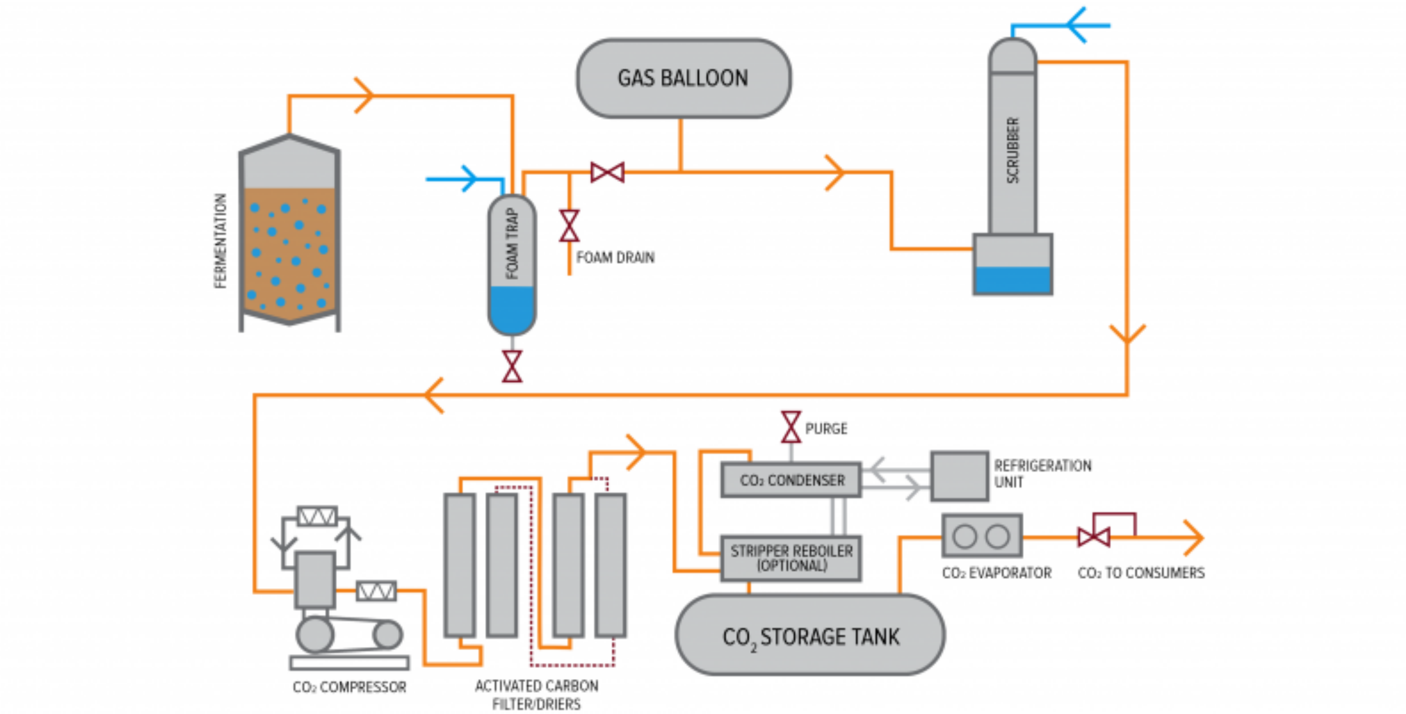
FIRST KEY
Consultants to the Brewing Industry



LOOKING CLOSER AT CO_2 RECOVERY AT YOUR BREWERY

For small breweries, purchasing liquid CO_2 can be a simple and effective method of operation. However, as production volumes and the resulting CO_2 usage volumes increase, the cost savings potential of installing CO_2 recovery equipment becomes increasingly attractive.

In some regions, concerns with reliability of purchased CO_2 supply and/or quality of the available CO_2 for purchase may be the more significant factor in considering the installation of a CO_2 system.

Packaged CO_2 recovery systems can be purchased with capacities ranging from 20 kg/hr to 10,000 kg/hr.

A 20 kg/hr collection system is suited to a brewery producing approximately 100,000 bbl/year. This equates to a 50-bbl x 4-vessel brewhouse producing 8 brews per day.

CO_2 is typically fed to the main compressors using either booster compressors or using a low pressure CO_2 storage balloon. A CO_2 storage balloon has the advantage of allowing the main compressors to run at full capacity on an on/off basis. This is the most economical mode of operation.

If booster compressors are used, the main compressors will need to run partially or fully unloaded periods of lower CO_2 generation rates, resulting in a lower efficiency.

A brewery with annual production as low as 50,000 bbl/yr could operate a CO_2 recovery system complete with CO_2 storage balloon running on an on/off basis. However, the economic justification becomes more difficult with lower production volumes and in this case reliability and quality of purchased CO_2 supply or a policy to reduce CO_2 emissions will more likely be the main driving force behind the decision to purchase.

Typical CO_2 Generation Amounts

The following chart shows the typical generation amounts for a 50-bbl brewhouse during the blow-off or venting period, collection period and tails period (typically not collected due to very low CO_2 production quantities):

Rate of CO_2 Generation during Fermentation

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SUMMARY

Original Gravity	18.0 °P
Brew Volume (in Fermenter)	50.0 bbls
	= 58.7 hLs
N° of Brews per Day	8.0

ITEM	BLOW-OFF PERIOD	COLLECTION PERIOD	TAILS PERIOD	TOTALS
Apparent Gravity at end of period (°P)	16.0	4.0	3.2	-
Calculated Actual Gravity at end of period (°P)	16.38	6.69	6.05	-
Extract Fermented this period (kg/bbl)	2.17	12.46	0.80	15.42
CO_2 Generated this period (kg/bbl)	1.01	5.77	0.37	7.14
Mass of CO_2 Vented/Collected (kg)	402	2,307	148	2,857
Average CO_2 Collection Rate (kg/hr)	-	23	-	-

Note: Typically 1.5 vols/vol of CO_2 per volume of beer remains dissolved in the beer out of fermenting. This equates to 0.327 kg CO_2 / bbl. This quantity dissolves during the Blow-Off period so that all the CO_2 generated during the Collection Period is available for collection.

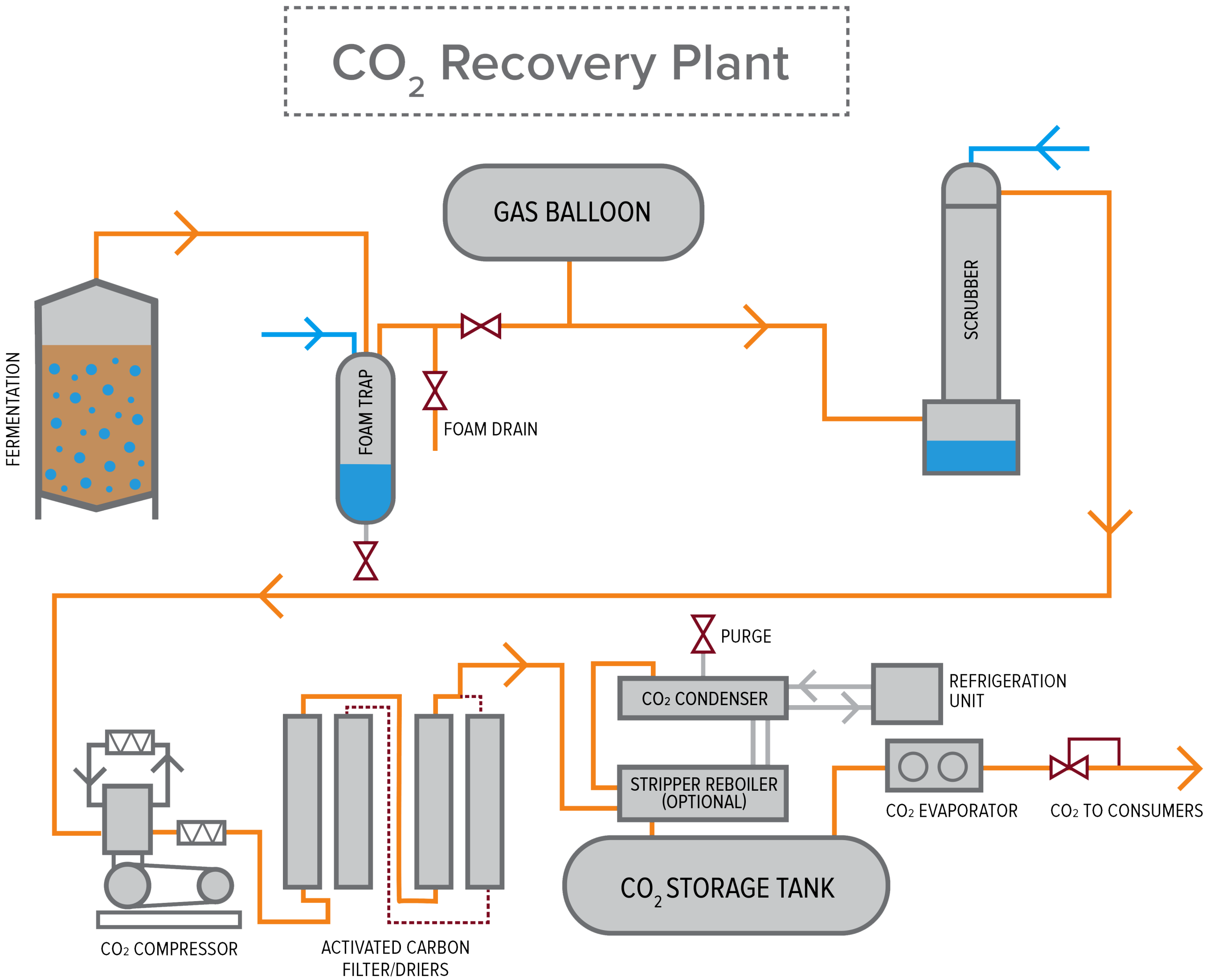
From the table above, for a 100-bbl fermenter, 5.77 x 100 = 577kg or 1,272 lb. CO_2 is generated and available for collection.

On this basis and assuming 10% loss negates increased fermenting volume due to 10% shrink, a facility with a 100,000 bbl/year final product volume could collect up to 1,272,000 lb./year of CO_2.

CO_2 Recovery Systems

CO_2 recovery systems specifically designed for brewing operations are available from a number of major national and international equipment suppliers and typically include the following:

- Foam trap
- Either a booster compressor or a low pressure storage balloon
- Scrubber/gas washer
- CO_2 compressor with intercooler and aftercooler
- Dual-tower CO_2 deodorizer and desiccant dryers
- CO_2 condenser
- Optional liquid CO_2 stripping column and reboiler for collection at lower purities.
- Liquid CO_2 storage tank
- CO_2 vapourizer



Foam Traps

Foam traps can be either vertical or horizontal vessels with city water directed spray nozzles to knock down any foam that may carry over from the fermentation vessels.

The recommended installation uses two horizontal foam traps; one vent trap and one CO_2 collection foam trap, tied in to multiple fermenting vessels. This arrangement allows for the CIP of the CO_2 vent/collection pipe from each fermenting vessel to be CIP'd as part of the normal fermenter CIP operation. Sepa nozzles should also be provided in the foam traps. Foam trap CIP must only be initiated when all fermenters are isolated from the foam traps.

For safety reasons, it is recommended that two independent automated drain valves be installed on the foam trap drain line to ensure that CO_2 is not vented into the room should one of the valves fail open. Area CO_2 monitors and alarms should be installed throughout all fermenting, ageing and bright beer cellars.

Fermenter Connections

It is recommended that the CO_2 vent/collection line be provided with a connection to the fermenter that is separate from the CIP supply to the high pressure tank C.I.P. device. A single line can be used for both CIP supply and CO_2 vent/collection. The two connections must be closely connected to the single CIP/vent/collection line with an automated butterfly valve in the line to the CO_2 vent/collection connection on the fermenter.

The butterfly valve is open during all process operations and closed only during tank CIP to force the CIP solution through the tank CIP device.

A good option for CIP of the short CO_2 vent/collection branch to the fermenter can be accomplished by drilling two small holes through the butterfly valve seat directed toward the pipe walls. The holes should be sized for a total flow 5 to 10 USGPM at the required pressure drop for the tank high pressure CIP device.

Booster Compressor or Low Pressure Gas Balloon

In North America, breweries typically use booster compressors to increase the CO_2 pressure from the 1 to 3 psig fermenter pressure to approx. 10 psig to supply the main compressors. This allows for a reduction in the CO_2 pipe size, but results in a less efficient operation of the main compressors which must often run unloaded due to fluctuating CO_2 flow rates.

European breweries commonly use a gas balloon to store CO_2 at fermenter pressure. This system has the advantage that the main CO_2 compressor(s) operate at 100% capacity on an on off basis. This provides the highest efficiency for operation of the compressors. The gas balloon requires more space than the booster compressor system and larger diameter piping from fermenting through to the CO_2 compressor(s).

Scrubber/Gas Washer

Prior to compression, the low pressure CO_2 must pass through a counter-flow water scrubber to remove water-soluble impurities such as ethanol.

If aerosols (similar to sugars) are determined to be present in the CO_2 from the fermenting vessels, an aerosol washer can be added to the scrubber to prevent compressor valve fouling and the resulting higher maintenance costs.

CO_2 Compressor

The main CO_2 compressor is a two stage unit designed to handle wet CO_2. The compressors are designed to compress the CO_2 from fermenter pressure to approx. 250 psig and include an inter-cooler and after-cooler with moisture separation.

CO_2 Deodorizer and Drier

The high pressure CO_2 is passed through a twin tower activated carbon purifier/deodorizer and Dry ensure that the CO_2 is suitably purified for food-grade usage and dried prior to condensing. Regeneration is accomplished in the off-line tower using hot air or purge gas.

CO_2 Condenser

The deodorized and dried high pressure CO_2 is now suitable for condensing using a Freon/CO_2 condenser.

For breweries using ammonia as their prime refrigerant, a cascade ammonia condenser system is required to ensure that CO_2 cannot leak into the main plant ammonia system resulting in the precipitation of solid ammonium carbonate which is destructive to the system.

CO_2 Liquid Stripping Column

Conventional CO_2 recovery systems require the CO_2 from the fermenter to be at least 99.7 vol% CO_2. To reach this concentration, the fermenters must be vented for at least 24 hours prior to switching over to collection.

The addition of a CO_2 liquid Stripping Column and Reboiler will strip oxygen from the CO_2 liquid allowing the fermenter to be switched over to collection at 95 vol% CO_2 which occurs after approx. 16 hours from start of fermentation for an additional 8 hours of collection on each fermentation cycle.

Adding a CO_2 liquid stripping column will also increase the purity of the CO_2 delivered to the CO_2 storage tank from > 99.97% for a conventional system to > 99.998% /
O_2 < 5 ppm.

Liquid CO_2 Storage Tank

Because CO_2 gas is 1.5 times heavier than air, the Liquid CO_2 Tank presents a serious, possibly fatal safety risk in the event of a major leak.

Therefore liquid CO_2 storage tanks are recommended to be located outside and away from areas of possible impact.

In the event that a liquid CO_2 storage tank must be located inside, it must be enclosed in a separate room which is provided with an emergency ventilation system and CO_2 monitors/alarms.

CO_2 Vapourizer

High CO_2 usage rates require the addition of a vapourizer to provide the necessary heat source to vapourize the liquid.

Electric vapourizers are commonly used in breweries though other options including atmospheric air exchangers are in use.

Additional CO_2 Savings Opportunities

The addition of horizontal foam traps to ageing tanks (e.g. if cylindro-conical tanks (CCTs) are operated as multi-use tanks rather than as uni-tanks) and to bright beer tanks will allow the transfer of CO_2 directly from a tank being filled with beer to a tank that is being emptied without the risk of foam carry-over. This opportunity comes with the provision that the beers on the shared system are all similar so that there are no concerns with migration of flavours through the counter-pressure system.

Beers flavoured with such additives as lime or other similar strong flavouring must be isolated from a shared counter-pressure system to avoid cross contamination.

This type of foam trap set-up has the added advantage of serving as the demarcation point between the infrequently cleaned CO_2 supply system and the regularly cleaned production system.

Installing a system to allow for acid CIP of bright beer tanks under CO_2 counter-pressure provides another CO_2 savings opportunity. Some CO_2 is lost to the CIP solutions but typical tank pressures after an acid CIP vary between 1 and 4 psig assuming a starting pressure of 12 psig depending on the CIP rates and times. Even with the losses, a considerable volume of CO_2 can be saved by installing facilities to enable CIP under CO_2 counter-pressure on bright beer tanks.

Process Engineering, Environment, Health, Safety