Cornelius Kegging Systems

WARNING! Working with carbon dioxide is potentially very dangerous. CO_2 cylinders are under very high pressure. If a valve were to break off of the cylinder, it would become an unguided missile, possibly causing injury or death. For this reason it is important you immobilize CO_2 cylinders by securing them (chains, bungee cords, etc.) Also, a CO_2 gas leak in an enclosed area could cause asphyxiation. Always test gas handling systems for leaks.

Inventory

- A Cornelius-style soda keg
- Filled CO_2 cylinder (needed, but not included in the kit)
- CO_2 regulator
- Faucet tubing kit - 5 feet of 3/16" ID 'foam free' tubing with a black liquid disconnect on one end and a plastic faucet tap on the other.
- Gas connector kit - 3' of 1/4" ID tubing with gray gas disconnect on 1 end and a swivel nut on the other.
- A refrigerator is recommended

Overview

It is easy to build a small draft beer system around a three-, five-, or ten-gallon "soda" keg, manufactured by the IMI Cornelius Company, Firestone, or a handful of other companies. These kegs are the same type of kegs used in the soft drink industry. After the fermentation, beer may be siphoned into these kegs. At this point, most home brewers *force carbonate* their beer, using a CO_2 cylinder and a regulator to pressurize the keg and force carbon dioxide into the beer. Alternatively, the beer may be primed and carbonated just like in bottles.

Once the beer is carbonated, the beer is dispensed from the keg by pressurizing the head-space inside the keg with carbon dioxide gas, again provided by the regulator and CO_2 cylinder. The use of carbon dioxide (as opposed to air) keeps the beer fresh and carbonated.

The CO2 cylinder

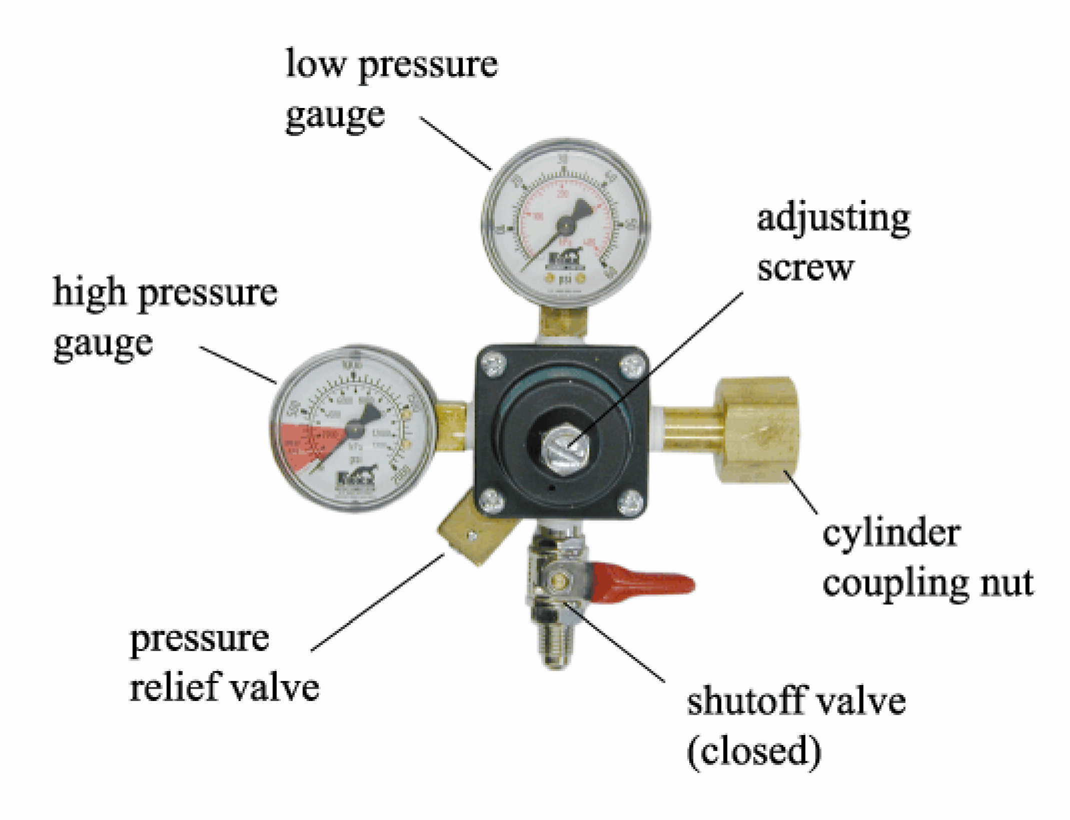
A filled CO_2 cylinder contains carbon dioxide in a liquid state. This liquid CO_2 exerts *vapor pressure,* filling the head space of the cylinder with gaseous CO_2. At room temperature, the vapor pressure of carbon dioxide is about 800 pounds per square inch (PSI). If you put your CO_2 cylinder in the refrigerator, you may notice the vapor pressure drop as low as 400 PSI.

As you draw CO_2 gas from the cylinder's head space, the liquid CO_2 evaporates to maintain a constant vapor pressure. If you monitor the pressure inside the CO_2 cylinder, you will notice that the pressure remains constant even as you draw off CO_2. The pressure in the cylinder will not drop until until the liquid CO_2 is depleted, at which point the pressure will drop rapidly.

Because of this phenomenon, the best way to measure CO_2 usage is to weigh the cylinder, and subtract the cylinder's *tare weight,* or the weight of the empty cylinder. The tare weight is usually stamped into the cylinder and is prefixed by the letters "TW". An experienced brewer will know when the cylinder needs more gas just by lifting the cylinder and assessing its weight.

A shutoff valve is located at the top of the cylinder. Keep this valve closed until you attach a regulator to the cylinder. To open this valve, you need only crack it open 1/2 turn.

Cornelius Regulator



As you might expect, CO_2 pressures in your keg system are regulated by a CO_2 regulator, pictured above. The regulator is attached to the high-pressure CO_2 cylinder by the cylinder coupling nut. The regulator is attached to the keg through a low-pressure port; our regulators have a shutoff valve installed in this port, which allows the brewer to conveniently, quickly, and absolutely shut off CO_2 flow to the keg. When the valve's lever is perpendicular to the valve stem, the shutoff valve is closed; it is open when the lever is parallel to the stem.

The regulator has two pressure gauges. The high pressure gauge, opposite the coupling nut, measures the pressure inside the CO_2 cylinder in pounds per square inch. The low pressure gauge, located on the top of the regulator body, measures the internal regulator pressure. If this pressure is greater than the pressure inside the keg, the regulator will deliver gas to the keg until the regulator pressure and the keg pressure are equal. You can simultaneously increase the regulator's internal pressure and the pressure in the keg by turning the regulator's adjusting screw clockwise. You can decrease the regulator's internal pressure (but not the keg pressure) by turning the adjusting screw counterclockwise.

The regulator also contains a pressure relief valve that will help to protect the regulator from damage if the internal regulator pressure gets too high.

The keg

A Cornelius-style keg is a cylindrical tank made of stainless steel. On top of the keg are two posts for attaching *quick disconnect* couplings, allowing you to quickly and easily attach fluid lines, such as gas or beverage tubing.

Underneath the post labeled "IN" is a very small gas down tube which is used to deliver CO_2 gas into the head-space of the keg. When filling a keg, you should make sure that this down tube is never immersed in liquid, or else liquid could get forced into the gas hose.

The post labeled "OUT" is attached to a much longer liquid down tube, which extends to the bottom of the keg. This tube remains immersed in liquid until all the liquid has been dispensed from the keg.

When cleaning or siphoning beer into the keg, access to the inside is provided via the oval lid. A rubber o-ring provides a positive seal between the lid and tank. The lid contains a pressure relief valve, which can be manually opened to vent excess CO_2 pressure from the keg. This pressure relief valve also serves as an emergency overpressure valve, automatically venting CO_2 if the pressure exceeds the maximum safe pressure of 130 PSI.

Initial Assembly and Leak Test

1. Use a wrench to tighten the connections on the gas connector kit and the faucet tubing kit. The swivel nut should be snug, but do not over-tighten.
2. Attach the gas connector kit to the regulator's shutoff valve and tighten with a wrench.
3. Attach the regulator to the CO_2 tank. Make sure to place the nylon washer between the cylinder and the regulator. Tighten firmly with a wrench. Make sure the regulator's shutoff valve is closed, and the adjusting screw is backed all the way out. Crack open the valve at the top of the CO_2 cylinder. There should be no hissing or other signs of leaks and regulator gauge readings should remain steady.
4. Attach the disconnects to the keg's posts. The black liquid disconnect attaches to the keg's liquid/out post. The gray gas disconnect to the keg's gas/in post.
5. Open the regulator's shutoff valve. Pressurize the keg to 10-15 PSI by turning the adjusting screw clockwise. Test all threaded connections, quick disconnects and pressure relief valves with soapy water or gas leak detector (available at any hardware store). Even a small leak will drain your CO_2 cylinder, and in some cases it could even be dangerous.

Sample Kegging procedure

When fermentation is complete, you are ready to keg. Thoroughly clean and sanitize your equipment: Remove the oval tank lid by lifting upward on the metal locking bars. Fill tank with 2 1/2 gallons of the sanitizing solution of your choice. We recommend using Star San, as it requires no rinsing. *Do not use chlorine, as it reacts with stainless steel and may cause 'pitting' of the surface.* Flip the keg upside down once to ensure that all surfaces remain in contact with the sanitizer. Attach gas line (gray disconnect) to "In" post of tank. Attach liquid line (black disconnect, with faucet) to "out" post. Crack open the valve on the CO_2 cylinder. Adjust gas regulator to a low pressure (1 to 5 PSI). Open the regulator shutoff valve (located at the base of the regulator) by turning it down in line with the tubing. Depress the faucet head to begin liquid flow. After running the sanitizing solution through the system, release pressure by, first, turning regulator shutoff valve to the off position; second, release pressure in tank by pulling upward on the pressure relief valve in the keg lid. If you are not using a no-rinse sanitizer, finish with a sterile water rinse.

Carbonation

There are two options to carbonate using the Cornelius kegging system. Bulk priming as you do with bottles or force carbonating using the CO_2 from your tank.

Bulk priming

1. Dissolve 1/3 cup corn sugar in a cup of H_2O and boil for 5 minutes. Add to an empty, sanitized keg.
2. To reduce oxidation during transfer, you may wish to purge the air out of the keg. Attach the gas/in line. With the lid off, adjust the regulator to a low pressure (less than 5 PSI) and run CO_2 into the open keg for several seconds. CO_2 is heavier than air and will displace it.
3. Siphon beer from the secondary fermenter into the keg.
4. Attach the lid and pressurize to about 10 PSI to seat the lid.
5. Keep keg in an area with temperatures equal to or above that of fermentation temperature to finish carbonating. Expect carbonation to be complete after a few weeks.

Forced carbonation

When beer is stored under CO_2 pressure, it will absorb the CO_2 gas until it reaches a state of equilibrium. There are two factors that determine how much CO_2 will become dissolved in beer: temperature, and pressure.

- Temperature's effect on CO_2 solubility is easy: it is easier to dissolve CO_2 in cold beer than warm beer.
- And as to pressure: the higher the CO_2 pressure, the more readily CO_2 gets dissolved in beer.

Brewers express the amount of carbonation in a beer in *volumes.* A volume is defined as the volume the CO_2 in beer would occupy at 0° F and atmospheric pressure, relative to the volume of the beer itself. For example, the CO_2 in one pint of British Ale carbonated to 2 volumes of CO_2 would occupy two pints of space.

For reference, here is a list of beer styles and the corresponding amount of carbonation:

- British Ale: 1.8 to 2.2 volumes
- German Lager: 2.5 volumes
- American Lagers and Ale: 2.6 to 2.8 volumes
- Wheat Beers: 3.0 volumes

With the assistance of a carbonation chart, it is possible to precisely carbonate a beer to any arbitrary level of carbonation. The carbonation chart shows the relationship of CO_2 solubility in beer at various temperatures and pressures. The top row contains the pressure in pounds per square inch. The first column lists beer temps. The numbers in the center represent the volumes of CO_2 to be dissolved in the beer at equilibrium.

In order to duplicate the carbonation of a German Lager, for example, you would need to force 2.5 volumes of CO_2 into the beer. If you know your refrigerator is set at 45° F, you can consult the carbonation chart below to determine that 2.5 volumes of CO_2 is achieved at 15 PSI. If you were to lower the temperature of the refrigerator to 35° F, you would need just 10 PSI of pressure to achieve the same level of carbonation.

Temperature	5 PSI	10 PSI	15 PSI	20 PSI	25 PSI	30 PSI
30° F	2.23	2.82				
35° F	2.02	2.52	3.02			
40° F	1.83	2.30	2.75	3.19		
45° F	1.66	2.08	2.51	2.94		
50° F	1.50	1.90	2.30	2.70	3.10	
55° F		1.75	2.12	2.47	2.83	3.18
60° F		1.62	1.95	2.27	2.60	2.92

Simply setting the regulator pressure to the proper level will cause the beer to become carbonated. However, it may take many days for the beer to reach equilibrium with this method. Many brewers speed up the carbonation process by shaking the keg back and forth, which drastically increases the surface area of beer in direct contact with CO2. As you do this, you will hear the regulator delivering CO2 as it is being rapidly dissolved into the beer. You should shake the keg until it becomes increasingly difficult to get CO2 to dissolve into the beer. When you are finished, leave the CO2 line attached to the beer so it may complete the process.

You can further speed up the carbonation process by over-pressurizing the keg during the shaking process. By setting the regulator to a very high pressure, say 30 PSI, it will be easier to force CO2 into the beer. There is a possibility that you can over-carbonate the beer with this method, however. Be sure to lower the regulator pressure to the proper pressure when you are finished shaking.

If the beer becomes over-carbonated, it is possible to decarbonate the beer. You should periodically pull the pressure relief valve on the keg, de-pressurizing the head space. This will cause CO2 to come out of solution and re-pressurize the head space, at which point you can repeat the process. In extreme cases of over-carbonation, or very full kegs, you may find it advantageous to leave the keg open to the atmosphere by attaching a gas disconnect to the "IN" post.

Dispensing beer

In order to dispense a nice glass of beer (as opposed to a glass of foam), the beer needs to be gradually transitioned from the relatively high pressures inside the keg to the low (atmospheric) pressures outside of the keg. Foaming is caused when the beer experiences a rapid drop in pressure, and also when the beer splashes into a glass at excessive velocity.

In general, there are two ways to pour a good beer from a draft system. You can constantly manipulate the pressures inside the keg, or you can build a well-balanced system which requires no manipulation.

Constantly manipulating pressures

1. When you wish to begin dispensing beer, reduce the regulator pressure to low, between 3 and 5 PSI.
2. Reduce the head pressure by opening the pressure relief valve on the keg.
3. Dispense beer.
4. Over time, head space will re-pressurize, and you may need to relieve keg pressure prior to dispensing.
5. Restore the keg pressure to proper carbonation pressures for storage.

A balanced system

The optimal dispensing scenario is that you dispense beer at the same pressure at which it is carbonated, and you never modify the pressure inside the keg. In order to accomplish this you need to balance the applied pressure, or the pressure in the keg's head space, and the total restriction of the beverage system.

Nearly all of the restriction in a beverage system comes from the beverage tubing. It is harder to push beer through a long length of tubing than a short length because of the frictional resistance of the tubing's surface. The frictional resistance generated by tubing is called *flow resistance.*

The actual flow resistance of a tube is influenced by many factors, such as material, inner diameter and the degree to which it bent or coiled. The most dramatic effect is tubing diameter. All other things being equal, it is much harder to force beer through a narrow diameter tube than a large diameter one. The approximate flow resistance of 1/4" vinyl beverage tubing is 0.65-0.85 pounds/foot. Compare that to narrower 3/16" beverage tubing at approximately 2.2-3.0 pounds/foot. In practical terms, if you carbonate beer at 15 PSI, this means you will need 13-23 feet of 1/4" beverage tubing to have a balanced system. In comparison, you will need just 5-7 feet of 3/16" tubing to achieve the same result.

For most home brewers' draft systems, it is impractical to use anything but 3/16" beverage tubing. In most cases 5-7 feet will give good results, however you may need to modify the length if your conditions are unusual.

Cleaning

The most rigorous way to keep kegs clean and sanitary is to completely disassemble them after each use. You will need a ratchet with deep sockets to remove ball lock posts. Underneath the ball lock posts are down-tubes: a short gas down tube and a much longer liquid down tube. Each down tube has an o-ring attached to it. I even pop the poppet valves out of the posts. With the post removed, apply pressure to the top of the poppet valve with a small screwdriver. Even the disconnects can be disassembled and fully cleaned. I use a stainless strainer to rinse all the small parts, and then I clean them in a solution of Powdered Brewery Wash (PBW). Clean the keg shell with any non-abrasive cleaner. Chlorine can pit stainless steel and is not recommend.

Used Keg Tips

There is very little standardization among Corny kegs. Used kegs come with a variety of parts that may not be original and correct for a particular keg. Regardless of their looks or mismatched parts, most used kegs make great home-brew containers.

Before Use

- Completely disassemble keg and thoroughly clean before use. Socket wrenches can remove ball-lock disconnects. Eventually, rubber gaskets pick up the soda flavors that are impossible to eliminate. So unless you're making root beer ale, replace the lid and disconnect post gaskets with new ones. You may also replace two small rubber gaskets out of sight under the gas and liquid down tubes. The rubber visible in the poppet valve in the disconnect is part of the poppet and can't be replaced separately.
- After cleaning the keg and replacing the rubber gaskets, attach the lid (centering it as best as you can within the oval manhole) and pressurize to 10 PSI. Test lid, disconnects and relief valve surfaces for leaks with a soapy water solution.
- You often can fix leaks simply by re-attaching a lid or quickly depressing a poppet valve. Work with your keg and learn its idiosyncrasies.

In-Service Kegs

- Always visually check for gas or liquid leaks when removing a disconnect. A small leak on a pressurized keg at night may mean 5 gallons of beer on the refrigerator floor in the morning.
- Keep pressures as consistent as possible. No-foam tubing should allow you to use one pressure level to maintain both proper carbonation and dispensing. You can "strip" flavor from you beer, or give in a "CO2 soda water bite" by constantly de-pressurizing and pressurizing the tank.