Recirculation-spray cleaning of bulk raw milk holding tanks, and other dairy equipment that may be essentially enclosed during cleaning, has been accomplished with apparent satisfaction in many instances, as determined by visual observation of results. Harper and Seiberling (1), noting that uniform results were not obtained with portable sprays because of differences in tank size, found that permanently installed spray assemblies, tailored to provide adequate coverage, cleaned tanks more effectively by recirculation than by hand cleaning. Their results were determined through bacteriological evaluation, using swab counts on 40-sq. in. areas, as recommended by Standard Methods (2) for large surfaces.

This study was made in order to measure recirculation-spray and manual cleaning of a range of areas in tanks using a chlorinated detergent, typical of several commercially available products, in addition to periodic application of acid detergent. A newly designed "Teardrop" spray bulb was used.

**Procedure**

Three 2,000-gallon rectangular tanks were cleaned following storage of "grade A" raw milk. Milk was held in tanks approximately 24 hours before emptying and washing. Two of the tanks were equipped with a spray bulb located permanently at the top of the tanks and equi-distant from the corners. The bulbs were of special design to provide a spray of cleaning solution to all areas of the tank. The rinse and washing solutions were circulated by a 5-H.P. centrifugal pump, delivering 60 gpm at 40 psi.

The manual cleaning prescribed consisted of (a) rinsing with warm water until the effluent was clear; (b) scrubbing with a long-handled brush from a 3-gallon pailful of washing solution containing 2.25 oz. of the chlorinated detergent, equal to 0.5% concentration; (c) the tank was rinsed with tempered water for a full 3-minute period using a hand spray nozzle; and (d) after each fifth cleaning with the chlorinated detergent, an acid milkstone treatment was applied over the entire inner area.

Recirculation-spray cleaning consisted of (a) rinsing with 50 gallons of 80°F. water sprayed into the tanks in three equal intervals, allowing drainage between each. A second 50-gallon quantity of 80°F. water was sprayed at one time into the tanks and drained. (b) Recirculation washing used 25 gallons of 0.5% chlorinated detergent solution at 140° or 160°F., as indicated by Table 1. Washing was continuous over a 15-minute period. (c) Tanks were rinsed by the same procedure as pre-rinsing. (d) Acid solution for removing milkstone was applied after each fifth washing with the chlorinated detergent solution. A 25-gallon solution of 0.5% organic acid detergent was recirculated for 10 minutes at 140°F., followed by rinsing with clear water.

The level guage tube was connected with the cleaning system and was washed on the inside by recirculation at the same time the tank lining was cleaned by spraying.

The areas selected for examination by swab counts were distributed so as to determine cleaning effectiveness throughout the tanks (Figure 1). Standard Methods (2) procedures were used with 8-sq. in. areas being swabbed within one hour after washing and prior to sanitizing.

**Results**

The data are presented in Table 1. Thirteen manual washing trials yielded a logarithmic average swab count of 27 bacteria per area. The average number of organisms per area was fairly uniform, with 70% of the areas having average counts ranging from 13 to 14, inclusive. The average counts of 6 and 10 cleaning trials after recirculation washing at 140°F. were 6.3 and 7.0, respectively. When the temperature of the washing solution was increased to 160°F., the over-all cleaning effectiveness, as measured by swab counts, was improved as shown by 6 trials averaging 5.5 organisms per area and 4 trials averaging 4.5 organisms per area.

Determination of the cleanability of the spray unit bulb was of special interest. Results in Table 1 showed that the collar over the spray bulb, the area around the collar and of the roof close to the bulb yielded low swab counts, practically equal to those in other nearby sections. As a whole, the upper and side areas of the tanks cleaned by recirculation had the lowest swab counts. Slightly higher counts resulted from corner areas and air vent collars than from areas that were sprayed more directly by the cleaning solution.

Visual observation and bacteria counts of swabbed surface indicated that the floor of the tanks and the areas below the cleaning solution level were most dif-
TABLE 1. LOGARITHMIC AVERAGE NUMBER OF ORGANISMS PER EIGHT SQUARE INCHES FROM VARIOUS AREAS IN MILK STORAGE TANKS AFTER WASHING

<table>
<thead>
<tr>
<th>Area*</th>
<th>Number of trials</th>
<th>Manual 110°F.</th>
<th>Manual 140°F.</th>
<th>Recirculation 140°F.</th>
<th>Recirculation 160°F.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1 2 3</td>
<td>1 2</td>
<td>1 2 3</td>
<td>1 2 3</td>
</tr>
<tr>
<td>a</td>
<td></td>
<td>4.6 9.9</td>
<td>3.3 2.3</td>
<td>4.6 9.9</td>
<td>3.3 2.3</td>
</tr>
<tr>
<td>b</td>
<td></td>
<td>4.8 2.1</td>
<td>2.6 8.1</td>
<td>4.8 2.1</td>
<td>2.6 8.1</td>
</tr>
<tr>
<td>c</td>
<td></td>
<td>1.6 3.4</td>
<td>1.4 1.1</td>
<td>1.6 3.4</td>
<td>1.4 1.1</td>
</tr>
<tr>
<td>d</td>
<td></td>
<td>13 2.2</td>
<td>7.8 3.7</td>
<td>13 2.2</td>
<td>7.8 3.7</td>
</tr>
<tr>
<td>e</td>
<td></td>
<td>5 6.8</td>
<td>3.9 13.0</td>
<td>5 6.8</td>
<td>3.9 13.0</td>
</tr>
<tr>
<td>f</td>
<td></td>
<td>8 2.9</td>
<td>3.3 1.6</td>
<td>8 2.9</td>
<td>3.3 1.6</td>
</tr>
<tr>
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<td></td>
<td>164 2.6</td>
<td>3.7 7.8</td>
<td>164 2.6</td>
<td>3.7 7.8</td>
</tr>
<tr>
<td>h</td>
<td></td>
<td>14 7.2</td>
<td>8.1 4.9</td>
<td>14 7.2</td>
<td>8.1 4.9</td>
</tr>
<tr>
<td>i</td>
<td></td>
<td>13 3.8</td>
<td>5.6 7.4</td>
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<td>5.6 7.4</td>
</tr>
<tr>
<td>j</td>
<td></td>
<td>14 13.0</td>
<td>14.0 4.6</td>
<td>14 13.0</td>
<td>14.0 4.6</td>
</tr>
<tr>
<td>k</td>
<td></td>
<td>13 3.1</td>
<td>2.7 2.9</td>
<td>13 3.1</td>
<td>2.7 2.9</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>26 6.3</td>
<td>7.0 5.5</td>
<td>26 6.3</td>
<td>7.0 5.5</td>
</tr>
</tbody>
</table>

*Location of areas listed alphabetically in Figure 1
a = Collar over spray unit
b = Area just outside collar
c = Point of roof closet to spray bulb
d = Point of roof close to end of tank
e = Two corners ceiling area
f = Two sight glass sleeves
g = Air vent collar
h = King guage pipe below milk level
i = Back side of agitator blades
j = Floor of tank
k = Side of tank where best cleaning should be expected

All tanks that were cleaned yielded bacterial counts considerably lower than the Standard Methods (2) tolerance of 100 organisms per 8-sq. in. In the manually cleaned tanks 21% of the individually swabbed areas, had more than 100 colonies per swab; 4 swabs produced colonies too numerous to count. Only 4% of the recirculation washings showed counts in excess of 100 per swabbed area and none were too numerous to count.

Acid treatment was not planned originally but was included as part of the cleaning procedure after several washings, using the chlorinated detergent solution only, left a noticeable deposit on the stainless steel. The hardness of the water used, 320-360 ppm was believed responsible for mineral deposition. The acid treatment, used after each fifth washing with both manual and recirculation washing, kept the tanks free of visible film.

The recirculation cleaning operation required more water, steam, and washing powder; but the cleaning job, measured by swab count and visual inspection, was superior to manual cleaning.

DISCUSSION

Experience with cleaning operations and results secured showed that the areas most difficult to clean were the floor, the vents, and the bottom side of the agitator blades. The floor was believed to receive little physical cleaning action because there was no flow across its surface. The cleaning operator found that a series of short blasts with the pump, during rinsing, increased the washing effect. Also agitator blades should be in operation intermittently in order to clean all surfaces.

SUMMARY AND CONCLUSION

The study showed that recirculation cleaning of bulk milk holding tanks, using the specially designed "Teardrop" spray bulb, was more effective than manual washing. This conclusion was based on measurement of swab counts from thirteen similarly located areas in each of three tanks. A chlorinated detergent was used as the cleansing agent for both washing systems. After each five washings with chlorinated detergent solution, the tanks were washed with acid detergent.
Throughout the fluid milk industry, processors are currently studying the effect and the necessity for ultra high temperatures (UHT) in pasteurizing and the use of Flavor Control equipment with relation to their Grade A bottled milk market. Undoubtedly, the installation of machinery to accomplish either or both of the above by a competitor will result in any plant giving serious consideration to the purchase of similar equipment.

It, therefore, behooves milk sanitarians, laboratory technicians, pasteurizer operators, as well as dairy machinery suppliers to develop an understanding of UHT and flavor control equipment and what it will accomplish for the industry.

The two should be considered together, for as research and field experience have shown, optimum flavor control can not exist without steam treatment, and with steam treatment UHT is available.

To properly understand a process and the equipment used, it is necessary to know why it was developed in the first place. Necessity, being the mother of invention, has again played its part.

Beginning at the source, it is the job of the Grade A dairy farmer to produce, in as sanitary a manner as possible, milk that has good flavor and low bacteria count. It must be cooled and maintained cold until picked up for delivery to the plant.

Good flavor is the one factor over which the Grade A producer has only limited control. Naturally, it is dependent to a great degree on the cows diet. In the past, its control has been based on pasture selection and feeding schedule. This is most difficult, for the diffusion rates of the numerous feed and weed flavoring substances and their retention in milk vary so widely that effective preventative feeding and milking schedules are almost impossible to work out for the entire year. Furthermore, the milking cow is often enticed by the most noxious things, even when she is knee-deep in excellent pasture.

Unless the processor can standardize the flavor, his product will appeal to the consumer at times and repel at other times the taste acceptance of his customers. Milk is but one of many products available to the public. In competition, millions of dollars are invested in the soft drink industry, coffee, tea, etc. These people are leaving no stone unturned to improve and standardize the flavor of their product to attract the buyer.

The chosen task of the processor is to accept farm produced milk in sufficient quantities to fill the demands of his customers; to process it in such a manner as to result in its retaining a high quality under present marketing methods until consumed; and to be attractive enough to compete for the consumers' money. Under present processing methods, milk is still a highly perishable product.

The population trend to the suburbs, along with the rapid development of supermarkets, has resulted in a great many families resorting to once a week buying. Centralization of milk processing plants leading to expanded marketing areas results in greater hauling distances. All in all, a great deal more time is elapsing between production, processing, and consumption than was the case a few years ago.

Therefore, the processor must accomplish the two things for which UHT and flavor control equipment was developed. To understand the net result to the milk itself, we must study the published results of many researchers from all parts of the country.

In solving the problems, we cannot create greater ones by changing the product so as to create a resistance from the ultimate milk consumer. That is, UHT must be so controlled as to not develop an objectionable cooked or carmelized flavor. It has been determined that less cooked flavor will develop at 160°F for 15 seconds than at 145°F for 30 minutes (3,8). This indicates that cooked flavor is more a function

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1 Presented at the Annual Meeting of the Kansas Association of Milk Sanitarians and Kansas Society of Public Health Sanitarians November 6, 1958, at Kansas State College, Manhattan, Kansas.

208 SPRAY VERSUS MANUAL CLEANING

ACKNOWLEDGMENT

This study was made possible by a grant-in-aid from Wyandotte Chemicals Corporation, Wyandotte, Michigan.

REFERENCE

(1) Seiberling, D. A., and Harper, W. J.

UHT AND FLAVOR CONTROL PROCESSING OF MILK1

M. F. COGDILL

The Creamery Package Mfg. Company, Kansas City, Mo.
