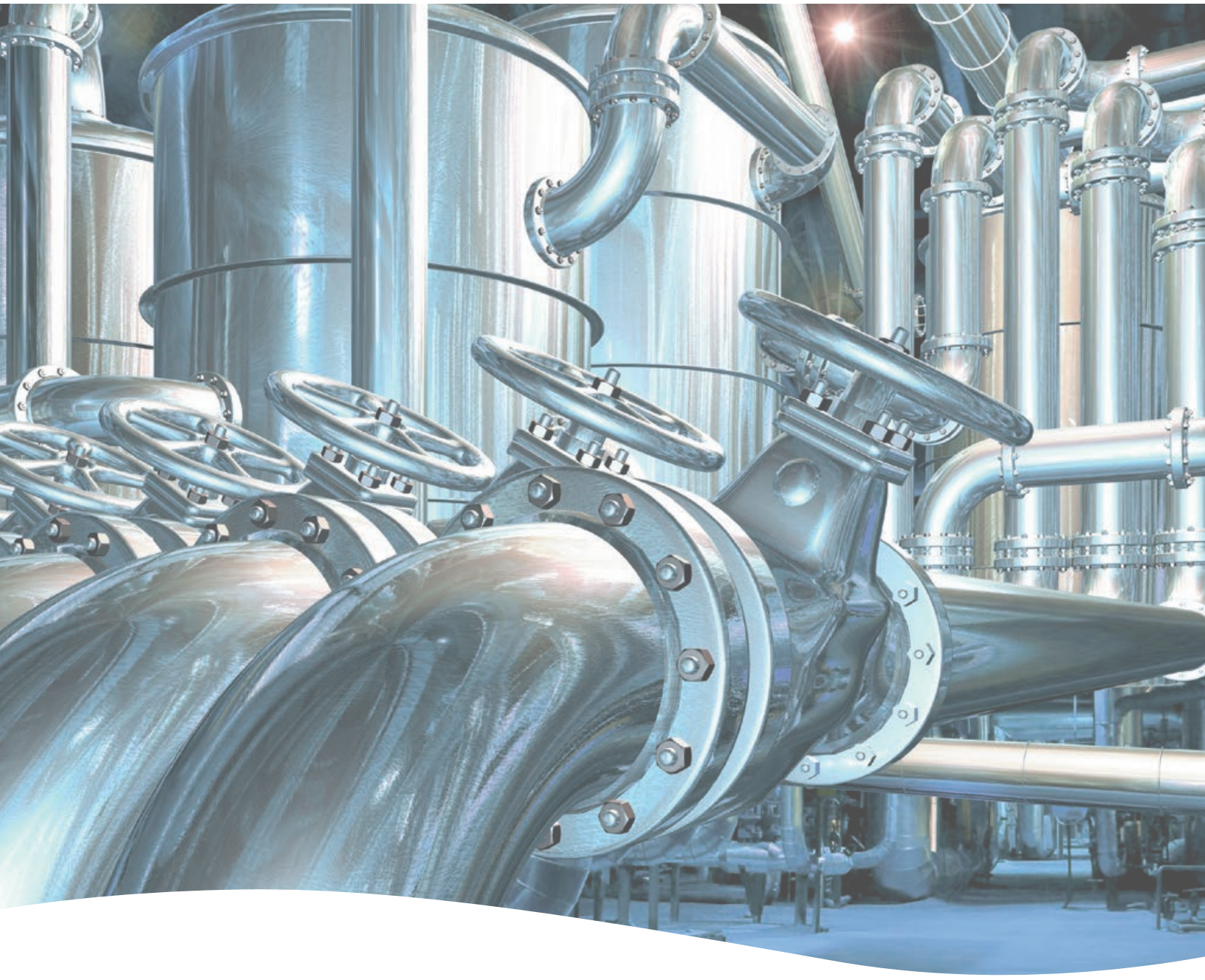
FLOWSERVE

DECEMBER 2019

Application Solutions Guide

BREWERY



Experience In Motion

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THE GLOBAL BREWING INDUSTRY LANDSCAPE

Overview

Beer brewing and drinking are social activities that have been part of the human experience seemingly since the dawn of civilization, dating back to the fifth millennium BC, with written historical records from ancient Egypt and Mesopotamia. The oldest written documentation pertaining to beer making can be traced back several thousand years ago, when mankind began to move away from living as nomadic hunter/gatherers and toward settling down in one spot to farm land. Grain, a vital ingredient in beer making, was then cultivated by these new agricultural societies.

Today, beer is one of the oldest beverages humans have ever produced and has spread all over the world. It is a product valued by its physicochemical properties as in its quality and traditional link with culinary and ethnic distinctiveness.

Accordingly, the history of beer brewing is not only one of scientific and technological advancement but also about the tale of people themselves in their self-governance, economy, rites and daily life, aside from encompassing the growing demand of the grain markets.

As almost any cereal containing certain sugars can undergo spontaneous fermentation due to wild yeasts in the air, it is possible that beer-like beverages were independently developed throughout the world soon after a tribe or culture had domesticated cereal. Historical findings in many different parts of the world indicate that beer was in fact produced as far back as 7000 years ago. This discovery reveals one of the earliest known uses of fermentation and is the earliest evidence of brewing to date, which contains the oldest surviving beer recipe, describing the production of beer from barley via bread. Some other records also showed that beer was brewed using barley and other types of grains. Thus, the inventions of bread and beer have been argued to be responsible for humanity's ability to develop technology and build civilization.

During the Neolithic period, beer was mainly brewed on a domestic scale. Women brewers dominated alcohol production on every occupied continent until the commercialization and industrialization of brewing occurred, although by the 7th century AD, beer was also being produced and sold by European monasteries.

During the Industrial Revolution (~18th–19th century), the production of beer moved from artisanal to industrial manufacture. Brewers devised a set of standards for beer and began commonly mass-brewing, rather than home-brewing it, which ceased to be significant by the end of the 19th century. These mass production methods and guidelines quickly spread throughout Europe.

The development and advent of scientific instruments like hydrometers and thermometers also changed the art of brewing by allowing a brewer more control of the process along with greater knowledge of the results.

In North America and many other parts of the world, the brewery market has had some 'disruptive change' in the last five years with the explosion of smaller craft beers currently preferred by millennials. This trend has actually resulted in larger brewery companies (like Anheuser-Busch InBev [AB InBev] and SABMiller) closing their older larger breweries and purchasing their smaller craft competitors.

Today, the global brewing industry is still a thriving business, consisting of several dominant multinational companies and many thousands of smaller microbreweries (smaller than 15 000 U.S. beer barrels) and nano-breweries to regional breweries with a total global production of more than 1.93 billion hector-liters (51 billion U.S. gallons) in 2015.

A CLOSER LOOK AT THE BEER BREWING PROCESS

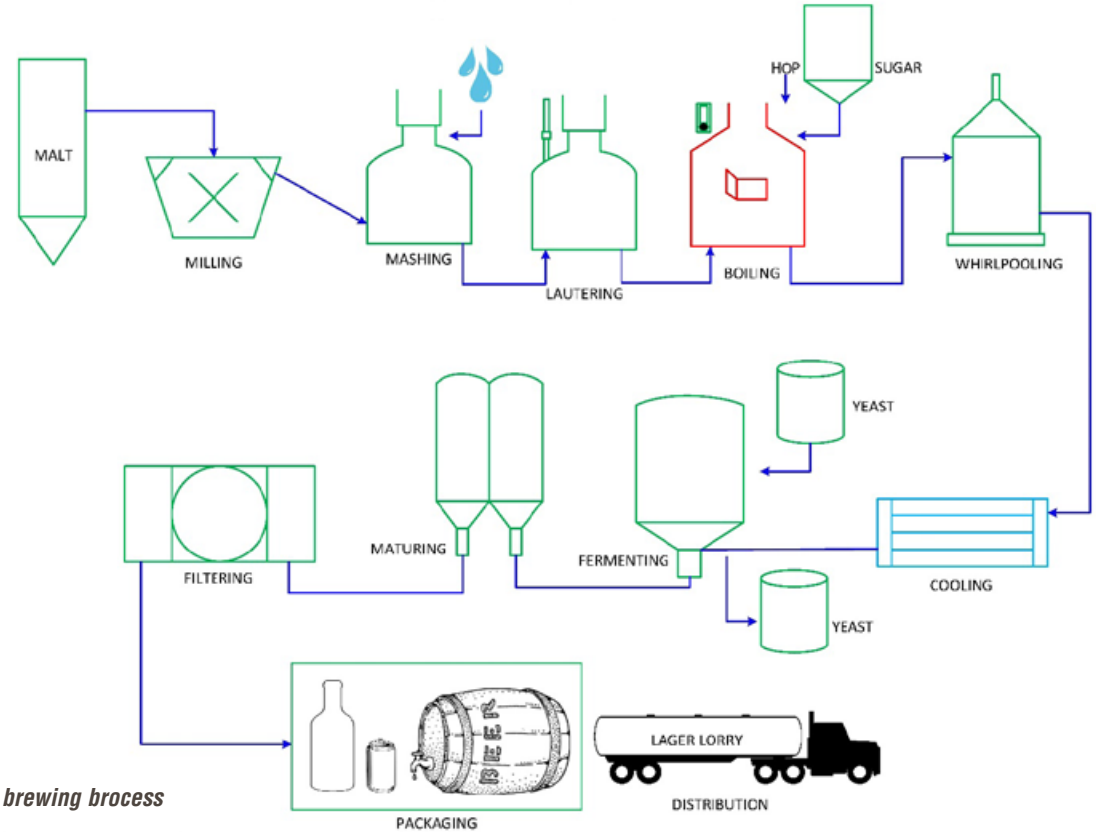


Figure 1:
The beer brewing brocess

Beer is the product of the alcoholic fermentation process by yeast extracts of malted barley. While the chemical reaction between malt and yeast contributes substantially to the distinctive character and flavor of beers, its quality still very much remains a function of the *water* and, more significantly, the *hops* used in its production.

Most of the sugars from which the alcohol is derived in the majority of the world's beers came from the barley starch. It is enclosed in the cell wall and proteins within the barley, and these wrappings are stripped away in the malting process (essentially a limited germination of the barley grains), leaving the starch preserved.

In traditional ale brewing, the beer is mixed with hops, some priming sugars and isinglass finings from the swim bladders of certain fish, which settle out the solids in the cask. In traditional lager brewing, the 'green beer' is matured by several weeks of cold storage prior to filtering.

Today, the majority of beers, both ales and lagers, receives a relatively short conditioning period after fermentation and before filtration. This process is ideally performed at -1°C (30.2°F) for a minimum of three days, under which conditions more proteins drop out of the solution, making the beer less likely to become cloudy in the package or glass. The filtered beer is adjusted to the required carbonation before packaging into cans, kegs, glass or plastic bottles.

Depending on the size of the plant, some of the breweries are equipped with a Waste Water Treatment Plant (WWTP) within their facility, which means that you may have a Diatomaceous Earth (DE, that can be sent to local organic farmers for use as a soil amendment) press system and a Waste Water Digester (WWD) equipment as well.

Mashing

In the brewery, the malted grain must first be milled to produce relatively fine particles, which are for the most part starch. They are then thoroughly mixed with hot water in a process called *mashing*. The quality of water used is of great essence and must possess the right mix of salts, similar to what fine ales are produced from waters with high levels of calcium. Conversely, famous pilsners are from waters with low levels of calcium. A typical mash will be comprised of three parts water to one part of malt and stand at a temperature of around 65°C (149°F). The granules of starch convert from an indigestible granular state into a 'melted' form, which is much more susceptible to enzymatic digestion.

The enzymes which break down the starch are called *amylases*. They are developed during the malting process, but only start to act once the gelatinization of the starch has occurred in the mash tun. Some brewers will have added starch from other sources, such as maize or rice, to supplement that from malt. These other sources are called *adjuncts*.

After perhaps an hour of mashing, the liquid portion of the mash, known as *wort*, is recovered, either by straining through the residual spent grains or filtering through plates. The wort is run to the kettle (sometimes known as the *copper*, even though they are today fabricated from stainless steel) where it is boiled, usually for one hour. Boiling serves various functions, including sterilization of wort, precipitation of proteins (which would otherwise come out of the solution in the finished beer and cause cloudiness), and the driving away of unpleasant grainy characters originating in the barley. Many brewers also add some adjunct sugars at this stage and at least a proportion of their hops.

Hops

The hops have two principal components: *resins* and *essential oils*. The resins (also called *a-acids*) are changed (i.e., isomerized) during boiling to yield iso-a-acids, which provide the bitterness to beer. This process is rather inefficient. Today, hops oils are often extracted with liquefied carbon dioxide and the extract is either added to the kettle or extensively isomerized outside the brewery for addition to the finished beer (thereby avoiding losses due to the tendency of the bitter substance to stick onto yeast).

The oils are responsible for the 'hoppy nose' on beer. They are very volatile, and if the hops are all added at the start of the boil, much of the aroma will be blown up the chimney. In traditional lager brewing, a proportion of the hops is held back and only added toward the end of boiling, which allows the oils to remain in the wort. For obvious reasons, this process is called *late hopping*.

In traditional ale production, a handful of hops is added to the cask at the end of the process, enabling a complex mixture of oils to give a distinctive character to such products. This addition is called *dry hopping*. Liquid carbon dioxide can be used to extract oils as well as resins. These extracts can also be added late in the process to make modifications to a beer's flavor.

After the precipitate produced during boiling has been removed, the hopped wort is cooled and pitched with yeast. There are many strains of brewing yeast; brewers jealously guard their own strains because of their importance in determining brand identity.

Fermentation

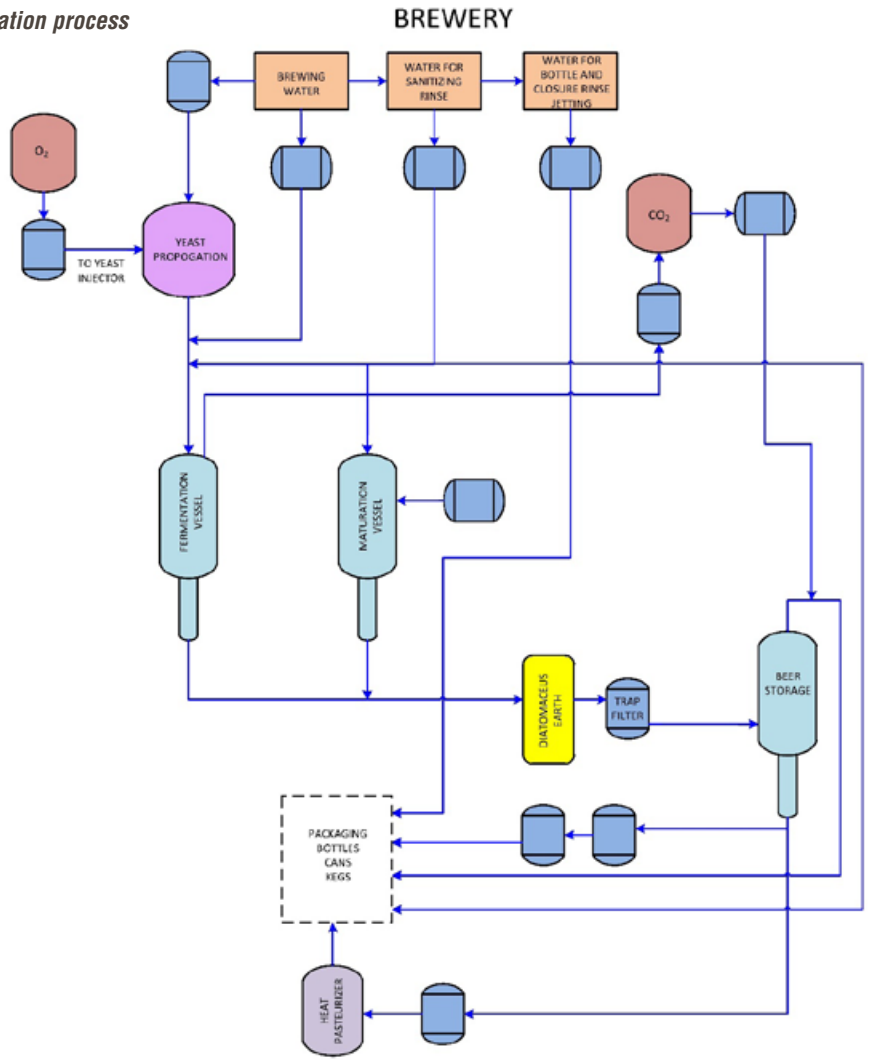
Fundamentally brewing yeast can be divided into *ale* and *lager* strains, the former type collecting at the surface of the fermenting wort and the latter settling to the bottom of a fermentation (although this differentiation is becoming blurred with modern fermenters). Both types need some oxygen to trigger off their metabolism, but otherwise the alcoholic fermentation is anaerobic.

Ale fermentations are usually complete within a few days at temperatures as high as 20°C (68°F), whereas lager fermentations at as low as 6°C (42.8°F) can take several weeks.

Fermentation is complete when the desired alcohol content has been reached and an unpleasant butterscotch flavor, which develops during all of the fermentations, has been mopped up by yeast. The yeast is harvested for use in the next fermentation.

In addition to the mashing, hopping and fermentation process, a water source is the next most critical ingredient needed, not only for the beer itself but also in the sanitizing activities across the whole plant to ensure conformance to the required hygiene standards needed in the brewing process.

Figure 2: Fermentation process



BREWING INDUSTRY PROJECT MODEL

Route to Market (RTM)

In Flowserve context, the RTM is via the wide use of distributors in many parts of the world, and is especially true for the North American markets. For maximum sales opportunities, the brewery size is paramount, starting from 1 million+ barrels per year capacity (where only a small volume of sales can be expected) to a brewery generating more than 3 million barrels per year (where there is a potential for higher sales opportunities).

For most project executions, the brewery is usually built by several installers (often known as *EPC contractors*), who will receive the project order directly from the brewery company's plant owner. All equipment orders will be placed entirely by the contractors; thus, success at this stage will be helpful in laying out the foundations for the aftermarket (AM) business.

Each of these contractors will normally have their own equipment-approved vendor list (AVL) or preferred suppliers with whom they could choose to work. As such, it is absolutely critical and strategically important for us to have our products and services qualified upfront to get into this AVL, before the contractor can start placing any orders with us.

For example, when working with Interbrew, a large Belgium-based brewing company which owned many internationally known and some smaller local beers, Flowserve SIHI® vacuum pumps are specified for their process vacuum application. However, we are not yet in their AVL for other processes using centrifugal or sanitary pumps.

A typical large brewery project will normally encompass a construction contract with the scope of work involving the following areas:

- Brew House
- Utilities
  - Power
  - Steam delivery
- Packaging
  - Keg line
  - Bottling and canning lines
- Waste Treatment

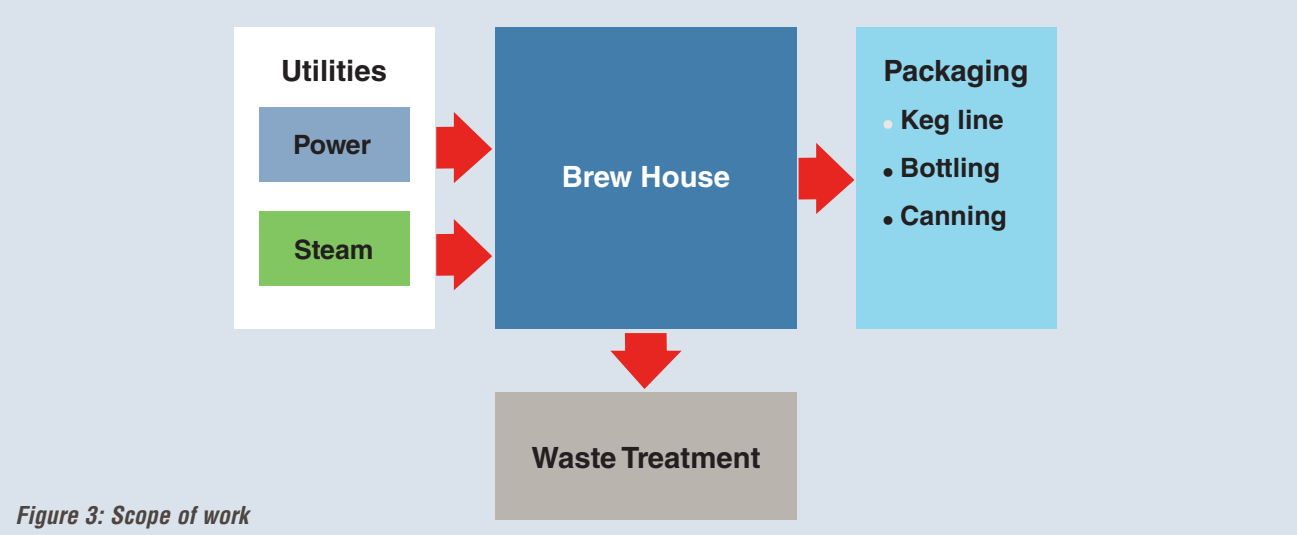
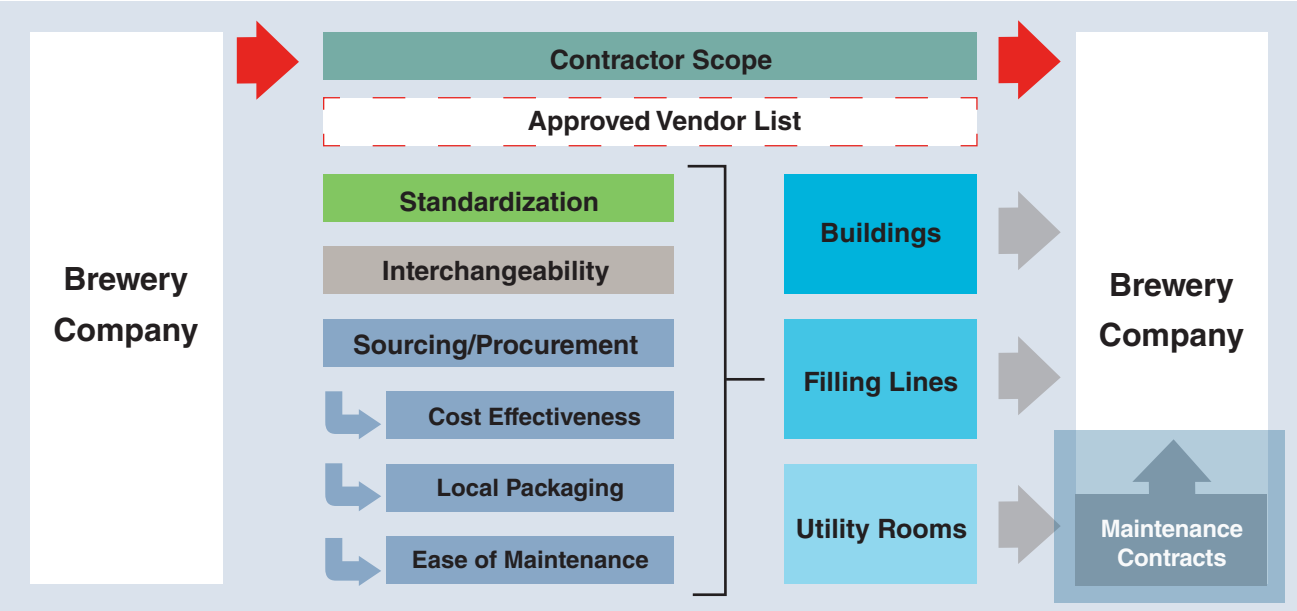


Figure 3: Scope of work

In general practice, construction in these process areas can be carried under three main contracts covering the various facilities infrastructures as shown in Figure 4:

- **Buildings**
  - o Building equipment for HVAC services like heating and air conditioning applications that is mostly supplied by general industry pump OEMs like Grundfos or Wilo. Some other local OEMs include Kirloskar Brothers Limited (KBL), SPX Johnson and Microfinish, etc. in the India market.
- **Filling Lines**
  - o For the filling lines, vacuum pump services are deployed. Here, we have a well-known German company named Kronos, a very important Flowserve SIHI customer, buying a lot of our vacuum pumps for filling bottles in the majority of their executed projects.
- **Utility Rooms**
  - o For the utility rooms requirement, there can be a number of contractors covering main process activities such as:
    - Degassing of CO_2
    - Preparation of the malt to beer

Figure 4



Business Model – EPC Projects

The general business model applied in most brewery new installation/upgrading projects follows a universally accepted path and is widely applied across the globe.

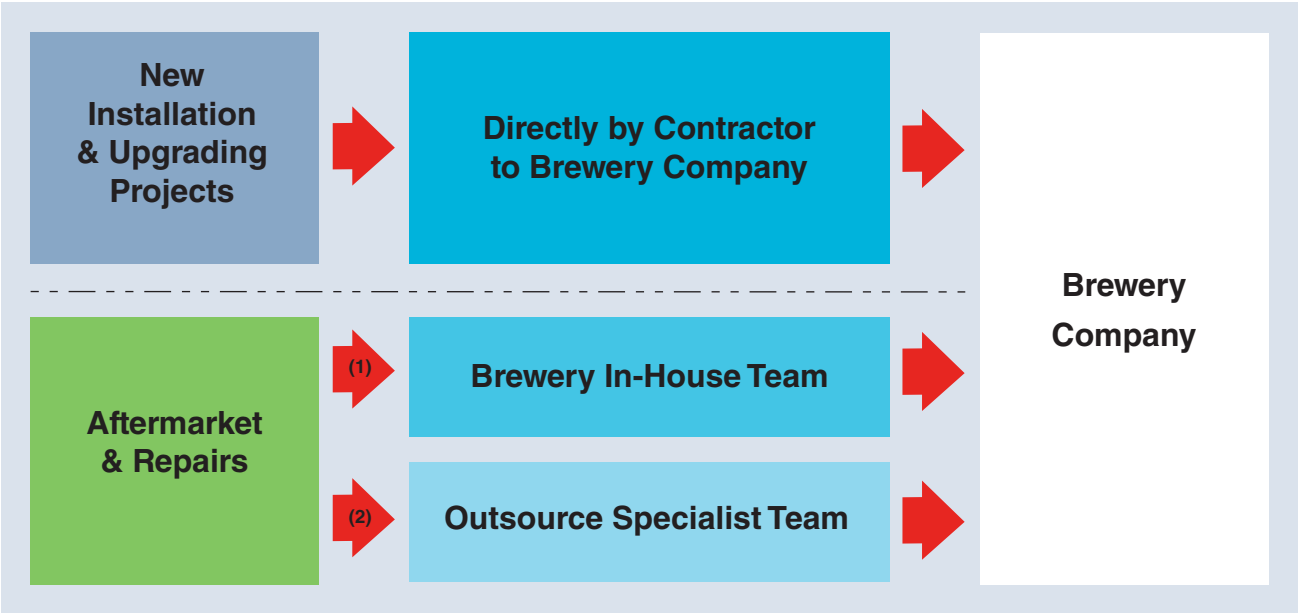
For example, in the Australian market, a majority of the large breweries will typically deal directly with one of the dominant industry players like Brewpack, Krones and KHS, who specialize in new installations and upgrade projects, particularly for bottle filling and process packaging facilities. Many pump OEMs will in turn deal with these EPC contractors for their respective projects regarding brewery machinery requirements.

As for aftermarket and repairs services requirements, most large breweries have their own in-house maintenance teams. Others like ABB's reliability division have a fixed-term maintenance contract with the largest brewery here, e.g., Carlton & United Breweries (CUB), a subsidiary of the Foster's Group — thus competitors from their customer, which is a typical route to market for some of these companies in the maintenance and repairs segment.

Note: This approach bears close semblance to the Flowserve Strategic Alliance Life Cycle Advantage (LCA) programs, mainly deployed in the O&G and chemical markets. More details on how a typical LCA program works can be obtained upon request to the Global Strategic Alliance team.

The chart below shows a standard approach to how new installation and upgrading projects and aftermarket and repairs businesses are handled by many brewery companies globally. This framework helps us to identify the Key Buying Influence (KBI) in the process.

Figure 5: Project management approach



THE BREWING INDUSTRY-FLOWSERVE INTERFACE

Business Impact and Focus Areas

The Big Picture

Beer is the most popularly consumed alcoholic beverage in the world. Competing with the world's biggest breweries are craft breweries, micro-breweries as well as thousands of die-hard beer lovers who cook beer at home or other small home-based breweries.

In terms of the brewery market size for pumps/valves/seals, there's no readily available published Total Addressable Market (TAM) or Served Addressable Market (SAM).

The Flowserve Fit in the Brewing Industry

Flowserve, through our global presence and food and beverage capabilities, has the distinct advantage of being a one-stop supplier of process equipment for the brewing industry. We have the unique opportunity to provide an array of products and services ranging from pumps and precision mechanical seals to control and manual valves.

Competition in the brewing market is extremely steep and challenging, with critical success factors linked to distribution channels, advertising, promotion, and competitive prices in the food and beverage market. For the brewery operational requirement, quick response to their field service requests with short delivery time supported by the right level of inventoriesserve as a primary requirement to support fast turnaround.

The Flowserve presence in this market is mainly through the strong and proven range of Durco® and SIHI products, including special packages for the various services needed in a brewery. This presence is further complemented with the other heritage Flowserve range of products available to the general industry through the Industrial Product Operations (IPO).

For more details on specific pump, valve and seal applications, please refer to the section on "Flowserve Opportunities in the Brewing Industry" from page 13 onward.

Gaps and Non-Competitive Awareness

The changing trend brought about by millennials' preference for craft beer in the last five years prompted the explosion of larger breweries acquiring smaller breweries to meet the changing drinking patterns of this new group of consumers.

With this market change, Flowserve does not currently have a pump product for this growing trend in the new brewery market; the demand is mostly met by closed-coupled sanitary pumps such as SPX's Waukesha Cherry Burrell S200 Series pump (widely used in pasteurization equipment).

The Sanitary 200 Series pump used to be a common pump in the smaller flow areas within craft breweries, but now it is even catering to new projects of larger breweries for small/medium duty services.

Waukesha Cherry-Burrell Sanitary 200 Series Pump

The Flowserve weakness in the brewery market is due to the fact that we are not listed in the AVL of most EPCs for centrifugal and sanitary pumps. Besides centrifugal and sanitary pumps, there is also the requirement for positive displacement pumps, which are commonly used in the fermentation and filtration phases of the brewery process.

The stringent requirement of CIP is also an area of critical concern due to the regulatory mandate for all production equipment in the food and beverage market.

However, there seems to be no brand loyalty to the original brand supplied with the equipment, as the AM business is open to those who have the repair and service capabilities for both the wet and vacuum sides of the business in the country — a critical success factor required with the adequate level of inventories needed for maintenance and repairs.

Products for the Brewing Industry – At a Glance

Pumps

There are two main types of pumps normally used in most of the breweries around the world:

1. Centrifugal

2. Positive displacement (PD)

The centrifugal pump is the most common liquid transfer pump in breweries. It is normally a motor-driven, skid-mounted pump. Beer and cleaning solutions are commonly transferred using these types of pumps.

The PD pump, which is also commonly used, features a robust design that creates an area where fluid is trapped and moved forward via the action of the pump. The PD pump will move fluids in a controlled and staggered manner. Common uses in the brewing process are yeast dosing and filter media injection.

Valves

Many types of valves are commonly used in a brewery to regulate the flow of fluids throughout process pipes in a plant.

The simplest type of valve used is the manual plug valve, which is a plug with a hole that can be turned to restrict or stop flow. The easily recognizable plug valve sometimes has a handle that turns 90 degrees, from fully open to fully closed.

Another type is the diaphragm valve, in which a soft diaphragm is pushed against a bell-shaped feature using a mechanical screw. This mechanism allows gas or liquid flow to be controlled within the valve's total variability, but the flow pressure tolerances are fairly tight.

The butterfly valve is the next most commonly used valve in breweries due to its compact design and wide pressure and flow tolerances. It consists of a metal disc which rotates within the body of the valve and closes against a rubber seal. Its flow-through design makes it easy to clean.

The fourth type of valve used is the manifold valve, which is common in large breweries where systems are hard-piped. This complex valve can be installed vertically and crossed with horizontal piping, and is common in release matrixes. While very useful, it tends to be very costly.

Seals

A mechanical seal and a suitably selected support system can greatly enhance reliability in all stages of the brewing process, from process product transfer to the final stage of beer bottling.

For example, hot wort in the brewing process can damage most industrial pumps, as the sugar compound contained within alcoholic liquids builds up around the mechanical seals and crystallizes. This can cause premature seal failure (often referred to as *seal hang-up*), which causes the pump to leak and suffer severe damage to both the pump and motor.

Therefore, the proper selection and application of mechanical seals and systems are crucial to efficiently operate the whole brewery pumping system.

FLOWSERVE OPPORTUNITIES IN THE BREWING INDUSTRY

Flowserve Products and Capabilities in the Brewery Process

Overview

Unlike wine making, where its quality, taste and flavor depends on the regions where the grapes are grown and harvested, beer brewing is very much a universal process all around the world, with light variations in between the processes.

In general, there are several steps involved in the brewing process, which Flowserve can provide via its products and services. These processes can be broadly classified into three main areas, namely:

- **Brewing**
  - ✓ includes malting, milling and mashing

The initial processes mentioned above are the toughest applications in the brewery and the most regulated for final product.

- **Fermentation**
  - ✓ includes lautering, boiling, fermenting, conditioning and filtering

The three main fermentation methods are warm, cool and wild (aka spontaneous). Fermentation may take place in open or closed vessels. There may be a secondary fermentation which can take place in the brewery, cask or bottle.

- **Packaging**
  - ✓ putting the beer into the containers in which it will leave the brewery. This process typically means putting the beer into bottles, which are filled in the bottle filling machine.

Outside of the brewery process area, after brewing, fermentation and packaging commence, the final logistical requirement is the important task of distribution to consumers via the various channels to retail outlets such as restaurants, bars and entertainment establishments.

In most countries, distributors are regulated by the government or states and provide a large variety of beer brands and styles to licensed retailers at a great value while protecting the public. There is normally a system made up of brewers, importers, distributors and retailers.

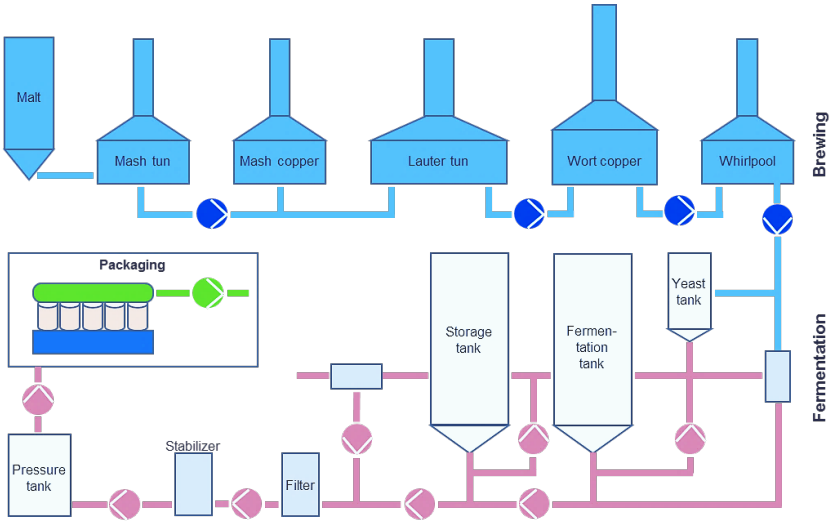
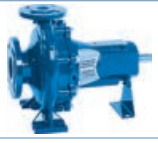


Figure 6: Three primary brewing processes

Products

Pumps

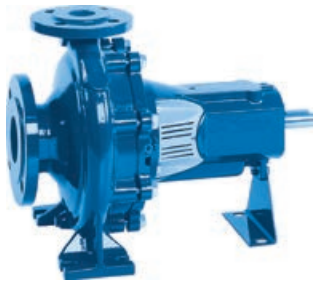
The recommended pumps within the SIHI product lines along with the selected materials of construction are tabulated according to the different processes within the beer brewing process, as illustrated below:

Process Pumps	Pump Types	Pump Execution	
Malting Milling	**Centrifugal pump** Type DBS		Capacity: Max. 800 m³/h Shaft sealing: Mechanical seal Material: Cast iron, stainless steel
	Centrifugal pump Type CBT		Capacity: Max. 2200 m³/h Shaft sealing: Mechanical seal Material: Cast iron, stainless steel
Mashing	**Centrifugal pump** Type CBT		Capacity: Max. 2200 m³/h Shaft sealing: Mechanical seal Material: Cast iron, stainless steel
	Centrifugal pump Type DBS		Capacity: Max. 800 m³/h Shaft sealing: Mechanical seal Material: Cast iron, stainless steel
Lautering Boiling Fermentation Conditioning	**Centrifugal pump** Type ZLN		Capacity: Max. 1800 m³/h Shaft sealing: Mechanical seal Material: Cast iron, stainless steel
	Centrifugal pump Type CBT		Capacity: Max. 2200 m³/h Shaft sealing: Mechanical seal Material: Cast iron, stainless steel
Packaging	**Vacuum pump** Type LPHX/LPH, LEM		Capacity: Max. 10 700 m³/h Shaft sealing: Mechanical seal Material: Cast iron, stainless steel
	Hygienic system Type SIHI*sanivac*		Capacity: Max. 1000 m³/h Shaft sealing: Mechanical seal Material: Stainless steel

Additional details on the Flowserve and SIHI products for breweries are listed as follows:

SIHI

ZLND



- Flows to: 1800 m^3/h (7925 gpm)
- Heads to: 140 m (459 ft)
- Pressure to: 16 bar (232 psi)
- Temp: to 170°C (338°F)

LPH

- Flows to: 10 350 m^3/h (45 570 gpm)
- Pressure to: 33 to 1013 mbar (0.5 to 14.7 psi)
- Temp: 160°C (320°F)

DBS

- Flows to: 1200 m^3/h (5283 gpm)
- Heads to: 100 m (328 ft)
- Pressure to: 10 bar (145 psi)
- Temp: max. 110°C (230°F)

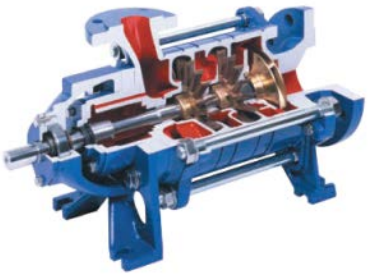
CBT

- Flows to: 2200 m^3/h (9686 gpm)
- Heads to: 160 m (5251 ft)
- Pressure to: 25 bar (363 psi)
- Temp: max. 350°C (662°F)

HEGA

- Flows to: 145 m^3/h (640 gpm)
- Heads to: 390 m (1280 ft)
- Pressure to: 40 bar (580 psi)
- Temp: 194°C (380°F)

CEHA



- Flows to: 35 m^3/h (154 gpm)
- Heads to: 354 m (1161 ft)
- Pressure to: 40 bar (580 psi)
- Temp: 180°C (356°F)

LPH

Liquid Ring Vacuum Pump (for larger breweries)

LEM

Liquid Ring Vacuum Pump (for craft and microbreweries)

Design Aspects

The hygienic volute casing pump is designed with an open impeller (for optimized pumping of shear-sensitive media) rotating on a robust shaft. The thick-walled stainless steel casing is fixed by a sturdy quick-release clamp ring with sanitary grade O-ring sealing. All process-wetted parts are constructed from electro-polished AISI 316L stainless steel.

Importantly, the volute casing is rolled steel, while the casing cover is forged in order to provide a heavy-duty construction. All other parts are made of AISI 304. The pump range is in accordance with food-grade standards 3A1 with a surface roughness Ra<3,2 µm (other standards are optional).

The modular and compact design, use of standard motors and several options guarantee reliable performance within the food and beverage industry.

Hygienic centrifugal pumps are used within the F&B industry in breweries and dairies. Application areas for these pumps include brewing (mash, wort, beer); dairying (milk, cream, fats); filtration (filtration, separation, mixing); cleaning (up and downstream CIP); filling (beer, soft drinks, juices); and sterile and pure water.

FLOWSERVE

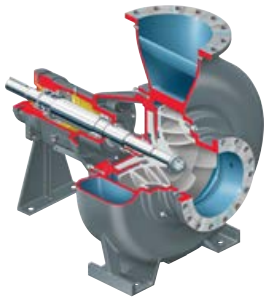
Durco Mark 3 ISO

- Flows to: 4540 m³/h (20 000 gpm)
- Heads to: 215 m (700 ft)
- Pressure to: 27 bar (400 psi)
- Temp: -73°C to 370°C (-100°F to 700°F)

Durco Mark 3 ANSI

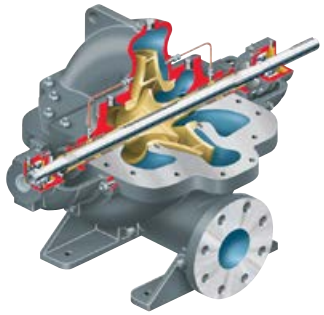
- Flows to: 4540 m³/h (20 000 gpm)
- Heads to: 215 m (700 ft)
- Pressure to: 27 bar (400 psi)
- Temp: -73°C to 370°C (-100°F to 700°F)

FRBH



- Flows to 9085 m³/h (40 000 gpm)
- Heads to: 100 m (325 ft)
- Pressure to: 14 bar (200 psi)
- Temp. to: 150°C (300°F)

LR



- Flows to 2000 m³/h (8800 gpm)
- Heads to: 170 m (560 ft)
- Pressures to: 21 bar (300 psi)
- Temp. from: -30°C to 150°C (-20°F to 300°F)

Valves

In the brewing process, some of the most commonly used valves are:

- Ball
- Butterfly
- Control
- Three-way
- Diaphragm

In addition, there are application areas for three-way and bottom-drain flow valves within the brewing process.

In addition, for the "Food-safe" grade, there will be the need for high-purity and aseptic process performance valves.

Typical Flowserve valves used in different brewery processes include critical and general services applications such as the following:

Control valves

• Globe	Valtek® FlowTop and Mark One™
Globe – Mixing/Diverting	Valtek FlowTop and Mark One
Globe – Sanitary, Aseptic	Kammer® 190000
Globe – Tank Bottom	Kammer 051000
• Eccentric Plug	Valtek MaxFlo® 4
• Segmented Ball	Valtek and NAF™
• High-Performance Butterfly	Valtek Valdisk™

On-off manual valves

• Ball	Worcester® Food-Safe
• Butterfly	Serck Audco™ and FX
• Lined	Atomac™

Pneumatic actuators

• Automax™	Flowserve®
• Norbro™	Flowserve

Non-return valves

• NAF Check Tilting Disc Check	NAF

Control valves

Valtek FlowTop/ GSV (Globe)

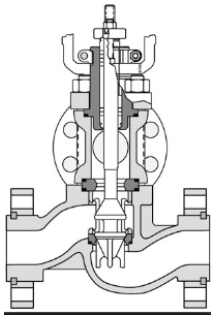
Value added:

- High capacity
- High performance
- Ease of maintenance

Valtek Mark One (Globe)

- Heavy top guiding
- High performance
- Severe service trim available
  - o Noise reduction trim
  - o Anti-cavitation trim
- VL Series actuator
  - o Field reversible
  - o Double-acting spring return

Valtek Mark One (Mixing/Diverting)



- Highest rated C_v
- Precise control
- Reliable shut-off

Kammer Aseptic

- Different surface finish – 0.4 to 0.6 µm
- Bellows option
- Standard – without dead lag
- Ultra-clean aseptic version

Kammer Tank Bottom Valve (Globe)

- Seal-welded standard construction
- Seat ring designed to fit tank outlet dimensions
- Compact and lightweight
- Different outlet angle

Valtek MaxFlo 4 (Eccentric Plug)

- Seat design options
- Stuffing box packing options
- Primary steam seal plus two optional secondary seals provide triple-leak protection
- Wide range of optional materials includes: D20, DMM, DC2, DC3, DNI and DNIC
- Exceeds shut-off requirements of ASME/ FCI 70-2 for all classes

Valtek Valdisk (Butterfly)

- Jam-lever toggle soft seat
- Single pivot point for actuator to disc connection
- Self-centering seal
- Non-selective disc and shaft for cost reduction

Valtek and NAF (Segmented Ball)

- Highest capability and rangeability
- Abrasive, erosive and corrosive fluid
- Slurry, two-phase flow

NAX Torex Butterfly Valve

- Seat design options
- Stuffing box packing options
- Primary steam seal plus two optional secondary seals provide triple-leak protection
- Wide range of optional materials includes: D20, DMM, DC2, DC3, DNI and DNIC
- Exceeds shut-off requirements of ASME/ FCI 70-2 for all classes

On-off manual valves

Worcester Three-piece Ball Valve

- Wide applications in steam and water process lines
- Total ball seat interchangeability
- Fire-safe design
- Low torque
- Bi-directional seal
- Ease of maintenance

Worcester Food-Safe Valve (Three-piece Design)

- Certified to meet EC food safety regulations:
  Regulation (EC) No 1935/2004
  Regulation (EC) No 2013/2006
  Regulation (EC) No 10/2011
- High performance
- Severe service trim available
  o Noise reduction
  o Anti-cavitation
- VL Series actuator
  o Field reversible
  o Double-acting spring return

Worcester Clean Valve

- High purity and aseptic applications
- Wrought body material, 316L combined seat and body seal, solid ball
- Standard internal surface finish
- Tri-clamp, XBO and other end connections
- Standard internal surface finish to 0.6 µm

Non-return valves

Worcester (Multiple Ports) – Series 18

- True three-way valve seat on every port
- Additional seat on blank port to balance forces
- Size from ½ to 6 inches
- Endless variety of port arrangements
- Available as flanged or weld/screw connections
- Wrought material up to 4 inches

Worcester Three-piece Steam Isolation Valve

- Continuous saturated steam service up to 250psi (17 bar)
- Also for thermal fluids/hot oils up to 280°C
- PTFE-coated metal body
- Carbon-filled PTFR steam seals
- Sizes 8$\frac{1}{N}$ - 50 mm
- Carbon steel and stainless steel with end connections
- Ease of maintenance

NAF Check Tilting Disc (Check Valve)

- Large range of sizes and torques
- Materials: carbon and stainless steels
- Dimension: DN 40 to 1000 (ANSI 2 to 24 inches)
- Pressure Class: PN 10–40 (ANS 150–300)
- Connection: Wafer
- Temperature: 350°C (660°F)

Pneumatic actuators

Norbro Rack and Pinion (Actuator)

- Large range of sizes and torques
- Compact rack and pinion
- Balanced weight (no stem side loads)
- Unique guide rod design
- Meets international standards
- Fast acting
- Reverse design

Flowserve Butterfly Valve (Butterfly)

- Integral bi-directional travel stop
- Field-reversible action (180 degrees)
- Concentric nested spring design
- Broad size range for optimum actuator sizing
- Internationally accepted mounting standard (ISO 5211/Namur VDI/VDE 3845)
- Exceeds shut-off requirements of ASME/FCI 70-2 for all classes

Seals

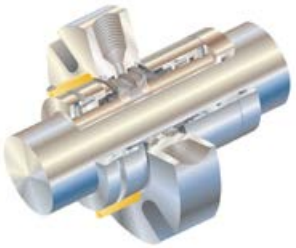
ISC2-BBW

- Speed: up to 23 m/s
- Pressure to: 20 bar (300 psi)
- Temp: -40°C to 204°C (-40°F to 400°F)

BX

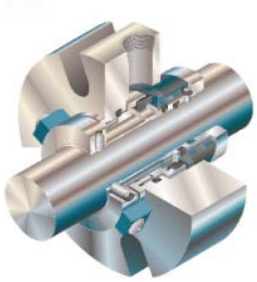
- Speed: up to 23 m/s
- Pressure to: 27 bar (400 psi)
- Temp: -40°C to 204°C (-40°F to 400°F)

P-200



- Speed: up to 30 m/s
- Pressure: 27 bar (400 psi)
- Temp: -40°C to 204°C (-40°F to 400°F)

P50

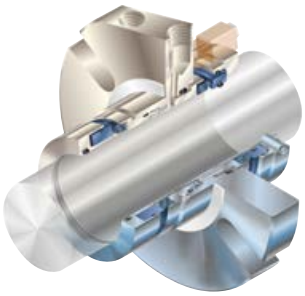


- Speed: up to 30 m/s
- Pressure to: 20 bar (300 psi)
- Temp: 150°C (300°F)

RO

- Speed: up to 23 m/s
- Pressure to: 20 bar (300 psi)
- Temp: cryogenic to 260°C (500°F)

CPM



- Speed: up to 30 m/s
- Pressure: vacuum to 27 bar (400 psi)
- Temp: -40°C to 204°C (-40°F to 400°F)

Seal Support Systems and Piping Plans

The following show some typical service conditions with the recommended seals and flushing plans used in the brewing process:

Process Service	Temperature Range	Other	Seal Type	Material Code	API Flush	Notes
Beer Fermentation	< 60°C (< 140°F)		CPMPX	CPMPX----ECXA-	Plan 11 or 13 With Standard Bore, Plan 02 With Taper Bore	
	60–71°C (140–160°F)		CPMPX	CPMPX----ECXA-	Plan 11 or 13 With Standard Bore, Plan 02 With Taper Bore	See Note 3
	< 60°C (< 140°F)		ISC1PX	CSCPX----ECXV-	Plan 11 or 13 With Standard Bore, Plan 02 With Taper Bore	
	< 60°C (< 140°F)		ISC1EX	CSCEX----ECXV-	Plan 11 or 13 With Standard Bore, Plan 02 With Taper Bore	
	< 60°C (< 140°F)		ISC1BX	CSCBX----ECXV-	Plan 11 or 13 With Standard Bore, Plan 02 With Taper Bore	
	< 71°C (< 160°F)		CPMPP	CPMPP----ECCA-	Plan 54	
	< 71°C (< 160°F)		ISC2PP	CSCPP----ECCV-	Plan 53 or Plan 54	See Notes 1 & 2
Beer Bottoms	118–150°C (244–300°F)		BX / BX	5AAZ / 5AAZ	Plan 52 or Plan 54 With Water Barrier Fluid	See Notes 1 & 2
	118–150°C (244–300°F)		P-200	(K/E)(U/DR)2KFVV	Plan 53 or Plan 54	See Note 1
Beer Reboiler	118–150°C (244–300°F)		BX / BX	5AAZ / 5AAZ	Plan 52 or Plan 54 With Water Barrier Fluid	See Notes 1 & 2
	118–150°C (244–300°F)		P-200	(K/E)(U/DR)2KFVV	Plan 53 or Plan 54	See Note 1

Notes:

1. It is recommended to use a Plan 54 water injection system or a Plan 53 with automatic water make-up.
2. Cooling coils are required in reservoirs when process temperatures are 71°C (160°F) or greater.
3. Plan 62 consists of a very low-flow water quench.

Special Packages

Flowserve offers two main packages for bottle filling. They are SIHI*sanivac* and SIHI*compact*. Along with the SIHI*sanivac* and the SIHI*compact*, standalone LRVPs are also used.

Larger breweries use the LPH 65320 and 65327 for their fillers; many craft and microbreweries use the smaller LEM range.

For some duty conditions, you will also find a range of ISO pumps for the CIP and hygienic pumps in abundance for the process. CIP is a method of cleaning the interior surfaces of pipes, vessels, process equipment, filters and associated fittings, without disassembly. Up to the 1950s, closed systems were disassembled and cleaned manually.

Slurry pumps can also be found handling residue product.

SIHI*sanivac*

SIHI*compact*

Aftermarket Opportunities

Key Advantages for Flowserve

Over the last few decades, the capabilities of the Flowserve Quick Response Centers (QRC) have been constantly improved as new technologies were developed. With efficiency and reliability improvements, there is a high potential for upgrading existing installations to help plant owners in their operations in the following areas:

- Increase plant efficiency
- Improve plant output
- Reduce emissions output
- Overall plant operational safety
  - o Danger zone concerns — added attention and caution should be exercised in the use of ammonia for the refrigeration of beer or chlorine gas used in water purification systems.
  - o Hot wort can also pose a risk of burning when spillage happens.

These critical operational key performance areas can be successfully handled and achieved by close monitoring and maintenance of existing plant equipment with a focus on reliability enhancement and/or hydraulic upgrades where needed — all of which can be provided through the Flowserve global network of QRCs.

Flowserve QRC facilities for pumps, valves and seals are strategically located globally in locations with major installed bases. They are equipped with the necessary engineering, manufacturing and servicing capabilities and equipment to serve customers in the brewery industry.

Flowserve Positioning in the Brewing Industry

Value Proposition

Flowserve	Proposition	Customer Benefit
Ethical business practices	Flowserve sets the highest standards in business integrity in its dealings with suppliers and customers	A trustworthy partner to work toward their project success
Quality	Flowserve manufactures to the most rigorous quality standards to provide reliable products.	Satisfaction in supplier choice, on-time commissioning and project startup
Engineering excellence	The Flowserve depth of engineering experience is unparalleled in the F&B industry	Optimized product and material selection for each application ensures reliable operation
Experience	Flowserve has been a key player since the beer brewing process was commercialized on a large scale	Lessons learned have been built into today's products, increasing reliability, maintainability and product life
Aftermarket support	Dedicated after-sales support engineers	Implanted within the aftermarket group with the sole objective to resolve operational issues quickly and provide expert recommendations on upgrades and safety outlook
Local Quick Response Centers	Fully equipped Quick Response Centers are located in many regions around the globe	Skilled team to handle upgrades and repairs. Localized to reduce downtime, full access to Flowserve component drawings, procedures and standards
Aftermarket solutions	Long-term maintenance	Specialist group capable of maintaining, servicing and upgrading equipment to meet operating throughput goals
Industry partnerships	Constant discussions with all process licensors and dedicated to the communication of concerns and developments	End users and licensors have direct access to engineers to influence design needs and ensure concerns are properly communicated

Innovative Ways Flowserve Addresses Customer Challenges

Expertise and Experience	• Flowserve has many years of experience in the F&B industry and has been a key supplier of pumps, valves and seals for breweries, especially through its SIHI range of pumps. • Together with the Flowserve pumps range, we have one of the best product offerings for brewery applications. • Specialist "Virtual Centers of Excellence" ensure that expertise acquired over multiple products and manufacturing sites is shared across the global Flowserve organization.
Single-Source Provider	• Flowserve offers a full range of pumps, valves and seals for brewery applications for our customers. • Global Commercial Operations organization ensures knowledgeable and professional review and response to customer RFQs, including those with the most complicated technical requirements.
Streamlined Execution	• Each Flowserve factory has efficient and professional project management organizations to ensure on-time completion of projects to customer requirements. • Where projects involve multiple Flowserve manufacturing locations, global project managers can be provided to coordinate order fulfillment. This ensures fewer errors and delays and simplifies communications between Flowserve and customers.
Local Support Worldwide	• A large field service organization ensures technicians are available for installation, commissioning and troubleshooting without delay. • Service and maintenance contracts for highest availability and continuous efficiency optimization can be tailored to customer needs. • A global network of Flowserve Quick Response Centers means that local service and repair are always available. • Product upgrades are continuously being introduced to improve the performance and reliability of Flowserve products in the field. • Full operation and maintenance training is available to end users.
Optimized Efficiency	• The Flowserve close involvement with the F&B industry has provided the feedback needed to develop the range of hydraulics best suited to customer requirements, ensuring the best and most efficient selections are always available. • As one of the largest engineered pump manufacturers in the world, the Flowserve hydraulic engineering capabilities and resources are second to none. Flowserve is able to provide pumping equipment that consumes the least amount of power.

Summary

The tradition of beer drinking is prevalent throughout the world. With the advent of craft beers and micro-breweries, the reach is even further across all strata of the global population. With this large following, the beer brewing market shall continue to grow among changing conditions such as the green environment necessitating some approaches to industry and/or beer brewing.

For example, the newly launched beer in May 2017 named 'Pisner' — a word-play combining the word *pilsner* with local slang for urine — contains no human waste, but is produced from fields of malting barley fertilized with human urine rather than traditional animal manure or factory-made plant nutrients — a new innovative approach to the beer brewing industry.

Such new market trends or developments will help energize the beer brewing industry as we move into the future, but conventional beer brewing methods will largely remain the same, requiring the same processes and equipment, thus ensuring and prolonging the lifecycle of this market.

Beside the beer brewing market, there are also adjacent markets like distilleries where the process is almost identical to the beer brewing processes.

APPENDIX

Sourcing Guide

Flowserve Pumps

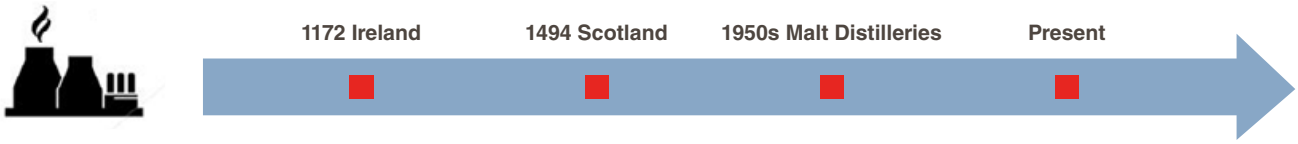
Pump Family	Primary Market Segment	Pump Model	1-Arnage 2-Pozuelo 3-Chesapeake 4-Taneytown 5-Itzehoe 6-Trappes 7-Toltecas	Coimbatore	Suzhou	Shanghai	Chonburi
General Service	General Industry	FRBH	4	■	■		
		LPH	5			■	■
	F&B — Brewery	Mark 3 ISO	3	■	■		
		Mark 3 ANSI	2	■	■		
		LR	1, 2	■			
		CEH	6			■	■
		ZLND	2			■	■
		HEGA	7			■	■
		DBS	2			■	■
		CBT	2				

Legend

- **Design Center and Primary Manufacturing**
- **Packaging or Other Manufacturing**
- **Secondary Manufacturing**

The Distilling Process

History



Whiskey production, albeit on a small scale, actually began in Ireland sometime around the 12th century and was subsequently brought across to Scotland. Early records indicate the grain spirit in Ireland dates back to 1172; it was not until 1494 that a firm record showed the existence of the same spirit in Scotland. It is worth noting that until about the 1950s, all malt distilleries would carry out the entire process on-site — malting, fermenting and distilling. Nowadays, only a few distilleries carry out their own maltings.

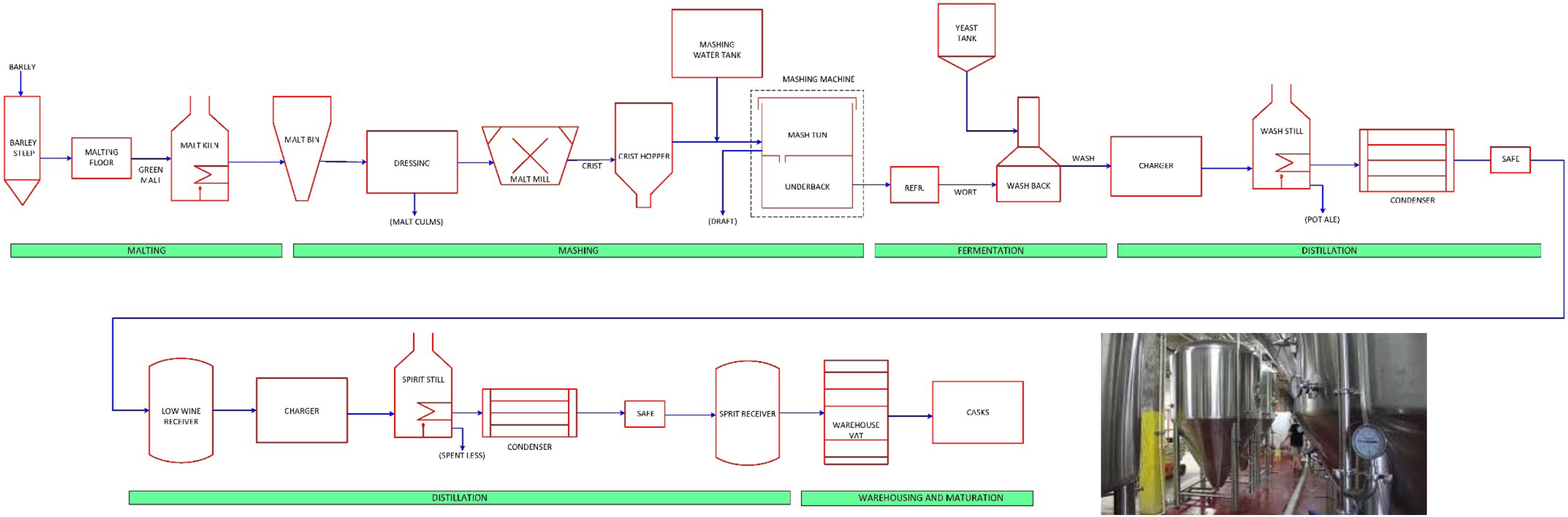
The Whiskey Year

Many distilleries began their operations from farms. In most circumstances, distilling season began right after the grain harvest and continued until late April. Right until modern times, this cycle was followed by all distilleries, and even now there is a 'silent season', usually in August when many distilleries are closed — an important point to note where equipment maintenance timing is concerned.

The Malting Process

As has been stated above, the process of malting converts the plain barley grain into malted barley and by so, doing greatly changes its chemical makeup. The barley is first soaked for a period of between 48 to 72 hours in tanks (or *steeps*) and left to germinate. Germination releases heat, which has to be controlled in order to keep the temperature around 16°C (60°F) and avoid the barley killing itself from its own generated heat. Traditionally, the malting barley was drained and spread out over a large floor then turned regularly by hand with rakes or shovels. This method was repetitious and arduous work, sometimes leading to a shoulder-strain injury. Modern malting methods utilize either mechanical rakes (Saladin box) or large revolving drums to achieve the same effect.

Malt Whiskey Manufacturing Process



The Malt Kiln

The fully germinated malt is next transferred to the kiln for drying on a mesh over a fire containing a certain amount of peat, thus contributing to the peaty taste evident in many malt whiskies. Traditional malt kilns draw hot air from the peat furnace through the malt by way of a chimney effect generated by the characteristic steep roofs and pagoda heads of many Scottish distilleries. The pagoda roof was introduced around the 1890s. It offered an improved air draught, fanning the peat furnace to core temperatures, which can reach between 800°C and 1200°C (1472°F to 2192°F). In most cases, where many distilleries buy in their malt they have generally lost their function other than a piece of visual identity. The malt is dried and roasted in the peat reek at 60°C (140°F) for two days and is then ready for the next stage.

Dressing

The malt contains much detritus or *combings*, principally rootlets. These are removed and used as cattle food. The malt is then coarsely ground and becomes known as *malt grist*.

Mashing and Brewing

The malt grist is fed into the mash tun where it is combined with a carefully measured quantity of hot water. This process completes the conversion of dextrin into maltose and produces a fermentable solution of the malt sugars called *worts*. Again, after several washings to draw out the malt, the solid residue, commonly known as *draff*, is removed and sold as cattle food. The worts are held in a receiver called an *underback*. This device must be cooled to prevent unwanted decomposition of the maltose and allow yeast to be introduced. The cooled worts are injected with yeast and left to ferment in a tank or tanks called *washbacks*. Approximately 36 hours later, violent fermentation sometimes produces a weakly alcoholic (~10°C) (14°F) clear liquid called *wash*, which will then get distilled.

Distillation

Distillation takes place in pear-shaped copper vessels called *pot stills*. At least two are required of different types.

The wash is first distilled in the wash still to produce an impure intermediate product called *low wine*s. This product is then fed via the spirit safe into the low wines charger ready for the next stage of distillation. The spirit safe is a heavy glass-fronted and padlocked box in which the emerging distillate may be inspected and directed onward or back for re-distillation, as appropriate. When ready, the low wines are discharged into the low wines still and the process gets repeated. The final product: raw, unmatured whisky passes via the spirit safe to spirit receiver and spirit store, ready for filling into barrels. Early and late distillation fractions (*foreshots* and *feints*) contain impurities, so they get recycled back for re-distillation with the low wines. The *safes* used for spirit storage are exactly that measure. The moment the intermediate product contains alcohol, it comes under the control of the excisemen; the safes are a necessary means of ensuring that the spirits stay where they are supposed to be and are accurately accounted for.

Stills

The horizontal pipe from the top of the still to the worm is called the *Lyne Arm* (sometimes *lye pipe*). There is a fair variation in the design of these; distilleries will vigorously defend the design of each as contributing something unique to the final product.

Further refinements include a bulge at the base of the column (*Milton Ball*) and in particular the Lomond still, which has a refluxing coil in the head which enables the still to be 'tuned' to produce a lighter or heavier spirit. Lomond stills were designed to allow a company to widen the character and style of its malts by using stills which had an additional condenser in the head, which altered the reflux action in a controlled manner.

A few stills have water cooling of the neck. Each still has a large hatch on the top of the base of the still, i.e., the 'man door' for inspection and cleaning. Further up the neck, a small glass porthole can be seen, which allows inspection of the contents of the still to ensure it does not rise too far up the neck and boil over. Before the advent of the porthole, a wooden ball was swung against the neck of the still and the resulting 'ding' used to determine the state within.

Casks

Casks are critical to the taste and appearance of the final whiskey. There is a need for casks which will impart a characteristic taste to the whiskey without dominating it or imparting a 'woody' flavor. Principally, two types of casks are used: Oloroso sherry casks and American oak bourbon casks. Some distilleries use intact barrels; others remake barrels from selected staves from more than one source. Barrels may be charred before use, a process which apparently assists the release of vanillin from the wood. No two casks are the same; one may produce a fine whiskey and may be refilled and used again, whereas its neighbor's whiskey may taste woody after one filling.

Maturation

The whiskey is left a minimum of three years, but usually between eight and 25 years in wooden barrels to mature. The bonded warehouses are cool and earth-floored to provide an even temperature and humidity. The barrels lose about 2% alcohol per annum — the so-called *angel's share*. It is worth noting the investment tied up in each one of these modest low-stone warehouses: each full-size cask can easily contain up to 110 gallons.

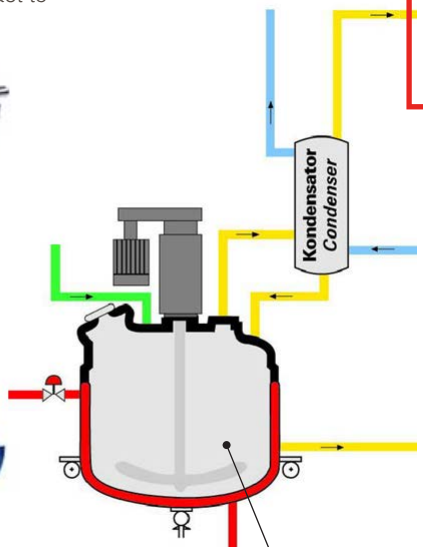
Marrying

Occasionally, bottlings are produced from one single cask — the so-called *single single* malts. More normally, several casks of similar ages from the one distillery will be 'married' by vatting them together then maturing them further for a few months.

A Typical Flowserve Pump Application for the Distillation Process

5. **Vacuum pumps/systems**
Vacuum pumps for running the process under lower temperatures

1. **Feed pumps**
Centrifugal pumps for feeding the react to the distillation vessel.



4. **Cooling water pumps**
Centrifugal pumps for circulation of cooling media at heat exchangers

2. **Heat transfer pumps**
Centrifugal pumps for handling high-temperature fluids

3. **Discharge pumps**
Centrifugal pumps for transferring the distillation product into next production stages or storage tanks

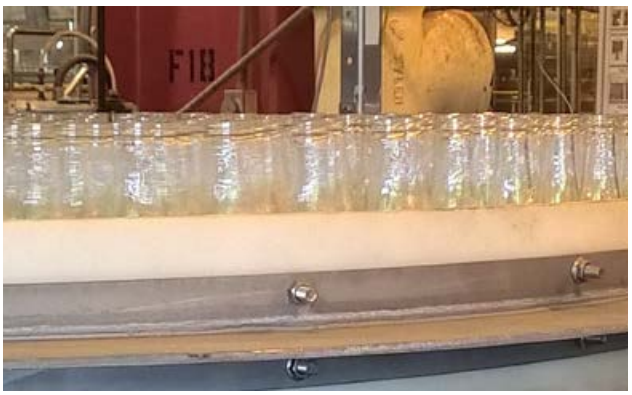
Installation References

Brewing


Mash Transfer Pump

Fermentation

Packaging



Glossary

AM	Aftermarket
AVL	Approved Vendor List
CIP	Clean-In-Place
Comm Ops	Commercial Operations
DE	Diatomaceous Earth
EPC	Engineering, Procurement and Construction
F&B	Food and Beverage
HVAC	Heating, Ventilation and Air Conditioning
KBI	Key Buying Influence
LCA	Life Cycle Advantage
LRVP	Liquid Ring Vacuum Pump
OEM	Original Equipment Manufacturer
OTD	On-Time Delivery
PDP	Positive Displacement Pump
QRC	Quick Response Center
RTM	Route to Market
SAM	Serve Addressable Market (Serve Available Market)
SCM	Supply Chain Management
TAM	Total Addressable Market (Total Available Market)
T&C	Terms and Conditions
WWD	Waste Water Digester
WWTP	Waste Water Treatment Plant

North America

Latin America

Europe

Middle East

Africa

Asia-Pacific

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Experience In Motion

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