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Technical information note

Cleaning in place (CIP) systems

Cleaning in place (CIP) involves automatic cleaning and sanitising without major disassembly of processing equipment. The system consists of chemicals, equipment, pipework and automatic controllers that manage the circulation of cleaning and sanitation agents through the food equipment and pipework.

CIP systems that are correctly designed and operated enable dairy processing equipment and pipework to be consistently and efficiently cleaned and sanitised without the need for time-costly dismantling or reassembly of equipment. This note provides guidance on what to consider in the selection of a suitable CIP system for a dairy application.

Types of CIP systems

CIP systems fall broadly into three categories.

1. In a *single use system*, water and solutions are sent to drain immediately after a single CIP cycle.
2. *Multi-use systems* recover appropriate quality chemical solutions and rinse water for repeated re-use, usually with topping-up the chemical strengths of solutions.
3. *Full recovery systems* (commonly known as re-use CIP or recovery CIP systems) are typically complex and automated systems that will use technologies such as membrane filtration to recover up to 99 per cent of the cleaning solution, and with substantial water savings.

Advantages of a CIP system

- Systems can be designed to suit a range of dairy processing applications (simple to complex).
- Cost and reliability gains from reduced manual work.
- Savings from reduced water and chemical consumption.
- A reduced effluent load.
- Reduced risk of accidental recontamination through reassembly of equipment after cleaning and sanitising.
- Reduced potential for occupational health and safety (OHS) injury to operators.

Is a CIP system appropriate?

The following factors should be carefully considered, otherwise problems such as increased costs and complexity may outweigh the expected advantages of installing a CIP system.

Correct design of a CIP system

This will ensure that the plant is reliably and consistently cleaned. It also minimises the possibility of issues, such as the risk of chemicals contaminating product through incorrect pipe re-connections, wrong valve/tap settings, the risk of incorrect operation due to lack of alarm systems, or excessive waste and cost from incorrect valve type selection or sizing, and location.

Appropriate construction of a process system

The process must be specifically constructed for automated cleaning, for example, pump capacity to ensure turbulent flow and adequate pressure to remove soil deposits, radius of pipe bends, self-draining equipment and pipework (including support to prevent local sagging) and no 'dead ends' that cleaning agents can't reach. The important choice of a control system for how the interface between product, chemical and wash water will be managed also needs to be made. This will generally require a selection between timing devices and conductivity or turbidity meters. Note that an excellent CIP design cannot compensate for a poor process system. There are many examples where *incorrect assumptions* that a CIP system has been fully effective have led to product contaminations with serious consequences for dairy companies.

Adequate maintenance

Poorly maintained CIP systems can potentially increase the contamination risk, as cleaning failures can become less noticeable when automatic systems are used (i.e. equipment is rarely disassembled). Important requirements include: pump maintenance, regular calibration checks of control, periodic valve maintenance and visual inspections.

Hygiene principles for CIP systems

Effective cleaning relies on four main factors: time, temperature, concentration and mechanical force, all of which are inter-related.

Time

Circulation of detergents can be for up to an hour, depending on the concentration of cleaning solution applied, and the degree of soiling needing to be removed. (for example, long production runs of a milk pasteuriser or evaporator can lead to a build-up of deposits or biofilms that will be more difficult to remove).

Temperature

Cleaning effectiveness is highly dependent on the temperature of the solution. A cold water rinse usually precedes a wash with CIP detergents. Excessive temperatures of cleaning solution may 'bake-on' remaining milk protein soil, making it very difficult to remove. Conversely, low solution temperatures may also be ineffective with the chemical agent to completely remove soil. The CIP system should monitor and maintain the temperature at all parts of the system throughout the cleaning cycle to within the range recommended by the chemical supply company.

Concentration of cleaning chemicals and sanitisers

The strength of the cleaning/sanitising chemicals must be maintained within set ranges. Automated dosing CIP systems should be able to monitor concentrations and indicate with alarms if these are not maintained within the acceptable range. Concentrations of cleaning/sanitising chemicals that are too low will not clean and sanitise the plant effectively. Concentrations that are too high will be wasting chemical resources and cause a loss in efficiency.

Mechanical force

To ensure adequate cleaning, all equipment and pipework surfaces must be contacted with cleaning liquid with sufficient mechanical force, and to produce a turbulent flow through the system. 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.

Achieving a successful combination of all these factors will often require complex calculations. It is therefore recommended that professional advice is sought to design a CIP system best suited to the processing application.

The CIP cycle

The following table describes a typical cycle that constitutes a CIP cleaning and sanitising regime in a dairy process. There will however be variations from this cycle, depending on the particular dairy process application, the chemicals used, and complexity level of the CIP system.

The suitability of cleaning and sanitising agents needs to be considered carefully. They must be fit for purpose, and will differ between processing applications. They must be approved for use in food processing operations. Different cleaning detergents will target the removal of specific milk components, and may be used at varying frequencies. For example, caustic-based detergents will predominantly remove fats and carbohydrate/protein soiling, whereas acid-based detergents will remove deposited protein and mineral build-ups, and may be used less frequently.

Cleaning chemical companies, dairy manufacturers and other researchers are continually investigating new formulations and processes that can improve the effectiveness, efficiencies and environmental impact of cleaning. Adoption of these new approaches can also result in alterations to a 'regular' CIP regime.

Step	Purpose
Initial water rinse (may be cold or hot, depending on product composition)	Remove gross soiling/loose product residues
Cleaning chemical wash, often repeated (typically caustic, but also acid or other types of chemicals periodically)	Remove attached soil.
Rinse	Remove cleaning chemicals
Sanitise (chemical or hot water)	Reduce microbial load to a safe level
Final rinse (unless using no-rinse sanitiser or hot water above)	Remove sanitiser and clear CIP circuit of cleaning chemicals

Additional issues to consider

The CIP system effectiveness must be validated initially, such as through visual inspection, swabbing, rinse water assessments, and monitoring of microbial levels in product. This will then be followed by regular verification actions. Examples include monitoring and recording of detergent and sanitiser strengths, temperature recording and calibration of recording devices.

Any CIP cleaning system will need detailed and clearly worded operational manuals, and staff trained and competent to operate and monitor the system.

Recognising and responding to unusual processing circumstances, such as extended production runs that may lead to excessive build up ('burn-on') in a plate heat exchanger, which is subsequently not removed by the regular CIP program.

Adequate monitoring and control systems need to be in place to identify incorrect chemical concentrations, times, temperatures or flow rates (e.g. blocked spray balls).

The option for hot water sanitising may not be appropriate in some applications, due to the expansion of metal, particularly in tanks.

Allowances need to be made for the CIP system capacity to expand with growth in production (i.e. additional plant and equipment to clean).

Key points to consider

- A CIP system can be useful for a wide range and size of dairy processing applications.
- Both the design and processing aspects of any system must be compatible and suited to the operations.
- Knowledge of the system and appropriate training of the operators responsible for cleaning is a critical component.
- Selection of the cleaning/sanitising regime will vary according to the type and levels of soiling expected.
- Regular verification, maintenance and inspection is essential.

References

Hatlar Group, Cleaning in Place Best Practice Guidelines – Part III Extra information on CIP, Melbourne 2010.

H Lelieveld,T Mostert, J Holah, and B White, *Hygiene in Food Processing – Overview*, 1st edition, Woodhead Publishing Limited, Cambridge 2003.

Melrose Chemicals Ltd, C.I.P. Cleaning, September 2009.

P Prasad, Eco-efficiency for the Dairy Processing Industry, Fact sheet 8: Optimisation of CIP systems, Dairy Australia, Melbourne 2004.

Standards Australia, AS/NZS 2541:1998, *Guide to the cleaning-in-place of dairy factory equipment*, NSW 1998.

Further information

Further food safety technical information is available at **www.dairysafe.vic.gov.au**

Or contact Dairy Food Safety Victoria on **(03) 9810 5900** or **info@dairysafe.vic.gov.au**