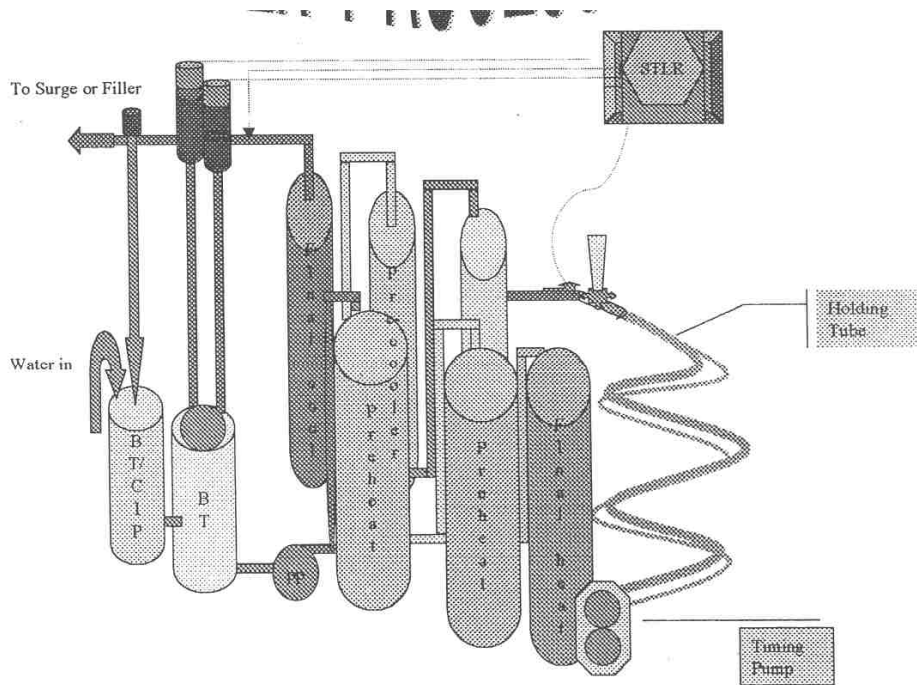


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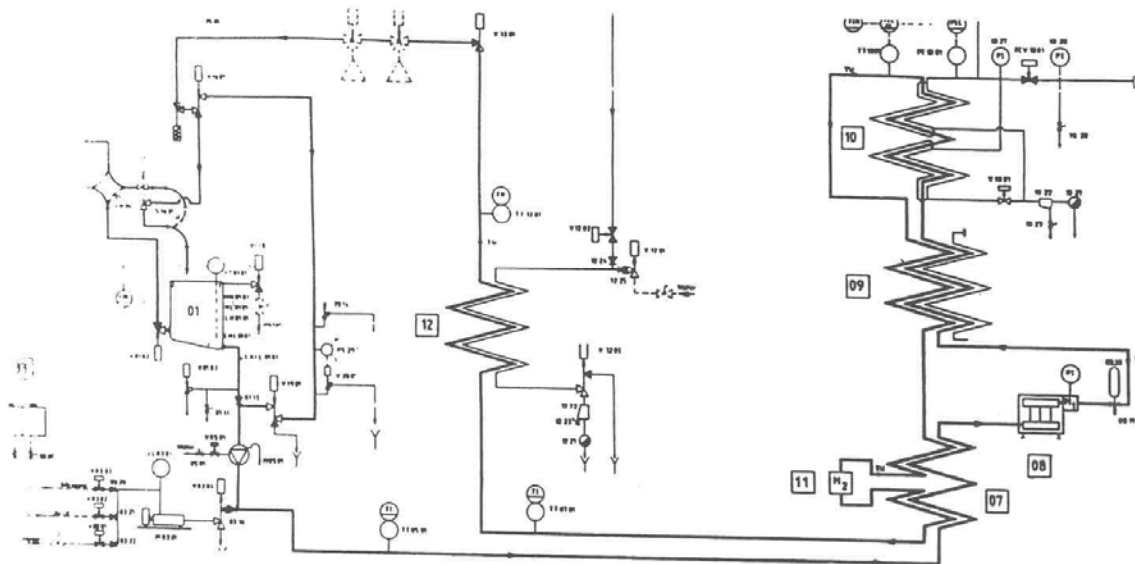
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Chapter VII

ADVANCED MILK PROCESSING SYSTEMS



Note: The use of trade names or equipment photographs is for training and educational purposes only and does not constitute endorsement by the Food and Drug Administration.





HHST, UP AND UHT SYSTEMS

DIRECT AND INDIRECT HEATED ADVANCED MILK PROCESSING SYSTEMS

PURPOSE: To provide applicable, comprehensive information regarding the evaluation and understanding of the design, operation, and function of advanced milk processing systems.

OBJECTIVES:

 To provide the basic criteria necessary for the evaluation of indirect and direct heated extended shelf life and shelf stable pasteurization and processing systems as they relate to applicable public health requirements.

 To describe the process design criteria and calculations necessary for the computation of holding tube lengths for advanced milk pasteurization systems.

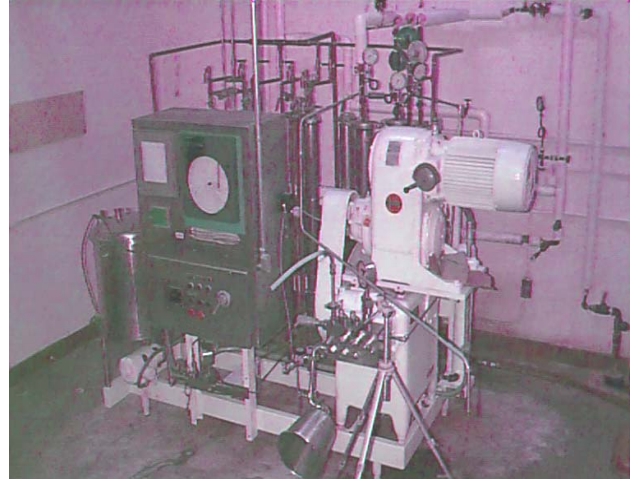
__ To provide the knowledge necessary to evaluate and test the required instrumentation and controls necessary for use in advanced higher heat pasteurization systems.

_ To describe the **public health controls** necessary in

product-water-product regenerators used in modern HHST and UHT pasteurization systems.

INTRODUCTION

With the trend toward consolidation of dairy plants and the resultant increase in distances required for distributing the pasteurized products, processors are opting for higher temperature pasteurization systems which in most cases greatly enhance keeping quality and shelf life of processed milk products.



The industry has expressed interest in processes that use higher temperatures (191° F and above) for shortened times (one second and less) for the processing/pasteurization of Grade A milk products. This process is appropriately called HHST (Higher-Heat, Shorter-Time) or Extended Shelf Life Systems. Most of these systems are being used to process Ultra Pasteurized products and require normal legal flow diversion devices. Also most of them operate temperatures in the 270°F to 300°F range.

These higher processing temperatures with shorter times, produce an increase in product shelf life without significantly affecting the desirable flavors of the milk product. The minimum required times and temperatures are based on the ice cream thermal death curve and computations assume full laminar flow. The calculated holding times are not required to be adjusted for higher product viscosities.



HHST-INDIRECT HEATING

Systems which employ the use of heat exchangers to

HHST, UP AND UHT SYSTEMS

pasteurize milk products at temperatures between 191° F to 212° F at holding times between 1.0 second and .01 seconds are designated as indirect heating HHST pasteurizers.

These systems either use plate heat exchangers as in conventional units or tubular heat exchangers. The tubular heat exchangers may either be of the triple tube type as previously discussed in Chapter IV ,or the tube-in-shell type which use spiral tubes inside a rigid thick wall shell.

1. PLATE HEAT EXCHANGERS- INDIRECT HEATING

The heat exchangers on these systems may either be of the MILK-TO-MILK,or MILK-TO-WATER-TO-MILK type regenerators.

Because of the high temperatures used in these systems, the flow diversion device is located at the end of the cooler or final regenerator section. This is necessary for the following reasons:

a) The response time for standard STLR's and diversion devices is **too slow to prevent forward flow of sub-legal product; and**

b) diversion at ultra high temperatures would result in severe **flashing** of product in the divert line.

Since the flow diversion device is located at the end of the system additional controls must be in place to assure sterility of the system following any condition periods of diverted flow and prior to system start-up.

Because of the short holding times and holding tube length, all HHST holding times must be determined from the pumping rate rather than the salt conductivity test. Laminar flow may occur in high viscosity products since the fastest particle can move at twice the speed of the average particle. Therefore, the holding tube lengths have been calculated as twice the length to compensate for laminar flow in the following table:

HOLDING TUBE LENGTH (INCHES) FOR
HHST INDIRECT HEATING PASTEURIZERS
ASSUMED PUMPING RATE = 1 GAL/SEC

HOLDING TIME (SECONDS)	TUBING SIZE (INCHES)				
	1	1 ½	2	2 ½	3
1	723.0	300.0	168.0	105.0	71.4
0.50	362.0	150.0	84.0	52.4	35.7

Note: Minimum processing temperatures must coincide with required holding times.

The conditions in these systems which require product diversion are:

1. Improper temperature; and
2. Improper pressures within the regenerator.
3. Excessive flow rate, if equipped with a meter based timing system.

REGULATORY CONTROLS - INDIRECT HEATING

1) MILK TO MILK REGENERATORS

- a) One controller is located at the end of the cooling section and
- b) the STLR located at the end of the holding tube; and
- c) a differential pressure controller is installed when a booster

just pr

pump

HHST, UP AND UHT SYSTEMS

Note: In the above instance the differential pressure controller is set to monitor the highest pressure in the raw product side and the lowest pressure of the pasteurized side in the regenerator as in conventional HTST systems.

d) In these HHST systems, since all product surfaces are exposed to liquid at pasteurization temperatures (191° F or above) following product diversion, the requirements for a vacuum breaker at the end of the pasteurized regenerator and the height requirement of the constant level tank may be eliminated.

2. Product-to-Water-to-Product Regenerators

GENERAL DESCRIPTION

REGENERATOR PRESSURE CONTROLS

These systems are engineered usually to preheat, heat and pre-cool the milk within the regenerator using temperature transfer of water to milk. The water in a closed loop system is recirculated in most cases is used in both the pre-heater and heater and pre-cooling sections of the regenerator. Within these systems very high pressures are used in the regenerators, particularly on the pasteurized product side of the regenerator. In HHST and aseptic methods the regenerators are protected on the product pasteurized side.

This is accomplished using an acceptable pressure differential controller.

1. The raw side sensor is located in the water loop immediately after the water pump to measure the highest water pressure prior to entering the regenerator.

2. The pasteurized or aseptic product side sensor is located in the PRODUCT line after the pasteurized or aseptic product exits the regenerator which measures the lowest pasteurized product pressure. Many of these systems use high pressure homogenizer pumps which can generate 2,000 to 3,000 psi which requires special high pressure type pressure differential controllers.

3. The product pressure in the pasteurized milk section must be under greater pressure than the water in the raw side at all times. The protection is on the pasteurized side of the system and is engineered to allow pasteurized product to leak into the heating medium in case of regenerator plate (or tubular) failures. The recorder controller is set to divert the system when the lowest pressure of pasteurized or aseptic product in the regenerator fails to exceed the highest pressure of heat transfer medium in the pasteurized or aseptic side of the regenerator by at least 6.9kPa (1psi).

4. In the case of aseptic processing systems, a differential pressure-recorder shall be used to monitor and record pressures of the aseptic product and the heat transfer medium.

5. Since the FDD is located at the end of the cooler section and because the entire system must undergo re-sterilization at pasteurization temperatures following diverted flow, the balance tank overflow height and vacuum breaker requirements are not required. Also the requirement for a time delay to allow the FDD to flush the area between the flow divert and leak detect valve is not applicable for HHST or UHT systems

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6. Flow promoting devices that may affect the proper regenerator pressures shall not be located downstream from the pasteurized milk outlet.
7. The heat transfer medium pump shall be wired so that it can operate only when the metering pump is in operation.

Indirect heating:

- 1) Requires that forward flow commences only after both sensors (at the holding tube and at the FDD located after the pasteurized or aseptic milk has exited the system) have reached the minimum cut-in temperature.
- 2) This test is done with the pressure switches by-passed to achieve forward flow.

Direct heating:

- 1) Requires that forward flow commences only after the sensors located at the holding tube, the coolest portion of the vacuum chamber, and the flow diversion device at the end of the system have reached the minimum cut-in temperature (after a time delay of >1 second).
- 2) If the unit has an excessive time delay, this would be by-passed and the pressure switches are by-passed to achieve forward flow during the test.

HHST- DIRECT STEAM HEATING

Some processors may elect to install equipment which adds steam directly to milk products during HHST pasteurization. This method of processing requires both conventional and supplementary controls to assure a product protection.

The two categories of direct steam heating systems are categorized as:

- a) **steam injection;**
- and
- b) **steam infusion.**

With injection, steam is forced through a properly designed sanitary nozzle into the milk flow.

With infusion, milk is introduced into a vessel having a steam atmosphere.

Vapor Removal Equipment

In all systems using either injection or infusion methods, large vessels are installed within the system to either remove the water (in the form of vapor's) following steam injection; or to add the steam and simultaneously remove the vapors as in steam infusion systems. These vessels are operated under adjustable vacuum atmospheres and are equipped with vapor/vacuum withdrawal piping (connected to a condensing system and vacuum pump) to remove these excess vapors.

They are termed "vacuum chambers", "flash chambers or coolers", and/or "vacuum pots" by the industry and require certain regulatory controls which are addressed later in this chapter.

HHST, UP AND UHT SYSTEMS

CONTROLS NECESSARY FOR DIRECT ADDITION OF STEAM

- a) Complete steam condensation before the heated product enters the holding tube;
- b) Prevention of vapor formation in the holding tube to assure adequate holding time;
- c) Selection of effective controllers;
- d) Location of sensing elements for these controllers;
- e) Prevention of water adulteration of the product;
- f) Assurance of thermal logic controller sequence logic.

It is also important to remember that in either steam injection or steam infusion, the requirement that the steam supply must be automatically controlled to shut off during periods of diverted flow or loss of power is not applicable for HHST and or UHT systems. The reason for this is that immediately following any period of diverted flow conditions, the entire system must be subjected to sterilization temperatures which requires steam heated water. Methods and requirements for these sterilization systems are discussed later in this chapter.

PROCESS DESIGN CRITERIA

1. STEAM INJECTION

During steam injection, the product is preheated in a heat exchanger; then heated to pasteurization temperature by **injecting steam into the milk stream**; held in a holding tube and then pre-cooled in a vacuum chamber whereby added water in the form of vapor is removed. The milk is then cooled to the desired storage temperature in a heat exchanger. **As in indirect heating systems the flow diversion device is also located at the end of the system as the product exits the cooler!**

a). ISOLATION OF THE STEAM INJECTOR CHAMBER

Steam injection is an inherently unstable process. When steam is injected into a fluid, **complete condensation of the steam must be assured within the injector.** This is accomplished by the properly designing and in some cases adjusting the steam injector itself.

Lack of complete condensation within the injection chamber may result in product temperature variations within the holding tube. This could lead to some milk particles being processed below the required pasteurization temperature. One method of isolation is to insert supplementary orifices on the product inlet and the heated product outlet of each injector. Most of the available manufactured injectors have a built-in orifice on the steam port; therefore a supplementary orifice is usually not necessary in the steam line. (Refer to manufacturer specifications for sizing and spacing parameters). **The injector must be interwired to permit the flow diversion device from assuming the forward flow position only when the differential pressure drop across the injector is at least 70 kPa (10psi).**

HHST, UP AND UHT SYSTEMS

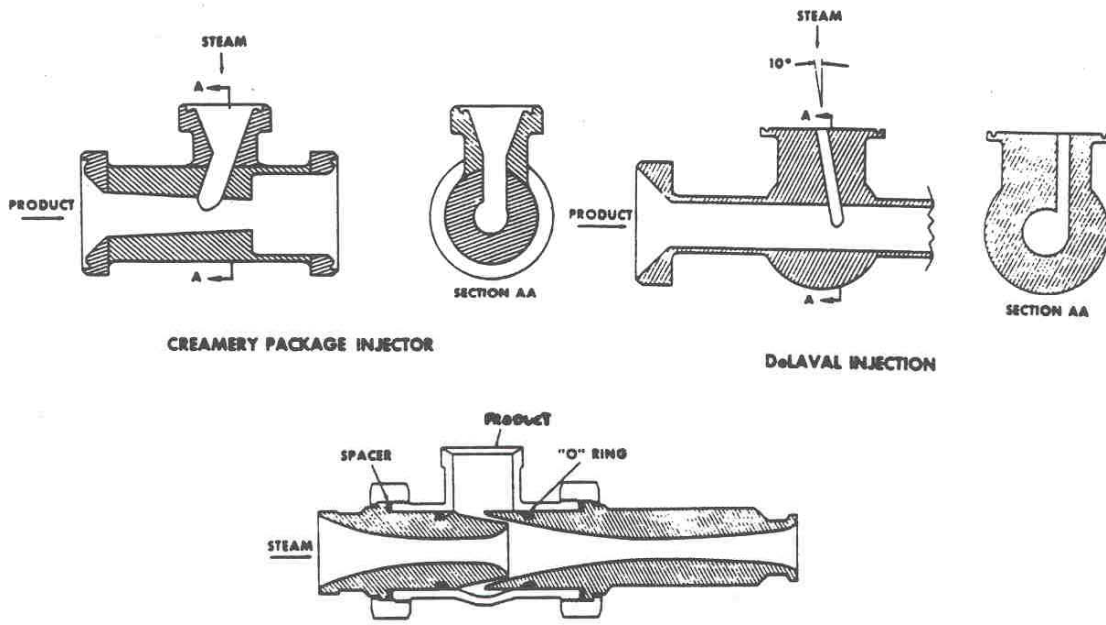


Figure 57
Examples of Steam Injectors

b). HOLDING TUBE PRODUCT PRESSURES

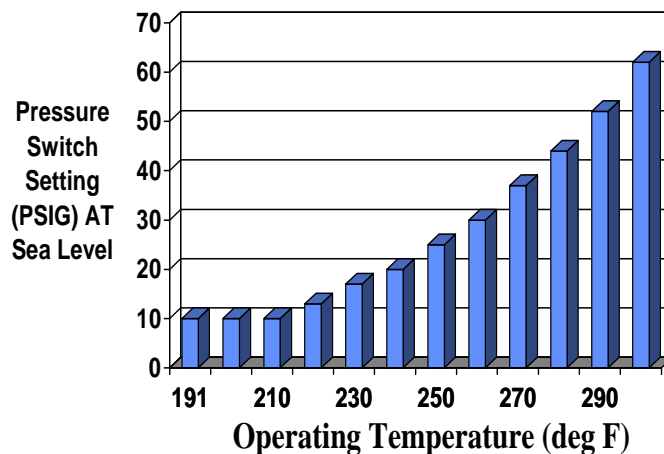
Product pressures must be sufficient in the holding tube in order to condense the steam and keep the product in the liquid phase. Low product pressures could allow vaporization and significantly reduced holding times.

In HHST systems a product pressure of 10 psi (69 kPa) in the holding tube is adequate for temperatures of 191° F through 212° F. The pressure switch must be interwired to divert the system if adequate pressure is not maintained.

Aseptic systems which operate at temperatures above 212° F must maintain holding tube product pressures of at least 69 kPa (10psi, at sea level), above the boiling pressure of the product at its maximum temperature in the holding tube). The pressure switch must be capable of recording pressures and interwired to divert the system if proper pressure is not maintained in the holding tube.

See *Table 40* for pressures which apply to installations operating from 212° to 300° F. For installations above sea level the operating pressures are increased accordingly to the locality.

Table 40-Pressure Switch Settings



HHST, UP AND UHT SYSTEMS

c.) Culinary steam used for steam injection must be free of non-condensable gases as these may reduce residence times in the holding tube. These non-condensable gases are usually removed by a use of a "De-aeration Tank". This de-aerator reduces the possibility of non-condensable gases collecting in the holding tube which could reduce the holding time of the product. Even though short, the holding tube must be properly sloped upward to meet the PMO requirements of 1/4 minimum inch per foot (2.1 cm/m).

d.) Steam used for steam injection must comply with Appendix H requirements for culinary steam. (See Figure 51).

e.) Systems using steam injection must have a **differential pressure limit indicator and a pressure switch** to ensure adequate isolation of the injection chamber. Should the pressure drop below the 10 psi minimum the FDD will divert. This switch must be tested and sealed by the regulatory authority.

CALCULATION OF HOLDING TUBE LENGTH

Because of the short holding tube length, the required minimum holding times must be calculated from the **pumping rate** rather than the salt conductivity test. Holding tube lengths have been calculated as **twice the length to compensate for laminar flow**.

With steam injection processes, the holding tube is adjusted since the product volume increases because of increased volumes in the holding tube.

With a 120° F temperature increase by steam injection, a volume increase of 12% will occur in the holding tube. The values in Table 1 reflect this volume increase, therefore, it is not needed to be included in field calculations. This

surplus water is subsequently evaporated as the pasteurized product is cooled in the vacuum chamber.

Note: Laminar flow adjustments for Aseptic System (shelf stable) holding tube lengths may not always be required by the "Process Authority" on milk processed in those systems having filed processes and meeting the Low Acid Canned Food (LACF) CFR Regulations.

TABLE 1

HOLDING TUBE LENGTHS FOR STEAM INJECTION PASTEURIZATION

ASSUMED PUMPING RATE = 1 GAL/SEC

HOLDING TIME (SEC)	TUBING SIZE (INCHES)				
	1	½	2	2 ½	3
1	810	336	188	118	80.0
0.5	405	168	94.0	59.0	40.0
0.1	81.0	33.6	18.8	11.8	8.00
0.05	40.5	16.6	9.40	5.90	4.00
0.01	8.10	3.36	1.88	1.18	.80

Note: These lengths assume fully developed laminar flow and temperature increase of 120°F by steam injection.

The table used for direct steam injection contains holding time calculations that have been adjusted for longer holding tube length's which compensates for the increased volume of product because of the injected steam prior to the holding tube. This increased volume could be as much as 13%.

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HOW TO USE THIS TABLE:

This table may be used to calculate the required holding tube length for any flow rate. This can be done by determining the time required for the pasteurizer operating on water at operating conditions to fill a vessel of known volume. This data is then converted by **division** to obtain the flow rate in gallons per second, and **multiplying** this value by the applicable number in Table 1. **The resulting calculations will provide the required length of the holding tube for the process.**

These calculations follow the equation: $A = B \times C$

where:

A = holding tube length (inches)

B = measured pumping rate (gallons per second)

C = holding tube length from Table 1 (inches per gallon per second)

Example 1:

The health authority knows the time-temperature standard and flow rate and wants to know the required length for the holding tube. The pasteurizer has a nominal capacity of 10,000 pounds per hour. The time required to fill a 10 gallon can with water from the pasteurizer is 32.5 seconds. The temperature-time standard is 204° F for 0.05 second, and the holding tube is 2 inches in diameter. The pumping rate is 10 gallons divided by 32.5 seconds, which is 0.308 gallon per second.

The required holding tube length, A is calculated from Equation 1 ($A = B \times C$). The pumping rate, B, is 0.308 gallon per second, and from Table 1, the holding tube length, C, required for a holding time of 0.05 second with a pumping rate of 1 gallon per second in 2 inch diameter tubing is 9.4 inches. For this example,

$$A = 0.308 \times 9.4$$

$$A = 2.9 \text{ inches}$$

Therefore the holding tube must be at least 2.9 inches long.

Example 2:

The health authority knows the temperature-time standard and the actual holding tube length and wants to know a the maximum permissible pumping rate.

The pasteurizer has a nominal capacity of 60,000 pounds per hour, and the temperature-time standard is 204° F for 0.05 second. The holding tube is 3 inches in diameter and 6 inches long. The pumping rate is calculated from Equation 1 ($A = B \times C$). The holding tube length, A, is 6 inches and from Table 1, the holding tube length, C, required for a holding time of 0.05 second with a pumping rate of 1 gallon per second in 3 inch diameter tubing is 4 inches. For this example;

$$6 = B \times 4$$

$$B = 6/4$$

Therefore... $B = 1.5$ gallons per second.

The maximum permissible pumping rate is 1.5 gallons per second. At this pumping rate, the time required to fill a 100 gallon vat is 100 gallons divided by 1.5 gallons per second, or 66.6 seconds.

INSTRUMENTATION AND REGULATORY CONTROLS

HHST, UP AND UHT SYSTEMS

Steam injection systems require a greater amount of instrumentation than do conventional systems. This is because of the following factors:

- 1.) Steam injection is **inherently an unstable process**;
- 2.) Microorganism lethality occurs in the **holding period**;
- 3.) **Holding tube lengths** for most systems are **sometimes short**;
and
- 4.) **Sterility must be assured after each diversion.**

In addition there is the product adulteration problem that must be dealt with. During pasteurization using direct steam addition, product may be diluted with water (condensed steam) by 1% for every 10° F temperature increase by steam injection.

REGULATORY CONTROLS REQUIRED-HHST WITH DIRECT STEAM HEATING.

1. Safety Thermal Limit Controller with three (3) sensors, located:

- a) At end of the holding tube
- b) In the coolest part of the vacuum (flash) chamber; and
- c) Just prior to the flow diversion device.

2. Ratio Controller

A ratio controller is required for systems applying direct steam to product to prevent water adulteration of the product. This ratio controller is interlocked with the vacuum pump and/or steam controller and automatically monitors and controls the amount of vacuum applied and/or the amount of steam injected.

This is accomplished by constantly monitoring the product temperature at the inlet and outlet of the chamber. One sensor is located immediately prior to the point of steam injection and the other is located immediately after the product exits the vacuum chamber.

Ideally, the product temperature at the exit point of the vacuum chamber should equal the inlet product temperature (measured prior to steam injection or infusion) less any product heat loss by heat radiating from the equipment. This determination is achieved by each individual processing plant based on a series of product analysis for total solids, added water and other applicable laboratory methods. Usually a system of trial and error is used for this determination. Individual plant ratio controller's temperature differential set point may be slightly dissimilar depending the total solids composition of the raw milk source and variances in equipment installations.

When a water feed line is connected to a vacuum condenser, and the vacuum chamber is not physically separated from the vacuum condenser, satisfactory methods must be installed to prevent adulteration of the product with water in the condenser. This is usually accomplished by installation of automatic shut-off valve on the water feed line. This valve would automatically shut off the water in case the condensate (product) pump shuts down for any reason.

3. All systems must be equipped with an approved indicating thermometer at the end of the holding tube as close as practicable to the recorder/controller sensor. It may be either of the mercury in glass or an acceptable electronic type.

Figure 58
ratio
controller
instrument

HHST, UP AND UHT SYSTEMS

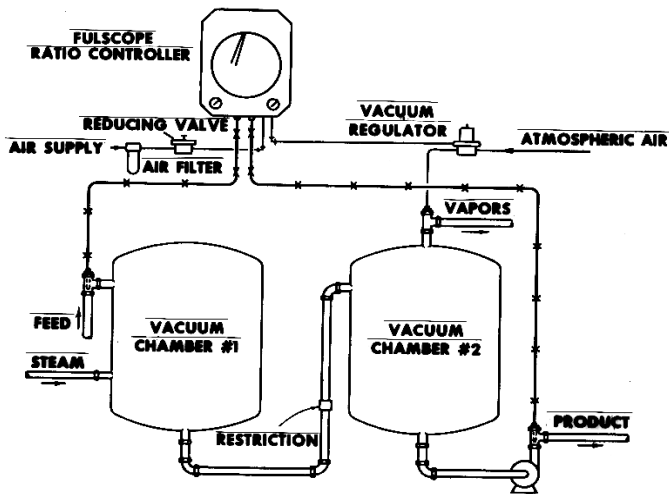
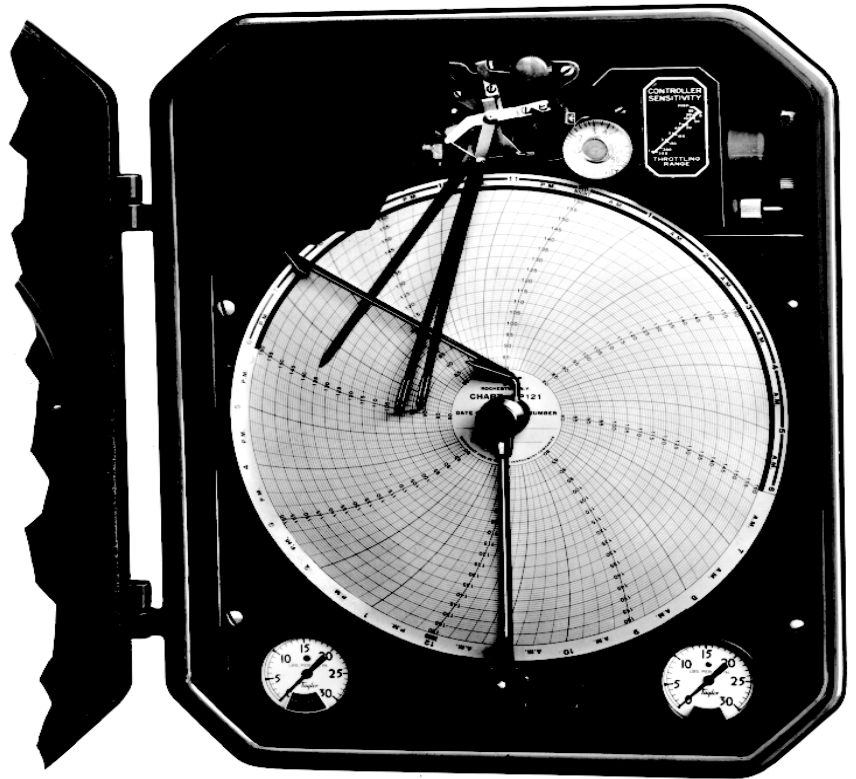


Figure 59 : Ratio Controller Placement with Direct Steam Systems

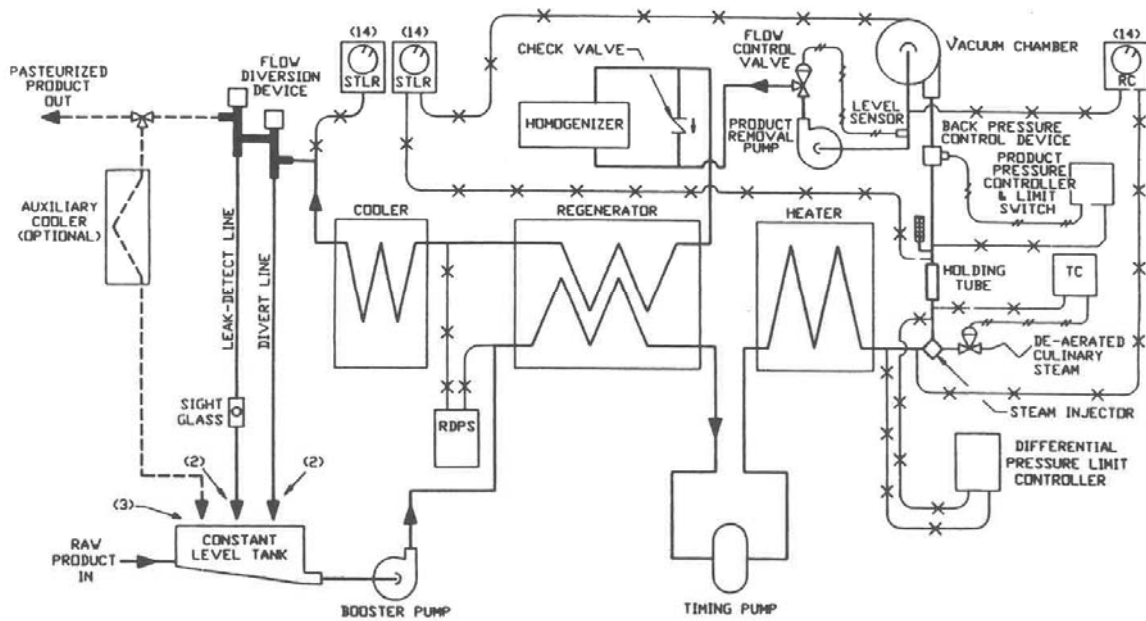


Figure 60: Steam injection pasteurization controls HHST with steam injection, vacuum cooling and flow diversion device at end of system.

(2) all divert, leak detection and recycle lines which return to the constant level tank must break to atmosphere at least two pipe diameters above the overflow level (3) the overflow level of the constant level tank must be lower than the bottom of the inlet of the raw regenerator.

(14) the safety thermal limit recorder (stlr) recorder controller for this system must have three sensing elements (at the discharge end of the holding tube, in the top of the vacuum chamber, and at the common port of the flow diversion device) the product temperature in the holding tube and the position of the flow diversion device (frequency pen) must be recorded on the main recorder controller while the other two sensing elements may be interlocked with the main recorder controller through auxiliary indicating controllers. Any other combination or modifications which are installed and operated with the above, and with the detailed provisions of these practices, may be utilized

HHST, UP AND UHT SYSTEMS

Figure 60
Steam Injection Pasteurization Controls
HHST with Steam Injection, Vacuum Cooling, and
Flow Diversion Device at End of System

Before the system can be allowed to go into forward flow, product/fluid temperatures at all three sensing elements must simultaneously be **at or above the minimum pre-set pasteurization temperatures for the minimum time required AND proper pressure relationships in the milk-water-milk regenerators must be satisfied.**

In HHST systems the booster pump is allowed to operate at all times. When the proper pressures; however, are not met:

- 1.) The system is automatically diverted, and
- 2.) The thermal limit sequence controllers will only allow forward flow **following complete sanitizing of all product contact surfaces downstream from the holding tube.** This includes both minimum times and temperature requirements, (i.e. all the above product surfaces must be exposed to fluid at pasteurization temperature for the minimum required pasteurization time).

This is achieved in a direct steam heating system by requiring that, following a temperature diversion, **all three sensing elements must attain pasteurization temperatures simultaneously and continuously for the required pasteurization time or a minimum of one (1) second.** This assures that all parts of the system have been properly heat sanitized prior to allowing the flow diversion device to move into the forward flow position. Once the minimum temperature and time have been satisfied for system sanitization, the two auxiliary controllers (at the FDD and vacuum chamber), then “drop out” and the **primary recorder-controller (STLR) at the end of the holding tube resumes its function as during normal processing.**

The product temperature in the holding tube and the position of the flow diversion device (frequency pen) **must be recorded on the main recorder-controller temperature chart (at the holding tube) as in conventional systems.**

Because of the cooling properties of the vacuum chamber and its appurtenances, it must have the temperature sensor located at its coolest part. When installed in this vacuum/condenser line, as in most cases, it shall be

HHST, UP AND UHT SYSTEMS

positioned at the point of downward slope back towards the condenser or vacuum pump.

The newly designed internal pass type vacuum chamber, as in the Tetra Pak system's would require positioning the outlet temperature controller sensor where the condenser tube exits the chamber at the bottom. This will **assure that the sanitization temperature in the chamber** achieves the minimum required pasteurization temperature. (You may note that in this type of vacuum chamber, the milk also enters at the bottom and exits at the bottom).

Without the sensing element positioned in the coolest part of the vacuum chamber, product could be above the required temperatures in the holding tube, cooled to **sub-legal temperatures in the vacuum chamber** and reheated to the required temperature in the regenerator. **Please do not confuse these controller sensors with the ratio controller sensors.**

Pressure Limit Controllers

Product pressures in the holding tube and across the steam injector are monitored and controlled to keep the product in the liquid form and to ensure adequate isolation of the injection chamber.

This instrument must have a pressure switch so that the flow diversion device will move to the divert position if the product pressure falls below 10 psi of the boiling pressure of the product.

Example: for operating temperatures between 191° and 212° F the pressure switch must be set at 10 psi (70kPa) at sea level.

Higher operating temperatures (above 212° F) require **higher holding tube pressures** to keep the product in the liquid phase.

Note: Figure 40 shows the pressure switch settings for operating temperatures from 212°F up to 300° F.

Differential pressure limit indicator - This control is needed to insure adequate isolation (supplementary orificing) of the injection chamber across the injector. The instrument must have a differential pressure switch to divert the system **in case the pressure across the injectors drops to below 10 psi**. This is accomplished by installing one sensor prior to the steam injector and the other injector immediately after the steam injector. If the 10psi differential is not maintained then the instrument will automatically divert the system. Pressure relationships must be adequate to assure complete steam condensation within the steam injector.

This instrument and its settings must be sealed after testing.

HHST, UP AND UHT SYSTEMS

Regenerator Pressure Relationships and Controls

a. **Milk to Milk Regenerators** - In these systems the product flow is identical as found in conventional HTST systems with one major exception. The exception is that in HHST systems processing at temperatures above 191° F (89° C), the FDD is located at the end of the cooling section. In these systems, the vacuum breaker at the end of the system and the booster pump inter-wiring requirement may be eliminated; **PROVIDED the differential pressure controller is interlocked with the FDD and set and sealed to sanitize ALL PRODUCT SURFACES IN THE SYSTEM in instances of improper pressures within the milk to milk regenerator.** The booster pump is allowed to run at all times.

b. **Milk-Water-Milk Regenerators.** - In these systems the product flows counter-current within a plate or tubular heat exchange system with a heat exchange medium (usually water) used on the opposite side of the plate or in the case of tubular within the surrounding tube(s). The heat transfer medium is looped within the system to preheat, heat, precool and cool the product to accepted standards. Sometimes warm vapors extracted from the vacuum (flash) chamber and the cooling properties of plant tower water systems are used for regeneration of the heat transfer medium.

ASEPTIC PROCESSING SYSTEMS (UHT)

Aseptic processing involves the application of a sufficient heat processing, using commercially sterile equipment, and subsequently filled under aseptic conditions in hermetically sealed packaging. The product is termed shelf stable and may be stored without refrigeration.

Regulations and guidelines for these processes may be found in the 21 Code of Federal Regulations, Sections 108 and 113 and in the PMO, Section 7, Item 16(p) and in the PMO Appendix I. **All milk aseptic operations are required to file the process with FDA by the "Process Authority who shares responsibility for plant operations.** In these systems, if sterility is lost for any reason, (pressure or temperature), then flow in and out of sterile surge tanks is interrupted using a product diversion system or valve, the packaging process is immediately interrupted and the entire system, including up to the filling/packaging machine is re-sterilized prior to resuming operation.

Aseptic (UHT) systems also require **identification of temperature indicating devices, differential pressure recorders, sterile air pressure at the filler, critical steam seals (valves, steam blocks, etc), a recorder at the final heater outlet and a process deviation log or record.**

Aseptic systems also require a **differential pressure recorder/controller** so that pressures of the aseptic product and heat-transfer medium are automatically controlled and recorded. Diversion of the product must occur when the aseptic product pressure drops to within 1 psi of the heat transfer medium pressure.

Location of the pressure sensors for these controls are;



HHST, UP AND UHT SYSTEMS

- a) At the heat-transfer medium (water) inlet on the aseptic side of the regenerator; and
- b) At the aseptic product outlet of the regenerator.

Note: Forward flow shall not occur until all product contact surfaces between the holding tube and the FDD are held at or above the required STERILIZATION temperature and held there continuously for at least the required sterilization times or minimum processing temperatures and times (as specified on the filed process).

Since these systems have the FDD located downstream from the cooler section, all product surfaces downstream from the holding tube must also be exposed to pasteurization temperatures following diverted flow and prior to the initial start up. Therefore, the sensing elements at the holding tube, at the vacuum chamber(coolest part), and at the end of the cooling section must all reach the minimum pasteurization/processing time and temperature, prior to allowing forward flow of the product.

Diverted flow therefore must occur when any one of the following conditions are evident:

- a. Loss of product temperature at the holding tube STLR sensor;

b. Improper product/heat transfer medium pressures in plate or double/triple tube heat exchange systems;

c. Improper differential pressures across the steam injectors at the holding tube (a 70 kPa, or 10psi pressure drop across the injector is required) ; or

d. Improper pressures in the holding tube. (Less than

70kPa

Note: If all the above conditions and controls are properly installed then the requirement of a vacuum breaker at the outlet of the pasteurized regenerator, the balance tank height requirement and the booster pump requirement that it may not run during diverted flow, may be eliminated.

STEAM INFUSION SYSTEMS - GENERAL FLOW AND CONTROLS

– Milk enters the system at the balance tank which is interlocked with a auxiliary CIP/FLUSH tank. Water is usually directly connected to this tank using an acceptable "block and bleed" type valving arrangement which prevents accidental contamination of the product. The water line is also protected from back siphonage by using an approved pressure-type back-siphonage protection device.

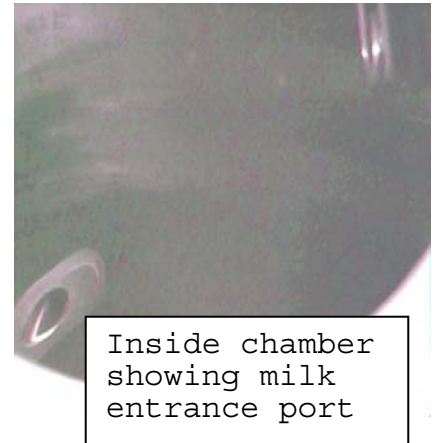
– Product is then fed by a centrifugal pump to a preheater, usually a plate type which uses hot water as the heat transfer medium. This is the first milk to water regenerator. In this regenerator, the raw milk should be under lower pressure than the heat transfer medium. This prevents contamination of the pasteurized product which will be discussed later.

– The product then proceeds to a positive pump which feeds the "sterilizer" chamber. This chamber is actually a steam infusion chamber whereby the product is introduced into a steam atmosphere.



HHST, UP AND UHT SYSTEMS

This process involves the introduction of culinary steam into the product within a falling film type vessel or chamber. These systems must also meet all applicable requirements of the *Ordinance* as covered in the above sections. In some of these infusers, the product is fed into the chamber inside two feed tubes connected to the side of the chamber. Each feed tube consists of a tube-within-a-tube having small drilled holes on top and the outer tube has a 3/16 inch wide slit on the bottom through which the milk exits the tubes.



— De-aerated, culinary steam enters the chamber at the top. Fitted on the chamber top is a **pressure relief valve (pop-off valve)**, which is one of the flow controlling forces of the system, regulating product pressure throughout the system to the flash chamber. Steam and pressure is thus the primary flow promoting element in this system. The pressure release valve is usually set at 60 psi to 75 psi. **This pressure release valve must be sealed by the regulatory agency.**

— The bottom portion of the sterilizer chamber is cone shaped and the cone is normally water jacketed so the chamber skin does not exceed 250° F. Product in the chamber is usually heated above 280°F. The milk undergoes heat penetration within the chamber by maintaining and controlling the density and thickness of the "falling film". The film of milk is thin enough to maintain effective heat penetration. Tempered water jacketing the bottom of the chamber helps to prevent "burn-on".

- _ Product leaving the sterilizer chamber then passes through a holding tube (calculated holding time) and enters a second vacuum vessel known as the FLASH CHAMBER through a sealed ORIFICE. This orifice is properly sized to maintain a back pressure which is another one of the flow rate controlling devices in the system.

- _ As the product enters into the flash chamber through the sealed properly sized orifice "side spiral" it is flash cooled 165° F. This chamber removes steam and milk vapors from the product and the milk is partially cooled. The vapors and heat that is removed from the product in the flash chamber is drawn by vacuum through a "goose neck" located at the top of the chamber by a vacuum pump. The hot vapors are condensed in a water heat-exchanger. In most installations this heated water is then used in the milk-water-milk regenerator in the pre-heating regeneration section.

- _ Product exits the flash chamber through the base leg and to a product removal pump which carries it to a high pressure pump (homogenizer type). From the high pressure pump the product is pre-cooled (water to milk) in a regenerator which reduces the temperature to approximately 75° F.

This water-milk pre-cooler regenerator requires a differential pressure controller to maintain pasteurized product pressures at least one psi above the water pressures. Digital readout pressure differential controllers are usually selected for installation in these systems.

- _ The pre-cooled product then is finally cooled in a refrigerated water or glycol regenerator cooler (down to 35-45° F), passes by the flow diversion device and proceeds to the aseptic surge tank prior to filling.

- _ System that process aseptically packaged products have the required steam blocks, sterile surge tanks, etc in the system located downstream from the product diversion valving system. Identified steam seals are required for sterility and the aseptic surge tank is equipped with 0.2 micron Pall cartridge air filters to maintain sterility.

HHST, UP AND UHT SYSTEMS

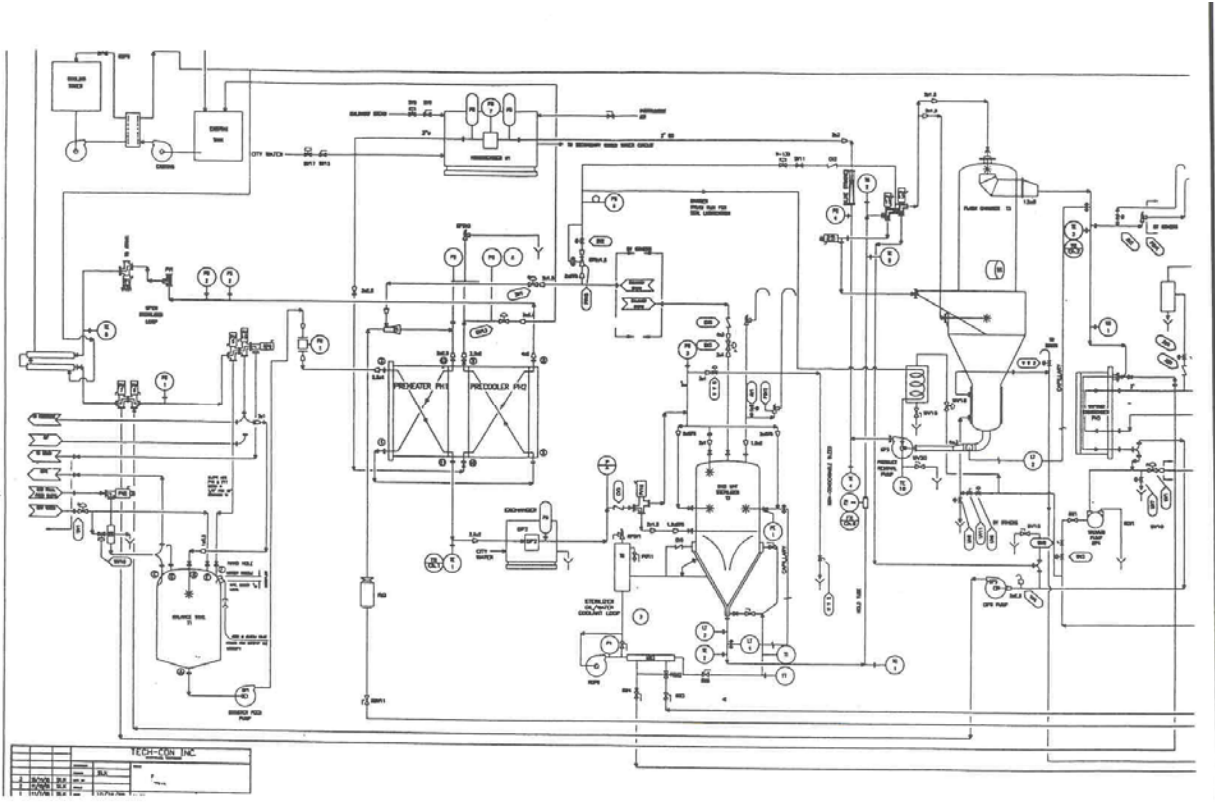


Figure 61
Falling Film (Dasi) Steam Infusion System

GENERAL INFORMATION ON STEAM INFUSION SYSTEMS

1. The pumps recirculating water through the PRE-HEATER or PRE-COOLER are not required to be interwired with the metering pump (as described on page 110, Item 16b of the PMO) since the system diverts upon improper pressures.

2. This system has no conventional timing pump.
3. The system does not require a vacuum breaker following the pasteurized regenerator section.
4. The booster pump does not have to be interwired with the flow diversion valve but must operate only when the timing pump is running.
5. The booster pump may not run if the FDD is not in the fully forward or fully diverted position.
6. Tower water is not acceptable in the raw or pasteurized regenerator. Tower water is open to airborne contaminants, bird droppings, rodents, even toxic chemicals. Tower water may be used to cool water which is subsequently used in a water to milk regenerator water but may not be used directly in the milk regenerators. Since this water system is subjected to subsequent superheating by steam, the possibility of contamination in these instances has been ruled to have a value of acceptable diminutiveness. No special controls are required for tower water plate exchangers used to cool water used in product-water-product heat exchangers.
7. Steam infusion systems used for the processing of "**ultra-pasteurized**" products **only** may use the flow rate at the exit end of the flow diversion valve to determine the holding time. Aseptic systems using direct steam infusion, providing shelf stable products, still must use the laminar flow calculations as described earlier. Product pressures in the holding tube must be monitored with a pressure limit switch as in other direct steam application systems.
8. The positive shut-off valve and vacuum breaker requirement (between the flash chamber and the pre-cooler section of the milk-water-milk regenerator) is not required on HHST falling film type systems since improper relationships in the pre-cooler will automatically result in diverted flow.
9. HHST systems may use an acceptable (FDA/MSB reviewed) digital indicating thermometer, RTD type, in place of the mercury in glass thermometer holding tubes. These RTD's must be sealed to maintain calibration integrity. (Pipeline size may be a limiting factor.)
10. Generally, these systems have not been modified for use in processing **shelf stable products** as in aseptic processing and packaging systems as covered in the PMO and LACF processing guidelines; however, this area is currently under FDA review.

HHST, UP AND UHT SYSTEMS

11. A typical system product flow may parallel the following;

BALANCE TANK ⇄ BOOSTER PUMP → RAW REGENERATOR (Water to Milk) → FEED PUMP ⇄ STEAM INFUSION CHAMBER ➤ HOLDING TUBE ➤ SIZED ORRIFICE → FLASH CHAMBER (Vacuum chamber) → PRODUCT REMOVAL PUMP → HOMOGENIZER OR HIGH PRESSURE PUMP ⇄ PASTEURIZED REGENERATOR (Water to Milk) ⇄ COOLER ⇄ FLOW DIVERSION DEVICE ⇄ STORAGE → PACKAGING

THE ULTRATHERM (Crepaco) INFUSION SYSTEM

Processing methods -

Raw milk is transferred from the balance tank by a booster pump to a plate regenerator which heats it to approximately 140° F. The preheated product is drawn by a timing pump through a plate pre-heater which further raises the temperature to about 170° F.

The preheated product then enters the infusion heater where steam is introduced to further heat the product to 295° F or above. The residence time of product in the steam infuser is about 4 seconds under pressure. A steam controller sensor is located in the product line near the bottom of the heater and another is in the middle of the holding tube. A ratio controller is necessary to prevent product adulteration.

Following the holder, the product enters the aseptic flash chamber. In the flash chamber all added steam is evaporated under a controlled vacuum while removing off flavors, weed and feed flavors, excess vapors, and non-condensable gases. These gases are passed through a plate vapor condenser with the aid of a vacuum pump.

The sterilized product exits at the bottom of the flash chamber and is pumped to a homogenizer, at about 170° F. Homogenization pressures are generally set at

1500 to 3500 psi. The product is then cooled to 45° F for ultra pasteurized product or 70° F for aseptic filling.

The flow diversion valve, as is the DASI system is located at the end of the final cooling section and the temperature sensor is located the beginning of the holding tube. If temperatures or pressures do not meet required pre-set values, the flow diversion device automatically diverts and the entire system is subjected to a sterilization process prior to restarting the product process. Complete sterilization temperatures often exceed 295° F.

HHST, UP AND UHT SYSTEMS

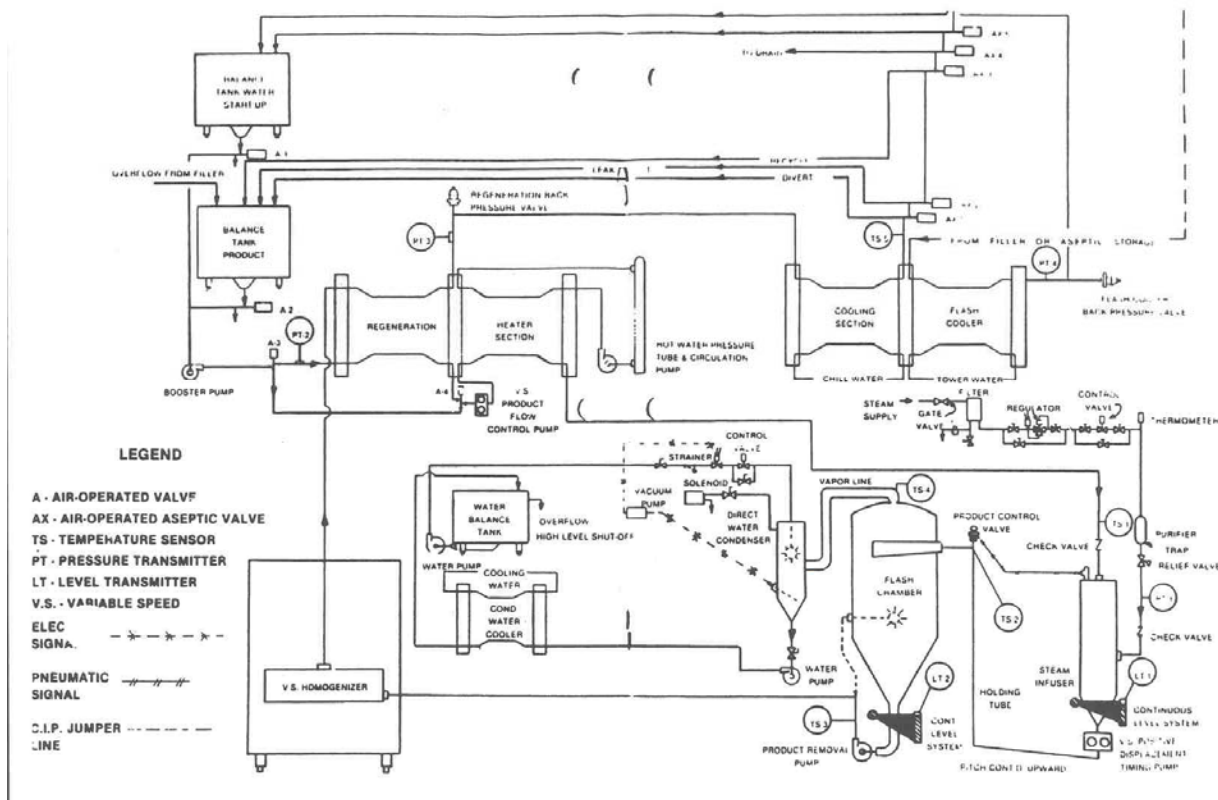


Figure 62
Ultratherm (Crepaco) Infusion System



HHST, UP AND UHT SYSTEMS

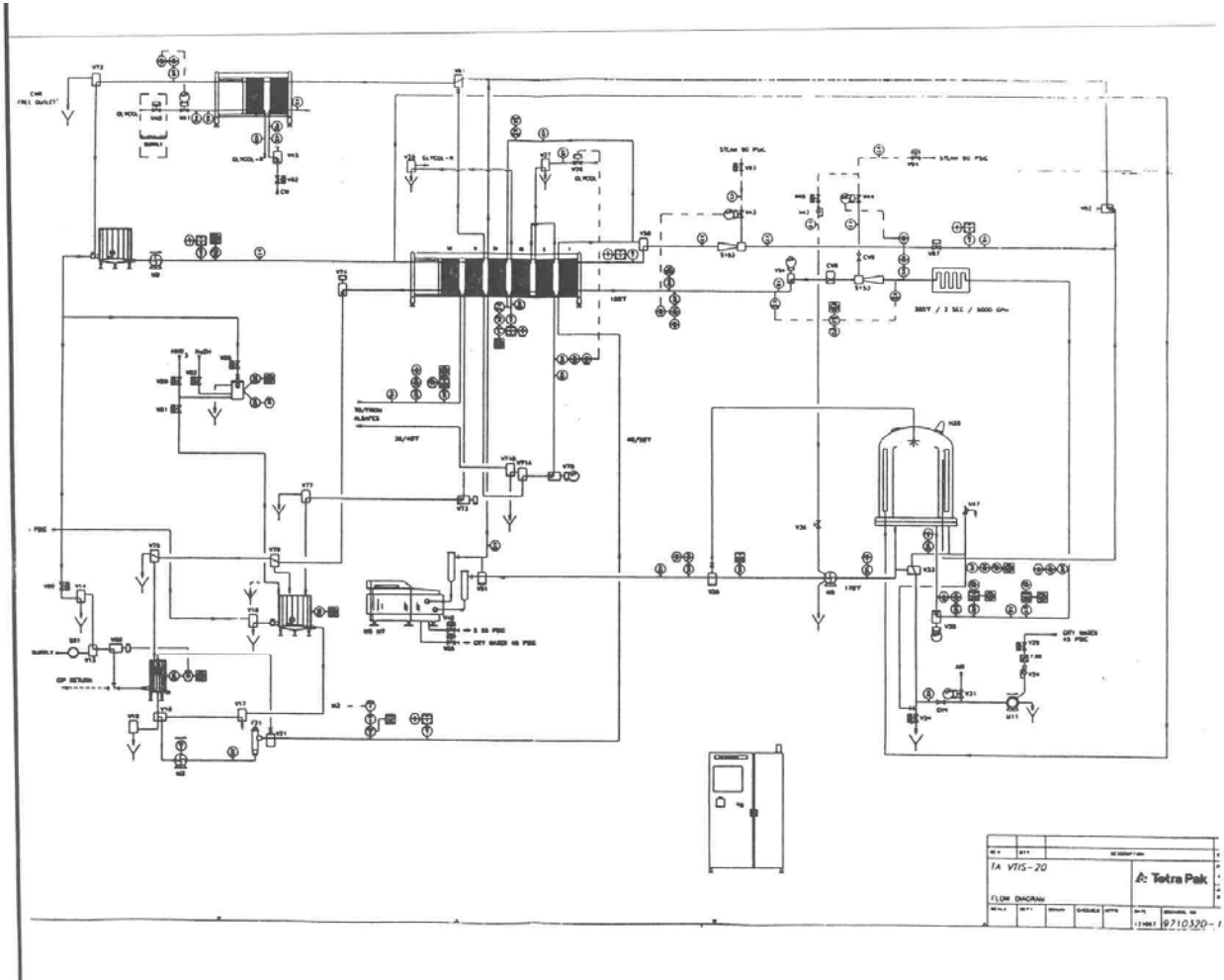
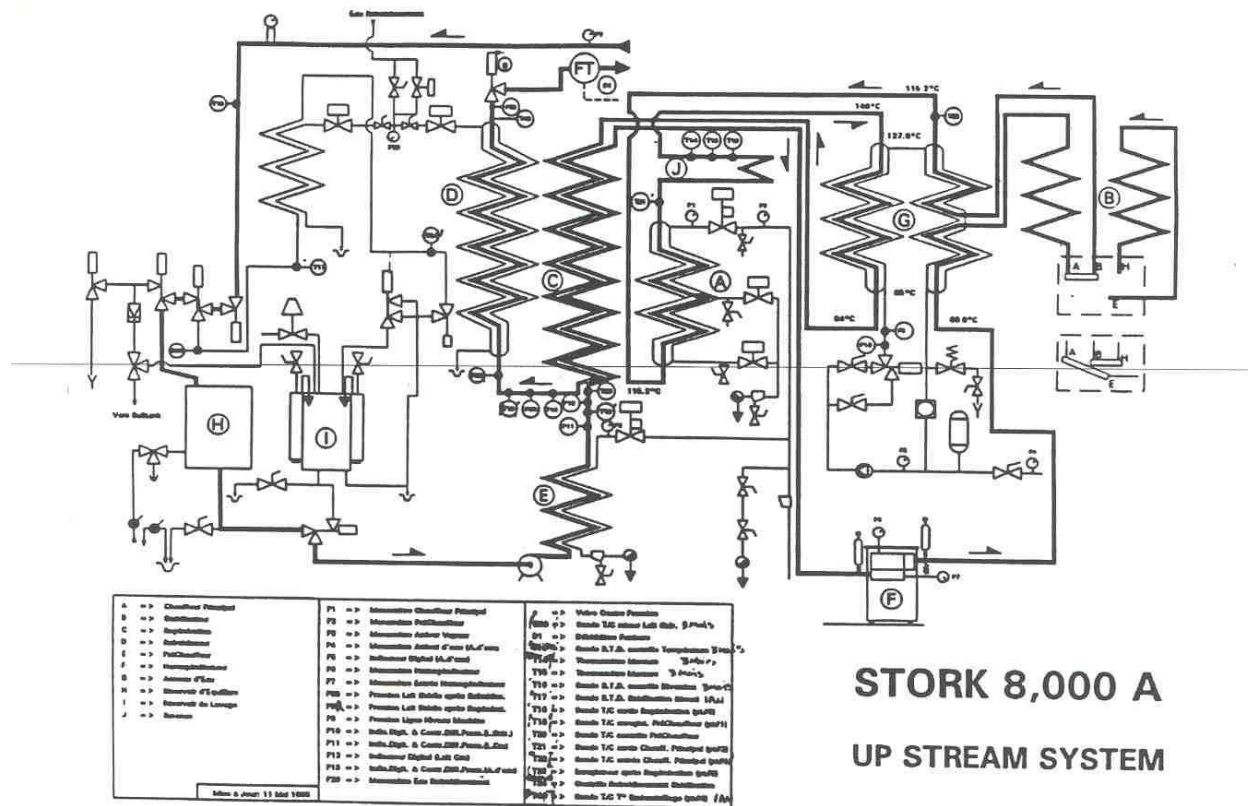


Figure 64
TetraPak VTIS Injection System



STORK 8,000 A
UP Stream System

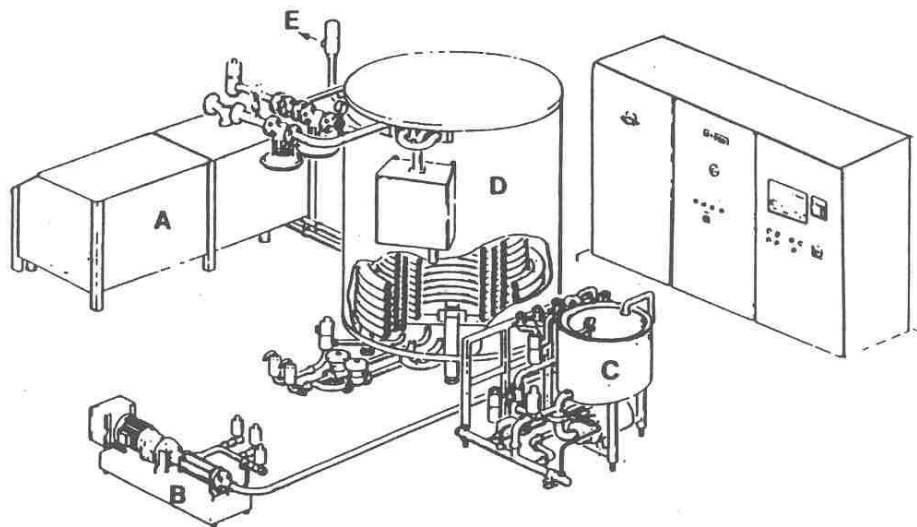


Figure 65
Tubular (STORK) UHT Systems

HHST, UP AND UHT SYSTEMS

CHAPTER REVIEW

1. Define the following:

a) steam injection

b) steam infusion

2. Why is it necessary to monitor pressure in the holding tube?

3. For each 30° F product temperature increase by steam addition the product volume will increase by ____%.

4. Using Table 1 and the information provided below, calculate the holding tube length for a steam injection system operating under the following conditions.

Time to fill 10 gallon can = 28.3 sec

Holding time = 0.5 sec

Holding tube diameter = 2.5 inches

5. In HHST systems, where is the flow diversion device located and why??

6. List the location of the required STLR and thermal limit controller sensors on steam injection systems.
 - a)
 - b)
 - c)

7. Explain the term "Thermal Limit Controller Sequence Logic" as it applies to advanced milk processing systems.

- 8.. What is the sensor location, purpose and operation of the following controls?
 - a) Ratio controller

 - b) Pressure Differential Controller

- 9.. Acceptable flow rates in the DASI system is determined by what components in the system and how are they adjusted?

10. Aseptic systems cannot operate with a conventional FDD. Explain why?

HHST, UP AND UHT SYSTEMS

11. Thermal limit controllers are required in both _____ and _____ HHST systems. What is their purpose?