Principles of cleaning and CIP

– CIP in the brewery (and food and beverage applications)

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What we'll talk about today

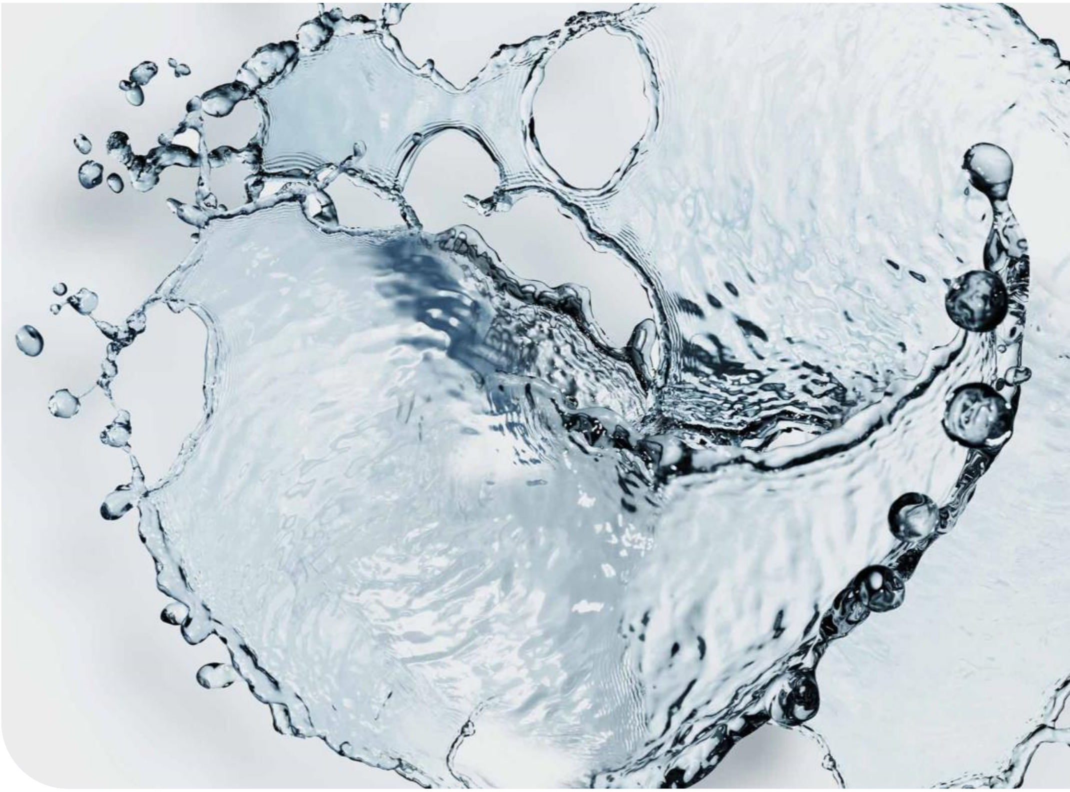
– Agenda

- Principles of cleaning and CIP
- CIP in the brewery (and food and beverage applications)
- Technologies for tank cleaning
- Optimization of CIP process
- Automated CIP solutions from Alfa Laval Brewery Systems

Purpose of cleaning and CIP

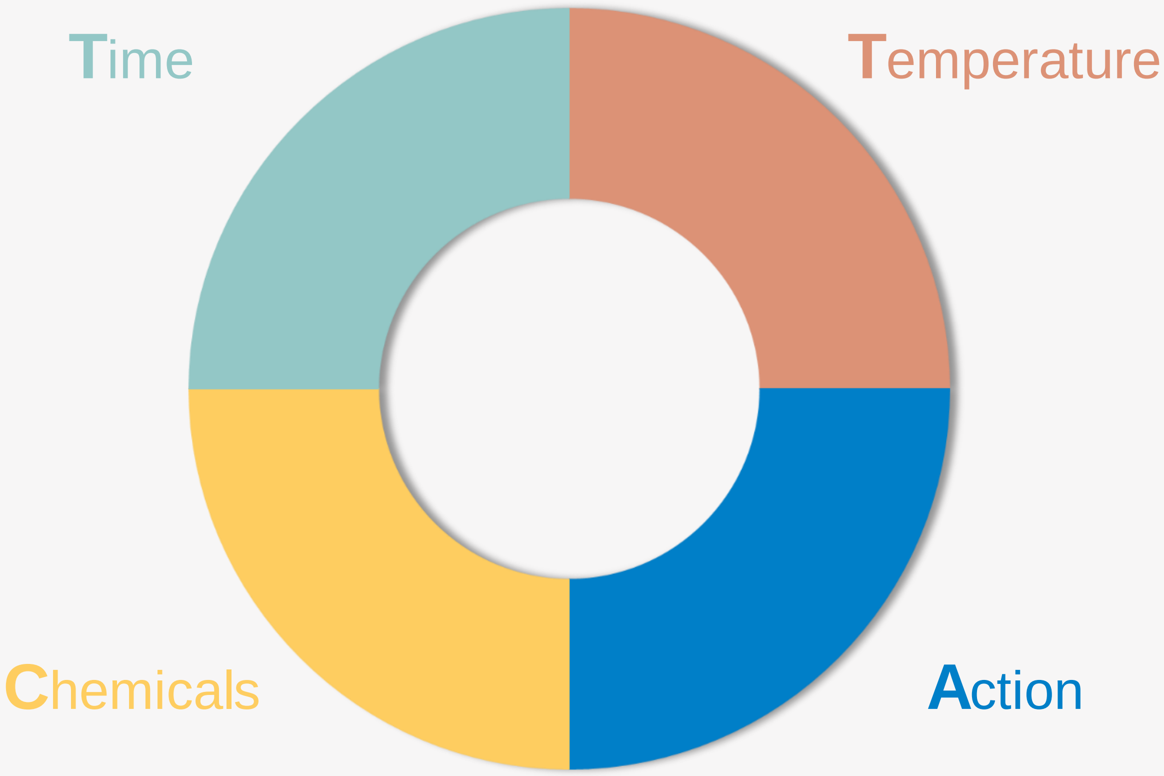
– Why do we clean?

- Maintenance of product **purity**, **quality** and **safety**
- Prevention of product **contamination** (e.g., spoilage)
- Prevention of **cross-contamination** (e.g., ingress of one product into another)
- Maximization of equipment **uptime** and production **capacity** (fastest possible resumption of production after completed batch)
- Maintenance of **control** of the production **process**



Principles of cleaning

TACT – Sinners Circle



- **Sinners Circle** represents the scope of a given cleaning task
- The combined elements of the circle (temperature, action, chemicals, time) accomplish the task
- Larger share of one or more elements allow smaller shares of the others (e.g., higher temperature allows less time, or more action allows less time, lower temperature, less chemicals)

Mechanical cleaning (action)

– Requirements for mechanical cleaning in the brewery

- **For pipes:** minimum fluid velocity >1.5 m/sec to generate sufficient turbulence to achieve the desired cleaning effect

- **For tanks:** cleaning machines generating geometric reach of all interior surfaces (coverage) and sufficient impact force on the surfaces

- **For special equipment** (e.g., separators and plate heat exchangers): clearly defined cleaning procedures and specifications to ensure optimum cleaning effect

Mechanical cleaning

– Minimum flow rates in pipes

Pipe size	Minimum flow rate	Velocity
DN 25	30 hl/h	1.7 m/s
DN 40	80 hl/h	1.8 m/s
DN 50	120 hl/h	1.7 m/s
DN 65	200 hl/h	1.7 m/s
DN 80	300 hl/h	1.6 m/s
DN 100	400 hl/h	1.4 m/s

Chemicals used in CIP

– Main types of cleaning chemicals and their purpose

Cleaning media	Chemical compounds	Function
Water	H_2O	Pre-rinses, intermediate rinses and final rinses remove solid residues and flush away chemical residues.
Caustic (~2%) at 85°C or 35°C	NaOH, KOH	Dissolves and removes organic residues like yeast and hops. Requires a CO_2-free atmosphere to prevent carbonate formation.
Acid (~0.5–1%)	HCl, H_3PO_4, CH_3CO_3H	Dissolves and removes inorganic residues like beer stone. Can be combined with disinfectant in a single step.
Disinfectant	ClO_2, O_3, H_2O_2	Kills bacteria, spores and hardy microorganisms that survive caustic wash. Can be combined with acid in a single step.
Water	H_2O	Pre-rinses, intermediate rinses and final rinses remove solid residues and flush away chemical residues.

Automated Cleaning-in-Place (CIP)

– What is it?

- Enables cleaning of tanks, piping and other process equipment without dismantling or manual cleaning processes
- Typically consists of tank cleaning machines installed inside the tanks
- Involves cleaning stages using water and chemicals that circulate through the CIP system to the equipment for thorough cleaning and disinfection
- Proceeds through the entire sequence of cleaning steps without requiring human intervention

Tank cleaning technology

– Characteristics of tank cleaning machines

Static spray ball

Easy-to-clean tasks
Max. diameter: 3 m
Pressure: 1–2 bar
Cleaning costs: High
Cleaning efficiency: Low
For small tanks, water, CIP

Rotary spray head

Moderate cleaning tasks
Max. diameter: 5 m
Pressure: 2–3 bar
Cleaning costs: Medium
Cleaning efficiency: Medium
For small process tanks

Rotary jet head

Difficult cleaning tasks
Max. diameter:15+ m
Pressure: 5–7 bar
Cleaning costs: Low
Cleaning efficiency: High
For fermenters and large tanks

Principles of cleaning – tank cleaning machines

– Effect of cleaning machine type on required cleaning parameters according to the Sinners Circle

Static spray ball

Rotary spray head

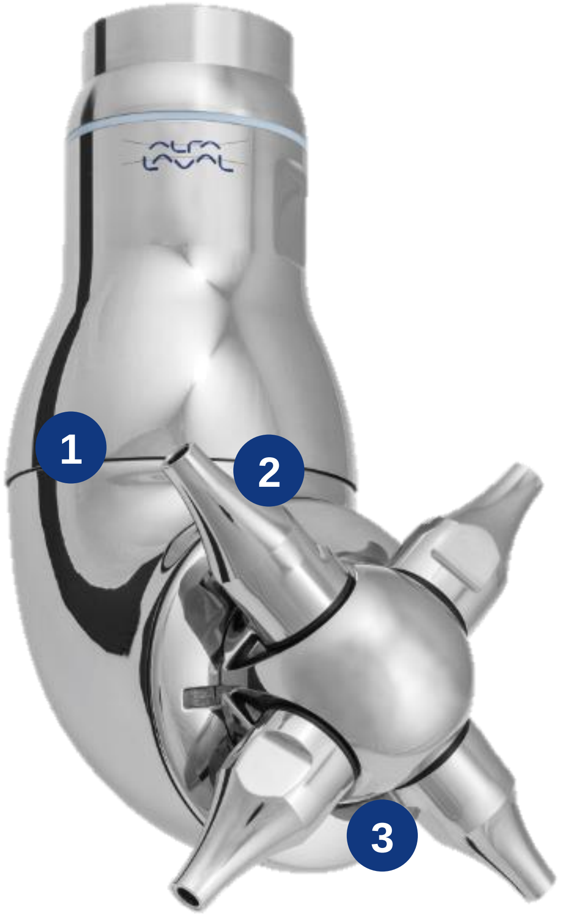
Rotary jet head

Alfa Laval TJ40G

– Best-in-class for rotary jet head tank cleaning with hygienic design and self-cleaning

Enhanced self-cleaning features of TJ40G

1. Self-cleaning of body
2. Self-cleaning of nozzles
3. Self-cleaning of cone



Alfa Laval TJ40G

– Self-cleaning demonstration using yogurt as the test media

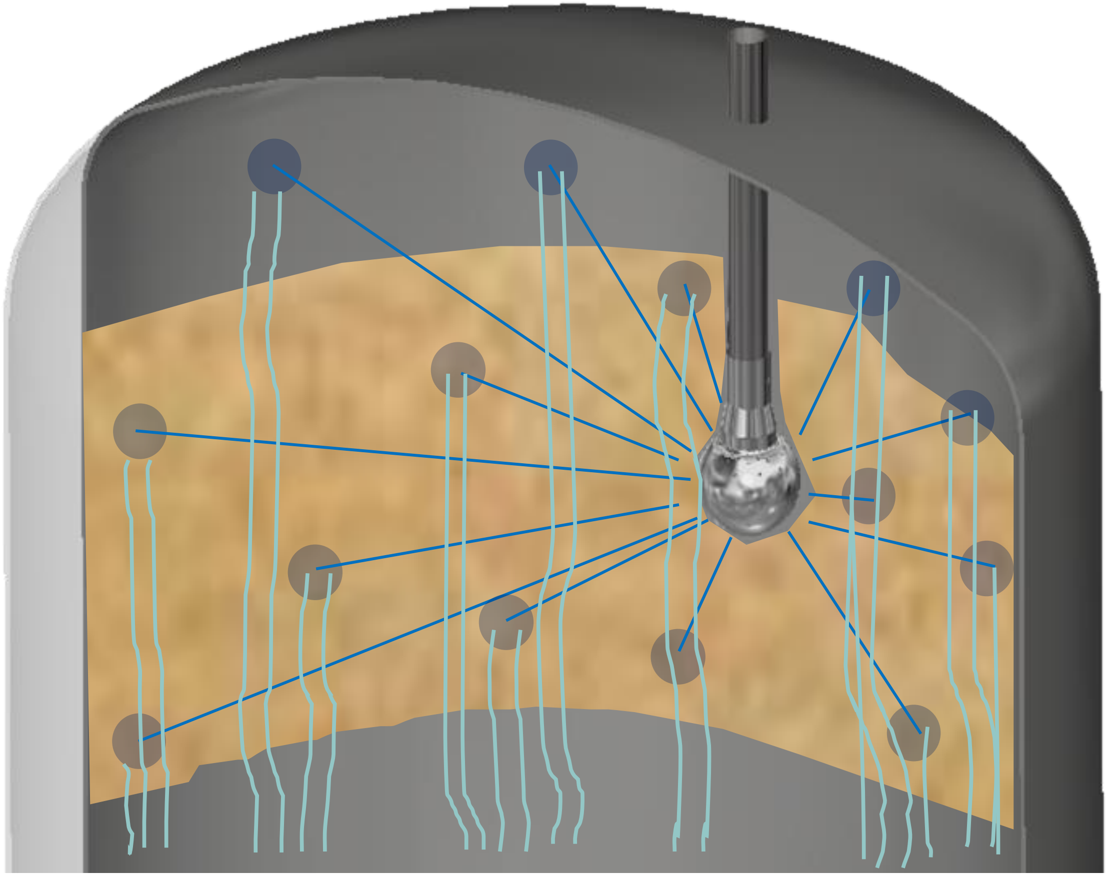
Challenging cleaning task

– Fermenter yeast ring

Static spray ball for fermenter yeast ring

– Fast wetting but low action: inefficient and expensive cleaning

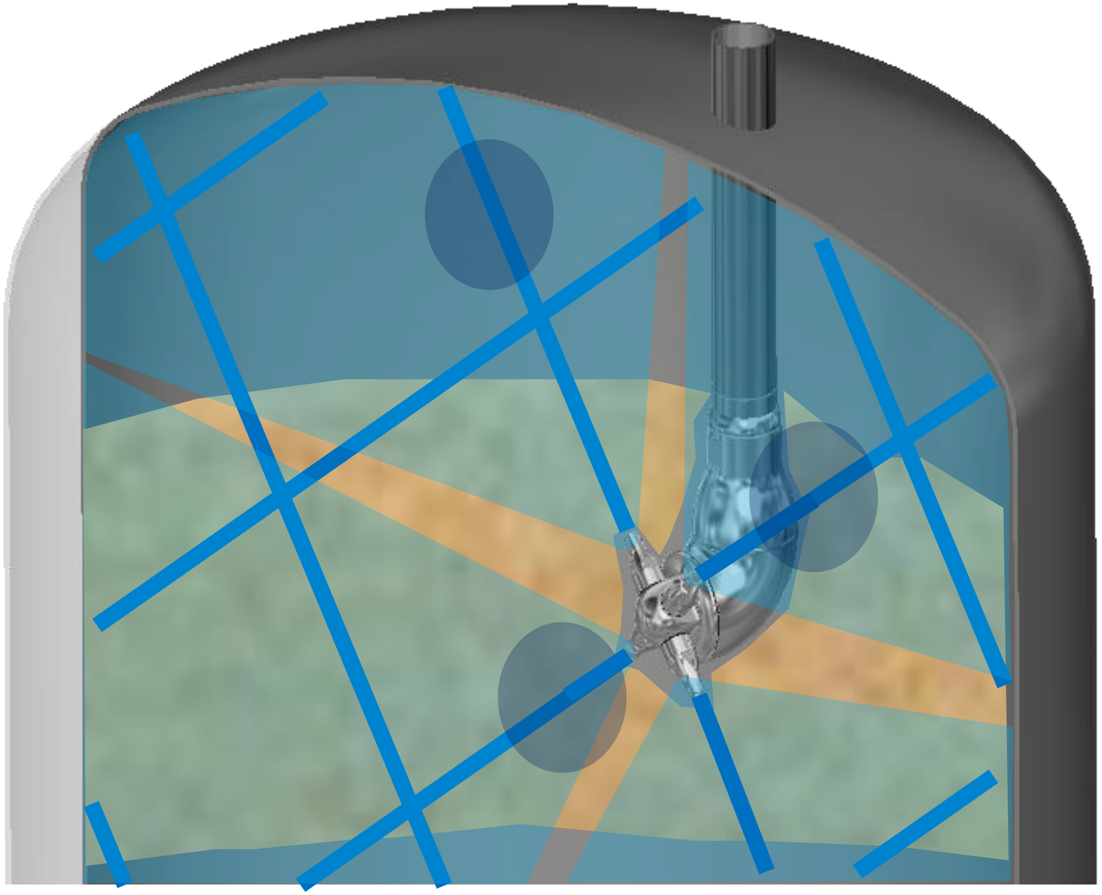
- Low cleaning action
- Long cleaning time
- High operating cost



Rotary jet head

– High-impact cleaning

- Fast effective wetting
- High cleaning action
- Fast cleaning time
- Low operating cost

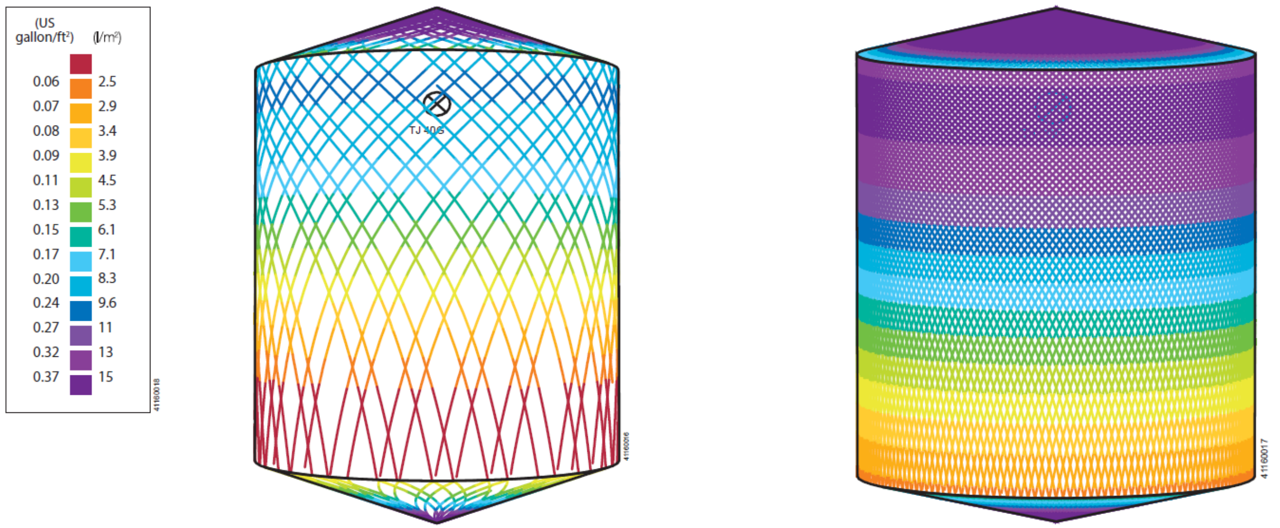


Development of TJ40G cleaning pattern

– TRAX simulation of time, wetting intensity and cleaning fluid consumption

- TRAX program illustrates wetting intensity in all areas of tank during the cleaning cycle
- Examples show wetting and water consumption after 2 minutes (1 cycle) and 16 minutes (8 cycles = 1 full pattern)
- Tank diameter: 4.6 m
- Cylinder height: 5.5 m
- TJ40G: 4 x 7.3 mm nozzles

Wetting Intensity

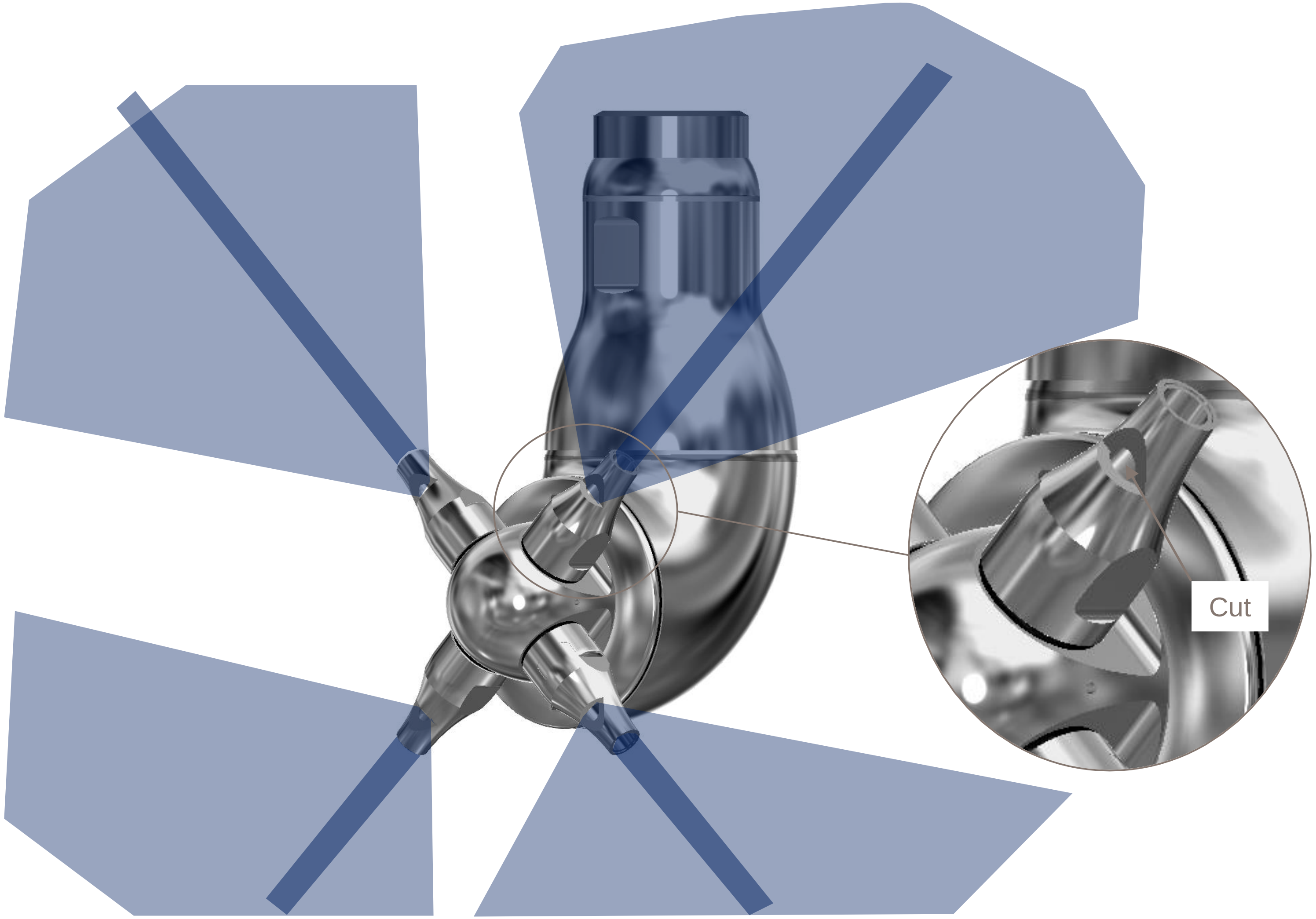


D4.6m H5.5m, Toftejorg TJ40G, 4 x ø7.3 mm, Time = 2 min., Water consumption = 700 l

D4.6m H5.5m, Toftejorg TJ40G, 4 x ø7.3 mm, Time = 16 min., Water consumption = 5600 l

Alfa Laval TJ40G Burst

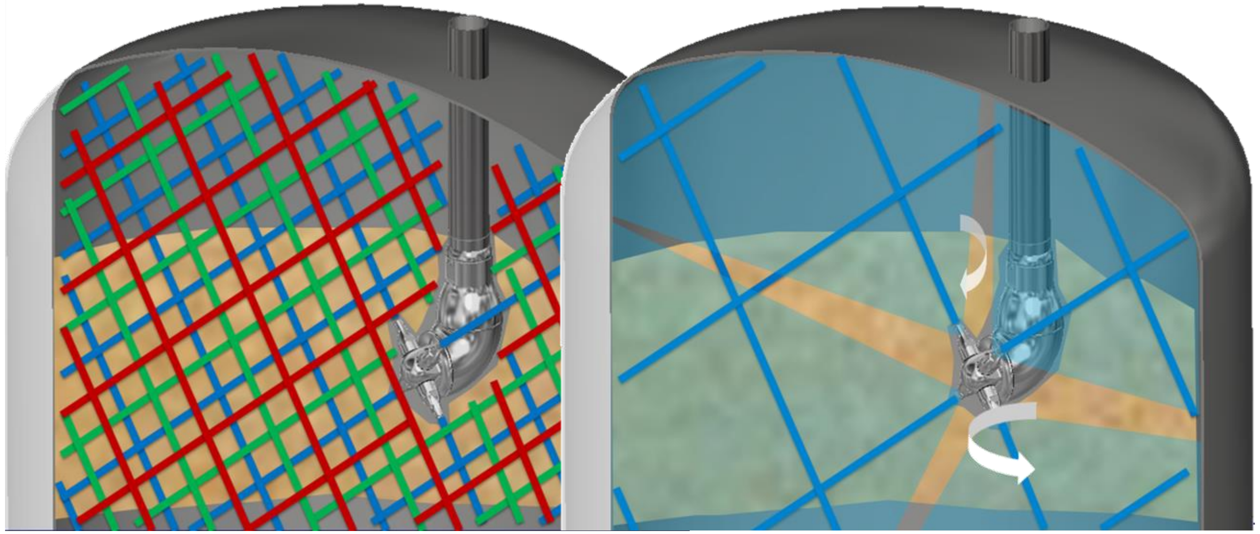
– Fast-wetting AND high-impact cleaning



Standard TJ40G versus TJ40G Burst

Standard TJ40G

TJ40G Burst



Less caustic is necessary to wet the tank surface using TJ40G Burst as there is no need to build up a dense cleaning pattern

Savings

– Standard spray ball CIP with caustic recovery

Steps	CIP program	Re-use factor %	Minutes	EUR
1	Water rinse	0	10	26.25
2	Caustic re-circulation	85	60	26.25
3	1 x water rinse (1 cycle)	50	5	6.56
4	8 x sterilant continues re-circulation	90	20	9.33
5	1 x final rinse (2 cycles)	100	6	0.00
	Total per year per fermenter		101	**EUR 2,529**

Five cleanings per month
Flow rate: Spray ball 350@hl/h

Savings

– Burst spray ball CIP without caustic recovery

Steps	CIP program	Re-use factor %	Minutes	EUR
1	1 x ambient caustic burst	0	1.5	4.38
2	Wait time		5	
3	1 x ambient caustic burst	0	1.5	4.38
4	Wait time		5	
5	1 x ambient caustic burst	0	1.5	4.38
6	Wait time		5	
7	1 x ambient caustic burst	0	1.5	6.13
8	Wait time		5	
9	1 x water rinse	50	5	6.56
10	8 x sterilant continues re-circulation	90	20	9.33
11	1 x final rinse	100	6	0.00
	Total per year per fermenter		57	**EUR 2,109**

Five cleanings per month
Flow rate: Spray ball 350@hl/h

Savings

– TJ40G Burst CIP without caustic recovery

Steps	CIP program	Re-use factor %	Minutes	EUR
1	1 x ambient caustic burst	0	1	2.22
2	Wait time		5	
3	1 x ambient caustic burst	0	1	2.22
4	Wait time		5	
5	1 x ambient caustic burst	0	1	2.22
6	Wait time		5	
9	1 x water rinse	50	2	1.43
10	8 x sterilant continues re-circulation	90	20	5.07
11	1 x final rinse	100	4	0.00
	Total per year per fermenter		44	**EUR 789**

Five cleanings per month
Flow rate: TJ40G Burst 190@hl/h

Comparison

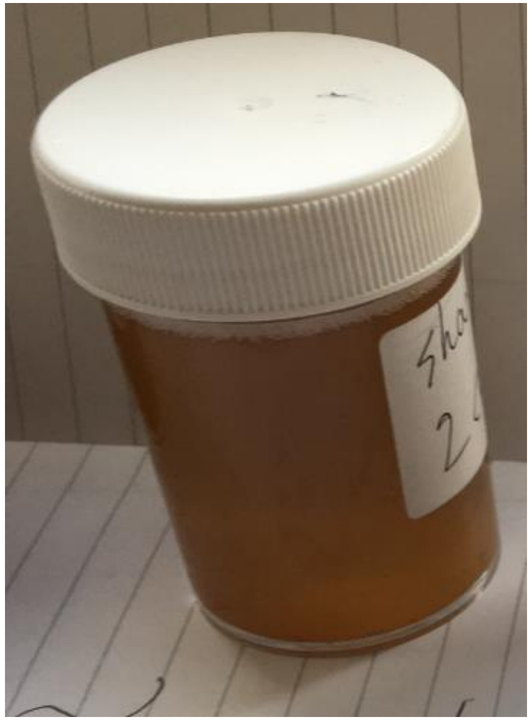
– Summary of savings

	Spray ball with caustic recovery	Spray ball without caustic recovery	TJ40G Burst without caustic recovery
Water	73 hl	15 hl	3 hl
Caustic	52 hl	35 hl	9 hl
Sterilant	12 hl	12 hl	6 hl
Yearly operation cost	2,530 EUR	2,100 EUR	789 EUR

Optimizing burst cleaning

– Trials to find appropriate number of repetitions

1st burst of 60 seconds

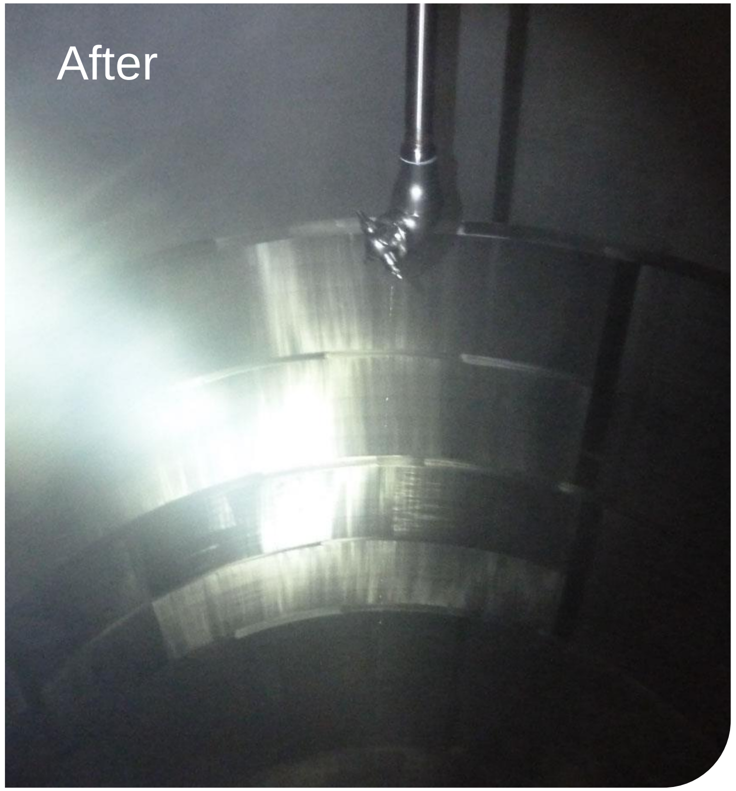


2nd burst of 60 seconds

3rd burst of 60 seconds

Optimizing burst cleaning

Evaluate and analyze the cleaning results!

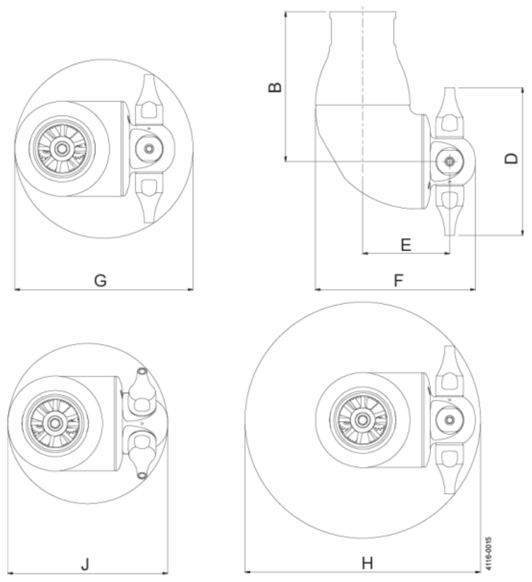


Considerations for retrofit to TJ40G Rotary Jet Head

– Insertion of machine into tank

- Most static spray balls are <100 mm in diameter
- Insertion flanges for these on tank tops are therefore typically 100 mm or smaller
- TJ40G Rotary Jet Head requires an opening of 180–200 mm to insert the machine
- It is not therefore feasible to use existing static spray balls flange openings to insert the head
- Ideal design for a TJ40G insertion flange would include the Alfa Laval Rotacheck validation instrument on the flange

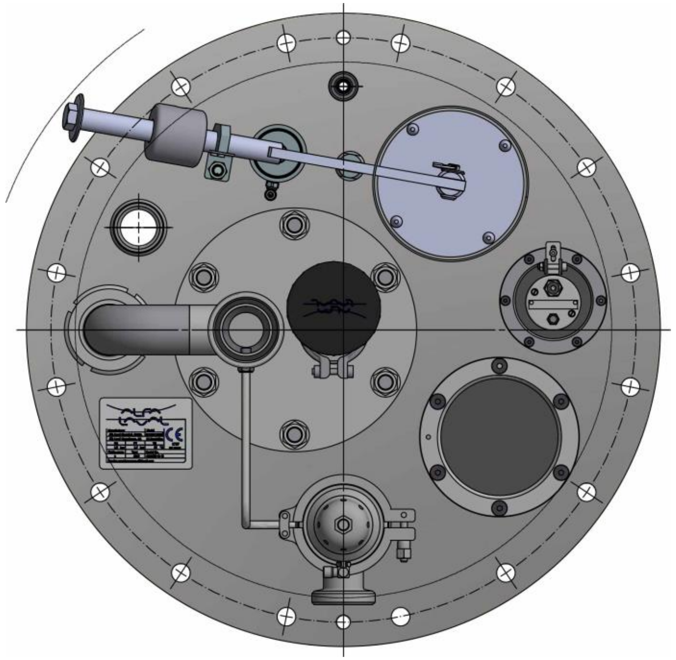
Dimensions (mm)

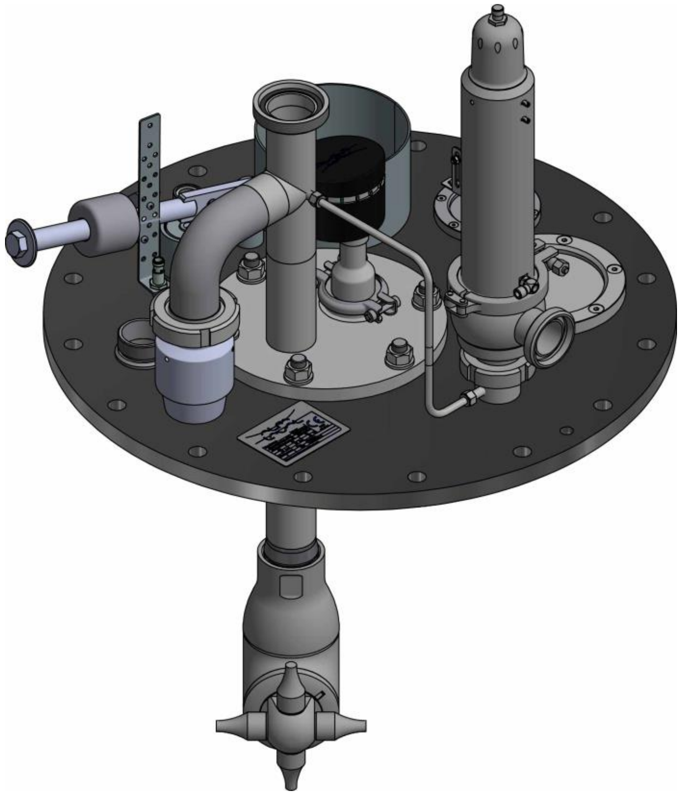


B	D	E	F	G	H	J
156	155	90.8	167	187	246	167

SCANDI BREW top plate with TJ40G and Rotacheck

– Insertion flange for TJ40G with optimal placement of Rotacheck validation instrument already mounted

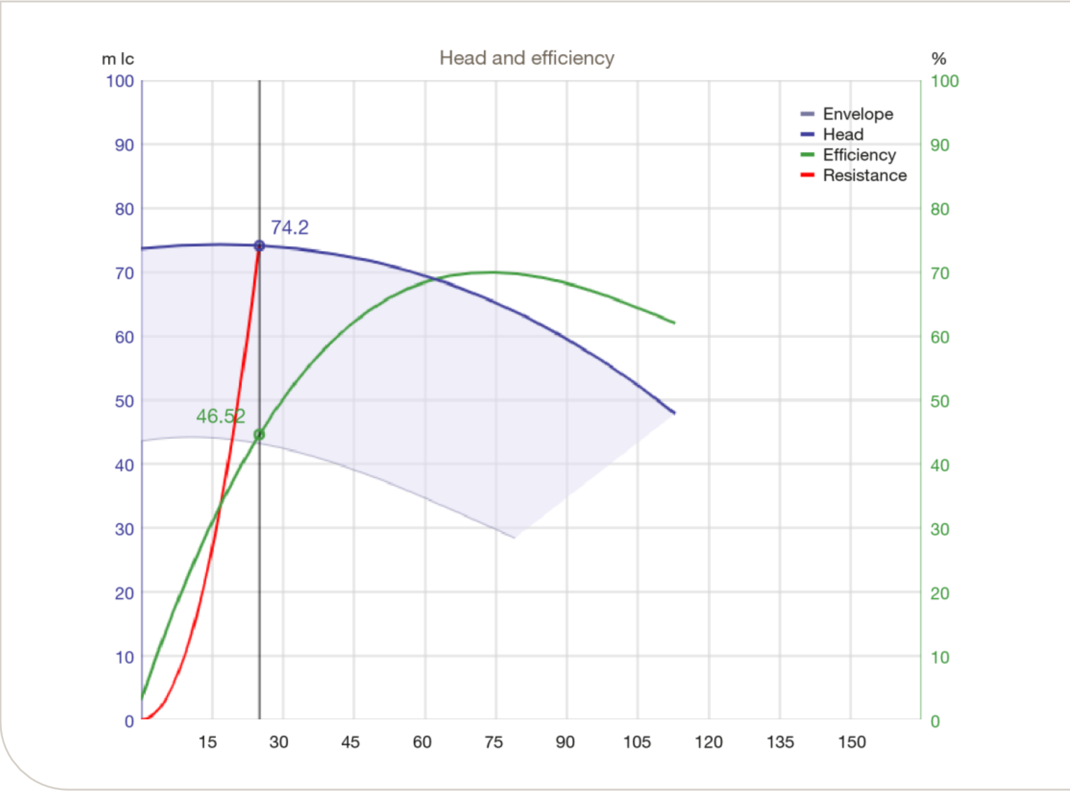




Considerations for retrofitting with a rotary jet head

– Required capacity for CIP-Forward pump

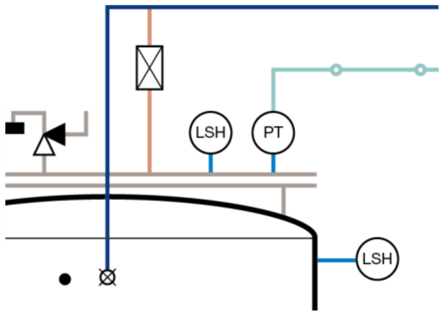
- Static spray balls typically require high flow rates but low inlet pressure (~2 bar at inlet)
- Rotary jet heads have lower flow requirements, but higher inlet pressure (5 bar at inlet)
- CIP-F pump capacity must be verified prior to retrofitting, particularly with respect to head pressure
- Typical requirement ~7.5 bar at CIP-F pump discharge

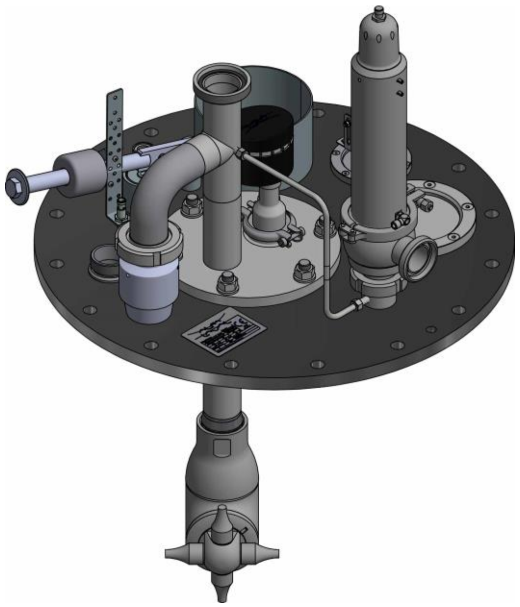


Process considerations for use of rotary jet head

– Risk: Gas flow through rotary jet head during pressurization and emptying

- Typical fermenter design: Cleaning-in-Place/CO_2 line with non-return valve (NRV)
- NRV should allow gas to flow out of tank during filling and fermentation – and into tank during emptying and pressurization
- NRV is closed during CIP, driving CIP liquid to the rotary jet head (RJH)
- Gas flows that are too high gas during pressurization can also close the NRV, forcing the gas through the RJH
- Dry run of RJH causes high vibrations and heat generation, which can rapidly lead to damage and failure of the RJH

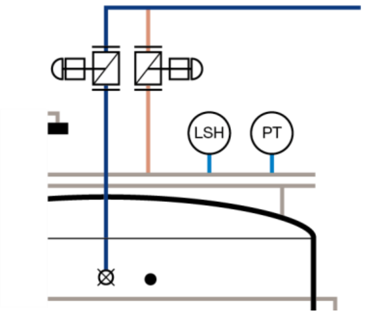


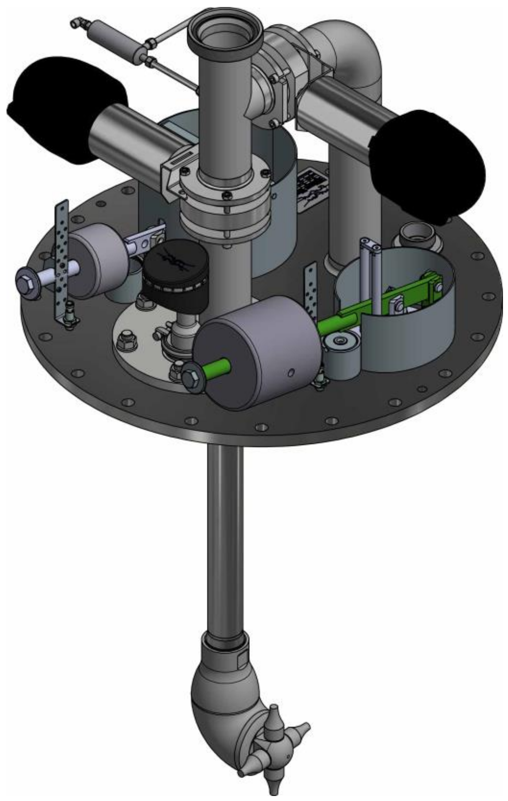


Process considerations for rotary jet head

– Improved design of fermenter CIP-CO_2 system for rotary jet head (RJH) applications

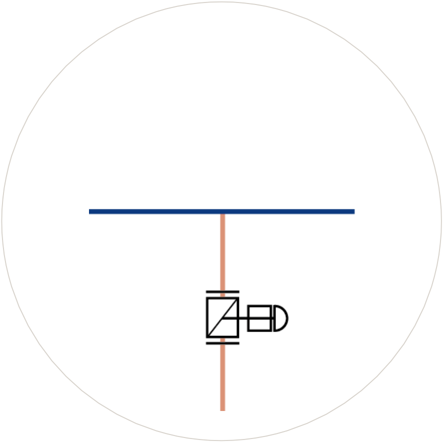
- Non-return valve is replaced with two automated butterfly valves
- During filling, emptying, pressurization and fermentation: valve to RJH closed, valve on CIP/CO_2 line open
- During cleaning: valve to RJH open, valve on CIP/CO_2 line closed



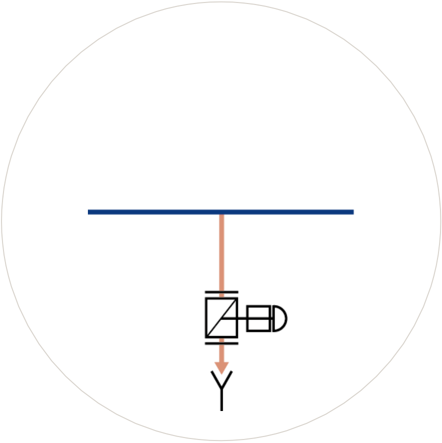


Process piping design for cleanability

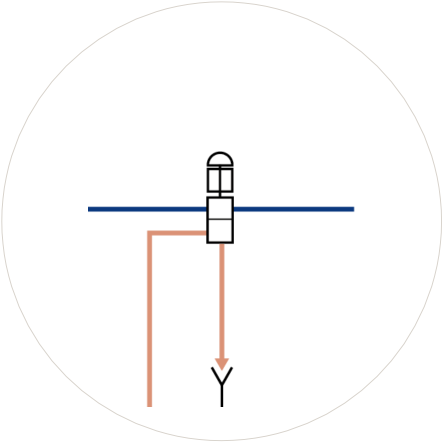
– Avoiding dead legs in piping branches



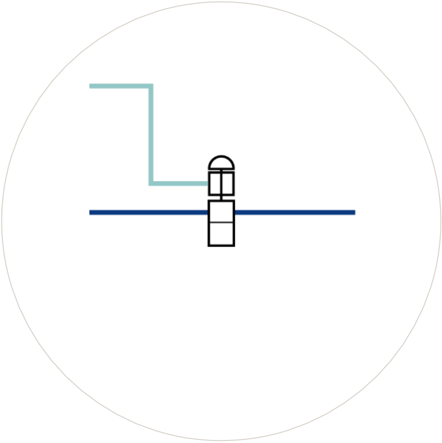
Butterfly valve



Butterfly valve with drain



Single seat valve



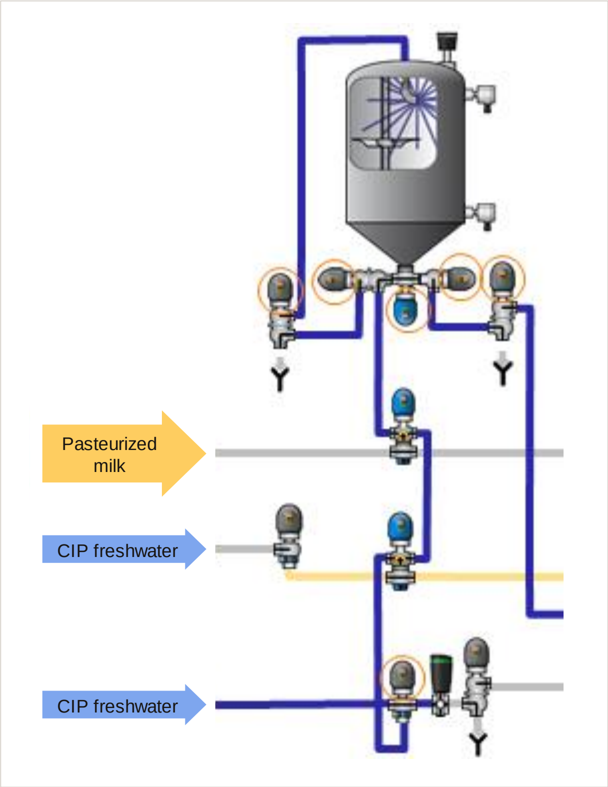
Unique Mixproof valve

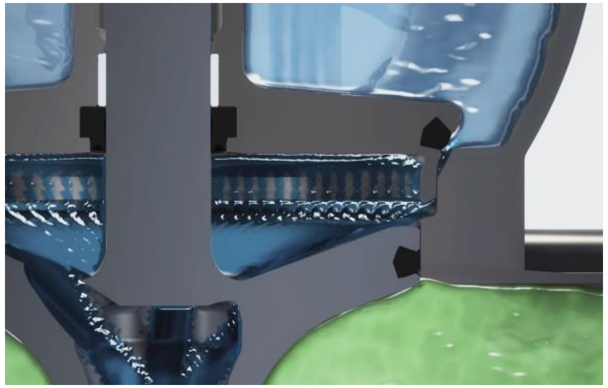
More dead leg
Poor cleanability

No dead leg
Optimal cleanability

Optimizing CIP of valves and piping

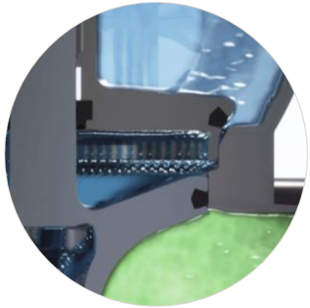
– Water and chemical savings with Alfa Laval Unique Mixproof valves





- Optimizing valve configuration and operation results in savings of water and chemicals
- Valve configuration determines the method of cleaning the valve (e.g. external valve CIP or seat lift
- Valve operation, such as seat lift timing and frequency, determines both timing as well as water and chemicals consumption

Seat lift CIP versus external valve CIP



Seat lift cleaning

- More hygienic solution
- 70% savings of water and chemicals
- Same investment cost
- Fewer pipe installations
- Less equipment to maintain
- Additional I/O points

External cleaning

- Standard offering (e.g., SPX and GEA)
- Cheaper solution from SPX and GEA
- Clean without CIP in pipe installations

Case story: Unique Mixproof seat lift cleaning

– Influence of CIP supply pressure on wall shear stress and cleaning efficiency

Flow through Unique Mixproof valve (seat lift)		
Pressure (bar)	0.5	4.0
Wall shear stress opening (Pa)	8.23	50.8
Wall shear stress laminar (Pa)	1.71	4.82
K_v (m^3/h)	2.5	
Flow rate (m^3/h)	1.77	5.0
Seat lift time (seconds)	5.0	0.5
Volume per seat lift (litres)	2.46	0.69

Higher CIP supply pressure gives stronger pulsations, which clean the opening more efficiently. This results in higher wall shear stress, which increases overall tank cleaning efficiency.

Size	DN/OD					DN						
ISO/DIN	38	51	63.5	76.1	101.6	40	50	65	80	100	125	150
Kv value												
Upper seat lift [m^3/h]	1.5	1.5	2.5	2.5	3.1	1.5	1.5	2.5	2.5	3.1	3.7	3.7
Lower seat lift [m^3/h]	0.9	0.9	1.9	1.9	2.5	0.9	0.9	1.9	1.9	2.5	3.1	3.1
Air consumption												
Upper seat lift * [n litre]	0.2	0.2	0.4	0.4	0.62	0.2	0.2	0.4	0.4	0.62	0.62	0.62
Lower seat lift * [n litre]	1.1	1.1	0.13	0.13	0.21	1.1	1.1	0.13	0.13	0.21	0.21	0.21
Main movement * [n litre]	0.86	0.86	1.63	1.63	2.79	0.86	0.86	1.62	1.62	2.79	2.79	2.79
Kv value – SpiralClean												
Spindle CIP [m^3/h]	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
External CIP of leakage chamber [m^3/h]	0.25	0.25	0.29	0.29	0.29	0.25	0.25	0.29	0.29	0.29	0.29	0.29

Case story: Unique Mixproof seat lift cleaning

– Water and chemicals savings using pressurized CIP supply and short seat lifts

Product	Periods
Milk	1–2
Yogurt	3–5
Beer	2–5
Cold wort	5–10

Advisory seat lift cleaning periods:
Cleaning periods of 3–6 seconds per CIP sequence

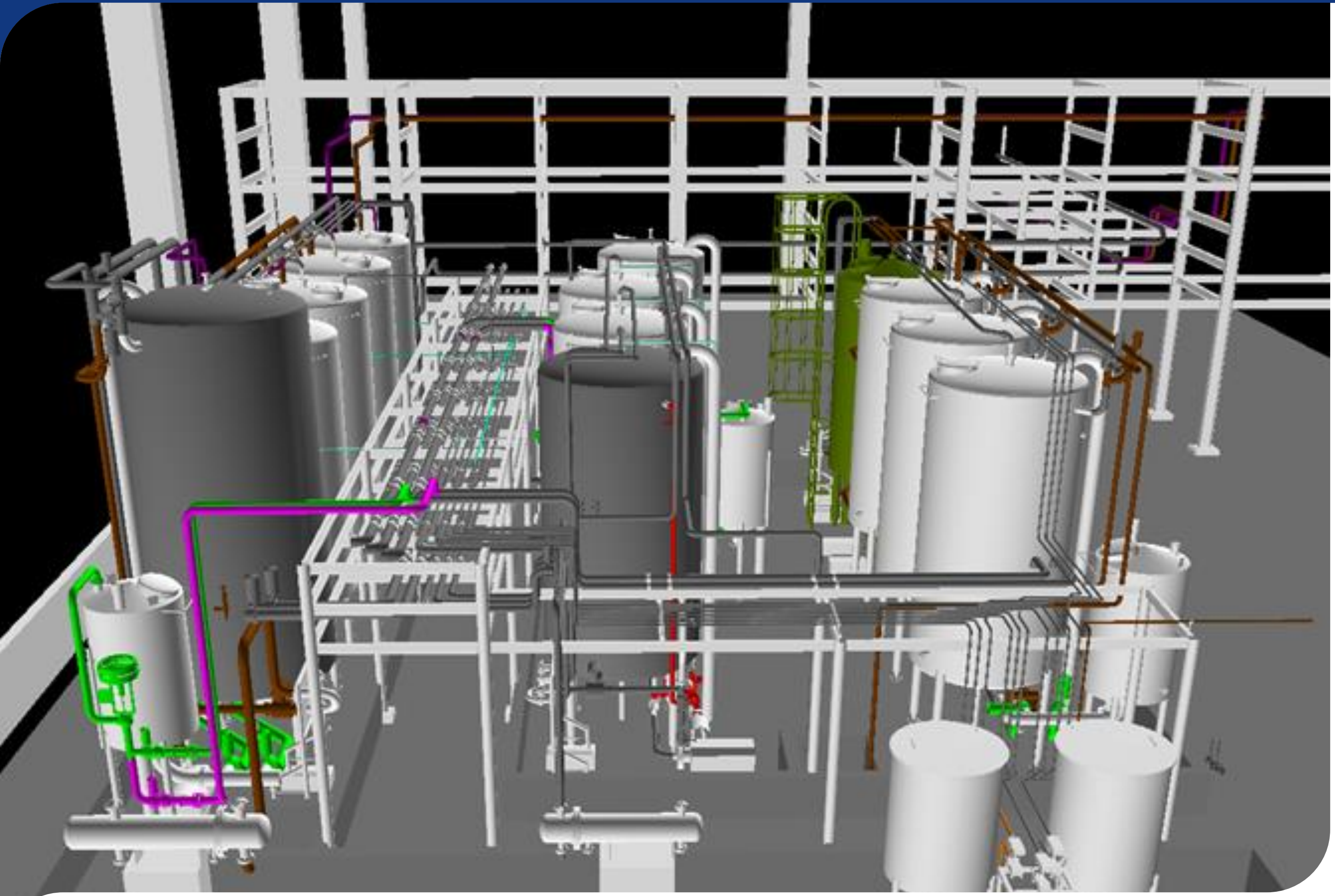
Possible water savings during CIP (Unique Mixproof 3" valve)			
Conditions during lift of seat		½ bar, 3x5 sec	4 bar, 3x½ sec
Water consumption per seat lift (litres)		7.37	2.08
Water consumption per seat push (litres)		5.60	1.58
Total water consumption (litres)		12.96	3.67
Savings in volume per valve (litres)		9.30	
Savings in relation	(index)	353.55	100
	(%)	100	28

Yearly water savings (30 Unique Mixproof valves)		
No of	**#**	**Litres**
Unique Mixproof valves	30	279
Steps in CIP sequence	3	837
CIP a day	3	2,510
Days a week	7	17,571
Weeks a year	52	913,705

Nearly 1,000 m^3 of water saved each year!

Size	DN/OD					DN						
ISO/DIN	38	51	63.5	76.1	101.6	40	50	65	80	100	125	150
Kv value												
Upper seat lift [m^3/h]	1.5	1.5	2.5	2.5	3.1	1.5	1.5	2.5	2.5	3.1	3.7	3.7
Lower seat lift [m^3/h]	0.9	0.9	1.9	1.9	2.5	0.9	0.9	1.9	1.9	2.5	3.1	3.1
Air consumption												
Upper seat lift * [n litre]	0.2	0.2	0.4	0.4	0.62	0.2	0.2	0.4	0.4	0.62	0.62	0.62
Lower seat lift * [n litre]	1.1	1.1	0.13	0.13	0.21	1.1	1.1	0.13	0.13	0.21	0.21	0.21
Main movement * [n litre]	0.86	0.86	1.63	1.63	2.79	0.86	0.86	1.62	1.62	2.79	2.79	2.79
Kv value – SpiralClean												
Spindle CIP [m^3/h]	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
External CIP of leakage chamber [m^3/h]	0.25	0.25	0.29	0.29	0.29	0.25	0.25	0.29	0.29	0.29	0.29	0.29

Automated CIP modules from Brewery Systems



- Standard CIP modules of up to four tanks
- Tank supply can be included or optional
- Central or local CIP plants with communication by Ethernet/Profibus
- Automatic and safe operation
- Optimal consumption of cleaning fluids
- CIP recovery to save cleaning fluids and avoid problems in the wastewater plant

CIP plant locations in a brewery

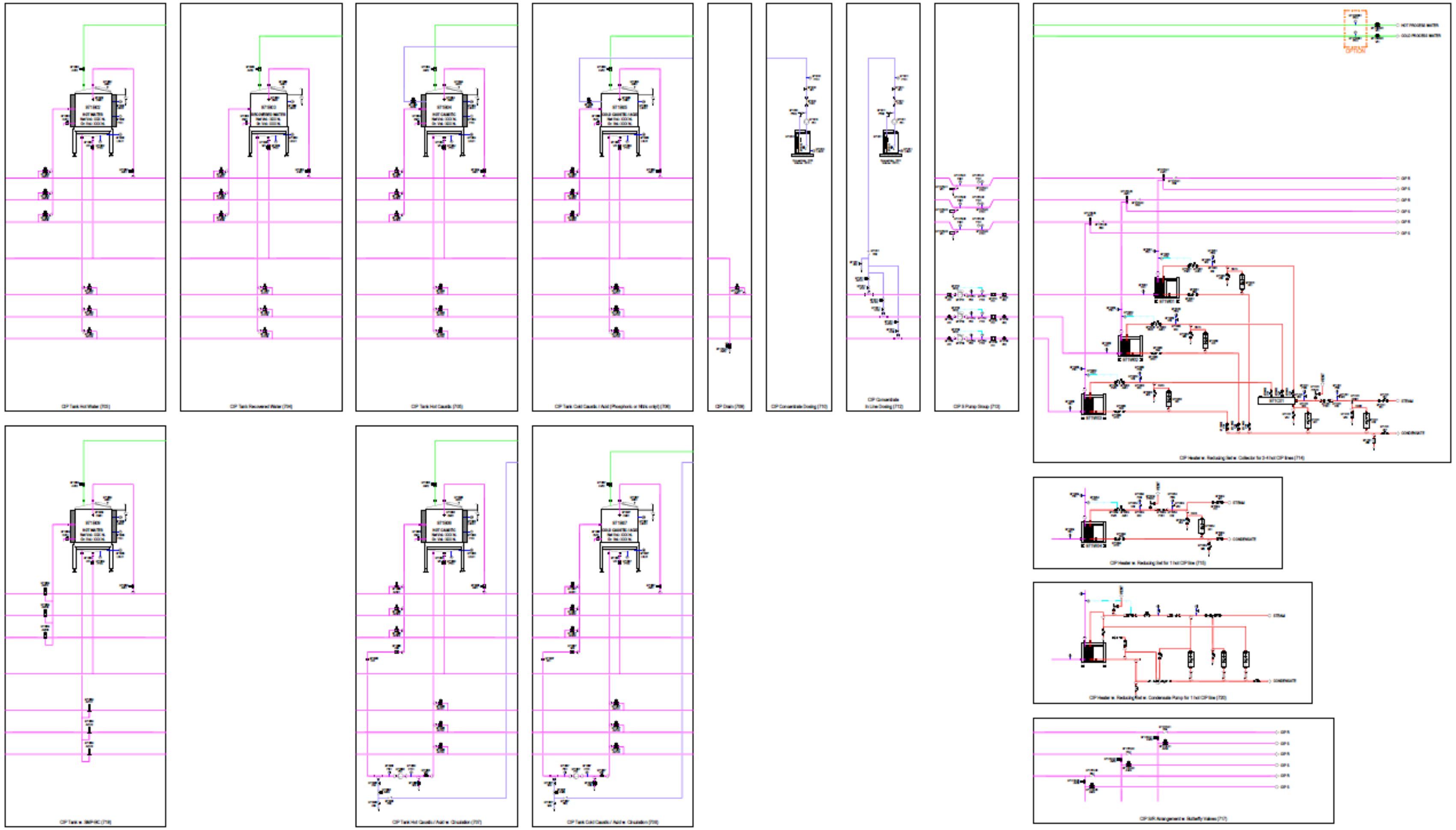
– Examples of individual CIP plant applications

CIP for:

- Brewhouse
- Wort line
- Fermentation and lagering cellars
- Filtration and beer conditioning
- Bright beer tanks, filling lines and fillers
- Yeast plants, propagation and storage
- Pasteurizers, beer sterile filtration and fillers

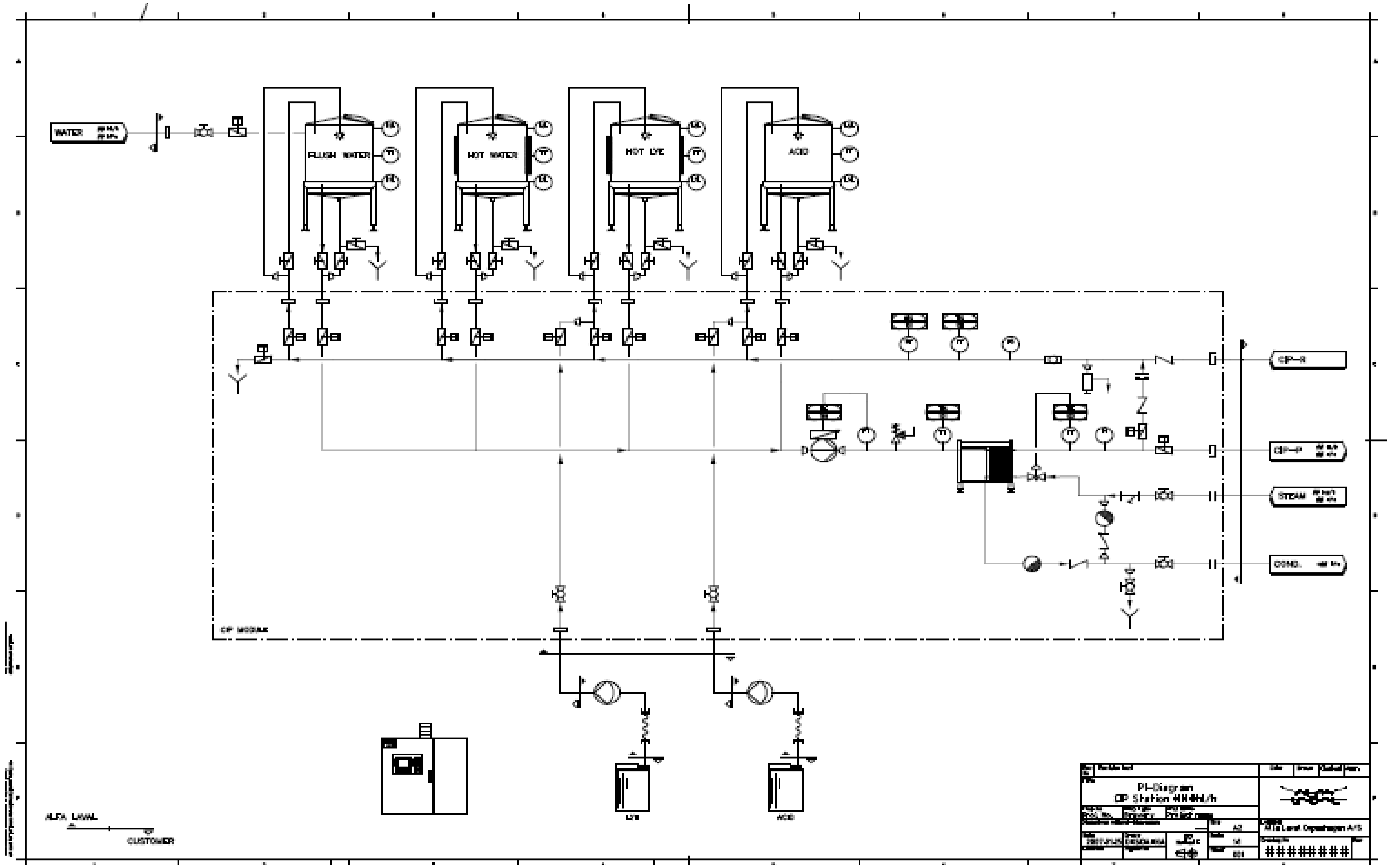
Brewery Systems construction set for CIP plant

– Each individual CIP plant can be tailored to fit your process requirements

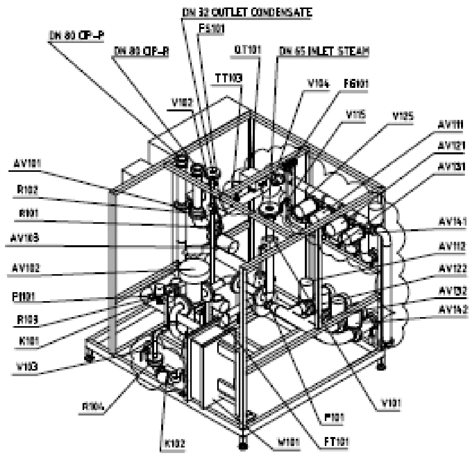


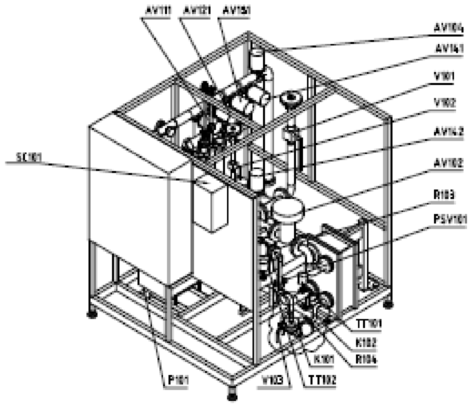
Sample P&ID of a CIP plant from Brewery Systems

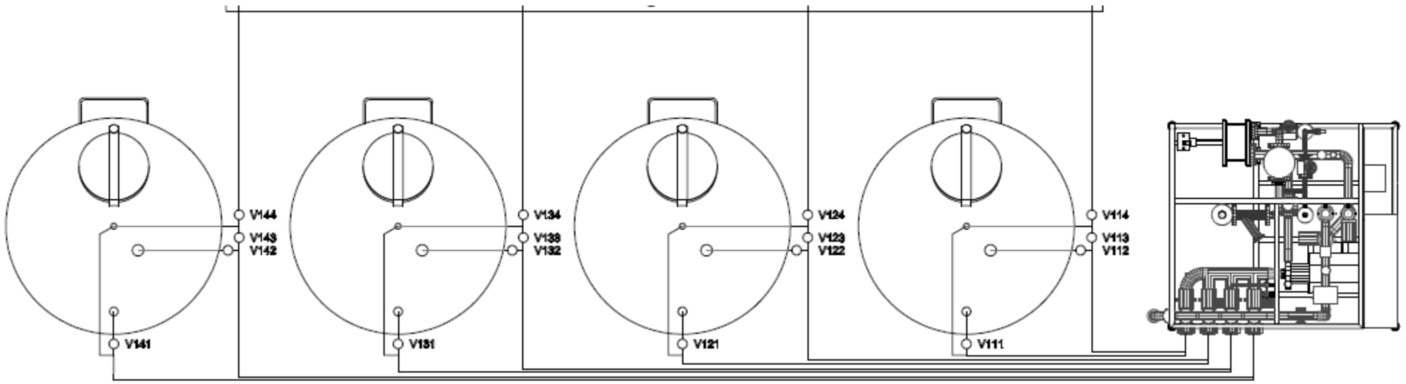
– Piping and instrumentation diagram



Sample layout of CIP plant from Brewery Systems







Webinars for brewers

– Upcoming webinar 25 June, 2020

Dry hopping II

Learn how you can streamline and optimize your dry-hopping processes

Dry hopping II

Webinar 25 June, 2020

Webinars for brewers

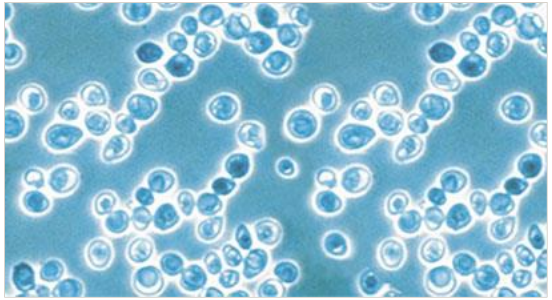
– Past events

Our brewery experts share their beer production know-how. Choose from a range of topics – from dry hopping to dealcoholization and more.

Click here to visit our webinar web page

Beer dealcoholization
Webinar 21 November, 2019

Separation for your brewery
Webinar 24 September, 2019

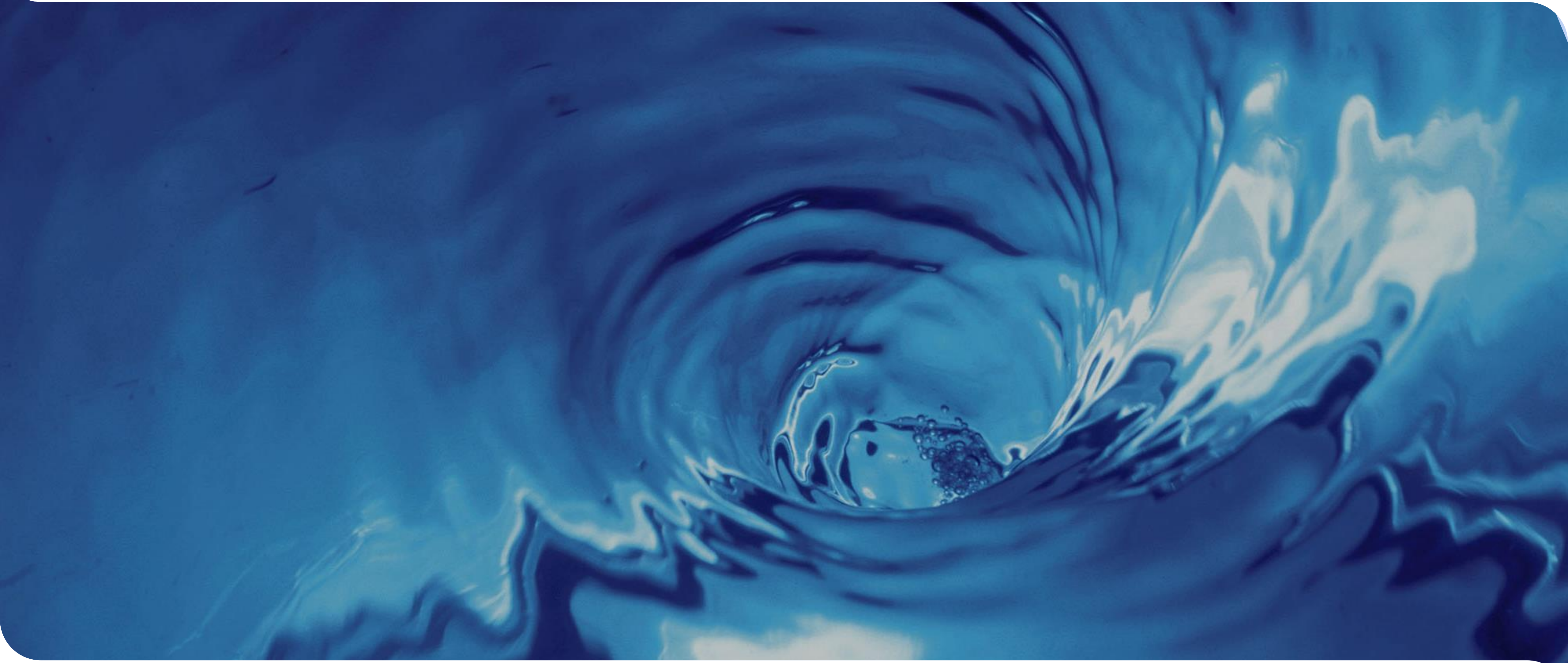


Yeast propagation
Webinar 26 June, 2019

Dry hopping
Webinar 6 March, 2019

Thank you for your attention!

– Any questions?



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