STERILIZATION OF ICE CREAM FREEZERS

A. C. DAHLBERG AND J. C. MARQUARDT

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STERILIZATION OF ICE CREAM FREEZERS
A. C. DAHLBERG AND J. C. MARQUARDT

ABSTRACT

The problem of sterilization of ice cream freezers has not been studied experimentally to any extent as it has been assumed that ordinary methods used in the dairy industry would be effective and freezers have usually not played an important part in ice cream contamination.

In the present study freezers were sterilized by steam, hot water, and chlorine solution. It was found that chlorine solution did not penetrate the bearings and that bacteria subsequently developed in the wet freezer. The cold refrigerant around the freezer chilled hot water so that excessively large amounts at very high temperatures were required to sterilize freezers by this means. Heating by steam was slow, but it was entirely possible to sterile satisfactorily by steam.

Sterilization of freezers with steam was particularly effective as it dried them and sterilized the bearings also. Rinsing with chlorine solution prior to use was found to be desirable as a supplement to steam sterilization.

THE PROBLEM

Recent legislation in New York State relating to frozen desserts provides that the Commissioner of Agriculture and Markets shall promulgate sanitary regulations pertaining to their manufacture and distribution. Obviously, methods of sterilizing equipment need to be specified and in the course of discussion pertaining to these regulations considerable difference of opinion developed regarding the sterilization of ice cream freezers. As a result and due to a lack of definite knowledge on the subject, the present investigation was undertaken.

Three procedures are recognized for the sterilization of dairy plant equipment, namely, rinsing with a solution of approximately 100 p.p.m. of chlorine; rinsing with hot water of not less than 180°F with

"Sterilization" as used throughout this paper means the destruction of a majority of micro-organisms rather than complete sterilization or complete absence of life. "Complete sterilization" is used to denote true sterilization as used by the bacteriologist.
definite contact with the surfaces to be sterilized for 1 or 2 minutes; and steaming.

Hot water rinsing followed by chlorine disinfection is almost universally used in ice cream freezers, but there are two problems upon which little published data are available, viz., the amount and temperature of hot water required to rinse freezers to secure a final temperature of 180° within the freezer and evidence that chlorine solutions actually penetrate and sterilize bearings within the freezers. On account of the presence of bearings and the large volume of cold refrigerant which must be warmed, the sterilization of ice cream freezers presents a special problem.

The sanitary code provides that equipment in ice cream plants shall be sterilized as follows:

**Regulation 23.**—Facilities for cleansing and sterilizing equipment: Suitable facilities and equipment shall be provided and used for the proper cleansing and sterilizing of freezers, vats, tanks, cans, racks, molds, slabs, forms, piping and other equipment and utensils with which frozen desserts come in contact during manufacture, transportation or preparation for sale. All equipment used in the making or direct handling of frozen desserts shall be rinsed, disassembled, cleaned with hot water and cleansing powder and sterilized promptly after each day’s use. After sterilization, equipment shall be maintained in a dry condition but shall not be wiped. Parts of equipment, if not immediately reassembled after washing, and all containers and utensils shall be suitably stored to permit drainage and prevent contamination.

**Regulation 24.**—Pipe Lines: Pipe lines and fittings used for conducting milk, milk products or any mixture containing milk or a milk product to be used in the manufacture of frozen desserts shall be taken apart after each day’s use and thoroughly washed and sterilized. Pipe lines used for conducting any other ingredient used in the manufacture of frozen desserts shall be maintained in a clean and sanitary condition.

**Regulation 25.**—Means of Sterilization: Sterilization of freezers shall be performed with steam under pressure, with “boiling” water or by such other method as the Commissioner shall prescribe in writing. Sterilization of other frozen desserts apparatus, utensils and tools shall be performed with steam under pressure, with “boiling” water, with chlorine or by such other method as the Commissioner shall prescribe in writing. When sterilization is performed by “boiling” water, the water as it comes in contact with the equipment to be sterilized must be maintained at a temperature of one hundred eighty degrees Fahrenheit (180°F.) for a period of two minutes or more. When performed by chlorine, the solution used shall contain not less than one hundred parts of available chlorine by weight per million parts of water.
PROCEDURE AND METHODS

Preliminary studies were conducted on a 10-gallon brine freezer in the dairy laboratories at this Station for the purpose of testing three methods which comply fairly well with established practises and which might be expected to give each method of sterilization a reasonable opportunity of accomplishing its purpose. Instructions were then sent to six ice cream factories having laboratories in order that they might sterilize freezers by the three methods at the same time in each plant. The authors conducted all of the tests in a local ice cream factory and directly supervised the work in two other factories. The data submitted have been limited to those secured in these three plants under close supervision.

In each plant three freezers were selected which stood side by side. Tests were made on these three freezers to determine their condition at the beginning of the experiment. The freezers were then used for freezing ice cream, and at the conclusion of this operation they were immediately washed and sterilized. The washing consisted of rinsing the 10-gallon brine freezers with 6 gallons of cold water. Rinsing was always accomplished by operating the dasher for one-half minute or more. It is objectionable to operate freezers too long when filled with water, washing solution, or chlorine rinse as it dulls the freezer blades and tends to produce coarser ice cream.

The hopper was then used as a receptacle for 6 gallons of water at 140° to 145°F containing a half pound of cleansing powder. After washing the freezer and strainer, this washing solution was drained into the freezer and the dasher was run for about one-half minute to accomplish satisfactory washing of the freezer. The head of the freezer was then removed, the bearing was washed out, the dasher and inside of the freezer examined, and the dasher removed and scrubbed if it showed any trace of grease, particles of fruit, nuts, etc. This treatment was applied to all freezers irrespective of the method of sterilization. In some of the latter tests, 9 gallons of water were used for rinsing and washing 10-gallon freezers and this quantity was finally recommended.

The method of sterilizing the freezer is discussed under each method of treatment so that the various procedures will not be confused in interpreting the data.

There is no accepted procedure for determining the sterility of ice cream freezers. Two methods seem obvious, namely, wiping a portion of the side of the freezer and the bearing with sterile cotton
swabs or rinsing the freezer with sterile water. Cotton swabs might be used to determine complete sterility, but their use is difficult to establish the degree of contamination. It is impossible to prepare conveniently sufficient sterile water to rinse a freezer, and for this reason tap water or tap water heated to the boiling point was used as a freezer rinse. This rinse water was introduced into the freezer at 100° to 110°F and a plate count was made upon the water before and after use so that the contamination in the water itself could be deducted. This method introduced certain errors, but it had the obvious advantage of giving numerical results and was sufficiently accurate to show degrees of sterility. No effort was made to determine the contamination in the rear bearing as this appeared to be impractical. Removable heads were taken off and the front bearings rinsed with 10 cc of sterile water. In the case of hinged heads, some difficulty was encountered in properly rinsing the bearings and only 2 cc of water could be advantageously used for each bearing.

All bacterial counts were made by the agar plate method in duplicate following the procedure outlined in Standard Methods of Milk Analysis, but practically all counts per cc have been multiplied by the total cc of rinse water to give the total bacterial content. In all cases three or more dilutions were made so as to assure one set of plates with a proper number of colonies for counting. Samples were incubated for 48 hours at 95°F (37°C), and the plates were counted under magnification. Since counts were made in three laboratories slight variations in technic were encountered, but the results were entirely comparable at each laboratory.

STERILIZATION WITH HOT WATER

Sterilization with hot water was accomplished immediately after washing with a washing solution at 140° to 150°F by two successive rinsings of the freezer with 6 gallons of water at 180° to 185°F. The temperature of the water was taken in the hopper so that it actually entered the freezer at the specified temperatures. In each case the freezer was operated for one-half minute after all of the water was in the freezer. Longer periods of time seemed undesirable as the water became so cold in the freezer that it could have little sterilizing action. Samples of the first and second rinse waters were taken and plated as they drained from the freezer. The temperature of the water leaving the freezer was also recorded. The freezers were then left for 20 hours and they were not taken apart after sterilization. The freezing
chamber was then rinsed with 6 gallons of water at 100°F and plate counts were again made. Inasmuch as chlorine sterilization is also generally used in ice cream freezers sterilized with hot water, these freezers were then rinsed with 6 gallons of water containing 100 p.p.m. of chlorine. The heads were immediately removed and the front bearings rinsed with sterile distilled water to determine the bacterial content. It is obvious that penetration of the chlorine rinse into the bearing would usually cause its satisfactory sterilization, as was the case for the freezing chamber.

The results of five trials in two plants are given in Table 1. They show that the temperature of the second lot of hot water in the freezer varied from 154°F to 164°F. These temperatures cannot effect satisfactory sterilization and this was clearly indicated by the total bacterial content of the rinse water which varied from 0 to 8,000,000. The freezer remained wet and warm for a considerable period of time and the plate counts clearly indicated contamination of the freezers 20 hours after sterilization. The freezer temperature is difficult to change on account of the volume of refrigerant and the insulation. The front bearing counts were particularly variable and high, ranging from 200 to 4,000,000. It is evident from the temperatures and from the bacterial counts that hot water sterilization was not effective nor did it comply with the sanitary code which specifies that the surfaces to be sterilized must be in contact with water at 180°F for 2 minutes. It should be recognized, however, that the rinsing of the freezer by almost filling with warm water just before use mechanically removes the majority of bacteria so that the bacterial content of the ice cream would not be greatly increased by failure to sterilize properly.

An endeavor was made to determine the amount of water required to heat properly a 10-gallon brine freezer immediately after use so that the freezer would be sterilized in accordance with the sanitary code. Immediately after use a 10-gallon brine freezer was rinsed with 9 gallons of cold water followed by 9 gallons of washing solution at 145°F. This amount of water was sufficient to fill the hopper to overflowing. The freezer was then rinsed three times, using 9 gallons of water per rinsing at a temperature varying from 200°F to 204°F. This temperature is rather impractical for plant operation. The data in Table 2 show that three rinsings were required to secure water at 180°F inside the freezer. The freezer was satisfactorily sterilized at this temperature, as indicated by bacterial counts, but the excessive quantities of water at a temperature too high for commercial opera-
Table 1.—Sterilization of 10-gallon Brine Ice Cream Freezers by Rinsing Successively with Hot Water at 180° to 185°F.

<table>
<thead>
<tr>
<th>Trial No.</th>
<th>Tempeature into freezer, °F</th>
<th>Temperature out of of freezer, °F</th>
<th>Total bacterial count per freezer†</th>
<th>Tempeature into freezer, °F</th>
<th>Temperature out of freezer, °F</th>
<th>Total bacterial count per freezer</th>
<th>Total plate count 20 hours later*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>184°</td>
<td>148°</td>
<td>10,000,000</td>
<td>178°</td>
<td>156°</td>
<td>54,000</td>
<td>300,000 200</td>
</tr>
<tr>
<td>2</td>
<td>180°</td>
<td>148°</td>
<td>940,000</td>
<td>180°</td>
<td>156°</td>
<td>700,000</td>
<td>240,000 1,300,000</td>
</tr>
<tr>
<td>3</td>
<td>180°</td>
<td>130°</td>
<td>110,000</td>
<td>180°</td>
<td>156°</td>
<td>54,000</td>
<td>— 330,000</td>
</tr>
<tr>
<td>4</td>
<td>180°</td>
<td>144°</td>
<td>27,000</td>
<td>183°</td>
<td>164°</td>
<td>0</td>
<td>1,300,000 4,000,000</td>
</tr>
<tr>
<td>5</td>
<td>180°</td>
<td>142°</td>
<td>13,000,000</td>
<td>180°</td>
<td>154°</td>
<td>8,100,000</td>
<td>4,600,000 3,000,000</td>
</tr>
</tbody>
</table>

*The bearing count was always made after the freezer had been rinsed with a chlorine solution of 100 p.p.m.
†Six gallons (27,000 cc) of water were used for each rinse. Hence, plate counts per cc of rinse water were multiplied by this factor for the total bacterial content of the freezer chamber and by 10 for the front bearing, as the latter was rinsed with 10 cc of sterile water.

Table 2.—Temperatures in a 10-gallon Brine Freezer Secured by Rinsing Successively with Water at 200° to 204°F.

<table>
<thead>
<tr>
<th>Trial No.</th>
<th>Rinsing No. 1</th>
<th>Rinsing No. 2</th>
<th>Rinsing No. 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>170°</td>
<td>180°</td>
<td>182°</td>
</tr>
<tr>
<td>2</td>
<td>170°</td>
<td>178°</td>
<td>180°</td>
</tr>
</tbody>
</table>

The freezer was rinsed with 9 gallons of cold water at 55°F immediately after use, washed with 9 gallons of water at 145°F containing 1 per cent cleansing powder, and then subjected to the hot water treatment given above, using 9 gallons per rinsing.
tion seemed to exclude the possibility of satisfactorily sterilizing ice cream freezers with hot water alone.

The hot water available for sterilizing purposes in ice cream plants was generally below 160°F. The most practical method of securing water at 180° to 185°F was to connect the hot water pipe to a steam syphon mixer so that the temperature of the hot water could be boosted by live steam to the desired temperature as required.

STERILIZATION WITH STEAM

In considering the details of sterilizing freezers with steam, it was assumed that plants equipped with steam would have an ample supply of hot water and that it would be good practice to rinse freezers after washing with water at 180°F. This would gradually increase the freezer temperature to reduce metal strain and would sterilize the hopper and strainer. For this reason, immediately following washing with a hot washing solution, the freezer was taken apart, washed, reassembled, and 6 gallons of water at 180°F were introduced into the hopper, drained into the freezer, and the dasher operated for a half minute. The water was then drained out and a steam pipe or hose introduced into the fruit hopper so that the steam blew directly into the freezer. The steam was turned on with sufficient force to show a definite flow from the freezer, but the amount of steam was not sufficient to create much pressure within the freezer. Preliminary trials showed that the maximum effect of steam sterilization could be secured within 3 minutes if an ample supply of steam was available. Tests were made for a 5-minute period, but the data reported in Table 3 are limited entirely to 3 minutes of steaming.

The data again showed the failure of water at 180°F to sterilize properly the freezer due to rapid cooling. Steaming for 3 minutes gave a condensate dripping from the freezer at a temperature of 180°F or higher, clearly indicating that the surfaces within the freezer were being subjected to temperatures sufficiently high for satisfactory sterilizing purposes. Generally, the temperature of the drip from the freezer during steaming reached 180°F within 2 minutes. The bacterial counts per cc of the water dripping from the freezers varied from 0 to 30 which seemed somewhat high, but it should be borne in mind that it is exceedingly difficult to collect this drip water without contamination as it runs over the metal at the freezer outlet and that the total volume of condensate is low, being only 2 to 5 pounds per freezer. Since the freezers were completely dried by the heat, there was little opportunity for bacterial growth. This is clearly indicated.
by the total bacterial content of the freezers 20 hours later which varied from 0 to 130,000, except for one freezer into which some mix accidentally leaked. After the freezers had been rinsed with chlorine solution, the front bearing counts varied from 0 to 20, thus indicating very satisfactory sterilization. It will be shown later that this satisfactory sterilization was not due to the chlorine rinse.

Table 3.—Sterilization of 10-gallon Brine Freezers with Steam for 3 Minutes.

<table>
<thead>
<tr>
<th>Trial No.</th>
<th>Temperature, °F</th>
<th>Total bacterial count per freezer</th>
<th>Temperature of drip, °F</th>
<th>Plate count per cc of condensed steam drip</th>
<th>Total freezer count 20 hours later</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Into freezer</td>
<td>Out of freezer</td>
<td></td>
<td></td>
<td>Freezer</td>
</tr>
<tr>
<td>1</td>
<td>180°</td>
<td>148°</td>
<td>10,000,000</td>
<td>198°</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td>180°</td>
<td>30</td>
</tr>
<tr>
<td>3</td>
<td>180°</td>
<td>140°</td>
<td>81,000</td>
<td>190°</td>
<td>11</td>
</tr>
<tr>
<td>4</td>
<td>180°</td>
<td>142°</td>
<td>6,700,000</td>
<td>180°</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>182°</td>
<td>153°</td>
<td>27,000</td>
<td>190°</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>182°</td>
<td>140°</td>
<td>27,000</td>
<td>196°</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>180°</td>
<td>142°</td>
<td>3,270,000</td>
<td>201°</td>
<td>1</td>
</tr>
</tbody>
</table>

*Some mix leaked into freezer before test was made.

In large ice cream plants it would be rather time consuming to steam freezers individually and it is difficult to keep a steam hose clean. For this reason, a removable connection was made in the steam line in one plant to which a \( \frac{3}{4} \)-inch pipe was connected which led to the front of the freezers and from which three \( \frac{3}{4} \)-inch pipes led directly into three ice cream freezers. These connections made it possible to sterilize three freezers simultaneously with flowing steam escaping thru one valve. After washing, the freezers were rinsed with hot water. The steam connection was then made to the freezers and the steam turned on for 3 minutes with sufficient force to show some steam escaping from each freezer. The temperature of the condensate dripping from the freezer was not taken and the results are indicative of what might be secured in commercial practise. The data in Table 4 show very effective sterilization of the front bearing and reasonably satisfactory sterilization of the freezing chamber itself. It is evident, however, that for best results the steam ought to have flowed into the freezers for about 5 minutes, even tho 3 minutes of steaming were reasonably satisfactory.


**Table 4.—Sterilization of Three 10-gallon Freezers with Steam Flowing Simultaneously into All Freezers for 3 Minutes.**

<table>
<thead>
<tr>
<th>Freezer No.</th>
<th>Hot Water*</th>
<th>Total Freezer Count 20 Hours Later</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Temperature, °F</td>
<td>Total bacterial count per freezer</td>
</tr>
<tr>
<td></td>
<td>Into freezer</td>
<td>Out of freezer</td>
</tr>
<tr>
<td>1</td>
<td>156°</td>
<td>112°</td>
</tr>
<tr>
<td>2</td>
<td>156°</td>
<td>112°</td>
</tr>
<tr>
<td>3</td>
<td>156°</td>
<td>112°</td>
</tr>
<tr>
<td>Trial 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>120°</td>
<td>110°</td>
</tr>
<tr>
<td>2</td>
<td>120°</td>
<td>110°</td>
</tr>
<tr>
<td>3</td>
<td>120°</td>
<td>110°</td>
</tr>
<tr>
<td>Trial 2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Hot water was used at temperatures available in the plant.

**Sterilization with Chlorine**

It was assumed that when chlorine sterilization was used the supply of hot water would be limited to that required for proper washing of the freezer. For this reason the freezers were not rinsed with water at 180°F before sterilization with chlorine. After the freezers had been washed with washing solution at 140° to 145°F, they were taken apart, washed, reassembled, and 6 gallons of chlorine solution containing approximately 100 p.p.m. of chlorine were introduced into each freezer at 100° to 110°F. The freezers were then operated for a half minute and the solution drained out. Twenty-four hours later the freezers were rinsed with 6 gallons of luke-warm water for the purpose of securing a plate count on the freezing chamber. The freezers were then rinsed with 6 gallons of chlorine solution operating the freezers again for a half minute. The front bearings were then removed and rinsed with sterile water to determine the contamination.

Chlorine sterilization after washing the equipment gave variable and unsatisfactory results. The data in Table 5 show that whereas the chlorine rinse usually left the freezer in a satisfactory condition, the total bacterial content of the freezing chambers 20 hours later was exceedingly high and varied from 1,500,000 to 9,450,000. These high counts are undoubtedly due to two conditions, namely the loss of activity of the chlorine in the solution remaining in the freezers and the growth of bacteria in this solution, for the freezers remained
warm for a considerable period of time. The counts on the front bearings were also very unsatisfactory, varying from 0 to 100,000,000. It is interesting to note that best results on the front bearing were secured in old freezers in which these bearings were worn thus permitting the entrance of some chlorine solution into the bearings.

Table 5.—Sterilization of 10-gallon Brine Freezers with Chlorine Solution.

<table>
<thead>
<tr>
<th>Trial No.</th>
<th>Chlorine rinse P.p.m.</th>
<th>Total bacterial count per freezer</th>
<th>Total freezer count 20 hours later Freezer</th>
<th>Front bearing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>115</td>
<td>0</td>
<td>5,400,000</td>
<td>100,000,000</td>
</tr>
<tr>
<td>2</td>
<td>105</td>
<td>0</td>
<td>6,500,000</td>
<td>400,000</td>
</tr>
<tr>
<td>3</td>
<td>115</td>
<td>108,000</td>
<td>4,940,000</td>
<td>5,000,000</td>
</tr>
<tr>
<td>4</td>
<td>110</td>
<td>0</td>
<td>1,500,000</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>100</td>
<td>27,000</td>
<td>8,700,000</td>
<td>1,300</td>
</tr>
<tr>
<td>6</td>
<td>100</td>
<td>0</td>
<td>9,400,000</td>
<td>600</td>
</tr>
</tbody>
</table>

The rinsing of freezers with chlorine immediately after use has little value in maintaining freezers in a sanitary condition and this practise may cause some difficulties. There is a possibility of corrosion of metal and of the mix dissolving this metal to such an extent that the ice cream may have poor keeping quality. The total bacterial content of the freezer chamber was determined prior to the second chlorine rinse and it is evident that the freezer condition was excellent immediately following the chlorine rinse while the condition of the bearing had not been affected.

SUMMATION OF STERILIZING DATA

The results of all of these tests on 10-gallon freezers are summarized in Table 6. No standards for judging the thoroness of sterilization have been established for ice cream freezers. At first thought it would seem reasonable to adopt the standards accepted by the International Association of Milk Dealers as representing a sterile 10-gallon can. It should be borne in mind, however, that a 10-gallon milk can is easier to sterilize than a 10-gallon ice cream freezer and that rinsing with 500 or 1,000 cc of sterile water will never remove as large a proportion of the bacteria as severe agitation of 27,000 cc (6 gallons) of water in an ice cream freezer. An empirical standard was established that a properly sterilized 10-gallon ice cream freezer should have a total bacterial content of less than 200,000 in the freezing chamber and of less than 2,000 in the bearing. Such freezers always showed no
bacteria of the *Escherichia-Aerobacter* group. Freezers which had a total bacterial content in the freezing chamber of 400,000 and 4,000 or more in the bearing or either bacterial content alone were considered to have been poorly sterilized. On this basis the seven freezers sterilized with chlorine were all in a poorly sterilized condition, while four of the five freezers sterilized with hot water were also poorly sterilized. Six of the seven freezers sterilized with steam were well sterilized, while three of the six freezers sterilized with steam for 3 minutes without consideration of the temperature of the condensate were also well sterilized. The results clearly indicate the desirability of steaming ice cream freezers to sterilize them.

**Table 6.—Summary of Tests on Steam, Hot Water, and Chlorine Sterilization of 10-gallon Ice Cream Freezers in Two Plants.**

<table>
<thead>
<tr>
<th>Method of sterilization</th>
<th>Condition of freezers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Excellent*</td>
</tr>
<tr>
<td>Steam†</td>
<td>3</td>
</tr>
<tr>
<td>Steam§</td>
<td>6</td>
</tr>
<tr>
<td>Hot water</td>
<td>0</td>
</tr>
<tr>
<td>Chlorine</td>
<td>0</td>
</tr>
</tbody>
</table>

*Plate count in freezer less than 200,000; in bearing less than 2,000; contamination of ice cream would be less than 10 per cc.
†Plate count in freezer more than 400,000; in bearing more than 4,000; contamination of ice cream would be at least 20 per cc.
‡Steamed three freezers at once for 3 minutes thru removable piping; no temperatures taken of condensed steam draining from freezer.
§Condensed steam drip from freezer 180°F or higher. Unsatisfactory freezer was due to mix leaking into freezer.

For the purpose of illustrating difficulties in freezer sterilization, the results secured at another plant are summarized in Table 7. It is interesting to observe that the hot water rinse at 180°F left the freezer at a maximum temperature of 144°F. The lowest total bacterial content of the freezers sterilized with hot water was 43,000,000. When the freezers were sterilized with steam for 3 minutes, the hottest temperature of the condensate dripping from the freezer was 132°F, clearly indicating that insufficient steam was being used. This was also shown by the high freezer counts which varied from 27,000,000 to 59,000,000.

It is interesting to note that, in spite of the poor sterilization of the freezing chamber, the bearing counts varied from 0 to 1,200 and were quite satisfactory due to the more rapid heating of the ends of the freezer. The use of chlorine again proved ineffective as the lowest freezer count was 29,700,000 and the lowest bearing count 840,000.

The data illustrate the very large number of bacteria which may be present in the ice cream freezer.
Table 7.—Summary of Tests Showing Failure to Sterilize 10-gallon Freezers in One Plant by Any Method Due to Slow Rate of Steaming.

<table>
<thead>
<tr>
<th>Total bacterial content of freezer and bearings*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial 1</td>
</tr>
<tr>
<td>--------------------------</td>
</tr>
<tr>
<td>Hot Water, 180°F</td>
</tr>
<tr>
<td>Second rinse from freezer at 138°–144°F</td>
</tr>
<tr>
<td>Freezer count 20 hours later</td>
</tr>
<tr>
<td>Front bearing count</td>
</tr>
<tr>
<td>Steam, 3 Minutes, Drip 130°–132°F</td>
</tr>
<tr>
<td>Freezer count 20 hours later</td>
</tr>
<tr>
<td>Front bearing count</td>
</tr>
<tr>
<td>Chlorine Rinse, 100 p.p.m.</td>
</tr>
<tr>
<td>Chlorine rinse from freezer</td>
</tr>
<tr>
<td>Freezer count 20 hours later</td>
</tr>
<tr>
<td>Front bearing count</td>
</tr>
</tbody>
</table>

*The bacterial counts of ice cream made in these freezers were not greatly increased as the freezers were rinsed with chlorine solution just prior to using, thereby destroying most of the bacteria in the freezer but not in the bearing.

Sterilization of 25-gallon Direct Expansion Freezers

Ice cream freezers vary markedly in their construction and this undoubtedly has a material effect upon sterilization. At one plant an endeavor was made to sterilize 25-gallon direct expansion freezers with hot water, with chlorine, and with live steam. The data secured with chlorine failed to show reasonably satisfactory sterilization and are not presented.

After washing with hot water these large freezers were rinsed twice, using 19 gallons of water at 180° to 185°F at each rinse. As shown in Table 8, these freezers had been rinsed with a total of 38 gallons of

Table 8.—Sterilization of 25-gallon Direct Expansion Freezers by Rinsing Successively with Hot Water at 180° to 185°F.

<table>
<thead>
<tr>
<th>Trial No.</th>
<th>Second rinse*</th>
<th>Bacterial counts 20 hours later</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Temperature into freezer, °F</td>
<td>Temperature out of freezer, °F</td>
</tr>
<tr>
<td>1</td>
<td>182°</td>
<td>138°</td>
</tr>
<tr>
<td>2</td>
<td>180°</td>
<td>140°</td>
</tr>
</tbody>
</table>

*19 gallons of water used at each rinse equals 86,000 cc. Plate counts per cc were multiplied by this factor to give total bacterial content of freezer. Plate counts per cc of rinse in bearings were multiplied by 2 as 2 cc were used to rinse these bearings.
†Sterilization probably due to chlorine solution entering bearing. All freezers were always chlorine rinsed just previous to making bearing count.
water entering the freezer at 180° to 185°F, and the maximum temperature of the water leaving the freezer was 140°F. As expected, such temperatures failed to give sterilization as indicated by the very high counts on the freezing chamber. In one of the two trials the front bearing was sterile undoubtedly due to the penetration of chlorine during the rinsing with the chlorine solution.

Sterilization of the 25-gallon direct expansion freezers with live steam is reported in Table 9. It will be noted that steaming for 3 minutes gave a temperature of the condensate dripping from the freezer of 145° to 178°F which is not sufficiently hot for sterilization purposes. The bacterial counts of this condensate were excessively high. The total counts on the freezing chambers varied from 12,000,000 to 57,000,000 and the bearing counts varied from 35,000 to 124,000. It is evident that the chlorine solution in these three tests did not penetrate any of the bearings.

In the next four trials the freezers were steamed for 5 minutes. The temperature of the steam condensate dripping from the bearing varied from 160° to 190°F and is not sufficiently high on an average. Nevertheless, the sterilization of freezers was much improved as the counts varied from 765,000 to 5,000,000 on the freezing chamber, while the highest count on the front bearing was 320. The flow of steam should have been greater or the time of steaming increased to secure satisfactory results.

In the next three trials the freezers were steamed for 7 minutes. The temperatures of the condensed steam dripping from the freezers were taken after 5 minutes and varied from 140° to 190°F, which compares favorably with previous tests. The total bacterial content of the freezer chambers were less than a million on the following day, and for these large freezers this represents a contamination of less than 10 per cc in the first batch of ice cream frozen in them. The total bacterial content of the front bearings was less than 250.

**DISCUSSION**

The extreme difficulty encountered in sterilization of ice cream freezers raises the question of the necessity of sterilization. It is difficult to conceive of sanitary codes and regulations which fail to prescribe procedures for sterilization of equipment, since proper sterilization is fundamentally associated with good sanitary practices. There is not much danger in most ice cream plants of producing ice cream with excessively high counts or containing disease-producing bacteria as a result of failure to sterilize ice cream freezers properly.
The counts of the ice cream are not materially increased because the almost universal practise is to rinse freezers several times with hot water after use and again with cold water or with chlorine solution

**Table 9.—Sterilization of 25-gallon Direct Expansion Freezers with Live Steam.**

<table>
<thead>
<tr>
<th>Trial No.</th>
<th>Hot Water*</th>
<th></th>
<th></th>
<th>Total Freezer Count 24 Hours Later</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Temp. into Freezer, °F</td>
<td>Temp. out of Freezer, °F</td>
<td>Total Bacterial Count of Freezer</td>
<td>Temp. of Drip, °F</td>
</tr>
<tr>
<td>1</td>
<td>180°</td>
<td>120°</td>
<td>13,500,000</td>
<td>178°</td>
</tr>
<tr>
<td>2</td>
<td>180°</td>
<td>132°</td>
<td>2,400,000</td>
<td>175°</td>
</tr>
<tr>
<td>3</td>
<td>180°</td>
<td>132°</td>
<td>3,100,000</td>
<td>145°</td>
</tr>
</tbody>
</table>

Steamed 3 Minutes

|           | 186°       | 136° | 9,600,000  | 170° | 138 | 760,000  | 100  |
| 4         | 176°       | 138° | 2,700,000  | 190° | 4  | 900,000  | 160  |
| 5         | 184°       | 136° | 7,200,000  | 163° | 18 | 5,000,000 | 320  |
| 6         | 179°       | 135° | 4,200,000  | 160° | 57 | 1,800,000 | 220  |

Steamed 5 Minutes

|           | 190°       | 140° | 770,000    | 140° | 24 | 450,000  | 180  |
| 8         | —          | —    | 770,000    | 168° | 5  | 800,000  | 80   |
| 9         | —          | —    | 430,000    | 190° | 1  | 600,000  | 240  |

Steamed 7 Minutes

*Pull hopper of hot water was 19 gallons, or 86,000 cc.
†Freezer rinsed with 10 gallons of water, or 45,000 cc; hence plate counts per cc of rinse were multiplied by this factor.

just before using. The freezers themselves are not subjected to conditions which tend to infect them with disease-producing organisms except for the handling of the dasher and head by the operator. The same situation exists regarding the necessity of sterilization of equipment in milk plants. The desirability of sterilization is essentially one of good sanitary procedure.

The tests reported here were all conducted in the cold months of December, January, and February so that freezer contamination was at a minimum. In some instances the temperature of the freezing room was below 50° in the evening and rarely exceeded 70°. Much higher counts might have been secured during the hot summer months.

At the present time the ice cream industry employs hot water and chlorine for sterilization purposes. Generally, the freezers are rinsed with cold water, then with a hot washing solution, which in turn is
followed by rinsing several times with hot water, usually below 160°F as it enters the freezer. Prior to use on the following day the freezers are rinsed with a chlorine solution. This investigation clearly demonstrated that this procedure does not accomplish good sterilization in the generally accepted use of the term. Furthermore, the condition of the freezers in the plants cooperating in this study would indicate that good work was being done in washing and sterilization from the viewpoint of the outlined commercial procedure. The freezers were physically clean and undoubtedly did not materially affect the bacterial count of the ice cream frozen in them. On the other hand, these freezers were not being satisfactorily sterilized as indicated by the fact that organisms of the *Escherichia-Aerobacter* group were found to be present in the bearings of one or more freezers at each of the three plants studied. This fact has a special significance in sterilization problems as it indicates failure of the procedures to destroy disease-producing organisms if such had been present and it also shows possible contamination of the ice cream with gas-producing organisms in the freezer itself.

There are two serious objections to the sterilization of freezers with with chlorine alone, namely, it is practically impossible to dry the freezer after use and the chlorine solution does not penetrate the bearings of most freezers. There is no advantage in rinsing freezers with chlorine solution after use for the bacteria multiply later in the wet freezer and there is danger of metal corrosion. Bacterial contamination may be held to a low value by rinsing the freezer with chlorine just prior to use to flush out and destroy the large number of bacteria which develop in the wet freezer. Since the bearings are generally not affected by this treatment, the freezer can hardly be said to be sterilized. Altho it is possible to flush out the front bearing with chlorine, this procedure is impractical or impossible for the rear bearing. The ice cream mix serves as a lubricant for the bearings so it is evident that the contamination within the bearings must gradually work into the ice cream and any method of sterilization ought to consider the bearings as well as the freezing chamber. Altho the rear bearings have not been considered in this study for obvious practical reasons, it is reasonable to assume that a procedure which sterilized the front bearings would also sterilize the rear bearings unless the front bearing is sterilized when the head of the freezer has been removed.

Sterilization of ice cream freezers with hot water is impractical, since approximately 27 gallons of water at 200°F or higher are re-
quired to sterilize one 10-gallon ice cream freezer. Water at this
temperature cannot be conveniently maintained in commercial plants
with present equipment. The best procedure to procure water at
200°F is to have a steam syphon mixer in the hot water line so that
steam may be turned into the hot water as it is discharged to the
hopper of the freezer. Sterilization with hot water as just mentioned
is satisfactory for the freezer promptly dries after the removal of the
water and the bearings are sterilized. The method is of scientific
interest rather than of practical significance however, as it is more
economical to use the steam directly in the freezers than to boost the
temperature of the hot water.

The sterilization of freezers with live steam can be readily accom-
plished and is particularly well suited for combination with chlorine
sterilization prior to using the freezer. This investigation would
indicate that steam sterilization is effective first on the bearings and
the ends of the freezer due to the fact that the steam is heating the
metal only. Observations would indicate that the exceedingly hot
temperature of the head of the freezer, particularly at the front bear-
ing, might be used as a practical index of the desired time to steam
freezers. The protruding front bearing of the Miller 10-gallon freezer
became too hot to hold after 2 minutes of steaming, clearly indicating
the penetration of heat. The walls of the freezing chamber are slower
to heat due to the large reservoir of cold refrigerant adjacent to them.
When the steam condensate was dripping from the freezer at a tem-
perature in excess of 180°F, these limited observations would indicate
that the freezer had been properly steamed. Under ordinary condi-
tions 3 minutes were ample, altho it might be better practise to recom-
mand 5 minutes for a 10-gallon freezer and 7 minutes for a 25-gallon
freezer.

In this connection it is interesting to note the statement of Fay and
Olsen\(^2\) that steaming an ice cream freezer for 3 minutes sterilized it
sufficiently for practical purposes for ice cream produced in such a
freezer showed no evidence of contamination from the freezer.

This investigation offers no evidence on the problem of the effect of
marked changes in the temperature within the freezer upon buckling
of the metal, opening of seams, etc. It should be noted, however,
that the refrigerant around the freezing chamber at the conclusion
of the freezing period is usually about 0°F. The freezing chamber
is first warmed with cold water, then with water at 140° to 145°F,
then with water at 180°F, and when the steam is turned into the

\(^2\)Kansas Agr. Exp. Sta. Cir. No. 103. 1924.
freezer its temperature should be around 130°F. The steam requires about 2 minutes to raise the temperature to 180°F or higher and rarely reaches a temperature of 200°F. This problem has been discussed with a limited number of ice cream manufacturers and dairy engineers and the belief seems almost unanimous that freezers will not be injured if the temperature changes are slow. Injury, if any, would be expected with the large direct expansion freezers.

Altho this investigation has been somewhat limited in extent, it seems ample to justify the recommendations of the following tentative methods of washing and sterilizing freezers. The first method given below is recommended. It will yield a dry freezer, bearings, and hopper in an excellent sanitary condition immediately after use and the chlorine rinse just prior to subsequent use is an added sanitary precaution. Steam is particularly effective in sterilizing bearings, the part which chlorine often misses. The second method is not recommended. It produces a wet, unsterilized freezer, bearings, and hopper which are stored unassembled to facilitate drying. Just prior to use the freezer and parts are satisfactorily sterilized with chlorine, but the rear bearing has not been affected. This method will prevent serious contamination from the freezer so far as total bacterial counts are concerned.

RECOMMENDED PROCEDURE FOR WASHING AND STERILIZING FREEZERS USING STEAM AND CHLORINE

At the conclusion of the freezing operation drain the ice cream from the freezer. Rinse the strainer, hopper, and outside of the freezer, particularly at the head, with cold water. Fill the freezer two-thirds full of cold water. Run one-half minute and drain.

Fill the hopper full of water at 140°F to 145°F and add a half pound (1 cup full) of cleansing powder. Wash the strainer, hopper, and outside of the freezer with a brush. Drain the solution into the freezer, (the freezer should be at least two-thirds full) run one-half minute, and drain the freezer.

Remove the head, scrub with a brush, being certain to clean out the front bearing. Wash the bearing end of the dasher with a brush, remove from freezer, and wash. Replace dasher and head.

Fill the hopper full of water at 180°F to 185°F so that the screen is immersed. Let it stand 2 minutes to sterilize the hopper and screen. Drain into the freezer, (the freezer should be at least two-thirds full) run one-half minute, and drain.
Partially close the freezer gate so that it is about one-fourth open. Turn steam into the freezer, thru a special removable pipe, with sufficient force to give a noticeable blowing of steam from the fruit hopper opening. Steam until the steam condensate dripping from the freezer is above 180°F. This will require 3 to 5 minutes for a 10-gallon freezer and 5 to 8 minutes for a 25-gallon freezer. Open the gate and let the freezer stand intact until ready for use.

Before using the freezer, fill the hopper with water at 100° to 110°F, making certain that the screen is covered. Add sufficient chlorine to give 100 p.p.m. and stir well. If desired, the chlorine solution can be pumped into the hopper from a special tank. Drain the chlorine solution into the freezer, operate the freezer for one-half minute, and drain. The freezer is then in excellent sanitary condition and ready for immediate use.

WASHING FREEZERS AND MAINTAINING LOW BACTERIAL CONTAMINATION WITH CHLORINE

At the conclusion of the freezing operation drain the ice cream from the freezer. Rinse the strainer, hopper, and outside of the freezer, particularly at the head, with cold water. Fill the freezer two-thirds full of cold water, run one-half minute, and drain.

Fill the hopper full of water at 140° to 145°F and add a half pound (1 cup full) of cleansing powder. Wash the strainer, hopper, and outside of the freezer with a brush. Drain the solution into the freezer, (the freezer should be at least two-thirds full) run one-half minute, and drain the freezer.

Remove the head, scrub with a brush, being certain to clean out the front bearing. Wash the bearing end of the dasher with a brush, remove from freezer and wash. Place dasher and head in sanitary place until used.

Before using the freezer, fill the hopper with water at 100° to 110°F, making certain that the screen is covered. Add sufficient chlorine to give 100 p.p.m. and stir well. If desired, the chlorine solution can be pumped into the hopper from a special tank. Pour some of the chlorine solution into the front bearing. Place dasher in freezer and fasten the head in place. Drain the chlorine solution into the freezer, operate the freezer one-half minute, and drain. The freezer is then in excellent sanitary condition, except that the rear bearing may be contaminated, and is ready for use.