WHITE PAPER:

NON-HYGIENIC PUMPS AND SYSTEMS FOR BREWERIES

OPTIMIZING PUMPS AND PROCESS SYSTEMS

Breweries are highly reliant on pumps and systems. Process pumps (beer pumps) convey the mash and wort in the brewhouse and green beer in the fermentation area, transfer matured beer from storage tanks for filtering, and transport finished brews (via the filtration and pressure tank) for filling.

As breweries invest more in automation to produce high-quality, consistent brews, Grundfos is well-positioned to support them with pumps, drive technology, sensors, and smart controls.

By partnering with a process pump expert like Grundfos, breweries can reduce energy consumption, increase efficient and effective water treatment, and further improve brewing processes.

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Introduction

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These are obvious applications in the brewing process, but other, less obvious applications are equally critical to brewery operations. Although Grundfos does not offer process beer pumps in its product portfolio, their pumps are still relevant for brewers, as they are used in the secondary, supply, and disposal processes.

Pumps installed in breweries are roughly divided as follows:

- Hygienic pumps: 50–60% (process beer pumps)
- Non-hygienic pumps: 30–40% (used in the secondary, supply, and disposal processes, such as water supply, water treatment, temperature control — heating, cooling and wastewater disposal)
- Dosing pumps: 10–20% (also predominantly used in secondary processes)

Key figures illustrate the importance of pumps and the relevance of energy-efficient processes. To produce 1 gallon of beer, breweries use between 3 and 4 gallons of water and have to dispose of between 2 and 3 gallons of wastewater. Around 30,000 watts of energy must be used per 26 gallons of beer — 46% for pumps, compressors, and other drives; 32% for cooling.

Pumps are one of the most important electricity consumers in a brewery. Grundfos offers a broad portfolio with a large number of relevant pumps in all secondary, supply, and disposal processes of a brewery.

Reliability and Service Life are Crucial

A survey initiated by Grundfos found that production and maintenance managers have the greatest influence on decisions about new or replacement pumps. The most important criteria when selecting pumps are:

- Service life (29%)
- Low maintenance (12%)
- Technical excellence (6%)
- Price and performance (6%)
- Availability of spare parts (6%) →

The results are not surprising. As in other industries, the expected reliability and service life of a pump system is often a deciding factor. After all, who needs problems with technology or loss of production?

Other decision criteria come into play depending on a brewery's size and organizational structure. For example, connectivity of a pump is most important for IT managers, while energy optimization and sustainability are more likely to be evaluated by environmental and energy managers.

Naturally, the master brewer plays a pivotal role. Depending on the size of the brewery, the master brewer can function as the technical manager; whereas, in other cases, he may be primarily involved in choosing process beer pumps.

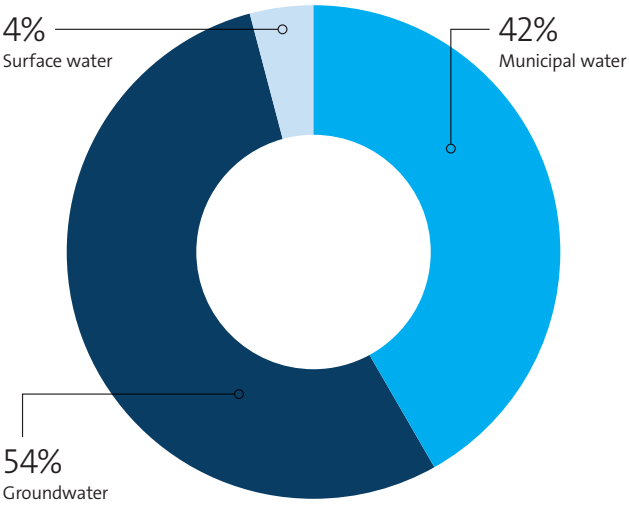
Pump systems in breweries are typically designed and built by plant manufacturers who work as general planners (OEM/EPC). Major suppliers also often recommend pumps. However, general planners will usually accept a brewery's request regarding a particular pump supplier.

Pumps in Water Extraction and Distribution

Water used in breweries primarily comes from three sources: (1) groundwater: extracted from a private well or borehole directly to the brewery; (2) surface water: extracted from rivers and lakes; or (3) water from a municipal utility system.

Depending on the water source, a variety of challenges can factor into pump selection. For one, the NPSH value of the pump (based on intake and pressure ratios) is crucial in pump selection to ensure the pump operates properly. Wells have a maximum amount of water they can hold at once, which must be taken into account when sizing the pump. Additionally, a brewery's water requirements usually fluctuate, leading to the need for variable speed pressure boosting systems. →

Brewery water sources, 2010



Water used in breweries usually comes from one of three sources.

Submersible SP Series pumps have been a cornerstone product of the Grundfos line since 1965.

Product offerings for water distribution available through Grundfos:

- SP pumps: Extract water from wells as groundwater pumps
- LCSE: Standard end-suction pumps used to pump water into buffer tanks; also used for mash and wort transport
- CR (E) / CRN (E): Vertical multistage pumps to increase pressure; Special range: CRN with flange connection according to DIN 11853-2, stainless steel AISI 316 (1.4401) and low surface roughness (option: electropolished dia ≤ 0.0003 inches), suitable for the beverage industry (not a hygienic pump)
- Hydro MPC: Variable speed boosting systems

Water Treatment

The quality of brewing water directly influences the taste of beer. The most important parameters for brewing water are water hardness (calcium and magnesium content), sodium content (metallic taste), and chloride and sulfate content. Each brewer decides on the taste they prefer for their own beer. Iron, sulfur, and manganese are always undesirable, as are chlorine and chloramines.

Because water quality varies greatly depending on its source, it must be conditioned accordingly. The process water for cleaning, heating, and cooling also has to be treated in many stages.

The first step for water treatment is filtration, which ranges from using simple sand filters, to various forms of membrane filtration (ultrafiltration, nanofiltration, and reverse osmosis), to an activated carbon filter and ion exchanger.

In all these technologies, the pressure drop that occurs during filtration must be compensated by pumps. For example, one could use a pressure boosting system that includes a connected series of several CR high-pressure pumps.

Dosing Pumps and Systems

Water treatment often requires adding chemical treatment to the raw water (for pH control, among other things). The efficiency and effectiveness of the dosing has a direct impact on the treatment results.

Grundfos offers SMART Digital Dosing pumps featuring a special drive concept, the stepper motor. One distinct advantage of these pumps is the extremely large turndown ratio of up to 3,000:1. A single pump type thus covers an enormously high performance range (e.g., 8 gph to .00067 gph) and reduces the number of other products and accessories needed. Another advantage is low pulsation and continuous dosing, which results in significantly higher process quality, with no need for downstream mixing.

Integrated FlowControl Monitoring allows precise diagnoses of the most common causes of dosing errors (defective valves, air bubbles, cavitation, or excess pressure). In addition, the AutoFlowAdapt function ensures the dosing process continues at a fixed target flow, even if external influences, such as air bubbles, cavitation, or fluctuating counter pressures occur. If the actual value deviates from the target value, this control feature regulates the speed of the drive.

These dosing pumps also are very user-friendly. The operator only has to enter the delivery rates in gallons per hour — and the pump does the rest of the work.

Thanks to integrated flow calculation, additional costs for appropriate measuring equipment can be eliminated. The current calculation of the flow is displayed on the SMART digital dosing pump screen.

Last but not least, Grundfos offers an accessory range for everything needed between the chemical tank and the injection point. →

A brewery's water use often fluctuates, requiring variable speed pressure-boosting systems with high-pressure CR pumps connected in series.

The Grundfos LCSE series, used to move large amounts of water efficiently and reliably.

By using the stepper motor, the digital dosing pumps achieve a turndown ratio of 3,000:1.

Disinfection Technologies

Dosing equipment also plays a vital role in process water disinfection. The four main sources of water that are disinfected within the brewery are: (1) brewing water, (2) CIP water, (3) bottle/keg cleaning water, and (4) cooling tower water. There are many common disinfection practices within breweries, including:

1. Chemical Addition:
   - Peracetic Acid (PAA) – not often used due to high cost
   - Chlorine Dioxide (ClO_2) – more effective, but must be generated on site
   - Sodium Hypochlorite (NaClO) – the most commonly used chemistry
   - Hydrogen Peroxide (H_2O_2) – 5 to 20 % concentration for CIP, 2 to 5 % for bottle washing, pH adjustment
2. Temperature: used less due to high energy consumption
3. Ultra-Violet Radiation: water flows through UV lights, killing a high percentage of microorganisms
4. Ozone: utilizes an unstable gas to destroy bacteria and viruses

The diversity of treatment options and modular equipment sizes allows for tailored water treatment and disinfection solutions for every size brewery. In all chemistry-added applications, Grundfos offers state-of-the-art options, both in standalone pump equipment and with complete chemical feed dosing systems. As discussed earlier, the stepper motor technology and high turndown ratios allow Grundfos to provide flexible and accurate solutions to chemistry-added disinfection processes.

The DSS is a pre-engineered floor or panel dosing system package that offers integrated controls and one, two or three pump configurations designed to accurately meter liquid chemicals for a variety of water supply/treatment systems, as well as industrial and manufacturing applications. At the heart of each DSS, are the Grundfos SMART Digital Dosing Pumps.

Pumps in Wastewater Disposal

Whether a brewery has its own wastewater treatment plant or not often depends on its size and local regulations.

This often correlates with the available water source. If a brewery gets water from its own well, it often cleans its own wastewater. If a brewery uses tap water, the untreated or pre-treated wastewater is delivered to the municipality.

In a brewery the chemical oxygen demand (COD) from all organic components (sugar, soluble starch, ethanol, volatile fatty acids, etc.) is typically high. The pH value of the wastewater depends on the amount and type of chemicals used for cleaning and disinfection (e.g., sodium hydroxide solution, phosphoric acid, nitric acid, etc.). Other critical parameters are the concentrations of ammonia, nitrate, phosphorus, and sulfate.

For wastewater transport, the SL range of wastewater pumps provide the highest total efficiency on the market up to 15 hp. And for higher performance coverage in dry and submerged applications, the SE range brings together intelligence, efficiency, and reliability. Designed for demanding situations, the Grundfos SL/SE pumps demonstrate Grundfos' approach to innovative technologies for the wastewater market, raising the bar for reliable wastewater pump systems and solutions for those transporting or treating wastewater on site.

The dosing pump and systems described above are also used in wastewater treatment for the input of flocculation aids. →

Water Reuse

Water reuse by breweries is increasing. In addition to being a sustainability issue, water reuse has economic ramifications. It reduces heating and cooling requirements, and as a result, boiler capacities and pump outputs are reduced as well. If water is reused, wastewater and disposal costs decrease accordingly. Additionally, breweries reusing water would need to buy less city water, which has further economic benefits for the brewery.

As part of its sustainability focus, Grundfos has broad experience in saving fresh water supply through water treatment. It has also developed simple and integrated solutions for safe and efficient water reuse. Among other solutions, reverse osmosis (RO) has proven to be a viable option for treating brewery wastewater for further process water reuse.

Possible applications for reusable, treated water include boiler feed, cooling tower make-up water, irrigation, partial CIP, and bottle rinsing.

Whether a brewery has its own wastewater treatment plant often depends on its size and local regulations.

Pumps in Temperature Control Processes

Boiler

Central steam boilers are typically used to heat the mash tun and boiler, as well as to clean (CIP) and disinfect/sterilize tools, tanks, and filling systems.

With its high pressures and temperatures, boiler feed is one of the more demanding tasks for pumps. The multitude of switch-ons and switch-offs put additional strain on a feed pump. In order to withstand such operating conditions, the CR multistage feed pumps have been fully optimized. Additionally, special designs with a low NPSH value work reliably and without cavitation, even with unfavorable inlet heights or low admission pressure. The pumps are also available with an air-cooled shaft seal chamber that prevents the mechanical seal from being damaged by high temperatures (The air-cooled top version can withstand up to +356°F without complex external cooling).

Refrigeration

Constant cooling is necessary for the fermentation/maturation process and beer storage. Even if a brewery reduces or ceases production, at least some cooling systems remain switched on, 24/7. Refrigeration technology is one of the largest electricity consumers in a brewery (around 40%), which is why it's important to optimize cooling systems and adapt output accordingly. Thanks to advances in motor technology, modern pump systems regularly offer higher levels of efficiency and, in turn, lower energy consumption. Therefore, it is often worthwhile to replace a pump or system that — while still functional — is outdated. →

Intelligent Solutions for Boiler Feed

Conventional boiler feed systems have a control valve, a circulation line, and typically oversized pumps. Grundfos has developed a boiler feed system that does not require a feed valve; instead, a variable-speed pump regulates it via a 4-20 mA level sensor mounted on the boiler. Based on stream consumption, the feed pump continuously adapts water supply, increasing speed when fill level is low and decreasing as fill level rises. Pump operation stops at the maximum fill level, and no bypass lines are required. With a direct supply, the chosen pump can be smaller, since there is no pressure loss from a valve. Because components like valves, bypass lines, and mixing circuits (to limit flow) are not required, the operator benefits from lower investment, installation, energy, and maintenance costs (the annual operating costs decrease by as much as 60%).

Optimizing Pumping Systems

It is possible to optimize pumping systems with the aid of variable speed CR pumps. A smaller main circulation pump can be installed in combination with a small pump for each refrigeration unit (e.g., wort cooling, fermenter, or pasteurizer), instead of control valves. The main circulation pump should be set to constant pressure, and the circulation pumps in the individual cooling units to constant temperature. The advantage: a variable speed pump can react faster than a motor-controlled valve. The elimination of throttle valves reduces pressure losses, saving energy and costs.

Pump Audit: A Working Example

Supply pumps are often used around the clock in breweries, so their efficiency should be checked from time to time.

At Pfungstädter Brauerei in Germany, Grundfos was commissioned to use a life cycle cost (LCC) analysis to evaluate refrigerant supply pumps. With the help of specially-developed software, values obtained from installed pumps were compared with those of potential new pumps, and the respective savings potential was determined using identical operating points. It quickly became evident that with an efficiency rate of 45%, the performance of the existing pumps resulted in unnecessarily high operating costs. An end-suction pump similar to the LCSE series was proposed as a possible replacement. This pump achieves an efficiency rate of 66% at the desired operating point.

Compared to the previous pump installation, the result brought savings of 92,020 kWh/year in electrical energy (at 8,600 operating hours/year and 23 hours/day). At a price of 13.19¢/kWh, this corresponds to an annual operating cost saving of $12,137/year, or 61% of the operating costs of the old pumps. This was accompanied by a reduction in CO_2 emissions of 41 tons/year. The total investment paid for itself after about 5 months.

Summary and Outlook

Grundfos offers a wide range of secondary pumps and disinfection solutions for breweries. In many cases, Grundfos' pumps and solutions can help optimize critical processes, such as:

- Extraction and distribution of water from wells
- Water treatment and disinfection
- Boiler feed
- Refrigeration
- Cleaning processes
- Treatment and disposal of wastewater

MLE permanent magnet motor with integrated frequency converter — classified as an IE5 high-efficiency motor up to 15 hp.

As breweries invest more in automation and process improvement, Grundfos is well-positioned with its self-developed and manufactured drive technology, sensors, and smart controls. The MLE permanent magnet motor with integrated frequency converter is rated up to 15 hp as an IE5 high-efficiency motor. With the associated PI controller and differential pressure sensor, pumps can significantly reduce their energy consumption and operating costs.

By working with Grundfos, breweries benefit from a single point of contact for their secondary pumps and systems, simplifying communication and maintenance. Additionally, Grundfos' solutions-based approach means that pumps and systems are optimized and coordinated with one another, so brewers can realize higher process efficiency and reliability. Ultimately, this allows brewers to focus more time and energy on what they are most passionate about – making great beer. ■

Crucial Trends for Breweries

- Specialty beers (e.g., craft beers) already enjoy market success and others will follow (bottle fermentation, new flavors).
  - Breweries will need additional fermentation tanks for this, and the need for related pumps is growing.
- Continuous rather than batch-oriented processes
- Differentiation of products through water quality
- Increased energy savings, primarily in cooling and heating systems
- The resulting decrease in heating and cooling requirements will lead to smaller boiler dimensions and thus, lower pump outputs.
- Water savings through water reuse

WE ARE IN THE WATER BUSINESS WITH YOU

As a pioneer and global leader in water pump technology, Grundfos creates intelligent, sustainable solutions to help solve the world's water and climate challenges. Through our heritage, we have the experience and innovative capabilities to help our partners, customers and communities move water in an increasingly energy and water efficient manner. We see this as not only a great business opportunity, but as an obligation to ensure the world heads toward a more sustainable tomorrow. Our complete portfolio of pumps and solutions are designed for commercial, residential, groundwater, municipal and industrial applications with emphasis in trendsetting, energy efficient technologies such as permanent magnet motors and advanced pump controls and monitoring. Because water matters, and so does your business.

To learn more, visit **grundfos.us** or follow us on Facebook and LinkedIn.

Visit grundfos.us/pei to learn more about Department of Energy (DOE) pump energy index (PEI) requirements and PEI ratings on specific Grundfos models.

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