THERMAL PROCESSING SYSTEMS FOR COMMERCIALLY STERILE MEAT AND POULTRY PRODUCTS

There are many types of commercially sterile – "canned" – meat and poultry products – and not all are packaged in cans. Glass jars, plastic cups and trays with heat sealed closures, plastic cups and bowls with double seamed ends, pouches, and paperboard boxes are also package types for "canned" foods. Canned foods include both foods that are low-acid (pH above 4.6) and those that have low-acid components that have been acidified to a pH of 4.6 or below. Types of canned meat and poultry products include those listed in Table 1 (this list is not all inclusive).

Table 1 – Examples of Canned Meat and Poultry Products

- Beef, pork, chicken or turkey in broth or natural juices
- Corned beef hash
- Pork/beef/chicken with barbeque sauce
- Soups – condensed and single strength
- Pasta with meat in sauce
- Luncheon meat
- Corned beef
- Beef stew
- Chicken and dumplings
- Baby and toddler foods
- Vienna sausages in broth

The objectives of this section are for you to be able to:

1. Describe the production flow and pertinent equipment for the production of low-acid and acidified canned foods products from batching to labeling.
2. Given photos, classify types of processing equipment.
3. Associate different retort systems with their corresponding critical start-up and operating parameters.

Process Familiarization

Because there are so many types of commercially sterile canned meat and poultry products produced today, we will not be able to examine how each one is made. But let's take a closer look at some commonalities with these products.

►Ingredients

The first steps are the same as have been previously covered in other FSRE courses: meat and/or poultry, other ingredients, and packaging materials are received and stored in the establishment until ready to use. Many establishments carefully control the quality of the incoming ingredients through purchasing specifications. Meat and poultry ingredients may have quality specifications such as percent fat, moisture, and protein. These are parameters that will affect the final quality of the product.

Meat and poultry ingredients will vary widely depending on the product being produced. Raw beef, pork or poultry products may be used and typically will be reduced in size (ground, comminuted, diced, sliced) depending on the product. Pre-cooked meat and poultry ingredients may also be used, again depending on the formulations. The cooked meat and poultry products may be received already sized or may undergo some preparation such as dicing or slicing. Some formulations will use variety meats such as beef tripe or beef hearts. Many of the canned meat and poultry products have standards of identity that will determine the percentage of meat required for a formulation.

Vegetable components will vary depending on the establishment's formulation. Vegetable ingredients (e.g., carrots, corn, tomatoes) may arrive already sized, frozen, fresh, dehydrated or canned (packed in 603x700 cans, 55 gallon drums or larger). The dispensing of ingredients can range from weighing in small totes or tubs to pumping through a closed metering system from the bulk container. Frozen and canned ingredients are generally used "as is" but there may be a need to chop, dice, or grind vegetables received whole. Vegetables received fresh may already be prepared at the supplier or may require some preparation work at the establishment.

Dry products such as beans, pasta, rice, textured (vegetable) protein (T(V)P) and some potato products (dehydrated or dehydrofrozen) will usually be rehydrated to some level before canning. This can be done by soaking in water for a specified period of time or blanching in hot or boiling water. The level of rehydration may impact the delivery of the scheduled process so products prepared without rehydrating dry ingredients would need to be addressed by the processing authority during the heat penetration tests. Some dry ingredients (such as T(V)P) will receive sufficient rehydration in the batch kettle during the blending process. Pasta may be manufactured at the establishment or purchased from the supplier.

Spices and flavorings are used to provide the desired flavor profile to the product. Spice blends may be prepared at the establishment from individual ingredients or prepared by the supplier according to a formulation. Some spice blends may include ingredients other than spices that may contribute properties

beyond flavoring. Hydrolyzed vegetable proteins, gums and starches may be components of seasoning blends that contribute to the thickness of the product.

Thickeners *(such as starch blends,* gums, flour, hydrolyzed vegetable protein (H(V)P *)* may be used to provide a desired thickness or texture to the finished product and to aid in filling by evenly suspending the ingredients in the sauce/gravy portion of the product. Starches are typically blended with a small amount of cold water to make a slurry prior to incorporating it into the batch. The batched product will be heated to a specified temperature to allow the starch to reach the desired thickening properties prior to filling.

►Formulating and Filling

Formulating (sometimes referred to as batching) and filling methods for canned products will vary as much as the types of products produced. Products are batched according to proprietary formulas, typically in steam-jacketed kettles or blending tanks. Mixing of the product is accomplished with various methods such as ribbon blenders or scrap-surface blades. After blending procedures are completed and the product is heated to the desired temperature, the product is pumped or transferred to a holding tank or directly to the filler. Products may be filled in a variety of ways. Some products, such as chili, are filled to the desired label weight in one operation (single-stage fill). Other products, such as ravioli with meatballs in sauce, may have the particulates and sauce added with separate fillers (multi-stage fill). Other products, such as Vienna sausages, may have the solid components added then filled to overflow with brine or sauce. Fillers are typically volumetric fillers with adjustable cups which can be set to fill a specific weight of product into the package. Other fillers – typically used for topping off with brine or thin sauce – will fill to an overflow of the can. If this is the case, paddle-packers or headspacers may be used to remove some of the liquid to allow for proper vacuum formation or headspace control.

►Container Cleaning Operations

Metal cans and glass containers are essentially clean when manufactured. Many packages, especially those that are stored already formed are cleaned prior to reaching the filler. To ensure the most efficient cleaning operation, containers should be inverted during the cleaning cycle. Depending upon the product itself, air or water may be utilized as the cleaning medium.

►Container Sealing

Container sealing is accomplished in different ways depending on the container type. We will discuss this in later sections of this chapter. The headspace of

many of the containers, especially metal cans and glass jars, is flushed with steam prior to sealing. The steam displaces the headspace and helps to form a vacuum in the container when it condenses.

►Container Coding

All commercially sterile products are required to be coded according to 9 CFR 318.301(e) and 9 CFR 381.301(e) which states: "Each container shall be marked with a permanent, legible, identifying code mark. The mark shall, at a minimum, identify in code the product … and the day and the year the product was packed." Codes will either be embossed (pressed into the metal lid of the can) or imprinted directly on the container with ink. Establishments will typically change their code throughout the day – about every 4-5 hours, at personnel shift changes, or batch changes. Each establishment will develop their own coding system based on an alpha-numeric system. Some codes are based on the Julian calendar date (each day of the year having a unique number) while some codes are based on a monthly calendar designation. Ink jet codes often provide the ability to include the actual time of coding so each package has a time stamp. It is to the benefit of the establishment to change codes frequently to help segregate product if there is a reason to place product on hold.

►Thermal Processing

Except for aseptically processed and packaged products, commercially sterile products receive a thermal process after the containers are sealed. We will discuss the retort process along with cooling, pasteurization, and aseptic processing and packaging in later sections of this chapter.

►Labeling

The labeling of most commercially sterile products occurs after cooling. Some establishments, especially those that co-pack for customers, will "bright stack" unlabeled cans in the warehouse. The unlabeled product will be retrieved from the warehouse and labeled at a later date. Labels are automatically affixed to the containers by different methods. Paper labels are wrapped around and glued to the cans or jars. Plastic or foam label sleeves may be slipped around plastic cups or glass jars and "shrunk" to the container with heat. Pouches and trays may be inserted into cartons. Some containers such as pouches, paperboard and some cans by have the label information already imprinted or lithographed onto the empty container or packaging material.

Containers and Container Handling

Up to this point we have focused on the preparation of the product. Now let's switch our focus to the types of containers used for commercially sterile products and handling procedures for those containers. As already mentioned, commercially sterile meat and poultry products may be packaged in metal cans with double seamed lids, glass jars, plastic cups and trays with heat sealed closures, plastic cups and bowls with double seamed ends, pouches, and paperboard boxes. The success of the canned food industry relies on many factors, one of which is the production and maintenance of hermetically sealed containers. A hermetically sealed container can be defined as one that is designed and intended to protect the contents against entry of microorganisms during and after thermal processing. Precautions are made while handling the empty and filled containers to protect the hermetic seal.

►Receiving/Handling

Empty containers for commercially sterile products are typically received in bulk quantities and packaged to avoid container damage in transit. For example, metal cans are typically received on pallets with a cardboard divider between each can layer or nested in paper sleeves on pallets; glass jars may be received in boxes with separate compartments for each jar; plastic bowls and cups may be received nested in cardboard boxes; and empty pouches may be received packed in cardboard boxes. Packages that are formed during the filling/sealing operation (such as some pouches, paperboard packages, and heat-sealable lidding material for plastic containers) are received in a roll-stock of the packaging material. Incoming shipments of containers, closures and packaging materials are inspected for obvious signs of damage or breakage. All container handling equipment from empty container storage through warehousing of finished products should be designed and operated in such a manner to avoid container damage. Prudent establishments will avoid denting can bodies or flanges or damaging container ends because this type of damage may result in closure defects and leaker spoilage. In addition, this careful handling of filled, processed containers continues through labeling, palletizing or casing, and warehousing because container damage and leaker spoilage may result from improper equipment operation, careless forklift maneuvers or improper stacking procedures.

Metal Cans

The metal can as we would recognize it today has been in use since the early 1900's. Metal cans are classified in the United States as three-piece cans or two-piece cans and can be made with steel (either tin-coated or tin free) or aluminum.

Three-piece cans are made from three pieces of metal, thus the name. The three pieces are a formed body with side seam and two ends. One end is placed on the can by the can manufacturer while the other is attached after the food is placed in the can. The ends are attached in a process referred to as double seaming. The double seaming process folds and interlocks the metal from the can body to the metal from the can end. We will further discuss the double seam later in this section. In 1991, food can manufacturers terminated their use of lead in solder. Since that time can manufacturers turned to welded side seams to replace the soldered side seams. There are no domestic cans that have the soldered side seam; all domestic three-piece cans have welded side seams. Soldered side seams on cans may still be used in other countries. The majority of cans are cylindrical in shape, however, cans used for meat and poultry products may also be rectangular or pear-shaped.

The two-piece can is formed in one of two ways – drawing and redrawing (DRD) or drawing and ironing (D&I). DRD produces cans with thicker metal to withstand pressure during thermal processing and vacuum formation upon cooling. This type of container is formed by drawing a piece of metal through various dies until the final can shape is attained. D&I is used mainly for aluminum cans where the gas pressure from the beverage production maintains the form of the can. This type of process produces thinner metal in the can walls than does the DRD method due to the ironing of the walls to form the final container.

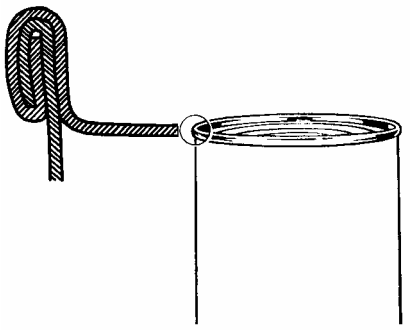
Regardless of the method used to form the cans, each can will have a flange and each end will have a curl – these are two structural components of the double seam. The flange is the edge of the can body that is flared outward resulting in a rim or ledge and is the portion of the body that is formed into the body hook during double seaming and becomes interlocked with the cover hook. The width and radius of the flange are determined by can manufacturers to meet the requirements of forming a proper body hook during the double seaming operation. The end curl – sometimes referred to as cover curl – is designed to provide sufficient metal to form a good cover hook and easy feeding of end units into the closing machine.

►The Double Seam

A double seam is the part of the can formed by joining the body of the can and the end (sometimes referred to as the cover). The body flange and the end curl interlock during the double seaming operation to form a strong mechanical structure. Each double seam consists of three thicknesses of the can end and two thicknesses of the can body with an appropriate sealing compound distributed through the folded metal forming a hermetic seal (Figure 1). Sealing compound is a rubber-based gasket material jet- or nozzle-applied into the annular groove of the can ends by the can manufacturer. The composition of the compound depends upon the product and the method of sterilization. The

sealing compound and the mechanically interlocked can end and body work together to make the double seam a hermetic seal. The double seam must be correctly formed because the compound, although resilient and able to fill voids in the double seam, cannot compensate for an improperly formed seam.

Figure 1 – Cross section of a can double seam.

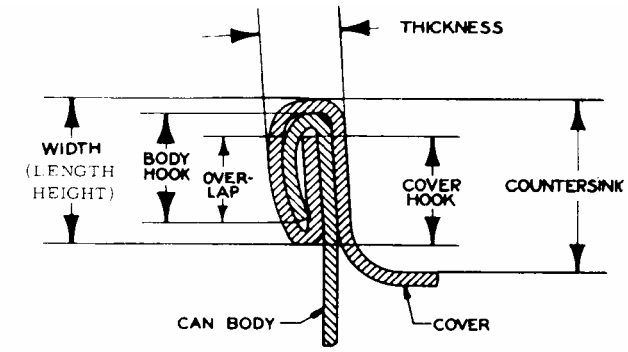


The can double seam is generally formed in two operations referred to as first operation and second operation – hence the name double seam. Each station of the closing machine has four parts that are involved with forming the double seam. 1) The **base plate** is a round plate which lifts the can and can end to the seaming chuck and applies upward pressure during the seaming cycle. 2) The **seaming chuck** is a flat round plate which fits snuggly inside the can cover and acts as an anvil for the double seaming roll pressure. 3) The **first operation seaming roll** is a roller adjacent to the seaming chuck that has a deep, narrow groove used to start forming the double seam. 4) The **second operation seaming roll** is a roller adjacent to the seaming chuck with a wide and shallow groove used to tighten and flatten the double seam. Precise adjustment of each of these basic parts is important in the formation of a good double seam.

►Critical Evaluation of the Double Seam

The double seam structure is judged by measurement and evaluation of specific components comprising the seam. Seam dimension guidelines for these components are normally furnished by the supplier of the can body and end to assist in maintaining acceptable seams during production. The final evaluation of the double seam can only be made by a visual inspection of the torn down seam in conjunction with the measurements. The seam measurements that can be taken to evaluate the double seam are shown in Figure 2 and are described on the next page.

Figure 2 – Components of the Double Seam



Countersink depth is the distance measured from the top of the double seam to the end panel adjacent to the inside wall of the double seam.

Seam thickness is the maximum distance measured across or perpendicular to the layers of material in the seam.

Seam width (also referred to as length or height) is the dimension measured from the top to the bottom of the double seam – parallel to the hooks of the seam.

Body hook and cover hook are formed during the double seaming operation from the body flange and end curl respectively and are the two interlocking structures within the double seam. They are internal to the seam and can not be measured unless a cross section cut of the seam is taken or the double seam is torn down.

Overlap is the degree or length of interlock between the body hook and cover hook.

Tightness is judged by the degree of wrinkling of the cover hook. During the first operation, the end curl is guided around and up under the body flange. This crowds the cut edge of the curl into a smaller circumference resulting in a wavy cut edge with accompanying wrinkles around the seam. The second operation roll presses the cover hook and body hook together to such a degree that the wrinkles may be ironed out sufficiently to ensure a hermetic seal. In a completed double seam, wrinkles may extend from the end curl cut edge downward on the face of the cover hook. The wrinkles help to indicate double seam tightness.

Tightness ratio is a numerical designation which indicates the relative freedom from wrinkles – the percentage of smoothness of the cover hook.

Pressure ridge is formed on the inside of the can body adjacent to the double seam, and is the result of the pressure applied by the seaming rolls during seam formation.

►Seam Guidelines

Double seam guidelines are provided to the establishment by the can and end supplier; they will vary depending on the can supplier, the plate weight or thickness of the metal of the can body and end, and roll contours of the double seamer. The guidelines detail the measurements, in thousands of an inch, of each attribute of the double seam for both the first and second seaming operations. They also provide a set-up aim or ideal starting dimensions for the set up of the double seamer. The operating limits set the range for good practice. However, it is extremely important to understand that seam measurements by themselves cannot be used for determining the quality of a double seam. The seam guidelines are to be used for setting up the double seamer initially and to assist in maintaining acceptable seams during production. The final judgment of the double seam can only be made by a visual inspection of the torn down seam in conjunction with measurements taken from the double seam component parts. This is done by a qualified seam technician.

During the examination of double seams, measurements that are outside the recommended guidelines or visual defects may be found. The seriousness of these out-of-normal conditions requires experienced judgment. Whether or not immediate corrective action must be taken depends upon the effect of the seam condition on the soundness of the container seal. For example if the body hook is slightly beyond the specified guidelines but the rest of the seam is evaluated and the overlap and tightness are within specified guidelines, then adjustments to the double seamer can be made at the next scheduled shut-down. However, if overlap measurement or tightness rating evaluation are below the minimum guidelines a resample from the seaming station should be made. If the resample continues to show out-of-guideline measurements in overlap and/or wrinkle the machine should be stopped and adjusted.

►Double Seam Evaluation Procedures

The two general types of double seam inspections include: (1) visual, non-destructive, external observations or measurements, and (2) destructive or tear-down procedures. Both of these types of examinations are typically made at the double seamer before processing. The importance of careful physical

measurement and visual examination of the double seam cover hook and body hook cannot be overemphasized. Nothing can replace experience and the good judgment of the closure technician in this part of the double seam evaluation.

Visual examinations

Visual examinations include regular observations for gross double seam and container defects. A trained double seam inspector will examine (by sight and touch) the double seams formed by each head of the double seamer for defects.

FSIS regulations (9 CFR 318.301(b) and 9 CFR 381.301(b)) require that visual examinations be conducted on at least one container from each closing machine head as often as necessary to ensure proper closure and should be conducted at least every 30 minutes of continuous closing machine operation. Additional visual examinations are to be made at the beginning of production, immediately following a container jam, and after machine adjustments. Actual frequency of inspection will be dependent on line speeds and conditions at the establishment. Documentation is made of each visual examination with a record made of any defects and corrective actions taken.

Teardown examinations

Physical or teardown examinations or tests are performed by a trained closure inspector. FSIS regulations (9 CFR 318.301(b) and 9 CFR 381.301(b)) require that physical examinations be conducted at intervals of sufficient frequency to ensure proper closure. Frequency of inspection will be dependent on line speeds and conditions at the establishment. Typical recommendations suggest that the examination intervals not exceed four hours of continuous closing machine operation and may be made at the double seamer; at least one container from each double seamer head shall be examined. Additional teardown examinations should be made at the beginning of production, immediately following a container jam, and after machine adjustments. Actually frequency of inspection will be dependent on line speeds and conditions at the establishment. The results of each teardown examination, and any defects and corrective actions taken, must be documented.

Teardown examinations are conducted with either a micrometer used to measure the physical components of a double seam which has had the cover hook carefully separated from the body hook or with a seam projector used to measure the physical components of a double seam cross section. Both methods require the removal of the cover hook to evaluate seam tightness and juncture rating (for three-piece cans only).

Good seam formation cannot be judged by purely mechanical means or measurements. The evaluation of good double seams requires experience and skill.

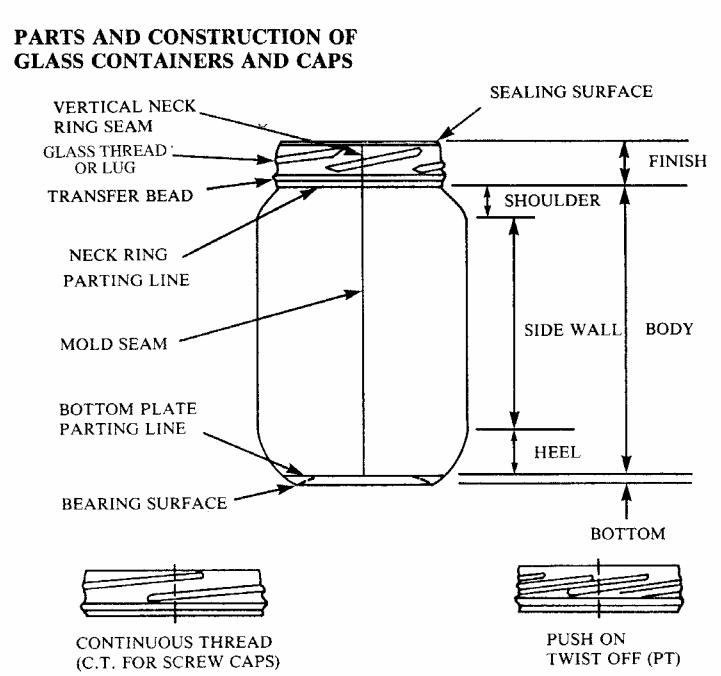
Glass Container

The glass container has a long and enviable record as a safe and desirable package for providing thermally processed food products to the consumer. The glass package commonly used for low-acid and acidified foods is made of two separate elements – the glass container and the metal closure. Both are essential for forming a proper hermetic seal. The glass container and the closure are supplied by different manufacturers. Specifications are maintained by the Glass Packaging Institute and the Closure Manufacturers Association to ensure that the two components of the package will work together.

►Glass Jar

Glass jars are manufacture by melting at very high temperatures (over 2600°F) ingredients such as sand, soda ash, limestone and recycled container glass. The molten glass is blown into molds the shape of the desired jar. The jars are slowly cooled in a process called “annealing” to give the glass container strength and stability. The containers are quality inspected by the glass manufacturer prior to shipping. The mold for making the jar is comprised of three parts: the finish, the body and the bottom. (See Figure 3 for the basic parts of the glass jar.)

Figure 3 – The Basic Parts of a Glass Jar



The Finish

The most essential part of the glass jar for producing and maintaining the hermetic seal is the finish. The finish is the very top part of the jar that contains threads or lugs that contact and hold the closure. The sealing surface on the finish is where the seal is developed between the glass jar and the closure (Figure 3).

Many different finishes exist for closing glass containers. Figure 3 shows only three general types, which may be varied for use with specific closures. Every type of closure for sealing glass containers has a specific glass finish with which the closure has been designed to function. Attempts to put a lug cap on a jar with a Press-on Twist-off (PT) finish would be futile.

►Closures

Metal closures are usually manufactured from tin-free or tin-coated steel plate. The closures are made in a multi-step forming operation to develop the skirts,

lugs and curls characteristic of each closure. Plastisol liners are inserted and the metal is coated for protection and design. The plastisol liner is the sealing gasket of the closure composed of a suspension of finely divided resin in a plasticizer. Plastisols are tailored to the product and process. For example, a closure intended for sealing a pasteurized product may not be suitable on a retorted product.

Key parts of the closures are lugs, gasket, and safety button or flip panel. **Lugs** are the horizontal inward protrusion that seat under the thread or lug on the finish of the glass container and guides the cap in position during application. The **Safety Button** is the raised area in the center of the panel that is used to detect low or no vacuum packages and indicate to the consumer a properly sealed container. As mentioned above the **gasket** is made of plastisol and is the actual sealing area of the closure. It makes direct contact with the sealing surface of the glass finish.

►Role of Vacuum

Almost all commercially sterile meat and poultry products packed in glass containers are sealed with vacuum-type closures. The vacuum within the package and the positive pressure on the outside of the cap play an important role in forming and maintaining a good seal. Two basic types of cappers apply caps while forming a vacuum in the container – the mechanical vacuum capper and the steam-flow capper. The **mechanical vacuum capper** applies the cap to the jar in an evacuated chamber. It is primarily used on dry products and rarely for commercially sterile processed foods. **Steam-flow cappers** utilize a controlled steam flow that displaces the headspace gases from the jar by a flushing action. The steam is trapped in the headspace as the cap is applied, and then condenses to form a vacuum. Steam-flow cappers can be either straight line or rotary. As an aid to good sealing, the gasket in plastisol-lined caps is softened by steam.

There are four primary factors affecting vacuum formation:

1. ***Headspace*** must be sufficient to trap an adequate amount of steam in the container for forming a vacuum and to accommodate product expansion during retorting. Inadequate headspace can result in displacement or deformation of the closure during retorting.
2. ***Product sealing temperature*** affects the final vacuum in the container due to the contraction of the product upon cooling. The higher the product temperature at the time of sealing, the higher the final package vacuum. Higher filling temperatures may also result in less air being entrapped in the product.

3. ***Residual air in the product*** can have a direct effect on the final package vacuum and should be kept at a minimum for good sealing. The more air that is trapped in the product, the lower the vacuum.
4. ***Capper vacuum efficiency*** is the ability of a steam-flow capper to produce vacuum in sealed containers. The cold-water vacuum check is the typical check of vacuum efficiency of a steam-flow capper.

►Closure Types

Currently, two types of vacuum closures – lug or twist cap and PT cap – are widely used on low-acid food products packaged in glass containers. In addition, the plastisol-lined continuous thread (PLCT) closure is used on acidified food products.

The ***Lug or Twist Cap*** is the predominant vacuum-cap type. It is a convenience closure because it can be removed without a tool and forms a good reseal for storage by the consumer. Structurally the lug cap consists of a steel shell and may have from three to eight metal lugs, depending on its diameter. It normally contains a flowed-in plastisol gasket. During closure application the headspace is swept by steam and the lug caps are secured to the glass finish by turning or twisting the cap onto the finish to seat the lugs of the cap under the threads on the glass finish. The top of the glass finish makes contact with the gasket on the inside of the cap. In most instances the caps are heated with steam to soften the compound and facilitate sealing. Both the lugs and vacuum hold the cap in place on the glass finish, but vacuum is the most important element.

Press-on Twist-off (PT) Caps are in widespread use for baby foods as well as other products. The cap consists of a steel shell with no lugs. The gasket is molded plastisol that covers a sealing area extending from the outer edge of the top panel to the curl of the cap. Most PT caps have a safety button or flip panel. The cap is first heated to soften the plasitisol. It is then pushed directly down on the glass finish after flowing steam over the headspace. The glass threads form impressions in the skirt of the cap gasket that allow the cap to be cammed-off and on by the consumer. The PT closure is held in place on the finish primarily by vacuum with some assistance from the thread impressions formed in the gasket wall when the cap is heated then cooled.

Plastisol-Lined Continuous Thread (PLCT) Cap consists of a metal shell with a continuous-threaded skirt curled at the end. It contains a plastisol gasket on the inside that makes direct contact with the top of the finish when the cap is screwed onto the container. The PLCT cap may be used in both steam and non-steam applications.

►Closure Evaluation Procedures

The two general types of closure inspections include: (1) visual, non-destructive, external observations or measurements, and (2) cap removal or destructive tests. Both of these tests and observations are made at the capper and after processing and cooling.

Visual examinations

Visual examinations include regular observations for gross closure defects. A trained container closure inspector will examine at least one container from each capper head for defects.

FSIS regulations (9 CFR 318.301(c) and 9 CFR 381.301(c)) require that visual examinations be conducted as often as necessary to ensure proper closure and should not exceed 30 minutes of continuous closing machine operation. Additional visual examinations shall be made at the beginning of production immediately following a container jam, machine adjustments or a prolonged shut down. It is also recommended that visual examinations follow changes in jar or cap supply or jar type. Frequency of inspection will be dependent on line speeds and conditions at the establishment. Visual closure inspections for straight-line cappers will typically involve a minimum of six samples taken at random and for rotary cappers, a minimum of one sample for each capper head. Inspections should be conducted with sample jars taken from the capper and after processing and cooling. Results of the visual examinations, and any defects and corrective actions taken, are documented.

Physical examinations

Physical examinations or tests are performed by a trained closure inspector. FSIS regulations (9 CFR 318.301(c) and 9 CFR 381.301(c)) require that physical examinations be conducted at intervals of sufficient frequency to ensure proper closure. Frequency of inspection will be dependent on line speeds and conditions at the establishment. Typical recommendations suggest that the examination intervals not exceed four hours of continuous closing machine operation and may be made before or after thermal processing. Any defects shall be recorded along with the corrective action taken. Physical examinations for straight-line cappers will typically involve a minimum of six samples taken at random and for rotary cappers, a minimum of one sample for each capper head.

Flexible and Semirigid Containers

The first flexible container used for low-acid foods was the retort pouch. This pouch was developed in the early 1960's by the U.S. military as a container for field rations and has recently gained greater consumer acceptance and is used for a wide variety of commercially sterile products. In 1981, hydrogen peroxide was approved as a sterilant for food contact surfaces of packages. This has allowed the use of semirigid and flexible packages for aseptically packaged low-acid foods. Advances in packaging technologies have lead to the development of the retortable plastic container with a double seamed metal end and the semirigid tray or cup with a heat sealed end and paperboard for retort applications.

As a way of classifying containers, the following definitions can be used.

Semirigid container – A container, the shape and contour of which, when filled and sealed, is not significantly affected by the enclosed product under normal atmospheric temperature and pressure, but which can be deformed by external mechanical pressure of less than 10 pounds per square inch gauge.

Flexible container – A container, the shape or contour of which, when filled and sealed, is significantly affected by the enclosed product.

Semirigid and flexible packages are primarily composed of single or multi-layers of different types of plastic materials such as polyethylene and polypropylene; however, some packages are manufactured with a paperboard and/or foil component. With the exception of plastic cans with double seamed metal ends, the closure seal is achieved by some form of heat sealing. The composition of the package is developed by the package manufacturer to meet specific performance needs such as retortability or oxygen barrier properties.

►Heat Sealing Methods

Currently there are four different methods of forming a heat seal. These are induction, impulse, hot bar and ultrasonic sealing. Parameters influencing seal integrity will vary depending on the method of seal formation. Typically pressure, temperature of the seal head, and/or dwell time will be controlled factors for forming a good heat seal.

Induction sealing employs the generation of a current in an electromagnetic field. The electrical resistance creates heat that fuses the lid to the container flange.

Impulse sealing utilizes rounded sealing bars that are not hot enough to form a seal until after the two sealing surfaces have been pressed together. The resulting heat and pressure applied by the sealing bars cause the polypropylene layers of the lid stock and container to melt and form a fusion seal.

Hot bar sealing also uses sealing bars but instead of gradual heating, the sealing bars are maintained at a constant high temperature.

Ultrasonic sealing employs the generation of ultrasonic wave vibrations. Friction caused by the vibrations generates heat, which forms the fusion seal.

►Inspection of Sealed Containers

Visual and physical examinations are conducted on semirigid and flexible containers to ensure the maintenance of the hermetic seal. Because the technology for manufacturing semirigid and flexible containers and producing the closures is varied and constantly evolving, the method of examining the seal integrity for these types of packages will vary depending on the sealing equipment and package composition. The establishment will work with the packaging supplier to develop the appropriate methods for examination.

FSIS regulations (9 CFR 318.301(d) and 9 CFR 381.301(d)) require that the heat seals be visually inspected by a trained closure technician with sufficient frequency to ensure proper closure. These examinations shall be performed before and after thermal processing on representative containers from each sealing head. Corrective action shall be taken when sealing defects are observed. Defects and corrective action shall be promptly recorded. Also, physical tests (for example burst tests) which are considered necessary to assess container integrity, must be conducted with sufficient frequency to ensure proper closure. FSIS regulations require that physical tests be performed after the thermal processing operation. Furthermore, FSIS recommends that sample containers be tested at least every two hours of production to ensure proper closure. The results of the tests, including any defects along with corresponding corrective actions, shall be recorded.

One type of semirigid package – the plastic cans with metal double seamed ends – are not sealed with a heat seal. Because this type of package is sealed with the same basic mechanism as metal cans with double seamed ends, the testing procedures are very similar.

For the remainder of this section we will provide an overview of the four most commonly used types of flexible and semirigid containers: semirigid containers with heat sealed lids, paperboard packages, flexible pouches, and plastic containers with double seamed metal ends

►Semirigid Containers with Heat Sealed Lids

Semirigid containers with heat sealed lids are used in retorted, hot-filled, cold-filled and aseptic operations for both high- and low-acid foods.

The containers may be purchased from the packaging manufacturer pre-formed, or they may be formed on-line by the food processor in conjunction with the filling operation. Containers may be formed with either of two different methods – blow molding or thermoforming. **Blow molding** involves forcing or air-blowing molten plastic into a mold to form the desired container shape. **Thermoformed** containers are manufactured by pressing the plastic rollstock into a die mold to form the container. The closures, which may be pre-cut lids or rollstock, are heat sealed onto the containers.

►Paperboard Packages

The basic construction of paperboard packages – whether for cold-filled, retorted or aseptically processed and packaged products – is a multilaminate of polymers, paper, and oftentimes foil. The composition is dependant on the application. Paperboard containers may be purchased from the packaging manufacturer as pre-formed flats, or they may be formed from web stock on-line in conjunction with the filling operation.

►Flexible Pouches

Pouches are used for low- and high-acid foods in hot-fill, aseptic and retort applications. They may be constructed of multi-layers of plastics and sometimes foil. Pouch film is supplied to the processor either as rollstock or as pre-formed pouches. If rollstock is used, the pouch forming operation is usually accomplished in the food processing plant by continuous form-fill-seal equipment. Depending on the manufacturer, the form-fill-seal equipment may be configured to form pouches either vertically or horizontally.

Filling pouches is an important stage in the operation; since it is essential that the pouch is filled to the proper level with product and that the product never contacts the seal area. Overfilling the pouch is to be avoided because it not only increases the potential for seal contamination and seal failure but could also lead to under-processing due to the greater thickness. Product dripping from the filler nozzle after the pouch has been filled is a potential seal contamination problem which must be prevented.

Various methods of air evacuation and heat sealing may be used to seal pouches in commercial production. The most commonly used procedures for air evacuation include:

1. Steam flushing of the headspace with saturated or super heated steam.
2. Drawing a mechanical vacuum in a vacuum chamber or by inserting a snorkel tube into the pouch.
3. Mechanically compressing the sides of the pouch to reduce or eliminate the headspace.
4. Hot filling the product to create a vacuum when the product cools.
5. Flushing the headspace with nitrogen gas.

Pouch sealers are generally equipped to apply either hot bar or impulse seals. The pouch seal area must be free of contamination and wrinkles in order to form adequate heat seals. Additionally, sealing temperature, pressure and dwell time must be maintained in accordance with the pouch manufacturer's specifications.

►Plastic Containers with Double Seamed Metal Ends

The double seamed metal can has long provided a means for the food processor to obtain a high level of container integrity and has become the most widely accepted package for shelf-stable low-acid foods. The plastic package with a double seamed end also provides a high level of container integrity. The double seam consists of five thicknesses of material: three thicknesses of metal from the end plus the flange and neck of the plastic container. These are folded, interlocked and pressed firmly together by the same basic closing machines used for metal cans. The container is typically shaped as a cup or bowl and may have a plastic cap covering scored metal end with a pull-tab to aid in microwavability.

Inspection of double seam

The same terms that are used to describe an all-metal double seam apply to the metal end/plastic body double seam. Sealing compound is also required for double seaming plastic cans and is important to package integrity. From an integrity evaluation viewpoint, the two most important measurements are double seam overlap and tightness. Countersink, cover hook and body hook measurements are generally used as diagnostic inputs providing additional data for evaluating the quality of the double seam when either the overlap or tightness are out of specification.

Container Closure Inspection Records

The maintenance of the hermetic seal is an important aspect in maintaining commercial sterility in products. Records of container closure inspections document the quality of the container closures and ensure that metal containers, glass containers and other packaging types are adequately sealed. The container closure inspection records provide proof that the required inspection program was carried out. In the event of spoilage, the closure records can be studied to determine if closure seal defects were causative factors of the problem.

Establishments maintain two types of container closure records: visual and destructive (or teardown). All record forms include appropriate columns for observations, measurements and steps taken to correct any deficiencies.

The regulations (9 CFR 318.301 and 9 CFR 381.301) specify that observations of container closures shall be made at intervals of sufficient frequency to ensure closure integrity. The regulations (9 CFR 318.307 and 9 CFR 381.307) further state that written records of all container closure examinations shall specify the product code, the date and time of container closure inspections, the measurements obtained and all corrective actions taken. In addition, the records shall be signed or initialed by the container closure inspector and reviewed and signed by the establishment within one working day after actual production.

Processing Methods for Commercially Sterile Products

Many methods exist for delivering the thermal process for commercially sterile products. These thermal processing methods will vary depending on whether the processing method is conventional canning, aseptic processing, or for acidified products. For organizational purposes only, we will discuss the systems for these three categories of thermal processing methods: ***retort processing*** for conventional canning, ***aseptic processing***, and atmospheric processing or ***pasteurization*** for acidified foods. Following the discussion on each of the thermal processing methods we will review some of the instruments, basic equipment, and operating precautions used for thermal processing.

Retort Processing

In simplest terms, a retort is a closed, pressurized vessel used for heating canned foods. Many different retorting systems are used for processing commercially sterile foods packaged in hermetically sealed containers, but all have a few common characteristics. 1) The systems are operated under pressure meaning that the temperatures delivered are much higher than boiling

water. 2) The systems use a medium (referred to as heating or processing medium) as the means to transfer heat to the product. The heating media used in retorting include pure steam, hot water (with the containers being either completely immersed in water, sprayed with water or cascaded (showered) with water), and steam/air mixture. Each type of retort thermal processing medium has specific requirements to ensure that the proper process is given to the hermetically sealed containers inside the retort. To facilitate the discussion, we will group the retort types by the processing medium utilized. Another way to further classify retorts is by the methods of handling containers – either by a batch or continuous method. A batch method is one where the containers are loaded into an unpressurized retort (with the door or lid open); once filled the retort is sealed and the heating medium is introduced and the process is started. A continuous process is one where the containers are continuously entering and exiting the pressurized retort during the process. A final way to further classify retorts is whether or not the containers remain stationary (still) or are rotated (agitated) during the process. Regardless of the configuration retort, the retort must be operated properly to ensure that the containers are processed to achieve commercial sterility.

►Determination of Retort Operating Procedures

Retorts must be constructed and operated in such a manner that the finished product will be commercially sterile. Operating procedures, developed by a processing authority or the equipment manufacturer, are established to ensure that each time the retort is run and the procedures are followed the temperatures within the retort are uniform.

Processing authorities use temperature distribution tests to assist in establishing operating procedures for all retort types. Temperature sensors or thermocouples are located between containers throughout the retort load. The temperatures are monitored during the process to ensure that the temperatures indicated on the MIG for the retort are representative of the temperatures throughout the retort.

Retort operating procedures shall be designed to provide uniform temperature distribution in the heating medium throughout the retort. Regardless of the heating medium, process timing shall not start until the MIG reaches processing temperature, and uniform temperature distribution has been attained within the retort. The specific operating steps depend upon whether steam, water or a steam/air mixture is the heating medium. In all cases, however, proper temperature uniformity should be accomplished during the come-up-time, which is defined as the elapsed time between the start of heating ("steam on") and the start of process timing. Process timing ordinarily begins when the retort reaches the prescribed processing temperature as indicated by the MIG and when required operating steps (e.g., venting procedures or come-up requirements) have been completed.

Workshop: Retort Operating Procedures

Read the following **Steps in a Retort Process Cycle** and then fill in the blanks and answer the questions about start-up procedures for a retort process. In some cases there may be more than one correct response; mark all that apply.

►Steps in a Retort Process Cycle

(**Note**: This is a simplified training example only.)

Starting a process cycle. After the retort door/lid has been closed and secured, steam is turned on after all bleeders and vents have been fully opened. Bleeders must be left fully open during the entire processing period.

Venting. All vent valves must be left fully open for a sufficient time and temperature after steam is turned on to ensure that all air is swept out of the retort. If the vent schedule is only partially completed, air will remain trapped in the inner areas of the retort load. Air in the retort may cause under-processing. Sometimes a bottom drain, which is not being used as a vent valve, is partially opened to remove the initial condensate buildup or cooling water residual. Unless the vent schedule specifies otherwise, this drain valve should be closed after the water is removed so that it does not interfere with the adequacy of the venting process.

The vent schedule must be timed with an accurate clock or timing device, not with the recorder chart. The vent temperature should be determined by reading the mercury-in-glass thermometer. After the schedule vent temperature and time have both been met or exceeded, all vent valves may be closed. Both time and temperature at which the vent valves are closed must be recorded.

Come-up-time. This is the period from the time steam is turned on until the appropriate process temperature is reached and maintained and the process timing begins. The vent schedule must be completed within this time. If the steam bypass is used to bring the retort up to processing temperature, it should be closed gradually to prevent a sudden temperature drop. Check the agreement between the temperature recorder and the mercury-in-glass thermometer. These readings should be taken and recorded after the retort temperature has stabilized.

Process timing. Timing of the process must not begin until the retort has been properly vented and the appropriate process temperature has been reached and maintained, as indicated by the mercury-in-glass thermometer, not the pressure gauge. Processes must be timed with an accurate clock or timing device rather than a wrist watch or temperature recorder chart.

Ending a process. Before turning off the steam, make the following checks.

1. Check that the appropriate process time has elapsed, as indicated by a clock or accurate timing device.
2. Check the temperature recorder chart to see that it shows at least the scheduled process time has been recorded.
3. Check the temperature recorder chart to see that no fluctuations below the required retort temperature have occurred.
4. Check the mercury thermometer to see that it indicates the appropriate process temperature.

If the check of any of these items is unsatisfactory, appropriate steps should be taken to provide an adequate process. If the check of all of the above items is satisfactory, the steam may be turned off.

►Questions

1. The steam is turned on after all bleeders and vents have been _____.

   a. opened
   b. closed

2. Bleeders are left _____ during the entire process.

   a. opened
   b. closed

3. What does venting do and why is it important? When is the vent valve closed?

4. The drain valve, sometimes used to remove condensate buildup or cooling water residual during the come-up-time, should be left _____ for a short period of time during the venting process.

   a. partially opened
   b. closed

5. Come-up-time is the period from the time steam is turned on until _____.

6. Process temperature is indicated by _____ and process time is measured with an accurate _____.

   a. mercury-in-glass thermometer, timing device
   b. pressure gauge, timing device
   c. mercury-in-glass thermometer, temperature recorder chart
   d. pressure gauge, temperature recorder chart

7. Timing of the process should begin after taking what steps?

   a. The retort has been properly vented.
   b. The appropriate processing temperature has been reached and maintained.

8. What device should be used to indicate the appropriate processing temperature?

   a. mercury-in-glass thermometer
   b. pressure gauge
   c. both the mercury-in-glass thermometer and pressure gauge

9. What checks should be made before turning off the steam?

   a. Check that the appropriate process time has elapsed, as indicated by a clock or accurate timing device.
   b. Check the temperature recorder chart to see that at least the scheduled process time has been recorded.
   c. Check the temperature recorder chart to see that no fluctuations below the required retort temperature have occurred.
   d. Check the mercury thermometer to see that it indicates the appropriate process temperature.

►Steam Retorts

Steam is a very efficient heating medium because steam carries considerable heat or "stored energy" from the conversion of water to vapor (steam). When steam condenses and turns back to water, this latent heat of vaporization is given up and transferred. This is how the containers in a retort are heated. Retorts that utilize steam as the processing medium need to allow for air removal prior to beginning the process. Air needs to be removed from the retort because it is not an efficient means of transferring heat. To demonstrate the comparison between the heat transfer rate of steam and air, think about the consequences of placing your hand in a dry heat oven at 250°F versus putting your hand over steam from a kettle at 212°F. If air is in the retort, it will act to insulate containers. Even small pockets of air can cause the containers contacted by air to be under-processed. The process of removing air from a steam retort is called “venting”. The process takes place before the operator can start timing the thermal process. The venting procedures will vary depending on the type of steam retort system. As long as the retorts are operated according to a prescribed operating procedure, air will be removed from the retort. Vent schedules typically will include a time and a temperature requirement. Both must be met to ensure adequate air removal. For steam retorts with continuous container handling, the retorts are vented at start-up before containers are introduced into the system. Retorts that utilize steam as the processing medium also need to provide good steam distribution during the process. This is done through the use of bleeders. Bleeders are small openings in the retort used to provide circulation of the steam and to remove any air which may enter the retort with the steam. Bleeders are generally from 1/16-inch to 1/4-inch in size and are wide open during the entire heating process. In addition anything that might impede the steam flow/distribution must be examined to assure that proper temperature distribution is maintained within the retort.

Depending on the retort and container size, containers may be partially or completely cooled in the retort. When pressure cooling is necessary, pressure is maintained in the retort while containers are cooled sufficiently to reduce their internal pressure to a safe level. Then the containers may be exposed to atmospheric pressure without danger of buckling the containers or straining the seals. There are no standard times for pressure cooling because the time is affected by a number of factors such as product, container size, process temperature, cooling water temperature and the amount of water used. In some instances where low retort temperatures are used, the smaller can sizes may be processed without pressure cooling. As a general rule, cans of 401 diameter or larger require pressure cooling when processed at 240°F or higher. Cans smaller than 401 diameter made with a light-weight tin-plate may require pressure cooling, especially when processed at higher than 250°F.

Still steam retort with batch container handling

A still retort is a batch-type vertical or horizontal pressure vessel with no movement of the containers during the process. Vertical retorts are configured with baskets that are lowered by an overhead hoist from the top and stacked one on top of each other (Figure 4). Vertical retorts will be sized to contain 1 to 6 crates and are about 42 inches in diameter. Horizontal retorts have baskets that are rolled or pushed into the retort and sit next to each other (Figure 5). Horizontal retorts will be sized to contain 1 to 12 or more crates. Generally, containers are stacked or jumble-loaded into racks, crates, cars, baskets, or trays for loading into and unloading from the retort. Still steam retorts are pressurized vessels (in order to attain temperatures greater than 212°F), with the doors or lids secured appropriately to maintain the vessel in a pressurized state. The pressure inside the retort is tremendous; at 250°F of pure steam, the pressure within the retort is 15 pounds per square inch pressure which equates to approximately 10 tons of force pushing against the lid or door of a retort.

Figure 4 – Vertical Retort

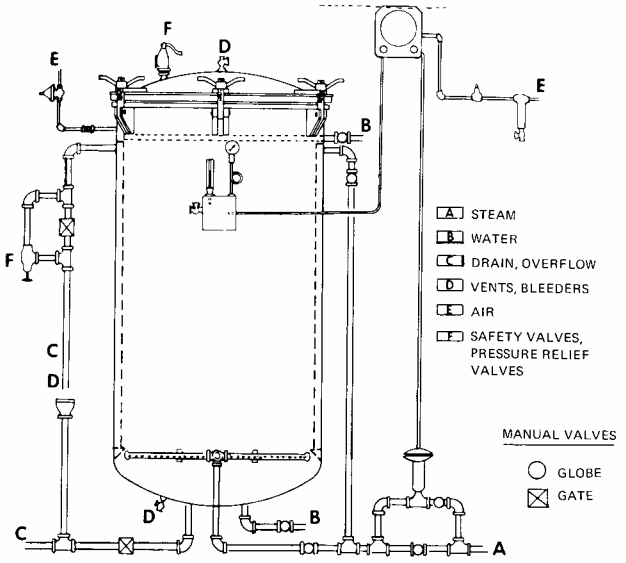
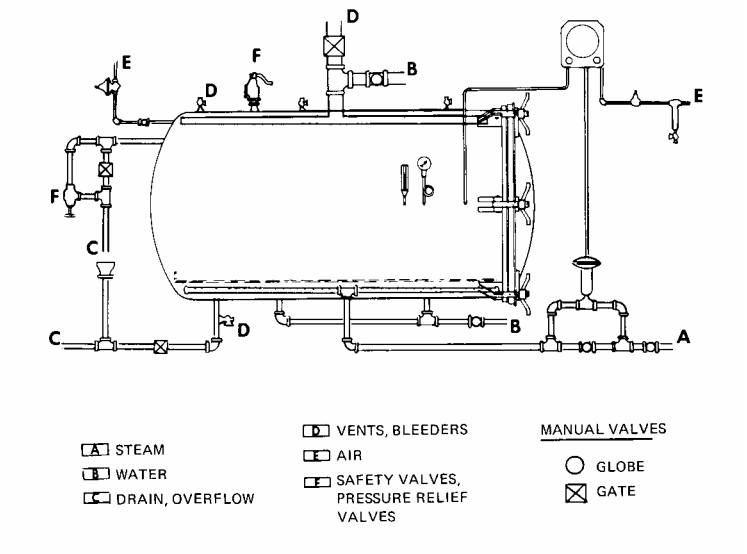


Figure 5 – Horizontal Retort



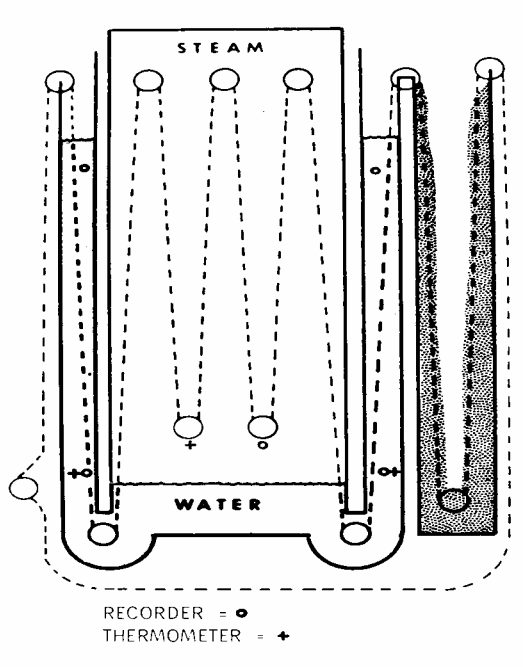
Crateless steam retorts are unique in that the containers are not placed in baskets, but are jumble loaded into the retort itself. The cans are conveyed from the double seamer and are metered into an open hatch at the top of the retort. The retort is filled about half full with water to cushion to fall of the cans into the retort. Once the retort is filled with cans the hatch is closed and sealed. Steam is introduced at the top of the retort to push the water and to vent air from the retort through an open valve at the bottom. At the conclusion of the cook, the cans exit the retort through a discharge door at the bottom of the retort.

Condensate is removed from the bottom of the crateless retort through a condensate bleeder normally located in the bottom door of the retort. A 1/8-inch bleeder is often placed between the false bottom door and the condensate bleeder to provide visual assurance to the operator that there is no condensate buildup in the retort during thermal processing. The false bottom door is utilized to separate the cans from any condensate that may collect at the bottom of the retort.

Hydrostatic retorts

The hydrostatic retort operates at a constant process temperature and has a continuous container-conveyor that transports containers through the retort (Figure 6).

Figure 6 – Path of Container-Conveyor in Hydrostatic Retort



Hydrostatic retorts usually operate with steam as the processing medium and with minimal or no container agitation during processing though there are some newer systems that provide axial (end-over-end) agitation of the containers. The thermal process in hydrostatic retorts occurs in a processing chamber that is maintained at a constant elevated temperature and pressure. To achieve a process temperature above the boiling point of water, the processing chamber must be pressurized. Unlike still steam retorts, which have doors or lids to maintain the pressure, the hydrostatic retort has no doors or valves separating the processing chamber from the atmosphere. The pressure within the chamber is counterbalanced by the weight (hydrostatic pressure) of water maintained in very tall columns holding the steam inside the steam chamber. This is the basis for the name of these retorts. Table 2 shows the height of the water legs in relationship to processing temperature.

Table 2 – Height of Hydrostat Water Legs in Relationship to Retort Temperature

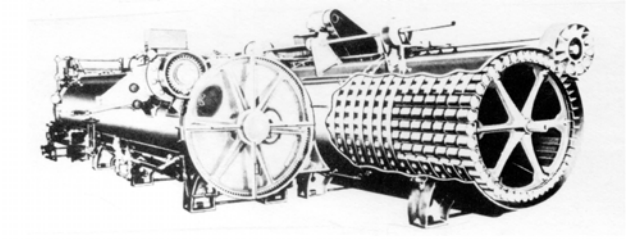
Steam Temperature	240°F	250°F	260°F
Steam Dome Pressure (Sea Level)	10.3 PSIG	15.1 PSIG	20.7 PSIG
Water Leg Height	24.6 ft	36.0 ft	49.4 ft

The container-conveyor enters and exits the processing chamber through these water columns. Hydrostatic retorts are limited to a maximum process temperature by the maximum height of the water legs. Also, a minimum temperature must be maintained because if the temperature drops, the corresponding pressure will drop which will upset the balance between the hydrostatic pressure and the steam pressure. A drop in pressure could result in water contacting containers in the steam dome (where the containers should only be exposed to pure steam). If water does contact those containers in the bottom loops of the container-conveyor, under-processing may occur. An automatic device should be installed to stop the container-conveyor should the water rise above the maximum level. If the water rises above the maximum water level, the containers affected by the high water level shall be segregated and held for evaluation by a processing authority.

Agitating continuous retorts

Agitating or rotary retorts provide continuous container handling and intermittent product agitation. Some establishments refer to this system as a rotary cooker, A-B cooker or Sterilimatic (this is the brand name of the retort system) (Figure 7).

Figure 7 – Cut-away View of Continuous Rotary Retort and Cooler



This retort system is made up of a series of cylindrical processing vessels called shells (58 inch diameter). Processing and cooling take place in separate shells. The design of the retort is dependent upon several factors, including product, container type and process conditions. When purchased, additional shells can be added for preheating in steam, pressure processing in steam, and/or cooling with or without pressure. The container conveying system is designed to take seamed cans continuously from the double seamer into the retort through the inlet valve; this valve – similar to a revolving door to a building – does not break the pressurized seal to the retort thus allowing containers to enter continuously into the pressurized environment through this valve. In the retort, a long piece of metal in the shape of a "T" is permanently attached to the inside surface of the shell; this piece of metal spirals on the inside circumference of the shell along the length of the retort and will be the guide in augering the cans through the retort. Inside the retort shell is a rotating reel composed of "steps" made of angle iron to support the containers as they auger through the retort. The turning of the reel in conjunction with the cans contacting the edge of the spiral-T augers the containers through the length of the shell. As the containers advance through a shell, the containers rotate as they roll along the bottom of the shell. This rolling provides intermittent agitation to provide more rapid product heating and cooling. During the free rotation phase, the containers roll freely along the inside bottom wall of the shell; the main product agitation occurs during this phase. When containers reach the end of one shell they are transferred to the next by means of a transfer valve.

The agitating continuous retort offers several advantages over still retorts. First, the process time is generally reduced due to intermittent agitation of the product during processing. This agitation may result in product movement within the container that increases the rate of heat penetration. Second, the product agitation also allows the use of high processing temperatures (up to 280°F). Third, in some instances, product uniformity and quality are improved. Finally, there is the possibility of reduced production cost through savings in labor and steam. Some of the possible disadvantages associated with this retort include a large initial investment, potential breakdown of product components due to the agitation, and additional critical factors to monitor and control. The retorts will accommodate only a limited range of container sizes due to the physical restrictions imposed by the reel steps, spacing of the spiral-T, and valve construction (transfer and inlet).

A means must be provided to remove condensate from the system while operating the retort; otherwise, there could be a buildup of condensate in the bottom of the retort that might interfere with container rotation and temperature distribution. Condensate is typically removed during venting by opening the drain valve for a short period of time. When the retort is at processing temperatures, draining of condensate occurs through a ¾ inch drain valve left partly open or

through an automatic condensate trap. A 1/8” bleeder at the bottom of the retort provides visual check that the retort is free of condensate.

Setting the reel speed for the agitating retort is important for two reasons: 1) it determines the residence or process time for the containers (since there is a set can capacity and the reel speed is set) and 2) it may affect the agitation of the product, which in turn affects the product heating rate. Heat penetration tests for products processed in this type of retort are conducted in a pilot version that simulates the can agitation during the process. This will allow for a faster product heating rate to be used for process establishment. Intermittent agitation will affect the rate of heating and cooling only if the headspace bubble and/or product are able to move within the container during free rotation. For example, solid packed items, such as corned beef hash, would not benefit from this type of agitation. Brine-packed items (such as peas, green beans and whole kernel corn), thin or slightly thickened products (such as sauces or soups) may have faster heating or cooling rates resulting from this type of agitation. The improved heating rates may allow the use of shorter processes than in still retorting.

►Retorts Providing Overpressure

Often overpressure during processing is required during processing to maintain the integrity of containers and counterbalance the buildup of pressure inside the container due to the limited resistance of internal pressure inside these packages. Additionally, overpressure is sometimes necessary to maintain the container at a certain thickness to allow for adequate processing. Examples of containers processed with overpressure are semirigid plastic containers with heat sealed lids or metal double seamed ends, flexible pouches, metal trays, paperboard containers, and glass jars.

The term "overpressure" refers to the pressure supplied to a retort in excess of that exerted by the heating medium at a given process temperature. In a steam retort, the pressure at 250°F is about 15 psig (pounds per square inch gauge); any pressure supplied to the retort in excess of that 15 psig is referred to as overpressure. Retort systems providing overpressure may operate at a pressure of 25-35 psig.

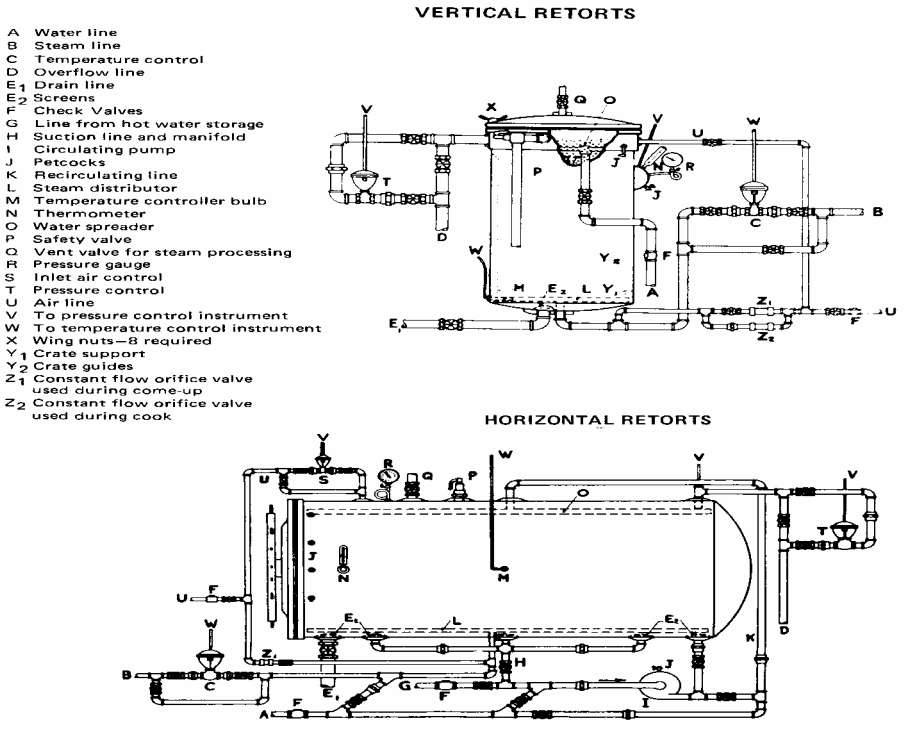
A variety of retort types are designed to provide overpressure during processing. The processing medium used in retorts providing overpressure include water in which the containers are totally immersed, water that cascades over the containers, a steam/air/water spray mixture, or a steam/air mixture. Depending on the system, steam or air may be used as the source of overpressure in the retort.

Each different container type may require a different amount of overpressure at different times in the processing and cooling cycles. Too much overpressure initially could panel or permanently distort plastic containers or lead to too great an impression in the plastisol in the closure for a glass jar. Insufficient overpressure during processing or the cooling period could cause the flexible containers to swell, which in turn could damage the container seals, affect the heating characteristics of the product and/or interfere with water circulation patterns in the retort, or cause lids on glass jars to release. In addition, factors such as product fill temperature, container headspace, container vacuum, entrapped air within the product and processing temperature may influence the overpressure required because these factors will impact the development of internal container pressure.

Water retorts with batch container handling

This is a broad class of retorts ranging from a simple design in a vertical retort orientation to a computer-controlled water spray system (Figure 8).

Figure 8 – Vertical and Horizontal Retorts with Water Immersion



The processing medium used varies from water in which the containers are totally immersed, to water that cascades over the containers, to a mixture of water sprays and steam/air. This class of retorts can accommodate a wide range of container types and sizes. The container racks can be custom designed to accommodate specific containers. Some retorts maintain the containers in a stationary (still mode) while others are fitted with a framework that will provide product agitation by rotating the containers that are positively held in baskets or racks.

For most of the water retorts, uniform temperatures throughout the retort are maintained by circulating the water with a pump. For the total immersion water retorts, containers need to be completely immersed in water during the entire process; if not, those exposed to the headspace in the retort should be segregated since they may not have received the proper process. For cascading water and water spray retorts, a minimum flow rate is required to maintain adequate temperature distribution. Vertical water retorts may be designed to circulate the water around the containers with compressed air that enters the retort with the steam. Although the heating medium is water for all of these retorts, the water is heated with steam – either directly or indirectly in a heat exchanger.

Proper installation and operation of each retort is essential to achieve satisfactory processing results. Operating procedures will be developed by a processing authority or equipment manufacturer to ensure that uniform temperatures are achieved and maintained in the retort during the process. Minimum come-up times may be established to allow for the water temperature to stabilize at or above the scheduled thermal processing temperature before the timing of the thermal process can begin.

The majority of the water retorts use a source of air to provide the overpressure requirements. There are a few systems that use steam as a source of overpressure. This steam is independently controlled from the steam that is used to heat the water and maintain the processing temperatures.

Hydrostatic retorts providing overpressure

While the majority of hydrostatic retorts utilize steam as the processing medium, some are designed to provide overpressure. The overpressure is maintained with multiple water legs to provide sufficient hydrostatic pressure to counterbalance the overpressure requirements in the processing chamber. Instead of steam, the heating medium is water which cascades over the containers as they travel through the processing chamber on the container-conveyor.

Steam-air retorts

Steam-air retorts are normally batch-type still or agitating retorts. They use a mixture of steam and air as the heating medium and the source of overpressure. A large fan is normally used to rapidly mix the steam-air mixture and to force this mixture to flow through the retort and around the containers during processing. The correct steam-air ratio must be maintained and is determined with temperature distribution studies. For the steam-air mixture, a minimum amount of steam is required and is calculated based on temperature and pressure.

►Cooling Operations

After the retort process, containers are usually water cooled. This is done either by cooling in retorts, cooling canals, agitating spin coolers, rotary pressure coolers or a combination of the above. During the thermal process, containers will build-up internal pressure as they heat. Small metal cans will be able to withstand situations where the pressure inside the container exceeds the pressure in the cooling system without distorting the can. Flexible and semirigid packages, glass jars and larger size cans will require pressure cooling to counter balance the pressure differential between the inside of the container and the cooling system and is necessary to maintain the integrity of the container and seals. When pressure cooling is needed, pressure is maintained in the retort while containers are cooled sufficiently to reduce their internal pressure to a safe level. Typically, containers that require overpressure during the thermal process will also require overpressure during the cooling process.

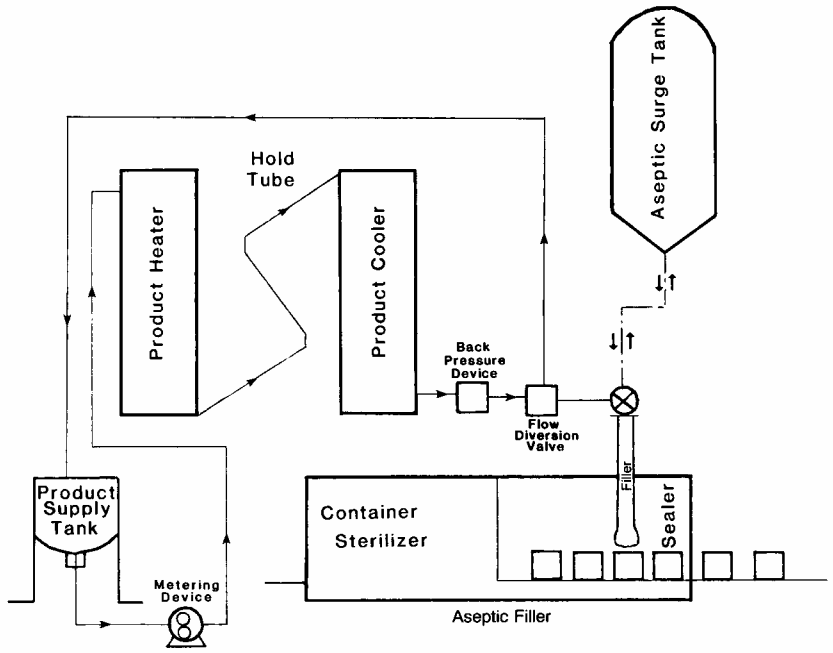
As the contents of the containers cool, a vacuum is being formed in the container. Any stress to the seam or seal may allow entry of minute amounts of cooling water. Because of this, the bacterial condition of the cooling water is important. The higher the number of bacteria, the greater the chances of leaker spoilage. Chlorination or other sanitizers are employed to keep contamination at a minimum. A measurable free chlorine residual at the discharge end of the cooler is required for cooling canals and recirculated water cooling systems, and it is recommended for single-use water systems. Other suitable sanitizers may also be used.

Aseptic Processing and Packaging Systems

Only a few FSIS-regulated products are aseptically packed because at this time aseptic processes have been establish only for homogeneous products such as beverages, broths or thickened products such as cheese sauces or puddings. Foods with particles (such as chunks of meat or vegetables) have not been accepted for processing aseptically in the United States. Aseptically processed

products involve combining packages and food product that are each brought to conditions of commercial sterility in separate systems. The commercially sterile package is then filled with commercially sterile product in a commercially sterile environment, closed and sealed in a commercially sterile chamber before exiting to the normal environment (Figure 9). Since aseptic processing is a continuous operation, the behavior of one part of the system can directly affect the overall performance of the entire system. As a result, the numerous critical factors associated with aseptic processing and packaging often require automated control systems.

Figure 9 – Simplified Diagram of an Aseptic Processing and Packaging System



►Determination of Aseptic Operating Procedures

Process establishment for aseptic systems must consider not only the commercial sterility of the product, the processing equipment and the downstream piping, but also the commercial sterility of the packaging material and equipment as well as the maintenance of commercially sterile conditions throughout the aseptic system. Production of a commercially sterile product cannot be assumed unless the cleaned processing system and filler have been adequately sterilized prior to starting production.

Proper preproduction sterilization of equipment is determined by temperature distribution and/or inoculation of the equipment to determine proper preproduction sterilization procedures and parameters such as exposure time, temperature, chemical concentration (such as hydrogen peroxide), etc. The packages must also be brought to a state of commercial sterility either prior to production (and maintained in a commercially sterile environment) or during production. The thermal process for the product is determined by the residence time of the product in the hold tube, which is based on the flow characteristics of the food. With this information, the proper temperature of the hold tube is set and maintained during processing as shown by the temperature indicating device such as the MIG or other acceptable temperature measuring device (such as an accurate thermocouple-recorder).

New aseptic systems are commissioned by running the system through a series of tests to ensure that all the interlocks, alarms, and connections are operating properly. Typically, a series of inoculated pack tests will validate the entire system as to its proper operation.

Components of aseptic processing and packaging systems are outlined below.

►Sterilizing the Equipment and Packages

Processing system – Some aseptic systems use saturated steam for sterilization of part of the system or the whole system. However, for most systems, equipment sterilization is accomplished by circulation of hot water through the system for a sufficient length of time to render it commercially sterile. When water is used, it is heated in the product heater and then pumped through all downstream piping and equipment up to (and generally past) the filler valve on the packaging unit. All product contact surfaces "downstream" from the product heater must be maintained at or above a specified temperature by continuously circulating the hot water for a required period of time. After this time has been achieved, the system will switch over to running product through the heating unit. The temperature measuring device is generally located at the most distant point from the heat exchangers. Timing of the sterilization cycle begins when the proper temperature is obtained at this remote location. Recording devices are recommended to provide a permanent continuous record to show that the equipment is adequately sterilized before each production run.

Packaging system – Aseptic packaging units are designed to combine commercially sterile product with a commercially sterile package resulting in a hermetically sealed commercially sterile product. Sterilization agents are used in aseptic packaging units to sterilize the packaging material and the internal equipment surfaces to create a commercially sterile packaging environment. In general, these agents involve either heat, chemicals such as hydrogen peroxide,

high-energy radiation, or a combination of these. For aseptic packages and packaging equipment, the sterilization agents utilized must be effective in providing the same degree of microbiological safety as that received in traditional canned foods. Food processors considering use of an aseptic packaging unit should request written assurances from the manufacturer that the equipment has passed effectiveness testing and that the equipment and sterilizing agents are acceptable to the regulatory agencies for their intended use.

Chemical agents such as hydrogen peroxide are often used in combination with heat as sterilization agents. The FDA regulations specify that a maximum concentration of 35 percent hydrogen peroxide may be used for food contact surfaces. If hydrogen peroxide is used as a sterilant, the packaging equipment must be capable of producing finished packages that also meet FDA requirements for residuals. Not more than 0.5 ppm hydrogen peroxide may be present in tests done with distilled water packaged under production conditions. These requirements apply also to FSIS-regulated products.

Other sterilants, such as high energy radiation – UV light, gamma or electron beam radiation could be used alone or in combination with existing methods. Completely new alternative sterilants may be developed in the future. Whatever methods are developed, they will have to be proven effective in order to protect the public health and will be compared with existing methods.

Packages – Containers filled and sealed in aseptic packaging systems are made commercially sterile by a variety of means. For example, one system using metal cans commercially sterilizes containers with superheated steam. In other systems, preformed plastic cups may be commercially sterilized by hydrogen peroxide and heat or by saturated steam. Systems using containers formed from paperboard laminates also utilize hydrogen peroxide and heat or hydrogen peroxide and ultraviolet irradiation to commercially sterilize packages. Thermoform-fill-seal containers may be commercially sterilized by the heat of extrusion (dry heat) or by hydrogen peroxide and heat. Plastic pouches or bags may be commercially sterilized by gamma irradiation, by the heat of extrusion, or by chemical means such as hydrogen peroxide.

►Processing the Product

Commercial sterilization time or residence time, as indicated in the scheduled process, is directly related to the rate of flow of the fastest moving particle/fluid stream through the system. The fastest moving particle is a function of the flow characteristics of the food. Consequently, a process must be designed to ensure that product flows through the system at a uniform and constant rate so that the fastest moving particle of food and/or fluid stream receives at least the minimum

amount of heat for the minimum time specified by the scheduled process. This constant flow rate is generally achieved with a timing or metering pump. Timing pumps may be variable speed or fixed rate. The pumping rate of the fixed rate pump cannot be changed without dismantling the pump. Variable speed pumps are designed to provide flexibility and allow for easy rate changes.

A product heater brings the product to sterilizing temperature. The two major categories of product heaters in aseptic food processing are direct and indirect. ***Direct heating*** involves direct contact between the heating medium (steam) and the product. One advantage of direct heating is a very rapid heating; this minimizes organoleptic changes in the product. A disadvantage of direct heating is the addition of water (from the condensation of steam in the product) into the product; this increases product volume, which subsequently increases the rate of product flow through the hold tube. This faster flow rate must be considered when establishing the scheduled process. Also, depending on the product being produced, the added water may need to be removed. Water removal is achieved during product cooling. ***Indirect heating units*** have a physical separation between the product and the heating medium. There are three major types of indirect heating units: ***plate***, ***tubular*** and ***scraped-surface heat exchangers***. The plates or tubes serve both as a barrier and a heat transfer surface with product on one side and the heating medium on the other. In order to conserve energy, there are systems that utilize product-to-product regenerators which allow the heat from the hot commercially sterile product (after the hold tube) to be transferred to the cool, incoming, non-sterile product. (There is a physical barrier between the commercially sterile and noncommercially sterile products.) Energy and cost savings can be significant by "recycling" the heat from sterile product. Product-to-product regenerators need to be operated and controlled so that the pressure of the sterilized product is at least one psi greater than the pressure of any non-sterilized product in the regenerators. This helps to ensure that any leakage will be from sterile product to non-sterile product.

Once the product temperature has reached the desired processing temperature in the heater, it can flow forward to a hold tube. The time that it takes for the product to flow through the hold time is the process time or also known as the residence time. The residence time is the time that the fastest product particle or fluid stream flowing through the hold tube remains within the hold tube. This residence time must be equivalent to or greater than the time specified in the scheduled process at or above the scheduled temperature. Hold tube volume combined with the flow rate and flow characteristics of the product determines the actual residence time of the product in the hold tube. The temperature of the food in the hold tube is monitored at the inlet and outlet of the tube. The temperature at the inlet of the hold tube is monitored and controlled with a temperature recorder-controller. A mercury-in-glass thermometer or other acceptable temperature measuring device (such as an accurate thermocouple-

recorder) and an automatic recording thermometer are installed in the product stream at the hold tube outlet.

After the product leaves the hold tube, it is commercially sterile and subject to contamination if microorganisms are permitted to enter the system. One of the simplest and best ways to prevent contamination is to keep the commercially sterile product flowing and pressurized. A back pressure device is used to prevent product from boiling or flashing; it maintains the entire product system at the elevated pressure. Effective barriers against microorganisms, such as steam seals, must be provided at all potential contamination points, such as rotating or reciprocating shafts and the stems of aseptic valves. Whatever the type of barrier used, it must be monitored visually to ensure proper functioning.

►Cooling the Product

Product flows from the hold tube into a product cooler to reduce the temperature prior to filling. In systems using indirect heating, the cooler will be a heat exchanger that may be heating raw product while also cooling sterile product. Those systems that use direct heating will typically include a flash or vacuum chamber. The hot product is exposed to a reduced pressure atmosphere within the chamber resulting in product boiling or “flashing”. The product temperature is lowered and a portion or all of the water that was added to the product during heating is removed by evaporation.

►Storage of Commercially Sterile Product Prior to Packaging

Aseptic surge tanks are used in aseptic systems to allow the establishment to hold commercially sterile product prior to packaging. These vessels, which range in capacity from about one hundred gallons to several thousand gallons, provide flexibility, especially for systems in which the flow rate of a product sterilization system is not compatible with the filling rate of a given packaging unit. If the valving that connects a surge tank to the rest of the system is designed to allow maximum flexibility, the packaging and processing functions can be carried out independently with the surge tank acting as a buffer between the two systems. A disadvantage of the surge tank is that a large amount of commercially sterile product is held in one location; therefore, if there is a contamination problem, a large volume of product is involved. One of the best ways to minimize the contamination risk in the tank is by keeping the product pressurized. This is accomplished with a commercially sterile air or gas supply system providing a protective positive pressure within the tank. Additionally, this positive air pressure will aid in pushing the product from the hold tank to the packaging system.

►Automatic Flow Diversion Device

An automatic flow diversion device may be utilized in an aseptic processing system to prevent the possibility of potentially unsterile product from reaching the commercially sterile packaging equipment. The flow diversion device must be designed so that it can be sterilized and operated reliably. Since the design and operation of a flow diversion system are critical, they should be done in accordance with recommendations of an aseptic processing authority. The flow diversion valve should divert product automatically if a deviation occurs. Examples of situations that may cause a diversion are a temperature drop below the scheduled minimum at the hold tube, inadequate pressure differential in the product-to-product regenerators, or the packaging unit dropping below minimum operating specifications.

►Aseptic Zone

The aseptic zone is the area within the aseptic packaging machine that is commercially sterilized and is maintained as commercially sterile during production. This is the area in which the commercially sterile product is filled and sealed in the commercially sterile container. The aseptic zone begins at the point where the package material is sterilized or where the pre-sterilized package material is introduced into the machine. The area ends after the seal is placed on the package and the finished package leaves the commercially sterile area. All areas between these two points are considered part of the aseptic zone. Prior to production, the aseptic zone must be brought to a condition of commercial sterility analogous to that achieved on the packaging material or other commercially sterile product contact surfaces. This area may contain a variety of surfaces, including moving parts composed of different materials. The sterilant(s) must be uniformly effective and their application controllable throughout the entire aseptic zone. Once the aseptic zone has been made commercially sterile, it must be maintained in this state during production. The area should be constructed in a manner that the physical barriers between commercially sterile and non-sterile areas can be made commercially sterile. Mechanisms must be provided to allow commercially sterile packaging materials to enter and hermetically sealed finished packages to leave the aseptic zone without compromising the commercial sterility of the zone. The commercial sterility of the aseptic zone can be protected from contamination by maintaining the aseptic zone under a positive pressure of commercially sterile air or other gas. As finished containers leave the aseptic zone, commercially sterile air flows outward, preventing contaminants from entering the aseptic zone. The commercially sterile air pressure within the aseptic zone must be kept at a level proven to maintain commercial sterility of the zone. Air or gases can be commercially sterilized using various sterilization agents, but the most common methods are incineration (dry heat) and/or ultrafiltration.

Pasteurizers

Pasteurizers or atmospheric cookers are used for products, such as acidified low-acid meat and poultry products, that require only a relatively mild form of heat treatment. Remember for acidified products, the control of *C. botulinum* is achieved with lowering the pH to 4.6 or below. The mild heat treatment may be necessary to destroy certain spoilage organisms that may grow in the product. This mild heat treatment may be delivered by using either hot-fill-hold techniques, aseptic procedures or atmospheric processing in a pasteurizer.

Pasteurizers may use either steam, hot water or cascading hot water to provide heat for processing acidified foods. Pasteurizers are maintained at atmospheric pressures and should use the same type of automatic steam control systems as described for retorts. Units using cascading water are the most common and may be a combination pasteurizer/cooler with the first sections using hot water and the remaining sections using cooling water. A continuous belt is used to convey the containers through the pasteurizer and provide a specific residence time based on the belt speed. Prior to introducing containers into the unit, the proper pasteurization temperature needs to be established, and the belt set to the proper speed. When containers enter the pasteurizer, they should be evenly distributed to ensure that the containers move through the pasteurizer uniformly. Uneven distribution of containers may lead to increased residence time and would be a quality – not a safety – concern. Both heating and/or cooling sections, if present, need to be maintained to ensure uniform operation and temperature distribution. Steam or water spreaders should be inspected and cleaned periodically to prevent any build-up around nozzles that could restrict the flow. Each pasteurizer shall be operated to ensure uniform temperature distribution throughout the processing system.

Product pasteurization can also be accomplished in retorts by the conventional canning method or in aseptic systems by attaining the proper level of sterility in and on the equipment, then processing the product to the proper pasteurization level and aseptically filling the product into the containers and hermetically sealing these containers. In addition, some establishments will use a hot-fill-hold technique by filling the acidified product into the containers hot, sealing the containers and holding the containers for a short period of time before cooling. The heat from the product will be enough to heat the container. Typically the containers will be inverted to provide heat to the container lid.

Thermal Processing Instrumentation and Equipment

►Temperature indicating device

Because the temperature within the retort is a critical aspect of the thermal process, each retort is equipped with devices to indicate and record that temperature. The mercury-in-glass thermometer (MIG) is the most widely used temperature measuring device in the canned food industry and serves as the official temperature indicating device for retort systems. FSIS regulations require that each retort system be equipped with at least one mercury-in-glass thermometer and that the thermometer have easily readable divisions to 1°F (0.5°C) and a temperature range that does not exceed 17°F (9.4°C) per inch of graduated scale. Other types of temperature indicating devices may be used for retorting systems.

The MIG thermometer needs to be installed in the retort in a location where it can be easily read and be protected from mechanical damage. Some establishments use metal guards to protect the thermometers. The thermometers should not be installed in the retort doors, lids or anywhere they would be subject to jolts or jars. The bulbs of mercury thermometers are installed within the retort shell or in external wells attached to the retort. If external wells are used, they are connected to the retort through at least a 3/4-inch diameter opening and equipped with a 1/16-inch or larger bleeder opening. The specific installation locations of these MIG thermometers will vary depending on the specific retort.

Since the MIG thermometer is not a foolproof instrument, it must be calibrated and maintained in good operating condition. Thermometers are tested against a known accurate standard upon installation, at least once a year thereafter, and at any time the accuracy of the thermometer is questionable, such as when the mercury column is divided. The accurate standard used in the United States is typically traceable to the National Institute of Standards and Technology (NIST). The records of thermometer accuracy checks shall be maintained and shall specify the date, standard used, methodology, results and person(s) performing the tests. Each thermometer should have a tag, seal or other means to identify that thermometer with the standardization records.

There are no specific requirements for a type of temperature indicating device for pasteurizers used to process acidified foods. Dial thermometers are used to monitor fill temperatures and mercury-in-glass or dial thermometers are used in pasteurizers as temperature indicating devices. Regardless of the type of thermometer used, it should be reliable and calibrated frequently enough to ensure accuracy.

For aseptic processing, a mercury-in-glass thermometer or other acceptable temperature measuring device (such as an accurate thermocouple-recorder) is used to measure the temperature of the product at the holding tube outlet.

►Temperature/time recording device

For low acid retorted foods, in addition to a temperature indicating device, each thermal processing system shall be equipped with at least one temperature/time recording device to provide a permanent record of the process. Because the temperature/time recorder provides the permanent documentation of the temperatures that are reflected on the official temperature indicating device (the MIG), it is adjusted to agree as closely as possible with – but in no event higher than – the temperature indicating device. FSIS regulations require that the temperature/time recorder be accurate to within 1°F (0.5°C) at the processing temperature. A means of preventing unauthorized changes in adjustment shall be provided. A lock or a notice from management posted at or near the temperature/time recording device warning that only authorized persons are permitted to make adjustments is a satisfactory means for preventing unauthorized changes. The temperature/time recorder should be used only with the appropriate chart paper for that particular instrument. Some of the more sophisticated temperature/time recorders are capable of printing their own time-temperature scales. The temperature chart graduations shall not exceed 2°F (1.1°C), within a range of 10°F (5.5°C) of the processing temperature. Each chart shall have a working scale of not more than 55°F per inch (12°C per cm) within a range of 20°F (11.1°C) of the processing temperature. Most instruments produce a continuous line that represents the recorded temperature. The location of the temperature recording bulb will vary depending on the type of thermal processing system. The bulb may be installed within a well attached to the retort or located directly within the retort shell. In general, the recorder bulbs are installed adjacent to the temperature indicating device.

For acidified foods, the FSIS requires that atmospheric cookers and pasteurizers be equipped with at least one temperature/time recording device. For pasteurizers using water as the processing medium, the probe of the temperature/time recording device should be installed in the hot water discharge or the coldest area of the heating portion of the pasteurizer. If steam is used as the heating medium, the probe should be installed in the cold zone of the unit.

For aseptic processing systems, the hold tube temperature at the inlet of the tube is monitored with a temperature recorder-controller sensor, which shall be located at final heater outlet and shall be capable of maintaining process temperature in the hold tube. Additionally, an automatic recording thermometer sensor shall also be located in the product at the holding tube outlet between the holding tube and cooler to indicate the product temperature.

►Pressure gauges

Each retort should be equipped with a pressure gauge or other suitable device to monitor pressure within the retort. If a gauge is used, it should be graduated with divisions not to exceed two pounds per square inch. A pressure gauge can provide the retort operator with useful information during operation and can serve as a safety device by alerting the retort operator to abnormal pressures because there is a direct correlation between temperature and steam pressure when processing in pure steam. For aseptic processing, there are times when a product-to-product regenerator is used; the pressure of the sterilized product in the regenerator must be at least one psi greater than the pressure of any non-sterilized product in the regenerator to ensure that any leakage in the regenerator will be from sterile product to non-sterilize product. This is monitored by an accurate differential pressure recorder installed on the regenerator.

►Temperature control systems

Each retort shall be equipped with an automatic steam (temperature) controller to maintain the retort temperature at the specified set-point. Most steam controllers and steam control valves are either operated pneumatically or electronically. The diaphragm-operated control valve installed in the retort should be the air-to-open type because if there is a failure in the air supply, these valves automatically close, thus preventing excessive temperature and pressure in the retort.

Pasteurizers may use either steam, hot water or cascading hot water to provide heat for processing acidified foods. These units are maintained at atmospheric pressures and should use the same type of automatic steam control systems as described for retorts.

Aseptic processing systems also utilize an automatic steam controller to maintain the product at the designated hold tube temperature. The location and application of these controllers depend on the type of product heating system being used.

Electronic controls for thermal processing systems are becoming more prevalent. These control systems can range from a simple, quick responsive temperature control system to a complex system precisely controlling an entire sequence of events. These systems can be programmed to control a complete thermal process. For retorting, this may include – venting, come-up-time, process temperature and time, cooling and overpressure. For aseptic systems, this may include preproduction sterilization, thermally processing the product to commercial sterility, automatic flow diversion, cooling, etc. Inputs may be made automatically, manually, or both. Based on operator inputs, some low acid food retort systems can select the proper thermal process for a particular product;

additionally, these systems are also capable of adjusting the thermal processing parameters while in operation based on the process information collected by the controller such that the new calculated thermal process compensates for any deviation(s) that occurred. Furthermore, since aseptic processing is a continuous operation that is highly coordinated, the behavior of one part of the system can directly affect the overall performance of the entire system. As a result, numerous critical factors are associated with aseptic processing and packaging systems often requiring automated control systems. Process establishment for aseptic systems must consider not only the sterilization of the product, the processing equipment and the downstream piping, but also the sterilization of the packaging material and equipment and the maintenance of sterile conditions throughout the aseptic system.

►Pressure control systems

For retort systems that require overpressure during the thermal process, overpressure is supplied in the form of air or steam, depending on the system. These types of retorts have an automatic pressure control unit to control the air or steam entering or leaving the retort to maintain the required overpressure. There are also times when overpressure is required only during cooling to maintain the package integrity by counterbalancing the internal pressure built-up in the container.

►*Timing devices*

Accurate analog or digital clocks are used for timing the thermal process to ensure that specific times are satisfied. The clock should be located so that it can be easily and accurately read by the operator. If the clock does not indicate seconds, a one-minute safety factor shall be added to each timed function. Personnel timing devices such as wrist watches should not be used.

►Valve types and uses

Basically two types of valves are used in thermal processing operations: globe valves, which are better sealing valves, and gate valves, which are full flow type valves. Vents are large valve-controlled openings in retorts used to remove air prior to processing in a steam atmosphere. Globe valves are not recommended for use in vent lines, because they reduce flow through the valve. Vents are controlled by a gate, plug cock or other adequate type valve that permits a rapid discharge of air and steam from the retort. All air lines and water lines connected to a retort are equipped with globe valves or other suitable valves to prevent air or water from leaking into the retort.

►Bleeders

Bleeders are small openings in the retort used to provide circulation of a steam heating medium, to remove any air entering the retort with the steam, to provide full flow of a heating medium past a thermometer bulb, or to remove condensate from the bottom of a retort. Bleeders can range from 1/16-inch openings or larger for a thermometer pocket to 1/4-inch openings on larger processing vessels. All bleeders are to be arranged in such a way that the operator can verify that they are functioning properly.

►Spreaders

Spreaders are continuations of a steam or water line inside the retort used to provide a uniform distribution of steam or water. Spreaders may also be used for other purposes, such as venting when connected to both vent and water lines.

►Mufflers

Mufflers may be used on bleeders or vents to reduce the noise level of the escaping steam and air. If mufflers are used it is important that they do not impede the removal of air or steam or interfere with the temperature uniformity within the retort.

►Condensate removal systems

Some retorting systems require that accumulated condensate be removed from the retort because this collected condensate may adversely affect the heating medium circulation and/or other critical parameters such as can rotation/agitation. For retorts with this concern, automatic condensate removal systems are installed in the bottom of the retort to provide for continuous removal of condensate during the entire process.

►Heating medium circulation methods

The retort heating medium must be circulated to provide uniform temperature distribution within the retort during processing. For example, in steam air retorts, there is a fan that is used to ensure a uniform mixture of the steam-air heating medium. For most water retorts, the water is pumped from the bottom of the retort and distributed back through spreaders or other distribution method at the top of the retort. For steam retorts, the steam is circulated with bleeders. Mechanical means of heating medium circulation (fans or pumps) are equipped with a signaling device (alarm or light) to warn the operator when it is not functioning.

Retort Room Operation

Establishments will have procedures in place to ensure that all product is processed to achieve commercial sterility. Training of operators and supervisors is key to a successful thermal processing operation.

►Preventing retort by-pass

A system for product traffic control in the retort room shall be established to prevent unretorted product from bypassing the retort process. All retort baskets, trucks, cars or crates containing unretorted products must be marked with a heat sensitive indicator or other effective means. Several marking systems are available – indicator paints, tags and tapes. Indicator paints or inks from the ink-jet coding system is a common method to mark each can. Tags are attached to the baskets, trucks, or cars. Tapes can also be attached to some of the containers on top of each basket.

Other practices to help prevent a retort by-pass include closing a retort only when the operator is ready to start the thermal process and destroying any stray containers found in the cook room or in the bottom of a retort.

►Initial temperature

The initial temperature designates the average temperature of the contents of the coldest container to be processed when the retort cycle begins. The initial temperature is determined by selecting a container representing the coldest container in the retort load. Just prior to the start of the process, the contents of the container are thoroughly mixed, and the temperature determined. For those retort systems that use water prior to or during processing, provisions shall be made to ensure that the initial temperature is representative of the coldest container or the water in the retort, whichever is colder. The thermal process used must be the process designated for the initial temperature of the retort load.

►Temperature/time recording device

The temperature/time recorder provides the continuous record of the temperatures delivered during the thermal process. Procedures are established to ensure that the instrument is working properly each day. Typical procedures include:

1. Checking that the recorder is functioning properly and supplied with the correct chart paper and adequate ink.

2. Assuring that the chart drive is turned on and functioning properly at the start of each shift.
3. Setting the chart for the correct time of day to correlate properly with the written records. FSIS canning regulations require agreement within 15 minutes between the chart time and the actual time of day.
4. Adjusting the temperature recording system to agree as closely as possible with but never higher than the MIG.

Thermal Processing Records

The delivery of the proper thermal process is a key component in producing a commercially sterile product. Records document the delivery of the thermal process to provide proof that the system is under control.

Establishments will design the thermal processing records to ensure that all of the critical elements of the thermal process are monitored and recorded. The FSIS canning regulations (9 CFR 318.306 and 9 CFR 381.306) outline required information for thermal processing records.

In addition to the thermal processing parameters, all critical factors specified in the scheduled process shall be measured and recorded at intervals of sufficient frequency to ensure that the critical factors remain within the limits specified in the scheduled process. These intervals should not exceed 15 minutes.

Processing records shall be signed or initialed by the operator and reviewed and signed by the establishment within one working day after actual production.

Copies of all required records of thermal processing, container closure, pH measurements, deviations in processing, and other critical factors are retained at the processing plant for one year from the date of manufacture and for an additional two years at a reasonably accessible location.

Workshop: Retort Identification

Pictures of retort systems or schematics will be shown to the class. Answer the following questions for each type of retort.

Retort #1

What type of retort is this?

What is the processing medium?

How is the processing medium circulated?

Is this a batch or continuous container handling system?

Does this retort provide product agitation?

Retort #2

What type of retort is this?

What is the processing medium?

How is the processing medium circulated?

Is this a batch or continuous container handling system?

Does this retort provide product agitation?

Retort #3

What type of retort is this?

What is the processing medium?

How is the processing medium circulated?

Is this a batch or continuous container handling system?

Does this retort provide product agitation?

Retort #4

What type of retort is this?

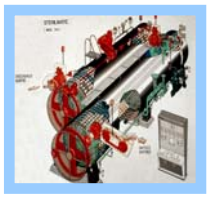
What is the processing medium?

How is the processing medium circulated?

Is this a batch or continuous container handling system?

Does this retort provide product agitation?

Retort #5



What type of retort is this?

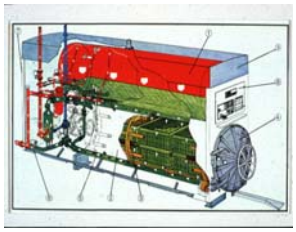
What is the processing medium?

How is the processing medium circulated?

Is this a batch or continuous container handling system?

Does this retort provide product agitation?

Retort #6



What type of retort is this?

What is the processing medium?

How is the processing medium circulated?

Is this a batch or continuous container handing system?

Does this retort provide product agitation?

Retort #7

What type of retort is this?

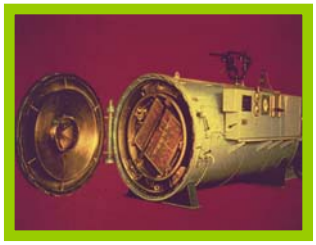
What is the processing medium?

How is the processing medium circulated?

Is this a batch or continuous container handing system?

Does this retort provide product agitation?

Retort #8



What type of retort is this?

What is the processing medium?

How is the processing medium circulated?

Is this a batch or continuous container handling system?

Does this retort provide product agitation?