Design for CIP

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Topics to be Covered

1. What is CIP?
2. Why CIP?
3. Advantages of CIP
4. Cleaning in Place Detail
5. Types of CIP Systems
6. Sterilisation in Place
7. Monitoring
8. Design Consideration
9. Summary
What is CIP (Clean in Place)?

**CIP - Clean in Place**
Equipment and techniques to allow cleaning of process equipment without dismantling or manual cleaning

**SIP - Sterilisation in Place**
Heat or Chemical Sterilisation of Process Equipment

**COP - Clean Out of Place**
Move Parts and Equipment to a COP system for cleaning
Cleaning of Surfaces & Walls
Why CIP?

- Reproducible, Repeatable and Controllable Results
- Reduction of Cleaning Time
  Automatic cycles ensure every item is cleaned every time
- Increased productivity through reduction of downtime
- Chemical Handling Reduction
- Simple Operation
Advantages of CIP

- Cost and Utility Savings including chemicals, water and effluent, labour time etc.
- Health and Safety
- Batch Traceability and Records
- Stronger Chemicals and higher temperatures can be used
- More complex processing systems can be used
- Environmental Issues and Legislation
Why Use CIP

1) CIP is superior to any cleaning method
   Automated, with parameter monitoring & control
   Repeatability → reliability
   Human errors eliminated
   Eliminate contaminated products

2) Lower operating costs
   Reduced labour costs
   Cleaning turnaround time reduced
   Water / solvents / detergents usage significantly reduced

3) Safety Improvement
   Reduced exposure of product to personnel
   No equipment dismantling / vessel entry
   Eliminates hazardous activities, eg HP water blasting
Temperature

Effect on cleaning operation:

<table>
<thead>
<tr>
<th>Soil</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proteins</td>
<td>medium</td>
</tr>
<tr>
<td>Fats</td>
<td>good</td>
</tr>
<tr>
<td>Sugars</td>
<td>good</td>
</tr>
<tr>
<td>Salts</td>
<td>good</td>
</tr>
</tbody>
</table>

Note: Generally a 10°C temperature increase will improve cleaning efficiency by 50% (above 30°C)
Effect on cleaning operation:

1) Turbulence in Piping

<table>
<thead>
<tr>
<th>Flow Type</th>
<th>Reynolds Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laminar flow</td>
<td>$Re &lt; 2,300$</td>
</tr>
<tr>
<td>Transition flow</td>
<td>$2,300 &lt; Re &lt; 3,000$</td>
</tr>
<tr>
<td>Turbulent flow</td>
<td>$Re &gt; 3,000$</td>
</tr>
</tbody>
</table>

Reynolds number, $Re = \frac{D \times \upsilon \times \rho}{\mu}$

- $D$ is pipe internal diameter
- $\upsilon$ is fluid velocity
- $\rho$ is fluid density
- $\mu$ is fluid viscosity

**Note:** Normally take velocity to be $>2 \text{ m/s}$

$\rightarrow$ 1½” tube at 2 m/s $\rightarrow Re = 78,000$
Effect on cleaning operation:

2) Action in Equipment

a) Automatic Tank Wash devices
   • Fixed Spray Devices
   • Self-powered Rotating
   • Self-powered Turbine
**Chemical (Detergent)**

**Effect on cleaning operation:**

<table>
<thead>
<tr>
<th>Soil</th>
<th>Water</th>
<th>Alkali</th>
<th>Acid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proteins</td>
<td>poor</td>
<td>good</td>
<td>medium</td>
</tr>
<tr>
<td>Fats</td>
<td>poor</td>
<td>good</td>
<td>medium</td>
</tr>
<tr>
<td>Sugars</td>
<td>good</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Salts</td>
<td>medium</td>
<td>medium</td>
<td>good</td>
</tr>
</tbody>
</table>

*Note:* required concentrations depend on soil level, processes used, working time, temperature, ....
Quality of Water used for aqueous cleaning is critical for performance:

- Chemical properties (pH, hardness, etc.)
- Biological properties (bioburden, endotoxins)

Pre-Rinsing. Solely for flushing out of residue prior to washing step. Usually based on practicality of what water is available.

Washing. Most critical is water hardness – affects efficiency of cleaning of aqueous surfactant solutions.

Rinsing. In general, the final rinse used for equipment should use the same quality water as used in the final stage of manufacture.
The duration of each CIP cycle step is to be optimised according to the main following parameters:

- Type of Process Equipment
- Type of Process Carried Out
- Duration of Process Run
- Cleaning solution temperature
- Chemical concentration
## Typical CIP Programme

<table>
<thead>
<tr>
<th>Step</th>
<th>Operation</th>
<th>Cleaning Agent</th>
<th>Temp. (°C)</th>
<th>Time (Min.)</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pre-Rinse</td>
<td>Water</td>
<td>20 – 30</td>
<td>2 – 5</td>
<td>To drain</td>
</tr>
<tr>
<td>2</td>
<td>Alkali Clean</td>
<td>2% Caustic</td>
<td>70 – 90</td>
<td>5 – 30</td>
<td>Re-circulated</td>
</tr>
<tr>
<td>3</td>
<td>Inter-rinse</td>
<td>Water</td>
<td>20 – 30</td>
<td>1 – 5</td>
<td>To drain</td>
</tr>
<tr>
<td>4</td>
<td>Acid clean</td>
<td>1% Phosphoric</td>
<td>50 – 70</td>
<td>3 – 15</td>
<td>Re-circulated</td>
</tr>
<tr>
<td>5</td>
<td>Inter-rinse</td>
<td>Water</td>
<td>20 – 30</td>
<td>4 – 10</td>
<td>To drain</td>
</tr>
<tr>
<td>6</td>
<td>Sterilant</td>
<td>Peracetic Acid</td>
<td>20 – 30</td>
<td>3 – 15</td>
<td>Re-circulated</td>
</tr>
<tr>
<td>7</td>
<td>Final Rinse</td>
<td>Water</td>
<td>20 – 30</td>
<td>4 – 10</td>
<td>To drain</td>
</tr>
</tbody>
</table>
Types of CIP Systems

- Boil Out (Fill / Flood) System
- Total Loss
- Single Use Recirculation
- Re - Use (Recovery)
- Multi Channel
- Fixed & Mobile Systems
- WIP and COP
Boil Out System (Fill/Flood)

**Advantages**
- No / Small Capital Investment
- Very Small Vessels
- Cleans Complicated Mixer Systems
- No additional Equipment Need
- Solvent based

**Disadvantages**
- High Detergent & Water Usage
- Extended Cleaning Times
- Health & Safety Considerations
- Difficult to Monitor /Validate
Total Loss System

Water

WATER BREAK TANK

CIP PUMP

DETERGENT DOSING PUMP

Spray ball

PROCESS VESSEL

DRAIN

ALTERNATIVE DOSING POSITION
Advantages

- Improved Health & Safety
- Simple Installation

Disadvantages

- High Detergent & Water Usage
- Extended Cleaning Time
- Difficult to Monitor / Validate
Advantages

- Flexible System
- Lower Cost Installation (than Re-Use)
- Good Economy for Local System
- Small Floor Space
- LOW CROSS CONTAMINATION RISK

Disadvantages

- Not Suitable for Large Centralised Systems
Re-Use System

Advantages
- Good Water / Detergent Usage
- Centralised Systems & Controls

Disadvantages
- Inflexibility
- Higher Equipment & Installation Costs
- CROSS CONTAMINATION RISK FOR DIS-SIMILAR PRODUCTS OR RAW/COOKED CONDITION
Re-Use System with Recovered Water Tank

- Detergent Dosing Pump
- DETERGENT TANK
- RECOVERED WATER TANK
- Drain
- Fresh Water
- CIP PUMP
- CIP RETURN PUMP
- Spray ball
- PROCESS VESSEL

Recovered Water Tank

Use System with Recovered Water Tank
Multi-Channel Re-Use System

1. FRESH WATER
2. CAUSTIC SOLUTION
3. ACID SOLUTION
4. REUSED WATER
5. ASEPTIC SOLUTION
Multi-Channel System

SOLUTION

Vessel A

Vessel B

cross-contamination
## System Comparisons

<table>
<thead>
<tr>
<th></th>
<th>Re-Use</th>
<th>Single Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solution Tanks</td>
<td>2 to 5</td>
<td>1 or none</td>
</tr>
<tr>
<td>Soln. Temperatures</td>
<td>Fixed</td>
<td>Adjustable</td>
</tr>
<tr>
<td>Soln. Concentrations</td>
<td>Fixed</td>
<td>Adjustable</td>
</tr>
<tr>
<td>Simultaneous operations</td>
<td>1 to 4</td>
<td>1 only</td>
</tr>
<tr>
<td></td>
<td>(Multi-channel)</td>
<td></td>
</tr>
<tr>
<td>Flexibility</td>
<td>Poor</td>
<td>High</td>
</tr>
<tr>
<td>Cross contamination</td>
<td>High Risk</td>
<td>Small Risk</td>
</tr>
<tr>
<td>Investment cost</td>
<td>Higher</td>
<td>Lower</td>
</tr>
<tr>
<td>Running Cost</td>
<td>Lower</td>
<td>Higher</td>
</tr>
<tr>
<td><strong>MAIN CRITERIA</strong></td>
<td><strong>CLEANING COST</strong></td>
<td><strong>CLEANING QUALITY</strong></td>
</tr>
</tbody>
</table>
**Example:** 3000 L Storage Vessel, with 100 Lpm Sprayball
1.5% Detergent. 5 min Rinses. 20 min Detergent

<table>
<thead>
<tr>
<th>SYSTEM</th>
<th>WATER</th>
<th>DETERGENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boil Out System</td>
<td>6500 L</td>
<td>45 L</td>
</tr>
<tr>
<td>Total Loss</td>
<td>3000 L</td>
<td>30 L</td>
</tr>
<tr>
<td>Single Use</td>
<td>1200 L</td>
<td>3 L</td>
</tr>
<tr>
<td>Partial Re-Use</td>
<td>1100 L</td>
<td>2 L</td>
</tr>
<tr>
<td>Full Re-Use</td>
<td>600 L</td>
<td>2 L</td>
</tr>
</tbody>
</table>
Typical Pharmaceutical CIP Unit
Mobile CIP Units

- Reduces Pipework Installation
- Limits to size of unit & Capacity
- Service Requirements
- Heating problems
- Ideal for small cleaning duties
There is no legislative distinction between Clean In Place (CIP) and Wash In Place (WIP), however the general industry view on the terminology is that CIP means a totally automatic cleaning sequence with no manual involvement, whereas as WIP includes some manual intervention. In practical terms CIP requires high levels of validation, against WIP which requires less stringent validation.
The introduction of the ATEX directive to include all components that are ATEX certified, mechanical as well as electrical.

The problems with component selection associated with systems that reside continually in an ATEX area.

Can use aqueous or solvent cleaning media.

ATEX rated spraydevices.

Inert atmospheres for spray cleaning.
When is a CIP Application not a CIP Application?

Answer: When it is a COP Application.

COP or Cleaning Out of Place is when the equipment is moved to the cleaning equipment prior to a CIP clean.
Sterilization is not to be considered as part of the cleaning process.

Purpose of Sterilization is to destroy any form of micro-organism.

Chemical Sterilization

- Chlorine, hypochlorite, hydrogen peroxide, ozone, peracetic acid

Thermal Sterilization

- dry heat, steam, superheated water
## Monitoring Systems

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conductivity</td>
<td>To Monitor Strength</td>
</tr>
<tr>
<td></td>
<td>To Separate Phases</td>
</tr>
<tr>
<td>Temperature</td>
<td>In Feed Line to Control</td>
</tr>
<tr>
<td></td>
<td>In Return Line to Monitor</td>
</tr>
<tr>
<td>Flow</td>
<td>In Feed &amp; Return to Confirm Rate</td>
</tr>
<tr>
<td>Pressure</td>
<td>In Feed Line for Spray Device</td>
</tr>
<tr>
<td></td>
<td>In Return for Integrity Testing</td>
</tr>
<tr>
<td>Time</td>
<td>From the Control System</td>
</tr>
<tr>
<td>Turbidity</td>
<td>In Return Line to Monitor</td>
</tr>
</tbody>
</table>
CIP/Process Design

- ‘Cleanability’ of components & fittings used for process installations
- Safety breaks & circuit separation
- Circuit balancing of CIP circuit
- Prevention of ‘dead legs’ in process circuits
- Surface finish of tanks and piping
- Welding techniques
Equipment/System to be cleaned...

- Made of corrosion-resistant and cleanable materials
- Must confine the cleaning solution
- Must be drainable, with no pockets or ledges
- Any corners should be rounded
- Gaskets & seals – crevice-free, non-absorbent, non-reactive, non-porous (FDA-approved elastomers)
- Minimum interconnecting fittings in piping
- All valves & instruments should be cleanable
- Use of hoses should be minimised
Circuit Separation
Circuit Balance

Always have a higher output flow than input flow for CIP
Always have safe separation between process and cleaning
Prevention of Deadlegs

Beware of Dead-legs in the process and cleaning circuits
Uncleanable limits of cleanability:
- **L = 5 D**
- **L = 3 D**
- **L = 1 D**
- **L = 0 D**

**Zero dead-leg valve** is the best option.

OK and best dead-leg valves are indicated.

Dead-legs are marked as uncleanable.
Laminar Flow (Low Velocity)
Re \leq 2300

Turbulent Flow (High Velocity)
Re > 3000

Ensure sufficient fluid flow velocities in the process and cleaning circuits.
Spray Devices – Fixed
Low Pressure – High Flow

Advantages

- No maintenance
- Special Spray Patterns
- Easier to Monitor
- Less Pump Power

Disadvantages

- Higher Water Usage
- Less Mechanical Action
- Less Bounce Back
- Longer cleaning times
Spray Device – Rotating
High Pressure – Low Flow

Advantages
- Lower Water Usage
- Greater Mechanical Action
- Greater Bounce Back
- Greater Throw Distances

Disadvantages
- Higher Pump Power
- More Difficult to Monitor
- Generally Higher Cost
- More Difficult to “Aim” Spray
- Higher Maintenance
Surface Finish

REDUCTION % OF MICRO-ORGANISMS AFTER A STANDARD CIP CYCLE (relative values)

TIME TO DESTROY 99,9% OF MICRO-ORGANISMS (relative values)
Welding Techniques

Poor Hand Weld
• Difficult to clean
• Drainage problems
• Corrosion

Orbital Weld
Evaluation of Cleaning Risk
CIP Unit Selection (Skid Packages)
Flexibility allowing Customisation
CIP / SIP / Process Interface from start
Incorporate Hygienic Design
Monitoring to Ensure Repeatability
Thank You For Your Attention

For More Information Contact Suncombe

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