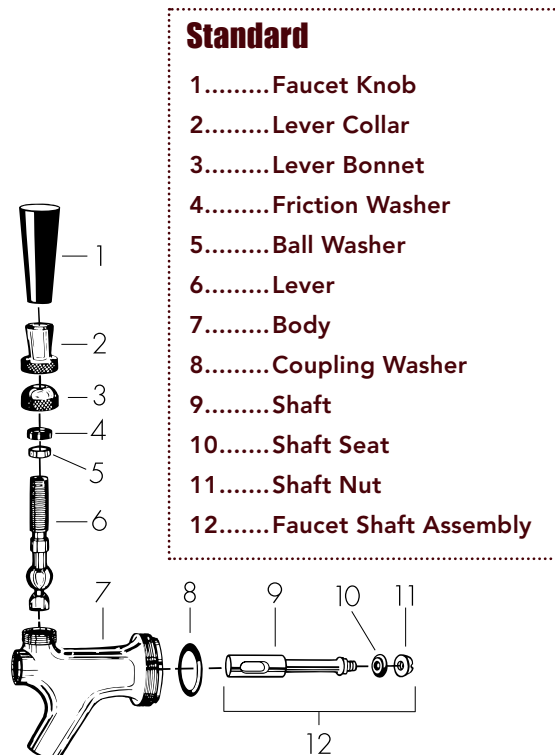


Roto-Faucet

Pros and Cons of Various Faucet Designs

Type	Valve	Flow	Pro	Con
Standard	Vertical, seals in back of shaft	Smooth	Low velocity	Barrel interior susceptible to microbial growth
European	Vertical, seals in back of shaft	Smooth	Low velocity	Barrel interior susceptible to microbial growth; may have threads that differ from standard U.S. thread size
Ventless with Shaft	Vertical, seals in front of shaft	Slightly twisting	Low susceptibility to microbial growth	High velocity flow may result in turbulence
Ventless without Shaft	Vertical, seals in front of faucet body	Slightly twisting	Low susceptibility to microbial growth	High velocity flow may result in turbulence
Nitro-Beer	Spring loaded cam-actuated plunger style valve. Restrictor plate and flow straightener in nozzle	Cascade of tiny bubbles	Gives unique texture needed for nitro beers	Nozzle susceptible to microbial growth from beer retained inside narrow opening; small nozzle parts require manual cleaning; use only with nitro beers
Spring-loaded, cam-actuated	Horizontal, top of nozzle	Slightly twisting	Low susceptibility to microbial growth	Nozzle susceptible to microbial growth from beer retained inside narrow opening; many small parts to clean
Flow Control	Vertical, seals in back of shaft	Smooth adjustable flow rate	Adjustable velocity may allow for increased dispense pressure	Barrel interior susceptible to microbial growth; may have threads that differ from standard U.S. thread size
Roto-faucet	Internal, rotating ball	Rapid velocity	Few parts, simple to clean	Some flow turbulence

Faucet Designs - Standard and Ventless





Gas Source

Draught systems depend on gas pressure to push beer from the keg to the faucet. To achieve this, kegs should be pressurized with carbon dioxide (CO_2), or a carbon dioxide and nitrogen (N_2) mix. Consult Chapter 4 to determine the proper blend of CO_2 and N_2 for individual applications.

⚠ Draught Safety ⚠

When transporting CO_2 cylinders, the valve should be turned off with the regulator removed. Proper transportation should be in a manner to prevent cylinders from creating a hazard by tipping, falling, or rolling. Do not attempt to lift cylinder by its valve.

Gas used for draught dispense should be “beverage grade.” Gas selection and purity affect the freshness and quality of the beer served through the draught system. Remember: the gas you use fills the keg as the beer drains. Thus, off-flavors or impurities in the gas quickly migrate to the beer to spoil its freshness and

flavor. Compressed air should never be used to pressurize a keg as the oxygen in the air generates stale flavors in beer within just a few hours. All gas used for beer dispense should meet the specifications of the International Society of Beverage Technologists or the Compressed Gas Association (See Appendix A).

No Air Compressors, Please!

Systems that use compressed air as a dispense gas expose beer to oxygen, which produces stale paper- or cardboard-like aromas and flavors in the beer. Brewers go to great lengths to keep oxygen out of beer to avoid these undesirable stale characteristics. Air compressors also push contaminants from the outside atmosphere into the keg, increasing the chance of beer-spoiling bacteria and off-flavors. For these reasons, compressed air should never be used in direct contact with beer.

Retailers may purchase beverage grade gas in cylinders that will be delivered by the gas vendor and swapped out when empty. Such cylinders are filled, maintained, and inspected by the vendor. High volume users may purchase a bulk gas vessel known as a Dewar that will be filled on location from a bulk gas truck. Bulk tanks can provide CO_2 for both soda and beer.

⚠ Draught Safety ⚠

Keep cylinders tightly closed and sealed until ready for use. Cylinders should be stored upright, with valve protection cap in place, and firmly secured to prevent falling or being knocked over. Cylinder temperatures should not exceed 125 °F.

CO₂ tanks contain both liquid and gas phases. The tank pressure is dependent on ambient temperature and—regardless of tank fill level—will vary from 600 – 1200 psi until empty. For safety reasons, CO₂ tanks should never be located inside the refrigerator or walk-in cooler as a leak could fill the space with deadly carbon dioxide. It also decreases yield over CO₂ stored at ambient temperatures. A gas filter may be installed to help reduce the likelihood that any contaminants in the gas reach the beer (be sure to follow manufacturer recommendations for filter maintenance intervals; see page 16 for more information).

⚠ Draught Safety ⚠

Breathing high concentrations of CO₂ can be deadly! Take care to prevent CO₂ buildup in enclosed spaces such as cold boxes. System leaks or beer pumps using CO₂ can cause this gas to accumulate in the cooler. To prevent this, beer pumps driven by CO₂ must be vented to the atmosphere. CO₂ warning alarms are available and recommended for installations with enclosed areas such as cold boxes containing CO₂ fittings and gas lines.



Braided Vinyl

Gas Line

Gas line should be selected to withstand the pressures in the draught system. Vinyl tubing intended to be used as gas line often has a greater wall thickness than vinyl beer line tubing. To help distinguish between gas line and beer line, colored vinyl is usually used for CO₂ supply line. Colored vinyl should not be used for beer because

it prevents visual inspection. An exception to this rule would be line exposed to sunlight, like what you might see in a temporary festival outdoor system poured off a jockey box. Clear vinyl may also be used for the gas line as it aids in troubleshooting by allowing you to see if beer has escaped the coupler and entered the gas line due to a faulty or missing Thomas valve. Because vinyl gas line will fail at lower pressures than braided vinyl or poly, it can also serve an important safety function in the event of secondary regulator failure by rupturing before a keg becomes over-pressurized.

Braided vinyl is often used for CO₂, particularly in high pressure situations (50+ psi) and in long CO₂ runs. Braided vinyl is commonly used in soft drink lines for both beverage and gas.



Primary CO₂ Bottle Regulator

Primary Nitrogen Bottle Regulator



Secondary Regulators

Regulator

A regulator adjusts and controls the flow of gas from any source. Each regulator typically has at least one, and often two pressure gauges that help in setting the outlet pressure and monitoring the gas level in the tank. Valves and an adjustment screw control the actual flow of gas from source to destination.

All gas systems employ a primary regulator attached to the gas source, namely a portable bottle or bulk tank. This regulator typically contains two gauges: one high-pressure gauge showing the tank or supply pressure, and a second low-pressure gauge showing what is being delivered to the keg. Some simpler regulators may contain only one gauge displaying the delivered pressure, making it more difficult to predict when the bottle is getting low. Some suppliers provide jockey box regulators preset with no gauges, since these are easily damaged in transit.

⚠ Draught Safety ⚠

Gas systems should frequently be checked for leaks and fixed immediately. Use adequate seals and gaskets; replace when they become worn. Paper seals are usually replaced every time the regulator is removed, while PTFE seals can last for extended periods.

Regulators are attached to the gas bottle with either an integrated “O” ring seal in the face of the regulator fitting, or a fiber or Teflon flat washer. These parts need to be replaced occasionally to prevent leaks and should be inspected every time the bottle is changed. Many regulators are also equipped with one or more shut-off valves located on the low-pressure outlet, allowing the CO₂ to be shut off without changing the set-screw or shutting off the main tank valve.

A primary regulator must also contain a safety relief valve to prevent dangerous system pressures in case of a malfunction or frozen regulator. Bottled CO₂ pressure can exceed 1000 psi, creating an extreme hazard if not handled properly.

Nitrogen regulators are designed for higher pressures and have a male thread with a conical fitting that (depending on the design) seats to the gas source with or without an O ring.

Pressure and Pressure Gauges

For the purposes of this manual, pressure is the amount of force acting on the surface of beer in a keg or serving vessel, and is often expressed in pounds per square inch (psi). **Absolute pressure** is the total pressure on the beer, and is the sum of atmospheric pressure plus any additional applied pressure from dispense gas. **Atmospheric pressure** is the amount of force exerted by the weight of air in the Earth’s atmosphere above an object. At sea level, atmospheric pressure is equal to 14.7 psi. If the dispense gas is applied at 15 psi, then the absolute pressure on the beer is 29.7 psi (14.7 psi + 15 psi).

Pressure can be measured several ways. Most pressure gauges are designed to measure the pressure of the dispense gas applied to beer beyond the local atmospheric pressure level. This is called **gauge pressure** or psig. Gauges in draught beer systems will nearly always read in psig. (Some specialized gauges are designed to measure the total pressure on the beer, or absolute pressure, in units of psia; these are very rare in draught beer dispense systems.)

As draught beer is dispensed, **the carbonation level will depend on the absolute pressure of the dispense gas, not the gauge pressure of the dispense gas.** This is true for both straight CO₂ as well as blended gas. The carbonation level in a beer is set by the brewer to maximize flavor, aroma, and presentation. One goal of draught beer dispensing is to maintain carbonation level. If the absolute pressure of the dispense gas is too high, the carbonation level of the beer will increase over time. If the absolute pressure of the dispense gas is too low, the carbonation level of the beer will decrease over time. More information about this very important topic can be found in Appendix C.

A Few Words about Elevation

Because atmospheric pressure changes depending on elevation, therefore so does the absolute pressure. So we need to take elevation into account while

designing draught beer dispensing systems and when we read carbonation tables. At higher elevations, the layer of air is thinner and therefore weighs less, so atmospheric pressure is also less. A good rule of thumb is that atmospheric pressure decreases by about 1 psi per 2,000 feet in elevation.

Let's look at an example in which the ideal dispense gas pressure for a beer brand in a particular draught beer system at sea level is determined to be 15 psig. At sea level, atmospheric pressure is equal to 14.7 psi, so at sea level a keg of beer with dispense gas pressure of 15 psig is under an absolute pressure of 29.7 psia (15 psig + 14.7 psi). That same keg of beer at an altitude of 5,000 feet with the same dispense gas pressure of 15 psig is only under 27.2 psia (15 psig + 14.7 psi– 2.5 psi). The chart below illustrates the

absolute pressure on a keg of beer at different elevations, assuming 15 psig dispense gas pressure.

Even though the gauge pressure on the keg of beer reads the same, the absolute pressure of the dispense gas on the keg is decreasing with elevation. Over time, the carbonation level of the beer being dispensed at elevation will slowly decrease because the absolute pressure of the dispense gas is lower than at sea level.

The charts below illustrate that in order to maintain the carbonation level of beer being dispensed at elevation, the gauge pressure of the dispense gas needs to be increased above the calculated dispense pressure at sea level. ■

Elevation (feet above sea level)	Atmospheric Pressure (PSI)	Dispense 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

Elevation (feet above sea level)	Atmospheric Pressure (PSI)	Dispense 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

chapter 2



temporary draught dispense

draught beer goes great with outdoor events, but the temporary setting prohibits use of traditional direct-draw or long-draw draught equipment. Instead, we usually use one of two different systems: hand pumps or jockey boxes.

Hand Pumps

Hand pumps allow draught beer dispense for a one-day occasion or event. These systems compromise accepted standards of draught dispense in order to offer a simple method for serving draught beer.

In the simplest systems, the beer flows to a simple plastic faucet attached to short section of vinyl hose. Gas pressure comes from compressed air introduced by way of a hand-operated pump integrated into the coupler. The pictures to the right show plastic and metal examples of hand pumps.

Since these systems introduce compressed air into the keg, they are suitable only for situations where the beer will be consumed in a single day. Also, these dispensing systems typically do not produce the best

serving results, since balancing the correct top pressure is very imprecise. For best results, the keg must be kept in ice and consistently—but not excessively—pumped as the contents are dispensed. Pumping the keg with the faucet closed will only serve to build up pressure into the head space, encouraging the absorption of oxygen into the beer.

Improved designs use single-use CO₂ cartridges with an integrated regulator. These units may also include a traditional vented faucet mounted on a short length of stainless steel beer line. This design overcomes the key shortcomings of hand-pumped taps.



Jockey Boxes

Jockey boxes offer another way to improve on the hand pump as a solution for portable dispense. Here, a normal coupler is attached to the keg and CO₂ is used to pressurize the system. Beer in route from keg to faucet passes through a cold plate or stainless steel tubing inside an ice chest in order to cool to the proper dispense temperature. A cold-plate-equipped jockey box uses ice to cool beer flowing through the cold plate. A jockey box equipped with stainless steel coils uses ice and water to chill beer flowing through the coil.

These systems are not appropriate for day-to-day use, as draught beer is perishable and room temperature storage accelerates aging. They are also used with high pressure CO₂, which can over-carbonate a typical keg when tapped longer than a day. Partial kegs remaining from temporary service are not usable in other settings.



Jockey Box Setup and Use

Because they have a relatively high surface area for chilling beer, i.e. beer goes through more tubing length, coil-style jockey boxes can pour beer at a faster rate than those equipped with a cold plate. Thus, they better suit situations where faster pour rates and volumes are needed. With lower surface areas for chilling, the cold-plate style is appropriate when beer dispense needs are a bit slower.

Kegs used with a cold plate should be iced if the ambient temperature is above 55°F since they have limited cooling capacity; however, coil boxes can pour beer efficiently even with the kegs at room temperature (64° – 74°F). If the ambient temperature is above room temperature, the coil-box kegs should be iced as well.

Beer line used with a jockey box should be colored since it is typically subject to light, which has the potential to cause light-struck beer. This is the **ONLY** time where flexible vinyl beer line is suggested to be dark. It does not allow for a visual inspection and so should be clear in all other situations.

Setup affects the efficiency of both jockey box styles.

To set up a cold plate:

- **Tap** the keg and run beer through the faucet before adding ice to the jockey box. This removes water left behind during the cleaning process before temperatures in the plate get cold enough to freeze it, causing turbulence or blockage of the beer flow.
- **Place** ice both underneath and on top of the cold plate in the ice chest. As time passes, the ice will “bridge” and should be removed for better contact with the cold plate. Ice should be added periodically and water drained from the ice chest.
- **Set** CO₂ pressure to 25 to 35 psi. This will vary depending on how much line is contained in the plate and thus how much resistance to flow is built into each line. Pressure can be adjusted to attain desired flow rate.

To set up a coil box:

- **Tap** the keg and run beer through the coil and out the faucet.
- **Add** ice to the ice chest and completely cover the coil.
- **Add** cold water to the top of the coil. This creates an ice bath, giving excellent surface contact. Ice water is also a better conductor than straight ice.
- **Set** CO₂ pressure to 35 to 40 psi on 120 ft. coils. Shorter coils are not recommended, but if used, should dispense at 30 to 35 psi. Since coil length varies, so too will psi. This is usually a trial and error process as opposed to an actual calculation.

⚠ Draught Safety ⚠

When not in use, all beer lines should be left clean and pH neutral. The lines should be blown out with CO₂ using a cleaning cup, or hung up vertically to air dry (if possible).

Cleaning and Maintenance

Temporary dispense equipment must be cleaned immediately after use. It is nearly impossible to remove the mold and biofilms that can result from storing a cold plate or jockey box that has had old beer left in the lines.

For cleaning jockey boxes, refer to the detailed electric cleaning pump procedures outlined in Chapter 7. Afterwards, the water in the lines must be blown out to prevent mold growth.

- If the recirculation pump is capable of being run dry: Before breaking down recirculation loop, remove inlet from rinse water with pump running so air pushes out all of the rinse water in the lines.
- If the recirculation pump is **not** capable of being run dry: After breaking down the recirculation loop and reattaching faucets, tap an empty cleaning canister and use the gas pressure to blow all of the water out of the lines. ■



chapter 3

equipment and configurations for direct-draw draught systems

Retailers use direct-draw systems in situations where the kegs can be kept refrigerated in very close proximity to the dispense point or faucet. In some cases, the beer sits in a cooler below the counter at the bar. In other cases, the keg cooler shares a wall with the bar, keeping the beer close to the point of dispense. Let's look at these two types of direct-draw systems:

- A self-contained refrigerator (keg box or “kegerator”) where the number of kegs accommodated will vary based on box and keg sizes.

- A walk-in cooler with beer dispensed directly through the wall from the keg to the faucet.

The nine components discussed in Chapter 1 appear in both direct-draw systems; only a little additional equipment comes into play. As with temporary systems, most direct-draw systems employ vinyl beer line and pure CO₂ gas. Compared to barrier tubing, vinyl beer line is relatively permeable to oxygen ingress, and the flavor of beer stored in these lines can change overnight. As part of their opening proce-



Direct Draw Kegerator



Walk-in Cooler



dures each day, some retailers will drain this beer or, in some cases, use it for cooking.

As permanent installations, direct-draw systems typically include a drip tray, and some systems also incorporate a tap tower. In addition, shanks support the faucets in either tower or wall-mount applications. The following sections discuss these elements of the system.

Drip Tray

Many draught systems include a drip tray placed below the faucets and most health departments require them.

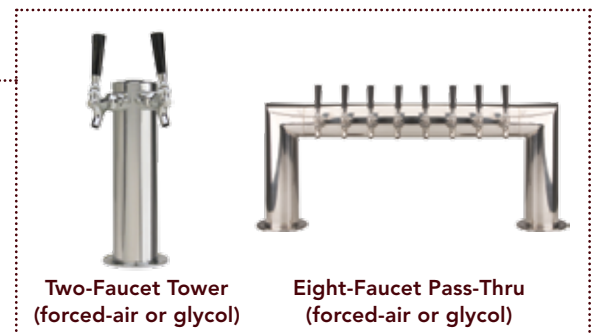
Many walk-in based direct-draw systems use a wall-mounted drip tray that includes a back splash. This design may be used on some air-cooled long-draw systems as well. Bars typically place surface or recessed drip trays under draught towers. The drip trays should be plumbed to empty into a drain or floor sink.



Towers

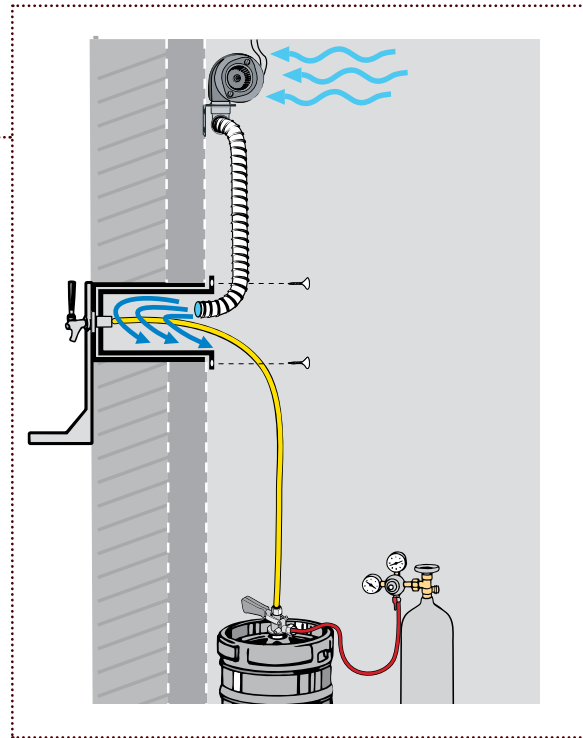
Direct-draw keg boxes and most long-draw systems mount the dispensing faucet on a tower. This tower attaches to the top of the bar or keg box. Towers come in various shapes and sizes and may have anywhere from one to dozens of faucets.

To achieve proper beer service, the beer line running through the tower to the faucet must be kept at the same temperature as the beer cooler. Direct-draw systems use air cooling, while long-draw systems typically use glycol cooling. The air-cooled towers are insulated on the inside and cold air from the cooler circulates around the beer lines and shanks. This works with direct-draw systems thanks to the close proximity of the tower to the cold box. Some keg boxes have specialized corrugated tubing connected to the refrigerator's evaporator housing. This tubing is designed to be inserted in the tower to provide for cold air flow up to the faucet. Typically cold air is supplied directly from the discharge of the evaporator and is colder than the keg temperature.



Shadow Box

In some direct-draw applications inside a walk-in cooler, it may be necessary to cut a section out of the cooler wall where the shanks are placed. The wall is then recessed in a “shadow box” to minimize the shank length and keep foaming to a minimum.



Shanks

Most draught systems firmly mount the faucet to either a tower or a wall, making it a stable point for beer dispense. A threaded shank with securing nuts creates the solid connection to the supporting tower or wall. The faucet then connects to one side of the shank and beer line connects to the other side by either an attached nipple or a tail piece connected with the usual washer and nut. Today, shanks with 1/4" and 5/16" bore diameters are most commonly available and recommended in the U.S., along with 3/16" bore diameter shanks, which are less common. The once-common practice of drilling out a 3/16" bore diameter shank to one of the larger sizes is not recommended as the resulting unfinished brass shank

bore surface will be detrimental to draught beer quality, and because drilling will likely damage shanks and glycol chilled towers beyond repair, meaning expensive replacement will be necessary.



⚠ Draught Safety ⚠

High concentrations of CO₂, which displaces oxygen, can result in death in less than 15 minutes. Carbon dioxide is a colorless, odorless gas and should be treated as a material with poor warning properties. It is denser than air and high concentrations can persist in low, enclosed areas. Gaseous carbon dioxide is an asphyxiant. Concentrations of 10% (100,000 ppm) or more can produce unconsciousness or death. Lower concentrations may cause headache, sweating, rapid breathing, increased heartbeat, shortness of breath, dizziness, mental depression, visual disturbances or shaking. The seriousness of the latter symptoms is dependent on the concentration of carbon dioxide and the length of time the individual is exposed. The response to carbon dioxide inhalation varies greatly even in healthy normal individuals.

Gas (CO₂)

CO₂ is the primary gas used to dispense draught beer. CO₂ in the headspace of the keg or serving tank serves to maintain proper carbonation within the beer and also provides pressure to help move the beer from the cooler through the beer lines to the faucet. CO₂ used for beverage dispense must be of sufficient purity and free of off aromas or organic or other contaminants. See Appendix A for detailed purity specifications.



In-Line Gas Leak Detector

Gas Leak Detectors

Gas leaks in a draught system can not only cost money in lost gas, but can also potentially cause pressure drops that can lead to foamy beer. In enclosed spaces, large CO₂ leaks can be extremely dangerous or even deadly. Gas leak detectors are available that are plumbed directly into the gas supply line to the draught system. When no beer is being poured, a float inside the device will rise if gas is leaking.

⚠ Draught Safety ⚠

While performing maintenance on any system involving CO₂, the gas should be shut off prior to any work being performed. If CO₂ is released inside an enclosed environment, it should be immediately ventilated to allow CO₂ levels to return to normal. Anyone working in such an environment should avoid working in low points where CO₂ accumulates.

Electronic CO₂ monitors are also available for installation in walk-in coolers. Such devices can prevent serious injury or death from CO₂ inhalation by sounding an alarm when CO₂ levels are elevated.



Gas Filters

Beverage grade CO₂ comes from many commercial and industrial operations and is supplied for many uses besides beverages (e.g., fire extinguishers, welding, food processing, etc.). CO₂ bottles can be contaminated by poor handling and storage. They can be contaminated by beer or soft drinks if a check valve malfunctions and the beer or soft drink flows back into an empty CO₂ bottle. A gas filter helps safeguard beer by removing unwanted impurities or contaminants from the gas. Filters must be replaced periodically per the manufacturer's instructions.

Units of Carbonation

In the U.S. and some other countries, the industry measures beer carbonation in units of "volumes of CO₂". A typical value might be 2.5 volumes of CO₂, meaning literally that 2.5 keg-volumes of uncompressed CO₂ have been dissolved into one keg of beer. Carbonation levels in typical beers run from 2.2 to 2.8 volumes of CO₂ but values can range from as little as 1.2 to as high as 4.0 in specialty beers.

In Europe and other countries, the industry may measure carbonation in terms of "grams per CO₂ per liter of beer". A good rule of thumb is to multiply volumes of CO₂ by 2 to estimate grams per liter. So, a beer with 2.5 volumes of CO₂ would contain about 5 grams per liter of CO₂. For more information on this calculation, see Appendix B.

Carbonation Dynamics

The level of carbonation in beer responds to changes in storage and serving conditions. Let's consider an average keg with a carbonation of 2.5 volumes of CO₂ and see what happens when conditions change.

Beer temperature and the CO₂ pressure applied to the keg influence the amount of CO₂ dissolved in any keg of beer. At any given temperature, a specific pressure must be applied to a keg to maintain the carbonation established by the brewery. If temperature or pressure varies, carbonation levels will change.

		CO ₂ pressure		
		9 psi	11 psi	13 psi
Temp	34 °F	2.5	2.7	2.9
	38 °F	2.3	2.5*	2.7
	42 °F	2.1	2.3	2.5

		CO ₂ pressure		
		9 psi	11 psi	13 psi
Temp	34 °F	2.5	2.7	2.9
	38 °F	2.3	2.5*	2.7
	42 °F	2.1	2.3	2.5
* Pressures rounded for purposes of illustration. Do not use these charts for system adjustment.				

		CO ₂ pressure		
		9 psi	11 psi	13 psi
Temp	34 °F	2.5	2.7	2.9
	38 °F	2.3	2.5*	2.7
	42 °F	2.1	2.3	2.5

Beer in a keg at 38°F needs a pressure of 11 psi to maintain 2.5 volumes of CO₂ as the beer is served. As long as the temperature and pressure remain constant, the beer maintains the same carbonation level.

If the temperature of the beer changes, so does the required internal keg pressure. In the above chart, we see that if the pressure remains at 11 psi but the temperature of the beer rises to 42°F, carbonation will begin to move from the beer to the headspace. Over a few days, the overall carbonation in the beer drops to 2.3 volumes of CO₂.

Alternately, if the temperature remains at 38°F, but the CO₂ pressure increases to 13 psi, then the carbonation level of the beer in the keg will increase to 2.7 volumes as the beer slowly absorbs additional CO₂.

The "ideal gauge pressure" for a beer is the pressure at which CO₂ is not diffusing from beer into the headspace and excess CO₂ is not absorbing in the beer. This value varies from account to account depending upon factors such as temperature, altitude, and carbonation level of the beer. Because beer carbonation can vary with the temperature of your cooler and the pressure applied to the keg, you must take care to maintain steady values suited to your system and beers.

A Note about Altitude

Pressure gauges used on draught systems measure in pounds-per-square-inch gauge, or "psig". This is the difference between the pressure in the keg and atmospheric pressure (14.7 psi at sea level). When dispensing beer at elevation, the carbonation level of the beer does not change but the pressure displayed on the gauge will read low, by approximately 1 psi per every 2,000 feet. So a keg dispensed at 10,000 feet would need to have the gauge pressure increased by approximately 5 psig above the calculated dispense pressure at sea level. See pages 17 & 18 for more details on correcting for elevation.

Determining CO₂ pressure in a Direct Draw System

Because direct-draw systems are typically quite short, the pressure of 100% CO₂ required to maintain proper carbonation is usually sufficient by itself to also deliver the beer from the keg to the faucet without over carbonating the beer.

You can determine ideal gauge pressure for pure CO₂ from the chart shown in the table above and in Appendix B. If you do not know the carbonation level in the beer, you can estimate it using the procedure found in Appendix B.

Determination of CO₂ equilibrium pressure given volumes of CO₂ and temperature

Vol. CO ₂	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1
Temp. °F	psi	psi	psi	psi	psi	psi	psi	psi	psi	psi	psi
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

* Chart assumes sea-level altitudes. Add 1 psi for every 2,000 feet above sea level.

System Balance and Achieving Flow

So far we have seen what happens to a beer's carbonation in the keg as the result of *applied pressure* and *temperature*. Beer must travel from the keg to the glass, and along the way it encounters a fourth measure, *resistance*. The beer line and changes in elevation impart resistance to the flow of beer from the keg to the faucet.

The pressure applied to the keg overcomes this resistance and drives the beer through the system and to the customer's glass. To achieve proper flow and beer quality, the pressure applied to the keg must equal the total resistance of the draught system.

We have already demonstrated that the pressure applied to the keg needs to be matched to the car-

bonation level of the beer. This creates a problem when the resistance of the system calls for more, or less, pressure than is needed to maintain the carbonation of the beer. To prevent conflicts and balance the system, draught technicians design system resistance to match the pressure applied to the beer.

A balanced draught system delivers clear-pouring beer at the rate of 2 ounces per second. This means it takes about eight seconds to fill a pint glass and about one minute to pour 1 gallon of beer.

For most direct-draw systems, balancing the system is quite simple. Most direct draw kegerators and walk-in coolers where the kegs are close to the faucets will simply take a 4-5 foot length of 3/6" ID vinyl tubing.

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
psig Applied CO ₂	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"

Some system setups benefit from flow rates faster or slower than 1 gallon per minute. If you try to achieve faster pours by increasing the gas pressure, you will create over carbonated beer and foam at the tap. Foamy beer can also be the result if you achieve slower pours by decreasing pressure. This can also create flat beer. If you need to change flow rate, the resistance of the system should be altered to achieve this result, not the

gas pressure. Gas pressure, once set for a particular beer, remains constant and should never be adjusted to alter the flow rate of the beer.

For long-draw systems or systems that need different flow rates, figuring restriction and choosing the correct tubing is more complex. For more information on these calculations, see page 74. ■

chapter 4



equipment and configurations for long-draw draught systems

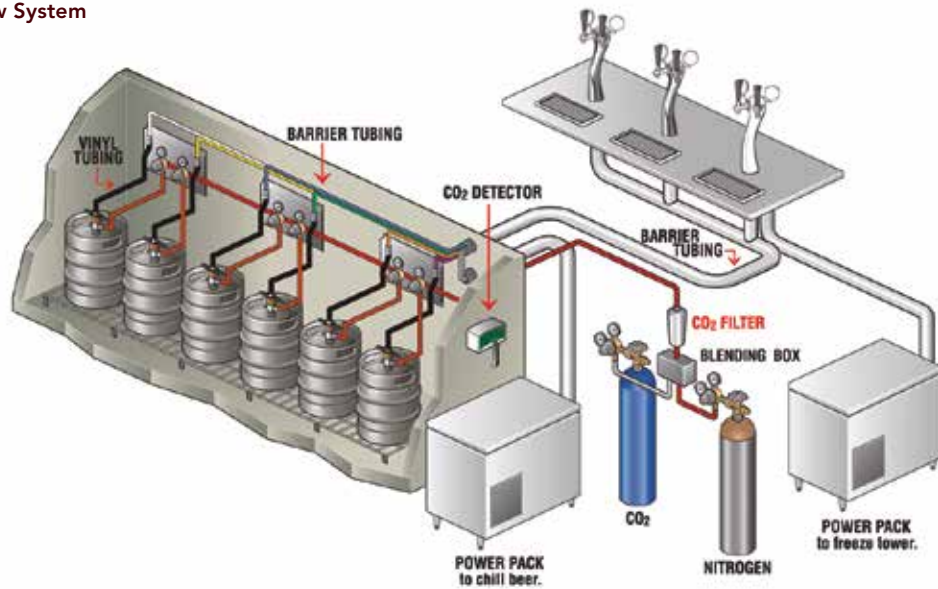
the most complex draught systems fall into the long-draw category. Designed to deliver beer to bars well away from the keg cooler, these systems usually employ equipment not seen in temporary and direct-draw setups. From around 1990 to 2010, the average long-draw system had doubled in complexity from roughly five faucets to more than 10 faucets. Today it is common to find very complex draught beer systems at retail with dozens of faucets. While long-draw systems offer designers the option to put beer far from the bar, providing keg handling or layout flexibility, the distances they cover come with increased opportunities for problems and increased costs for equipment, cooling, and beer waste. As with all systems, it is important to minimize line length and diameter where possible to minimize beer loss and facilitate cleaning.

Let us consider the three draught dispense sub-systems of beer, gas, and cooling to see what long-draw systems include.

Beer

While exceptions exist, most long-draw systems still push beer from kegs. Beer exits the keg through a coupler and usually enters a vinyl beer line just as we have seen with temporary and direct-draw systems. But here the vinyl does not last long. It typically goes about six feet before connecting to a wall bracket that serves as a transition to specialized barrier tubing. Designed for minimum resistance and superior cleanliness, barrier tubing should carry beer most of the distance from keg to faucet in long-draw systems. But barrier tubing is not the end of the journey; most draught towers use stainless steel tubing to carry the beer to the faucet. In

Long-Draw System



addition, many systems include some length of narrow-gauge vinyl tubing called “choker” between the end of the barrier tubing and the stainless steel tubing of the draught tower, to provide a way to accurately balance the system. In the end, however, the beer flows through a faucet just as we saw with the direct-draw systems.

You may also find Foam on Beer (FOB) detectors on the beer lines of many long-draw systems. Located in the cooler at or near the wall bracket, these devices fill with dispense gas when beer from a keg runs out, thereby shutting off flow to the main beer line. This prevents beer loss by keeping the main beer line full of pressurized beer while the keg is changed. The jumper line between the keg and FOB is then purged and normal beer service can resume. See page 31 for more information about FOBs.

Components

Barrier Tubing

Barrier tubing has a “glass-smooth” lining that inhibits beer or mineral stone deposits and microbial growth to maintain beer freshness. Its properties make it the only industry-approved beer line for long-draw systems.

⚠ Draught Safety ⚠

Appropriate engineering controls: Good general ventilation should be sufficient to control worker exposure. CO₂ detection devices should be installed and regularly inspected in enclosed environments such as walk-in coolers and storage rooms. Personal CO₂ or oxygen monitors can help workers to be aware of any asphyxiation hazards.

Barrier tubing may be purchased separately in various diameters, but most suppliers sell it in prepared bundles (called bundle or trunk housing) with beer lines and glycol coolant lines wrapped inside an insulating cover. These bundles vary by the number of beer lines they carry with popular sizes matching the number of faucets commonly found on tap towers.

Many older long-draw systems installed single-wall polyethylene tubing. This relatively porous material allows oxygen ingress, carbon dioxide to escape, and makes cleaning difficult, resulting in stale, flat, and potentially tainted beer in the lines. Today, you may find blue and red polyethylene tubing carrying glycol from and to

your glycol power pack; this is the only recommended use for polyethylene tubing in long-draw systems. Long-draw systems with vinyl or polyethylene lines (typical of much older systems) should be repacked with fresh beer each day due to the detrimental effects of oxidation; the beer drained during this process can be used for cooking, however. This expense alone can significantly decrease the payback time when replacing an old long-draw system with barrier tubing.

Vinyl tubing should only be used as jumpers between keg couplers and long-draw barrier tubing trunks, and as restriction tubing between barrier tubing trunks and faucet shanks. Vinyl and polyethylene tubing should never be used in long-draw bundles.

Choker Line

Choker line, also known as restriction tubing, is a section of 3/16" ID vinyl tubing of variable length installed at the tower end of a long-draw system. The purpose is to add to the overall system restriction and thus achieve the target flow rate at the faucet. It is connected at one end to the barrier tubing in the trunk housing with a reducing splicer, and at the other to a hose barb on either the back side of the shank inside the tower, or to the stainless tubing extending from the tower.

Using vinyl line to provide restriction is problematic, however, in that over time, because of its porous nature, it will become difficult to keep clean. It should be changed periodically, but this is not always practical in a sealed tower. A few different specially designed devices can be used as alternatives to constructing final choker restriction with long lengths of 3/16" ID polyvinyl hose. One such device is a series of plastic segments that are inserted into a short section of 1/4" ID barrier tubing just below the tower; another is a wire mesh device installed in the shank just behind the faucet. These devices are of varying restriction and, while potentially useful, also have some potential downside. For one, these items prevent beer line cleaning with sponges as an option.

Wall Brackets

Wall brackets join tubing together in a long-draw cold box. The wall bracket gives a solid connecting spot for jumper lines from the keg. Tubing is connected with a washer, nut, tail piece, and clamp combination. (Most of these installed in the past were made of plated brass, and should be inspected for wear and replaced with stainless steel.)



One-Faucet Wall Bracket Two-Faucet Wall Bracket

FOB (Foam On Beer)

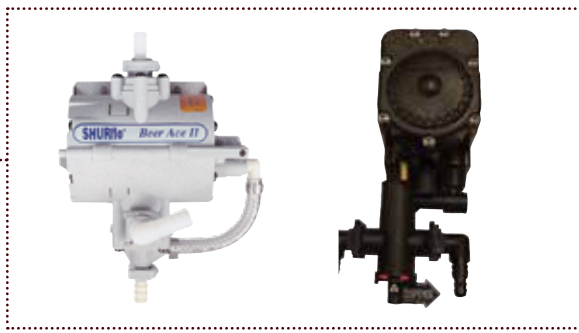
FOBs stop the flow of beer through a line once the keg empties. This reduces the beer loss normally associated with changing a keg and therefore reduces operating costs. While available in different designs, most feature a float in a sealed bowl that drops when beer flow from the keg stops. The FOB allows the beer lines to stay packed. This makes for less product loss and generates savings for the account. FOBs should be cleaned every two weeks when the draught system is cleaned and completely disassembled and manually cleaned every six months to ensure a clean system.



Stainless Steel FOB

Plastic FOB

Plastic FOB



Beer Pumps

Beer pumps draw beer from a keg or other beer-serving vessel and deliver it to the faucet. Rather than using gas pressure to drive beer, beer pumps use mechanical force to propel the beer through the system. Beer pumps are usually found in draught systems when working pressures for gas dispense get too high (above 35 or 40 psi). This includes very long runs (>200 feet) or high vertical lifts. Above these pressures, beer will absorb enough nitrogen from the blended dispense gas to create long-lasting, smaller-sized foam bubbles that in turn can cause problems dispensing beer. Beer pumps are often used on multi-barrel brewpub serving tanks that have low-pressure limits. Serving tanks must be constructed to American Society of Mechanical Engineers (ASME) standards in order to safely dispense beer above 15 psi.

Beer pumps themselves are powered by high-pressure gas or compressed air that does not come into contact with the beer. Most retailers power their beer pumps with CO₂; in these cases, **the pump exhaust CO₂ gas must be vented outside the cooler or building to avoid CO₂ buildup and asphyxiation**. CO₂ can be relatively expensive to use to power beer pumps compared to compressed air, but CO₂ is usually already available at any location serving draught beer, so is often simpler to use.

⚠ Draught Safety ⚠

The pump exhaust CO₂ gas must be vented outside the cooler or building to avoid CO₂ buildup and asphyxiation.

If using compressed air to drive beer pumps, pump and keg regulators must be separated—compressed air should never come into contact with draught beer. Also, high quality air compressors that clean and dry the air must be used to avoid damaging beer pumps; smaller, less expensive air compressors can deliver air with small amounts of moisture or oil that can damage beer pumps over time. Air compressors also can break down, leaving the retailer unable to dispense beer.

Some portion of the pump contacts the beer and, like anything else, it must be regularly cleaned to prevent beer stone buildup and microbial infection. See special cleaning considerations on page 66 of this manual.

Beer pump setups require two operational pressures: CO₂ pressure on the keg or tank to maintain beer carbonation, and separate gas pressure to the pump to propel the beer to the faucet. There are two basic beer pump types: fixed pressure and additive pressure. Fixed pressure pumps are becoming much less common today. Because fixed pressure pumps deliver beer at the same pressure being applied to the beer keg or tank, they are less useful in systems balanced at higher pressures. Additive pressure beer pumps are most useful for very long draw systems, since the pressure applied to the keg is added to the pressure of the gas driving the beer pump. Additive pressure pumps have one other advantage—beer may still be dispensed (although much more slowly) if they fail; whereas beer cannot be served if a fixed pressure pump fails.

Here are some good rules of thumb for using beer pumps in draught beer dispensing systems:

- Be sure to refer to detailed cleaning procedures provided by the pump manufacturer, and to procedures found on page 66 of this manual. Don't let your cleaning solution get too hot or you will damage your pump.

- Only use beer pumps that come fitted with a diverter or backflush fitting, so the pump can be properly cleaned using recirculation pumps, in either forward or backward direction. One such pump fitted with a flow diverter is shown on the previous page.
- Proper CO₂ pressure (ideal gauge pressure) should be applied to the keg or tank to maintain the beer's carbonation level (See Appendix B).
- When using additive pressure type pumps, set pump pressure so that the sum total of the keg pressure plus pump pressure together equal system resistance pressure.
- Most draught beer systems with beer pumps also use FOBs placed immediately after the beer pump. This keeps the pump from running dry when the beer supply to the pump runs out, a primary cause of pump failure.
- Vent CO₂ out of the cooler for the pump exhaust.
- Don't run more than two faucets per beer pump.
- Don't run more than two beer pumps per secondary regulator.
- For pumps to function properly, they should be located close to the source (the keg).



Quick-Connect (or Push) Fittings

Special fittings can join the different types of beer line found in long-draw systems. Quick-connect fittings work on hard or rigid tubing including polyethylene (used for glycol), barrier line, and stainless tubing. Couplers attach to square-cut tubing ends with an O-ring and gripper. Adding a vinyl adapter to the coupler allows for transition from barrier or stainless to vinyl tubing.

Defining Mixed Gases

For the purposes of this manual, as a convention in discussions involving mixed gas, the proportion of CO₂ will always be shown first, followed by the proportion of N₂.

Mixed Gas – Carbon Dioxide (CO₂) and Nitrogen (N₂)

Pushing beer across the distances found in long-draw systems usually calls for gas pressures well above what is needed to maintain proper beer carbonation levels with 100% CO₂.

As we have seen, beer readily absorbs carbon dioxide. Any change in CO₂ pressure on a beer results in a change in the carbonation of the beer. Nitrogen is different. For one, it does not absorb into beer at typi-

Straight CO₂ and Long-draw Systems

Straight CO₂ should only be used in a long-draw system when 1) ideal gauge pressure is sufficient to produce the proper flow rate, and 2) there is absolutely no temperature increase in the draught lines outside the cooler, both of which are highly unlikely. Since ideal gauge pressure with straight CO₂ is relatively low, even a slight temperature increase from the keg cooler to the draught line can allow the CO₂ to escape from the beer in the draught line, causing foamy beer at the tap. The higher pressure of blended gas can to some degree help eliminate foaming caused by such a temperature increase by keeping beer packed several pounds above the carbonation breakout pressure.

cal system operating pressures. Also, as an inert gas, it does not degrade the flavor of the beer. These qualities make it perfect for blending with CO₂ to achieve higher pressures without over carbonating the beer. Thus, in high resistance draught systems, we use a mixture of CO₂ and N₂ to achieve two objectives: 1) maintain proper beer carbonation and 2) overcome the system resistance to achieve a proper pour.

The exact mix of CO₂ and nitrogen depends on all the factors we have discussed: beer temperature and carbonation, system resistance, and the total applied pressure that's required. The details of these calculations are shown in Appendix C. There are also some excellent resources online, including easy-to-use calculators to help determine the exact custom blend needed for your draught beer system (see the online version of this manual for links).

The correct blend might be purchased pre-mixed in blended gas bottles, or custom blends can be mixed onsite from separate carbon dioxide and nitrogen sources. The use of custom gas blends brings new equipment into play, including gas blenders and possibly nitrogen generators.

Blended Gas Bottles

Blended gas bottles are gas vendor-mixed CO₂ and nitrogen gas mixes. Often called "G-Mix" or "Guinness Gas," these blends are typically available in blends of 30-25% CO₂ / 70-75% N₂ and are designed for use with nitrogenized or "nitro" beers. Although their use is commonplace, there are several limitations to this mixed gas source.

The physical characteristics of CO₂ limit the amount of blended gas that can be stored in a blended gas bottle, compared to pure CO₂ or N₂. CO₂ becomes liquid at the very high pressures needed to compress nitrogen, meaning the blended gas being dispensed from the headspace of the bottle will not

be the blend proportion anticipated if the bottle is overfilled. For this reason, blended gas bottles contain a very low volume of gas and are thus relatively expensive compared to other mixed gas sources such as gas blenders. When comparing the cost of a gas blender to the ongoing expense of pre-mixed cylinder gas, the payback period for the blender is often under a year.

Also, the higher percentage of CO₂ that goes into the blend, the lower the overall volume that can go into the cylinder before the CO₂ becomes liquid. This limits most of the blends in pre-mixed cylinders to very low CO₂, or "nitro" applications, and if a high-percentage CO₂ blend is made available in a pre-mixed cylinder, the overall volume will be extremely low.

Additionally, the tolerances of bottled blended gas are very difficult to manage during filling. Unless the bottled blend is well mixed, the bottle can become over-pressurized and the CO₂ can become a liquid, causing the gas being dispensed to vary considerably from the desired mixture. This deviation can result in over- or under-carbonated beer, therefore increasing expense and decreasing draught beer quality.

Pre-mixed cylinders containing a mix of between 30-25% CO₂ and 70-75% N₂ are only intended for use with nitrogen-infused beers or "nitro" beers. These blends are not intended for use with regularly carbonated beers (those with more than 2.0 volumes or 3.9 grams/liter of CO₂), even in high-pressure long-draw systems. Use of "nitro" beer gas on regularly carbonated beers causes these beers to lose carbonation in the keg or serving tank. This results in flat beer being served within three to five days. This flat beer is most noticeable near the end of the keg, with the amount of flat beer increasing the longer the beer is in contact with this gas. Similarly, straight CO₂ should not be used to dispense nitro beers, as they will over carbonate very quickly and become unpourable.

Gas Blenders

Gas blenders provide the most flexibility in obtaining mixed gas for draught dispense. They mix pure CO₂ and pure nitrogen from individual tanks in specified ratios and can provide one, two, or even three blends on a single panel.

Single product blenders will typically contain a CO₂-rich blend designed for regularly carbonated beers. For simplicity, many installers would put in a blender with little thought or planning as to what the blend is, simply deferring to what was the commonly stocked 60% CO₂/40% N₂ blend. Recent studies in retail establishments have shown that a 70% CO₂/30% N₂ blend will more likely result in proper carbonation of draught beer in most retail draught beer systems. This has led the industry to stock the 70% CO₂/30% N₂ blend as the default blend for installers who do not specify a specific blend. This is not necessarily the best blend for every situation, however. The best approach for high quality draught beer is to identify and use the exact correct gas blend for your particular draught beer system. See Appendix C of this manual for examples of this calculation, or consult your professional draught beer equipment installer or supplier for more advice.

Double product blenders usually have one CO₂-rich blend for regularly carbonated beers with the second blend being a 25% CO₂ / 75% N₂ blend for “nitro” beers.

Triple product blenders will have two different CO₂-rich blends calculated to adequately serve beers with a reasonable range of CO₂ volumes (e.g. 2.2-2.8 volumes of CO₂), with the third blend being the 25% CO₂ / 75% N₂ blend for “nitro” beers.

Existing one and two mix blenders can sometimes be upgraded to two and three blends; be sure to check with your supplier. Recommended features for a gas blender include:

- Output mix is preset by the manufacturer and is not adjustable onsite.
- Blender shuts down when either gas supply runs out, preventing damage from running on only one gas.



Single Mix Blender



Two Mix Blender



Three Mix Blender



Nitrogen Generator

Nitrogen Generators

Nitrogen generators extract nitrogen from the atmosphere. Air is supplied by either a remote or integrated air compressor. Nitrogen generators are typically equipped with a built-in gas blender.

To protect nitrogen purity from compromising draught beer quality, nitrogen generators should have the following features:

- Produce nitrogen with a purity of at least 99.7%.
- Have air inlets equipped with both an oil/water filter and a sterile air filter.
- Use "oil-free"-type air compressors.

All nitrogen generator filters should be inspected and replaced according to the manufacturer's specifications.

System Balance and Achieving Flow

Having identified our type of dispense gas, and then calculated our gas blend and applied pressure with the formulas in Appendix C, we can now balance the elements of the draught system to achieve our desired flow rate. Our goal is to identify and add up all of the elements in the system that contribute to system resistance and get that figure to match the applied pressure in psi.

Draught System Balance

When applied pressure equals resistance, a draught system will pour clear-flowing beer at the rate of 1 gallon per minute, or approximately 2 ounces per second.

In this manual we will be using degrees Fahrenheit (or °F) for all **temperature** measurements. Just remember that we want to know the temperature of the actual beer. Since it takes a keg of beer many hours to stabilize at the temperature of the cooler, the beer temperature can vary quite a bit from the setting of the thermostat in your cooler.

We measure **applied pressure** in pounds per-square-inch-gauge abbreviated as "psig," or often just "psi." The pressure applied to any keg is shown by the gas regulator attached to it.

Resistance comes from changes in elevation and draught system components like the beer line as the beer flows from keg to glass. We measure resistance in pounds and account for two types: static and dynamic. For the purposes of this manual, and generally speaking in the trade, pounds of resistance are considered equivalent to pounds per square inch of pressure when balancing a draught beer system.

Static resistance comes from the effect of gravity, which slows the flow of beer being pushed to a level above the keg. Here's one way to think about static resistance: if you have a U-tube filled with water, you can blow in one side and push the liquid up the other side of the tube. The weight of the liquid pushes back with hydrostatic (or "still-liquid") pressure. Each foot of increased elevation adds 0.43 pounds of hydrostatic pressure to a draught beer system that must be over-

come by dispense gas pressure. A figure of 0.5 pounds is often used in the trade for ease of calculation. For purposes of discussion and examples in this manual, we follow this convention by using 0.5 pounds of pressure per foot of elevation. If the beer travels to a faucet above keg level, each foot of increased height will add approximately 0.5 pounds of resistance to the system. If the beer travels to a faucet below keg level, each foot of decreased elevation will subtract approximately 0.5 pounds of resistance from the system. The gravity factor remains the same regardless of tube length, bends, junctions, or other configuration issues. When the keg and faucet heads are at the same height, there is no static resistance and this factor has a value of zero. In the past, the elevation difference used to determine static resistance was often measured from the base of the kegs being dispensed to the faucet height. Because a full keg will contain about 2 1/2 feet of beer, we recommend measuring from the middle of the keg being dispensed to the faucet height. Likewise for large serving vessels: measure from the middle of the serving vessel fill height to the faucet height.

Dynamic resistance derives primarily from beer line, and also from some of the many components in a draught beer system (so-called “hardware resistance”). Items like couplers and faucets usually have negligible resistance values, although some might have a specified value. Faucet towers can range from 0 pounds to as high as 8 pounds of dynamic resistance; be sure to check with the manufacturer for exact tower resistance.

The combination of beer line tubing may include the following: 1. the **jumper**, which is typically 5 or 6 feet of flexible vinyl tubing that runs from the keg coupler to the wall bracket; 2. the **trunk line**, which is the main section of tubing, usually barrier, that runs the length of the system from the wall bracket in the cooler to the tower; 3. the **choker**, which is a small diameter tubing, usually 3/16” vinyl, that connects the trunk line to the stainless steel tubing or sometimes the back of the shank inside

the tower. The choker is the biggest variable the installer uses to fine-tune system resistance to achieve balance. By varying the length of this high-resistance tubing, he or she can control flow rate to a large degree.

A few different specially designed devices can be used as alternatives to constructing final choker restriction with 3/16” vinyl tubing. One such device consists of a series of plastic segments inserted into a short section of 1/4” ID barrier tubing just below the tower. Another is a wire mesh device installed in the shank just behind the faucet. These devices are of varying restriction and, while potentially useful, also have some potential downsides. For one, these items prevent beer line cleaning with sponges as an option. Additionally, the increased surface area may increase the likelihood of bacterial buildup or foaming.

These three components that contribute to dynamic resistance all have different resistance values. This is due to 1. the tubing material 2. the tubing diameter and 3. the tubing length. Different resistance values per foot are shown in the chart for commonly used materials and diameters. (Note: This chart is provided as an example only. Please consult your equipment manufacturer for exact values for your specific beer lines and system components.)

BEER TUBING			
Type	Size	Restriction	Volume
Vinyl	3/16" ID	3.00 lbs/ft	1/6 oz/ft
Vinyl	1/4" ID	0.85 lbs/ft	1/3 oz/ft
Vinyl	5/16" ID	0.40 lbs/ft	1/2 oz/ft
Vinyl	3/8" ID	0.20 lbs/ft	3/4 oz/ft
Vinyl	1/2" ID	0.025 lbs/ft	1-1/3 oz/ft
Barrier	1/4" ID	0.30 lbs/ft	1/3 oz/ft
Barrier	5/16" ID	0.10 lbs/ft	1/2 oz/ft
Barrier	3/8" ID	0.06 lbs/ft	3/4 oz/ft
Stainless	1/4" OD	1.20 lbs/ft	1/6 oz/ft
Stainless	5/16" OD	0.30 lbs/ft	1/3 oz/ft
Stainless	3/8" OD	0.12 lbs/ft	1/2 oz/ft

Once the resistance values are obtained for the three main elements of dynamic resistance, plus any other significant parts (tower, etc.), that total dynamic resistance value is added to the value for the static resistance in the system. This number is our **total system resistance**. When total system resistance (in pounds) is equal to the applied pressure (in psi) our flow rate will be 1 gallon per minute.

Designing For Resistance

While the individual components in any draught system have a fixed resistance value, draught system designers select from a variety of choices to create systems with a target total resistance value. For instance, a 20-ft. run of 1/4" internal diameter vinyl beer line gives a total resistance of 17 psi while 5/16" barrier tubing of the same length only generates 2 pounds of resistance. If our target resistance value is 20 psi, the 1/4" vinyl system would need 1 foot of 3/16" choker line added at the tower end to achieve the total system target resistance, whereas the 5/16" barrier system would need 6 feet of 3/16" choker added at the tower end to reach the same target (see chart of beer tubing restriction values on page 37). Whenever possible, it is desirable to design the system so as to minimize, if not eliminate, the need for vinyl choker line at the tower end. This tubing is usually wrapped into a permanent installation where the recommended yearly change-out of vinyl tubing is not feasible.

Any draught system can be designed to operate under a range of applied pressure values. Whenever possible, the operating pressure will be set to maintain the carbonation of the beer being served. Unfortunately, in some systems this doesn't work. Consider the resistance created by long beer lines and climbs of two or more floors. Even with the lowest resistance components, the applied pressures for these systems often exceed that needed to maintain beer carbonation. These systems must use mixed gas or pneumatic beer pumps to overcome the problem.

Accommodating Beers with Varying CO₂ Volumes

A common issue that arises with draught system design is how to deal with beers with varying volumes of carbonation that are being poured on the same system. The typical system stores all the beer at one temperature and pours them all with the same gas blend at the same operating pressure through draught lines that all have the same restriction value. The net result is that some beers may lose carbonation while other beers will gain carbonation in the same system. This one-size-fits-all setup is not ideal. In order to accommodate for these differences, we can make certain changes with the system equipment and setup parameters.

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 blend panels typically accommodating nitrogenized beers with the second blend. Gas blending panels are now available that offer three blends: the nitro beer blend and two different CO₂-rich blends for regularly carbonated beers. As it turns out, most regularly carbonated beers can be divided into two general groups of carbonation levels. The higher percentage CO₂ blend can balance the higher carbonated beers. These new panels allow the installer to customize a gas blend for each of these two ranges by following the chart below:

2.5 v/v Median		
Pressure	Storage Temp. 35-37°F	Storage Temp. 38-40°F
16-20 psi	75% - 80%	80% - 85%
20-25 psi	65%	70%

2.7 v/v Median		
Pressure	Storage Temp. 35-37°F	Storage Temp. 38-40°F
16-20 psi	80% - 85%	80% - 90%
20-25 psi	70%	75%

		psi at 60% CO ₂				psi at 65% CO ₂				psi at 70% CO ₂	
		2.5 v/v	2.7 v/v			2.5 v/v	2.7 v/v			2.5 v/v	2.7 v/v
temp	40	27-33		temp	40	24-30	27-33	temp	40	21-26	24-29
°F	38	25-31	29-35	°F	38	22-28	26-31	°F	38	20-25	23-28
	37	25-30	28-34		37	22-27	25-30		37	19-24	22-27
	35	23-28	26-32		35	20-25	23-28		35	18-22	20-25

		psi at 75% CO ₂				psi at 80% CO ₂				psi at 85% CO ₂	
		2.5 v/v	2.7 v/v			2.5 v/v	2.7 v/v			2.5 v/v	2.7 v/v
temp	40	19-24	22-25	temp	40	17-21	19-24	temp	40	15-19	17-22
°F	38	17-22	20-25	°F	38	15-20	18-22	°F	38	14-18	16-20
	37	17-21	20-24		37	15-19	17-21		37	13-17	16-19
	35	16-20	18-22		35	14-18	16-20		35	12-16	14-18

*Add 1 psi for every 2,000 feet of elevation to account for differences in atmospheric pressure.

Applied Pressure Adjustment

Installers may choose to use a single gas blend for regularly carbonated beers and adjust the applied pressures on individual kegs to maintain proper carbonation. This is a helpful option in existing systems with a single CO₂-rich gas blend or when a multi-blend gas blender is not available for use. When regularly carbonated beers are divided into two different groups, depending on their carbonation level, appropriate pressures for individual beers can be determined from the chart above.

Most systems have all lines restricted equally, so applying different pressures to different beers will result in certain beers flowing faster or slower than others in the same system. These flow rate variances are normally not an issue and still allow for nearly optimal flow rates of 2 ounces per second, as long as the pressure variance between different beers is kept at or below 5 psi.

Applied Pressure Adjustment with Flow Control Faucets

In some instances, a beer's carbonation level can be so high that this limited pressure adjustment range still does not allow the beer to be poured. For these highly carbonated beers, the use of a flow-control faucet can

be very helpful. A flow-control faucet has a restriction lever on the faucet itself that allows the bartender to adjust the restriction of the system and the flow rate of the beer at the point of dispense. This allows the pressure to be significantly increased to keep a highly carbonated beer's carbonation level constant while still maintaining a manageable flow rate. Oftentimes this flow rate needs to be set much lower than 1 gallon/minute, as even this standard flow rate can cause very highly carbonated beers to foam in the glass.

The use of flow control faucets can be very helpful in all types of systems, including direct-draw systems using 100% CO₂. Some systems are outfitted with multiple gas blends inside the cooler and quick-disconnect fittings on individual gas lines. These setups allow the gas blend to be changed to a particular keg, depending on the carbonation level and the pressure/gas blend combination needed to balance the beer's carbonation.

Balancing Draught Systems

Having reviewed all the concepts behind draught system balance, let's examine two example systems to see how these variables are adjusted to create balanced draught systems in several different settings.

Example 1: Long-Draw, Closed-Remote System

This example assumes that the dispense gas blend mixture is already fixed; a vertical lift of 12 feet; and a beer trunk line total run of 120 feet. Find the operating pressure of the system, and then determine appropriate tubing size for the trunks, and length of restriction tubing.

- **Beer Conditions**

- Beer temperature: 35°F
- Beer carbonation: 2.6 volumes of CO₂ per volume of beer
- Dispense gas: 70% CO₂/30% nitrogen blend from Appendix C,
 $a = ((b+14.7)/c) - 14.7$
where a is the pressure, b is the ideal pressure of straight CO₂ for this situation (in this case, 10.7 psi, see chart in Appendix B), c is the proportion of CO₂ in the blended gas
 $a = ((10.7+14.7)/0.70) - 14.7$
 $a = (25.4/0.70) - 14.7$
 $a = 36.3 - 14.7$
 $a = 21.6$, or round to 22 psi
- Gas pressure needed to maintain carbonation = 22 psig

- **Static Pressure**

- Vertical lift = 12 feet (Tap 12 feet above the center of the keg)
- Static resistance from gravity = 12 ft. x 0.5 pounds/foot = 6.0 pounds

- **Balance**

- Applied dispense gas pressure of 22 psi must be balanced by total system resistance
- Since static resistance equals 6 pounds, the system will need a total of 16 pounds of dynamic resistance
- Restriction = 22 - 6 = 16 pounds
120 ft. of 5/16" barrier @ 0.1 pounds per foot = 12 pounds
1.3 ft. 3/16" vinyl choker = 4 pounds
12 + 4 = 16 pounds

Nitrogenized (Nitro) Beers

Nitrogenized beer is becoming more popular. It requires special attention, however, including a specific gas blend of nitrogen and carbon dioxide as well as a unique faucet.

Nitrogenized beer was developed in the 1960's as a way to replicate the creaminess and low carbonation of cask conditioned ale. It allowed retailers to be able to "push" a low carbonated product to dispense. Cask ales have carbonation levels that are significantly lower than force-carbonated beer but are pulled with a beer engine. Being able to "push" the low carbonated beer over "pulling" it meant that

the brewers and retailers could, in effect, get close to a cask experience with all the benefits of modern "push" draft dispense.

What is nitrogenized beer? First, it is important to note that nitrogen does not easily dissolve in beer. Its different molecular properties keeps it out of solution at lower pressures – all pressures encountered in long-draw dispense systems – which is why it is the perfect medium to apply the "push" necessary to get the beer where it needs to go in most long-draw systems without changing the properties of the beer. That is, it will not dissolve into the beer at lower pressures. Second, it is possible to force nitrogen into the beer, but this is done at pressures far exceeding

Example 2: Forced-Air 10 Ft. Run

In this example, the beer cooler is directly over the bar. There is a 10-foot fall from the middle of the kegs to the faucet height, and the total run length is also exactly 10 feet.

- **Beer Conditions**
 - Beer temperature: 33°F
 - Beer carbonation: 2.8 volumes of CO₂ per volume of beer
 - Dispense gas: 100% CO₂
 - Gas pressure needed to maintain carbonation = 11.7 psig (from chart in Appendix B)
- **Static Pressure**
 - Vertical fall = 10 feet (Faucet is 10 feet below the center of the keg)
 - Static resistance from gravity = 10 ft. x -0.5 pounds/foot = -5.0 pounds
- **Balance**
 - The applied dispense pressure of 11.7 psi, along with 5 pounds of static pressure, must be balanced by a total system resistance of 16.7 pounds
 - Restriction = 16.7 pounds
 - 10 ft. of 1/4" barrier @ 0.3 pounds per foot = 3 pounds
 - 4.6 ft. of 3/16" vinyl choker @ 3 pounds per foot = 13.7 pounds
 - = 3 pounds + 13.7 pounds = 16.8 pounds (Close enough to our target of 16.7)

dispense pressure and is done at the brewery. And third, nitrogen in the beer is only there to augment the existing carbon dioxide and typically amounts to 1.1 to 1.7 volumes. The amount of nitrogen actually forced into the beer is so small that it is measured in parts per million and not volumes.

Solubility of CO₂ is affected much more by temperature than is dissolved N₂. The takeaway is that a nitrogenized beer is still a beer with carbon dioxide in it (albeit at much lower volumes than a typical beer) as well as a small amount of nitrogen.

Since nitrogenized beer has had a small amount of nitrogen coerced into it at high pressure, it must maintain a relatively high applied pressure to keep it, and the CO₂ in solution (there is a relationship between the concentration and partial pressures of each gas dissolved in solution). And, since the amount of CO₂ is far below that of a regular beer, the applied pressure ratio of N₂ to CO₂ will be much greater. The volumes of CO₂ in the beer and the applied pressure calculation will work off of the same solubility charts that are used

for the other dispense calculations. Unfortunately, most charts do not go below 2.0 volumes of CO₂ and most nitrogenized beer is around 1.2 volumes. It is recommended that online calculators such as the McDantim Easyblend Calculator be used (see image on page 42).

The typical gas blend for nitrogenized beers at 1.2 v/v (volumes) of carbon dioxide is 25% CO₂ / 75% N₂ (this keeps the CO₂ in solution at the required 1.2 v/v). Using the McDantim Easyblend Calculator, the proper pressure of a nitrogenized beer dispensed at 38°F, in Denver (5280 feet above sea level), at 5.5% ABV (alcohol affects solubility), with a blend of 25% CO₂ and volumes of CO₂ at 1.2, will be 37.8 psi. As the individual parameters of a given beer change, so will the applied pressure.

This high pressure and special gas blend keeps these two gases in solution as the brewer intended. Non-nitrogenized beers should not be poured on this blend. The CO₂ in regularly carbonated beers will equalize over time to the CO₂ volumes of the nitrogenized beer (usually about 1.1 to 1.7) but without the benefit of nitrogen dissolved in the beer. Applied pressure in the



mid-30s is not enough to force nitrogen into the beer. It WILL go flat and there will be no creamy head.

The high pressure required by a nitrogenized beer must be balanced within the system which is done with a unique nitrogen faucet. These faucets apply additional resistance in the form of a restriction plate found within the housing of the faucet. It forces the beer through five tiny holes (of varying diameter, which will add or detract resistance) and typically account for around 20 pounds of added restriction to the system (depending on the diameter of the holes in the restriction plate used).

In addition, the restrictor plate has the added function of helping to break the nitrogen out of the beer.

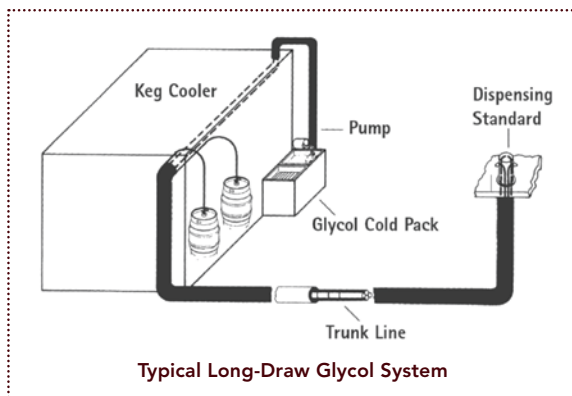
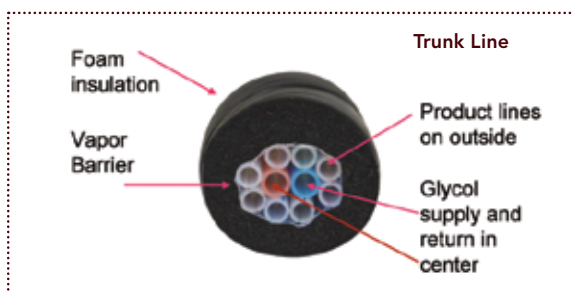
Nitrogen, though difficult to get into the beer, needs coaxing to come back out (because the atmosphere is 78% nitrogen, the gas does not readily want to leave). The agitation of the beer being forced through the tiny holes, combined with the sudden drop in pressure, will do the trick. The pressure on one side of the plate is in the mid 30s while the other side is somewhere around 14.7 (at sea level), depending on the altitude of the account. This pressure drop causes the nitrogen to break out and the small nitrogen bubbles begin to move to the surface of the liquid, in a slower fashion than the CO₂ which will also break out. These two gases moving from a dissolved state into a gaseous state happen at different rates. It is the breakout of the slower nitrogen and the faster carbon dioxide that causes the cascading effect so interesting in the presentation of the beer. The nitrogen creates a creamy head and because of the high concentration of nitrogen in the air, that head stays around for a longer period of time. In other words, the nitrogen has nowhere in particular to go, so it stays in the head and the bubbles tend not to coalesce (they don't get bigger and pop).

The distance of the draw is typically not a factor because an applied pressure in the mid 30s is enough to push the beer to the faucet in almost all long-draw systems (pouring without an added pump). And, the restrictor plate will ensure an even, consistent flow from the faucet.

The importance of the specialized faucet and a specific gas blend with a nitrogenized beer cannot be overstated. Nitrogenized beer will not pour correctly if treated as a regularly carbonated beer. At the same time, trying to pour regularly carbonated beer under conditions designed for a nitro beer will also be problematic.

Cooling

As with direct-draw systems, kegs reside in a walk-in cooler held at 34° to 38°F. But to keep beer cold throughout its journey from keg to faucet requires



additional cooling components that surround the beer lines themselves. We find two common designs: air-cooled and glycol-cooled.

In a **forced-air long-draw system**, beer lines travel through a tube or chase kept cold by a continuously operating recirculation fan. The fan pushes cold air from a condensing unit inside the cooler into and through the ductwork. In both single-duct and double-duct systems, cold air travels a route from the cooler to and through the tap tower as well as a return route

back to the cooler. Single-duct systems use a tube-in-tube design effective for runs of up to 15 feet. Runs of up to 25 feet can be created using double-duct systems where separate tubes carry the outbound and return flows. These systems can be especially vulnerable to temperature fluctuations in the outside environment. All ductwork should be well insulated. Careful assessment of the room temperature should be taken into consideration before installation. It is important to note that temperatures near the ceiling of an already hot basement or storage room where the ducts may run can be significantly higher than at ground level.

It is also important to consider the extra cooling load placed on the keg cooler with such an installation. Many coolers are specifically designed to cool the exact dimensions of the cold box, and adding a forced-air system may overload and compromise the entire cooling system.

Glycol-cooled long-draw systems service runs longer than 25 feet. Here, a separate chiller pumps a chilled mixture of water and food-grade liquid propylene glycol through cooling lines parallel to and in contact with the beer lines. These systems require well-insulated and carefully configured trunk line (see photo). Each beer line (usually barrier line) in a trunk touches a glycol line to keep the beer cold as it travels from keg to faucet. Glycol chillers work well as long as they are maintained; see suggested maintenance points on the next page.

Glycol towers attach coolant lines parallel to the beer lines (typically stainless) and surround them tightly with insulation. This cooling method allows towers to be located remotely from the cold box, up to several hundred feet away.

In addition to the glycol chiller used to maintain temperature of the beer lines, some systems, like those using frosted or “ice” towers, use a separate glycol cooling system to chill the tap tower.

Glycol Chiller Maintenance

Glycol chillers are key components to long-draw dispense systems. Chilled glycol helps to maintain the temperature of draught beer in the beer lines between the keg and the faucet. Glycol chillers are much less expensive to maintain than they are to replace; regular maintenance will increase both their service life and dependability. Here are some recommended maintenance practices; be sure to check with your manufacturer for items and procedures specific to your chillers.

- Glycol bath: Keep the cover of the glycol bath closed to prevent water vapor from diluting the strength of the glycol.
- Glycol bath temperature: Check every two weeks, making sure the bath temperature is within the range specified by the manufacturer. Many chillers have temperature gauges that are easily visible from the outside.
- Check motors monthly for smooth-sounding operation and no signs of overheating.
- Check pumps monthly; check connections and insulation for leaks or missing insulation, and for smooth-sounding operation.
- Inspect condenser monthly for dirt and airflow obstructions and clean as necessary. Remove and clean grills to expose the condenser fins. Remove all contaminants from the fin surface by using a stiff bristle brush, vacuum cleaner, or compressed gas discharged from the fan side of the condenser.
- Visually inspect trunk lines every six months for signs of ice buildup, insulation damage and glycol leakage.
- Glycol strength: Check viscosity and condition of glycol-water cooling mixture every six months. Test freezing point every 18 months with a refractometer and adjust or replace glycol mixture as needed. Typical ranges are 20-25% glycol; be sure the glycol concentration follows manufacturer recommendations. ■



section II

draught operations

draught systems from simple to complex can deliver high-quality beer—but only when properly operated and suitably maintained. Many who work with draught beer will never have the chance to buy or install the system components discussed in **Section I**, but all will pour beer from the faucet and nearly everyone will experience foaming or other problems at some time that can be traced to operating conditions. In **Section II** of this manual, we consider all the issues involved in operating a draught system and serving the customer a top-quality draught beer.

Chapter 5 covers practical issues related to the cooler and other “behind the scenes” aspects of beer service. **Chapter 6** looks at glass cleaning and the proper way to pour a beer.

Chapter 7 concludes our discussion of operating issues by taking a close look at maintenance and cleaning. Whether you clean your system yourself or hire an outside service, you owe it to yourself to understand proper cleaning methods. Without this knowledge, you cannot defend against a decline in beer quality at your establishment. ■



chapter 5

preparation to pour

While many of the issues relating to draught quality concern system settings and activities that occur at the bar, some operating issues require attention behind the scenes as well. In this chapter, we will present a checklist of system settings that will assist you in delivering great draught beer to the consumer, including a keg temperature guide as well as other behind-the-scenes preparations that will affect draught performance. Finally, we will cover some guidelines for linking kegs in series.

Behind the Scenes Checklist

Before you can be sure your draught system will operate properly and consumers are served the best possible beer, we recommend attention to the following items.

Outside the cooler:

1. Install or check confined space CO₂ detector for the area in order to stay safe and stay alive.
2. Check glycol bath for operation temp in the 27° F to 32° F window.
3. Visual check of dispense gas cylinders, Full CO₂ = 800psi and Full Nitrogen = 2,200 psi.
Bulk CO₂ tank gauges operate on an "E" for empty

and "F" for full scale. Nitrogen generators operate on a pressurized gauge. (set to above 100 PSI)

4. Beer line cleaning log between 7 and 14 days since last service. (Check local ordinances concerning any required frequency.)

In the cooler:

1. Cooler air temperature range = 36° to 38° F.
2. Liquid temperature thermometer range = 36° to 38° F.
3. Draught beer lines are full of beer and free of bubbles or kinks.
4. Draught beer on tap is within the brewer's freshness window to dispense. (Varies by brewer.) (Kegs on tap for longer than 45 days may have changed compared to the intended flavor.)
5. Cooler is free of beer leaks, drips or spills.
6. Check that all FOBs in the system are in the pouring position.
7. Check that all FOB drains are empty and free of buildup.
8. Visual check that all gas pressure gauges are operating in their ideal pressure setting.
 - Straight CO₂ for ales and lagers, 12 – 15 psi (direct-draw system)

- Blended CO₂ – Rich Blend (60 – 80% CO₂) for ales and lagers, 22-25 psi (long-draw system)
 - Pre-Mix 25% CO₂ / 75% N₂ for nitrogenized beers only, 30 – 35 psi (with restrictor faucet)
9. Visually check that gas valves are in the open position.
 10. Listen and feel around gas connections for leaks; big leaks have a “hiss” sound.

At the tower:

1. Flush the faucets with clean water and wipe dry with a clean micro fiber towel.
2. Pour 1 oz to 3 oz. of beer to be sure faucet works properly. Evaluate to be sure the tap marker matches the beer in the line.
3. Wipe down surfaces to be free of beer spills.
4. Check for fruit flies and other bugs living around the draft tower.
5. Check that glassware is free of any aromas, dust, lipstick or other imperfections.

These routine checks will keep you and your staff in charge of the operating conditions in your draught system. You’ll be proactive in the prevention of disruptions in service and delivery with your draught beer system.

Cold Storage and Proper Chilling of Kegs before Serving

To ensure fresh flavor and ease of dispense, draught beer should remain at or slightly below 38°F throughout distribution, warehousing, and delivery. Brewers and distributors use refrigerated storage for draught beer. In warm climates or long routes, they may also use insulating blankets or refrigerated delivery trucks to minimize temperature increases during shipping.

At retail, even a few degrees’ increase above the ideal maximum of 38°F can create pouring problems, especially excessive foaming. Ideally all draught beer delivered to retail will be stored cold until served.

⚠ Draught Safety ⚠

Buddy-lifting or use of a mechanical lifting system is recommended when moving kegs. A keg can typically weigh 165 lbs when full. Be aware of pinch-points and never get below a rolling or sliding keg.

Accounts that lack cold storage for their entire inventory of draught beer should allow adequate chilling time for recently refrigerated kegs in order to avoid dispense problems. In a similar vein, recently arrived kegs should be allowed adequate chilling time as they usually warm to some degree during delivery. In order to avoid dispense problems, every keg must be at or below 38°F while being served.

To help ensure that your kegs are properly chilled before serving, Chart 1 provides a guide to the approximate time needed to properly chill a keg to 38°F from a given starting temperature. Note that even kegs that “feel cold” (e.g., 44°F) may need to chill overnight in order to ensure proper dispense.

Chart 1

Start Temp	Time to 38° F
50° F	25 hrs
48° F	23.5 hrs
46° F	21 hrs
44° F	18 hrs
40° F	7 hrs
38° F	0 hrs

Chart 2

Time	Temp
0 hrs	38° F
1 hrs	39° F
2 hrs	41° F
3 hrs	42° F
4 hrs	43° F
5 hrs	45° F
6 hrs	48° F

Chart 2 shows how quickly a keg will warm up when exposed to temperatures above 38°F. From this you can see that a keg will warm up during delivery or storage at ambient temperature from 38° to 44°F in only four or five hours. But looking back at Chart 1, we see that same keg will need to be in the cooler for a full 18 hours before reaching a proper serving temperature of 38°F again.

Linking Kegs in Series

Busy accounts may connect kegs in a series or in a chain to meet peak capacity demands. Chaining two or three kegs of the same product together allows all of the chained kegs to be emptied before beer stops flowing.

The first keg in the series will be tapped with a normal coupler. The second (and subsequent) kegs in the series require that the Thomas valve be removed from the gas side of the coupler.

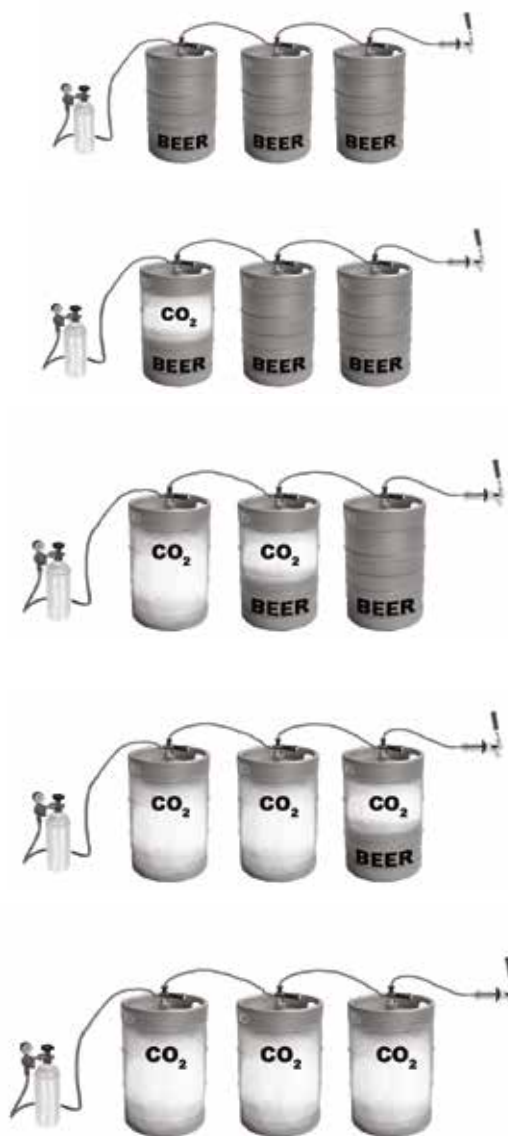
Tap the first keg with the normal coupler. Instead of sending the beer line from this first coupler to the bar faucet, connect it to the CO₂ inlet on the second keg's coupler. Subsequent kegs can be attached the same way.

When pressurized and pouring, beer flows from the first keg to the second and on to the third before it travels to the faucet. Once set, this arrangement will pour the contents of all the chained kegs before it runs empty.

A series arrangement should only be used in accounts that will "turn" or empty kegs rapidly. The account needs to completely empty the entire series on a regular basis. Failure to empty the series com-

pletely leaves old beer in the system. If a fresh keg is being rotated into a system that is not run dry, it is important to tap it in front of any empty or partial kegs in the system. **This prevents foaming from beer entering a keg that is not already full.** The diagrams below illustrate the progressive emptying of chained kegs. ■

Kegs linked in series





chapter 6

serving draught beer

properly designed and appropriately operated, your draught system will pour perfect draught beer from its faucets. But the consumer's experience can still be ruined by improper pouring, residue in glassware, and unsanitary practices. In this chapter, we review the serving practices required to deliver high quality draught beer.

To achieve the qualities the brewer intended, beer must be served following specific conditions and techniques. Let's review some of the critical conditions necessary for proper draught dispense.

- Beer stored between 34° - 38°F.
- Beer served between 38° - 44°F.
- To accomplish this, the glycol cooling the beer lines in a long-draw system should be set to 27° - 32°F.
- Balanced draught settings (pressure = resistance).
- Normal flow rate of 2 ounces per second.

Glassware Cleaning

A perfectly poured beer requires a properly cleaned glass. As a starting point, glassware must be free of visible soil and marks. A beer-clean glass is also free of foam-killing residues and lingering aromatics such as sanitizer.

A freshly cleaned glass should be used for every pour. We recommend that retailers never refill a used glass. This practice may also violate local health codes.

Two systems deliver effective beer glass cleaning:

1. Manual cleaning in the three-tub sink, or
2. Dedicated automatic glass washers.

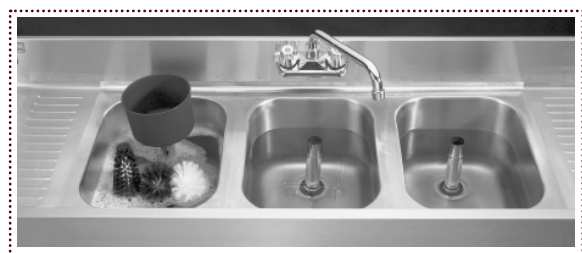
Each approach requires specific techniques and a certain degree of discipline. Let's look at what's involved with each one.

⚠ Draught Safety ⚠

Glassware sanitizing is accomplished with chlorine or quaternary alkyl ammonium compounds (also called "quat"). Know the correct dilution for your sink volume - excess sanitizer does not do a better job than the correct concentration and may be unhealthy for staff and customers. Keep chlorine levels at 100 ppm and quat levels at 200 ppm unless your local authority requires otherwise. Keep Safety Data Sheets nearby for reference. Regularly review sanitizer procedures with staff.

Manual or Hand Cleaning in the Three-Tub Sink

1. *Clean sinks and work area prior to starting* to remove any chemicals, oils, or grease from other cleaning activities.
2. *Empty residual liquid from the glass to a drain.* Glasses should NOT be emptied into the cleaning water as it will dilute the cleaning solutions.
3. *Clean the glass in hot water and suitable detergent.* Detergent must not be fat- or oil-based. Detergents suitable for beer glass cleaning are available through restaurant and bar suppliers.
4. *Scrub the glass with cleaning brushes* to remove film, lipstick, and other residue. Rotate the glass on the brushes to scrub all interior and exterior surfaces. Be sure to clean the bottom of the glass.
5. *Rinse glass bottom/butt down in cold water.* Water for the rinse should not be stagnant but should be continually refreshed via an overflow tube. If time permits, a double dunk is recommended and preferred.
6. *Sanitize in third sink filled with hot water and an appropriate sanitizer.* Sanitizers typically contain chlorine so check the pH and chlorine content of the sanitizing bath periodically to maintain proper conditions. Water temperature should be at a minimum 90°F. Chlorine concentration should be 100 ppm or at the required local health department concentration.



Automatic Glass Washing Machines

1. Dedicate this machine to cleaning bar and beer glassware only. Do not subject it to food or dairy product residue.
2. Use correct detergent, sanitizer, and rinse agents in properly metered amounts.
3. Check concentrations once each day using kits, or follow detergent and sanitizer supplier recommendations.
4. Use water temperatures of 130° to 140°F. High temperature machines designed to operate at 180°F can be used without additional chemical sanitizers. Please check your health department for local requirements.
5. Maintain the machine to assure good water flow through the system including free flow through each nozzle and washer arm.
6. Regularly service the machine based on the manufacturer's or installer's guidelines.

⚠ Draught Safety ⚠

Low foam glassware detergents can be caustic, use care in dispensing to avoid skin or eye contact, recommended personal protective equipment, clean up spills or skin contact with large volumes of water, keep SDS nearby, regularly review safety procedures with staff. Consult SDS or chemical supplier for proper use.

Handling Clean Glasses

Keep glassware clean and odor-free after washing:

1. Air-dry glassware. Drying glasses with a towel can leave lint and may transmit germs and odors.
2. Dry and store glasses in a stainless-steel wire basket to provide maximum air circulation. Similar deeply corrugated baskets or surfaces also work.
3. Do not dry or store glassware on a towel, rubber drain pad, or other smooth surface, as they can transfer odors to the glass and slow the drying process.

4. Store glassware in an area free of odors, smoke, grease, or dust.
5. Store beer glasses dry in a chiller. Never use a freezer. Chill glasses at 36° – 40°F.
6. Store chilled glasses in a separate refrigerator away from food products such as meat, fish, cheese, or onions as they can impart an odor to the glasses.



Testing for “Beer-Clean” Glass

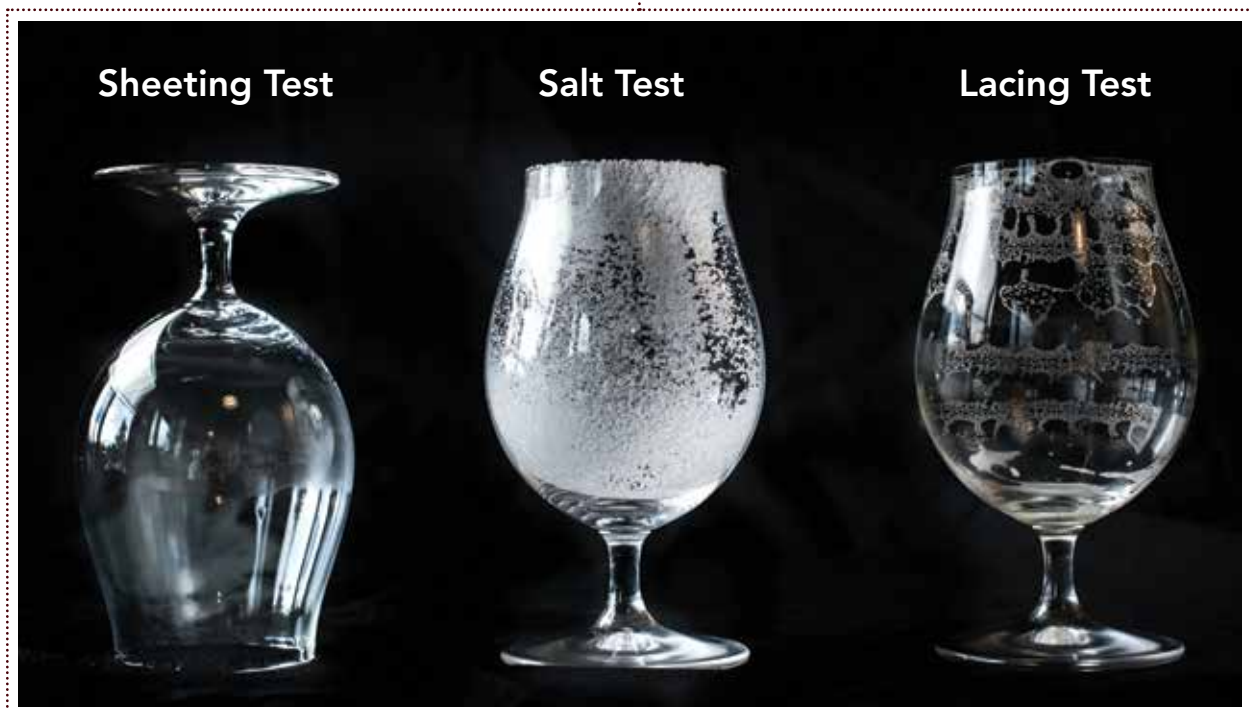
Beer poured to a beer-clean glass forms a proper head and creates residual lacing as the beer is consumed. After cleaning, you can test your glasses for beer-clean status using three different techniques:

sheeting, the salt test, and lacing. Let’s review each technique.

1. **Sheeting Test:** Dip the glass in water. If the glass is clean, water evenly coats the glass when lifted out of the water. If the glass still has an invisible film, water will break up into droplets on the inside surface.
2. **Salt Test:** Salt sprinkled on the interior of a wet glass will adhere evenly to the clean surface, but will not adhere to the parts that still contain a greasy film. Poorly cleaned glasses show an uneven distribution of salt.
3. **Lacing Test:** Fill the glass with beer. If the glass is clean, foam will adhere to the inside of the glass in parallel rings after each sip, forming a lacing pattern. If not properly cleaned, foam will adhere in a random pattern, or may not adhere at all.

Glassware Temperature

- Serving between 38° to 44°F delivers the best taste experience for most beer styles. Domestic lager beer can be enjoyed at 38° to 40°F if served in a chilled glass. Beer served at near-frozen temperatures retains more CO₂ gas (resulting in a more filling experience for the consumer) and blinds the



taste experience (taste buds are “numbed,” resulting in a bland taste experience) in comparison with beer served at recommended temperatures.

- Room temperature glasses are preferred for craft beer but may cause foaming on highly carbonated beer.
- Chilled glasses are preferred for domestic lager beer, but they should be DRY before chilling. Wet glassware should not be placed in a freezer or cooler as it may create a sheet of ice inside the glass.
- Frozen glasses will create foaming due to a sheet of ice being formed when the beer is introduced to the glass. Extremely cold glass surfaces will cause beer to foam due to a rapid release of CO₂ from the product.
- Water mist devices may be used to pre-wet and chill the glass interior prior to dispense. Glass interior should be mostly free of excess water before pouring.

Pouring Draught Beer

Proper serving of draught beer is intended to have a “controlled” release of carbonation to give a better tasting and sensory experience. The evolution of CO₂ gas during pouring builds the foam head and releases desirable flavors and aromas.



Technique

1. Hold glass at a 45° angle, open faucet fully.
2. Gradually tilt glass upright once beer has reached about the halfway point in the glass.

3. Pour beer straight down into the glass, working the glass to form a one-inch collar of foam (“head”). This is for visual appeal as well as carbonation release.
4. Close faucet quickly to avoid wasteful overflow.

Pouring Hygiene

- In no instance should a faucet nozzle touch the inside of the glass.
 - Nozzles can cause glassware breakage;
 - nozzles can transfer contamination from dried beer to glassware.
- In no instance should the faucet nozzle become immersed in the consumer’s beer.
 - Nozzles dipped in beer become a breeding ground for microorganisms.
- Importance of one-inch foam collar:
 - While retailers struggle with customers who demand their beer “filled to the rim,” brewers prefer beer poured with about a one-inch collar of foam (“head”).
 - A one-inch head maximizes retailer profit, as foam is 25% beer. Filling glass to the rim is over-pouring.
 - A proper head on a draught beer delivers the total sensory experience, including the following sensory benefits:
 - o Visual appeal of a good pour
 - o Aromatic volatiles in beer released
 - o Palate-cleansing effect of carbonation enhanced
- Textural and sensorial qualities of beer better presented to consumer



Free-Flow Pouring

- Beer pours best from a fully open faucet.
- To control the faucet during operation, hold the handle firmly at the base.
- Partially open faucets cause inefficiency and poor quality, namely:
 - Turbulent flow
 - Excessive foaming
 - Waste (inefficiency)

Pouring Growlers

Growlers are a great way to share the draught beer experience. They are a modern-day, clean way to bring beer home. Whether it is from a brewpub that doesn't bottle or for a person who wants a sustainable package, the tradition was started long ago. In the late 1800s, customers would take home beer in a galvanized pail with a lid. Today, glass jugs with tight-sealing lids are used in place of the old pail. Those lids can be flip-top or screw-on.

Growlers are typically about 1/2 gallon in size and are filled off the faucet of your local establishment. This section will help guide you through a successful growler filling experience. It is important to note that the bottle should be rinsed immediately upon emptying to keep from infecting future refills.

A good procedure for filling is to rinse the growler out with cold water immediately before filling. This helps to cool down the glass that could have been sitting in a warm car or out in the sun. This cooling process helps prevent excessive foaming during the fill. A tube is then inserted into the faucet that reaches to the bottom of the bottle. A 3/8" i.d. x 1/2" o.d. works perfectly for standard faucets. The faucet handle is opened all the way and the growler fills from the bottom up. If the glass is cold enough, when foam starts to come out of the top, you can close the faucet, remove the tube from the growler, and seal. Typically the growler will need to be rinsed off on the outside. Seal the top with tape or heat-shrink seal. Put a tag or label indicating what product is inside and you're

Safety Notes For Retailers & Consumers

Filled growlers can shatter or explode if allowed to warm or freeze, especially if they are overfilled. The internal pressure of a filled growler warmed to room temperature (68F) or in a hot car (90F) may be as high as 2.0 atm (29 psi) or 3.7 atm (52 psig) respectively. (Example assumes a growler filled to 99% of capacity with beer at 38F containing 2.5 volumes CO₂, and then sealed). Brewers Association recommends:

- only use growler containers specifically designed for packaged carbonated beer, and ask the container supplier to verify that the pressure rating is equal to or greater than the pressure from carbonation in the beer being filled. Many containers currently in use are not designed for carbonated beverages.
- if filling by counter-pressure, know the pressure rating of the system used and ensure the system includes shielding between the growler being filled and people nearby in case of failure
- do not overfill a growler. Always leave 5% headspace or fill to the manufacturers recommended fill line if one is shown.
- for growlers with threaded screw-on closures, consider using plastic rather than metal closures; plastic closures may vent more readily if over pressurization occurs; if using metal closures you may wish to discuss this issue with your supplier.
- keep filled growlers cold and dark, and never allow a filled growler to warm or to freeze, due to potentially hazardous shattering.
- visually inspect every growler before filling. Do not fill glass or ceramic growlers with cracks or chips, those which have been engraved, or older growlers with pitted or unsmooth glass surfaces, as the pressure strength of these growlers will be significantly reduced.

good to go. The filling tubes should be rinsed inside and out and put aside to dry.

Helpful hints:

- Laws vary from state to state, so check before starting a program. Some states require that establishments can only fill growlers with their logo or that they have sold.
- Pre-rinse growler before filling with fresh water run through a cold plate to pre-chill the growler prior to filling.
- Keep a container of sanitizer for the fill tubes behind the bar.
- Keep extra seals for either style cap behind the bar in case a customer brings in a different type of growler.
- Use brown bottles instead of clear glass. Brown glass will protect beer from the harmful effects of light.

For more information on growlers, refer to Facts about Growlers on www.draughtquality.org

Faucet Hygiene

We recommend quickly rinsing faucets with fresh water at the close of business each day. Studies have indicated that in retail locations that use this simple step, the faucets and beer lines stay significantly cleaner. As an added benefit, the faucet won't become sticky as beer dries out, so the first pour the next day will be much easier since the handle will move readily.

Faucet plugs are available that insert in or cover the faucet opening when beer is not being poured for extended periods. This may help to keep the faucet cleaner and more sanitary.



For notes on proper dispense hygiene when using a cask ale “beer engine,” see Appendix D. ■

chapter 7



system maintenance and cleaning

In addition to alcohol and carbon dioxide, finished beer contains proteins, carbohydrates and hundreds of other organic compounds. Yeast and bacteria routinely enter draught systems where they feed on beer and attach to draught lines. Minerals also precipitate from beer, leaving deposits in lines and fixtures.

Within days of installing a brand new draught system, deposits begin to build up on the beer contact surfaces. Without proper cleaning, these deposits soon affect beer flavor and undermine the system's ability to pour quality beer.

When undertaken using proper solutions and procedures, line cleaning prevents the buildup of organic material and mineral deposits while eliminating flavor-changing microbes. Thus, a well-designed and diligently executed maintenance plan ensures trouble-free draught system operation and fresh, flavorful beer.

Cleaning Guidelines

Many states require regular draught line cleaning, but all too often the methods used fall short of what is needed to actually maintain draught quality. In prepar-

draught beer line soil types

Hop resin	sticky
Grain protein	gummy
Yeast & micro	resistant
Minerals	hard
Bio-film	homogenous mass

ing this manual, our committee polled all sectors of the beer industry and called on our own many decades of cumulative experience to determine the necessary and sufficient conditions for proper draught maintenance. In this chapter, we recommend and detail the practices that have proven effective in sustaining draught quality.

⚠ Draught Safety ⚠

Draught line cleaning should only be performed by trained personnel.

Please note that all parts of the recommendations must be implemented. The proper cleaning solution strength will not be effective if the temperature is too cool or there is insufficient contact time with the lines. The lines themselves will remain vulnerable to rapid decline if faucets and couplers are not hand-cleaned following the recommended procedures.

As a retailer, you may or may not clean your own draught lines, but you have a vested interest in making sure the cleaning is done properly. Clean lines make for quality draught beer that looks good, tastes great, and pours without waste.

Take the time to review the guidelines in this manual and monitor your draught line cleaners—no matter who they are—to ensure that your system receives the service it needs to serve you and your customers well. Simple checks like maintaining cleaning logs, using a straw to scrape the inside of a faucet, and checking keg couplers for visible buildup will help to ensure your beer lines are being properly maintained and serviced.

Common Issues

Later in this chapter, we cover the details of cleaning solutions and procedures, but first let's review some related issues. We start with an important look at safety, then briefly discuss design considerations and wrap up with the long-term maintenance issue of line replacement.

Cleaning Safety

Line cleaning involves working with hazardous chemicals. The following precautions should be taken:

- Cleaning personnel should be well trained in handling hazardous chemicals.
- Personal protection equipment including rubber gloves and eye protection should be used whenever handling line cleaning chemicals.
- Cleaning solution suppliers are required to provide Safety Data Sheets (SDS) on their products. Cleaning personnel should have these sheets and follow their procedures while handling line cleaning chemicals.
- When diluting chemical concentrate, **always add chemical to water** and never add water to the chemical. Adding water to concentrated caustic chemical can cause a rapid increase in tempera-

⚠ Draught Safety ⚠

Personal protective equipment (PPE) should always be worn while working or handling hazardous materials.

- Proper eyewear includes splash resistant goggles, or safety glasses made from impact resistant plastic or tempered glass with side shields or wrap-around design.
- Proper hand protection includes seamless molded gloves that extend past the wrist. Choose synthetic chemical protective material (i.e. nitrile, neoprene, or butyl rubber gloves) compatible with hazardous chemicals being used by consulting Safety Data Sheets (SDS) and/or glove manufacturer's compatibility charts. Do not use latex, vinyl, or partially coated fabric gloves with chemicals.
- Proper footwear should be waterproof/chemical resistant boots composed of solid rubber or rubber impregnated fabric substrate with full enclosure of the foot. They should be waterproof, slip resistant, and chemical resistant (all components). Leather deteriorates with corrosives and has poor waterproofing properties.

Safe Work Practices:

- When mixing chemical solutions, be sure to add cleaner to water, not vice versa
- Keep cap on cleaners when not dispensing
- During cleaning, set cleaners on floor, not on bar top or shelf
- Store cleaners away from consumables
- Don't leave the job partially complete
- Keep chemicals away from other people
- Be aware of slip/trip hazards and notify other people in the area

ture, possible leading to violent and dangerous spattering or eruption of the chemical.

System Design and Cleanliness

Draught system designs should always strive for the shortest possible draw length to help reduce operating challenges and line cleaning costs. Foaming beer and other pouring problems waste beer in greater volumes as draw length increases. Line cleaning wastes beer equal to the volume of the beer lines themselves. Longer runs also place greater burdens on mechanical components, increasing repair and replacement costs.

New systems should be chemically cleaned and rinsed with cold water prior to pouring beer. A system cleaning will help to eliminate potential contaminants and will remove oxygen from the lines. It is also recommended to purge all gas lines with CO₂ prior to tapping kegs to prevent oxygen from being pushed into fresh kegs.

One-way keg systems may require specific equipment to achieve desired cleaning methods. Split lines may also pose cleaning challenges. Be sure to check with the manufacturers of the various components in any draught beer system to ensure that all components (line material, fittings, faucets, couplers, pneumatic pumps, fobs, etc.) are compatible with the cleaning methods and procedures you plan to use. The acceptable range of variables such as cleaning solution concentration, temperature, and pressure can vary by component and manufacturer.

Large venues like stadiums, arenas, and casinos often combine very long draught runs with long periods of system inactivity that further complicate cleaning and maintenance. Additional maintenance costs eventually outweigh any perceived benefits of a longer system.

A Few Words about Mechanical Cleaning

Mechanical cleaning methods use sponges to physically scrub the interior of beer lines. Because couplers, faucets, beer pumps, and FOBs need to be cleaned every two weeks, mechanical cleaning at an interval longer

than every two weeks is not recommended. There are advantages and disadvantages to mechanical cleaning. Potential advantages include more thorough cleaning relative to chemical cleaning alone, and time savings for draught beer cleaning service providers. Potential disadvantages include possible abrasion of the smooth beer line interior over time via scrubbing of the interior of the beer line by the sponge, and fittings or beer line that are too small in diameter, resulting in possible stuck sponges. Mechanical cleaning should only be used in draught systems that have been specifically designed to be cleaned in this way.

Other Line Cleaning Methods

Devices that purport to electrically or sonically clean draught lines are not a suitable substitute for chemical line cleaning. Although some sonic cleaners may inhibit bacteria and yeast growth, they have little or no cleaning effect on draught hardware and fittings. The success of sonic cleaners can be affected by the beer style and length of system, and can be interrupted by metal components in the system. Sonic cleaners may add some benefit to deter certain types of bacteria while having little to no effect on others. A maximum two-week chemical line cleaning cycle is recommended on all draught systems regardless of the use of a sonic cleaner.

All “automatic” cleaning systems or clean-in-place (CIP) systems should be able to achieve all recommendations included in this chapter, including a maximum two-week cleaning cycle, 15 minutes of recirculation, and disassembly and detailing of all hardware.

Line Replacement and Material

- All poly vinyl jumpers and poly vinyl direct-draw lines should be replaced every one to two years or anytime there is a bacterial or flavor contamination.
- Some suppliers have developed improved alternatives to poly vinyl tubing that could allow for

less frequent change-outs. At the time of this publication, it is too early to set specific parameters.

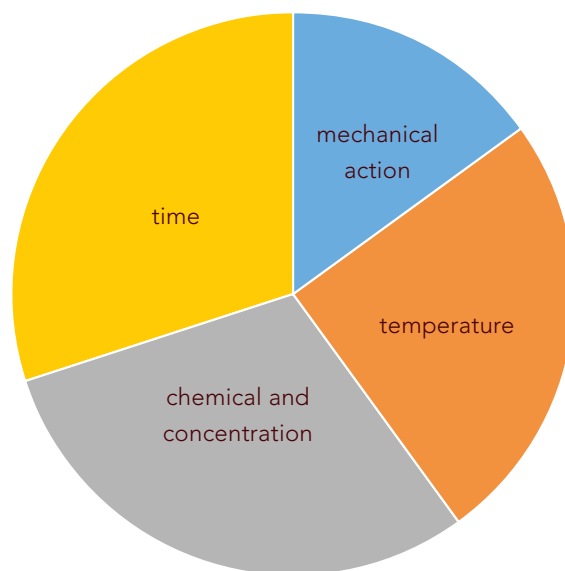
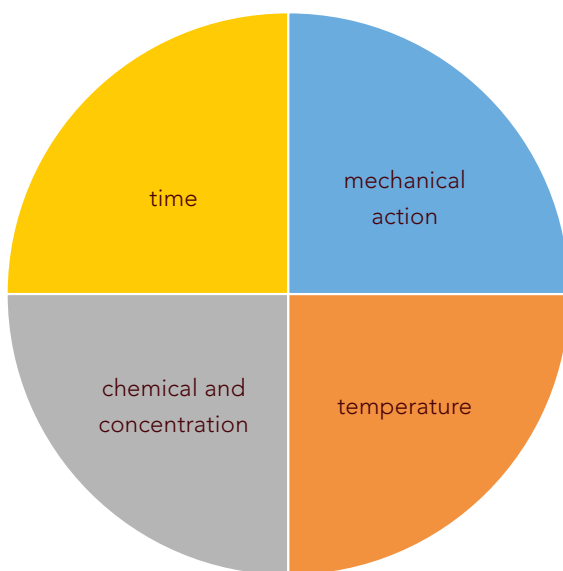
- All long-draw trunk line should be replaced in the following instances:
 - When the system is 10 years or older.
 - When flavor changes are imparted in a beer's draught line from an adjacent draught line.
 - When any line chronically induces flavor changes in beer.
- Draught lines may need to be replaced after pouring root beer, flavored beers, margaritas, wines, or ciders. Such beverages may permanently contaminate a draught line and possibly adjacent draught lines in the same bundle. Such contamination precludes future use of that draught line for beer.
- In the case where a coupler's gas backflow valve (Thomas valve) is or ever has been missing, the gas line may have been compromised and should be replaced.
- Ensure the material used in the manufacture of the draught beer lines is compatible with the chemicals, dilution rates, and temperatures outlined on the following pages (also see "Beer Line" in Chapter 1).

Detailed Recommendations

Time, temperature, mechanical action, and chemicals (including concentration) are the four interdependent factors that determine draught system cleaning effectiveness. These four factors are known as the 'Sinner's Circle' and are represented in the shape a circle. If one factor is reduced, the loss must be compensated for by increasing one or more other factors. For example, if mechanical action is lost because a recirculation pump is not used, the chemical concentration and contact time may need to be increased to account for the loss. Throughout this chapter, these four interdependent factors will be referenced.

The following sections detail more specific recommendations on draught line cleaning. We begin with the basic issue of tasks and their frequency, then move into the more involved questions of cleaning solutions and procedures. The final pages of this chapter detail the procedures for electric pump and pressure pot cleaning.

Sinner's Circles



Cleaning Frequency and Tasks

- Every two weeks (14 days)
 - Draught lines should be cleaned with a caustic line-cleaning chemical following the procedures outlined in this chapter.
 - All faucets should be completely disassembled and cleaned.
 - All keg couplers or tapping devices should be scrubbed clean.
 - All FOB-stop devices (a.k.a. beer savers, foam detectors) should be cleaned in line. Chemicals should be purged through the FOB-stop and vented out of the FOB drain hose.
- Quarterly (every three months)
 - Draught beer lines should be de-stoned with an acid line cleaning chemical or a strong chelator that is added to or is part of the alkaline chemical formulation. (The DBQ working group is working with brewing industry researchers to complete further studies on line-cleaning chemistry, including additives such as Ethylenediaminetetraacetic acid (EDTA).)
- Semi-annually (every six months)
 - All FOB-stop devices (a.k.a. beer savers, foam detectors) should be completely disassembled and hand-detailed (cleaned).
 - All couplers should be completely disassembled and detailed.

More aggressive cleaning schedules and practices may be needed for older systems, problematic systems, or when proper line cleaning practices are not in place.

Cleaning Solutions and Their Usage

Caustic-Based Cleaning Chemistry

- Caustic chemicals remove organic material from the interior of the draught line, hardware, and fittings. The removal of this buildup prevents growth of beer-spoiling bacteria such as lactobacillus, pediococcus, pectinatus, and acetobacter.
- Use a caustic cleaner specifically designed for draught line cleaning that uses either sodium hydroxide, potassium hydroxide, or a combination of both.
- Routine use of caustic line-cleaning chemical products that are “built” with EDTA or other chelating agents may help remove calcium oxalate (beer stone) from draught lines. Brewery testing has indicated that these additives can provide significant cleaning benefits.
- Never use solutions that contain any amount of chlorine for line cleaning. Testing indicates that properly formulated caustic-based cleaners without chlorine can be just as effective at cleaning draught beer lines. Chlorine is not compatible with some beer line materials, and residual chlorine can cause flavor changes in draught beer.
- Based on brewery and independent lab testing, we recommend mixing caustic-based line cleaning solutions to a working strength of at least 2% caustic (as sodium hydroxide). A 3% caustic solution is more appropriate for problem systems, heavily soiled systems, systems with older lines, or for any line that imparts a flavor change to the beer served from it. Chemical manufacturers should provide detailed mixing instructions on the bottle for 2% and 3% caustic solutions. If this information is not available, contact your chemical manufacturer to determine how much chemical is needed to achieve these recommended concentrations.
- We recommend the use of portable titration kits to confirm the working caustic strength of beer line-cleaning solutions.
- Mix caustic solution with water warmed to a temperature between 80° - 110°F.
- Caustic cleaner must remain in contact with the draught line for at least:
 - 15 minutes when solution is being recirculated, and
 - 20 minutes for static or pressure pot cleaning.

Acid Chemical

- Acid line cleaner removes inorganic materials such as calcium oxalate (beer stone) and calcium carbonate (water stone) from the interior of the draught line, hardware, and fittings.
- Routine use of caustic cleaning solutions with EDTA or other chelating agent additives may reduce calcium oxalate buildup in draught lines and may decrease the need to clean regularly with an acid-based cleaner. Acid-based line cleaners suitable for draught line cleaning contain solutions of phosphoric acid.
- Some acid-based cleaners use acids that can harm your draught equipment:
 - Hydrochloric acid corrodes stainless steel and should not be used for cleaning draught lines.
 - Nitric acid is not compatible with nylon products, including some commonly used draught line tubing, and should not be used for cleaning draught lines.
- Mix acid line cleaner to the solution strength recommended by the manufacturer.
- Mix acid line cleaner with water warmed to a temperature between 80° -110°F.
- Acid solution must remain in contact with the draught line for at least:
 - 15 minutes when solution is being recirculated, or
 - 20 minutes for static or pressure pot cleaning.
- Acid cleanings should be in addition to, not in place of, caustic cleanings.
- Caustic and acid should always be separate and should never come into contact with each other.

Water Rinsing

- Always flush draught lines with fresh water before pumping chemical into the line.
- Always flush draught lines with water **after** using any chemical solution (caustic and acid).
- Acid and caustic should NEVER be mixed in line

or in a common bucket. A thorough water rinse is recommended between chemicals.

- Continue water flushing until:
 - No solid matter appears in the rinse water.
 - No chemical residue remains in the draught line.
- Confirm chemical removal by testing the solution with pH strips or a pH meter.
 - Before beginning the rinse, draw a reference sample of tap water and test its pH.
 - During rinsing, test the rinse water exiting the draught system periodically.
 - When the pH of the rinse water matches that of the tap water, the chemical is fully flushed out.
- **Chemical solution must never be flushed from draught lines with beer.**

⚠ Draught Safety ⚠

Used cleaner solutions can be either highly alkaline or acidic, and likely contain high concentrations of organic material. This can be hazardous to put down the drain. The technician should become familiar with local laws and sewer capabilities before disposing of the waste water.

Cleaning Methods and Procedures

Because every draught beer system is different, there is no definitive procedure for cleaning them. There are, however, certain principles that apply to cleaning every system. To be effective, cleaning solutions need to reach every inch of beer line and every nook and cranny of the connectors and hardware. You can hand clean some items like couplers and faucets, but most of the system must be reached by fluid flowing through the beer lines. The industry currently uses two cleaning procedures for beer lines: recirculation by electric pump, and static or pressure pot cleaning.

Electric recirculating pump cleaning is recommended as the preferred method for nearly all systems. Recirculation pump cleaning uses the combination of chemical cleaning and mechanical action to effectively clean a draught system, by increasing the normal flow rate through the beer lines during the cleaning process.

While static or pressure pot cleaning is an alternative, it is significantly less effective and is not a recommended method for cleaning. This procedure requires additional time to ensure that the cleaning solutions have the right contact time in line, to make up for the lack of mechanical force.

Key Considerations in Setting up an Electric Recirculating Pump Cleaning

- The chemical flow should be the reverse of the beer flow wherever possible. Ideally, the flow direction should be alternated between cleanings.
- Ideal chemical flow rate achieves twice the flow rate of the beer. In standard systems, beer flows at 1 gallon per minute (gpm), and ideal chemical flow rate is 2 gpm. 2 gpm may not be attainable for all systems. In these cases, a minimum of 1 gpm should be achieved.

The flow rate can be controlled by:

- Minimizing the number of draught lines cleaned at one time.
- Increasing the size of the pump used.

The flow rate can be tested in a 15-second test. Multiply the volume of liquid dispensed by 4 to determine the ounces or gallons per minute (1 gallon = 128 ounces).

- The pressure on the draught lines during recirculation should never exceed 60 psi.
- Under these conditions, chemical solution should recirculate for a minimum of 15 minutes.

Static or pressure pot cleaning offers an alternative method to clean runs of less than 15 feet. This requires 20 minutes of contact time with the cleaning solutions to make up for the lack of circulation.

The remainder of this chapter covers use of these cleaning methods, starting with setup and proceeding to the detailed steps for each procedure.

Before You Start

Regardless of your cleaning methods, some system designs require specific attention before you begin cleaning. Here's a list of items to check and consider. See the Unique Situations section at the end of this chapter for more details.

- In pneumatic beer pump systems:
 - Turn off the gas supply to the pumps.
 - On the line(s) to be back-flushed, set the pump valve or flow diverter orientation to "Backflush" so that cleaning solution may flow through the pump body in the appropriate direction as needed.
- All legs in "split lines" (lines that are "teed" in the cooler or under the bar to feed more than one faucet from a single keg) must be cleaned as completely separate draught line.

Electric Recirculation Pump Cleaning Step-By-Step Procedure

1. Begin by connecting two keg couplers with a cleaning adapter or cleaning cup. Cleaning adapters are available to accommodate many different combinations of coupler types, with the most common being "D" type to "D" type as shown. Do not engage the couplers, or cleaning solution may travel up the gas line. The shaft on each side of the adapter raises the check ball within the coupler (see diagram on page 11) to allow cleaning solution to flow in either direction.
 - If cleaning four lines, connect a second set of lines with another cleaning coupler, creating a



second "loop." Cleaning more than four lines at once is not recommended, as it will be difficult to achieve the proper chemical flow rate.

- To clean the lines and couplers used for series kegs, connect the couplers attached to the gas lines and place series caps with check ball lifters on all other couplers.



2. On the corresponding lines at the bar, remove both faucets from their shanks.
 - For loops with long and/or numerous lines, prime pump by filling pump and pump jumper lines completely with water before attaching "Out" hose to shank
 - When cleaning two lines, attach the "Out" hose from the pump to one shank and a drain hose or spare faucet to the other shank.
 - When cleaning four lines, attach the "Out" hose from the pump to one shank, connect the other shank in the loop to a shank in the second loop with a "jumper" hose fitted with two cleaning adapters (one on each end), and attach a drain hose or spare faucet to the remaining shank in the second loop.
 - When cleaning four lines, ensure that the drain hose and "Out" hose from the pump are not on the same coupler "loop."
3. Fill a bucket ("Water Bucket") with warm water and place the "In" hose into the water.
 - Turn pump on and flush beer into a second bucket ("Chemical Bucket") until the line runs clear with water.
 - Shut pump off and discard the flushed beer.
4. Turn pump back on, allowing warm water to run into the clean Chemical Bucket.
 - Measure the flow rate of the liquid by filling a beer pitcher or some container with a known volume. A steady flow rate that ideally exceeds the flow rate of the beer is recommended.
 - If cleaning is configured for four lines and flow rate is too slow, remove the jumpers and clean each pair of lines separately.
 - Allow bucket to fill with just enough water to cover the inlet hose of the pump.
 - Add the appropriate amount of line cleaning chemical to achieve 2-3% caustic in solution based on age and condition of beer line.
5. Remove the "In" hose from the Water Bucket and place into the Chemical Bucket.
 - There should now be a closed loop.
 - Solution should be draining into the same

bucket that the pump is pulling from.

6. Allow solution to recirculate for a minimum of 15 minutes. While waiting:
 - Purge circulating solution through FOB-stop devices and ensure FOBs are filled with chemical and vented out of the FOB drain hose.
 - Clean your faucets.
 - Fill Water Bucket with cold water.
7. Begin your rinse by removing the "In" hose from Chemical Bucket and placing it into the Water Bucket (filled with cold water).
8. Continue pumping cold water from the Water Bucket into the Chemical Bucket (shutting off pump and dumping Chemical Bucket as needed) until all chemical has been pushed out of the draught lines and there is no solid matter in the rinse water. Use pH paper to verify chemicals have been rinsed.
9. Finish up by shutting off the pump, detaching the cleaning coupler, and replacing the faucets.

When Finished

- Be sure to return all system components to their original functional settings; e.g., turn on gas supply to pneumatic beer pumps, reset FOBs and pneumatic pump flow diverters, etc.

Static – Pressure Pot Step-By-Step Procedure

1. Fill the cleaning canister with clean water.
2. Untap the keg and tap the cleaning canister. Engage the tapping device.
 - When cleaning series kegs, connect the tapping devices attached to the gas lines and place series caps on all other tapping devices.
3. Open faucet until the beer is flushed out and clear water is pouring.
4. Untap the canister and fill the canister with cleaning chemical mixed to the appropriate strength to achieve 2-3% caustic in solution based on age and condition of beer line.
5. Tap the canister again. Please note: When applying CO₂ to a pressure pot containing a caustic solution, the CO₂ will weaken or neutralize the caustic solution. It is best not to agitate or let it stand in

the same container for an extended period. For the same reason, the use of pressure pots that feature a "spitting" action, whereby CO₂ is injected directly into the outflow of solution, is not recommended.

6. Open the faucet until the water is flushed out and chemical solution is pouring from the faucet.
7. Shut off the faucet.
 - At this point, it has been common practice that the canister is untapped and faucets are removed and cleaned. This practice is NOT recommended. By releasing the pressure from the system, chemical will leak from the system, eliminating chemical contact from all high points of the system.
8. Return to the cooler and purge cleaning solution through FOB-stop devices and ensure FOBs are filled with chemical and vented out of the FOB drain hose
9. Allow cleaning solution and beer line to be in contact for no less than 20 minutes.
10. Untap the canister.
 - If the system is driven with pneumatic beer pumps, shut off the gas supply to the pumps to turn them off.
11. Remove the faucet and clean.
12. Replace faucet
13. Empty, rinse, and fill the canister with clean, cold water and retap.
14. Open the faucet and rinse until all chemical has been flushed out and there is no solid matter in the rinse water. Use pH paper to verify chemicals have been rinsed.
15. Finish by untapping the canister, retapping the keg and pouring beer until it dispenses clear.



When Finished

- Be sure to return all system components to their original functional settings; e.g., reset FOBs, reset pneumatic beer pump cleaning diverters to dispense setting and turn on pump gas supply, etc.

⚠ Draught Safety ⚠

The best way to ensure complete rinsing of all chemical residue is by checking pH. This can be done very affordably with test strips. Your line cleaner supplier should be able to provide test strips. The pH of caustic cleaner should be 10-13.5. If an acid cleaner is used, the pH should be 2-4. pH of the rinse water should be equal to that of the local tap water.

Unique Situations When Cleaning with a Recirculation Pump

Electric recirculation pump cleaning is recommended as the preferred method for nearly all systems. However, at times the system design can inhibit the ability to effectively clean with a recirculation pump. The following is a guide for cleaning more complex systems with a recirculation pump.

Pneumatic Beer Pumps

Pneumatic beer pumps are not multi-directional, so pushing cleaning solution through a pump in the reverse direction is not possible without the appropriate modifications. Beer pumps should be installed with flow-reversal valves that allow for recirculation cleaning. Some beer pumps without existing flow-reversal-valves allow them to be added onto the existing pump. Other beer pumps may require inline quick-disconnects to be installed to reverse the liquid flow. In no cases should the cleaning solution bypass the beer pump.

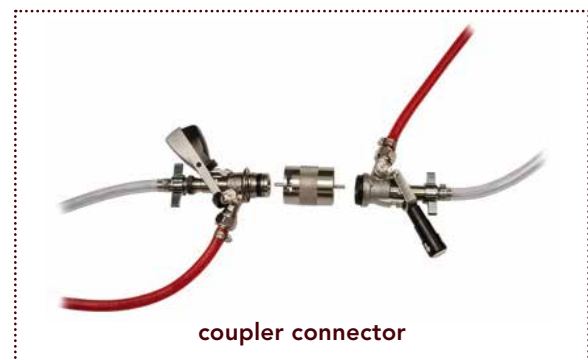
Split or Y'd lines

The preferred method to clean split lines is to clean each tower as its own separate system. This allows each system to get a complete recirculation clean. When using this method, it is important that the entire system is rinsed at the same time to ensure no residual chemical is caught in a split or "Y".

An alternative, but less effective, way of cleaning split lines is to set up recirculation cleaning on one tower and draw liquid through the remaining split towers. When using this method, a traditional recirculation cleaning is set up on one tower using a larger 3 to 5 gallon "chemical bucket." The chemical bucket should be nearly filled. Using an empty bucket of the same size, chemical will be drawn through the split lines into the empty bucket while simultaneously depleting the chemical bucket. Be sure to leave enough liquid in your primary chemical bucket to maintain recirculation. This step is repeated for each step of the cleaning process, including water pre-rinse, chemical, and water post-rinse. Because the split lines are receiving less mechanical action than the recirculation lines, additional time or chemical may be needed to make up for the loss of mechanical action (see Sinner's Circle at beginning of this section).

Challenging Cooler Connections

Equipment manufacturers make a variety of cleaning flushers that allow for connecting couplers of two different system types. Pictured is a flusher that will allow for a D or S system to connect to a U system coupler.



Custom cleaning flushers can also be built by using the various components pictured at the top of the next page. Building a custom coupler can also allow for connections between couplers of two different system types. The components pictured would connect a D or S system coupler to an A system coupler. In addition, custom lengths of poly vinyl tubing can be added between components to assist in making connections across large coolers.



These components can also be used to design a three-way coupler. Traditional recirculation pump cleanings use an even number of lines to create the recirculation loop. A three-way coupler (components pictured below) allows for an odd number of lines to be connected by utilizing two drain lines.



Testing for Cleanliness

The following are a few of the most common ways to test for draught system cleanliness.

Sensory Evaluation

A thorough sensory evaluation by a trained taster can reveal signs of a bacterial infection in a draught system. See Chapter 8: Troubleshooting for a list of off-flavor descriptions and corresponding bacteria. However, bacterial infections begin long before they are detected by human senses. Draught system maintenance is inherently a preventative maintenance designed to prevent bacterial infections. If only sensory evaluations are used for testing, it may be too late by the time bacteria reveal themselves through detectable tastes and aromas.

ATP Testing

ATP tests can be a convenient and portable way to test for cleanliness in the field. The ATP test is a process of rapidly measuring actively growing microorganisms through detection of adenosine triphosphate, or ATP, using a luminometer. While ATP testing can be an indicator of cleanliness, it is unable to differentiate between beer-spoiling organisms and other naturally occurring, less worrisome organic material.

Color-Indicating Chemicals

Some chemical manufacturers have color-changing chemicals that can provide indicators of a draught system's cleanliness. Similar to ATP testing, these methods are only an indicator of cleanliness and are unable to differentiate between beer-spoiling organisms and other naturally occurring, less worrisome organic material.

Plating

Taking sterile samples, plating on media, and growing bacterial colonies is the only way to truly identify specific bacteria that are growing in a draught system. Plating and interpreting samples can identify each type of bacterium and how prevalent it is. Unfortunately this process is cumbersome in the field, time-consuming, and costly.

At this point there are few reliable and realistic ways to test for draught system cleanliness in the field. Because of this, the draught system cleaning and maintenance recommendations from this chapter are designed to be preventative. Once a bacterial infection has taken hold, it becomes extremely difficult if not impossible to completely remove. The best defense against bacterial growth is to prevent it with recommended routine hygiene practices. ■

Summary of Draught System Cleaning and Service Recommendations

These guidelines reflect the key actions needed to maintain draught systems and pour trouble-free, high-quality beer. Before performing these actions, please read the detailed recommendations found at www.draughtquality.org as they contain many details important to effective and successful cleaning.

Perform draught line cleaning at a minimum every two weeks [14 days], as follows:

- Clearly posted documentation of line cleaning and servicing records is recommended in all keg coolers (visit www.draughtquality.org/f/CleaningLog.pdf for a printable line cleaning log).
- Push beer from lines with warm water.
- Clean lines with caustic solution at 2% or greater concentration for routine cleaning of well-maintained lines, or at 3% for older or more problematic lines. Contact your chemical manufacturer to determine how much chemical is needed to achieve these recommended concentrations. If you use non-caustic-based cleaners such as acid-based or silicate-based cleaners, be sure to use the cleaning concentrations recommended by the manufacturer. For best results, maintain a solution temperature of 80° - 110°F during the cleaning process.
- Using an electric pump, caustic solution should be circulated through the lines at a minimum of 15 minutes at a steady flow rate that ideally exceeds the flow rate of the beer. If a static or pressure pot is used (though not recommended), the solution needs to be left standing in the lines for no less than 20 minutes before purging with clean water.
- Disassemble, service, and hand-clean faucets; hand-clean couplers.
- After cleaning, flush lines with cool fresh water until pH matches that of tap water and no visible debris is being carried from the lines.

Acid Cleaning quarterly [every three months], as follows:

- Perform acid cleaning of draught lines as follows:
 - Acid cleanings should be in addition to caustic cleanings, not as a replacement.
 - Push beer or caustic cleaner from lines with warm water.
 - Clean lines with an acid line cleaner mixed to manufacturer's guidelines. Maintain a solution temperature of 80°-110°F.
 - Circulate the acid solution through the lines for 15 minutes at a steady flow rate that ideally exceeds the flow rate of the beer. If a static or pressure pot is used (though not recommended), the solution needs to be left standing in the lines for no less than 20 minutes before purging with clean water. After acid cleaning, flush lines with cool fresh water until pH matches that of tap water and no visible debris is being carried from the lines.

Hardware Cleaning semi-annually [every six months], as follows:

- Disassemble, service, and hand-clean all FOB-stop devices (a.k.a. beer savers, foam detectors).
- Disassemble, service, and hand-clean all couplers.

chapter 8



troubleshooting

Perfectly poured draught beer is the result of proper temperature, gas pressure and mixture, and a well-maintained draught beer system. It's easy to take all the variables for granted when beer is pouring well. But improperly pouring beer can be very frustrating, and can result in loss of sales. This chapter is intended to provide useful troubleshooting steps anyone can follow to solve draught beer dispense problems.

The single most common cause of problems encountered in draught beer dispense systems is temperature control. The first step in solving any dispensing problem is to confirm that the temperature of the keg and the cooler are where they are supposed to

be. In air-cooled and glycol-cooled systems, the next step is to check the temperature of the beer being delivered to the faucet, confirming that the air and glycol systems used to maintain proper beer line temperature are working properly.

The troubleshooting steps that follow are organized by the type of draught beer system and how the systems are cooled, using air or glycol. Direct-draw systems and long-draw systems cooled by air or glycol each have unique features that are addressed in the troubleshooting steps.

Other steps including gas pressure and supply, beer supply, and mechanical issues are also discussed.



DIRECT DRAW SYSTEMS		
Problem	Possible Cause	Possible Solution
Beer Foaming	Temperature too warm (should be 38° F)	Adjust temperature control or call qualified service person
	Temperature too cold/frozen beer in lines (should be 38° F)	Adjust temperature control or call qualified service person
	Kinked beer line	Change beer line
	Wrong diameter or length beer line (should be 4 to 5 ft. of 3/16" vinyl tubing or possibly even longer)	Change beer line
	Applied pressure too high (should be 12 to 14 psi for most beers)	Adjust CO ₂ regulator to brewer's specification
	Applied pressure too low (should be 12 to 14 psi for most beers)	Adjust CO ₂ regulator to brewer's specification
	Coupler washers bad	Replace coupler washers
	Faucet washer bad	Replace faucet washers
	System dirty	Clean system or call customer's line cleaning service
	CO ₂ leaks or out of CO ₂	Check fittings, clamps, shut-offs and regulators, replace as necessary
	Beer foaming in jumper – keg valve seal torn or ripped	If seal is ripped/torn, gas enters the liquid flow stream causing foaming. Replace keg and report defective keg to distributor
	Beer foaming in jumper - physical obstructions at coupler-valve junction	Remove any physical obstructions or debris (e.g. a piece of a dust cover) that could allow gas to enter the liquid flow
	Beer foaming at faucet – clogged vent hole(s)	Disassemble and clean faucet, or call line cleaning service
No Beer at Faucet	Empty CO ₂ bottle	Replace with full CO ₂ bottle
	Regulator shutoff closed	Open shutoff
	CO ₂ bottle main valve turned off	Turn on CO ₂ bottle main valve
	Keg empty	Replace with full keg
	Coupler not engaged	Tap keg properly and engage coupler
	Check ball in coupler stuck	Free check ball
	Line/faucet dirty	Clean line/faucet

For air-cooled systems, the maximum recommended distance for a double-duct system is 25 feet (tube side by side) and for a single-duct system is 15 feet (tube within a tube).

AIR-COOLED SYSTEMS		
Problem	Possible Cause	Possible Solution
Beer Foaming	Check temperature at faucet - too warm (should be 38° F)	Blower fan air flow obstructed Adjust temperature control or call qualified service person System designed improperly: too long, wrong size fan, etc.
	Check if temperature at faucet is too cold (should be 38° F)	Adjust temperature control or call qualified service person
	Kinked beer line	Change beer line
	Wrong size beer line	Change beer line
	Applied pressure too high (should be 12 to 14 psi for most beers)	Adjust CO ₂ regulator to brewer's specification
	Applied pressure too low (should be 12 to 14 psi for most beers)	Adjust CO ₂ regulator to brewer's specification
	Wrong gas (mixed gas blenders recommended)	Change to mixed gas blender, use target pressure
	Coupler washers bad	Replace coupler washers
	Faucet washer bad	Replace faucet washers
	System dirty	Clean system or call customer's line cleaning service
	Beer foaming in jumper – keg valve seal torn or ripped	If seal is ripped/torn, gas enters the liquid flow stream, causing foaming. Replace keg and report defective keg to distributor
	Beer foaming in jumper - physical obstructions at coupler-valve junction	Remove any physical obstructions or debris (e.g. a piece of a dust cover) that could allow gas to enter the liquid flow
	Beer foaming at faucet – clogged vent hole(s)	Disassemble and clean faucet, or call line cleaning service
No Beer at Faucet	Empty CO ₂ bottle, N ₂ bottle, or mixed gas bottle	Replace with appropriate full gas bottle
	Regulator shutoff closed	Open shutoff
	Gas bottle main valve turned off	Turn on gas bottle main valve
	Keg empty	Replace with full keg
	Coupler not engaged	Tap keg properly and engage coupler
	Check ball in coupler stuck	Free check ball
	Line/faucet dirty	Clean line/faucet

A glycol system is designed to maintain liquid beer temperature from the cooler to the point of dispense.

GLYCOL-CHILLED SYSTEMS		
Problem	Possible Cause	Possible Solution
Beer Foaming	Check temperature at faucet - too warm (should be 38° F)	Check glycol chillers for proper operation; adjust glycol bath temperature if too warm (most systems are designed to operate between 28° and 34° F; check unit's manufacturer specs)
		Adjust temperature control or call qualified service person
	Check temperature at faucet - too cold (should be 38° F)	Check glycol chillers for proper operation; adjust glycol bath temperature if too cold (most systems are designed to operate between 28° and 34° F; check unit's manufacturer specs)
		Adjust temperature control or call qualified service person
	Wrong gas (glycol systems usually require a mixed gas blender)	Change to mixed gas blender, use target pressure
	Glycol pump functioning (check return line)	Call qualified serviceman to adjust glycol chiller temperature or operation
	Gas regulators incorrectly set	Contact installer
	Applied pressure too low (should be 12 to 14 psi for most beers)	Adjust CO ₂ regulator to brewer's specification
	Coupler washers bad	Replace coupler washers
	Faucet washer bad	Replace faucet washers
	System dirty	Clean system or call customer's line cleaning service
	Power pack – check condenser, glycol concentration	Call qualified serviceman to clean clogged condenser fins, check glycol strength, service glycol chiller
	Beer foaming in jumper – keg valve seal torn or ripped	If seal is ripped/torn, gas enters the liquid flow stream causing foaming. Replace keg and report defective keg to distributor.
	Beer foaming in jumper - physical obstructions at coupler-valve junction	Remove any physical obstructions or debris (e.g. a piece of a dust cover) that could allow gas to enter the liquid flow
	Beer foaming at faucet – clogged vent hole(s)	Disassemble and clean faucet, or call line cleaning service
No Beer at Faucet	Empty CO ₂ source, N ₂ source, or mixed gas bottle	Replace with appropriate full gas bottle, refill bulk CO ₂ or N ₂ receiver, check nitrogen generator
	Regulator shutoff closed	Open shutoff
	Gas bottle or bulk tank main valve turned off	Turn on gas bottle or tank main valve
	Keg empty	Replace with full keg
	Coupler not engaged	Tap keg properly and engage coupler
	Check ball in coupler stuck	Free check ball
	Line/faucet dirty	Clean line/faucet
	FOB detector	Reset FOB detector
	Pneumatic beer pumps	Check gas supply to pumps; check pump diverter setting

Off Flavors in Draught Beer

The purpose of this manual is to explain how to maintain the brewery-intended flavor of draught beer products. When fresh and properly dispensed, draught beer tastes the way the brewer intended—clean, flavorful, and enjoyable. Draught beer is susceptible to damage from a host of factors, such as age, heat, and air. But the number one factor affecting the quality of draught beer flavor and aroma is poor hygiene. Improper cleaning of beer system lines and components from the coupler in the cooler to the faucet at the bar can lead to significant changes in beer flavor, all of them unwelcome. Over time, poor beer line hygiene will inevitably result in loss of sales due to customer dissatisfaction, and to

replacing beer lines at great expense. Staying ahead of these potentially costly outcomes is key to serving great-tasting draught beer.

The chart on page 72 lists the most common off flavors that occur due to post-brewery unhygienic conditions and the mishandling of draught products. Beer-spoiling bacteria will ruin a beer's flavor and aroma, and will inevitably lead to lost repeat business and potential sales. While these microorganisms are not health risks, they will cause bacterial infections in draught systems that are often difficult, if not impossible, to completely remove. By following the guidelines outlined in this manual, the occurrence of these off flavors can be prevented. ■

OFF FLAVOR NAME	FLAVOR DESCRIPTION	BACTERIA	LIKELY CAUSES	HOW TO PREVENT AND RESOLVE
Diacetyl	Buttery, Buttered popcorn, Butterscotch, Caramel, can have a slick or milky mouthfeel at high levels	Anaerobic Bacteria* Pediococcus (most likely), Lactobacillus (less likely)	Pediococcus and Lactobacillus occur from unhygienic conditions in draught beer systems. Diacetyl is the most common off flavor associated with dirty draught systems. These bacteria are most likely to develop when: <ul style="list-style-type: none"> • The cleaning frequency is allowed to span beyond a two-week cycle • Regular use of an electric recirculating line cleaning pump is not in use • Associated draught equipment is not properly disassembled, serviced, and hand-cleaned on the recommended intervals • Improper chemicals or low chemical concentrations are used • Beer lines are older than their recommended age • Kegs in series are not completely emptied on a weekly basis • Ineffective line cleaning procedures are used 	Removing a bacterial infection from a beer line can be very difficult, if not impossible to completely remove. Even after a cleaning, these bacteria may remain in the beer line and keg at initially undetectable levels. However, in a short time, these anaerobic bacteria will resurface as an overpowering infection. The goal is to completely rid the system of any traces of bacteria so the off-flavors never return.
Lactic Acid	Sour, Sour Milk, Acidic (note- the bacterial load would have to be very large to pick up this flavor)	Anaerobic Bacteria* Lactobacillus (most likely), Pediococcus (less likely)		Prior to cleaning, begin by replacing infected hardware and beer lines wherever possible, and always replace any kegs that have been tapped into an infected system. Follow the step-by-step pump cleaning procedures in Chapter 7, rotating between caustic and acid cycles to maximize your chances of removal.
Acetic Acid	Sour, Vinegar	Aerobic Bacteria* Acetobactor	Acetobactor will often begin its growth in dirty drains, spill trays, bar tops, or used bar rags and will eventually spread to the beer dispense faucet. Serving staff submerging a faucet into a beer will increase the growth-rate of these bacteria.	Serving staff should be thoroughly trained on proper serving techniques (Chapter 6). Beer faucets should be completely disassembled and hand-detailed using caustic chemicals every two weeks.
Oxidation	Papery, Cardboard, Fruity, Bready, Vinous, Vegetal (These are only a few descriptors as oxidation is a very broad term and different ingredients will take on different oxidative properties)	N/A. Oxidation in beer is a reaction that occurs when a beer is exposed to oxygen molecules.	The leading cause of acetobactor comes from faucets not being completely disassembled and hand-detailed on a two-week cycle. Oxidation comes from time, temperature, or direct exposure to oxygen. All beers have an expiration date. This is the date by when a brewery feels the beer has taken on significant oxidative properties, and that the beer no longer represents the brewery-intended flavor. This expiration date can easily be shortened with the addition of warm temperatures. Draught beer should be kept cold (below 50° F) at all times to maximize its freshness. The longer a beer is kept warm and/or the higher the temperature, the faster the beer will oxidize. If a beer ever rises above 80° F, for any amount of time, the beer is likely ruined. In draught beers, oxidation can happen with the use of an air compressor. If an air compressor is used to dispense draught beer, oxygen will be forced into the keg, and can oxidize a beer within 24 hours (Chapter 1).	Stainless steel is the best material for faucets to prevent bacterial buildup. Monitor brewery-recommended best-consumed-by-dates and temperature specifications. Ensure any kegs in series have been completely emptied (series kegs should be completely emptied and replaced once per week). Never use compressed air in direct contact with draught beer. Use barrier and stainless steel tubing whenever possible.

appendix a

ISBT guidelines for beverage grade carbon dioxide

Purity	99.9% min*
Moisture	20 ppm max
Oxygen	30 ppm max
Carbon monoxide	10 ppm max
Ammonia	2.5 ppm max
Nitric oxide/nitrogen dioxide	2.5 ppm max each
Nonvolatile residue	10 ppm (wt) max
Nonvolatile organic residue	5 ppm (wt) max
Phosphine	0.3 ppm max
Total volatile hydrocarbons	50 ppm max
Acetaldehyde	0.2 ppm max
Aromatic hydrocarbon	20 ppb max
Total sulfur content	0.1 ppm max
Sulfur dioxide	1 ppm max
Odor of solid CO ₂	No foreign odor
Appearance in water	No color or turbidity
Odor and taste in water	No foreign taste or odor

All specification based on volume (v/v) unless otherwise noted.

appendix b

CO₂ gauge pressure, temperature and carbonation level reference chart

Table 1. Determination of CO₂ equilibrium pressure given volumes of CO₂ and temperature

Vol. CO ₂	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1
Temp. °F	psi	psi	psi	psi	psi	psi	psi	psi	psi	psi	psi
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

Based on Data from "Methods of Analysis," American Society of Brewing Chemists, 5th Edition - 1949

- The values in this table 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's 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 psi for every 2,000 feet above sea level. For example, a retailer at sea level would use 11.3 psi gauge pressure to maintain 2.5 volumes of CO₂ in beer served at 38° F. That same retailer would need 13.3 psi gauge pressure at 4,000 feet elevation to maintain 2.5 volumes of CO₂.

Figuring ideal gauge pressure of straight CO₂ when carbonation level is not known:

1. Set the regulator pressure to 5 psi.
2. Tap a fresh keg. **Make sure the keg has been in the cooler long enough to be at the cooler temperature.**
3. Pour a small amount of beer through the faucet.
4. Observe the beer in the draught line directly above the keg coupler (with a flashlight if necessary), inspecting for bubbles rising up from the beer in the keg.
5. If bubbles are present, raise the regulator pressure 1 psi.
6. Repeat steps 3 - 5 until no bubbles are present.
7. Check the keg temperature 24 hours after setting the initial gauge pressure to assure temperature stability, and to reset the gauge pressure as needed due to a change in keg temperature.

This is the lowest pressure at which the gas in the beer is not escaping. This is your ideal gauge pressure.

Converting Volumes of CO₂ to Grams per Liter of CO₂:

In the U.S., carbonation is expressed in units of "volumes of CO₂". What this means is that one keg of beer carbonated to 2.5 volumes of CO₂ contains 2.5 kegs worth of CO₂ compressed and dissolved into the beer. In other countries, carbonation is often expressed in units of grams per liter. To convert between volumes of CO₂ and grams per liter, the quick and easy answer is 2 g/L equals 1 v/v.

However, "2" is not exactly correct. Several alternative values and a method to calculate the value are listed.

A first approximation can be found by assuming that CO₂ has a molar mass of 44 grams per mol and that one mol of gas at STP conditions (0°C, 1 ATM) occupies a volume of 22.4 liters. Converting from g/L to v/v is then,

$$\frac{1 \text{ g CO}_2}{1 \text{ L Beer}} * \frac{1 \text{ mol CO}_2}{44 \text{ g CO}_2} * \frac{22.4 \text{ L}}{1 \text{ mol CO}_2} * \frac{22.4}{44} = 0.509$$

Inverting this value gives us the conversion factor for converting from v/v to g/l.

$$\frac{1}{0.509} = 1.965$$

For a slightly more accurate answer we can use the value of 44.01 g/mol for CO₂ and 22.426 L/mol for the STP volume of the gas. We can also take account of the fact that CO₂ does not behave strictly in accordance with the Ideal Gas Law and has a compressibility factor (Z) of 0.99952 under the stated conditions. Using these values we get 1.966 instead of 1.965. Not much improvement there, but perhaps a better sense of accuracy.

Another tool is the NIST Standard Reference Database 23, Ver 9.0, 2010. This database gives a value for the density of CO₂ at STP conditions of 1.9768 g/L. This may be accepted as the most accurate value and it is the one to use if doing an exact analysis.

So, for quick conversions that most people can do in their head, "2" is an acceptable answer. In cases where one wants to have more accuracy, they can use 1.9768 or whatever rounded-off value they feel comfortable with. ■

appendix c

carbonation, blended gas, gas laws & partial pressures

Carbonation

In general, the amount of carbonation in beer depends primarily on the pressure of CO₂ applied to the keg of beer being dispensed, and the temperature of the beer. In reality, many other factors can also affect carbonation levels including blended gas proportion of CO₂, alcohol content, and specific gravity. Knowing a bit about these factors can help you fine-tune your draught dispense system to achieve the perfect pour for every brand dispensed.

Temperature: In general, gas is less soluble in liquid as the temperature rises. This seems obvious—a nice cold keg of beer dispenses easily, while that same keg of beer dispenses as foam if it gets warm.

Proportion of CO₂ in blended gas: This is directly related to the pressure of the CO₂ in the headspace over the beer within the keg. Two different gas laws (Dalton's Law of Partial Pressures and Henry's Law) can help us make sense of what's going on. This is most easily described by example, along with a little math. Consider a situation in which a keg of beer is dispensed using gas at 20 psi. If pure CO₂ is used to dispense

beer, then all of the pressure on that keg is due to CO₂. But what if the gas being used is a blend of 75% CO₂ / 25% N₂? In this case, Dalton's Law can help us figure out what's going on. Dalton's Law of partial pressures says that *the total pressure exerted by a gaseous mixture is equal to the sum of the partial pressures of each individual component in a gas mixture*. This means the partial pressure of CO₂ is equal to the proportion of CO₂ in the gas, in this case 75%, times the total absolute pressure of the blended gas, or 34.7 psia (20 psig + 14.7 psi atmospheric pressure = 34.7 psia). In this case, the partial pressure of CO₂ is:

$$75\% \times 34.7 \text{ psia} = 26.0 \text{ psia}$$

$$26.0 \text{ psia} - 14.7 \text{ psi atmospheric} = 11.3 \text{ psi gauge.}$$

So, in this example using blended gas, the carbonation of the beer will be proportional to 11.3 psi of CO₂, NOT 20 psi CO₂. It's important to note this calculation must be done in absolute pressure, then converted to gauge pressure (if you used gauge pressure of 20 psi rather than 34.7 psia, 75% of that value would result in 15 psi as the partial pressure of CO₂ in this scenario, which is not correct.) Consulting the carbonation

chart on page 74 and assuming a temperature of 38 °F and 11.3 psi CO₂ pressure, the carbonation level in this example would be 2.5 volumes (rather than 2.8-2.9 volumes, which would be the 15 psi result if you had incorrectly used gauge pressure).

Alcohol Content and Specific Gravity: Most of the liquid in beer is water. The standard carbonation table is based on beer containing 4.8% alcohol by volume (abv), where approximately 95% of the liquid is water. As it turns out, CO₂ is more soluble in ethanol than it is in water, which by itself would increase the solubility of CO₂ in the beer as abv increases. The degree to which solubility is affected in different beers is hard to calculate, however, due to the opposing effects of a beer's density on CO₂ solubility.

Specific gravity, or the density of the beer, is affected by other compounds in solution, such as carbohydrates and proteins that provide mouthfeel, body, color and flavor. As the density of beer increases, there is effectively less liquid available in which CO₂ can dissolve. While not always the case, high abv beers tend to have a higher specific gravity. Therefore, a high abv beer may have an increased CO₂ solubility from the alcohol content, but that effect is outweighed by the opposing decrease in solubility from increased density of carbohydrates, proteins and other compounds within the beer.

Blended Gas Dispense Examples

Henry's Law states: *"At a constant temperature, the amount of a given gas that dissolves in a given type and volume of liquid is directly proportional to the partial pressure of that gas in equilibrium with that liquid."* This turns out to be really useful when dispensing beer in systems where more than 12-15 psi of dispense pressure is needed to move beer to the taps, such as long-draw systems.

The partial pressure of a gas within a blend can be calculated by multiplying the total pressure of the gas

blend (in psia, not psig) times the proportion of that gas in the blend. Let's consider a couple of scenarios in which draught beer is 1) dispensed using blended gas at 70% CO₂/30% N₂, and 2) dispensed using straight CO₂. In both scenarios, let's assume the dispense temperature is the same at 39°F, and that the system has been designed and balanced to dispense beer at an operating pressure of 20 psig, or, $20 + 14.7 = 34.7$ psia.

Scenario 1:

Dispensing with blended gas at 70% CO₂/30% N₂

The carbonation in the beer will depend on the partial pressure of CO₂, which equals 34 psia (the total dispense pressure) x 70% (proportion of CO₂ in the blend) = 23.8 psia. At sea level, atmospheric pressure is 14.7 psi; $23.8 \text{ psia} - 14.7 = 9.1$ psig. A partial pressure of 9.1 psi for CO₂ at 38°F would result in about 2.3 volumes of carbonation in beer. For most brands of beer, this carbonation rate is a bit lower than typical values of 2.5 – 2.7 volumes.

Scenario 2:

Dispensing with straight CO₂

The carbonation in the beer will depend on the partial pressure of CO₂, which equals 34.7 psia (the total dispense pressure) x 100% (proportion of CO₂ in the blend) = 34.7 psia. At sea level, atmospheric pressure is 14.7 PSI; $34.7 \text{ psia} - 14.7 = 20$ psig. A partial pressure of 20 psi for CO₂ at 38°F would result in about 3.3 volumes of carbonation in beer. For most brands of beer, this carbonation rate is a bit higher than typical values of 2.5 – 2.7 volumes.

From these examples, we can see that at the operating parameters of the system in question, straight CO₂ would result in carbonation levels that are too high. The blend we chose, at 70% CO₂, would result in carbonation levels that are a bit too low. So, is there a way to use Henry's Law to figure out the exact blend for our draught beer system? And, looking at this another way, is there a way to use this math to figure out the ideal pressure to use, given a certain blend of gas?

As it turns out, there are tools available online to do both of these tasks with a great degree of accuracy. There are also some relatively straightforward calculations that do the same things very quickly, shown here. The following equation is very useful for converting back and forth between gauge pressure and absolute pressure, and proportion of CO₂ in a blend:

$$c = \frac{b + 14.7}{a + 14.7}, \text{ where}$$

a = gauge pressure of the blended gas;

b = ideal gauge pressure of straight CO₂ (from the carbonation table in Appendix B);

c = % of CO₂ in the blend

Determining the ideal blend of CO₂/ N₂ mixed gas for a given draught beer dispense system.

Let's get back to our example above, in which a draught beer dispense system was designed to operate at 39°F, and at 20 psig. Let's also assume that the beers being poured contain 2.5 volumes of CO₂.

From the carbonation table, we see that a beer at 2.5 volumes of CO₂ at 39°F has an equilibrium pressure of 11.9 psi of CO₂.

So now we know that a = 20 psi, and b = 11.9 psi.

$$c = \frac{11.9+14.7}{20+14.7} = \frac{26.6}{34.7} = .767 \text{ or } 77\% \text{ CO}_2 \text{ rounding up}$$

What if we wanted to also dispense beers with 2.7 volumes of CO₂ in this same retail establishment? From the carbonation table, we see that a beer at 2.7 volumes of CO₂ at 39°F has an equilibrium pressure of 14.1 psi of CO₂. In this case, a = 20 psi, and b = 14.1 psi.

$$c = \frac{14.1+14.7}{20+14.7} = \frac{28.8}{34.7} = .830 \text{ or } 83\% \text{ CO}_2$$

In this case, a gas blender with more than one blend of mixed gas would be very helpful. You would use the 77% CO₂ to dispense the beers with 2.5 volumes of carbonation, and the 83% blend to dispense the beers with 2.7 volumes of carbonation.

Determining the correct pressure for a given blend of CO₂ / N₂ mixed gas

What if in the above example, we only had access to one blend of gas? Could we adjust the pressure a bit to achieve more than one level of carbonation, and still dispense beer in the same draught beer system? Well, maybe. This is very similar to the procedure outlined on Page 27 of this manual. Let's get back to our example above, in which a draught beer dispense system was designed to operate at 39° F and at 20 psig. We want to dispense beers containing both 2.5 and 2.7 volumes of CO₂.

From the above example, we know that the 77% CO₂ blend is correct for the 2.5 volume beers. What pressure would we have to use to correctly dispense beers with 2.7 volumes of CO₂ using this 77% blend?

Looking back at our equation:

$$c = \frac{b + 14.7}{a + 14.7}, \text{ where}$$

a = gauge pressure of the blended gas; in this case, a is our unknown

b = ideal gauge pressure of straight CO₂ (from the carbonation table in Appendix B); in this case, b = 14.1

c = % of CO₂ in the blend; in this case, c = 0.77

$$a = (b + 14.7)/c - 14.7$$

$$a = 28.8/.77 - 14.7$$

$$a = 37.4 - 14.7$$

$$a = 22.7 \text{ psi}$$

So in theory if we increase the dispense pressure from 20 psi up to 22.7 psi on those kegs of beer with 2.7 volumes of CO₂, we could use the same 77% CO₂ blend to dispense them and maintain proper carbonation. This may or may not work in reality—the beer might pour too fast at the bar, creating turbulence within the glassware. Or it might result in an acceptable pour with the right amount of carbonation. Experimentation at the bar would reveal if the pressure increase worked, or if an additional blend were needed to pour these beers. ■

appendix d

notes on serving cask ale

Cask Ale

Cask ale, sometimes called “cask conditioned beer” or “real ale,” is draught beer dispensed and served in a traditional method. Cask ale is generally served at warmer temperatures than regularly carbonated draught beer, and without an extraneous propellant. The result is a beer with different presentation, flavor, and aroma, wholly unique from the same beer force carbonated, and dispensed with CO₂ or mixed gas applied pressure.

In this appendix, we focus on a few particulars of dispensing cask ale that represent basic knowledge and best practices. The production of cask ale is an art unto itself, sometimes referred to as “cellarmanship,” the details of which are well beyond the scope of this manual.

Temperature

Cask ale is typically conditioned and dispensed at 45°-55°F, unlike the colder 36°-38°F range for regularly carbonated draught beer. The temperature is warm enough to allow the beer within the cask to develop its own natural carbonation due to the presence of living yeast. This increased temperature also means that CO₂ is not as soluble in the beer, so it contains far less carbonation.

Carbonation

Because cask ale is handled at warmer temperatures, and since CO₂ is less soluble at warmer temperatures, cask ale contains much lower levels of carbonation than regular draught beer. Cask beer typically contains from 0.9-1.2 volumes of CO₂, far less than the 2.5 to 2.7 volumes typical of carbonated draught beer.

The carbonation in cask ale arises from natural secondary fermentation within the cask, rather than from force carbonation at the brewery. The relatively warmer cellaring temperatures allow this fermentation to occur after the cask leaves the brewery.

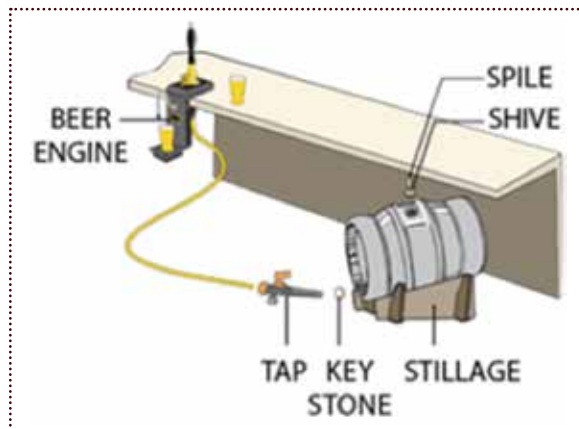
Dispensing Cask Ale

Cask ale is normally dispensed from a cask located relatively close to the bar, or even on the bar or back bar. Most modern casks are metal, although a few wooden varieties are sometimes still found. Most casks contain two openings that are filled with wooden or plastic plugs called shives (for letting gas in) and keystone (for tapping and removing beer). The cask is placed on its side with the shive up and the keystone down. Cask ale is dispensed without top pressure, meaning that it either pours from the cask

through a faucet-like tap directly into the glass using gravity, or the beer is pumped a short distance using a pump called a beer engine.

The cask should be allowed to settle for several hours up to a day before serving. This process, called “still-aging,” allows the yeast in the cask to settle to the bottom and the beer to pour clear.

Gas is allowed to enter the cask being emptied in order to prevent a vacuum from forming. Busy bars that empty a cask in one to three days will sometimes allow air to enter the cask, while other locations will use CO₂ at atmospheric pressure to fill the headspace. CO₂ is preferable in terms of preserving the beer; there may be some disagreement about whether this practice is “proper” or traditional, but this manual is not the forum for that discussion.



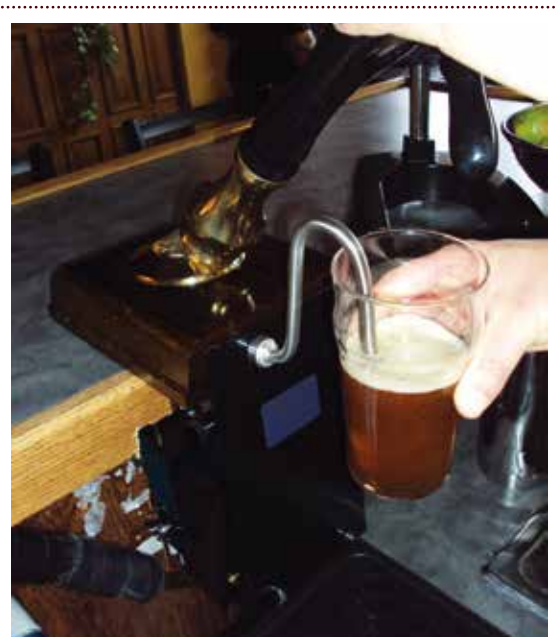
Cask ale dispensed directly from a cask using a gravity dispense tap will usually have very low amounts of foam in the glass. Cask ale dispensed from a beer engine may be poured through a fitting called a sparkler that serves to create foam from the very low level of carbonation present.

Beer Engines

Beer engines dispense cask beer. Pulling the handle actuates a piston or chamber of the engine and pumps beer from the cask to the customer's glass. Beer engines can be clamp-on or built into a bar.



Some breweries that make cask ales will require a sparkler (perforated disk) that attaches to the end of the pouring spout.



Cask Ale Pouring, Hygiene, and Best Practices

Pouring cask ale from a swan neck beer engine faucet is the only instance when the faucet should come into contact with the inside of a beer glass. Due to the unique nature of this beer dispense system, a list of guidelines must be followed to ensure proper sanitation and high product quality.

1. At the start of the day, discard the first pull of beer as this empties the beer engine cylinder of beer that has been sitting overnight.
2. Always use a beer-clean glass for every serving

of cask ale dispensed from a beer engine. This is the case when pouring any draught beer, but even more so with cask ale due to the potential to transfer germs from one glass to another.

3. The closing bartender should do one final clean of the cask faucet, drip tray, and the surface of the entire cask pump when the bar closes. This cleaning should be done with restaurant/bar sanitizer approved by your local and state health code. If the cask faucet uses a sparkler, the sparkler should be removed and soaked overnight in the same sanitizer at a soaking concentration listed by the manufacturer.
4. The opening bartender should wipe the cask faucet with a clean towel wetted with fresh water before the first cask beer is pulled to ensure any residual sanitizer from the previous night is removed. If the cask pump is fitted with a sparkler, thoroughly rinse the sparkler under fresh water before attaching it to the cask faucet.
5. After the cask has been emptied, remove the shive and rinse the inside of cask thoroughly with warm water as soon as possible.

Notes on Cask System Hygiene

- Run clean, warm water through the beer line and beer engine between every cask.
- Perform regular beer line cleaning every 14 days, just like regular draught beer lines. Be sure to check with the manufacturer of the beer engine to ensure the cleaning solution concentration is compatible with the piston, so as not to damage

it. Using the hand pump, draw the chemical solution through the beer line until beer engine is filled with chemical solution. Allow for 20 minutes contact time. Purge the system of the chemical solution by drawing through cool water. Ensure that all of the chemical is removed by testing the pH of the rinse water.

- Cleanliness is paramount in the handling of cask ale. Unlike kegged draught beer, items are being inserted into beer such as taps, spiles, ale extractors, etc. These all give an opportunity for bacteria to be introduced.

Importance of one-inch collar of foam:

- Well-prepared cask ale will easily allow for one inch of head or more if a sparkler is fitted on the end of the faucet. Without the sparkler device, a full 1-inch collar of foam may be difficult to achieve. The bar or restaurant manager should consult the brewer to discuss how their particular beer is intended to be served.

The purpose of a proper head on any cask ale is the same as a draught beer; the head helps to deliver the total sensory experience, including the following benefits:

- Visual appeal of a good pour
- Aromatic volatiles in a beer are released
- Palate-cleansing effect of carbonation is enhanced
- Textural and sensorial qualities of beer are better presented to consumer.

appendix e

tools of the trade

Quality draught beer requires the technician to be equipped with the proper tools assuring professional installation and service. Valuable tips and lists of suggested tools and equipment for draught beer service professionals follow:

Tool Tips

- Put safety first and always wear eye protection
- Buy the best tools you can afford, as they will last a lifetime
- Always use the right tool for the job
- Keep your tools clean, sharp, calibrated, and organized

Beer Hand Tools

1. Side Cutters & O-Clamp Crimpers
2. Spanner / Faucet Wrench
3. Tube Gauge
4. Faucet Brushes - 3/8" & Mini Wire Brush
5. Box and Open End Wrench Set, Particularly 9/16"
6. Tower Wrench- 1" & 1-1/6"
7. Multi Screwdriver
8. Large 12" Flat Blade Screwdriver
9. 10" Crescent Wrench
10. Small & Large Channel Lock
11. Needle Nose Pliers
12. Side Cutter Pliers
13. Small Pipe Wrench
14. Vise Grip
15. 3/8" Drive Socket Set
16. Awl or Center Punch
17. Hammer
18. Rubber Mallet
19. Small Pry Bar
20. Bolt Cutter

21. 12' & 100' Tape Measure
22. Combination Square
23. Pinch Off Pliers - Vise Grip Brand
24. Allen Wrench Set
25. Torpedo Level
26. Chalk Line & Chalk
27. Pencils / Markers
28. Stud Finder
29. Rope & String
30. Rope Puller Come Along
31. Heavy Duty Fish Tape/Chain Hoist
32. Hack Saw
33. Small Utility Hand Saw
34. Scissors
35. Tin Shears
36. Razor Knife & Blades
37. Hose Cutters
38. Knife
39. Pipe Cutter
40. Sharpie Pen
41. Pull lube (Poly G)

Miscellaneous

42. Tool Box / Bag
43. Parts Organizers
44. Graduated Cylinder
45. Soldering Torch, Gas, Sand Paper & Flux
46. Quick-Grip Clamps
47. Sponge/ Bucket
48. Small Vacuum
49. Extension Cords
50. 3-Way Plug
51. Step Ladder
52. Work Lights
53. Flashlight
54. Headlamp
55. Voltmeter
56. First Aid Kit
57. Safety Glasses
58. Lifting Belt
59. Hard Hat
60. Moving Blankets
61. Gloves - Work & Latex
62. Box of Rags
63. 5 Gallon Buckets
64. Cargo Straps
65. Tool Belt
66. Hand Truck
67. Walkie Talkies
68. Cell Phone
69. Labels or Labeler

Tooling

70. Drill Bit Set - Cobalt Steel Bits with 135° Points
71. 12 1/4" Drill Bit
72. Hole Saw Extender
73. Hole Saws - Many Sizes
74. Cutting Oil
75. Coring Bits For Stone / Concrete

Power Tools

76. 1/2" Hammer drill motor
77. Hole Saw
78. Reciprocating Saw
79. Dremel Tool
80. Angle Grinder
81. Circular Saw
82. Impact Driver
83. Angle Drill

Specialty Tools

84. Cobalt Steel Bits
85. Refractometer – Glycol Checker
86. ATP Meter
87. Pressure Tester
88. Thermometer - Two Types
(Recording thermometer)
89. Beer Gas Analyzer
90. Cleaning Kit – Recirculating Pump, Line
Cleaner, Cleaning Pot, Titration Kit, Fittings
91. CO₂ Bottle with Regulators & Adapters for
Various Tubing Connections

draught beer glossary

Acid Cleaner – Although several blends of acid cleaners are recommended to assist in beer stone and water stone removal, some acids react with system components. Phosphoric acid-based blends are the only ones safe on all materials.

Balance – Ensuring that the applied pressure matches the system requirements so that the beer dispenses at the optimum rate of about 2 ounces per second or 1 gallon per minute while maintaining brewery-specified carbonation level.

Barrier Tubing – Plastic tubing with a lining of nylon or PET that provides a gas barrier to better protect the beer from oxidation.

Beer Pump – A mechanical pump that is generally driven by compressed air or CO₂ that can move beer great distances without changing the dissolved gases.

Beer Stone- Calcium Oxalate – A mineral deposit that forms slowly on a surface from beer and is very difficult to remove.

Caustic or Caustic Soda or NaOH – Sodium hydroxide – a high pH chemical commonly used in blending draught line cleaning solutions that will react with organic deposits in the draught beer line. Very effective, but also very dangerous. Commonly used in oven cleaners.

Caustic Potash or KOH or Potassium Hydroxide – Similar to sodium hydroxide, but offers slightly different chemical properties in a blended cleaning solution.

CO₂ – Carbon dioxide, a natural product of fermentation and the gas used to push beer in draught beer systems. CO₂ leaks in the gas system are dangerous because high concentrations of CO₂ will displace air and cause asphyxiation.

CO₂ Volumes – The concentration of CO₂ in beer expressed as volumes of gas at standard conditions per volume of beer.

Coil Box – A cooling system to bring beer to serving temperature at the point of dispense consisting of a coil of stainless steel immersed in ice water. Often used at picnics or events where normal keg temperature cannot be maintained.

Cold Plate – A cooling system to bring beer to serving temperature at the point of dispense consisting of a stainless steel coil embedded in an aluminum plate in contact with the ice. Cooling is the result of melting the ice rather than just heat transfer, so water must be drained away from the cold plate. Often used at picnics or events where normal keg temperature cannot be maintained.

Coupler – The connector to the keg.

Dewar – An insulated, pressurized container for liquified gas such as CO₂.

Direct Draw – A draught beer system that has a short jumper connection from the keg to the faucet.

EDTA – Ethylene Diamine Tetracetic Acid – A cleaning solution additive that can dissolve calcium mineral deposits in draught beer systems.

Faucet – The dispensing end of the draught beer system that controls the flow of beer.

Flash Chillers – Mechanical cooling systems to bring beer to serving temperature at the point of dispense. Often used with flash-pasteurized kegs that can be stored at room temperature.

FOB – Foam on Beer detector. A device that stops the flow of beer when the keg is empty before the beer line is filled with foam.

Glycol or Propylene Glycol – A food-grade refrigerant that is recirculated through insulated tubing bundles to maintain beer temperature.

ISBT – International Society of Beverage Technologists, who created a quality standard for CO₂ for beverage use.

Jockey Box – A cooler with a coiling coil or cold plate and faucets to chill the beer at the point of dispense.

John Guest Fittings – A specific brand of quick connect for stiff plastic tubing.

Jumper Tubing – The flexible piece of vinyl tubing used between the keg and draught beer system that should be replaced annually.

Lift – The change in height from the keg to the faucet that is a component of system balance.

Line – Tubing that makes up the draught beer flow path.

Long Draw – A draught beer system over 50 feet long that uses barrier tubing in a refrigerated bundle that typically requires a mixed gas to avoid overcarbonation.

Nitrogen Generator – A system designed to separate nitrogen from compressed air, typically by membrane. Nitrogen used for beer dispense in a mixed gas application must be >99% pure.

NSF – National Sanitation Foundation: An organization that certifies food service equipment for performance and cleanability.

Party Pump or Picnic Pump - A hand pump that uses compressed air to dispense beer. This type of pump should only be used when the entire keg will be dispensed at one time, because oxygen will damage the beer.

PE – Polyethylene – Stiffer tubing used in older refrigerated bundles (this oxygen-permeable material contributed to oxidation of the beer remaining in the lines and is now only recommended for use as glycol tubing).

Pot – Pressure Pot, Cleaning Pot – A canister for cleaning solution or rinse water that is connected to a pressure source pushing the solution through the lines like beer. Does not give sufficient velocity for (mechanical) cleaning, so this should only be used on short lines with longer chemical exposure.

PSI – Pounds per square inch. A unit of measure of gas pressure.

PSIA – Pounds per square inch, absolute. A measure of gas pressure against a perfect vacuum so it includes the atmospheric pressure of 14.7 psi at sea level.

PSIG – Pounds per square inch, gauge. A measure of gas pressure against the atmospheric pressure, typically seen on gas regulator gauges. Since atmospheric pressure varies with altitude, the gauge pressure must be adjusted with altitude.

PVC – Polyvinyl Chloride – Flexible jumper tubing.

Regulator – A gas control valve that delivers a set gas pressure regardless of tank pressure. There may be a primary regulator on the gas source and a secondary regulator at the gas connection for each keg.

Resistance (or System/Component/Line Resistance) – A measure of the pressure drop across a component or over a length of tubing at the optimum beer flow rate.

Sanitizer – An EPA-registered product that is designed to kill microorganisms.

Sankey – The modern style of keg coupler. It is available in several versions to fit specific styles of keg valves produced in Europe and the U.S.

Sequestrants – Chemicals that hold metal ions in solution and prevent mineral deposits.

Series Kegs – Hooking multiple kegs together so the beer from the first flows through the second and then into the next so that the kegs can be changed less frequently.

Shank – The connecting piece that goes through the cold box wall or tower and connects the tubing and tail piece to the tap. It also can help provide system pressure reduction.

Short Draw – A draught system under 50 feet long that can be run on straight CO₂ or mixed gas, and can use air-cooled or refrigerated lines.

Surfactants – Compounds used in blended draught beer line cleaners that lower surface tension to enhance surface wetting, break the bond between deposits and the tubing surface, and suspend soils in cleaning solution so they can be removed.

Tail Pieces – The connectors that allow a piece of tubing to be attached to a piece of equipment.

Tap – The connector from the draught system to the keg (more properly referred to as a coupler).

Tavern Head – The connector from the draught system to the keg (more properly referred to as a coupler).

Tower – The mount on the bar that holds the faucets and is cooled to maintain beer temperature up to the point of dispense.

Water Conditioners – A component of a blended cleaner that is intended to carry away soils.

Water Stone – Calcium Carbonate – A mineral deposit that forms from water and can be removed with acid. ■

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