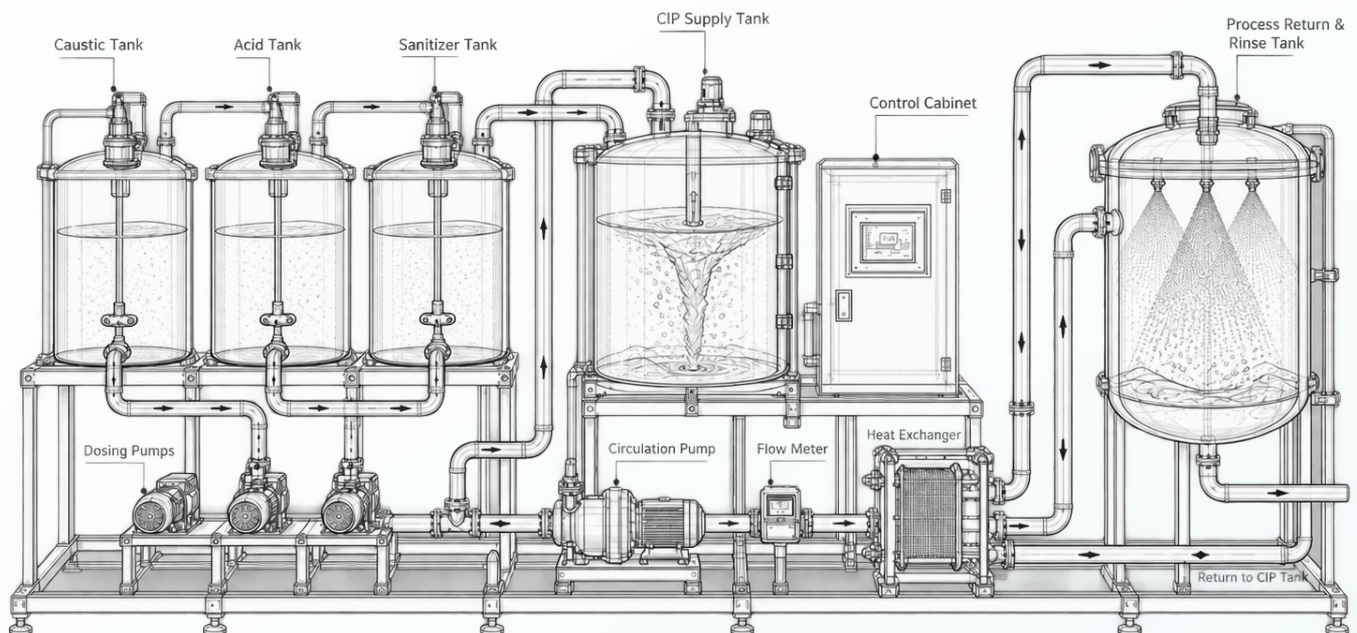


Optimising CIP Processes

Assessing water, chemicals, time and hygiene risk
together



Efficiency depends on a proven hygienic result

THE DECISION SEQUENCE

- 01 Time
- 02 Temperature
- 03 Chemistry
- 04 Flow and wetting

Cleaning in place (CIP) is a recurring production step with direct effects on food safety, plant availability, water demand and cost. Optimisation cannot end with shorter cycles or lower chemical consumption. It must show that a changed recipe works reproducibly under real operating conditions.

Start with a clearly defined cleaning result. Then adjust time, temperature, chemistry and mechanical action to achieve that result with the necessary, rather than automatically maximum, use of resources. A shorter cycle is no success if effectiveness is merely assumed. The four factors act together and changes must be evaluated as a system. Validation, routine monitoring and verification are three different evidence tasks that complement one another.

Make volume, duration, temperature, concentration, energy and lost production time visible for every step. Change parameters gradually, guided by a hypothesis and within a proven operating window. Set acceptance criteria, retain process data and check the hygienic result before release. The subject of optimisation is not one component but the demonstrable link between generation, dosing, process control, return flow and release.

A CIP cycle is a sequence of defined states

The necessary steps depend on product, soil, material, plant geometry and hygiene goal. Standard recipes may appear robust while containing extra rinses or contact times whose benefit has never been tested with data. These margins should not be removed wholesale; they should be investigated under control.

Protein, fat, sugar, mineral deposits and biofilm respond differently. Product families and levels of soiling may therefore need separate validated recipe windows. The step sequence should state what condition starts a phase, what condition ends it and how that condition is recognised.

If one factor is reduced, the whole system must remain stable

In a closed system, mechanical action principally means adequate flow, wetting and turbulence. Shortening contact time without considering concentration, temperature or flow can reduce cleaning effectiveness. Conversely, good hydraulics may allow chemical or time margins to be reduced under control.

Soil is a fifth context: its type, amount and degree of drying determine the required process energy. Each optimisation window must match the product family, production duration and real plant load. Reduce a factor only within a tested range and against an agreed result. Adjust other factors deliberately where needed, and assess process data together with the hygiene outcome.

The largest cost may not be on the chemical invoice

Water costs include fresh water, pre-rinse and intermediate rinse, final rinse and wastewater. Energy includes heating, holding temperature, pumping and wastewater treatment. Time includes production downtime, equipment occupancy and lost capacity.

The cost of one CIP cycle also includes cleaning agents, labour and product loss. Allocate these costs to each process step. Link volume and duration with temperature, concentration and return condition. This reveals whether an extra rinse, long heating phase or late recognition of the endpoint is the main opportunity.

Direct media costs are easy to calculate. The value of lost production time depends on plant utilisation, product changes, bottlenecks and cleaning frequency. Bring technical and commercial data into the same model. Optimisation starts where measurable consumption or time ceases to add a hygienic benefit. The economic case always remains tied to the demonstrated cleaning result.

Measurements justify the endpoint; they do not clean the plant

Conductivity, temperature, flow, pressure, turbidity or product-specific signals can show transitions between product, water and cleaning solution. Used correctly, sensors allow a phase to end when the required state is reached rather than after a fixed maximum time. Their meaning depends on sensor location, response time, calibration and plant geometry.

A probe on a common return line cannot identify every local dead space. Connect readings with technical inspection and validation. Automatic shortening is appropriate only inside a demonstrated operating window. For each signal, ask whether the sensor is at the decisive location, reacts quickly enough, is calibrated and plausible,

and whether the shutdown threshold has been hygienically validated.

Chemistry has limited power against poor cleanability

A cleanable system needs drainable pipework, suitable surfaces, well-flushed valves and vessels, and a geometry without inaccessible areas. If components are not fully wetted or drained, a more aggressive recipe can compensate only to a limited degree.

Inspect flow paths, spray devices, valve positions, return flow, seals and possible product traps. Connect abnormalities with the process condition, not just photographs. Inadequate wetting, trapped air or poor return paths may require longer cycles and more chemistry. Correcting hydraulics can therefore yield a major part of the gain.

Distinguish a recipe problem, where parameters lie outside the validated window or do not fit the soil, from a construction problem, where surfaces cannot be reached, drained or flushed adequately. Technical reference: EHEDG Guideline 50, Hygienic Design Requirements for CIP Installations, first edition 2019; check current updates with the publisher.

Test each change against a technical hypothesis

First stabilise the reference cycle and document its full process and result. Then state which step may contain an unnecessary margin and why. Change a limited parameter range and record all relevant data. Finally test difficult but realistic cases such as high load, long production runs, cold starts and demanding recipes.

A good result under ideal conditions does not demonstrate robust cleaning. The trial must include unfavourable, realistic states. Choose product family, production time, soil drying, starting temperature and equipment condition so critical

combinations are represented. Let the risk question determine the number of trials rather than a fixed template.

Define acceptance criteria and stop rules before the trial. After successful validation, approve the recipe, operating window, sensor limits, response to deviations and repetition rules. Give operators a clear working logic. Monitor the first production cycles closely before transferring the new standard to routine verification. The data should explain which change produced which effect.

Keep validation, monitoring and verification distinct

Validation asks whether the defined process can achieve the hygiene goal. It takes place before release or after a material change, using a trial plan, process data and a check of the result to approve an operating window.

Routine monitoring asks whether each cycle stayed within that approved window. It occurs for every cycle using, as appropriate, time, temperature, concentration, flow and process status. It supports a decision to accept or block the cycle.

Verification asks whether the system continues to work over time. It is planned and risk-based, drawing on trends, checks, audits and samples to confirm the process or trigger reassessment.

Define sampling methods, locations, limits, action values and responsible people before assessment. State when a cycle may be repeated, when production must be blocked and when cause analysis or revalidation is required. An auditable record connects recipe version, plant state, batch, process curve, deviation and release decision. Isolated tables without context are insufficient. Capture enough data to support a decision, rather than maximising data volume.

Recovery needs clear use and rejection limits

A water stream suitable for an initial pre-rinse may be unsuitable for a final rinse. Recovering rinse water or cleaning solution can reduce resource use, but only if carry-over, concentration changes, storage time and microbiological risk are controlled.

For each reused stream, define its purpose, quality criterion, maximum storage time and condition for rejection or diversion. Quality cascades avoid both unnecessary treatment of every stream to the highest standard and uncontrolled recirculation without evidence of suitability. Check quality, then reuse or divert according to the stated rule.

From a historic recipe to a controlled operating window

Phase 1 records the current process: steps, volumes, times, temperatures and results. Phase 2 checks geometry, hydraulics, measurement points and cleanability. Phase 3 tests hypotheses under critical operating conditions. Phase 4 embeds the validated standard through training, monitoring and periodic verification.

A step-by-step balance often reveals waiting time, unclear rinse endpoints or media loss immediately. These findings guide the deeper investigation. Do not change the production standard until the objective, trial, acceptance criteria and responsibilities are defined.

An optimised CIP process uses the time, energy, chemicals and water needed for a proven cleaning result. The economic benefit follows from data, hygienic design and controlled change. The result is a robust operating window that can be run and released traceably in everyday production, not a one-off shortened cycle. Every CIP step should have a purpose, measurable endpoint and verifiable result.

Sources and working check

Legal context: Regulation (EC) No 853/2004 on the hygiene of foodstuffs, establishing food-business responsibility, good hygiene practice and HACCP-based procedures. EUR-Lex consolidated version of 24 March 2021: <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:02004R0852-20210324>

International hygiene foundation: FAO/WHO Codex Alimentarius, General Principles of Food Hygiene, CXC 1-1969, 2022 edition / 2023 publication; check the current version with the publisher.

Hygienic design: EHEDG Guideline 50, Hygienic Design Requirements for CIP Installations, first edition 2019. Check the latest revision with EHEDG before use.

Check that the hygiene goal and acceptance criteria are explicit; time, temperature, chemistry and mechanics are evaluated together; media and time costs are visible by step; sensor positions and limits are plausible; cleanability and hydraulics are assessed; changes are tested against hypotheses; validation, monitoring and verification are kept distinct; reuse has defined purpose and rejection limits; and deviation and renewed release are governed.

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