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EFFECTIVE CLEANING AND SANITIZATION OF DAIRY PLANTS: 1. DETERGENTS AND SANITIZERS

This bulletin includes technical and latest development on products, systems, techniques etc. reported in journals, companies' leaflets and books and based on studies and experience. The technical information on different issues is on different areas of plant operation. It is hoped that the information contained herein will be useful to readers.

The theme of information in this issue is **Effective Cleaning and Sanitization of Dairy Plants: 1. Detergents and Sanitizers**. It may be understood that the information given here is by no means complete.

In this issue:

- ***Introduction***
- ***Cleaning Requirements***
- ***Required Properties of Cleaning Compounds***
- ***Detergents***
- ***Sanitizers***
- ***Cleaning Efficiency***

1. INTRODUCTION

It is a precondition for the production of hygienically good and high quality dairy products that processing plants are effectively cleaned and sanitized. Inadequate hygiene can have very serious consequences because milk solids are a perfect nutrient substrate in which bacteria multiply very rapidly. If milk or its product comes in contact with surfaces inadequately cleaned, then it may get contaminated with micro-organisms resulting in poor quality and unsafe product. All equipment, their parts, fittings etc. must be cleaned immediately after the end of production. At the start of the next production the plant must be clean and free from pathogenic organisms.

It is, therefore, necessary that plant management reviews its plant cleaning system and makes required modifications in it to make it effective. In a series of issues Technews would provide a practical guide on dairy detergents and sanitizers and dairy plant cleaning systems alongwith practical tips. This issue presents important, useful details on dairy detergents and sanitizers.

2. CLEANING REQUIREMENTS

In the dairy plant, deposit / soil consists primarily of constituents of minerals, lipids, lactose and proteins. Other soil constituents may be dust, lubricants, microorganisms, cleaning compounds and sanitizers.

Lactose is water soluble and hence easily removable. More difficult when caramelized.

Protein is water insoluble, slightly acid soluble and alkali-soluble. Very difficult to remove. Denatured proteins are extremely difficult to remove.

Fat is water insoluble but can be removed with hot water containing surface-active agents. Is alkali-soluble. Difficult to remove. Polymerized fat is more difficult to remove.

Mineral salts are water soluble and acid soluble, and hence are more or less easily removed with water depending on their composition, but rather easily with acid solution. Dried deposits and those interacted with other constituents more difficult to remove.

Deposits on plant surfaces could be loose, cold milk deposits; dried milk solids; milkstones or waterstones. Each has different cleaning procedure.

Milk solid deposits and waterstones usually accumulate slowly on unheated surfaces because of poor cleaning or use of hard water, or both. Calcium and magnesium salts precipitate when sodium carbonates are added to hard water. During cleaning some of this precipitate may adhere to surface, forming a film of waterstone.

Milkstones are milk solids deposits formed due to high temperature used for the heat treatment of milk[(1)]. Serum proteins denatured by heat deposit to surfaces and are saturated with calcium phosphates and calcium citrate that are formed in large quantities at high temperatures and are insoluble. Milkstones harbour microbial contaminants and defy sanitizing methods. Milkstone occurs in large amounts in heat exchanges.

Deposit formation on plant surfaces can be reduced and subsequent removal eased by application of following principles[(1,2,3)]:

- Heating should be done at the minimum required temperature for the minimum time with the minimum possible temperature difference across the heating surface.
- Milk with low acidity forms less deposits.
- Low velocity movement of product and poor agitation during the operation result in higher deposits.

- Where practical, product heating surfaces should be cooled immediately after emptying vat or equipment.
- Where possible, the deposits should be kept moist until the cleaning operation starts.
- Foams and other products should be rinsed after the production before they dry.
- Rinsing should be done with soft, warm, say about 45°C, water, and not hot water.
- In Ultra High Temperature (UHT) plant, preheating milk, say at 65°C - 90°C, and deaeration reduce deposit formation.

3. REQUIRED PROPERTIES OF CLEANING COMPOUNDS

- The cleaning compound should be able to wet the surface and penetrate the deposit.
- It should be able to dislodge the milk solids from equipment surfaces: saponify fat (produce soluble soap), peptize (dissolve) protein, dissolve lactose, and dissolve minerals.
- It should have ability to break up the deposits into small particles and keep them dispersed so that they are not re-deposited.
- Should have the ability to hold calcium salts in solution so that no scale deposits are left after cleaning.
- Should be soluble in water.
- In circulation cleaning, it should be of low-foaming type.
- Should have high bactericidal effect.
- It should be non-corrosive to equipment.
- It should be economical.

No single detergent possesses all the above properties. Therefore, a suitable mixture of different detergents is used in cleaning dairy equipment.

4. DETERGENTS

The detergents that are required to be used in dairy plant cleaning are alkaline detergents and acid detergents. Table 1 gives comparative properties of some important detergents[2].

Alkaline Detergents[1,2,4]

Strong cleaners, such as sodium hydroxide (caustic soda), which is commonly used, have protein dissolution, defloccution / emulsifying and germicidal properties. Caustic soda is used in removing heavy organic soils, and is cheap. These cleaners are corrosive.

These are not effective for removing mineral deposits. These are damaging to human skin, hence are not used as manual cleaners. Other strong alkalis are sodium silicate and sodium sesquisilicate.

Heavy-duty cleaners have moderate dissolving power and are generally slightly corrosive or non-corrosive.

Examples are sodium metasilicate, sodium carbonate (both good buffering agents), sodium hexametaphosphate, sodium pyrophosphate and trisodium phosphaste (has good soil-emulsification activity). The addition of sulfites tends to reduce the corrosion attack on tin and tinned metals. These are often used with high-pressure or other mechanized systems. These are excellent for removing fats but cannot remove mineral deposits. Sodium carbonate is relatively cheap and is used in heavy-duty and manual cleaning.

Mild cleaners are used for manual cleaning of lightly soiled surfaces. Examples are sodium bicarbonate, sodium sesquicarbonate, tetrasodium pyrophosphate, sequesters and surfactants. These have poor emulsifying property and cannot control mineral deposits. They however have good water-softening property.

Table 1 : Comparative properties of common detergents

Detergent	Emulsi-fication	Saponi-fication	Wetting	Dispe-rsion	Suspen-sion	Water softening	Mineral Deposit Control	Rins-ability	Non-corrosive	Non-irritating
Basic alkalis										
Sodium hydroxide (caustic soda)	L	H	L	L	L	L	N	N	N	N
Sodium metasilicate	M	M	L	M	L	L	L	M	M	N
Sodium carbonate (soda ash)	L	M	L	L	L	L	N	L	L	N
Trisodium phosphate	M	M	L	M	M	H	N	M	L	L
Complex Phosphates										
Sodium tetraphosphate	H	L	L	H	H	M	M	H	VH	H
Sodium tripolyphosphate	H	L	L	H	H	H	M	H	VH	M
Sodium hexametaphosphate	H	L	L	H	H	M	M	H	VH	H
Tetrasodium pyrophosphate	M	M	L	M	M	H	M	H	VH	M
Organic compounds										
Chelating agents	L	L	L	L	L	VH	H	H	VH	H
Wetting agents	VH	L	VH	H	M	L	L	VH	H	H
Organic agents	L	L	L	L	L	H	VH	M	H	H
Mineral acids	L	L	L	L	L	H	VH	L	N	N

Note : VH = Very high value, H = high, M = medium, L = low, N = negative

Polyphosphates are effective emulsifying and dispersing agents, as well as soften the water. The most commonly used ones are sodium triphosphate, sodium tetraphosphate, sodium hexametaphosphate (Calgon) and tetrasodium pyrophosphate. Polyphosphates are a desirable additive in most alkaline detergent solutions. However, phosphates act as nutrients in water courses.

Sequestrants or chelating agents prevent precipitated calcium or magnesium salts from forming insoluble compounds in the detergent solution. They are stable at high temperatures also and can be used together with quaternary ammonium bases. Polyphosphates are suitable sequestrants for weak alkaline solution such as manual detergents. However, organic chelating agents are more effective than phosphates in sequestering calcium and magnesium irons and in minimizing scale build-up. Most widely used are ethylene-diamine-tetra-acetic acid (EDTA) and nitrilo-tri-acetic acid (NTA). Other chemicals like gluconic acid and citric acid are also used.

Surfactants (surface-active or wetting) agents facilitate the transport of cleaning and sanitizing compounds over the surface to be cleaned. Their major function, therefore, is wetting and penetrating. They however also have other desirable characteristics. Surfactants could be:

- cationic (+vely charged) such as quaternary ammonium compounds (Quats) which are poor wetting agents and detergents but excellent bactericidal;
- anionic (-vely charged) such as alkyl sulphates and alkyl aryl sulphates (Teepol) which are excellent detergents with very effective wetting property, poor bactericides, inexpensive and usually highly foaming;
- noniomic surfactants are excellent detergents with very effective wetting property but have no bactericidal property; and
- amphoteric (cationic in acid solution and anionic in alkaline solution) agents are effective disinfectants.

Following are some useful tips in using detergents for cleaning dairy equipment:

- In making detergent solution, add the detergent to the water, not the other way around.
- Cationic and anionic surfactants should never be mixed together as the product would have no surfactant property.

Cleaning compounds used in cleaning dairy plants generally are complex mixtures of chemicals combined to achieve a specific desired purpose. Such a detergent always contain alkali (usually sodium hydroxide) polyphosphates, surfactants and sequesters of some kind. These are either blended carefully in the plant by experienced and well-trained personnel, or formulated cleaners are commercially available.

Acid Detergents[1,2,4]

Acid cleaners are used for removing encrusted deposits (milkstones) formed due to elevated temperature treatments, and dissolving mineral deposits and carbonate scales, as these are not removed by alkali solutions. An acid wash may be preceded or followed by an alkaline cleaning step. Acids are not as effective for removing fats and proteins as are alkalis.

Most widely used in dairy cleaning are two inorganic acids: nitric acid (HNO_3) and phosphoric acid (H_3PO_4). The former is more effective but the latter is less corrosive – at normally used concentration of 0.5-1.5%, it does not damage acid-proof stainless steel. Acid cleaning materials based on hydrochloric acid, hydrofluric acid or sulphuric acid must not be used.

5. SANITIZERS

After cleaning, sanitizers (or disinfectants) should be applied to the

cleaned surface to destroy microorganisms. In dairy plants, most commonly used sanitization methods are thermal (hot water, stream) or chemical agents. Table 2 provides the characteristics of commonly used santitizers[2]:

Table 2 : Characteristics of commonly used sanitizers

Characteristics	Steam	Iodophors	Chlorine	Acid	Quats
Germicidal efficiency	Good	Vegetative cells	Good	Good	Somewhat selective
Yeast destruction	Good	Good	Good	Good	Good
Mold destruction	Good	Good	Good	Good	Good
Toxicity					
Use dilution	-	Depends on wetting agent	None	Depends on wetting agent	Moderate
Self strength	-	Yes	Yes	Yes	Yes
Stability					
Stock	-	Varies with temperature	Low	Excellent	Excellent
Use	-	Varies with temperature	Varies with temperature	Excellent	Excellent
Speed	Fast	Fast	Fast	Fast	Fast
Penetration	Poor	Good	Poor	Good	Excellent
Film forming	No	None to sight	None	None	Yes
Affected by organic matter	None	Moderate	High	Low	Low
Affected by other water constituents	No	High pH	Low pH and iron	High pH	Yes
Ease of use	Poor	Excellent	Excellent	High foam	High foam
Cost	High	Moderate	Low	Moderate	Moderate

In **hot water** sanitizing, hot water at 80ºC-85ºC at the outlet is circulated through the assembled equipment for 15 minutes. This process is however expensive. This process kills vegetative bacteria, yeasts and moulds[1].

Steam sterilization is more effective than hot water sanitizing. Steam at 120-130ºC is used on the equipment surfaces. After the condensate leaving has reached 80-85ºC, steaming should continue

for about 15 minutes[1,2].

Chemical sanitizers used in dairy plants usually are chlorine compounds, iodine compounds or quaternary ammonium compounds. Most widely used chlorine compounds are hypochlorites, usually calcium and sodium hypochlorite, which are not active, too. They are used in water at a concentration of 50-250 ppm of available chlorine at temperature upto 50ºC, as above this its solubility decreases rapidly[2]. The hypochlorites may also be added to cleaning compound solutions to provide a combination cleaner-santizer. Chlorine sanitizers are effective against gram-positive and gram-negative bacteria and conditionally against certain viruses and spores.

The contact time should be around 15 minutes. For aluminimum, the available chlorine concentration should be less than 200 ppm.

Among chloramines, sodium dichloroisocyanurate is more active than sodium hypochlorite against *E. coli, S. aureus* and other bacteria. Other chloramines are less effective than hypochorites.

Iodophores (iodine complexed with surfactants) have greater bactericidal activity under acidic conditions (around pH 3). They will prevent accumulation of minerals, if used regularly.

Quaternary ammonium compounds (QAC or Quats) are less corrosive than hypochlorits and are most suitable for longer contact times and higher temperatures. For complete bacterial action, concentrations of quats of 150-250 ppm at temperatures greater than 40ºC and contact times of not less than 2 minutes are required. Hard water reduces the activity. It leaves a film on the surface unless rinsed with enough water. Quats do not destroy spores. These are more effective against gram-positive bacteria (staphylococci, streptococci) than gram-negative ones (coliform, psychrotrophs).

Table 3 gives common application of these sanitizers[2].

Table 3 : Chemical sanitizer applications

Sanitizer	Application
Chlorine	All food contact surfaces, spray, CIP, fogging
Iodine	All food contact surfaces, approach as a hand dip
Peracetic acid	All food contact surfaces, CIP, especially cold temperature and carbon dioxide environments
Acid anionics	All food contact surfaces, spray, combines sanitizing and acid rinse into one operation
Quaternary ammonium compounds	All food contact surfaces, mostly used for environment control; walls, drains, tiles

6. CLEANING EFFICIENCEY

The cleaning efficiency depends on 5, WATCH (water quality, agitation, time of cleaning, concentration and type of detergent and heat or temperature of the detergent solution), parameters[1,3,5].

Water should be soft. Hard water hinders the action of the detergents, and may also leave behind a residue of minerals. Use of sequestrants in detergent formulation overcomes the effects of hard water.

Agitation of the detergent solution should be vigorous providing scouring effect. Detergent flow velocity should be more than 1.5 m/sec to provide turbulent flow.

Time of detergent solution contact with the soiled surface should be adequate. It would depend on the nature of deposit, detergent solution concentration and temperature. Too long time, however, might corrode the surface.

Concentration of detergent solution depends on the nature of soil and the type of detergent used. Concentration should be optimum; too high concentration in fact might actually hinder the cleaning, besides being expensive. It might also damage the cleaning surfaces. An optimum concentration of 0.5% NaOH has been suggested.

Heat or temperature of detergent solution greatly affects its cleaning efficiency: higher the temperature, higher the efficiency. Generally, every 10ºC increase in solution temperature increases its activity two-fold. Thus, compared with the cleaning efficiency of a detergent solution at 30ºC, its efficiency at 70ºC would be 16-fold (2x2x2x2). Optimum temperature lies around 70ºC.

Suitable cleaning and sanitization systems for different dairy equipment would be detailed in the next issue of Technews.

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