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ELECTRIC EQUIPMENT FOR THE BACTERICIDAL TREATMENT OF DAIRY UTENSILS

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VIRGINIA AGRICULTURAL AND MECHANICAL COLLEGE AND POLYTECHNIC INSTITUTE
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FOREWORD

Laboratory tests and field observations on electrically operated humidified hot air sterilizers have been completed by the Agricultural Engineering Department of the Virginia Polytechnic Institute. The results of this work show that this type of equipment will effectively and economically destroy bacteria on dairy utensils. The purpose of this bulletin is to discuss the operation and use of the humidified hot air sterilizer as applied to Virginia dairy farms.

The Dairy and Food Division of the Virginia State Department of Agriculture cooperated in analyzing test data, resulting in the approval of this method of sterilization. Acknowledgement is made of the suggestions and guidance of Professor C. W. Holdaway, head of the V. P. I. dairy department, and of the assistance of S. M. Beane and R. H. Jones in conducting the laboratory tests.

Electric Equipment for the Bactericidal Treatment of Dairy Utensils

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Introduction

The treatment of dairy utensils with either heat or a disinfectant for the purpose of lowering the bacterial count of milk has been a step required in dairy production for many years. The continual demand for higher quality dairy products, supported by more rigid requirements of health authorities and inspection services, makes the treatment of utensils for the reduction of bacteria an even more important step in the operation of a dairy.

Equipment or processes used for treating dairy utensils for reducing the number of living micro-organisms on the utensils should be designed to produce two results. The most important result is that of destroying living organisms to the extent that the utensils will approach sterility. This is the primary purpose of the treatment; however, unless the utensils are left in a clean, dry condition after treatment, harmful bacteria will grow on them at a rapid rate by the time they are used in the dairy again. Of the many methods of treating utensils in the past, few of them consistently do a thorough job of killing bacteria and few, at the end of the processes, leave the utensils dry enough to prevent the growth of bacteria on them.

During recent years much study and research work has been done on the development of equipment that will produce these results both consistently and economically. The outcome of this work is an electrically heated cabinet, the operating temperature of which is controlled automatically. The equipment is generally referred to as a "Humidified Hot Air Sterilizer," because of the principle on which it operates.

The rapid extension of electric distribution lines into the rural areas of Virginia, and the low cost of electricity on the farm in most cases, are making it possible for a large number of Virginia dairymen to utilize this new equipment. The purpose of this bulletin is to explain the humidified hot air electric dairy utensil sterilizer, its operation and use as applied to Virginia dairy farms.

The Principle of the Humidified Hot Air Treatment

It has been found by laboratory tests that sterilization is primarily a function of time and temperature (Rahn of Cornell), but the moisture content of the air influences the time and temperature necessary to accomplish satisfactory sterilization. *No practical heating process has been developed that will kill all living micro-organisms, thereby attaining complete sterilization. The terms "Sterilizer" and "Sterilization" are, therefore, used to denote sufficient bacterial reduction to make utensils bacteriologically clean for dairy purposes.*

Laboratory tests on the type of utensil sterilizer discussed in this bulletin proved that a longer holding period and a higher temperature were necessary when the utensils were placed in the cabinet dry than when they were washed and packed into the cabinet wet. Although satisfactory sterilization resulted from each of these methods of operating the equipment, the higher temperatures and longer holding period required by the dry method obviously resulted in a higher consumption of electricity and, therefore, a higher operating cost. The principle of humidified hot air sterilization simply means the treatment of utensils in a heated cabinet in which a limited amount of water has been evaporated to increase the humidity of the air in the cabinet. The small quantity of water that clings to utensils after washing supplies a sufficient amount of water for this purpose. It is fortunate that this method of operation has proved to be more economical because it enables the dairy operator to wash the utensils and place them in the cabinet without drying them, thereby saving time and labor.

The actual procedure in using this type sterilizer in processing utensils in a dairy is: As the utensils are washed, they are placed in the cabinet. When the cabinet is full, or when all the utensils to be sterilized are placed in the cabinet, the door is closed tightly. A push button is provided on the termostat which, when tripped, starts the cabinet to heating. The sterilizer will then complete the job without any further attention of the operator. When the air inside the cabinet reaches the proper temperature (approximately 200° F.), the thermostat automatically turns off the electricity. The insulated cabinet will keep the temperature above the required minimum of 180° F. for fifteen minutes, completing the sterilizing process. The high temperature within the cabinet will drive off all the moisture through the vent located in the bottom of the cabinet, and the utensils are left in the sterilizer, remaining clean and dry, until they are used again.

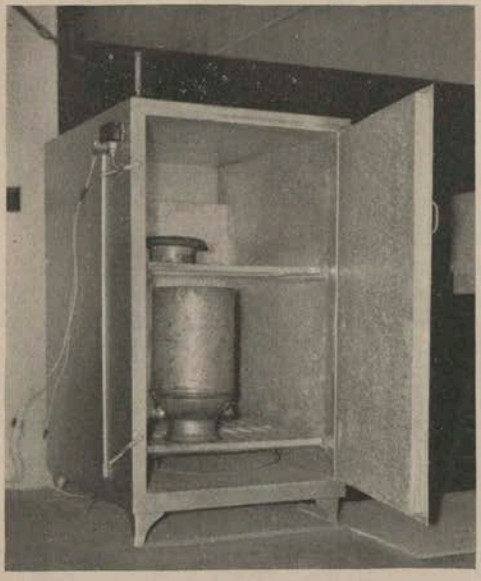


Figure 1.—A commercially built humidified hot air dairy utensil sterilizer for four ten-gallon cans. The top compartment is for milking machine parts, pails, and other smaller utensils.

Description of the Equipment

The humidified hot air electric utensil sterilizer consists of a well insulated cabinet large enough to hold all the dairy utensils that are to be sterilized at a given time. The cabinet is cubical in shape and is constructed of rust-and-corrosion-resisting metal over a wood or metal frame. At least two inches of mineral wool insulation, or the equivalent, is necessary in all sides of the cabinet for economical operation. Heat is produced by electric "strip" or "space" heaters located in the bottom of the cabinet, over which is mounted a baffle plate to aid in maintaining a uniform temperature throughout the cabinet. The electric heaters are controlled by an adjustable thermostat located on the outside of the cabinet. A permanently installed indicating thermometer is placed in the top of the sterilizer to enable the operator to observe the actual temperature of the air on the inside. An angle iron rack for supporting cans or other large utensils is located just above the baffle plate, and another angle iron rack is provided near the top for supporting smaller utensils and equipment. The actual shape of the cabinet and location of utensil racks depend on the type and quantity of utensils to be treated. Figure 1 illustrates a typical commercially built unit.

Results of Sterilizer Tests at V. P. I.

In order to provide Virginia dairy operators with information on the humidified hot air sterilizer as applied to their particular needs and operating requirements, a series of laboratory tests and field observations were made by the Agricultural Engineering Department at the Virginia Agricultural Experiment Station. This study was planned to thoroughly test commercially made sterilizer units of this type and to improve the design of the equipment to make it more adaptable to Virginia requirements. Two commercially built units were tested in the laboratory, and a laboratory unit was constructed and tested. The laboratory unit was used chiefly to test various design features of this type of sterilizer. Observations were made and data recorded on several units in actual operation in the field. The information and recommendations given on the use of the equipment are based on the data secured, and on the results of the tests made.

Tests were first made to determine the time and temperature required to kill bacteria in the humidified hot air type cabinet. One commercial unit and the laboratory-constructed unit were used in the tests where bacteria counts on the utensils were made before and after processing to determine the bacterial reduction. Dairy utensils in regular use in the V. P. I. dairy were used in making the tests. The general procedure for each test was: The utensils were washed in warm water and granulated soap and a definite quantity of sterile water was poured into each of them and used as a rinse for the utensil. The ten-gallon cans were rinsed with 1000 c.c. of sterile water and the three-gallon cans with 200 c.c. After shaking the utensil with the rinse water in it, a sample of the rinse water was poured into a sterile sample bottle and analyzed by the plate count method as prescribed by the American Public Health Association for milk analysis. The remainder of the rinse water was then emptied, and the utensil was numbered for identification and placed in the sterilizer cabinet.

When the sterilizer was filled with utensils, the current was turned on and the cabinet was heated to the temperature desired for that particular test. A 15-minute holding period was allowed after the current was automatically cut off in each test. Each utensil was again rinsed with the standard quantity of sterile water, and another sample was taken and tested for bacteria count as before.

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

Results of tests on both the laboratory-built and commercial unit showed that bacterial reduction was as complete when the utensils were heated to 180° F. as it was when the sterilizer temperature was increasd to 212° F., the utensils being held above each of these temperatures for at least 15 minutes. This result confirms the Public Health Service Ordinance and Code requirements for bactericidal treatment in a steam cabinet, which calls for a temperature of 170° F. for a period of 15 minutes. The consumption of current was from 25 percent to 30 percent less when the equipment was operated at 180° F. than when the sterilizer was heated to above 212° F. Since the bacterial reduction was just as complete at the lower temperature, it is, therefore, recommended for general practice.

The utensils must be held at or above 180° F. for at least 15 minutes. It was found that the temperatures within the sterilizer cabinets varied at different points, depending on the arrangement of utensils and the type of utensils being sterilized. In order to store in the cabinet enough heat that the minimum temperature remained above 180° F. during the 15-minute holding period, it was necessary to set the thermostat at 200° F. at which temperature the current was cut off. In the tests where a cabinet temperature of 212° F. was desired, the thermostat was set to cut off at 220° F.

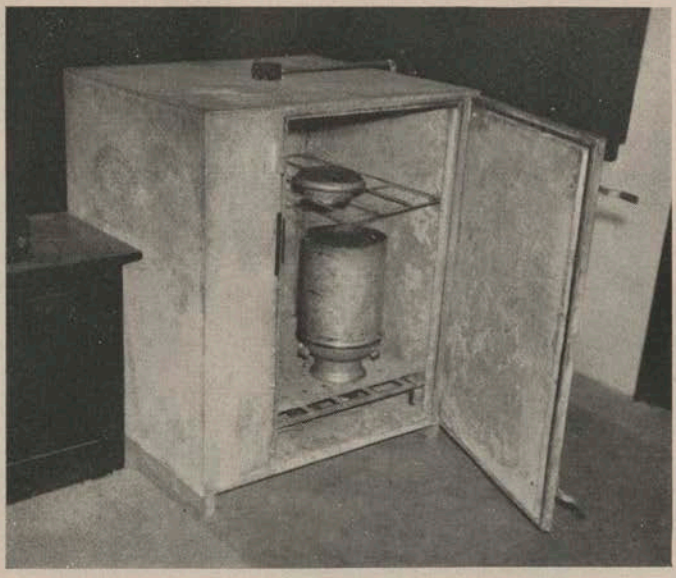


Figure 7.—A humidified hot air electric utensil sterilizer constructed in the laboratory for test purposes. Plans are available for building homemade sterilizers of this type.

One small sterilizer was tested that had built into it provisions for heating up to three gallons of hot water. This unit proved to be well adapted for use on farms where up to eight cows were being milked. The heating units in this type of sterilizer are controlled by a time clock instead of a thermostat; however, the time clock controls both the water heating and sterilizing operations automatically. This equipment requires no special wiring, and is designed to operate on 115 volts. The retail price is approximately $65 and it consumes about 125 kilowatt-hours per month in processing the utensils for up to an eight-cow dairy.

Summary of Test Data on Electric Dairy Sterilizers with Cabinets Loaded

COMPARISON OF TESTS HEATING TO 212°F
HUMIDIFIED HOT AIR

Sterilizer unit	Average volts	Average amperes	Average watts	Total Kwh used	Cabinet volume	Kwh per cu. ft. volume	Installed watts per cu. ft. vol.	Average max. temp.	Average room temp.	Time required to cut off
					Cu. ft.			°*F.*	°*F.*	*Min.*
Commercial	234	11.2	2560	4.6	30	.153	83	216	78	108
Homemade	234	13.2	3100	4.4	38	.116	80	214	77	85
Commercial comb.[1]	115	8.35	944	.98	8	.121	125	198	81	57

COMPARISON OF TESTS HEATING TO 180°F
HUMIDIFIED HOT AIR

Commercial	233	11	2540	2.75	30	.091	83	187	77	65
Homemade	230	13	3000	3.00	38	.080	80	181	80	60
Commercial comb.[1]	115	8.35	944	.98	8	.121	125	198	81	57

COMPARISON OF TESTS HEATING TO 220°F
DRY AIR

Commercial	233	11.2	2560	4.4	30	.148	83	226	79	106½
Homemade	229½	13	2990	4.6	38	.123	80	228	80	92
Commercial comb.[1]	116	8.55	962	.86	8	.107	125	201	83	57

[1]Operation controlled by a time switch having a fixed period of operation.

Homemade Sterilizers

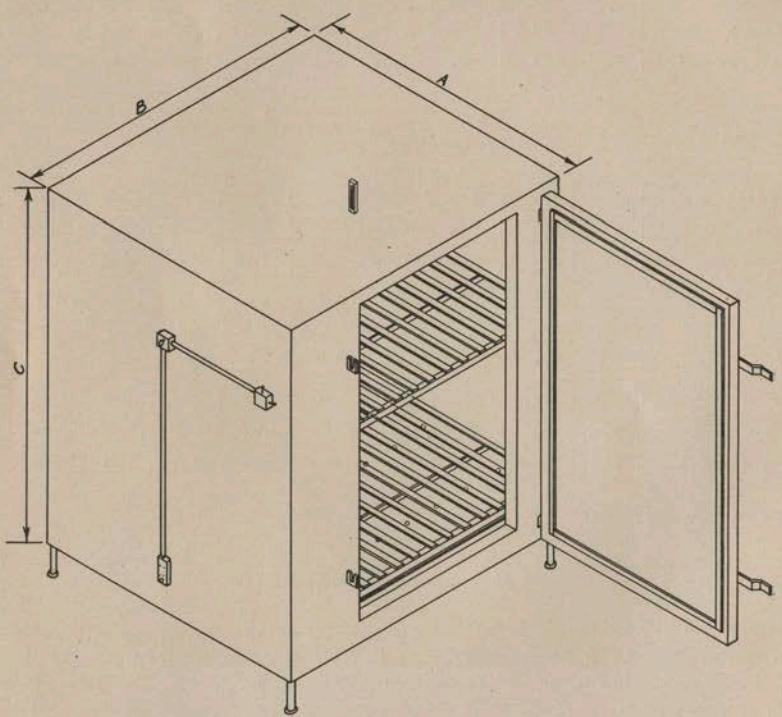
Under some conditions it is to the advantage of the dairy operator to have a local tinsmith build the humidified hot air sterilizer. It is often possible to build a unit locally cheaper than it can be bought commercially. The size of cabinet needed is sometimes so large that the door to the milk house will not permit its passage, therefore, it is necessary to assemble the sterilizer in the milk house. Where a homemade unit is to be built, care should be taken to secure the proper materials and the services of a mechanic who is qualified to do a good job. Figure 8 shows an isometric view of a homemade unit. The dimensions A, B, and C are given in the following table for various size cabinets:

Table of Dimensions for Homemade Humidified Hot Air Electric Sterilizers

Capacities[1]		Outside dimensions			A. C. heating units		Plan No.[2]
Quart cases	10-gal. cans	A	B	C	Watts	Volts	
4	2	34	25	55	1500	230	B-530-1
8	4	44	34	55	2500	230	B-530-2
12	6	44	48	55	3000	230	B-530-3
16	9	48	58	55	4000	230	B-530-4
20	12	48	72	55	5000	230	B-530-5

[1]Capacities shown are for lower compartments of cabinets. Upper compartment will hold small utensils for corresponding size dairies. Removal of top rack will double the capacity of cabinet for cases of quart bottles.

[2]Working drawings for any of the above cabinets may be secured by writing the V. P. I. Agricultural Engineering Department and requesting the plan number shown.



ISOMETRIC VIEW

Specifications for Electric Humidified Hot Air Sterilizer

It is necessary that electric dairy utensil sterilizers of this type meet certain specifications in design and accessories in order to assure the dairyman of consistently satisfactory operation. The Dairy and Food Division of the Virginia State Department of Agriculture and health inspectors require that units meet these specifications before approval can be given for their use. These requirements are as follows:

1. The outside covering and inside lining of the cabinet shall be of rust-and-corrosion-resisting metal that can be easily cleaned. The steel racks and interior fittings shall be painted with two coats of good grade aluminum paint to prevent rust.

2. The cabinet walls, top and bottom, shall contain at least two inches of mineral wool or insulation of an equivalent insulating value.

3. The electric heating units shall be controlled by an adjustable thermostat, incorporating the features of automatic "cut off" and "manual reset."

4. The sterilizer shall have a permanently installed indicating thermometer located on the outside so that the inside temperature may be observed at any time.

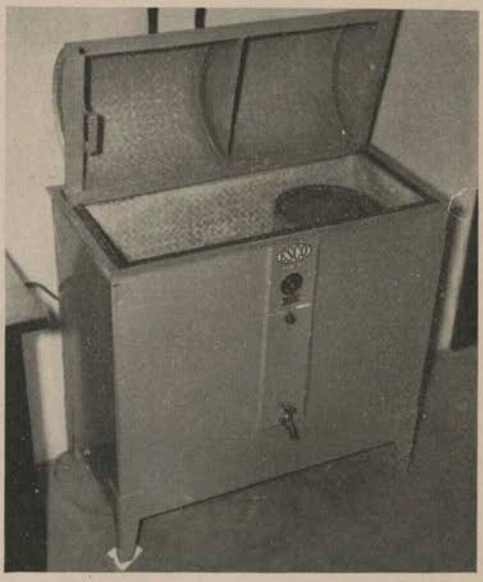


Figure 6.—A small combination electric water heater and utensil sterilizer available for small dairies. A three-gallon tank for heating water is located in the center of the cabinet. Note the design of the cabinet lid which provides vats for holding wash water.

Methods of Providing Hot Water

The design of the humidified hot air electric sterilizer is such that it will not provide hot water for washing utensils in the dairy (except the small combination unit), therefore auxiliary equipment must be provided for heating water. A study of electric rates in Virginia shows that where the cost of electricity is low enough for the dairyman to use electricity for sterilizing utensils, a satisfactory rate is also available for heating water with electricity. The types of electric water heaters suitable for use in the dairy can be placed in three general groups. A brief description of this equipment, and electric rates usually applicable, follow:

1. **Small electric water heaters.**—This group includes various types of water heaters with a capacity of 3 to 20 gallons each. Sizes up to 10 gallons are usually manually controlled in operation and the 10-gallon or larger sizes are usually automatically controlled with a thermostat. Usually water heaters in this group require no pipe connections or plumbing, and the power requirements are low enough that no special wiring is necessary. The price will vary from $18 for the smallest manually controlled unit to $55 for the 20-gallon automatic unit. Approximately four gallons of water can be heated to 150° F. with one kilowatt-hour of electricity in well constructed water heaters. Units of this type are operated on the regular farm or domestic service electric rates. This means that the cost of the electricity will usually be from 1¼ cents to 2½ cents per kilowatt-hour, depending on present usage and the electric rate of the company serving the farm.

2. **Large automatic storage water heaters.**—This group includes units of 30 to 120 gallons capacity. These heaters consist of heavily insulated tanks containing immersion-type heating units automatically controlled with a thermostat. They are designed to be permanently installed with rigid pipe connections, and to provide hot water on tap without the attention of an operator. The power requirements of this type heater are such that it cannot be operated from a convenience receptacle, therefore, it must be served direct from the main switch box in the milk house. Where an electric sterilizer is used, the switch box provided is large enough to carry the water heater also. This equipment operates very efficiently due to the heavy insulation, and the current consumption per gallon of water heated is slightly less than that of the small units. The equipment is operated on the regular farm or domestic service rate at a cost of 1¼ cents to 2½ cents per kilowatt-hour, except where electric service companies have a special rate provision, which should lower the cost to 1 cent or 1¼ cents per kilowatt-hour. Storage type water heaters cost from $65 up, depending on the capacity of the tank.

3. **Time controlled automatic storage water heaters.**—This type water heating equipment is essentially the same as that described in Group 2 except that an automatic time clock is built into the unit to control the operation of the heating units. This time clock is set by the Electric Service Company so that the water heater will operate during "Off Peak" hours, a period when the load on the power lines is lowest. For this reason a special low rate for electricity is given, and the electricity used for heating water is measured by a special meter. The rate usually applicable to this type equipment is one cent per kilowatt-hour. Because of the principle on which this type water heater operates, it is usually advisable to install a larger size unit in order to be assured of an abundance of hot water while the heater is not operating. The cost of this equipment is from $80.00 up, depending on the capacity of tank required.

The size and type electric water heater best suited for a particular dairy will depend on a number of conditions, such as the amount of hot water required per day, electric rates available, the value of automatic operation, etc. Practically all of the commercially made types of equipment are simple in design and will give long, trouble-free service. If the dairy has water under pressure available, the most efficient and satisfactory equipment is usually an automatic storage type heater, permanently installed.

Comparison Between Different Treatments

The use of a steam boiler with either a steaming jet or steaming cabinet has been the most popular approved method of heating water and sterilizing dairy utensils in Virginia. This equipment, when properly installed and operated, has produced a satisfactory reduction of bacteria. A study of the principle and procedure involved in the operation of this equipment as compared with the use of the electric humidified hot air sterilizer and storage water heater indicates that the electric method offers certain advantages over the steam boiler method. These comparisons and advantages from an operation standpoint are as follows:

1. The humidified hot air treatment is equally as effective as the steam boiler method in reducing bacteria on dairy utensils.

2. Sterilizing results are more consistently uniform with the automatic electric equipment since the human element is removed from the operating procedure.

3. Labor requirements are practically eliminated since there is no fuel or ashes to handle and no fire to kindle, nor is the attention of an operator required in operating the equipment.

4. There is no time lost waiting for water to heat or steam to generate.

5. The hazard of an open fire around the dairy buildings is eliminated.

6. There are no odors, dust or dirt, resulting in a cleaner and more sanitary milk house.

7. The wash room is practically free of steam.

8. The utensils are left dryer and the cabinet provides a clean, dry storage place for them between milkings.

9. The equipment is simple in design and has long life, resulting in low maintenance and depreciation costs.

10. The cost of the milk house is lowered by eliminating the need for the room required by a boiler.

A survey was made of a number of dairies, ranging in size from 20 to 40 cows, in which steam boilers fired with coal were being used. The survey showed that on an average, 85 pounds of coal were required per cow per month. The survey also showed that an average of 40 minutes per day were required of the operator for handling kindling material, fuel and ashes and firing the boiler.

It was found in the tests of the electric humidified hot air sterilizer that when the cabinet is designed to hold all the utensils at any one milking, the current consumption for sterilizing will average approximately eight kilowatt-hours per cow per month. These average figures for fuel consumption are for a 30-cow dairy. In larger dairies, the fuel requirement is less per cow and in smaller dairies the fuel consumption is higher per cow. Standard storage type water heaters use approximately one kilowatt-hour of electricity in raising the temperature of four gallons of water 100° F. In normal operating practice, water is heated to about 155° F. for washing and rinsing. Assuming that the temperature of the

water is around 55° F. when it enters the heater, current consumption for heating water can be estimated to be one kilowatt-hour for heating four gallons.

Using these figures, a fairly accurate comparison of the actual fuel costs for heating water and sterilizing by the two methods can be made. To illustrate, assume that a dairy operator has 30 cows and he wishes to wash and sterilize utensils twice daily. The amount of coal required would be 30 × 85 pounds = 2550 pounds per month, which is approximately 1¼ tons. The amount of electricity required for sterilizing would be 30 × 8 kwh. = 240 kilowatt-hours per month. Assume that 30 gallons of hot water is required per day, and that one kilowatt-hour heats four gallons of water. Then, 30 × 30 days = 900 gallons per month, divided by 4 = 225 kilowatt-hours of electricity per month for heating water. Assume further that in the community where this dairy is located, coal costs $6.00 per ton, that the electricity used for sterilizing will average 2 cents per kilowatt-hour, and that electric water heating rate is one cent per kilowatt-hour. A comparison of total fuel costs by each method in this case would be:

Coal: 1¼ tons @ $6.00		$7.50
Electricity: 240 kwh. @ 2 cents	$4.80	
225 kwh. @ 1 cent	2.25	
Total		$7.05

The cost of coal varies from $3.00 to $14 per ton in Virginia, electric rates also vary among the electric service companies. The logical procedure to follow in comparing the cost of each method is to check the cost of coal delivered to the dairy and get complete information from the rural service representative of the company providing the electric service on the cost of electricity according to the applicable rate. If the labor item is considered, it will add to the cost of the steam boiler method since it requires an average of 40 minutes of an attendant's time per day.

The first cost of the sterilizing equipment is approximately the same for both methods, therefore the comparative cost of fuels and the value of automatic operation are the most important factors to consider in comparing the two methods.

Recommendations for Use of the Equipment

The humidified hot air type electric sterilizer is adaptable for use in dairies having up to 75 cows. The size and shape of unit required will be obviously determined by the quantity of bottles and utensils that are to be processed.

For small milk producers having up to 8 cows, the small combination water heater and sterilizer unit is ideal. It provides hot water, and will do a good job of sterilizing utensils with a low investment in equipment, and at low operating cost.

The larger sterilizer units are usually rated according to the capacity of the cabinet in terms of the number of ten-gallon cans or crates of quart bottles that it will hold. In selecting the proper size unit for a particular dairy, the simplest and easiest plan is to select the size that will hold all the ten-gallon cans or crates of bottles in the lower compartment; the top compartment will usually be large enough to hold the smaller utensils, such as pails, strainers, milking machine parts, tubular coolers, etc.

If any increase in the size of the dairy herd is anticipated in the near future, it is wise to consider this factor also and install a unit large enough to handle adequately the increased number of utensils that will be needed.

Summary and Suggestions

1. The humidified hot air electric utensil sterilizer will do a positive and uniform job of killing bacteria on dairy utensils.

2. The advantages of this type equipment merit the consideration of any dairy operator where the equipment is adaptable.

3. It is essential that adequate electric wiring be provided for the economical operation of either sterilizing or water heating units. Consult a good electrician, or the rural service engineer of the electric service company serving the farm.

4. Be sure that the sterilizer unit meets the necessary specifications so that it will be approved by the dairy inspector.

5. The operating cost of electric sterilizers and water heaters will depend on the amount of electricity already being used and the available electric rate. For this information, see the rural service engineer of the local electric service organization or write the V. P. I. Extension Division, giving complete details.

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