**PREFACE**

This manual has been prepared as a tool to be used in the training and the development of more knowledgeable, competent high temperature-short time (HTST) pasteurizer operators. It represents an effort to fulfill the need for a concise review of the design, function, and operation of modern HTST pasteurizer systems. The manual is the result of approximately 18 months of planning and preparation by the Education and Training Committee of the Oregon Association of Milk, Food and Environmental Sanitarians, Inc. This project has been conducted with the sponsorship and the full support of the Sanitarians Association.

The Committee did not conceive this manual to be a complete text on the operation and the maintenance of HTST pasteurizer systems. It is an information source calling attention to the important basic information for understanding the product flow, time and temperature controls, the principles of heat exchange, and the necessity for operational safeguards. Important regulations and laws pertinent to HTST pasteurizer operation and sanitation requirements are included in the text. The pasteurizer operator will also need to study or to refer to the equipment manufacturer's instruction manuals covering his equipment.

On the premise that knowledge of the fundamentals of dairy microbiology, chemistry, cleaning, and sanitizing are essential to the development of a better-qualified dairy plant employee, brief presentations of material from these subject areas are included in the manual. A glossary of terms and definitions is included for orientation and review purposes. An appendix provides a discussion of several detailed operation and maintenance operations for individual equipment items.

The primary purpose for this publication is to serve as a single, comprehensive source of study materials for Oregon HTST pasteurizer license applicants. Criticism of this second edition is welcomed as a guide in the preparation and the improvement of future editions. We hope that this manual is in fact what the title implies - a most helpful, authoritative *HTST Pasteurizer Operation Manual*.

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ACKNOWLEDGMENTS

The preparation committee gratefully acknowledges the assistance and the cooperation of the following firms, agencies, and associations:


2. The Pennsylvania State University for permission to adapt certain material from the Manual for Dairy Manufacturing Short Courses.


5. The Syandotta Chemicals Corporation, J.B. Ford Division, for granting permission to utilize data from Wyandotte Technical Service Bulletin S-401 Revised.

We would especially like to express appreciation to Mrs. Irene Hodary and Mrs. Darlene Steffani for their excellent secretarial and typing assistance in preparation of the first edition. Without their patience and understanding, this endeavor would have been much more difficult.

The Oregon Association of Milk, Food and Environmental Sanitarians, Inc. wishes to dedicate this second edition of the HTST Pasteurizer Operation Manual to Jim Green, formerly milk plant superintendent of the Carnation Company milk plant, Portland, Oregon. Jim was a co-author and the industry representative on the committee which prepared the first edition of this manual.

Jim received his B.S. degree in dairy industries from Iowa State University. After operating his own dairy for a few years, Jim joined Carnation at Waterloo, Iowa on May 5, 1952. In 1957, he was transferred to Mason City, Iowa as Assistant Plant Superintendent. In 1962, Jim returned to Waterloo as Quality Control Director. In 1966, Jim transferred to Portland as Quality Control Director. In April, 1970, Jim was promoted to Milk Plant Superintendent. Jim was truly dedicated to the dairy industry, having served actively on several committees for the International Association of Milk, Food, and Environmental Sanitarians. Jim's knowledge of the dairy industry, integrity, and sense of fair play was recognized and respected by everyone who knew him.
HTST PASTEURIZER OPERATION MANUAL
PART 1
INTRODUCTION TO THE HTST SYSTEM
SECTION A
Public Health Significance

Pasteurization, at this time, is the most practical means of insuring a consistently safe milk supply. Pasteurized milk is now one of our safest foods; but when contaminated, it may become the most dangerous because milk is a perfect medium for bacterial growth.

The high temperature-short time (HTST) pasteurizer unit is designed with safeguards to prevent human error or equipment malfunction. These safeguards are necessary to insure pasteurization of every particle of milk.

The heating and the cooling regeneration features of the HTST unit offer important efficiencies by conserving heat, refrigeration, space, and time requirements.

Carefully selected temperature and time relationships (one is as important as the other) are required to destroy pathogenic or disease-producing bacteria and coliform microorganisms found in raw milk. Emphasis must be placed on the fact that pasteurization should not be considered a substitute for good sanitary practices.
SECTION B
Glossary of Terms

Air Relief Valve - See Vacuum Breaker.

Air Supply - A supply of clean, dry, oil-free compressed air.

Balance Tank - See Constant Level Supply Tank.

Bonnet - The flow diversion valve housing, which contains the valve actuating mechanism. 

Booster Pump - An optional auxiliary pump used to assist the timing pump to promote flow through the raw milk regenerator.

Bourdon Coil (or Bourdon Spring) - A component of the recorder controller consisting of a coiled metal tube which expands or contracts under influence of the temperature sensing bulb in the holding tube, actuating the recorder controller mechanism.

Capillary Tube - An armored flexible tube containing other derivative which actuates a Bourdon coil in the recorder controller in response to temperature changes in the holding tube.

Centrifugal Pump - Any pump which produces flow by centrifugal force.

Clarifier - A machine which removes foreign matter from milk by centrifugal force.

Constant Level Supply Tank - A tank situated in such a way as to provide a constant supply of raw milk to the HTST system.

Cooler or Cooling Section - The section of heat transfer plates which cools the milk after pasteurization, having a cooling medium on one side of each plate and pasteurized milk on the other.

Deflector Plate - A plate designed to route the flow of milk through groups of plates (passes) in the refrigerator.

Diaphragm - A rubber-like disc in the flow diversion valve housing which will respond to air pressure and thereby actuate the flow diversion valve.

Diversion Line - A sanitary pipeline from the diverted flow port of the flow diversion valve back to the constant level supply tank.

Diverted Flow - The flow of sub-legal milk from the flow diversion valve back to the constant level tank.

Downstream, Upstream - Terms used to describe the relative locations of components of the HTST system. Downstream - In the direction of flow. Upstream - In the opposite direction of flow. Example - The raw milk regenerator is located downstream from the balance tank, or further along in the direction of flow.

Float Tank - See Constant Level Supply Tank.

Flow Diversion Valve (FDV) - A three-way valve designed for controlling the direction of the product flow.

Forward Flow - The flow of legally pasteurized milk through the forward flow port of the flow diversion valve and downstream through the pasteurized milk regenerator and the cooling sections.

Frequency Fan - A second pan on the recorder controller which changes position to record the time the flow diversion valve is in the forward flow position.

Heat Exchanger Plate - A thin layer of stainless steel usually having an embossed pattern to promote heat transfer, past which milk flows on the one side and a heating or cooling medium flows on the other side.
**Hermetic Seal** - An airtight seal designed to be impervious to outside influence.

**Holding Tube** - The part of the HTST system in which heated milk is held for the required legal holding time. (See Table 3, page).

**Homogenizer** - A sanitary, high-pressure positive pump which forces milk through a homogenizing valve, breaking the fat globules up to such an extent that they do not readily separate from the milk.

**Hot Water Temperature Controller** - The instrument which controls the temperature of the heating medium.

**HTST** - Abbreviation for the term "High Temperature-Short Time" pasteurizer.

**Indicating Thermometer** - A mercury actuated thermometer located at the downstream end of the holding tube near the temperature sensor of the recorder controller.

**Metering Pump** - A positive displacement type pump which controls the rate of flow through the HTST to insure that every particle of product is held for the minimum legal holding time in the holding tube.

**Milk Flow Stop** - See Flow Diversion Valve.

**Orifice** - A flow restrictor of sanitary design which may be installed in the diversion line if needed to maintain approximately equal pressures during diverted flow as those pressures which occur during forward flow. It provides back pressure approximately equal to that developed in the cooling section.

**Pasteurization** - The process of heating every particle of milk product to legal pasteurization temperature and holding it continuously at or above the temperature for at least the specified legal holding time, in equipment which is properly operated and approved by the health authority. (See Table 3, page).

**pH** - An expression of the hydrogen ion concentration, which reflects the relative level of acidity or alkalinity of substance. On a scale of pH 14.0 pH 7.0 is considered the neutral point. A pH of less than 7.0 is on the acid side of the scale.

**Pneumatic** – Refers to equipment which is operated by air under pressure.

**Pressure Gauge** – A direct reading gauge which indicates milk pressure in pounds per square inch. (Required only if booster pump is used.) One is to be located at the discharge of the booster pump, and one is to be located downstream from the pasteurized milk regenerator.

**Pressure Switch** – A pressure actuated switch located downstream from the pasteurized milk regenerator, which controls the operation of the booster pump.

**Ratio Controller** – An instrument used with vacuum-heat flavor treating equipment to control and record the temperature differential between the point of steam injection and the outlet of the vacuum chamber; essential for the prevention of adulteration.

**Recorder Controller** – The instrument used to control the operation of the flow diversion valve, record pasteurizing temperatures, and record the length of time the flow diversion valve is in forward flow.

**Regenerator** – The section of heat transfer plated in which incoming raw milk on one side of each plate is partially heated by outgoing hot pasteurized milk on the opposite side of each plate. The pasteurized milk is, in turn, partially cooled.

**Restrictor** – See Orifice.

**Safety Thermal Limit Recorder** – Correct nomenclature for “recorder controller” (also referred to as “STLR”).
**Solenoid Valve** – A valve used in an equipment unit to either activate or deactivate an air-operated component or control the flow of liquids. The energizing of an electrical coil forces a plunger to change positions and permits pressurized air to flow to the air-operated component or controls liquid flow.

**Sub-legal Milk** – Milk which reaches the flow diversion valve at less than legal pasteurization temperature.

**Temperature Recorder** – See Recorder Controller.

**Three A Standards (3-A Sanitary Standards)** – Sanitary standards for the design, construction, and installation of milk handling and processing equipment, formulated jointly by the:
- International Association of Milk, Food and Environmental Sanitarians, Inc.
- United States Public Health Service
- Dairy Industry Committee of the Dairy and Food Industry Suppliers Association

**Timing Pump** – See Metering Pump.

**Vacuum Breaker** – A sanitary air relief valve which, when installed on a milk pipeline, remains closed as long as milk is flowing through the line under pressure, but opens to admit air as soon as the milk pressure within the line drops below atmospheric pressure.

**Vacuum-Heat Treating Equipment** – Equipment designed to subject heated milk to a vacuum to remove volatile flavor compounds or odors.

**SECTION C**

**Component Parts and Basic Flow**

Milk Flow Through Basic HTST Pasteurization System (Figure 1)

1. Raw milk, in a constant level supply tank at approximately 40° F, is sucked into the regenerator section of the HTST pasteurizer.
2. In the regenerator section, the cold raw milk is warmed to approximately 135° F by hot pasteurized milk flowing in a counter current director on the opposite sides of thin stainless steel plates.
3. In turn, the hot pasteurized milk, at least 161° F, is cooled to approximately 90° F by the cold raw milk.
4. The warm raw milk, which is still under suction, passes through a positive displacement timing pump.
5. The timing pump, having pulled the milk from the constant level supply tank, delivers the milk under pressure through the rest of the HTST pasteurization system.
6. The warm raw milk is pumped through the heater section where hot water on the sides of thin metal plates opposite the milk heats the milk to a temperature of at least 161° F.
7. The milk, now at pasteurization temperature, and under pressure, flows though the holding tube.
8. The maximum velocity of milk through the tube predetermined by adjusting the maximum speed for the timing pump and the length of the tube, is such that each particle of milk is held in the holding tube for at least 16 seconds (Oregon).

**Note:** The USPHS Grade “A” Pasteurized Milk Ordinance and Code specifies a minimum holding time of 15 seconds.

9. Located at the end of the holder are two thermometers, one an indicating thermometer and one a recorder controller. The milk passes the bulbs of both these instruments.
10. The milk then passes into the flow diversion valve which automatically assumes a forward flow position if the milk passes the recorder controller bulb at 161° F or higher.
The valve automatically assumes the diverted flow position if the milk passes the recorder controller bulb below 161° F.

11. Improperly heated milk flows through the diverted flow line back to the raw milk constant level supply tank.

12. The heated milk flows through the forward flow line to the regenerator section where it heats the cold raw milk and is simultaneously cooled to approximately 90° F.

13. The warm pasteurized milk passes through the cooling section where coolant, opposite the pasteurized milk, cool the milk to a temperature of 40° F or below. The coolant may be refrigerated water, non-toxic food-grade propylene glycol, or a combination of the two.

14. The cold pasteurized milk then passes to a storage tank or vat to await packaging.

Heat Exchangers
1. The heat exchanger plates are constructed of seamless stainless steel with synthetic rubber gaskets bonded to the plates.
2. The gaskets are impervious to absorption.
3. The number of plates used must be adequate to provide maximum number of counter current streams and a turbulent flow. (Figure 2)
4. No by-pass or short circuits around the plates are permitted, except automatically controlled valves for start-up, as may be provided in accordance with the USPHS Pasteurized Milk Ordinance and Code.
5. The raw product passage baffle plate is drilled to permit drainage of raw product. (Figure 2)

Requirements for the Holding Tube
1. The velocity of a constant volume of fluid flowing through a tube will increase upon decreasing the diameter of the tube. The holding tube is required to continuously slope upwards from the inlet of the holding tube to the flow diversion valve, to preclude the entrapment of air. Such air entrapment has the effect of decreasing tube diameter and increasing product velocity. (Figure 3)
2. To prevent variances in the slope of the holding tube, the tube supports should be permanently fixed.
3. Shortening the holding tube will decrease holding time. No short circuiting of the tube is permitted. In the case of holding tubes which form a loop, short sections of pipe on opposing sides shall be of unequal length to prevent omitting a section.

PART II

INSTRUMENTS AND CONTROLS
SECTION A
Introduction

Certain instruments and control mechanisms are essential for the automatic, precise operation of dairy processing equipment, especially the HTST pasteurizer. These control devices actually act to extend the human senses of temperature, pressure, and time concept to the equipment system involved. Instruments can detect with extreme accuracy and sensitivity, certain essential physical properties which can only be sensed crudely by human senses. Large scale automatic processing of liquid dairy products is made possible only through the maintenance of control and the monitoring of operations by these refined engineering accomplishments.
The instrumentation and the control techniques in the dairy industry have one very important prerequisite – sanitary design. Any instrument component which is in contact with the food product must be designed to rigid 3A standards to facilitate cleaning and sanitizing and for minimizing product contamination. The design of various control elements must be consistent with the operating conditions in dairy plants – stainless steel usage, special gasketing, high moisture content of air, water splashing, etc.

DEFINITIONS:

Instrument – a device which senses a physical condition of a process and produces a useful signal or indication. Examples – thermometer or pressure gauge.

Controller – a device which receives information, makes a decision, and produces a command signal. Indicating Controller – combines a visual indication with a control action.

Recorder Controller – combines a chart record with a control action.

Recorder – makes a time record of a process variable. The records are made by means of pens, each of which is actuated by a Bourdon coil, bellows, or electric motor.

Control Panel – is the center of an automated system. Process information such as temperature, pressure, time, etc., are sensed at the point of measurement and transmitted back to the control panel gauges, pilot lights, charts, etc.

Control Actions (types)

On-off Control makes a single decision. Example – a flow diversion is caused if product temperature falls too low.

On-off Differential Gap Control produces two decisions. Example – a two-people level control starts the pump at low level and stops it at high level.

TEMPERATURE MEASUREMENT:

Depending on the level of control or the results desired, various temperature sensing techniques are employed:

Mercury Indicating Thermometers

These are the simplest and the most accurate means of measuring temperature.

Two general forms are in use: (1) long stem (for use in open vats and tanks) and (2) short stem (suitable for application to pipe lines and storage tanks).

Recording Thermometers

Pasteurization is regulated by law: therefore, instruments which will permanently record the time and the temperature are absolutely necessary as evidence to the authorities that all regulatory requirements have been met. Recording thermometers must be of sanitary construction, accurate, sensitive to slight changes in temperature, able to withstand daily routine in handling and cleaning, and of a chart design which meets public health requirements.

Recording thermometers are the pressure-spring type, usually actuated by a volatile liquid (generally an ether derivative). The entire length of the tubing extending between the case of the instrument and the temperature sensing bulb is one unit; therefore, any break or leak in it will make the instrument inoperative.

The basic principle of the operation of a recording thermometer is as follows:

The thermal-actuating element is composed of three parts hermetically sealed together:

A responsive bulb (9) which is inserted into the medium to be tested for temperature: an armored flexible capillary tube (8); and a Bourdon coil (4). In addition to these three parts there is a pen (1) which is connected to the Bourdon coil by means of a link (3). A continuous record
is made of the movement of the pen on a chart (5), which is rotated by an electric clock mechanism (6). (See Figure 4)

As the bulb is heated, the Bourdon coil tends to straighten, causing the pen to rise on the chart. Conversely, as the temperature of the bulb drops, the reduced pressure within the thermal system causes the Bourdon coil to contract, allowing the pen to descend.

SECTION B
HTST Pasteurizer Control System

Automatic temperature control equipment is an important part of a high temperature-short time (HTST) pasteurizing system. The usual installation, aside from utilizing an indicating thermometer, employs:

A. A high temperature-short time pasteurizer control panel:
   1. Left-hand side. The Safety Thermal Limit Recorder (STLR) provides a record of the temperature of the milk leaving the holding tube. It electrically controls the air supply to the diaphragm housing of the flow diversion valve and also records whether the flow diversion valve is in the forward or the diverted flow position.
   2. Right-hand side. The indicating water temperature controller maintains a constant water temperature for circulation through the heater section.

B. A flow diversion valve. (Refer to Section D)

C. A hot water temperature controller. (Refer to Section E)

D. A timing pump. (Refer to Section F)

Section C
Safety Thermal Limit Recorder

Figure 5 shows a typical safety thermal limit recorder with the chart and the seal plates removed. The instrument contains a sensitive temperature-actuated pneumatic detecting device which, in turn, actuates a split contact microswitch. As the temperature at the bulb increases to the cut-in temperature, the recorder energizes the flow diversion valve solenoid causing the valve to move to its forward flow position. As the temperature falls to cut-out temperature, the recorder de-energizes the flow diversion valve solenoid permitting the valve to move to its diverted flow position (refer to Section D).

The frequency pen, which records the position of the flow diversion valve, is located near the upper left-hand corner of the case. The pen, actuated through the valve microswitch, moves toward the outer edge of the chart to indicate forward flow.

Signal lights are provided. A green light signifies forward flow and a red light signifies diverted flow.

The cut-in and the cut-out temperatures, as shown by the indicating thermometer, shall be determined at the beginning of each day's operation and entered upon the recorder chart daily by the plant operator. It is suggested that this test be made at the start of the run by reducing the steam supplied to the heater so as to reduce the milk temperature slowly, not over 1 degree F. for each 30 seconds. The temperature shown by the recorder controller shall be checked shall be checked daily by the plant operator against the temperature shown by the indicating thermometer. Readings shall be recorded on the chart. The recorder controller shall be adjusted to read no higher than the indicating thermometer.
When an HTST pasteurizer is used to pasteurize milk, milk products, and frozen dessert mix which require different temperature-time values for proper pasteurization, a dual diversion recorder-controller can be used to divert product at the proper temperature. Such an instrument is to be adjusted and sealed at two different diversion temperatures. Dual diversion recorder-controllers shall be provided with a pen to record on the chart the diversion temperature setting. The selection of the proper diversion temperature should be through positioning of an electrical switch which may also be used for other interlocking purposes. In case of motivating power failure, the diversion point should automatically revert to the higher temperature.

SECTION D  
Flow Diversion Valve

The flow diversion valve (FDV) is essentially a three-way valve designed for controlling the direction of the product flow. The valve is actuated by an air-operated diaphragm and a positive action spring. A solenoid, energized by the recorder-controller, actuates an air valve within the control box which admits air to, and exhausts air from, the diaphragm. When compressed air is admitted to the diaphragm, the spring is depressed, the lower portion of the valve seats itself, the upper portion of the valve is pulled away from its seat, and forward flow results. Any loss of air pressure or electrical power automatically returns the valve to its normal position which is the diverted flow position.

A. Location
The FDV is located at the downstream end of the holding tube.

B. Principle parts (Figure 6)
- Valve seat
- Stuffing box
- Diaphragm
- Connecting key
- Microswitch and roller
- Plunger
- Push rod
- Solenoid
- Ports
- Push plate
- Housing or bonnet
- Valve stem
- Spring
- Manual diversion button

C. Design features required by law to insure proper operation
1. Connecting key--To insure the proper assembly of the valve and to insure that it assumes the fully diverted position during periods of sub-legal milk temperature flow, a connecting clip or key is employed to connect the valve-stem to the push rod.
2. Microswitch (Figure 7) -- If the flow diversion valve is assembled properly and is in the fully diverted position, a small roller connected to a microswitch in the valve housing rides in a groove in the push plate housing. In this position, microswitch contacts keep the timing pump in operation and the red light on the recorder controller box lighted. If the key is not in place, or if the valve is not assembled or seated properly, the roller will not ride in the groove, the timing pump will not operate during periods of sub-legal temperature, and the green light will be on. Pulling out the connecting key during sub-legal temperatures should immediately stop the timing pump. Removal of the key during periods of forward flow should not affect the pump's operation.
3. Stem packing -- It should be impossible to tighten the stem packing in the diaphragm stuffing box to the extent to prevent the valve from assuming the fully diverted position.
4. Leak detector ports -- Leak detector ports or leak escape ports permit the escape, to the atmosphere, of product at sub-legal temperature which may have leaked past the first gasket seal on the forward flow portion of the valve. They prevent sub-legal milk from
entering the forward flow line, and leakage at this point should warm the operator that the valve "O" rings are faulty. These ports must never be obstructed.

5. Push rod -- The length of the push rod must not be altered by the user to insure that proper seating of the valve is not disturbed.

6. Manual diversion button -- This device permits bactericidal treatment of the divert flow line at temperatures above 160 degrees F, and also permits the operator to return pasteurized milk to the constant level tank, if necessary.

7. Diversion line -- The pipeline from the diversion port of the flow diversion valve must be self-draining, and free of any restrictions or valves which would permit stoppage of the line. If an orifice is installed, it must be in the vertical portion of the line to permit free drainage.

8. Valve response time -- The interval between the moment of power cut-out, during descending temperatures, and the moment when the forward flow of milk ceases shall not exceed 1 second.

SECTION E

Hot Water Temperature Controller

The hot water temperature controller controls the temperature of the water in the heater section of the high temperature-short time unit. The heater section brings the milk up to pasteurizing temperature. The hot water circulating unit and the control system are neither connected to nor operated by the milk temperature. This equipment merely maintains a fixed water temperature which in turn results in the desired milk temperature.

A temperature controller has two functions to perform: to measure the temperature, and to operate a mechanism. In this instance the mechanism is a steam valve which will correct any tendency of the temperature to deviate from the desired reading.

For accurate control it is necessary to employ an external source of power to operate valves, and in this controller it is compressed air at a pressure of about 20 psi. The temperature is measured by the same system as the type used in the temperature recorder controller with the addition of a very small air valve requiring only slight power to operate (Figure 8).

It must be remembered that all controllers are error operated, and therefore cannot commence to correct a temperature until it has deviated from the normal. The speed with which a deviation is corrected and the amount of the deviation from the set temperature depend upon the type of controller employed and the characteristics of the HTST unit. A controller must be matched to the unit, and if extensive alterations are made to the unit, it may be necessary to alter the hot water controller.

The proportional type of temperature controller is used and operates as follows:

Compressed air at about 20 psi is used to operate a diaphragm valve on the steam line. If the full pressure is applied to the flexible diaphragm of the valve it will open, and when the air released the valve will close. A valve working in this manner is sometimes known as "reverse acting" or "air to open" type. The pressure of the air applied to the diaphragm valve is controlled in the instrument by the operation of an air relay valve. This relay device is opened or closed by the action of the Bourdon coil in accordance with temperature changes. When applied to a heating process, a fall in the water temperature will be detected by the bulb of the controller, which will cause the air relay valve to close. This valve closure will allow air to reach the diaphragm-operated steam valve so that it will open to admit more steam. When, as a result of this, the water temperature rises, the air relay valve will open, and as the air pressure is released.
on the diaphragm of the steam valve, that will also close. This cycle is repeated continuously, but in actual practice the instrument is adjusted to the HTST unit so that the diaphragm valve assumes a position to pass sufficient steam to maintain a steady temperature. In this position, the steam valve generally operates 30 percent.

SECTION F
Timing Pump

The timing pump governs the uniform rate of flow through the holding tube so that every particle of product is held for the legal minimum period of time. The power unit employed may be either a constant-speed induction type motor or any other type of motor which is connected with a governor to limit its maximum speed.

Variable-speed drives used in connection with the timing pump must be constructed in such a manner that wearing or stretching of belts result in slowing down the pump.

The setting of the governor at the legal maximum speed must be sealed by a regulatory agency so that the minimum holding time cannot be changed without detection. The operation of the timing pump at a capacity below the sealed maximum is permitted.

The timing pump must be interwired with the flow diversion valve so that the pump cannot operate at sub-legal pasteurization temperatures unless the valve is in its fully diverted position.

Two factors which would prevent the timing pump from operating would be improper assembly of the flow diversion valve and lack of electrical current, such as a blown fuse.

The timing pump must be located upstream from the holding tube and in normal operation is located between the outlet of the raw regeneration section and the inlet of the heater section of the pasteurizer.

In operation the timing pump sucks the raw product from the balance tank through the raw milk regeneration section, and thereafter, delivers the milk under pressure through the rest of the HTST pasteurizer system.

Any change in the line resistance of the system after the maximum speed of the pump has been set will alter the holding time. Increasing the line resistance by the addition of plates or piping or the use of wide flange gaskets in the fittings (when not required), etc., will lengthen the holding time. This increase in flow resistance in effect reduces the efficiency of the pasteurizer. Decreasing the line resistance by the removal of plates, pipes, or auxiliary units will decrease the holding time. Wear of the drive belts and pump impellers due to normal operation will gradually decrease the rate of flow through the system, thereby increasing the holding time.

If the system in altered in any manner, the regulatory agency must be notified. This includes such alterations as addition or removal of plates, pipes, or auxiliary units and timing pump repairs (i.e., belt exchanges or impeller replacement).

The timing pump is the heart of the HTST pasteurizer, and every effort must be exerted to maintain it in proper operating order from both an efficiency and a public health standpoint.

PART III
HTST PASTEURIZATION AUXILIARY EQUIPMENT

Various product processes, supplementary to the pasteurization process, integrate quite well into basic HTST pasteurization units. The following accessory equipment may be incorporated into such units:

A. Raw product booster pump
B. Homogenizer
C. Flavor control equipment
D. Clarifier
E. Separator
F. Auxiliary pumps
G. Filters

When such equipment is installed and operated in conjunction with an HTST pasteurizer, it must be connected into the system so that:

A. It will not reduce the holding time below the legal minimum.
B. It will not interfere with the detection, or the stoppage, of the forward flow of milk which is below legal pasteurization temperature.
C. It will not disturb the maintenance of the proper pressure relationships within the regenerator section.

SECTION A
Raw Product Booster Pump

A raw product booster pump may be installed in a conventional HTST pasteurization system under specific provisions. The booster pump is utilized to supplement the timing pump in moving raw milk from the constant level tank through the regenerator section. It may be used to reduce excessive vacuum, and subsequent "flashing" or vaporization, in the regenerator section (particularly when the constant level tank is located an unusual distance from the timing pump).

When a raw product booster pump is permitted to supplement the timing pump, it must be a centrifugal type pump. The motor, casing, and impeller must be properly identified, and records must be maintained as directed by the health authority.

When a raw product booster pump is incorporated into the HTST system, it is located between the balance tank and the inlet to the raw milk side of the regenerator.

The raw product booster pump must be permanently wired so that it cannot operate unless (1) the timing pump is in operation, (2) the flow diversion valve is in forward flow position, and (3) the pasteurized product pressure at the outlet of the regenerator exceeds, by at least 1 psi, the maximum pressure developed by the booster pump. (if the pasteurized outlet is at the bottom of the press, the 1 psi must be increased by an amount equal to the liquid head pressure of product in the regenerator).

The proper pressure relationship between the pasteurized product and the pressure developed by the booster pump must be maintained by the use of a sanitary pressure switch installed at, or downstream from, the pasteurized product outlet of the regenerator. The pressure switch must be set to permit the booster pump to operate only when the pressure in the pasteurized side of regenerator exceeds by at least 1 psi the maximum pressure developed by the booster pump on the raw milk. The pressure switch must be provided with a method for sealing by the health security.

Pressure gauges shall be installed at the discharge side of the booster pump and at the pasteurized outlet of the regenerator (or the outlet of the cooling section provided it is an integral part of the HTST pasteurizer). The pressure gauge at the pasteurized product outlet may be combined with the required automatic pressure switch.

Optional by-pass provision:
The raw product side of the regenerator may be by-passed when the raw milk booster pump is not in operation. This by-pass system permits the cold product to be drawn directly to
the timing pump from the constant level tank. When the required conditions (timing pump operating, flow diversion valve in forward flow, and the product pressure in the pasteurized regeneration section) meet the requirements, the booster pump will start to operate, feeding raw product to the regenerator. The by-pass line, which may be manually or automatically controlled by a valve, is not used when the booster pump is in operation. Entrapment of product in the by-pass line during periods when the booster pump is in operation shall be precluded by (1) close-coupled by-pass connections, (2) design of the manually or automatically controlled valve which will permit a slight movement of product through the by-pass line, or (3) by other equally effective system.

Two-speed raw product booster pump:
This pump can be used for cleaning, only when the pump is interlocked so that it can be operated only at its low speed during processing operations. Means other than the use of a two-speed motor to obtain the capacity and the pressure required for cleaning may be used provided they are interlocked so that they conditions required for booster pumps are maintained during processing operations. One acceptable method of satisfying the above requirements is an interlock with an automatically programmed C.I.P. system.

SECTION B
Homogenizer

When the homogenizer is operated in conjunction with the HTST pasteurizer, it shall be installed so that it will not reduce the holding time below the legal minimum.

When the homogenizer is used as a conventional timing pump, it must be interwired with the flow diversion valve so that they homogenizer cannot operate at sub-legal pasteurization temperature unless the flow diversion valve is in its fully diverted position. Under these conditions, a time-delay relay may be installed in this circuit to permit the homogenizer to continue running during the normal time it takes for the flow diversion valve to move from forward to diverted flow. The time delay should not be more than one second. If the homogenizer motor stops it should not restart automatically. It shall not be possible to restart the homogenizer motor at sub-legal temperature unless the flow diversion valve is in its fully diverted position. The time-delay relay may be of the fixed time or the adjustable time type. If the time-delay relay is adjustable, means of sealing the unit must be provided.

If the homogenizer is of lower capacity than the timing pump at its maximum sealed flow, and the timing pump feeds product to the suction side of the homogenizer, it shall be installed upstream from the flow diversion valve. A sanitary relief line from the discharge side of the timing pump to the balance tank may be provided. This line is equipped with a relief valve capable of maintaining sufficient back pressure to assure a full supply of product to the homogenizer. Since the homogenizer an produce flow through the holding tube when the timing pump is stopped, an electrical interlock is required between the homogenizer and the timing pump, which causes the homogenizer to stop when the timing pump stops. A time-delay relay should be installed in the electrical circuit so that during the normal movement time of the flow diversion valve (one second or less from forward to diverted flow), the homogenizer motor will remain running.

When the "output" of the homogenizer exceeds the maximum sealed capacity of the timing pump, a recirculating line, connecting the suction line and the pressure line of the homogenizer, is installed to prevent "starving" the homogenizer. This line must be the same size as, or larger than, the inlet line to the homogenizer. When such a recirculation line is used, it is
not necessary to interwire the homogenizer and the timing pump, since the homogenizer cannot flow through the holding tube.

When the homogenizer is installed upstream from the flow diversion valve, it normally is placed between the raw product outlet of the regenerator and the inlet of the heating section. When the homogenizer is installed downstream from the flow diversion valve, it normally is placed between the outlet of the flow diversion valve and the inlet of the pasteurized side of the regenerator. Installation shall be made in such a way that the homogenizer cannot apply negative pressure at the forward flow port of the FDV.

Section C
Flavor Control Equipment

Feed and weed flavors in milk and milk products have been problems of considerable importance for many years in the dairy industry. During the past few years there has been increasing use of vacuum-heat equipment for removing volatile flavors such as onion, alfalfa, silage, etc. from milk.

Flavor control equipment, which includes vacuum and steam-vacuum treatment systems, may be installed and operated in conjunction with HTST pasteurization systems, provided that such equipment will:

1. Not interfere with the detection, or the stoppage, of the forward flow of the unpasteurized product.
2. Not influence the proper pressure relationships within the regenerator.
3. Not reduce the holding time below the required minimum.
4. Not contaminate the product with toxic substance or foreign matter from steam distribution systems.
5. Not adulterate the product with added water.

Flavor control equipment may consist of:

1. A single vacuum chamber, with no direct addition of steam, installed upstream from the heating section.
2. A single vacuum chamber, with no direct addition of steam, installed downstream from the FDV.
3. A single or double vacuum chamber system with direct steam addition, upstream or downstream from the flow diversion valve.
4. A double vacuum chamber system, installed as a combination of (1) and (2) above.

When vacuum equipment is located downstream from the flow diversion valve, automatic means shall be provided to prevent negative pressure at the forward flow port of the FDV and/or lowering of product level and loss of pressure in the pasteurized side of the regenerator.

When vacuum equipment is located downstream from the FDV (Figure 9), the holding time must be tested with the timing pump operating at maximum capacity, and the vacuum equipment at maximum attainable vacuum.

Flavor control equipment that does not utilize direct steam injection may use an indirect sanitary condenser to prevent concentration of the product.

Steam used in contact with the product shall be of culinary quality. Boiler compounds containing toxic ingredients shall not be used. Effective vacuum breakers and positive check valves must be located at both the inlet and the outlet of the vacuum chamber(s).
When culinary steam is introduced into the product downstream from the FDV, means shall be provided to preclude the addition of steam to the product unless the FDV is in the forward flow position. Such means shall include an automatic steam control valve with a temperature sensor located downstream from the steam inlet, or an automatic solenoid shut-off valve installed in the culinary steam line. Each must be wired through the FDV to stop the introduction of steam when the FDV moves into diverted flow position.

When a water feed line is connected to a direct water-vapor vacuum condenser, supplementary means shall be provided to preclude the back-up and the overflow of water and/or condensate from the vacuum condenser into the product vacuum chamber in case of discharge pump failure. Such means shall include the use of a high water level sensing device and an automatic safety shut-off valve installed on the water feed line, which would effectively shut off the inflowing water, if the water and/or condensate rises above a predetermined level in the condenser. This valve may be actuated by water, air, or electricity and shall be so designed that failure of the primary motivating power will automatically stop the flow of water into the vacuum condenser or the vapor line.

When culinary steam is introduced directly into the product, automatic controls shall be provided to maintain a proper temperature differential between the incoming and the outgoing products to preclude product dilution. Such controls include an automatic ratio controller which (1) senses the temperature of the product at the outlet of the flow diversion valve (prior to the addition of steam) and either in the vacuum chamber or at its exit (depending upon the most effective point to measure the results of evaporative cooling), and (2) automatically adjusts the operating vacuum in the vacuum chamber to assure the removal, by evaporative cooling, of all water added in the form of steam. The proper temperature differential between the incoming and the outgoing products shall be determined for each HTST installation by a total solids determination on the product prior to entry into and after and after exit from the vacuum chamber. This differential is then set on the ratio controller. Under no circumstances shall the product discharge temperature be higher than the incoming product temperature. An air-operated pressure switch, installed in the air control line between the ratio controller and the vacuum regulator, shall stop the introduction of steam into the product when the operating vacuum in the vacuum chamber is insufficient to prevent product dilution.

**Section D**

**Clarifier**

A clarifier is a centrifugal device that efficiently removes foreign particles or sediment from milk by centrifugal force. When a clarifier is used in an HTST system, it shall be spaced to provide adequate access for cleaning. Since the clarifier will not pump milk unless fed by a pump, there is no hazard involved in allowing the clarifier to run with the timing pump stopped. However, it is well to wire the clarifier to the timing pump so that in case the clarifier stops (e.g., fuse blowout), the timing pump will also stop.

**Section E**

**Separator**

When a separator is used in an HTST system, it shall be spaced to provide adequate access for cleaning. When placed adjacent to the timing pump, it shall not be capable of producing flow unless supplied with product under pressure. When the separator is not discharging to the heating section, it shall be located downstream from the FDV. When a pump
is required to feed the separator, there shall be a break to the atmosphere between the FDV and the pump. When the separator does not require a feed pump, no break in atmosphere is required.

Either cream or skim milk from the separator may be reintroduced into the HTST pasteurizer at a point beyond the flow diversion device, by a direct sanitary line from the separator, so that either product may be cooled.

Section F
Auxiliary Pumps

When an auxiliary pump(s) is used in an HTST pasteurizer system, it must be installed and operated in such a way that it will not (1) interfere with the detection, or stoppage, of the forward flow of unpasteurized milk, (2) influence the proper pressure relationship within the regenerator, or (3) reduce the holding time below the required minimum.

If an auxiliary pump is used to move the product from the HTST pasteurizer system to a surge tank, the pump shall be located downstream from the required atmospheric break.

From an operational point of view, it is desirable to have a homogenizer force-fed so that the product is under positive pressure at the homogenizer suction intake manifold. Large capacity homogenizers will not operate properly unless pressure on the intake is of the order of 5 to 30 psi, depending on the make. When a homogenizer is used as a timing pump, a centrifugal type pump may be installed between the raw product outlet of the regenerative section and the inlet manifold of the homogenizer to supply the desired product to the homogenizer. Such a pump must be interwired with the homogenizer so that it will operate only when the homogenizer is running.

Section G
Filters

When a filter using disposable filtering media or a strainer acceptable to the health authority is used in conjunction with an HTST pasteurizer, the filter or the strainer shall be placed upstream from the final heater and spaced to provide adequate access for cleaning.

Disposable filtering media, and any removable parts which restrict flow, must be removed from the filter or the strainer when the HTST pasteurizer is being timed.

Part IV
Dairy Microbiology and Chemistry

Section A
Dairy Bacteriology

The dairy industry provides an excellent example of an area in which bacteria, yeasts, molds, and viruses are very important in determining the quality of the final products. The well known nutritional values of milk and milk products permit the rapid growth of many microorganisms if conditions are favorable.

Microorganisms are considered the smallest and simplest forms of plant life, so small that they can be seen only with the aid of a microscope. These various microorganisms are widely distributed in nature, which complicates their control or destruction. Bacteria are the most widely distributed and are of the greatest economic importance to the dairy industry.

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Lactic acid-producing bacteria and other types of microorganisms are used for the preparation of various cheeses and cultured milk products. This is an example of the beneficial characteristics of certain microorganisms. Some microorganisms are disease-producing types and are called pathogens.

Considerable effort is expended in the dairy industry to control microorganism which cause various types of spoilage. All dairy processing equipment must be designed to minimize contamination and simplify cleaning and sanitizing. Familiarization with the various types of microorganisms common to dairy products will aid the dairy plant employee in processing high quality products consistently.

**GENERAL NATURE OF BACTERIA**

Definition: Bacteria are one-celled plants, ranging in size from about 1/75,000 to 1/10,000 inch in diameter and from about 1/25,000 to 1/5,000 inch in length. The reproduce by simple asexual cell division: i.e., one bacterial cell alone can reproduce by cell division.

The useful functions of bacteria can be enumerated as follows:

1. They are a necessary segment in nature’s biological balance (i.e. maintaining soil fertility).
2. Some bacterial species cause serious economic losses through spoilage of foods and other products.

**CHARACTERISTICS VISIBLE UNDER THE MICROSCOPE**

Shape and Groupings.

1. Rod-shaped or cylindrical--called bacilli (pl.)
2. Spherical or round--called cocci (pl.) coccus
   a. Micrococci--occur as single spheres
   b. Streptococci--occur as spheres in chains like strings of beads
   c. Staphylococci--occur as irregular grape-like clusters
   d. Sarcine--occur as cubicle packets of eight cells
3. Corkscrew or spiral-shaped--(very few are important in the dairy industry)

Special Bacterial Structures

1. Spores. Hard-walled, seed-like bodies that form inside the cell, only in certain species. They are very resistant to killing by heat, chemicals, ultraviolet light, drying, etc. One bacterial cell forms only one spore.
2. Capsules. A few species can form a gelatinous protective coating that often becomes many times larger than the bacterial cell. It can cause "ropy" milk.

**Gram Staining Reaction**

By a special staining procedure that stains "gram positive" bacteria violet and "gram negative" bacteria red, bacteria can be classified into two distinct groups that differ from each other in many respects.

**PHYSIOLOGICAL CHARACTERISTICS OF BACTERIA**

Food intake and Excretion

1. Bacteria live in a water solution of their food. Their digestive enzymes are secreted out through the cell wall and the food in solution diffuses into the cell.

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2 Adapted from The Pennsylvania State University MANUAL FOR DAIRY MANUFACTURING SHORT COURSES. 1957. University Park, Pa. P.1-5.
2. The waste by-products of metabolism are excreted from the cell by diffusion into the surrounding solution. As these wastes (for example lactic acid) accumulate, they become toxic to the bacteria and eventually stop their growth.

3. Milk furnishes the needed food for a wide variety of bacteria, proteins (for cell building), lactose (for energy), minerals, and vitamins.

   Temperature Required for Growth
   1. *Thermophiles*. Grow best in a temperature range of 113 to 158°F (45 to 70°C).
   2. *Mesophiles*. Grow best in a temperature range of 68 to 104°F (20 to 40°C).
   3. *Psychrotrophs (psychrophiles)*. Capable of growing from freezing temperature to room temperatures. On the upper limit they overlap the mesophilic range, but only a few can grow above 90°F (32°C).

   Oxygen Requirements for Growth
   2. *Anaerobes*. Cannot tolerate atmospheric oxygen ordinarily.
   3. *Facultative anaerobes*. Can grow under either anaerobic or aerobic conditions.

GROUPING OF BACTERIA ACCORDING TO ACTION IN MILK

   Lactic Acid Produced from Lactose
   1. *Streptococcus lactis* and related streptococci. Used as "starters," where acid production is needed. Can occur naturally in raw milk, causing souring when cooling is inadequate.
   2. *Lactobacillus* species. Used in fermentation process, but not troublesome in raw milk supplies.
   3. Other miscellaneous rods and cocci.

   Acid and Gas Produced from Lactose.
   Chief among these is the so-called "coliform group."
   Proteolysis (protein digestion)
   1. *Psychrotroph group*
   2. *Bacillus species* (aerobic spore-forming rods).
   3. *Clostridium* species (anaerobic spore-forming rods).

   Lypolysis (fat digestion).

Chief among these in raw milk is the psychrotroph group.

SOME TROUBLESONE NON-PATHOGENIC GROUPS OF BACTERIA

   Aerobic or facultative anaerobic gram negative non-spore forming rods that ferment lactose with the production of acid and gas.
   1. Called coliforms because some members of the group are found in the intestines (colon) of all warm blooded animals. They are not generally considered pathogenic (disease producing) but rather and "fellow travellers" with intestinal pathogens.
   2. Present in barn dust, on cereal grains and hay, in polluted water, and commonly grow on damp, improperly cleaned equipment.
   3. Always found in raw milk, but can be kept low in numbers with good production methods and good cooling (less than 100 ml.).
   4. Do not survive pasteurization. When found in pasteurized milk, they indicate recontamination after pasteurization.
   5. Tested for routinely in pasteurized milk products for detection of possible recontamination.

Thermodurics.
A miscellaneous group of bacteria that are capable of surviving pasteurization but will not grow at high temperatures.

1. Most thermodurics are cocci.
2. Chief sources of thermodurics are poorly cleaned equipment, especially old, cracked rubber in milking machines; also found in milkstone deposits and in cow's udder during late lactation.
3. High thermoduric counts in raw supplies will result in bacteria counts for pasteurized milk that exceed legal limits.
4. Thermodurics are seldom, if ever, psychrophiles; therefore, in milk that is kept at 40 F or lower they cause no spoilage problem.
5. Thermodurics are not associated with diseases. The objection to them lies in the fact that they indicate contamination with decaying milk residues and can result in high bacteria counts for pasteurized milk.

Psychrotrophs

Bacteria capable of growing at 41 F or lower; however their optimum temperature is from 68 to 86 F. They cause off-flavors and physical defects in products stored under refrigeration.

1. The most commonly occurring Psychrotrophs are gram negative non-spore forming rods belonging to the genus *Pseudomonas* or the genus *Achromobacter*. The ropy milk *Alcaligenes* is also a psychrotroph.
2. Psychrotrophic rods usually occur in small numbers in water supplies, increasing numbers in water storage tanks, recirculated cooling water and in tank-type can coolers.
3. They thrive in damp, drippy, poorly ventilated areas and will grow on damp surfaces of cleaned equipment. Washed equipment should drain dry quickly and be stored at low humidity.
4. All milk processing equipment should be properly sanitized immediately before use.

Thermophiles

Bacteria that not only survive pasteurization, but will actually grow during vat pasteurization. They usually are not a problem in raw milk supplies.

DISEASES THAT MAY BE SPREAD BY PATHOGENIC MICROORGANISMS IN MILK

Diseases of the Cow that can be Spread to Man.

1. Brucellosis (also called Bang's disease, infectious abortion in cows, undulant fever in man) is caused by the microorganism *Brucella abortus*.
2. Bovine tuberculosis (*Mycobacterium tuberculosis*).
3. Q fever. A virus disease, having a reservoir in wild rodents, which can be contracted by cattle and hence transmitted through raw milk to man. (*Coxiella burnetti*).
4. Many other diseases or abscess-producing organisms found in dairy cattle are capable of producing diseases in man.

Diseases of Man Spread by Contaminated Milk

1. Typhoid and paratyphoid fevers (*Salmonella Sp.*).
2. So-called "food poison" *Salmonella* infections.
3. Scarlet fever and septic sore throat (streptococcal infections).
4. Others. There is a remote chance of spreading diphtheria, human tuberculosis, myelitis, and others.

True Food Poisoning.

Certain bacteria growing in plant products produce toxic metabolic end products.
1. Staphylococcal (staph) food poisoning that results in fevers, nausea, and diarrhea. The bacteria are killed by pasteurization, but the toxin, if already formed, remains active.
2. So called *Salmonella* "poisoning."
3. Botulinus (botulism) poisoning. High mortality rate, but has not been implicated with raw milk supplies.

Control of the Spread of Diseases
1. Keep herds healthy. Segregate sick cows and discard their milk.
2. Allow only healthy personnel to work in dairy operations.
3. Keep premises and equipment clean.
4. Cool milk promptly and keep it refrigerated.
5. Pasteurize milk and prevent recontamination after pasteurization.

**BACTERIOLOGICAL TESTS ON RAW MILK SUPPLIES**

Standard Plate Count.
1. Detects those bacteria that are living and are capable of growing under conditions of the test.
2. More precise than other counting methods, especially when bacteria counts are low.
3. Requires two days for completion of the test.

Thermuduric Count
This is a plate count made on a portion of milk sample that has been pasteurized in the laboratory just prior to plating.

Direct Microscope Count.
1. Not precise, especially when counts are much below 100,000/ml.
2. Results can be obtained within an hour if needed in a rush.
3. With high count milks, the microscopic picture may indicate the cause of the source of the problem if the slides are properly prepared.

Coliform Test.
1. While used as a standard test in the sanitary analysis of water, the coliform test is not a standard test at present for raw milk supplies. Interest in the test in raw milk is increasing.
2. Most commonly mentioned standard for raw milk is a maximum of 100/ml.
3. The test results are available in one day.
4. Dye Reduction Tests (methylene blue and resazurin). They have limited value in present day low bacteria count milk supplies.

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**Section B**

**Yeasts, Molds, and Viruses**

**YEASTS**

Yeasts are single-celled plants considerably larger in size than bacteria. The oval-shaped yeasts reproduce by budding, a process in which a small bump or bud appears on one side of the mother cell and grows until it is pinched off as a new yeast cell. Yeasts are usually found where there is an abundant supply of sugar that they can ferment. Yeasts develop readily in whey, sour milk, and sour cream since they thrive better than most bacteria in an acid environment. The

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common results of active yeast growth are yeasty odors and flavors, frequently accompanied by a vigorous, gassy fermentation. Yeasts grow rapidly at temperatures above 60 F, but are readily destroyed by pasteurization.

MOLDS

Molds are small, many-celled plants (fungi) that generally reproduce by spore formation. Most molds produce a filamentous type of growth (hyphae). These networks of hyphae appear as fuzzy- or velvety-appearing colonies when molds grow on surfaces. Large numbers of spores are formed by some molds. These light spores are easily carried by air currents in most environments. Mold spores are highly resistant to drying and freezing, which enables them to survive long, unfavorable periods. Furthermore, molds have the ability to grow at much lower moisture levels than yeasts and bacteria. Molds can actually grow on painted surfaces with little more than atmospheric moisture and dust as nutrients. With few exceptions, molds are readily destroyed by pasteurization.

VIRUSES

Viruses are characterized by their ability to pass through bacterial filters. A type of virus of particular importance to the dairy industry is the bacteriophage that attack bacterial cells of the lactic-acid producing group and stop acid production. Bacteriophages act as parasites, multiply within the bacterial cells, and cause lysis (bursting) of the cells and liberation of tremendous numbers of new active phage particles. Bacteriophage are destroyed by high heat treatment (185 F for 30 minutes) and 200 ppm chlorine solutions.

Section C
Enzymes

The miscellaneous group of milk constituents includes a number of enzymes of which phosphates and lipase are particularly important. Enzymes are "biological catalysts" which have the ability to hasten or retard chemical changes without themselves participating in the reactions. The enzymes are protein-like substances, specific in their actions and inactivated by heat. They often act by splitting the component for which they have an affinity.

PHOSPHATASE

The phosphatase enzyme is a normal constituent of raw milk and is characterized by its ability to split (or hydrolyze) certain chemical linkages of organic phosphoric acid compounds. The important characteristic of phosphatase is that the time-temperature treatment needed to inactivate phosphatase is the same as that required for pasteurization. The absence of phosphatase from milk indicates that the milk has been heated to at least the minimum time-temperature combination required for pasteurization. This is the basis for the phosphatase test for pasteurization.

Phosphatase tends to follow the cream portion: therefore, greater heat treatment is needed for cream than for milk to inactivate a proportionate amount of the phosphatase.

LIPASE

The enzyme lipase is also a normal constituent of raw milk. It has the ability to hydrolyze or "split" the milk fat to produce "free" fatty acids. Certain low molecular weight fatty acids have disagreeable aromas and contribute to the rancid flavor found in some products.

To be effective in causing rancidity, the lipase enzyme must come into physical contact with the substrate (fat). Anything with increases the probability of collision between lipase and

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Fat particles will increase the probability of rancidity. Thus agitation (i.e., shaking, high-speed pumping, or homogenization) increases rancidity in proportion to the intensity of agitation. Since homogenization causes a six-fold increase in the surface area of the fat, this tends to increase the probability of collision with lipase has not been inactivated by heat, the milk will become rancid in a relatively short time. In normal distribution channels and with storage under home refrigeration, the development of rancidity in the bottled product is usually evidence of improper pasteurization or contamination with raw milk after pasteurization.

Part V
Cleaning and Sanitizing
Section A
Cleaning Dairy Plant Equipment

Cleaning of dairy plant equipment, in simple terms, consists of removing the soil from the surface of the equipment by dissolving or suspending it in a warm solution of suitable chemicals. The soil is primarily milk or milk product residues. The soil may be more or less modified by processing treatment or by interaction with water minerals or with cleaning materials previously used, or by dust, dirt, or other foreign matter.

Milk or milk product residues consist of:
1. Milk sugar, or lactose, which is the only main component of milk solids that is completely soluble in cold or warm water and down not appear to form insoluble products.
2. Butterfat, which in its normal, emulsified condition is readily dispersed in water. When the emulsion is broken, the fat may form a continuous, insoluble film over soluble soil. Fats in stable emulsions, for example in raw milk, are readily removed by a cold water rinse. Otherwise they are most economically removed by the aid of emulsifying agents at temperature above the melting point of the fat (84 to 97 F).
3. Unchanged proteins as in fresh raw milk films are readily dispersed or dissolved in water. Milk proteins are easily changed or denatured by the action of heat or acid and then may no longer be soluble or dispersible in water alone. These denatured proteins may be dissolved readily in dilute alkaline solutions or in chlorinated alkaline solutions. They are not soluble in dilute acids. The addition of dispersing agents speeds up the removal of denatured protein films.
4. Mineral salts from fresh raw milk residues may be readily dissolved or dispersed in water. But, mineral deposits found in (1) hot milk films, (2) films left from previous incomplete cleanings, or (3) in deposits from hard water and alkaline materials are usually insoluble in water and in straight alkalis. These deposits are usually referred to as milkstone. Mineral deposits are slowly soluble in polyphosphate solutions and are more soluble in acid solutions with a pH of 5 or less. For really rapid solution, the pH of the solution must be less than 3. At the lower pH level, the acid is very corrosive and should be kept away from skin and clothing.

The cleaning tank should remove all residual soil following each use of equipment. This task must be done with a minimum of physical effort, in the shortest time, and at the lowest cost. Some of the factors which make the daily cleaning process simpler and shorter are:
1. All processing equipment should be designed for ease of cleaning and made of all-welded, polished stainless steel. Sharp corners, cracks, and exposed threads should be

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eliminated on all inside and outside surfaces. In case of manual cleaning, all interior surfaces should be easily reachable for cleaning and inspection from the outside.

2. Sufficient ventilation and adequate lighting on all surfaces to be cleaned.
3. Floors of smooth non-skid, impervious material, properly sloped to an adequate number of floor drains.
4. Equipment located far enough from floor, walls, ceiling, and other equipment to provide ample space for the cleaning operations.

Successful and economical cleaning demands the adoption of precautionary measures to keep film formation to a minimum during processing, cleaning, and sanitizing. These measures include:

1. Heating at the minimum temperature for the minimum time with the heating medium at the lowest practical temperature.
2. Cooling milk heating surfaces before and during emptying of vats if possible and practical.
3. Rinsing away foam and milk film from equipment surfaces immediately after processing each batch, if possible, or at least immediately after the run.
4. Keeping the film on equipment surfaces moist until ready to clean by avoiding steam or hot water leaks to vat jackets and other heated surfaces, and by leaving some water in closed equipment at the end of the run if some time must elapse before cleaning.
5. Rinsing with soft, tempered water (115 F) and not with hot water.
6. Using sodium (in place of calcium) hypochlorite for sanitizing, if a hypochlorite is used.

To avoid rust, discoloration, or pitting of equipment during washing, care should be taken:

1. Not to use a water supply having a high iron or sulfur content, unless the water has been properly treated.
2. Not to allow corrosive chemical sanitizers or cleaners to remain on equipment too long.
3. Not to allow rubber protective items to remain in contact with stainless steel surfaces thus preventing the surface from drying.
4. Not to allow wrenches, sanitary fittings, and other metal objects to lie on wet surfaces of stainless steel equipment.

If, in spite of precautions, equipment becomes rusted or discolored or pitted, it should be polished immediately with a stainless steel polishing compound of the correct grit in order to prevent condition from progressing. Passivating acids may also be used. After using acid solutions, it is important to rinse the metal with warm water and dry thoroughly.

Section B

Suggested HTST Pasteurizer Cleaning Procedures

"Over-Ride" (O-R) Circulation Procedure (Acid First)

1. The moment the pasteurizing run ends, the last milk is flushed from the system with water. As soon as the discharge is clear, the unit is shut down and the cooling section turned off.
2. The flow diversion valve piston is removed and the divert part is capped.
3. Fill balance tank with clean water and pre-rinse until discharge is clear and free of milk solids.
4. With the HTST system completely filled with water and the balance (circulating) tank half full, add the recommended amount of acid cleaner (sufficient quantity to result in a pH of 3.0 or less).

5. Start circulating pump and set the control panel temperature adjustment to maintain the temperature recommended by the manufacturer of the acid cleaner. Circulate the hot acid solution for 30 minutes.

   NOTE: After acid solution has reached desired temperature, back off HTST press to allow for expansion of metal plates.

6. Add the recommended amount of alkaline cleaner (sufficient quantity to "override" the acid) slowly and directly into the acid solution. The alkalinity of this cleaning solution should approximate pH 11.0.

7. Circulate the over-riding cleaning solution for 30 to 45 minutes at a temperature 10/°F above the highest pasteurization temperature employed, but not to exceed 185/°F.

8. Turn off heat supply to the unit. Position the discharge line to drain to the floor. Add fresh water to the balance tank and flush through the unit until the discharge is completely clear and free of cleaning solution.

9. Adjust level of clean water in balance tank to insure proper volume and add recommended quantity of acid to the cold water. The pH should be approximately 5.0. Circulate for 10 minutes or sufficient time to cool the press to touch.

10. Open the press and inspect for degree of cleanliness and condition of plates and gaskets.

CONVENTIONAL CIRCULATION PROCEDURE (Alkali First)

1. Force the last milk from the unit with clean water and flush to drain until water is clear and unit is cooled.

2. If the HTST unit has been operated over 12 hours or has excessive "burn-on," a general cleaner soak will make cleaning easier. Dissolve a pound of good general cleaner into the balance tank and pump into the unit with the last rinse water. Turn off timing pump. The unit is soaked with cleaner while converting the unit to the circulating cycle.

3. Connect circulating pump between surge tank and regenerator.

4. Pipe a by-pass line around timing pump. By-pass homogenizer so part of solution may go through and part around.

5. Remove piston from flow diversion valve, remove divert line and cap divert port.

6. If propylene glycol is used as a coolant, drain from cooling section.

7. Connect pasteurized milk outlet to surge tank.

8. Fill surge tank and start circulating pump.

9. Flush to drain until water runs clear.

10. With water circulating, slowly add caustic cleaner to water, the quantity in accordance with manufacturer's recommendations.

11. Heat solution to a temperature 10/°F above the highest pasteurization temperature and circulate for 30 to 60 minutes. Loosen press slightly. Time, temperature, and concentration should be adjusted to the soil conditions.

   NOTE: Temperatures over 185/°F or concentrations over 1% can be detrimental to gaskets.

12. Flush solution from pasteurizer.

13. Add the acid cleaner according to the manufacturer's recommendations to fresh clean water to attain a pH of 3.0 or less.
14. Heat solution to at least 155º to 160º F or as recommended and circulate for 20 minutes.
15. Flush to drain with cold water until press is cool.
16. Open plates and inspect. Brush if necessary. (If brushing is necessary, increase time, temperature, and/or concentration of the alkali solution the following day.)
17. Leave pasteurizer open and plates separated for as long as possible.

**SPLIT CIRCULATION**

In a large pasteurizer a very high pressure is developed when attempting to pump the solution at velocities of at least 1 1/2 times the product capacity. This high pressure results in reduced capacity, reduced velocity, and often in poor cleaning.

When the circuit is split, the raw side of the regenerator and the final heater are circulated in one circulation and the pasteurized side of the regenerator and the final cooler are circulated in a second circuit. Both circuits are circulated at the same time with the same pump. The reduction in pressure results in greater volume and velocity than if the press is circulated in one circuit. All the manufacturers, except Cherry-Burrell, recommend loosening the press until there is a slight drip of the cleaning solution. The reasons for loosening the press are:

1. To prevent excessive pressure on the unit due to expansion of plates with the higher temperature cleaning solution.
2. To prevent flattening of gaskets.
3. To allow cleaning solutions to wash around gaskets.
4. To help prevent excessive pressures of the cleaning solution.
5. To aid cleaning at metal-to-metal contact points.

**Flow Diversion Valve.** The correct procedure for the flow diversion valve during circulation is to either (1) by-pass the flow diversion valve or (2) remove the piston and cap the divert port (providing the valve is stainless steel).

**Opening Plates.** All manufacturers except A.P.V. recommend that the plates be opened. Opening the plates permits rebuilding of the passive film on the stainless steel and gives the gaskets a chance to spring back from their compressed condition. Plates should be left open overnight if possible. A.P.V. recommends loosening the plates to the extent that piping does not have to be disconnected.

**Proper Cleaning Solution Velocity.** Table 1 shows that cleaning solution velocity should be 1 1/2 to 3 times that of product flow, depending on the type of pasteurizer.

Table 2 shows the number of seconds necessary to fill a 10 gallon can with water during circulation at recommended velocity. The left-hand column shows rated capacity of the press. The other three columns are calculated as 1 1/2, 2, or 3 times the product flow.

**SPECIAL RECOMMENDATIONS AND PRECAUTIONS FOR HTST CIRCULATION**

**Loosening Press.** Many plant operators object to loosening the press during circulating, due to the danger of warping the plates or "blowing" the gaskets.

As can be seen from Table 1, all manufacturers recommend loosening the plates. There is no danger if recommended maximum pressures are not exceeded.

**SECTION C**

**Equipment Sanitizing**

Sanitation is a term used to refer to the germicidal or bactericidal treatment of dairy equipment. Sanitization rarely results in the complete sterilization of an equipment surface; but when sanitization is properly performed, it destroys most of the microorganisms present.
Sanitization of milk plant equipment is an absolute necessity. It should be performed not more than 30 minutes prior to the use of the equipment.

A number of approved methods are practiced for treating dairy equipment to destroy microorganisms. The most common are the use of steam, hot water or chemical sanitizers such as hypochlorites (chlorine), iodophors, and quaternary ammonium compounds (quats).

SANITATION OF ASSEMBLED EQUIPMENT

Steam. When steam is used, each group of assembled piping shall be treated separately by inserting the steam hose into the inlet and maintaining steam flow from the outlet for at least 5 minutes after the temperature of the drainage at the outlet has reached 200º F. (The period of exposure required here is longer than that required for individual cans, etc., because of the heat lost through the large surface exposed to the air.) Covers must be in place during treatment.

Hot Water. Hot water may be used by pumping it through the inlet if the temperature at outlet end of assembly is maintained to at least 170º F for at least 5 minutes.

Chemicals. When chlorine or another chemical solution is used, the solution appearing at the outlet end shall show in excess of the minimum required strength. The chemical solution shall be pumped through the entire equipment for at least 1 minute. Unions and other connectors should be slightly loosened to permit treatment of gaskets and threads, except on lines cleaned-in-place. Surfaces which are not reached by the chemical solution shall be treated with steam as previously described, spray application of chemical solution, or by other acceptable means. Header ends and connecting piping of cabinet coolers should not be overlooked, since condensation from them may enter the collecting trough. Chemical sanitizing solutions should be prepared fresh for each use.

EFFECTIVENESS OF CHEMICAL SANITIZERS

Certain chemical compounds are effective for the sanitation of milk utensils, containers, and equipment. The bactericidal activity of such compounds is influenced by temperature, hydrogen-ion concentration (pH), and, in some instances, by interfering substances in the water in which they are used.

The activity of chemical sanitizers may also be adversely effected by ingredients in washing compounds and organic matter carried over from the wash solution. Consequently, a rinse between washing and bactericidal treatment is important in maintaining the strength of solutions. Similarly, deposits of milk solids on utensil surfaces interfere with bactericidal activity, and chemical sanitizers cannot be relied upon unless the surfaces to be treated are clean.

Temperature, pH, and exposure time also influence the corrosive action of the chemical bactericides and sanitizers on materials used for product-contact surfaces of equipment, containers, and pipelines. Minimum treatment consistent with sanitizing requirements will aid in preserving the sanitary finish of surfaces.

Hypochlorites. Either calcium or sodium hypochlorite (stock powder or solution) is a satisfactory chemical sanitizer.

An exposure period of at least 1 minute to at least 50 ppm available chlorine should be maintained when the temperature is at least 75 º F. Under these conditions, an exposure of 1 minute is considered adequate for all hypochlorites, including the slower, more alkaline compounds. Lower solution temperatures result in slower action: for each 18º F drop in temperature, approximately double the exposure time is needed to achieve equivalent bactericidal action with the same strength of solution. It is also possible to compensate for lower temperatures by increasing the concentration of the bactericide.
Hypochlorite bactericides cannot be relied upon in the presence of large amounts of milk or other organic matter. A sharp decline in the available chlorine content of a sanitizer after circulation through milk processing equipment is usually regarded as evidence of inadequate cleaning and should be promptly investigated. When a spray is used in lieu of circulation or immersion, the above specified concentrations of available chlorine should be doubled.

Quaternary Ammonium Compounds (Quats). Certain quaternary ammonium compounds are effective bactericides for the treatment of milk utensils, containers, and equipment. Their bactericidal effectiveness varies and is influenced by the chemical nature of and the concentration of active agent, temperature, pH, exposure time, and by interfering substances present in natural waters.

These compounds have been found to be bactericidal effective when used (1) at concentrations of 200 ppm or more, (2) at pH levels of 5.0 or higher, (3) at temperatures of 75º F or higher, and (4) for a 30-second exposure period.

Iodine Compounds. Another type of halogen sanitizer that has been found effective consists of a combination of iodine with certain nonionic substances. Although iodine is only slightly soluble in water and is volatile, in combination with nonionic wetting agents as an iodophor, it is readily soluble in water and is less volatile. When diluted for use, iodophors have a low pH which enhances their germicidal qualities. Increasing the temperatures of a sanitizing solution containing iodophors also increases its effectiveness, but above 120º F iodine volatilizes, resulting in a decrease in solution strength.

In solution, iodophors are yellow or amber in color and the intensity is proportional to the concentration of iodine. Concentrations of 12.5 ppm when used as a bactericide only and of 25 ppm when used as a detergent-sanitizer have been found effective.
PART VII
QUESTIONS AND ANSWERS FOR HTST PASTEURIZER OPERATORS

1. What are the health requirements for all personnel handling dairy products?
   Ans. All handlers of dairy products shall be free of open sores, cuts, abrasions on hands and arms, and communicable disease which may be transmitted through dairy products, and they may be required to take such physical examination as the Department of Agriculture may direct.

2. What is the requirement on personnel cleanliness?
   Ans. All persons engaged in the transportation, handling, and processing of milk, milk products, containers, or equipment shall wear clean light colored outer garments, suitable head covering, and shall keep their hands clean at all times while thus engaged.

3. How often must containers and equipment be cleaned?
   Ans. All milk and milk products multiple use containers and equipment shall be thoroughly cleaned at least once daily.

4. When must containers and equipment be sanitized?
   Ans. Immediately before each usage, containers and equipment must be subjected to an approved bacterial treatment.

5. What is meant by approved bactericidal treatment?
   Ans. It means an approved application to containers and equipment of steam, hot water, chlorine solution, or any other bactericide which has been submitted for examination and approved by the State Department of Agriculture.

6. What is the cleaning requirement of tankers used in bulk milk transportation?
   Ans. Tanks used in the transportation of bulk milk shall be thoroughly cleaned at least once daily. Exterior surface of equipment shall be kept clean.

7. Are racks necessary for storage of containers and disassembled or demountable equipment?
   Ans. Yes, storage racks are necessary.

8. What are the specifications for these racks?
   Ans. Sanitary utensil racks shall be provided for storing cleaned equipment and containers at least 18 inches off the floor in an inverted position or in such a manner as to drain dry.

9. How much sanitized containers and apparatus used for milk or milk products be stored?
   Ans. In the room where used with full protection from contamination.

10. How must sanitized containers and apparatus be handled?
    Ans. In a manner to prevent any part of the person or clothing from contacting milk or any milk product surfaces.

11. What is required of equipment that has contained raw milk before it may be used for pasteurized milk?
    Ans. The equipment must be thoroughly cleaned and effectively subjected to an approved bactericidal process.

12. What is the requirement of all supplies used in handling, processing, and packaging of dairy products?
    Ans. The supplies must be purchased and stored only in sanitary tubes, wrapping, cartons, or containers and kept in a clean, dry room or cabinet until used.

13. How should supplies bye handled when removed from containers?
    Ans. In a sanitary manner.
14. What is overflow or drip milk?
   Ans. Milk which is accumulated from leaky valves, fittings, pipe lines, or other milk or milk product equipment.
15. How should overflow of drip milk be handled?
   Ans. It should be disposed of. Overflow or drip milk shall not be used in the processing, manufacturing, or mixing of milk and milk products.
16. Steam which is injected directly into milk or milk products as a part of the manufacturing process must meet what requirements?
   Ans. Such steam shall be of a sanitary quality and must pass through a steam strainer and a steam purifier equipped with a steam trap.
17. At what temperature must milk or cream be maintained prior to pasteurizing or processing?
   Ans. At 50° F or less in equipment approved by the Department of Agriculture.
18. How soon after receiving must milk and cream be maintained prior to pasteurizing or processing?
   Ans. Two hours. (This requirement probably refers to milk and cream picked up on can routes. Bulk milk picked up in tankers must be 50° F or below on arrival.)
19. To what temperature must pasteurized milk and milk products be cooled?
   Ans. 45° F or below (temperatures of 33° to 38° F are preferred for maximizing shelf-life).
20. May any water supply be used as a cooling medium?
   Ans. No. The water supply must meet the purity requirement of the State Board of Health.
21. What is meant by the term "Pasteurization"?
   Ans. "Pasteurization," "Pasteurize," and similar terms refer to the process of heating every particle of milk or milk products at a sufficient temperature and time to destroy or render harmless pathogenic microorganisms.
22. What is the definition of "High Temperature-Short Time (HTST) Pasteurizer"?
   Ans. HTST Pasteurizer refers to the equipment employed in pasteurizing a continuous flow of milk or milk products in which the pasteurizing time and the temperature period are automatically controlled.
23. What is a "Vacreator Pasteurizer"?
   Ans. It is the equipment used where a continuous flow of milk or milk products in which the pasteurizing time and the temperature period are automatically controlled.
24. What is the meaning of "Milk Flow Stops"?
   Ans. "Milk Flow Stops" means automatic devices which stop the forward flow of milk whenever its temperature drops below the specified minimum pasteurization temperature.
25. How should the milk flow stop be designed?
   Ans. It should be so designed that failure of the primary motivating power will automatically stop or divert the flow.
26. What devices are included in a "Milk Flow Stop" and what are their functions?
   Ans. A. Milk-Pump Stops--which automatically start and stop the milk pump motors at the required temperature.
   B. Flow Diversion Valves--which automatically divert the milk back to the heater when it falls below the required temperature and automatically resume forward flow when the milk again reaches the required temperature.
27. What is the time-temperature requirement for holder type pasteurization of milk and milk products?
   Ans. Milk and milk products shall be heated at least 145° F and maintained at that temperature for not less than 30 consecutive minutes. Cream and cream products must be heated at least 150° F and maintained for at least 30 consecutive minutes.

28. What is the time-temperature requirement for holder type pasteurization of an ice cream mix or any frozen dessert mix containing milk and/or milk products?
   Ans. Ice cream mix or frozen dessert mix shall be heated to at least 155° F and maintained at that temperature for not less than 30 consecutive minutes.

29. What is the time-temperature requirement for milk and milk products pasteurized by the HTST method?
   Ans. They shall be heated to at least 161° F and maintained at that temperature for not less than 16 consecutive seconds. For milk products having a higher milk fat content than milk and/or contain added sweeteners shall be heated to at least 166° F for at least 16 consecutive seconds.

30. What is the time-temperature requirement for ice cream mix or any frozen dessert mix containing milk and/or milk products by the HTST method?
   Ans. They shall be heated to at least 175° F for not less than 30 consecutive seconds.

31. What is the time-temperature requirement for milk or milk products pasteurized by the vacreator method?
   Ans. 194° F

32. Must HTST and vacreator pasteurizers be equipped with indicating thermometers?
   Ans. Yes

33. What must be the scale range for a HTST indicating thermometer?
   Ans. It must have a range of not less than 20 degrees Fahrenheit, including the specified pasteurization temperature plus or minus 5 degrees.

34. What graduation of degrees are required on the HTST indicating thermometer?
   Ans. It must be graduated in 0.5 degree divisions throughout the scale range, with not more than 8 degrees per inch of scale.

35. How accurate must the HTST indicating thermometer be?
   Ans. It shall be accurate to within 0.5 degree plus or minus throughout the specified range.

36. Is it necessary for all pasteurizers to be equipped with a recording thermometer?
   Ans. Yes. All pasteurizers shall be equipped with recording type Fahrenheit thermometers for the purpose of making a written record of pasteurization time and temperature.

37. What is the temperature range requirement for HTST recording thermometers?
   Ans. The range shall be 145° to 200° F with extension of scale on either side permitted.

38. How accurate must the recording thermometer be?
   Ans. The recording thermometer shall be accurate to within one degree at the specified pasteurization temperature.

39. How must the temperature chart for recording thermometers be graduated?
   Ans. Charts must be graduated into temperature scale divisions of one degree, spaces not less than one-sixteenth of an inch apart within a range of one and half degrees on either side of the specified pasteurization temperature.

40. What is the greatest amount of time that may be represented by the smallest time scale division?
Ans. 10 minutes.

41. What is the smallest allowable distance between time scale divisions in the specified temperature range of the recording chart?
   Ans. One-fourth inch.

42. Recording thermometer charts shall be graduated for a maximum of how much time?
   Ans. 12 hours.

43. If the time of recorded operation runs for 12 1/2 hours, is it all right to overlap on the chart for the extra half hour?
   Ans. No. A new chart must be installed for the extra half hour.

44. How should the recorded temperature of a recording thermometer compare with the indicating thermometer on a HTST pasteurizer?
   Ans. Recording thermometer should be kept adjusted to never read higher than the indicating thermometer at pasteurization temperature.

45. What is the purpose of a recording chart?
   Ans. It is a written record of the pasteurizer's operation.

46. May a pump be located between the pasteurized milk outlet of HTST regenerator and the nearest downstream point open to the atmosphere?
   Ans. No.

47. What must be the maximum response time for the milk flow stop in HTST units?
   Ans. One second.

48. Would electrical power failure have any effect on the position of the flow diversion valve?
   Ans. Yes. It would take the diverted position.

49. Why are the timing pump and the flow diversion valve temperature adjustment locked and officially sealed?
   Ans. To prevent the under heating and/or under holding of the milk.

50. What is the purpose of the leak detectors of the flow diversion valve?
   Ans. They open when the flow diversion valve is in the diverted position to prevent any raw milk from leaking past the top gasket of the FDV.

51. How should the operator determine the temperature at which the flow diversion valve diverts (cut-out), and the temperature that it goes into forward flow (cut-in)?
   Ans. By observing these temperatures on the indicating thermometer.

52. How long must recording charts be kept on file?
   Ans. For at least 60 days (Oregon), USPHS requirements specify 90 days.

53. What information must each chart contain?
   Ans. A. Date
       B. Name of dairy
       C. Name of licensed pasteurizer operator
       D. Number or location of recorders, if more than one is used.
       E. Name of product being pasteurized
       F. Record of unusual occurrences
       G. The indicating thermometer temperature must be recorded on the HTST chart after the temperature has settled down in forward flow.
       H. Cut-in and cut-out temperatures as checked by the indicating thermometer.
54. What are the primary reasons for pasteurization?
   Ans. (1) To protect the health of the public by destroying organisms harmful to human beings and (2) to improve the keeping quality of milk and milk products.
55. What diseases can be transmitted to man through milk or milk products?
   Ans. Tuberculosis, diphtheria, scarlet fever, septic sore throat, typhoid fever, paratyphoid fever, and gastrointestinal diseases.
56. What are the pathogenic type organisms?
   Ans. Disease-producing organisms.
57. Why must the pressure of the pasteurized milk in the regeneration section be higher than that of the raw milk?
   Ans. In case of a leak the higher pressure prevents the raw milk from passing into the pasteurized milk section.
58. Must as much pressure be exerted on the milk while in diverted flow as when it is in forward flow?
   Ans. Yes. This is accompanied by placing an orifice (restrictor) in the diversion line side of the flow diversion valve of the milk flow stop of such diameter as will maintain at least as high a pressure on the diverted flow as there is when milk is in forward flow.
59. Where must the restrictor in the diversion line be located?
   Ans. In the vertical section, so that milk can drain back to the balance tank.
60. What is the function of the variable speed timing pump?
   Ans. It regulates the rate of flow of the milk or milk products through the HTST pasteurizer.
61. Where must the timing pump be located?
   Ans. It must be located between the outlet of the raw milk side of the regenerator and the inlet of the heating chamber.
62. Why must this pump be sealed by a regulatory agency?
   Ans. The pump must be sealed at maximum speed so that it does not exceed the approved rated capacity of the HTST pasteurizer.
63. What are the requirements of a booster pump if installed in the HTST pasteurizer system?
   Ans. A. It must be wired to the metering pump so that it will not operate unless the metering pump is running.
   B. It must be controlled by a pressure switch, located at the pasteurized milk outlet of the regeneration section, which is set and sealed so as to complete the circuit only when the flow diversion valve is in forward flow and when the pasteurized milk pressure exceeds by at least one psi, and the maximum pressure developed by the booster pump.
64. What are the psychrophilic (psychrotrophic) organisms?
   Ans. They are organisms that grow readily even under refrigerated conditions (under 50°F).
65. Why are we concerned about psychrophilic organisms?
   Ans. They can produce off-flavors in milk or milk products within several days.
66. Are psychrophilic organisms destroyed during pasteurization?
   Ans. Yes.
67. How do psychrotrophic organisms find their way into pasteurized products?
   Ans. By past-pasteurization contamination via improperly cleaned or unsanitized equipment.
68. What test is used to determine the efficiency of pasteurization?  
   Ans. The phosphatase test.
69. How does this test work?  
   Ans. The test measures colorimetrically the amount of the enzyme "phosphatase" present in the milk or milk product. In properly pasteurized products the enzyme is completely destroyed.
70. What are the maximum bacterial counts of milk and milk products under Oregon standards?  
   Ans.  
   
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<thead>
<tr>
<th></th>
<th>Oregon</th>
<th>USPHS (FDA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Raw milk for pasteurization (producer count)</td>
<td>80,000/ml.</td>
<td>100,000/ml.</td>
</tr>
<tr>
<td>B. Pre-pasteurized count-plant Bulk</td>
<td>160,000/ml.</td>
<td>300,000/ml.</td>
</tr>
<tr>
<td>C. Pasteurized count - Milk Bulk</td>
<td>20,000/ml.</td>
<td>20,000/ml.</td>
</tr>
<tr>
<td>C. Pasteurized count - Milk Cream</td>
<td>20,000/ml.</td>
<td>20,000/ml.</td>
</tr>
<tr>
<td>C. Pasteurized count - Milk Mixes</td>
<td>50,000/ml.</td>
<td>--------------</td>
</tr>
<tr>
<td>D. Coliform Count (fluid milk and cream)</td>
<td>10/ml.</td>
<td>1/ml.</td>
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</tbody>
</table>
71. What responsibility is assumed by a person receiving a pasteurizer license?  
   Ans. A person receiving a pasteurizer license becomes responsible for the proper pasteurization of all milk products during the period of pasteurizer operation.
72. When must regulatory personnel check the holding time of the HTST pasteurizer, other than the routine checks required by law?  
   Ans. The regulatory agency must be contacted to check the holding time of the HTST pasteurizer when any change has been made in the unit affecting the flow and/or instrument adjustment. This would include:
   A. When it is necessary to adjust the recorder controller setting, alter the maximum speed setting of the timing pump, adjust or alter pressure control switch on pasteurized section of regenerator.
   B. When there is an addition or a removal, or the changing of size of any equipment of the pasteurizer system, such as homogenizer, booster pump, timing pump, etc.
   C. When there is a replacement or repair of worn parts, particularly in the timing pump such as drive belt, variable speed pulleys, impeller blades, etc.
   D. When plates are added or removed, pipe lines increased or decreased in length or size, and holding tube altered in any way.
73. What effect would worn impellers have on the holding time?  
   Ans. Worn impellers would increase the holding time since they would reduce the efficiency or the capacity of the pump.
76. What are the construction requirements of the holding tube?
   Ans. They must be constructed of sanitary piping and fittings with uniform bore throughout the length. They must have a continuous slope from the outlet of the heat exchanger to the flow diversion valve with a minimum rise of 1/4 inch per foot of tubing to prevent entrapment of air in the tubes. Supports for tubing must be permanent to maintain all parts of the tube in a fixed position.
77. What effect would entrapped air in the holding tube have on the holding time?
   Ans. It would decrease the holding time since the entrapped air would, in a sense, reduce the diameter of the piping and increase the rate of flow through the holding tube.
78. What effect would air leaks on the low pressure (suction side) of the HTST pasteurizer have on the holding time?
   Ans. The holding time would be increased since the injection of air into the system would decrease efficiency, thereby reducing the rate of flow.
79. What actuates the flow diversion valve in forward flow? In diverted flow?
   Ans. Forward flow -- air pressure on diaphragm
   Diverted flow -- spring tension
80. What components of the HTST pasteurizer are air actuated?
   Ans. A. Recorder controller (pneumatic type)
        B. Flow diversion valve (forward flow)
        C. Hot water temperature controller
        D. Steam valve for the hot water controller
81. Why must the pasteurized milk line from the outlet of the HTST system rise to an elevation of at least one foot above the height of any raw milk line in the pasteurizer and be open to the atmosphere at that elevation and above?
   Ans. To maintain a greater pressure (of at least 1 psi) in the pasteurized section of the regenerator.
82. Why must there be a break in the atmosphere or vacuum breaker at the maximum height of this outlet line?
   Ans. To prevent any siphoning of the product from the pasteurizer to a lower point downstream which would reduce the pressure in the pasteurized section of the regenerator.
83. When the pasteurizer has been shut down, what provision is made so that a greater pressure will be maintained in the pasteurized milk section than in the raw milk section to permit raw milk to drain back to the balance tank from the regenerator?
   Ans. Small holes are drilled in the lower part of the deflector plates which allow the raw milk to drain back into the balance tank.
84. What three components of the HTST pasteurizer must be sealed by the regulatory agency?
   Ans. A. The cut-in and cut-out temperature adjustments of recorder controller.
        B. Maximum speed setting of the timing pump.
        C. The sanitary liquid level or pressure switch located at the pasteurized milk outlet of the regenerator section.
85. What would be the most common causes preventing the timing pump from running?
   Ans. A. Lack of electrical power (fuse out).
   B. Improper assembly of flow diversion valve (microswitch roller out of groove).
86. Why must the restrictor in the diversion line, which regulates pressure against the milk when in diverted flow, be in the vertical plane?
   Ans. To allow the diversion line to drain completely. If it were located in the horizontal pipe, warm raw milk would be entrapped, not allowing the line to completely drain.
87. Which of the following materials used in the construction of dairy equipment will be more readily stimulate the development of oxidized flavor in milk: Stainless steel, copper, white metal, glass, brass, or iron?
   Ans. Copper, white metal, brass, and iron act as catalysts in the development of an oxidized flavor in milk.
88. Which metal is far superior to others for the construction of dairy equipment?
   Ans. Stainless steel.
89. What constitutes a "disease-free" herd, according to the public health code?
   Ans. One that is free of tuberculosis and brucellosis (Bang's disease).
90. What is milkstone?
   Ans. It is an undesirable accumulation of milk minerals plus protein, fat, and trapped moisture on equipment surfaces. Inadequate washing and rinsing procedures cause milkstone formation.
91. Of what significance is milkstone?
   Ans. It harbors bacteria and is a source of contamination.
92. Are chemical sanitizers effective in the presence of milkstone on an unclean surface?
   Ans. No, they will not penetrate the unclean surface.
93. How is the strength of chemical sanitizing solutions designated?
   Ans. In parts per million (ppm).
94. What are the three (3) recommended methods of sanitizing dairy equipment?
   Ans. A. Approved chemical sanitizers, using recommended strength and exposure time.
   B. Hot water--at least 180º F for an exposure time of at least 5 minutes.
   C. Steam--at least 200º F for an exposure time of at least five minutes.
95. What are enzymes?
   Ans. Any substance which stimulates or speeds up chemical reactions but does not enter into the reaction itself.
96. Of what significance are enzymes in milk and milk products?
   Ans. A. Some may cause off-flavors. Example: Lipase stimulates the breakdown of fatty acids, causing a rancid flavor.
   B. Some may be used to denote certain conditions of the milk. Example: the presence of phosphatase in processed milk indicates improper pasteurization.
97. How sensitive is the phosphatase test?
   Ans. It will indicate the presence of a minimum of one part of raw milk in 2,000 parts of pasteurized milk.
98. How may yeast and mold be controlled?
   Ans. Primarily through good general housekeeping practices and the controlling of dust and unclean damp storage areas.
99. What are thermophilic and thermoduric bacteria?
   Ans. Thermophilic organisms are capable of growing at pasteurization temperatures. Thermoduric organisms are capable of enduring pasteurization temperatures.

100. Why must we be concerned with thermophilic and thermoduric organisms?
   Ans. High contamination of these organisms in the raw milk may render it impossible to meet the bacterial standards for the pasteurized milk. Improper cleaning of the pasteurizer or prolonged operation of the pasteurizer without cleaning may cause a high incidence of these organisms, which are capable of producing off-flavors in milk.

101. Define pasteurization.
   Ans. Pasteurization is the process of heating every particle of milk or milk product to a specific temperature and maintenance at this temperature for a specific holding period in approved and properly operated equipment.

102. Is the coliform organism destroyed by pasteurization?
   Ans. Yes.

103. What is the significance of coliform organisms in pasteurized milk products?
   Ans. They indicate post-pasteurization contamination.

104. Is it possible to adjust the temperature recording pen on the recorder controller?
   Ans. Yes, the adjusting screw is readily accessible and should be corrected when it does not correspond to the indicating thermometer. The recorder thermometer should never read higher than the indicating thermometer (a responsibility of the operator).

105. Under what conditions may an operator's license be revoked?
   Ans. A license may be revoked if licensee fails to comply with laws and regulations pertaining to pasteurization equipment.

106. Is it possible for an unlicensed person to operate a pasteurizer under the guidance of a licensed operator?
   Ans. Yes.

107. What are the qualifications of an applicant for a pasteurizer license?
   Ans. A. Must be 18 years old.
        B. Free from communicable diseases.
        C. Able to read and write.
        D. Must have six months experience.

108. What are possible causative factors resulting in a wavy temperature line on the recorder chart?
   Ans. A. Fluctuation in raw milk temperature.
        B. Intermittent feed back of hot milk to the balance tank through the diversion line.
        C. Variations in hot water temperature.
        D. The suction of excessive amounts of air into the system.
        E. Erratic air pressure from supply.

109. What is a 3-A Sanitary Standard?
   Ans. A 3-A Sanitary Standard for Dairy Equipment is a voluntary standard, developed by conferees representing sanitarians, equipment fabricators, dairy processors, and the U.S. Public Health Service. It covers features of sanitary design for an indicated item of machinery or process.
110. Why is it called "3-A"?

Ans. 3-A stands for three associations. In the 1920's, two trade associations and one professional association formulated uniform standards for fittings used on milk pipeline. The trade groups are now known as Milk Industry Foundation and the Dairy and Food Industries Supply Association; the professional group is now known as the International Association of Milk, Food, and Environmental Sanitarians. The standards for fittings evolved in those days became popularly known as "3-A" standards. Since 1944, every major dairy processing group, suppliers and equippers, and the U.S. Public Health Service have taken part—but the results are still referred to as 3-A Sanitary Standards.

111. Who develops a 3-A Sanitary Standard?

Ans. Standards are formulated by the 3-A Sanitary Standards Committees—which meet together once or twice a year. They are:

A. The Committee on Sanitary Procedure of International Association of Milk, Food, and Environmental Sanitarians.

B. The Sanitary Standards Subcommittee of Dairy Industry Committee, representing the following associations of processors--American Butter Institute, American Dry Milk Institute, Evaporated Milk Association, International Association of Ice Cream Manufacturers, Milk Industry Foundation, National Creameries Association, and National Cheese Institute—and also representing the association of equippers and suppliers, Dairy and Food Industries Supply Association.

C. Representatives of the Milk and Food Program, Division of Environmental Engineering and Food Protection, B.S.S., U.S. Public Health Service.

Invited to a regular meeting of all the Committees, moreover, are representatives of all manufacturers of record (regardless of association affiliation) of equipment of the type or types under consideration there.

112. How are 3-A Sanitary Standards formulated?

Ans. The primary suggestion for a 3-A Sanitary may come from anyone--public health officials, dairy processors, or equipment manufacturers. The suggestion may be communicated to any of the groups participating in the 3-A program which will pass it on to the Executive Committee to have merit and timeliness, it is passed on in due course to the Technical Committee of Dairy and Food Industries Supply Association. The Technical Committee appoints a Task Committee of representatives of all known manufacturers of the equipment involved in the suggestion. The Task Committee develops a tentative draft of a standard, which is sent to the appropriate committees and officers of Dairy Industry Committee, International Association of Milk, Food, and Environmental Sanitarians, and U.S. Public Health Service.

Usually, many rewritings are necessary before a tentative standard is drafted which merits discussion at a meeting of the 3-A Sanitary Standards Committees. Frequently, even after a tentative standard has progressed that far, it may be sent back to the Task Committee for further work. If the tentative standard is agreed to by all participating parties at such a meeting then it is formally approved.

Within a year, the 3-A Sanitary Standard is published in The Journal of Milk and Food Technology, and thousands of reprints are circulated to all persons involved. Additionally, copies of each 3-A Sanitary Standard are maintained on file in the national headquarters of the major trade groups, and are always available to any interested party.
PART VIII
APPENDIX
SECTION A

Care and Maintenance of Recording Thermometers

To obtain maximum uninterrupted service from any recording thermometer:
1. Do not mount the instrument where it is subjected to vibration.
2. Do not kink the flexible connecting tubing or bend it unnecessarily. A hook should be provided adjacent to the apparatus for holding the bulb out of the way during cleaning operations. A permanent bracket to hold the bulb can be made by using a No. 15 threaded ferrule on the end of a 2-inch sanitary pipe conveniently attached with bracket. The pipe should be long enough to shield the bulb. The union nut which holds the bulb in line can be screwed to the ferrula to hold the bulb securely while not in use.
3. Wash the pen occasionally with hot water or alcohol to remove any dried ink.
4. If a spring-type clock is used, care should be taken not to wind it too tightly. The movement should be cleaned and re-oiled by a competent person once a year. No maintenance is required for an electric clock.
5. Store new charts in a dry atmosphere. Moist charts will not show clear records.
6. Adjust the pressure of the pen so that it will not bear down too heavily on the chart.
7. When inserting a new chart, be sure it is centered accurately.
8. When rinsing equipment, avoid playing water on the thermometer case. Wipe off the case with a wet sponge and then with a dry cloth. A waterproof canvas bag can be placed over the case, or a metal cabinet can be made to house the entire recorder during washdown periods.
9. Do not attempt to adjust the indication of the pen unless there is very definite evidence of inaccuracy.
10. Be sure bulb end and entire stem are clean. A dirty stem may lead to inaccurate readings and will contribute large numbers of bacteria to the milk.

THERMOMETER ADJUSTMENTS

If it is certain that the recorder pen is not indicating correct temperatures, the bulb should be removed from the apparatus for tasting in a water bath at approximately the same temperature at which the instrument is ordinarily used. A 10-gallon milk can makes a good water bath and a steam hose can be used to bring cold water to the proper temperature.

Immerse the bulb, together with a test thermometer of known accuracy, in the water bath. An etched stem thermometer is made according to specifications of the U.S. Public Health Service especially for this purpose. It is calibrated for 4-inch immersion with a range of 142º to 168º F, graduated in 1/5-degree divisions. For testing at temperatures above and below this range, use a general test thermometer having a range of 30º to 220º F in 2-degree divisions.

Agitate the water vigorously. After a period of at least 2 minutes—or when the recorder pen comes to rest—compare the temperature indicated by the pen with that of the check thermometer. For best results this operation should be carried out by two persons, one to read the test thermometer and one to adjust the recorder.

The above procedure will correct most inaccuracies in recording thermometers. Occasionally, however, when a recorder is adjusted to read correctly at a low point on the chart, it will read incorrectly at a point near the upper limit. In such a case the instrument is said to be out of calibration. Sometimes, after use or mechanical injury, the pen arm will not move when
the temperature of the bulb changes, and adjustments will restore accurate readings for only brief periods. This difficulty is due to a leakage of the actuating medium, and the thermal element should be returned to the manufacturer for repair. Spare thermal elements are available and it is good practice to keep one on hand. Some records are especially designed so that by following the manufacturer's instructions a new precalibrated thermal element can be installed with little loss of time.

TIMING ADJUSTMENT
If the chart revolves too rapidly or too slowly, correction may be made by adjusting the regulator of a spring-type clock toward "faster" or "slower" as required. Make a small adjustment at a time. Most spring-wound clocks are provided with a starter button which engages the balance wheel. If the clock is wound and fails to start of its own accord, the starter button should be manipulated. If the clock is electrically operated and requires adjustment, it may be returned to the factory.

PEN ADJUSTMENT
If the pen is not adjusted correctly, it will not follow the time arc on the chart. This is most noticeable when the pen must move over a large part of the chart in a short interval of time as in the heating period in vat pasteurizer operation. This difficulty may be due to improper location of the pen arm or to the position of the pen point.

By immersing the bulb alternately in hot and cold water, the pen can be moved across the chart and checked. If the movement is faster than that indicated on the time arc of the chart when moving from a low to a high temperature, the point of the pen should be bent upward; if the reverse is true, the point should be bent down.

If the pen does not move smoothly across the chart, there may be excessive friction in the mechanism or the pen may be pressing too hard on the chart. Friction is usually caused by corrosion of pivots in the movement or be bent links or levers. The trouble can be remedied by cleaning the parts in a solvent such as carbon tetrachloride and by straightening out any bent levers or links. Excessive pressure of the pen may be relieved by grasping the pen arm near the upper end and bending it slightly away from the chart.

SECTION B
Air Supply Requirements

Air Supply Equipment. The compressing equipment should be of such a design to preclude contamination of the air with lubricant vapors and fumes. Oil-free air may be produced by one of the following known methods or its equivalent:

1. Use of a carbon ring piston compressor
2. Use of an oil-lubricated compressor with effective provision for removal of any oil vapor by cooling the compressed air.
3. High pressure water-lubricated or non-lubricated blowers.

The air supply must be taken from a clean space or from relatively clean outer air and should pass through a filter upstream from the compressing equipment. This filter must be so located and constructed that it is easily accessible for examination. The filter media should be easy to remove for cleaning or replacement. This filter should be protected from weather, drainage, water, product spillage, and physical damage.

Where it is necessary to store air, an air tank(s), if used, should meet the requirements of ASME and/or National Board of Underwriters Code for unfired pressure vessels.
Moisture Removal Equipment. If it is necessary to cool the compressed air, a liquid-cooled after-cooler should be installed between the compressor and the air storage tank for the purpose of removing moisture from the compressed air. A compressor which incorporates the after cooling function does not require a separate after cooler. Other moisture removal equipment may be used downstream from the compressing equipment prior to the final point of application. The resultant condensate from the after cooler must flow to a properly trapped outlet and discharged to the atmosphere.

Filters and Moisture Traps.
1. Filters must be constructed to assure effective passage of air through the filter media only.
2. The air under pressure must pass through an oil-free filter and moisture trap for removal of solids and liquids. The filter and trap should be located in the air pipeline downstream from the compressing equipment, and from the air tank, if one is used. The filter must be readily accessible for examination, cleaning, and for replacing the filter media. The moisture trap must be equipped with a petcock or other means for draining accumulated water.

Air Piping. The air piping from the compressing equipment to the filter and moisture trap must be readily drainable.

SECTION C
The CIP Flow Diversion Valve

The recent introduction of self-draining clean-in-place (CIP) flow diversion valve (Figure 11) permits a new dimension in cleaning and sanitizing of this most important HTST system component. Accumulation of "unsafe" product in the system always presents the danger of contamination of the product under process. Periodic flushing of such material, especially between forward and divert positions of a flow diversion valve may only provide periodic sanitation. In the new self-draining CIP flow diversion valve proper body design and full port leak protection eliminate contamination hazards.

FLOW DIVERSION VALVES -- Clean in Place Types

PURPOSE -- The conventional flow diversion valve is essentially a three-way valve designed for automatically controlling the direction of product flow.

OPERATION -- Each manufacturer has approached the design in a little different way. All valves have two bodies. Each body has a pneumatic actuator with a spring loaded valve plunger. All are designed to be fail safe--that is loss of power or air, the valve either stays in divert or returns to divert position. Leak detector parts are handled differently as the Figures show. The valves are controlled by two solenoid valves which deliver air to the valve actuators. The microswitches located under the end cap of each actuator. Microswitches operate in series and functions as described for the Taylor FDV valve.

According to a G & H Products, In. bulletin the new valve has four control functions (via a 4-way switch):

RUN -- In this switch position, the valve is controlled by the Safety Thermal Limit Recorder. If the product temperature is below the legal limit, the valve assumes the diverted flow position, and the timing pump is controlled by the valve microswitches located in the valve actuators.

When the product temperature is above the legal limit, the valve assumes forward flow position. However, the valve may be diverted manually by depressing a momentary "Divert" button at the valve itself; the valve will remain diverted as long as the button is depressed. Thus,
installations using booster pumps, are provided with a means for rapid checking of booster pump cut-off.

DIVERT -- This switch position will cause the valve to divert and remain diverted as long as the switch remains in this position.

CIP -- When the switch is moved to this position, a 15 second delay is initiated to allow the timing pump to coast to a stop. Following this delay, the valve is ready for CIP cleaning according to the present schedule established on the timer.

INSPECT -- The "Inspect" control position is intended to permit assembly of valve stems to actuators after inspection. While disassembly can be accomplished manually, assembly is greatly simplified with power assistance. Control in the "Inspect" position institutes a 15 second delay period which assures complete stoppage of the timing pump. Immediately following the delay, the valve assumes the forward flow position. Valve stems may then be assembled to the actuators.

SECTION D
The Sanitary Pressure Differential Indicator

The recently developed sanitary pressure differential indicator (Figure 12) is a dual volumetric pressure indicator with a control circuit for operating the booster pump if the pressure differential between the pump outlet and the pasteurized regenerator outlet does not meet regulatory agency requirements. The instrument is sealed to prevent unauthorized adjustment.

This pressure indicator carries out the intent of the U.S. Public Health Service Code for a sanitary indicator that operates on differential pressure, rather than via time delay-relay. Two pressure indications are shown on the instrument, the booster pump pressure and the pasteurized regenerator outlet pressure.

SECTION E
Chlorinated Cleaners and Stainless Steel Corrosion

Stainless steel occupies a most important place in the diary industry due in part to its high corrosion resistance. It has been found to be durable under wise temperature ranges, from high heat to extreme cold it has a pleasing appearance and is easy to clean.

Stainless steel gets its corrosion resistance from an oxide coating formed on the surface. When this monomolecular oxide coating covers the entire surface, the surface is said to be passive. When breaks in this coating occur the more reactive materials beneath it (such as iron) are subject to corrosion.

"TRAMP" METAL CAUSES TROUBLE

In order to insure maximum corrosion resistance of stainless steel after fabrication some manufacturers use chemical cleaning procedures as a passivation treatment. When this treatment is used, possible contamination of non-stainless materials such as free iron or "tramp" metal particles is eliminated. If free iron or "tramp" metal particles are not removed after fabrication, rust spots will form at these points. Rust spots such as these are occasionally found in bulk tanks. They are most evident in the seam weld on sidewalls of the tank or covers. Rust spots are caused by the deposition of tramp metal particles from grinding wheels during the polishing procedure. Rust spots can be evident on the bottom of a tank where "tramp" particles have collected during fabrication and then not properly removed. In time such rust spots will lead to pitting of the stainless steel.
Stainless steel can be given proper passivation treatment after manufacturing and fabrication, making it uniformly resistant to corrosive action under normal conditions. As previously stated, the surface is covered with an oxide coating through passivation, but any break in this coating will leave the surface subject to corrosion. Therefore, it is important that this protective coating be maintained.

DON’T OVER USE CHLORINE

A major cause of attack on oxide coatings is misuse of chlorinated cleaners and chlorine-bearing sanitizers. Chlorinated cleaners can cause corrosion when not properly rinsed from equipment. In order to condition and remove protein soil, this type of cleaner must be used. It is equally important to remove it completely in the post rinse. Acidified rinse procedures must be utilized to insure complete removal of all cleaner residual. Chlorine-bearing sanitizers can cause corrosion if they are over used, equipment is sanitized at a time other than prior to use, or chlorine is mixed with acid cleaners for cleaning purposes. Chemical manufacturers continually emphasize: "Follow directions."

Soil deposits can be cause of corrosion. Milkstone deposits left on a surface for an extended period of time will have a tendency to choke off air to the oxide coating, thereby causing corrosion.

Certain types of water supplies have a corrosive effect, such as water containing high levels of chlorides, or high sulphur content. Rust or iron particles found in water supplies can be corrosive when left on stainless steel surfaces.

OTHER CAUSES

Another cause of corrosion is through air contamination. Although this is not frequent, it can take place in coastal regions.

Still another possible cause is the contact of dissimilar metals. This often occurs by setting foreign metal objects on the stainless steel surface (i.e. wrenches, etc.). Iron or galvanized pipes that are not attached without proper insulation can be problem.

There are other causes of corrosion, but those listed above are some of the main offenders. While some water supplies may require special treatment, corrosion problems can be eliminated with a sound cleaning program followed by an acidified rinse, using a passivating type acid (i.e. hydroxyacetic acid, phosphoric acid, etc.).

A reminder: "Follow directions."

SECTION F

A Compact HTST Controller

A recently introduced single-case HTST controller (Figure 13) is described as a complete, simple design and easily maintained pasteurizer control unit.

Right-hand mechanism. A thermal element, located in the holding tube, reflects the temperature of the milk as it leaves the heating section of the pasteurizer and operates directly the recording pen. Should milk temperature fall below the safety limit, the switching segment electronically actuates a relay to signal for diversion. The event pen records diversion time on the periphery of the chart, and the red alert light energizes. The same system will record CIP temperatures of the cleaning cycle.

Left-hand mechanism. The hot water temperature is pneumatically controlled. The set point and temperature indication are registered on the transparent plastic scale located over the recording chart.
SECTION G
Ultra Pasteurization Milk Processing

The term "ultra-pasteurized", when used to describe a dairy product, means that such product shall have been thermally processed at or above 280°F (138°C) for at least 2 seconds, either before or after packaging, so as to produce a product which has an extended shelf life under refrigerated conditions.

The objective of the ultra-pasteurization process is to produce a "commercially sterile" product. Following the heat treatment, the product is aseptically filled into the appropriate package.

Two basic types of heat exchangers are used in ultra-pasteurization: (1) direct and (2) indirect heating. In the direct heat process milk is usually first heated indirectly with a plate or tubular heat exchanger and then is mixed with saturated steam under pressure. Steam may be either injected into the milk or the milk may be sprayed into an atmosphere of steam. In either case, the milk is cooled after a short steam exposure by injection into a vacuum system.

The vacuum is controlled so that water added to the milk during the steam injection phase is removed as vapor in the vacuum system. During evaporation of the vapor, the milk is cooled rapidly to a temperature near that which it had before mixing with steam. The steam which is to be mixed with the milk must be high culinary quality steam and contain no chemical compounds as a result of the boiler feedwater treatment.

The milk is heated via a stainless steel barrier which separates the milk from the heating medium in the indirect heat system. The heat exchange surface may be a corrugated plate (as in many HTST systems) or a tubular system, or a scraped-surface type in which the product flows through an ice cream-freezer-like cylinder. The cylinder is heated externally by steam, and the inside wall of the cylinder is scraped continuously rotating blades. The scraped surface system is used primarily for relatively viscous products where turbulence would be hard to obtain.