Food Protection Services

dairy processing plants

Code of Good Practice for High Temperature Short Time Pasteurizers (HTSTs)

Critical Design, Operational & Testing Criteria



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INTRODUCTION

The pasteurizer unit is the most important safety control point in the dairy processing industry.

Pasteurization, when properly applied to milk is the only practical commercial measure to destroy all milkborne disease organisms. Experience conclusively confirms its value in protecting public health.

The purpose of this publication is to provide the dairy plant licencee with a concise manual outlining the key public health requirements for pasteurizers. All installations must, in addition, conform with the provisions of the *British Columbia Milk Industry Act and Regulations*. As such, dairy plant licensees and equipment installers should refer to the complete requirements of the legislation and to 3A Sanitary Standards referred to therein.

Key design, operational and test requirements for each component of an HTST pasteurizer is listed in Part I of this manual. Part II outlines the requirements for batch pasteurization equipment and controls. A record of all tests must be kept on file at the dairy plant. It is strongly recommended that an individual experienced in pasteurizer installation design and install this critical equipment.

In addition to the *British Columbia Milk Industry Act*, other legislation may apply to the pasteurizer equipment. Plants subject to federal certification are encouraged to contact Canadian Food Inspection Agency to ensure that any proposed modifications or installations comply with all applicable standards.

Information and standards discussed in this manual deal exclusively with pasteurizer requirements under the *British Columbia Milk Industry Act*.

Originally Published in 1991

PART I

HTST DESIGN AND OPERATIONAL CRITERIA

HTST DESIGN CRITERIA

- 2 -

HTST DESIGN CRITERIA

A. Pasteurization

The process of heating every particle of milk or milk product in properly designed equipment for a minimum time and at a minimum temperature as specified in Table 1.

Table 1

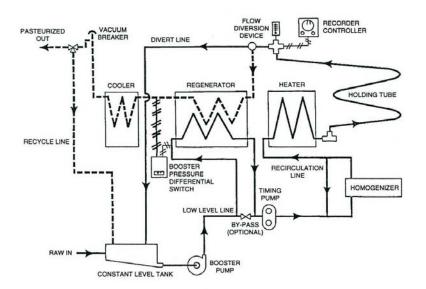
HTST Pasteurization Requirements

Dairy Product	Time/Temperature
fluid milk	16 seconds at 72°C
cream (≥10% BF)	16 seconds at 75°C
ice cream, ice cream mix, and sugared dairy beverage	25 seconds at 80°C

Figure 1 illustrates the major components of a typical HTST pasteurizer. This figure is for reference only and is not intended to include all components or design variations.

Figure 1

Typical HTST Pasteurizer



Plans must be submitted to the Dairy Plant Specialist for approval before an HTST pasteurizer is installed or modified. The installation or modification must also be approved before milk products are processed and made available for public consumption.

B. Raw Product Constant Level Tank

- 1. The raw product constant level tank shall conform with the applicable sections of 3A Sanitary Standards.
- 2. The divert, leak detect, recycle and water lines must be designed to prevent the siphonage of raw milk into the pasteurized milk or water lines. This is accomplished by ensuring that the lines break to atmosphere at a distance equal to or greater than two times the diameter of the largest return line above the maximum flood level of the constant level tank.
- 3. When product to product regeneration is employed, the overflow point shall be lower than the bottom of the raw regenerator.
- 4. The constant level tank shall have a lid.

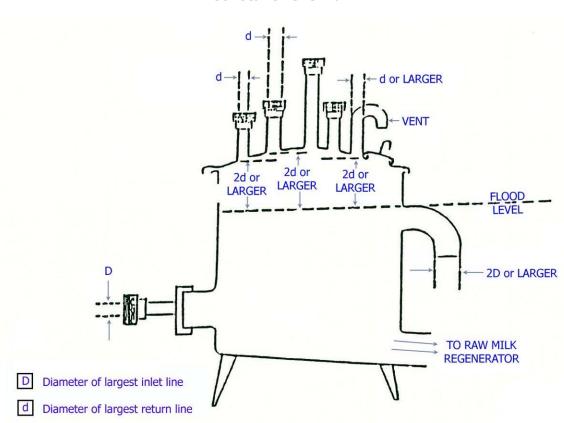


Figure 2 Constant Level Tank

C. Product Contact Surfaces

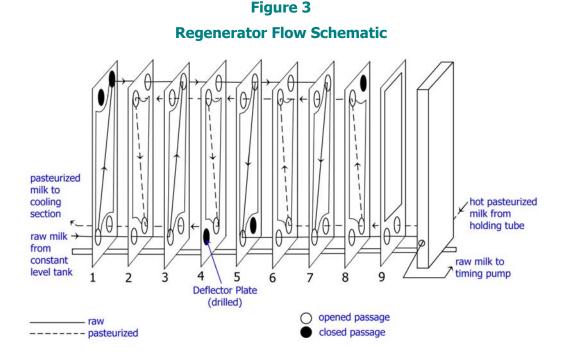
- 1. Product contact surfaces must comply with the applicable 3A Sanitary Standards.
- 2. All product contact surfaces designed to be mechanically cleaned must also be designed so that they are easily accessible for inspection.
- 3. All surfaces not designed to be mechanically cleaned must be easily accessible for cleaning and inspection either when assembled or removed.

D. Raw Product Booster Pump and Auxiliary Pumps

- 1. All pumps shall be designed, installed, and operated in accordance with 3A Sanitary Standards.
- 2. All auxiliary pumps must be installed and operated so as not to interfere with the proper product pressure relationships, or with the holding time in the HTST system.
- 3. Except during the cleaning cycle, the raw product booster pump shall be permanently wired so that it cannot operate unless:
 - a) the timing pump is in operation.
 - b) the flow diversion device is in forward flow position, and
 - c) the pasteurized product pressure in the pasteurized product regenerator exceeds by at least one (1) psi the pressure of the milk in the raw regenerator .
- 4. The cleaning mode shall be designed and installed to ensure that it cannot be activated during the pasteurization cycle.

E. Regeneration Section

- 1. The regeneration section must be designed, installed, and operated in accordance with 3A Sanitary Standards.
- 2. When product to product regeneration is employed, the pressure in the pasteurized product passages must, at all times, be higher than the pressure in the raw product passages.
- 3. All raw product in the regenerator shall drain freely to the raw product constant level tank when the raw product pump is shut down and the raw line is disconnected at the regenerator outlet. This may be accomplished by:
 - a) drilling a two (2) mm hole in the raw product channel deflector plates, and
 - b) feeding the raw milk into the bottom of the regeneration section.



- 4. All raw sections of a split regenerator must be free draining.
- 5. The raw product side of the regenerator may be bypassed provided that:
 - a) the bypass line is close coupled, or
 - b) the bypass control valve is designed to permit a slight movement of product through the bypass line.
- 6. The plates shall be checked annually for perforations.
- 7. Where a plate heat exchanger is installed, a diagram must be kept at the dairy plant which depicts:
 - a) the port operating sequence,
 - b) the proper location of the drain holes, and
 - c) the product flow patterns through the system.

F. Timing Device

- 1. The timing device shall be a positive displacement pump, which conforms to 3A Sanitary Standards. Any timing device which has been demonstrated to be equally effective as a positive displacement type timing pump and has been approved by the Dairy Plant Specialist may be used.
- 2. The timing device must be installed in accordance with 3A Sanitary Standards.
- 3. The timing device shall be installed upstream from the holding tube.
- 4. The timing device shall be interwired with the flow diversion device and the recorder controller so that it will operate only in the fully forward and fully diverted position.
- 5. The timing device shall not be excluded from the system during pasteurization.
- 6. Variable speed driving mechanisms shall be designed to permit sealing against pump operation at greater capacity than that which gives legal holding time.

G. Meter Based Timing Systems

- 1. Only approved magnetic flow meters may be used.
- 2. The meter based timing systems must have a flow recorder capable of recording flow at the high flow alarm set point and also at least 19 litres per minute higher than the high flow alarm setting. The flow recorder shall have an event pen, which shall indicate the position of the flow diversion device with respect to flow rate.
- 3. A high flow alarm with an adjustable set point shall be installed which will automatically cause the flow diversion device to be moved to the divert position whenever excessive flow rate causes the product holding time to be less than the legal holding time for the pasteurization process being used.
- 4. A low flow or loss of signal alarm shall be installed which will automatically cause the flow diversion device to be moved to the divert position whenever there is a loss of signal from the meter or the flow rate is below the pre-set minimum flow rate.
- 5. When the legal flow rate has been re-established following an excessive flow rate, the flow diversion device must remain in the diverted flow position for 16 seconds when pasteurizing milk or cream, or 25 seconds when pasteurizing chocolate drink or ice cream.

- 6. A sanitary product check valve shall be installed in the system to prevent positive pressure in the raw milk side of the regenerator whenever a power failure or shut down occurs. The check valve must be installed between the magnetic flow meter and the start of the holding tube.
- 7. Installation of the individual components in the system shall comply with the following conditions.
 - a) The centrifugal pump shall be located downstream from the raw milk regenerator section.
 - b) The magnetic flow meter shall be placed downstream from the centrifugal pump with no components such as valves or pumps between them.
 - c) For single speed centrifugal pumps a control valve must be placed downstream from the magnetic flow meter and upstream from the holding tube.
 - d) The centrifugal pump and the magnetic flow meter shall be located upstream from the holding tube.
 - e) Product must not be fed into or extracted from the system (i.e. cream or skim milk from a separator or other product components) between the A-C variable frequency centrifugal pump and the flow diversion device.
 - f) The magnetic flow meter shall be installed such that the product has contact with both electrodes at all times when there is flow through the system. This is most easily accomplished by mounting the flow tube of the magnetic flow meter in a vertical position with the direction of flow from the bottom to the top. However, horizontal mounting is acceptable when other precautions are taken to assure that both electrodes are in contact with product at all times.
 - g) The magnetic flow meter shall be piped in such a manner that at least ten (10) pipe diameters of straight pipe exists upstream and downstream from the centre of the meter before any elbow or change of direction takes place.
- 8. When computers or programmable logic controllers are used they must be installed in such a manner that critical control equipment is not influenced by the computer or programmable logic controller. The computer or programmable logic controller may however control the speed of an A-C variable frequency centrifugal pump provided the high flow alarm is set and sealed to provide for diversion of the flow diversion device whenever the design flow rate is exceeded.

H. Holding Tube

- 1. All holding tubes must be installed and constructed in accordance with 3A Sanitary Standards.
- 2. The holding tube must be designed to provide for the continuous holding of every particle of product for at least the minimum required holding time.
- 3. The dairy plant licencee shall provide evidence that the holding tube is providing the required holding time.
- 4. The holding tube must have a continuous slope of 1/4 inch per foot (2%) upwards to the flow diversion device. Any piping from the outlet of the heater to the flow diversion device that has less than the required slope shall not be considered part of the holding tube.
- 5. The holding tube must have permanent support.

6. The holding tube shall be equipped with the necessary fitting for checking the holding time by means of saline solution.

I. Sensing Chamber

- 1. The sensing chamber and all thermometers inside the sensing chamber must be designed, installed and operated in accordance with 3A Sanitary Standards.
- 2. The sensing chamber must contain the indicating thermometer probe and the recorder controller temperature probe.
- 3. The indicating thermometer and the recorder controller temperature sensor shall be located as close as practical to one another.
- 4. Only the thermometer fitting openings in the sensing chamber are permitted to be higher than the inlet connection to the flow diversion device.
- 5. The recorder controller temperature sensor shall not be more than 18 inches upstream from the inlet of the flow diversion device.

J. Indicating Thermometer

- 1. All indicating thermometers shall be designed and installed in accordance with 3A Sanitary Standards.
- 2. Indicating thermometers shall be of a 3A approved type. Alternate type thermometers may also be approved providing they meet the intent of and are as fail safe, accurate, reliable, and meet the scale and thermometric response specifications for 3A approved type thermometers.
- 3. All indicating thermometers shall be calibrated upon installation and once every three months thereafter. The dairy plant licensee shall keep on file information pertaining to the testing and calibration of all indicating thermometers.
- 4. The temperature reading of the product in the sensing chamber shall be easily readable by the operator during pasteurization of the product.

K. Flow Diversion Device

- 1. All high temperature short time systems must have a flow diversion device that is designed, installed, and operated in accordance with 3A Sanitary Standards.
- 2. The flow diversion device shall divert the product flow at sub-legal temperatures.
- 3. The flow diversion device must have an operating leak detector with complete leak detection capabilities, and
 - a) dual valve flow diversion devices shall be equipped with separate free draining lines back to the constant level tank with a sight glass on the leak detect line,
 - b) single stem flow diversion devices must have functional leak detection poppets.
- 4. The flow diversion device shall be free from any device that may jeopardize the safety of the pasteurized product.

L. Clarifier and Separator

- 1. The clarifier and separator must be installed in accordance with 3A Sanitary Standards.
- 2. The separator is considered to be a flow-promoting device and, as such, must not influence the required pressure relationship within the regenerator.
- 3. The separator shall be interwired with
 - a) the timing device when installed adjacent to the timing device,
 - b) the flow diversion device when installed downstream from the flow diversion device.

The interwiring must be designed such that the separator or clarifier is excluded from the system during power interruptions.

M. Homogenizer

- 1. The homogenizer must be designed, installed and operated in accordance with 3A Sanitary Standards.
- 2. The homogenizer, when acting as the timing device, must be interwired in the same manner as a timing" pump except that the homogenizer may have a time delay of not more than one second which allows the homogenizer motor to remain running during the normal transit time of the flow diversion device.
- 3. The homogenizer, when not acting as the timing device, must be interwired with the timing pump or contain a bypass that renders it a non-flow-promoting device. The bypass line must be of equal or greater diameter than the homogenizer inlet line and be free of constrictions.

N. Pasteurized Product Discharge

- 1. The pasteurized product downstream from the regenerator must rise to an opening to the atmosphere at least 12" above any raw product contained in the system. The opening to atmosphere must be located prior to any valve, flow promoting device or other equipment that might interfere with the pressure relationships in the regeneration section.
- 2. All regenerator sections of a split regenerator must be considered separately with respect to maintenance of pressure relationships.
- 3. A device may be approved for use as an opening to atmosphere subject to its ability under:
 - a) forward flow,
 - b) diverted flow, and
 - c) shut down conditions

of ensuring the proper pressure relationship in the regeneration section(s).

O. Recorder Controller (Safety Thermal Limit Recorder)

- 1. The recorder controller must be designed, installed, and operated in accordance with 3A Sanitary Standards.
- 2. The thermometric response and accuracy of the recorder controller's temperature sensor must conform with 3A Sanitary Standards.

- 3. Each recorder controller unit shall have diversion control capability for all products. Where a unit pasteurizes two or more dairy products requiring different pasteurization temperatures, separate diversion capabilities for each product must be provided. If the diversion control is set for the product of the highest pasteurization temperature, then a single diversion temperature may be used.
- 4. All dual diversion recorder controllers shall be provided with a third pen to record the diversion temperature setting on the chart. Where a third arm is not present to track the cut-in/cut-out temperature, the cut-in/cut-out setting shall be verified before the product is processed.
- 5. The recorder controller shall be equipped with a frequency pen and a temperature recording pen that track together on the chart.
- 6. All recorder controllers shall be serviced upon installation and at least semi-annually thereafter. The dairy plant licencee shall maintain current records pertaining to the servicing.
- 7. Testing, and calibration of the recorder controller.
- 8. Any switches, controls, or bypasses that may jeopardize the safety of the final pasteurized product are prohibited within the system.

P. Pressure Relationships

- 1. Pasteurized milk must be maintained at a higher pressure than the raw milk. As well, milk pressure must be higher than the pressure of the cooling and heating medium. Pressure relationships under the following conditions must be considered:
 - a) forward flow,
 - b) diverted flow, and
 - c) shut down.
- 2. No pump, other than a centrifugal pump, may be placed before the raw regenerator.
- 3. Where a booster pump is used, a means to measure and control the pressure relationships within the regeneration section shall be provided. In split regeneration sections, this capability must be applied to all sections.
- 4. The dairy plant licencee shall maintain records that confirm that the product pressure in the cooling section of the HTST is greater than the pressure of the cooling medium.

TEST PROCEDURES FOR HTST EQUIPMENT AND CONTROLS

A. Thermometers

TEST 1: Indicating Thermometer-Temperature Accuracy

<u>Reason</u>

To verify that the indicating thermometer reflects the true processing temperature.

Frequency

Upon installation and every three (3) months thereafter.

<u>Apparatus</u>

- a) A test thermometer accurate to $\pm~0.1^{\circ}\text{C}^{1}$ as determined by the National Bureau of Standards.
- b) A water bath and agitator.
- c) A suitable means of heating the water bath.

- a) Compare the indicating thermometer reading to that of a test thermometer when both are exposed to a water bath adjusted to within 2°C of pasteurization.
- b) The indicating thermometer must be within 0.5°C of the test thermometer.

¹ See Appendix A, Fahrenheit/Centigrade Temperature Conversions.

TEST 2: Recording Thermometer - Temperature Accuracy

<u>Reason</u>

To verify that the recording pen reflects the true processing temperature after exposure to extreme conditions.

Frequency

Upon installation, every three (3) months and whenever the recording pen requires frequent adjustment.

<u>Apparatus</u>

- a) The verified indicating thermometer.
- b) Three water baths and agitator.
- c) A suitable means for heating the water bath.
- d) Ice.

- a) Adjust the recording pen to agree with the indicating thermometer after a stabilization period of five (5) minutes at pasteurization temperature.
- b) Prepare a water bath by heating it to the boiling point and a second bath with melting ice.
- c) Immerse the sensing element of the recorder in boiling water for not less than five (5) minutes.
- d) Heat a container of water to pasteurization temperature.
- e) Remove the sensing element from the boiling water and immerse it in water heated to pasteurization temperature. Allow a five (5) minute stabilization period for both indicating and recording thermometers. The two readings must be within $\pm .5^{\circ}$ C.
- f) Remove the sensing element from the bath and immerse it in melting ice for not less than five (5) minutes.
- g) remove the sensing element from the ice water and immerse it in water at pasteurization temperature. Allow a five (5) minute stabilization period for both indicating and recording thermometers. The two readings must be within \pm .5°C.

TEST 3: Indicating Thermometer - Thermometric Response

<u>Reason</u>

To verify that the indicating thermometer moves through a 7°C range in no more than four (4) seconds.

Frequency

Upon installation and every three (3) months thereafter.

<u>Apparatus</u>

- a) A test thermometer.
- b) A stopwatch.
- c) A water bath and agitator.
- d) A suitable means for heating the water bath.

- a) Immerse the indicating thermometer in a water bath held at a temperature at least 11°C higher than the minimum scale reading on the indicating thermometer. The bath temperature must be higher than the maximum pasteurization temperature for which the thermometer is used.
- b) Immerse the indicating thermometer in ice water for several seconds to cool it.
- c) Insert the cool indicating thermometer in the hot water bath.
- d) Start timing when the indicating thermometer reads 11°C below the bath temperature.
- e) Stop timing when the indicating thermometer reads 4°C below the bath temperature.
- f) The response time must be no more than four (4) seconds.

TEST 4: Recording Thermometer - Thermometric Response

<u>Reason</u>

To verify that the recording thermometer moves through a specific 7°C range in no more than five (5) seconds.

Frequency

Upon installation and every three (3) months thereafter.

<u>Apparatus</u>

- a) The verified indicating thermometer.
- b) A stopwatch.
- c) A waterbath and agitator.
- d) A suitable means for heating the waterbath.

- a) Adjust the recorder controller pen to agree with the indicating thermometer reading at pasteurization temperature.
- b) Remove the sensing element and allow it to cool to room temperature.
- c) Heat a water bath to exactly 4°C above the cut-in temperature.
- d) Immerse the recorder controller bulb in the bath.
- e) Start timing when the recording thermometer reaches a temperature of 7°C below the cutin temperature.
- f) Stop timing when the controller cuts in.
- g) The thermometric response time must be no more than five (5) seconds.

TEST 5: Recording Thermometer - Time Accuracy

<u>Reason</u>

To verify that the recorded time of pasteurization is the same as the true elapsed time.

Frequency

Upon installation and every three (3) months thereafter.

<u>Apparatus</u>

a) A stopwatch.

- a) Check that the recording chart is appropriate to the recorder.
- b) Inscribe a mark on the recording chart at the pen point for the start of the testing period and record a start time.
- c) At the end of 30 minutes inscribe a second mark at the pen point position on the chart.
- d) Determine the distance between the two marks and compare the distance with the timescale divisions on the recording chart at the same temperature.

TEST 6: Recording Thermometer - Check Against Indicating Thermometer

<u>Reason</u>

To verify that the recording chart is in agreement and reads no higher than the indicating thermometer.

Frequency

Upon installation, and daily by the plant operator.

<u>Apparatus</u>

None

- a) Read the indicating thermometer when the milk is at a stabilized pasteurization temperature.
- b) Record the indicating thermometer reading on the chart and indicate the time at which the reading was taken.
- c) The recording thermometer shall not read higher than the indicating thermometer and must be accurate within 0.5°C.

TEST 7: Milk-Flow Controls - Temperatures (Cut-In and Cut-Out)

<u>Reason</u>

To verify that the flow diversion device cuts in and cuts out at or above the minimum pasteurization temperature.

Frequency

Upon installation, and daily by the plant operator.

<u>Apparatus</u>

None

Procedure

a) Cut-in temperature.

Increase the water temperature in the holding tube by no more than 0.5° C each 30 seconds. Record the indicating thermometer reading on the recording chart when forward flow starts.

b) Cut-out temperature.

Allow the water to cool at a rate not exceeding $0.5^{\circ}\mathrm{C}$ each 30 seconds and record the indicating

B. FLOW DIVERSION DEVICE

TEST 8: Leakage Past Valve Seat(s)

<u>Reason</u>

To verify that raw milk cannot leak past the flow diversion device into the pasteurized milk channels.

Frequency

Upon installation and every three (3) months thereafter.

<u>Apparatus</u>

a) Tools to dismantle the flow diversion valve and sanitary piping.

- a) While operating the system with water, place the flow diversion device in the diverted flow position.
- b) Disconnect the forward flow piping and verify that the valve seat does not leak.
- c) Repeat for the leak detector valve.
- d) Check the leak escape ports of a single stem device to ensure that they are open.

TEST 9: Operation of Valve Stem(s)

<u>Reason</u>

To verify that the valve moves freely when the stuffing box nut is fully tightened.

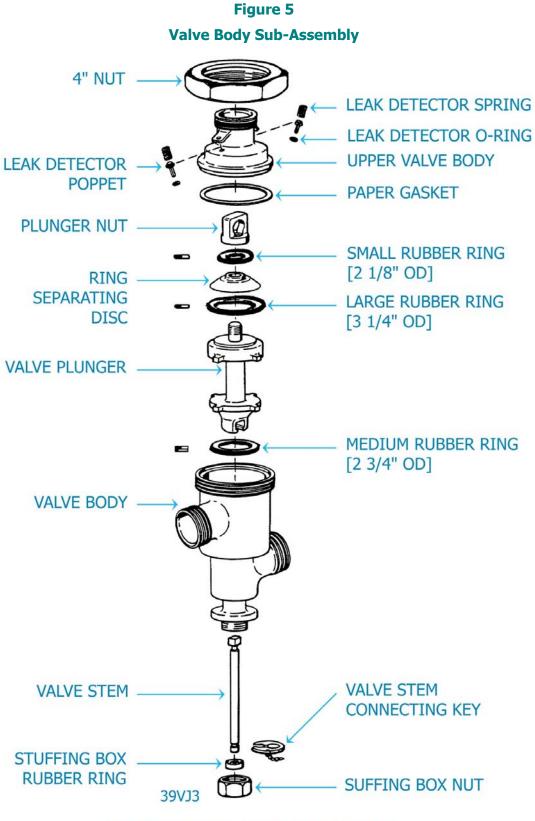
Frequency

a) Upon installation and every three (3) months thereafter.

<u>Apparatus</u>

a) Wrench.

- a) Tighten the stuffing box nut as much as possible.
- b) Operate the HTST and place the flow diversion device in forward and diverted flow several times.
- c) Observe that the valve stem moves with ease.



VALVE BODY SUB-ASSEMBLY

TEST 10: Device Assembly. Single Stem Device

<u>Reason</u>

To verify that the metering pump and all other flow promoting devices stop when the valve is improperly assembled.

Frequency

Upon installation and every three (3) months thereafter.

Apparatus

a) Tools to dismantle the flow diversion valve and sanitary piping.

- a) With the HTST pasteurizer in diverted flow, remove the piping connected to the forward flow part of the valve. Unscrew the four (4) inch nut at the top of the valve 180°. Observe that the metering pump and all other flow promoting devices stop as a result of this procedure.
- b) With the HTST system in operation and the flow diversion device in the diverted position, remove the connecting key located at the base of the valve stem. Observe that the metering pump and all other flow promoting devices stop.

Figure 6 Dual Stem Flow Diversion Device

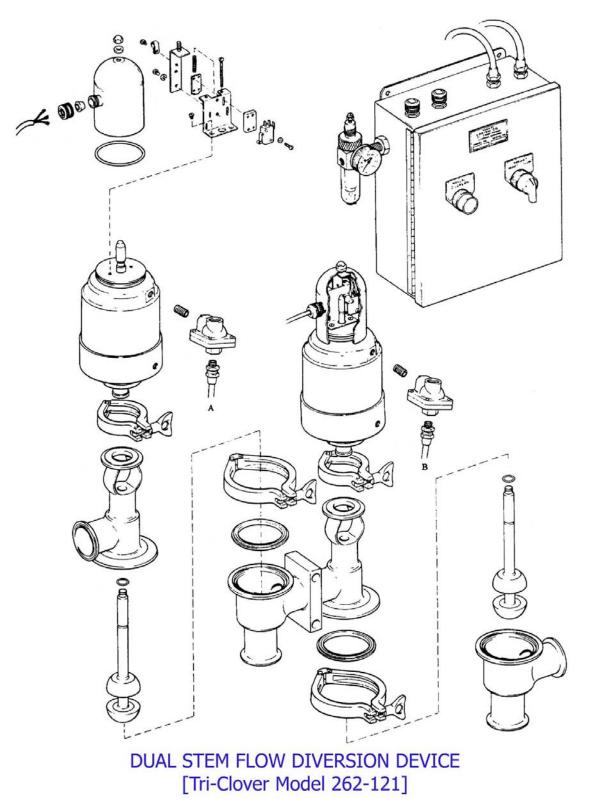
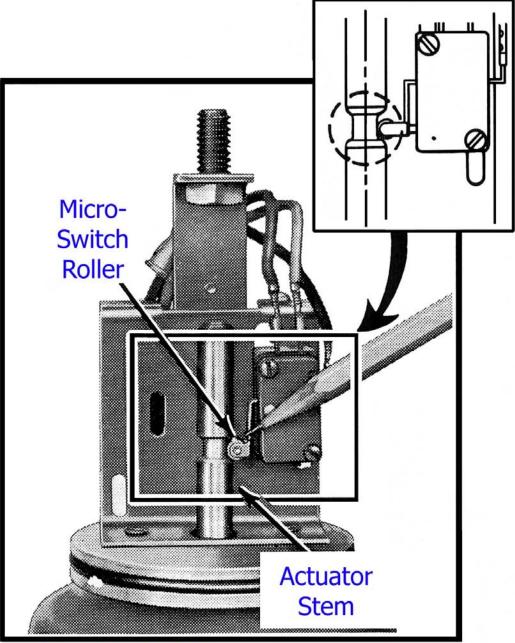


Figure 7 Microswitch Setting



Set roller in bottom of groove when valve is in the divert position.

MICROSWITCH SETTING TRI-CLOVER

TEST 11: Device Assembly. Dual Stem Device

<u>Reason</u>

To verify that the metering pump and all other flow promoting devices stop when the flow diversion device is improperly assembled.

Frequency

Upon installation and every three (3) months thereafter.

<u>Apparatus</u>

a) Tools to dismantle the flow diversion device.

Procedure A

- a) With the pasteurizer in diverted flow, remove one actuator clamp from the valve.
- b) Move the valve to the forward flow position and disconnect the stem from the actuator.
- c) Move the valve to the diverted flow position and turn on the metering pump.
- d) Observe that the metering pump and all other flow promoting devices stop.
- e) Reassemble the valve by moving it to the forward flow position and reconnect the stem to the actuator.
- f) Move the valve to the diverted flow position and replace the actuator clamp.
- g) Repeat the procedure for the other actuator.

Procedure B

a) With the flow diversion device in the diverted flow position, move the microswitch away from the contact groove in each valve stem. Observe that the metering pump and all other flow promoting devices stop.

Procedure C

- a) With the pasteurizer in forward flow, insert a bolt into the diversion valve quick exhaust port.
- b) Reduce the processing temperature below the cut-out temperature.
- c) Observe that the diversion valve does not immediately move to the fully diverted position, that all flow-promoting pumps stop and the separator is bypassed.
- d) Repeat the test for the leak detect valve.

TEST 12: Manual Diversion

<u>Reason</u>

To verify that the booster pump stops when the flow diversion device is manually diverted.

Frequency

Upon installation and every three (3) months thereafter.

Apparatus

None

- a) With the HTST system in operation and the flow diversion device in the forward flow position, press the manual diversion button. Observe that the flow diversion device assumes the divert position, and that the booster pump stops. The pressure differential between raw and pasteurized milk in the regenerator must be maintained during the test run.
- b) Activate the manual divert button while operating the HTST system at its maximum operating pressure. Confirm that the spring tension of the flow diversion device is capable of diverting the system at maximum operating pressure.
- c) Operate the HTST system in forward flow and activate the manual divert button until the raw side pressure reaches zero (0) psi. Release the manual divert button and observe that the pressure differential between the raw and pasteurized milk in the regenerator is maintained.

TEST 13: Response Time

<u>Reason</u>

To verify that the flow diversion device moves to the fully diverted position in no more than one (1) second.

Frequency

Upon installation and every three (3) months thereafter.

<u>Apparatus</u>

a) Stopwatch

Procedure

a) Determine the time required for the flow diversion device to move to the fully diverted flow position as a result of a temperature cut-out. The response time interval must not exceed one (1) second.

TEST 14: Time Delay Interlock with Metering Pump

(for dual stem flow diversion devices with a manual forward flow switch)

<u>Reason</u>

To verify that the system cannot manually enter forward flow while the metering pump is running or any flow promoting device is in operation.

Frequency

Upon installation and every three (3) months thereafter.

<u>Apparatus</u>

None

Procedure

With the system running in forward flow, move the control switch to the "Inspect" position. Observe that the following events automatically occur in sequence:

- a) The flow diversion device immediately moves to the diverted flow position. The metering pump de-energizes and all other flow promoting devices must stop. Separators and clarifiers shall be automatically valved out of the system.
- b) The device remains in the diverted flow position while the metering pump and all other flow promoting devices run down (including the automatic valving out of separators and clarifiers).
- c) After the metering pump and all other flow promoting devices stop turning, and any separators and clarifiers have been valved out of the system, the device should assume the forward flow position without reactivating the pump.

C. PRESSURE DIFFERENTIAL

TEST 15: Pressure Differential Controller

<u>Reason</u>

To verify that the pressure differential controller is installed and operating correctly.

Frequency

Upon installation, every three (3) months and whenever the pressure differential controller is adjusted or repaired.

<u>Apparatus</u>

None

Procedure A

- a) Loosen the process connection at both pressure sensors and wait for any liquid to drain through the loose connections. Observe that both pointers are within \pm 0.5 psi of zero psi.
- b) Remove both sensors from the processor and mount them in a tee at the discharge of the booster pump. Note the difference between the sensor readings. The change in elevations of the sensors may have caused some change in the zero readings. Turn on the booster pump switch and depress the test push button to operate the booster pump. Observe that the difference between the sensor readings is within 1 psi of that observed before pressure was applied.
- c) Turn off the booster pump switch and return the pressure sensors to their normal process locations. Manually move and hold the white pointer (raw side of the regenerator) at the normal operating pressure of the booster pump. Press the test button while manually moving the orange pointer (pasteurized side of the regenerator) upscale until the pilot light turns on, then slowly move the orange pointer downscale until the pilot light turns off. Observe that the pilot light does not turn on until the orange pointer is at least two (2) psi higher than the white pointer. and the pilot light turns off when the orange pointer is no less than two (2) psi higher than the white pointer. If necessary, adjust the differential setting.

Procedure B

- a) Follow steps a) and b) in Procedure A.
- b) Operate the HTST system in forward flow. Reduce the pressure in the pasteurized product regeneration section by slowly opening the back pressure control valve. Observe that the booster pump stops and the pressure differential controller pilot light goes out when the pasteurized product pressure is no less than 2 psi higher than the raw product pressure. The booster pump cut out point is indicated by a sudden decrease in raw product pressure.
- **NOTE:** The two (2) psi differential represents the sum of the one (1) psi differential required between raw and pasteurized product in the regenerator, plus the one (1) psi imprecision permitted between the two pressure sensors. Should the pasteurized milk regenerator outlet be at the bottom of the HTST, the pressure differential must be increased by the head pressure within the HTST pasteurizer.

D. HOLDING TIME

TEST 16: Salt Conductivity Test

<u>Reason</u>

To verify that every particle of milk is held for the minimum holding time in both forward and diverted flow.

Frequency

Upon installation, semi-annually and whenever any alteration affecting the holding tube or velocity of flow is made.

<u>Apparatus</u>

- a) Salt conductivity meter
- b) Wrenches

- a) Examine the entire system to ensure that all flow promoting equipment is operating at maximum capacity and all flow impeding equipment is adjusted or bypassed so as to provide minimum resistance to the flow. There must be no leakage on the suction side of the timing pump.
- b) Install one electrode at the inlet to the holding tube and the other electrode at the holding tube outlet.
- c) Adjust a variable speed pump to its maximum capacity (preferably with a new belt and full size impellers). For meter based timing systems adjust the set point on the flow alarm to its highest setting.
- d) Operate the pasteurizer at pasteurization temperature.
- e) Quickly inject 50 ml. of saturated sodium chloride solution into the holding tube inlet.
- f) Record the holding time.
- g) Repeat the test six or more times, until six successive results are within 0.5 seconds of each other. The average of these six tests is the holding time for water in forward flow. When consistent readings cannot be obtained, purge the equipment, check the instruments and connections, and check for air leakage on the suction side of pumps. Should consistent readings still not be obtained, use the fastest time as the holding time for water.
- h) Repeat steps (d) through (g) for the holding time in diverted flow.
- i) Time the filling of a 10-gallon can with a measured weight of water with the system adjusted as above. The discharge outlet must have the same head pressure as in normal operation.
- j) Repeat procedure (i) using milk.
- k) Compute the holding time for milk from the following formula. Values for forward flow and diverted flow must be calculated separately.

Holding time for milk = $\frac{1.032 TM_w}{W_w}$ (by weight), in which:

1.032 = specific gravity for milk

T = average holding time for water

 M_v = average time required to deliver a measured weight of milk

 W_v = average time required to deliver an equal weight of water

The holding time for milk may also be computed from the following formula by volume. Compute the values for forward flow and diverted flow separately.

Holding time for milk = $\frac{TM_v}{W_v}$ (by volume) in which:

T = average holding time for water

 M_v = average time required to deliver a measured volume of milk

 W_v = average time required to deliver an equal volume of water

Table 2

COMPARISON OF PREDICTED RESIDENCE TIMES BY THE SALT TEST ON WATER AND MEASURED RESIDENCE TIMES USING RADIOACTIVE TRACER IN PRODUCTS

Product	Product Viscosity	Predicted Residence Time Sec.	Measured Residence With 1 131 Sec.	Error In Predicting Product Residence Time By The Salt Test %
Condensed Skim Milk (40% solids)	17	25.6	17.2	33
Ice Cream Mix (16% Milk Fat) 15		26.5	21.9	17
Ice Cream Mix (10% Milk Fat)	11	26.3	23.5	11
Cream (40% Milk Fat)	4	26.3	22.7	14
Chocolate Milk	1.2	16.6	15.5	7
Whole Milk	1.0	16.6	15.8	5

TEST 17: Calculated Method

<u>Reason</u>

To determine the minimum holding tube length to ensure that each particle of product is held for a minimum holding time.

Frequency

Upon installation and whenever any alteration affecting the holding tube or velocity of flow is made.

<u>Apparatus</u>

a) Tape measure.

Procedure

- a) Determine the length and diameter of the holding tube.
- b) Using Tables 3 and 4 calculate the Reynolds Number (Re).

$Re = \frac{pVd}{u}$	where:	 p = fluid density V = mean fluid velocity d = tube inside diameter u = viscosity
$V = \frac{Q \times 0.1603}{3600 \times A}$	where:	Q = product flow rate, imp. gal./hour A = cross sectional area of holding tube 0.1603 = cubic feet/imperial gallon 3600 = number of seconds/hour

b) Calculate the minimum holding tube length (L).

$L = \frac{Q \times t}{3600 \times E \times Q_1}$	where:	Q = product flow rate in imp. gal./hour t = minimum legislated holding time in seconds E = 0.75 when Re is greater than 8,000 E = 0.5 when Re is less than 8,000 Q_1 = Volume/unit length of pipe in imp. gal./ft 3600 = the number of seconds/hour
		5000 = the humber of seconds/hour

Table 3

HOLDING TUBE DATA ASSUMING 16 swg PIPE

	ITSIDE INSIDE DIAMETER METER (d)			REA A)	VOLUME (Q ₁)			
in	cm	in	ft	cm	ft ²	cm ²	Imp gal / foot	l/m
1	2.54	0.872	.073	2.215	.0042	3.853	.0262	.3853
11/2	3.81	1.372	.114	3.485	.0103	9.539	.0643	.9539
2	5.08	1.872	.156	4.755	.0191	17.758	.1192	1.7758
21⁄2	6.35	2.372	.198	6.025	.0307	28.511	.1916	2.8511
3	7.62	2.872	.239	7.295	.0450	41.800	.2808	4.1800
4	10.16	3.872	.323	9.835	.0818	75.97	.5104	7.5970

 $1 \text{ imp. gal.} = 0.16026 \text{ ft}^3$

Table 4

Density and Viscosity Values

PRODUCT		DENS	[TY (p)	VISCOSITY (u)		
ТҮРЕ	TEMP	g/l	lb/ft ³	сР	lb/fts	
Milk	72°C	1.012	63.15	0.515	0.000346	
Cream 40%	75°C	.9826	61.3	3.4	0.00228	
Ice Cream Mix	80°C	1.1	68.64	150	0.1008	

NOTE: These figures incorporate a safety factor in recognition of the potential variances in product formulations and hatching procedures.

E. METER BASED TIMING SYSTEMS

TEST 18: High Flow Alarm

<u>Reason</u>

To verify that product flow is diverted when the flow recorder event pen indicates a diversion.

Frequency

Upon installation and every three (3) months thereafter.

<u>Apparatus</u>

None

- a) Operate the pasteurizer in forward flow at the maximum legal flow rate.
- b) Adjust the set point on the alarm slowly downward until the event pen on the recorder indicates the flow has been diverted.
- c) Observe that the flow diversion device immediately moves to the diverted position while the system operates above pasteurization temperature.
- d) Record the flow alarm set point.

TEST 19: Flow Cut-in and Cut-out

<u>Reason</u>

To verify that product cut-in or cut-out occurs at or below the maximum legal flow rate.

Frequency

Upon installation and every three (3) months thereafter.

Apparatus

None

- a) Operate the pasteurizer in forward flow.
- b) Using the flow controller slowly increase the flow rate until the event pen on the recorder indicates a flow diversion. Observe that the flow diversion device assumes the diverted position. The event pen movement must be synchronized with the pen movement of the flow recorder. Record the cut-out flow rate from the flow recorder.
- c) With the pasteurizer operating above the pasteurization temperature and with the flow diversion device diverted because of excessive flow rate, slowly decrease the flow rate until the event pen on the flow recorder indicates the start of a forward flow movement. The flow diversion device should not move immediately to the forward flow position because of the time delay relay described in Test 21. Record the reading from the recorder the instant flow cut-in occurs.

TEST 20: Loss of Signal Alarm

<u>Reason</u>

To verify that the product flow is diverted when the transmitter fails.

Frequency

Upon installation, semi-annually and whenever the seal on the high flow/loss of signal alarm is broken.

<u>Apparatus</u>

a) A six (6) inch piece of copper wire with an alligator clip at each end.

- a) Operate the pasteurizer in forward flow.
- b) Adjust the loss of signal alarm to 0%.
- c) Jumper the alarm terminals with the wire and alligator clips. This will short the transmitter signal to the alarm and simulate a loss of transmitter signal.
- d) Observe the flow diversion device moves to the diverted position and the event pen in the flow recorder controller indicates diverted flow.
- e) Remove the jumper wire from the terminals. Observe the flow diversion device assumes the forward flow position after the reset time of the time delay relay and the event pen on the flow recorder controller indicates forward flow.

TEST 21: Time Delay Relay (Flow Recorder)

<u>Reason</u>

To verify that the time delay for entering forward flow is greater than the legal holding time.

Frequency

Upon installation and every three (3) months thereafter.

Apparatus

None

- a) Operate the pasteurizer in forward flow.
- b) Slowly increase the flow rate using the flow recorder controller until the event pen indicates that the flow has been diverted and the flow diversion device transfers to the diverted position. Observe that the event pen and the flow diversion device move in unison.
- c) Operate the pasteurizer in diverted flow due solely to an excessive flow rate.
- d) Slowly decrease the flow rate using the flow recorder controller. Start timing the instant the event pen on the flow recorder controller transfers to indicate forward flow. The flow diversion device will remain in the diverted position until the time on the time delay relay has elapsed.
- e) Stop timing the instant the flow diversion device begins to transfer to the forward flow position.
- f) The time delay must be greater than or equal to the longest legal holding time.

TEST 22: Time Delay Relay (CIP mode)

<u>Reason</u>

To verify that the flow diversion device remains in the diverted flow position for at least 10 minutes after the mode switch is moved from "product" to "clean".

Frequency

Upon installation, semi-annually and whenever the seal on the time delay relay is broken.

<u>Apparatus</u>

None

- a) Operate the pasteurizer in forward flow.
- b) Move the mode switch on the flow diversion device control panel to the "clean" position. Observe that the flow diversion device moves immediately to the diverted position. Start timing when the flow diversion device moves to the diverted position.
- c) Stop timing when the flow diversion device moves to the forward flow position for its initial cycle in the CIP mode.
- d) The time delay must be at least 10 minutes.

PART II

BATCH PASTEURIZERS DESIGN AND OPERATIONAL CRITERIA

DESIGN CRITERIA FOR BATCH PASTEURIZERS

BATCH PASTEURIZER INSTALLATION AND OPERATIONAL STANDARDS

A. PASTEURIZATION

1. The process of heating every particle of milk or milk product in properly designed equipment for a minimum time and at a minimum temperature as specified in Table 5.

Table 5

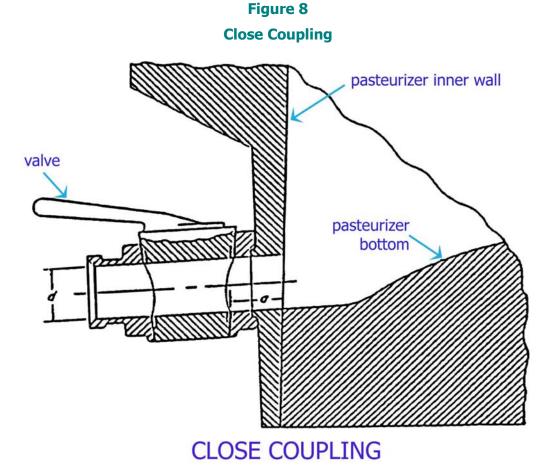
Pasteurization Requirements

Dairy Product	Time/Temperature
fluid milk	30 minutes at 63°C
cream (≥10% BF)	30 minutes at 66°C
ice cream, ice cream mix, and sugared dairy beverage	30 minutes at 69°C

- 2. The timing period for batch pasteurization begins only when:
 - a) the product temperature is equal to or higher than the minimum pasteurization temperatures for that product and
 - b) the airspace temperature is at least 3°C higher than the minimum pasteurization temperature for that product.
- 3. Nothing shall be added to a dairy product that is being pasteurized once the holding time begins except good quality products that are microbiologically safe and conform to health standards.
- 4. All inlet lines shall be disconnected during the holding, cooling and emptying periods.
- 5. All outlet lines shall be disconnected during the filling, heating and holding periods.

B. OPENINGS AND COVERS

- 1. All openings and covers shall conform to the requirements of 3-A Sanitary Standards.
- 2. Both openings and covers shall be designed to prevent the entrance of condensate, water and other contaminants.
- 3. All openings shall be kept closed during the heating, holding and cooling period.
- 4. The outlet valve shall be close coupled to the vat.
- 5. The outlet valve shall be of a leak protect type, or its equivalent.
- 6. The line to the outlet valve shall be disconnected from the pasteurized lines during filling, heating, and holding periods for product in the pasteurizer.
- 7. The inlet lines shall be disconnected when heating, holding, cooling, and emptying product from the pasteurizer.



* Note: a < d

C. AIRSPACE HEATERS

- 1. The airspace above the product shall be kept at least 3°C higher than the minimum required product pasteurization temperature during the holding period.
- 2. Airspace heaters shall use culinary steam.
- 3. Airspace heaters shall conform to the requirements of 3-A Sanitary Standards.

D. THERMOMETERS

- 1. Thermometers shall conform to the requirements of 3-A Sanitary Standards.
- 2. The batch pasteurizer shall have a:
 - recording thermometer
 - indicating thermometer
 - airspace thermometer
- 3. The bulbs of the indicating and recording thermometers shall be kept submerged in the dairy product throughout the heating, holding, and cooling period.
- 4. A record of the indicating thermometer and airspace thermometer temperature readings taken during the holding time shall be included on the recording chart.

TEST PROCEDURES FOR BATCH PASTEURIZERS

A. THERMOMETERS

TEST 1: Indicating Thermometer - Temperature Accuracy

<u>Reason</u>

To verify that the indicating thermometer reflects the true processing temperature.

Frequency

Upon installation and every three (3) months thereafter.

<u>Apparatus</u>

- a) A test thermometer accurate to $\pm 0.1^{\circ}\text{C}^2$ as determined by the National Bureau of Standards.
- b) A water bath and agitator.
- c) A suitable means of heating the water bath.

- a) Compare the indicating thermometer reading to that of a test thermometer when both are exposed to a water bath adjusted to within 2°C of pasteurization.
- b) The indicating thermometer must be within 0.5°C of the test thermometer.

² See Appendix A, Fahrenheit/Centigrade Temperature Conversions.

TEST 2: Recording Thermometer - Temperature Accuracy

<u>Reason</u>

To verify that the recording pen reflects the true processing temperature after exposure to extreme conditions.

Frequency

Upon installation, every three (3) months thereafter and whenever the recording pen requires frequent adjustment.

<u>Apparatus</u>

- a) The verified indicating thermometer.
- b) Three water baths and agitator.
- c) A suitable means for heating the water bath.
- d) Ice.

- a) Adjust the recording pen to agree with the indicating thermometer after a stabilization period of five (5) minutes at pasteurization temperature.
- b) Prepare a water bath by heating it to the boiling point and a second bath with melting ice.
- c) Immerse the sensing element of the recorder in boiling water for not less than five (5) minutes.
- d) Heat a container of water to pasteurization temperature.
- e) Remove the sensing element from the boiling water and immerse it in water heated to pasteurization temperature. Allow a five (5) minute stabilization period for both indicating and recording thermometers. The two readings must be within $\pm 0.5^{\circ}$ C.
- f) Remove the sensing element from the bath and immerse it in melting ice for not less than five (5) minutes.
- g) Remove the sensing element from the ice water and immerse it in water at pasteurization temperature. Allow a five (5) minute stabilization period for both indicating and recording thermometers. The two readings must be within $\pm 0.5^{\circ}$ C.

TEST 3: Recording Thermometer - Time Accuracy

<u>Reason</u>

To verify that the recorded time of pasteurization is the same as the true elapsed time.

Frequency

Upon installation and every three (3) months thereafter.

<u>Apparatus</u>

a) A stopwatch.

- a) Check that the recording chart is appropriate to the recorder.
- b) Inscribe a mark on the recording chart at the pen point for the start of the testing period and record a start time.
- c) At the end of 30 minutes inscribe a second mark at the pen point position on the chart.
- d) Determine the distance between the two marks and compare the distance with the timescale divisions on the recording chart at the same temperature.

APPENDIX A

Test procedures for Pasteurization Equipment and Controls

- means greater than or equal to. means less than or equal to. Note: ≥
 - ≤

HTST TEST RESULTS

#	TEST NAME	CRITERIA	RESULTS	RESPONSE
1	Indicating Thermometer	±0.5°C		
	- temperature accuracy			
2	Recording Thermometer	±0.5°C		
	- temperature accuracy			
3	Indicating Thermometer	Four (4) seconds		
	- thermometric response	under specified conditions.		
4	Recording Thermometer	Five (5) seconds		
	- thermometric response	under specified conditions.		
5	Recording Thermometer	= true elapsed time.		
	- time accuracy			
6	Recording Thermometer	≤ indicating		
	- check against indicating thermometers	thermometer.		
7	Milk-Flow Controls	Cut-in and cut-out >		
	- milk temperatures at cut-in and cut- out	pasteurization temperature.		
8	Leakage Past Valve Seat(s)	No leakage past valve seat.		
9	Operation of Valve Stem(s)	Freedom of action of valve stem.		
10	Device Assembly, Single Stem Device	Stops metering pump.		
11	Device Assembly, Dual Stem Device	Stops metering pump.		
12	Manual Diversion	Valve to divert position and stops the booster pump.		
13	Response Time	\leq 1 second.		
14	Time Delay Interlock with Metering Pump	Sequence of events to occur as per test procedure.		

HTST TEST RESULTS

#	TEST NAME	CRITERIA	RESULTS	RESPONSE
15	Pressure Differential Controller	No Booster Pump Operation unless ≥ 2 psi differential.		
16	Holding Time - Salt Conductivity Method	legal minimum holding time.		
17	Holding time - Calculated Method	≥ legal minimum holding time.		
18	High Flow Alarm	Diverted flow occurs when the flow event pen indicates a divert.		
19	Flow cut-in/cut-out	Forward flow occurs only at legal flow rates.		
20	Loss of Signal Alarm	Diverted flow upon loss of signal to the alarm.		
21	Time Delay	≥ longest legal hold.		
22	Time Delay Relay	Flow diversion device remains in the diverted position for at least 10 minutes after the CIP mode switch is activated.		

APPENDIX B

Food Protection Services

BC Centre for Disease Control

DAIRY PLANT SAFETY PROGRAM APPLICATION TO MODIFY/INSTALL HTST PASTEURIZERS

NAME OF DAIRY	MANUFACTURER	MANUFACTURER		
ADDRESS	CAPACITY (lbs per hr)	DATE OF MODIFICATION/INSTALL	ATION:	
	DRAWING EQUIPMENT LAYO	OUT (attach as addendum)	TYES	NO

	МАКЕ	MODEL	NUMBER OF PLATES:	Plates
TIMING PUMP			PRODUCT REGENERATOR	
TIMING PUMP DRIVE			PRODUCT HEATER	
FLOW-DIVERSION VALVE			PRODUCT COOLER	
RECORDER CONTROL				
FLOW RECORDER CONTROLLER				
FLOW SENSING HOOD				
FLOW TRANMITTER				
AUXILIARY PUMP				
CLARIFIER				
FILTER				
SEPARATOR				
HOMOGENIZER				
		HOLDING TIME	1	
HOLDING TUBE Length:	Diameter:			
EQUIPMENT REMARKS:				
I certify that the modification/installation will comply with the requirements of the 3A Sanitary Standards.				

Signed:		Date:
	Equipment Installer	
Signed:		Date:



DAIRY PLANT SAFETY PROGRAM **REPORT OF MODIFICATION/INSTALLATION** d Protection Services HTST PASTEURIZERS **BC Centre for Disease Control** MANUFACTURER NAME OF DAIRY ADDRESS CAPACITY (lbs per hr) DATE OF MODIFICATION/INSTALLATION: T YES D NO DRAWING EQUIPMENT LAYOUT (attach as addendum) Thermo 1. CONTROL INSTRUMENTS Make Serial No. Accuracy A. Indicating Thermometer (Hot Product) Cut-in Point Cut-out °C seconds °C °C Seconds °C B. HTST Recorder-Controller 1. Flow diversion device: Response time in seconds _ Yes No 4. Do the leak escapes open properly? 2. Does water leak past the forward flow seat during diverted flow? 5. Does the timing pump stop when valve fails to seat properly? 3. Does the valve seat properly? Chart Range Make Serial No. Separate C. Flow Recording Controller (for magnetic flow meter) Make Serial No. Hi-Alarm Trip Low Alarm Trip D. Flow Alarm (for magnetic flow meter) Make Size Transmitter Make Calibrations GMP LPH E. Flow Meter: Sensing Head (for magnetic flow meter) 2. REGENERATOR PRESSURES (when a booster pump is used) Pressure Sensor: a) Reading of test pressure gauge Reading of regenerator inlet pressure sensor nsi b) Reading of test pressure gauge Reading of pasteurized product outlet pressure sensor psi 3. TIMING PUMP Make Serial No. RPM at Max Cap Setting Rate of flow at Max rated capacity (lbs per hr) A. Pump Head: Make Serial No. High Low Range of rated capacity (lbs per hr) B. Variable Speed Drive 4. HOLDING TIME (Variation between maximum and minimum time should not be over 0.5 seconds) A. To be established in accordance with the "Determination of Holding Time" (Salt Conductivity Test), Appendix Section I of the 3A Sanitary Standards. B. Computed average holding time for milk $T = holding time with water M_V = time required to pump a measured$ where 3 2 4 5 6 1 Actual Time = $\frac{TM_{\nu}}{T}$ Forward Flow wolume of product W_v = time required to pump an identical volume of water W_{ν} Actual Time (sec) Diverted Flow Actual Time (sec) C. Holding Tube: minimum slope of holding tube 96 I certify that this HTST pasteurizer has been modified/installed and tested in accordance with the requirements of the 3A Sanitary Standards. 5. TEST to determine the volume of product at start-up and time to discharge product at shutdown. A. These tests are to be carried out in accordance with H.3.2. (for volume) and H.6.2. (for time) of the APPENDIX TO "3A Accepted Practices for the Sanitary Construction, Installation, Testing and Operation of HTST Pasteurizers". Approved FOR OFFICE USE ONLY □ Not Approved B. Recorded Volume 10 Gal. cans, or Total gal. a) Start-up Signed: Dairy Plant Specialist b) Shutdown SEC. Date: ____

HLTH 4661 03/01

APPENDIX D

Centigrade/Fahrenheit

TEMPERATURE CONVERSION TABLE

CELSIUS	FAHRENHEIT
-18	-0.4
0	32.0
4	39.2
60	140.0
61	141.8
62	143.6
63	145.4
64	147.2
65	149.0
66	150.8
67	150.6
68	154.4
69	156.2
70	158.0
71	159.8
72	161.6
73	163.4
74	165.2
75	167.0
76	168.8
77	170.6
78	172.4
79	174.2
80	176.0
81	177.8
82	179.6
83	181.4
84	183.2
85	185.0
95	203.0
100	212.0
132	269.6

APPENDIX E

CONVERSION TABLE

1 Imperial Gallon	=	4.546 litres
1 US Gallon	=	3.785 litres
°C	=	(°F - 32) x 5/9
°F	=	(°C x 1.8) + 32
1 Pascal	=	0.00001 bar
1 lb/in ²	=	0.06895 bar
1 pound	=	0.454 kilogram
1 meter	=	39.370 inches

References

- 1. APV Technical Information Sheet. No. 83, <u>Holding Tube Efficiency</u>, 1984.
- 2. <u>Electronic Flow Meter Replacement of Timing Pump for HTST Pasteurization Control</u> <u>Systems, Field Procedure for Testing System</u>, Accurate Metering Systems Inc, 1984.
- 3. <u>Grade "A" Pasteurized Milk Ordinances</u>, United States Public Health Services, 1989.
- 4. <u>3A Accepted Practices for the sanitary Construction, Installation, Testing, and Operation of High Temperature Short Time Pasteurizers, 603-05</u>, 3A Sanitary Standards.