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.

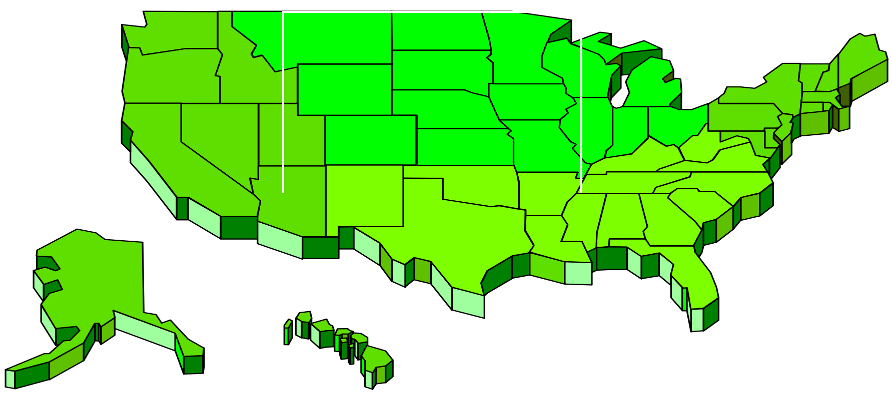
Milk Pasteurization Controls and Tests
Course #302

STATE TRAINING BRANCH
COURSE MANUAL

8**th 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.



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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.

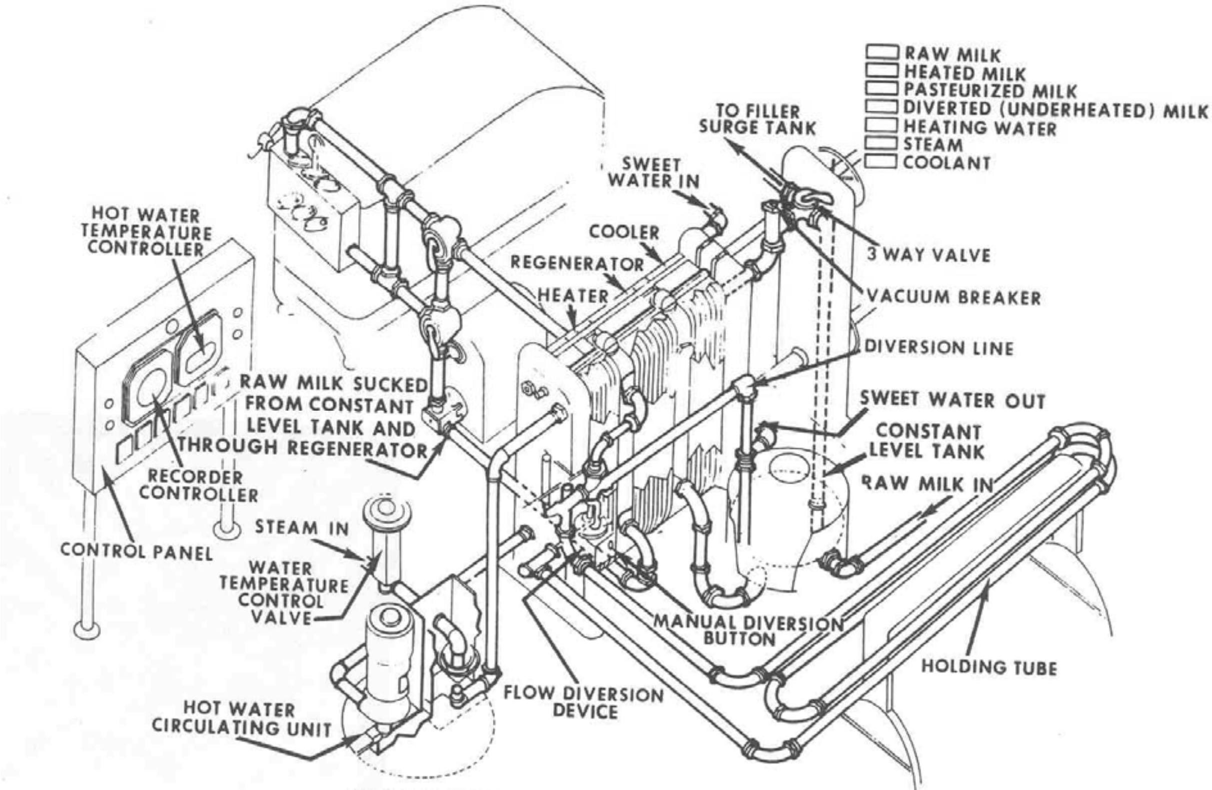
Table of Contents

PASTEURIZATION

TIME/TEMPERATURE REQUIREMENTS

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

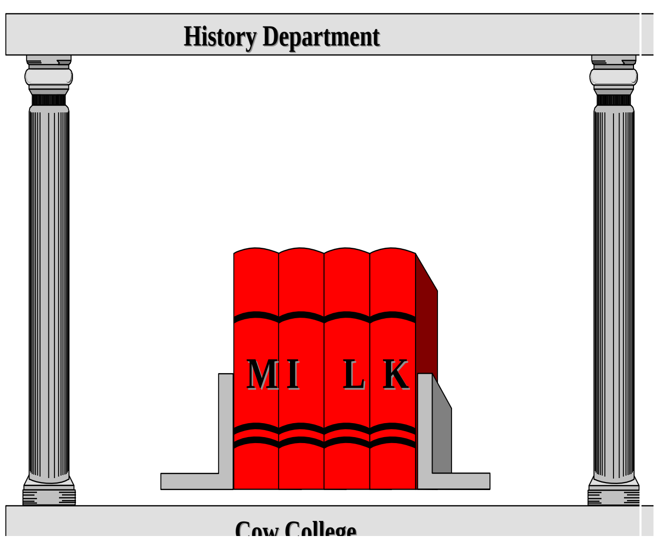
Note: Those pasteurized milk products that are further heated in an acceptable system to a minimum of 280^o F for a minimum of 2.0 seconds are to be labeled as "Ultra Pasteurized".



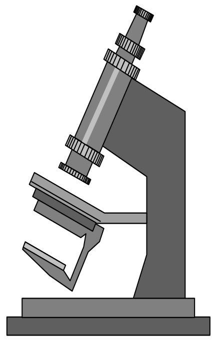
HIGH-TEMPERATURE, SHORT-TIME PASTEURIZER

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.**

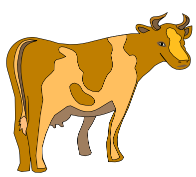
Pasteur, along with other renowned scientists of the era, such as **Abraham Jacobi**, **N.J. Fjord,** and **Albert Fesca** made significant contributions to the equipment designs used for milk processing systems.

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**.

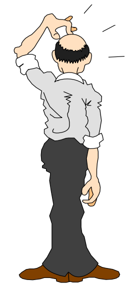
Following engineering studies (known as the **Endicott Experiments** since they were conducted in Endicott, N.Y.) conducted by **Dr. Charles E. North** of the North Public Health Bureau and the Borden Farm Products Company, the Public Health Service published a bulletin (no. 147) attesting that there 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.

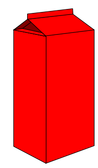
The work between this state and the federal government eventually led to the development of the **first proposed Standard Milk Ordinance** (November 7,1924--Public Health Reports). This first milk code initiated actions by other interested states and in 1927 a uniform national Code was published which 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.



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 *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.

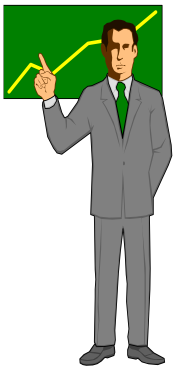
Dr. Ben Freedman, in his benchmark reference book for sanitarians entitled Sanitarians Handbook" proclaims that "*Milk is the first food of human life*." *It is the most nutritious food known, but also the most quickly perishable food as a result of bacterial action".* He also has written that from the 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.

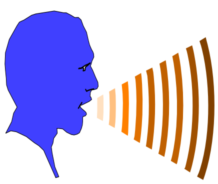
**1986 - Listeria monocytogenes causative agent responsible for 146 confirmed cases of Listeriosis when a nurse at a large Los Angeles hospital reported accelerated cases of miscarriages in _ Hispanics. There were 89 deaths. Investigation that followed implicated Mexican style (soft) cheese processed 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.

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

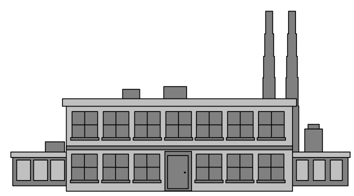
   b) Time of exposure varies

   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.

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**.

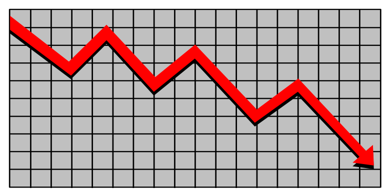
THERMAL PROCESS DESIGN and PASTEURIZATION THEORY

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^{o} C (169.8^{o} 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.