American Society of Brewing Chemists

Online Resources

2003 Annual Meeting - Hyatt Regency Tamaya, New Mexico

CO2 Quality Seminar summary

The CO2 Quality Seminar was held on June 11 at the Tamaya Resort in New Mexico. Dirk Bendiak (ASBC president, Molson) facilitated the seminar, and scribe responsibilities were performed by Rob Maruyama (Coors). Approximately 20 people attended. Dirk opened the session by summarizing the issues facing brewers with regard to CO2: purchase, recollect, and use. Dirk asked the audience what their expectations were for the seminar. The attendees wanted more information on off-load CO2 criteria, CO2 in packaging, measuring CO2 purity, environmental impact of CO2 discharge from fermenters, and CO2 standards.

Dirk introduced the first speaker, Jeff Prophet, from Coca Cola North America. Jeff's presentation, titled "The CO2 Industry," was very interesting and paralleled the issues facing the brewing industry. Jeff provided the attendees an opportunity to learn more about CO2 and how the soft-drink industry manages the important process of handling CO2.

CO2 comes from many sources, and the end user must know and understand the implications of the specific source used. Historically, ammonia plants were the most common source of the gas. Refineries also generate CO2 as a by-product of hydrogen production. In some locations, CO2 comes from natural wells, which tend to be the cleanest sources. The fastest-growing source of CO2 in the Midwest is ethanol-production facilities. The cleanest sources are becoming more rare, and fermentation processes appear to be the primary source of CO2 for the future.

Jeff detailed the CO2 generation processes in more detail. The ammonia process uses methane, water, and heat cracking to produce carbon and hydrogen. Addition of air converts carbon monoxide to CO2. Typical compounds found as contaminants are hydrocarbons, carbon monoxide, sulfur compounds, aromatic hydrocarbons, and alcohols. The refinery process is similar to ammonia generation, but air is not added. The feedstock is usually a hydrocarbon off-gas source. Hydrocarbons and aromatic compounds are typical contaminants found in this process. In some locations, natural wells are found in geological formations. CO2 is removed from these wells; corrosion inhibitors are typically added; and a compressor is used to liquefy the raw CO2. Hydrocarbons, sulfur compounds, aromatic hydrocarbons, moisture, and corrosion inhibitors are typical contaminants. During ethanol processing, CO2 is produced by fermenting grain. Scrubbers are typically used to purify the CO2 and remove common contaminants such as alcohols, sulfur compounds, aromatic hydrocarbons, and moisture.

Jeff stated that a number of purification processes are used to improve the quality of the CO2. Molecular sieves, catalytic oxidizers, distillation processes, and activated carbon are used to remove hydrocarbons. Typically, all plants have some type of distillation process to remove the noncondensable hydrocarbons. High levels of sulfur are removed by using zinc oxide or an iron sponge bed application, which is expensive. Low levels of sulfur can be treated by a low-cost method using metal-impregnated carbon or molecular sieves with heat regeneration. Alcohol removal is accomplished by using water scrubbers for high levels and a molecular sieve with heat generation for low levels of alcohols. Moisture levels in purified CO2 are maintained by using alumina, molecular sieve, or distillations processes.

The standards of the International Society of Beverage Technologists (ISBT), guidelines of the Compressed Gas Association (CGA), and ISO 9000 Standards are typically used as CO2 standards. Coca Cola developed its own standards because of the variations observed with existing standards. Jeff suggested that each company should develop its own CO2 standards document that outlines its specific requirements. This document should contain quality system information, operations methods, and requirements for calibration, storage and handling, training, and self-auditing.

Jeff has found that audit tools are very effective in managing CO2 quality. The audit covers all customer and supplier requirements. The auditor is calibrated for consistency; performance scores for the supplier's plants are generated; and the audit scores are communicated to the supplier and the user.

What does the CO2 market look like in North America? Jeff gave the attendees an overview of North American CO2 production. Ten different supply companies use over 100 supply points. Of those supply points, 75% are located near sources of raw gas and 25% are near rail depots, which are located near sources. This information suggests that the customer must be aware of the source and transportation processes of its suppliers.

Jeff closed his presentation by providing the attendees with a look into the near future. He stated that the bulk of the CO2 is produced at ammonia plants, which typically provide high-quality CO2 consistently. Currently, the ammonia industry is weakening due to higher natural gas costs. The CO2 capacity is nearly sold out, so CO2 shortages could be a reality. In the CO2 business, beverage (soft drink) manufactures represent about 10% of CO2 sales and brewing represents about 1%. The bottom line is that brewers and beverage (soft drink) manufactures are not the gorillas (big users) in the industry.

Quality requirements have raised the basic cost structure of the CO2 provider. The CO2 industry is looking at less-pure sources (refiners, wells, ethanol plants, stack gases) and at internal/non-traditional sources. New sources of high-quality CO2 can help the industry. Brewers are seen as an underutilized source of CO2.

After Jeff's presentation, Dirk introduced the next speaker, Dwight D. Garrells from Anheuser-Busch. Dwight's presentation was titled "Management of Brewery-Recovered CO2." This presentation dovetailed nicely with the industry information Jeff had just presented. Dwight talked extensively about how CO2 is managed within a brewing facility.

Dwight reviewed the importance of CO2 on beer characteristics (foam retention, appearance) and on beer quality and freshness (blending water carbonation; elimination of air in lines, tanks, and packages before beer contact). He also described how CO2 is typically captured as a fermentation by-product. Generally, the fermenter is open to the air, filled, and vented for the first 20 hr of fermentation. As more CO2 is generated and less air exists, the collection starts. That collection stream contains volatiles and beer foam. Typically, 1 lb of extract equals 0.48 lb of CO2, of which 0.08 lb/bbl is absorbed into the beer and 0.40 lb/bbl is available for collection.

Air or oxygen concentrations are usually controlled by how long the fermenter is vented (between 10 and 40 hr) before collection begins. Fermentation-based compounds like acetaldehyde, dimethyl sulfide (DMS), and ethanol are natural by-products found in CO2.

A typical CO2 train includes fermenters, a foam trap, a seal tank (physical back pressure <1 psi), a booster pump (3 psi), scrubbers (for water-soluble contaminants), a water trap, deodorizers/activated carbon (for organic contaminants), a booster pump to 65 psi, a cooler, a moisture trap, and storage at 65 psi. The CO2 can be used at this point or stored (at 240 psi). It then goes through a cooler, dryer, filter, and condenser (vapor to liquid), is stored in fermented liquid storage tanks, goes through a vaporizer, and then is sent back to the brewery. Brewers can also add purchased CO2. This is rarely done, and purchased CO2 isn't used for blending, only for cover gas. Typically, the purchased and captured CO2 streams aren't mixed.

There are a number of brewery uses for CO2. It is used in degasified water carbonation, line purging and/or packing after cleaning, counter-pressure gas in beer tanks (12-15 psi), beer press-outs (water and CO2 used), and tank purging before beer fill. Its packaging uses include purging bottles two or three times before filling, removing O2 in packaging containers, and providing positive pressure during filling. The key to packaging beer is to reduce the O2 content, which in turn improves beer shelf life.

After Dwight concluded, Dirk introduced the next speaker, Jeff Cornell from the Coors Brewing Company. Jeff's presentation was titled "CO2 Quality and Purity Analysis-An Approach from the Brewing Industry." Like the prior speakers, Jeff's presentation thoroughly covered the analytical issues associated with analyzing CO2 in a brewing facility. He pointed out that we should be concerned with CO2 quality because it is an ingredient, not just a utility. Brewers have the product's flavor, image, and reputation at stake.

The previous speakers eloquently covered the sources of CO2 and their contaminants, so Jeff addressed the CO2 sampling and analysis issues. He stated that sampling is typically done during incoming inspection (liquid from a tanker) or during CO2 recovery. How do you get representative samples from the right place at the right time? Jeff commented that having an inert sample pathway, especially for sulfur, is critical. He mentioned a product produced by Restek (Sulfurnert) as being a good way to achieve an inert pathway for the CO2 samples. He also identified the importance of purging or evacuating lines. Samples must be homogenous. One also must consider the implications of pressure, flow, temperature, and moisture (ice plugs, humidity) during sampling.

At this point, Jeff walked the participants through a typical installation of in-line CO2 monitoring equipment. He talked about needing input on certain factors during planning. They include installation requirements, roles and responsibilities for operation and maintenance of the instrument, location of analyzer and utilities, frequency of analyses, desired access to results (because this need drives the level of automation desired/required), selection of instrumentation and automation, and use of a multidisciplinary project team (analytical, engineering, utilities, finance, and vendors).

Jeff reviewed the approach Coors has taken. Coors is using an in-line automated system to evaluate the quality of "house" CO2 and the process control of CO2 purification. The system performs analysis of incoming truck loads, which allows for accept/reject before unloading. The system requires minimal operator intervention, and ISBT guidance is followed. Calibration of the system is easy. System flexibility meets current and future needs. A single vendor for service/support has been nice, and these systems are used to ensure consistency in a multiplant setting.

Jeff reviewed some of the components that the system needed to analyze: total and speciated sulfur (DMS, H2S, COS-low ppb levels), total and speciated aliphatic hydrocarbons, hydrocarbons, oxygen, HCN, arsine, phosphene, oil, moisture, and ammonia. The results are displayed as simple pass/fail at a PLC. The panel views are real time and can be accessed via plant information systems. New data points are collected every 30 min (train1, train2, and combined). The data are used to monitor DMS purification by looking for a breakthrough, which indicates that carbon tower changes are needed. The system is also used to optimize utility processes (valves, etc.), and tracking trends in purchased CO_2 is also possible.

Dirk concluded the seminar by asking the attendees if their original expectations had been met. As he reviewed the expectations captured at the beginning of the meeting, everyone felt their questions had been answered. Dirk thanked the presenters and the attendees. The session was closed.

-Rob Maruyama