Principles and Practice of Cleaning in Place

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BRIGGS of Burton INC

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Contents

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

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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.

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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)

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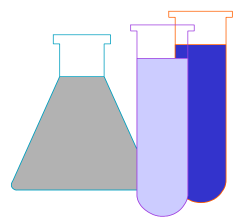
Factors affecting CIP

- 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

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Typical CIP Times

	Vessel CIP	Mains CIP
Pre-Rinse	10 to 20 mins	5 to 10 mins
Caustic Detergent	30 to 45 mins	20 to 30 mins
Rinse	10 to 15 mins	5 to 10 mins
Acid Detergent	20 to 30 mins	15 to 20 mins
Rinse	15 to 20 mins	10 to 15 mins
Sterilant	10 to 15 mins	5 to 10 mins

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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

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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 CO_2 forming carbonate.
  - Ineffective at removing inorganic scale.
  - Poor rinsability.
  - Not compatible with Aluminium
  - Activity affected by water hardness.

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Acid Detergents

- Advantages
  - Effective at removal of inorganic scale
  - Not degraded by CO_2
  - 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

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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.

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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

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CIP Systems

- Single Use
  - Water/Effluent/Energy costs
- Recovery
  - Detergent Recovery
  - Rinse/Interface Recovery
- Tank Allocation
- Number of Circuits

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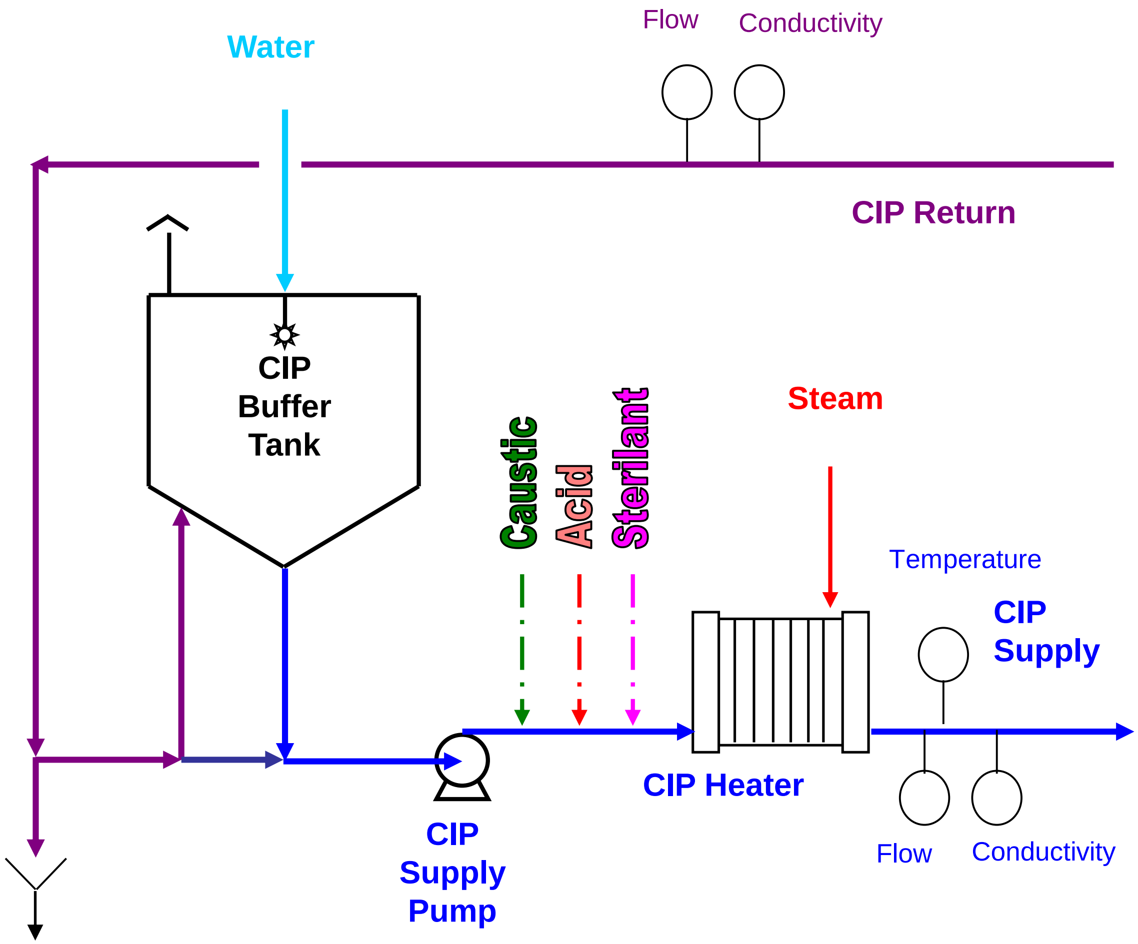
Single Use CIP Systems



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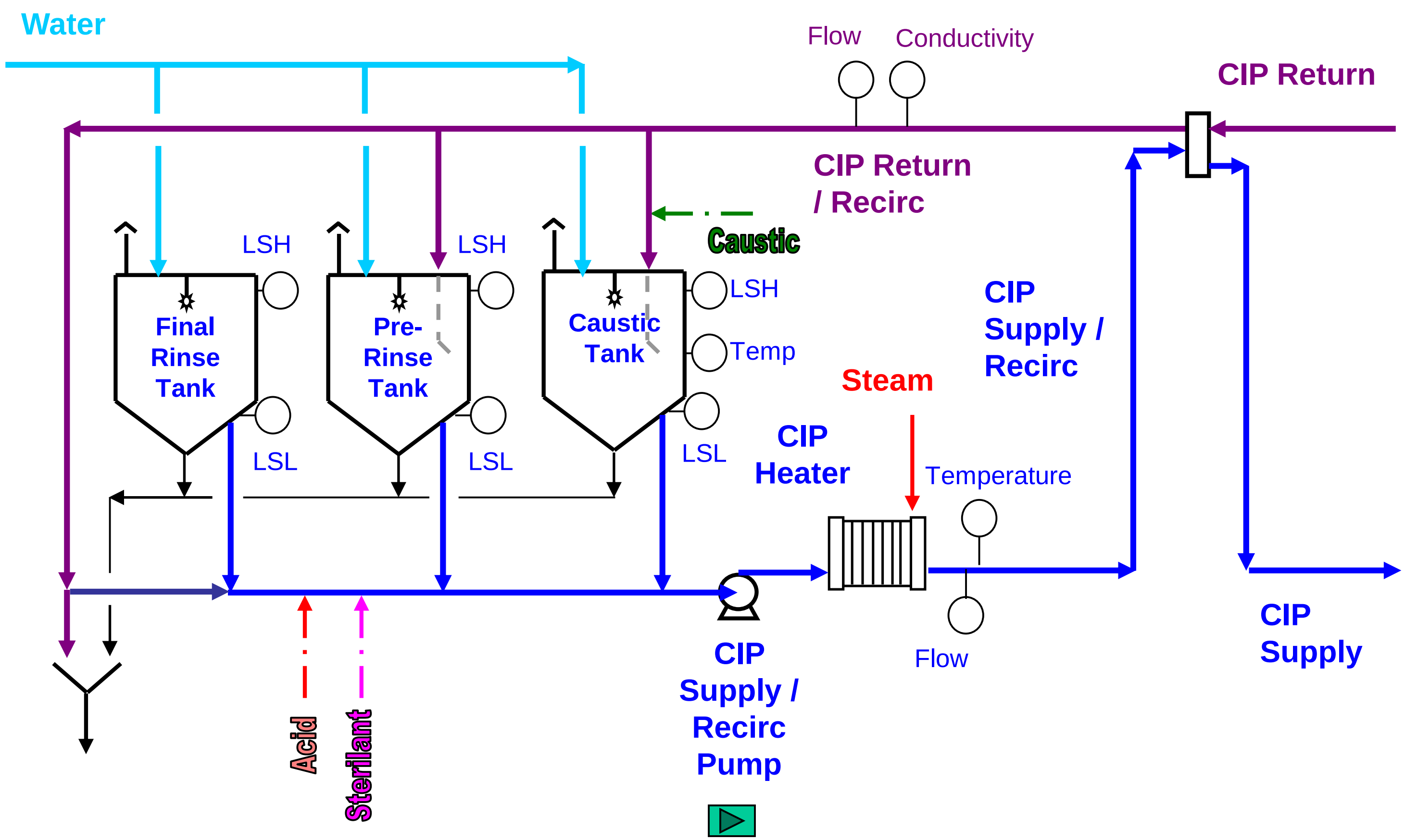
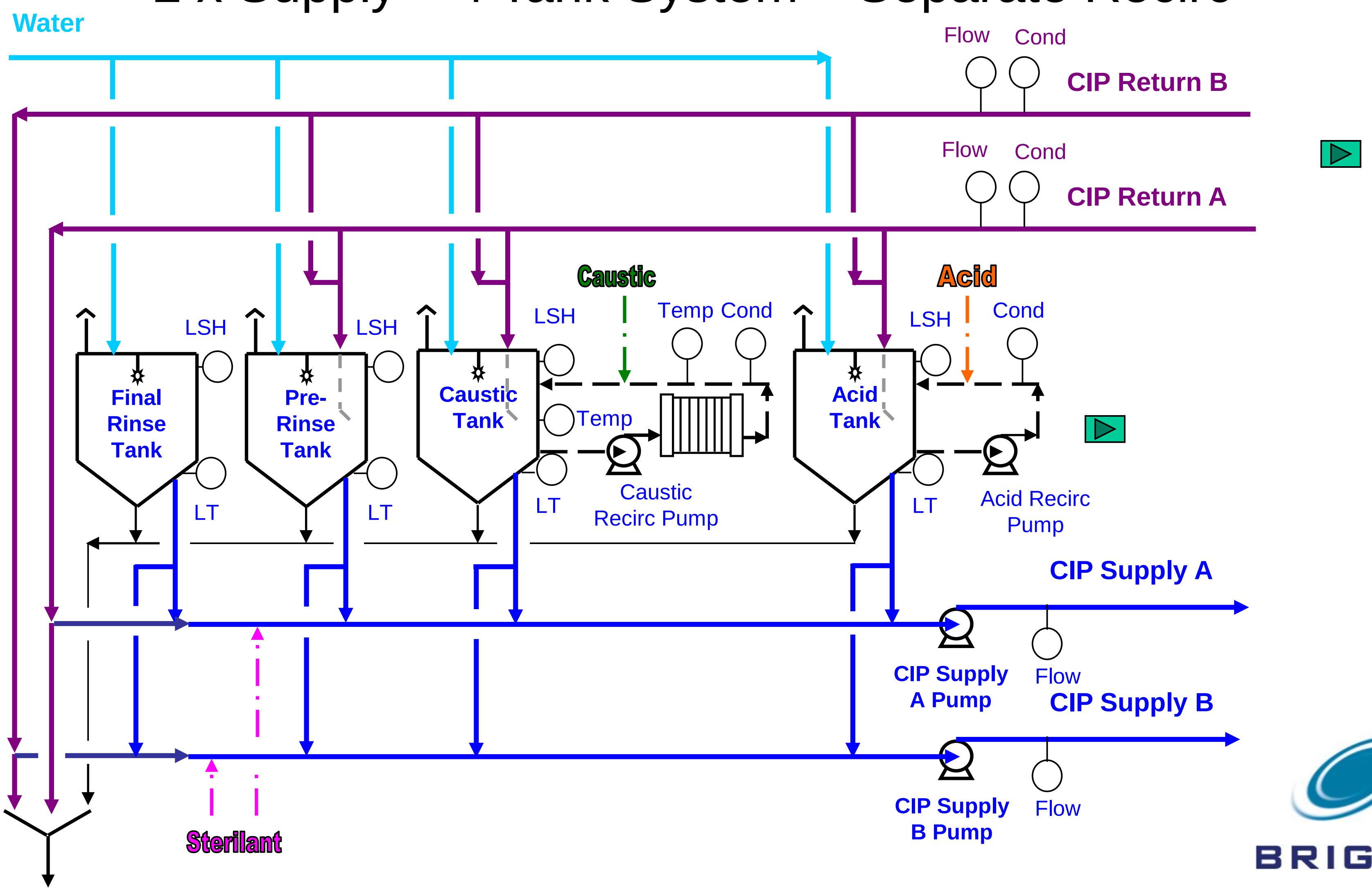
Recovery CIP Systems

1 x Supply – 3 Tank System



Recovery CIP Systems

2 x Supply – 4 Tank System – Separate Recirc



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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

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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

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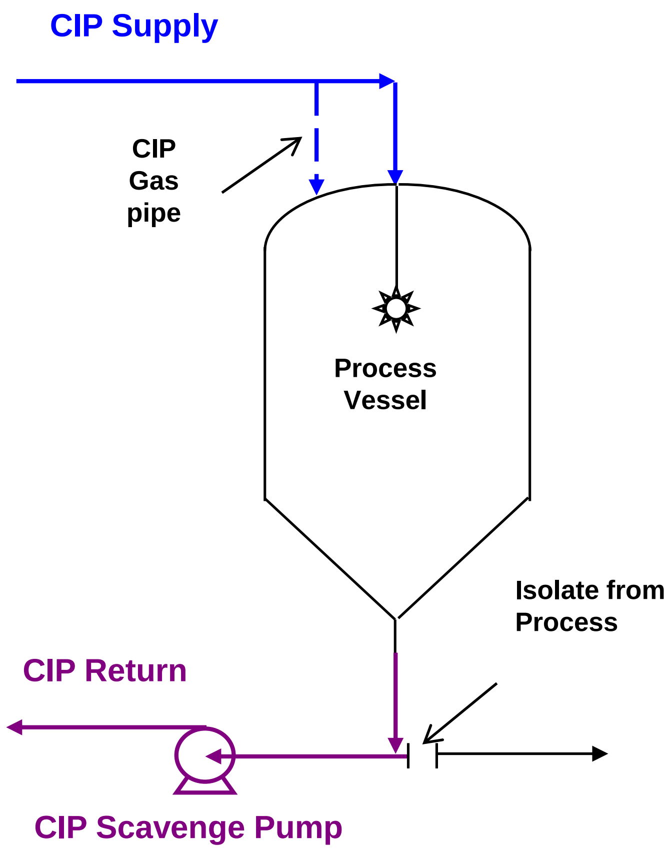
Vessel CIP

- 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

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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 CO_2 by caustic

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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

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Vessel CIP – Cleaning Machines

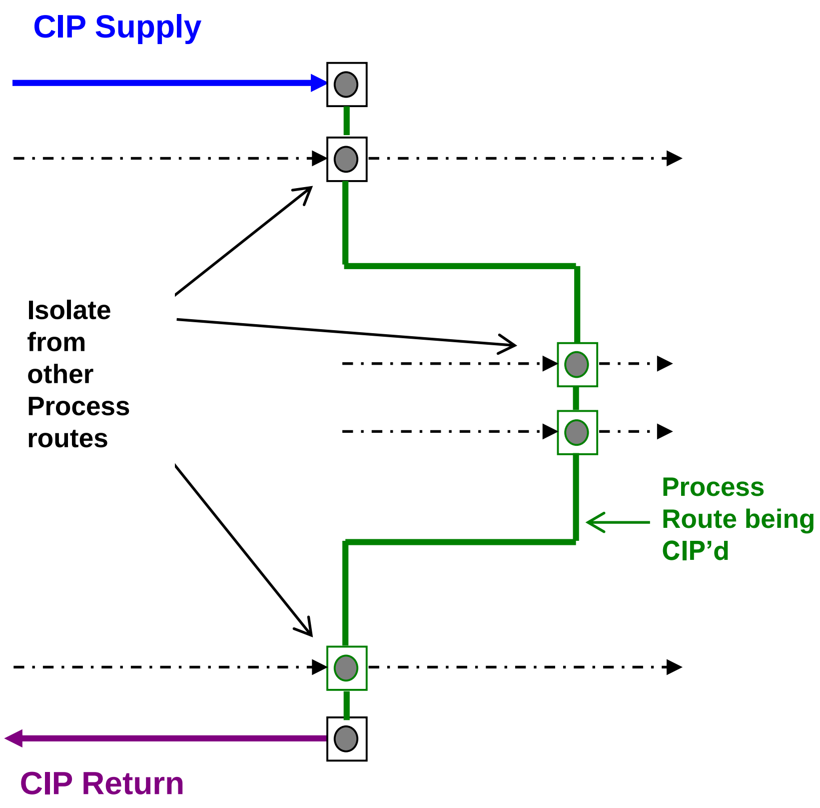
- Advantages
  - High impact, aggressive cleaning
  - Good for heavy duty cleaning
  - Low water/energy use
  - Low effluent
  - Effective in large vessels
  - Lower absorption of CO_2 by caustic
  - Lower Flow means smaller Pipework

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



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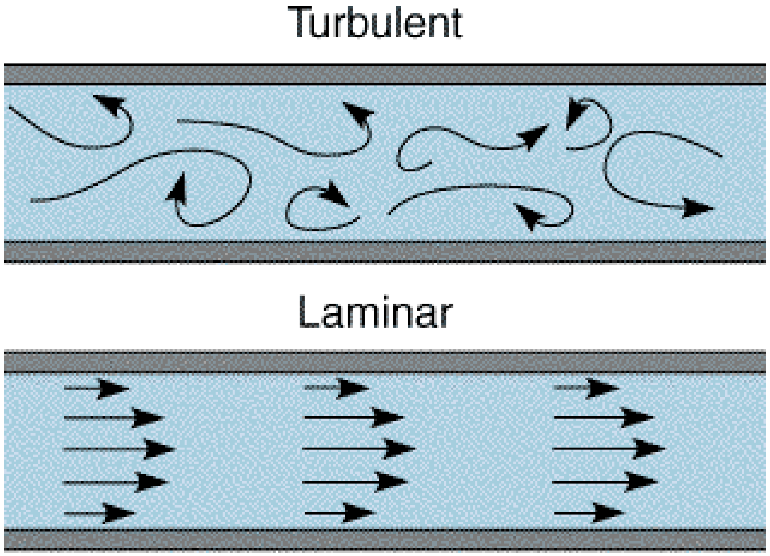
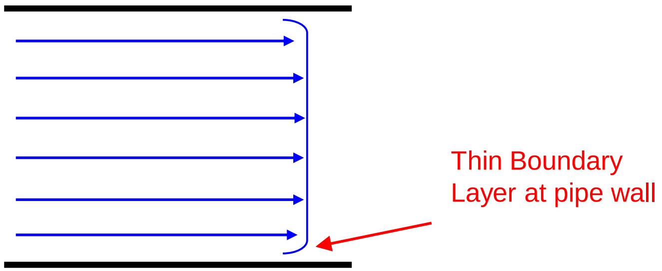
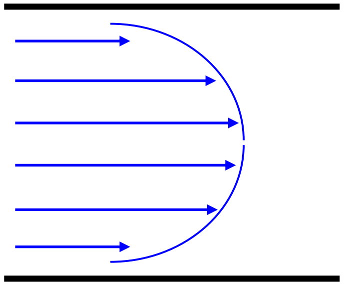
Mains CIP
Turbulent & Laminar Flow



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





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Mains CIP

- Turbulent Flow –
  - Re > 3000
- Minimise Boundary layer –
  - Laminar layer on internal pipe wall
- Minimum CIP velocity (in process pipe) $\geq$ 1.5 m/s.
- Excessive velocity
  - High Pressure drop / Energy input

Mains CIP – CIP Flow

Process Pipe dia (mm)	Minimum CIP Flow (m^3/h)	CIP Supply / Return dia (mm)
25	2.1	25
38	5.2	38
50	10	50
65	16	65
75	24	65
100	42	75
125	70	100
150	100	125
200	170	150
250	280	200
300	400	200
350	520	250
400	700	250
Min CIP Velocity	**1.5**	**m/s minimum**
Based on o/d tube to 100 mm and metric I/d above 100 mm.		

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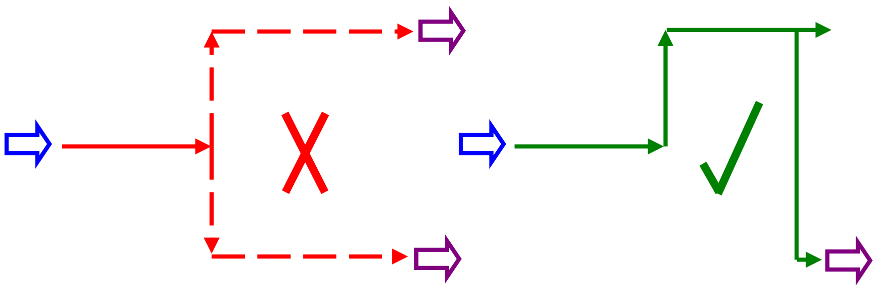
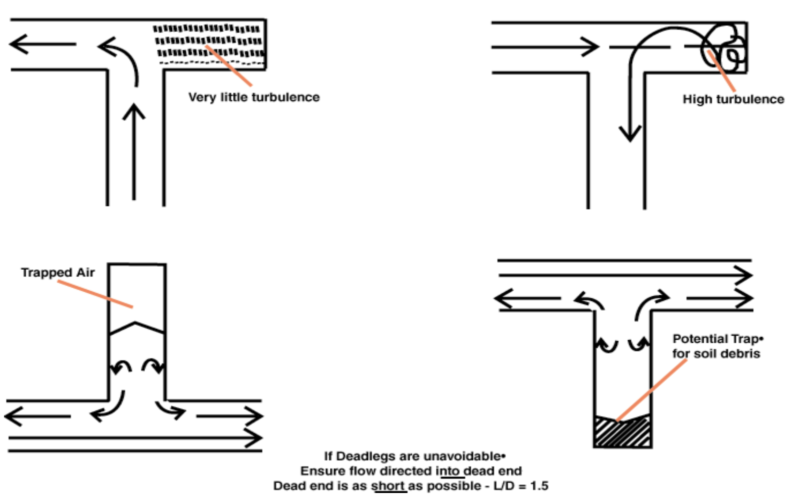
Process Pipework Design for CIP

- Ensure Total Route coverage
  - Avoid Split routes

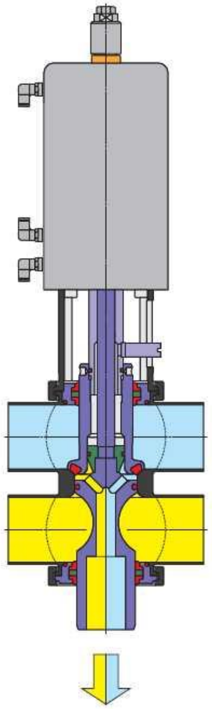


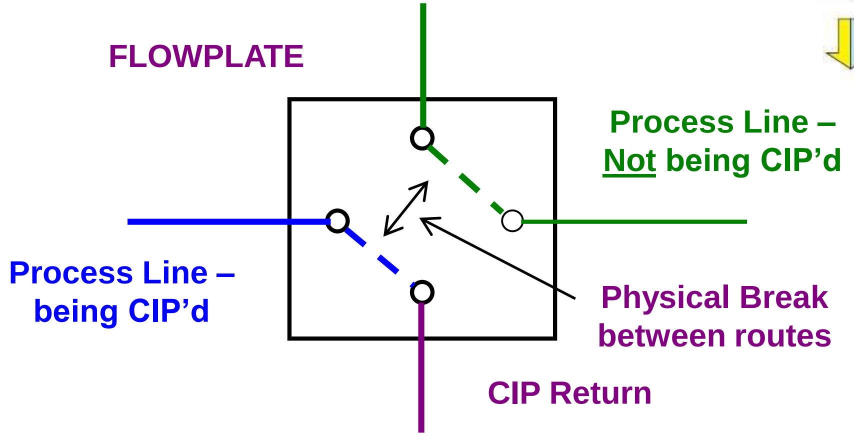
  - Avoid Dead ends
  - Avoid Tees
  - Most Critical on Yeast & nearer packaging



Process Pipework Design for CIP

- Isolate CIP from Process
  - Mixproof Valves
  - Flowplates





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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.

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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

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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

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