Food Protection Services

dairy processing plants

Guidelines For the Cleaning of Dairy Plant Processing Equipment

BC Centre for Disease Control
AN AGENCY OF THE PROVINCIAL HEALTH SERVICES AUTHORITY

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PART I

INTRODUCTION

The safety and wholesomeness of dairy products is highly dependent upon the effective control of unwanted micro-organisms in the dairy plants. Pasteurization destroys disease-causing bacteria and significantly reduces the numbers of spoilage organisms. Cultured products are made through the controlled growth of desired bacteria in uncontaminated milk.

A critical step in the production of a safe and wholesome product is the effective cleaning and sanitation of equipment and the surrounding environment. Ineffective sanitation will, at the very least, cause premature spoilage; and at its worst, cause death (Mexican-style cheese, 1985).

Improper use of cleaning and sanitizing chemicals can as well be dangerous, expensive and ineffective. The purpose of this publication is to outline basic sanitation practices and concerns. It is strongly recommended that this guideline be used in conjunction with the services of a sanitation specialist.

All chemicals used on food contact surfaces should be approved. To this end, the dairy plant licencee should request confirmation from the supplier that each cleaning chemical is suitable for use in dairy processing plants. Where documentation is not available, the dairy plant licencee may contact Health Canada, for further guidance.

PART II

GENERAL PRINCIPLES OF CLEANING AND SANITIZING

CLEANING STEPS

Manual and automatic cleaning systems appear to be straightforward and foolproof. However, improper cleaning and sanitizing protocols have resulted in high costs, product spoilage, equipment damage and hospitalization of personnel. Great care must be taken in the initial program design to ensure that all equipment is safely and effectively cleaned.

All good cleaning protocols involve at least four steps: pre-rinse, wash, post rinse and sanitizing. Removing any of these steps will inevitably increase the cost of cleaning, and more importantly result in the ineffective cleaning of equipment. Table 1 outlines the purpose of each cleaning step.

Table 1 - Cleaning Steps

STEP	PURPOSE	CIP TEMPERATURE
Pre-rinse:	Remove visible soil. Melt butterfat. Prevent protein adherence. Prevent thermal shock.	36°C
Wash:	Remove remaining soil. Chemicals lift biofilms that bind to equipment surfaces.	55°C - 66°C
Post-rinse:	Removes suspended soils and chemical residues. Prepares surface for sanitizing.	36°C
Sanitizing:	Kills bacteria that remain on equipment surface. Must contact surfaces for at least one minute.	5°C - 25°C

FACTORS AFFECTING CLEANING

Many variables work together to provide an effective cleaning program. The following seven variables are most commonly considered when developing a cleaning regime.

I. SOLUTION TEMPERATURE

Table 2 - Effect of Solution Temperature on Cleaning

Minimum temperature	Melt and suspend butterfat. Ensure minimum chemical activity. Temper tanks to prevent thermal shock.
Maximum temperature	Some chemicals are ineffective at high temperatures. Chemicals may be much more corrosive (chlorine). Equipment may not be able to withstand high temperature stress.
Final temperature	Should cool equipment.

II. DURATION OF APPLICATION

- all treatments must have a minimum contact time
- maximum contact times apply to highly corrosive chemicals

III. MECHANICAL ACTION

- equipment surfaces must be adequately scrubbed by mechanical action
- effective CIP cleaning require minimum flow rates

IV. CHEMICAL CONCENTRATION

- the correct type and concentration of chemical must be used. Improper use can be:
    - ineffective
    - harmful to equipment
    - dangerous to personnel

V. SOIL SOLUBILITY

- specific soils are resistant to certain chemicals
- select chemical to dissolve soil typical of your operation
- see Table 3

VI. WATER HARDNESS

- interferes with cleaners and sanitizers
- equipment subject to staining and film build-up
- controlled by additives

VII. OTHER WATER IMPURITIES

- can cause difficult stains, films or corrosion
- controlled by additives
- see Table 4

SOIL CHARACTERISTICS

Table 3 - Soil Characteristics

SOIL COMPONENT IN MILK	HOW TO REMOVE	EFFECT OF HEATING
Lactose	Water	More difficult to clean
Fat	Surface active solutions	More difficult to clean
Protein	Alkaline solutions	Difficult to clean
Mineral salts	Acid solutions	Difficult to clean

Table 4 - Water Impurities

IMPURITY	MAXIMUM CONCENTRATION	CONCERN
Total Dissolved Solids	500 ppm	Filming
Iron	0.3 ppm	Staining
Chloride	250 ppm	Corrosion
Manganese	0.2 ppm	Corrosion
Silica	10 ppm	Filming
Copper	3 ppm	Filming/Staining
Sulfate	250 ppm	Filming

CLEANERS

Chemical cleaners are used to penetrate and lift bio-films from equipment surfaces. Modern detergents are a complicated blend of compounds as no single chemical possesses all desired detergent properties.

The most commonly used chemical cleaners can be classified as:

- alkali detergents
- acid detergents

Key operational information for each class is listed in Table 5. Safety concerns outlined in Table 6 should be discussed with your chemical supplier or a sanitation specialist as these chemical cleaners, when improperly used, have damaged equipment and hospitalized staff.

Table 5 - Cleaner Overview

	ALKALI	ACID
Examples	Sodium Hydroxide Sodium Carbonate Sodium Metasilicate Trisodium Phosphate	Nitric Acid Phosphoric Acid
Effective on	Organic deposits • fat • protein	Inorganic deposits • milkstone • rust • waterscale • shining stainless
Cautions	May corrode • aluminium • tin • zinc May erupt if blended with acid or water. Can cause severe burns. May cause scale or films on equipment if not properly formulated.	May corrode • chrome • nickel • galvanized surfaces May erupt if blended with alkali or water. Can cause severe burns. Produces a highly toxic and corrosive gas when blended with chlorine or chlorinated cleaner.
Normal use level	0.1 - 2.0%	0.1- 2.0%

Table 6 - Cleaner Safety

DO'S	DON'TS
DISCUSS chemical suitability and safety with a sanitation specialist. ADD chemicals to water. WEAR protective clothing. WEAR protective eyewear. PROVIDE sufficient eyewash and shower stations near chemical use areas.	NEVER blend with unknown chemicals. NEVER blend acid with caustic. NEVER blend acid with chlorine. NEVER add water to chemical.

SANITIZERS

Sanitizers are applied to equipment after the cleaning steps have been properly completed. Sanitizers are designed to kill all bacteria that remain on equipment surfaces. Residual soils interfere with sanitizer efficiency by protecting the bacteria. Chemical sanitizers, as normally used, are ineffective against bacterial spores and unreliable against mold spores.

Table 7 summarizes the advantages and disadvantages of the common chemical sanitizers. Note that chlorine, iodophors and acid anionics are effective only in narrow pH ranges.

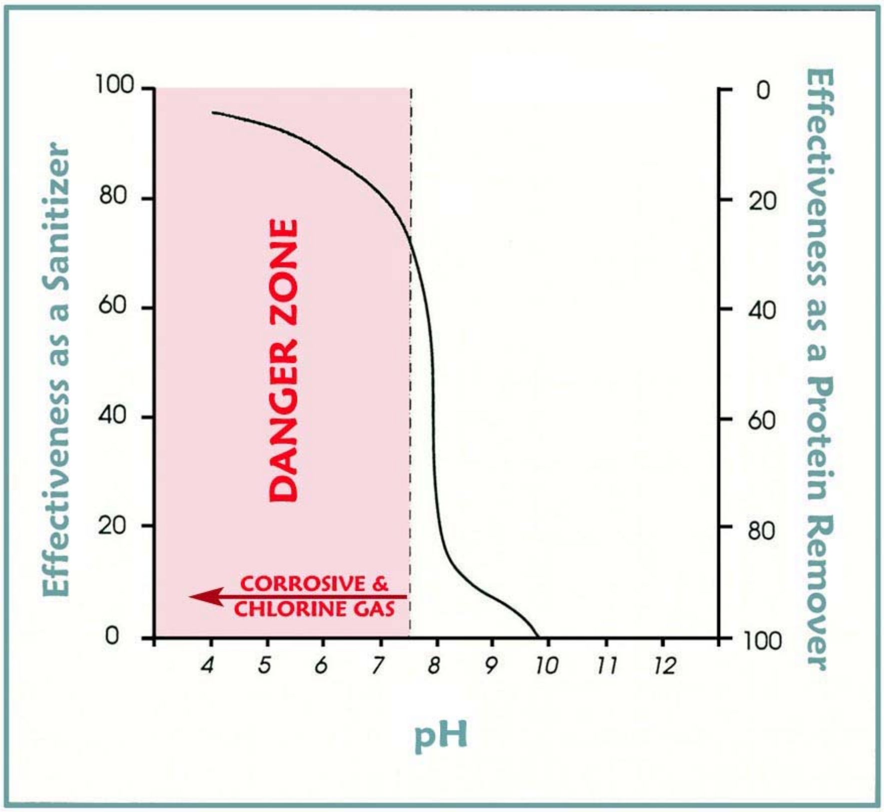
Table 7 - Advantages/Disadvantages of Sanitizers

	HEAT	CHLORINE	IODOPHORS	QUATS.	ACID ANIONICS
Effective against bacteria	Yes	Yes	Yes	Yes	Yes
Effective against bacteriophage	Yes	Yes	No	Yes	Yes
pH sensitive	No	Yes	Yes	Some	Yes
Forms foams	No	No	Yes	Yes	Yes
Corrosive	No	Yes	Yes	No	No
Stains	Yes	No	Some	No	No
Irritating	Yes	Yes	No	No	Some
Residuals	No	No	No	Yes	Some
USE LEVEL	80°C final	50-200 ppm	25 ppm	200 ppm	100 ppm
CONDITIONS	not always suitable	don't blend with acid pH 7.5 - 8.5	pH 3-3.5	don't use near cultured products	pH 3-3.5

CHLORINE

Chlorine is a commonly used yet complicated sanitizing product as indicated by Figure 1. Improper use of this product can be ineffective or cause severe damage to equipment, and injury to staff.

Figure 1 - Chlorine Effectiveness

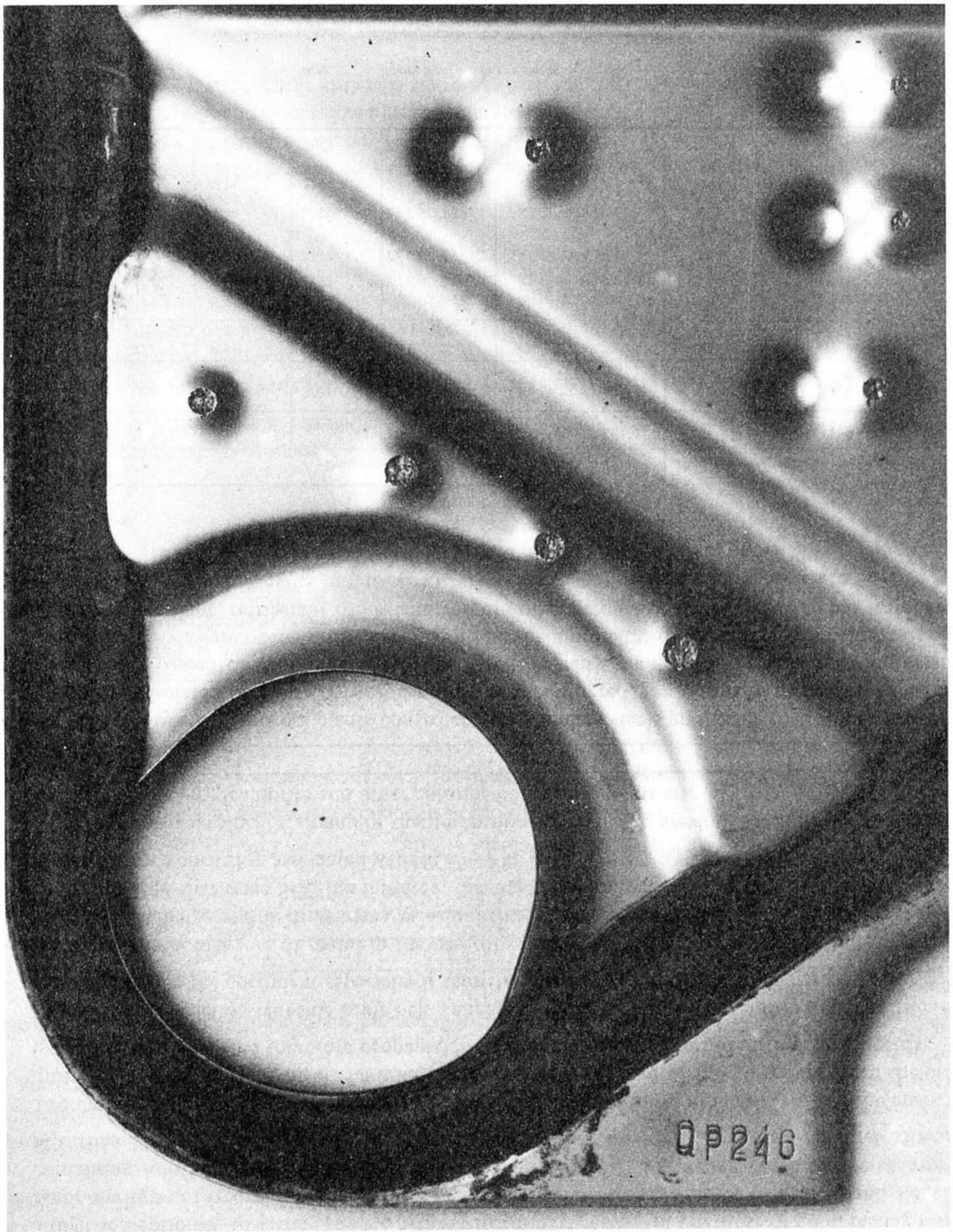


CHLORINE SAFETY

Table 8 - Chlorine Safety

DON'TS	REASON
DON'T use below pH 7.5	PRODUCES a highly toxic gas
DON'T sanitize above pH 8.5	INEFFECTIVE as a sanitizer
DON'T blend with unknown chemicals	PRODUCES a highly toxic gas
DON'T leave in contact with equipment	CORROSION
DON'T use hot	CORROSION
DON'T blend with acid	PRODUCES a highly toxic gas
DON'T blend with ammonia	PRODUCES a highly toxic gas

Figure 2 - Chlorine Corrosion in an HTST



SOIL IDENTIFICATION

Films can be identified by visual examination or by simple chemical tests. Table 9 outlines visual characteristics of films, their cause and means of removal. If after a visual examination you are unable to decide whether acid or chlorinated alkali detergents should be used to remove a film, try washing a small area with each. Use the most successful chemical to wash the equipment. Note that not all alkali or acid detergents are the same and specialized detergents may be necessary to remove difficult films.

Table 9 - Soil Identification

DESCRIPTION	SOIL	CAUSE	REMOVAL
Blue/rainbow hue	protein	1. Using non-chlorinated cleaner 2. Inadequate pre-rinse	1. Chlorinated alkali 2. Strong acid
White or yellow deposits	milkstone	1. Mineral from milk 2. Mineral from water	1. Chlorinated alkali 2. Strong acid
Greasy appearance	fat	1. Low temperature or improper detergent concentration 2. Regular use of acid wash	1. Alkali
White, grey, chalky deposits	mineral	1. Improper rinse 2. Minerals from water 3. No acid rinse 4. Incompatible alkali 5. Failure to use acid detergents	1. Acid
Red to brown/black deposits	iron	1. Water supply	1. Strong acid

PART III

CLEAN IN PLACE
(CIP)

CLEAN-IN-PLACE (CIP)

Clean-in-place (CIP) systems were developed to minimize cleaning time by removing the need to dismantle equipment. General principles outlined earlier in this document also apply to CIP systems. Solution temperature, duration of application, flow-rate, chemical concentrations, and valving actions are key variables in a CIP system.

Cleaning problems may result as follows:

I. SOLUTION TEMPERATURE

PROBLEM: **Returning solution is too cold.**

CAUSE:
- Cold water being added to a CIP unit that is too small for its application.
- Insufficient steam supply.
- Thermostat failure.

PROBLEM: **CIP solution too hot.**

CAUSE:
- Steam valve or thermostat malfunction.

Solution temperatures should be randomly checked as it returns to the CIP reservoir.

II. CHEMICAL CONCENTRATION

PROBLEM: **Chemical concentration too low.**

CAUSE:
- Solution being diluted with 'make-up' water in an undersized system.
- Chemical pump cannot replenish levels rapidly enough.
- Concentration sensors malfunctioning.
- Soil in water interfering with the concentration sensors.

Chemical concentrations should be tested periodically throughout the cleaning shift using test kits supplied by your chemical supplier.

III. DURATION OF APPLICATION

The time periods for each cleaning step are determined and set on installation. However, operators may be able to advance the cycles to reduce cleaning time. CIP programs should be designed to preclude alterations by the operators.

IV. VALVING ACTIONS

CIP programs cause specific valves to activate, thereby altering the flow of cleaning solution through the milk line system. Errors in programming, valves in poor repair, missing air lines, and stuck valves cause specific areas of a cleaning circuit to remain dirty. Lines found to be dirty following CIP require immediate investigation, correction, re-washing and sanitizing prior to running product.

FLOWRATES

Turbulent flow conditions provide the mechanical action by which equipment is scrubbed during CIP. Turbulent flow is created by maintaining high flowrates in the cleaning system. Basic rules of thumb for critical flow rates are as follows:

Pipes: Maintain a minimum flow rate of five feet per second.
Calculate the flow rate using the largest diameter pipe in the system.
Do not split the system into parallel circuits.

Table 10 provides the necessary information to ensure that this flow rate is achieved. The system will have sufficient flowrate if the time to deliver 10 imperial gallons of water is less than that stated for the pipe diameter,

Table 10 - Pipe Flowrates

Pipe Size (inches)	Velocity (feet/second)	Flowrate (Imp. gal/min.)	Maximum time (to deliver 10 Imp.gal)
1.5	5	20.0	20.0 seconds
2.0	5	35.8	16.8 seconds
2.5	5	57.5	10.8 seconds
3.0	5	84.1	7.2 seconds
4.0	5	149.9	4.2 seconds

HTSTs: Maintain a minimum flowrate of 1.25 - 1.5 times the maximum product flowrate.

Tanks: Flow coverage values, rather than flow rates are used when designing a CIP system for a product tank. Table 11 indicates recommended flow coverage values for horizontal and vertical tanks.

Table 11 - Flow Coverage Values

TANK DESIGN	FLOW COVERAGE
Horizontal	0.08 - 0.24 Imp. gal./min square foot of internal surface
Vertical	2.1 - 2.9 Imp. gal./min foot of circumference

Cleaning solution is carried to the tank in a pipe and distributed over the equipment using spray balls. As indicated in Table 12, sprayballs are designed to operate under specific coverage, fiowrate and pressure conditions. Large horizontal tanks may contain several sprayballs that satisfy the needs of specific areas within the tank. Poor maintenance or tampering with the sprayball or delivery system design may significantly influence the effectiveness of the cleaning program. Also tanks must be properly vented to prevent damage.

Figure 3 - Improperly Vented Tank

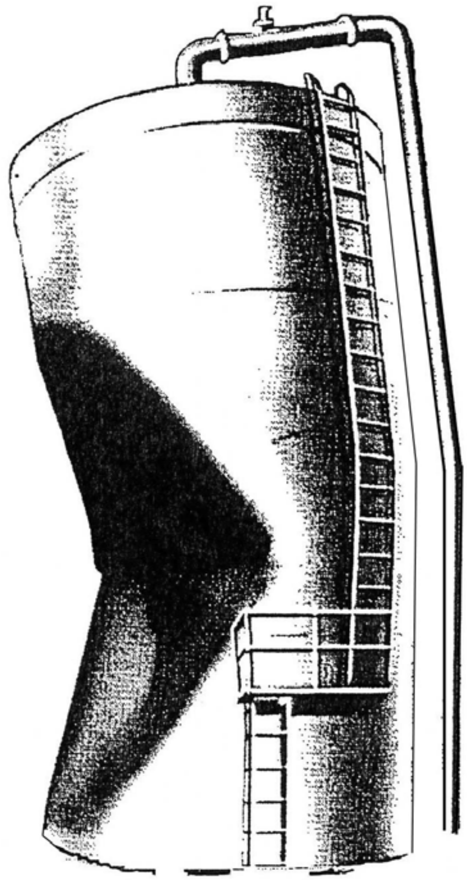


Table 12 - Sprayball Criteria

SPRAYBALL TYPE	MAXIMUM COVERAGE (feet)	FLOWRATE (Imp gal/min)	PRESSURE (psi)
SB - 1 Tee Spray	16	66.6	25
SB - 2 4" Ball	12	66.6	25
SB - 5 4" Ball	8	33.3	25
SB - 8 Road Tanker Drop in	40	87.4	55
SD - 6 Silo/Spray Disc	12	74.9	20

Care must be taken in all CIP systems to ensure that all connections are properly cleaned. Line connections should be loosened during the CIP process to allow for cleaning around the gasket. Also, these connections should be checked regularly to verify the effectiveness of the cleaning program.

DESIGN

Guidelines for permanently installed clean-in-place (CIP) systems can be found in *3A Sanitary Standards, 605-03*. To prevent product contamination, all connections between a cleaning solution circuit and product must:

a) have a complete physical separation or

b) be separated by at least two automatic valves with a drain-able opening to atmosphere between the valves. The opening should be equal to the area of the largest pipeline opening.

Further, no cross connection between the potable water supply and any source of pollution (milk or chemical) is permitted unless protected by an air gap or effective backflow preventer.

Dead-ends, parallel cleaning circuits and variable pipe diameters should be avoided. Dead-ends create sections of pipe that are difficult to clean. Parallel cleaning circuits and variable pipe diameter may reduce solution flowrates below 5 feet per second.

CLEANING SEQUENCE

The following time sequences for CIP cleaning are provided as a general guideline for a CIP program. However, these times and temperatures may vary radically depending on the CIP design, length of pipe, type of equipment to be washed, and the detergent effectiveness. These parameters must be tailored to the needs of each plant in consultation with a sanitation specialist.

Table 13 - Pipeline Cleaning Sequence

SEQUENCE	TIME (MIN)	TEMPERATURE (°C)
Rinse	4	40
Wash	10	65
Rinse	6	40

Table 14 - Tank Cleaning Sequence

SEQUENCE	TIME (MIN)	TEMPERATURE (°C)
Rinse	5	40
Alkali	10	65
Rinse	7	40

Table 15 - HTST Cleaning Sequence

SEQUENCE	TIME (MIN)	TEMPERATURE (°C)
Pre-rinse	5	60°C
Alkali	20	75°C
Rinse	5	75°C
Acid	15	75°C
Rinse	10	Cold Water

PART IV

SUMMARY

Plant sanitation plays a critical role in the production of safe and wholesome products. Many factors, ranging from cleaner effectiveness to the protection of staff and equipment must be considered before a sanitation program is implemented. As such, individuals trained and experienced in dairy sanitation must be involved in the design and installation of your cleaning program. Further, an effective monitoring program, including visual and microbial verification of the cleaning effectiveness, must be implemented to ensure the consistent production of a safe and wholesome product.