Milkstone—It Can Be Controlled

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Milkstone is a complex heterogeneous mixture of organic and inorganic substances which adhere tenaciously to milk heating surfaces. It is a substance closely related to boiler scale in steam generators, the relationship being that both are the result of heat treatment. The hard-water minerals cause boiler scale in a manner similar to the formation of milkstone by the mineral salts of milk.

Temperature a Factor in Formation of Milkstone

The amount of milkstone formed in a piece of milk-heating equipment, as well as its composition, bears a direct relationship to temperature. It has been shown by chemical analysis that the milkstone formed at low temperatures (vat pasteurization) is largely composed of adhesive fat and protein material. However, at higher temperatures (short-time, high-temperature pasteurization, 161° F. and higher) large amounts of ash materials, especially calcium and phosphorus, are precipitated. It has been further shown that milkstone formation is greatest at the temperatures that are favorable to the coagulation of albumin. X-ray studies have confirmed the composition of milkstone films.

There is some confusion about the terms milkstone and burn-on. Burn-on is the material "cooked" onto the surface of milk-heating tubes, plates, or jackets, and it consists largely of the solids found in milk. Alkaline detergents will easily remove the burn-on material from these surfaces. Milkstone, however, being largely composed of milk minerals from the ash portion of milk, is not readily removed by alkaline detergents alone but must be subjected to acid treatment for complete removal.

Many factors, in addition to temperature, influence milkstone formation. Among these are rate of heating, rate of flow of milk through equipment, type of product processed, amount of product processed, type and construction of equipment, kind of metal involved, and the surface area used for heating.

The formation of milkstone is the cause of one of the most important problems with which the milk plant operator must cope, namely, the cleaning of heating equipment. The use of HTST pasteurization equipment, as well as high-temperature preheaters and forewarmers, has greatly increased the milkstone problem because in these units large volumes of milk are heated to very high temperatures in relatively confined spaces.

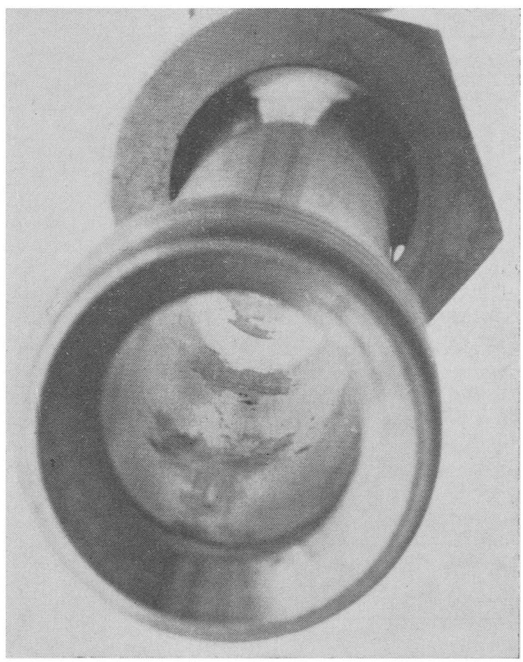

Fig. 1. Photograph of milkstone deposit in a sanitary milk line.

Figure 1 shows a deposit of milkstone in a sanitary milk line used to carry hot milk from a heater. Milkstone usually does not form in a line where there is no heating taking place; there may be a slight deposit, however, in such lines, which will gradually become heavier if the film is not removed every day. Equipment with a heavy layer of milkstone can be discovered by merely looking at the surface when it is dry, but light films may go undetected for a long time unless special examination is made. Ultra-violet light causes milkstone deposits to fluoresce in the dark, and special lamps are now available for detecting milkstone in pipes and vats and in other difficult and remote places.

The removal of milkstone is a must with the dairyman. It is the most common source of high thermoduric counts in pasteurized milk, since these organisms are afforded excellent protection when imbedded in the milkstone deposit. These bacteria can be the cause of poor keeping quality, off-flavors, and objectionable odors in dairy products.

Milkstone acts as an insulator in milk-heating equipment, and if not removed regularly it will reduce the rate of heat transfer and consequently the heating capacity of the equipment.

Prevention Methods

What can the dairy plant operator do to prevent the formation of milkstone in his milk product–heating equipment? It has been found that high velocity flow through small tubes will inhibit the formation of milkstone to a certain extent. However, even equipment which has the most favorable flow conditions will become inefficient in a few hours if cold milk is heated directly to temperatures at or above the boiling point of milk. By heating the milk in two stages, say, up to 190° or 200° F. in the first-stage preheater and then up to final temperature in a second-stage heater, the milkstone deposit can be greatly reduced. If the milk-heating equipment is designed so that there is a holding tube, surge tank, or hotwell inserted in the system between the two stages of heating, a large amount of the albumin precipitate can be eliminated from the high temperature tubes of the second-stage heater. Equipment employing these principles has been designed and operated with final temperatures as high as 280° F.

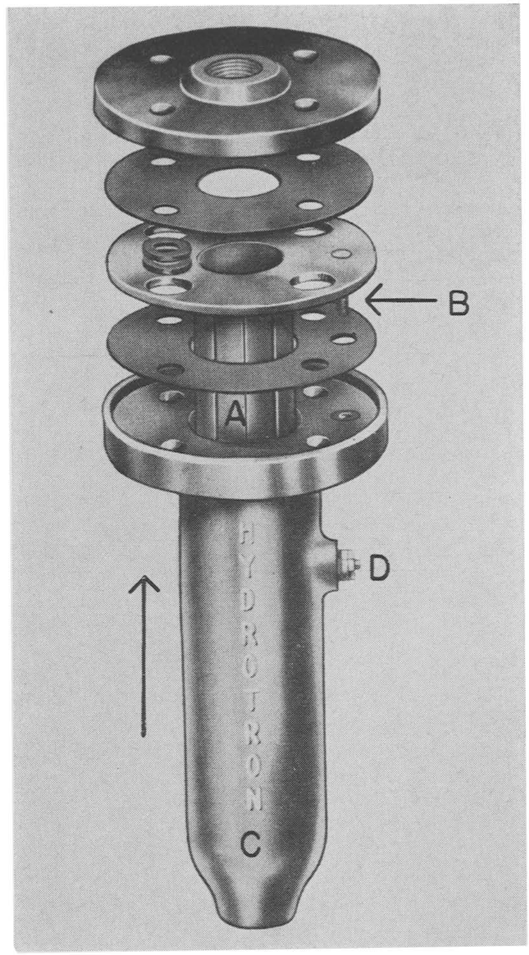

FIG. 2. An exploded view of the Hydrotron; A = inner tube, B = positive pole of circuit, C = housing of unit, D = negative pole of circuit.

TABLE 1
Results of commercial installation of the Hydrotron on milk precipitation in a short-time pasteurizer

Trial	No. of gal. treated	Milli-amperes	Cleaning time *(min.)* Acid	Alkali	After circulation[a]
1a	2,970	Control	25	25	Plates clean
1b	3,970	1.0	10	20	Plates clean
2a	2,940	Control	10 + 17	20	After 10 min. of acid, precipitate still very hard and held to plates; 17 min. more of acid circulation needed
2b	3,450	1.0	10	15	Plates clean
3a	3,910	Control	10	10	Plates of regenerative section clean; heater section had gritty material in large amounts; brushing necessary
3b	4,000	1.0	10	10	Plates clean

[a] Before circulation, milkstone precipitate to 18th hot plate of regenerator, protein-like (sticky); all heater plates were gritty with mineral precipitate.

A unit called the Hydrotron has been used experimentally on a commercial HTST milk pasteurizer. It is an instrument developed and patented by A. G. Freeborn, an English engineer. (See Figure 2.) It prevents boiler scale formation in all types of steam generators. The instrument uses a small electrical current to charge a conducting cell through which the water passes, and this treatment affects the crystalline structure of the minerals when they are precipitated.

This unit was placed in the raw milk line of the pasteurizer so that all the milk entering the pasteurizer would be treated with the small electric current provided between the electrodes of this device. Tests made with this experimental installation indicated that the use of small electric currents in milk has an effect upon the amount and character of the milkstone which is formed by high-temperature, short-time heating. The important factors involved were found to be the rapidity of heating, the final temperature attained, and the current application from the Hydrotron. The optimum setting of the Hydrotron for the prevention of milkstone formation was in the range of 1.0 to 2.0 milliamperes.

The data in Table 1 show that with the Hydrotron in operation, the normal acid and alkali circulation times required to clean the plates could be reduced by more than one-half and it was not necessary to brush the plates after circulation when the Hydrotron was used.

What effect the Hydrotron would have in heaters operated above the boiling point of milk is not known, but indications are that the milkstone film would be reduced, if not entirely prevented.

Removal of Milkstone

It is not possible to completely prevent the formation of milkstone in high-temperature milk-heating equipment despite the use of various procedures or types of heaters described above. It is important therefore to know how to remove the milkstone film from heating surfaces. Ordinary alkaline cleaning compounds are ineffective when used alone. It is necessary to employ special organic acids, as well as alkaline cleaners. For this type of cleaning a recirculating system must be arranged so that the acid solution and the alkaline solution can be forced through the heater for 20 to 45 minutes. With alternate cleaning, the acid is circulated first and drained out of the system, and then the alkali is circulated. Recently one of the manufacturers of cleaners has developed a system for circulation cleaning of heating equipment in which the alkali solution is added directly to the acid after the acid has circulated for a while. By this means the salts of the organic acids are produced, which have definite chelating or sequestering properties that are advantageous in hard-water areas. Sequestering the hard-water components prevents their precipitation as water films on equipment surfaces.

During the last 4 or 5 years the C.I.P. (cleaned-in-place) system of cleaning sanitary pipe lines has become a widely adopted and successful operation. Milkstone has not been a problem in pipelines cleaned in this manner since no heating takes place in them. Where only hard water is available for flushing and cleaning C.I.P. lines, waterstone deposits may be a problem. By using soft water or by using alkaline detergents containing sufficient sequestering ingredients, waterstone may be controlled; however, if waters with a hardness of 25 grains or more per gallon are used, an organic acid detergent may be required at least every second day.

By using well designed equipment and following the procedures for heating milk to high temperatures as outlined, the dairy product manufacturer should not have too much trouble with milkstone. By proper circulation-cleaning of equipment with the correct cleaning agents, a small amount of milkstone can be easily and efficiently removed.

The Selection and Use of Nonfat Dry Milk Solids in the Manufacture of Cottage Cheese

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The employment of dry nonfat solids in the manufacture of cottage cheese has increased steadily since World War II. This has been due chiefly to the following factors:

1. The scarcity of fluid skimmilk at certain times.
2. The introduction of low heat spray powder after the importance of the heat treatment was fully recognized.
3. The discovery that the cottage cheese making operation is improved and the yield per pound of solids is higher when the total solids of the milk for setting is increased.
4. The recognition that more cottage cheese may be produced per vat when standardization of the total solids is practiced.

Dry nonfat solids may be used to advantage to raise the total solids of liquid skimmilk and