

Pall “SUPRA” Solutions Key to Achieving Flexibility and Quality in Craft Brewing

Overview

In recent years, the craft brewing industry has grown exponentially, with a focus on delivering high quality and innovative, uniquely-flavored beer to consumers with increasingly sophisticated palates. From the early beginnings of microbrewing in the 1970's, when brewers sought inspiration from centuries-old brewing techniques, the craft brewing industry has expanded worldwide. The USA Brewers Association, a trade group of over 2400 operating craft brewers contributing to \$19.6 billion in sales and 11% market share by volume in 2014, has set a goal to achieve over 20% US beer market share volume by 2020¹.

Regardless of how craft breweries are distinguished from corporate or mainstream breweries in various countries, what is universal for these producers is their need for filtration equipment that is flexible, cost-effective, and produces high quality products.

Filtration is a key operation of the brewing process, which focuses on delivering a visually appealing, high quality, and shelf-stable product.

Diatomaceous earth (DE) filtration and sheet filter technology are the most common traditional methods of filtration for clarifying and fine-filtering beer. These methods ensure effective removal of coarse and fine particles, yeast, and colloids, and have been in use for more than 60-100 years. DE filters are well-proven for primary clarification after fermentation and maturation. For trap and fine filtration downstream of DE filters, sheet filtration provides an ideal solution, removing unwanted contaminants by a combination of surface, depth and adsorptive filtration.

The Challenge

While the filtration targets for turbidity reduction and yeast removal in craft beer may be similar to those of large mainstream breweries, the operating requirements and economic realities vary according to brewery size and manufacturing scale.

Craft brewing spans a wide range of brewery types. For example, in the USA it is classified partially by output, with microbreweries producing up to 17,550 hL per year, and regional craft breweries stretching the range up to 7 million hL annually^{1,2}. Craft beer industry market segments further distinguish between brew pubs, microbreweries, regional craft breweries and contract brewing companies.



On the lower end of the spectrum, brew pubs and microbreweries may run small, less frequent batches, and as a result, filtration may not receive the proper attention. Strong market growth or changing consumer preferences can demand capital investment for relatively quick expansion and new production methods. Craft brewers may also produce a high variety of different beers, requiring many product changes resulting in yield losses and labor-intensive operation. While overall economics may limit stepping up to very sophisticated system-based technologies, step-wise improvements must be made nonetheless.

Filtration solutions must satisfy not only quality but also production magnitude and economic requirements.

Where DE filters are employed, these provide economic and environmental disadvantages such as product yield losses, high waste disposal costs, operational labor intensiveness, high energy and cleaning costs, and DE handling challenges, which can include occupational health risks.

Where filter presses with sheet filters are employed, these pose challenges such as labor-intensive handling and change-out, large hold-up volumes making product changes difficult, drip losses resulting in lower yields, hygienic challenges such as potential for mold growth on exposed edges of filter sheets, and large footprint.

The Solution

Pall offers a comprehensive range of modern and cost-effective filtration solutions to the brewing industry.

- For a wide variety of craft brewers, these include the sheet-based SUPRADisc™ and SUPRApak™ module product families for clarification, trap and fine filtration, backflushable cartridges for polishing, and final membrane cartridges for microbial control in cold-filtered beer.
- For very large brewers, Pall offers systems for high capacity DE-free clarification (PROFI), beer recovery from yeast (Keraflux™), continuous beer stabilization (CBS System), and microbial and final filtration (CFS System).
- For value-added quality monitoring, Pall offers its GeneDisc® System for easy, quick, and reliable detection of beer spoilage bacteria in beer and process water in a matter of hours.

“SUPRA” Solutions for the Craft Brewery

Pall's SUPRADisc II and SUPRApak product lines provide a cost-effective and flexible option mainly within the filter cellar. These filter modules capitalize on the excellent removal performance of filter sheets while overcoming the marked disadvantages of filter presses. They consist of the same sheet media already proven over many years of use in the brewing industry.

As these filter modules are used in enclosed systems, there is limited to no oxygen uptake in the beer as typically experienced with open systems, there are no drip losses, no sticking of sheets to filter press frames, and beer can be pressurized out of the housing installation to further improve yield.

The choice between a SUPRADisc II or a SUPRApak solution depends largely on beer characteristics (solids load, nature of contaminants), volume, batch size, filtration goal, and capital investment. Given the strong merits of each of these product families, the right technology is matched to the application.

SUPRADisc II Modules – for Brew Pubs and Microbreweries

SUPRADisc II (SD II) lenticular modules are Pall's substantial design improvement over classical stacked disc modules (Figure 1). The modules have a patented double separator design which provides both upstream and downstream support. Sheet media is individually sealed between separation plates, which optimizes flow through the available surface area and creates an extremely robust module (Figure 2).

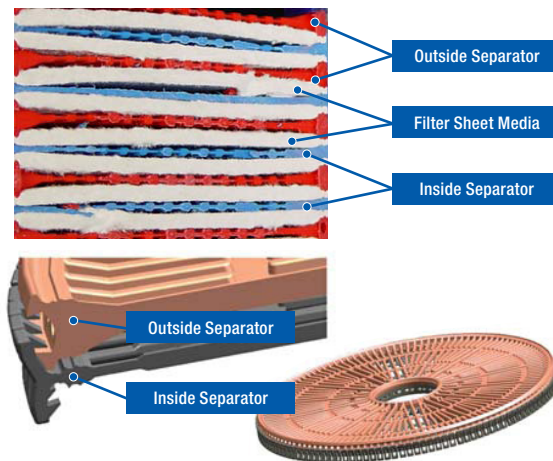


Figure 2: SD II module cutaway and separators feature a unique, patented design. The result is modules which are robust, cleanable, backflushable, and in-place steamable, satisfying rigorous production requirements in breweries.

With multiple successful installations in breweries worldwide, they are typically positioned in the following types of applications:

- Trap filtration following a DE filter
- Fine filtration, including removing haze-forming particles and reducing microorganisms³, prior to bright beer tank or upstream of final membrane cartridges in the filling area
- Primary clarification after fermentation and maturation/fining⁴

SD II modules in 287 or 410 mm (12 or 16 inch) diameter size are installed in sanitary lenticular housings holding from 1-4 vertically stacked modules (Figure 3). Flexibility in housing design enables the use of multiple lengths of hardware center posts that make it possible to use from 1.8 to 7.2 m² (19.4 to 77.6 ft²) or from 5 to 20 m² (53.8 to 215.3 ft²) of modules in the given housing, to accommodate different batch sizes.



Figure 3: Pall's WSFZ housings for SD II modules provide flexibility in production. By installing internal center posts of different lengths, filtration can be run at 25, 50, 75 and 100% of capacity. Special adaptors enable retrofitting with SUPRApak modules as production capacity increases.

▶ Figure 1: SD II 410 mm/16 inch diameter modules offer the highest filtration area among lenticulars in the industry, namely 5 m²/53.8 ft², exceeding the closest commercially available ones by 28%. Regeneration by backflushing additionally increases service life.



SD II modules can be multi-cycle water flushed in a forward flow direction, at up to 85 °C (185 °F). More typically flushing is done at 60 °C (140 °F), enabling a very good release of contaminants soluble in hot water without denaturing proteins that could cause premature plugging of the modules. SD II modules can additionally be regenerated by backflushing multiple times, to release surface load of hop particulates and residues, yeast and other particles. Flushing in forward and reverse direction is a common operation used in breweries to increase the overall throughput of the modules⁵.

The modules can be repeatedly steamed in place (SIP) at 121 °C (250 °F) without compromising their structural integrity. This feature is useful when breweries opt to reduce microbial loads on the modules, such as in very tight grade filtration, or prior to or after storage of the modules in between batches.

Where lenticular filters in a wide variety of housings are already in use, SD II modules provide a commanding retrofit alternative due to their often higher filtration area, increased service life due to full utilization of the filtration area and backflushing capability, and pronounced mechanical robustness which enables multiple cycle cleaning, in-place steaming, and ease of handling both pre- and post-filtration.

Table 1 shows that in a typical fine filtration application, a brewery operating 8 hours per day, 5 days per week, 50 weeks per year can process up to 80'000 hL of beer through a single SUPRAdisc II 4-high housing using 16 inch diameter modules.

Unlike standard flat filter sheets, SD II modules can be stored in between batches for reuse at a later date.

Table 1: SUPRAdisc II Lenticular Filtration in Brewing Applications

Nominal module diameter	287 mm (12 inch)	410 mm (16 inch)
Module filtration area	1.8 m ² (19.4 ft ²)	5 m ² (53.8 ft ²)
Maximum filtration area per housing (4 modules)	7.2 m ² (77.5 ft ²)	20 m ² (215.3 ft ²)
Typical module flow rates (trap filtration post-DE filter)	2.7-4.5 hL/hour	7.5-12 hL/hour
Typical module flow rates (fine filtration)	2.7-3.6 hL/hour	7.5-10 hL/hour
Typical module flow rates (primary clarification) ⁴	1.8-2.7 hL/hour	5-7.5 hL/hour

Typical throughputs can range from a few hundred to several thousand hectoliters for each SD II module, depending on the applications. The higher the filterability of the beer, the higher the module capacity. Filterability is influenced by raw materials, mashing and brewing process, beer type, fermenter yeast type and yeast management, turbidity of the unfiltered beer, and influences of the upstream process steps.

A unique version of the SUPRAdisc product family is SUPRAdisc HP, which combines two layers of different grades of filter sheets within the same module. While this approach halves the available filtration area of any one sheet type within the module, it is well suited for small batch processing, due to a two-step filtration done in one housing. More difficult to filter beers or beers with a wide particle size distribution can benefit from an initial coarse filtration followed by fine filtration. Sizing would be approximately half that shown in Table 1.

Main Benefits of SUPRAdisc II Technology for Microbreweries and Small Breweries

- Flexible and compact installation, ideal for smaller producers and shorter production batches
- High yield and product protection, due to enclosed system
- Substantially higher throughput than classical stacked disc modules, due to backflushing capability
- Cost-effective due to increased service life, and the capability to store and reuse modules
- Simple handling and filter change-out due to robust design

SUPRApak Product Family – For a Wide Range of Craft Breweries

The SUPRApak product family, including the newly available SUPRApak Plus module, is Pall's latest innovation in depth filtration (Figure 4). The modules feature an entirely unique design and flow configuration. They are extremely high-density packs of filter sheets rolled around a center permeable core. Their innovative design results in a unique flow pattern (called "edge flow") in which fluids travel through the sheet parallel to the sheet surface. This flow path results in far better filtration performance than flat sheet filtration, in which fluids travel perpendicular to the sheet surface.

Edge flow maximizes the adsorptive filtration capability of the sheets, which enhances removal of hop resins, proteins, phenols, high molecular alpha and beta glucans and other haze-causing substances. It is the key to achieving excellent filtrate quality.

High filtration area combined with enhanced filtration performance makes the SUPRApak product line an excellent fit for a wide range of brewery outputs, from about 1,000 to 4,000,000 hL per year.



Figure 4: SUPRApak Plus is Pall's newest addition to the well-known SUPRApak product range.



Offering economic, game-changing benefits, the SUPRApak solution has gained significant acceptance in brewing worldwide. SUPRApak modules are primarily positioned in the following applications:

- Trap filtration following a DE filter
- Fine filtration, including removing haze-forming particles and reducing microorganisms³, prior to bright beer tank or upstream of final membrane cartridges in the filling area
- Primary clarification following a centrifuge⁴

Where microbreweries are already using SD II modules in Pall lenticular housings, SUPRApak modules can be substituted in the same housings by using simple adaptors, to address production expansion or to handle more complex, tougher to filter batches of beer. A 16 inch SD II module typically sized to process 8 hL per hour can be replaced by a 16 inch SUPRApak module typically sized to process 20 hL per hour– a 2.5 fold increase in capacity.

In new installations, SUPRApak modules are installed in hygienic single and multi-round SUPRApak housings. Table 2 and Figure 5 show the sizes and available capacity of the most common housing options. In single-round housings, modularity of housing design enables the number of modules used in the housing to be varied to match changes in required production capacity (Figure 6).



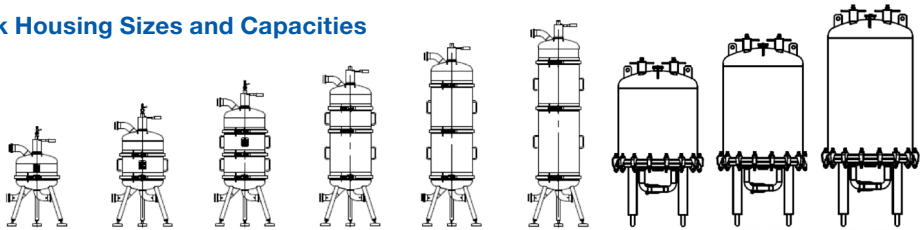
Figure 6: SUPRApak L-421 (4-high) housing, shown with standard accessories, can be operated as a 1,2,3 or 4 high housing.

Typical throughputs achieved depend largely on beer filterability, influenced by the same factors as previously indicated for SD II modules.

With the introduction of SUPRApak Plus modules, even further improvements are realized. In one side by side comparison in a brewery downstream of a DE filter, the SUPRApak Plus modules provided a

Table 2: SUPRApak Housing Sizes and Capacities

Figure 5: SUPRApak housings accommodate from 1 up to 24 modules. They provide flexibility and high capacity in a very compact footprint.



Housing type	Single-Round Housings						Multi-Round Housings		
	L-100	L-210	L-311	L-421	L-522	L-632	MS-400	MS-500	MS-600
Max. no. of modules	1	2	3	4	5	6	16	20	24
Capacity (hl/hour)	20	40	60	80	100	120	320	400	480

Table 3 illustrates that in a fine filtration application, running 8 hours per day, 5 days per week, 50 weeks per year, a single SUPRApak L 6-high housing can process 120 hL per hour or up to 240,000 hL of beer. Due to its modular design, the same housing can alternatively be set up to use 1, 3 or 4 modules to process 17%, 50%, or 67% of this volume.

50% higher throughput than SUPRApak modules, while maintaining the same filtrate quality. Both SUPRApak and SUPRApak Plus modules can be multi-cycle flushed or regenerated and sanitized in a forward flow direction at up to 85 °C (185 °F). SUPRApak Plus modules can additionally be steamed in place (SIP) repeatedly at 125 °C (258 °F).

Table 3: SUPRApak Filtration in Brewing Applications

Nominal module diameter	287 mm (12 inch) (Size "M")	410 mm (16 inch) (Size "L")
Number of filter sheets/area replaced by 1 SUPRApak module	29 40 x 40 sheets OR 13 60 x 60 sheets (4.7 m ² /50.6 ft ²)	83 40 x 40 sheets OR 37 60 x 60 sheets (13.3 m ² / 143.2 ft ²)
Typical module flow rates (trap and fine filtration post-DE filter)	7 hL/hour	20 hL/ hour
Typical module flow rates (filtration post-centrifuge ⁴)	3-5 hL/hour	12-20 hL/hour

Main Benefits of SUPRApak Technology for Craft Breweries

- Long production runs with less downtime than classical methods
- Modular and flexible, matching capacity to production volume
- Significant OPEX cost savings, due to savings in labor and handling, maintenance, cleaning operations, water, energy and disposal costs
- High yield and product protection, due to enclosed system
- Extremely compact footprint and reduced CAPEX
- Short hardware lead times compared to typical alternative technologies, enabling quick expansion



Quality Monitoring in the Craft Brewery

As craft brewing processes increase in size and complexity, a manufacturer's risk of exposure to economic loss due to quality insufficiencies increases. Robust and high performing filtration techniques deliver desired outcomes, however an integrated quality assurance program that monitors critical control points in the process is indispensable.

Every step of the process, from raw material receiving to final packaging and managing utility fluids (e.g. water), is a potential point of unwanted microbial contamination. Pall's GeneDisc Real-Time PCR system is a rapid, reliable, and easy to use detection method for beer spoilage bacteria (*Pediococcus*, *Lactobacillus*, *Pectinatus* and *Megasphaera*), yielding results in a matter of hours. This quick confirmation tool for product quality not only reduces time to shipment, but also provides informative monitoring with which processors can diagnose or prevent problems at the different critical control points of a process⁶.

The Benefits

Characterized by innovation, varied brewing methods, wide differences in manufacturing scale, and exponential growth, the craft brewing industry requires cost-effective filtration solutions that fit uniquely into each process, while satisfying these universal requirements:

- Flexibility for handling varying batch sizes and enabling future expansion
- Superior filtration performance resulting in desirable and consistent beer quality
- High throughput with a compact system
- High production yield with no drip losses
- Simple operation, with quick and easy change-over between batches

Pall "SUPRA" products meet the challenge and provide solid value to the craft brewing industry.

About Pall Corporation

Pall Corporation is a global filtration, separation and purification leader providing solutions to meet the critical fluid management needs of customers across the broad spectrum of life sciences and industry. We work with our customers to advance health, safety and environmentally responsible technologies. Pall Food and Beverage provides products and services to ensure product quality and maintain process reliability in beverage and food production. Our solutions also assist in consumer protection, waste minimization and reduction of operating costs.



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Coupled with Pall's GeneDisc Real-Time PCR system, these products best position breweries for successful outcomes.

Pall Food and Beverage Brewing Expertise

Brewing beer is a complex process of marrying art with science. With over sixty years of application experience and product development in brewing applications, Pall offers itself not only as a filtration solutions provider but as an informed technical partner, who understands the interplay of brewing operations with the resulting characteristics and quality of the brew.

References and Footnotes

¹ USA Brewers Association 2014 data, www.brewersassociation.org

² Beer volumes are also expressed in terms of barrels, which have slightly differing definitions around the globe. 1 US Barrel equals 1.17 hL. 1 UK imperial barrel equals 1.64 hL.

³ Microbiological claims based on LRV values do not apply, as with all filter sheets in general, as there is no official standardized method to qualify the microbiological performance, and sheet performance is highly dependent on process conditions.

⁴ Successful applications for SUPRAdisc and SUPRApak modules in primary clarification or post-centrifuge applications are dependent on beer filterability and filtration requirements. Sizing post-centrifuge depends additionally on centrifuge type and performance. Please contact Pall for an assessment of suitability.

⁵ Backflushing requires the use of simple backflush hardware. Please contact Pall regarding protocols for backflushing, cleaning and sanitization suitable for your application.

⁶ Please request Pall Application Bulletin FBABGDBEEREN "Implement High Value-Added Quality Control in Breweries with the GeneDisc System."