CIP (Cleaning In Place) Systems

A CIP system consists of equipment, pipework and automation systems that manage the circulation of cleaning and sanitation materials through the targeted food equipment and pipework. CIP systems that are correctly designed and operated enable food processing equipment and pipework to be consistently cleaned and sanitised to the desired standard without costly dismantling or reassembly of equipment.

Advantages and disadvantages

The advantages of using CIP systems include; cost and reliability gains from reduced manual work and the reduced risk of accidental recontamination from the need to reassemble equipment after it has been cleaned and sanitised. To gain these types of advantages, the three main factors given below should be carefully considered, otherwise disadvantages such as increased costs and complexity may arise.

1. A correctly designed CIP system: This ensures that the plant is clean. It also prevents issues such as risk of chemicals contaminating the product side, excessive waste/cost from poor valve selection/sizing and location, or risk of incorrect operation due to lack of alarm systems.
2. A correctly designed process system: The process must be specifically constructed for automated cleaning, e.g. radius of pipe bends, self-draining equipment and pipework (including adequate support to prevent local sagging) and no 'dead ends.' An excellent CIP side will not compensate for a poor process side.
3. Adequate maintenance: Poorly maintained CIP systems can increase the contamination risk as cleaning failures become less noticeable when automatic systems are used (i.e. equipment is rarely disassembled). Important requirements include: pump maintenance, regular calibration checks, recalibration and periodic valve maintenance. Professional advice should be obtained to assist in identifying the preventative maintenance requirements of a given CIP system.

Hygiene principles for CIP systems

Effective cleaning relies on four main factors: time, temperature, concentration and mechanical force.

1. Time: Up to an hour depending on the quantity and concentration of cleaning solution applied.
2. Temperature: Cleaning effectiveness is highly dependent on temperature selection. Extreme temperatures may 'cook'/'bake' soil on, making it very difficult to remove. Low temperatures may reduce cleaning efficiency so that soil is not completely removed. The CIP system should monitor and maintain the solution temperature at all parts of the system throughout the cleaning cycle, and prevent production if the system has not been adequately cleaned.
3. Concentration (cleaning chemicals and sanitisers): Concentrations (i.e. the strength) of the cleaning/sanitising chemicals must be maintained within set ranges. The system should prevent production if concentrations were not maintained within the acceptable range. Too lower concentrations or too higher concentrations of cleaning/sanitising chemicals will not clean and sanitise the plant effectively.
4. Mechanical force: To achieve adequate cleaning, the equipment or pipework surfaces must be contacted with cleaning liquid with sufficient mechanical force. This is achieved by supplying the cleaning liquid at fluid velocities between approximately 1.5 to 3 m/s and ensuring adequate contact time with the cleaning liquid. The required flowrate/s of liquid will vary according to the actual pipe sizes used in the pipework, or the size of the equipment. For example; spray balls located and sized to ensure that all parts of the tank receive adequate cleaning force, and cleaning liquid pumped out at a rate that ensures the tank remains empty. This ensures that the tank bottom can be contacted by the cleaning spray.

Typical CIP cycle

Step	Purpose
Initial rinse	Remove gross soiling.
Cleaning chemical wash (often repeated)	Remove attached soil. (Typically caustic, but also acid or other types of chemicals).
Rinse	Remove cleaning chemicals.
Sanitise	Reduce microbial load to a safe level.
Final Rinse	Remove sanitiser (unless using no-rinse sanitiser) and clear CIP circuit of cleaning chemicals.

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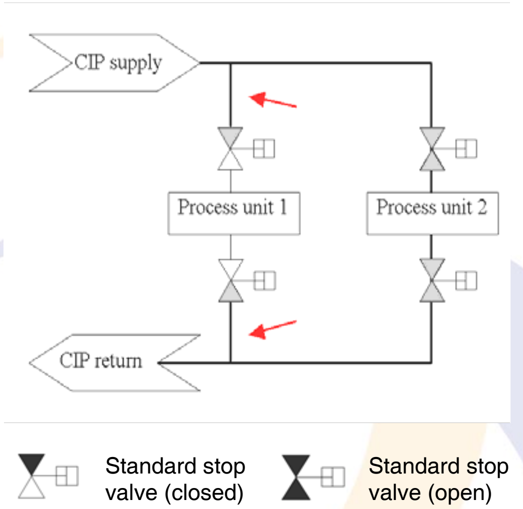
The diagram below shows Process Unit 2 being cleaned (Process Unit 1 closed off). Arrows indicate dead areas where material can collect during cleaning.



These dead areas will contain a mix of cleaning chemicals, sanitiser and water which would contaminate Process Unit 1 when the valves are opened. In addition, Process Unit 1 is not protected from chemical contamination in the case of valve leakages.

Problem areas such as these can be eliminated by good design. In very small and simple systems, design issues and their solutions may be relatively easy to identify, given sufficient time and process design experience. However, larger systems require a significant investment in professional advice and experience to prevent inadvertent contamination risks. It is not recommended to design CIP and process systems without professional advice.

Types of CIP systems

The two main types of CIP systems include:

1. ***Single use:*** These do not reuse the cleaning solution and are often limited to small systems (i.e. servicing one or two pieces of equipment and associated pipework). Typically used for heavily soiled or critical hygiene processes.
2. ***Re-use:*** If the equipment being washed does not tend to be heavily soiled, the cleaning solution is re-used by adding more chemical concentrate as required.

For reuse CIP systems, cleaning solutions may be made up on demand, according to the required application (i.e. these systems are often referred to as multiple applications). For example; 1-2% caustic solutions for tanks and heat exchangers, or 1% solutions for pipework, at the various temperatures as required.

Example: Single-use CIP systems

Basic single-use systems include make-up tank/s, a heating system (e.g. steam injection or heat exchanger) and pump/s, connected into a suitably designed process. These would be supported by instrumentation and control systems.

The cleaning cycle begins with several rounds of pre-rinse water to remove gross soil deposits and minimise the cleaning task. For this step as well as all the following steps, the number and duration of each round is pre-determined, e.g. via cleaning trials.

Next, the cleaning chemical is made up to the required concentration and temperature, pumped through the process for a set time and then sent to drain. Solution temperature and concentration are typically monitored at one point (the end of the processing line) but they can be monitored at two points (at make-up and on the return line) so that adjustments can be made as necessary. Similarly, flow rates should be monitored using pressure gauges or flow meters.

The system is then rinsed out and the process repeated for the acid wash, if used. Note that it is extremely important that chemicals be rinsed out thoroughly. This is not only to prevent product contamination or chemical inactivation, but also to prevent the interaction of for example an acid cleaner and a sanitiser (e.g. hypochlorite) which can react and produce harmful chlorine gas.

The system is then sanitised and rinsed (final potable water rinse). Time, temperature, flow rate and concentration are monitored and controlled as before, to ensure that the cleaning cycle complies with the intended program.

Common issues

1. Verification: CIP system effectiveness must be validated initially, and then verified regularly. Methods: Visual inspection, swabbing and rinse water assessments.
2. Unusual circumstances: e.g. Excessive build up in a plate heat exchanger due to an extended production run. The temperature of the heating fluid rises to compensate, causing burn-on which is subsequently not removed by the standard cleaning program.

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3. Monitoring and control: Inadequate process monitoring to identify incorrect chemical concentrations, times, temperatures or flow rates, e.g. from blocked spray balls.

Recommended Reading

Lelieveld, H., L. M., Mostert M. A., Holah, J., and White, B., (2003), 'Hygiene in Food Processing – Overview: Chapters 11, 10 & 8' 1st edition, Woodhead Publishing Limited.

Further information

Other Dairy Food Safety Notes are available at www.dairysafe.vic.gov.au

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