Principles and Practice of Cleaning in Place

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BRIGGS of Burton INC
Contents

• CIP/SIP – Definitions / Function
• Principles of CIP
• CIP Detergents
• CIP Systems
• Vessel CIP
• Mains CIP
• Monitoring/Control
CIP / SIP - Definition

• CIP = Cleaning in Place
  – To clean the product contact surfaces of vessels, equipment and pipework in place. i.e. without dismantling.

• SIP = Sterilise in Place
  – To ensure product contact surfaces are sufficiently sterile to minimise product infection.
How CIP Works

• **Mechanical**
  – Removes ‘loose’ soil by Impact / Turbulence

• **Chemical**
  – Breaks up and removes remaining soil by Chemical action

• **Sterilant/Sanitiser**
  – ‘Kills’ remaining micro-organisms (to an acceptable level)
Factors affecting CIP

- Mechanical
- Chemical
- Temperature
- Time
CIP Operation

• PRE-RINSE
  - Mechanical Removal of Soil

• DETERGENT
  - Cleaning of Remaining Soil
    - Caustic, Acid or Both

• FINAL RINSE
  - Wash Residual Detergent/Soil

• STERILANT/SANITISER
  - Cold or Hot
## Typical CIP Times

<table>
<thead>
<tr>
<th></th>
<th>Vessel CIP</th>
<th>Mains CIP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Rinse</td>
<td>10 to 20 mins</td>
<td>5 to 10 mins</td>
</tr>
<tr>
<td>Caustic Detergent</td>
<td>30 to 45 mins</td>
<td>20 to 30 mins</td>
</tr>
<tr>
<td>Rinse</td>
<td>10 to 15 mins</td>
<td>5 to 10 mins</td>
</tr>
<tr>
<td>Acid Detergent</td>
<td>20 to 30 mins</td>
<td>15 to 20 mins</td>
</tr>
<tr>
<td>Rinse</td>
<td>15 to 20 mins</td>
<td>10 to 15 mins</td>
</tr>
<tr>
<td>Sterilant</td>
<td>10 to 15 mins</td>
<td>5 to 10 mins</td>
</tr>
</tbody>
</table>
Typical CIP Temperature

- Brewhouse Vessels: Hot 85°C
- Brewhouse Mains: Hot 85°C
- Process Vessels: Cold < 40°C
- Process Mains: Hot 75°C
- Yeast Vessels: Hot 75°C
- Yeast Mains: Hot 75°C
CIP Detergent - Requirements

- Effective on target soil
- Non foaming or include anti-foam
- Free rinsing / Non tainting
- Non corrosive – Vessels/pipes, joints
- Controllable - Conductivity
- Environmental
Caustic Detergents

• Advantages
  – Excellent detergency properties when “formulated”
  – Disinfection properties, especially when used hot.
  – Effective at removal of protein soil.
  – Auto strength control by conductivity meter
  – More effective than acid in high soil environment
  – Cost effective

• Disadvantages
  – Degraded by CO₂ forming carbonate.
  – Ineffective at removing inorganic scale.
  – Poor rinsability.
  – Not compatible with Aluminium
  – Activity affected by water hardness.
Acid Detergents

• Advantages
  – Effective at removal of inorganic scale
  – Not degraded by CO2
  – Not affected by water hardness
  – Lends itself to automatic control by conductivity meter.
  – Effective in low soil environment
  – Readily rinsed

• Disadvantages
  – Less effective at removing organic soil. New formulations more effective.
  – Limited biocidal properties - New products being formulated which do have biocidal activity
  – Limited effectiveness in high soil environments
  – High corrosion risk - Nitric Acid
  – Environment – Phosphate/Nitrate discharge
Detergent Additives

• Sequestrants (Chelating Agents)
  – Materials which can complex metal ions in solution, preventing precipitation of the insoluble salts of the metal ions (e.g. scale).
  – e.g. EDTA, NTA, Gluconates and Phosphonates.

• Surfactants (Wetting Agents)
  – Reduce surface tension – allowing detergent to reach metal surface.
Sterilant / Sanitiser Requirements

- Effective against target organisms
- Fast Acting
- Low Hazard
- Low Corrosion
- Non Tainting
- No Effect On Head Retention
- Acceptable Foam Characteristics
Sterilants / Sanitisers

- Chlorine Dioxide
- Hypochlorite
- Iodophor
- Acid Anionic
- Quaternary Ammonium
- Hydrogen Peroxide
- PAA (Peroxyacetic Acid) – 200-300 ppm
CIP Systems

• Single Use
  – Water/Effluent/Energy costs

• Recovery
  – Detergent Recovery
  – Rinse/Interface Recovery

• Tank Allocation

• Number of Circuits
Single Use CIP Systems
Recovery CIP Systems

1 x Supply – 3 Tank System

Water

Final Rinse Tank

Pre-Rinse Tank

Caustic Tank

CIP Return / Recirc

CIP Supply / Recirc

LSH

LSL

Flow

Conductivity

CIP Return

CIP Supply

Steam

CIP Heater

Temp

Temperature

Flow

Acid

Sterilant

CIP Supply / Recirc Pump
Recovery CIP Systems
2 x Supply – 4 Tank System – Separate Recirc
Recovery CIP System
Single Use vs Recovery

- Single Use CIP
  - Low Capital Cost
  - Small Space Req.
  - Low Contamination Risk
  - Total Loss
    - High Water Use
    - High Energy Use
    - High Effluent Vols.
  - Longer Time/Delay
  - Use for Yeast

- Recovery CIP
  - High Capital Cost
  - Large Space Req.
  - Higher Contamination Risk
  - Low Loss
    - Low Water Use
    - Low Energy Use
    - Low Effluent Vols.
  - Shorter Time/Delay
  - Use for Brewhouse & Fermenting
CIP Systems
CIP Tank Sizing

• Pre-Rinse
  – CIP Flow x Time

• Detergent
  – Vol of CIP in Process Mains & Tank + Losses

• Final Rinse
  – Flow x Time – Water Fill
CIP Systems
Practical Points

• CIP Supply Pump
• Recirculation
  – Shared/Common with CIP Supply, or
  – Dedicated to Tank
• CIP Supply Strainer
• CIP Return Strainer
• CIP Tank Connections
Types of CIP

- VESSEL CIP
  - Sprayhead Selection
  - Scavenge Control
- MAINS CIP
  - Adequate Velocity
  - Total Route Coverage
- BATCH/COMBINED CIP
  - Complex Control
  - Time Consuming
Vessel CIP

- Flow of CIP fluid from CIP supply to vessel sprayhead
- Internal surfaces cleaned by spray impact / deluge
- Return from vessel by CIP scavenge (return) pump
Vessel CIP - Sprayheads

- Static Sprayballs
  - High Flow / Low Pressure
- Rotating Sprayheads
  - Low Flow / Medium Pressure
- Cleaning Machines
  - Low Flow / High Pressure
  - High Impact
Vessel CIP – Sprayballs

- **Advantages**
  - No moving parts
  - Low Capital Cost
  - Low pressure CIP supply
  - Verification by Flow

- **Disadvantages**
  - High Water & Energy Use
  - High Effluent volumes
  - Limited throw – Small vessels
  - Spray Atomises if Pressure High
  - No impact - long CIP time and/or high detergent strength
  - Higher absorption of CO₂ by caustic
Vessel CIP – Rotary Sprayheads

• Advantages
  – Not too Expensive
  – Some Mechanical Soil Removal
  – Lower Flow
  – Reasonable Water/Energy Usage
  – Reasonable Effluent

• Disadvantages
  – Moving parts
  – Limited throw – Small vessels
  – Possible blockage
    • Rotation verification
    • Supply strainer
Vessel CIP – Cleaning Machines

• Advantages
  – High impact, aggressive cleaning
  – Good for heavy duty cleaning
  – Low water/energy use
  – Low effluent
  – Effective in large vessels
  – Lower absorption of CO2 by caustic
  – Lower Flow means smaller Pipework
Vessel CIP – Cleaning Machines

• Disadvantages
  – Expensive
  – Moving parts
  – High pressure CIP supply pump
  – Possible blockage
    • Rotation verification
    • Supply strainer
Mains CIP

- Flow of CIP fluid from CIP supply, through process pipework and back to CIP set
- The entire process route must see turbulent CIP Flow
- No/Minimal Tees/dead legs
- Isolate from other process lines
Mains CIP
Turbulent & Laminar Flow
Mains CIP
Turbulent & Laminar Flow

• Turbulent Flow
  – Flat velocity profile
  – Thin Boundary layer
  – Effective CIP

• Laminar Flow
  – Streamline flow
  – Velocity profile, faster at centre
  – Ineffective CIP

Thin Boundary Layer at pipe wall
Mains CIP

- Turbulent Flow –
  - Re > 3000

- Minimise Boundary layer –
  - Laminar layer on internal pipe wall

- Minimum CIP velocity (in process pipe) \( \geq 1.5 \text{ m/s} \).

- Excessive velocity
  - High Pressure drop / Energy input
# Mains CIP – CIP Flow

<table>
<thead>
<tr>
<th>Process Pipe dia (mm)</th>
<th>Minimum CIP Flow (m³/h)</th>
<th>CIP Supply / Return dia (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>2.1</td>
<td>25</td>
</tr>
<tr>
<td>38</td>
<td>5.2</td>
<td>38</td>
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<tr>
<td>50</td>
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<tr>
<td>350</td>
<td>520</td>
<td>250</td>
</tr>
<tr>
<td>400</td>
<td>700</td>
<td>250</td>
</tr>
</tbody>
</table>

**Min CIP Velocity** 1.5 m/s minimum

Based on o/d tube to 100 mm and metric I/d above 100 mm.
Process Pipework Design for CIP

- Ensure Total Route coverage
  - Avoid Split routes
- Avoid Dead ends
- Avoid Tees
- Most Critical on Yeast & nearer packaging
Process Pipework Design for CIP

- Isolate CIP from Process
  - Mixproof Valves
  - Flowplates
Batch/Combined CIP

• Combines CIP of
  – Vessel/s and
  – Pipework in one clean

• Why?
  – Pipework too large for ‘mains’ CIP
    e.g. Brewhouse 200 to 600 mm.
  – Pipework linked to Vessel
    e.g. Recirculation Loop or EWH.
Batch/Combined CIP

• Supply of a batch volume of CIP to process vessel
• Internal recirculation of CIP within/through process vessel
• Transfer of CIP to next vessel
• Pumped return of CIP batch volume to CIP set.
CIP Monitoring & Control On-Line

- Detergent Temperature
- Detergent Strength - Conductivity
- Return Conductivity
  - Detergent Start Interface
  - Detergent End Interface
  - Rinse Conductivity
- Return Flow
- Recirc/Return Time
- Supply Pressure
CIP Monitoring & Control Off-Line

- Visual Inspection
- Final Rinse return sampling
  - pH
  - Micro
  - ATP
- Vessel/Pipework swabs
  - pH
  - Micro
  - ATP
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