

# Optimization of Cleaning-In-Place (CIP) processes in bottled water industry

V. Davy, Nestlé Waters MT  
AquaFit4Use Mid-Term Conference, Oviedo  
15<sup>th</sup> June 2010



The Healthy Hydration Company™



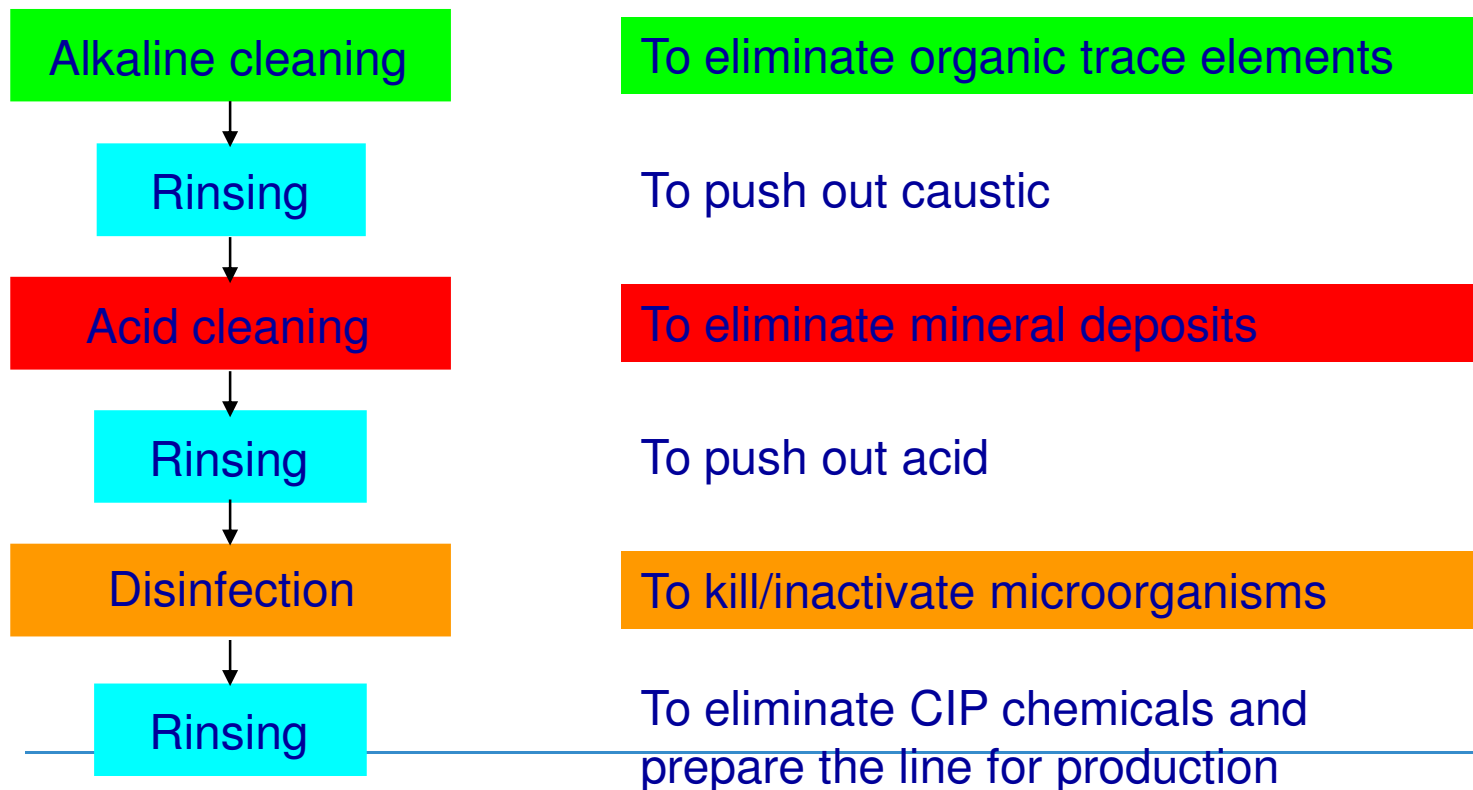
# Introduction

## CIP principles



### ➤ Cleaning-In-Place (CIP):

- Fully or semi-automated, integrated cleaning technique that allows to clean closed or open circuits without dismantling equipments
- Standard CIP sequence:



# Introduction

## CIP principles



- Standard CIP sequence consumes:
  - WATER: preparation of chemical / hot water solutions, rinsing steps
  - TIME: preparation of CIP solutions, cleaning & disinfection steps, rinsing steps
  - CHEMICALS: alkaline, acid, disinfectant
  - ENERGY: heating and cooling
- ➔ Need to optimize existing processes and/or investigate other technologies that could save water, time, chemicals, and energy

# Introduction

## CIP principles



- **Prior to optimize water consumption during CIP processes**, the key parameters (5 T's) to ensure the effectiveness of CIP systems must be in place:

<b>Turbulence</b>	Flow velocity in all parts of the system being cleaned
<b>Time</b>	Duration of each step of the CIP procedure
<b>Temperature</b>	Of the cleaning solutions and water at the beginning and end of the circuit
<b>Titration</b>	Chemical concentration in the supply tanks, in the circuits
<b>Technology</b>	Design of CIP station, CIP network, complete water lines (from well to filler)



# Introduction

## Content of study

- Focus on the reduction of water consumption during Cleaning-In-Place (CIP) processes
  
- Two steps:
  1. Optimization of existing CIP processes
  
  2. Evaluation of alternative CIP technologies

# 1. Optimization of existing CIP processes Methodology for data collection

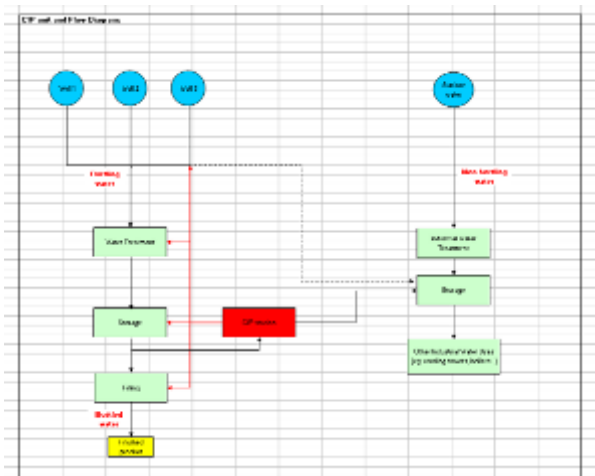


## ➤ Collect information on CIP processes in several factories:

- Mapping of water circuits, including CIP circuits (P&ID, flow diagram)
- Description of CIP stations (design, P&ID)
- Description of CIP sequences per circuit, including water and chemicals consumption
- Summary of CIP consumption vs. production



Template\_CIP data questionnaire



4 CIP STEPS		Description		CP sequences		CP P&ID parameters						Water used to prepare chemical solutions				Water used for rinsing			
CP station name	List of CP steps (named and described within CP sequence)	Frequency (range)	CP step	Mass compound of the chemical product (active agent)	Concentration for use (KANCH product)	Duration	Temperature	Criteria for stop duration to restart the end of the step	Origin	Quality	Quantity	Quality of associated chemical water (L/ha scale)	Origin	Quality	Flow rate for rinsing step	Approximate duration of the rinsing step			
		Unit	Value		Unit	Value	Conductivity (µS/cm)	min	°C			m <sup>3</sup>			m <sup>3</sup> /h	min			
CP station: Tank 1 (200 m <sup>3</sup> )	Storage tanks	times/year	Alkaline cleaning	sodium hydroxide (NaOH)	% (v/v)	1,5	30	88	time	Boiling water	Treated boiling water before filter	0	90	Boiling water	Treated boiling water before filter				
			Rinsing						time	Boiling water	Treated boiling water before filter	8	90	Boiling water	Treated boiling water before filter				
			Acid cleaning	phosphoric acid	% (v/v)	1,8	7,8	88	time	Boiling water	Treated boiling water before filter	8	90	Boiling water	Treated boiling water before filter				
			Rinsing						time	Boiling water	Treated boiling water before filter	8	90	Boiling water	Treated boiling water before filter				
	CP station: Tank 2 (100 m <sup>3</sup> )	times/month	1	Chemical disinfection	peracetic acid hydroperoxide	% (v/v)	0,4	2,5	88	time	Boiling water	Treated boiling water before filter	0	90	Boiling water	Treated boiling water before filter			
				Rinsing						time	Boiling water	Treated boiling water before filter	0	90	Boiling water	Treated boiling water before filter			
				Acid cleaning	phosphoric acid	% (v/v)	1,5	7,5	88	time	Boiling water	Treated boiling water before filter	0	90	Boiling water	Treated boiling water before filter			
				Rinsing						time	Boiling water	Treated boiling water before filter	0	90	Boiling water	Treated boiling water before filter			
CP station: Tank 3 (300 m <sup>3</sup> )	times/year	4	Alkaline cleaning	sodium hydroxide (NaOH)	% (v/v)	1,8	30	88	time	Boiling water	Treated boiling water before filter	8	90	Boiling water	Treated boiling water before filter	70,0			
			Rinsing						time	Boiling water	Treated boiling water before filter	8	90	Boiling water	Treated boiling water before filter	70,0			
			Acid cleaning	phosphoric acid	% (v/v)	1,8	7,8	88	time	Boiling water	Treated boiling water before filter	8	90	Boiling water	Treated boiling water before filter	70,0			
			Rinsing						time	Boiling water	Treated boiling water before filter	8	90	Boiling water	Treated boiling water before filter	70,0			
	CP station: Tank 3 (300 m <sup>3</sup> )	times/month	1	Chemical disinfection	peracetic acid hydroperoxide	% (v/v)	0,4	2,5	88	time	Boiling water	Treated boiling water before filter	0	90	Boiling water	Treated boiling water before filter	70,0	60	
				Rinsing						time	Boiling water	Treated boiling water before filter	0	90	Boiling water	Treated boiling water before filter	70,0	60	
				Acid cleaning	phosphoric acid	% (v/v)	1,5	7,5	88	time	Boiling water	Treated boiling water before filter	0	90	Boiling water	Treated boiling water before filter	70,0	60	
				Rinsing						time	Boiling water	Treated boiling water before filter	0	90	Boiling water	Treated boiling water before filter	70,0	60	



# 1. Optimization of existing CIP processes

## Main outcomes from data collection

- The results have highlighted the importance of:
  - a) Good hygienic design of the installations:  
**“Good cleaning cannot be achieved without hygienic design and engineering of the installations”**
  - b) Design of CIP station
  - c) Optimization of rinsing step

# 1. Optimization of existing CIP processes

## a. Hygienic Design

### ➤ Materials & surface roughness:

#### Materials:

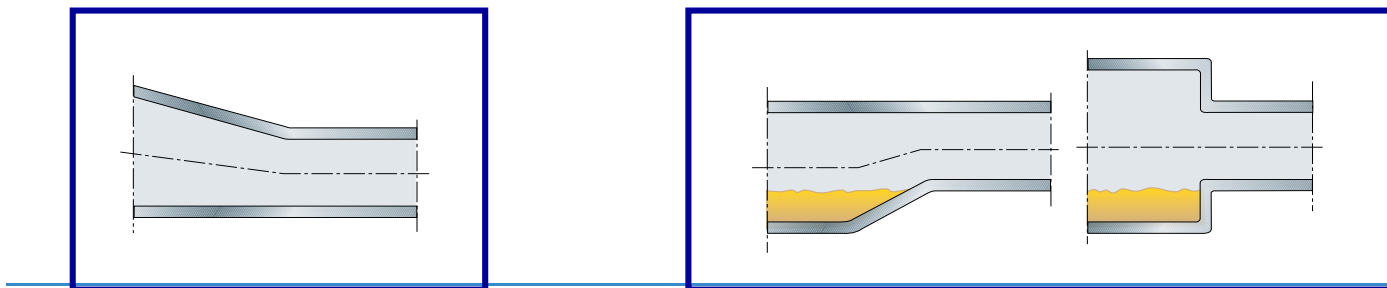
- Be able to withstand mechanical, thermal and chemical actions
- 304(L) or 316(L) stainless steel recommended

Surface Roughness (Ra) < 0.8 μm

### ➤ Pipes and equipments must be able to drain:

Design to “self drain”

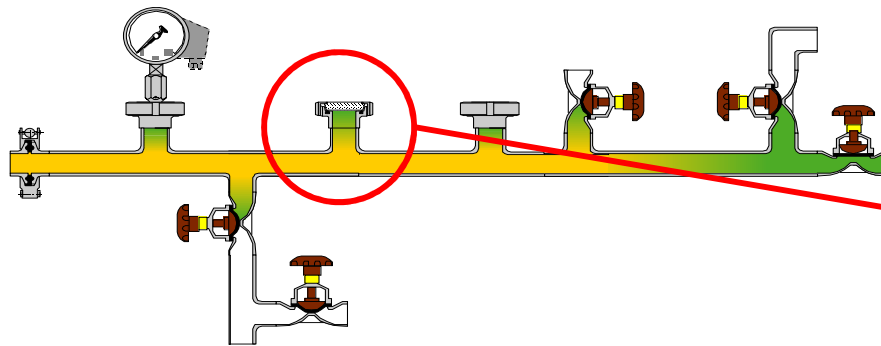
Avoid abrupt changes in pipe diameter & concentric reductions



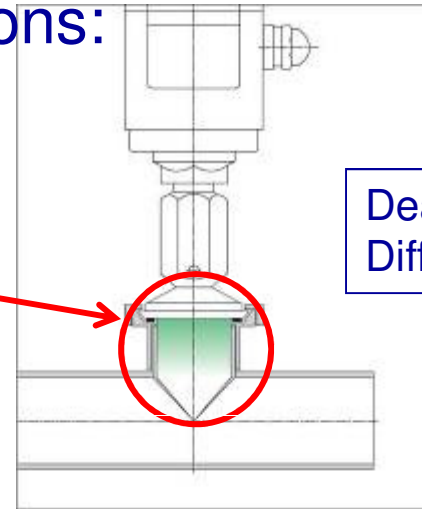
# 1. Optimization of existing CIP processes

## a. Hygienic Design

➤ Avoid dead ends in pipe connections:



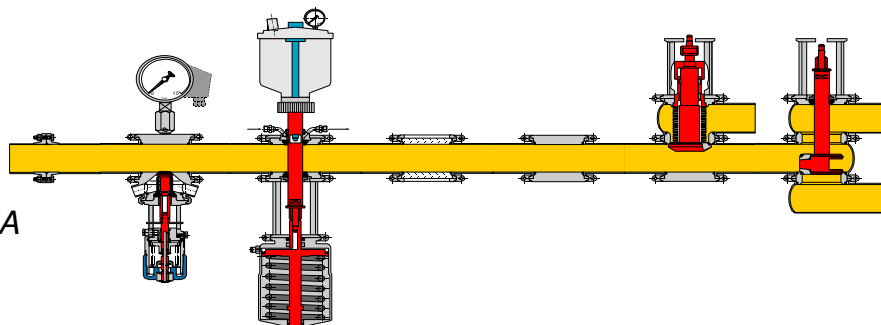
**Not preferred solution**



Dead End /  
Difficult to clean

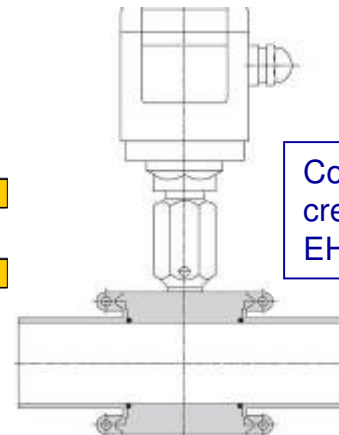


**As short as possible** ( $< 1.5 D$ )



From GEA

**Hygienic solution – State of the art**



Continous line, no dead ends or  
crevices.  
EHEDG certified for cleanability



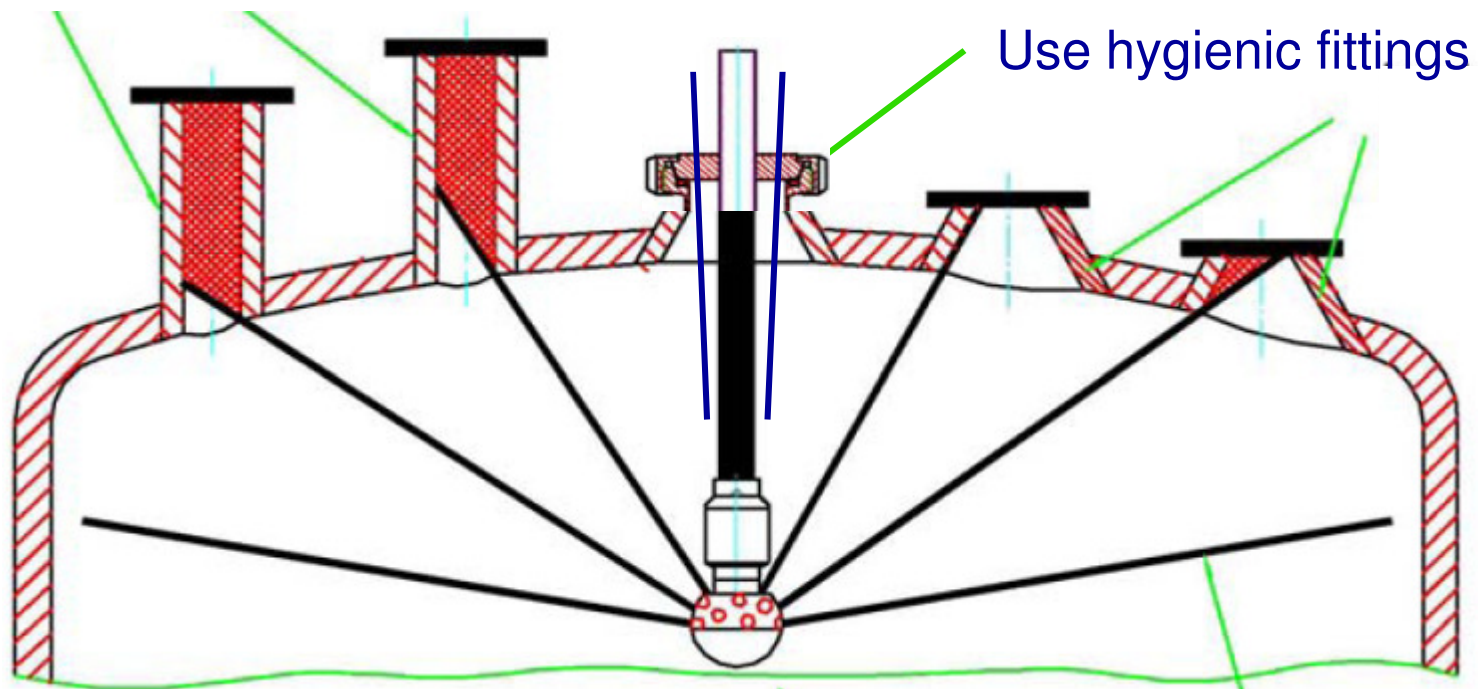
# 1. Optimization of existing CIP processes

## a. Hygienic Design



- Avoid dead end in tanks:

Dead ends





# 1. Optimization of existing CIP processes

## a. Hygienic Design

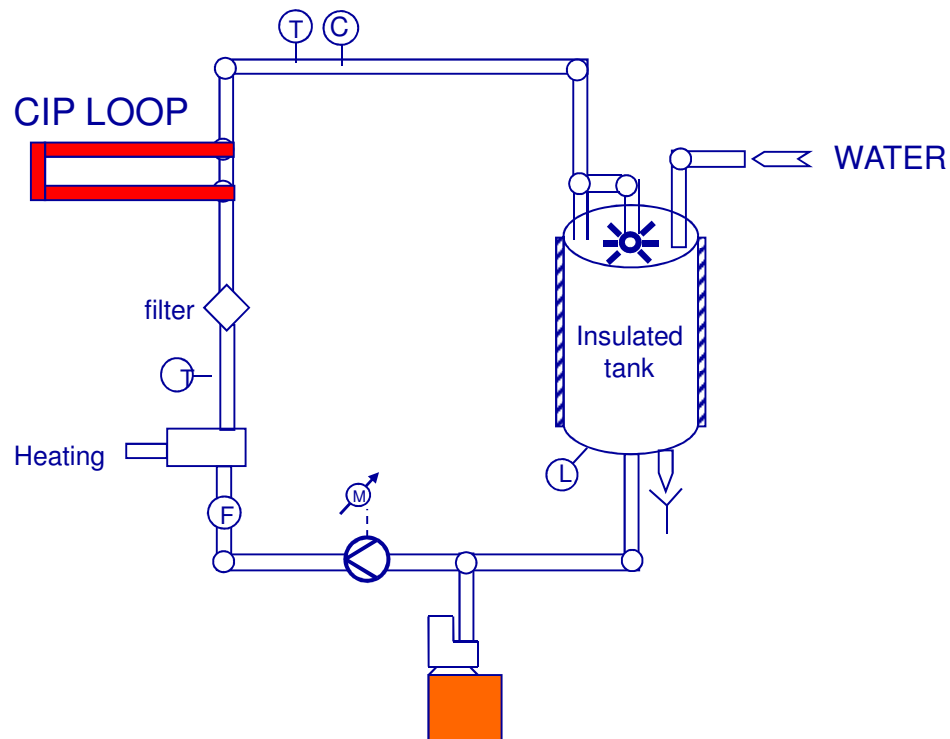
- A minimum velocity is required in the cleaning agent to:
    - Create a mechanical shear stress to remove the soils from the wall (boundary layer where residues will deposit)
    - Transport the soil out of the line
- A velocity of 1.5 m/s will guarantee enough shear stress & turbulent flow to remove the soils

# 1. Optimization of existing CIP processes

## b. CIP station design

- Single-use system: cleaning solution is used only once and discharged to drain after use → single tank

*Example:*



(+)

- Simple, not very costly installation
- Could be applied for:
  - Small installations (decentralized CIP system)
  - Processes where cross-contamination is a concern
  - Heavy soiled equipments

(-)

- High operational costs
- Environmental impact

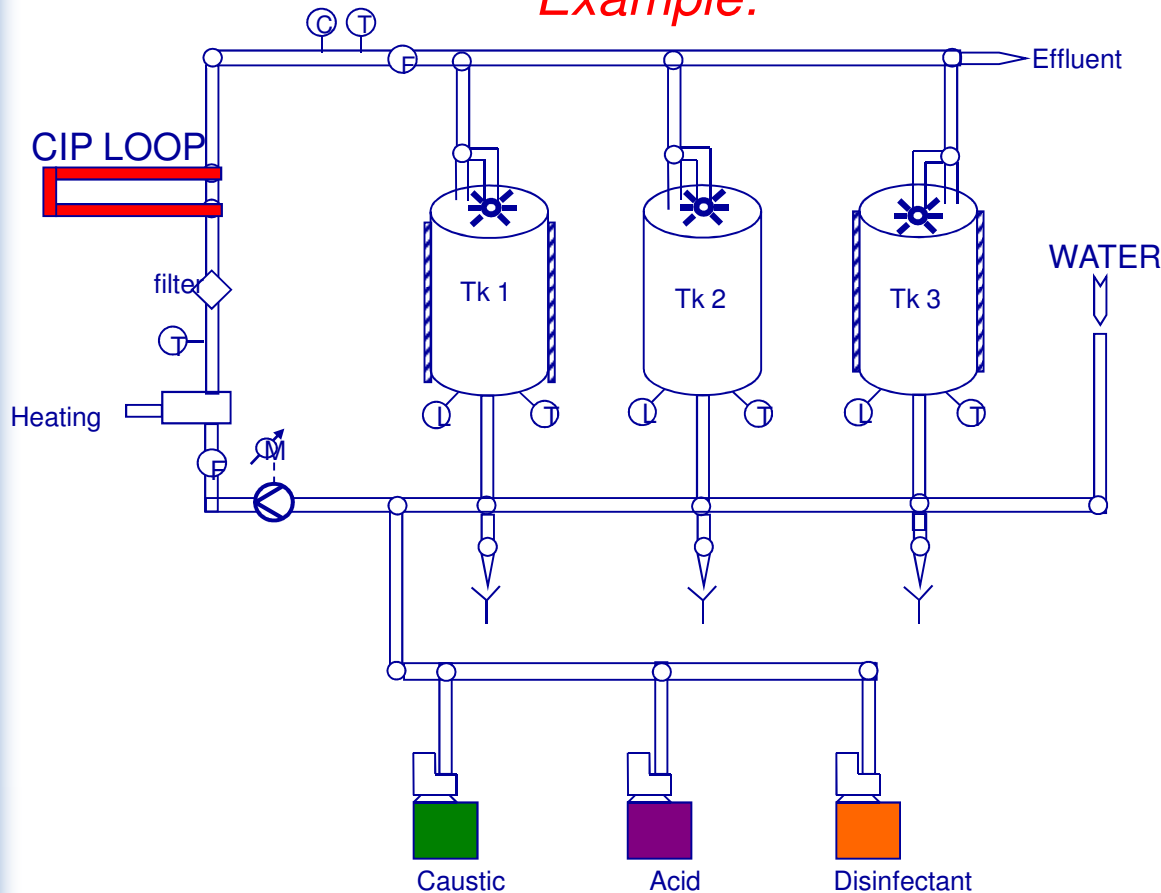
# 1. Optimization of existing CIP processes

## b. CIP station design



- Re-use system: the same cleaning solution is used for a large number of cleaning operations (recover & reuse) → multi-tanks

*Example:*



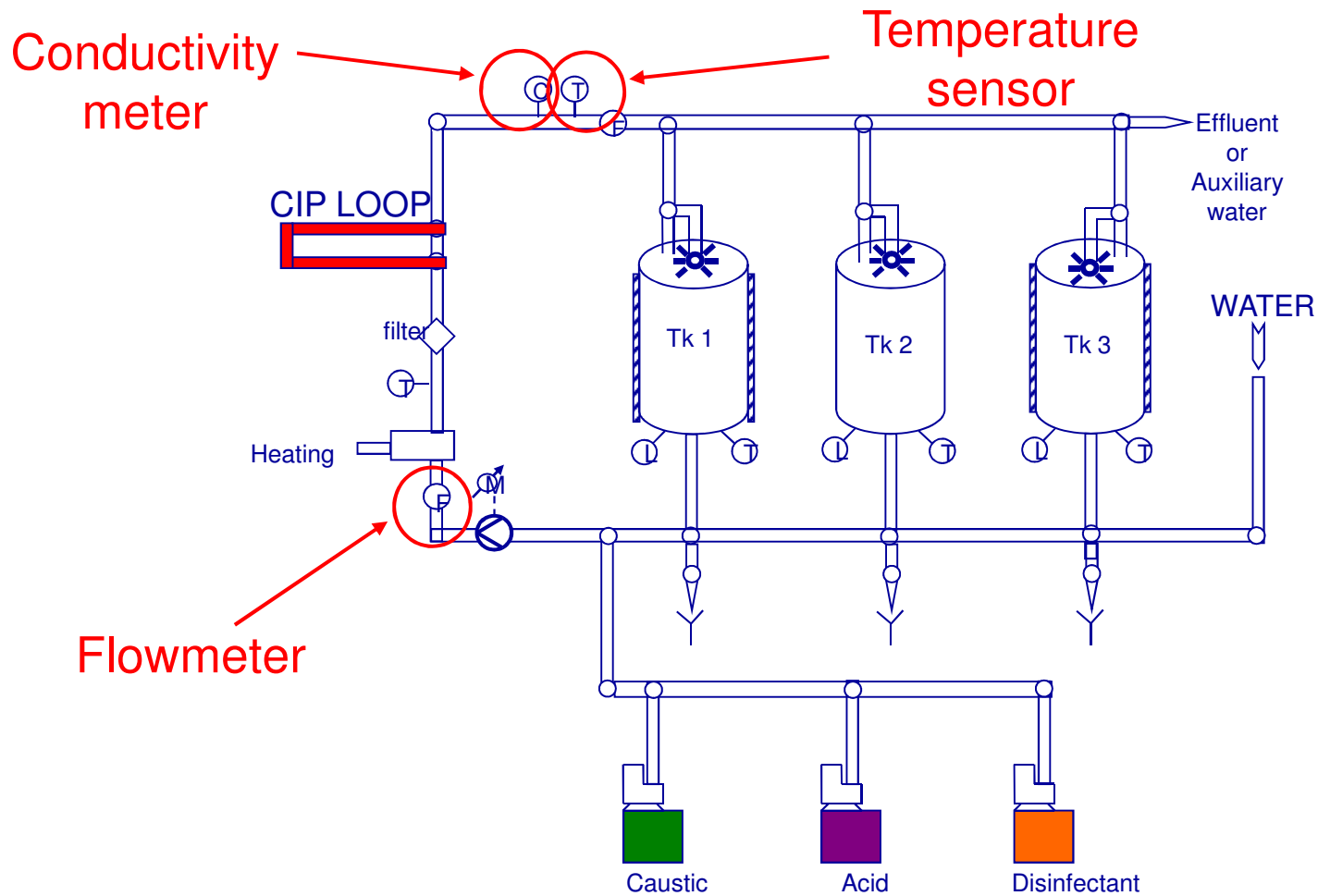
- (+)
  - Lower operational costs
  - Lower environmental impact
  - Could be applied for:
    - Large installations
    - (centralized CIP system)
- (-)
  - Installation can be complex and very costly
  - Regular control of the cleaning power of cleaning solutions

# 1. Optimization of existing CIP processes

## b. CIP station design



- Recommendation: re-use system with monitoring tools





# 1. Optimization of existing CIP processes

## c. Rinsing step

- Rinsing time based on temperature and/or concentration (not only based on time)
- Reduce rinsing time between chemical solutions
- Re-use of rinsing water for other industrial water uses:
  - Based on temperature and/or conductivity value

→ Optimization on a case-by-case basis



# 1. Optimization of existing CIP processes

## Conclusions

- Methodology to collect data on CIP processes
- Basic principles of hygienic design must be respected
- CIP station design: re-use system with chemicals recovery equipped with required monitoring tools
- Reduction of water consumption:
  - Optimization on a case-by-case basis through reduction of rinsing time and/or re-use of rinsing water for other industrial uses



# Introduction

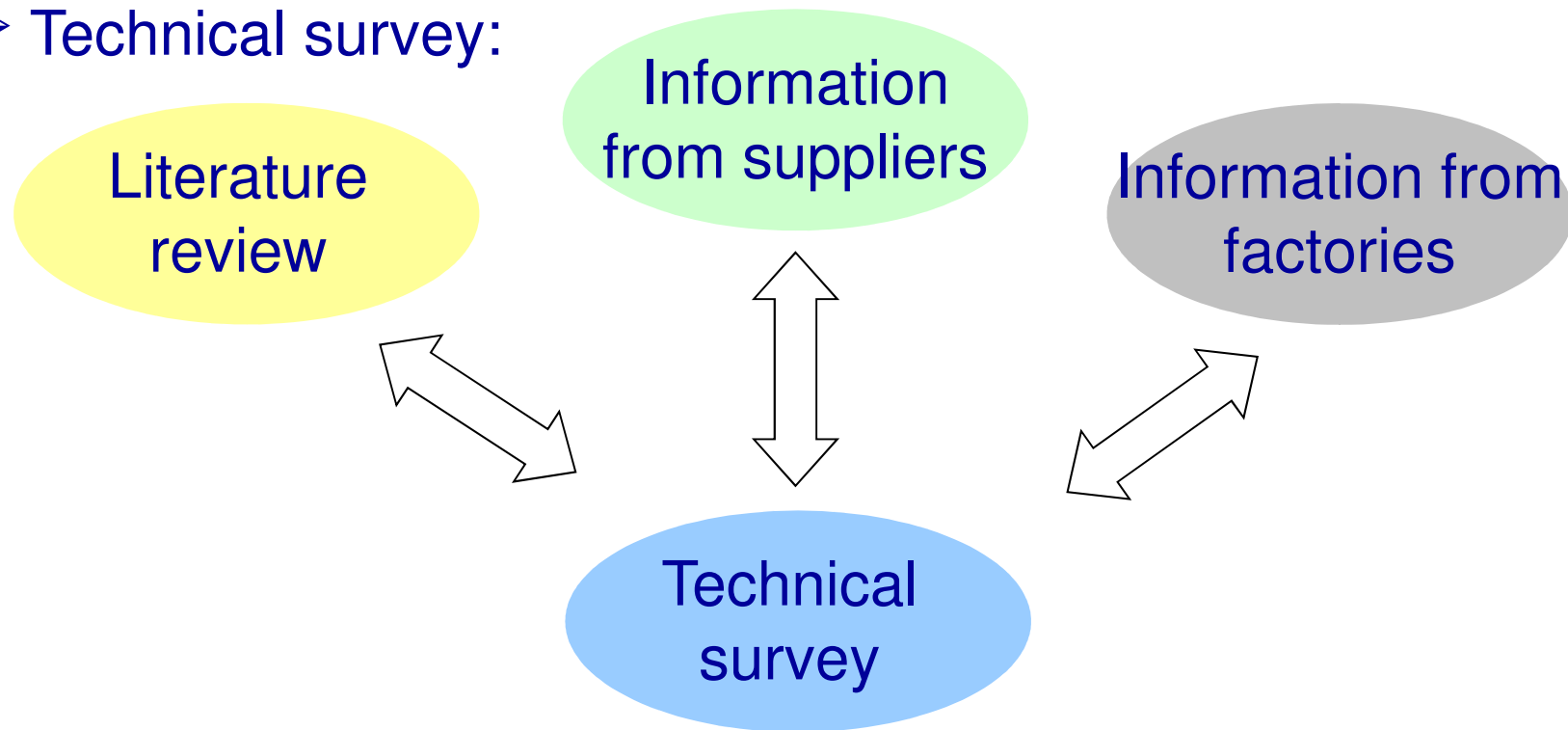
## Content of study

- Focus on the reduction of water consumption during Cleaning-In-Place (CIP) processes
  
- Two steps:
  1. Optimization of existing CIP processes
  2. Evaluation of alternative CIP technologies

## 2. Alternative CIP technologies Objective & methodology

➤ Objective: evaluate alternative technologies that could help to save water, time, chemicals and/or energy

➤ Technical survey:



## 2. Alternative CIP technologies Objective & methodology



### ➤ Criteria used for the evaluation:

Status of the technology	In development Available in the market
Technical feasibility	Could be applied for Cleaning-In-Place Could be applied for bottling water industry Integration into existing CIP processes
CIP efficiency	Cleaning efficiency Disinfection efficiency
Consumption, Savings	Water, Time, Chemicals, Energy
Costs	Capital costs Running costs
Miscellaneous	Material compatibility Safety risks



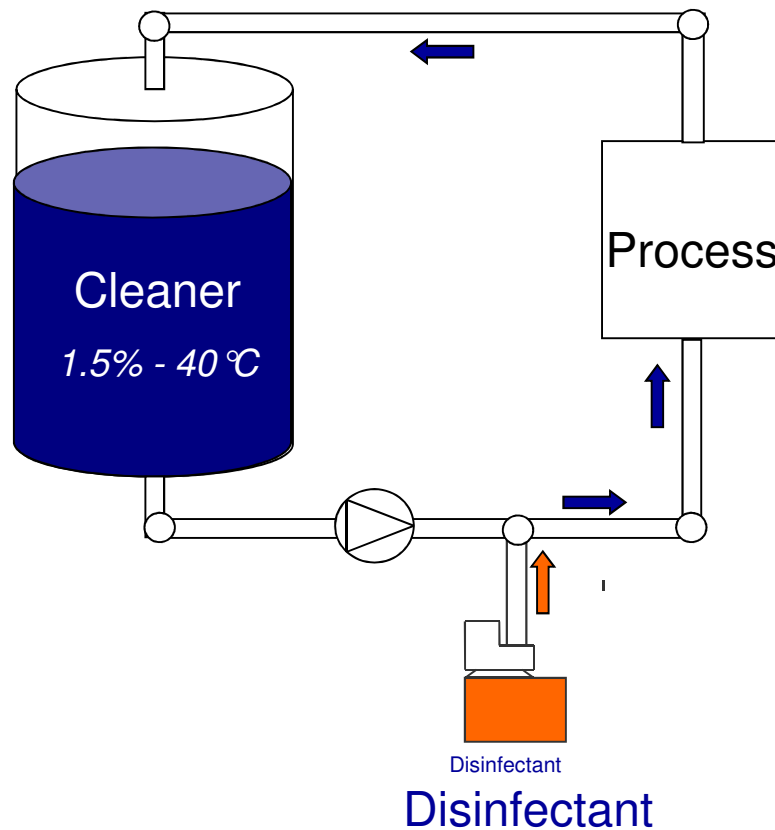
## 2. Alternative CIP technologies

### List of evaluated technologies

- Ice blasting
- Plasma cleaning
- Ultrasonic cleaning
- Supercritical CO<sub>2</sub>
- “Whirlwind” technology
- Electrolyzed water
- Pulsed flow
- Air scouring
- Chemicals “2 in 1”
- O<sub>3</sub> disinfection
- ClO<sub>2</sub> disinfection
- Pigging

## 2. Alternative CIP technologies Chemicals “2 in 1”

- Principle: Chemicals that clean and disinfect at the same time



1. Circulation of Cleaner
2. Addition of Disinfectant
3. Rinse

➔ **Cleaning & disinfection  
in 1 step**



## 2. Alternative CIP technologies Chemicals “2 in 1”

### ➤ Pros & Cons - Summary:

- + Available in the market with minimum capital costs
- + Seems to be as efficient as standard cleaners & disinfectants
- + Potential savings on water, time (and energy)
- Higher chemical costs
- Suitable for process of good hygienic design

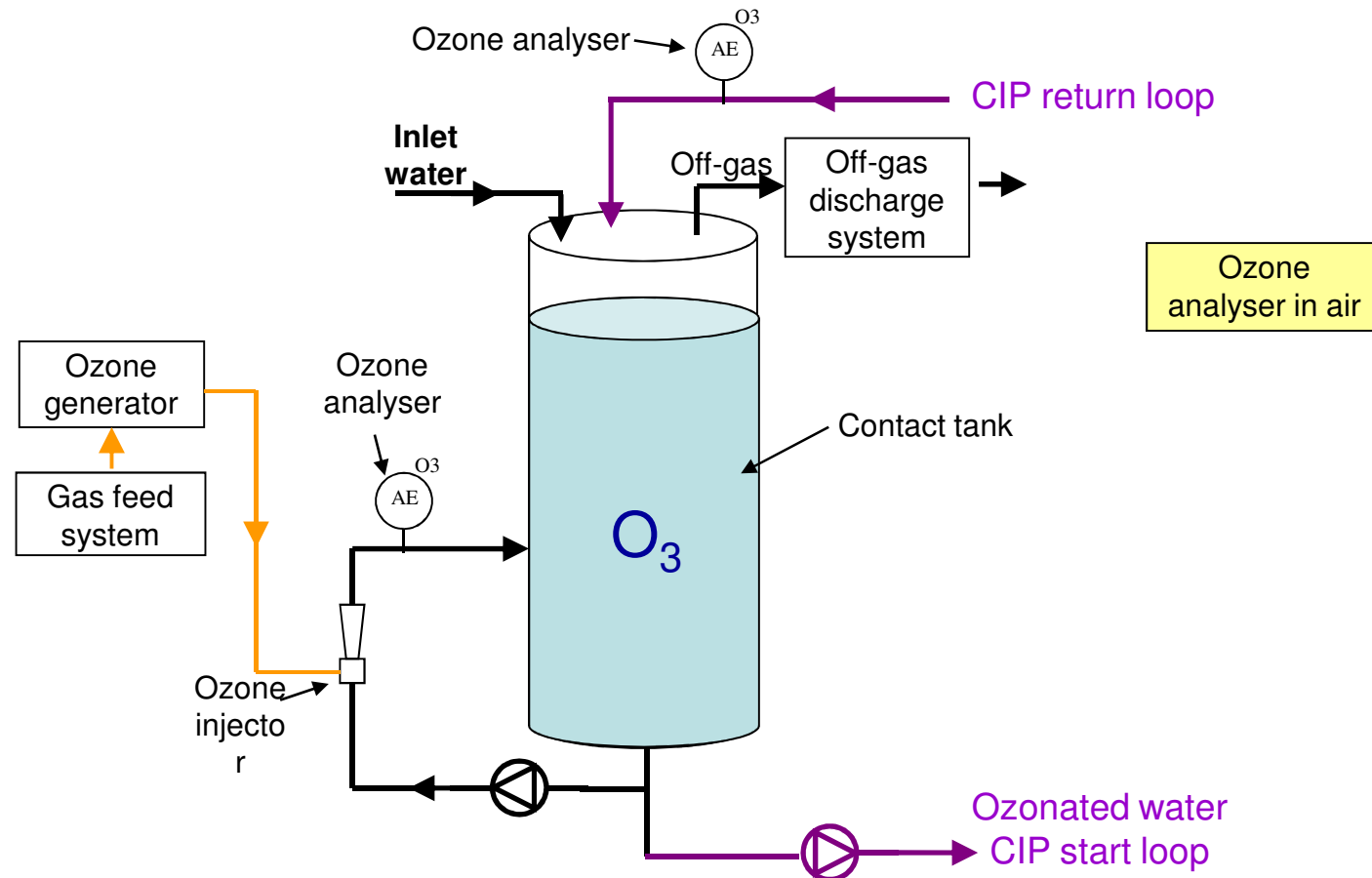
➔ Interesting products for factories where there is a need for additional production time

## 2. Alternative CIP technologies

### Ozone disinfection



- Principle: Use ozonated water as CIP-disinfection step





## 2. Alternative CIP technologies

### Ozone disinfection

#### ➤ Pros & Cons - Summary:

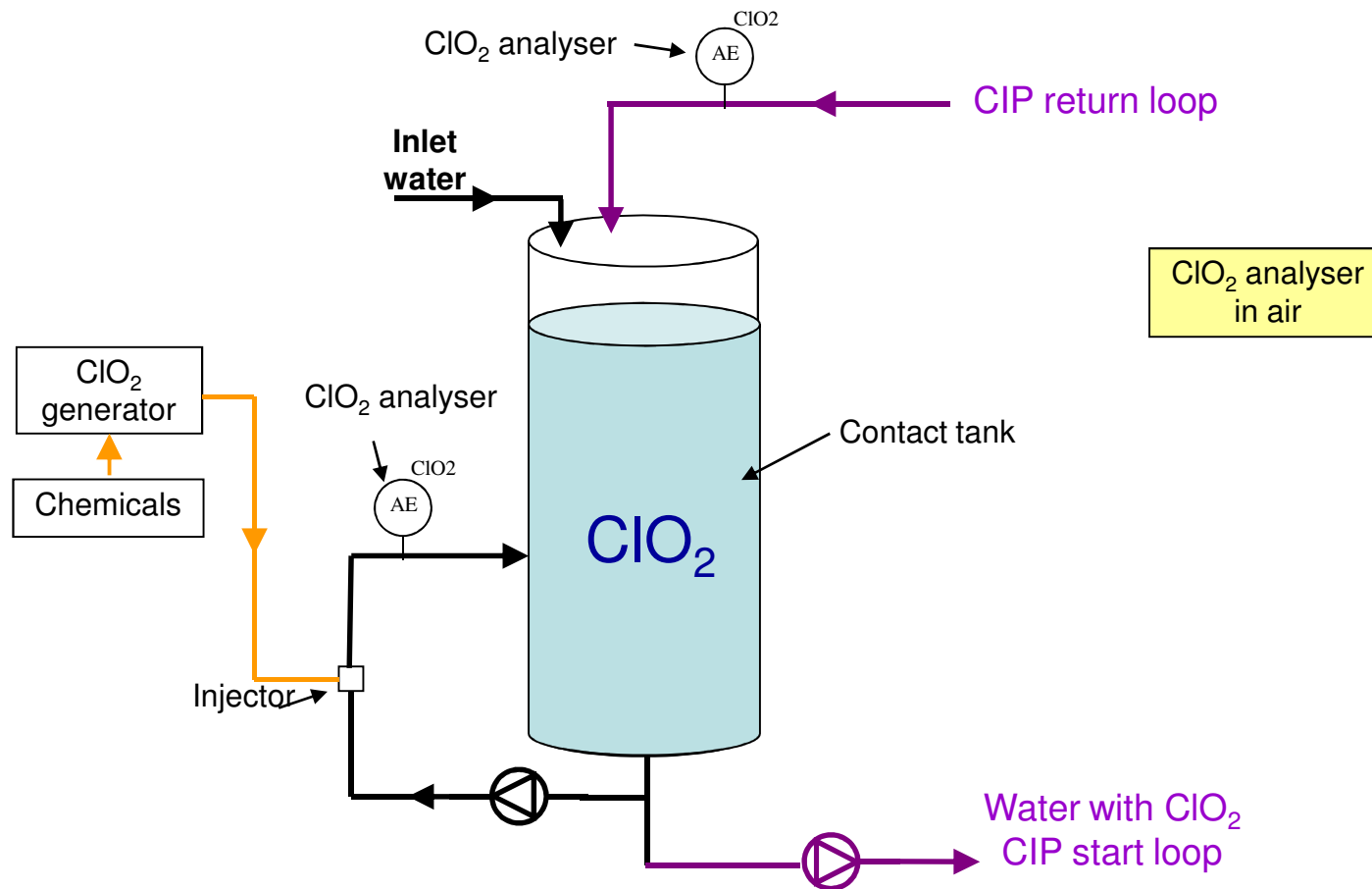
- + O<sub>3</sub> skid available in the market
- + Ozone-CIP: some applications in food & pharmaceuticals industries
- + Seems to be efficient on a wide range of micro-organisms
- + Potential savings on water, chemical (and energy)
- Capital costs
- Adjustment of CIP parameters is process-dependent
- Safety issues (O<sub>3</sub> gas)
- Material incompatibility with ozone

➔ Interesting technology that could be further evaluated at industrial scale

## 2. Alternative CIP technologies

### Chlorine dioxide disinfection

- Principle: Use of water containing chlorine dioxide as CIP-disinfection step





## 2. Alternative CIP technologies

### Chlorine dioxide disinfection

#### ➤ Pros & Cons - Summary:

- + ClO<sub>2</sub> generation skid available in the market
- + Seems to be efficient on a wide range of micro-organisms (but less than ozone)
- + Potential savings on water (and energy)
- Most applications with ClO<sub>2</sub>: water disinfection, bottle rinsing (not for CIP)
- Capital costs
- Adjustment of CIP parameters is process-dependent
- Still chemical consumption
- Safety issues (ClO<sub>2</sub> gas)

➔ Could be investigated at industrial scale but seems less interesting than ozone

## 2. Alternative CIP technologies Pigging

- Principle: Circulation of a “pig” in a pipe to clean the pipe and remove deposits

### Pigs



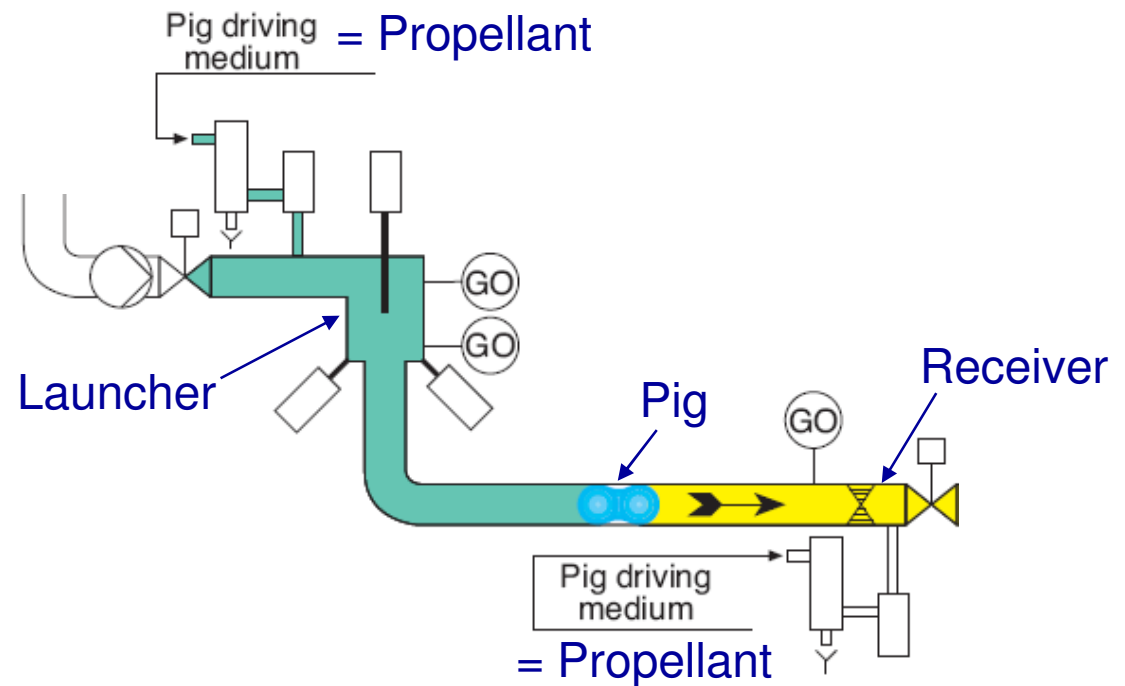
Girard Polly-Pigs



HPS Bi-Directional Pigs



GEA pig



From GEA



## 2. Alternative CIP technologies Pigging

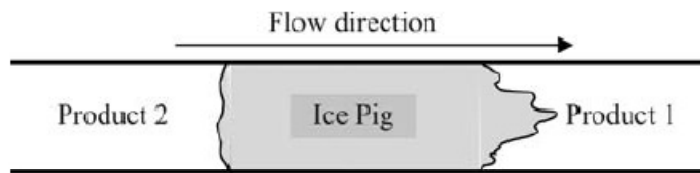
### ➤ Pros & Cons - Summary:

- +/- Most applications are for product recovery; a few applications for pipe cleaning
- + Will enhance chemical cleaning (though mechanical action)
- + Potential savings on water and chemicals
- Need to investigate its efficiency on biofilm removal
- Can only be used in pipe designed for pigging
- Capital costs

➔ Interesting technology that could be further evaluated at industrial scale for pipe cleaning

## 2. Alternative CIP technologies Pigging

- Additional information: Ice pigging:
  - Patented technology at Bristol university (UK)



*Quarini J., 2007*



- + Could be applied for all types of piping (no need for a specific design)
- + No need for launching & receiving station
- + No risk that the pig remains blocked in the pipe

➔ Interesting technology that could be further evaluated at industrial scale for pipe cleaning



## 2. Alternative CIP technologies Conclusions

- Technical survey carried out on alternative CIP technologies
  
- It has highlighted several “interesting” technologies:
  - Innovative chemicals
  - Ozone or chlorine dioxide disinfection as CIP-disinfection step
  - Pigging for pipe cleaning
  
- Next steps: industrial tests



**THANK YOU FOR YOUR ATTENTION!**