BEST PRACTICES GUIDE TO QUALITY CRAFT BEER

Delivering Optimal Flavor to the Consumer

BREWERS ASSOCIATION®

This brochure is designed to provide general guidelines for distributors, shippers, publicans, sales staff, grocery stores, liquor outlets, bars and restaurants to better deliver high-quality craft beer.

INTRODUCTION

This document is intended to provide some guidelines and tips to help maintain beer in the best possible overall condition. We will show you how to keep your beer "brewery fresh" from bright tank to consumer's glass. Beer is a perishable product and many things can diminish a beer's quality from the time it is brewed to the moment of consumption. In this guide, brewers, distributors and servers will learn the skills necessary to preserve beer quality, so that consumers receive a consistent product every time.

First, we'll cover the basics: definitions of beer quality, stability parameters, and flavor perception. Then we'll look at what can cause beer quality to deteriorate, why those negative changes take place, and how best to prevent them. Once these issues are understood, it is possible to present details of best practices that can help everyone in the distribution process minimize damage to beer while in trade.

QUALITY

Beer quality is measured by a complex set of sensory characteristics that include appearance, aroma, taste and texture. These indicators of beer quality build a sensory profile specific to your brand, and are what craft beer consumers come to enjoy and expect from your brewery. Maintaining and preserving consistent quality in turn builds brand loyalty. Understanding how that beer sensory profile can deteriorate with age is critical to delivering a consistently fresh product.

Beer is a delicate, perishable product, and in most cases it is at its best before it leaves the brewery. That means the minute it leaves the brewery, chances increase that its quality will decrease. And the further it travels from the brewery, the more difficult it becomes to maintain that quality. Therefore, everyone involved in the production, distribution and service of craft beer shares a responsibility for familiarizing themselves with, and maintaining, product freshness.

The reputation and success of the craft brewer relies on the ability to consistently deliver a product that satisfies the consumer.

STABILITY

Product stability can generally be broken down into three categories: physical, which mainly affects clarity; microbiological stability, usually affected by spoilage or contamination; and flavor stability. The first two are most easily prevented by the brewer, but these problems may occasionally crop up at draught dispense—more on this later. Flavor stability usually becomes an issue over time in transportation, distribution and service. Let's take a closer look at physical and biological stability before we delve into beer flavor properties, and how our perception of beer flavor can change as it ages.

Quality Characteristics of Beer: A Brief Overview of Sensory Perception

Broadly speaking, beer is evaluated with all the senses: flavor, including taste and aromatics; appearance, including color, clarity, carbonation (and the resulting tactile sensations) and foam (the appearance, rise and release of gas bubbles); and stability, again covering clarity (absence of hazes caused by physical mechanisms or microbial contamination) and foam stability (long-lasting with good cling).

Brewers, distributors and servers should all have a thorough understanding of these factors. With the exception of natural aging, many of these properties or attributes are mostly under control by the brewer but, as seen below, can be negatively affected by poor handling at any point between leaving the brewery and eventual consumption.

Physical stability: Hazes and precipitates – Over time, clarified (filtered or fined) beer in trade can show light precipitates or colloidal gels as proteins and other compounds coagulate. Unfiltered or heavily hopped beer may be naturally hazy.

However, if lighter styles like Pilsners for example are clear at packaging but are aged too long, they will sometimes show the aforementioned gels and precipitates. This is usually accompanied by oxidized flavors and staling notes as outlined below. Haze in traditionally clear beer styles may be seen as a quality issue by consumers. "Born on" or "Best by" dating actually came as a response to haze-related issues by major brewers. These days, flavor deterioration is likely to be noticed by consumers before potentially unsightly hazes and precipitates but this "quality factor" should not be overlooked in the distribution chain.

Microbiological Stability – Microbiological contamination by wild yeasts, molds and a wide variety of bacterial species can cause off-flavors (aroma and taste), souring of beer, over-carbonation of beer, gushing (violent eruption of beer from bottles) and serious hazes and gels/particulate matter (scums and biofilms) in beer. Bacteria and associated flavor notes that might affect beer in trade are outlined under the Draught dispense sections and in Tables 2 and 3. Beer provides a good nutrient source for many (fortunately non-pathogenic but still undesirable) organisms. Dirty containers, taps, lines, kegs, bar towels and drains can all be bacterial sources of contamination. Preventative measures for beer that has already undergone brewery packaging are outlined below. Distributors and servers who adopt a thorough, regularly scheduled cleaning regime to maintain hygienic conditions can easily prevent beer spoilage by microbiological contamination. Of course, there is also the issue of cross-contamination for brewers who produce spontaneously fermented, sour or wild beers. (Wild yeasts can also "spoil" beer if they are introduced unintentionally, but this issue is beyond the scope of this guide.)

Flavor Stability – So, physical and microbiological stability issues are primarily and largely controlled by various means by the brewer; but it is noted and emphasized that things can go wrong in trade if beer is not handled correctly. Such issues are broadly presented through the text and tables below. Flavor issues are, however, the most important for the present discussion so we next consider the general flavor properties of beer in order to better understand its overall quality perception.

PERCEPTION

A number of factors affect perception and the overall reception of beer. Such information should be understood by those serving beer to quality conscious consumers.

Beer color and clarity – These are the first impression. As the saying goes, consumers first drink with their eyes. Color sometimes implies (often incorrectly) strength but does define many styles and expectations. Some beers may be hazy by design; wheat beers, some bottle conditioned beers if the yeast sediment is disturbed, and occasionally, heavily dry-hopped beers). Other beers are expected to be crystal clear.

Beer foam (or head) – Most customers expect beer to have an attractive foamy (or moussy) head which lasts a good length of time and that will lace and cling to the sides of the glass. Foam traps volatile flavors from readily escaping to the atmosphere and thus enhances the overall flavor perception. Correct pouring/dispense and use of suitable, clean glassware will help promote the correct foam characteristics and ultimately the optimum sensory perception of beer.

Beer aroma – Aromatics are defined by process, raw materials, soundness of the beer, and style. Rough handling during distribution, or dirty tap lines at dispense can lead to off-aromas. Correct serving temperature, correct type of glass, and carbonation level all affect the volatility, aroma release and perception of the beer.

Beer carbonation – The correct level of gas in beer is important. Carbon dioxide is the most commonly used gas, though carbon dioxide/nitrogen blends are used for some styles, and may alter tactile sensations, volatility/release of flavor components, and visual perception. Nitrogen helps soften the flavor of the beer.

Body and balance – Beer produces tactile sensations: thin/watery, full mouth coating, warming (alcohol notes), and fizzy or "tingling" sensations from carbonation. This is also related to visual perception of carbonation bubbles in the beer. Flavor balance also includes sweetness/maltiness and dryness/hop bitterness. These qualities vary considerably by style.

Beer flavor – Beer flavor is a combination of many of the above component parts; an interplay of individual ingredients which work together to form the overall flavor impression. Consumers, as previously mentioned, expect a specific beer to have a consistent flavor: that is, it should be "true to type" or "true to brand". The focus for understanding how to handle beer in trade and dispense will, therefore, now be on off-flavors that can arise in beer. Examples may include souring or slick/fatty/buttery notes or sensations, arising due to contamination of beer lines, and papery/stale notes due to aging or oxidation. There are many features and properties of beer that can be controlled to minimize deterioration of overall quality.

Understanding Beer Flavor and Aging - Flavor Changes

Beer flavor is an exceedingly complex balance of over a thousand different compounds. Many of these are present in levels below or just at sensory threshold (the point at which we can detect them). However, via complex aging reactions, certain existing flavor compounds can change chemically; new flavor notes may be generated, causing numerous flavor faults or off-flavors in beer. It is these flavor notes that must be monitored and managed by careful control in distribution, during warehousing/storage, and in delivery of packaged goods or during bar-dispense to the consumer's glass (See Table 1 and Figure 1).

Whether a flavor is regarded as undesirable or not depends upon several factors: the beer style, the sensitivity of the taster, and the consumer's expectation.

HOW DOES BEER AGE OR DETERIORATE WITH TIME?

Beer flavor is not static; it is in a constant state of change. Deterioration starts once beer is packaged. Stronger beers such as IPAs and imperial stouts were specifically made to last longer. Beer style should be considered when choosing portfolios or flagship beers to ship long distances and over extended periods of time.

A beer's composition (alcohol carbonation, hops), exposure to oxygen and temperature can all affect its flavor stability. This is true from brewing to packaging through to consumption. Consumers are becoming ever more educated in what constitutes the appropriate flavor notes and "freshness" of beer. But it is the brewer who must dictate the shelf life, given an understanding of the "average conditions" their beers will see in trade.

Research since the 1970s, dealing with the stability and aging of beer, led to the generation of a general profile for "typical aging" of beer (attributed to Dalgliesh, 1977). Figure 1 shows the major changes that take place in beer as it ages. Not all beers age in the same way, but this is a general profile to serve as a starting point for understanding when beer may need to be pulled from store shelves or bar/restaurant menus.

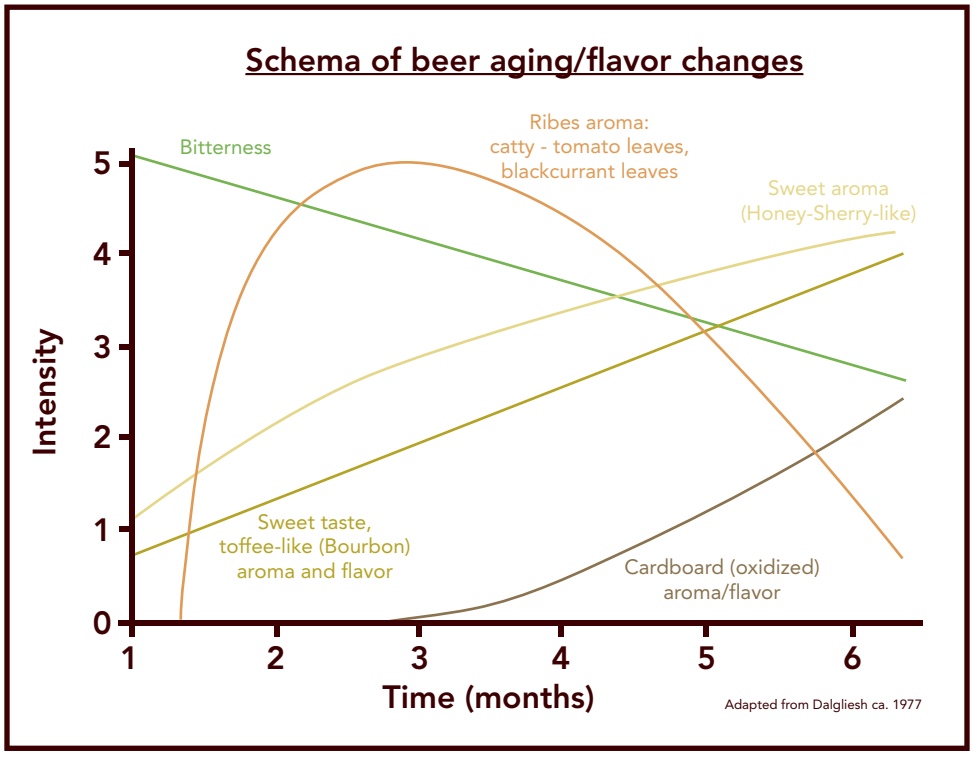

Figure 1: *General schematic showing how beer ages - the details are generic and to be taken on a timeline basis as a guide only (some schemes do not indicate a timeline but assume a 6 to 12 month x-axis). Different beers age in different ways and this depends on composition, storage and handling. Some similar schemes, for example, illustrate oxidation starting even earlier than shown here, but still with an initial gentle rise. As with the beer flavor wheel, this graphic representation of flavor evolution is to be used as a tool to guide sensory testing of each particular beer and, for example, to understand when it is past its "best by" date.*

In general, beer bitterness declines with age, and a concomitant oxidized sweetness (toffee or Bourbon) that masks bitterness appears progressively along with caramel, honey, burnt sugar, and/or toffee-like and sherry-like aromas (sometimes described as leathery or dark-dried fruits). As these changes take place, the characteristic of ribes (reminiscent of blackcurrant leaves, or sometimes referred to as "catty" – see Table 1) rises quite rapidly and then declines. Next, as beer starts to show age and oxidation, the characteristic wet paper or cardboard oxidation notes appear. Once full oxidation has occurred, the beer is aged/old and will never recover. If this flavor note can be avoided or its appearance slowed, then the beer will enjoy a long(er) shelf life. Harsh after-bitter and astringent notes may also become present in the taste and positive flavor notes and attributes such as fruity/estery and floral aromas may disappear (see below).

Decreases in regular flavor characteristics can be as significant as increases in flavors normally associated with aging. So all involved in beer distribution/dispense need to understand what the beer should taste like when in peak condition.

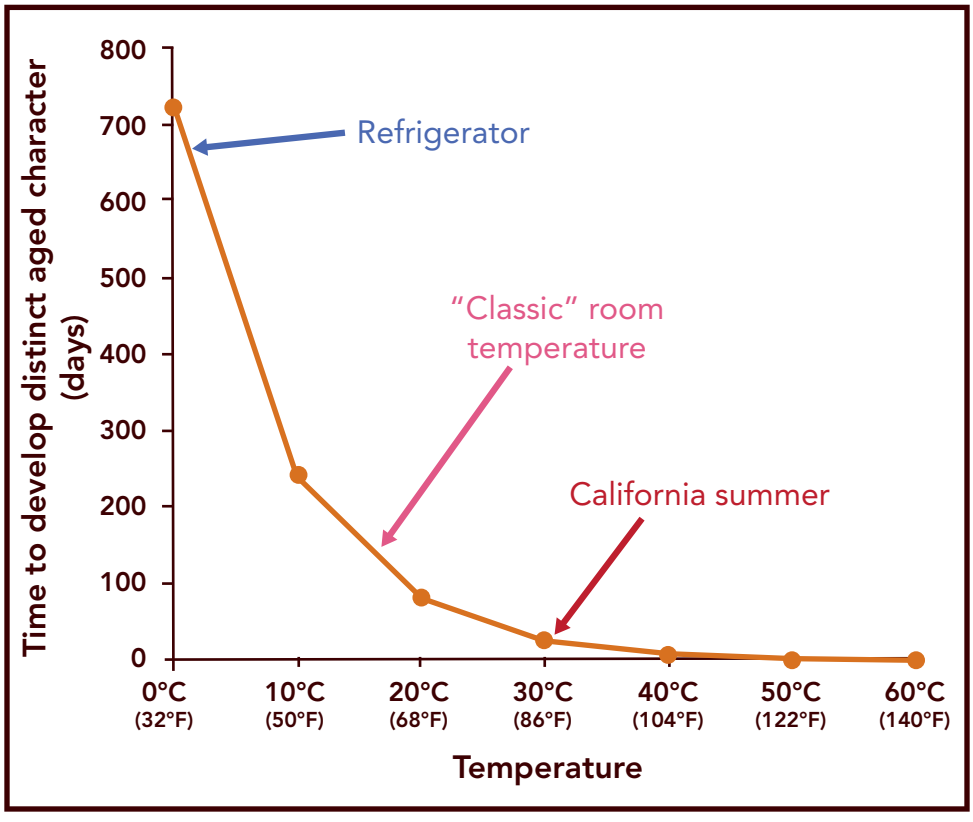

Figure 1.5: *Expected time to beer spoilage vs. beer storage temperature. The colder it is, the longer it will stay fresh (courtesy of Charlie Bamforth, UC Davis).*

High levels of oxygen in beer lead to more severe oxidative damage and there is a close correlation between ribes odor and headspace air. Therefore, minimizing oxygen uptake during brewing and packaging is critical. Storage temperature can also affect beer staling. Lagers aged at 25° C tended to develop caramel characteristics. The same beers aged at 30-37° C developed cardboard-like notes. So once packaged, beer can really suffer from heat, especially if long shelf times are expected. Time and temperature play together (with any residual oxygen or other oxidizing agents that might be naturally present in beer) to cause flavor deterioration. Lower temperatures for shipping and warehouse storage will preserve beer quality; beers tested at 4° C (39° F) were shown to have a shelf life of 112 days. This was reduced to only 28 days when tested at just 20° C (68° F). Warmer conditions increase the rate of many chemical reactions including oxidation reactions which might involve oxygen directly or other oxidants such as mineral ions. Figure 1.5 shows the relationship between storage temperature and the time it takes for beer to developing distinct age-related off-flavors. Quite rapid flavor changes are to be expected if consistently low temperatures are not maintained.

Three things that will help lock in brewery freshness: low oxygen levels, low temperatures and fast turnaround times from brewery to glass.

HOW TO KNOW IF A BEER IS STALE

"Stale" is not a specific, consistent off-flavor. It has different characteristics depending on beer style but broadly (compared to fresh beer flavor) we can note:

- Slightly staled – Ribes flavor (characteristic note of blackcurrant leaves and stems and associated with high headspace air content – also described as "catty" and like tomato plants. Found in the early stages of oxidation), cardboard impression, loss of estery notes, and astringent bitterness. (See Table 1 for further definitions.)
- Staled – Bready flavor notes, changes in body or mouthfeel, and harsh bitterness.
- Very Stale – Honey-like flavor, decomposed bitterness.
- Extremely Stale – Sherry. (Later leathery notes may appear.)

And in relation to specific classes or styles:

- Lagers – Increase in sweet, stale (ale) papery/cardboard and metallic notes. But alcoholic, floral, and DMS (dimethyl sulfide) (See page 11) characteristics decrease. Become less lager like—more ale-like.
- Ales (low gravity) – Ale character retained but is diminished as sweet (molasses), dried fruit, cheesy, and, in extreme cases, catty flavors arise. Perceived estery aroma and flavors decrease (due to masking rather than physical diminution). Vinous (wine and sherry-like) notes may appear.
- Stouts – Oxidation damages malty and caramel notes. Cheesy notes may arise as well as stale flavor.
- Strong beers – Quite flavor-stable, relatively speaking. Do not develop the papery, leathery, and metallic notes common in lower strength beers. Caramel, licorice, and astringent flavors are increased. Alcoholic and burnt notes change. In general, it seems stronger beers mellow (get smoother) with age. But as yeast cells age and die, they can autolyze, giving rise to salty, soy sauce-like/MSG notes. These notes have interesting effects on overall flavor and may not all be regarded as bad.

More detailed flavor notes associated with beer aging and spoilage are presented in Table 1. As a complement to Figure 1, the data in that table shows the flavor attributes to look out for when tasting any beer along with some notes on how to minimize or avoid deterioration of the beer.

As staling progresses, alcohol, floral, malty, and caramel notes and body (mouthfeel) decline.

Table 1 *(Opposite Page). Flavor notes associated with aging. Most are considered "off-flavors" but other reactions and conditions can cause other flavor notes to change that detract from "fresh flavor" or that are otherwise detrimental to the taste of beer.*

Table 1

Flavor Note	Descriptor	Notes
Acetaldehyde	Green apples, bruised apples, grassy, latex paint.	Associated with overly fresh "green beer" but also an indicator of oxidation with very old beer. Also from bacterial infection. (Zymomonas, Acetobacter, Gluconobacter - some organisms described in more detail in Table 2.)
Caproic Acid	Stale, goaty, cheesy, sour, tallowy, dull.	Produced as beer ages. Associated with the breakdown of fatty acids.
Catty, Ribes	Catty, cat-box, or tomato plant (leaves), blackcurrant leaves.	Sometimes noted – distinct cat-urine note in old oxidized beer. Often not a big taste issue once initial aroma perception is overcome. Some newer hop varieties can convey this note (along with onion-like notes and hints of garlic).
Diacetyl - Listed here as an aging flavor based on heat conversion of precursors BUT see also Table 2 – Other beer off flavors and their causes.	Butter, butterscotch – roundness or slickness on the palate.	Acceptable in some levels in English ales but coming under scrutiny as an undesirable food component. May arise from precursors remaining in finished beer if beer is subjected to high temperatures with some oxygen contact.
DMS (Dimethyl sulfide) - Can possibly diminish over time by forming complexes with other compounds or staling components such as phenyl ethanol (a rose-like flavor)	Cooked corn, veggie-like, tomato juice, oysters and the ocean (spray) (nuances in the overall flavor perception arise, from left to right, as the concentration rises).	May be produced from insufficient boil time in the kettle, excessive oxygen/ pasteurization, or from bacterial spoilage. Not typically an aging flavor as such but diminishes in intensity in lagers with age.
Honey	Clover honey, sweet notes.	Oxidation of lager beer.
Meaty, Bouillon, Marmite (Yeast Extract Spread) (Strong beers with yeast present.)	Salty, MSG-like, soy sauce notes.	From the autolysis of yeast. A component of barley wines but also a potential issue with any bottle or cask conditioned beer.
Older (stale) Beer, Bready *See "Oxidation" – these are complex issues but stale notes are different (more cooked like) than the papery/cardboard-like dryness of "true" oxidation. Derived from complex chemistry taking place during malting, brewing and aging.*	Oxidized, stale toast, cooked flavors.	From beer subjected to high extremes of heat. Pasteurized beers can also show these flavor notes. Time and age factors also at play.
Papery, Oxidized *As noted above under "Older (Stale) beer" these notes are different and arise through different mechanisms than "typical" thermally-induced staling reactions. Again derived through complex chemical reactions.*	Paper, wet cardboard,lipstick, fatty acid-like.	High oxygen levels can cause this, especially during packaging, unless the displacement gases are carbon dioxide, nitrogen or a mixture.
Skunky, Lightstruck	Skunk-like sulfury notes.	Hop acids (bittering compounds) react with sulfur compounds in the presence of light (sunlight and fluorescent lights). Brown glass is somewhat protective; beer packaged in green or clear glass particularly susceptible. Bottled beer in any color glass should not be exposed to bright light such as store shelves. Maintain in outer packaging boxes, etc., in the dark and cool as much as possible.
Stale Hops, Isovaleic Acid	Cheesy (Asiago), sweaty socks.	From use of old hops or possible staling of highly dry hopped beers.
Sufidic	Rotten eggs, hard-boiled eggs, hair permanent solution.	Possibly arising from yeast in bottle conditioned beers if appropriate refermentation takes place. Lager yeasts produce more sulfur than ale yeasts. Pectinatus or Megasphaera bacterial infections of beer can also produce sulfur notes.
Other Notes:		
Leathery	Older beer flavors.	See text.
Metallic	Older beer flavors.	See text.
Toffee, Syrupy	Toffees, candy-like notes, etc. (See Figure 1.)	Oxidation or associated with diacetyl.

Light-induced Beer Damage - While not strictly related to the aging profile presented in Table 1, for bottled beers, coverage must include a brief discussion of light-induced damage. Beers made with traditional hops or hop extracts convey bitterness from isomerized alpha acids. These acids can produce a potent, "skunky" sulfur compound when exposed to strong light, sometimes noted as the "imported beer flavor". Amber (brown) glass is a little more protective, as it can screen out damaging ultraviolet light. Green glass offers less protection; clear glass offers almost none. But in truth, no bottles should ever be exposed to sunlight or fluorescent lights; otherwise the light-struck or "skunking" reaction will occur to some varying extent.

Quality Issues to Monitor Beyond the Brewery: "Of Brewers, Distributors and Wholesalers"

From the review of the beer aging process we now see that beer quality, and especially beer flavor quality, always needs to be considered once it has left the brewery. The brewer has done everything possible to ensure a quality product, and in order to maintain their reputation, they should choose distributors who understand the baseline characteristics of their beer and will recognize when it is no longer at its best.

The supply chain needs to be a coherent and unified partnership. Brewer, distributor/ wholesaler, shipper and point of sale staff all need to be on the same page.

BEER DISTRIBUTION: COLD, DARK AND CLEAN

Maintaining the integrity of beer. In this section, we will discuss the various stages of distribution, with steps offered to assist all involved to maintain overall product integrity (see also Tables 2 and 3).

Shipping and Trucking – Coast-to-coast trucking in the US takes about 5 days. It takes 3-6 weeks to ship to most foreign locations. Refrigerated shipping can be more expensive in the short term, but it may be the best option for ensuring product quality and consistency. Most brewers today, though not all, are leaning towards refrigerated shipping. Brewers should make the call, and distributors should follow their lead.

Warehousing (Cellars or Coolers) – Ideally, packaged beer should reach the customer as fast as possible. However, due to the impossibility of matching packaging runs and shipping times to the consumers' demands, it is often necessary to provide a buffer store of product ready for sale when the demand is there. With this in mind, the following factors can contribute to maintaining product integrity when beer reaches consumers.

- *Stock rotation* – "First in, first out" should be a rule! Retailers of perishable products usually rotate older stock to be sold before newer stock. However, if possible and economically viable, brewer and retailer should agree on a ("positive release") system that ensures that only beer that remains "true to brand specifications" should be released for consumption.

- Storage conditions should reflect the style of product being stored.

- *Temperature* – The optimal temperature range for filtered beer storage is below 40˚ F (4˚ C). Temperatures exceeding 50˚ F begin to rapidly encourage the development of off-flavors, and of course, staling (see Figure 1.5)

Beer should not be stored too cold or chill haze may form. Chill haze may become permanent or may be reversible upon subsequent beer warming. Overchilling and extended aging can also lead to colloidal haze with the appearance of opaque or slightly beige tinged protein particulates that float near the bottom of the bottle or appear after line dispense in the glass (see Physical stability section above). Apart from diminished visual appeal, the particulates are not usually an issue but the beer (if bottled) will likely also now show the characteristic cardboard oxidation flavor. If beer freezes in transit then particulates and hazes can form which also lead to fobbing (over foaming) or gushing (violent eruption of beer—or "wild beer") and the freezing can damage the bottle leading to rupture.

- Cask conditioned beers have a narrower temperature range due to the presence of living yeast with any beer conditioning needing to occur under optimal conditions (typically 10-17° C or 50-62.6° F). Such conditioned beers are, however, not covered under the objectives of this particular review.

- Note: Condensation problems will affect stretch wrapped pallets if packages of beer bottles or cans following warm shipment are transferred to a cold warehouse. For the same reason, air humidity needs to be low to prevent condensation on beer packages which can destroy packaging materials, beer labels or render susceptibility to molding of cardboard trays and boxes etc.

- *Handling* – Beer packages need to be handled with care—bottles can be broken, scuffed and cans are easily crushed—causing microbial growth issues (which may taint remaining product) and produce unsightly packaging. Physical appearance of the package, including outer cartons, six pack holders and cans form a first visual indicator of potential quality to the consumer.

Stock control – The brewer and distributor/wholesaler should work together to reduce the time beer is in the warehouse. For bottled and canned goods, both parties should plan to make it easy for the consumer to understand the age of the beer by freshness date codes, " born on" or "pull by" dates, and adhere to those guidelines at all times. This means becoming cognizant of demands (seasonal changes in beer drinking habits), stock delivery times (aiming for a just-in-time delivery if possible), stock storage and rotation as well as correct display, dispense and serving. The details of born on dating, Julian codes and best before or pull dates vary from brewer to brewer and details should be conveyed to the distribution chain, and ultimately to the consumer. It should be clear to all exactly what information is conveyed by such codes. Each brewery must work to use such types of codification for consumer awareness, tracing and tracking purposes. Breweries who ship product to foreign countries should also be aware of their date code requirements and regulations. Ultimately, however, the major reason for such coding is to ensure product is correctly being rotated throughout the system leading to the delivery of the most consistent beer possible to the consumer.

Good communication between brewer and wholesalers/distributors – Brewers and wholesalers/distributors should be in frequent communication to track beer throughout its journey. They should also be in agreement on how the beer will be stored, handled, distributed and monitored. Following on from the discussions above we can propose several topics for coverage between brewer and supply chain management.

Topics worth including in those discussions might be:

1. Beer refrigeration and/or temperature control
2. Stock rotation
3. Beer shelf life and practices to be followed as beer approaches its best before/by dating (see above regarding date coding systems)
4. Beer display (e.g. keeping bottles inside packaging whenever possible. Avoiding heated or lighted display cases.)
5. The brewery might also consider details of "buy-back" programs if applicable (with domestic or more local distribution)

Matt Meadows, Director for Field Quality at New Belgium Brewing and contributor to the *Draught Beer Quality Manual,* has summarized a couple points regarding good communication between brewer and wholesalers.

1. Brewers should clearly outline expectations for wholesalers.
2. For those who serve or stock product, instill tracking measures to maintain quality and consistency, like regular line cleaning or stock rotation programs. Have wholesalers periodically report on the flavor characteristics of beer following on from training so they understand what is expected via flavor delivery.
3. Train field sales staff in the art of quality. On and off-site inspections should include monitoring draught dispense systems and tasting product. Teach the art of pouring beer as it should be poured!
4. Maintain audit frequency and reporting.
5. Provide ways for consumers to share feedback, communicate with the brewer and find out more about the brand.

The brewer needs to convey the quality and flavor expectations for his or her beer after shipping, and set limits on allowable age before consumption. Many brewers have defined,

via sensory analysis, the shelf-life of each beer in their portfolio. It is understood that the beer will never be brewery fresh at consumption but an understanding of the flavor profile at the point of consumption and the ability to maintain all physical parameters will help to ensure delivery of a consistent flavor profile. The brewer and distributor must both be attuned to the "true-to-brand flavor profile" for each beer and distributors and sales staff should understand when the beer has gone beyond the acceptable profile, is not maintaining requirements and has deteriorated to the point that it should be withdrawn from sale.

DELIVERY AND BEER DISPENSE

Types of Packaging – Beer is bulk shipped, packaged in glass, cans, sometimes in plastic bottles, kegs or casks, and occasionally still in wooden maturation vessels. Each type of packaging has its own advantages and disadvantages with respect to conditions for storage, shipping, and distribution, including at point of sale and in dispense or delivery to the consumer. Cask conditioned beer shipped in bulk is not considered here but bottled (including filtered and naturally conditioned beer – with yeast), canned, and keg beer is.

Bottled and Canned Beer – Beer in bottles and cans should ideally be kept cool during shipping, storage and distribution. Most successful craft brewers reported, following a survey generated for this project, that they insist on cold shipments which, while more expensive, maintain the stability, quality, and flavor profile of their beers much longer. Cans are becoming more popular and, regarded as "mini-kegs", they protect beer from light and provide a weight savings advantage over shipping glass while also reducing the ecological footprint. Several breweries have used thermochromic inks in beverage cans that indicate when the beer is cooled or has even attained the correct serving temperature.

Draught Beer – Draught or keg beer has different requirements than bottled products as this beer is consumed from the package over a period of time and the remaining beer must be protected until fully dispensed. The details on keeping kegged beer are presented in detail in the Draught Beer Quality Manual. Points to consider here: 1) Hazy, buttery or sour beer can be caused by dirty tap lines, even if draught beer has been treated well otherwise; and 2) Dirty or poorly-rinsed glassware can destroy head retention, or cause phenolic or chlorine sanitizer off-flavors. [See Table 3 for more tips and guidelines for better serving of beer.]

Draught system delivery requires beers to be poured without excessive foaming, at the correct temperature, with controlled CO_2 (or mixed gases) levels, in reasonable time and with no flavor change from keg to glass (lines free of sanitizers, bacteria).

- *Kegs* – Keg storage temperature should always stay the same—no wide fluctuations—to prevent early aging in the keg. At delivery, cold kegs should enter coolers right away and the beer should be kept cold until the keg is empty. The lines to the tavern head and taps should also be chilled.

- *Temperature* – At the tap, temperatures should be no higher than 7° C (45° F) not higher. Drinking temperature, 5-8° C (41.0-46.4° F) varies with regional preference. Temperature control should be maintained throughout varying seasonal temperatures and conditions.

- *Time* – Time on tap should be as short as possible—optimum time will vary (a few days to a few weeks) but should be understood by the brewer and information relayed to dispense staff. Longer times will always negatively impact quality.

- *CO_2 content* – High gas content in general is typical today; as high as 4.0-7.0 g/L (2.0-3.5 v/v) in some cases (for example, in wheat beers). The CO_2 content should not be changed while the keg is on tap. This will be defined for each beer and style – Review the *Draught Beer Quality Manual* for best practices. Ensure pure gases of the right blend (CO_2 or nitrogen) are all at the correct pressure for delivery.

- *Foam head* – The head of a beer preserves flavor and aroma. Foam should show tight, consistently small bubble formation, and exhibit good cling and be long lasting. Correct head pressure, a clean dispense system and clean glassware ensure good foam characteristics.

- *Glassware* – Beer should be served into "beer clean" glasses, of a design appropriate to the beer style, using proper dispense techniques. Specific glassware should be dedicated only to beer service. Avoid the tendency to chill beer glasses, especially if their final rinse is in chlorinated water. The topic of serving draught beer and "beer clean" glasses has also been extensively covered in the Draught Beer Quality Manual (see also Table 3 here for some details). Testing for beer clean glass, as discussed in the aforementioned manual, includes three typical tests: sheeting, salting, and lacing. Refer to that material as an excellent companion to the present guide for a full understanding of this important topic.

- *Hygiene* – Ensure beer lines are always clean. Understand and use routine sanitation practices and always follow with a final rinse to remove sanitizers. Bar drains should be clean and flushed free of waste beer frequently to prevent microbial growth and fruit flies. Ensure taps are cleaned with no residual beer present at the end of the day. Glassware should be washed completely at the end of every shift. Old beer has an unpleasant aroma, is a breeding ground for bacteria, mold, insects and pests. (See Table 3 for summary details.)

Table 2

Off Flavor Component Common Name	Flavor Descriptors or Sensory Impact	Type of Package, Storage or Dispense System Affected
Acetaldehyde - Some notes also covered in Table 1.	Green apples, bruised apples, grassy, latex paint.	Cask beer and beer cellars and potential bacteria in kegs/bottles. Bacterial infections can spread throughout a draught system.
Acidic – or sour/tart notes - Covers Acetic and Lactic Acids (These are sometimes covered separately, but as both types of acid are found in contamination situations they are presented under one heading.)	Acetic acid : Sour, vinegar noted aromatically as well as taste. Lactic acid. No aroma, only taste: Sour, sour milk, lactic acid (yogurt-like), tart and softens/flattens beer – "smoothens out" or "dulls" the flavor/impact.	Mainly Draught beer (and Cask) systems.
Butyric acid	Rancid, sickly notes (vomit).	Rarely an issue but sometimes bad microbial contaminations seen with kegged and (more so) with cask-conditioned beers. Perhaps an issue in poorly managed cellars today.
Diacetyl	Butter, butter-popcorn, butterscotch. Oily or silky mouthfeel (viscosity, roundness or slickness on the palate) – may even be perceived by some consumers who cannot taste the flavor.	Bottles, cans, kegs and casks and dispense systems. But beer spoilage organisms in dirty beer lines are a big culprit. Pediococcus and lactobacillus especially involved.
DMS – dimethyl sulfide	Cooked corn, vegetables, tomato juice, oysters, ocean air.	Low levels can be acceptable in a few styles –but can be an issue from contamination.
Methyl Butene Thiol (potent sulfury note) See also Table 1.	Skunky or tomcat or lightstruck.	Bottled beer (can even occur in the glass of beer served on a bright sunny day).
Phenolic, Ortho-chloro-phenol - Chlorine or chlorophenols	Medicinal, dentist or Band-Aid note. Chlorine bleach, phenolic notes, hospital or disinfectant-like.	Beer dispensed into glasses. Chlorine and beer phenolic components rapidly form chlorophenols, which have a very low flavor detection threshold.
Oxidation (Staling Aldehydes) - Overall a complex set of components gives rise to "oxidized characters" See also Table 1 (Aging Flavors) and Older Beer Stale Flavors – Bready in Table 1.	Papery, Cardboard, Fresh linen and a particular dryness like chewing on paper or wet cardboard. Not to be confused with bready or stale notes which also develop via heat and oxygen OR fruity (see acetaldehyde), dry-dark-stone fruits and sherry-like.	All forms packaged beer if not handled correctly and a natural aging reaction – time, temperature and exposure to air dependent.
Soapy (alkaline, slick, fatty)	Soapy (alkaline, slick, fatty).	Beer lines in draught dispense systems.
Sufidic	Sufury, rotten eggs, hardboiled eggs, hair permanent solution.	Possibly arising from unhealthy yeast. Lager yeasts produce more sulfur than ale yeasts.

Potential Causes	Preventative Measures (For Beer on Dispense a Fuller Discussion Appears in the *Draught Beer Quality Manual*
Associated with overly fresh – "green beer" but also an indicator of oxidation with very old beer. Also from bacterial infection (Zymomonas, Acetobacter, Gluconobacter).	For beer dispense all couplings, lines and fittings in contact with beer should be clean, undamaged and sterilized (stainless steel of defined quality for contact with beer) and then free of odor and solutions prior to use.
Spoilage organisms in draught beer lines, beer drains, etc. Acetic acid bacteria, lactobacillus and pediococcus strains are prime suspects. These bacteria grow quickly in the presence of air in spill trays, drains and bar cloths. Can eventually contaminate the beer faucet.	If serving beer via dispense read the *Draught Beer Quality Manual* to completely understand the issues and protocols needed to minimize microbial infection. But clean faucets and proper serving techniques for beer and bar cleanliness will help minimize or reduce this problem.
From bacterial spoilage including Megasphaera, Pectinatus spp. Pectinatus also – liquid manure – odd taste and flavor. Megasphaera – cheesy flavor. Both can also produce mucous-like strings or "ropiness" and hazes.	Clean beer cellars, hygiene controls and clean beer lines. Avoid old kegs which might get infected and then cross infect new kegs during switchover to dispense system.
(1) Diacetyl is a natural product of yeast fermentation and often controlled by the brewer but precursors of diacetyl and related compounds may still be present in beer. (2) Origin is usually anaerobic bacteria; Pediococcus may also produce notable sourness and sometimes Lactobacillus strains. See also: acidic.	(1). If beer in package is exposed to extremes of heating the precursor to Diacetyl can be converted into the low threshold and very flavorful buttery note. (2) Bacteria grow under unhygienic conditions in draught beer systems. Maintain cleanliness, sanitation and routine line cleaning. (See also Table 3.)
For this article its presence is assumed to be from contaminated draught lines.	Above protocols apply for bacterial contamination of beer dispense systems.
Beer made with traditional hop bittering acids undergoes a light-induced reaction to create a very potent compound.	Beer is best (but not totally) protected in brown glass. Green glass and clear glass allow in more light at the right wavelength and are damaged faster and more easily. Beer should be kept dark (avoid direct sunlight and fluorescent lighting) and cool at all times prior to serving.
Derived from chlorinated water or chlorine-iodine based sanitizers. Untreated chlorine water used for final rinsing of glasses, insufficiently rinsed sanitizers or chlorine from beer dispense lines, some plastic lines can impart medicinal notes in the absence of chlorine.	Beer glasses should never see a final rinse in water containing chlorine or chlorinated sanitizers prior to dispense of beer. Many local regulations, however, demand that glasses are rinsed with a chlorine-based sanitizer prior to storage.
All beer has an expiration date (see flavor changes over several months in Figure 1). Different beers, strengths and styles age in different ways. The brewery should decide when the beer has oxidized and changed its flavor profile sufficiently to warrant its removal from a "freshness" point of view.	Oxidation giving the characteristic papery dryness is the usual factor involved and is so potent that it is usually clear when it has developed to a point detrimental to the desirable consumption of the beer. Keep beer cool and dark and use rotation and "best-by" date pull practices. Draught beer should be kept cold at all times (below 40° F/4° C). Avoid air ingress in keg systems and beer lines, push beer through lines with carbon dioxide or inert nitrogen – never air, and monitor practices as discussed in Table 3 and the *Draught Beer Quality Manual*.
Poor understanding of line cleaning/sanitation.	Inadequate rinsing of detergent from cleaned beer lines.
Pectinatus or Megasphaera beer infections can produce sulfur notes.	Clean beer cellars, hygiene controls and clean beer lines. Avoid old kegs which might get infected and then cross infect new kegs during switchover to dispense system.

***Table 2**. Beer off-flavors are caused primarily by unhygienic or exposed conditions. Flavors associated with the natural or forced aging of beer are presented in Table 1. The major beer-spoilage notes that are associated with bad beer are shown here.*

***Table 3**. Storage of Beer and Dispense Guidelines. Summary of controls for maintaining beer quality in trade – shipping, storage/cellar, bars/supermarkets and for supply system dispense.*

Beer Shipping Storage/ Cellar, Bar or Supermarket	Hygiene Issue or Process and Suggested Action to Take.
Well ventilated and clean shipping containers, cellars or storage or point of dispense cabinets	Dry and mold free – lacking infection will prevent off-flavors or contamination of beer. Mop floors for spilled beer. Rinse mops and cloths thoroughly; do not leave with beer residues. Infection can rapidly contaminate the entire draught system.
Temperature control	Consistent temperature between 6-9° C (33-49° F). Draught beers below 4° C (40° F). To reduce oxidation and flavor staling.
Used casks, kegs, bottles	Empty beer containers should be rinsed or sealed and stored away from fresh beer to prevent cross-contamination.
Cleaning and sterilizing facilities	For beer dispense all couplings, lines and fitting in contact with beer should be clean and sterilized and then free of odor and solutions prior to use.
No food	Beer storage areas should be free of food to prevent growth of microorganisms and possible food odors and flavors that could taint beer or beer packaging.
Clean facilities	Storage areas and dispense/display cabinets should be cleaned regularly. Avoid strong detergents that could taint beer flavor.
Dark conditions	Beer in bottles should be exposed to light as little as possible (even if in brown glass) to prevent generation of light-induced sulfur flavors – known as "skunky" in the US.
Inspect and taste	Beer for dispense from batches should be inspected and tasted by cellar person or staff to ensure appropriate quality for serving. An understanding of the "fresh beer" should be understood.

Supply System - Dispense	Some Details are Included in the BA *Draught Beer Quality Manual*
Clean hoses and lines	All hoses and lines for beer dispense should be of approved food grade material, clean and free of taints.
Pipe runs	Piping from kegs or bulk tanks should be of shortest length possible to hold the least amount of beer between fills or pours.
Beer lines	Should be flushed clean at the end of every day and beer in lines discarded. Lines should be cleaned with approved cleaning agents at least every two weeks to prevent growth of microorganisms which can lead to sour and diacetyl – infected (buttery) beer. After cleaning, lines should be rinsed to remove traces of detergent. After rinsing, faucets could be capped or covered.
Next bar session	Beer lines should be free of the final rinse water/cleaning solution. Then the first pull of beer should be inspected and tasted by staff to ensure appropriate for consumption by the customer.
Fresh cask or kegs	Staff should be aware of the need to clean and sterilize then rinse fittings, apply appropriate head pressure and set up each new cask or keg to be ready for dispense. Clean or seal and store old kegs correctly (see above storage conditions).
At Bar or Final Dispense	Use clean, undamaged glasses free of detergent and chlorine. Beer tainted with chlorine has a phenolic note and is most unpleasant. Beer clean glasses are covered in the BA *Draught Beer Quality Manual* and other brochures. Beer glasses dedicated for beer only. No mixed drinks.
	Distributors and bar staff must be trained about each beer product served to best inform customers about their forthcoming experience and to judge the quality of the beer. They need to assess the taste, color, clarity, and foam properties of each style of beer and be able to resolve any issues related to dispense at the tap and the cleanliness of beer lines. An understanding of typical off-flavors in beer is summarized in Table 2.
	All staff should know proper dispense hygiene. This will help deliver the freshest beer possible.

SUMMARY

When fresh and properly served, quality craft beer tastes the way the brewer intended and expected: clean and flavorful with the right characteristic fingerprint for the style. As shown here, beer is susceptible to damage and spoilage from light, heat and air (along with physical agitation) and also from poor hygiene. This guide has presented beer as a complex, delicious but perishable product that can undergo a broad range of changes if it is treated improperly (Figure 1).

We've followed beer along the distribution chain and explored the importance of good communication between brewer and distributor/wholesaler. We've addressed the importance of hygiene and handling from brewing and packaging to consumption (see Table 3). We've compiled two tables summarizing off-flavors associated with abuse and improper handling, and included a third table for maintaining beer during shipping, storage, small package sales and draught dispense. We've provided a graphical tool that generalizes the flavor profile of beer as it ages to provide a timeline for distribution, storage, stock rotation, pull-by-dates and correct dispense of beer. A thorough understanding of the flavors in "brewery fresh" beer along with a clear appreciation of the beer off-flavors and spoilage outlined here will go a long way towards serving only the best beer possible to the benefit of both US craft brewers and discerning consumers.

This guide was developed in response to a recognized need for improved and more standardized craft beer storage and handling practices in the U.S. and in markets around the world. The Brewers Association thanks Gary Spedding of Brewing and Distilling Analytical Services for his leadership in content and copy development. We also thank Ken Grossman (Sierra Nevada Brewing Company), Greg Koch (Stone Brewing Company), Eric Wallace (Left Hand Brewing Company), Eric Rosenberg (Bryant Christie Inc.), Amahl Turcyzn Scheppach (Brewers Association) and Bob Pease (Brewers Association) for their contributions to the publication.

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ABOUT THE BREWERS ASSOCIATION

The Brewers Association (BA) is the not-for-profit trade association dedicated to small and independent American brewers, their craft beers and the community of brewing enthusiasts. The Brewers Association represents more than 70 percent of the brewing industry, and its members make more than 99 percent of the beer brewed in the U.S.

The BA organizes events including the World Beer Cup®, Great American Beer Festival®, Craft Brewers Conference & BrewExpo America®, SAVOR: An American Craft Beer & Food Experience and American Craft Beer Week®. The BA publishes *The New Brewer* magazine and CraftBeer.com, and its Brewers Publications division is the largest publisher of contemporary and relevant brewing literature for today's craft brewers and homebrewers. Additionally, more than 35,000 members comprise the BA's American Homebrewers Association® division. Learn more at BrewersAssociation.org.

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