PARTICIPANT REGISTRATION
(please print legibly)

COURSE TITLE: MILK PASTEURIZATION CONTROLS AND TESTS, #302

COURSE LOCATION:

DATE(S):

NAME: JOB TITLE:

JOB RESPONSIBILITIES:

ADDRESS: WORK ( ) HOME ( )

WORK PHONE NUMBER:( )

NUMBER OF YEARS IN CURRENT PROFESSION:

DURING THIS COURSE WHICH AREA(S) WOULD YOU LIKE TO HAVE EMPHASIZED?

SPECIFIC QUESTION(S) THAT YOU WOULD LIKE TO HAVE ANSWERED DURING THIS TRAINING :

1.

2.

3.

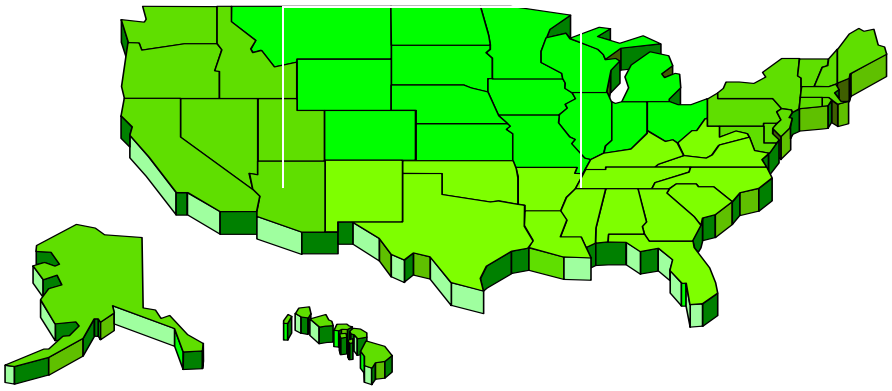
Milk Pasteurization Controls and Tests
Course #302

STATE TRAINING BRANCH
COURSE MANUAL

8th Edition
2003

Department of Health and Human Services
Public Health Service/Food and Drug Administration
Division of Human Resource Development
State Training Branch

The purpose of this course is to develop and/or increase the knowledge, skills and proficiency necessary for the inspection and testing of milk pasteurization equipment. Emphasis is given to the controls and tests necessary to assure effective pasteurization of milk and/or milk products . The course is designed to teach the public health reasons for the requirements which govern design, function and operation of milk pasteurization equipment.



Richard D. Eubanks, CAPT United States Public Health Service
Training Officer
with edits by Ray Niles

Gary German, Director
Food and Drug Administration
Division of Human Resource Development
State Training Branch
5600 Fishers Lane, (11919 Rockville Pike)
Rockville, MD 20857
Phone (301)827-8697

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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.

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Acknowledgments--The development, preparation, and publication of this course manual is the responsibility of the State Training Branch, Division of Human Resources Development, Food and Drug Administration. The updated schematics of HTST systems were taken from the 3-A Accepted Practices for the Sanitary Construction, Installation, Testing and Operation of High-Temperature Short Time and Higher-Heat Shorter-Time Pasteurizer Systems, Revised, Number 603-06. The National Conference on Interstate Milk Shipments has resolved in their Conference agreements to fully support the training efforts of the FDA

The requirements and legal aspects found within this manual were taken from previous editions and printing of this manual and the current edition of the Grade A Pasteurized Milk Ordinance and acknowledgment is given to all the previous contributors of that document.

This edition of the training manual was compiled, prepared and edited by CAPT Richard D. Eubanks, USPHS, Training Officer, FDA/ ORA/DHRD, State Training Branch with major rewriting of the HHST,UHT Chapter and revisions in other portions of the testing section. Technical and word processing assistance was provided by CDR Artis M. Davis, USPHS, Regional Milk Specialist, Southwest Region. Appreciation is also given to the Regional Milk Specialist, State Rating and Regulatory Officials and the milk industry for their support and contributions to the development of this manual. CDR Robert F. Hennes also assisted by providing much needed technical and grammatical editing. Mr. Steven T. Sims, FDA/CFSAN Milk Safety Branch has also provided excellent detailed information on the inspection and testing of HHST/UHT systems. Others contributing technical information are Dr Joseph Schlesser, FDA/CFSAN/HACCP/Division of Food Processing and Packaging, Mr. Richard Gleason, California Department of Food and Agriculture and Mr. Roger Krug of the Oregon Department of Agriculture provided technical suggestions and assistance.

The "RED COW BOOK", as it is presently known, is to be used as a training and reference source. It has evolved over the years as a result of previous milk training officers assigned to FDA's State Training Branch. It was through the energies of individuals such as I. H. Schlafman, K. L. Pool, Roger Dickerson, Jr., R. B. Read, Jr., Robert B. Carson, Harold (Tommy) Thompson, Harold Faig, Ronald Smith, O.D.(Pete) Cook, Brenda Holman and others, and under the direction and support of State Training Branch Directors such as James P. Sheehy, Harry Haverland and Gary E. German that this manual has developed into its present form. Providing much of the regulatory and practical aspects of inspecting and testing pasteurization systems were the FDA Regional Milk Specialists, FDA's Milk Safety Branch, State Milk Rating Officers, state and local milk regulatory individuals, and the milk industry and academia who have all contributed to the further development of this training manual.

FOREWORD

This Course is designed primarily for state milk regulatory and rating personnel, local milk inspection staff, FDA milk specialists and investigation personnel, elements of the milk industry,(including quality assurance), plant management, plant engineers, industry consultants, colleges and university staff and students, military food and milk specialists, and other personnel engaged and concerned with the safe processing of milk and milk products.

Fundamental principles of the theories and sanitary operation of milk pasteurization systems are presented in both lecture and class participation formats. Lectures and demonstrations are enhanced with visual aids, handouts, slides, overheads and videos. Class discussions and problem solving sessions constitute a vital entity in this course. The trainees are ultimately involved in the "hands-on" portion using actual pasteurization controls and equipment in the classroom. This demonstrates the proper methods to be used in the testing of equipment while enabling the participants to become familiar with the basic components of actual milk plant equipment.

This course manual is a collective reference booklet to equip the course attendees with those principles, theories, and regulatory controls necessary to assure the proper pasteurization of milk and milk products. The manual was developed over the years using the current edition of the Grade A Pasteurized Milk Ordinance (PMO), the current 3-A Sanitary Standards and Accepted Practices, applicable Memoranda issued by the FDA's Milk Safety Branch and information gathered at various seminars and training courses**.**

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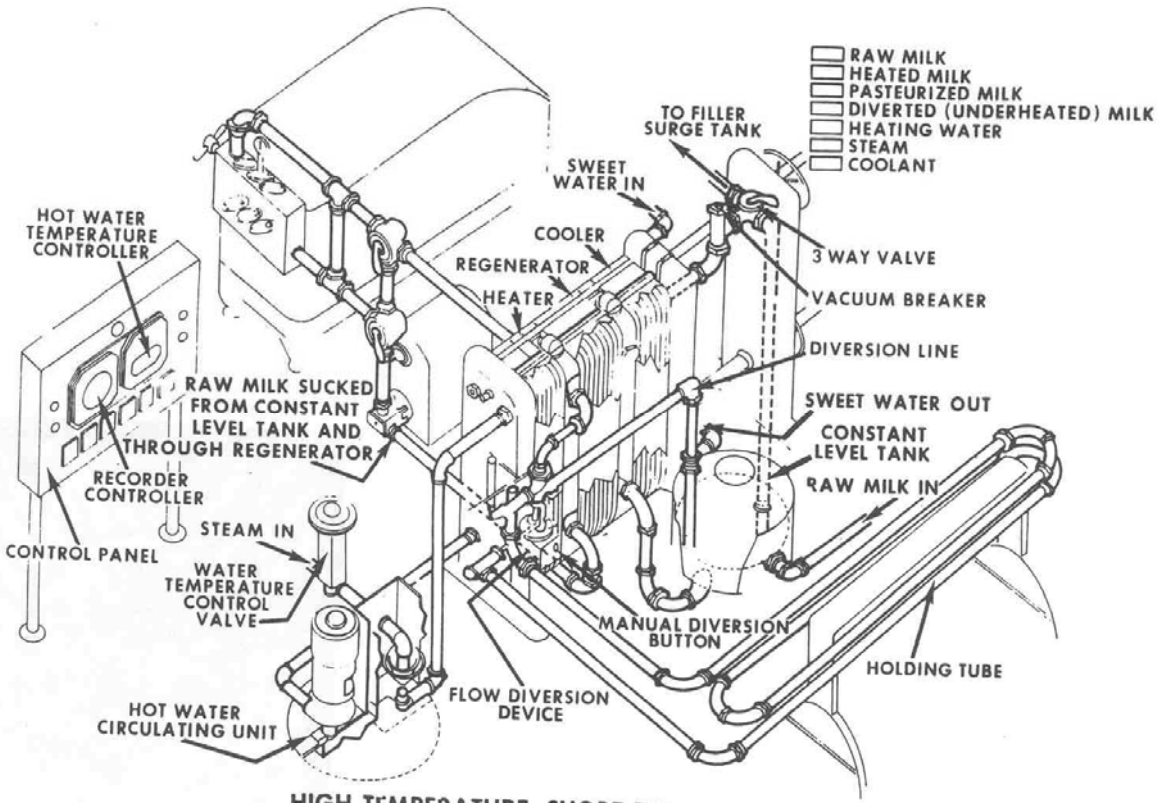
PASTEURIZATION

TIME/TEMPERATURE REQUIREMENTS

PRODUCT	VAT	HTST	HHST
	TIME TEMP	TIME TEMP	TIME TEMP
WHOLE MILK, LOW FAT, SKIM	30 MIN 145° F	15 SEC 161° F	1.0 SEC 191° F 0.5 SEC 194° F 0.1 SEC 201° F .05 SEC 205° F .01 SEC 212° F
MILK PRODUCTS- with increased viscosity, added sweetener, or fat content 10% or more	30 MIN 150° F	15 SEC 166° F	SAME
EGG NOG, FROZEN DESSERT MIXES	30 MIN 155° F	25 SEC 175° F 15 SEC 180° F	SAME

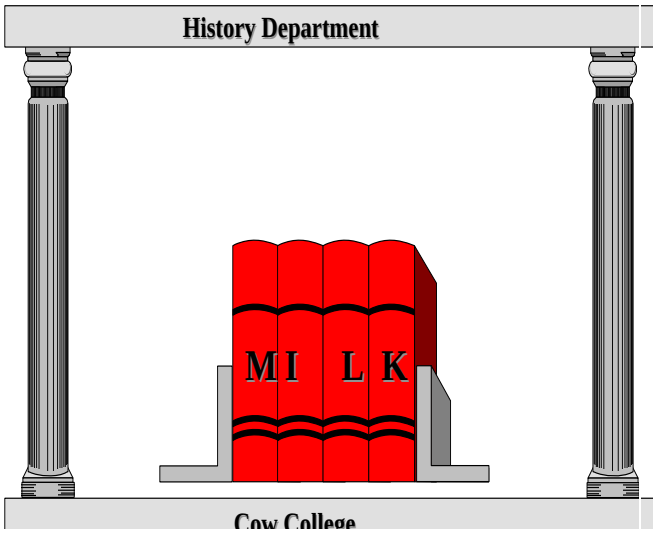
Note: Those pasteurized milk products that are further heated in an acceptable system to a minimum of 280° F for a minimum of 2.0 seconds are to be labeled as "Ultra Pasteurized".



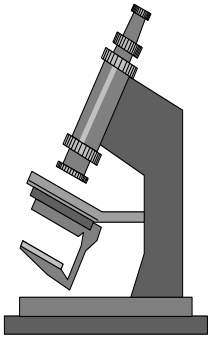
HIGH-TEMPERATURE, SHORT-TIME PASTEURIZER

Chapter I

BACKGROUND AND HISTORY



MILK PASTEURIZATION, THEN AND NOW



Although **Louis Pasteur** is the one name most often referenced in discussions the inception of what we now know as pasteurization, actually the concern for methods to **preserve the safety of milk** began long before Pasteur's first experiments of heating wine to preserve its freshness. As early as the 1500's Austrian officials implicated milk in an epidemic which led to much thought concerning safety issues of milk consumption.

However, it was not until 1824 that **William Dewees** recommended the application of **heat** to milk as a method of **preservation**.

Following several illnesses in the late 1800's, thought to be typhoid outbreaks, and after investigations into the so called "**slop-dairies**", authorities from the New York Academy of Medicine considered the definite need for some type of preservation process to be applied to milk used by **babies** and the **old and infirm**. This group met with little success since these "slop-dairies" were being utilized for spent grain disposal from the large breweries in the New York area. In these operations the milk was produced and processed in the same grossly unsanitary facilities connected with the breweries and distilleries.

Surprisingly, before Mr. Pasteur in 1857 officially reported that the lactic fermentation (souring and/or curdling) of milk was greatly delayed by applying heat to milk, **Gail Borden** was busy applying for a patent for the **condensing** of milk under vacuum in 1853. Also, Massachusetts was adopting milk control programs (1856).

Thus, scientists around the world were theorizing that undesirable changes in food products were attributed to the **presence of microorganisms in the food and that these "germs" could be controlled by the application of heat.**

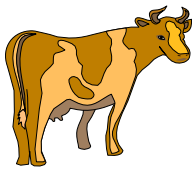
Pasteur, along with other renowned scientists of the era, such as **Abraham Jacobi**, **N.J. Fjord,** and **Albert Fesca** made significant contributions to the equipment designs used for milk processing systems.

Some of the early equipment was very crude; however many are simply prototypes of the equipment we see in large modern dairies today. It is important to note here that the concepts of **continuous agitation and processing** were employed in Fjords system known then as the "Danish Pasteurizer".

Denmark enacted a law in 1898 requiring the heating of all calf fed milk to 185^{o}F to prevent the spread of bovine tuberculosis. This was indeed one of the first forerunners of **modern commercial milk pasteurization**.

Nathan Stauss, a noted philanthropist, in 1893 saw the marketing advantage of heating milk for infant feeding and later financed a "chain" (perhaps the first real milk franchise) of what he called "milk depots" in New York City. He utilized pre- sterilized glass bottles (dry heat method) and the milk was heated to 167^{o} F for 20 minutes, cooled, and sold for consumption.

Some adversaries believed that destruction of some of the organisms in milk could allow others to produce toxins in the milk, cause undesirable flavor problems, and destroy many nutrients. Fortunately, however, researchers furthered Pasteur's experimentation and proved that the use of **lower temperatures** destroyed spoilage organisms and incidentally…**pathogens**.



After **Park and Holt** had showed evidence of the positive attributes of feeding pasteurized, vs. raw milk to infants in tenement houses in 1903, the United States Public Health Service began studies and confirmed the public health benefits of heat treating (now being called pasteurization) milk.

Milk, as nature's most perfect food, is therefore also a **perfect medium in which bacteria can thrive**. Realizing this attribute, many states, Illinois being one, began to develop laws regarding the **tuberculin testing of dairy herds**, and restricting milk sales to those herds which had been tested. In 1914 New York City required by law that all milk sold must be pasteurized. In 1920 the American Public Health Association's Committee on Milk Supply reported

almost **4200 milk plants failed to meet even minimum milk pasteurization standards**.

Following engineering studies (known as the **Endicott Experiments** since they were conducted in Endicott, N.Y.) conducted by **Dr. Charles E. North** of the North Public Health Bureau and the Borden Farm Products Company, the Public Health Service published a bulletin (no. 147) attesting that there were indeed **MAJOR improvements necessary to protect the public health and assure a milk product free of pathogens**.

Perhaps the single most contributing factor to the public health regulatory control of milk pasteurization and safety occurred in 1924, when the state of **Alabama** initiated a request for assistance from the U. S. Public Health Service to develop a milk sanitation program.

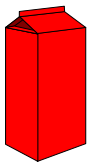
The work between this state and the federal government eventually led to the development of the **first proposed Standard Milk Ordinance** (November 7,1924--Public Health Reports). This first milk code initiated actions by other interested states and in 1927 a uniform national Code was published which included both technical and administrative notes for satisfactory compliance. This was a major milestone. Now minimum pasteurization standards could be further developed and established on a uniform nationwide basis. Little did they realize that 25 years later the National Conference would be established from these initial efforts.

Developments then flourished. The **first plate heat exchangers** were introduced into the U.S. in around **1928**. Earlier in 1927 the application of a higher heat process was evolving in Europe. Pennsylvania in 1931 conducted studies relative to the thermal destruction of pathogens using 160^{o}F for a 15 second hold time.

Only slight changes were made to the pasteurization requirements in the 1930's. The **1939 edition of the Milk Ordinance and Code**, although not requiring pasteurization, highly recommended that cities adopt the Ordinance if permitted in their local codes.

BACKGROUND AND HISTORY

In 1950, the Bell studies suggested that the organism *Coxiella burnetii which is* responsible for several **Q-fever (Query fever) outbreaks in Southern California** could survive the then current pasteurization requirements. This is a febrile rickettsial disease producing flu-like symptoms



As a result, the USPHS in cooperation with University of California-Davis recommended increasing the minimum batch pasteurization temperature from 143^{o} to 145^{o} F (maintaining the 30 minute minimum holding period). Also those milk products with added sugar and/or fat would require an additional 5 degrees heat.

The application of heat to milk for the purposes of preservation, with the extra benefit of the protection of public health, continues to develop. Innovative methods are now available for processing milk at **ultra high temperatures** (UHT) with reduced holding times.

Pasteurization systems have become more complex. Methods of concentration have evolved from the mid-1850's G. Borden's vacuum condenser to the ultramodern methods of concentration. Modern systems process milk and milk products through micro-membranes and multi-stage evaporator calandria systems utilizing highly efficient heat recovery/ regeneration systems. One of the latest major developments of the 1980's in the U.S. has been the **aseptic processing and packaging** or so called "sterile" milk systems which can effectively provide six to nine months shelf life under non-refrigerated conditions.

WHY ALL THE FUSS??

Perhaps, now that we have followed the development of pasteurization

BACKGROUND AND HISTORY

we must ask another question.....why?

Most of us have knowledge of at least the basics of the biological sciences and may have advanced degrees in biological sanitary sciences. Others might also have advanced degrees in engineering, public health, or dairy processing, and are familiar with the inherent problems associated with milk and its ability to support the growth of disease producing organisms.

Dr. Ben Freedman, in his benchmark reference book for sanitarians entitled Sanitarians Handbook" proclaims that "*Milk is the first food of human life*." *It is the most nutritious food known, but also the most quickly perishable food as a result of bacterial action".* He also has written that from the period 1938 to 1950, milk was eight times more powerful in causing illness than were water borne diseases, and that it is through the work of milk sanitarians and the dairy industry that milk has become one of the nations safest and most widely consumed foods.

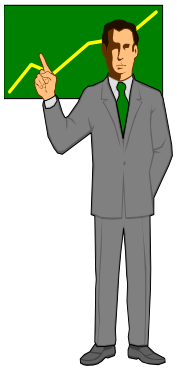
However, we must not "leave the chicken house unguarded." Milk does not exit the teat end of a lactating dairy animal in sterile form. Even if extracted in a sterile manner, milk would be likely to contain organisms from within the cow's udder.

Although varying in number, the average plate count of milk drawn in this manner would vary from 10 organisms per cubic centimeter to several thousand.

Udder diseases known as **mastitis** also contribute significant numbers of bacteria, including Streptococci, Staphylococci, Tubercle bacilli, and Brucella abortus. The environment can contribute other organisms such as Salmonella, Escherichia coli, Aerobacter micrococcus, Lactobacillus, and the more recently identified Listeria, Yersinia and Campylobacter.

Actually you cannot name even one pathogen that would **NOT** thrive readily in milk. Therefore, we still are not out of the water completely and must

continue to be aware of the potentials associated with handling and processing a "potentially hazardous food."



Just recently the FDA and CDC have received reports implicating milk products in the transmission of pathogens and responsible for human illness.

**1982 - 172 confirmed with Yersiniosis from drinking pasteurized milk in Little Rock, Memphis and Greenwood, MS. Of these 172, 10% were misdiagnosed and underwent unnecessary appendectomy operations. Investigation revealed pig farmer collecting route returns and returning contaminated cases back to plant. The causative was not found in the milk, however was isolated from the swine, empty returned cases, and cultures isolated from the victims.

**1984 - Brucellosis in humans, causative factor, illegal Mexican style cheese in Texas.

**1985 - Salmonella outbreak in Chicago, 16,000 culture confirmed cases, 2 deaths, from consumption of pasteurized milk. Plant never reopened.

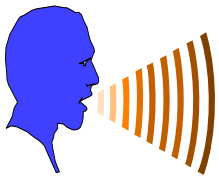
**1986 - Listeria monocytogenes causative agent responsible for 146 confirmed cases of Listeriosis when a nurse at a large Los Angeles hospital reported accelerated cases of miscarriages in _ Hispanics. There were 89 deaths. Investigation that followed implicated Mexican style (soft) cheese processed at a small plant in the L.A. area. Plant inspection revealed problems with cross connections and post pasteurization contamination.

**1990 - Outbreak of Staph enterotoxin associated with whipped butter in a large hotel in Reno, NV. Suspect temperature abuse at the processing plant. Testing at the source of butter manufacturer showed negative for staph organisms.
**1992 - E. Coli 0157 outbreak reported transmitted by ingestion of

unpasteurized milk.

**1993 - Type A Botulism toxin caused at least one death in Georgia. Problem associated with institutional packaged (#10 can) cheese spread in small convenience type store.

1994 - Salmonellosis enteritidis outbreak, THOUSANDS of cases reported from consuming contaminated ice cream. Plant located in Midwestern state shipping to 48 states. Firm received mix and did not re-pasteurize prior to freezing and packaging. Follow-up shows mix was hauled in a tanker which was just prior used to haul raw liquid eggs. Two consumer samples were presumptive positive. Product was immediately recalled from the market. This outbreak **should send a message to the frozen dessert industry that all mix SHALL BE PASTEURIZED in the plant of packaging and the unnecessary handling of pasteurized milk products must not be condoned.



**1995 - Yersiniosis enterocolitica outbreak reported in New England. Epidemiological studies placed suspect on contamination of pasteurized milk from operation of a small swine operation on the premises of the producer-processing dairy responsible. There was no case washer in the plant. The bottle washer had no sanitizer.The pigs were housed in the same barn with the dairy animals. Five culture confirmed illnesses were confirmed in two states. Samples of raw milk showed positive Yesinia. Environmental swabs were taken and the organism was not found to be present in the plant environment.

**1995 - Listeria outbreak in Ohio. Suspected source was product from frozen dessert plant. A follow-up inspection of the plant revealed several problems with the pasteurizer problems (flow diversion valve and flow promoters not operating properly) and direct cross connections between raw and pasteurized lines.

**1998-Outbreak caused by E.Coli 0157:H7 (Enterohemorrhagic - Escherichia

coli) which manifest itself by Diarrhea, often bloody, abdominal cramps. Contaminated Cheddar and Colby cheese curd from adding raw milk to processing vat using a common bucket. Investigation found pasteurizer cut-out temperature at 159 degrees F, dripping condensate over cheese vat, use of unpasteurized city water to "push" pasteurized product in lines, cross connections between water and product throughout the plant and poor re-working practices at a receiving plant. 40 known cases of illness with 20 culture confirmed cases on record.

In FY93 alone there were twenty two official nationally documented FDA product recalls of dairy related processed/packaged products. Some of the problems and reasons for these recalls were:

1. Product contaminated with Listeria monocytogenes. (Three separate cases of U.S. hard and semi-soft cheeses.)
2. Product contained undeclared food colorings.
3. Product contaminated with (unnamed) bacteria.
4. Metal fragments found in packaged product.
5. Botulism potential in product (pasteurized process cheese).
7. Powdered whole and low fat milk contaminated with Salmonella.
8. Yogurt and shake mix contaminated with Salmonella organisms.

Noting the above, we, as public health professionals, milk industry quality control consultants, plant management and employees, must evermore realize and stress the significance of assuring the proper production, processing and handling of milk and milk products.

Pasteurization is the only public health measure which, if properly applied, will adequately protect against all infectious milk-borne disease organisms which may have entered the milk prior to pasteurization.

We cannot, however, assume that the pasteurization of milk will completely assure a safe product for the consumer. The "human factor" and equipment failures can play an equally significant role in the safety and wholesomeness of any food product, and even more so in milk.

This manual will concentrate efforts towards the principles, theories and mechanics of proper pasteurization techniques. System controls will be discussed; time-temperature- pressure relationships will be repeatedly stressed. Methods of assuring the minimum standards will be emphasized, and probably more importantly for this course, the acceptable and legal requirements and recommended techniques for testing of **legal pasteurizers** will be emphasized.

This course manual in subdivided into the three basic types of pasteurization, vat, or "batch" type, high-temperature, short-time, and a short section on steam injection pasteurization.

In HTST pasteurization, chapters are also devoted to the use of auxiliary equipment and associated required controls. There is also a section on magnetic flow meters, or meter based systems that will provide the participant with the current requirements for their installation and testing.

The manual has been supplemented with various drawings, graphics, photos, and product flow schematics for the student's reference.

As more and higher quality milk has become available, questionable and often inferior supplies have been largely eliminated. Reliable information about the quality of milk products is readily available and the need for costly duplication of regulatory efforts has been largely eliminated.

The success of the National Conference of Interstate Milk Shipments has increased confidence for the work of other food related control activities. The milk program, which operates on the basis of promoting uniformity and reciprocity of inspection programs, is currently serving as a model for many food control and inspection programs.

For example the Interstate Shellfish Sanitation Program and many of the current HACCP (hazard analysis of critical control points) concepts were borne from the basics and diligence of milk inspection principals, regulations and methods of inspection.

Consumers can now be relatively assured of the safe and wholesome quality of milk products purchased from the retail shelves. Seldom are milk products implicated in major food-borne outbreaks. The development of methods, procedures, equipment, and yes, regulations and standards, over the years has resulted in an effective method of providing the consumer one of the safest and most wholesome foods available in the nation today.

COURSE OBJECTIVES

AT THE END OF THIS COURSE THE PARTICIPANTS SHOULD BE ABLE TO:

❶ Describe the basic process methods, principles and requirements of Batch, High Temperature Short Time (HTST), and Higher Heat, Shorter Time (HHST) pasteurization systems.

❷ Be able to explain the reasons for, and methods used, to evaluate and regulate the TIME-TEMPERATURE-PRESSURE relationships in pasteurization systems.

❸ Be able to list the basic and auxiliary equipment components of pasteurization systems, including vat, HTST, meter based, HHST systems and give the PMO requirements and public health reasoning for legal installation.

❹ Correctly perform the required tests for pasteurization systems by using the classroom pasteurization demonstration unit and/or the HTST unit at a milk plant during the class field trip.

❺ To be able to correctly trace product flow through pasteurization systems, and explain the public health controls necessary to satisfy the time-temperature-pressure requirements, including regulatory seals where required, using the case study method.

SIGNIFICANT EVENTS IN THE DEVELOPMENT OF *MILK PASTEURIZATION*

1765 THE ITALIAN NATURALIST, SPALLANZANI, NOTED THAT BOILING PRESERVES MEAT EXTRACTS.

1782 THE SWEDISH CHEMIST, SCHEELE, PRESERVED VINEGAR BY BOILING

1810 APPERT USED HEAT TREATMENT TO PRESERVE FOODS (CLOSED CONTAINER).

1861 THE "GERM THEORY" WAS DEVELOPED

1864 PASTEUR REPORTED THAT HEAT APPLICATION TO WINE AND BEER PREVENTS ACID, BITTER AND ROPY DEFECTS IN WINE. (THIS PROCESS WAS TERMED "PASTEURIZATION".)

1867 PASTEUR APPLIES HEAT TO MILK AND REPORTS THE PROCESS POSTPONED MILK SOURING.

1886 THE HEATING OF MILK (BOILED IN A BOTTLE) FOR INFANT FEEDING REDUCED ILLNESS AND SAVED LIVES BY ELIMINATING PATHOGENS WAS ADVOCATED BY SOXHLET (GERMANY), JACOBI (U.S.).

1893 STRAUS SET UP FACILITY TO PASTEURIZE MILK FOR INFANTS.THE FIRST MEDICAL COMMISSION WAS FORMED TO OVERSEE THE PRODUCTION OF “CERTIFIED MILK”.

1920's“ENDICOTT STUDIES” OCCURRED IN ENDICOTT, NY BY DR’S NORTH AND PACK DEVELOPING TEMPERATURE DESTRUCTION CURVES RELATIVE TO MYCOBACTERIUM AND TUBERCULOSIS

1924 THE USPHS CREATED "THE OFFICE OF MILK INVESTIGATIONS" UNDER THE STRONG LEADERSHIP OF LESLIE CARL FRANK.

BACKGROUND AND HISTORY

1924 THE STATE OF ALABAMA WORKED CLOSELY WITH THE USPHS TO DEVELOP THE FIRST FEDERAL MILK ORDINANCE PATTERNED AFTER "THE ALABAMA STANDARD MILK GRADING ORDINANCE."

1941 PYREX HEAT-RESISTANT GLASS PIPING USED IN DAIRY INDUSTRY AS A MEANS OF CONSERVING CRITICAL MATERIALS DURING WARTIME.

1952 SEVERAL STATES MET IN ST LOUIS TO DISCUSS THE PROBLEMS OF RECIPROCITY FOR SHIPPING MILK ACROSS STATE LINES. THIS WAS THE FIRST NATIONAL CONFERENCE ON INTERSTATE MILK SHIPMENTS. ALSO MUCH RECOGNITION TO DR. C.A.ABELE AND DR. EVERETT WALLENFELDT FOR THEIR EARLY PIONEERING EFFORTS IN THE DEVELOPMENT OF THE GRADE A MILK PROGRAM.

1953 THE FIRST 3-A STANDARD FOR CIP CLEANING WAS PUBLISHED.

1955 THE FIRST AUTOMATED CIP SYSTEM INSTALLED IN AN OHIO MILK PLANT.

1956 MINIMUM TEMPERATURE FOR VAT PASTEURIZATION WAS RAISED FROM 142^{o}F TO 145^{o}F BASED ON HEAT RESISTANCE OF Coxiella burnetti. BASED ON UNIVERSITY OF CALIFORNIA-DAVIS STUDIES IN LATE 1940'S

1966 FDA MEMORANDUM ACCEPTS DUAL STEM (CIP) FLOW DIVERSION DEVICE TO BE USED IN HTST SYSTEMS.

1978 FIRST U.S. UHT “STERILE” MILK SYSTEM COMMISSIONED IN GEORGIA.

1979 MAGNETIC FLOW METER SYSTEMS FOUND ACCEPTABLE FOR USE AS REPLACEMENT FOR CONVENTIONAL TIMING PUMPS.

1985 MAJOR SALMONELLOSIS OUTBREAK IN CHICAGO SPAWNED INCREASED EMPHASIS ON MILK PROCESSING SANITATION. BECAME KNOWN AS THE “DAIRY INITIATIVES”. EMPHASIS PLACED ON IN-DEPTH FDA AND STATE RATINGS INVOLVING DOWN- TIME EQUIPMENT INSPECTIONS, PRODUCT SAMPLING, AND TRACING PRODUCT FLOWS TO EVALUATE POSSIBLE CROSS CONNECTIONS.

BACKGROUND AND HISTORY

1986 LISTERIA OUTBREAKS IN CALIFORNIA FUELS FURTHER INVESTIGATIONS ON POST PASTEURIZATION CONTAMINATION PROBLEMS IN CHEESE AND MILK PLANTS.

COMPUTER CONTROLS ACCEPTED FOR MILK PASTEURIZATION SYSTEMS

1994 SALMONELLA OUTBREAK TRACED TO ICE CREAM. PROBABLE ETIOLOGY WAS HAULING OF RAW LIQUID EGGS IN MILK TANKER WHICH WAS USED TO SUBSEQUENTLY HAUL PASTEURIZED MIX. FREEZING AND PACKAGING WAS DONE WITHOUT RE-PASTEURIZING THE MIX. LARGE NUMBERS OF CULTURE CONFIRMED CASES.

1994 CONTAMINATED WATER IN A PLANT WAS SUSPECTED CAUSE OF PACKAGED MILK TRANSMITTING E. COLI TO CONSUMERS IN MONTANA. FAILURE OF WELL DISINFECTANT LED TO SUBSEQUENT CONTAMINATION OF PASTEURIZED MILK STORAGE TANK. CULTURE CONFIRMED CASES. PLANT CLOSED.

THERMAL PROCESSING

The term "thermal process" generally refers to a process during which a food product is subjected to high temperatures with the objective of inactivating undesirable microorganisms or enzymes.

TYPES OF HEAT PROCESSING

1. PASTEURIZATION

a) Temperatures are generally below 212^{o} F

b) Time of exposure varies

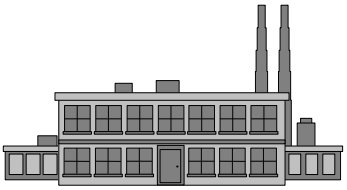
c) Time-temperature is lethal to pathogens in vegetative state; many non-pathoge

2. CANNING

a) Temperatures are above 212^{o} F

b) Time of exposure varies

c) Lethal to spores (rod shaped), "botch cook"



3. STERILIZATION

a) Temperatures are above 250^{o} F

b) Time of exposure is short to minimize product damage

c) Implies "commercial sterility" where level of viable cells is a statistic.

Commercial sterility is defined as the time\temperature relationship necessary for destruction and\or inhibition of the organisms of public health significance as well as all significant spoilage organisms and is specific for each food type and formulation.

Thermal process is necessitated by the fact that plant and animal tissue and fluids are normally and naturally contaminated with microorganisms and/or enzymes which may cause undesirable changes in the product during storage.

BACKGROUND AND HISTORY

Pasteurization is a thermal process that kills **part but not all of the vegetative microorganisms** in the food and is consequently used for foods which are further processed or are stored under conditions which minimize growth.

In the case of milk, pasteurization is used to **kill pathogenic microorganisms**.

Since some vegetative spoilage organisms and spores may **survive** this heat treatment, it is necessary to keep pasteurized milk refrigerated in order to obtain the desired shelf life. Therefore, in addition to the destruction of pathogens and undesirable bacteria, pasteurization also extends **the useful life** of the product with minimal alteration of flavor and physical characteristics.

Milk or cream used for manufactured products such as butter, cheese, and ice cream, are subjected to heat treatments which relates to desirable characteristics of the end product.

Organoleptically speaking, a high temperature short time process (161^{o} F for 15 seconds) for fluid milk is preferred, rather than a low temperature long time treatment (145^{o} F for 30 minutes), since HTST usually results in **less nutrient destruction and fewer sensory changes**.

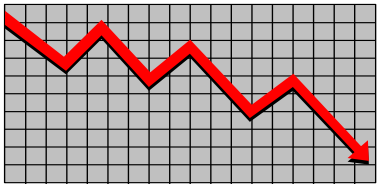
For market milk, pasteurization conditions and requirements are based on thermal destruction of *Coxiella burnetii,* **the rickettsia organism responsible for Q fever**.

THERMAL PROCESS DESIGN and PASTEURIZATION THEORY

Designing a thermal process to accomplish the inactivation of spores or vegetative cells requires two pieces of information:

- ☆ The **rate of destruction** of the microorganism or spores, and the **dependence of the rate on temperature.**
- ✵ The **temperature history** of the product.

In the canning industry the term D-value; **the time in minutes at a given temperature necessary to reduce the population of microbes or spores by 90%**, is widely used.



D values may be calculated by using Stumbo's equation as follows:

$$D_n = \frac{t}{\log a - \log b}$$

Where,

D = Time in seconds at a given temperature for a 90% reduction in bacteria in whole milk,

$_n$ = process temperature

t = equivalent holding time at a process temperature,

log a = the initial bacterial population per m/l

log b = the survivor concentration per m/l

By plotting different D values on semi-log paper a straight line curve may be obtained. The slope of this line in the "Z" value of an organism. This value relates directly to the temperature increase that effects a ten-fold reduction in holding time while maintaining the same lethality of the process. For example the figure below using $D_{120}o^{F}$ = 8 minutes, a reduction of from 10,000/ml to 0.0001/ml (1/10,000 ml) is equivalent to 8 log reduction or 99.999999% reduction of organisms.

Studies on the heat resistance of pathogens were used in arriving at the D Value necessary to assure safe and acceptable levels in the pasteurized product.

Escherichia coli, as an example which is one of the more heat resistant of the coliform organisms was isolated after thermal process of 76.7° C (169.8° F) with an initial concentration of 2 X 10^{6} /ml and the survivor rate was <10^{-3} /ml (1/1,000 ml). From these values a D Value of 0.246 can be established for the *Escherichia coli* organism. In the early 1920's when Ball and others were establishing procedures for calculating thermal processes, the observation was made that the logarithm of the D-value was linearly related to temperature.

The figure relating log D to temperature is call the **thermal death curve**. This is an extremely significant observation in the development of thermal process calculations, because the thermal death time curve or the equation which describes it provides a means for **equating various time/temperature treatments** in terms of thermal destruction of microorganisms or spores.

Knowing this and the temperature history of the product, the thermal process which will inactivate a given load of vegetative organisms and spores can be established.

According to the logarithmic order of bacteria by exposure to lethal heat, it follows that it is not possible to completely inactivate a given population of an organism in a milk sample of infinite size as in encountered with continuous flow milk pasteurization. Therefore to obtain process standards an arbitrary D

value must be established for achieving unit lethality.

PASTEURIZATION

What is it?

The application of a heat process to good quality milk for the purpose of rendering it a safe and nutritious food product which will survive on the shelf for a ten to 20 day period under refrigerated conditions has been the industry standard for over 5 decades. Pathogens are destroyed, industry and the consumer are happy and healthy and the nation's milk supply is safe and wholesome.

Pasteurization has been described as the principal safeguard between a potentially dangerous milk supply and the consumer. Methods must be dependable and equipment constructed of material and of a type that permits easy and effective cleaning. Adequate precautions must be taken to detect and avert faulty operational procedures.

Let's now legally define the process of pasteurization!

PASTEURIZATION - **The process of heating EVERY PARTICLE of milk and milk products to the minimum required TEMPERATURE (for that specific milk or milk product), and holding it continuously for the minimum required TIME in equipment that is PROPERLY DESIGNED and OPERATED.**

Pasteurization has also been described as a heat treatment or thermal process used to kill part but not all of the vegetative microorganisms present in the food.

This is important to remember since the D-value was established on a 90% microbe deactivation. This is why milk spoils under refrigeration. Biology

informs us that certain bacteria are "heat resistant" (thermophiles) while others are cold resistant (psychrophiles) and may withstand the heat process of pasteurization. Certain of these non-mesophilic organisms may be introduced into the product after pasteurization, and some may survive the pasteurization process. No pathogens have been demonstrated to survive pasteurization in properly designed, installed and operated equipment.

Generally, we can say that pasteurization involves a time/temperature exposure sufficient to destroy or slow down the growth of spoilage microorganisms, inhibit enzyme activity, kill any disease producing bacteria, and yet retain the desired properties of the product.

Fast flowing liquids, such as wine, fruit juices, milk, etc lend themselves to efficient handling in standard pasteurizing equipment.

CHAPTER REVIEW

1. ALL PASTEURIZERS MUST MEET THESE THREE REQUIREMENTS:

    1. T:_____
    2. T:_____
    3. P:_____

2. PASTEURIZATION

    DEFINITION:_____
    _____
    _____
    _____
    _____.

    D-VALUE

    DEFINITION:_____
    _____
    _____.

3. Fill in the blanks:

1. Pasteurization temperatures are usually _____°F___ which destroys _____

2. Canning processes are at temperatures above_____and aimed at _____destruction.

3. Sterilization temperatures are above _____ which render all_____a statistical entity. It is specific for _____ and _____.

4. The last revision of pasteurization temperatures was in the 1940's and based on the destruction of the organism_____, which is responsible for the disease_____.

5. Three general types of bacteria thrive at different temperature ranges. They may be classified as:

a) _____.
b) _____.
c) _____.

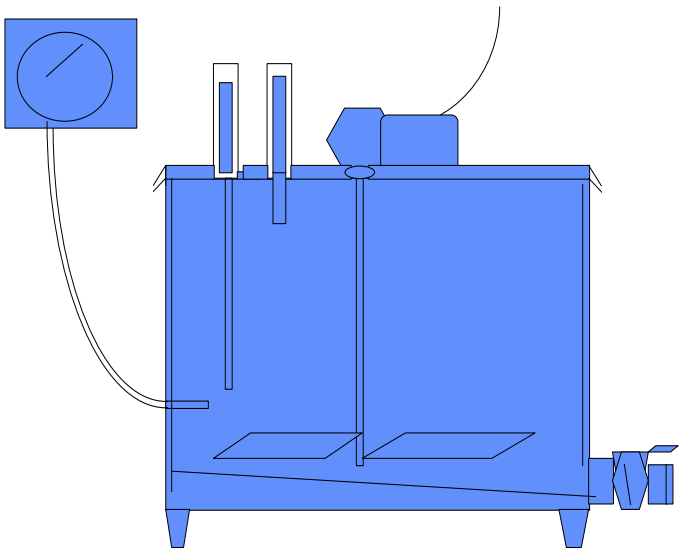
6. Most pathogens are found in the a( ), b( ), or c( ) grouping.

BACKGROUND AND HISTORY

BACKGROUND AND HISTORY

Chapter II

VAT PASTEURIZATION



VAT PASTEURIZATION

PURPOSE: To understand the basic principles, and public health reasons for the requirements of proper design and operation of a batch type or vat pasteurizer.

OBJECTIVES:

☞. To understand and be able to list and explain the compliance and construction requirements of a vat pasteurizer.

✌. To list the correct operational methods of a vat pasteurizer.

☞. To be able to describe and perform all required regulatory tests for a vat pasteurizer.

➔. Know and be able to list the CRITICAL CONTROL POINTS of a vat pasteurizer.

GENERAL DISCUSSION

The heating of milk in a vessel has long been one of the most effective methods of rendering a relatively organism free and hopefully pathogen free milk product.

The product is heated in a **jacketed stainless steel vat** which has been fitted with water and steam to the jacket liner, **thermometers** to monitor and record product temperatures, and some means of **agitation** to assure uniformity in temperature distribution. Other requirements include properly designed **valves**, time/temperature requirements, and **methods of operation** which will be discussed in this chapter.

VAT PASTEURIZATION

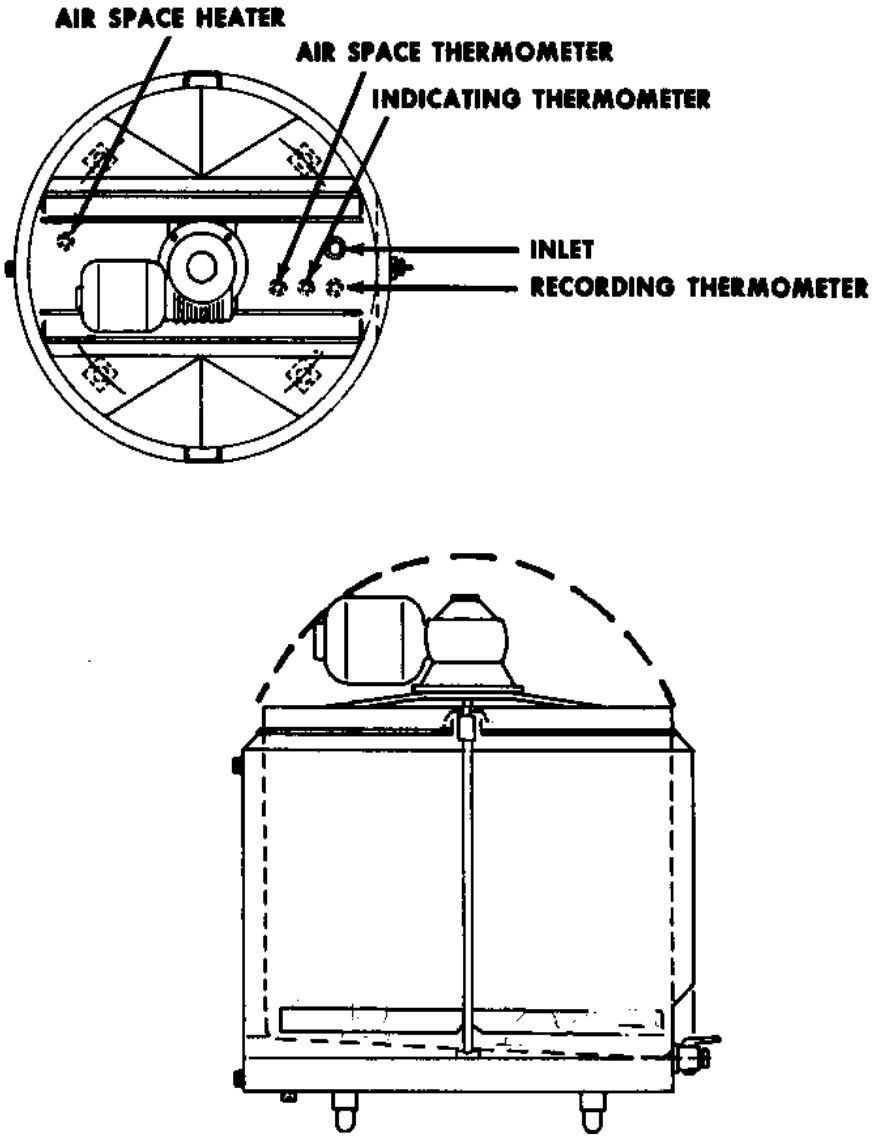
Generally, we can say that all vat or batch type pasteurizers should conform to **"The 3-A Sanitary Standards for Non-Coil Type Batch Pasteurizers for Milk and Milk Products", Number 24-01.** This standard provides guidelines for the installation, approved materials, finish, and fabrication of vat pasteurizers. Also all vat pasteurizers must comply with Item 16p(A) of the PMO, including all operational and construction requirements.

VAT PASTEURIZATION-CRITICAL CONTROL POINTS

- ✓ *TIME AND TEMPERATURE REQUIREMENTS MET*
- ✓ *NO TEMPERATURE ABUSE*
- ✓ *COVERS IN PLACE DURING OPERATION*
- ✓ *VAT CONSTRUCTION WITHIN COMPLIANCE*
- ✓ *AGITATION DURING OPERATION*
- ✓ *NO INGREDIENTS ADDED AFTER PASTEURIZATION*
- ✓ *PRODUCT PROTECTED AFTER PASTEURIZATION*

Figure 1

Schematic of a Vat Pasteurizer



BATCH PASTEURIZER CONSTRUCTION STANDARDS

1. Valves - Outlet valves must comply with the close coupling standards established by the 3-A Standards.

a. The valves must be constructed of **solid stainless steel** to permit adequate heat transfer to the inner portions of the valve and so designed as to prevent the accumulation of unpasteurized milk in the milk passages of the valve when the valve is in a closed position.

b. All outlet valves must be of the **leak protector type**, which are designed to prevent leakage of raw milk past the valve body. The leak detector groove must be at least 3/16 inch in width and 3/32 minimum depth at the center to prevent clogging. (Note - presently there are no air operated valves acceptable for use as vat pasteurizer outlet valves).

A limited number of cone bottom tank protector type valves were fabricated; however their current availability is extremely limited. These valves are designed with spiral shaped grooves designed which expel any leakages past the valve seat to the floor. If cone bottom vats are utilized as vat pasteurizers special consideration should be given to proper product agitation capabilities and other construction requirements of these type vats.

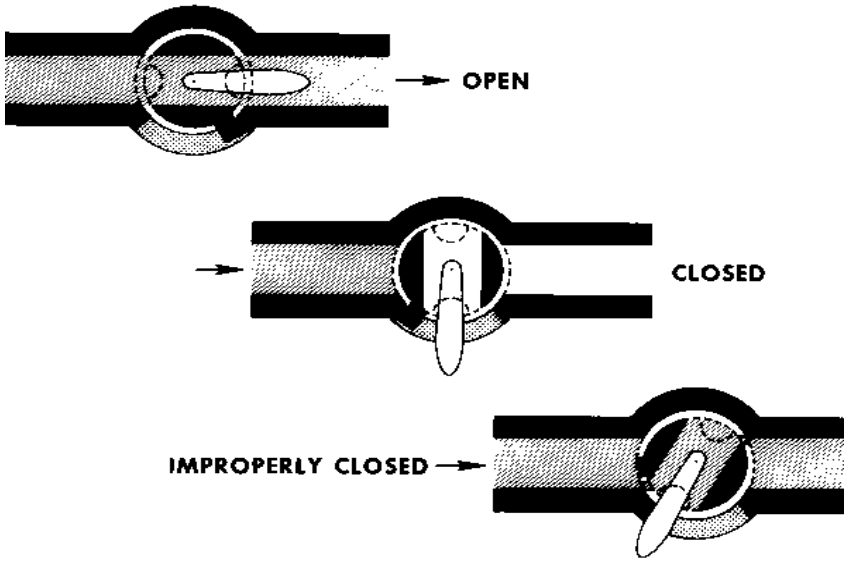
c. All vat pasteurizer outlet valves must be fitted with **stops** which provide the operator with a physical indication of complete valve closure during the **entire filling, heating, and pasteurization holding period operation**.

d. Outlet valves must be of the **close coupled** design; that is, designed so as to prevent the accumulation of unpasteurized milk in the milk passage of the valve when in the closed position.

e. All vats used for pasteurization must be fitted with adequate means of **continuous mechanical agitation**.

f. The requirements outlined in Ma-76 prohibits the practice of leaving the raw milk fill line to remain in place in the vat pasteurizer during the holding time phase since complete separation between raw and pasteurized milk product is required at all times.

g. Outlet valves which are **mounted vertically**, as on cone bottom vats, must have a leak detector groove arrangement which will allow free drainage of any product past the plug while in the closed position. Grooves must be curved or placed at such an angle to accomplish proper draining. Diagrams of these valves may be found in the 3-A Standard 08-17, Part 2, drawings 100-28 and 100-29.



IMPORTANCE OF PROPER STOPS ON PLUG VALVES

Figure 2

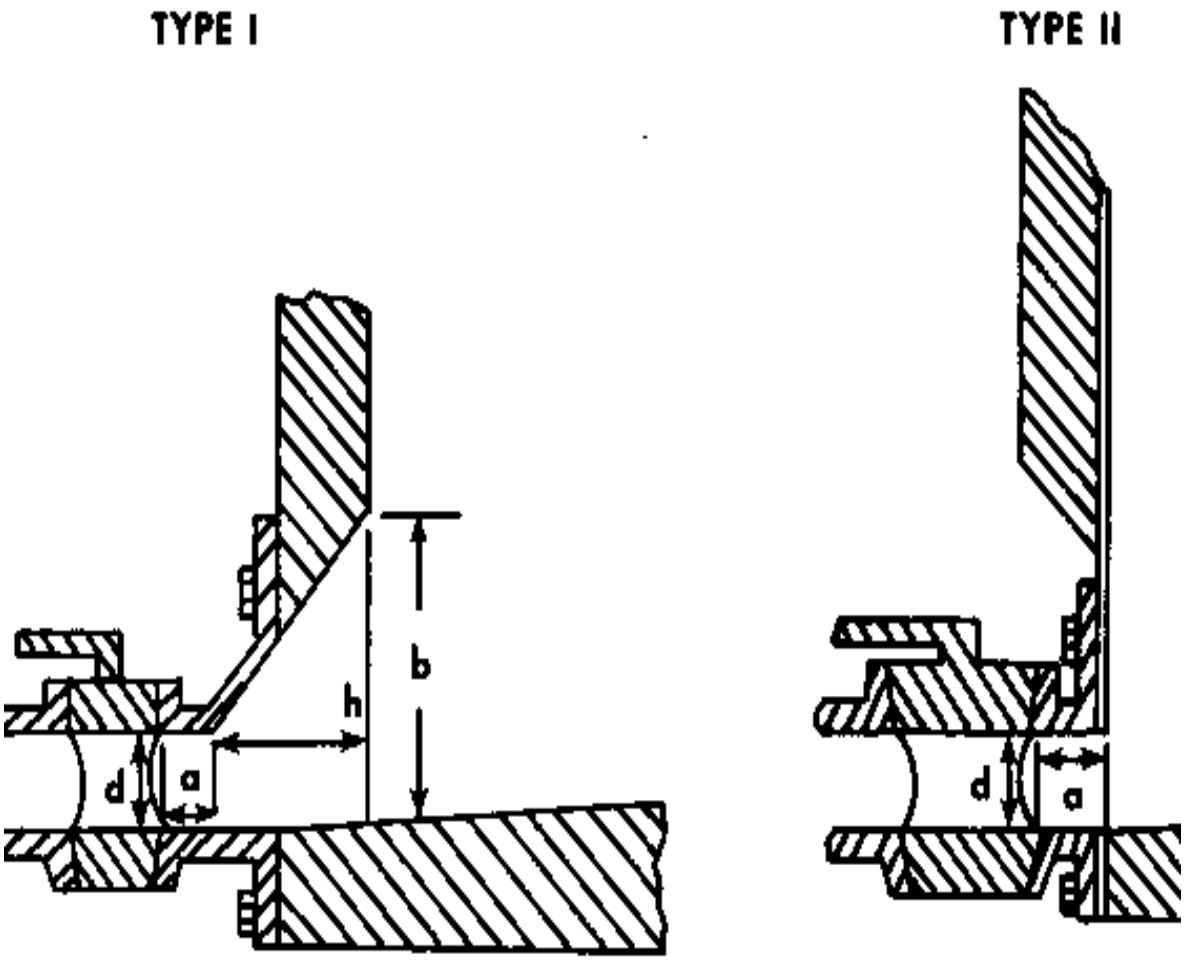


Figure 3
Close Coupled Outlet Valves

2. Covers

a. All openings must be provided with **covers constructed to prevent the entrance of surface contamination or foreign material.** The main cover or lid shall be designed to remain in the open position (to facilitate processing and/or cleaning), and shall be sufficiently rigid and self draining. The main lid shall be designed so that raising will not allow any liquid or other contamination to enter the pasteurizer.

b. Openings in the tank or vat cover must be equipped with **raised edges** to prevent surface drainage into the milk.

c. The vat cover and any opening into the tank interior must have **overlapping** or "shoe box" type edges. The covers must be relatively close fitting and overlap the opening.

d. All pipe, thermometer, agitator shafts, or other appurtenances that extend down into the vat **must do so only through condensation diverting aprons** unless a water tight joint is used.

3. Agitators

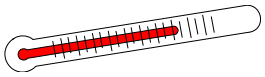
a. All vats used for pasteurization **must be equipped with a mechanical means** of assuring that each and every particle of milk is heated. This is accomplished by **mechanical/electrical motor driven agitators**. The most efficient agitators will be designed to push the product down and sweep the product across the heat exchange surface on the sides and bottom of the vat. Agitators shall be designed to result in uniform product and temperature throughout the vat. Product temperatures variances **must not exceed 1^{o}F** between any two points within the vat at any time during the holding period.

b. Agitators must meet construction criteria for **milk contact surfaces** and be designed to be easily cleanable and/or removable for manual cleaning.

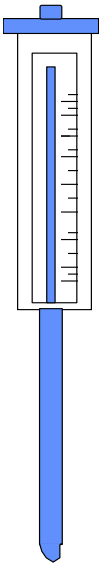
c. Agitator shafts must be fitted with **effective drip deflection shields** to prevent contamination of the milk.

d. Agitator shaft openings shall have a minimum diameter of one inch to allow for **removal and cleaning of the agitator shaft**.

e. The annular space around the agitator shaft shall be fitted with an umbrella or drip shield of sanitary design to protect against the entrance of contaminants.



4. Indicating and Recording Thermometers



a. Indicating thermometers shall be of the **mercury actuated**, direct-reading type, scaled to a minimum of 0.625 of an inch, with a span of not less than 25 degrees F which includes the pasteurization temperature (plus or minus 5^{o} F) and graduated in 1^{o} F, and accurate to within 0.5^{o} F. Provided that electronic RTD direct reading type thermometers that meet the requirements and are acceptable to FDA may be used as indicating thermometers on batch type pasteurizers.

b. The sensing bulb of the indicating thermometer (official thermometer) must be designed to **extend fully into the product during pasteurization**.

c. Each vat pasteurizer must be provided with an approved **air space** thermometer. The air space thermometer must meet the same general requirements of the indicating thermometer with exception of the bulb length, degree increments, and accuracy requirements.

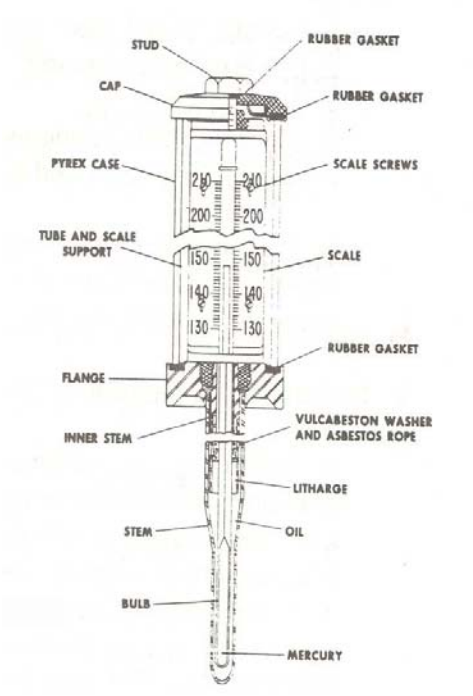
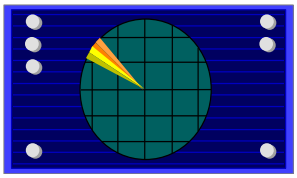


Figure 4 – Indicating Thermometer



The bottom of the bulb chamber for air space thermometers must not be **less** than 2 inches nor **more** than 3.5 inches below the underside of the top enclosure, bridge, or cover. The bottom of the bulb must never be less than 1 inch from the top surface of the product during pasteurization. The air space thermometer may be graduated in 2 degree maximum increments and must be accurate to plus or minus 1 degree F.

d. Each vat must also be equipped with a **recording thermometer**. This thermometer must be graduated in 1^{o} F increments between 140^{o} F and 155^{o} F.

The chart must be graduated in time scale divisions of not more than **10 minutes** for a maximum record of 12 hours and must be specifically designed (and so identified) for the type of recorder being used.

e. On those vats used **solely** for pasteurizing at temperatures greater than 160^{o} F, the recording chart may be graduated in 1^{o} C **(2^{o} F)**. The 1^{o} C **(2^{o} F)** increments shall be in the **150^{o} to 170^{o} F** range. On these type vats, the chart may be graduated in **15 minutes** for a maximum of 24 hours.
The recorder device may be either electric or spring driven.

Required recorder chart information (for each product batch):

1) Name of milk plant.

2) Date.

3) Signature or initials of the operator.

4) Identification of the recorder when more than one vat is

5) Record of holding time including empty and fill times as

6) Reading of air space thermometer at the beginning of the

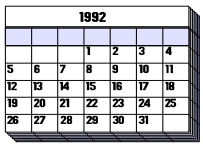
7) Reading of indicating thermometer at an indicated point

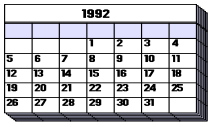
8) Amount and name of product represented by each batch.

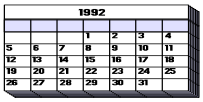
9) Record of any unusual occurrences.

Charts shall be retained for 3 months.

VAT PASTEURIZATION







5. Air space heaters may be necessary to maintain minimum air space temperatures. These devices must be of sanitary design, meet all 3-A Sanitary requirements, including installation and culinary steam requirements. The air space heater must be easily demountable for cleaning (See Appendix H of the PMO, for culinary steam requirements or Figure 5 below.)

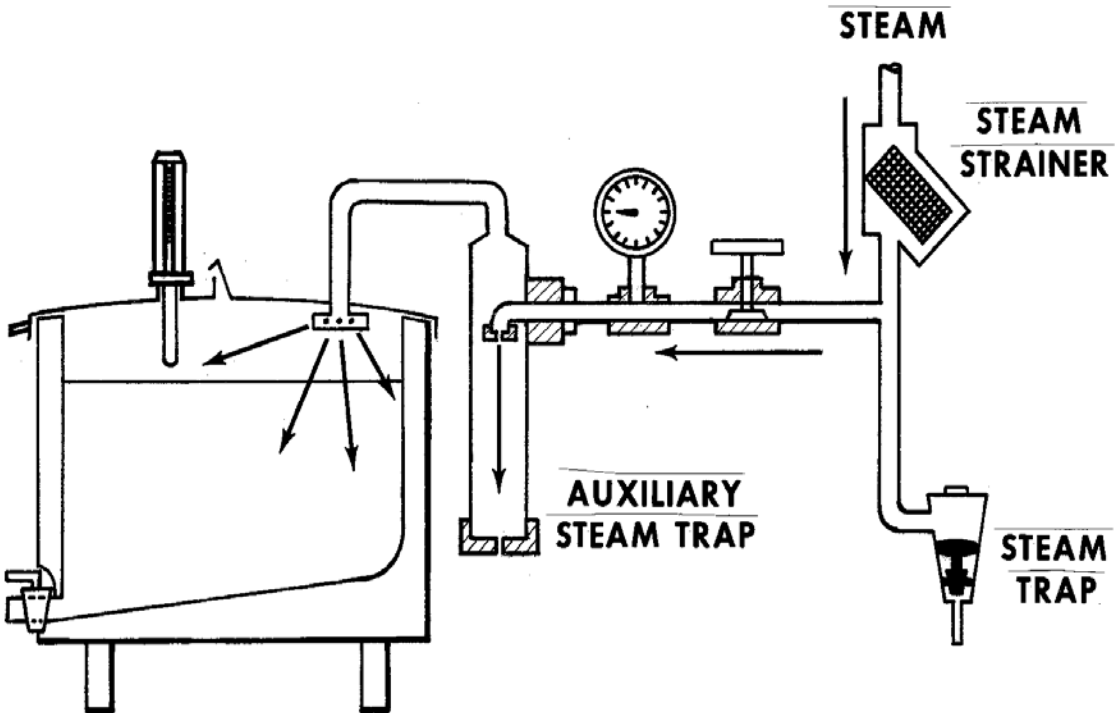


Figure 5
Air Space Heating

BATCH PASTEURIZER OPERATING STANDARDS

1. All product components must be added to the batch **prior to beginning the pasteurization process**. This includes any liquid sugar and sweeteners, water, milk powders and all other dairy products, flavorings, stabilizers, cocoa products, emulsifiers, and vitamins.

There are certain flavoring ingredients that may be added **after** pasteurization. These include flavoring ingredients having an a_w of 0.85 or less, high acid content, dry sugars, fruits and roasted nuts, safe and suitable bacterial culture organisms, and flavorings containing a high alcohol content. Fruits and vegetables may be added to cultured products having a pH of 4.7 or less.

Such ingredients addition shall be done in a sanitary manner and the ingredients must be of a safe and wholesome quality.

2. Pasteurization must be performed in equipment which is properly designed and operated, and which insures that every particle of product will be held **continuously** for the minimum time and temperature. Vats should be designed so that product can be heated to pasteurization temperatures **in as short a time as practicable**. **In no case should this time exceed 4 hours**. Following pasteurization the product must be cooled to $<45^{o}$ F as soon as possible. The only exception for this cooling requirement is for cultured products processing.

3. If for any reason the vat lid or any cover is lifted or mechanical failure of any kind (agitator malfunction, loss of temperature below the required minimum, etc) occurs after beginning of the pasteurization cycle, **the timing process must be restarted and notes to that effect must be made on the recording chart** by the operator.

4. **The official thermometer is the indicating thermometer** and the recording thermometer functions to only provide a record of the pasteurization cycle. For each product batch the operator is required to verify the accuracy of the recording thermometer using the indicating thermometer as the standard. This comparison is noted on the recording thermometer chart. **No batch of milk shall be pasteurized unless the sensors of both thermometers are covered**.

5. The air space thermometer reading must also be recorded on the recording chart during pasteurization. To assure that the minimum air space temperatures are being maintained, the air space indicating thermometer shall be read and recorded at the **beginning** of the holding period. It is also strongly recommended that the air space temperatures be noted and recorded **during and at the end of the holding period**. During pasteurization, the air space temperature must never be less than **5°F** above the minimum legal pasteurization temperature required for the milk product contained in the vat.

6. Recording charts must be used only for the length of time for which it has been designed. **Overlapping of information on circular charts is never acceptable and is a violation of the PMO. Required information on the recording chart must be legible and meet all the requirements as spelled out in the PMO**.

7. The outlet valve is designed to **detect and expel any leakage past the valve seat and is close coupled to prevent cold pockets of milk from accumulating in the valve or piping**.

8. **At no time during the pasteurization cycle or following pasteurization may the outlet piping be directly attached to any line or vessel containing raw milk or any other contaminating substance.**

ASSURANCE OF HOLDING PERIODS

1. Vats must be operated so that every particle of milk is held for **at least 30 minutes** at or above the minimum required temperature for the specific product processed.

2. When the milk product is heated to pasteurization temperature **in the vat and is partially cooled in the vat** before opening the outlet valve, the recorder chart must show at least 30 minutes at or above the minimum pasteurization temperature.

3. When the milk product is **preheated** to pasteurization temperature prior to entering the vat, the recorder chart **must** show a holding time of 30 minutes **plus the filling time of the vat from the level of the recorder bulb sensor to the maximum level of normal operation (pasteurization).**

4. When **cooling is begun after the outlet valve is opened** or is done entirely outside the vat, **the chart must show a holding time of 30 minutes plus the time necessary to empty the vat to the level of the recording thermometer bulb**.

5. These filling and/or emptying times **must be indicated on the chart by the operator** by inscribing the start and end of the official 30 minute holding time.

6. Upon close inspection, vat pasteurization recording charts used that have been used must show clearly the four identifying holes (marks) which verify the chart has not been rotated or manually turned to give a false time line accuracy.

VAT PASTEURIZATION

CHAPTER REVIEW

1. The requirements for vat pasteurization may be found in Section ___, Item _____ on pages _____ of the current edition of the _____.

2. Another good reference for vat pasteurizers may be found in:_____.

3. Currently vat pasteurizers found in many modern processing plants are used for products such as_____ _____.

4. Batch Pasteurization Time Temperature Standards:

Product	**Temperature**	**Time**
Whole Milk	_____	_____
Skim Milk	_____	_____
Half and Half	_____	_____
Eggnog	_____	_____
Frozen Dessert Mix	_____	_____

5. The PMO requires that if the fat content of the milk product is_____percent or more, or if it contains added sweeteners or solids, the specified minimum temperature shall be increased by _____degrees F.

6. The FDA Dairy, Inc, vat pasteurizes their cheese milk at 173^{o} F. The operator Mr. I.M. Messed Up must always check to make sure that the air space temperature reads at least _____^{o} F during the entire holding time.

7. What is the purpose of VALVE close coupling?

8. You are the night manager of a large milk processing plant. The vat pasteurizer

operator notifies of the following:

CONDITION	**YOUR SOLUTION**
a) He forgot to add dry sugar to the mix prior to pasteurization, however did add the sugar at only five minutes into the beginning of the 30 minute time and then added 25 minutes to the time after adding the sugar. The mix was packaged last night and is ready for shipment.	
b) The air space thermometer was damaged and the mercury slightly separated, however since the milk was pasteurized at 170 degrees he had decided to package the product and was delivered this morning to the store.	
c) The boiler lost steam pressure during pasteurization , but since the temperature never got below 145, the cream was packaged and in the plant cooler anyway.	
d) Pasteurized skim was put in a processing vat, super heated, culture was added, and then pumped to the vats for cottage cheese processing.	
e) The operator discovered that they had used the last vat recorder chart the previous day. HTST charts were used on the vat recorder, since the charts included the normal pasteurization temperature range used by the plant of 160 degrees F.	

9. Are any regulatory seals required on a vat pasteurizer? Y____N____. Explain.

10. Provide the following vat pasteurizer thermometer criteria:

	SPAN	*^{o} F grads*	*ACCURACY*	*Chart speed*	
Indicating	_____^{o} *F*	_____^{o} *F*	_____^{o} *F*	*NA*	
Recording	_____^{o} *F*	_____^{o} *F*	_____^{o} *F*	*1 rev/____hrs**	
Air Space	_____^{o} *F*	_____^{o} *F*	_____^{o} *F*		

For Pasteurizers using temperatures greater than 160^{o} F-see PMO, pages 217-220.

Indicating	_____^{o} *F*	_____^{o} *F*	_____^{o} *F*	*NA*
Recording	_____^{o} *F*	_____^{o} *F*	_____^{o} *F*	*1 rev/____hrs**
Air Space	_____^{o} *F*	_____^{o} *F*	_____^{o} *F*	*NA*

**Except that strip charts may show a continuous recording over a ___hour period.*

VAT PASTEURIZATION

10. List the four significant requirements for a vat pasteurizer outlet valve.

a)
b)
c)
d)

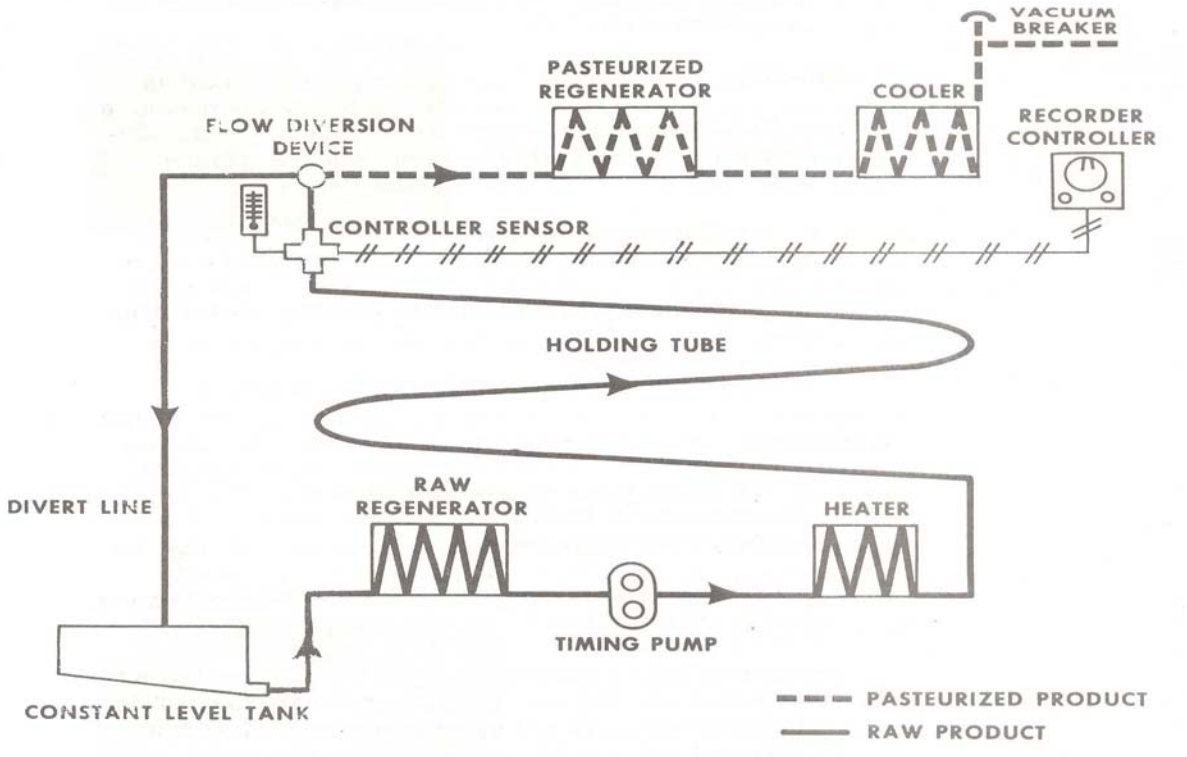
11. Explain the reasoning for the requirement that when pre-heated product is brought into a vat for pasteurizing, the filling time must be adjusted. How is this added time measured?

Notes:

VAT PASTEURIZATION

Chapter III

BASIC HTST PASTEURIZATION



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Note: The use of trade names or equipment photographs is for training and educational purposes only and does not constitute endorsement by the U.S. Department of Heath and Human Services, Public Health Service, Food and Drug Administration.

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HTST PASTEURIZATION
BASIC DESIGN, FUNCTION, AND OPERATION

PURPOSE: To understand the principles and public health reasons for the HTST process. This section reviews the basic design, function and operation of the HTST system as relative to product flows and how it influences the time-temperature-pressure relationships within the system.

OBJECTIVES: Following the completion of this instructional unit, the participant should be able to:

❄ Follow the basic flow sequence in an HTST system and give the critical control point connected with each major component.

_ List and understand the function and installation of the basic components of an HTST system and how they interrelate to the time-temperature-pressure requirements.

❁ Give the public health reasoning for each of the requirements relative to the time-temperature-pressure concerns.

HTST - CRITICAL CONTROL POINTS

- **INDICATING THERMOMETER**
  ACCURACY
  SCALE

- **RECORDER CONTROLLER**
  ACCURACY
  DIVERSION SET POINT SEAL
  SENSOR LOCATION
  FUNCTION/OPERATION
  CHART IN COMPLIANCE

- **TIMING/METERING PUMP**
  LOCATION
  SEAL IN PLACE

- **HOLDING TUBE**
  PROPER SLOPE
  UNCHANGEABLE

- **FLOW DIVERSION DEVICE**
  ASSEMBLY
  FUNCTION
  TIME DELAYS
  DIVERT/LEAK-DETECT LINE SLOPE
  BREAK AT BALANCE TANK

- **VACUUM BREAKER**
  PROPER LOCATION

HTST PASTEURIZATION

I. INTRODUCTION

a. Definition

High temperature short time or HTST pasteurization is the process of heating every particle of milk product in properly designed and operated equipment to the minimum temperature requirement and held continuously at or above that temperature for at least the minimum time required.

For example: Whole milk must be held at 161° F for 15 seconds, while milk with higher milk fat content and/or added sweeteners shall be heated to at ≥166° F and held for at least 15 seconds.

b. HTST BASIC DESIGN AND FLOW PRINCIPLES (Figure 9)

1. COLD RAW MILK enters the constant level tank (approximately 40 degrees) and is drawn under reduced pressure into the regenerator section of the press.

2. **In the regenerator section**, the cold raw milk is **pre-warmed** by the heat given up by the hot pasteurized milk flowing in a counter current direction on the opposite side of the milk to milk regenerator plates.

3. The raw milk, still under suction, is drawn through a **positive displacement** timing pump which delivers it under positive pressure through the remainder of the HTST system.

4. Under positive pressure the raw milk is pumped through the **heater section** where steam heated hot water on opposite sides of the stainless steel plates continues to heat the milk to a temperature exceeding the minimum pasteurization temperature.

5. The hot milk, now at or above legal pasteurization temperature, and under pressure, flows through the **holding tube**

where the transit time ("hold") is at least 15 seconds. The velocity or rate of flow of the milk through the holding tube is totally governed by the speed of the timing (metering) pump. We could say then that the residence time of the milk in the holding tube is determined by the **pumping rate of the timing pump**, the **length of holding tube**, and **the surface friction** of the milk product.

6. The milk then contacts the sensing bulbs of the **indicating thermometer** and the **recorder controller**. If the milk temperature is not at or above the minimum required set point, then the sub-legal milk is **returned back to the constant level tank** via the diversion port and line of the flow diversion device.

7. If the milk contacts the STLR **at or above** the minimum set point (161^{o}F), the recorder controller signals the flow diversion device to assume the **forward flow** position and the milk flows through the **forward flow port** of the flow diversion device. The milk from **this point** continues its flow through the system as **legally pasteurized product**.

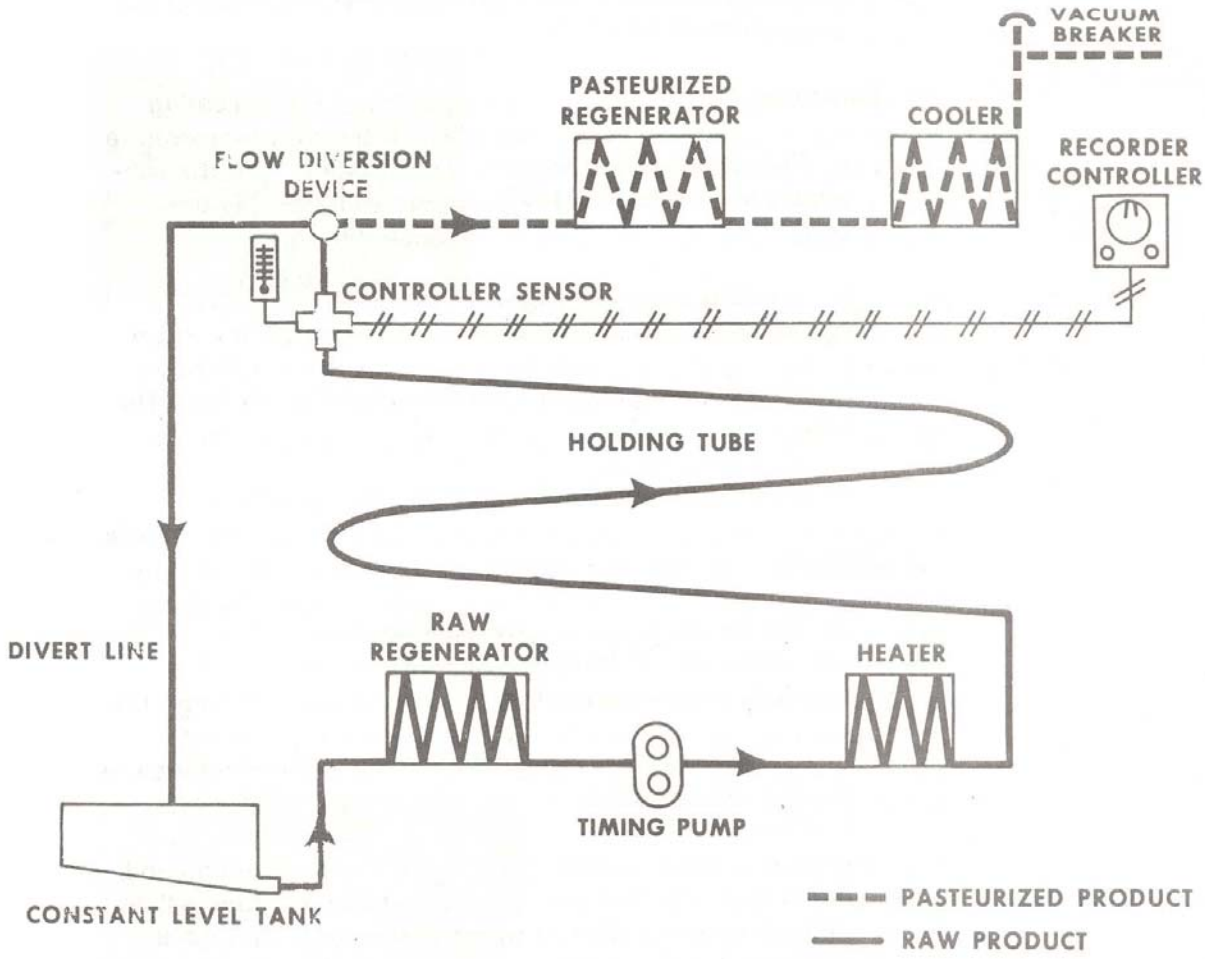
8. The hot pasteurized milk then passes through the **milk to milk regenerator (on the pasteurized side of the plates)** and gives up heat to the cold raw product on the opposite side of the plate. In turn, the pasteurized milk is partially cooled.

9. The partially cooled pasteurized milk then passes through the **cooling section**, whereby re-circulated coolant water (sweet water or propylene glycol) is used to reduce the milk temperature to below 45^{o}F.

10. The cold pasteurized milk then exits the cooler section and **rises to an elevation of at least 12 inches above any raw milk in the HTST system and is opened to the atmosphere through a sanitary vacuum breaker at that point (or higher).**

11. From this point, the pasteurized milk may travel directly to a storage or surge tank for subsequent packaging or may be returned back to the constant level tank.

Basic HTST Pasteurization



II. COMPONENTS OF THE BASIC HTST SYSTEM

A. CONSTANT LEVEL SUPPLY TANK (Balance Tank)

1. Sanitary Design

The balance tank must be of a sanitary design, meet all criteria of the PMO, 3-A Standards, and the design dimensions of MI-87-3.

2. Functions

a. Provides a continuous supply of milk to the HTST unit.

b. Provides return storage for sub-legal milk from the flow diversion valve.

c. Provides a means for the recirculation of pasteurized milk.

d. Provides a reservoir for CIP/ cleaning purposes.

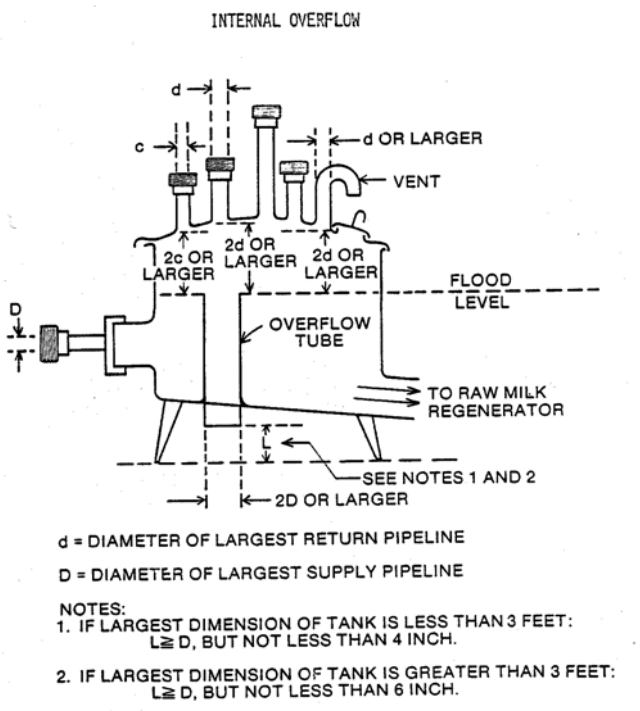
3. Controls

a. The overflow level of the balance tank must be installed (recommended at least one inch) below the lowest level of raw milk in the regenerator.

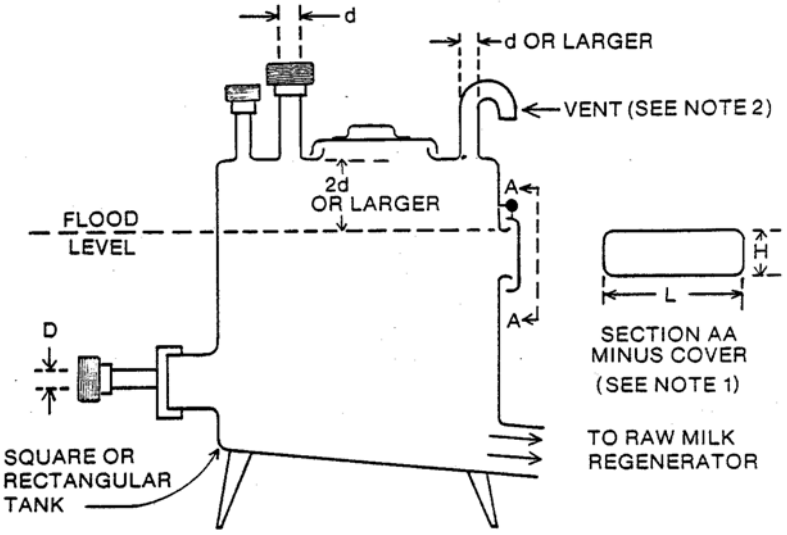
b. Raw milk generally must enter the regenerator section at the bottom of the press. If the system is equipped with a start-up regenerator by-pass line with a non-restricting intervening valve, then the raw milk line may enter at the top of the "press".

Figures 8

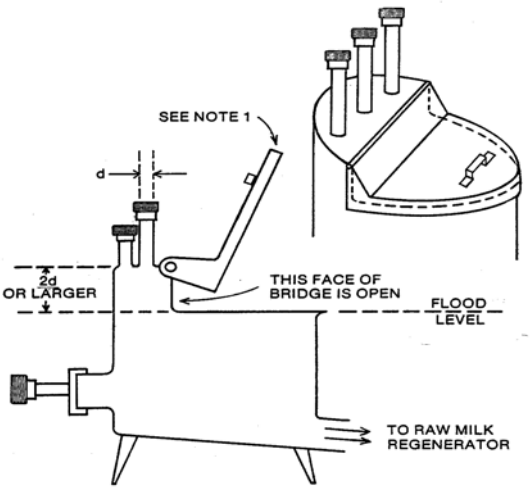
Acceptable Balance Tank Designs



SIDE OVERFLOW (DOOR)



ELEVATED SIDE BRIDGE



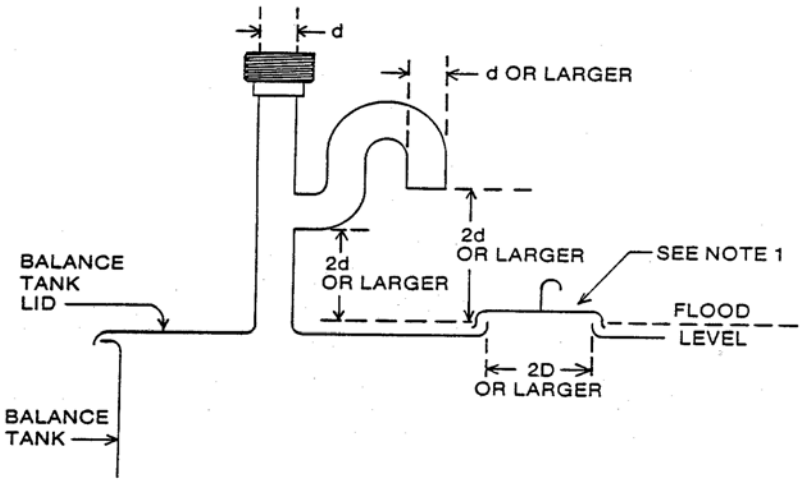
d = DIAMETER OF LARGEST RETURN PIPELINE

NOTE:
1. COVER MUST BE LIGHT ENOUGH TO BE LIFTED BY OVERFLOW AT FLOOD LEVEL.

d = DIAMETER OF LARGEST RETURN PIPELINE

D = DIAMETER OF LARGEST SUPPLY PIPELINE

NOTES:
1. IF $L \geqq 4H$, AND $LXH \geqq \pi D^2$, THE BOTTOM OF THE OPENING MAY BE TAKEN AS THE FLOOD LEVEL.
2. IF THE CONDITIONS OF NOTE 1 ARE MET, AND $H \geqq 2D$, THE VENT ON THE TOP OF THE TANK MAY BE ELIMINATED.



d = DIAMETER OF RETURN PIPELINE

D = DIAMETER OF LARGEST SUPPLY PIPELINE

NOTE:
1. COVER MUST BE LIGHT ENOUGH TO BE LIFTED BY OVERFLOW AT FLOOD LEVEL.

B. THERMAL EXCHANGE SYSTEMS

1. Plate Heat Exchangers

    a. Sanitary design and construction

    b. General sections are:

        1). heating
        2). cooling
        3). regeneration

    c. Flow patterns

    d. Proper maintenance and inspection

    e. Controls

Figure 9 Plate Heat Exchanger Frame Press

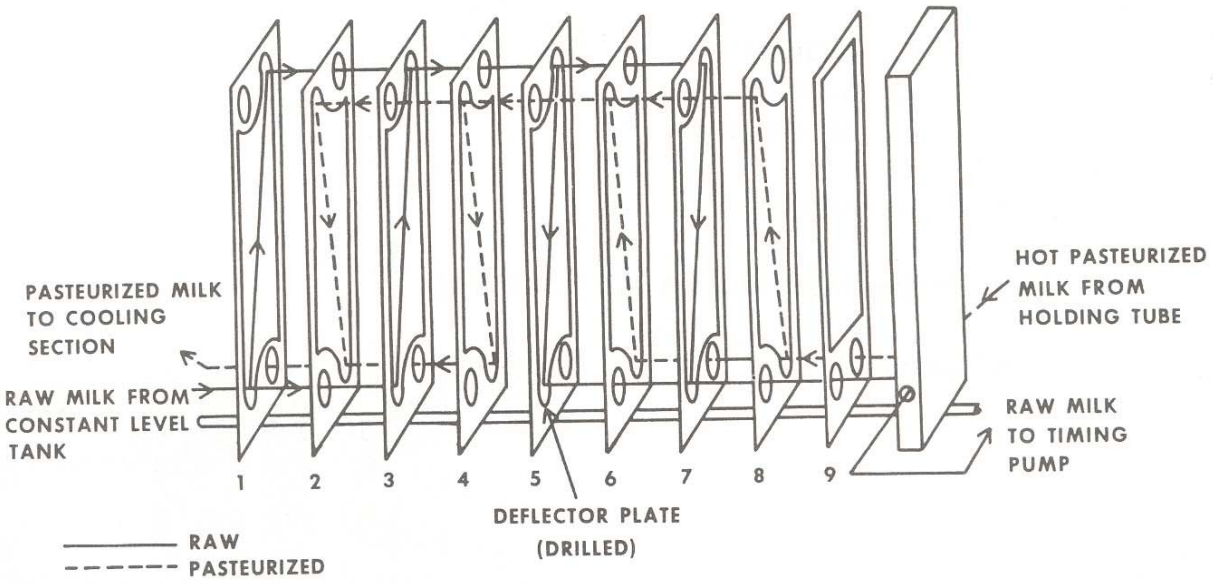


Figure 10, Plate Heat Exchanger - Flow Patterns

2. Tubular Heat Exchangers

a. Sanitary design and construction. The interior of these "pipe-in-a pipe" regenerators must be smooth and cleanable and have access points for inspection.

b. Flow patterns. Raw and pasteurized milk flow in opposite directions which enhances heat exchange.

c. Controls. Milk-milk tubular heat exchangers must meet all requirements of plate heat exchangers, i.e., pressure controls (if applicable) and in all cases vacuum breaker installation (in HTST systems).

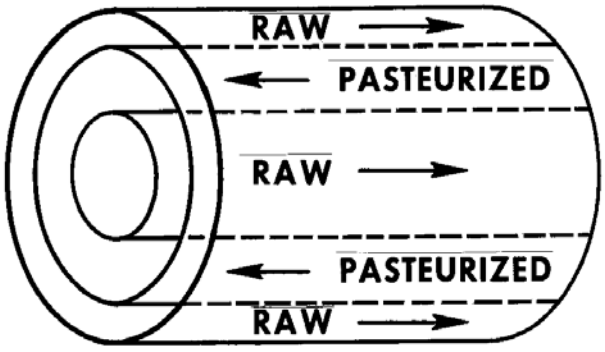


Figure 11
Tubular Heat Exchangers-Flows

C. TIMING (METERING) PUMP

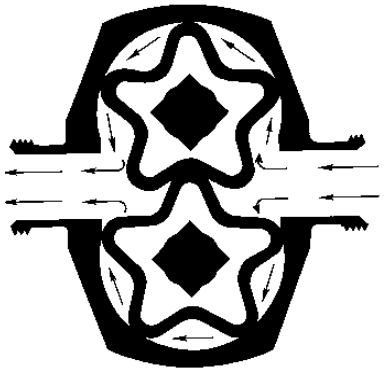
1. Location

In basic HTST systems, the conventional timing pump will be the only flow promoting device in the system. Timing pumps, when used in systems with milk-to-milk regenerators, must always be placed downstream from the raw regenerator. This is to assure that during operation **raw milk pressures** in the milk to milk regenerator are relatively less than **pressures on the pasteurized** side of the plates. Timing pumps may be speed adjustable but are always set and sealed at the **fastest minimum legal pasteurization time(s).** Some timing pumps are electronically controlled and this controller must also be under regulatory seal. Timing pumps may operate at any time except when the dual stem flow diversion device mode switch is in the "**Inspect**" position or during **diverted flow,** the flow diversion device is improperly assembled and the **micro switch is not in the proper position**.

2. Types

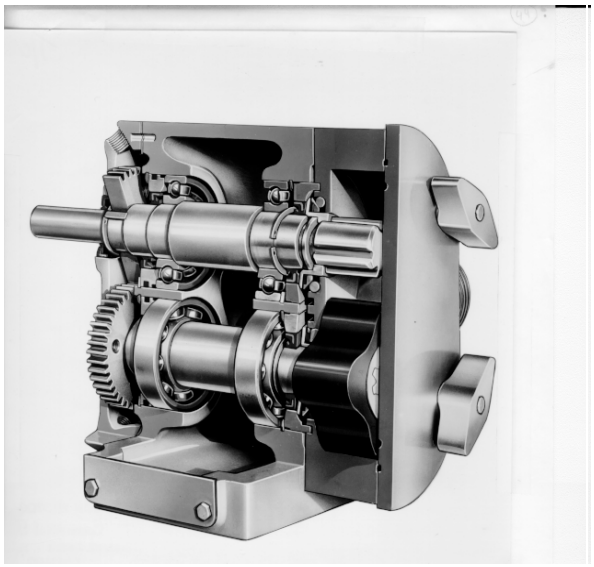
a. Positive displacement type - Positive pumps may be of several types, two of which are in common usage in the continuous flow pasteurizer.

One is the gear driven type pump where two rotors or impellers revolve within an oval case. Close tolerances between the gears and the outer case make the space or pockets between the teeth or lobes carry the fluid around the periphery of the pump body. The size of these pockets and the speed at which they revolve determine the volume that will be pumped. It is important to remember that the efficiency of these impeller type pumps may be greatly influenced by the **temperature and type** of liquid they are pumping. This becomes important when performing the holding time water: milk tests and calculations for systems with these type (PD) pumps.



During operation, the gears are lubricated by the fat in the product.
The impellers must be disassembled at the end of each operating period and manually cleaned and should be lubricated with a sanitary lubricant when reassembling.

Figure 12
Positive Displacement Rotary Pump Function



b. Another type pump frequently used is the belt/pulley driven **piston type pump such as the homogenizer**. Homogenizers are very efficient positive displacement pumps and are frequently used as the timing pump in continuous pasteurizers.

c. The other type of acceptable timing pump is magnetic flow meter based system which uses a centrifugal pump in conjunction with product flow controlling methods. These systems will be discussed in Chapter V Meter Based Systems.

3. Controls

a. The timing pump must be sealed by the regulatory authority at the **maximum speed** to assure that the minimum holding time requirements are satisfied.

b. It must also be inter-wired with the flow diversion device and recorder/controller. This is to prevent the sub-legal flow of milk into the pasteurized side of the system.

c. Generally there is only **one primary timing device in system**. When both a positive displacement pump and homogenizer are used as timing pumps, both must be timed separately and together to assure minimum holding times are achieved.

D. HOLDING TUBE

1. It must be of **sanitary design.**

2. It must be installed on permanent supports to assure alignment and proper slope and pipe size changes shall be properly designed and installed...

3. The entire length of the holding tube must be properly slope to preclude air entrapment and assure uniform product flow. The minimum upward slope is 0.25 inch per running foot, or 2.1 centimeters per meter.

4. It must be fabricated to eliminate short circuiting. (no alterable sections)

5. The holding tube starts at the salt injection port or fitting and ends at the flow diversion device.

Figure 13
Holding Tube Installation

6. Holding tubes must be designed to assure temperature variation not to exceed 1^{o} F.

7. Heat shall not be applied to the holding tube at any point and the holding tube shall not be fitted with insulation materials. The purpose of this is to allow for inspection of the tube for proper slope and to detect any unauthorized changes in length.

The "Official" Thermometer

E. INDICATING THERMOMETER –

1. Purpose

To indicate the accurate temperature of the product.

2. Location

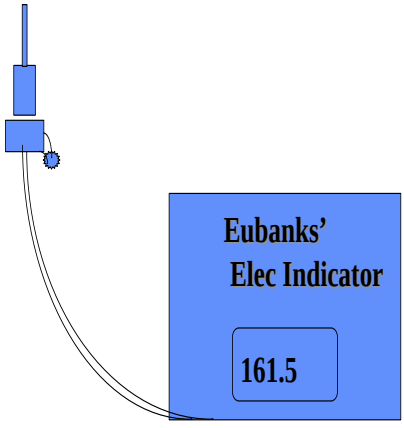
At the end of the holding tube and as close as practical to the recording thermometer sensor.

3. Specifications

a. Type -**mercury actuated,** direct reading, corrosion resistant case.

b. Scale - Span not less than 25° F including pasteurization temperature plus or minus 5° F, graduated in 0.5° F divisions.

c. Accuracy - 0.5 degrees F, plus or minus throughout scale.



d. Thermometric response - 4 seconds to travel 63% (12 degrees which includes the pasteurization range) of a 19 degree span.

e. Type - **electronic**

On November 27, 1991 the FDA's Milk Safety Branch through M-b-314 allowed the use of the digital reference thermometer (DRT) as a replacement for the mercury actuated (MIG) indicating thermometer for use in pasteurization systems.

Basic HTST Pasteurization

The Anderson and Taylor Companies offer the digital reference type thermometer, analogue type which uses a dual wound sensor on the 1000 ohm RTD (sensor device).
Differences in resistance resulting from temperature changes are converted directly to a temperature value which is displayed on the panel.

Fail safe operation of the DRTs is accomplished by using two separate resistance temperature devices (RTD's). If the two RTD's read more than 0.5 degrees F difference, the display blanks out making it impossible for the operator to observe the temperature.

Testing of the DRT is identical to conventional tests as described in Test 1 and 7 of Appendix I of the PMO, and some additional guidelines may be helpful in the DRT instruction manual for performing these tests.

Because of the self-diagnostic circuitry, the thermometric response test is required as with mercury actuated type thermometers.

M-I-93-1, issued April 18, 1993 provides specific criteria for evaluation of the new digital thermometers.

These criteria are:

1. No more than 0.5^{o} F (0.25^{o} C) drift over 3 months use on an HTST system compared to a certified thermometer.

2. Readout is displayed in units of temperature with at least count of 0.1^{o} F.

3. Display changes at a rate that can be noted by the operator or public health authority during the thermometric lag test (Test 7, Grade A PMO).

4. Self-diagnostic circuitry which provides constant monitoring of all, input and conditioning circuits. The diagnostic circuitry should be capable of detecting "open" circuits, "short" circuits, poor connections and faulty components. Upon detection of failure of any component, the device shall blank or become unreadable.

5. The effect of electrical noise shall be documented and available to public health authorities. Protocols for these tests shall be developed by vendors with FDA concurrence.

6. The effect of high temperature and/or humidity shall be documented. The device should show no effect after exposure to 100^{o} F and 80% relative humidity for 7 days.

7. Both probe and display case shall be constructed so that they may be sealed by a health authority.

8. Calibration of the device shall be protected against unauthorized changes.

9. The device shall be protected against unauthorized component or sensing element replacement. Replacement of any component or sensing element shall be regarded as a replacement of the indicating thermometer and subject to health authority inspection and all applicable PMO tests.

10. The sensing element shall be encased in appropriate material constructed so that final assemble meets PMO Item 11p, Construction.

F. RECORDER CONTROLLER (STLR)

1. Purposes

To **automatically** record pasteurization temperatures and times, a record of the position of the glow diversion device and to **automatically** control the position of the flow diversion device.

2. Location

The temperature sensor **of the recorder controller shall be located within 18 inches of, and up stream from the flow diversion device.**

3. Design and Operation

The recorder controller or STLR is an electronic instrument actuated by either a Bourdon coil attached to an ether derivative (water and glycerin) filled **capillary** which responds to temperature change or may be one of the newer type **electronic programmable** recorder controllers which utilize electronic remote temperature sensing devices and/or computer logic.

The illustration of the following page shows the mechanical works of the older type Taylor 352R STLR. Behind the cut-a -way is found the Bourdon Coils, the linkages of the temperature recording and event pens arms, the capsular chamber and diversion setting and controlling mechanism, and the micro switches. The cabinet half on the right is the hot water controller or "set" and contains no controls of public health significance, hopefully.

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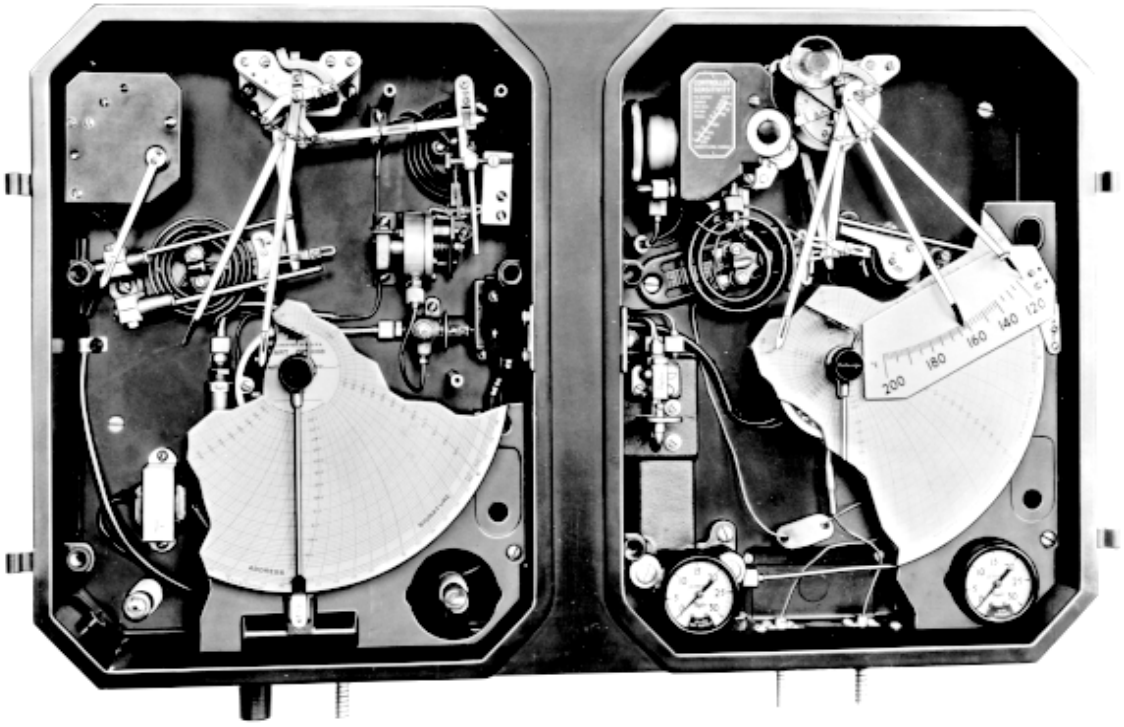
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180
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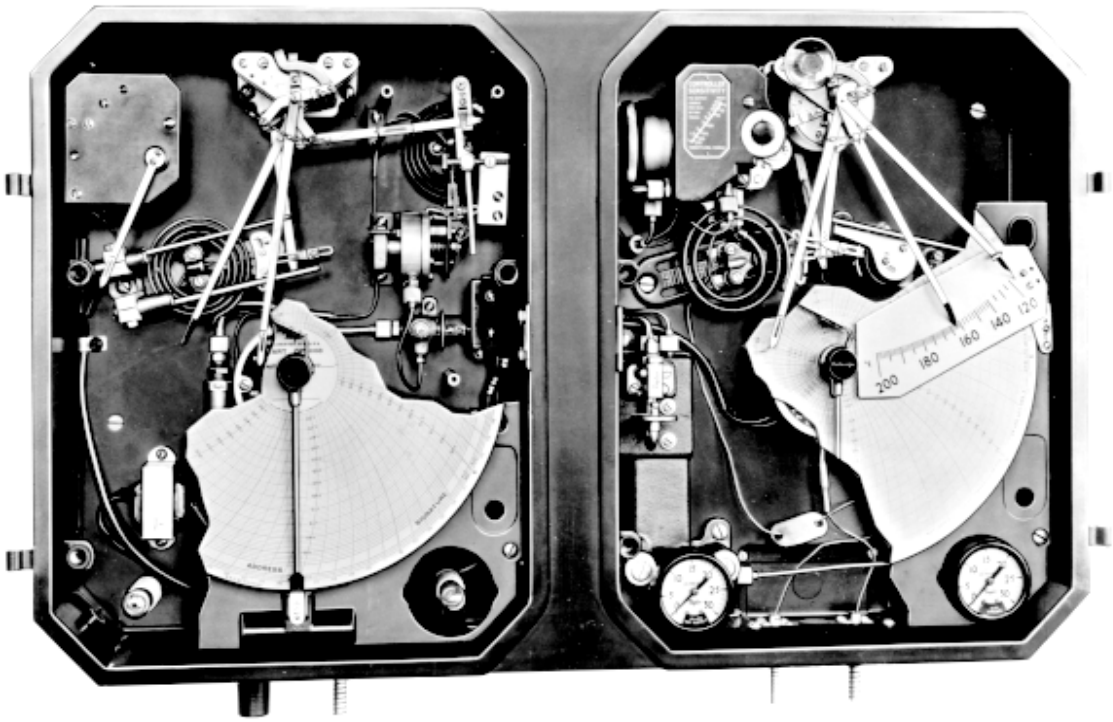
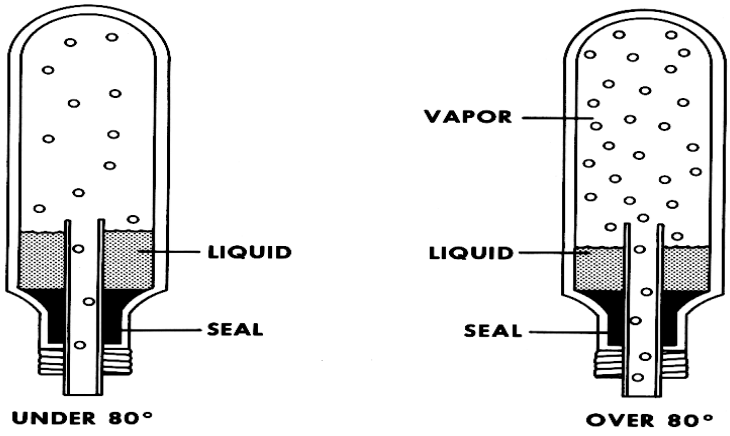
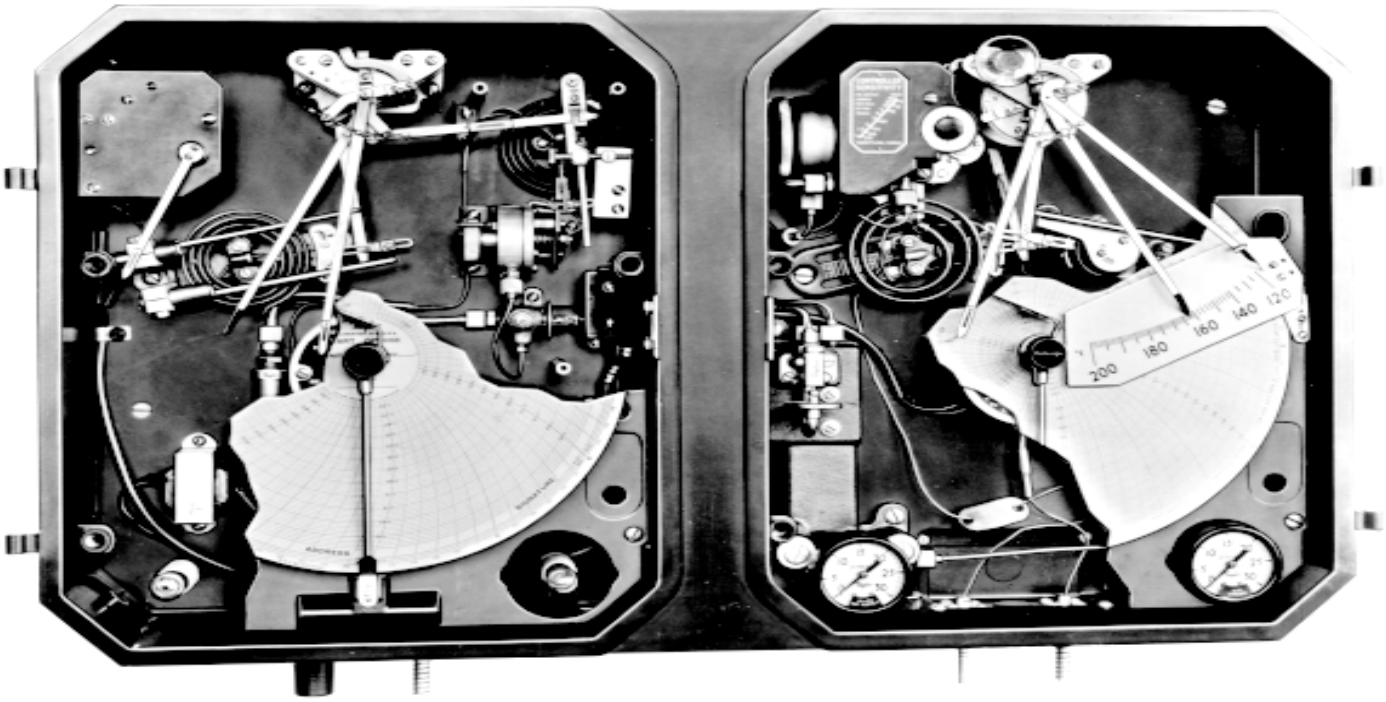


VAPOR THERMAL SYSTEMS

This type utilizes two Bourdon coils, one coil activates the **recording pen arm**; the second coil actuates the contact assembly to initiate **forward or diverted flow**. Both single and dual diversion controllers are available



The Taylor 351R STLR showing wiring, pneumatic controls and micro-switches. Note the split capillarys, capsular chamber and diversion set screw



As the temperature increases, the Bourdon spring tends to unwind. This moves the zero screw until the baffle contacts the nozzle. The baffle thus **stops the air flow through the nozzle** increasing the back pressure and supplying pressure in the **capsular chamber**. The action of the push rod of the capsular chamber places the micro switch in the normally open (NO) position which the flow diversion device solenoid which allows air at approximately 40 psi to compress down on the diaphragm and spring, moving the flow diversion device to the forward flow position.

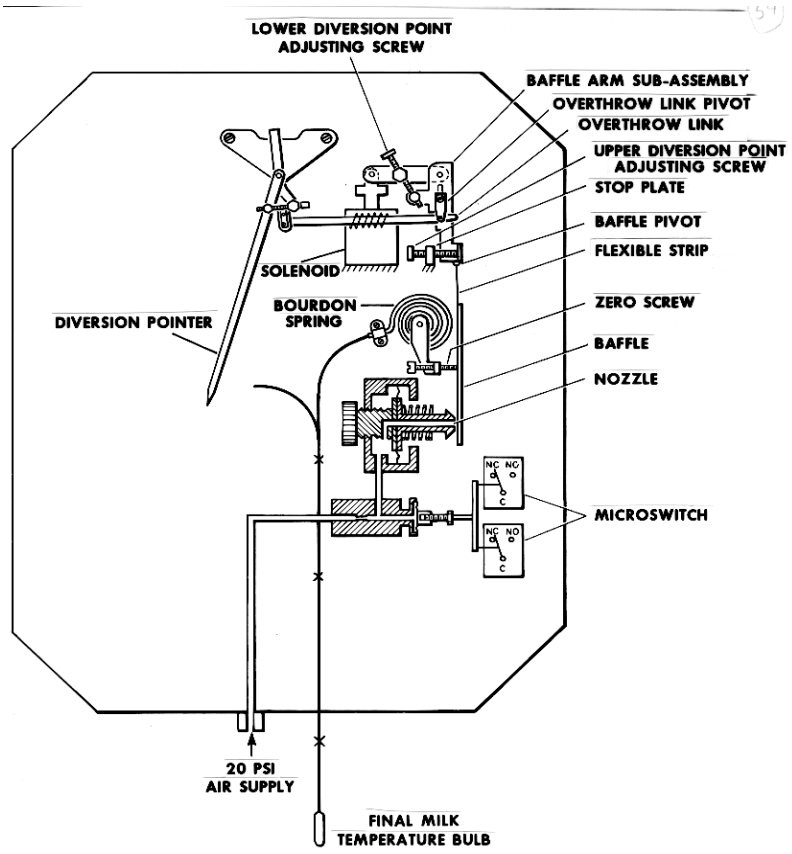
Therefore, in FORWARD FLOW, the timing pump is solely energized through the recorder controller micro switch.

Conversely, as the temperature decreases to below the diversion set point (cut-out), this allows the Bourdon coil to retract and air to escape through the nozzle, releasing the air from the capsular chamber, allowing the push rod to move to the left which allows the micro switch to assume the normally closed (NC) position. This action de-energizes the flow diversion device air solenoid, preventing air from depressing the diaphragm and spring in the FDD, assuring **DIVERTED FLOW**.

Because of the design of the recorder-controller i.e. pneumatically driven to the right (cut-in) and spring driven to the left (cut-out), and the delay necessary for the capsular chamber to “depressurize”, the "cut-in" temperature **will** normally be slightly higher than the "cut-out" temperature on mechanical/capillary driven recorder-controllers. This differential temperature may be adjusted to suit operator and plant standards, **but both cut-in and cut-out MUST be higher than the required minimum pasteurization temperatures.** Electronic STLR’s diversion differentials are pre-set at the factory and are usually 1-1½ degrees difference.

This recorder-controller requires a separate hot water temperature controller to automatically control the temperature of the steam heated water used in the heating section of the press. The hot water controller automatically controls the steam valve which increases or decreases the amount of steam allowed into the heating medium, depending on operator setting.

Illustrated below is the basic design/function of a recorder-controller.



PNEUMATIC COMPONENTS OF DUAL-DIVERSION RECORDER CONTROLLER

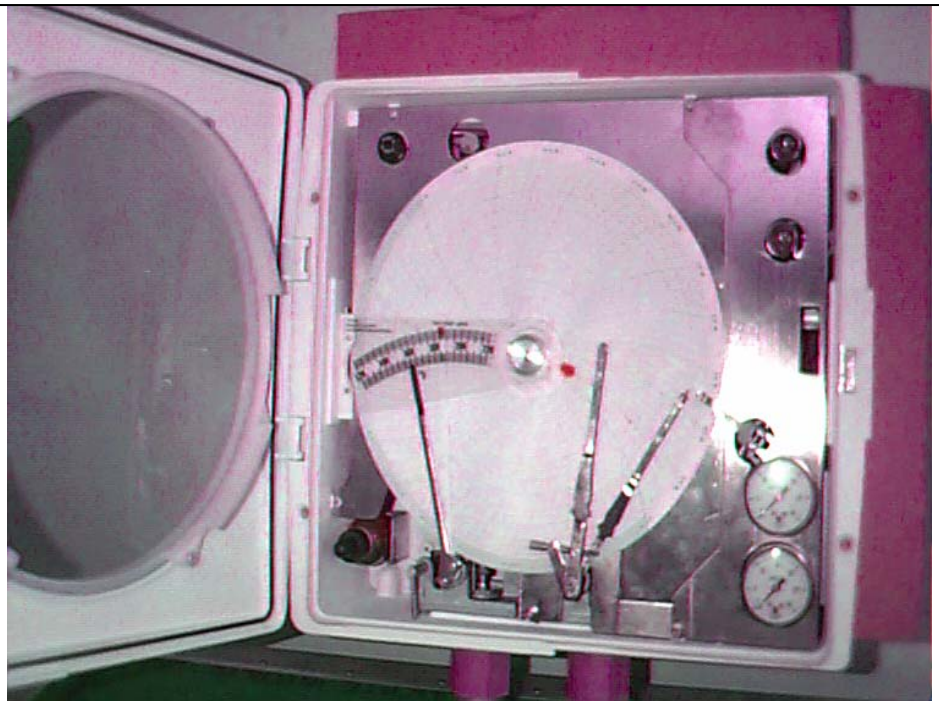
Figure 15-Taylor STLR

Basic HTST Pasteurization

The Partlow Recorder Controller

This recorder-controller combines both the flow diversion device recorder-controller and the hot water temperature controller. The right side mechanism which uses a liquid filled sensing bulb to activate a plunger/mechanical switching system to control the recorder pen and the flow diversion device. The sensing bulb is located at the outlet of the holding tube.

The Partlow STLR, Model J755A, showing door open with temp recording pen, hot water set (on left) , and sealing plate



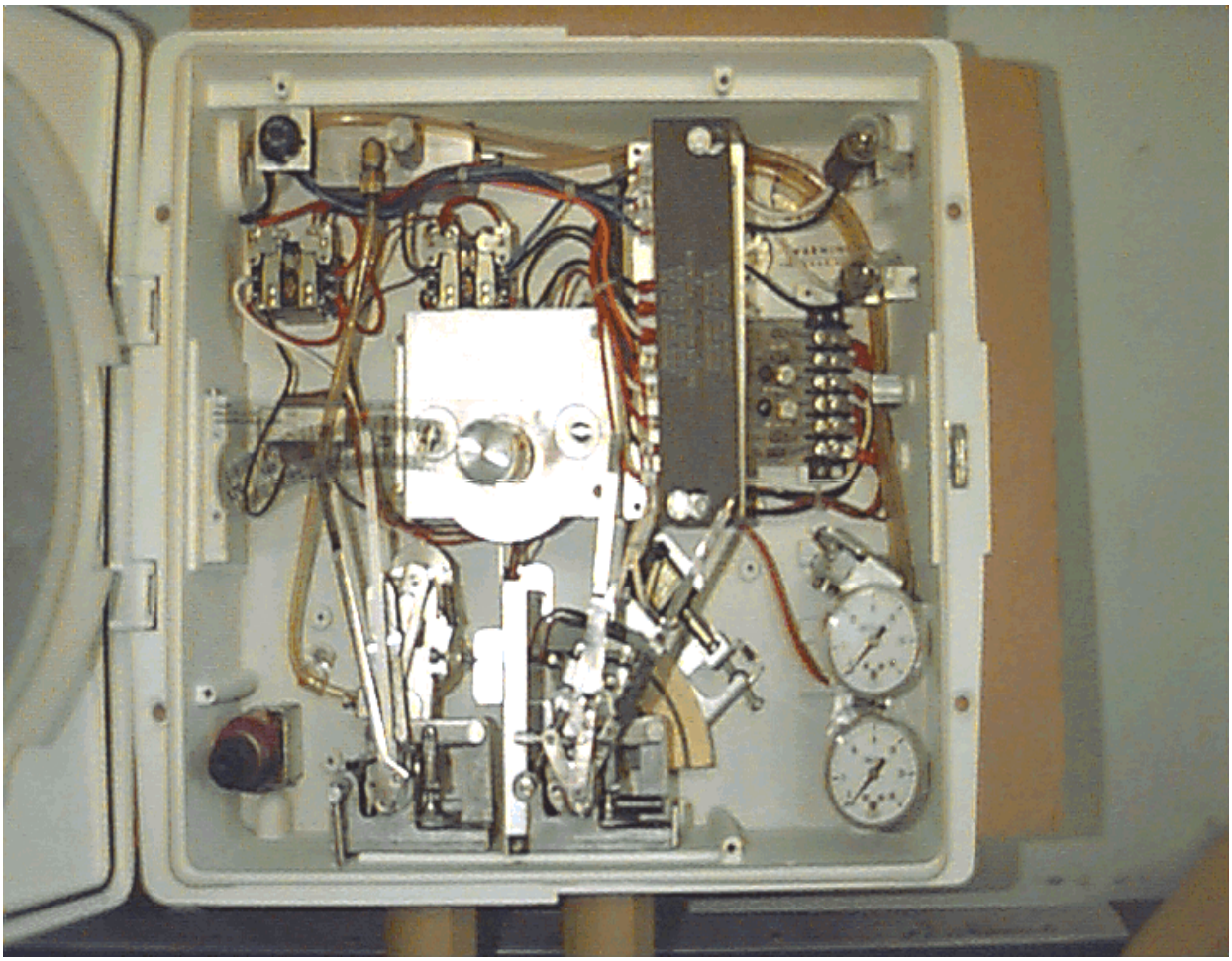
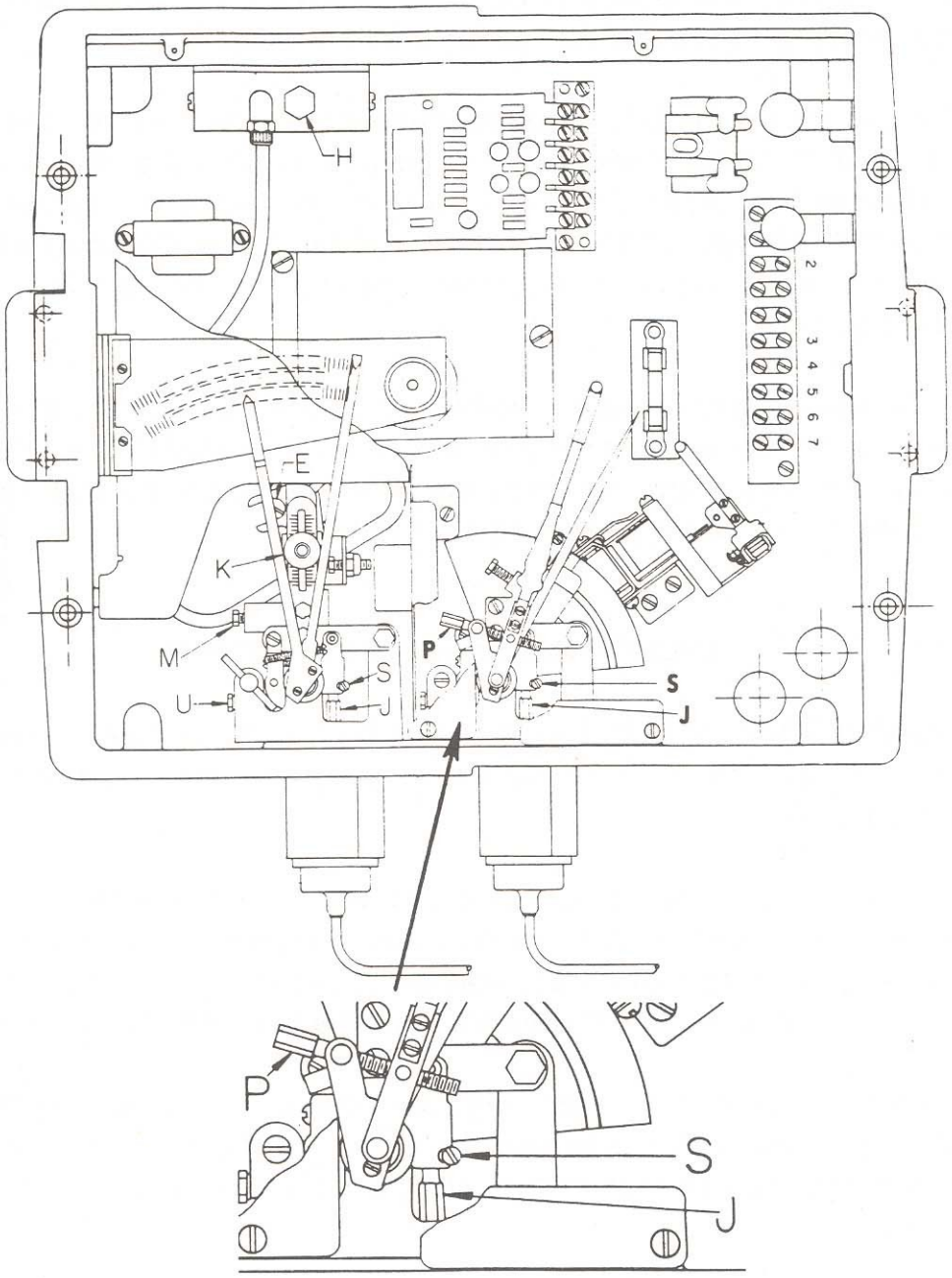


Photo of Partlow STLR with front plate removed (figure 16)

Figure 16 – Schematic Drawing of Partlow Controller



J - PUSH ROD ADJUSTMENT, CUT-IN AND CUT-OUT
P - TEMPERATURE PEN ADJUSTMENT SCREW
S - SET SCREW

The diversion set point is altered by **adjusting a small threaded push rod (J) which is locked into place with a set screw (S).** This adjusting mechanism is provided with a cover plate fitted with drilled screws for regulatory sealing. (See illustration on previous page)

The sensor on the left of the recorder-controller controls the water temperature in the heater section of the press through a pneumatic system. Temperature of the heating medium water is set on the transparent scale located on the left side of the recorder. The heated water **temperature** entering the heating section may be directly read on the adjacent indicating pointer.

c. Others - There are other manufacturers of recorder-controllers available. All use the same principals but operate in slightly different ways. If these systems are encountered in the field one should consult the manufacturer's manual for operating parameters.

MICRO-PROCESSOR TYPE STLR'S

On January 6, 1989, M-b-303 was issued by the FDA's Milk Safety Branch which allowed the use of computer based programmable logic in HTST Recorder Controllers.

These controllers are linear based programmable microprocessors which have the capability of recording all functions, alarm settings, events and other public health parameters of pasteurization by programming into mounted keys and observed digital configurations on the front of the instrument.

The recorder is provided with **two digital displays**. The main display indicates the measured process variable of any of the pens specified. The secondary display is used for instrument configuration and error messages.

Basic HTST Pasteurization

GENERAL REQUIREMENTS FOR ELECTRONIC RECORDER CONTROLLERS (ERC'S).

1. The ERC must not contain communication ports which allow over-riding of the public health controls from another computer.

2. The chart span shall be no greater than 100°F and be a 12 hour maximum chart. Most of the available charts are 10 inch circular charts with 4-1/8 calibrated width.

3. The temperature sensor shall be a platinum Resistance Temperature Detector (RTD) fast response tip that meets Test 8 requirements.

4. The ERC requires two regulatory seals, one on the RTD cap and the other on the back panel of the ERC which seals the programmable microprocessor and the control switch in the locked position.

5. ERC's are approved as a part of a control system and must use the temperature sensor approved for that system.

6. The four regulatory tests required of these models of ERC's are:

a. Programming of process values.

b. Instrument calibration

c. Cut-in and cut-out temperatures.

d. Locking and sealing of instrument.

Testing of ERC's will be discussed in the testing section of this manual. On the single diversion models, the red pen records the temperature and the blue pen is the event pen that records the position of the flow diversion device. On the dual diversion models there is a green pen that records the diversion temperature selected.

How do they work??

A. A 4 to 20 milliamp (mA) signal is provided on the red pen to drive a 5.5 mA low alarm for the dual diversion instrument.

b. The RTD sensor device is installed in the normal position at the end of the holding tube.

c. The product temperature is sensed by the 1/4 inch diameter platinum quick response tip, converted to a 4-20mA signal within the terminal block and relays this signal to the ERC.

d. The ERC automatically records the value transmitted and provided the values are at or above the set low point (legal pasteurization temperature) the flow diversion device solenoid in energized. This allows air to pass to the diaphragm thereby placing the flow diversion device in **forward flow**. Flow diversion valve solenoids may be either electro/mechanical or electric switches or relays.

4. **Recorder Specifications**

a. Must be electrically operated. The chart scale - not less than 30^{o} F including the set diversion temperature and at least +/- 12^{o} F. It shall be graduated in 1^{o}F divisions at least 1/16 in apart at the diversion temperature and time scale divisions of not more than 15 minutes.

b. Temperature accuracy - within 1^{o} F at set temperature plus or minus 5^{o} F.

c. Chart speed - circular charts not more than 12 hours to make one revolution, strip charts may show a continuous 24 hour recording.

d. Frequency pen - records the position of the flow diversion device (forward or diverted flow) on the outer edge of the chart. Both the frequency pen and the temperature recording pen must track in the reference "arc" inscribed on the STLR case.

e. Thermometric response - 5 seconds or less to change 12^{o} F (63%) of a 19 degree span that includes the cut-in point temperature.

Basic HTST Pasteurization

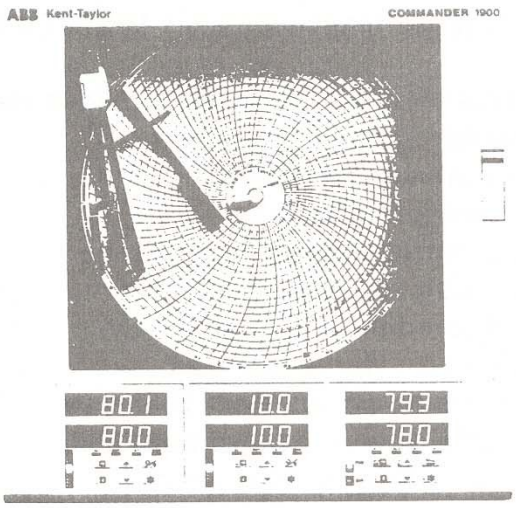
COMMANDER 1950

Pasteurizer Recorder and Recorder Controller

S.T.L.R. & H.T.S.T.

*

- **Dedicated Pasteurizer Recorder/Controller**
  -designed to meet requirements of the pasteurization processes
- **High clarity digital displays**
  – continuous indication of hot product and divert temperature
- **Compliance Review**
  - meets PMO requirements
- **Pasteurizer status indicator**
  - LED indication to show forward or diverted flow
- **True time event pen**
  – 4-position event, records divert and forward flow plus optional CIP (clean in process) and secondary divert
- **Up to eight diversion set points**
  – local or remote selection of hot product divert temperature settings
- **Hot product pen calibration**
  – optimization of pen reading to independent thermometer
- **Second resistance thermometer option**
  - A reference thermometer option connected to an independent sensor with additional alarm/divert protection



The complete recording and control solution for pasteurization processes

ABB Kent-Taylor

ABB

ELECTRONIC IMPUT STLR'S (Analogue type)

This electronic recorder-controller **(Anderson)** has a dual element, 1000 ohm Resistance Temperature Detector (RTD). This Anderson model of the STLR contains no programmable microprocessor. The 3-wire signal is linearized over any of the acceptable optional charts available. The dual primary RTD element supplies the recording/thermal limit signal and the secondary RTD supplies the verification for that signal.

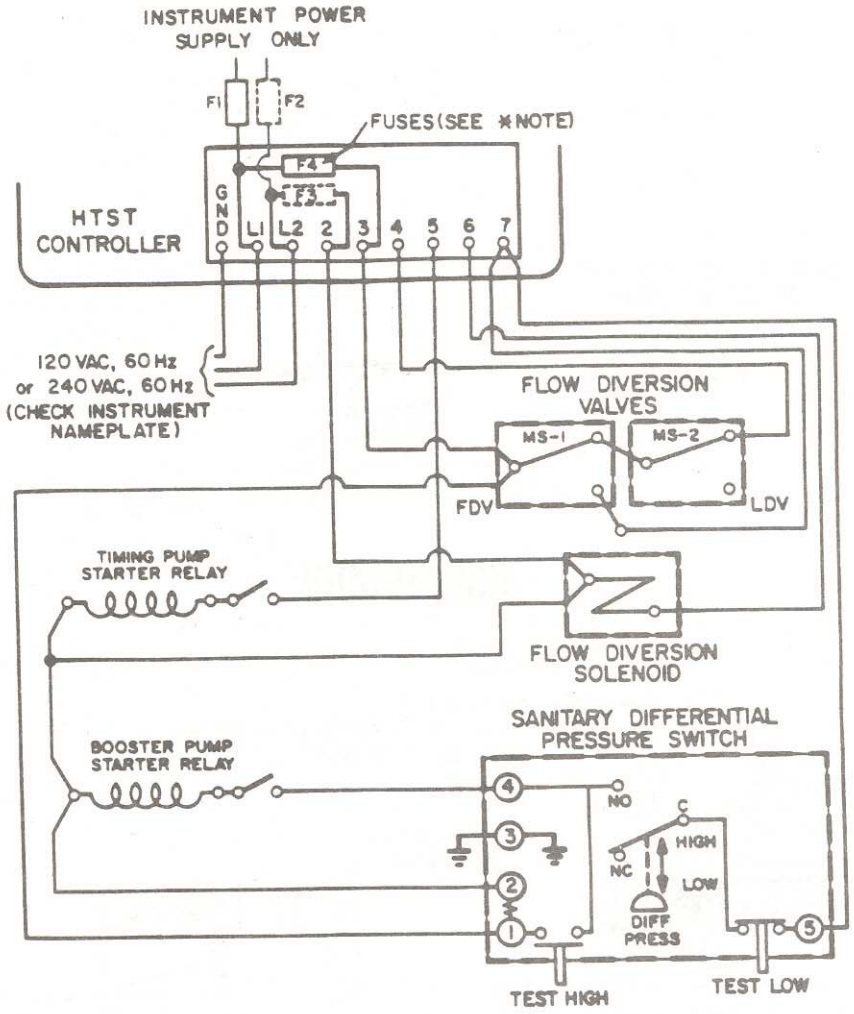
The standard chart in #41369; 120-220^{o} F;12 hr rotation; linear, 1^{o} F divisions.

Optional ranges include: 190^{o}-290 F; and 220-320^{o} F charts.

This recorder-controller provides for up to 4 selecting diversion set points which are adjustable with an internally mounted dial; however calibration adjustments are pre-set at the factory and should only be adjusted by a trained service person. The factory set diversion occurs from 0.1^{o} F to 0.2^{o} F above the displayed set point. To raise the cut-in temperature, SCREW CR-15 is turned counter clockwise. The cut-in is factory set at about 1.5^{o} F above cut-out.

Basic HTST Pasteurization

Figure 18, Anderson STLR Wiring Diagram



FUSE RATING REQUIRED

FUSE	120 V	240 V
F1	.25 AMP	.125 AMP
F2	JUMPER	.125 AMP
F3	JUMPER	1.5 AMP
F4	3 AMP	1.5 AMP

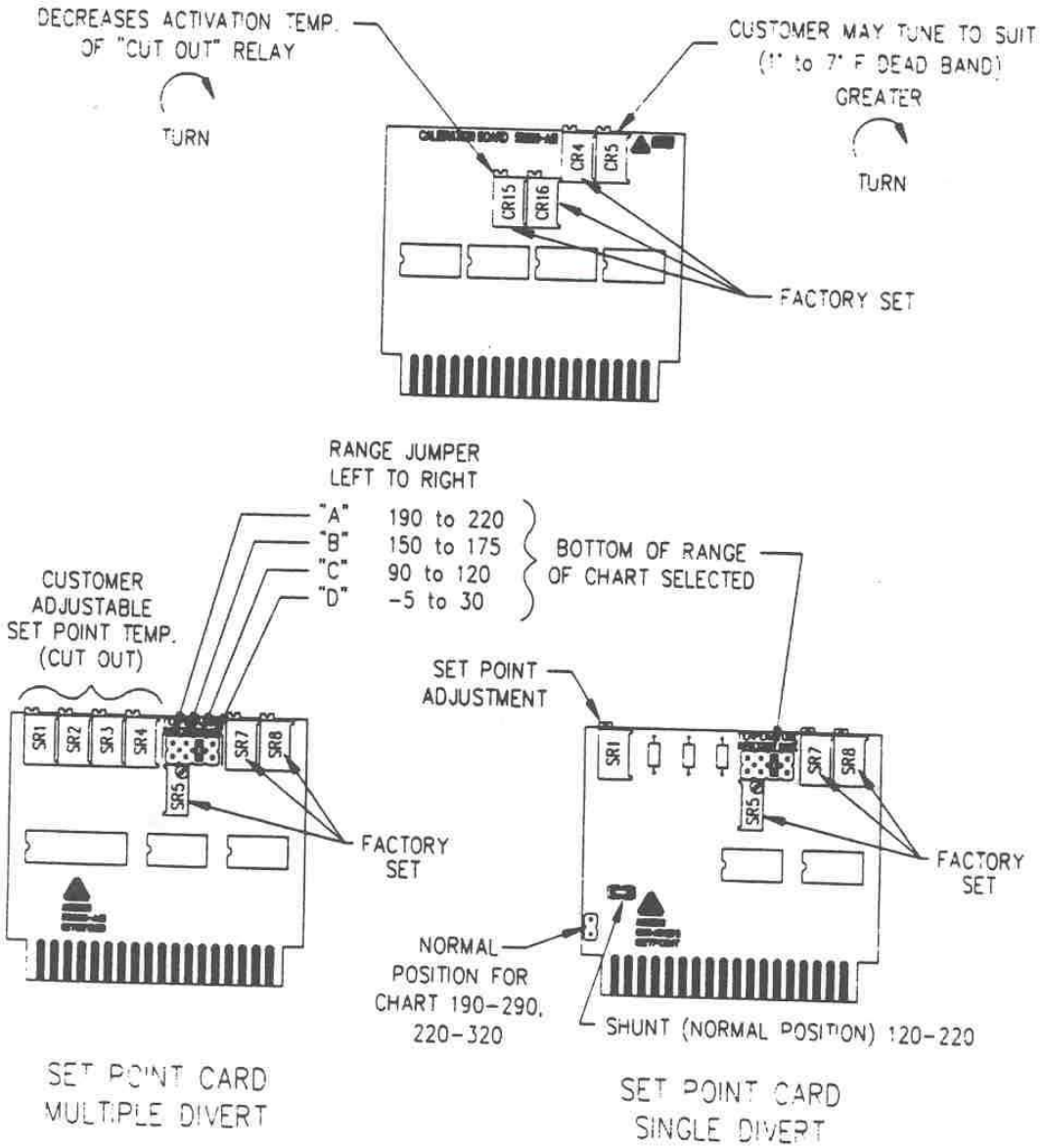


Figure 19
Anderson STLR Set Point Calibrations

Basic HTST Pasteurization

HONEYWELL ELECTRONIC STLR

BASIC DESCRIPTION

This is a microprocessor based circular chart recorder which has the unique function of a "one-pen" style print head which will print up to four analog traces (signals) on a blank heat sensitive chart. The chart parameters are key controlled and include chart range, speed, alarm set point, etc. All public health programs are protected from inadvertent change by a locking switch which is under regulatory seal.

Requirements for installation of this system are:

1. Must not contain a communications option (would allow it to receive instructions from another computer)

2. Meets wiring specifications submitted to FDA/MSB

3. Chart specifications;

    a. 12 hour maximum with 15 minute divisions and 1^{o} F maximum scale divisions.
    b. Span must include the low alarm set point (plus or minus 12^{o} F).
    c. Platinum RTD fast response tip meeting thermometric lag Test #8.
    d. Regulatory sealable at:

        σ RTD connecting cap
        σ Configuration switch cover
        σ Hold down screw for chart plate

4. The four additional tests required for this instrument are:

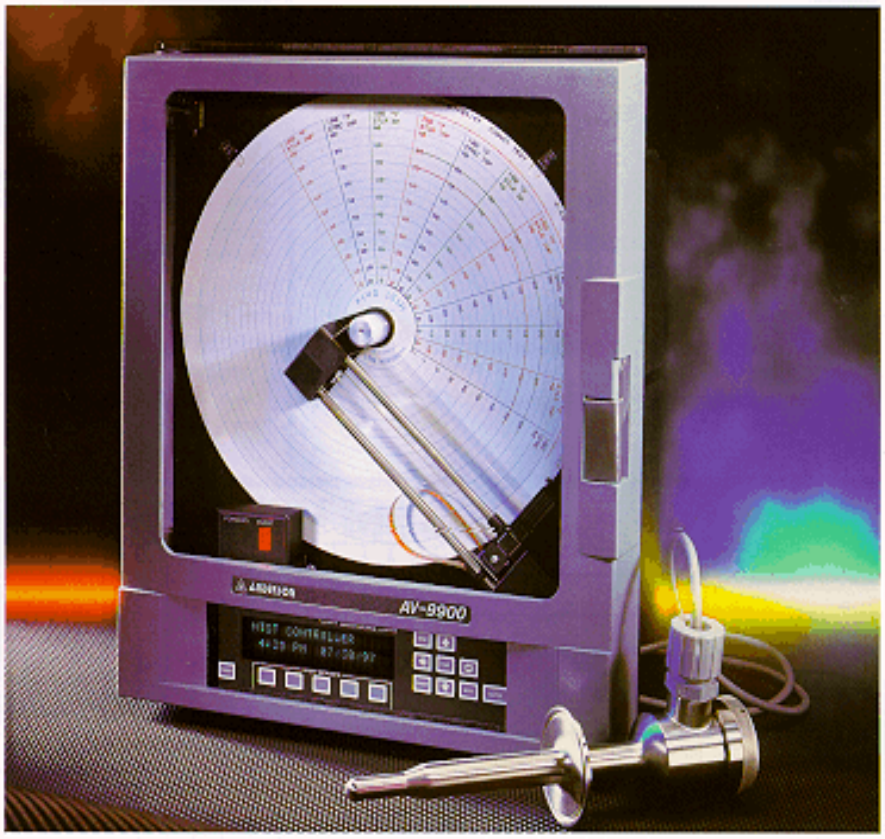
    *configuration of process parameters
    *Instrument calibration
    *Cut-in/cut-out temperatures
    *Locking and sealing of instrument and sensor

ANDERSON

GAUGES
THERMOMETERS
TRANSMITTERS
RECORDERS
CONTROLLERS
LIQUID LEVEL SYSTEMS
RTDS

AV-9900 HTST Recorder Controller

- *New four color recording technology prints all trends, scales, events and customer specific messages on a plain paper, 12" chart.*
- *Hot product, cold product, hot water, and flow-rate all recorded and/or controlled in a single unit.*
- *Meets all PMO requirements for HTST, HHST, and UHT applications.*



The new AV-9900 HTST recorder controller is specifically designed for use in continuous pasteurization applications. The unit combines failsafe protection for the pasteurization process with the broadest range of configuration options ever available in an HTST control package. This is accomplished via a unique, four color printing technology which prints on plain paper, 12", 100 division charts. Each unit is programmable for up to 4 independent recording ranges and input types. Each scale is color coded to its' trend pen to provide a chart that is simple to read, even with multiple variables.

The standard unit provides legal Safety Thermal Limit Recorder (STLR) functionality with up to 5 selectable diversion setpoints. Product temperature is monitored via our time proven dual element, 1,000 ohm RTD sensor. The STLR monitors sensor balance between the two elements to insure failsafe operation. The hot product scale, temperature, and flow diversion valve frequency trend are printed in red. When configured for multiple divert, the activated setpoint temperature is continuously printed in green.

The unit can be optionally specified to include hot water control (HWC). This variable is normally displayed and controlled, but not recorded. For multiple divert applications, separate hot water setpoints can be programmed to be selected automatically when the diversion setpoint is changed.

Cold product can be optionally specified for Recording (CPR), or Recording/Controlling (CPRC). The range for this function is programmable to provide maximum readability in the product range while including CIP temperature. The standard color for this variable is blue.

Finally, the unit will soon be available with a Safety Flow Limit function for systems with meter based timing. This option can include Recording (SFLR) or Recording and Control (SFLRC). Range can be configured in percent flow or engineering units (GPM etc.). The standard color for this function is black.

Figure 20 Honeywell STLR

Note: These tests are required upon installation and quarterly thereafter or when any regulatory seal is broken. Tests 2, 3 and 8 are required as is Tests 4 and 10. With the earlier models of this STLR, as with the first model of the ABB Kent Taylor, the recording temperature is not adjustable as with conventional systems and requires the breaking of regulatory seals.

5. Recording Thermometer Charts

a. All charts used for the pasteurization of milk must contain all the following information:

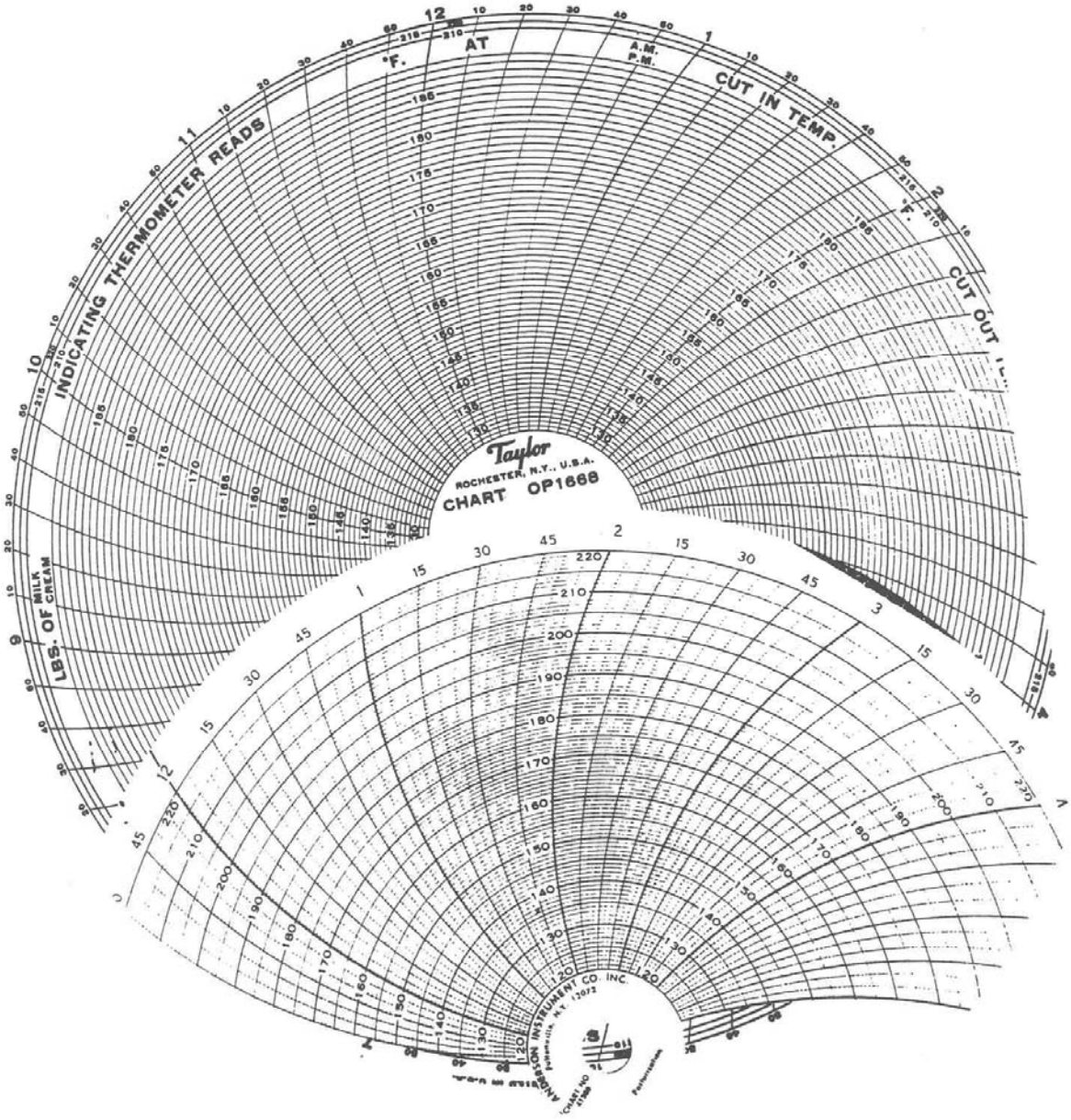
1) Plant name and location
2) Date
3) Identification of pasteurizer if more than one
4) Name or initials of operator
5) Cut-in and Cut-out temperatures as checked at start of day's production
6) Reading of indicating thermometer at a specific
7) Amount and identity of each product in the run
8) Record of any unusual occurrences
9) Record of the position of the FDD

b. Charts must be neat and legible and contain NO overlapping information.

c. Charts must be retained for at least 3 months,

d. Temperatures recorded on the charts verify that the higher minimum required temperatures for products containing added sugars or higher fats have been met.

Basic HTST Pasteurization


INDICATING THERMOMETER READS
°F.
AT
A.M.
P.M.
CUT IN TEMP.
°F.
CUT OUT
LBS. OF MILK
CREAM
Taylor
ROCHESTER, N.Y., U.S.A.
CHART OP1668
ANDERSON INSTRUMENT CO. INC.

. FLOW DIVERSION DEVICE - SINGLE STEM

1. Purpose

Too safely and accurately control and separate raw and pasteurized product flow.

The single stem flow diversion device is a specially designed three way valve that, in conjunction with a recorder-controller, is capable of **automatically controlling** the direction of product flow in a pasteurizing system.

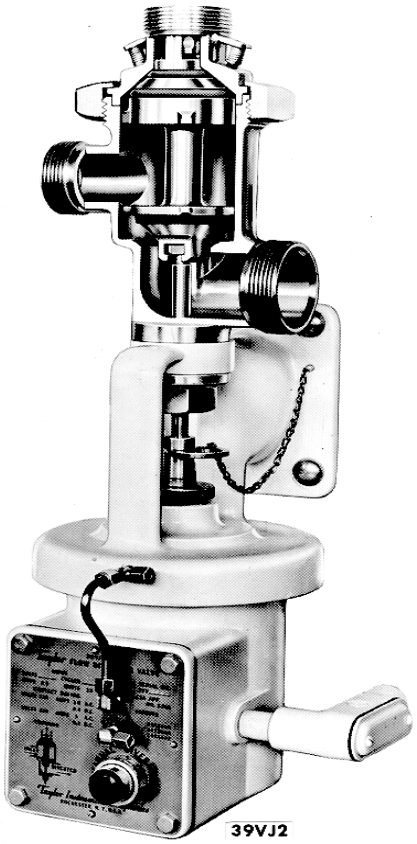


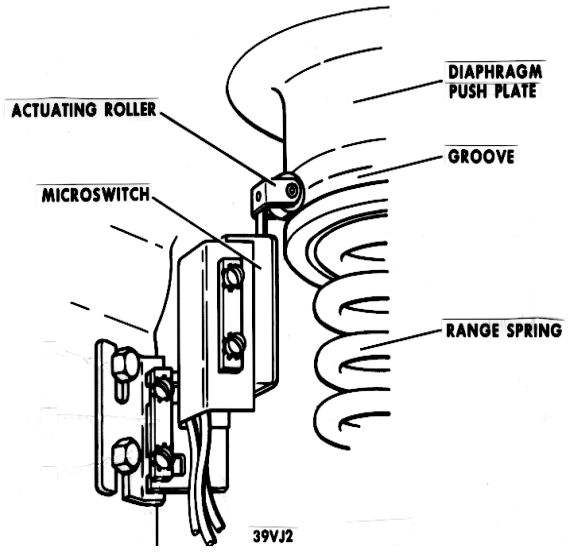
Figure 21
Single Stem Flow Diversion Device

2. Operation

a. The single stem flow diversion device is **air activated for the open position (forward flow) and spring activated for the closed (divert or fail-safe) position.** To activate (open) the valve to the forward flow position, compressed air is admitted past the solenoid and presses down against the diaphragm. This compresses the spring and moves the valve to seal off the divert line and opens the forward flow port. Compressed air at the top of the diaphragm is controlled through an air activated solenoid valve. This solenoid receives an electronic from the recorder-controller micro switch when the preset (cut-in) temperature is reached. **Loss of air pressure or electrical signal from the recorder-controller causes the spring to automatically return the valve to the closed or fail-safe divert position**.

b. **When the flow diversion device is properly assembled and in the fully diverted position**, **the micro switch roller will be positioned in the valve diaphragm push plate groove. In this position the micro switch provides power to the timing pump and the red light on the recorder-controller.**

c. When the flow diversion device is in the forward flow position, the roller rides above the groove and the micro switch energizes the green light and the frequency pen arm on the recorder controller. During legal forward flow the timing pump is energized by the recorder controller micro switch.



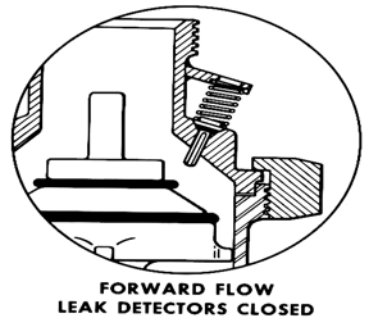
d. **If, during diverted flow, the diversion device is not properly assembled or seated, the micro switch roller will be mis-positioned out of the groove and the timing pump will not run**. This prohibits any sub-legal milk from entering the forward flow port of the valve during divert.

3. **Basic Requirements**

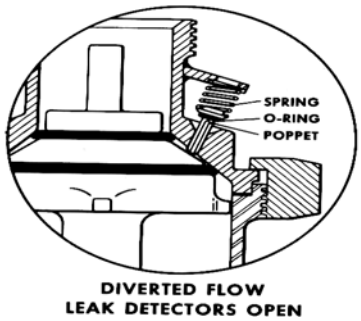
a. Systems shall be provided to insure proper positioning of the FDD to operate only when properly assembled and then only when in the fully forward or full diverted position.

b. It must be impossible to tighten the stem packing nut so as to prevent the valve from assuming the fully diverted position within the prescribed time (1 sec.).

c. Leak escape ports must be unobstructed and on the forward flow side of the flow diversion device seat. The forward flow seat shall close tight enough so that any leakage past the seat will not exceed the capacity of the leak escape device. The poppet valves, as they are known, are held in place be springs and "O rings". When the valve is in diverted flow, the leak detectors allow milk to leak past the sealing rings (gaskets) of the valve plunger and escape to the atmosphere. In forward flow the springs hold these poppets against their seat which prevents leakage. Milk pressures in excess of 20 psi may prevent their proper seating and result in leakage.



FORWARD FLOW
LEAK DETECTORS CLOSED



DIVERTED FLOW
LEAK DETECTORS OPEN

d. The length of the connecting rod shall not be adjustable.

e. Power failure or loss of air pressure shall automatically move the valve to the fail safe (diverted) position.

f. The flow diversion device shall be located downstream from the holding tube. (Except in HHST systems)

g. The divert line shall be self draining and shall be free of restrictions or valves unless a readily identifiable restrictor is used, and are so designed that stoppage of the divert line cannot occur. There shall be no valves or other obstructions in the flow divert line.

h. This valve must be completely dissembled and manually cleaned after each use.

Basic HTST Pasteurization

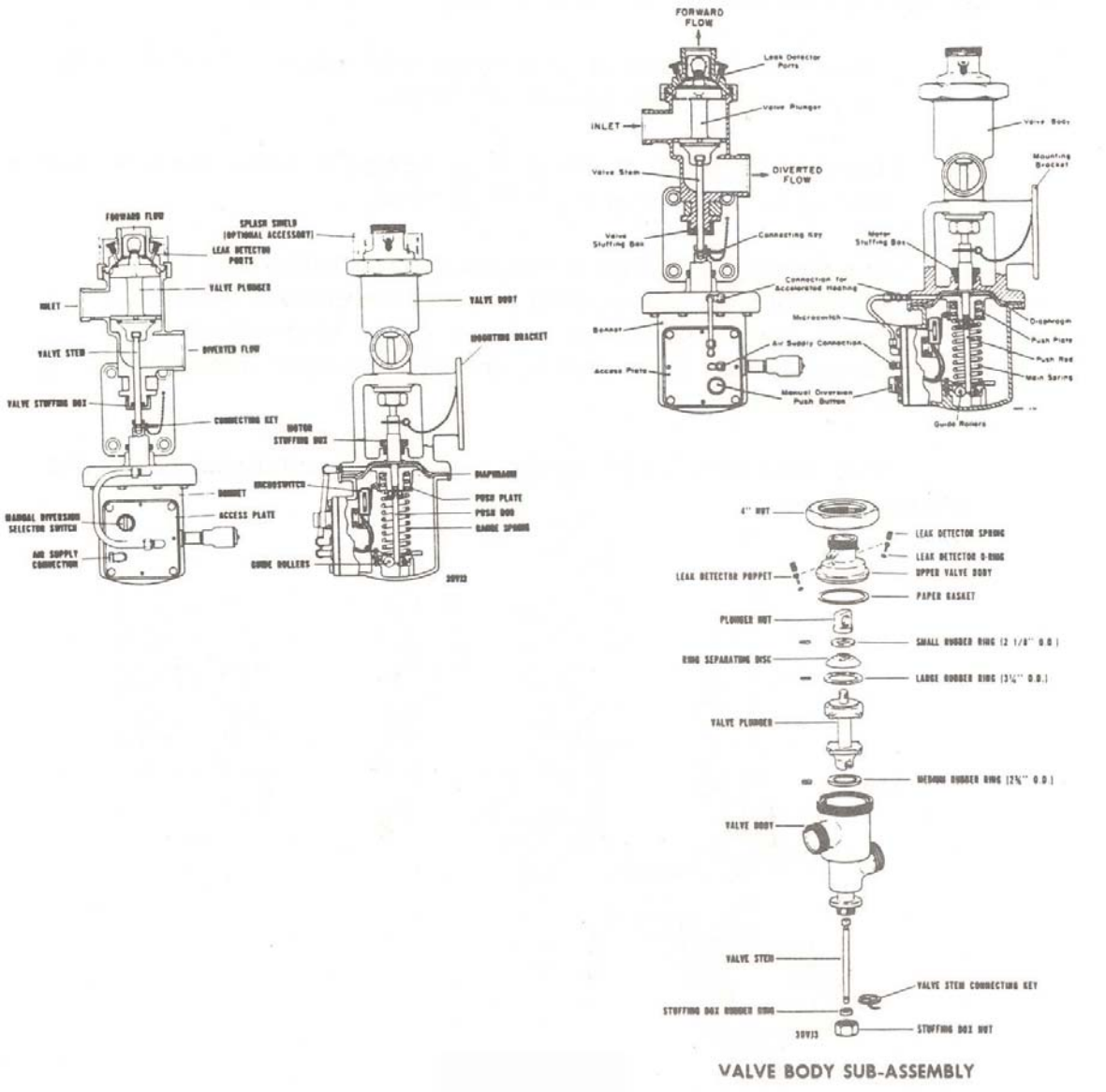


Figure 22a Function – Single Stem Valves

H. FLOW DIVERSION DEVICE - DUAL STEM

1. Purpose

To safely and accurately control and separate raw and pasteurized product flow.

A dual stem flow diversion device is basically two, three-way valves in tandem which automatically control the direction of product flow. This type valve or device was designed to be cleaned-in-place.

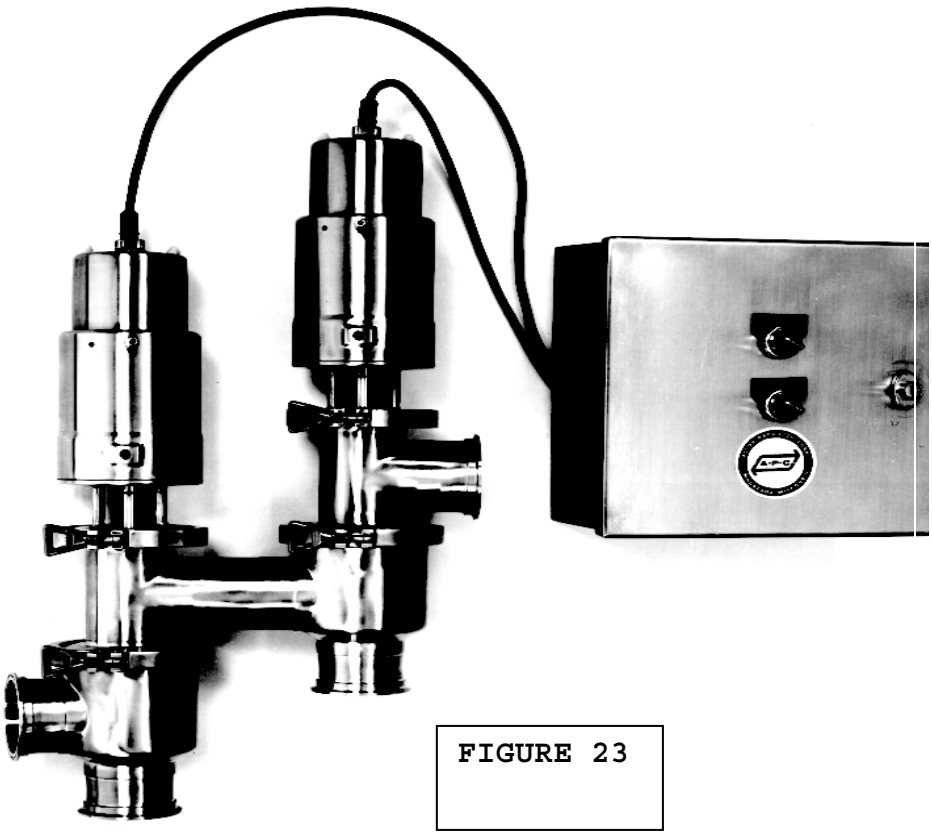
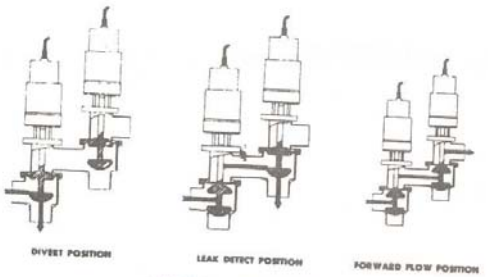


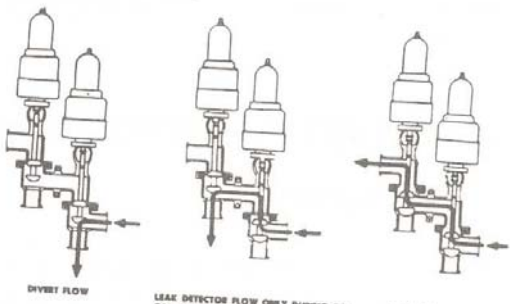
FIGURE 23

DUAL STEM FLOW DIVERSION DEVICE
ALLOY PRODUCTS CORPS.

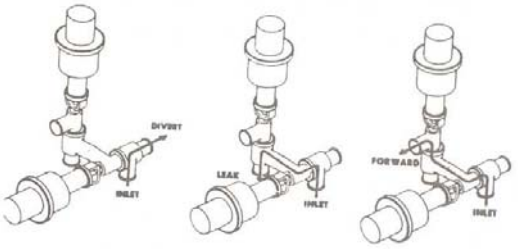
Basic HTST Pasteurization



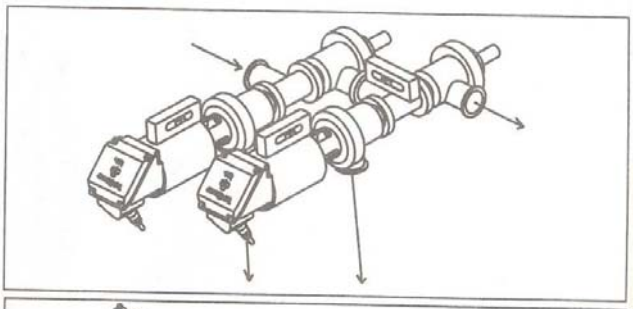
PRINCIPLES OF OPERATION
ALLOY PRODUCTS CORP.
MODEL FDV 7500

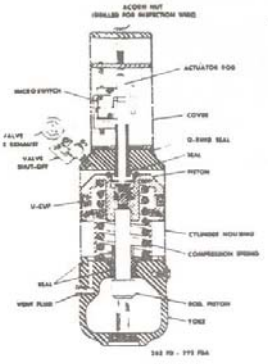


PRINCIPLES OF OPERATION
TRI-CLOVER

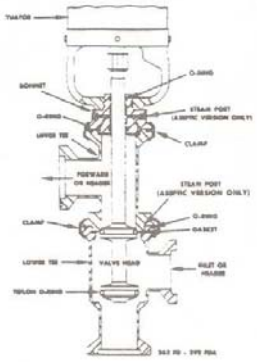


PRINCIPLES OF OPERATION
G & H FLOW DIVERSION DEVICE





ACTUATOR



VALVE BODY

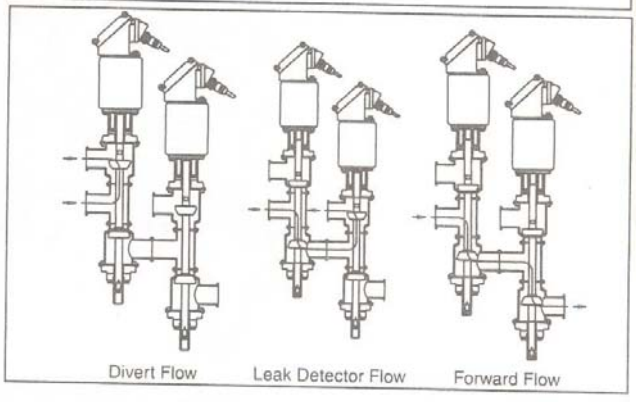


Figure 24
Dual Stem Devices and Function

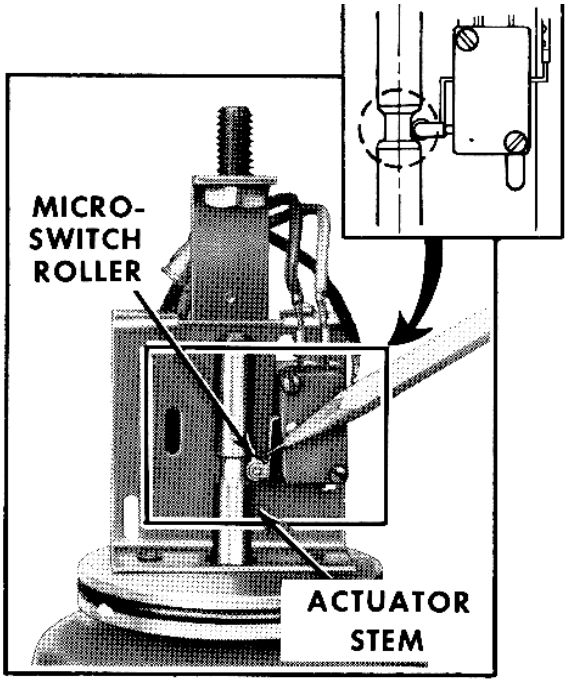
2. Operation

a. Each manufactured brand of valve is slightly different in design, however all have two bodies with an interconnecting yoke, pneumatic actuators and spring loaded valve plungers.

b. All are designed to move to, and/or to remain at, the fail safe divert position in the event of loss of adequate temperature, electronic power or air pressure.

c. Each valve is actuated by a non-restricted quick exhaust type solenoid valve that controls the air to each valve.

d. Micro switches are located near the top of each actuator stem in the valve bonnet, and operate and function identical to those in the single stem flow diversion device. (Control power signal to the timing pump, frequency pen and panel indicator lights).

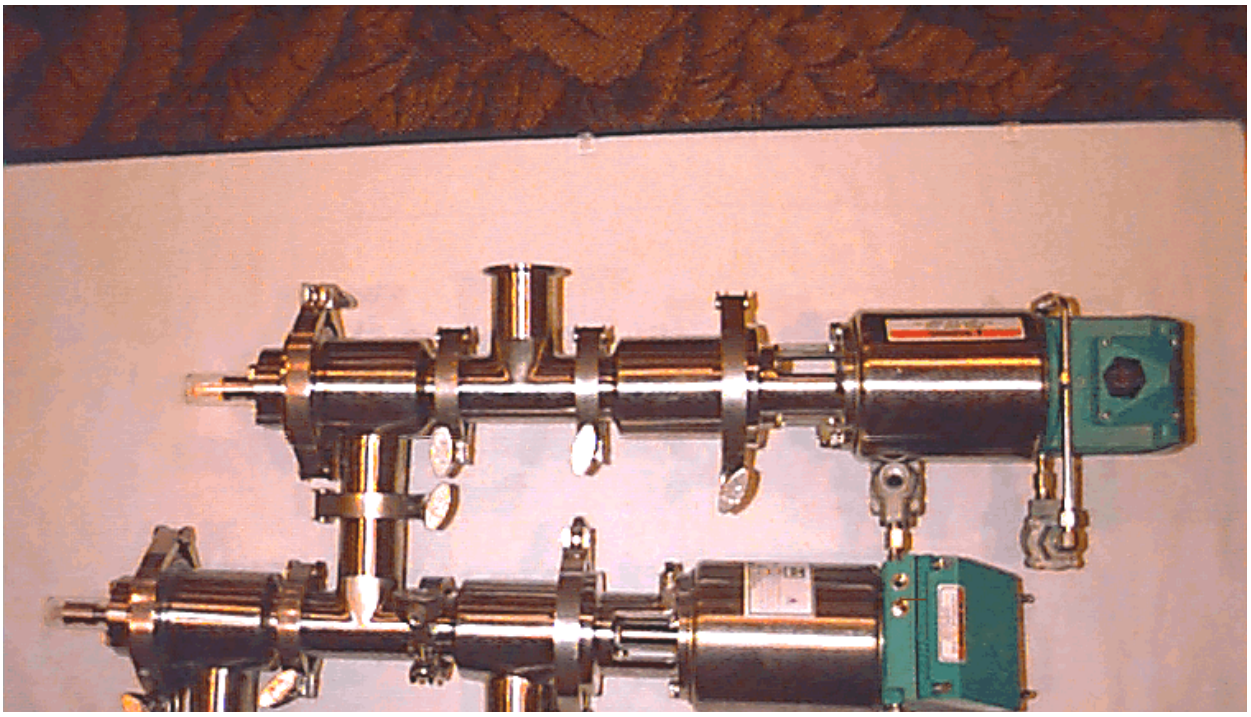


SET ROLLER IN BOTTOM OF GROOVE WHEN VALVE IS IN THE DIVERT POSITION.

Basic HTST Pasteurization

Recently introduced into the market under memorandum from the FDA Milk Safety Branch is the new Tri-Clover Flo-Diversion Valve and Panel, Model 762-227 MRAL Reverse Acting FDD.

This valve operates similar to previous models other than it is horizontally mounted which eliminates most hydraulic shock in systems where the differential pressure across the valve is 30 psig or greater. The design of the valve allows closing against the process flow rather than with the flow as do conventional valves.
Drainage between the two valves is accomplished through a tangential connecting line between the two valve bodies. Two piece stems allow for assembling and disassembling the valve and are joined together with a nut and 0-ring seal. In case of o-ring failure, leakage flows through leak detect



holes in the short stem and is visible through a clear plastic stem guard. This FDD and its components are shown in the following illustration:

Reverse acting FDD, figure 24a

3. Basic Requirements

a. Systems shall be designed to assure proper operation of the flow diversion device only when properly assembled and only when in the fully forward or fully diverted position.

b. It must be impossible to tighten the stem packing so as to prevent the valve from assuming the fully diverted position within the prescribed time (<1 sec.).

c. The length of the connecting rod shall not be adjustable.

d. Power failure or loss of air pressure shall **automatically** move the valve to the fail safe (diverted) position.

e. The flow diversion device shall be located downstream from the holding tube and indicating and recording thermometer sensors.

f. The divert line shall be **self draining** and shall be free of restrictions or valves unless readily identifiable and are so designed that stoppage of the divert line cannot occur.

g. The leak detect line shall be designed to discharge all leakage to the floor, or back to the constant level tank. **This leak detect line must not be connected to the divert line and shall not have any restrictions.** A sight glass must be installed in the leak detect line if connected to the constant level tank. This sight glass must be of the full see-through (clear material providing vision on both sides of the cross fitting) design and be installed in the vertical line. The only exception to this requirement is the provision for a transparent tube assembly which is self draining may be installed horizontally.

.

1. YOKE FLUSH TIME DELAY

At least one second between actuation of the divert valve and the leak detect valve, when moving from the diverted flow to the forward flow position. The purpose of this is to flush the connecting line of any possible raw milk remaining in this connecting "yoke".

On systems having identifiable restrictors in the divert line, the maximum time delay, (divert valve to leak detect valve "flush time") must never exceed 5 seconds. This prevents sub-legal (< 15 seconds milk which may have been traveling down the UNRESTRICTED leak detect line) milk from entering into the pasteurized side of the system at the instant of forward flow. This maximum 5 second flush delay does not apply to systems using a magnetic meter timing system.

Dual stem valves which have both bodies mounted vertically must have sealed time delays.

The G&H FDD (including the newer vertically mounted G&H) because the connecting "yoke" is configured to be self draining, is exempt from this time delay requirement.

2. INSPECT TIME DELAY

When the mode switch is moved from the "PRODUCT " or "PROCESS" position to the "INSPECT" position, the valve must immediately assume the DIVERT position and all flow promoting devices must be immediately de-energized. After all flow promoting devices have completely stopped (or have been effectively valved out of the system) the flow diversion device may move to the FORWARD FLOW position for inspection or servicing.

Note: A maximum of one second time delay is allowed during transition movement times of the flow diversion device. Provided that; a one second maximum "off" time delay is allowable to maintain the flow-promoting device in the "on" position through the travel time of the valve(s).((NCIMS-93)). This removes the requirement for de-energizing the flow promoters (i.e., timing pumps, homogenizers, and valving out of separators) during times required for the flow diversion device to move to the forward or divert flow position.

3. CIP TIME DELAYS

Condition #1 = timing pump or other flow promoting devices not operating during the CIP operation

Requirement - Time delay for "run down" times of all flow promoters while FDD remains in DIVERT.(The FDD then is under full control of the CIP system controller and no flow promoting devices used for processing may operate during the CIP cycle). This applies to those systems which utilize a separate CIP pump which is installed after shut down.

Condition #2 = Timing pump or other flow promoting devices allowed to operate during CIP.

Requirement - A 10 minute minimum time delay when the mode switch selector is placed in the CIP position. During this time period the FDD must immediately assume the DIVERT position and all product flow promoters which may induce improper pressure relationships within the milk-to-milk regenerator must be deactivated or effectively valved out of the system during the 10 minute time delay. This includes:

1. **BOOSTER PUMP**
2. **RAW MILK SEPARATOR LOCATED BETWEEN TWO RAWSIDE REGENERATORS.* (INCLUDES SEPARATOR STUFFER PUMP.)**
3. **PASTEURIZED MILK SEPARATORS.***

***Separators are effectively valved out of the system, since separator plates will continue to spin even when power is not provided. They are powerful flow promoters.**

Following the 10 minute time delay, the system in under control of the CIP program, the valves may begin their cycling function and the booster and other auxiliary equipment may operate.

Basic HTST Pasteurization

Programmable Logic Controller systems for Dual Stem Flow Diversion Devices; Manufacturer (Custom Control Products, Mb-313, 3/15/91)

This system for controlling all functions of the dual stem flow diversion device includes electronic EEPROM pre-programmed entries for the time delays and CIP functioning of the devices.

The controller may be used for those devices with air solenoids mounted on the valve (APC) on in the control panels (Cherry Burrell, Tri-clover and G&H).

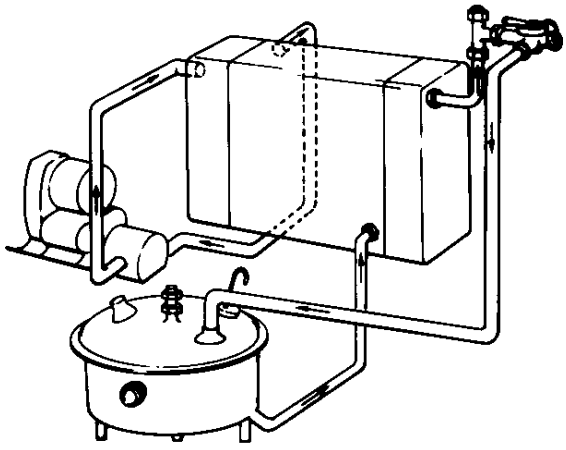
The controller is fitted with a clear Plexiglas cover which is sealed to prohibit unauthorized access to the programming port and memory cards. The EEPROM is supplied by the installer and cannot be permanently reprogrammed and is identified to prohibit replacement.

Otherwise this instrument performs the identical functions of any conventional flow device controller which operates the timers, CIP functions, etc via rotating drums and mechanical timing devices.

Regenerator Pressures

As previously noted in the HTST Design and Flow section, pasteurized and raw milk in the regenerator section are separated only by thin stainless steel plates and a series of gaskets in the regenerator section. Thus the requirement that the pasteurized milk MUST always be under greater pressure than the raw milk in the system. In the event of leakage due to either gasket or metal failure the pasteurized milk will be forced into the raw side of the regenerator and not vice versa.

This pressure relationship must always be maintained during all phases of operations. This includes initial start-up, during processing (including diverted flow) and during any periods of sudden loss of power or shutdown.



In the basic HTST system this is accomplished by the following required methods:

1. The overflow level of the balance tank must be lower than the lowest milk level within the regenerator.

2. The timing pump must be located between the outlet of the raw regenerator and the beginning of the holding tube.

3. No pump, other than a properly designed, installed and operated booster pump, shall be installed between the balance tank and the raw milk inlet to the regenerator.

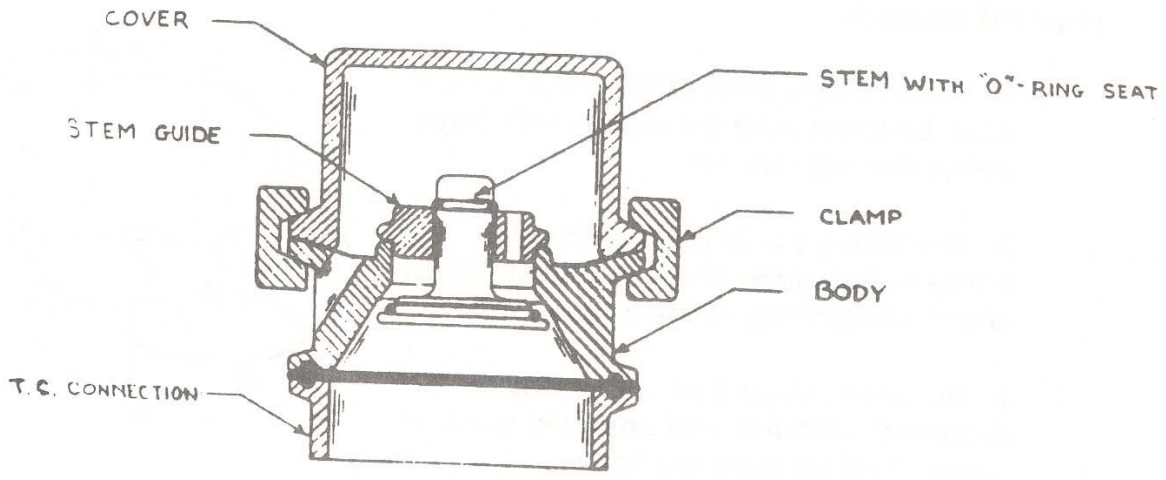
4. The raw milk deflector plate(s) is drilled to allow drainage of raw milk back towards the balance tank during system shut downs resulting from loss of power.

HTST PRESSURE RELIEF VALVES

5. There is a properly installed atmospheric type sanitary vacuum breaker installed in the system. This vacuum breaker must be located in the milk line following the pasteurized milk outlet from the regenerator (or cooler section) and this line shall be at least 12 inches above the highest raw milk in the pasteurizer system. The top of the highest raw line and the bottom of the pasteurized milk line on which the vacuum breaker is installed shall be the effective measurement points.
Note: ***A 2.3 foot water column will provide one (1) psi backpressure.***

6. No flow promoting device which can affect the pressure relationships within the regenerator may be located between the pasteurized milk outlet of the regenerator and the vacuum breaker.

7. Raw milk must enter at the bottom of the regenerator (unless properly installed regenerator by-pass is installed) and must be able to drain freely back to the balance tank during periods of shut down or loss of power. This is facilitated through the small drilled holes in the bottom of the raw milk regenerator. To facilitate this, the outlet to the raw milk regenerator should be disconnected.



Sanitary Vacuum Breaker, Figure 25

PRESSURE RELIEF VALVES, LOCATED WITHIN HTST, HHST AND ASEPTIC PROCESSING SYSTEMS

Pressure relief valves are allowed between the Timing Pump and the beginning of the Holding Tube if:

a.) The pressure relief valve is a fail-safe/spring-to-close valve with a spring pressure greater than the highest normal operating pressure of the system when operating in "Product" mode; or a fail-safe/spring-to-close valve with overriding air pressure.

b.) Provisions are made for cleaning the valve whenever the system is cleaned. Except as provided above, if pressurized air is used to overcome the pressure relief valve spring, the flow of this air must be enabled only in "CIP" mode, after the minimum required ten (10) minute time delay relay has expired. If a computer controls the air, that computer must comply with the requirements of Appendix H., V.-Criteria for the Evaluation of Computerized Systems for Grade 'A' Public Health Controls of this Ordinance.

c.) The pressure relief valve vent opening is such that any leakage is readily visible. This may be accomplished by opening the valve vent directly to the floor or by providing sanitary piping from the valve vent to the constant-level tank. If the later option is utilized, the piping shall be properly sloped to assure drainage to the constant-level tank and provide a means of leak detection, such as by a properly located and installed sight-glass.

d.) The pasteurizer shall not be timed if the valve is leaking.

e.) If the valve is leaking during operation, the system is considered in violation of Item 16p.(D) PASTEURIZERS AND ASEPTIC PROCESSING SYSTEMS EMPLOYING REGENERATIVE HEATING of this Ordinance, unless the loss of the pasteurized side regenerator pressure, during a shutdown in forward flow, is otherwise effectively prevented.

For Example: In a magnetic flow meter based timing system there is a fail-safe, spring-to-close valve or check valve that must also be located between the timing pump and the holding tube. This item is satisfied if the pressure relief valve is located prior to this fail-safe valve or check valve.

Pressure relief valves are allowed to be located downstream from the Holding Tube in HTST Systems if:

(1.) The pressures in the pasteurized side of the regenerator is protected from falling within 6.9 kPa (1 psi) of the pressures in the raw side of the regenerator at all times, including during shut down. A relief valve and line on the pasteurized side of the FDD can meet this criterion if:

a.) After the relief valve and before the entrance to the pasteurized side of a regenerator, all product rises at least 30.5 centimeters (12 inches) higher than the highest raw milk in the system, and is open to the atmosphere at that

point; or

b.) After exiting the pasteurized regenerator, and before the pressure relief valve, all product must rise at least 30.5 centimeters (12 inches) higher than the highest raw milk in the system, and be open to the atmosphere at that point; or

c.) The pressure relief valve is spring-loaded and plumbed so that it cannot be opened or forced open in any mode, “Product”, “CIP” or “Inspect”, without the assistance of pressure from the liquid flowing through the system. In this case, a leaking pressure relief valve can cause an unacceptable loss of pressure in the pasteurized side of the regenerator during a shut down and is considered a violation of Item 16p.(D) PASTEURIZERS AND ASEPTIC PROCESSING SYSTEMS EMPLOYING REGENERATIVE HEATING of this Ordinance.

Laminar Flow

LAMINAR FLOW

When milk and milk products flow through the holding tube of a high-temperature short-time pasteurizer, flow rates vary within the tube itself. Further the milk in the central portion of the holding tube will move at a greater velocity than product nearest the tube wall which moves at slower rates. These wide variances in flow rates causes concern over the assurance of meeting minimum legal holding times.

Laminar flow is best described as the variances in product flow profiles through uniform sized length of piping. Studies by Knudson and Katz in their 1958 involvement with fluid dynamics and by R.Dickerson and A Scalzo (1968) in evaluating residence times of milk products in holding tubes have shown that the central portion, termed the parabola will traverse through the holding tube at sometimes twice the velocity as the surrounding product.

These variances in flow rates were accomplished using trace measurements of radioactive iodine. Using Reynolds number formulation determinations were made to postulate water flow variances at 18% less than average time while milk flow variances were 50% less than average time.

This flow condition is greatly influenced by product viscosity which, unlike water which produces turbulent flow, product will produce a laminar flow in which the maximum velocity is assumed to equal twice the average velocity.

In another study by Jordan and March it was demonstrated that the variance between fastest and slowest particles was as much as 10 seconds in a 15 second holding tube. It is also interesting to point out that among the products tested, skim condensed milk exhibited the shortest residence times, differing from a fully developed laminar flow by only <8%.

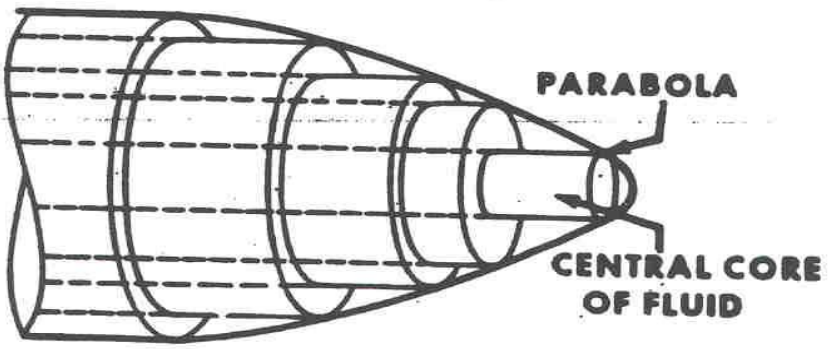


Figure 26
Laminar Flow

For the above reasons the requirement that holding time tests performed on conventional gear driven impeller timing pumps, must be converted to calculated product holding times using water vs. product measured pumping rates. Continuous pasteurizers using homogenizers operating at ≥120% minimum required holding times; and all meter based magnetic flow timing systems are exempt from this calculated holding time requirement.

Laminar flow must be considered when calculating holding tube lengths, and most significantly those used in Ultra High Temperature Pasteurization.

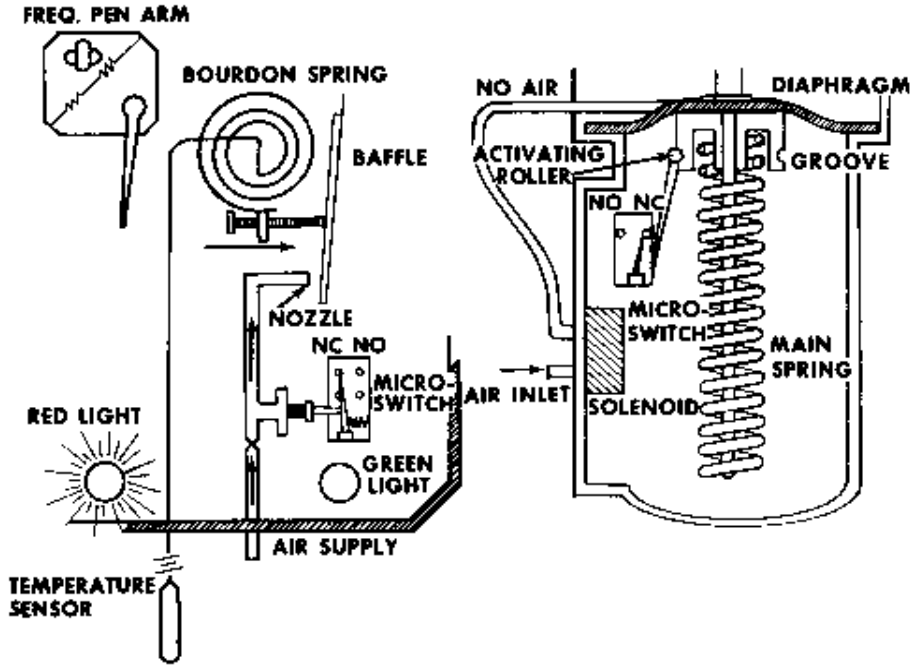
Calculations are made using the following equation:

$$L = 588 \frac{Qt}{D^2}$$

Where,

L = holding tube length
Q = pumping rate(gallons)
t = holding time standard (second)
D = inside diameter of holding tube

DIVERTED FLOW



RECORDER CONTROLLER

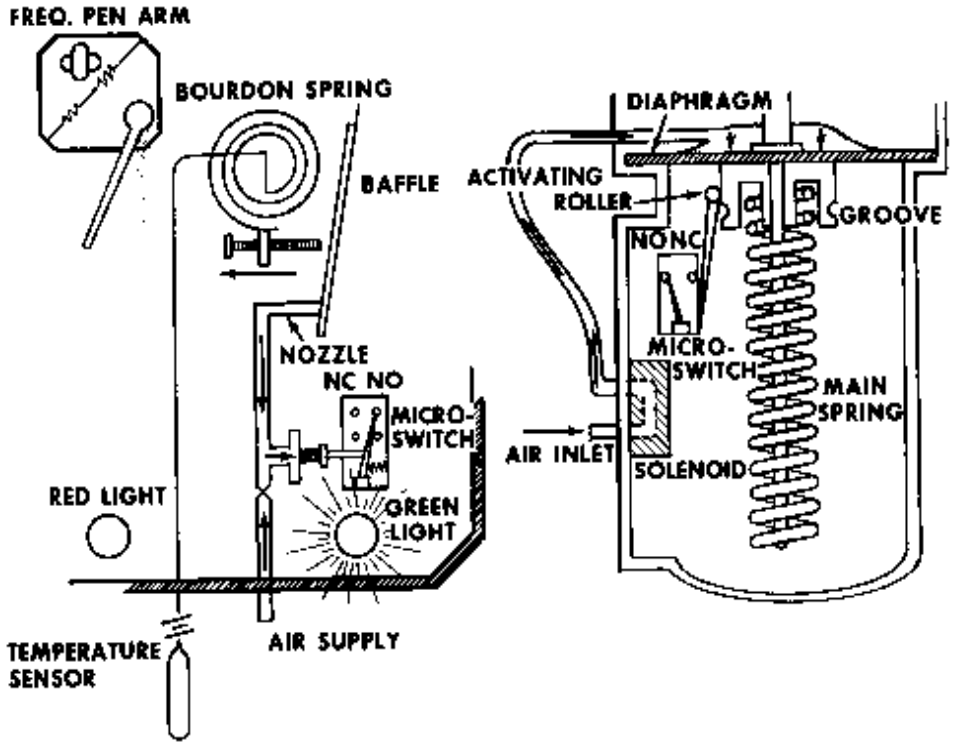
1. MILK TEMPERATURE BELOW CUT-IN SETTING
2. AIR EXPELLED TO WASTE THROUGH NOZZLE
3. MICROSWITCH CONTACT (NC) CLOSED
4. NO CURRENT TO FDV SOLENOID
5. NO DIRECT CONTROL OVER TIMING PUMP
6. NO CURRENT TO FREQUENCY PEN ARM
7. RED LIGHT ON

FLOW DIVERSION DEVICE

1. FDV SOLENOID NOT ENERGIZED
2. MICROSWITCH ROLLER CENTERED IN PUSH PLATE GROOVE
3. MICROSWITCH CONTACT (NC) PROVIDES CURRENT TO TIMING PUMP AND TO RED LIGHT IN CONTROLLER
4. AIR SUPPLY EXHAUSTED THROUGH SOLENOID. NO AIR SUPPLY TO DIAPHRAGM
5. SPRING TENSION KEEPS VALVE PLUNGER AGAINST FORWARD FLOW SEAT

Figure 27
STLR and FDD Function-Divert Flow

FORWARD FLOW



RECORDER CONTROLLER

1. MILK TEMPERATURE AT OR ABOVE CUT-IN SETTING
2. COIL EXPANSION PERMITS BAFFLE TO CLOSE AIR NOZZLE
3. AIR BACK-PRESSURE DRIVES MICROSWITCH CONTACT (NO) INTO CLOSED POSITION, PROVIDING CURRENT TO FDV SOLENOID AND TO TIMING PUMP
4. FREQUENCY PEN ENERGIZED
5. GREEN LIGHT ON

FLOW DIVERSION DEVICE

1. FDV SOLENOID ENERGIZED BY RECORDER CONTROLLER MICROSWITCH
2. AIR SUPPLY PASSES OVER DIAPHRAGM DEPRESSING MAINSPRING
3. MICROSWITCH ROLLER RIDES ABOVE GROOVE
4. MICROSWITCH CONTACT (NO) PROVIDES CURRENT TO FREQUENCY PEN ARM AND TO GREEN LIGHT

Figure 28
STLR and FDD Function-Forward Flow

Basic HTST Pasteurization

CHAPTER REVIEW

Fill in the blanks.

1. H_____ T_____ S_____ T_____.

S_____T_____L_____R_____.

R_____T_____D_____.

D_____R_____T_____.

2. a. Whole Milk _____^{o} F for _____sec

b. Cream _____^{o} F for _____sec

c. Skim _____^{o} F for _____sec

d. Eggnog _____^{o} F for _____sec

3. Trace the basic flow through an HTST pasteurizer by placing the correct numerical in ascending order.

_____Holding tube

_____Heater section

_____Vacuum breaker

_____To filler or storage

_____Cooler section

_____Metering pump

_____Constant level tank

_____Raw side of regenerator

_____Flow diversion device

_____Recording thermometer sensor

_____Pasteurized side of regenerator

_____Indicating thermometer

4. Explain regeneration, as it is normally applied to continuous pasteurization.

5. The official thermometer on any pasteurizer is the _____. The (a) recording, (b) indicating thermometer must be located within (c) 12, (d) 18 inches of the flow diversion device. (Circle the correct choice).

6. What is the purpose of maintaining an upward slope on the holding tube?

7. Where does the timing pump get its power from in diverted flow?

8. Four functions served by the balance tank are:

1._____.

2._____.

3._____.

4._____.

9. Describe the methods of pressure controls utilized on a basic HTST system.

10. What is the purpose of the small drilled hole in the milk to milk regenerator deflector plate(s)??

11. Why are we concerned about holding times for milk when the flow diversion device is in the diverted position?

12. Flow diversion devices are _____activated into forward flow and _____operated to the diverted position.

13. Quick disconnects are allowed only on those flow diversion devices which have the ____ _____ located within the valve bonnet.

14. T or F , The leak detect line requires a sight glass and may or may not have an identifiable restrictor in the line.
15. In a basic HTST system, when are the <u>two</u> times the metering pump is <u>not allowed</u> to operate?

Basic HTST Pasteurization

16. Describe the placement, purpose and function of the atmospheric vacuum breaker in a basic HTST system.

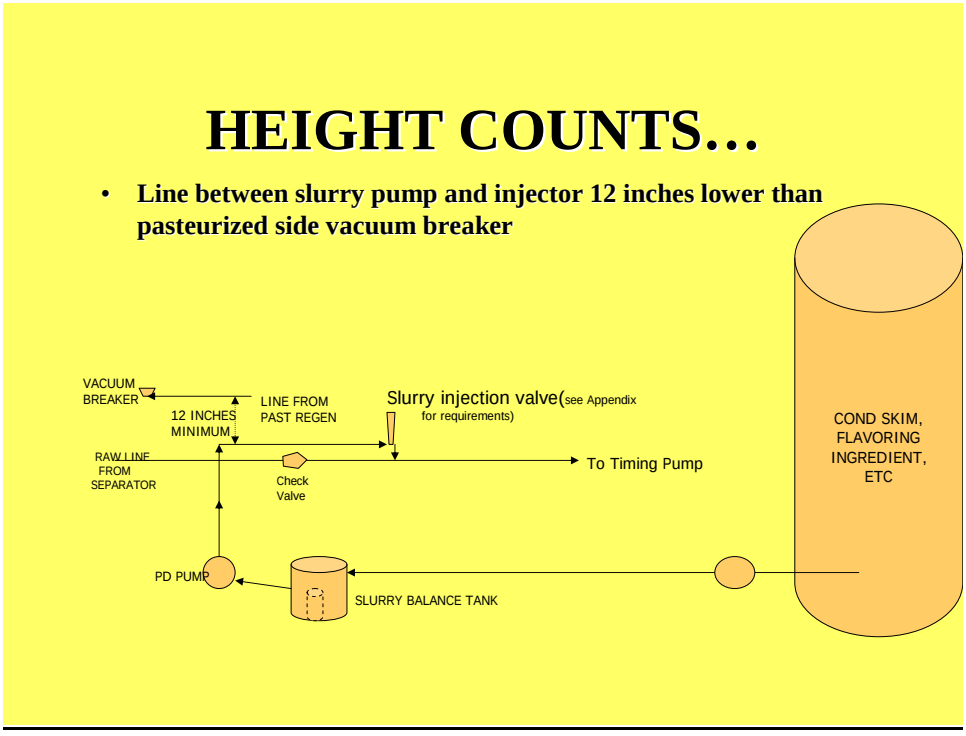
17. Milk is considered pasteurized when:

a. It exits the cooler section of the press
b. It reaches the end of the holding tube
c. Regenerator pressures are maintained in the system by proper placement of the flow promoting components.
d. It exits the forward flow port of the leak detect valve of a dual stem flow diversion device.

Liquid Ingredient Injection Systems

It has become commonplace in the dairy industry to use liquid ingredient injection systems in continuous flow pasteurization systems. Milk flavoring slurries, condensed products, and cream or skim for standardization and similar ingredients may be injected at a point after the last regenerator and before the timing pump if all of the following conditions are met:

1. The slurry injection valve or vales are closed and the slurry pump is de-energized when: (a.) the FDD is in the inspect mode (b). the timing pump is not operating, and (c.) the temperature is below the required pasteurization temperature and the FDD is not in the fully diverted position.



the above represents one way to be in compliance, it does not preclude other methods that may be reviewed and found acceptable

.

2. The slurry injection valve(s) is (are) of the fail-safe type, spring-to-close and air-to-open, and are "block-and-bleed" design with a full port open to the atmosphere between the HTST isolation seat and the slurry pump when slurry is not being injected.

3. The slurry piping between the slurry pump and the injection point may rise to a height that is higher than the overflow level of the slurry supply tank(s) but is at least 30.5 centimeters (12 inches) lower than the required opening to the atmosphere on the pasteurized side.

4. The slurry supply tank has an overflow that is at least twice the diameter of the largest inlet pipe, or all inlet pipes are disconnected and the openings capped during operation of the slurry pump.

5. There is a check valve in the flow stream of the milk line from the last regenerator, typically after the separator, upstream of the injection point valve.

6. If the slurry contains milk and/or milk products, tanks used to blend and hold such slurry shall be completely emptied and cleaned after each four (4) hours of operation or less, unless it shall be stored at a temperature of 7°C (45°F) or less, or at a temperature of 66°C (150°F) or more and be maintained thereat until the time of injection.

7. If computers or programmable controllers are used to provide any of these required functions, they shall meet the applicable portion of Appendix H., V.

8. Appropriate test procedures shall be provided to evaluate the required inter-wiring and function

Chapter IV

Auxiliary Equipment

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Note: The use of trade names or equipment photographs is for training and educational purposes only and does not constitute endorsement by the U.S. Department of Heath and Human Services, Public Health Service, Food and Drug Administration.

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HTST Auxiliary Equipment

DESIGN, INSTALLATION, AND OPERATION OF HTST PASTEURIZATION AUXILIARY EQUIPMENT

PURPOSE: To describe and understand the, function, operation, and requirements for installation of auxiliary equipment within a HTST pasteurization system.

OBJECTIVES: Following completion of this instructional unit the participant will be able to:

①. Describe the operation and function of each of the basic types of auxiliary equipment when installed within the HTST pasteurization system.

②. Describe the requirements and criteria for installation of auxiliary equipment within the HTST pasteurization system.

③. Explain the public health reasons for installation requirements of auxiliary equipment and their relationship to the **time, temperature, and pressure** influences within the HTST pasteurization system.

CRITICAL CONTROL POINTS - AUXILIARY EQUIPMENT

☞ **BOOSTER PUMP**

- LOCATION
- WIRING
- CONTROLS
- SENSOR LOCATION
- REGEN BY-PASS
  - CLOSE COUPLED
  - ALLOWS REGEN DRAINAGE ON SHUT-DOWN

☞ **HOMOGENIZER**

- LOCATION
- FLOW PROMOTION?
- BY-PASS LINE SIZE AND RESTRICTIONS

___ **SEPARATOR**

- LOCATION
- VALVED-OUT AS REQUIRED

___ **STUFFER/FEED/PRODUCT PUMPS**

- PROPERLY WIRED

⇨ **VACUUM CHAMBERS**

- LOCATION
- CONTROLS IN PLACE
- STEAM IN COMPLIANCE

HTST Auxiliary Equipment

I. INTRODUCTION

A. Auxiliary Equipment

Various product treatments, in addition to the basic HTST pasteurization, can readily be incorporated into the HTST system. The following are examples of some of the auxiliary equipment that may be added to these basic systems:

1. Homogenizers

2. Separators and Clarifiers

3. Auxiliary raw product pumps (Booster Pumps, Stuffer Pumps)

4. Flavor control equipment (Vacuum-Heat)

B. Basic Installation Criteria

When any of this equipment is added to an HTST system it must be designed,

a. Will **not reduce the holding time** below the legal minimum.

b. Will **not interfere with the proper pressure relationships** within the milk to milk regenerator section.

c. Will **not** adversely affect the minimum **required product temperature,** the **proper operation of the flow diversion device** nor the functions of the **recorder controller**.

II. **HOMOGENIZERS AND SEPARATORS**

A. **Homogenizers**

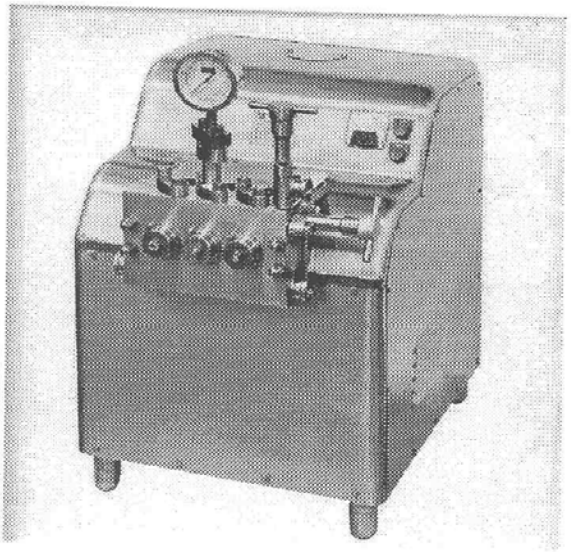
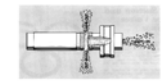


Figure 29
Two Stage Homogenizer



Figure
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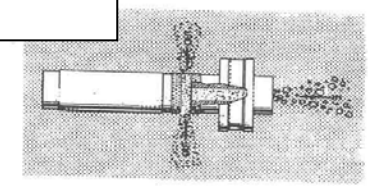
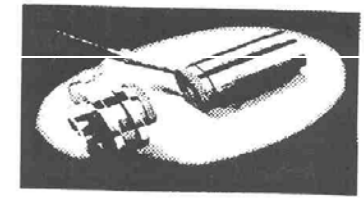


THEORY OF HOMOGENIZATION
CHERRY-BURRELL



HOMOGENIZING VALVE PLUG AND SEAT
WITH REPLACEABLE VALVE CAPS
CHERRY-BURRELL

Figure 29
Two Stage Homogenizer

HTST Auxiliary Equipment

1. **Definition** - Homogenization is the process of reducing the fat globule size to such an extent that after 48 hours of storage no visible separation will occur. The fat content also must not differ by more than 10% throughout the product. This process is accomplished by forcing whole milk through small openings at extremely high pressures.

Homogenizer Operation

The homogenizer is a piston type pump utilizing usually three or five pistons driven by a crankshaft. The sanitary stainless steel head contains the suction and discharge valves and the homogenizing valve or valves. In the orifice type of homogenization system the pistons force product through a small orifice or tightly woven stainless steel valve. This is accomplished under high pressure which "sheers" the fat globules into minute particles. Fat globules are squeezed through a valve under pressure which elongates the globules and accelerates their movement. This helps attain a uniform product. Homogenizers are capable of producing great pressures for the homogenization of milk and milk products usually in the range of 1200 to 3000 psi.

Homogenizers are available using either a one or two stage homogenizer valve. The average size of a fat globule is around four (4) microns. Most homogenizers accomplish a 10:1 micron reduction in size when properly operated.

Homogenization also requires the fat to have been warmed to a liquid or oil phase.

Homogenizers are sometimes of the belt driven variable pulley type, and two speed motors are not uncommon. Since it is veritably impossible to synchronize two positive pumps, measures must be taken to assure proper operation of homogenizers installed in systems using gear driven timing pumps.

2. Application in the HTST system - Homogenizers are always considered as positive displacement pumpsd or flow promoting devices, therefore consideration must be given to their placement in the system.

3. **The regulatory controls necessary for homogenizers are as follows**.

a. When installed on the raw side of the HTST system, the homogenizer must be designed, installed and operated as a non-flow promoting device, **unless used as the timing pump.** *Figure 31* shows the homogenizer installed with a non-restricted recirculation line (5), with an optional by-pass line (4) used when homogenization is not desired.

b. *Figure 32* shows the homogenizer installed after the heating section. A one way sanitary check valve may be installed in the recirculating line (5) to prevent non-homogenization. In this installation the homogenizer is of larger capacity than the timing pump.

c. When the homogenizer is of smaller capacity than the timing pump, as is *Figure 33,* then a pressure relief valve and relief line must be installed at the inlet of the homogenizer to allow product to return to the balance tank in those instances when the system supplies more product to the homogenizer than it can normally handle. The pressure relief valve is installed at a pre-set value and releases (opens) under conditions when product flows are in excess of homogenizer capacities.

d. Homogenizers may be installed in conjunction with conventional timing pumps when it is desired to process homogenized milk and use the homogenizer as the timing pump as is *Figure 34*. In these systems the homogenizer by-pass line (4) must be equipped either with pinned manual valves or positive fail safe air operated shut-off valves. This method prevents slippage by either device which could result in sub-legally timed product. In these systems both the homogenizer and the timing pump must be sealed at the fastest speed and both are considered as legal timing pumps.

HTST Auxiliary Equipment

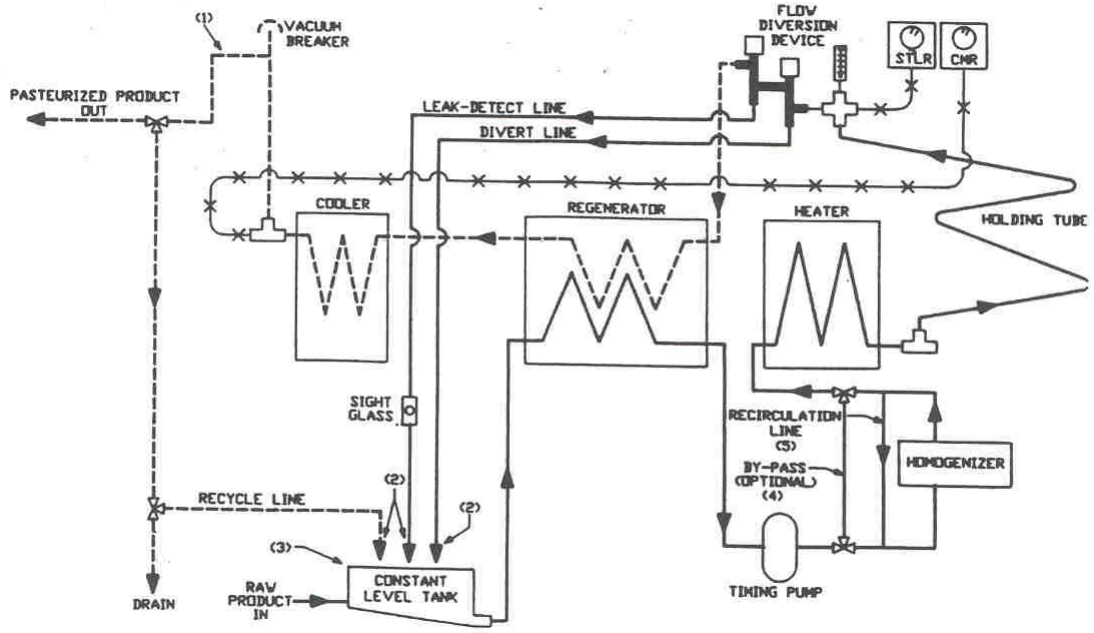


Fig. 31 Homogenizer as a Non-Flow Promoter (1) THIS LINE MUST BE A MINIMUM OF 12 INCHES ABOVE ANY RAW MILK IN THE SYSTEM. (2) ALL DIVERT, LEAK DETECTION, AND RECYCLE LINES WHICH RETURN TO THE BALANCE TANK MUST BREAK TO ATMOSPHERE AT LEAST TWO PIPE DIAMETERS ABOVE THE OVERFLOW LEVEL. (3) THE OVERFLOW LEVEL OF THE BALANCE TANK MUST BE LOWER THAN THE LOWEST RAW MILK IN THE RAW REGENERATOR.

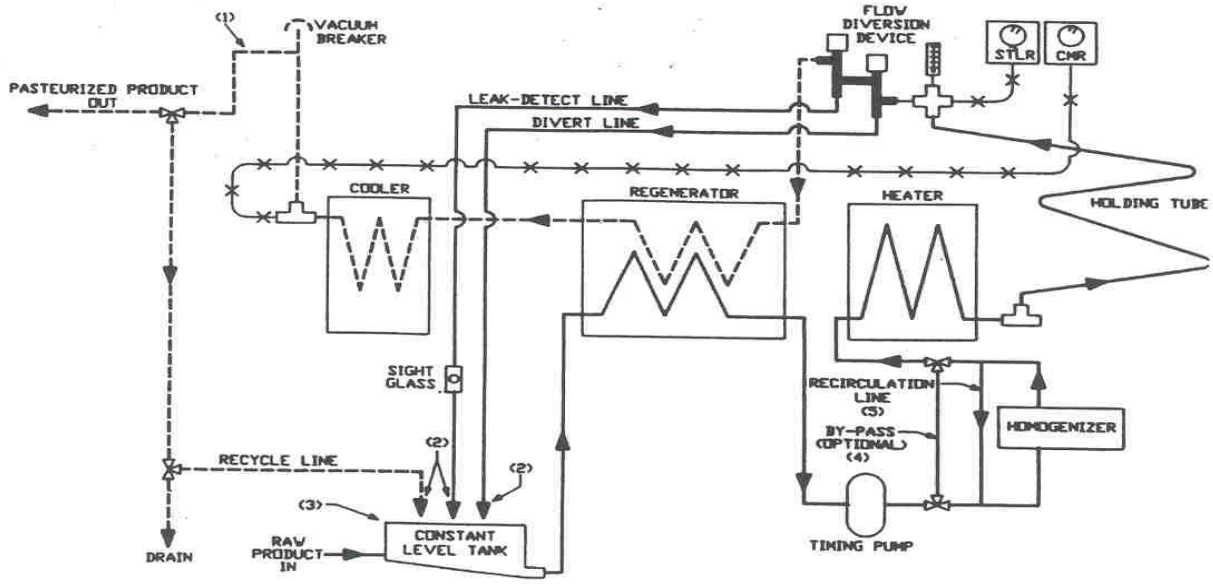


Fig. 32 Homogenizer as Non-Flow Promoter Downstream from Heater Section (1) THIS LINE SHALL BE HORIZONTAL AT LEAST 12 INCHES ABOVE ANY RAW PIPING IN THE SYSTEM (2) ALL DIVERT, LEAK DETECTION AND RECYCLE LINES WHICH RETURN TO THE CONSTANT LEVEL TANK MUST BREAK TO ATMOSPHERE AT LEAST TWO PIPE DIAMETERS 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 (5) REQUIRED WHEN HOMOGENIZER HAS GREATER CAPACITY THAN THE TIMING PUMP.

ANY OTHER OMBINATIONS OR MODIFICATIONS WHICH ARE INSTALLED AND OPERATED IN ACCORDANCE WITH THE DETAILED PROVISIONS OF THESE PRACTICES, MAY BE UTILIZED

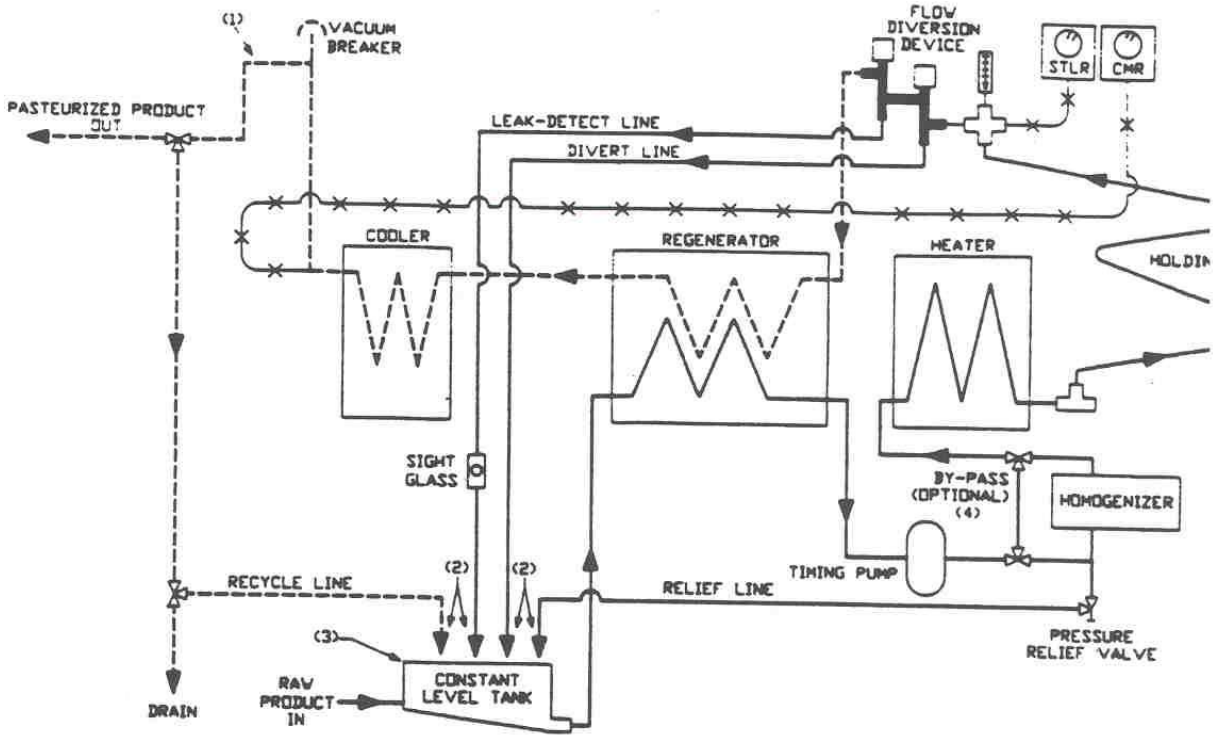


Figure 33 Homogenizer of smaller capacity than the Timing Pump

(1) This line shall be horizontal at least 12 inches above any raw piping in HTST 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. (4) if by pass valves are used, they must be pinned to prevent improper positioning ANY OTHER COMBINATIONS OR MODIFICATIONS WHICH ARE INSTALLED AND OPERATED IN ACCORDANCE WITH THE DETAILED PROVISIONS OF THESE PRACTICES, MAY BE UTILIZED.

HTST Auxiliary Equipment

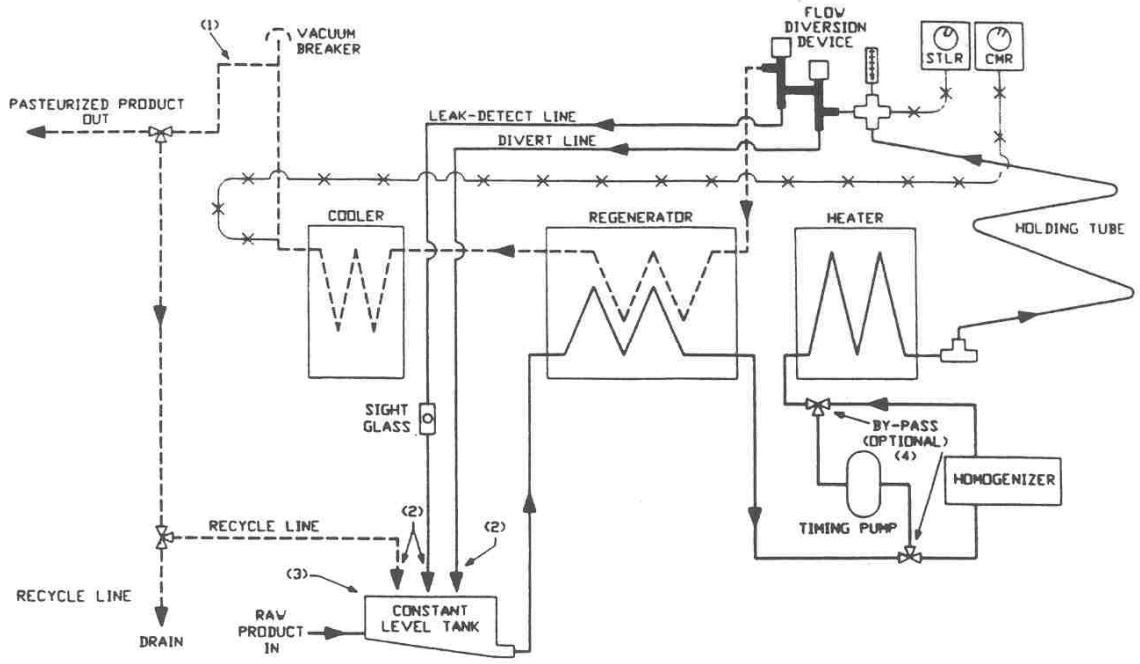
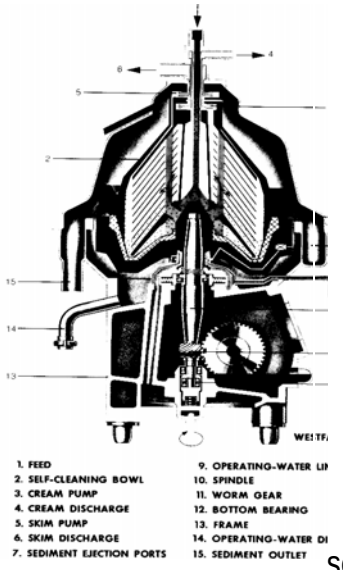


Figure 34
Homo used as Timing Pump when Homogenization is desired

Separators

1. Definition - Separation of whole milk is used for the partial or complete removal of milk fat particles (cream) from the product. This process is accomplished by exposing the whole milk to a centrifugal force through a series of high speed rotating discs or plates.

2. Application - Whole milk enters the separator, it is accelerated to high speeds. The plates within larger separators rotate at speeds from 4500 - 5500 rpm. During this "centrifugation" process the heaver skim portion is forced to the outside and out one exit (the skim line) and the lighter cream moves inward toward the center and exits through a separate cream line.



There are two types of separators presently in use in the milk processing industry. These are:

(a) earlier style manually cleaned smaller capacity units, and
(b) the larger capacity CIP cleanable, automatically de-sludging higher efficiency units.

3. The regulatory concerns for clarifiers and both types of separators are essentially identical. The importance of evaluating separators in HTST systems are for the following reasons:

a) They are highly efficient pumps or flow promoters, and
b) They alter the flow of product through removal from the system by removing a portion of the higher fat product.

Separators located on the raw side of the pasteurizer must be located prior to the timing pump and must be **automatically valved out of the system during periods of loss of power or shut down, or when the FDD control panel selector switch is moved to the INSPECT position.** (Remember that cream separated on the raw side must be immediately cooled and re-pasteurized at minimum product standard temperatures prior to final packaging.)

If the raw cream is processed at temperatures of 125^{o} F - 160^{o} F and subsequently bulk shipped, the product must then be classified as "heat treated cream" and must meet the current labeling, temperature and sampling requirements.

Separators located between two milk to milk regenerators on the raw side must meet all requirements of a booster pump, for example, they must be interwired with the flow diversion device, the timing pump, and a pressure differential controller device. This also applies to the stuffer pump if located in the same position. The reason for this is obvious. During divert or shutdown the separator and/or stuffer pump could continue to pump milk into the raw side of the regenerator causing possible contamination of raw milk into the pasteurized milk side. Also, should the timing pump suddenly lose power the separator assembly could continue to act as the timing device in the system.

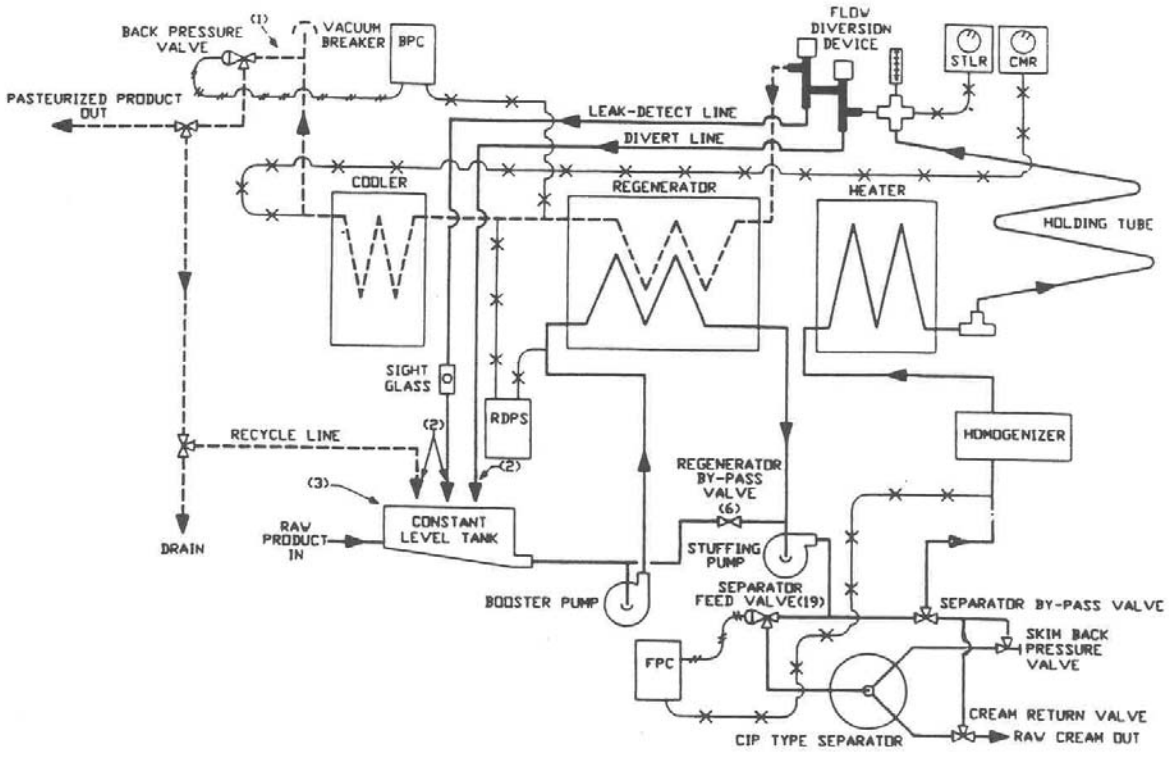


Figure 36
HTST with Booster Pump, Stuffing Pump, Raw Separation

4. Separators located on the pasteurized side of the system must be automatically valved out of the system during periods of **diverted flow and loss of power or shut down** and when the FDD control panel selector switch is moved to the **INSPECT** position. This helps assure proper pressure relationships in the regenerator, and prevents negative pressure on the forward flow port of the FDD.

Separators located on the pasteurized side are usually placed after the pasteurized regenerator for functional purposes. In these cases, a vacuum breaker and fail safe positive shut off valve must be installed. This vacuum breaker must meet the 12" height requirement. Cream from separators located in this position is legally classified as pasteurized cream and does not require re-pasteurization if packaged as either a standardized product (blended with other pasteurized products to formulate low fat milk, etc) or as a defined cream product.

If the separator is located between two split milk to milk regenerators on the pasteurized side, a second vacuum breaker is necessary between the separator outlet and the entrance to the pasteurized regenerator. This vacuum breaker serves the purpose of protecting the pasteurized regenerator, in case the positive valving out system leaks or fails, preventing negative pressure from being applied on the pasteurized regenerator. Also during normal operation, and forward flow this vacuum breaker would protect the pasteurized regenerator during the automatic separator desludging process.
Note: The above vacuum breakers are necessary in addition to the vacuum breaker located after the pasteurized regenerator

If the cream from a pasteurized side separator is returned to be precooled in a regenerator using raw milk on the opposite side of the plates then an additional vacuum breaker is required between the beginning of the cream line and the entrance to this regenerator.

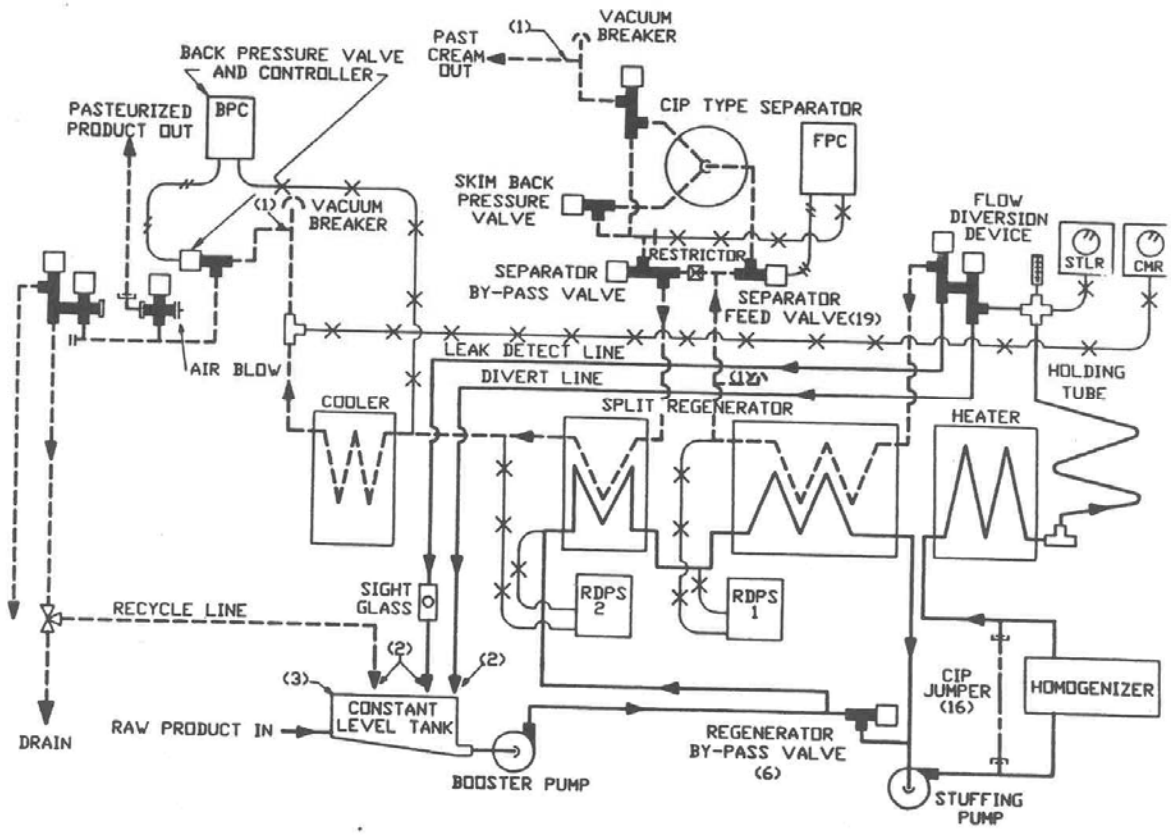


Figure 37
HTST with Booster Pump, Stuffer, and Pasteurized Separator

III. AUXILIARY RAW PRODUCT PUMPS

CENTRIFUGAL SANITARY PUMPS

Centrifugal sanitary pumps are usually direct motor driven and their pumping capacity varies with; (1) motor and impeller size, and (2) amount of back or downstream pressure. The pump will not be damaged by closing off of the discharge. Their maximum pumping pressure may be lessened by shortening of the impeller, or through the use of slower speed electric motors.

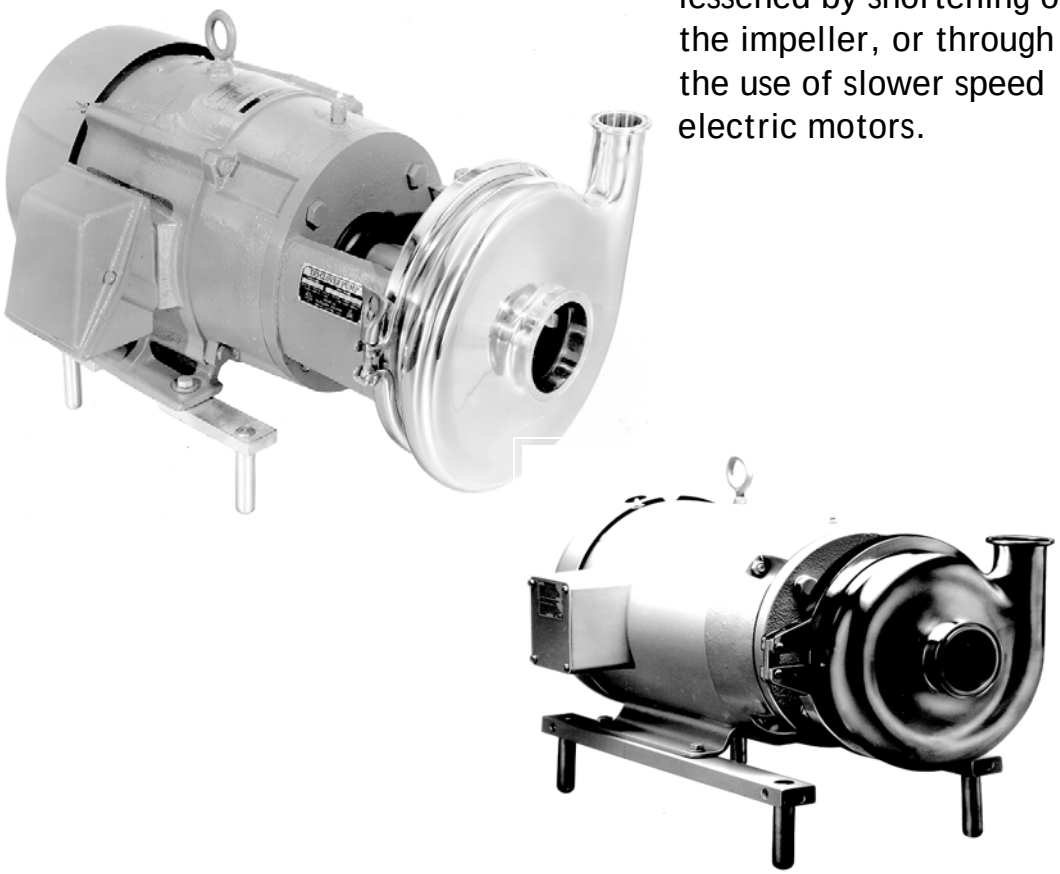


Figure 38
Centrifugal Pumps

High speed (3600 rpm) motors are frequently used in clean-up operations. Since extended back pressures on centrifugal pumps can damage the pump motor, high speed motors which can produce greater pressures are not usually used as booster pumps, however two speed pumps may be used as dual purpose booster and CIP pumps. In these cases an electrical interlock is used to prevent the high speed motor winding from being used during processing operations.

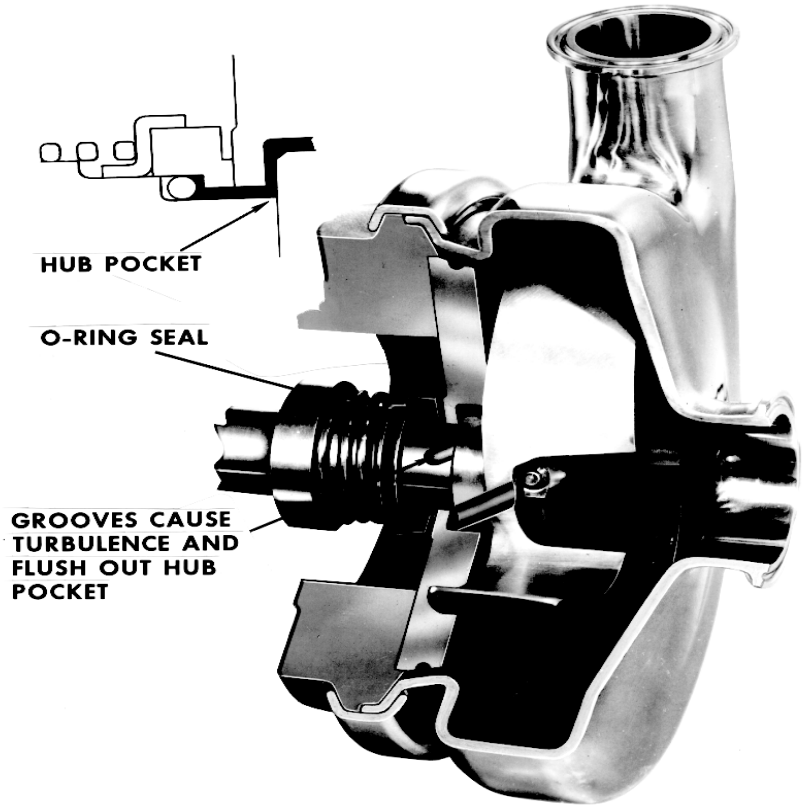


Figure 39
Centrifugal Pump Interior

HTST Auxiliary Equipment

BOOSTER PUMPS

A. Introduction

A booster pump may be installed in continuous pasteurizer systems under certain closely controlled conditions. Booster pumps serve several functions in modern HTST systems including:

1) Assist the timing pump in moving raw milk from the balance tank to the raw regenerator,

2) provides pressure to the homogenizer when the homogenizer serves as the timing pump,

3) increases regenerator efficiency,

4) reduces excessive vacuum and the associated "flashing " of raw milk in the regenerator, and

5) must always be of the centrifugal design.

B. Installation Requirements

1. Booster pumps may be installed between the balance tank and the raw regenerator and **may operate only when ALL of the following conditions are met;**

✓ The booster pump is interwired with the timing pump and can only operate when the **timing pump is running.**

✓ The booster pump is interwired with the flow diversion valve and can only operate when the **valve is in forward flow**.

✓ The booster pump must be wired through an automatic pressure control device that will only permit the booster pump to operate when **the pressure in the pasteurized side of the regenerator exceeds by at least 1 pound per square inch the pressure generated by the booster pump**. This pressure control device must be set and sealed at the required differential values by the regulatory agency. Testing of the differential pressure controllers will be discussed later in the testing section of this manual.

2. **REGENERATOR PRESSURE CONTROLLERS**

a). The **differential pressure controller is the most commonly used booster pump controller**. **Both capillary and electronically operated pressure differential controllers are available**.
The mechanical capillary type controllers provide a visual indication of both the raw and pasteurized pressure within the regenerator, while maintaining the correct pressure relationship. The electronic controllers display the differential set point and a continuous reading of the system differential pressure.

The differential pressure controller utilizes two sanitary pressure sensors. The raw sensor is located between the discharge side of the booster pump and the entrance to the raw regenerator and the pasteurized sensor is located at the outlet of the pasteurized regenerator. The controller is interwired with the booster pump and permits it's operation only when the pre-set pressure differential is satisfied.

3. **Stuffer, product and feeder pumps-**

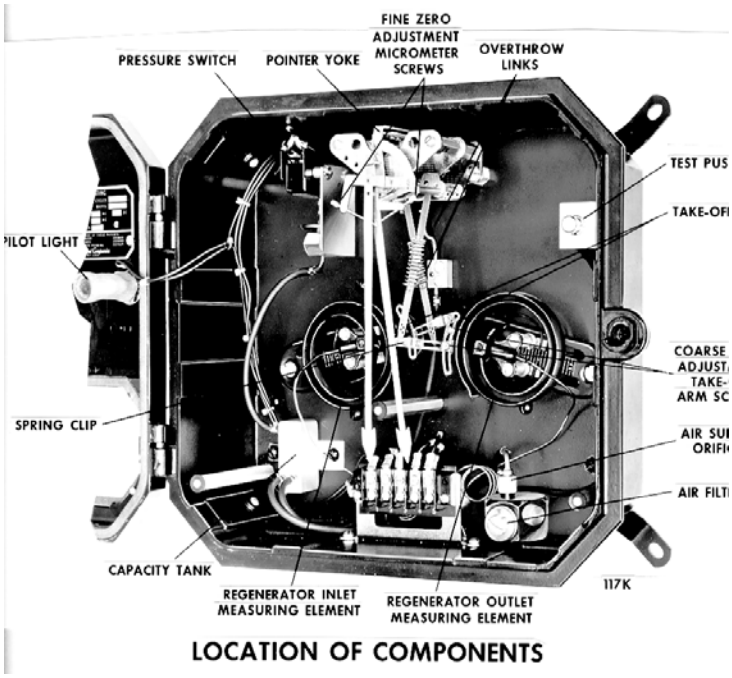
This is the term used for centrifugal pumps placed elsewhere in the system to either feed (stuff") or remove product from processing auxiliary components. The use of stuffer pumps are common to feed product to separators, vacuum chambers and homogenizers in most pasteurization systems. In the magnetic flow timing systems, centrifugal pumps are used as the timing pump.(Meter based timing systems are discussed in detail in a later chaper).

It is very common to see stuffer pumps feeding product to homogenizers used as timing pumps. **In this installations, the stuffer must always be interwired with the homogenizer to prohibit operation unless the homogenizer is operating. In fact, all flow promoters in the HTST system are only allowed to operate in conjunction with the timing pump.**

Product removal pumps (or tail pumps) are used to remove product from flavor enhancing equipment (vacuum chambers). The only difference between any of the above uses of these pumps and booster pumps is their **location in the system.**

Remember, a centrifugal pump placed between the raw milk balance tank and the raw milk inlet to the milk to milk regenerator is always considered as booster pump even though it may appear identical to other centrifugal pumps in the pasteurization system.

The following illustrations depict two of the more common type of booster pump differential controllers. These pressure differential controllers (PDC's) are interwired to provide constant control over the booster pump and deactivate the booster pump immediately should regenerator pressures approach the 1 psi required differential.



LOCATION OF COMPONENTS

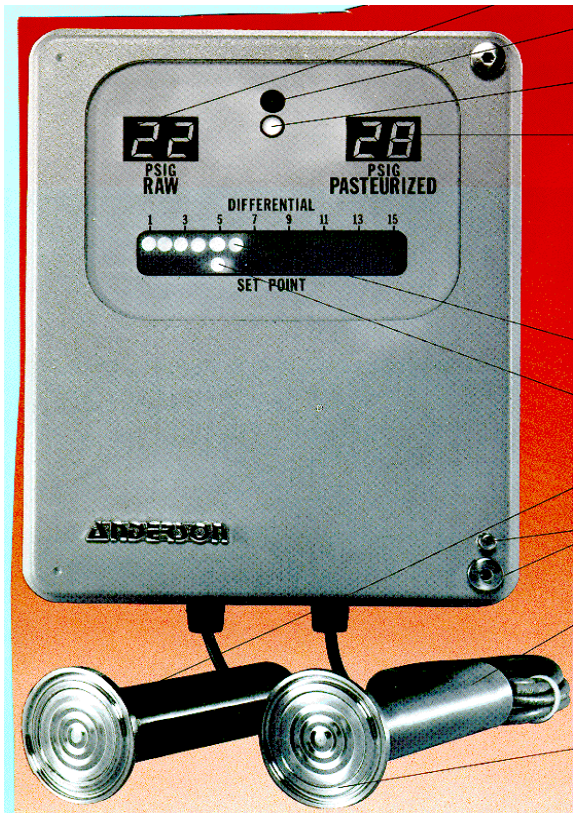


Figure 40 Booster Pump Controls

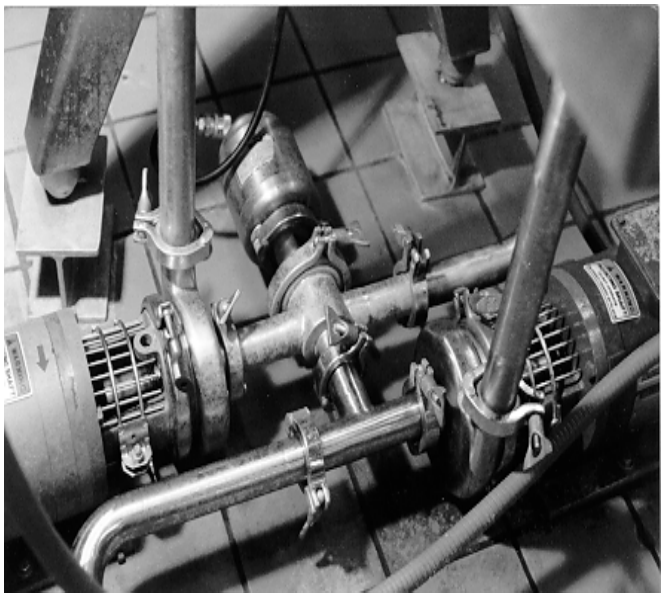
b). One of the early methods of booster pump controls included a combination **sanitary pressure gage and switch.** This gage/switch is installed at the exit to the pasteurized regenerator. The switch must be set and sealed at a pressure at least 2 pounds greater than the maximum pressure generated by the booster pump. A major problem with these type controls is inability to constantly monitor/control pressures within the raw side of the regenerator. An accurate sanitary pressure gauge was also required between the booster pump and the raw regenerator. **Few, if any, of these type controls exist in milk plants today.**

3. **Regenerator by-pass lines.**

These configurations are commonly used to aid during start-up of modern high capacity HTST systems. Their purpose is to allow the pasteurized side of the milk-to-milk regenerator to become**"pressurized"** while in forward flow which allows the booster pump to be energized.

These lines and the associated valves allow cold raw product from the balance tank to by-pass the raw regenerator and feed directly to the timing pump. Often when the homogenizer is used as the timing pump, a centrifugal stuffing pump will feed the inlet side of the homogenizer. The by-pass line valves may be automatically or manually controlled. This line is not used when the booster pump is in operation.

The by-pass line and valves must be designed, installed and operated to **prevent product from being trapped in the dead-ended\blocked line for extended periods of time**. This may be achieved by **having the line and valve close-coupled or by having the valve designed to permit a small amount of product to flow through the line** during normal product runs in forward flow. Other effective systems may also be used.



Close coupled booster pump bypass (booster at left, stuffing pump at right)

When an **automatic back pressure control device** is installed prior to the vacuum breaker, it must be installed in a manner (preferably after the vacuum breaker) that will not interfere with the proper pressure relationship within the regenerator during periods of shut-down or loss or power.

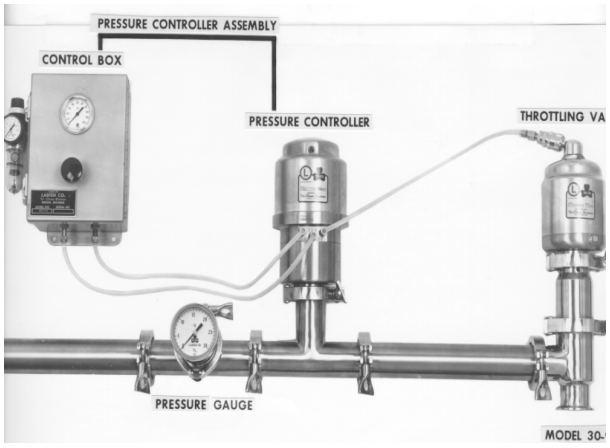
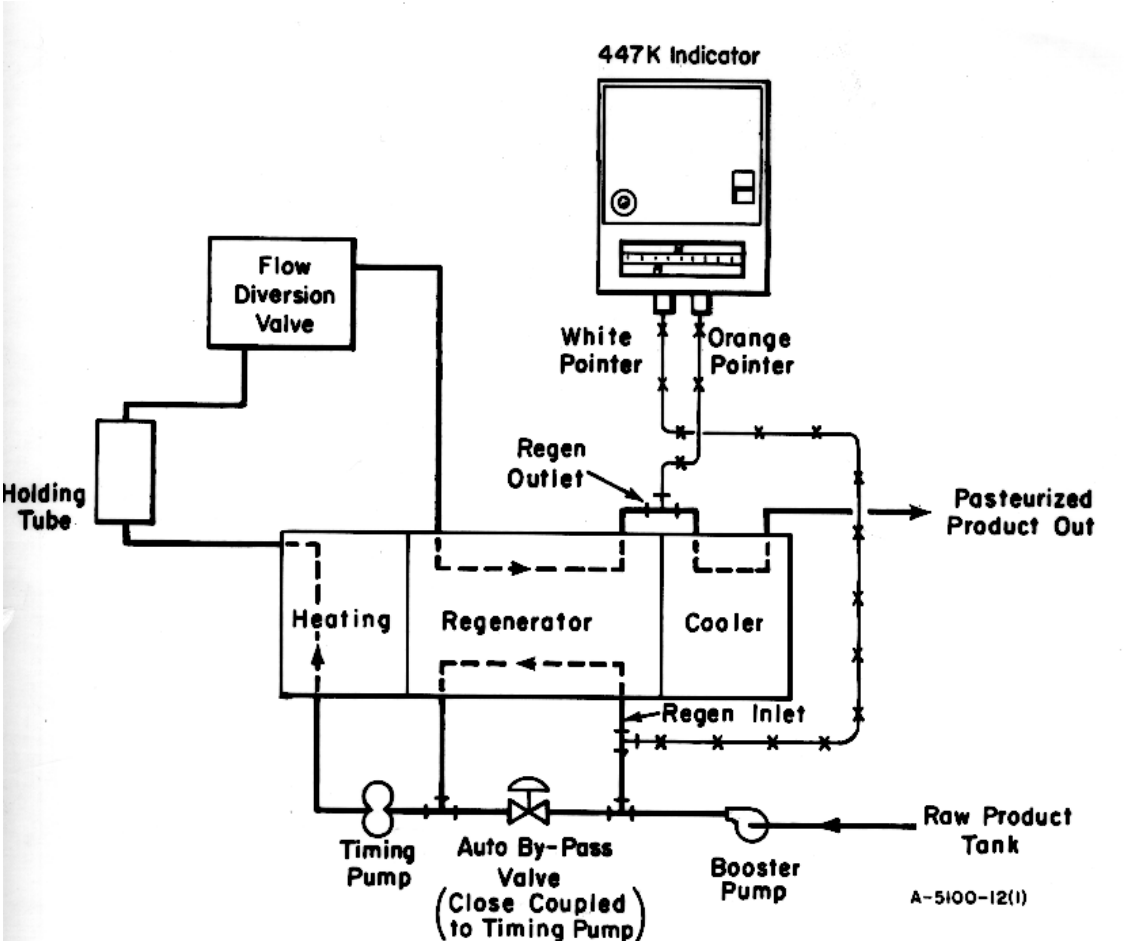


Figure 41
Automatic Pasteurized Regenerator Back Pressure Assembly

HTST Auxiliary Equipment

The following picture illustrates the correct method for installation of a regenerator by-pass in a HTST system showing a booster and a stuffer pump.



Note that the by-pass valve is installed as air-to-close/ spring-to-open, which helps assure raw regenerator drainage back to the constant level tank in case of system shut-down.

Figure 42
Regenerator By-Pass Assembly, Showing Booster Pump, Stuffer, and By-Pass Coupling

<u>Combination systems</u>.

The following systems are provided to show necessary placement of auxiliary equipment and the controls necessary to meet the requirements of the *Ordinance.*

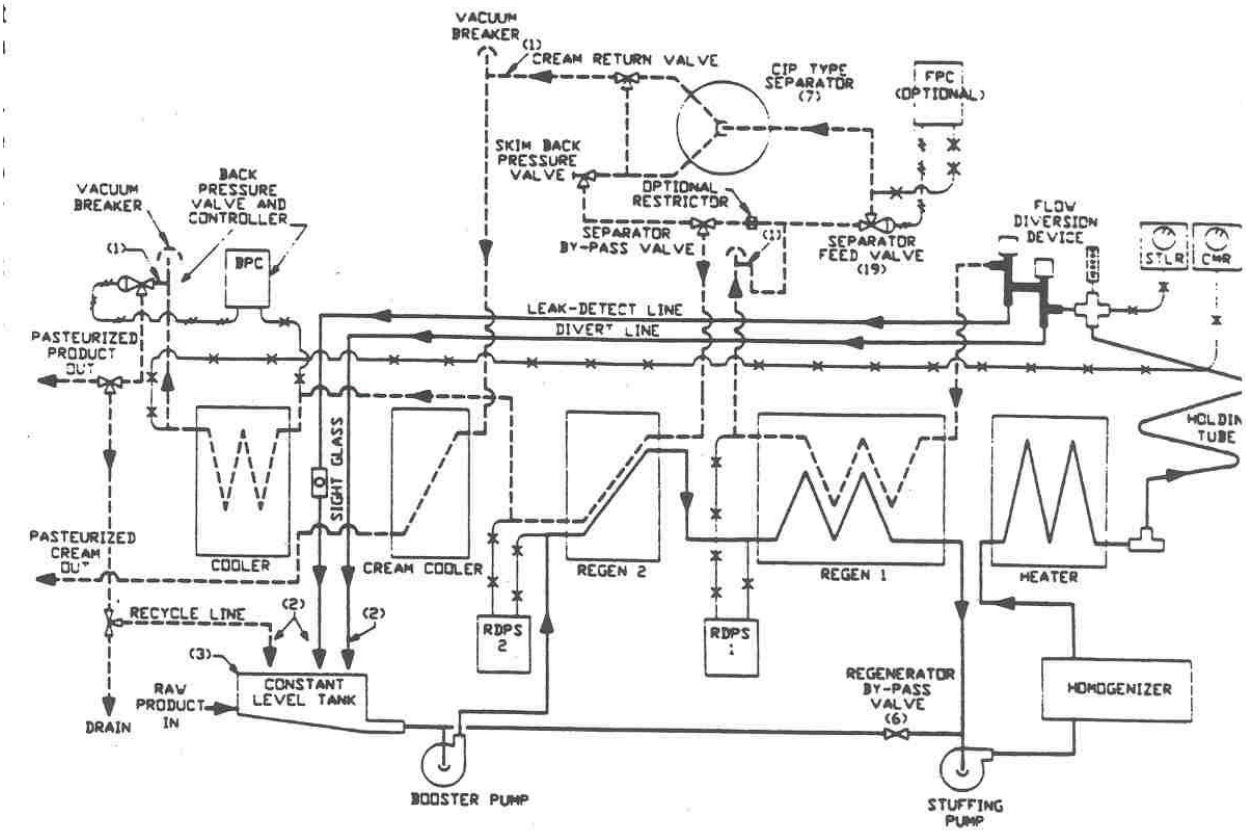


Fig 43, HTST with booster pump, homo timing pump and separator between two pasteurized regenerators, with cream cooler.

(1) This line shall be horizontal at least 12 inches above any raw piping in HTST 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. (4) regenerator by pass valves must be installed to be drainable, and must prevent dead ends, or be drilled. A drilled check valve may be used between inlets of booster pump and timing pump. Air operated valves must be normally open, automatically operated and controlled to open if timing pump stops. (5) when separator or clarifier is an integral part of the HTST or HHST system and is located upstream of the timing pump or downstream of the flow diversion device , it shall be automatically valved out of the system with fail safe valves properly interwired with the timing pump. ANY OTHER COMBINATIONS OR MODIFICATIONS WHICH ARE INSTALLED AND OPERATED IN ACCORDANCE WITH THE DETAILED PROVISIONS OF THESE PRACTICES, MAY BE UTILIZED.

HTST Auxiliary Equipment

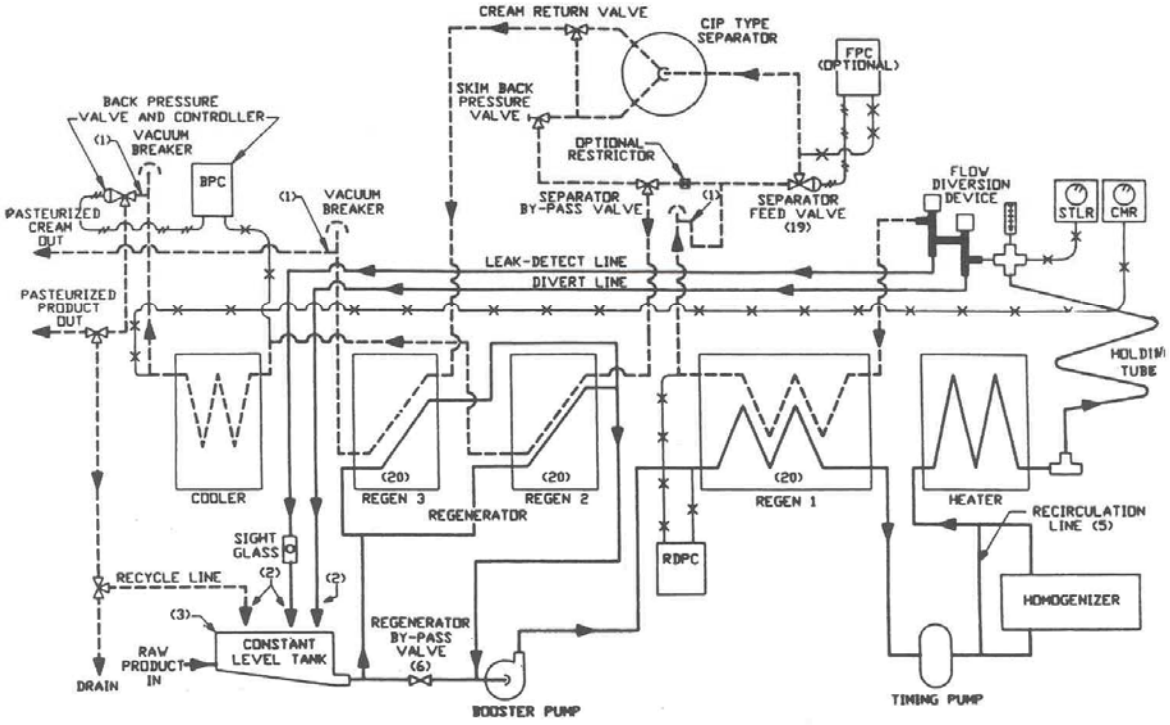
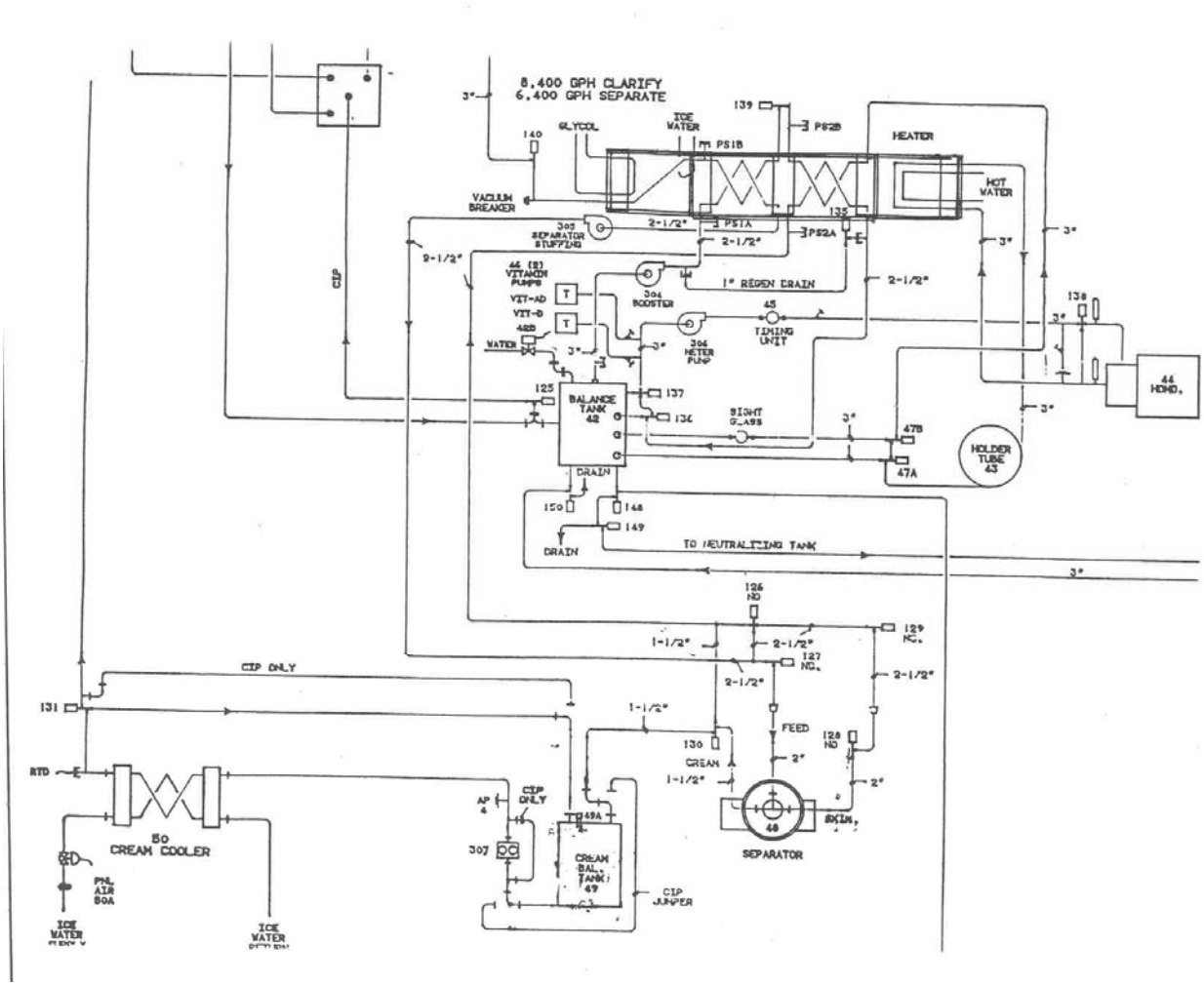
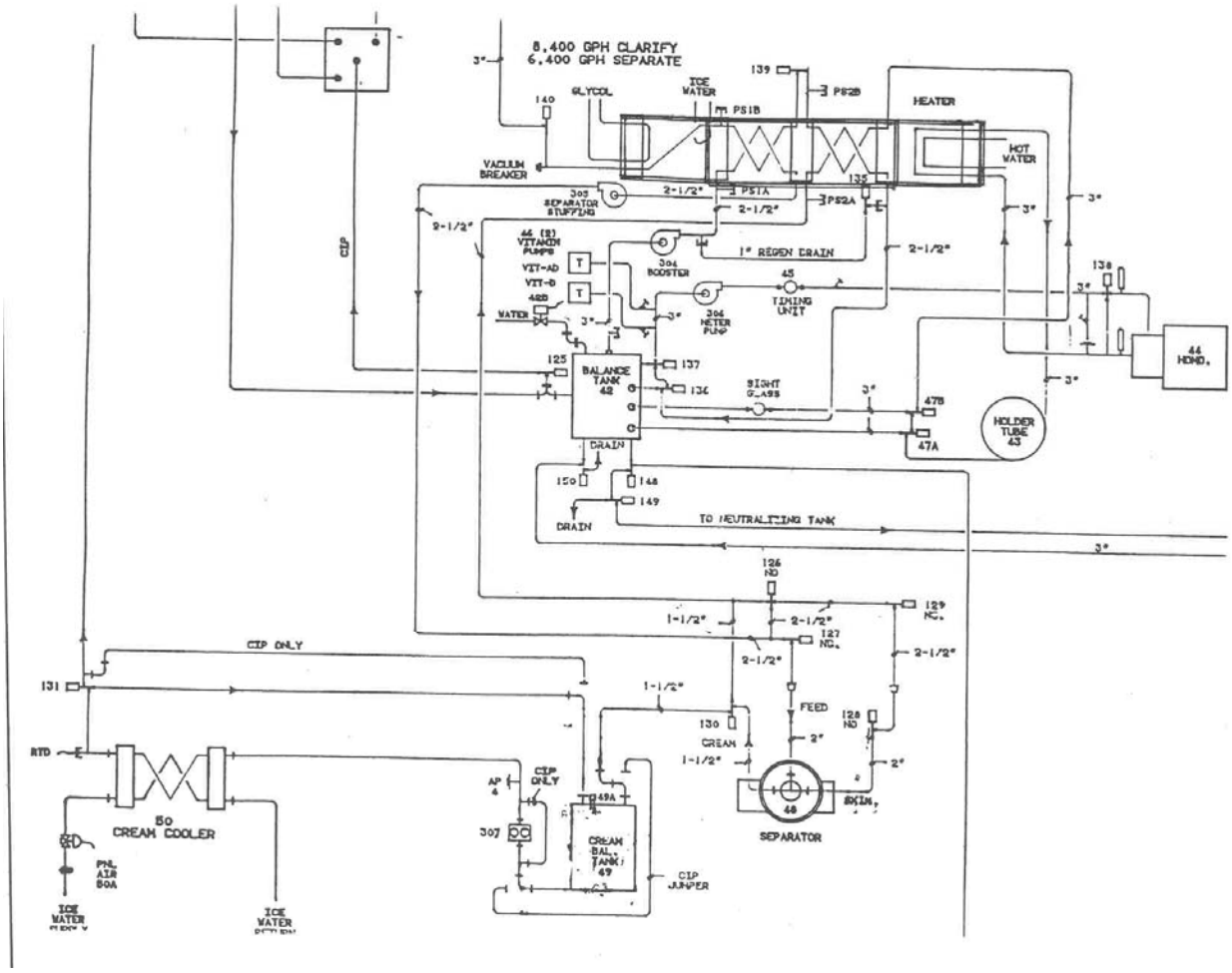


Figure 44 : HTST with vacuum raw milk regenerators, pasteurized separator between two pasteurized regenerators

HTST Auxiliary Equipment




8,400 GPH CLARIFY
6,400 GPH SEPARATE
3"
139
140
GLYCOL
ICE WATER
PS2B
HEATER
HOT WATER
VACUUM BREAKER
305 SEPARATOR STUFFING
2-1/2"
PS1A
PS2A
135
3"
CIP
44 (B) VITAMIN PUMPS
VIT-AD
VIT-B
48B
WATER
304 BOOSTER
1" REGEN DRAIN
45 TIMING UNIT
304 METER PUMP
138
44 HOMO.
125
BALANCE TANK 42
137
136
SIGHT GLASS
47B
47A
HOLDER TUBE 43
DRAIN
150
148
149
TO NEUTRALIZING TANK
126 ND
129 NC.
127 NC.
CIP ONLY
131
1-1/2"
FEED
130
CREAM
128 ND
RTD
50 CREAM COOLER
AP 4
307
49A
CREAM BAL. TANK 49
CIP JUMPER
46 SEPARATOR
SKIM.
PNL AIR 80A
ICE WATER

HTST Auxiliary Equipment

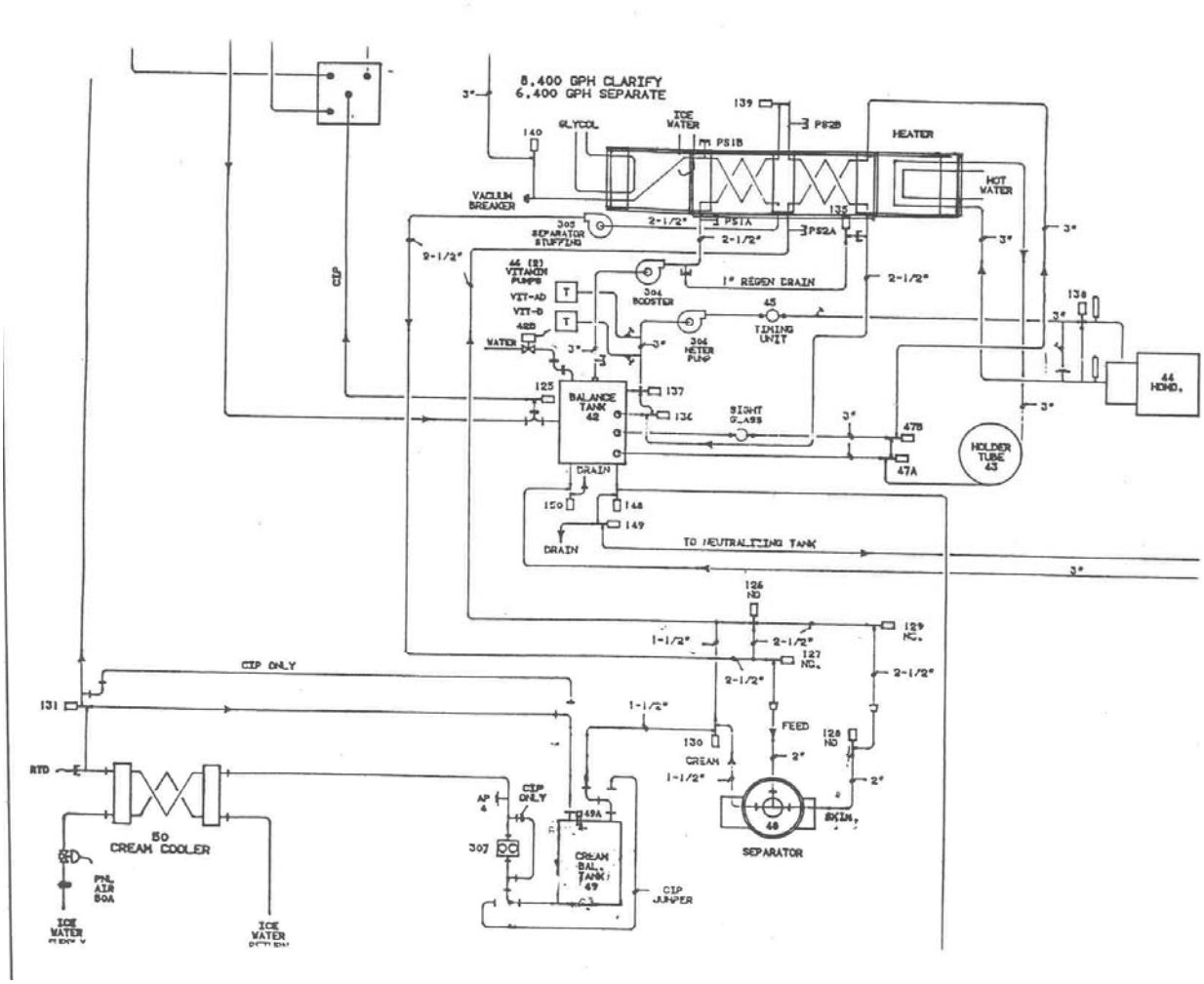


Figure 45: Separator on raw side between split regenerators

B: Types of Systems:

1. Single chamber vacuum sytem with no adition of steam, installed upstream of the heater section.

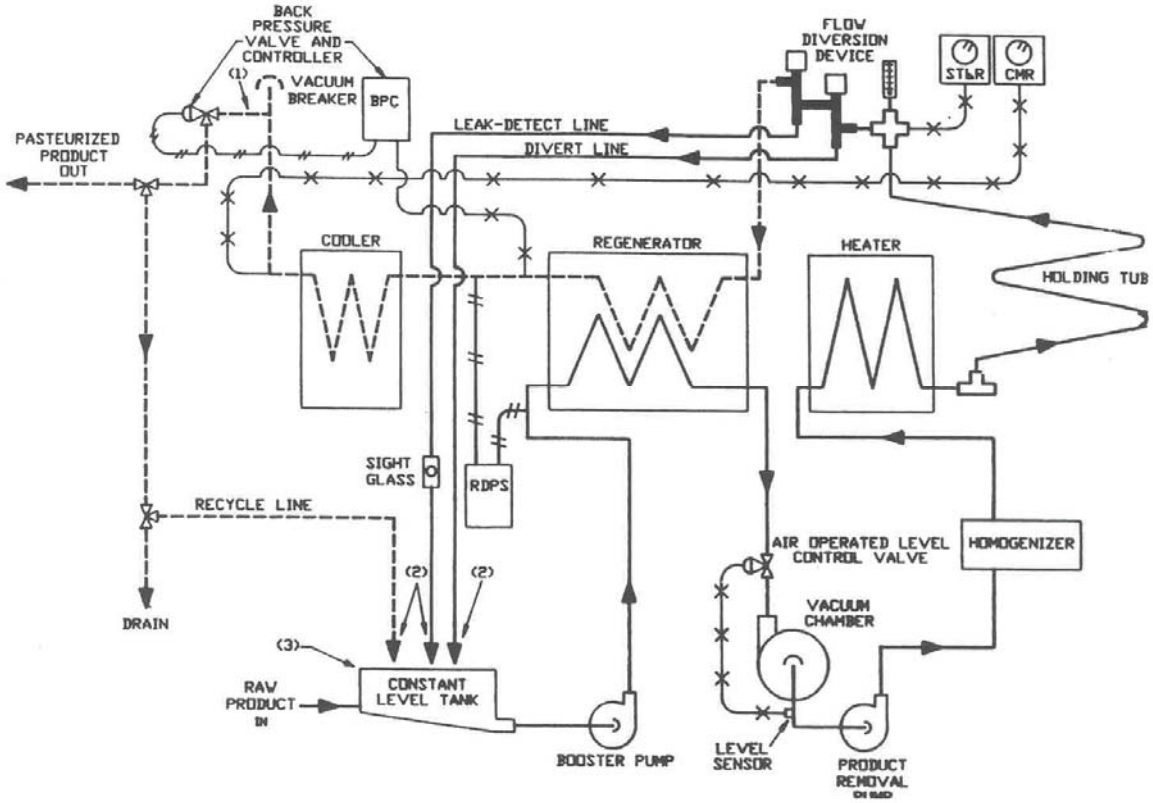


Figure 46: Vacuum chamber on raw side with no steam addition

HTST Auxiliary Equipment

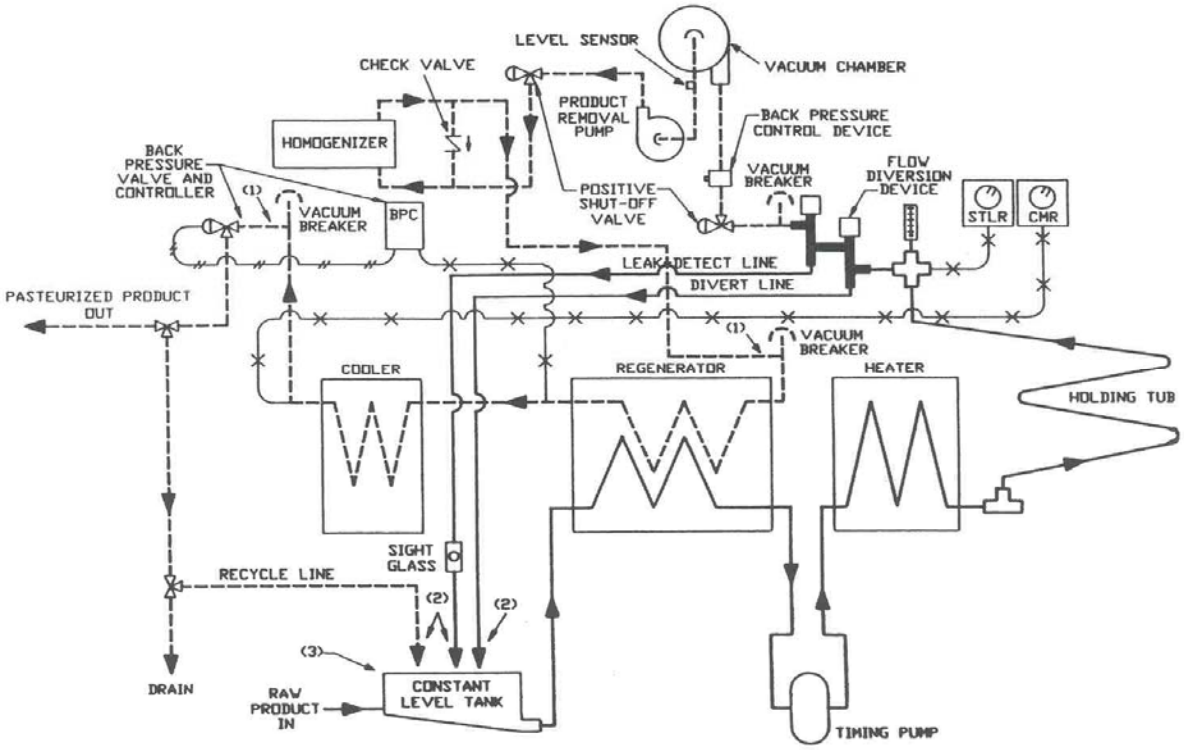


Figure 47: HTST with vacuum system located downstream from flow diversion device (no steam added)

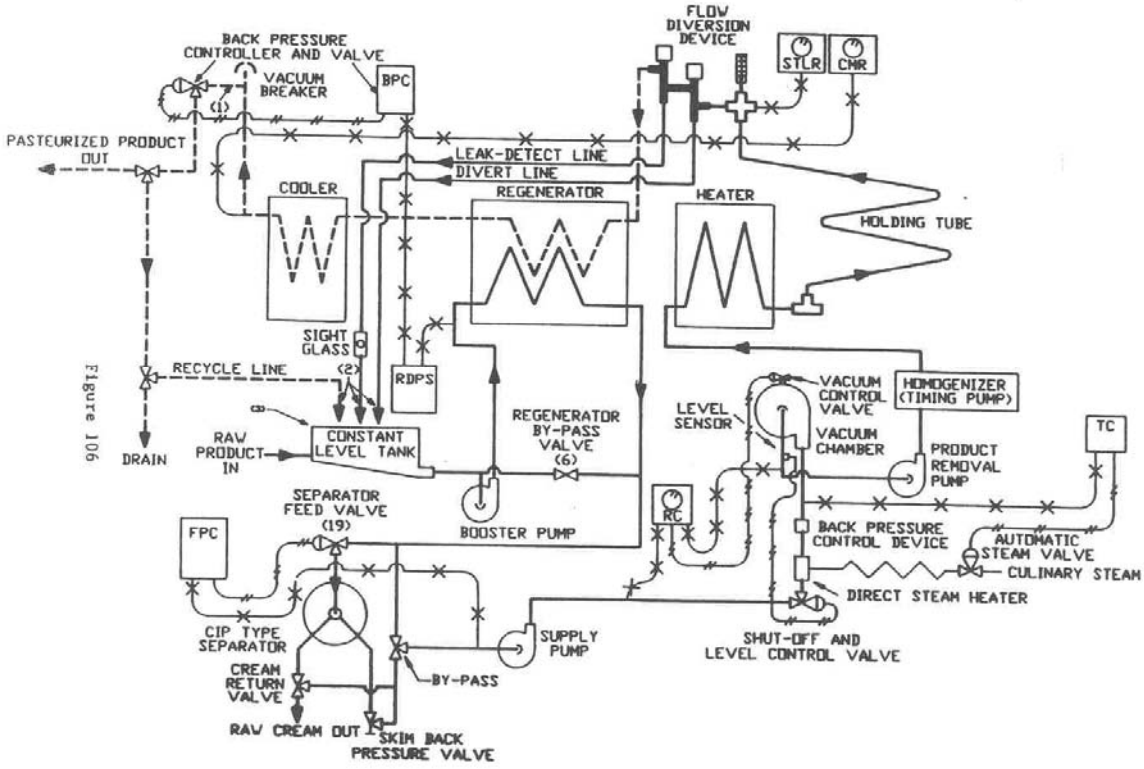


Figure 48: HTST system with raw separation and vacuum chamber with direct addition of steam

HTST Auxiliary Equipment

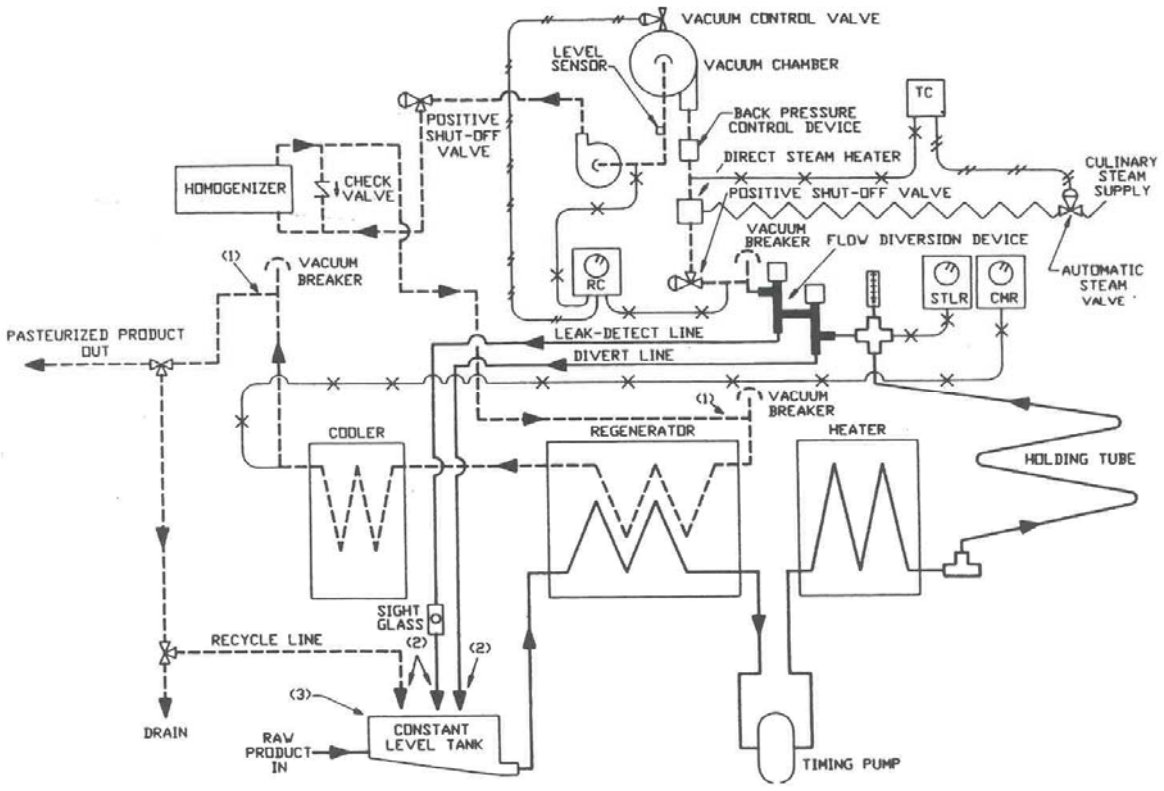


Figure 49: HTST with vacuum system downstream from flow diversion device and direct addition of steam

IV. **FLAVOR CONTROL EQUIPMENT**

A. **General Information**

Flavor control equipment which can include vacuum and vacuum/steam systems may be installed in HTST pasteurization systems if **ALL** the following conditions are met.

The equipment does not:

1. Interfere with the operation of the flow diversion device.

2. Adversely affect the proper pressure relationships in the regenerator section of the press.

3. Reduce the holding time below the legal minimum.

4. Contaminate the product with toxic or other deleterious material from the steam.

5. Add water to the finished product.

C: Requirements:

1. When vacuum equipment is located **downstream from the flow diversion device** an effective means of preventing negative pressure between the forward flow port of the flow diversion device and the inlet to the vacuum chamber is required. This is especially significant during periods of diverted flow or shutdown.

This is accomplished by installing directly downstream from the flow diversion device, and prior to entrance into the vacuum chamber an **effective vacuum breaker plus an automatic fail-save**

positive spring loaded, air operated, shut-off valve. This vacuum breaker does not have a height requirement and must be installed in the piping prior to the installation of the positive shut-off valve, i.e., flow diversion valve ⇨ vacuum breaker ➔ positive shut-off valve ➔ vacuum chamber….

2. Also, when vacuum equipment is located downstream from the flow diversion device, means shall be provided to prevent the lowering of the pasteurized milk level in the milk to milk regenerator during periods of diverted flow or shutdown.

This is accomplished by the installation of an **automatic check valve or positive type shut-off valve (as above) and an effective vacuum breaker.** This vacuum breaker shall be installed after the positive shut-off valve in the line between the outlet of the vacuum chamber and the inlet to the pasteurized regenerator. **This vacuum breaker must be installed so that the milk rises at least 12 inches above any raw milk in the system,and at that point be open to the atmosphere i.e.,** vacuum chamber > positive shut-off valve > vacuum breaker.> entrance to pasteurize regenerator….

Note: The effectiveness of this system shall be evaluated by disconnecting the milk inlets to the the vacuum system (with maximum vacuum) and while the system is in diverted flow and inspect the piping to the vacuum system for negative pressure.

3. When vacuum equipment is located downstream from the flow diversion device, the holding time shall be tested with the timing pump operating at maximum capacity and the vacuum equipment operating at maximum vacuum.

4. When culinary steam is introduced into the product downstream from the flow diversion device, means shall be provided to **prevent the addition of steam** unless the flow diversion device is in the **forward-flow position**. This shall include an **automatic steam control valve** with a temperature sensor located downstream from the steam inlet, or an **automatic solenoid shut-off valve** installed in the culinary steam line. These controls must be wired through

the flow diversion device so as to **stop the introduction of steam when the flow diversion device moves to the diverted flow position or during periods of loss of power or shut-down**.

5. Steam used in contact with product shall be of culinary quality. **Only those boiler compounds** that comply with 21 CFR Part 173.310 "Boiler Water Additives," shall be used.

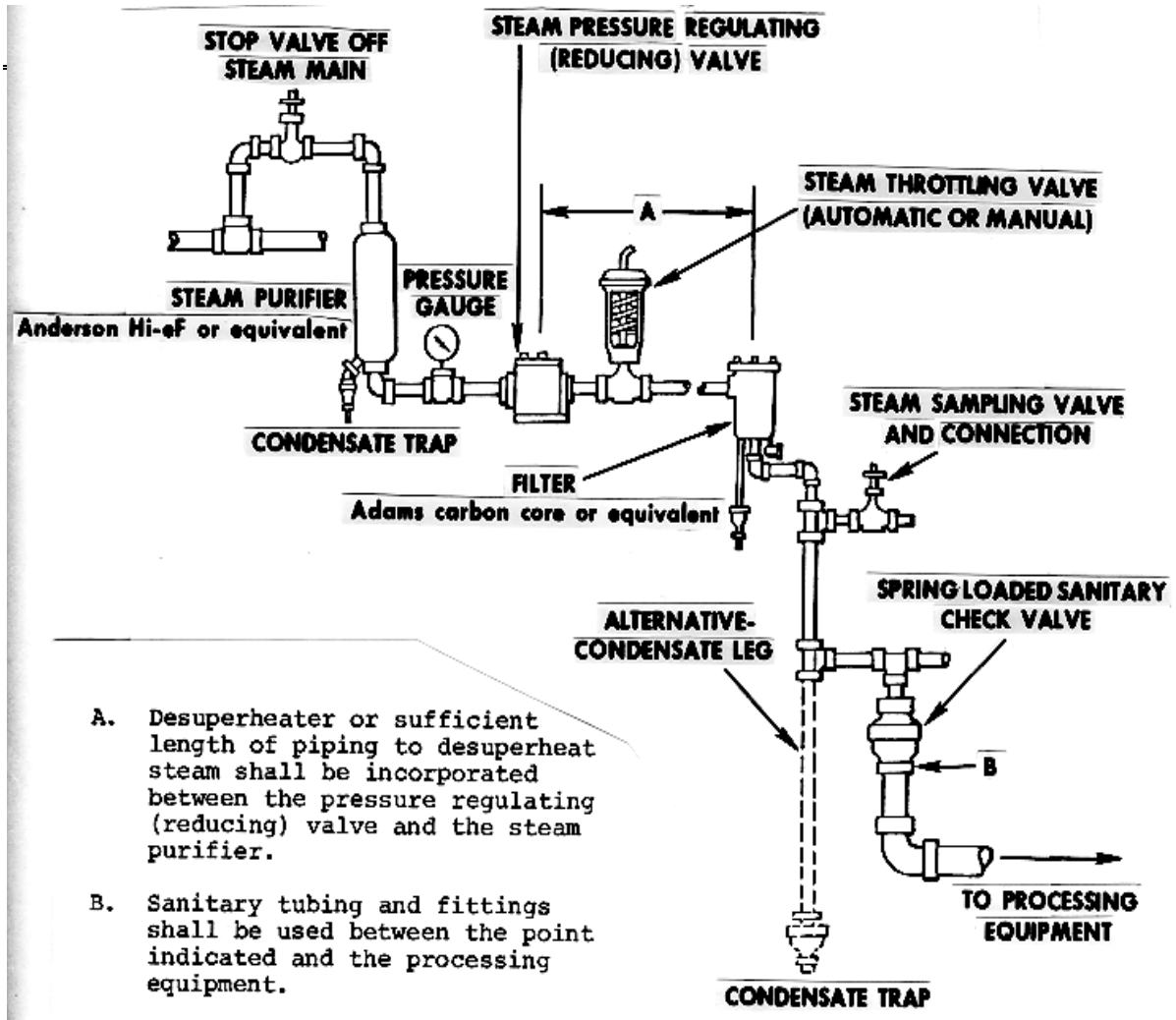


Figure 50
Culinary Steam Piping Assembly for Direct Addition to Milk

6. When a water feed line is connected to a direct water-vapor vacuum condenser, supplementary means shall be provided to **preclude the back-up and overflow of water and/or condensate from the vacuum chamber into the product vacuum chamber** in the event of condensate pump failure or power failure. Such means shall include the use of;

a. An **automatic shut-off valve** installed in the water feed line, coupled with;

b. A high **level sensing device installed in the condenser** which would shut-off the condensing water, if the water or the condensate rises above a predetermined level in the condenser.

This valve may be water, air, or electrically operated and must be designed so as to cut off the flow of water into the vacuum pan in the event of power failure.

7. When culinary steam is introduced directly into the product, automatic means shall be provided to **maintain a proper temperature differential between incoming and outgoing product to preclude product dilution** and to assure original product composition. Such means may include:

An automatic ratio controller which;

a) Senses the **temperature** of the product at the outlet of the flow diversion device (prior to the addition of culinary steam) and either in the vacuum chamber or at its exit. This will depend upon the most effective point to measure the results of evaporative cooling, and

b) automatically **adjusts the operating vacuum** in the vacuum chamber so as to assure the removal, by evaporative cooling, of all water added in the form of steam, or,

c) any other system which will automatically preclude adulteration.

The optimum temperature differential between the incoming and outgoing product shall be determined for each HTST and normal raw milk supply by means of a Majonnier, or substantially equivalent total solids determination (by trail and error), Such temperature differential shall be set on the ratio controller. Ideally the product should exit the vacuum chamber at the same temperature of the product entering the chamber , less any radiant temperature loss in the chamber and appurtenances.

An air-operated pressure switch, installed in the air control line between the ratio controller and the vacuum regulator, or the steam valve adjust the amount of steam into the product when the operating vacuum in the vacuum chamber is insufficient to prevent product dilution.

Note: Steam injection/infusion as applied to HHST and UHT systems will be discussed in Chapter VI of this manual.

CHAPTER REVIEW

1. The primary difference between a booster and stuffer pump is

_____

2. The conditions which must be met before the booster pump may operate are:

a)

b)

c)

3. Homogenizers are always considered to be flow promoting devices unless a _____ _____ is installed between the _____ and _____ of the homogenizer. The size requirements of this line is:_____ __.

4. T F HTST systems will contain either a booster pump or a stuffer pump, but never both.

5. T F Homogenizers, when used as the metering pump, may have a recirculating line if it has a one way check valve.

6. The separator must be automatically valved out of the system under which conditions if installed on the:

a) Raw side:
   1.
   2.
   3.
b) Pasteurized side:
   1.
   2.

3.

7. Describe the controls necessary for vacuum chambers (without steam injection or infusion) under the following conditions:

a) vacuum chamber located on the raw side of the system .

b) vacuum chamber located downstream from the flow diversion device.

8.Which arm (needle) on the Taylor Pressure Differential Controllers #117K and 447K Model A, represents pasteurized regenerator pressure?_____. For operational (scale calibration) purposes pressure differentials on these instruments are usually set at a minimum of _____pounds.

9. Which statement is most accurate about differential pressure controllers.

a. Controls the pressures within the milk to milk regenerator
b. Operates only in forward flow.
c. Is interwired with the timing pump
d. Shuts off the booster pump when the pre-set differential is not met.

10. What is the purpose of a Ratio Controller?

11. What boiler additives may be used in milk processes using direct steam contact with milk product?

13. Explain why raw milk separators must be installed prior to the timing pump._____
_____
_____
_____.

14. Describe installation and operation of differential pressure controller sensors.

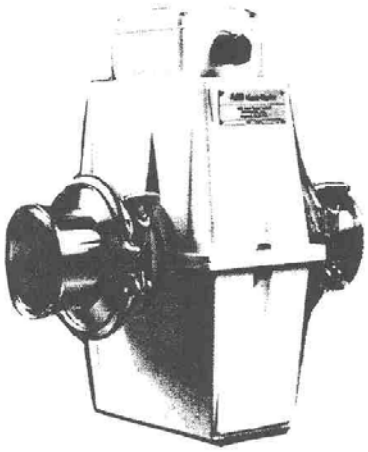
OPERATING CONDITION	TIMING PUMP	BOOSTER PUMP	HOMO-GENIZER	STUFFER PUMP	FDD	SEPARATOR		VACUUM SYSTEM	
						Raw	Past	Raw	Past
DIVERT									
POWER FAILURE									
INSPECT									
CIP									
FDD NOT PROPERLY SEATED									

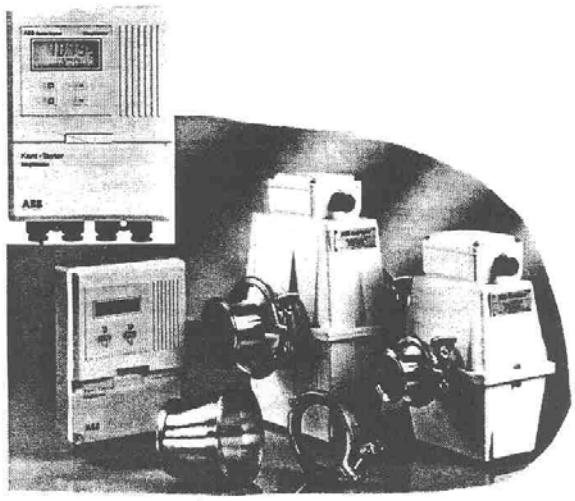
Comments:

Figure 51
Operation Condition Exercise

Chapter V

METER BASED TIMING SYSTEMS





MAGNETIC FLOW METERS

PURPOSE: To describe the purpose of using a magnetic flow meter in a HTST pasteurization system, including, function, operation, and installation requirements.

OBJECTIVES:

- To understand the principles, function, and purpose of using a magnetic flow meter in an HTST pasteurization system.

- To become familiar with the public health controls and installation requirements of meter based systems as they relate to **time, temperature, and pressure,** relationships within the HTST pasteurization system.

- To become familiar with the required HTST tests for systems using magnetic flow meters within the system as a replacement for the conventional timing pump.

I. BACKGROUND AND THEORY

Early in 1980 the first **meter based system** was submitted for compliance review to the FDA's Milk Safety Branch. The proposal was for the use of a magnetic flow based system to be used **in lieu of the conventional timing pump in HTST systems.**

These systems presented a radical departure from conventional HTST systems, therefore the first installations in dairy plants were under close surveillance by the regulatory authorities. Initially, these systems were limited to use with non-regenerator systems processing milk products with a viscosity no greater than whole milk.

Meter based systems are based on the principles of **electromagnetic induction** first reported by Michael Faraday in 1839. Systems based on these theories were first applied in industrial use in the early 1950's.

The theoretical basis of a meter based system can be stated as follows:

a). A conducting fluid passing at right angles through a magnetic field induces a voltage across the conductor. This theory may be calculated using the following formula;

$$E_g = Bvd$$

where: E_g = generated signal
B = magnetic flux density
v = velocity
d = distance between electrodes

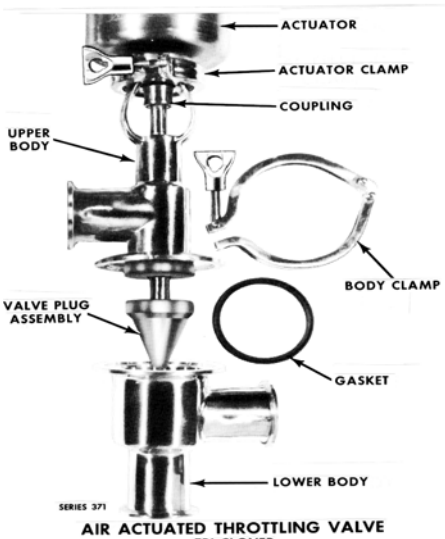
b). The electric voltage signal generated is directly proportional to the velocity of the conducting product. This signal is detected by the 316 SS or equivalent electrodes (sensors) installed within the internal pipe of the flow meter {installed vertical}.

c). This alternating signal is relayed to the electronic components of the meter based system. These components are comprised of an **electrical transmitter**, a **transducer (converts an electronic signal to a pressure value), a flow recorder-controller.**

d). The product velocity is controlled by either a **flow control valve** or an **AC drive variable speed centrifugal product pump**.

e). These components receive the generated signal from the magnetic flow meter, process the information, and **control the flow of the product through the system.**

On the following page illustrations of both a magnetic flow meter aow control or throttling valve used in milk systems is provided.



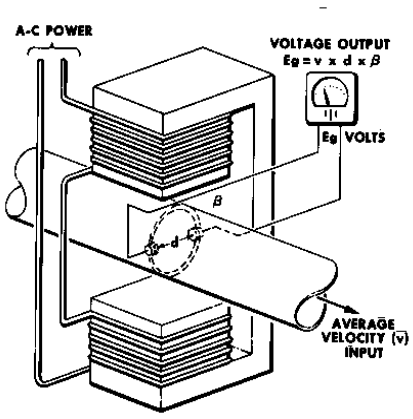


FIGURE 53

FLOW CONTROL VALVE AND METER

II. **APPLICATION IN HTST SYSTEMS**

Magnetic flow meter systems are used to replace the conventional timing (metering) pump in HTST, HHST and aseptic processing and packaging systems. In the previously discussed conventional systems **only the <u>temperature</u> is monitored to control the flow diversion device and the product flow remains at a constant set speed.** In meter based systems the **<u>flow rate</u>** of the product through the holding tube, metered prior to the product entering the holding tube, is also **constantly monitored and controlled**, resulting in forward flow **only** when a pre-set acceptable flow rate is achieved and maintained.

The system must be adjusted so that when the product flow **exceeds** a preset sealed value, the flow diversion device immediately assumes the **diverted flow position**. Also, **should the flow drop to a level that will not allow accurate flow rates,** the flow diversion valve must also assume the diverted flow position. Methods of testing these parameters will be discussed in the testing section of this manual. After the flow rate returns to an acceptable level a time delay is required before the flow diversion device is allowed to return to the forward flow position. The purpose of this is to **assure that all products in the holding tube have been held for the minimum required time(s).**

Although the initial installations were limited to use in systems without regenerators and less viscous products, current systems may now be **employed on all HTST systems for all milk products**.

Except for those requirements related to the physical presence of the metering pump, all requirements of the PMO are applicable.

II. BASIC COMPONENTS OF METER BASED SYSTEMS.

A. Centrifugal pump

1. Fixed speed

2. Variable speed

B. Magnetic flow meter

A short piece of sanitary tubing containing two electrodes surrounded by a housing, that contain coils which generate a magnetic field. The electrodes used are either Hastelloy C4 (Accurate Metering), or Carpenter 20 Cb3 SST(ABB Kent -Taylor). Both meters use Teflon as the pipe liner, as it is non-conducting, thus insulating the electrodes from the pipe. Both Accurate Metering and Taylor use PTFE (non-filled virgin teflon) for liners in food applications.

C. Flow control valve

Air operated, sanitary design, designed to regulate product flow.

D. Flow recorder (or SFLR, Safety Flow Limit Recorder/Controller) with high flow alarm.

E. Sanitary **check valve** or suitable fail safe air operated valve.

F. Electronic transmitter/transducer

Converts an electronic signal to a pneumatic value.

III. **TYPES OF SYSTEMS**

A. System utilizing a **single speed centrifugal product pump and flow control valve** to regulate product flow.

1. Magnetic flow meter.

2. Single speed centrifugal pump.

3. Sanitary check valve or suitable automatic fail safe valve.

4. Flow control valve.

5. Transmitter/transducer.

6. Flow recorder/controller with suitable alarms.

7. Suitable flow diversion device.

B. System utilizing **variable speed centrifugal pump** (AC drive).

1. Magnetic flow meter.

2. AC variable frequency motor control drive on a centrifugal pump.

3. Sanitary check valve or other suitable automatic valve.

4. Pneumatic transducer (I/P).

5. Flow recorder-controller with suitable alarms.

6. Suitable flow diversion device.

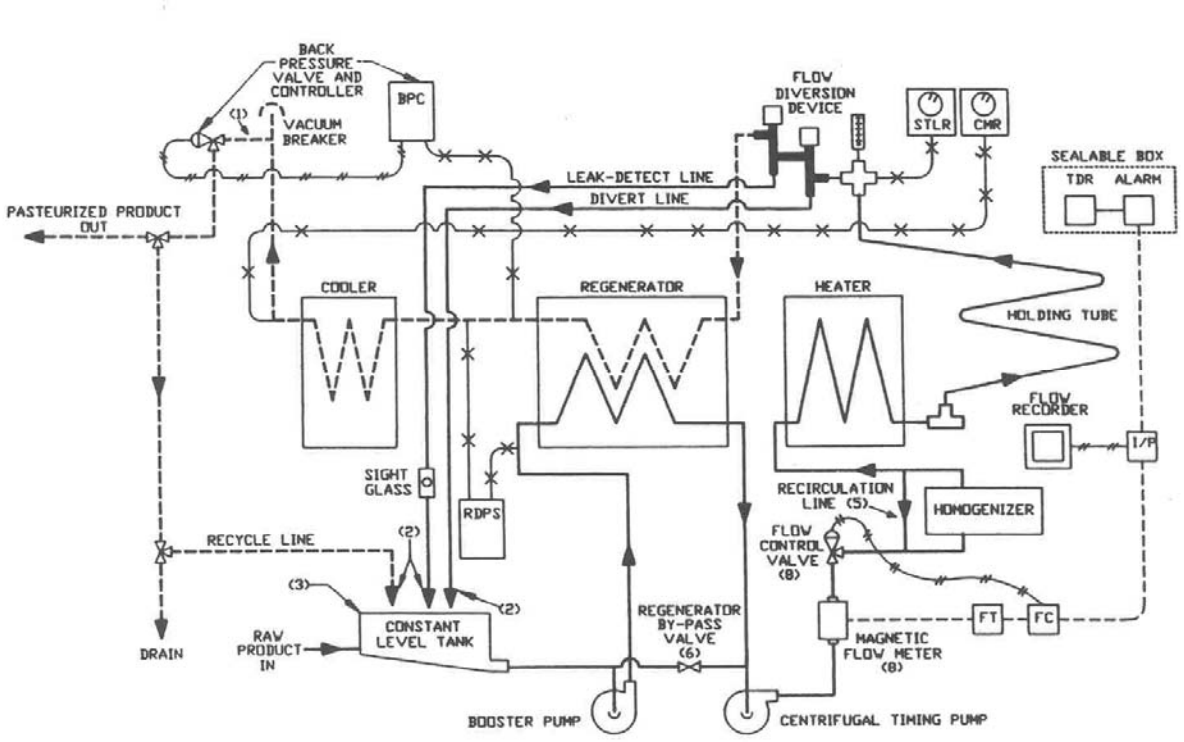


Figure 54: Meter Based System with flow control valves

(1) this line shall be at least 12 inches above any raw product piping in the HTST system
(2) all divert, leak detection and recycle lines which return to the constant level tank must break to atmosphere at lest two pipe diameters above the over flow level (3) the overflow level of the constant level tank must be lower that the bottom of the inlet of the raw regenerator (5) required if homo is greater capacity than timing pump (6) regenerator bypass valves must be installed to be drainable, and must prevent dead ends, or be drilled. A drilled check valve may be used between inlets of booster pump and timing pump. Air operated valves must be normally open, automatically operated and controlled to open if timing device stops. (8) straight pipe per manufacturers recommendations required on both sides of the centerline of the magnetic flow meter. Meter shall be located so electrodes are flooded. No product can enter or leave the system between the centrifugal timing pump and the flow diversion device. The flow control valves if used shall be normally closed, air to open. This valve may be replaced with a sanitary check valve for systems equipped with variable speed centrifugal timing pumps. A homogenizer downstream of the timing system (for example centrifugal timing pump, magnetic flow meter, and flow control valve or check valve) must be provided with a recirculation line.
Any other combination of modifications which are installed and operated with the above and with the detailed provisions of these practices may be utilized

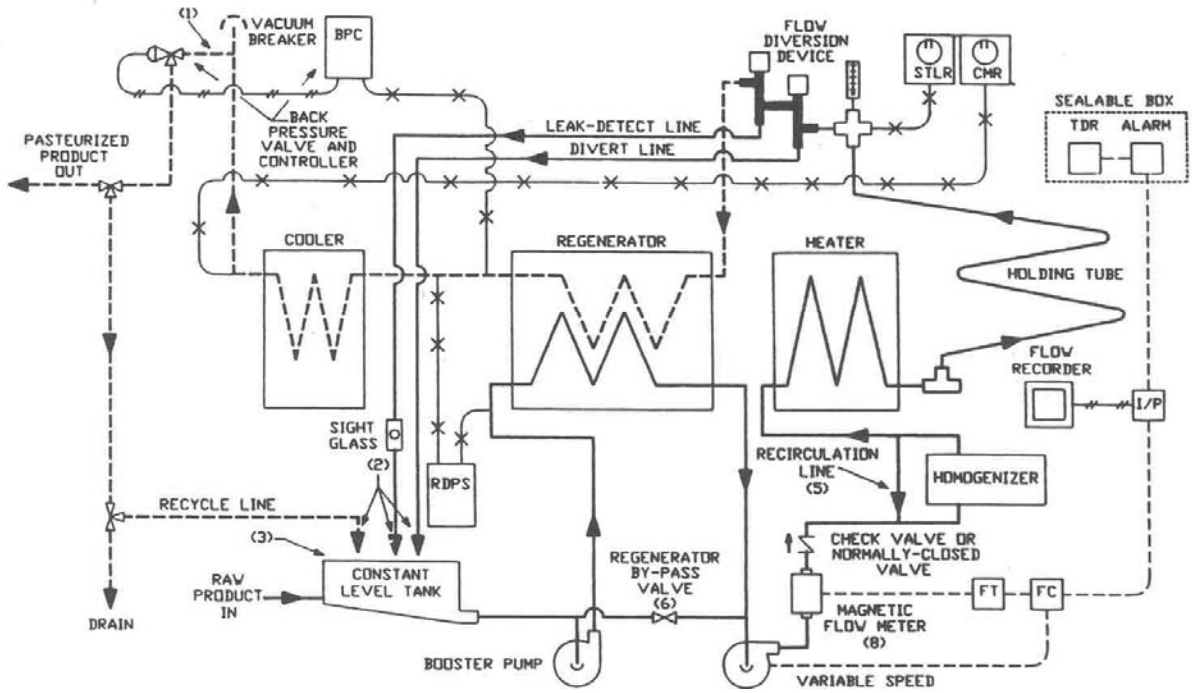
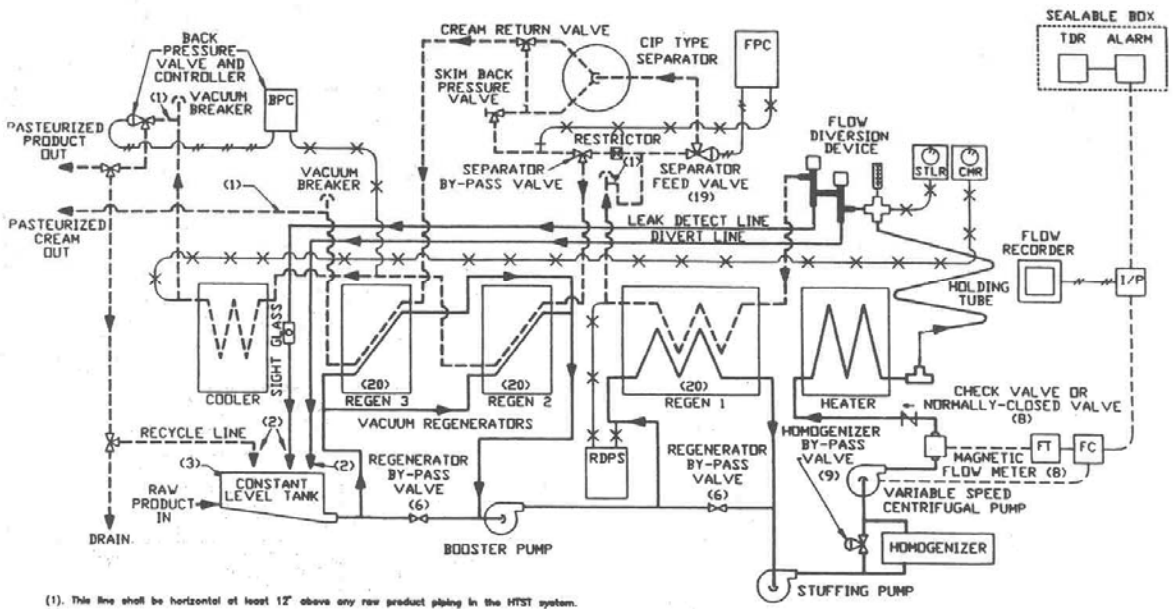


Figure 55: Meter based system with AC variable speed drive

(1) this line shall be at least 12 inches above any raw product piping in the HTST system
(2) all divert, leak detection and recycle lines which return to the constant level tank must break to atmosphere at lest two pipe diameters above the over flow level (3) the overflow level of the constant level tank must be lower that the bottom of the inlet of the raw regenerator (5) required if homo is greater capacity than timing pump (6) regenerator bypass valves must be installed to be drainable, and must prevent dead ends, or be drilled. A drilled check valve may be used between inlets of booster pump and timing pump. Air operated valves must be normally open, automatically operated and controlled to open if timing device stops. (8) straight pipe per manufacturers recommendations required on both sides of the centerline of the magnetic flow meter. Meter shall be located so electrodes are flooded. No product can enter or leave the system between the centrifugal timing pump and the flow diversion device. The flow control valves if used shall be normally closed, air to open. This valve may be replaced with a sanitary check valve for systems equipped with variable speed centrifugal timing pumps. A homogenizer downstream of the timing system (for example centrifugal timing pump, magnetic flow meter, and flow control valve or check valve) must be provided with a recirculaton line.
Any other combination of modifications which are installed and operated with the above and with the detailed provisions of these practices may be utilized



Gigure 56 meter based system with AC variable speed drive and Pasteurized milk separation

(1) this line shall be at least 12 inches above any raw product piping in the HTST system
(2) all divert, leak detection and recycle lines which return to the constant level tank must break to atmosphere at lest two pipe diameters above the over flow level (3) the overflow level of the constant level tank must be lower that the bottom of the inlet of the raw regenerator (6) regenerator bypass valves must be installed to be drainable, and must prevent dead ends, or be drilled. A drilled check valve may be used between inlets of booster pump and timing pump. Air operated valves must be normally open, automatically operated and controlled to open if timing device stops. (8) straight pipe per manufacturers recommendations required on both sides of the centerline of the magnetic flow meter. Meter shall be located so electrodes are flooded. No product can enter or leave the system between the centrifugal timing pump and the flow diversion device. The flow control valves if used shall be normally closed, air to open. This valve may be replaced with a sanitary check valve for systems equipped with variable speed centrifugal timing pumps. A homogenizer downstream of the timing system (for example centrifugal timing pump, magnetic flow meter, and flow control valve or check valve) must be provided with a recirculation line. (9) homogenizer by pass valve is optional and may be normally open or normally closed with all components of MBT system downstream. (19) when a separator or clarifier is an integral part of the HTST or HHST system an is located upstream of the timing pump or downstream of the flow diversion device it shall be automatically valved out of the system with fail safe valves properly interwired with the timing pump. (20) Regen 1 is the first section of a split milk to milk regenerator and Regen 2 is the subsequent second section . each requires a regenerator differential pressure switch. Regen 3 is a cream to milk regenerator operating at a negative pressure and requires no regenerator differential pressure switch.
Any other combination of modifications which are installed and operated with the above and with the detailed provisions of these practices may be utilized

IV. REGULATORY CONSIDERATIONS

NOTE: Meter based systems, in order to comply with the Ordinance, shall be installed as complete systems **as submitted and reviewed by FDA.** In other words, a complete system shall be deemed to mean a system consisting of those specific components, including wiring diagrams, that have been formally submitted and reviewed by the FDA. The installation of other components are to be reviewed and/or acceptable on an individual basis.

A. **CONSTRUCTION**

1. The centrifugal pump shall be located downstream from the raw milk regenerator, (if a regenerator is used in the system).

2. The magnetic flow meter shall be **downstream from the centrifugal pump.** There shall be **no intervening components** (valves or control devices) in the system other than normal sanitary piping.

3. Both the centrifugal pump and the magnetic flow meter (and the control valve when applicable) shall be located **upstream** from the holding tube.

4. All other flow promoting devices such as booster pump, stuffer pumps, separators, clarifiers, and homogenizer, as well as the centrifugal pump, **shall be properly interwired with the flow diversion device. These flow promoters may run and produce flow only when the flow diversion device is in fully forward or fully diverted flow position when in the product run mode.**

5. Homogenizers and separators installed in meter based systems must otherwise follow the same requirements as previously listed for conventional systems.

6. **There shall no product entering or leaving the system (i,e.,cream or skim from a separator or other product components) between the centrifugal pump and the flow diversion device. Also it is important that there shall be no flow promoting devices installed downstream from the meter based timing system.**

7. The magnetic flow meter shall be installed so that the product has contact with both electrodes at all times when there is flow through the system. This is 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. Also the meter must be installed to assure that the sensing probes are horizonally positioned on a within the meter which helps assure constant contact with the fluid within the piping.

8. The magnetic flow meter shall be piped in such a manner that **at least ten (10) pipe diameters of straight pipe** exists both upstream and downstream measured from the **center** of the meter.

9. There shall be an automatic means to assure proper pressure relationships in the milk to milk regenerator in cases of interruption in normal operation of the system. Acceptable methods are by installation of automatic fail safe valve at a location between the outlet of the raw regenerator and the holding tube. This will prevent back flow of product through the system which not only overflows the balance tank but more significantly could create positive pressure in the raw milk side of the regenerator.

10. There must be a sealed time delay installed which delays movement of the flow diversion device to the forward flow position following a diversion due to an excessive flow rate. This time delay must delay movement of the FDD to forward flow for at least 15 seconds (milk) or 25 seconds (egg nog or mix) after the legal rate has been established.

11. **Regulatory seals** must be provided in the following areas:

    a. **Flow alarm** (excessive flow alarm set point and loss-of-signal alarm)

    b. **Time delay #1** (Delay after divert for **excessive flow** rate)

    c. **Time delay #2** (10 minute **CIP**)

B. **OPERATIONAL**

Generally, we can say that a magnetic flowmeter is used in a pasteurization system to accurately measure the volume of flow rate of a wide range and viscosity of liquids. The only requirement of the product is that it must have a minimum level of conductivity.

A meter based timing system has some advantages over a conventional timing system in that it has few moving parts (as does a positive displacement pump), does not obstruct the product flow, and is not affected by changes in conductivity, temperature, viscosity, or density.

Flow meter systems are required to have high and low flow or loss of signal alarms. The purpose of these alarms are to assure the system will assume the divert position in those cases of excessive or inadequate product flows.

The purpose of the low flow or loss of signal alarm is to prohibit produce false readings on the flow controller or when there is a signal interruption to the flow meter. The setting of the low flow alarm should be left to the discretion of the processor. This may be accomplished by the installation of a power interrupt switch located between the meter and the flow recorder/controller.

When the flow meter system is powered and at rest (no flow condition), the flow rate alarm event marker must show an unsatisfactory (diverted flow) condition and the FDD must be in the diverted flow position regardless or product temperature. This loss of signal alarm is described in the testing procedures, however may be evaluated by disrupting the power to the magnetic flow meter by electronic deactivation switch.

The signal may be disrupted at any location which simulates interruption of power in the flow meter system and may be done at any location convenient for the equipment vendor and processor.

Another important point to remember is that the 15 second time delay is not required in those instances of **diverted flow as a sole result of inadequate temperature. Moreover, it would be impossible to properly conduct the recording thermometer thermometric response test if the 15 second delay is installed to occur on both excessive flow conditions and on temperature diversions. This will be addressed more thoroughly in the testing chapter of this manual.**

Regulatory testing of this system precludes the necessity for determining water:milk conversion flow rates, divert flow rates, and the flush time delay between the divert and leak detect valve on dual flow diversion valve systems.

CHAPTER REVIEW

1. a). What is a magnetic flow meter?

b). The basic components of a variable speed (AC drive)meter based systems are:

1.
2.
3.
4.
5.

2. T F Centrifugal pumps may be used to replace the timing pump in a magnetic flow system.

3. Three seals are required in the testing procedures for magnetic flow meters. What are they?

a)
b)
c)

4. The purpose of the required automatic shut off valve downstream from the mag meter and upstream from the holding tube is:

5. The purpose of the I/P Transducer in a Mag Flow system is to convert _____to_____.

6. In case of diversion resulting from excessive flow rates, the system must have a built in _____of _____seconds. The reason for this is_____
_____
_____.

7. One of the requirements for mag flow meter installation is that they be installed downstream from the timing pump and preferably in the_____position

which helps eliminate foam and assures a contact of the sensors with the conducting fluid, thus eliminating air pockets. There shall be a minimum of _____pipe diameters on each side of the mag meter, measured from the _____
of the _____.

8. A 2 ½ inch magnetic flow meter would need a minimum of _____inches of uniform straight product flow piping on each side of the meter to meet the PMO requirements.

9. T___F___ In all cases meter based systems are required to have flow control valves which function to control rate of flow through the system.

10. Raw milk separators may not be located between the timing pump and the holding tube since;(check all that apply)

a.___ proper pressure relationships in the milk to milk regenerator could be affected.
b.___ fluctuations in minimum required holding time may occur in the system.
c.___ loss of temperature is probable during the separation process.
d.___ stuffing pumps will exert positive pressure on the flow diversion device.
e.___ raw cream is illegal according to the FD&C federal code.
f. ___ product may not be added or removed after the timing system.

Notes:

****

Note: The use of trade names or equipment photographs is for training and educational purposes only and does not constitute endorsement by the U.S. Department of Heath and Human Services, Public Health Service, Food and Drug Administration.

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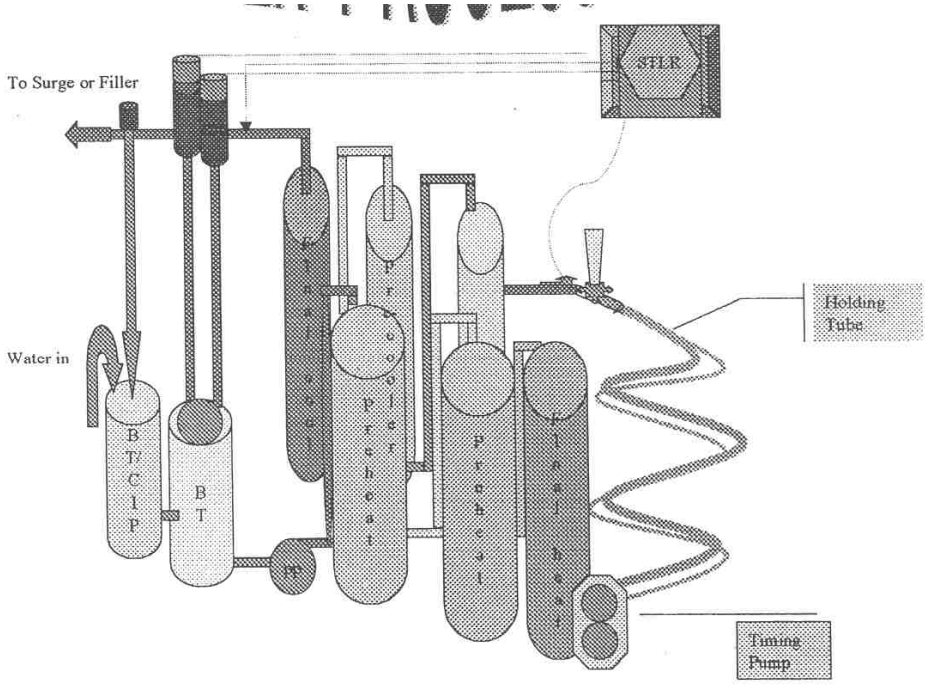
Chapter VII

ADVANCED MILK PROCESSING SYSTEMS



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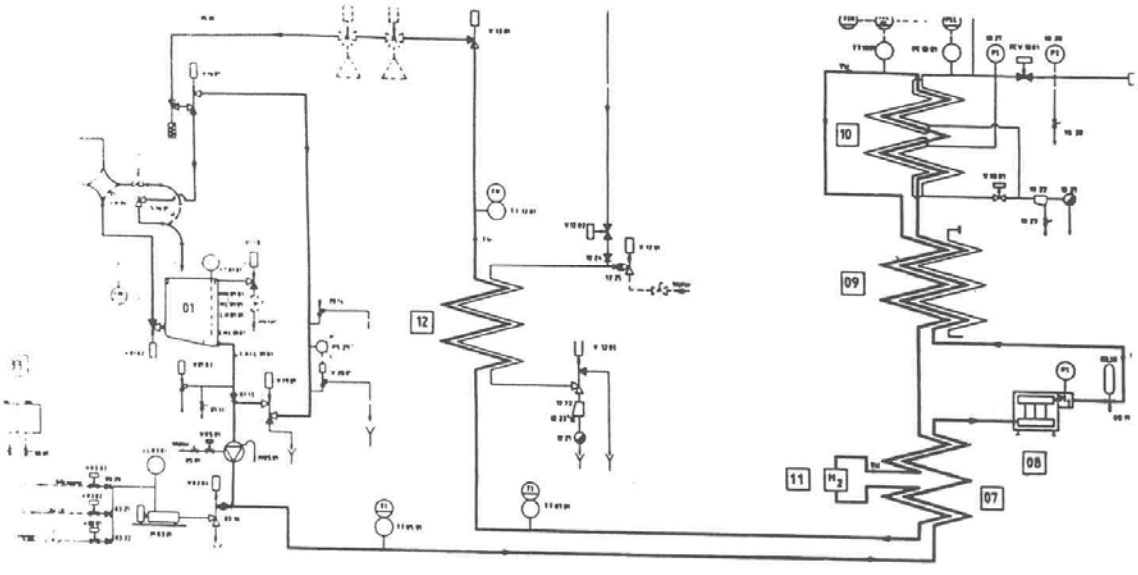
Note: The use of trade names or equipment photographs is for training and educational purposes only and does not constitute endorsement by the Food and Drug Administration.



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:

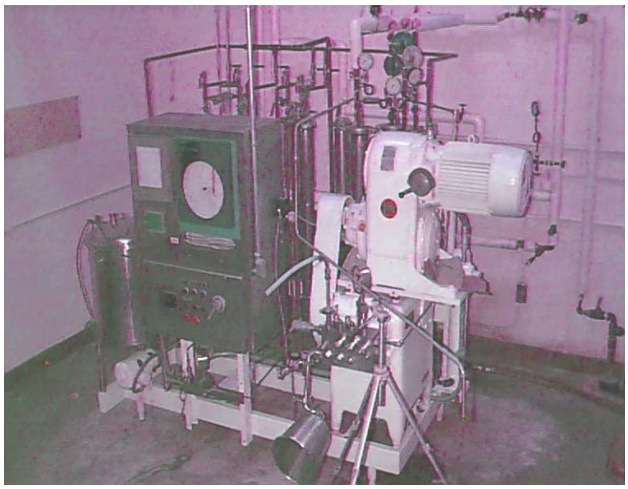
To provide the basic criteria necessary for the evaluation of indirect and direct heated extended shelf life and shelf stable pasteurization and processing systems as they relate to applicable public health requirements.

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^{o} 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 just pr

b) the STLR located at the end of the holding tube; and

c) a differential pressure controller is installed when a booster pump

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^{o} 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 PRESSSURE 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 is 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, particularity 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 presssure 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 pressue-recorder shall be used to monitor and record pressures of the asepic 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 are between the flow divert and leak detect valve is not applicable for HHST or UHT systems**

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 aspectic 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 catagorize 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).**

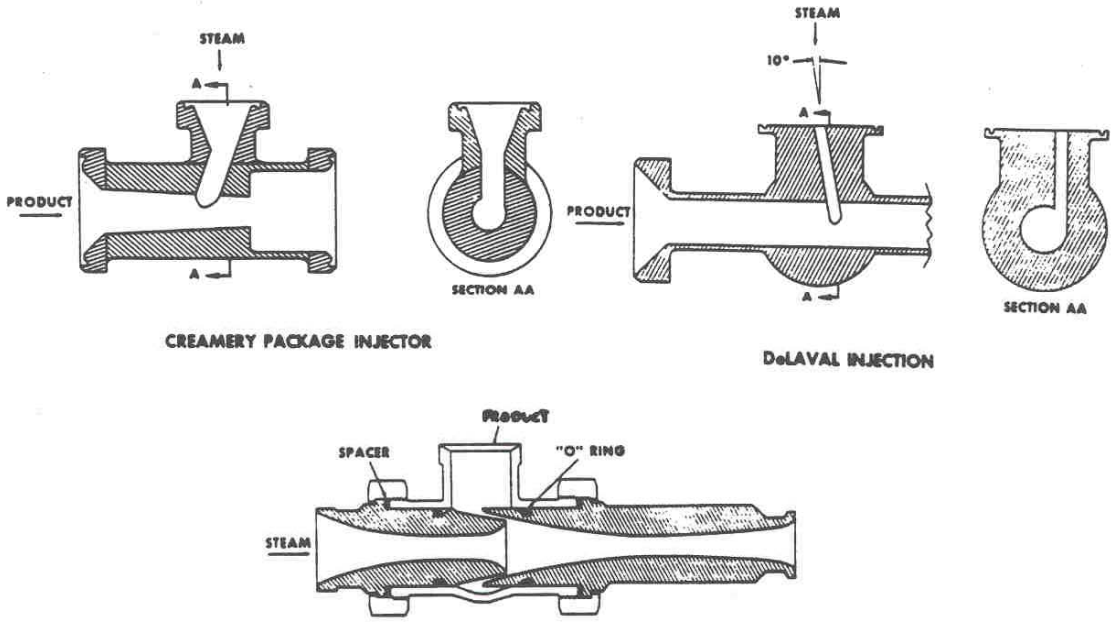


Figure 57
Examples of Steam Injectors

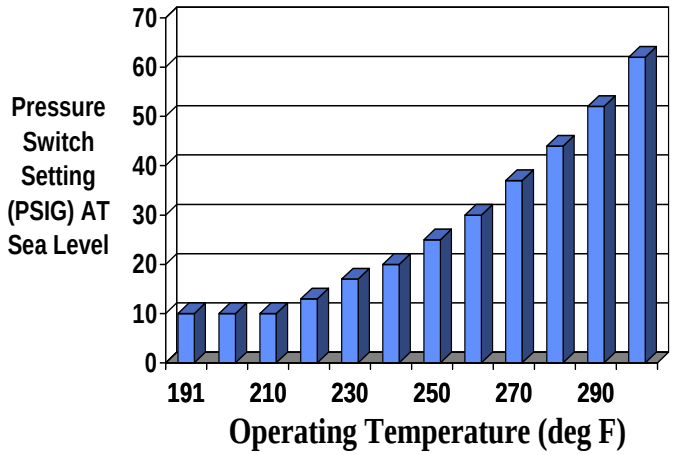
b). HOLDING TUBE PRODUCT PRESSURES

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 in 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



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^{o} 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 subsequentially 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%.**

HHST, UP AND UHT SYSTEMS

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 them 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 X 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^{o} 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 = BxC). 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^{o} 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 = BxC). 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 addtition, 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.

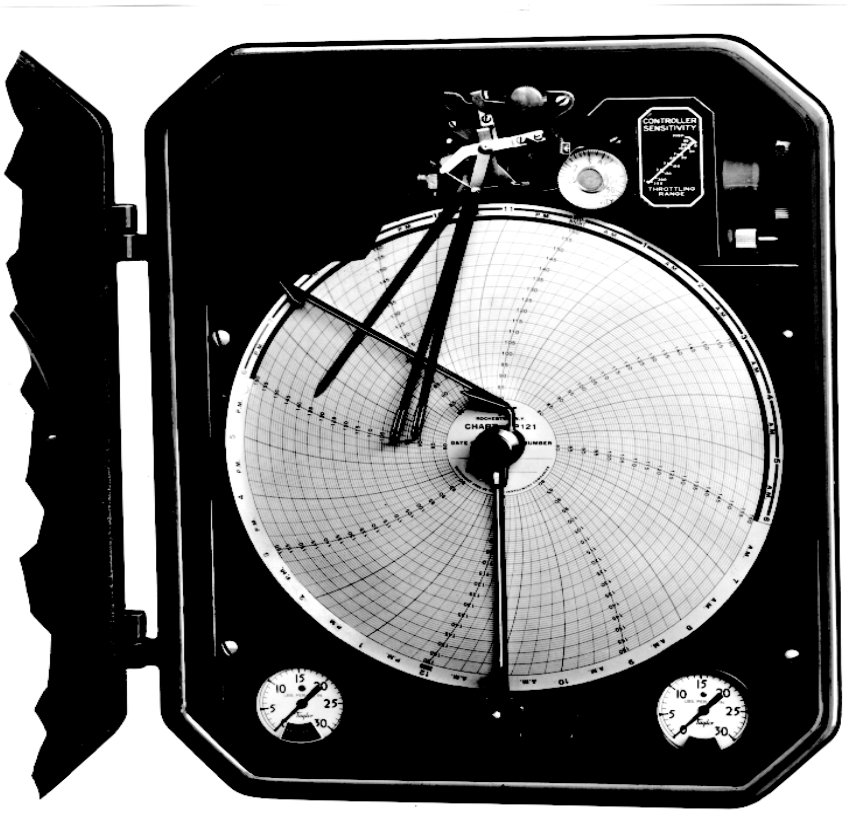
This is accomplished by constantly monitoring the product temperature at the inlet and outlet of the chamber. **One sensor is located immediately prior to the point of steam injection and the other is located immediately after the product exits the vacuum chamber**.

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 practable to the recorder/controller sensor. It may be either of the mercury in glass or an acceptable electronic type.**

Figure 58 ratio controller instrument



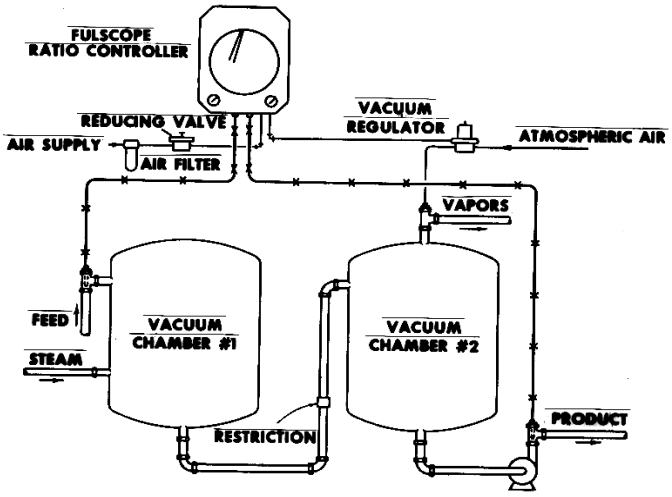


Figure 59 : Ratio Controller Placement with Direct Steam Systems

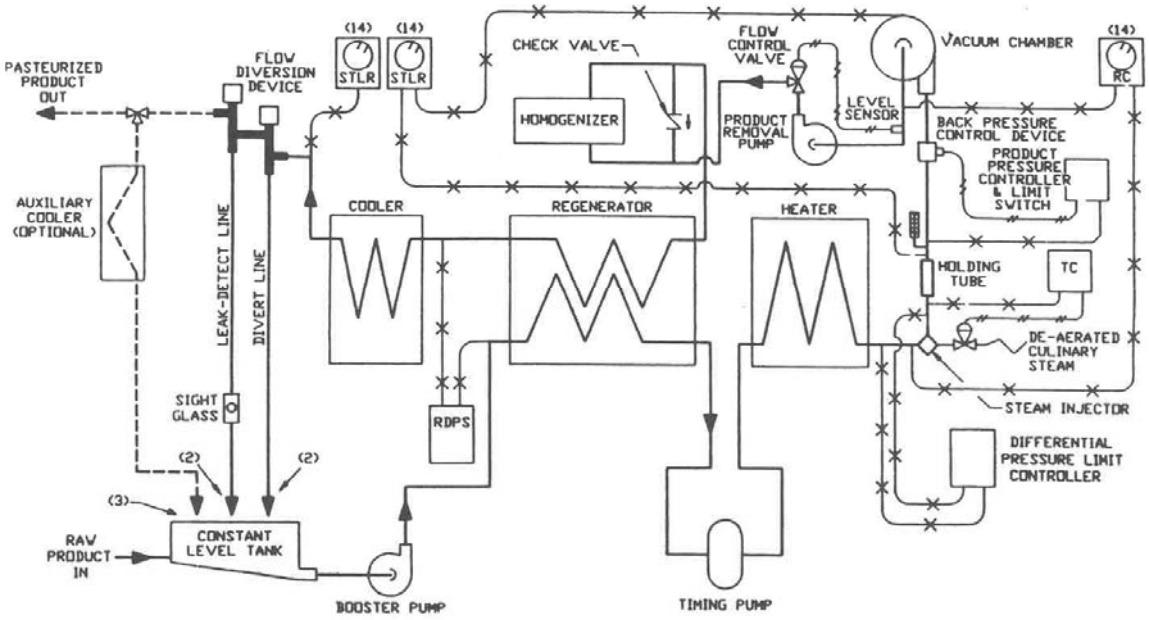


Figure 60: Steam injection pasteurization controls HHST with steam injection, vacuum cooling and flow diversion device at end of system.

(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

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 miminum 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 it 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 it's 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

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^{o} and 212^{o} F the pressure switch must be set at 10 psi (70kPa) at sea level.

Higher operating temperatures (above 212^{o} 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^{o} 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 in 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

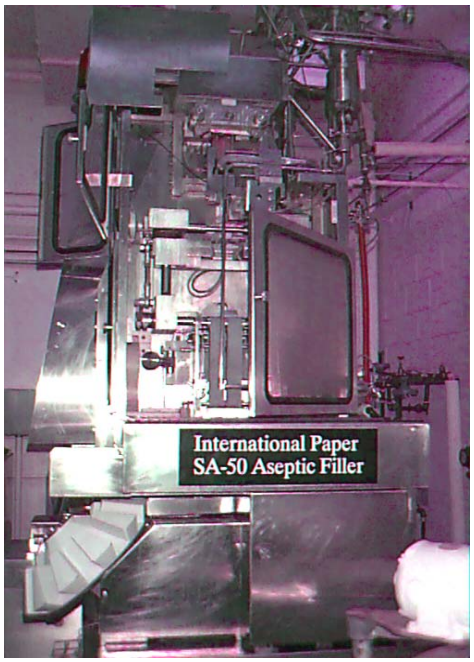
a. **Milk to Milk Regenerators -** In these systems the product flow is identical as found in conventional HTST systems with one major exception. The exception is that in **HHST** systems processing at temperatures above 191° F (89° C), the FDD is located at the end of the cooling section. In these systems, 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 subsequentially filled under aspetic 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 th 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 interupted using a product diversion system or valve, the packaging process is immdiately 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;

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

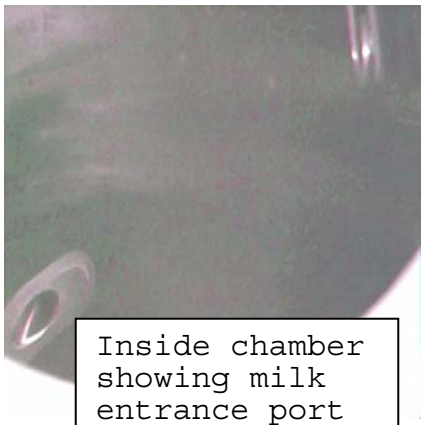
_ Milk enters the system at the balance tank which is interlocked with a auxiliary CIP/FLUSH tank. Water is usually directly connected to this tank using an acceptable "block and bleed" type valving arrangement which prevents accidental contamination of the product. The water line is also protected from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



Inside chamber showing milk entrance port

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^{o} F. Product in the chamber is usually heated above 280^{o}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^{o} 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^{o} 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^{o} 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.

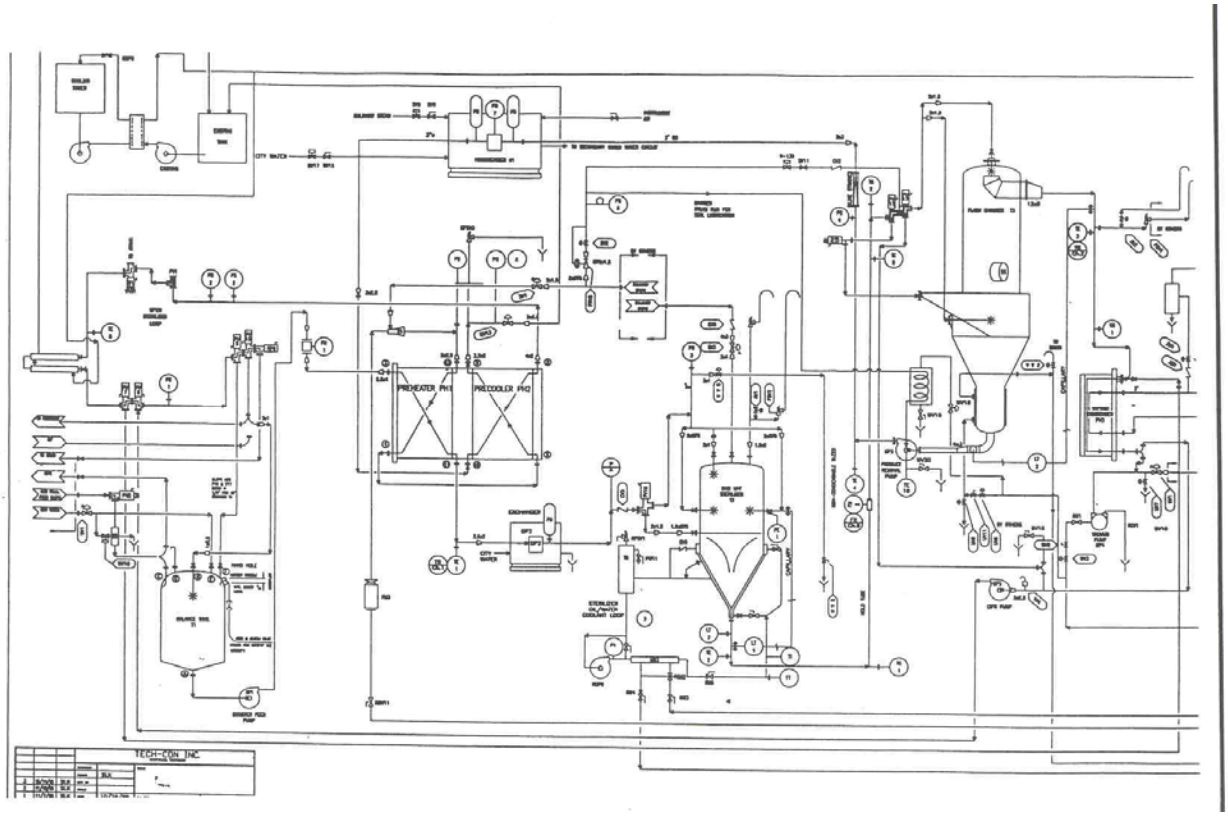


Figure 61
Falling Film (Dasi) Steam Infusion System

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 contaminats, 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 possiblity 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.

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^{o} F. The preheated product is drawn by a timing pump through a plate pre-heater which further raises the temperature to about 170^{o} F.

The preheated product then enters the infusion heater where steam is introduced to further heat the product to 295^{o} 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^{o} 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.

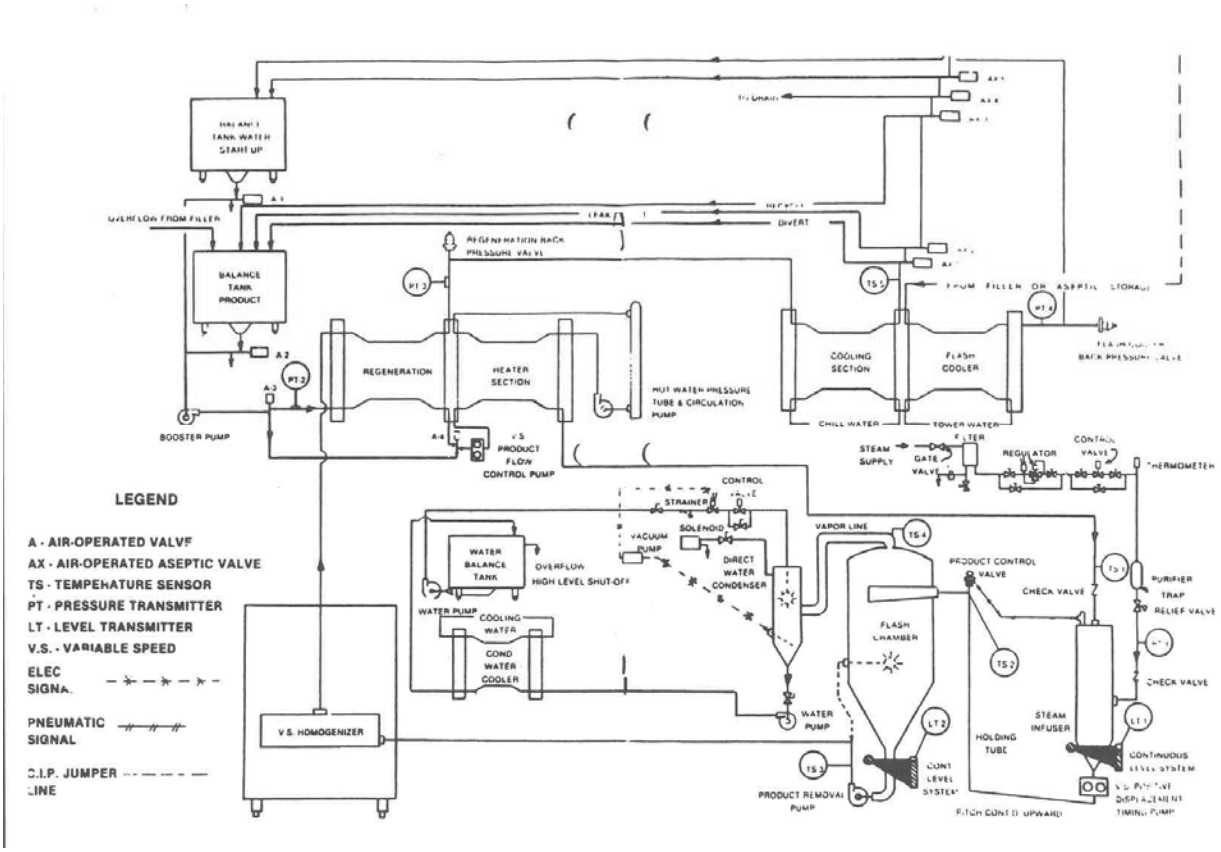


Figure 62
Ultratherm (Crepaco) Infusion System

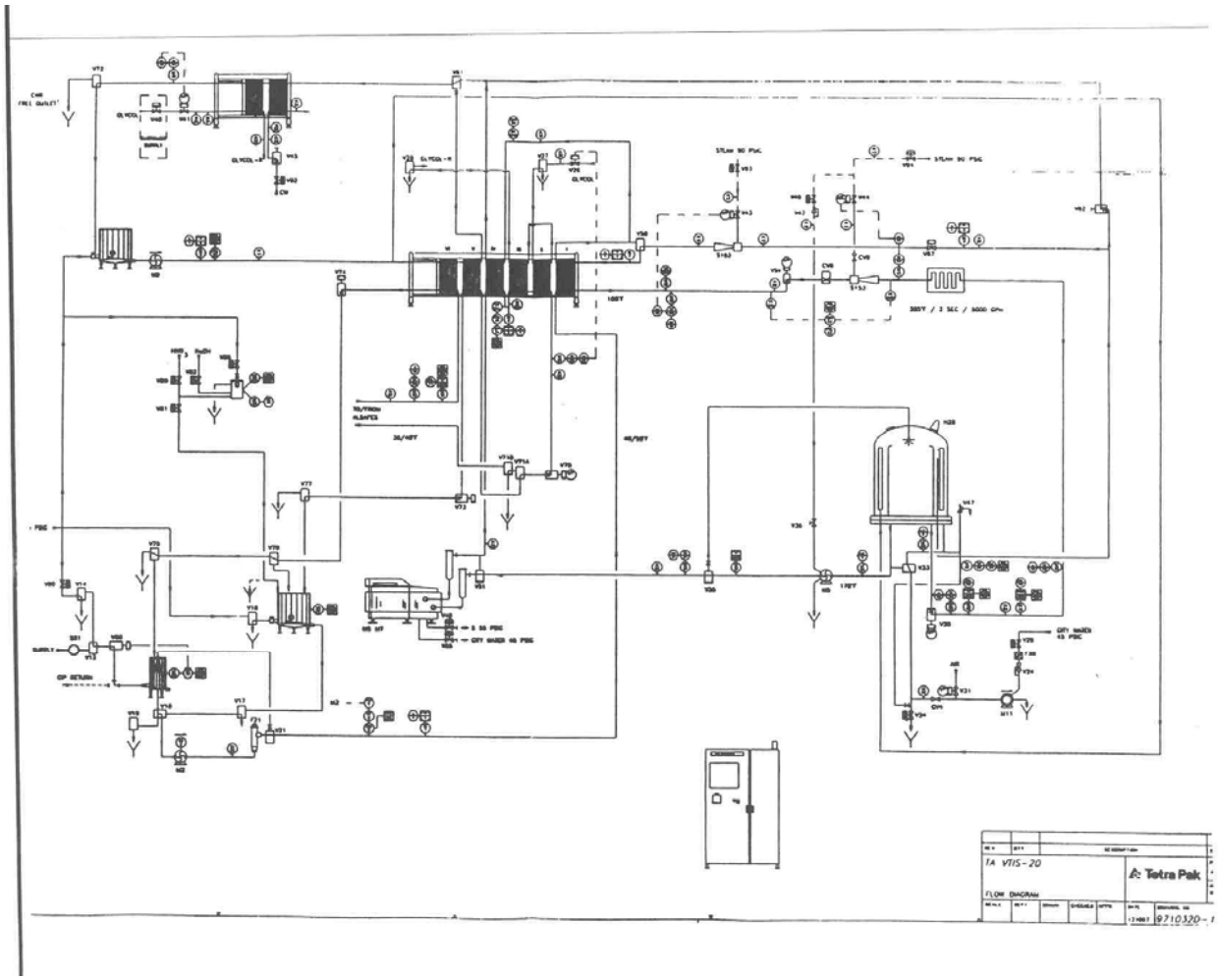


Figure 64
TetraPak VTIS Injection System

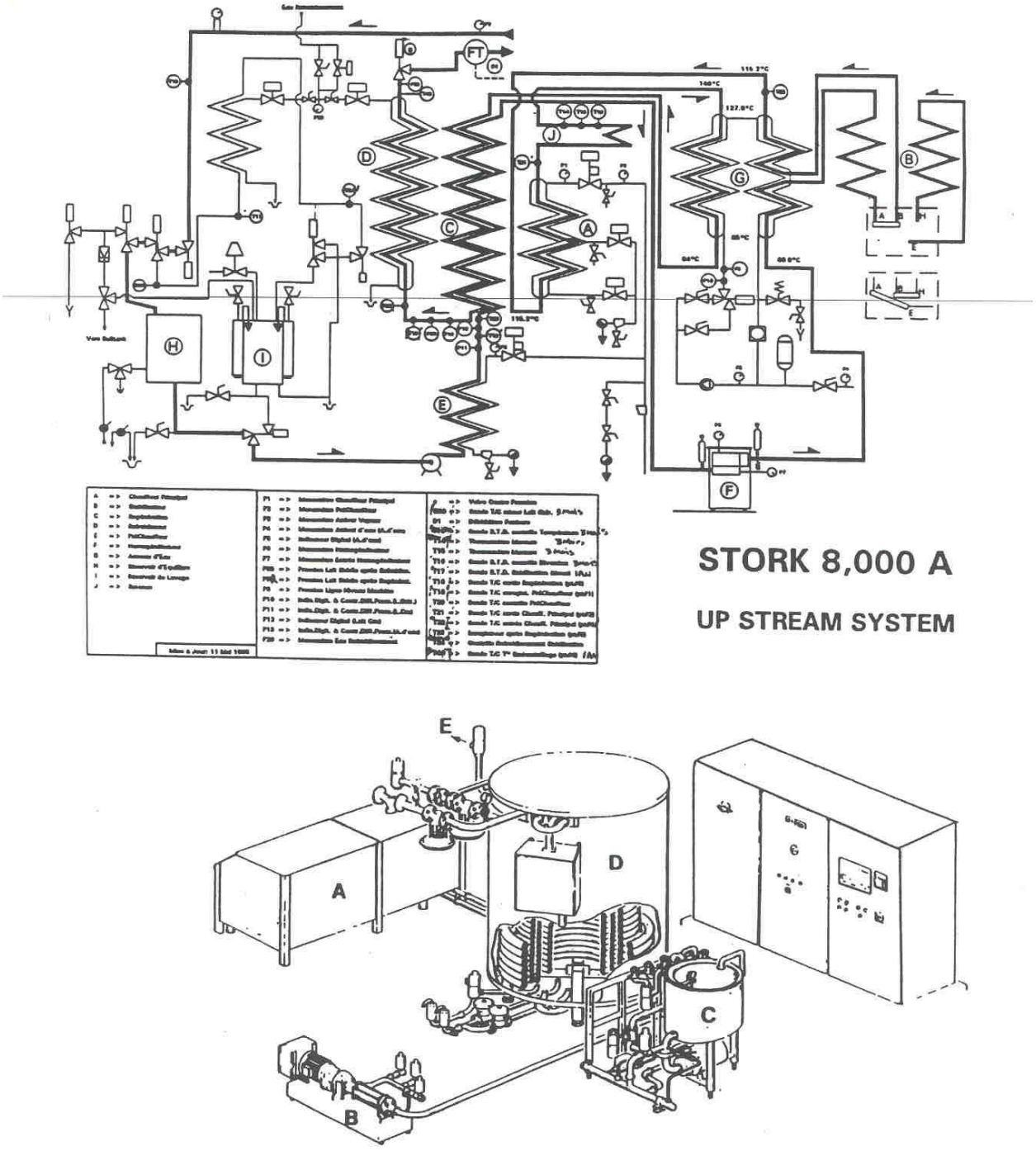


Figure 65
Tubular (STORK) UHT Systems

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^{o} 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

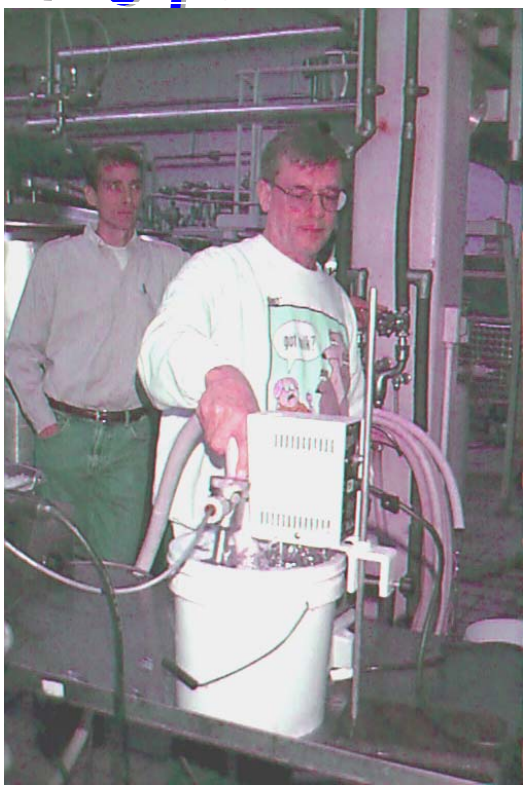
9.. Acceptable flow rates in the DASI system is determined by what components in the system and how are they adjusted?

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

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

Chapter VIII

Pasteurization System Testing



PASTEURIZATION EQUIPMENT CONTROLS AND TESTS

I. TESTING APPARATUS SPECIFICATIONS

TEST THERMOMETER

Type.--Mercury-actuated; readily cleanable; plain front, enameled back; length 305 m

Scale Range.--At least 7° C (12°F) below and 7° C (12°F) above the pasteurization temperature at which the operating thermometer is used, with extensions of scale on either side permitted, protected against damage at 149° C (300°F).

Temperature Represented by Smallest Scale Division.--0.1° C (0.2°F).

Number of Degrees per 25 millimeters (Inch) of Scale.--Not more than 4 Celsius deg

Accuracy.--Within 0.1° C (0.2°F) plus or minus, throughout specified scale range. The accuracy shall be checked against a thermometer which has been tested by the National Bureau of Standards.

Bulb.--Corning normal or equally suitable thermometric glass.

Case.--Suitable to provide protection during transit and periods when not in use.

GENERAL PURPOSE THERMOMETER

Type.--Pocket type.

Scale Range.---1°C (30°F) to 100°C (212°F), with extension on either side permitted. Protected against damage at 105°C (220°F).

Temperature Represented by Smallest Scale Division.--I°C (2°F).

Accuracy.--Within 1°C (2°F) plus or minus, throughout the specified scale range. Checked periodically against a known accurate thermometer.

In the case of mercury actuated general purpose thermometers, the following additional specifications shall apply:

Magnification of Mercury Column.--To apparent width of not less than 1.6 millimet

Number of Degrees per Inch of Scale.--Not more than 29 Celsius degrees or not more than 52 Fahrenheit degrees.

Case.--Metal, provided with a fountain pen clip.

Bulb.--Corning normal or equally suitable thermometric glass.

ELECTRICAL CONDUCTIVITY MEASURING DEVICES

Type.-; Manual or automatic.

Conductivity.--Capable of detecting change produced by the addition of 10 ppm of sodium chloride, in water of 100 ppm of hardness. Other equivalent chemical solutions may also be used as desired.

Electrodes.--Standard.

Automatic Instruments.--Electric clock, time divisions not less than 0.2 of a second.

STOPWATCH

Type.--Open face,electronic or mechanical indicating fractional seconds.

Accuracy.--Accurate to 0.2 of a second.

Scale.- Divisions of not over 0.2 of a second.

Crown.--Depression of crown (or push buttons) starts, stops, and resets to zero. (Digital stopwatches operated as instructions prescribe).

II. TEST PROCEDURES

Equipment and field tests to be performed by the regulatory agency are listed and suitably referenced below. The results of these tests shall be recorded on suitable forms and filed as the regulatory agency shall direct.

<u>On an emergency basis, the pasteurization equipment may be tested and temporarily sealed by a dairy plant employee provided the following conditions are met:((NCIMS-1993)).</u>

a. The individual applying the seal(s) is employed in a supervisory capacity by the plant in which the seal was removed.

b. The individual has satisfactorily completed a course of instruction, acceptable to the regulatory agency, on tests controls for pasteurization equipment that includes a minimum of 8 hours classroom instruction, and

c. The individual has demonstrated the ability to satisfactorily conduct all pasteurization control tests, in the presence of a regulatory official within the past year; and

d. The individual is in possession of authorization from the regulatory agency to perform these tests; and

e. The individual will immediately notify the regulatory agency of the time of the shutdown that would necessitate the removal of the regulatory seals. Permission to test (and seal) the equipment must be obtained for each specific incident. The individual will also notify the regulatory agency of the identity of the controls affected, the cause(if known) of the equipment failure, the repairs made and the result of testing (when completed). The individual will provide the identity and volume of products processed during the period that temporary seals were applied to the regulatory agency; and

f. If regulatory tests reveal that equipment or controls are not in compliance with the provisions of this document, all products that were processed during that period will be recalled; and

g. The regulatory agency will remove the temporary seals, retest the equipment and apply seals within 3 working days of notification by industry; and

h. No Grade A dairy products will be processed after three working days without the affected equipment being tested and sealed by the regulatory agency.

II. TEST PROCEDURES

TEST 1
INDICATING THERMOMETERS--
TEMPERATURE ACCURACY

Reference.--Item 16p(E).

Application.--To all indicating thermometers used for the measurement of product temperature during pasteurization or aseptic processing, including airspace thermometers.

Frequency.--Upon installation and once each 3 months thereafter or whenever the thermometer has been replaced or the regulatory seal on a digital sensor or the digital control box has been broken.

Criteria.--Within 0.25°C (0.5°F) for pasteurization and aseptic processing thermometers and 0.5°C (1°F) for airspace thermometers plus or minus, in a specified scale range. Provided, that on batch pasteurizers used solely for 30 minute pasteurization of products at temperatures above 71°C (160°F), indicating thermometers shall be accurate to within 0.5°C (1°F) plus or minus.

Apparatus.--

1. Test thermometer meeting specifications under Appendix I, Part 1. Provided that types other than mercury actuated may be used when they have been 1) recognized by the Food and Drug Administration to be equally fail safe, accurate, reliable and meet the scale and thermometric response specifications and 2) which are approved by the regulatory agency.

2. Water or oil bath, or other suitable heating media to within a range of 2°C (3°F) of the appropriate pasteurization or airspace temperature, or aseptic processing temperature.

3. Suitable means of heating the water or oil bath.

Method--Both thermometers exposed to a water or oil medium of uniform temperature. Indicating thermometer reading is compared to the reading of the test thermometer.

Procedure:

1. Prepare a quantity of water in a milk can or a quantity of oil in an oil bath, or a quantiy of other suitable heating media, by raising the temperature of the water or oil or other suitable heating media to within a range of 2°C (3°F) of the appropriate pasteurization or aseptic processing temperature or airspace temperature.

2. Stabilize the bath temperature and agitate the water or oil bath rapidly.

3. Continuing agitation, insert the indicating and test thermometers to indicated immersion point.

4. Compare both thermometer readings at the appropriate pasteurization or aseptic processing temperature within the test range.

5. Repeat comparison of readings.

6. Record thermometer readings, thermometer identification, or location.

7. Install seals as appropriate on sensors and control boxes of digital thermometers. Record identity of Indicating Thermometers used in Aseptic Processing Systems.

Corrective Action.--Do not run the test if the mercury column has been split or the capillary tube is broken. Broken thermometers should be returned to the factory for repair. When the indicating thermometer differs from the test thermometer by more than 0.25°C (0.5°F) and the airspace thermometer by more than 0.5°C (1°F), the indicating thermometer should be adjusted to agree with the test thermometer. Retest the thermometer after adjustment. Note: Electronic digital read out thermometers not meeting the above criteria shall be repaired, adjusted, or replaced as recommended by the applicable manufacturer.

TEST 2
RECORDING THERMOMETERS--TEMPERATURE ACCURACY.

Reference--Item 16p(E).

Application--To all recording and recorder/controller thermometers used to record milk temperatures during pasteurization or aseptic processing.

Frequency.--Upon installation, at least once each 3 months and whenever recording pen-arm setting requires frequent adjustment, when sensing element has been replaced, or when a regulatory seal has been broken.

Criteria.--Within 0.5°C (1°F) plus or minus, in specified scale range. Provided that on batch pasteurizers used solely for 30-minute pasteurization of products at temperatures above 71°C (160°F), recording thermometers shall be accurate to within 1°C (2°F), plus or minus, between 71°C and 77°C (160°F and 170°F)

Apparatus--Pasteurizer or aseptic processor indicating thermometer previously tested against a known accurate thermometer, water baths or suitable vats or containers, agitator, suitable means of heating water baths, and ice.
Note: When this test is performed on recorder/controllers used with HHST pasteurization or aseptic processing systems operating at or above the boiling point of water, an oil bath shall be substituted for the processing (operating) temperature water mentioned in steps 1,4,5,6, and 7 as well as the boiling water mentioned in steps 2, 3, and 5. The temperature of the oil bath which is used in place of the boiling water shall be above the normal operating range but below the highest temperature division on the chart.

Method--The testing of a recording thermometer for temperature accuracy involves the determination of whether or not the temperature pen-arm will return to within 0.5°C (1°F) or 1°C (2°F) as provided above, of its previous setting after exposure to high heat and melting ice.

Procedure.

1. Adjust the recording pen to read exactly as the previously tested indicating thermometer in the temperature range for the process being used after a stabilization period of 5 minutes (2 minutes for electronic recorder controllers) at a constant temperature. The water bath shall be rapidly agitated throughout the stabilization period.

2. Prepare one water bath by heating to the boiling point and maintain temperature. Prepare a second container with melting ice. Place water baths within working distance of the recorder sensing element.

3. Immerse the sensing element of the recorder in boiling water for not less than 5 minutes(2 minutes for electronic recorder controllers).

4. Remove the sensing element from the boiling water and immerse in ater at a temperature within the testing range for the pasteurization process being used. Allow a 5-minute(2 minutes for electronic recorder controllers) stabilization period for both indicating and recording thermometers. Compare readings of the indicating and recording thermometers. The recorder reading should be within 0.5^{o}C (1^{o}F), plus or minus, of the indicator thermometer reading.

5. Remove sensing element from bath at operating temperatures and immerse in melting ice for not less than 5 minutes(2 minutes for electronic recording controllers).

6. Remove sensing element from ice water and immerse in water at a temperature within the testing range for the process being used. Allow a 5-minute (2 minutes for electronic recorder controllers) stabilization period for both indicating and recording thermometers. Compare readings of the indicating and recording thermometers. The recorder reading should be within 0.5^{o}C (1^{o}F) plus or minus, indicator thermometer reading.

7. Re-seal regulatory controls as necessary and record indicating and recording thermometer readings at steps 1, 4 and 6.

Corrective Action.--If the pen does not return to 0.5°C (1°F) or 1°C (2°F), plus or minus of indicating thermometer reading, the recording thermometer should be repaired.

TEST 3
RECORDING THERMOMETERS--
TIME ACCURACY

Reference--Item 16p(E).

Application--To all recording and recorder/controller thermometers used to record time of pasteurization.

Frequency--Upon installation and at least once each 3 months thereafter or whenever the seal of a programmable recorder/controller has been broken.

Criteria--The recorded time of pasteurization shall not exceed the true elapsed time.

Apparatus--

1. A watch graduated at intervals not to exceed 1 minute, and accurate to within 5 minutes in 24 hours.

2. A pair of dividers, or any other suitable device for measuring short distances.

Method--Comparison of the recorded time over a period of not less than 30 minutes with a watch of known accuracy. For recorders utilizing electric clocks, check cycle on face plate of clock with a known cycle; observe that clock is in good operating condition.

Procedure.

1. Determine if chart is appropriate to recorder. Insure that the recording pen is aligned with the time arc of the chart at both the center and the outside.

2. Inscribe reference mark at the pen point on the recorder chart and record the time.

3. At the end of a minimum of 30 minutes by the watch, inscribe a second reference mark at the pen point position on the chart.

4. Determine the distance between the two reference marks and compare the distance with the time-scale divisions on the record chart at the same temperature. Use of an engineering type divider will greatly increase the accuracey of this measurement.

5. For electric clocks, remove face plate, compare cycle specification on face plate with the current cycle utilized.

6. Enter finding on chart and initial. Record results. Reseal regulatory controls as necessary.

Corrective Action--If recorded time is incorrect, the clock should be adjusted or repaired.

TEST 4
RECORDING THERMOMETERS-
CHECK AGAINST
INDICATING THERMOMETERS

Reference--Item 16p.

Application--To all recording and recording/controller thermometers used to record milk temperatures during pasteurization or aseptic processing.

Frequency--At least once each 3 months by regulatory agency; and **daily by the plant or pasteurizer/aseptic processor operator**.

Criteria--Recording thermometer shall not read higher than corresponding indicating thermometer.

Apparatus--No supplementary materials required.

Method--This test requires only that the reading of the recording thermometer be compared with that of the indicating thermometer at a time when both are exposed to a stabilized pasteurization or aseptic processing temperature.

Procedure.--

1. While the indicating and recording thermometers are stabilized at an acceptable pasteurization or aseptic processing temperature, read indicating thermometer.

2. Immediately inscribe on the recording thermometer chart a line intersecting the recorded temperature arc at the pen location: record on the chart the indicating thermometer temperature; initial.

3. Record results.

Corrective Action--If recording thermometer reads higher than indicating thermometer, the pen shall be adjusted for accuracey by the operator. Re-sealing may be necessary on some earlier models of computer programmable STLR's.

TEST 5
FLOW-DIVERSION DEVICE--
PROPER ASSEMBLY AND FUNCTION

Reference--Item 16p(E).

Application-- To all flow-diversion devices used with HTST flow pasteurization with the following exceptions. **Parts 1 through 9 do not apply to aseptic processing systems.** Parts 5 and 9 apply **only** to flow diversion devices used with HTST pasteurizers, and parts 1 to 4 and 6 to 8 apply to all flow diversion devices used with continuous flow pasteurizers.

.

Frequency--Upon installation and at least once each 3 months thereafter or whenever a regulatory seal has been broken.

Criteria--The flow-diversion device shall function correctly in operating situations and **in the event of malfunction or incorrect assemply**, **shall de-energize the metering pump** and all other flow promoting devices capable of producing flow through the holding tube.

5.1 LEAKAGE PAST VALVE SEAT(S)

Apparatus--For all flow diversion devices including both single and dual stem types. Suitable tools are necessary for the dissasembly portion of this test.

Method--Observe leakage past the valve seat(s) for the single stem, or the leak detect valve piping (dual stem) of the flow-diversion device for leakage.

Procedure--With the system operating with water, place the flow-diversion device in **diverted-flow position**.

A) For Single Stem Valves, disconnect the **forward flow piping** and observe the valve seat for leakage. Check leak escape ports to see if they are open.

B) With the dual stem device, observe the **leak detect line discharge or sight glass for leakage.**

Corrective Action--If leakage is noted, device must be dismantled and defective gaskets replaced, new plugs valve stem plugs installed, or other suitable repairs made.

5.2 OPERATION OF VALVE STEM(S)

Apparatus--Suitable tools for tightening single stem packing nut. and as necessary tools for dissembly of some dual stem flow-diversion device stem's and actuators and other sanitary piping wrenches.

Method--Observe flow-diversion device valve stem(s) for ease of movement.

Procedures--When a stem packing nut is used, tighten stem packing nut as much as possible. Operate system; place device in forward and diverted flow several times. Note freedom of action of valve stem.

Corrective Action--If valve action is sluggish, suitable adjustment or repair shall be made to permit stem to act freely in all positions, with packing nut, when applicable, is fully tightened.

5.3 DEVICE ASSEMBLY, SINGLE STEM DEVICE

Apparatus--Sanitary fitting wrench and suitable tools for tightening the packing nut on the stem.

Method--During diverted flow, by temperature, observe function of metering pump and all other flow promoting devices capable of causing flow through the holding tube, when flow-diversion device is improperly assembled.

Procedures.--a. Place the flow diversion device in diverted flow either by lowering the temperature or by removing the STLR sensor from the water bath. Disconnect the forward flow piping (not the large 13H hex nut at the top of the

valve)which negates any downward force on the hex nut and with all flow promoting devices in HTST system in operation and in **diverted flow**, **unscrew by one half turn, the 13H hex nut which holds the top of the valve to the valve body.** This should de-energize the metering pump and all other flow promoting devices capable of causing flow through the holding tube.

b. With the HTST system in operation below the required process temperature**(diverted flow**), **remove the connecting key located at the base of the valve stem.** The metering pump and all other flow promoting devices should be de-energized.

Corrective Action.--If metering pump or flow promoting device fails to respond as indicated, immediate checks of the device assembly, the micro-switch, and wiring are required to locate and correct the cause.

5.4 DEVICE ASSEMBLY, DUAL STEM DEVICE

Note: 1. The test procedure presented in the section is typical of tests accepted by regulatory authorities. Testing details may vary for individual flow diversion device types are provided in the device operators manuals which hav been reviewed by FDA.

2. The word "metering pump" or "timing pump" found in the manufacturers manuals testing section shall be interpreted to include all other flow promoting devices capable of causing flow through the holding tube.

Apparatus--Suitable tools as required or recommended by the individual flow diversion type.

Method--Observe function of metering pump all other flow promoting devices capable of causing flow throughthe holding tube when the flow-diversion device is improperly assembled.

Procedures.--

a. With the device in **diverted-flow, by temperature,** when flow-diversion device is properly assembled remove the valve actuator (top) clamp.

b. Move the device to the forward-flow position and disconnect the stem from actuator. **This may be accomplished using the INSPECT mode locate on the device control panel**.

c. **Move the device to the diverted-flow position .** This may be accomplished by moving the mode switch on the control panel to the DIVERT position. **Turn on the metering pump and all other flow promoting devices**. The metering pump or other flow promoting devices should not run. If any pump starts momentarily and then stops, it may indicate improper wiring of the one second time delay as allowed in 16p.B.2.b. Separators must be effectively valved out of the system.

d. Reassemble the device by moving it to the forward-flow position and reconnecting the stem to the actuator. **This may be accomplished on some dual stem valve systems by placing the mode switch in th INSPECT position**.

e. Move the device to the diverted-flow position and replace the actuator clamp then **repeat procedure for the leak-detect device assembly**.

f. Re-seal regulatory controls as necessary.

Corrective Action.--If any flow promoting devices fail to respond as indicated, an immediate check of the device assemply and wiring is required to locate and correct the cause.

Cherry Burrell Flow Diversion Device (Models Manufactured after 1/1/83)

Device Assembly Test Procedures

1. With the system temperature at sub-legal (divert), set the FDV MODE Switch to INSPECT.

2. After the valves have assummed the **FORWARD FLOW** position, turn the air shut-off valve handle 90 degrees which traps the air and retains the valve in the Forward Flow position.

3. Set the **FDV MODE** Switch to **PROCESS** and turn on the timing pump. The timing pump **should not operate.**

4. Set the **FDV MODE** Switch to **OFF**. Slowly open the actuator air Shut-Off valve until the piston rod moves very slightly (about 1/4 inch), then close the Shut-Off valve.

5. Using two open-end wrenches, unscrew the valve stem from the piston rod (about 1/8 inch). Slowly open the Shut-Off valve again allowing the valve to assume the **DIVERT** position.

6. Set the FDV MODE Switch to PROCESS and turn the timing pump on. **The TIMING PUMP OR OTHER FLOW PROMOTING DEVICES SHOULD NOT RUN!**

7. Repeat the above steps for the leak detect valve.

8. Attach a new sealing wire to the air Shut-Off Valve handles and record your results.

DEVICE ASSEMBLY - CHERRY BURRELL FDD

1. With the system temperature at sub-legal (divert), set the FDV MODE Switch to INSPECT.

2. After the valves have assumed the FORWARD FLOW position, turn the air shut-off valve handle 90 degrees which traps the air and retains the valve in the forward flow position.

3. Set the FDV MODE Switch to PROCESS and turn on the metering pump. The pump or any other flow promoting devices should not operate.

4. Set the FDV MODE Switch to OFF. Slowly open the actuator air Shut0Off valve until the piston rod moves very slightly (about 1/4 inch), then close the Sutt-Off valve.

5. Using two open-end wrenches, unscrew the valve stem from the piston rod (about 1/8 inch). Slowly open the Shut-Off valve again allowing the valve to assume the Divert position.

6. Set the FDA MODE Switch to PROCESS and turn the metering pump on. The metering pump nor any other flow promoting device should not operate.

7. Repeat the above steps for the leak detect valve.

8. Attach a new sealing wire to the air Shut-Off Valve handles and record your results.

TESTING METHOD: TRI-CLOVER DUAL STEM DEVICE

1. Remove the recorder/controller temperature sensor from the water bath or cool the bath to a temperature that will allow diverted flow.

2. Remove **one actuator clamp** On most dual valves this is the TOP CLAMP.

3. Turn the mode switch on the FDD control panel to **INSPECT**.

4. Once the valve has assumed the forward flow position, disconnect the stem from the actuator.

5. Turn the mode switch back to **PRODUCT** which will allow the valve to assume the divert position. Turn on the metering pump switch. The **metering pump should not run.** Note: At this time you may want to complete disassembly of the valve and inspect for construction, gaskets, "O" rings, etc.

6. Turn the mode switch back to **INSPECT** and allow the valve to assume the forward flow position.

7. Reconnect the stem to the actuator.

8. Turn the mode switch from **INSPECT** to **PRODUCT** and allow the valve to assume the divert flow position.

9. Reconnect the actuator clamp.

Corrective Action--If metering pump fails to respond as indicated, an immediate check of the device assembly, MICROSWITCH, and wiring is required to locate and correct the cause.

TESTING METHOD, TRI-CLOVER :REVERSE-ACTION FDD

1. Make certain the valves are properly assembled, paying particular attention to the actuator mounting bolts, yolk mounting bolts, body clamps, and the valve stem to actuator stem connection.

2. Make sure the temperature sensing element of the STLR is below legal pasteurization temperature.

3. Momentarily turn on the timing pump to make sure it is operating properly , and then turn it off.

4. Remove the valve body clamp and the uper valve body port clamp on the valve. Lift the valve off the lower body. Turn the selector switch to the **"INSPECT"** position. After a time delay, the valve will switch to the forward flow position. Unscrew the valve stem off the actuator stem enough to insert the gap guage between the two stems. Tighten the valve stem onto the guage.

5. Turn the selector switch to the **"PRODUCT"** position and observe the timing pump. It should not operate nor should any flow promoting device be operable during this time.

6. Remove the gap guage and reassemble the valve. Ensure that the valve is properly assembled. The timing pump should now operate normally in the divert position.

7. Repeat procedure for remaining valve.

5.5 MANUAL DIVERSION (when booster pump is installed in the HTST system)

Apparatus.--None.

Method.--Observe the response of the system to manual diversion.

Procedure:

a. With the HTST system in operation and the flow-diversion device in the forward-flow position, press the manual diversion button. This should;

1. Cause the valve to assume the **divert** position, and

2. **de-energize the booster pump**; (the pressure differential between raw and pasteurized milk in the regenerator should be maintained).

b. Operate the HTST system at its **maximum operating pressure** and activate the manual divert button. Confirm that the spring tension of the flow-diversion device is still 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 pressure reaches zero (0) psi. Deactivate the manual divert button and observe the raw milk and pasteurized milk pressures. **The pressure differential between raw and pasteurized milk in the regenerator should be maintained**.

Corrective Action--If the above described actions do not occur when procedures a, b, and c are performed, or the necessary pressure differential between raw and pasteurized milk is not maintained, the assembly and wiring

of the HTST system must be immediately reviewed and the indicated deficiencies corrected or proper adjustments made.

5.6 RESPONSE TIME

Apparatus--STOPWATCH. The stopwatch should be used to determine that the response time interval does not exceed 1 second.

Method--Determine the elapsed time between the instant of the activation of the control mechanism at **cut-out temperature on declining temperature and the instant the flow-diversion device takes the fully diverted-flow position.**

Procedure:

a. With water bath or oil bath at a temperature above cut-out temperature, allow the water or oil to cool gradually. At the moment the cut-out mechanism is activated, start the watch and the moment the flow-diversion device takes the fully-diverted position, stop the watch.

b. Record results.

c. Re-seal regulatory controls as necessary.

Corrective Action--Should response time exceed 1 second, immediate corrective action must be taken.

5.7 TIME DELAY INTERLOCK WITH METERING PUMP.

Application--To dual stem flow-diversion devices with a manual forward-flow switch.(**INSPECT** position on the mode switch).

Apparatus--None.

Method--Determine that the device does not assume a manually induced forward-flow position while the metering pump or other flow promoting devices capable of causing flow through the holding tube is running.

Procedure--With the system running in **forward flow**, move the control switch to the **"Inspect**" position and observe that the following events automatically occur in sequence:

a. The device **immediately moves to the diverted-flow** position and the metering pump and all other flow promoting devices are turned off or in the case of separators are effectively falved out of the system.

b. The device remains in the diverted-flow position while the metering pump and all other flow promoting devices are running down or in the case of separators, are valved out.

c. After the metering pump and other flow promoting devices have stopped, or valved out, the device assumes the forward-flow position.

d. Repeat the above procedure by moving the control switch to the clean-in-place (CIP)position for those systems in which no milk flow promoters are allowed to operated during CIP.

d. Record test results and seal the control enclosure as necessary.

Corrective Action--If the above sequence of events does not occur, either a timer adjustment or wiring change is required.

5.8 CIP TIME DELAY RELAY

Application--To all continuous flow pasteurizer systems in which it is desired to run the **timing pump and/or other flow promoting devices during CIP** without the controls required during processing.

Criteria.--When the mode switch on the flow diversion device is moved from process product to CIP, the flow diversion device shall move immediately to the diverted position and remain in the diverted position for at least 10 minutes with all controls and safe guards required in product mode in placed and functioning, before starting its normal cycling in the CIP mode. In HTST systems, the booster shall be de-energized during this 10minute time delay.

Note: Also, any flow promoting devices capable of causing improper pressure relationships in the milk-to-milk regenerator must either be deactivated or automatically valved out of the system during this ten minute time delay. An example of this would be pasteurized side flavor control equipment, and/or separators located on the pasteurized side of the system.

Apparatus.--Stopwatch.

Method.--Determine that the set point on the time delay is **equal to, or greater than 10 minutes.**

Procedure.--

a. Operate pasteurizer in forward flow with the mode switch on the flow diversion device in the PROCESS/PRODUCT position, using water above the cut-in temperature. In systems equipped with magnetic flow meter based timing systems, operate the system at a flow rate below the Flow Alarm set point and above the Loss-of-Signal Alarm set point.

b. Move the mode switch on the flow diversion device to the **CIP position**. The flow diversion device should move immediatey to the diverted position. **Start the stopwatch when the flow diversion device moves to the diverted position**. Check all controls and safeguards which are required to be in operation when the system is in PRODUCT mode and in diverted flow. For

example, in HTST systems, the booster pump must stop runing. Separators located between raw regenerator sections or those located on the pasteurized side of the system must be effectively valved out and stuffer pumps for such separators must be de-energized.

c. **Stop the stopwatch when the CIP timer times out**. On most systems this is when the flow diversion device moves to the forward position for its initial cycle in the CIP mode. **At this time the system may be operated without the controls and safe guards normally required during product processing**. For example, the booster may start at this time without requiring proper regenerator pressures.

d. Record results for the office record.

e. Install and seal enclosure over the time delay relay if necessary.

Corrective Action.--If the flow diversion device does not remain in the diverted position for at least 10 minutes after the mode seitch is moved from PRODUCT/PROCESS to CIP, increase the set point on the time delay and repeat the test procedure. All required safe guards and controls must be functional during this entire 10 minutes. If any of these required safeguards or controls are not functional during this 10 minutes, adjustments or repairs are needed. In HTST systems, if the booster pump runs at any time during the 10 minute delay, the booster pump wiring is in need of repair.

METER BASED SYSTEMS - While operating the system on water at or above the minimum pasteurization temperature and with a flow rate below the Flow Alarm set point and above the Loss-of-Signal Alarm set point;

1. Turn the flow diversion device mode switch to the CIP position. The flow diversion device should move immediately to the diverted position, and the booster pump should stop running and separators located between regenerator sections or on the pasteurized side of the system must be effectively valved out and stuffer pumps for such separators must be de-energized..

2. Start the stopwatch when the flow diversion device moves to the diverted position.

3. Stop the stopwatch when the flow diversion device moves to the forward position for its initial cycle in the CIP mode. The booster pump and other flow promoting devices (separators and stuffer pumps) may start at this time.

b. Record results for the office record.

c. Install and seal enclosure over the time delay relay.

Corrective Action.--If the flow diversion device does not remain in the diverted position for at least 10 minutes after the mode switch is moved from process product to CIP, increase the set point on the time delay relay and repeat this test procedure. If the booster pump runs at any time during the 10 minute delay, the booster pump wiring is in need of repair.

5.9 Leak Detect Valve Flush - Time Delay

Application- - The minimum one second delay applies to HTST systems in which space between the divert and leak detect valves are not self draining in the diverted flow position.

IMPORTANT: The five second maximum flush delay does not apply to systems that do not have a restrictor in the divert line or to meter based timing systems.

Criteria -- The **piping joining the divert and leak detect valve will be flushed for at least one second and not more than five seconds after the divert valve moves to the forward flow position and before the detect valve moves to the forward postion.**

Apparatus -- A stopwatch.

Method-- Observe the movement of the divert and detect valves to the forward flow positiojn and measure the time interval between the movement of the two valves.

Procedure --

1. Move the flow diversion device from the diverted flow position to the forward flow position either by raising the temperature above the cut-in set point or by operating the HTST pasteurizer above the cut-in temperature in manual divert mode and releasing the manual divert activating (NO)push button or switch.

2. When the **divert valve begins to move to the forward flow position, start the watch.**

3. When the **leak detect** valve begins to move to the forward flow position, **stop the watch.**

4. Record the elapsed time.

5. If the elapsed time is **at or above one second (all systems), and at or below five seconds, (meter based systems or non-restricted divert lines systems not applicable) seal the time delay.**

Corrective Action-- If the elapsed time is less than one second or greater than five seconds, appropriate changes to the system or system controls must be made.

TEST 6
LEAK PROTECTOR VALVE-BATCH PASTEURIZERS

Reference--Item 16p(E).

Application--To all **batch (vat) pasteurizer outlet valves**.

Frequency--Upon installation and at least once each 3 months thereafter.

Criteria--No leakage of milk past the valve seat in any closed position.

Apparatus--No supplementary materials required.

Method--By observing when the piping is disconnected from the valve outlet whether or not leakage past the valve seat occurs when pressure is exerted against the upstream face of the valve.

Procedure.--

1. During normal operation, while milk pressure is exerted against the valve inlet, fully close the outlet valve and disconnect the outlet piping.(Caution: care must be taken to avoid contamination of the valves or the piping.)

2. Observe whether or not any milk is leaking past the valve seat into the valve outlet.

3. Turn the valve to the just-closed position, and examine the leakage into the valve outlet.

4. Reconnect the outlet piping.

5. Record identity of the valve, and findings, for office record.

Corrective Action--If leakage past the valve seat should occur in any closed position, the valve plug should be reground, gaskets replaced, or other necessary steps be taken to prevent leakage.

TEST 7
INDICATING THERMOMETERS ON PIPELINES-- THERMOMETRIC RESPONSE

Reference--Item 16p(E).

Application--To all **HTST indicating thermometers** located on pipelines and used for determination of milk temperatures during pasteurization.

Frequency--Upon installation and once each 3 months thereafter and whenever the seal on a digital thermometer has been broken..

Criteria--Four seconds under specified conditions.

Apparatus--Stopwatch, water bath, agitator, heat supply, and indicating thermometer from pasteurizer.

Method--By measuring the time required for the reading of the thermometer being tested to increase 7°C (12°F) through a specified temperature range (temperature range must include pasteurization temperature). The temperature used in the water bath will depend upon the scale range of the thermometer to be tested. See chart on following page for recommended water bath temperatures.

Note: This test is temporarily suspended for indicating thermometers used on UP and UHT systems until research demonstrates effective and safe alternative methods. See M-a-81, June 20, 1993, or section AND Chapter entitled "PROCESS DESIGN CRITERIA, CHAPTER VI, STEAM INJECTION AND INFUSION".

Procedure.--

1. Immerse indicating thermometer in water bath heated to a temperature at least 11°C (19°F) higher than minimum scale reading on indicating thermometer**. The bath temperature should be 4°C (7°F) higher than maximum required pasteurization temperature for which thermometer is used.**

2. Immerse indicating thermometer in bucket of cold water for several seconds to cool it.

Note.--Continuous agitation of water baths during the performance of steps 3, 4, and 5 is required. Elapsed time between end of step 1, and beginning of step 3 should not exceed 15 seconds so hot water bath does not cool significantly.

3. Insert indicating thermometer in hot water to proper bulb/sensor immersion depth.

4. **Start** stopwatch when indicating thermometer reads 11°C **(19°F) below bath temperature.**

5. **Stop** stopwatch when indicating thermometer reads 4°C **(7°F) below bath temperature.**

6. Record thermometric response time for office record.

Examples:--On a thermometer with a range of 66°C to 80°C (150°F to 175°F) used at pasteurization temperatures of 72°C and 75°C (161°F and 166°F), a water bath of 78.3°C (173°F) could be used. 10.6°C (19°F) below 78.3°C (173°F) would be 68.7°C (154°F); 3.9°C (7°F) below 78.3°C (173°F) would be 74.4°C (166°F). Hence, after immersing the thermometer which has been previously cooled, place the thermometer in the 78.3°C (173°F) bath, the stopwatch is started when the thermometer reads 67.8°C (154°F) and stopped when it reads 74.3°C (166°F).

NOTE.--The above test included the pasteurization temperature of 71.7°C (161°F) and 74.4° C (166° F). If the pasteurization temperature set points had been 71.7° C (161° F) AND 79.4° C (175° F) it would

have not been possible to include both set points within a 6.7° C (12° F) span. With these set points the test would have to be done separately for each set point.

Therefore, a thermometer used at pasteurization temperature of 175° F could use a water bath of 182° F and the measured time span would be 163° F to 175° F.

THERMOMETRIC RESPONSE TEST

QUICK REFERENCE

PASTEURIZATION TEMPERATURE	WATER BATH TEMPERATURE	TIMED 12°F SPAN	
		Start Timer	Stop Timer
161°F, 166°F	173°F	154°F	166°F
175°F	182°F	163°F	175°F

Corrective Action--If the response time should exceed 4 seconds, the thermometer should be replaced or returned for repair.

TEST 8
RECORDER/CONTROLLER-THERMOMETRIC RESPONSE

Reference--Item 16p(E).

Application--To **all HTST recorder/controllers** used in connection with continuous-flow pasteurizers **except** those in which the flow-diversion device is located at the end of the cooler section, ie, HHST and Aseptic Processing Systems.

Frequency--Upon installation and at least once each **3 months** thereafter.

Criteria--Five seconds, under specified conditions.

Apparatus--Previously tested indicating thermometer (on pasteurizers), stopwatch, water bath, agitator, and heat supply.

Method--Measure the time interval between the instant when the recording thermometer reads 7°C (12°F) below the cut-in temperature and the moment of cut-in by the controller. This measurement is made when the sensing element is immersed in rapidly agitated water bath maintained at **exactly** 4°C (7°F) above the cut-in temperature.

Procedure.--

1. Check and, if necessary, adjust the pen-arm setting of the recording thermometer in the proper reference to agree with the indicating thermometer reading at pasteurization temperature.

2. Determine the cut-in temperature of controller (Test 10, p. 224), either while in normal operation or by using a water bath.

3. Remove sensing element and allow to cool to room temperature.

4. Heat water bath to exactly 4°C (7°F) above the cut-in temperature while **vigorously agitating bath** to insure uniform temperature.

5. Immerse recorder/controller bulb in bath. **Continue agitation during steps 6 and 7 below.**

6. Start stopwatch when the recording thermometer reaches a temperature of **7°C (12°F) below the cut-in temperature.**

7. **Stop stopwatch when the controller cuts in.**

8. Record thermometric response time for office record. Re-seal any regulatory seals broken during the test.

Corrective Action: If the response time should exceed 5 seconds the recorder controller must be repaired.

TEST 9
REGENERATOR PRESSURE CONTROLS

Reference--Item 16p(E).

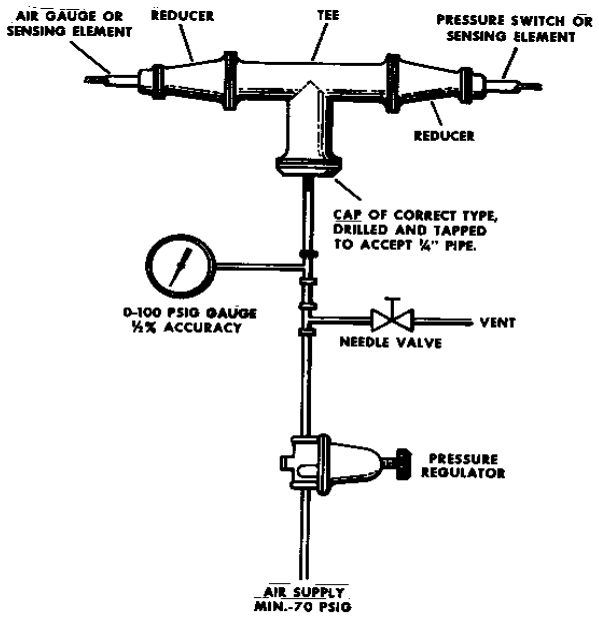
9.1 PRESSURE SWITCHES.--Used to control operation of booster pumps.

Application--To all pressure switches controlling the operations of booster pumps **on HTST pasteurizer systems employing regenerators**.

Frequency--Upon installation, **each 3 months** thereafter, after any change in the booster pump or the switch circuit, and/or whenever the pressure switch seal is broken.

Criteria--The pump shall not operate unless there is at least a 6.9kPa (1psi) pressure differential on the pasteurized milk side of the regenerator.

Apparatus--Sanitary pressure gauge and pneumatic testing device, for checking and adjusting pressure switch settings. (See illustration)



PNEUMATIC TESTING DEVICE

1. A simple inexpensive pneumatic testing device may be made from a discarded 50 millimeter (2 inch) - 7BX sanitary tee, with two additional 13H nuts, one of which is provided with a 16A cap, drilled and tapped for a 13 millimeters (½-inch) galvanized iron nipple for the air connection.

2. A hose connection is made to a compressed air source in the plant by means of a snap-on fitting. The air pressure can be controlled by an inexpensive pressure reducing valve (range [0-60] psig) followed by a 13 millimeters (½ inch) globe type bleeder valve connected into the side outlet of a 13 millimeters (½-inch) tee installed between the pressure reducing valve and the testing device.
3. The pressure switch to be tested is disconnected from the pasteurizer and connected to another of the outlets of the sanitary tee, and the pressure gauge is connected to the third outlet of the sanitary tee.

4. By careful manipulation of the air pressure reducing valve and the air bleeder valve, the air pressure in the testing device may be regulated slowly and precisely. (In operating the device, care should be taken to avoid exposing the pressure switch and the sanitary pressure gauge to excessive pressure which might damage them). This can be done by first closing off the air pressure regulating valve and opening fully the bleeder valve; these may then be manipulated slowly to bring the air pressure in the testing device within the desired range.) A test light of proper voltage can be placed in series with the pressure switch contact and in parallel with the electrical load (booster pump starter) so the actuation point may be readily determined.

Method--Check and make adjustment of pressure switch so as to prevent the operation of the booster pump unless the pressure of the pasteurized milk side of the regenerator is greater by at least 6.9 kPa (1 psi) than any pressure that may be generated on the raw side.

Procedure:- Early type

a. Determine maximum pressure of booster pump.

(1) Install sanitary pressure gauge in tee at discharge of booster pump.

(2) Operate the pasteurizer with water with the flow-diversion device in forward-flow position, the metering pump operating at minimum speed possible, and the booster pump operating at its rated speed. If vacuum equipment

is located between the raw outlet from the regenerator and the metering pump, it should be bypassed while this determination is made.

(3) Note maximum pressure indicated by pressure gauge under these conditions.

b. Check and set the pressure switch.

(1) Install a sanitary pressure gauge of known accuracy on the pneumatic testing device to which the pressure switch sensing element should also be connected.

(2) Remove the seal and cover to expose adjustment mechanism on pressure switch.

(3) Operate the testing device and determine the pressure gauge reading at the **cut-in point of the pressure switch which will light the test lamp**. (If the switch is short circuited, the lamp will be lighted before air pressure is applied.)

(4) The cut-in point should be adjusted, if necessary, so as to occur at a pressure gauge reading at least 6.9 kPa (1 psi) greater than the maximum booster pump operating pressure, as determined under section a. of this method. Where adjustment is necessary, refer to manufacturer's instructions for adjusting procedure. After adjustment, recheck actuation point and readjust if necessary.

(5) Replace cover and seal the pressure switch and restore sensing element to original location.

(6) Record test results for the office record.

9.2 DIFFERENTIAL PRESSURE CONTROLLER

Application--Part 2.1 applies to all differential pressure controllers used to control the operation of booster pumps on **HTST and HHST** systems, or used to control operation of flow-diversion devices on HHST and aseptic processing systems when no vacuum breaker is located downstream from the holding tube.

Part 2.2 applies only to HTST systems

Part 2.3 applies to the testing of HHST systems in which the differential pressure controller is used to control the operation of the flow diversion dievice. Test 2.3 also applies to aseptic processing systems in which the differential pressure controller is used to control the flow diversion device, product divert system, product divert valve or other acceptable control system.

Frequency--Upon installation, **each 3 months** thereafter, and whenever the differential pressure controller is adjusted or repaired or whenever the regulatory seal is broken.

Criteria--The booster pump shall not operate or the pasteurizer shall not operate in forward flow unless the product pressure in the pasteurized side of the regenerator is at least 6.9 kPa (1 psi) greater than the product pressure in the raw side of the regenerator. When the differential pressure controller is used to control the flow-diversion device on HHST systems, and improper pressure occur in the regenerator, the flow diversion device shall move to the diverted-flow position and remain in diverted flow until proper pressures are re-established in the regenerator and all product contact surfaces between the holding tube and flow-diversion device have been held at or above the required pasteurization temperature, continuously and simultaneously for at least the required pasteurization time as defined in Definition S of this *Ordinance*.

Apparatus--A sanitary pressure gauge and a pneumatic testing device described under PRESSURE SWITCHES (Test 9,1) above can be used for checking and adjusting the differential pressure switch setting.

Method--The differential pressure switch is checked and adjusted to prevent operation of the booster pump, or prevent forward flow, unless the product pressure in the pasteurized or aseptic side of the regenerator is at least 6.9 kPa (1 psi) greater than the pressure in the raw side of the regenerator.

9.2.1 CALIBRATION OF DIFFERENTIAL PRESSURE CONTROLLER PROBES

Procedures--

a. Loosen the process connection at both pressure sensors and wait for any liquid to drain through the loose connections. (**Note: At this point do not remove sensors from their location on the press).** Both pointers should be within 3.5 kPa (0.5 psi) of .0 kPa (0 psig). **If not, adjust pointer(s) to read 0 kPa (0 pounds psig).**

b. **After identifying both sensors (raw and pasteurized)** remove them from the processor and mount them in a tee, either at the discharge of the booster pump, or connected to the pneumatic testing device. Note (in writing, if necessary) the separation between the two pointers. (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.

> **Note:** *If the pneumatic testing device is used in lieu of the booster pump, adjust air pressure to the normal operating pressure of the booster pump.*

Note that the pointer, or digital display reading separation is within 6.9 kPa (1psi) of that observed before pressure was applied. If not the instrument requires adjustment or repair.

c. Record the test results for the office record. Reseal the instrument controller and any seals broken on electronic pressure sensor devices.

FOR PNEUMATIC OPERATED PRESSURE DIFFERENTIAL CONTROLLERS

1. Quickly exhaust the air from the pneumatic tube while closely observing the pressure indicators as they drop to their static position or "0". If the comparison exceeds ± scale unit during the drop , the unit in need of further evaluation. Probable causes may be:

a) Unequal sized capillaries (raw v.s. pasteurized)
b) Unequal lengths of capillaries.
c) Damaged capillary(s), (crimped, etc)

Note: Both raw and pasteurized capillary tubes should be replaced at the same time. Also both should be the same length and internal diameter.

2. Note that both of the pointers separation is within .07 kPa (1 psi) of that observed before pressure was applied. If not, the instrument, sensors or capillary are malfunctioning and require immediate maintenance.

c. Device specific testing procedures

TESTING THE DIFFERENTIAL CONTROLLER WITH A CDT DEVICE

A. DEVICE ACCURACY TEST

1. Attach the tubing from **OUTLET A** to the **PASTEURIZED SENSOR.**
2. Attach the tubing from **OUTLET B** to the **RAW SENSOR.**
3. Attach an supply air hose to the CDT.
4. Place the selector switch in the **AA position.**
5. Turn regulator **A** until the pressure gauge on the CDT reads 40 psi.
   both sensors should also read 40 psi (within ½ of scale division)
6. Turn regulator **A** to the left until all of the air is released.
   both sensors should read 0 psi (within ½ of scale division)

B. HTST DIFFERENTIAL PRESSURE CONTROLLER TEST (Taylor Model's #117 and 447K)

1. Place the selector in the **AB** position.
2. Turn regulator **A and regulator B** to the right until the plants differential pressure controller (DPC) reads 40 psi for both pointers.
3. Depress the test (or over-ride) button on the DPC and simultaneously adjust regulator **A** to the right (increasing the air pressure on the pasteurized sensor) until the pasteurized pressure has increased a minimum of one scale division. The DPC indicator light should go on.
4. Gradually (no faster than 1 psi per 5 seconds) decrease the pasteurized sensor air pressure by turning regulator **A** to the left. At the point when the indicator light goes off, note the pressure differential on the plants DPC. This is recorded as the official tested PRESSURE DIFFERENTIAL.

5. Quickly release all air pressure from both sensors until both sensors on the DPC read 0 psi.
6. Repeat test #3. The pressure differential should be identical at 0 psi and 40 psi.
Note: A suitable test light or voltage meter across two leads from the magnetic starter may be used to test booster pump on and off operation.

9.2.2 HTST--INTERWIRING OF THE PRESSURE DIFFERENTIAL CONTROLLER WITH THE BOOSTER PUMP

Method--Determine if the booster pump stops when the pressure differential is not properly maintained in the regenerator.

Procedure.--

a. Connect the **pasteurized pressure sensor** to a testing tee with the other end of the tee capped. Caution-- If there is water in the HTST system, ensure that the recorder/controller probe and the pasteurized sensor ports are capped before the metering pump is turned on.

b. Turn on the metering pump and the booster pump.

c. Place the **recorder/controller probe in hot water** which is above the cut-in temperature.

d. **Apply and adjust air supply** to the tee to provide an **adequate pressure differential to start the booster pump.**

e. Decrease the air supply to the testing tee until the pressure is less than **14 kPa (2psi)** of the pressure on the **raw milk** pressure sensor. **The booster pump should have stopped. Ensure that the flow diversion device remains in the forward flow position and the metering pump continues to operate.**

f. Reseal regulatory controls as necessary and record test results fot the office record.

Corrective Action--If the booster pump fails to stop when the pressure differential is not maintained, have the plant maintenance personnel or manufacturers service representative, etc, determine and correct the cause.

9.2.3 HHST AND ASEPTIC PROCESSING -- INTERWIRING OF THE PRESSURE DIFFERENTIAL CONTROLLER WITH THE FLOW DIVERSION DEVICE IN AN HHST SYSTEM OR AN ACCEPTABLE ALTERNATIVE DEVICE OR SYSTEM IN ASEPTIC PROCESSING EQUIPMENT.

Application--

a. To all differentail pressure controllers used to control the operation of flow diversion devices on HHST systems when no vacuum breaker is located downstream from the holding tube, and

b. To all differential pressure controllers used to control the operation of flow diversion devices, product divert systems, product divert valve(s) or other acceptable control systems used in aseptic processing equipment.

Apparatus.--A sanitary pressure guage and a pneumatic testing device, described under PRESSURE SWITCHES, (Test 9.1) above can be used for checking and adjusting the differential pressure switch setting.

Method.--The differential pressure switch is checked and adjusted to prevent forward flow, unless the product pressure in the pasteurized side of the regenerator is at least 6.9 kPa (1 psi) greaater than the pressure in the raw product side of the regenerator. In the case of product to water to product regenerators protected on the pasteurize or aseptic side, the water side of the regenerator shall be considered to be the “raw product” for purposes of this test.

Procedures.--

a. Wire a test lamp in series with the signal from the pressure differentail switch to the flow diversion device.

b. Calibrate the pressure switch and probes (using test 9.2.1)

c. 1. Adjust the pressure on the pressure switch sensors to their normal operating pressures (with the pasteurized, or aseptic pressure at least 14 kPa (2 psi) higher than the raw product pressure.

2. The test lamp should be lit. If the test light is not lit, increase the pasteurized, or aseptic pressure (or lower the raw product pressure) until the test light is lit.

3. Gradually lower the pasteurized, or aseptic side (or raise the raw product pressure) until the test light turns off.

4. The test light should turn off when the pasteurized, or aseptic pressure is 14 kPa (2 psi) or more haigher that the raw product pressure.

5. Note the differential pressure at the point the light turns off.

6. Gradually raise the pasteurized, or aseptic pressure (or lower the raw product pressure) until the test light turns on.

7. The test light should not turn on until the pasteurized, or aseptic pressure is grater than 14 kPa (2 psi) higher than the raw product pressure. Note the differential pressure at the point the light turns off.

Note: This test may be completed using a pneumatic testing device capable of producting differential pressures on the probes. This device should be capable of being operated in a manner so as to duplicate the conditions described above.

d. Seal the instrument and record the test results for the office record.

9.3 ADDITIONAL HTST TESTS FOR BOOSTER PUMPS

Application.--To all booster pumps used for HTST systems.

Criteria.--The booster pump shall be wired so it cannot operate if the flow diversion device is in the diverted position or if the metering pump is not in operation.

Apparatus--A sanitary pressure gauge and pneumatic testing device as described in Test 9. 1, and water with heat source.

9.3.1 BOOSTER PUMPS-- INTERWIRED WITH FLOW-DIVERSION DEVICE

Method--Determine if the booster pump stops by dropping the temperature and causing flow-diversion device to divert.

Procedures:

a. Connect pasteurization pressure sensor to testing tee with the other end of the tee capped. (Caution: if there is water in the HTST system, ensure that the recorder controller probe and pasteurized pressure sensor ports are capped before the metering pump is turned on).

b. Turn on the metering pump and the booster pump.

c. Place the recorder controller probe in hot water which is above the cut-in temperature.

d. Turn on the air supply to provide adequate pressure differential to start the booster pump.

e. Remove the recorder controller probe from the hot water.

f. When the flow-diversion device moves to the diverted flow position, **the booster pump must stop**. Ensure that the pressure differential remains adequate and the metering pump continues to operate.

g. Reseal regulatory controls as necessary and record test results for office records.

Corrective Action--If the booster pump fails to stop when the flow-diversion device is in the diverted flow position, have the plant maintenance personnel check the wiring and correct the cause.

9.3.2 BOOSTER PUMPS-- INTERWIRED WITH METERING PUMP

Method--Determine if booster pump stops when metering pump is off.

Procedure.--

a. Connect pasteurization pressure sensor to testing tee with the other end of the tee capped. (Caution: if there is water in the HTST system, ensure that the recorder controller probe and pasteurized pressure sensor ports are capped before the metering pump is turned on).

.

b. Turn on the metering pump and the booster pump.

c. Place the recorder/controller probe in hot water which is above the cut-in temperature.

d. Provide an adequate pressure differential to allow the booster pump to start.

e. Turn off the metering pump. The booster pump must stop. Ensure that the pressure differential remains adequate and the flow diversion device remains in the forward flow position.

f. Record the test results for the office record.

Corrective Action.-- If the booster pump fails to stop when the metering pump is turned off, have the plant maintenance personnel determine and correct the cause.

Test 10
MILK FLOW CONTROLS- MILK TEMPERATURES AT CUT-IN AND CUT-OUT

References-- Item 16p(B), 16p(E).
Milk flow controls shall be tested for milk temperature at cut-in and cut-out by one of the following applicable tests at the frequency prescribed.

10.1 HTST PASTEURIZERS

Application--All recorder/controllers used in connection with HTST pasteurizers.

Frequency--Upon installation and at least once each three months by the regulatory agency; daily by the plant operator, or when a regulatory seal has been broken.

Criteria--No forward flow until pasteurization temperature has been reached. Flow diverted before temperature drops below minimum pasteurization temperature.

Apparatus--No supplemental materials needed.

Method--By observing the actual temperature of the indicating thermometer at the instant forward flow starts (cut-in) and stops (cut-out).

Procedure:

a. **CUT-IN TEMPERATURE**

(1) While milk or water is completely flooding the sensing element of the recorder/controller and the indicating thermometer, increase the heat gradually so as to raise the temperature of the water or milk at a rate not exceeding 0.5°C (1°F) every 30 seconds. If a water bath is used in place of water or milk flowing through the system, the water bath shall be adequately agitated during this test.

(2) Observe the **indicating thermometer** reading at the moment the **forward flow starts (i.e., flow-diversion device moves)**. Note: Observe that the frequency pen reading is synchronized with the recording pen on the same reference arc.

(3) Record the indicating thermometer reading on the recorder chart; inscribe initials. The regulatory agency shall record test findings.

b. **CUT-OUT TEMPERATURE.**

(1) After the cut-in temperature has been determined and while the milk or water is above the cut-in temperature, allow the water to cool slowly at a rate not exceeding (0.5°C) 1°F per 30 seconds. Observe **indicating thermometer** reading at the instant forward flow stops.

(2) Reseal the regulatory controls as necessary and record the indicating thermometer reading on the recorder chart and initial.

Corrective Action.--Should the reading be below the minimum pasteurization temperature, the cut-in and cut-out mechanism and/or the differential temperature mechanism should be adjusted to obtain proper cut-in and cut-out

temperatures by repeated tests. When compliance is achieved, seal the controller mechanism.

10.2 HHST PASTEURIZERS AND ASEPTIC PROCESING SYSTEMS USING INDIRECT HEATING

Application.--All HHST pasteurizers and aseptic processing systems using indirect heating. When testing aseptic processing systems, the "product divert system" or product divert valve or acceptable control system may be substituted for the flow diversion device when it is referenced in this test.

Frequency--Upon installation, and every 3 months thereafter; whenever the thermal controller seal is broken.

Criteria--The pasteurizer or aseptic processor shall not operate in forward flow unless pasteurization or aseptic processing temperature has been achieved. The product flow shall be diverted at a temperature no lower than the chosen pasteurization or aseptic processing standard.

Apparatus--No supplemental materials needed.

Method--The cut-in and cut-out temperatures are determined by observing the actual temperature in the constant temperature bath at which the two sensing elements signal for forward flow (cut-in) and diverted flow (cut-out).

Procedures:

a. Wire the test lamp in series with the control contacts of the sensing element (holding tube). Immerse this sensing element in the constant temperature bath. Raise the bath temperature at a rate not exceeding 0.5°C (1°F) every 30 seconds. Observe the temperature reading at the cut-in temperature. Record the temperature for the office record.

b. After the cut-in temperature has been determined and while the bath is above the cut-in temperature, allow the bath to cool slowly at a rate not exceeding

0.5°C (1°F) per 30 seconds. Observe the temperature reading on the controller when the test lamp goes out (cut-out temperature). Determine that the cut-out temperature on the thermal limit controller is equivalent to or greater than the chosen pasteurization or aseptic processing standard

Corrective action-Where adjustment is necessary, refer to manufacturer's instructions. After adjustment, repeat the procedure above and when the results are satisfactory, record results for the office records.

c. Repeat the procedure for the other sensing element, (flow-diversion device). When proper cut-out temperature has been verified for both sensing elements, seal the controller system.

10.3 HHST PASTEURIZERS AND ASEPTIC PROCESSING SYSTEMS USING DIRECT HEATING

Application--All HHST pasteurizers and aseptic processing systems using direct contact heating. When testing aseptic processing systems, the "product divert system" or product divert valve" or "acceptable control system" may be substituted for the "flow-diversion device" when it is referenced in this test.

Frequency--Upon installation, and every 3 months thereafter, whenever the thermal limit controller seal is broken.

Criteria--The pasteurizer or aseptic processorshall not operate in forward flow unless pasteurization or aseptic processing temperature has been achieved. The product flow shall be diverted at a temperature no lower than the chosen pasteurization or aseptic standard.

Apparatus--No supplemental materials needed.

Method--The cut-in and cut-out temperatures are determined by observing the actual temperature in the constant temperature bath at which each of the three sensing elements signals for forward flow (cut-in) and diverted flow (cut-out).

Procedures:

a. Wire the test lamp in series with the control contacts of the sensing element (the holding tube). Immerse this sensing element in the constant temperature bath. Raise the bath temperature at a rate not exceeding 0.5°C (1°F) every 30 seconds. Observe the temperature reading on the controller when the test lamp lights (cut-in temperature). Record the temperature for the office record.

b. After the cut-in temperature has been determined and while the bath is above the cut-in temperature, allow the bath to cool slowly at a rate not exceeding 0.5°C (1°F) per 30 seconds. Observe the temperature reading on the controller when the test lamp goes out (cut-out temperature). Determine that the cut-out temperature on the thermal limit controller is equivalent to or greater than the chosen pasteurization or aseptic processing standard. Where adjustment is necessary, refer to manufacturer's instructions. After adjustment, repeat the procedure above and when the results are satisfactory, record the results for the office record.

c. Repeat the procedure for the other two sensing elements, i.e., the vacuum chamber and flow-diversion device. Rewire the test lamp in series with the control contacts from each sensing element, respectively. When proper cut-out temperatures have been verified for all three sensing elements, seal the controller system.

TEST 11
CONTINUOUS FLOW HOLDERS-HOLDING TIME

Reference--Item 16p(B).
Continuous flow holders shall be tested for holding times by one of the applicable tests.

11.1-- HTST PASTEURIZERS--(except for magnetic flow meter systems)

Application--To all HTST pasteurizers.

Frequency--Upon installation and semiannually thereafter, whenever seal on speed setting is broken; any alteration is made affecting the holding time, the velocity of the flow (such as, replacement of pump, motor, belt, drive or driven pulleys, or decrease in number of HTST plates or the capacity of holding tube); or whenever a check of the capacity indicates a speedup.

Criteria--Every particle of milk shall be held for at least 15 seconds in both the **forward and diverted flow positions**.

Apparatus--Electrical conductivity measuring device, Appendix I, capable of detecting change in conductivity, equipped with standard electrodes; table salt (sodium chloride), suitable method of injecting saline solution, stopwatch; suitable container for salt solution.

Method--The holding time is determined by timing the interval for an added trace substance to pass through the holder. Although the time interval of the fastest particle of milk is desired, the conductivity test is made with water. The results found with water are converted to the milk flow time by formulation since a pump may not deliver the same amount of milk as it does water.(1)

Procedure.--

a. Examine the entire system to insure that all flow promoting equipment is operating at maximum capacity and all flow impeding equipment is so adjusted or bypassed as to provide the minimum of resistance to the flow. There shall be no leakage on the suction side of the timing pump.

b. Adjust variable speed pump, including electronic pump control boxes, to its maximum capacity (preferably with a new belt and full size impellers). Check homogenizers for seals and/or gears or pulley identification.

c. Install one electrode at the inlet to the holder and the other electrode in the holder outlet. Close the circuit to the electrode located at the inlet to the holder.

d. **Operate the pasteurizer using water at pasteurization temperature**, with flow-diversion device in forward-flow position.

e. Quickly inject 50 ml. of saturated sodium chloride solution or other suitable conductant (such as an adequate strength acid solution) into the holder inlet.

f. Begin the timing process (automatically or with stopwatch) with the first movement of the indicator of a change in conductivity or by other automatic means. Open the circuit to the inlet electrode and close the circuit to the electrode at the outlet of the holder.

g. End the timing process (automatically or with a stopwatch) with the first movement of the indicator of a change in conductivity.

h. Record results.

I. 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 instruments and connections, and check for air leakage on suction side. Repeat tests. Should consistent readings not be obtained, use the fastest time as the holding time for water.

j. Repeat steps d. through I. for testing time on water in **diverted flow**.

k. With the pump at the same speed and equipment adjusted as in a. above, **time the filling of a 38 liter (10-gallon) can with a measured weight of water using the discharge outlet with the same head pressure as in normal operation.** Average the time of several trials. (Since flow rates of large capacity units make it very difficult to check by filling a 38 liter (10-gallon) can, it is suggested that a calibrated tank of considerable size or other acceptable methods be used.)

l. For all gear type timing pumps, and homogenizer timing pumps with measured time of less than 120% of the legal holding time, repeat procedure 'k.' using milk.

m. Compute the holding time for milk from the following formula by weight, using the average specific gravity. Compute separately for forward flow and diverted flow.[(1)]

Tm=**(1.032xTw)(Wm/Ww)**, in which--
1.032=specific gravity for milk;
TW=average holding time for water;
Tm= Adjusted holding time for milk
Wm=average time required to deliver a measured weight of milk.
Ww=average time required to deliver an equal weight of water.

n. Record results for office record.

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

Tm= T(Mv/Ww),in which:

Tm=Adjusted holding time for milk
T=average holding time for water;
Mv=average time required to deliver a measured volume of milk;
Ww=average time required to deliver an equal volume of water.

(1) The computation portion of this test is not required for meter based systems; nor for those **homogenizer based timing systems** with a measured holding time of more than 120% of the legal holding time(s).(for

example, (15 sec=18sec, 25 sec= 30sec). **All gear driven (conventional positive displacement type impeller timing pumps) based timing systems must have computed holding times as described above.**

Corrective Action--When the computed holding time for milk is less than that required either in forward flow or diverted flow, the speed of the timing pump shall be reduced or adjustment made in the holding tube, and the timing test repeated until satisfactory holding time is achieved. Should an orifice be used to correct the holding time in diverted flow, there should be no excessive pressure exerted on the underside of the valve seat of the flow-diversion device. Governors shall be sealed on motors that do not provide a constant speed as provided in Item 16p(B)5b.

11.2A MAGNETIC FLOW METER SYSTEMS; HOLDING TIME

Application.--To all HTST pasteurizers with a Magnetic Flow Meter System used in lieu of a metering pump.

Frequency--Upon installation and semiannually thereafter, whenever seal on the Flow Alarm is broken; any alteration is made affecting the holding time, the velocity of the flow or the capacity of holding tube; or whenever a check of the capacity indicates a speedup.

Criteria--Every particle of milk shall be held for at least a minimum holding time in the **forward flow position**.

Apparatus--Electrical conductivity measuring device, capable of detecting change in conductivity, equipped with standard electrodes; table salt (sodium chloride or other suitable conductive substance), and a suitable method of injecting the conductive solution; a stopwatch or automatic means of determining holding times and suitable container for conductive solutions.

Method--The holding time is determined by timing the interval for an added trace substance to pass through the holder.

Procedure.--

a. Examine the entire system to insure that all flow promoting equipment is operating at maximum capacity and all flow impeding equipment is so adjusted or bypassed as to provide the minimum resistance to the flow.

b. Adjust the set point on the Flow Alarm to its highest possible setting.

c. Adjust the set point on the Flow Controller to a flow rate estimated to yield an acceptable holding time.

d. Install one electrode at the inlet to the holder and the other electrode to the holder outlet. Close the circuit to the electrode located at the inlet to the holder.

e. Operate the pasteurizer using water above pasteurization temperature, with the flow diversion device in **the forward flow position**.
f. Quickly inject 50-ml of saturated sodium chloride solution into the holder inlet.

g. Begin the timing process either automatically or with a stopwatch when the solution first contacts the inlet probes as indicated by a movement of the indicator(change in conductivity) or by other automatic means.

h. End the timing the stopwatch with the first movement of the indicator of a change in conductivity or by automatic means.

I. Record results.

j. 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 instruments and connections, and check for air leakage on suction side of the pump located at the raw product supply tank. **If six consecutive readings within 0.5 seconds cannot be achieved in forward flow, the pasteurizing system is in need of repair.**

Note: The requirement for Magnetic Timing System holding time testing in the diverted flow position is no longer required (NCIMS 1997). The reasoning is that in the event of a diversion because of excessive flow rate, the system requires a time delay (15 seconds for milk, 25 seconds for eggnog or frozen dessert mix) after acceptable flow is attained, before the diversion valve can assume the forward flow position. If, during a temperature only divert flow condition, and the maximum allowable flow is exceeded, a 15 second, time delay will be activated automatically before the valves assume the forward flow position.

k. With the Flow Controller at the same set point and equipment adjusted as in © above, time the filling of a 38 liter (10 gallon) can (or a calibrated tank) with a measured volume of water using the discharge outlet with the same head pressure as in normal operation. Average the time of several trials. Other acceptable methods may be used..**Note: The COMPUTED HOLDING TIME (timing of a known**

weight or volume of water and milk and computing the adjusted holding time) is not required for Magnetic Flow Meter Timing based systems.

m. Record this result for office record and reseal the controls as necessary.

Corrective Action.--When the computed holding time for milk is less than that required in forward flow, the set point on the Flow Controller shall be decreased, or adjustment made in the holding tube, and the timing test repeated until satisfactory holding time is achieved.

11.2B CONTINUOUS FLOW HOLDERS--FLOW ALARM

Application--To all continuous flow pasteurization and aseptic processing systems using a Magnetic Flow Meter System to replace a metering pump. When testing aseptic processing systems, the "product divert system" or product divert valve" or "acceptable control system" may be substituted for the "flow-diversion device" when it is referenced in this test.

Frequency--Upon installation and semiannually thereafter, whenever the seal on the Flow Alarm is broken; any alteration is made affecting the holding time, the velocity of the flow or the capacity of holding tube; or whenever a check of the capacity indicates a speedup.

Criteria--When flow rate equals or exceeds the value at which the holding time was measured, the Flow Alarm shall cause the flow diversion device to assume the diverted position, even though temperature of the milk in the holding tube is above pasteurization or aseptic processing temperature.

Apparatus.--None.

Method--Adjust the set point of the Flow Alarm so that flow is diverted when the flow rate equals or exceeds the value at which holding time was measured.

Procedure.--

a. Operate the pasteurizer or aseptic processing equipment in forward flow, at the flow rate at which holding time was measured, using water above pasteurization or aseptic processing temperature.

b. Adjust set point on the Flow Alarm slowly downward until the frequency pen on the Recorder indicates that flow has been diverted. Note: When performing this test on systems which operate above the boiling point of water, assure that the balance tank resolution return system is cooling and engaged to avoid the possibility of serious burns.

c. Observe that the flow diversion device moves to the diverted position while water passing through the holding tube remains above pasteurization or aseptic processing temperature.

d. Reseal the regulatory controls as necessary and record the set point of the Flow Alarm, the occurrence of flow diversion, and the temperature of the water in the holding tube, for the office record.

Corrective Action.--If the flow diversion device does not move to the diverted position when the frequency pen of the Recorder indicates a diversion, a modification or repair of the control wiring is required.

11.2C CONTINUOUS FLOW HOLDERS; LOW FLOW/LOSS-OF-SIGNAL ALARM

Application--To all continuous flow pasteurization and aseptic processing systems using a Magnetic Flow Meter System to replace a metering pump. When testing aseptic processing systems, the "product divert system" or" product divert valve" or "acceptable control system" may be substituted for the "flow diversion device" when it is referenced in this test.

Frequency--Upon installation and semiannually thereafter, whenever seal on the Flow Alarm is broken; any alteration is made affecting the holding time; the velocity of the flow or the capacity of holding tube; or whenever a check of the capacity indicates a speedup.
Criteria--Forward flow occurs only when flow rates are above the Loss-of-Signal Alarm set point.

Apparatus--None.

Method--By observing the actions of the frequency pens on the recorder and the position of the flow diversion devise.

Procedure.--
a. Operate pasteurizer or aseptic processing system in forward flow, at a flow rate below the Flow Alarm set point and above the Loss-of-Signal Alarm set point, using water.

b. Disrupt power to the magnetic flow meter or decrease the flow through the flow meter below the low flow alarm set point. Observe that the flow diversion devise and both the safety thermal limit recorder frequency pen and the flow rate frequency pen assume the diverted flow position.

c. Reseal regulatory controls as necessary and record results for the office record.

Corrective Action--If the valve does not divert or the pens do not move. Adjustment of the Low Flow Alarm or modification or repair of control wiring is required.

11.2D CONTINUOUS FLOW HOLDERS; FLOW CUT-IN AND CUT-OUT

Application--To all high-temperature short-time pasteurizers using a Magnetic Flow Meter System to replace a metering pump.

Frequency--Upon installation and semiannually thereafter, whenever seal on the Flow Alarm is broken; any alteration is made affecting the holding time, the velocity of the flow or the capacity of holding tube; or whenever a check of the capacity indicates a speedup.

Criteria--Forward flow occurs only when flow rates are below the Flow Alarm set point and above the Loss-of-Signal Alarm set point.
Apparatus--None.

Method--By observing the Recorder readings along with the action of the frequency pen on the Recorder.

Procedure.--

a. Operate pasteurizer in forward flow, at a flow rate **below** the Flow Alarm set point and **above** the Loss-of-Signal Alarm set point, using **water above pasteurizer cut-in temperature**.

b. With the pasteurizer **operating on water above the pasteurizer cut-in temperature and the flow diversion valves in the forward flow position**, use the Flow Controller to **slowly increase the flow rate** until the frequency pen on the **Recorder indicates a flow diversion (flow cut-out point**). The **flow diversion device will also assume the diverted position.** Observe the reading of flow rate from the Recorder the **instant flow cut-out occurs**, as indicated by the frequency pen.

c. With the flow diversion device diverted because of excessive flow rate, and assuring the water remains above the pasteurizer cut-in temperature, slowly **decrease flow rate until the frequency pen on the Flow Recorder indicates the start of a forward flow movement (flow cut-in point)**. Because of the time delay relay described in Test E, the flow diversion device will not move immediately to the forward flow position. Observe the reading from the Flow Recorder, the instant flow cut-in occurs, as indicated by the frequency pen.

d. Reseal regulatory controls as necessary and record results for the office record.

Corrective Action--If the cut-in or cut-out point occurs at a flow rate equal to or greater than the value at which holding time was measured, adjust the Flow Alarm to a lower set point, and repeat the test.

11.2E. CONTINUOUS FLOW HOLDERS- TIME DELAY RELAY

Application--To all high-temperature short-time pasteurizers using a Magnetic Flow Meter System to replace a metering pump.

Frequency--Upon installation and semiannually thereafter, whenever seal on the Flow Alarm is broken; any alteration is made affecting the holding time, the velocity of the flow or the capacity of the holding tube; or whenever a check of the capacity indicates a speedup.

Criteria--Following a flow cut-in, as described in the test for flow cut-in and cut-out, forward flow shall not occur until all product in the holding tube has been held at or above pasteurization temperature for at least the minimum holding time.

Apparatus--Stopwatch.

Method--Set time delay equal to or greater than the minimum holding time.

Procedure:

a. Operate pasteurizer in forward flow, at a flow rate below the Flow Alarm set point and above the Loss-of Signal Alarm set point, using water above pasteurization temperature.

b. Using the Flow Controller**, increase flow rate slowly until the frequency pen on the Flow Recorder indicates a diversion movement, and the flow diversion device moves to the diverted position.** There shall be no time delay between the movements of the frequency pen and the flow diversion device.

c. **With the pasteurizer operating on water above the pasteurizer cut-in temperature, with the flow diversion device diverted because of excessive flow rate, slowly decrease flow rate.**

d. **Start** the stopwatch the instant the **frequency pen on the Flow Recorder** indicates the start of a forward flow movement.

e. **Stop** the stopwatch the instant the **flow diversion device starts to move to the forward flow position.**

f. Record results for the office record.

g. Install and seal enclosure over the time delay relay.

Corrective Action--If the time delay is less than the minimum holding time, increase the time setting on the time delay and repeat this test procedure.

11.3 CALCULATED HOLD FOR INDIRECT HEATING

Application--To all **HHST pasteurizers using indirect heating**.

Frequency--When installed and **semiannually** thereafter; whenever seal on speed setting is broken; whenever any alteration is made affecting the holding time, the velocity of the flow, e.g., replacement of pump, motor, belt, driver or driven pulley, or decrease in number of heat-exchange plates, or the capacity of holding tube; whenever a check of the capacity indicates a speedup.

Criteria--Every particle of product shall be held for the minimum holding time in both the forward and diverted-flow positions.

Apparatus--No supplemental materials needed.

Method--Fully developed laminar flow is assumed and holding tube length is calculated. An experimental determination of pumping rate is required; this is accomplished by determining the time required for the pasteurizer to fill a vessel of known volume, converting these data by division to obtain flow rate in gallons per second, and multiplying this value by the proper number in **Table 12** in this

section, to obtain the required length of holding tube. Holding tube lengths for HHST pasteurizers with indirect heating for a pumping rate of 1 gallon/second are as follows:

TABLE 12
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
0.1	72.3	30.0	16.8	10.5	7.14
0.05	36.2	15.0	8.4	5.24	3.57
0.01	7.23	3.0	1.68	1.05	.71

Procedures.--

a. Examine the entire system to ensure that all flow promoting equipment is operating at maximum capacity and all flow impeding equipment is so adjusted or by-passed to provide the minimum of resistance to the flow. This means that in-line filters must be removed, booster pumps must be in operation, and vacuum equipment in the system must be operating at a maximum vacuum.

Also, before the tests are begun, the pasteurizer should be operated at maximum flow for a sufficient time to purge air from the system (about 15 minutes) and pipe connections on the suction side of the metering pump should be made tight enough to exclude the entrance of air. Increase the temperature to the

pasteurizer cut-in temperature. With the pasteurizer operating with water and in forward-flow, adjust the metering pump to its maximum capacity, preferably with a new belt and full-size impellers.

b. Determine that no flow exists in the diverted line, and **measure the time required to deliver a known volume of water at the forward-flow discharge line**. Repeat the test at least once to determine that the measurements are consistent.

c. Repeat the steps in paragraphs a. and b. of this procedure in diverted flow by measuring the flow (using identical know volume) at the discharge of the divert line.

d. Select the greatest flow rate (shortest delivery time for the known volume) and calculate the flow rate in gallons per second by dividing the known volume by the time required to collect the known volume. **Multiply this value with the appropriate value in Table 12 to determine the required holding tube length.**

e. Determine the number and type of fittings in the holding tube and convert these to equivalent lengths of straight pipe with the use of **Table 13** of this - section. Determine the total length of the holding tube by adding the equivalent lengths of the fittings to the measured straight lengths of pipe. Record the number and type of fittings, the number and length of straight pipe, and the holding tube configuration for the office record. **If the temperature sensor is located at the beginning of the holding tube, the holding tube shall be protected against heat loss by material that is impervious to water**. Reseal regulatory controls as necessary

Alternate procedure--For pasteurizers of large capacity, the method of measuring flow rate at the discharge of the pasteurizer is inconvenient, and the following alternate test procedure may be used.

TABLE 13
Centerline Distances of 3-A Fittings (Inches)

3-A Designation (90°Bend)	FITTING SIZE (Inches)				
	1	1½	2	2½	3
2C	3.4	4.8	6.2	8.0	9.7
2CG	3.1	4.5	5.8	7.6	9.3
2F	3.4	4.8	6.2	8.0	9.7
2FG	3.1	4.5	5.8	7.6	9.3
2E	3.4	4.8	6.2	8.0	9.7
2EG	3.2	4.6	6.0	7.7	9.4

Alternate procecure.--For pasteurizers of large capacity, if the method of measuraing flow rate at the discharge of the pasteurizer is inconvenient, the following alternate test procedure may be used.

1. Remove the divert line from the raw-product supply tank, and turn off the product pump feeding the raw-product supply tank.

2. Suspend a sanitary dip stick in the raw-product supply tank, and operate the pasteurizer at maximum capacity.

3. Record the time required for the water level to move between two graduations on the dip stick. The volume of water is calculated from the dimensions of the raw-product supply tank and the drop in water level.

4. Flow rate is determined as follows: Divide the volume of water removed from the raw-product supply tank by the time required to remove it.

Corrective Action--If the length of the holding tube is shorter than the calculated length, reseal the metering pump at a slower maximum speed, or lengthen the holding tube, or both, and repeat the above determination.

11.4 CALCULATED HOLD FOR DIRECT HEATING

Application--To all HHST pasteurizers using direct contact heating.

Frequency--When installed and **semiannually** thereafter; whenever the seal on the speed setting is broken; whenever any alteration is made affecting the holding time, the velocity of the flow, e.g., replacement of pump, motor, belt, driver or driven pulley, or decrease in the number of heat exchange plates, or the capacity of the holding tube; whenever a check of the capacity indicates a speedup.

Apparatus--No supplemental materials needed.

Criteria--Every particle of product shall be held for the minimum holding time in **both forward- and diverted-flow positions.**

Method--Fully developed laminar flow and a temperature increase by steam injection of 67°C (120°F) are assumed, the temperature-time standard is chosen by the processor, and the required holding tube length is calculated from an experimental determination of pumping rate.

Procedures.--

a. Examine the entire system to ensure that all flow promoting equipment is operating at a maximum capacity and all flow impeding equipment is so adjusted or bypassed as to provide the minimum resistance to the flow.

b. Remove in-line filters, make certain booster pumps are operating and that vacuum equipment in the system is operating at maximum vacuum.

c. Operate the pasteurizer on water at maximum flow for a sufficient time to purge the air from the system (about 15 minutes) and tighten pipe connections on the suction side of the metering pump to exclude entrance of air.

d. Adjust the metering pump to its maximum capacity. Determine that no flow exists in the diverted line, and **measure the time required to deliver a known volume of water at the discharge of the pasteurizer in forward flow**. Repeat the test at least twice to determine that the measurements are consistent.

e. Repeat the last step (a. above) in **diverted flow** by collecting the effluent at the discharge of the divert line.

f. Select the greatest flow rate, the shortest delivery time for the known volume, and calculate the flow rate in gallons per second by dividing the known volume by the time required to collect the known volume.

g. Multiply this value, gallons per second, with the appropriate value in **Table 14 of this paragraph to determine the required holding tube length.**

TABLE 14

Holding Tube Length, HHST

Direct Heating

HOLDING TIME-(seconds)	**TUBING SIZE (Inches)**				
	1	**1½**	**2**	**2½**	**3**
1	**810.0**	**336.0**	**188.0**	**118.0**	**80.0**
0.5	**405.0**	**168.0**	**94.0**	**59.0**	**40.0**
0.1	**81.0**	**33.6**	**18.8**	**11.8**	**8.0**
0.05	**40.5**	**16.8**	**9.40**	**5.90**	**4.0**
0.01	**8.10**	**3.36**	**1.88**	**1.18**	**0.8**

h. **Determine the number and type of fittings in the holding tube**, and convert these to equivalent lengths of straight pipe with the use of Table 13.

I. Determine the total length of the holding tube by **adding the equivalent lengths of the fittings to the measured lengths of straight pipe**. If the actual holding tube length is equivalent to or greater than the required holding tube length, record; a) the number and type of fittings, b) the number and length of straight pipes, and c) the holding tube configuration, for the office record. (Make sure that the holding tube slopes upward at least 6.35 millimeters (0.25 inch) per foot.) The holding tube shall also be protected against heat loss with insulation that is impervious to water if the temperature sensor is located at the beginning of the holding tube. Reseal as necessary.

Alternate procedure--For pasteurizers of large capacity, the method of measuring flow rate at the discharge of the pasteurizer is inconvenient, and the following alternate test procedure may be used.

a. Remove the divert line from the raw product supply tank, and turn off the product pump feeding the raw-product supply tank.

b. Suspend a sanitary dip stick in the raw-product supply tank, and operate the pasteurizer at maximum capacity.

c. Record the time required for the water level to move between two graduations on the dip stick. Calculate the volume of water from the dimensions of the raw-product supply tank and the drop in water level.

Determine flow rate as follows: Divide the volume of water, in gallons, removed from the raw-product supply tank, by the time, in seconds, required to remove it. Then use Table 14 to calculate the required holding tube length.

Corrective Action--If the length of the holding tube is shorter than the calculated length, reseal the metering pump at a slower maximum speed, or lengthen the holding tube, or both, and repeat the procedure.

11.5 HOLDING TIME--STEAM INFUSERS WITH STEAM POP-OFF VALVE AND VACUUM CHAMBER ORIFICE USED IN PLACE OF A TIMING PUMP

Application.--To all **HHST pasteurizers using direct steam infusion heating** and using a **steam pressure relief valve** and a **vacuum chamber orifice** in place of a timing pump.

Frequency.--Upon installation, and **every 3 months** thereafter, or when a regulatory seal has been broken.
Apparatus.--No supplemental materials needed

Criteria.--Every particle of product shall be held for the minimum holding time in both forward and diverted flow position.
The following controls are required:
a. **A steam infuser shell or feed line shall be equipped with a pressure relief valve**. This pressure relief valve shall be located and sized so that the total pressure insiede the infuser can never exceed the set point on this pressure relief valve.

b. **An orifice or restrictor, permanently installed in a noticeable fitting, shall be placed in the holding tube just prior to the vacuum (flash) chamber**. The opening in this orifice shall be sixed to insure a minimum product residence time at least as long as that specified in the chosen HHST standard.

c. The size of the opening in the orifice or restrictor and the setting of the steam pressure relief valve shall be determined by trial and error. Once an appropriate maximum flow rate has been determined and a legal minimum holding time has been calculated**, both the restrictor or orifice and the steam pressure setting on the pressure relief valve shall be sealed so that neither can be changed.**

d. The state regulatory authority shall keep records of the orifice or restrictor size the location, size, setting and manufacturer of the pressure relief (pop-off) valve.
Procedures.--

a. Examine the entire system to ensure that all flow promoting equipment is operating at a maximum capacity and all flow impeding equipment is so adjusted or by-passed as to provide the minimum resistance to the flow.

b. The steam pressure in the infuser shall be raised to a level just below the pressure relief point on the pop-off valve.

c. Any back-pressure valves or other variable restrictions in the holding tube shall be normally placed into the fully open position.

d. All air bleeds to the vacuum chamber shall be closed so that the chamber will be operating under maximum vacuum.

e. Before the tests are begun, operate the pasteurizer at maximum flow for a sufficient time to purge the air from the system (about 15 minutes) and tighten the pipe connections on the suction side of the metering pump to exclude entrance of air.

f. Determine that no flow exists in the diverted line, and measure the time required to deliver a known volume of water at the disharge of the pasteurizer in forward flow.

g. Repeat the test at least twice to determine that the measurements are consistent.

h. Repeat the last step (a. through e. above) in diverted flfow by collecting the effluent at the discharge of the divert line.

i. Select the greatest flow rate, the shortest delivery time for the known volume and calculate the flow rate in gallons per second, by dividing the known volume by the time required to collect the known volume.

j. Multiply this value, gallons per second, with the appropriate value in Table 14, to determine the required holding tube length.

k. Holding tube lengths for direct contact heating pasteurizers with a pumping rate of 1 gallon/second are specified in Table 14.

l. Determine the number and tupe of fittings in the holding tube, and convert these to equivalent lengths of straight pipe with the use of Table 13. Determine the total length of the holding tube by adding the equivalent lengths of the fittings to the measured lengths of straight pipe.

m. Make sure that the holding tube slopes upward at least 6.35 millimeters (0.25 inch) per foot.

n. The holding tube shall also be protected against heat loss with insulation that is impervious to water if the temperature sensor is located at the beginning of the holding tube.

o. If the actual holding tube length is equivalent to or greater than the required holding tube length, record the number and type of fittings, the number and length of straight pipes and the holding tube configuration, for the office record. Re-seal regulatory controls as necessary.

Corrective Action.--If the length of the holding tube is shorter that the calculated length, lengthen the holding tube and repeat the above determination.

TEST 12
THERMAL LIMIT CONTROLLER
FOR CONTROL-SEQUENCE LOGIC

References--Items 16p(B), 16p(E).

Thermal limit controllers used with **HHST and aseptic processing systems** that have the flow-diversion device located downstream from the regenerator and/or cooler shall be tested by one of the following applicable tests at the frequency specified.

12.1 HHST PASTEURIZATION AND ASEPTIC PROESSING-- INDIRECT HEATING

Application--To all HHST and aseptic processing systems pasteurizers using indirect heating. When testing aseptic processing systsems, the "product divert system" or "product divert valve" or "acceptable control system" may be substituted for the "flow-diversion device" when it is referenced in thei test.

Frequency.--Upon installation, and **every 3 months** thereafter or when a regulatory seal has been broken.

Criteria.--The pasteurizer or aseptic processing equipmentshall not operate in forward flow until the product surfaces downstream from the holding tube have been sanitized or in the case of aseptic processing equipment, sterilized. On start up; surfaces shall be exposed to fluid at pasteurization or is the case of aseptic processing equipment, sterilization temperature for at least pasteurization or sterilization time. If the product temperature falls below the pasteurization or sterilization standard in the holding tube, forward flow shall not be re-achieved until the product surfaces downstream from the holding tube have been re-sanitized, or is the case of aseptic processing equipment, resterilized.

Apparatus.--A constant temperature bath of water or oil and the test lamp from the pneumatic testing device described in Test 9,1, can be used to check the control-sequence logic of the thermal limit controller.

Method.--The control-sequence logic of the thermal limit controller is determined by monitoring the electric signal from the thermal limit controller during a series of immersions and removals of the two sensing elements from a bath heated above the cut-in temperature.

Procedures.--

a. Heat a constant temperature water or oil bath a few degrees above the cut-in temperature on the thermal limit controller. Wire the test lamp in series with the signal from the **thermal limit controller to the flow-diversion device**. If some processors have time delays built into their control logic in excess of that required for public health reasons, bypass these timers or account for their effect in delaying forward flow.

b. Immerse the sensing element of the flow-diversion device in the bath, which is above the cut-in temperature. The test lamp should remain unlighted, i.e., diverted flow. Leave the sensing element in the bath.

c. Immerse the sensing element from the holding tube in the bath. The test lamp should light up, i.e., forward flow after a minimum time delay of 1 second for continuous flow pasteurizatin systems. For aseptic processing systems, no delay is required if the filed process includes a documented sterilization period.

d. Remove the sensing element of the flow-diversion device from the bath. The test lamp should remain lighted, i.e., forward flow.

e. Remove the holding tube sensing element from the bath. The test lamp should go out immediately, i.e., diverted flow.

f. Re-immerse the sensing element of the holding tube in the bath. The test lamp should remain unlighted, i.e., diverted flow. Re-seal regulatory controls as necessary.

Corrective Action--If the control-sequence logic of the thermal limit controller does not follow this pattern, the instrument shall be rewired to conform to this logic.

12.2 HHST PASTEURIZATION AND ASEPTIC PROCESSING SYSTEMS-- DIRECT HEATING

Application--To all HHST pasteurizers and aseptic processing systems using direct contact heating. When testing aseptic processing systsems, the "product divert system" or "product divert valve" or "acceptable control system" may be substituted for the "flow-diversion device" when it is referenced in thei test.

Frequency--Upon installation, and **every 3 months** thereafter and when a regulatory seal has been broken.

Criteria--The pasteurizer or aseptic processing equipmentshall not operate in forward flow until the product surfaces downstream from the holding tube have been sanitized or in the case of aseptic processing equipment, sterilized. On start up; surfaces shall be exposed to fluid at pasteurization or is the case of aseptic processing equipment, sterilization temperature for at least pasteurization or sterilization time. If the product temperature falls below the pasteurization or sterilization standard in the holding tube, forward flow shall not be re-achieved until the product surfaces downstream from the holding tube have been re-sanitized, or is the case of aseptic processing equipment, resterilized.

Apparatus--A constant temperature bath of water or oil and the test lamp from the pneumatic testing device described in Test 9,1, can be used to check the control-sequence logic of the thermal limit controller.

Method.--The control-sequence logic of the thermal limit controller is determined by monitoring the electric signal from the thermal limit controller during a series of immersions and removals of the three sensing elements from a bath heated above the cut-in temperature.

Procedures.--

a. Heat a water or oil bath to a constant temperature, a few degrees above the cut-in temperature on the thermal limit controller. Wire the test lamp in series with the signal from the thermal limit controller to the flow-diversion device. If some processors have time delays built into their control logic in excess of that required for public health reasons, bypass these timers or account for their effect in delaying forward flow. Before performing this test, make sure the pressure switches which must be closed to achieve forward flow have also been bypassed.

b. Immerse the sensing element from the flow-diversion device in the bath which is above the cut-in temperature. The test lamp should remain unlighted, i.e., diverted flow. Remove this sensing element from the bath.

c. Immerse the sensing element from the vacuum chamber, in the bath. The test lamp should remain unlighted, i.e., diverted flow. Remove the sensing element from the bath.

d. Immerse two sensing elements, from the vacuum chamber and flow-diversion device, in the bath. The test lamp should remain unlighted, i.e., diverted flow. Leave the two sensing elements in the bath.

e. Immerse the sensing element from the holding tube in the bath. The test lamp should light up, i.e., forward flow after a minimum time delay of 1 second for continuous flow pasteurizatin systems. For aseptic processing systems, no delay is required if the filed process includes a documented sterilization period.

f. Remove one sensing element, the flow-diversion device, from the bath. The test lamp should remain lighted, i.e., forward flow.

g. Remove another sensing element, the vacuum changer, from the bath. The test lamp should remain lighted, i.e., forward flow.

h. Remove the last sensing element, the holding tube, from the bath. The test lamp should go out, i.e., diverted flow, immediately.

I. Re-immerse the sensing element, holding tube, in the bath. The test lamp should remain unlighted, i.e., diverted flow. Re-seal regulatory controls as necessary.

Corrective Action--If the control-sequence logic of the thermal limit controller does not follow the pattern set out in the procedures section, the instrument shall be rewired to conform to this logic.

TEST 13
SETTING OF CONTROL SWITCHES FOR PRODUCT PRESSURE IN THE HOLDING TUBE

Reference-- Item 16p(B).

Application--To all HHST pasteurizers and aseptic processing systems which are capable of operating with product in forward flow mode, with less than 518 kPa(75 psig) pressure in the holding tube. When testing aseptic processing systsems, the "product divert system" or "product divert valve" or "acceptable control system" may be substituted for the "flow-diversion device" when it is referenced in thei test.

Frequency--Upon installation, and every 3 months thereafter; whenever the pressure switch seal is broken; and whenever the operating temperature is changed.

Criteria--The pasteurizer or aseptic procesor shall not operate in forward flow unless the product pressure in the holding tube is at least 69 kPa (10 psi) above the boiling pressure of the product.

Apparatus--A sanitary pressure gauge and a pneumatic testing device described in Test 9,1, can be used for checking and adjusting the pressure switch setting.

Method--The pressure switch is checked and adjusted so as to prevent forward flow unless the product pressure in the holding tube is at least 69 kPa (10 psi) above the boiling pressure of the product.

Procedure.--

1. From Figure 40, determine the pressure switch setting necessary for the operating temperature (not the diversion temperature) being used in the process.

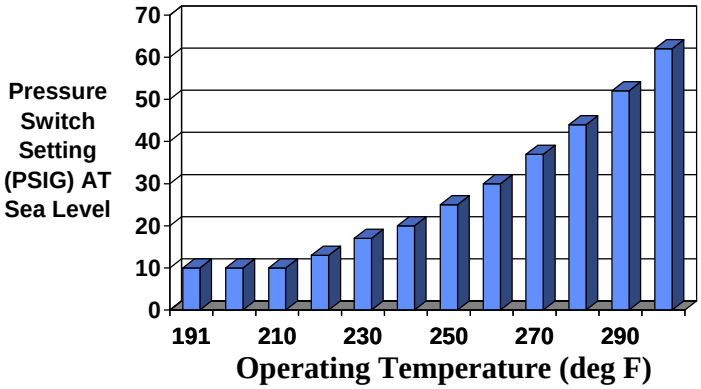
2. Install the sanitary pressure gauge of known accuracy and the pressure switch sensing element on the pneumatic testing device.

3. Remove the seal and cover to expose the adjustment mechanism on the pressure switch.

4. Place the test lamp in series with the pressure switch contacts or use some other method to monitor the cut-in signal.

5. Apply air pressure to the sensing element, and determine the pressure gauge reading at the cut-in point of the switch which will light the test lamp. If the switch is short circuited, the lamp will be lighted before air pressure is applied.

Table 40-Pressure Switch Settings



6. Determine that the cut-in pressure on the switch is equivalent to or greater than the required pressure from Figure 40. Where adjustment is necessary, refer to manufacturer's instruction. After adjustment, repeat the procedure set out in this paragraph.

7. When the results are satisfactory,seal the pressure switch setting and record the results for office record. For each operating temperature on HHST pasteurizers using direct contact heating, the product pressure switch setting is determined from Table 40.
Note: *The pressure setting shall be adjusted upward by the diffierence between local normal atmoshperic pressure and at sea level.*

TEST 14
SETTING OF CONTROL SWITCHES FOR DIFFERENTIAL PRESSURE ACROSS THE INJECTOR

Application--To all HHST pasteurizers and aseptic processing systems using direct contact heating. When testing aseptic processing systsems, the "product divert system" or "product divert valve" or "acceptable control system" may be substituted for the "flow-diversion device" when it is referenced in thei test.

Frequency--Upon installation, **every 3 months** thereafter and whenever the differential pressure controller seal is broken.

Criteria--The pasteurizer or aseptic processor shall not operate in forward flow unless the product pressure drop across the injector is at least .7 KPA (10 psi).

Apparatus--A sanitary pressure gauge and a pneumatic testing device described in Test 9,1, can be used for checking and adjusting the differential pressure controller.

Method--Check the differential pressure switch and adjust it so as to prevent forward flow unless the differential pressure across the injector is at least 69 kPa (10 psi).

Procedure.--

1. Remove both pressure sensing elements from their original locations on the pasteurizer or aseptic processor.

2. Install the sanitary pressure gauge of known accuracy and the pressure sensing element that is installed prior to steam injection on the pneumatic testing device. Leave the other pressure sensing element open to the atmosphere but at the same height as the sensing element connected to the pneumatic testing device.

3. Wire the test lamp in series with the micro switch of the differential pressure controller or use the method provided by the instrument manufacturer to monitor the cut-in signal.
4. Apply air pressure to the sensing element and determine the pressure gauge reading at the cut-in point of the differential pressure switch that will light the test lamp. Determine that the differential pressure cut-in on the controller is at least 69 kPa (10 psi). Note: *this test is to assure at least a 10psi pressure loss of product at exit end of the steam injector.This assures complete condensation of the steam within the injector*.

5. After adjustment, repeat the procedure.

6. When the results are satisfactory, seal the instrument and record the results for the office record.

Testing of micro-processor STLR's

Testing the AV-9900 HTST Recorder Controller

The STLR functions the same as the existing Anderson EHT-700, as it utilizes a dual element RTD with an internal comparator to insure failsafe operation.

Program/Run Selection - All tests may be performed with the unit sealed and in the "Run" moe. In order to make adjustments to any settings other than pen accuracy, the chart plate seal must be removed and the internal sedurity "shunt" must be moved from the "run" (upper) position to the "program" (lower) position. This shunt is located on the STLR "interconnect" board in ht e lower left hand corner of the instrument. It is labeled JU1 and is positioned 1 inch below the upper right corner of the board. For program mode, position the shunt on the lower two pins. For run mode, move it up one position. The unit will only operate in run mode. Finally, during initial installatin, make a note of the labels on the EEPROM chips labeled U7 and U8 inside the unit before applying the health authority seal.

Test 2 and 4: Temperature Accuracy

This is the only health code related function that can be adjusted I the "run" mode. It allows the operator or health authority to adjust the pen to agree with a verified indicating thermometer.

After testing the accuracy using the PMO procedure adjust the recording pen to agree with the verified indicating thermometer as follows:

1. Press the scroll key on the keypad (just to the right of the ESC key). The display will read:
   SELECT (-)
   FUNCTION SETUP

2. Press the DOWN arrow key. Use the scroll key until STLR flashes on the display.

3. Press the unlabeled button under the flashing STLR display. The display will read: STLR INP DISPLAY OPT

4. Press the Scroll Key until the display reads:

   STLR INP CORRECTION

   .____F (or C)

To properly test for response time, simply start the stopwatch when the display reads a temperature 12 degrees below the cut-in temperature. If the display moves too quickly or "skips" over the start temperature, you may start the watch at a temperaure 2-3 degrees below the desired temperaure. The result should be well within the 5 second maximum. Stop the watch when the display changes from:

"STLR OUR OFF" to "STLR OUT ON"

Test 10: Milk Temperature at Cut-in and Cut-out.

These tests may be performed as outlined in the PMO. If a change is required to the cut-out temperature or to the amoujnt of dead-band between cut-in and cut-out, proceed as follows:

1. Remove the regulatory seal and open the chart plate. Reposition the security shunt to the "Program" mode as outlined above.

2. Press the SCROLL Key until the display reads:
   SELECT (-)
   CONTROLLER SETUP

3. Press the the DOWN Arrow Key. STLR will be flashing in the lower left display.

4. Press the button below the flashing STLR.

5. Press the scroll key until the display reads the appropriate set point (1 thru 5). The displayed setpoint is the cut-out value. If you wish to change the setting, press the MOD Key. This will underline the value. Then use the UP/DOWN keys to modify.

6. Press the ENTER KEY to program the new value.

7. Press the skoll dey again to display the aount of deadband between Cut-in and Cut-out for that set point. Each set point will have its own deadband. Press MOD Key and then use the UP/DOWN Keys to modify.

8. Press the ENTER Key to program the new value.

9. Press the RESET Key.

10. Re-position the security shunt to the run (upper) position. Verify that EEPROM's U7 and U8 are labeled as noted during initial installation. Re-seal the chart plate.

Test 3: Time Accuracy

With the unit in the "Run" mode and while a chart is being printed, use an accurate watch to test for time accuracy as follows:

1. Begin timing when the unit prints a major time line (solid color).

2. Stop timing when the mechanism prints the second minor time line (second dotted line). The elapsed should be 30 minutes.

Test 8: Thermometric Response

The standard test may be used except theat the display must be utilized to start the stopwatch at eh proper temperature. If the display has been configured to opeate in the seuintial mode, the test will be simplified by first programming it to display in the continuous mode as follows:

1. Wait until the display reads
   STLR INP
   STLR OUT

   Press the DISP Key twice. The display will read:
   MODIFY
   DISPLAY PARAMETERS

2. Press the DOWN Arrow Key. The display will read:
   DISPLAY MODE
   CONTINUOUS SEQUENCE (flashing)

3. Press the Scroll Key. Now CONTINUOUS will be flashing

4. Press the ENTER Key and then RESET Key. The display will now continuiusly display the STLR Temperature constantly. Just below this line on the display will be the status of the STLR Output. ("STLR OUT OFF" signifies a temperature below Cut-In). After completion of this test, use the same procedure to return the unit to sequential display.

TESTING THE ELECTRONIC RECORDER-CONTROLLER(Early type)

The four test required for Electronic recorder controllers (ERC's) are:

A. Programming of process values (upon initial installation or when a change in the process is made)

B. Instrument calibration (quarterly)

C. Cut-in and cut-out temperatures (quarterly, daily by the operator)

D. Locking and sealing of instrument (quarterly)
Tests A, B, and C are also to be conducted when Test 1 is performed.

TEST A - PROGRAMMING OF PROCESS VALUES

APPLICATION - To all Taylor ER/C Recorder-controllers used in connection with continuous flow pasteurizers.

FREQUENCY - Upon installation and whenever a process value needs to be changed.

CRITERIA - The selected process variables shall be programmed with the values stated in this test.

APPARATUS -none

METHOD - The regulatory official shall scan through the display prompts of the firmware for the recorder controller according to the vendor's operations manual and program the appropriate process values for HTST operation.

Taylor ERC (First Model) Testing

PROCEDURE 1 - With the power off to the recorder-controller, open the back case and move the control switch to the unlocked (run) position. Close the recorder-controller and turn on power.

Set the following process values:

2. Move display prompt to Level 2 CH.Lo (chart low). Set process value at 120° F.*

3. Move display prompt to Level 2 CH.H1 (chart high). Set process value at 220° F.*

4. Move display prompt to Level 2 deG.C. Set process value as "no" (Fahrenheit temperature scale selected).

*Note: These process values are for chart No. 500P1225-35, with low and high limits of 120° F and 220° F. If a different chart is used, the low and high limits of that chart must be used. If a different chart is used, it must meet the specifications of Appendix H.

5. Move the display prompt to Level 2 FILt. Set process value as no (chart damping filter disabled).

6. Move display prompt to Level 2CHrt SPed. Set process value at 12 (chart rotation period in hours).

7. Move display prompt to Level 3 ALr.H. Set process value at 220° F or the maximum temperature on the chart (high alarm set point).

8. Move display to Level 3 ALr.lH. Set process value at least o,5° F higher than the minimum pasteurization temperature (low alarm set point).

9. Move display prompt to Level 3 A.HYS. Set process value at 1° F (alarm hysteresis which determines the difference between cut-in temperature and cut-out temperature).

10. Move display prompt to Level 3 ACK. Set process value as no (deletes acknowledge routing to level 1).

11. Move display prompt to Level 4 CAL.H (calibrate all pens to the outer edge of the chard). Observe that the recording pen and event pen drop to the outer temperature line on the chart. If the pens do not, plant personnel or the instrument vendor would make the appropriate adjustment.

12. Move display prompt to Level 4 CAL.L (calibrate all pens to the inner edge of the chart). Observe that the recording pen and the event pen drop to the inner temperature line on the chart. If the pens do not, plant personnel or the instrument vendor should make the appropriate adjustment.

13. Move display prompt to Level 5 t.CAL: then, attempt to move display prompt to Level 6. If a Level 6 can be accessed on the recorder-controller, the instrument contains a RS-422 Communications Port which permit the process values to be changed after the instrument is sealed

CORRECTIVE ACTION - If the process values cannot be set as described in this test, contact the vendor for repairs or further operating instructions. If Level 6 can be accessed, contact the vendor to remove the RS-422 Communications Port.

TEST B - Recorder-Controller Calibration

APPLICATION - To all Taylor ER/C recorder-controllers used in connection with continuous flow pasteurizers.

FREQUENCY - Upon installation and every three months thereafter.

CRITERIA - The recording thermometer shall not read higher than the corresponding indicating thermometer. This test must be conducted before the test for cut-in and cut-out temperatures.

APPARATUS - Indicating thermometer that has been calibrated with a thermometer traceable to or certified by the National Bureau of Standards, and a water or oil bath with a control system capable of maintaining a mean bath temperature of 0.5^{o} F (plus or minus).

METHOD - The indicating thermometer and the sensing element for the recorder-controller are immersed in the circulating water or oil bath. The temperature reading from the recording pen is compared to that from the indicating thermometer and adjusted, if necessary.

PROCEDURE 1 - Adjust the water or oil bath to a temperature that is approximately 2^{o} F above the diversion temperature. Sufficient agitation and/or circulation is needed to maintain a uniform bath temperature.

2. On the Taylor ER/C recorder-controller, move display prompts to Level 5 PEn.1 t. CAL (pen 1 temperature calibration).

3. Immerse the indicating thermometer and the sensing element of the recorder-controller to their appropriate immersion levels in the water or oil bath. Allow three or four minutes for the bath temperature to regain equilibrium.

4. Record the temperatures shown on the indicating thermometer, digital display on the recorder-controller, and the recording pen for the office record.

CORRECTIVE ACTION - If the digital display or the recording pen (both on the recorder-controller) read higher than the indicating thermometer, adjust the calibration factor of the recording pen so that they do not read higher than the indicating thermometer. Record the calibration factor for the office record.

TEST C - Taylor ER/C recorder-controller Cut-in and Cut-out temperatures.

APPLICATION - to all Taylor ER/C recorder-controllers used in connection with continuous flow pasteurizers.

FREQUENCY - Upon installation and once every three months thereafter.

CRITERIA - Forward flow cannot occur until the minimum pasteurization temperature has been reached. Diverted flow must occur before the temperature drops below the minimum pasteurization temperature.

APPARATUS - Indicating thermometer that has been calibrated with a thermometer traceable to or certified by the National Bureau of Standards, and a means of changing temperature in the holding tube, or water bath, or oil bath at a rate not exceeding 1^{o} F every 30 seconds.

METHOD - Observe the actual temperature of the indicating thermometer at the instant the flow diversion device moves to the forward flow position (cut-in) and the flow diversion device moves to the diverted flow position (cut-out).

PROCEDURE - Same as for conventional STLR

CORRECTIVE ACTION - If the cut-in or cut-out temperature is lower than the minimum pasteurization temperature, raise the low alarm setting on the ER/C recorder-controller according to the procedures outlined in Test A (Programming of Process Values). Repeat the test.

TEST D - LOCKING AND SEALING OF INSTRUMENT

APPLICATION - To all earlier model (not for 5100 series Commadore models) Taylor ER/C recorder-controllers used in connection with continuous flow pasteurizers.

FREQUENCY - Upon installation, every three months thereafter, and whenever a process value is changed.

CRITERIA - The process values are programmed, locked with the values stated in this test, and finally the locking mechanism is sealed by the regulatory official.

APPARATUS - none

METHOD - The regulatory official shall lock the process values programmed into the firmware and then seal the back panel of the recorder-controller. The regulatory official shall also confirm that the process values, once locked and sealed, cannot be changed by plant personnel without breaking the seal.

PROCEDURE 1 - After all the required tests are satisfactorily completed, open the back panel of the recorder-controller and move the control switch (run or lock) to the locked position (see vendor's operation manual). Close the recorder-controller panel.

2. Move the display prompts through the following Level - positions to confirm the programmed process values, and attempt to alter them (see vendor's operations manual).

a) Level 2 CH.Lo (chart low) - 120^{o} F
b) Level 2 CH.HI (chart high) - 220^{o} F
c) Level 2 dEG.C (Celsius temperature scale selected) -no
d) Level 2 FILt (chart damping filter enabled) - no
e) Level 2 CHrt SPed (chart Speed) - 12 hrs
f) Level 3 ALr.H (high alarm set point) - 220^{o} F
g) Level 3ALr.L (low alarm set point) - 0.5^{o} F above minimum pasteurization temperature or higher.
h) Level 3 A.HYS (hysteresis) - 1^{o} F
i) Level 2 ACK (alarm acknowledge routing to Level 1) - no
j) Level 5 PEn.1 t.CAL (recording pen calibration factor) - same value as determined in Test B.

3. Record programmed process values for the office record.

4. Seal the back panel on the recorder-controller.

CORRECTIVE ACTION - If any of the programmed process values can be altered (see vendor's manual) with the control switch in the locked position, contact the vendor for repairs or replacement of the recorder-controller. If any of the programmed process values (a. through j.) do not have the values shown in this test, repeat Test A.

CASE STUDIES

CASE STUDIES

CASE STUDIES IN THE DESIGN, INSTALLATION AND OPERATION OF HTST PASTEURIZATION SYSTEMS

PURPOSE: The purpose of these case studies are to provide the participant with some guidance and insight into milk flow sequences within a pasteurization system. Also this should to give the participant an opportunity to make determinations for the placement of public health controls in various systems.

METHOD: Using the list of pasteurizer components provided on the following page, and your assigned case study, construct an acceptable flow diagram showing the proper location of each component in the system including the following parameters.

1. The effects that your flow arrangement has on the **TIME-TEMPERATURE-PRESSURE** relationship within the system.

2. The flow promoting equipment operational requirements during **divert, shut-down, inspect, CIP, and improper flow diversion device seating**.

3. The **location of all public health controls and the location of regulatory seals required to safeguard the system**.

The **major** public health consideration in using **auxiliary equipment** is to determine effects on **time-temperature-pressure** relationships within the system. Specifically, this equipment must be installed so that:

1. It will not reduce the **minimum required holding time** below the requirements.

2. It will not interfere with the detection of, or stoppage of forward flow of milk which is **below the minimum pasteurization temperature.**

3. It will not disturb the maintenance of **proper pressure relationships within the regenerator section** of the system.

EQUIPMENT COMPONENT LIST

recorder-controller

flow diversion device

holding tube

divert line

regenerator

balance tank

recirculation line

recycle line

vacuum breaker

separator

stuffing pump

back pressure valve

check valve

centrifugal pump

regulatory seal

booster pump

cooler section

heater section

homogenizer

leak detect line

timing pump

by-pass line

pressure differential controller

indicating thermometer

by-pass valve

positive shut-off valve

magnetic flow meter

pressure sensor

flow recorder-controller

sight glass

CASE STUDIES

CASE #1 a). HTST pasteurizer with a homogenizer of larger capacity than the timing pump and booster pump.

b). Cream pasteurizer with conventional timing pump, without a milk-to-milk regenerator.

CASE STUDIES

CASE #2 HTST pasteurizer with homogenizer as timing pump with a stuffing pump and a booster pump.

CASE STUDIES

CASE #3 HTST pasteurizer with a booster pump, homogenizer as the timing pump, and a raw milk separator with a stuffing pump.

CASE STUDIES

CASE #4 HTST pasteurizer with a booster pump, stuffing pump, and a homogenizer as the timing pump. There is separator on the pasteurized side of the system and an automatic back pressure control valve. One of the milk to milk regenerators is a "vacuum" regenerator.

CASE STUDIES

CASE #5 HTST pasteurizer with a booster pump, homogenizer of equal capacity to the timing pump, a separator on the raw side of the regenerator, and a regenerator back pressure control valve.

CASE #6 HTST pasteurizer with a booster pump, a homogenizer of larger capacity than the timing pump, a separator on raw side, a stuffer pump, a meter based timing system, with AC variable speed drive.

CASE STUDIES

CASE #7 HTST pasteurizer with a booster pump, a meter based timing system, a separator on the pasteurized side, and a flow control valve.

CASE STUDIES

CASE #8 HTST pasteurizer with flavor control equipment and a CIP separator on the raw side, with a homogenizer as timing pump. (centrifugal pumps as needed).

CASE STUDIES

CASE #9 HTST pasteurizer with a CIP separator on the pasteurized side between regenerator #1 and #2, with a homogenizer located on the pasteurized side and a meter based variable frequency AC drive system. In this particular system, the booster pump is located between raw regenerator #1 and raw regenerator #2. Cream is precooled through raw regenerator #1.

CASE STUDIES

CASE #10 HHST pasteurizer with positive displacement timing pump, a vacuum chamber (flash chamber) with direct steam infusion, using milk-water-milk regenerative heating, FDD at the end of the cooler section, and a centrifugal pump between the balance tank and the raw regenerator.

CASE STUDIES

COURSE CRITIQUE

MILK PASTEURIZATION CONTROLS AND TESTS #302

DATE/LOCATION:_____
_____
_____.

Excellent Poor

1. What is you overall rating of this course? 6 5 4 3 2 1

2. How would you rate the facility? 6 5 4 3 2 1

3.What was the most useful aspect of the program?_____
_____
_____.

4.What suggestions can you offer for improving this course._____
_____
_____
_____.

5. Please give us your comments on course handouts and manuals._____
_____
_____
_____.

6. Would you recommend this course to others working in the milk sanitation field? Y( ) N( ) explain_____
_____
_.

7. What subject matter or topics would you like to include in future courses?
_____
_____

_____
_____.

Comments_____
_____
_____
_____
_____
_____
_____
_____.

BEST PART OF THE COURSE:

1.

2.

3.

WORST PART OF THE COURSE:

1.

DEFINITIONS

DEFINITIONS

AMPERAGE (AMPS) - The amount of current flow through a conductor.

ATMOSPHERIC PRESSURE- The force exerted on an area by the column of air above that area. Atmospheric pressure at sea level is 14.7 pounds per square inch.

BALANCE TANK - Raw product tank located at the start of a pasteurization system used to maintain a constant supply of product to the pasteurizer.

BOOSTER PUMP - A centrifugal pump placed in a pasteurizing system between the balance tank and the raw regenerator and capable of producing positive pressure in the raw regenerator.

BOURDON COIL (spring) - A sealed flat metal tube filled with a gas mixture that has been formed into a coiled spiral, located inside the recorder-controller. This spiral expands or contracts in response to the vapor pressure of the gas mixture. This coil is located on one end of the capillary tube with the recorder-controller temperature sensing bulb at the other.

CMR - A temperature recording device, usually installed at the end of the cooler section on a pasteurizer system providing constant record or milk temperature.

CAPILLARY TUBE - A thin metal tube, containing a mixture of liquids with low vapor pressures, that connects the bourdon tube in the recorder-controller with the temperature

sensor bulb located at the flow diversion device. This thin tube is usually protected by a flexible metal cable.

CENTRIFUGAL PUMP - A high speed pump that produces product flow due to the velocity increase of the liquid caused by the rotation of the pump impeller.

CONSTANT LEVEL TANK - See Balance Tank.

COOLING SECTION - The section of a heat exchanger (press) in which one of several non-toxic coolants flows in a counter current direction on the opposite side of a stainless steel plate of the pasteurized product.

DEFLECTOR PLATE - A stainless steel plate in the regenerator section of the press designed to change the direction of flow.

DMO - The latest edition of the Dry Milk Ordinance. This Ordinance covers all Grade A milk drying and condensing plants.

DRT - Digital Reference Thermometer. This is usually referred to the electronic indicating thermometer which provides a readable L.E.D. display provided by a signal from a dual element, 8 wire, resistive (1000 ohm) type sensor element.

FLOW DIVERSION DEVICE - Either a single stem (one three-way valve) or dual stem device (two, three-way valves connected by a common yoke), designed to change the direction of product flow,controlled by the recorder-controller. (FDD).Prevents the forward flow of raw milk.

FLOW CONTROLLER - An instrument used in meter based systems which compares the flow signal from the flow transmitter to a set point and either controls the centrifugal pump speed or regulates a flow control valve downstream of the meter and centrifugal pump. (FC)

FLOW TRANSMITTER - An instrument used in meter based systems which converts signals from the magnetic flow meter to a 4-20ma current. (FT)

FREQUENCY PEN - A solenoid actuated recording pen (located on the outer edge of the recording chart) that records the position of the flow diversion device in a continuous flow pasteurization system. This pen on a meter based system only records the flow diversion device position that has been electronically signaled by the flow recorder/controller.

HEAT EXCHANGER - Equipment designed to effect heat transfer between two or more mediums.(plate type, triple tubes, etc).

HOLDING TUBE - The section of piping in continuous flow pasteurizers of sufficient length to provide the minimum legal residence time for heated milk.

HOT WATER TEMPERATURE CONTROLLER - A system which controls the temperature of the heating medium by regulating a mixture of steam and water that circulates through the heating section of the press.

I/P Transducer - An instrument used in a meter based system that converts a 4-20ma current signal to an air signal (usually 15-30 psi) which drives the flow recorder pen.

kPa - Metric measurement equivalency (kilograms) of pounds per square inch. Conversion factor is 0.1449 divided by psi=kPa, ie, 1 psi=6.9 kPa.

LAMINAR FLOW - The movement of high viscosity products through a pipe in concentric layers where the fastest particle may move at twice the speed of the average particle.

METERING PUMP - See Timing Pump

METER BASED SYSTEM - The term used for those pasteurization systems employing the use of approved components of a magnetic flow control system to replace other conventional timing pumps in a HTST system.

MICROSWITCH - A mechanically activated electric NO (normally open), NC (normally closed) switch. It is a small level actuated switch used in the control circuit and is sometimes referred to as a limit switch. Microswitches may have three terminals, one to supply current, and the two others are marked "no" for normally open and "NC" for normally closed. External pressure on the lever will change the position from "NO" to "NC" or vice versa, depending on the switch wiring. Used to "break" or "make" a control circuit.

PMO - The current edition of the Pasteurized Milk Ordinance.

PNEUMATIC - Operated by compressed air.

PRESSURE RELIEF VALVE - A valve which is designed to automatically open when subjected to the determined pre-set pressure. AKA “pop-off valve”.

REGENERATOR BY-PASS VALVE - A automatic or manually controlled valve used in combination with the booster pump for the purposes of start up of a continuous pasteurizer with a milk to milk regenerator. This valve allows for by-passing the regenerator in order to provide the proper pressure relationships in the regenerator, thus allowing the booster pump to operate.

SANITIZATION - The application of any effective method or substance to a **clean** surface for the destruction of pathogens, and of other organisms as far as is practicable. Such treatment must not adversely affect the equipment , the milk or milk product or the health of consumers. Sanitization may be accomplished by either the application of heat or suitable chemicals used in accordance with good manufacturing practices.

SAFETY THERMAL LIMIT CONTROLLER The term sometimes used interchangeably when referring to the recorder-controller.

SOLENOID - An electronically operated valve used in to open or close a valve or to open or close a magnetic relay switch.
SNAFU - Situation normal, all fouled up.

STUFFING PUMP - Any centrifugal pump used in the system for the purposes of enhancing product flow to a component, other that those located between the balance tank and the raw regenerator.

TIME DELAY RELAY (TDR) - An adjustable timer(either mechanical or electronically controlled) used to maintain a set time period equal to or greater than the required minimum. All required TDR's must be sealed by the regulatory agency.

TIMING PUMP - Sanitary , positive displacement -type (rotary or piston) or in the case of meter based systems a centrifugal product pump, which provides a constant measured rate of flow to the continuous pasteurization system. Homogenizers may be used as timing pumps since they are piston type (always odd numbers of pistons) pumps and positive displacement pumps. All timing pumps are capable of crating suction and do not slow down under discharge pressure.

THROTTLING VALVE - A spring-to-close valve used in conjuction with a magnetic flow meter timing system having a single speed timing pump, to control flow speed of product.

TURBULENT FLOW - Flow where considerable mixing occurs across a pipe cross section and the velocity is nearly the same across this section. Turbulent flow occurs most frequently in less viscous liquids and is often characterized by higher friction losses than would be expected.

VACUUM BREAKER - An air relief valve held in the closed position by product flow pressures and which opens and admits air when the product pressure goes below atmospheric pressure. Uses include maintaining proper pressures in a milk to milk regenerator during system shut-down and preventing suction of product past the flow diversion device during operation. Other uses are to provide protection on pasteurized installed vacuum chambers.

VOLTAGE - The force between the electrical leads or from one lead to ground. It is measured across two unconnected leads (open circuit voltage) and standard voltages are 6, 12, 24, 110, 220, or 440. Neutral or ground is used as the second lead for measurement of the lower voltages (single phase).

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Note: The use of trade names or equipment photographs is for training and educational purposes only and does not constitute endorsement by the U.S. Department of Heath and Human Services, Public Health Service, Food and Drug Administration.
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APPENDIX

HTST PASTEURIZATION EQUIPMENT TESTS

PLANT_____ DATE:_____
Address_____ HTST #_____
_____ SANITARIAN_____

NO	(√)	CRITERIA/METHOD	PROCEDURE	RESULTS
#3		STLR-Time Accuracy	Compare at 30 Min	STLR Time_____ Actual_____
#1		IND-TEMP Accuracy(IND=.5^{o} F;AS=1^{o} F)	At Past. Temp, using Cert Therm	Ind_____ AS_____
#2		STLR-Temp ±1^{o} F	5 Min Stabilization @ Past 5 Min @Boil;5 Min @ Stabilization 5 Min in Ice;5 min @ Past(RTD=2 min)	Ind_____ STLR_____
#4		STLR v.s.Ind(Daily) ±1 STLR not higher	Compare at past temp using milk	Ind_____ STLR_____
#10		Cut-In;Cut-Out	Ind Therm reading when valve changes FF,DF; (<1^{o} F/30 sec)	Cut-In_____ Cut-Out_____
#7		Ind Therm-Response	<4 sec; 12 ^{o} F span, H20 bath,173^{o} F, Start-154. stop-166	Time_____
#8		STLR Therm-Resp	<5 sec; start 12^{o} F below cut-in, stop @ system cut-in.(bath 7^{o} above cut-in)	Time_____

#9		(#4)Regenerator Pressure Controls (#5)Booster pump wiring	(#4) ≥1 psi on Past side (set Taylor DPC @2 psi) (#5) a. interwired w/FDD b. " w/PDC c. " w/timing pump	(#4)Using device: range travel, quick release, and differential pressure: diff pressure=_____psi. (#5) a. FF to DF, BP should stop( ) b. @FF, <2psi stops BP( ) c. TP off = BP off( )
# 11		Holding Time	Salt test 6X w/i .5 sec	DF:1___2___3___4___5___6___ FF:1___2___3___4___5___6___ Can fill time:FF_____DF_____
#5		Flow Diversion Device(FDD) Proper Assembly	<u>DUAL STEM</u> 1. leakage past seat 2. operation of valve stem 4. device assembly 5. manual diversion 6. response time 7. interlock with flow promoters (INSPECT and CIP time delays) 8. 10 min CIP time delay (if applies) <u>SINGLE STEM</u> 1,2,3 (hex nut <½ turn stops TP),5,6,omit #7&8).	1. no leakage( ) 2. operates freely ( ) 3. metering pump stops when improperly assembled yes( ) no( ) 4. <1 sec ( ) 5. manual divert;a,b,&c parts 6. response time <1 sec 7. Time delays (INS,____sec;CIP,____sec) 8. 10 minute TD in CIP(whenapplies) ___min.

RDE/FDA/STB

WATER TO MILK HOLDING TIME CONVERSION

METHOD: VOLUME ( ) WEIGHT ( )

Time required to fill measured volume of water =_____seconds.

Time required to fill identical measured volume of milk =_____seconds.

Compute adjusted holding time using formula where:

Volume method:

T = salt time test results_____.
Mv = average time required to deliver measured volume of milk_____.
Wv = average time required to deliver equal volume of water_____.

$$\frac{T(Mv)}{Wv} = \text{calculated holding time for milk}$$

Weight method:

T = salt time testing results_____.
Mw = average time required to deliver measured weight of milk_____.
Wv = average time required to deliver equal weight of water_____.
1.032 = specific gravity of milk.

$$\frac{1.032(TMw)}{Ww} = \text{calculated holding time for milk}$$

Note: This test is not required for meter based systems; nor for those homogenizer based timing systems with a measured holding time of ≥120% of the minimum required holding time. (Example; 15 second = 18 seconds, 25 seconds = 30 seconds)

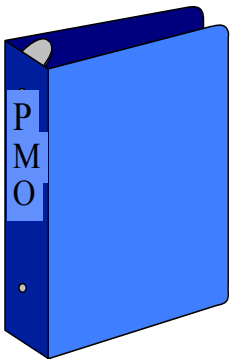
ALL GEAR DRIVEN TIMING SYSTEMS REQUIRE CALCULATED HOLDING TIMES

Public Health Service MILK PASTEURIZATION CONTROLS TEST REPORT
Food and Drug Administration

TEST NO.	TEST		TEST FREQ.	TESTED (X or NA)	TEST RESULTS
1	Indicating Thermometers (including Air Space) Temperature Accuracy		3 months		
2	Recording Thermometers: Temperature Accuracy		3 months		
3	Recording Thermometers: Time Accuracy		3 months		
4	Recording Thermometer Checked against Indicating Thermometer		3 months	Daily by operator	
5	FDD Assembly and Function				
	5.1	Leakage past valve seat			
	5.2	Operation of valve stem	3 months		
	5.3	Device assembly (microswotch), single stem	3 months		
	5.4	Device assembly micro-switches) Dual stem	3 months		
	5.5	Manual Diversion, Parts A,B,and C,	3 months	HTST ONLY	
	5.6	Response Time	3 months		
	5.7	Time Delay-Inspect	3 months		
	5.8	Time Delay-CIP			
	5.9	Time Delay-LD Flush			
6	Leak -protector, outlet, valves:leakage(Vats)		3 months		
7	Indicating Thermometers in Pipeline: Thermometric Response		3 months	HTST ONLY	
8	Recorder Controller: Thermometric Response		3 months	HTST ONLY	
9	Setting of controls:Regenerator				
	9.1	Pressure switches	3 months	HTST ONLY	
	9.2	Differential Pressure Controllers	3 months		
	9.2.1	Calibration	3 months		
	9.2.2	Interwiring-Booster Pump	3 months	HTST ONLY	
	9.2.3	Interwiring - FDD (HHST and Aseptic Only)	3 months		
	9.3	Additional interwiring			

Public Health Service MILK PASTEURIZATION CONTROLS TEST REPORT
Food and Drug Administration

9 continued	9.3.1	Booster pump interwired with FDD	3 months	HTST ONLY	
	9.3.2	Booster Pumps Interwired with metering pump	3 months		
10	Milk-flow controls: cut-in and cut-out temperatures		3 months		Daily by operator(except HHST)
11	Holding TimeVerification		6 months		
	11.1	HTST except magnetic flow meter systems)	6 months		Adjusted product time if applicable
	11.2 a	Magnetic Flow Meters	6 months	HTST ONLY	
	11.2 b	Flow Alarm(HTST, HHST, and Aseptic	6 months		
	11.2 c	Loss of signal/low flow alarm(HTST,HHST and Aseptic) Flow cut-in/cut-out	6 months		
	11.2 d	Flow cut-in and Cut-out,	6 months	HTST ONLY	
	11.2 e	Time Delay (after divert)	6 months	HTST ONLY	
	11.3	HHST Indirect heating	6 months		
	11.4	HHST Direct Injection Heating	6 months		
	11.5	Direct Infusion Heating	3 months		
12	Controller: Sequence logic (HHST and Aseptic 12.2 or 12.2)		3 months		
13	Product pressure control switch setting (HHST and Aseptic)		3 months		
14	Injector differential pressure				
Remarks					
PLANT	IDENTITY OF PASTEURIZER		LOCATION	DATE	SANITARIAN



The evaluation of Computer Controlled Milk Pasteurization Systems

CRITERIA FOR THE EVALUATION OF COMPUTERIZED SYSTEMS FOR GRADE A MILK PASTEURIZATION SYSTEMS

BACKGROUND

Computers are different from hard-wired controls in three major categories. To provide adequate public health protection, the design of computerized systems must address these **three major differences.**

1. **The computer**, unlike conventional systems which provide full-time monitoring of the public health controls, **performs its tasks sequentially**. The computer may be in real time contact with the flow diversion device for only one millisecond. During the next 100 milliseconds (or however long it takes the computer to cycle one time through its tasks), the flow diversion device remains in forward flow, **independent of temperature in the holding tube.** Normally, this is not a problem, because most computers can cycle through 100 steps in their program, many times during one second. The problem occurs when;

   a) the public health computer is directed away from its tasks by another computer, or

   b) the computer program is changed, or

   c) a seldom used JUMP, BRANCH, OR GO TO INSTRUCTION, diverts the computer away from its public health control tasks.

2. In a computerized system, **the logic is easily changed** because the computer program is easily changed. A few keystrokes at the keyboard will completely change the control logic of the computer program. Conversely, hard wired systems require tools and a technician to make wiring changes. Once the hard-wired systems were properly installed and working, it was never changed. **This problem can be solved by sealing the access to the computer.** Some procedure is needed to ensure that the computer has the correct program when the regulatory seal is applied.

3. Error free computer installations cannot always be assured. For public health controls, the computer program must and can be made error-free. Since the programs required for public

health controls, unlike the very large complex programs, are relatively brief, error-free installations are attainable.

GLOSSARY

Address: The Numerical label on each input or output of the computer. The computer uses this address when communicating with the input or output.

Computer: A very large number of on-off switches arranged in a manner to sequentially perform logical and numerical functions.

Default mode: The pre-described position of some memory locations during start-up and standby operations.

EAPROM: An electrically alterable programmable, read-only memory. Individual memory locations may be altered without erasing the remaining memory.

EEPROM: An electrically erasable programmable, read-only memory. The entire memory is erased with one electrical signal.

EPROM: An erasable, programmable, read-only memory. The entire memory is erased by exposure to ultra-violet light.

Fail Safe: Design considerations that cause the instrument or system to move to the safe position upon failure of electricity, air, or other support systems.

Field alterable: A device having a specific design or function that is readily changed by user and/or maintenance personnel.

Force off: A programmable computer instruction that places any input or output in the "off" state, independently of any other program instructions.

Force on: A programmable computer instruction that places any input or output in the "on" state, independently of any other program instructions.

Input: A data set applied to the input bus of the computer that is used by the computer to make logical decisions on whether or not to activate one or more outputs. Input consists of data from temperature and pressure instruments, liquid level controls, tachometers, microswitches, and operator-controlled panel switches.

Input/Output bus: An electrical connection panel that provides for the connection of all inputs and outputs to the computer. The input/output address labels are found on the panel. Indicator lights showing the status (on/off) of all inputs and outputs are usually available on this panel.

Last state switch: A manually operated switch located on the input/output bus that instructs the computer to place all outputs in the "on" or "off" or "last state" during a start-up. The "last state" position instructs the computer to place the outputs in whatever state (on or off) occurred during the last loss of power.

Operator override switch: A manually operated switch located on the input/output bus that permits the operator to place any input or output in the on or off position, independently of any program instructions.

Output: Electrical signals from the computer that turn on or off: valves, motors, lights, horns, and other devices being controlled by the computer. Outputs may also consist of messages and data to the operator.

Programmable controller: A computer, with only limited mathematical ability, that is used to control industrial machines, instruments and processes. Most computers used on HTST pasteurizers will be programmable controllers.

RAM: Random access memory. A memory used by the computer to run programs, store data, read input and control outputs. The computer may either read the memory or write data into the memory.

ROM: Read-only memory. A memory used by the computer to run its own internal unchangeable programs. The computer may only read from the memory; it cannot write in to the memory or alter the memory in any way.

Standby status: the computer is turned on, running, and waiting for instructions to start processing input data. This instruction is usually accomplished by a manually-operated switch.

Status printing: Some computers are programmed to interrupt printing of the chart record and print the status of the set points and conditions such as: cold milk temperature, holding tube temperature, diversion temperature setting and chart speed.

CRITERIA

The following listed criteria shall be complied with for all computers or programmable controllers when applied to HTST,HHST and UHT pasteurization systems used for Grade A milk and milk products. In addition, all systems shall conform to all other existing requirements of the Grade A Pasteurized Milk Ordinance.

1. A computer or programmable controller used for public health control of Grade 'A' pasteurizers **must be a system dedicated only to the public health control of the pasteurizer**. The public health computer shall have no other assignments involving the routine operation of the plant.

2. The public health computer shall NOT be **under the command or control of any other computer system.** It shall not have an address to be addressable by any other computer system. A host computer cannot override its commands or place it on standby status. All output addresses of the public health computer must be ready to process date at any time.

3. **A separate public health computer must be used on each pasteurizing system.**

4. **The status of the Input/Output bus of the public health computer may be provided as "inputs" only, to other computer systems.** The wiring connections must be provided with isolation protection such as solenoid relays, diodes, or optical-coupling devices to prevent the public health Input/Output bus from being driven by the other computer system.

5. **On loss of power to the computer, all public health controls must assume the FAIL-SAFE position**. Most computers can be placed in standby status by either a program instruction or manual switches. When the computer is in STANDBY status, all public health controls must assume the FAIL-SAFE position. Some computers have internal diagnostic checks that are performed automatically during start-up. During this time, the computer places all outputs in default mode. In this default mode, all public health controls must be in the FAIL-SAFE position.

6. Some computers or programmable controllers have Input/Output buses with "LAST-STATE switches" that permit the operator to decide what state the output bus will take on power-up after a shutdown or loss of power. The choices are ON, OFF, or LAST-STATE occurring when the computer lost power. These "LAST-STATE switches" must be placed in the FAIL-SAFE position.

7. The computer performs its tasks sequentially, and for most of real time, the computer outputs are locked in the ON or OFF position, while waiting for the computer to come back through the cycle. Consequently, **the computer program must be written so the computer monitors all inputs and updates all outputs on a precise schedule -- at least once every second.** Most computers will be capable of performing this function many times in one second.

8. **Computer programs must be stored in some form of read-only memory or (ROM),** and be available when the computer is turned on. Tapes or discs which allow access to the public health controls of the pasteurizer are not acceptable.

9. **The computer program access must be sealed.** Any telephone modem accesses must also be sealed. If the Input/Output bus contains "LAST STATE" switches, the Input/Output bus must also be sealed. The vendor must supply the Regulatory Official with procedures and **instructions to confirm that the program currently in use by the computer is the correct program**. The Regulatory Official will use this test procedure to confirm that the correct program is in use, during a start-up, and whenever the seal is broken.

10. If the computer contains FORCE-ON or FORCE-OFF functions, **the computer must provide indicator lights showing the status of the FORCE-ON, FORCE-OFF function.** The Vendor instructions must remind the Regulatory Official that all FORCE-ON, FORCE-OFF functions must be cleared before the computer is sealed.

11. The INPUT/OUTPUT buses of the public health computer shall contain NO OPERATOR OVERRIDE SWITCHES.

12. Computerized systems which provide for printing the recording chart by the computer must **ensure that proper calibration is maintained**. During chart printing, the computer must not be diverted from its public health tasks for more than one second. Upon returning to public

health control, the computer shall complete at least **one full cycle** of its public health tasks before returning to chart printing.

13. When printing a chart, some systems provide status reports on the chart paper of selected Input/Output conditions. This is usually done by interrupting the printing of the chart and printing the Input/Output conditions. Such interrupts, for status printing, are **permitted only when a continuous record is recorded on the chart.** When an interrupt is started, the time of the start of the interrupt will be printed on the chart at the beginning of the interrupt and at the end of the interrupt. The time interval during which the computer is diverted from its public health control tasks for status printing **SHALL NOT EXCEED ONE SECOND**. Upon returning to public health control, the computer shall complete at least **one full cycle** of its public health tasks before returning to status printing.

14. When the computer prints the temperature trace of temperature in the holding tube, at specific intervals, rather than a continuously changing line, **temperature readings shall be printed not less than once every FIVE seconds,** except that during the THERMOMETRIC RESPONSE test, the temperature shall be printed or indicated fast enough that the Regulatory Official can place the temperature sensor in a water bath at a temperature 7^{o} F above "CUT-IN" and accurately determine the elapsed time when the temperature rises from a point 12^{o} F below CUT-IN to the time of CUT-IN which accurately times the thermometric response for pasteurizer recorder-controllers.

15. When the computer prints the frequency pen position (the position of the flow diversion device, forward or divert) at specific intervals, rather that continuously, **all changes of position shall be recognized by the computer and printed on the chart**. In addition, the frequency pen position and temperature in the holding tube must be printed on the chart in a manner that the temperature in the holding tube can be determined at the moment of a change of position of the flow diversion device.

16. <u>The vendor shall provide a built-in program for test procedures, or a protocol shall be provided so that all applicable public health tests of Appendix I for each instrument can be performed by the Regulatory Official; i.e.,</u>

RECORDING THERMOMETER:

Temperature Accuracy
Time Accuracy
Daily accuracy check against indicating thermometer
Thermometric Response

FLOW DIVERSION DEVICE:

Valve seat leakage
Operation of valve stem(s)
Device assembly
Manual diversion
Response time
time delay intervals, if used

BOOSTER PUMP:

Proper wiring
proper pressure control settings

FLOW PROMOTING DEVICES:

Holding time
Auxiliary (separator, product pumps) Proper wiring interlocks

17. Computers require high quality (clean) well regulated power supplies to operate reliably and safely. Spurious voltage spikes can cause unwanted changes in computer random access memory (RAM). Some mechanical and electrical components also deteriorate with age. One solution is to have two permanent programs in the computer; one in RAM and one in ROM (read only memory). Through a self-diagnostic test, these two programs could be compared

routinely. If there were differences in the programs, the computer would go into default mode.

Another solution would be to down-load the program from ROM to RAM at every start-up.

A third solution would be to have the computer read program directly from ROM, that is unchangeable. However, this approach is practical only in larger volume applications such as microwave ovens. For most small volume applications, the ROM are field alterable, such as erasable, programmable read-only memories (EPROMS), electrically erasable, programmable, read-only memories (EEPROMS), and electrically alterable, programmable read-only memories (EAPROMS). EPROMS, EEPROMS, and EAPROMS, cannot be relied upon to maintain a permanent record. Something is needed to ensure that the proper program is in computer memory when the Regulatory Official seals the computer.

18. Computer programs used for Public Health Controls on Grade 'A' Pasteurizers must conform to the attached logic diagrams. Minor modifications to these diagrams are permissible to accommodate or delete items that are unique to a specific HTST system, such as; magnetic flow meter timing systems and flow diversion device time delays. The vendor must provide a protocol in the user's manual so that the installer, user, and/or Regulatory Official can demonstrate that the program performs as designed under actual production conditions.

19. The logic diagrams for the flow diversion device and booster pump show programmed CIP operation as part of the computerized system. Some plant operators may wish to use another computer for CIP operations, so that CIP programs may be changed by plant personnel as needed. When this is done, **the connections between the flow diversion device, booster pump, and plant computer must be provided with solenoid relays or similar devices on the outputs to the flow diversion device and booster pump to prevent them from being operated by the plant computer**, except when the mode switch of the flow diversion device is in the CIP position.

20. The public health computer logic must also **prevent illegal operation of flow promoting devices (timing pump, booster pump, other product pumps) when the mode switch is placed in the INSPECT position**. This will prohibit any forward flow of any sub-legal product when the flow diversion device assumes the forward flow position following (after the required time delay).

CONSIDERATIONS FOR USE OF NON-PUBLIC HEALTH COMPUTERS ON PASTEURIZER CONTROLS

1. BOOSTER PUMP.

The booster pump may be operated by the plant computer ONLY IN THE CIP MODE. Its operation must be interfaced through the flow diversion device control panel. If the booster pump has an address, which it will, in the computer, key it up. If the Output red light is "on" and blinking, then examine whether it is actually operating. It shouldn't in the PRODUCT mode. It may run in the CIP mode.

2. TIMING PUMP.

The timing pump may be operated by the plant computer only if the flow diversion device is properly assembled and only in the PRODUCT OR CIP MODE. NEVER IN THE INSPECT MODE.

3. STUFFING PUMP.

Stuffing pumps may be operated by the plant computer at any time the timing pump may be allowed to operate.

4. SEPARATOR BY-PASS VALVES.

a. Pasteurized separator by-pass valves may not be operated by the plant computer during diverted flow.

b. Raw product separator by-pass valves may not be operated by the plant computer when the timing pump is not running.

5. FLOW DIVERSION VALVE.

Flow diversion valves may be operated by plant computer only in the CIP mode.

Flow diversion device microswitches must not be controlled directly or overridden by the computer. There shall be no output "override" switches on the Output bus.

6. MANUAL DIVERT.

There are no direct wiring connections operable by the plant computer to the flow diversion device, i.e., FORCE ON or FORCE OFF capabilities.

7. COMPUTERIZED PUBLIC HEALTH CONTROLS.

ROMS and PROMS require verification only one time at the factory. EPROMS. EEPROMS, and EAPROMS require verification each time the unit is sealed.

RAMS, computer disks, and/or tapes are NOT ACCEPTABLE to operate computerized public health controls for pasteurizers.