A STUDY OF

ELECTRIC DAIRY STERILIZERS

TESTS AND STUDY
BY

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DATA COMPILED AND REPORTED
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COOPERATIVE EXTENSION WORK
IN
AGRICULTURE AND HOME ECONOMICS
State of Virginia

EXTENSION SERVICE

ELECTRIC DAIRY EQUIPMENT STERILIZERS

Tennessee Valley Authority
And
Virginia Polytechnic Institute, Cooperating

INTRODUCTION:

The importance of dairy sterilizing equipment has increased tremendously during the last few years with the ever increasing rigidness of sanitary and health laws. This condition applies not only to distributors of milk and other dairy products, but to the producer also, regardless of the extent of his activity in the production of dairy products. With this requirement facing the dairy farmer, it is timely and necessary that proper information on all types of sterilizing equipment be made available to him, in order that he may select wisely the most practical and economical method of sterilization.

There are many methods of sterilization practiced at the present time, including live steam from boilers heated by coal, oil, wood and electricity; chemical treatments; combination water heaters and sterilizers; and cabinet types in which the amount of steam is controlled, finally leaving the utensils dry. Practically all of these methods are familiar to the average dairyman with the exception of those types of sterilizers which use electric energy for supplying heat. The purpose of the study described in this report was to ascertain facts regarding the practicability, adaptability, operating economy and desirability of electricity as an energy source for operating dairy sterilizing equipment. After a general study of all types of electrically operated dairy sterilizers, one particular type of sterilizer was to have been selected for complete investigation, this investigation to result in definite recommendations for an electric dairy sterilizer most adaptable on dairy farms in the states of the T. V. A. area.

JUSTIFICATION OF THE STUDY:

The dairy industry may be considered one of the basic rural industries in the states of the T. V. A. area. According to the 1930 census there were 24,968 dairy farms in these states, and this number has undoubtedly increased since 1930. A large per cent of these dairy farms are comparatively small, having dairy herds of 50 cows or less. Practically all types of electric sterilizers are especially adaptable to small dairies and, therefore, would find many applications in the T. V. A. area.

The rapid extension of rural electric lines making electric service available on many more dairy farms, and the continually lower trend of rates for electric energy, are the two most conspicuous factors paving the way for

a more generous and economical use of electricity on dairy farms. No one denies the fact that electric energy as a heat source for dairy sterilizers offers every advantage over all other fuels. There are then three things that must be proven feasible relative to the equipment before its use can be generally recommended and adopted: First, the cost of the equipment; second, the cost of operation; third, the efficiency of operation or effectiveness of sterilization.

A large number of state health departments have already approved the use of certain types of electric sterilizers and the use of the equipment has become general in these areas, where rates for electric energy have been such that the equipment could be operated economically. State health departments in Virginia, Tennessee and other states of the T. V. A. area, do not list any type of electric sterilizer as approved equipment in their regulation standards.

OBJECTIVES OF THE STUDY:

The objectives of this study may be listed thus:

1. To determine the most practical type of electric dairy sterilizer for dairy farms of the T. V. A. area.

2. To test the type selected for operating cost, effectiveness of sterilization, and adaptability.

3. To determine the possibility of dairy farmers constructing or having constructed locally electric sterilizers, reducing first cost of the equipment.

4. To obtain definite results on the operation of the sterilizer selected, both from laboratory and field operation; this information to be submitted to the proper state authorities so that the equipment can be either disapproved or recommended as to conform with equipment regulation requirements.

COOPERATING AGENCIES:

Tennessee Valley Authority: The T. V. A. assigned S. M. Beane, Agricultural Engineer, to conduct the study on dairy sterilizers.

University of Tennessee: The Department of Bacteriology assisted Mr. Beane in testing sterilizers in operation at the University by conducting the laboratory bacteria counts.

Virginia Polytechnic Institute: The Agricultural Engineering Department of V. P. I. furnished the technical direction, consulting advice, laboratory facilities and necessary equipment for the study. The Bacteriology Department at V. P. I. made official bacteria counts during the tests of the laboratory sterilizer.

PROCEDURE:

The first step taken in beginning the study of electric dairy sterilizers was that of assembling all available information. The result of this investigation was a varied assortment of experimentation bulletins, manufacturers literature and experiences of various electric utilities with electric sterilizers. The fact was disclosed that the following types of electric dairy sterilizers are being used in various sections of the United States:

1. Electric controlled humidity type cabinet sterilizers.

This type of sterilizer is more generally used than any other one type of electric sterilizer. It consists of a well insulated cabinet, heated with electric strip heaters with a capacity of 1500 watts up depending on the size of cabinet. The desired temperature in the cabinet is automatically controlled by an adjustable thermostat. This sterilizer is simple in design and operation. The method of operation is such that the human element is practically removed from the sterilizing process. As the dairy utensils are washed, they are packed into the sterilizer while wet. When the cabinet has been filled or all utensils placed inside it, the door is closed and the current turned on manually. The particles of water which cling to the utensils go into steam as the temperature rises in the sterilizer and when the desired temperature is reached, the thermostat cuts off the current. The insulated cabinet holds the heat, completing the sterilization of the utensils. The cabinet then provides a clean, dry place for storing the utensils until they are to be used again.

Comments:

(a) The sterilizer is simple in construction and fool-proof in operation, assuring a positive job of sterilization.

(b) Commercially manufactured models are comparatively high priced, ranging from $175 for the four can size upward.

(c) The simplicity of design and construction make it possible for any carpenter or tinsmith to build a sterilizer of this type at the place where it is to be operated.

(d) Efficient in operation.

(e) Provides ideal storage space for utensils.

(f) Does not provide means of heating water.

(g) Flexible in size so that the sterilizer can be built to suit the needs of any size dairy.

(h) If homemade, the cost is comparatively low.

2. Combination electric dairy water heater and sterilizer.

This type of sterilizer has not been used to any great extent, however, it does have a number of desirable features. It consists of an insulated tank so designed that a trough about six inches wide and six inches deep extends across the bottom. An immersion type electric heating element of 3 to 5 kw is screwed into the side of the tank and into the trough. The drain from the tank is located just above the heating element. Water is run into the tank and heated for washing purposes. The water, when drained from the tank to be used for washing, leaves the tank warm and ready for the washed utensils. The current is again turned on and the small amount of water remaining in the trough gives off sufficient steam for sterilizing the equipment.

The first electric sterilizer of this type was designed and built by the agricultural engineering department in 1930.* This sterilizer has been in continuous operation at a wholesale dairy near Roanoke, Virginia, for over five years. It heats wash water and sterilizes all the equipment for this 20-cow dairy, using an average of 185 kwh of current per month. The owner is well pleased with its operation and values it second only to his refrigeration equipment.

Comments:

(a) Takes care of two separate and necessary jobs at the dairy: heating water and sterilizing equipment.

(b) Comparatively low in first cost. (Can be built for $60.00 locally or $125.00 commercially.

(c) The size of the equipment limits its use to retail dairies of not over 12 cows, and wholesale dairies of not over 20 cows.

(d) Not so efficient in operation.

(e) Can be automatically operated by a thermostat to assure proper sterilization temperature but the utensils must be removed while hot for drying.

3. Electric heated steam boiler.

The electric steam boiler has been developed on the west coast recently. It consists of a well insulated boiler tank with pressure accessories and an immersion heating element of low wattage (1500 or 2000 w.). The principle of operation is that of a low wattage element heating over a long period of time, the heat being conserved in the heavily insulated tank.

* Thesis problem of a graduate student, Agricultural Engineering Department, Virginia Polytechnic Institute.

Comments:

(a) Provides hot water for washing and steam for sterilizing.

(b) First cost $175.00 and up, depending on size.

(c) Not manufactured in the east at present.

(d) Cannot be built at the dairy advisedly because of dangers involved in high steam pressures.

(e) Requires long period of time for making steam, therefore, would not provide for emergency demand.

4. The Small [redacted] steam generator.

This sterilizer is another recent development. Complete tests were made to determine its place in the dairy. The generator consists of a copper boiler holding one pint of water. A 1,000 watt Cromolux immersion heating element is built inside the boiler. Water is stored in a one gallon jug and runs by gravity into the generator. The test results will be found elsewhere in this report.

Comments:

(a) The sterilizer, as it is, can be used only for single utensils such as buckets, cans, etc.

(b) Its use must be limited to small wholesale dairies, or as an auxiliary sterilizer in larger dairies.

(c) Purchase cost is low, cost is $18.50, complete.

(d) Efficient in operation and cheap to operate.

(e) Requires no special wiring.

(f) Can be used for heating small quantities of water.

In view of the objectives set forth in beginning this study, a number of sterilizer installations of various types were visited and checked from every standpoint. It was decided that the controlled humidity type sterilizer most nearly met the requirements desired for dairies in the T.V.A. area. The Herrick steam generator appeared to have possibilities as the answer to the needs of the small producer whose business is of sufficient volume to justify a larger expenditure for equipment. As a result of this decision, further study was devoted to these two types of sterilizers and the results of the study are as outlined in the remainder of this report.

The Small [redacted] Electric Steam Sterilizer

The principle of operation of this sterilizer is that of providing intense heat in a small area so that, as water enters the heated chamber, it goes into steam almost immediately. A small hole in the top of the copper boiler serves as the jet through which the live steam escapes. Utensils are sterilized by inverting them, one at a time, over the jet.

Tests were made on the sterilizer by the departments of Bacteriology and Agricultural Engineering in the laboratories at V. P. I. Fifteen different utensils were used under various conditions, the time and bacteria counts checked for each test. The utensils used in the tests consisted of 10 gallon milk cans, three gallon closed top pails, and three gallon open top pails.

Preparation of Utensils for Sterilization:

Ten gallon milk cans and 3 gallon pails were picked at random from the V. P. I. creamery. Various methods of cleaning the utensils were used before steaming them for sterilization. The method of cleaning the utensil is indicated on the data sheet in each case. In some cases the utensils were not cleaned at all, but were rinsed with the sterile water after the milk was emptied from them and the bacteria count made from this sample. The methods of cleaning the utensils before taking the first sample for bacteria count were; rinsing with hot water, rinsing with cold water, scrubbing with hot water, scrubbing with cold water, scrubbing with hot water and soap powder and scrubbing with cold water and soap powder.

Collecting Samples:

After cleaning the utensils by one of the methods listed, a definite quantity of sterile water was poured into the utensil and used as a rinse for the utensil. The ten gallon utensils were always rinsed with 1000 c. c. of sterile water and the 3 gallon utensils with 200 c. c. of sterile water. The utensil was always thoroughly shaken, then a portion of the rinse water was poured into a sterile sample bottle and analyzed for the number of bacteria as given by the A. P. H. A. for milk analysis.

When the remaining rinse water had been emptied, the utensil was then placed over the steam jet and exposed to the live steam for a recorded number of minutes. As soon as the utensil had been steamed, it was again rinsed with the standard quantity of sterile water, the sample was taken and the bacteria count was again made as with the first sample.

The dilutions made on each sample for bacterial analysis were always plated out in duplicate and incubated at a temperature of 37 degrees C. for 48 hours. The average count of the two samples was accepted as the number of bacteria contained in each c. c. of the rinse water.

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Sterilizer Operation:

When cold water was used in the storage jar on the sterilizer, it required about 3½ minutes for the boiler to heat up and start giving off steam. A thermometer was held immediately over the steam jet and the mercury rose to a temperature of 95 degrees C (203° F.). Hot water drawn from the faucet on the sterilizer had a temperature of 96° C (205° F.). The three gallon pails were heated to 90° C. when held over the steam jet for three minutes.

The tabulation below shows the results of tests made under various conditions to determine the effectiveness of the steaming for destroying bacteria.

Small [redacted] STEAM STERILIZER
Test Data Sheet

Sample No.	Size of Container	Amount Sterile Water	Condition of can before first rinse	No. of bacteria per cc of first rinse water	Time Steamed	No. of bacteria per cc of rinse water after steaming
1	10-gal. can	1000 cc	After pouring milk	420,000	4 min.	206,000
2	10-gal. can	1000 cc	After rinsing with hot water	60,000	4 min.	1,500
3	10-gal. can	1000 cc	After pouring milk	96,670	5 min.	750
4	10-gal. can	1000 cc	After washing with hot water	2,500	5 min.	200
5	10-gal. can	1000 cc	After washing with hot water	1,000	4 min.	00
6	10-gal. can	1000 cc	Washed with cold water	76,500	4 min.	3,050
7	10-gal. can	1000 cc	Washed with soap and warm water	165,000	4 min.	11,300
8	2½ gal. pail	200 cc	Washed with cold water	8,500	2 min.	90
9	2½ gal. open top pail	200 cc	Washed with warm water and soap	6,850	2 min.	80
10	2½ gal. open top pail	200 cc	Washed with cold water	23,000	2 min.	1,205
11	10-gal. can	1000 cc	Washed with cold water and soap	65,000	4 min.	980

(Over)

12	10-gal. can	1000 cc	After pouring milk	10,800,000	4 min.	195,000
13	3-gal. closed pail	200 cc	Washed with cold water	2,100,000	2 min.	7,200
14	3-gal. closed pail	200 cc	Washed with hot water	332,100	2 min.	6,790
15	10-gal. can	200 cc	Washed with cold water	106,000	4 min.	43,700

Conclusion:

A comprehensive study of the sterilizers operation, and the results of the tests made, indicate:

1. The time required for sterilizing any utensil effectively varies according to the size of the utensil.

2. Small utensils can be sterilized more effectively. A three gallon pail should be steamed at least 2 minutes, and a 10 gallon can at least 5 minutes, to attain a temperature of 90 degrees C. and sterilization.

3. The simplicity and low cost ($18.50) of the sterilizer make it desirable for the use of the small wholesale producer.

4. The sterilizer is very economical in operation, compared with the cost of other methods.

5. Will provide sufficient hot water for washing the utensils.

6. From a cold start, the sterilizer requires 3½ minutes to develop steam for sterilization.

CONTROLLED HUMIDITY TYPE CABINET STERILIZER

Two installations of this type sterilizer were observed near Bluefield, West Virginia, both of which were constructed locally with the aid of a tinsmith. The first is located on a dairy farm at Mullens, West Virginia, and has been in constant service for two years. This sterilizer consists of an insulated cabinet 42" x 37" x 31" and is heated by ten 500 watt electric strip heaters. An adjustable thermostat controls the operating temperature of the sterilizer and no attention is required after the utensils have been placed in the cabinet and the current turned on. Sterilization is accomplished by maintaining a

temperature of 190 degrees F. for a minimum period of 20 minutes. The average current consumption is 2½ kwh per sterilization.

Prior to the installation of this sterilizer, chemicals had been used for sterilizing. The electric sterilizer reduced the bacteria count from over 500,000 to less than 5,000. The actual construction cost was approximately $60.00 exclusive of labor.

The owner of this dairy states. " I do not think there is any better sterilizer to be had than the electric one we use. Our bottles are always dry, there is no odor from chemicals and we know that the bacteria is killed." A storage type water heater is used for supplying hot water.

The other sterilizer near Bluefield was similar to the one just described, and the opinion of the owner was that the equipment was both economical and satisfactory.

The controlled humidity type sterilizer seemed to be the most generally practical one for dairies in the T. V. A. area for reasons already stated in this report. It was, therefore, decided to make tests on at least two commercially made units of this type, and to build a laboratory model for similar tests. This procedure seemed desirable because one of the main objectives of this study was to determine the possibilities of developing an efficient home-made model, flexible in size and desirable for dairies in the T. V. A. area. The remainder of this report will describe the construction of the laboratory sterilizer and the tests conducted on it and two commercially manufactured sterilizers.

1. [redacted] Sterilizer: No 1.

This sterilizer is located at the University of Tennessee dairy farm, Knoxville. The cabinet holds two ten gallon cans and other small utensils. The connected load is 1500 watts, and the temperature is automatically controlled by a thermostat. The cost of this sterilizer is approximately $175.00.

Several tests were made to determine the effectiveness of sterilization, current consumption and time required for sterilization. Each of these tests are illustrated on the following charts. The bacteria counts were made by the department of bacteriology at the University of Tennessee.

2. [redacted] Sterilizer; No 2

This unit is also located on the University of Tennessee Dairy Farm. It consists of an insulated cabinet with a capacity of 3 ten gallon cans and small utensils. The connected load is 2500 watts and the temperature is controlled by an adjustable thermostat. The cost of the unit is approximately $225.00.

Operating tests were made under normal operating conditions, the results and descriptions of which are shown on the following graphs. All bacteria tests were made by the department of bacteriology at the University of Tennessee.

3. Laboratory Sterilizer;

The working drawing included in this report is that of the electric sterilizer which was constructed for this study. The cabinet was constructed, using 2" x 4" wood framing, which was covered on both the inside and outside with copper bearing steel. This design provides a two inch spacing between the metal in walls, top and bottom, which was packed with mineral wool insulation. All corners and seams on the inside were soldered with high temperature solder to prevent moisture from entering the insulation. The hinged door was designed to be held tightly shut by two self tightening clamp latches, and the facing was lined with a composition rubber gasket to insure an air tight fit. The inside dimensions of the cabinet were $34\frac{1}{2}$" deep, $42\frac{1}{4}$" wide and 50" high with a volume of approximately 45 cu. ft.

A steel rack was constructed to support the electric strip heaters and the electric wiring. To assure a definite circulation of air within the sterilizer and to aid in dissipating the heat uniformly, a perforated sheet metal baffle plate was constructed and installed over the heaters. Utensil racks were constructed of 1/2" steel rods welded together. A 1/2 inch air vent was built into the bottom of the cabinet to allow excess water to drain out, and to prevent an excessive pressure from building up at sterilizing temperature. An automatic adjustable thermostat was used to cut off the current when the desired temperature was attained in the cabinet.

In testing the sterilizer to determine the most efficient wattage of heating elements, and its effectiveness for sterilizing utensils, temperature measurements were taken with a self compensating indicating performeter and thermocouple. The thermocouples were first checked against a structural thermocouple. In all tests the temperature was taken at various points in the cabinet simultaneously to determine the maximum temperature differential.

Tests were made to determine the radiation loss through the two inch mineral wool insulation. This was done by varying the total wattage to determine the number of watts required to maintain a constant sterilizing temperature. It was found that 500 watts would maintain a constant temperature of 184 degrees F. when the room temperature was 70 degrees F. The heat loss through the walls of the cabinet with a temperature differential of 114 degrees was 0.35 b.t.u. per sq. ft. per minute. Tests were continued with various wattages to determine the best operating wattage for the sterilizer. It was found that the temperature differential inside the cabinet was less, or that a more uniform temperature was obtained, with a total wattage of 3000. Using 3000 watts with the cabinet loaded with utensils, approximately one hour's operation was required to attain a sterilizing temperature. Wattages of 1500, 2000, 2500, 3000, 4000, and 5,000 were tried. Six 500 watt strip heaters were, therefore, permanently installed in the sterilizer, and all the operating tests covered in this report were made with this wattage.

Numerous tests were made in an effort to determine the most economical sterilizing temperatures. It was found that when the utensils were heated to 180 degrees F. and held at this temperature for 30 minutes, sterilization was as complete as was attained with a temperature of 212 degrees F. maintained for 30 minutes. By using an operating temperature of 180 degrees F. then, the current consumption difference was .8 kwh per sterilization and the time of sterilizing was 14 minutes less than was required when a temperature of 212 degrees F. was used.

The attached curves with the bacteria count shown on the same sheet illustrate the sterilizing results and time involved in each test.

CONCLUSIONS:

1. The controlled humidity type sterilizer does a positive job of sterilizing utensils.

2. The size of the sterilizer can be varied and designed to meet the needs of any size dairy.

3. The cost of materials for constructing the sterilizer built for this study was approximately $58.00.

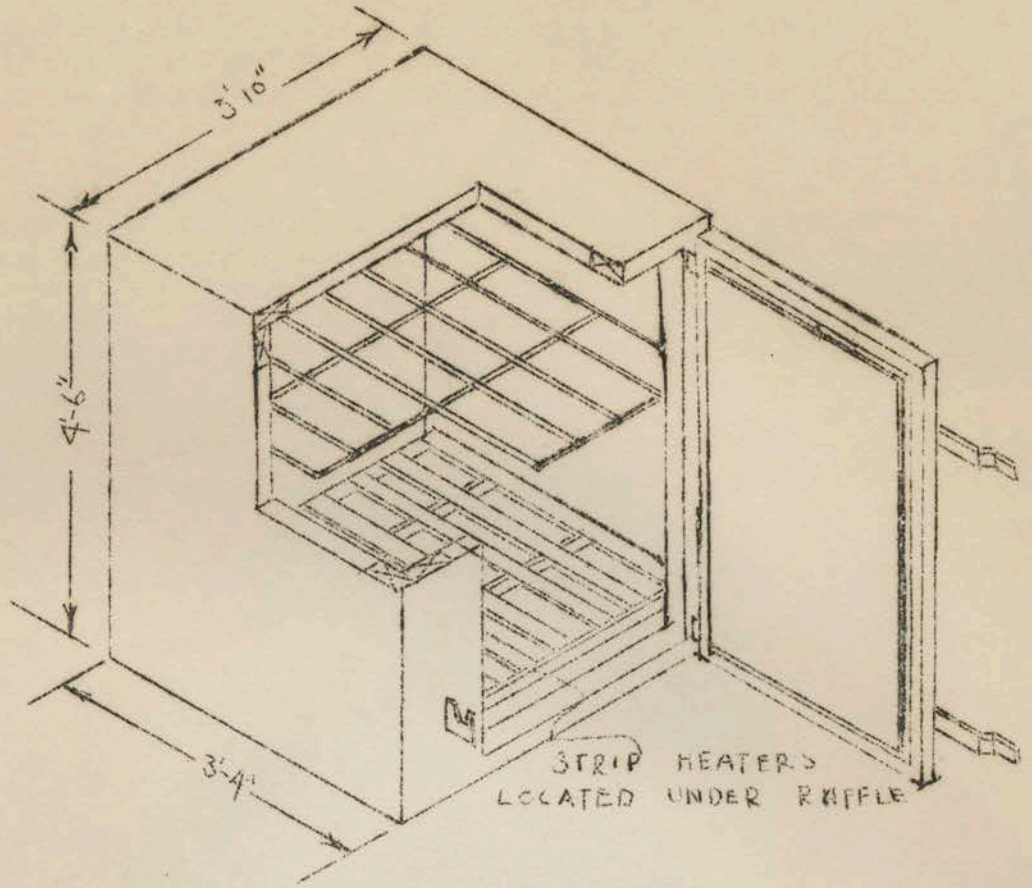
4. The laboratory sterilizer proved more efficient than either of the two commercial units tested. This may have been due to a better fitting door, better insulation or a more efficient operating temperature.

5. This type sterilizer can be constructed by any one with the aid of a tinsmith, saving considerable on the first cost, and at the same time be "tailored to the needs" of the dairy where it is to be operated.

6. An operating temperature of 180 degrees maintained for 30 minutes is the most practical and economical and will insure thorough sterilization.

7. In designing sterilizers of this type, the necessary wattage can be determined by allowing 65 watts per cu. ft. cabinet volume where 2 inches of mineral wool or its equivalent is used for insulation and the approximate room temperature is 70 degrees. Where the room temperature will be below 70° F., 5 watts should be added per cu. ft. cabinet volume for each 10° F. that the room temperature might be under the standard of 70° F.

7. This type of sterilizer does not provide means of heating water, however, it has been found that the most satisfactory and economical method of heating water with electricity in dairies is by the use of a storage type hot water heater. Although this involves the purchase of an additional piece of equipment, the total cost of the sterilizer and water heater would not exceed that of a single unit to do both jobs for the same dairy. On practically all localities special "off peak" rates are available for water heaters, thereby reducing costs for current.



ISOMETRIC VIEW
OF
LABORATORY STERILIZER

BILL OF MATERIAL

6 - 500 Watt Strip Heaters @ 2.25	$ 13.50
100 - lbs. mineral wool	4 30
1 - Thermostat	12.00
100 - ft 2"x 4"	2.00
7 - Sheets 20 gauge copper bearing Metal 45" x 96"	18.00
Metal for racks	1 00
Hinges, pipe, wire, etc	7 20
	$58.00

Scale 3/4" = 1'-0"

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