PERANCANGAN PABRIK: HYGINE PABRIKASI

YUSRON SUGIARTO
Cleaning

- Sanitary design of buildings and equipment are essential
- Careful planning of a cleaning system is also important
  - Define the cleaning job
  - Use the right tools
  - Does cleaning improve productivity
  - Decreases down time as well as labor wages
WET CLEANING

• Proper selection of chemicals
  • Dirt and surface films

• Quality of water
WATER QUALITY

• Cleaning water should be of potable quality
• It must be soft, and hot
  • Soft 0-3.5 grains/gallon; Na zeolite softening; dealkalization of water—reduces CO\textsubscript{2} in steam
  • Less corrosion of steam pipes
  • Hard 7-10.5 grains/gallon (Ca, Mg)
• Hard water limits detergent activity
• 110-155°F – adequate for maximum detergent action
Some cleaning terms

- Clean-out-of-place systems (COP)
- Clean-in-place systems (CIP)
- Central cleaning systems (CCS)
COP systems

- Moving it to a cleaning station
- Disassembling it (may be)
Cleaning room

• Impervious to moisture; well lit
• Large enough to accommodate the largest equipment piece
• Walls, ceiling, floor – amendable to wet cleaning
• Quarry tile, acid proof brick floor with epoxy grouting
• Floor drain
• Floor slope 3/16 inch per foot
Figure 9-2 - Large deep-well stainless steel sinks are used for utensil cleaning.
Figure 9-4 - The turbulent cleaning action of the water in clean-out-of-place (COP) tanks can clean small parts with little effort.
Figure 9-3 - Wall-mounted spray-type sanitizing units should be included in every equipment cleaning room.
• Deep well stainless steel utensil cleaning sink
• Taps with hot and cold water
• Hose station; low pressure, high volume
• Sanitizing station hooked to hose
• Shelves, hangers for cleaned utensils
• Tank-type washer for small parts
CIP systems

- Piping systems
- Bins
- Tanks
- Mixing equipment
- Proper water velocity; temp; sanitizer mix essential
- Spray assembly is important
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
- Steam
- Temperature
- Flow
- Conductivity
- LSH
- LSL
- Caustic
- 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

[Diagram of turbuulent and laminar flow with arrows indicating flow directions and a notation for thin boundary layer at pipe wall]
Mains CIP

• Turbulent Flow –
  • $\text{Re} > 3000$

• 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>
</tr>
<tr>
<td>50</td>
<td>10</td>
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<td>65</td>
<td>16</td>
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<td>75</td>
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<td>100</td>
<td>42</td>
<td>75</td>
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<tr>
<td>125</td>
<td>70</td>
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<td>300</td>
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<td>200</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 l/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
Principles and Practice of Cleaning in Place
• Permanently installed within the equipment
• CIP solution circulation, 10 gallons/hour
• 4000 gallons/h for >3000 capacity tanks
• Prerinse, wash, postrinse, and sanitize cycles
• Recirculating systems
Figure 9-5 — A typical clean-in-place (CIP) cleaning system used for liquid line or tank cleaning is shown. CIP cleaning reduces cleaning costs, and improves cleaning quality.
Automatic CIP process pipe systems

- For dairy products
- Highly specialized design
Central cleaning systems (CCS)

- Number of cleaning stations
- Supplied with hot water/chemical line
- Low pressure, high volume or vice versa
- Use of brushes/scrubbers may be needed
- 9-12 gallons/minute or greater - HV
Cleaning stations

• Clearly marked
• Clearly identified valves for controlling water/chemicals
• 50–75 ft high pressure water hose; hose racks or hose reels
• Hoses must withstand high temperatures and water pressures
• Temperature gauge
Figure 9-10 – Hose station; note the clearly identified valves.
Applicator guns/spray nozzles

• Length, nozzle type vary
• Automatic shut-off features
• Should not corrode
• Spray pattern (variable) – generally 15°
• High pressure should be maintained at least 6 inches from the nozzle.
Figure 9-11 – A cleaning gun assembly with a fail-safe water valve automatically closes when the trigger is released.
Chemical feeders

- Chemicals distributed from a central location
- Or at strategically placed points
- Prevent backflow
- Verify concentration are proper
- Some have pesticide label!
Figure 9-12 – A chemical feed pump can assure chemical accuracy.
Hot water supply units

• Provide adequate supply of hot water
• Gas fired, electric, or steam generated
• Size of hot water heaters depends on need
Figure 9-13 – Separate hot water boilers, properly sized, can provide the needed quantity of water to all central cleaning hose stations.
Foam and gel

- Are added to central wet cleaning systems
- Foaming and gelling detergents and compressed air at 60-90 PSI
- Improves adherence to surfaces
- Duration of contact is proportional to cleaning effectiveness
Figure 9-14 – Foam and gel agents hold the cleaning chemical to the surface, allowing the cleaning action of the chemical to take place.
Individual hot water hose station

- Not hooked to the CCS
- LPHV station is best for remote areas of the plant
- City water pressures
- Chemical systems can be added
Figure 9.15 – Individual hose stations with steam/water mixing valves provide an instant supply of hot water.

Figure 9.16 – Chemical feed systems and booster pumps increase the effectiveness of this type of hose station.
CLEANING

WET CLEANING

DRY CLEANING
Most jobs in food plant are dry cleaning jobs

Sweeping, brushing, wiping, blowing, and vacuuming

Brushes — should not lose bristles

Vacuuming preferred
  • Portable
  • Central
Central systems

• Multiple use
• Used for cleaning spills
• Emergency dust control
• Should not be neglected
• Wall, floor, or ceiling cleaning
• One station should cover 50 ft-extensions
• Inside diameter of hoses, 1.5–2.5 inches
• 80 cfm
• Wet or dry vacuums
Figure 9-8 – Cleaning system with central chemical distribution system
Portable equipment

• For inaccessible locations of plant
• For dry or wet vacuuming
• Less efficient than central systems
Cleaning chemicals

- Acid soils – fats, proteins, and carbohydrates: Alkaline cleaners
- Alkaline soils – mineral salts and water hardness: Acid cleaners
- Combination soils
Cleaners will:

- Soften water; suspend hardness
- Emulsify fats and some proteins
- Turn fats into soap
- Penetrate through wetting action
- Disperse particles
- Suspend particles
- Peptize proteins (make them soluble)
- Rinse freely
- Dissolve readily in water
- Do not corrode
- Adjust pH to help cleaning
Alkaline cleaners

- Used on fats, greases, and oils
- Sodium hydroxide (caustic soda)
- Sodium metasilicate (corrosion inhibitor)
- Trisodium phosphate (general cleaner)
- Sodium carbonate (soda ash)
Acid cleaners

- Used to remove hard water deposits; some proteins
- Also used to brighten
- Organic
  - Glycolic, lactic, acetic or citric
- Inorganic
  - Phosphoric, hydrochloric, sulfuric, and nitric
- PPE important
Material Safety Data Sheet
Tank Cleaning Process

Step 1 – Spraying and Degassing

- Set-up and test circulation pumps
  - 1 pump (250-450 gpm) will be required for cleaning most tank sizes
  - Standard 2” to 3” circulation lines should be adequate
  - Consult with nozzle supplier to size spray nozzle with the size of existing tank and pump
- Place a basket strainer at output of pump
- Dilute and mix CS-1 or CS-2 as directed in material storage tank
- Pump solution into tank thru top side access port
  - Pressure and GPM as per nozzle specs
  - Airless, Sherwin Williams, Gamajet, Butterworth or Cloud nozzle (or similar) recommended
- Spraying process degasses tank and cleans top and side surfaces inside tank
- Solution settles on bottom of tank over the sludge layer (estimated to be 50-100 mm thick)
  - Amount of solution is calculated to cover sludge with 2 feet of solution
  - Prepares tank for Step 2 in Process
Tank Cleaning Process

Step 2 – Circulation and Degreasing of Sludge

- Using circulation pump, circulate CS-1 or CS-2 solution throughout tank
  - Pump solution out of tank thru lowest access port - a floor sump is typically used
  - Suction line returns to pump and solution is re-sprayed back into tank after passing through the basket strainer
  - Basket strainer will capture all the freed solids from the sludge layer in the tank
  - Monitor pressure gage. If pressure drops, empty basket strainer and resume pumping.
- Circulate CS-1 or CS-2 for 24–36 hours
  - Dissolves sludge into solution
  - Separates solids from hydrocarbons which will float on top of the solution
  - If product recovery is desired, this can be done by skimming product from top layer of liquid before the evacuation stage in Step 3
    - Although, for the tanks with minimal sludge, product recovery unlikely to be practical.
- Prepares tank for Step 3 in Process
Tank Cleaning Process

Step 3 – Solution Evacuation and Liquefied Sludge Removal

- After 24-36 hours, solids in sludge will have been liquefied and pumped from tank
- Hydrocarbons will be separated from solids in sludge and emulsified into CS-1 or CS-2 solution
- Solids will have been recovered from basket strainer and will be ready for removal from site
- Reconfigure pump to evacuate wastewater from tank
- Pump wastewater from tank
  - Oily wastewater can be pumped to API pit
  - Alternately, this wastewater can easily be bioremediated using microbial additives, if desired
- In cases where product recovery is desired, the wastewater can be left to stratify and product can be skimmed from the surface
Tank Cleaning Process

Step 4 – Second Cleaning (if necessary)
- Repeat steps 1 and 2 with second batch of CS-2 solution
- Inner tank surfaces should be very clean
- Remaining CS-2 solution should be fairly clean
- Remove spray nozzle from tank
- Pump CS-2 out into storage tank for re-use as first wash on next tank

- If second cleaning is not needed, spray water through nozzle for 3-4 hours
- Remove nozzle
- Pump out tank, send wastewater to API pit
- If maintenance requirements dictate, an air mover (such as a COPUS blower) can be introduced into the tank to dry tank and promote air circulation