Egg Products Plant Operations

Objectives

After completing this module, participants will be able to do the following:

1. Identify the key steps and procedures in egg products plant operations and the inspector's role in each.
2. Understand cooling and temperature requirements for liquid egg products.
3. Understand minimum temperature and holding requirements for pasteurization.
4. Cite the steps for conducting final product inspection.
5. Identify the actions to take when egg products are off condition.

Introduction

All egg products plants are required to produce an unadulterated product. All egg products in commerce must be *Salmonella* negative. The regulations establish the basic sanitation requirements that are the foundation for egg products inspection. They also list the specific requirements for operating parameters such as temperature requirements or sampling protocols.

Since operations vary and plants may use different processes, it is not possible to cover every requirement in the time allowed for this course. In this module, we will cover key regulatory requirements for the different operations in breaking and liquid egg products production. The regulations in 9 CFR 590 set out the requirements for the plant. To perform your duties effectively, you must have a good working knowledge of these regulations.

General Operating Procedures

This section outlines procedures the plant must follow to comply with the regulations (§590.504).

- Operations must be conducted in a sanitary manner.

- Pasteurization, heat treatment, stabilization, and other processes must be conducted as per the regulations in §590.

- Processes and temperatures must prevent deterioration of the egg products. Egg products are highly perishable.

Specific Procedures:

- All loss and inedible eggs must be placed in a container labeled **"**inedible" and must be denatured in accordance with the regulations. Plants may request permission from the District Office to ship non-denatured inedible products (intended for industrial use or animal feed) in accordance with the regulations. To do so, it needs to be properly packaged, labeled, segregated, and must be shipped under government seal and accompanied with a PY-200 form.

- Operations like pasteurization, drying, or stabilization must be started as soon as possible after breaking to prevent deterioration of the product, preferably within 72 hours. (This does not apply to egg whites, which are to be stabilized.)

- When equipment and utensils become contaminated during production, they must be immediately removed from the production area and must not be used again until cleaned and sanitized.

- All substances and ingredients used in egg products must be clean and fit for human use.

- Containers must be clean before use. Only new containers and used containers that are clean and lined with a suitable liner are acceptable.

- Inspectors must conduct a finished product inspection.

- All blood and meat spots must be removed, in addition to shell fragments and foreign materials.

- Egg products are to be tested for *Salmonella* to assure the adequacy of the pasteurization or heat treatment process.

- If product is positive for *Salmonella* and the plant does not want to condemn the product, it must be

    - Reprocessed
    - Pasteurized
    - Retested for *Salmonella*

- Shipping non-pasteurized or *Salmonella* positive product is allowed only when the product is to be pasteurized, repasteurized, or heat-treated in another official plant. All containers in which the product is shipped must be sealed and accompanied by a USDA certificate describing the state of the product.

Definitions

It is critical that inspectors understand the following terms to perform their duties. Use regulation §590.5 for further reference on definitions.

- **Egg:** the shell egg of the domesticated chicken, turkey, duck, goose, or guinea.

- **Nest Run:** eggs which are packed as they come from the production facilities without having been washed, sized and/or candled for quality, with the exception that some checks, dirties, or other obvious undergrades may have been removed.

- **Eggs of Current Production:** eggs that move through the usual marketing channels from the time of laying and are not in excess of 60 days old.

- **Clean Egg:** an egg whose shell is free from adhering dirt or foreign material. Only clean eggs are satisfactory for breaking. Though these eggs do not require washing prior to breaking, it is a good practice to do so. All shell eggs need to be sanitized prior to breaking using potable water and an approved, correctly diluted sanitizer.

- **Clean and Sound:** a clean and sound egg is defined as any egg whose shell is free of adhering dirt or foreign material and is not cracked or broken.

- **Dirty Eggs (Dirties):** eggs that have an unbroken shell with adhering dirt or foreign material. This may also include shells with prominent stains. If dirt, foreign matter, or stains are present, the eggs must be washed and sanitized with water 90 ºF or warmer. There is no threshold for “a little dirt or foreign material”; this is a zero tolerance rule.

- **Checks:** eggs with a broken or cracked shell whose shell membrane is intact and whose contents are not leaking.

- **Spots (§590.510(c)(3)):** either blood or meat spots on the interior of an egg. This interior defect is detected during the candling process. Blood spots show up as a cloudy image through the candling. Meat spots are from sources other than blood spots. If the plant is able to remove the blood or meat spot in an acceptable manner, the eggs may be used.

- **Hatchery Culls or Classified:** shell eggs from hatcheries that are eligible to be broken. They may be washed or not and may be sized or segregated or not.

- **Leakers:** eggs whose shell has a crack or break in the shell and shell membrane to the extent that the egg contents are exposed or extruding or free to exude through the shell.

  There are different categories of leakers.

  1. Leakers discovered prior to transferring or candling, or resulting from something other than washing (thermal expansion), are exempt from breaking. These are classified as loss eggs.

  2. Eggs whose shells are damaged during transfer or candling may be used for breaking only if the yolk is unbroken and the shell is clean. These eggs must be properly segregated, put in clean leaker trays, and broken only by specially trained personnel.

  3. Some eggs may show evidence of albumen along a crack because of thermal expansion caused by the washing operation. These eggs may be broken if the breaking is done immediately. Inspectors are to verify that the crack was part of thermal expansion and not due to improper handling.

- **Restricted Eggs:** any check, dirty egg, incubator reject, inedible egg, leaker, or loss.

Inedible or Loss Eggs

The egg products regulations under §590.510 explain the classification of eggs used in the processing of egg products. We can find the definition of terms used for inedible or loss under §590.5. Following is a list of the most common terms.

- **Loss:** an egg that is unfit for human food for one of the following reasons: it is smashed or broken so that its contents are leaking; it is overheated, frozen, or contaminated; it is an incubator reject; it contains a bloody white, large meat spots, a large quantity of blood, or other foreign material. All eggs ineligible to be broken are loss.

- **Incubator Reject:** an egg subjected to incubation and removed from incubation during the hatching operations as infertile or otherwise unhatchable.

- **Inedible:** inedible eggs that cannot be broken and eaten. Descriptions may include the following: black rots, yellow rots, white rots, mixed rots, sour eggs, eggs with green whites, eggs with stuck yolks, moldy eggs, musty eggs, eggs showing blood rings, and eggs containing embryo chicks (at or beyond the blood ring stage). *Inedible egg* conditions are defined as follows:

    1. Black Rots are caused by bacteria from the *Proteus* and *Pseudomonas* groups. Black rots are generally opaque when viewed before the candling light and are characterized by the presence of gas; since the shell membranes apparently become impermeable, the pressure created within the egg is often sufficient to burst the shell and scatter the egg's contents. When broken, the contents have a muddy brown appearance and give off a repulsive, putrid odor.

    2. Blood Rings and Embryo Chicks are caused by germ development, occurring in fertile eggs held at incubation temperatures. At an early stage in incubation (after 24 hrs), the embryo develops a circulatory system and if the embryo dies the blood drains to the outer edge of the germ disc, causing the blood disc. Before the candling light, it appears as a brilliant blood-red circle and the circle’s diameter depends on the stage of development.

    3. Bloody White is an egg that has blood diffused through the white. Such a condition may be present in freshly laid eggs and this condition is classified as loss.

    4. Green Whites or Green Rots are usually caused by members of the *Pseudomonas* group of organisms, which are commonly found on the surface of the egg shell. Certain species of *Pseudomonas* multiply in the albumen, from which they synthesize a characteristic fluorescent green pigment. These were very common types of "inedible" eggs 30 years ago; many egg products processing facilities installed black lights on the breaking equipment so that they could readily detect these inedible eggs.

    5. Large Blood Spots or Meat Spots in an egg require that they be classified as loss. Blood spots shall not be due to germ development; they may be on the yolk or in the white. Meat spots may be blood spots that have lost their characteristic red color or tissue from the reproductive organs.

    6. Mixed Rots (addled eggs) occur when the vitelline membrane of the yolk breaks and the yolk mixes with the white, resulting in

murkiness throughout the interior of the egg when viewed before the candling light.

7. Moldy Egg is an egg, usually found in humid storage conditions, whose shell is covered in mycelium "whiskers". The shell pores are penetrated and growth occurs on the shell membrane. You often see gelling around the albumen, which shows up as dark or colored patches or rings when candled. As the mold progresses, it will further break down the yolk membrane.

8. Mottled Yolks result from a non-uniform distribution of water in the yolk or from a separation of the vitelline membrane and chalaziferous layer of the albumen (inner and outer membranes).

9. Musty eggs frequently appear clear and free from foreign material when viewed before the candling light and can generally be detected only by the characteristic musty odor emanating from the egg.

10. Sour Eggs have a peculiarly pungent odor when opened, and their defects are not readily detected by candling. The albumen may be turbid, and the yolk and albumen may be somewhat mingled. The *Pseudomonas* bacteria cause sour eggs. These organisms produce a material that fluoresces under ultraviolet light, giving off a green sheen. The use of ultraviolet light ("blight light") in candling has made detecting this type of loss easier.

11. Stuck yolk occurs when the yolk membrane becomes attached to the shell membrane. It generally occurs in older eggs that have been left in a fixed position for a long time. When the thick white becomes thin, the yolk floats close to the shell and becomes attached to the shell membrane.

12. White Rots occur when the white and yolk have liquefied into a single mass when the egg is broken out, and there is no longer any definition to the yolk or albumen. White rots may be detected in the early stages by the presence of threadlike shadows in the thin white layer. In later stages, the yolk appears severely blemished when viewed before the candling light, and, when broken, shows a crusted appearance. The content frequently gives off a fruity odor.

Egg Products Processing Operations

Now we will turn our attention to specific operations in egg products processing and the requirements unique to each operation. For the following egg product

processing procedures, use FSIS Form 5400-12 (previously PY-203) and FSIS Form FSIS 5400-11 (previously PY-159) to document your daily observations and actions during the operation shift. To document noncompliance, use a Noncompliance Record, FSIS Form 5400-4. For additional detail on documentation and enforcement efforts, see the "Documentation and Enforcement" section.

Receiving

The in-plant inspector observes the condition of the eggs at this point. The eggs received for processing in an egg products plant are usually Nest Run or Restricted Eggs.

As stated in the definitions, a restricted egg is defined as a check, dirty egg, incubator reject, inedible egg, leaker, or loss. The container for restricted eggs must be properly labeled. Restricted eggs shall be identified as required by §590.800.

Nest Run eggs are not required to be labeled.

Plants may also receive liquid egg products from another official egg products plant. Liquid egg products being shipped must meet specific regulatory temperature requirements at the origin plant. These temperature requirements are in 9 CFR 590.530(c) Table 1 – *Minimum Cooling and Temperature Requirements for Liquid Egg Products.* However, this regulation only applies to egg products at the origin plant at the time of shipping. They do not apply to egg products received at another official plant.

When a plant receives product that exceeds the temperatures identified in *Table 1- Minimum Cooling and Temperature Requirements for Liquid Egg Products*, the plant has to decide if they will accept or reject the product.

- If the plant rejects the product, they may return it to the origin plant, ship it to a different official plant for further processing, or send it to inedible processing. Regardless of the final destination, you will follow established procedures for verifying disposition of the affected lot.

- If the plant accepts the product, it should get priority processing so the temperature is reduced as quickly as possible. The plant may do this by pumping the product through a chill press or by pasteurizing the product. How long it takes to reduce the temperature depends on the plant's product handling capabilities.

Because this regulation doesn't apply to the receiving plant, don't write an NR simply because the plant received egg products that exceed this regulatory temperature requirement.

Shell Egg Cooler

Most egg products plants hold the eggs in a shell egg cooler prior to breaking. As part of your inspection duties, you will verify that the shell egg cooler is maintained in a sanitary manner.

Transfer Room – §590.508

In the transfer room, shell eggs are loaded or delivered to the shell egg washer.

In preparation for processing, shell eggs are placed on pallets and/or on filler flats and then onto a conveyor. They are then staged to start the candling, washing, sanitizing, and breaking process. Shell eggs are placed in the transfer room prior to being transferred onto the shell egg washer. Time in the transfer room serves two purposes:

- It allows the cold eggs to warm slightly after being in the shell egg cooler, a process called *tempering.* Tempering helps to prevent the eggs from expanding and cracking during washing and sanitizing. It is also important to prevent the eggs from sweating. Sweating occurs when cooled eggs from storage are placed directly into the warm moist environment of the transfer/washing room.

- It increases the yield from each egg, since cold fresh eggs don't yield as much of the content as warmer eggs.

The conveyor belt moves the eggs to a vacuum loader. The loader uses suction cups to lift and transfer the shell eggs to the washer.

While the eggs are on the conveyor, the inspector has another opportunity during their regularly scheduled tasks to observe the condition of the eggs and the condition of the equipment. If a strong odor is detected from either the shell eggs or the cartons, the plant must segregate and candle the eggs prior to breaking and have them examined by qualified plant personnel.

If slight mold is detected on packaging material or on an occasional sound shell egg, both the plant and the inspector need to further investigate before the eggs are washed. The product must be re-examined by both the plant and IPP to determine the source of the odor before the eggs are washed, since washing will remove the visible mold. Because moldy eggs are inedible and are not eligible for breaking, you need to take the following actions:

- Stop operations in the transfer room until the affected lot is removed.

- Verify that the plant washes and sanitizes all affected transfer room equipment prior to restarting operations.

- Place the affected shell egg lot under U.S. Retention until management informs you of product disposition (for example, the eggs are to be hand segregated or discarded to inedible).

If you have reason to believe that moldy eggs have already entered the breaking room, you also need to take the actions specified above for the affected breaking room operations, equipment, and product.

Candling

In the candling process, the eggs are mechanically rotated several times over a bright light to examine the internal quality of the egg. This is a critical processing step, because it's the last opportunity to remove inedible eggs before they're broken. Egg products plants may have more than one candling area (before and after the washer), depending on the segregation procedures, egg-shell quality and classifications, and conveyor speed.

Plant employees sort, classify, and segregate the eggs to ensure that only eggs eligible for breaking enter the breaking room. As part of the segregation process, employees will remove inedible eggs. To prevent interruption of the breaking operation, employees may replace any dirty, leaker, inedible or loss eggs with sound shell eggs that have been cleaned.

The inspector is to verify that inedible eggs are identified and removed before breaking.

Washing – §590.515

The next step in the process is washing the shell eggs. The regulation covering egg cleaning operations is §590.515. Because shell eggs have bacteria on their surface, they must be clean before breaking.

The washing operation must meet the following requirements:

1. The temperature of the wash water shall be maintained at 90 ºF or higher, and shall be at least 20 ºF warmer than the temperature of the eggs to be washed. These temperatures shall be maintained throughout the cleaning cycle. This prevents thermal cracks due to expansion of egg contents.

2. Potable wash water shall be changed approximately every four hours, or more often if needed to maintain sanitary conditions, and at the end of each shift.

3. Replacement potable water shall be added continuously to the wash water to maintain a continuous overflow. Rinse water and chlorine sanitizing rinse may be used as part of the replacement water. Iodine sanitizing rinse may not be used as part of the replacement water.

4. The washing operation shall be continuous and shell eggs shall not be allowed to stand or soak in water.

5. An approved cleaning compound shall be used in the wash water.

Sanitizing and Drying – §590.516

Sanitizing must be conducted just prior to the breaking operation.

- Immediately prior to breaking, all shell eggs shall be spray rinsed with potable water containing an approved sanitizer of not less than 100 parts per million (ppm) nor more than 200 ppm of available chlorine or its equivalent.

- In lieu of sanitizing shell eggs washed in the plant, alternative procedures may be approved by the Administrator.

- Shell eggs shall be sufficiently dry at the time of breaking to prevent contamination or adulteration of the liquid egg product from free moisture on the shell.

Breaking Room Operations – §590.522

In the breaking room, shell eggs are broken and the contents are separated from the shell. After the egg is broken, the breaking machine can separate the yolk from the white.

The egg-breaking and separating machine is the heart of an egg products plant.

Its main components are:

- *Cracker assembly:* the mechanism that receives, cracks, and opens the shell egg and retains the shell until it is ejected

- *Cracker knife:* the part of the cracker assembly that penetrates the shell and assists in retaining the open shell

- *Receiving cup assembly:* the mechanism that receives the shell egg content from the cracker assembly for inspection; it may also separate whites and yolks

- *Product trays:* trays that collect liquid egg and deliver it to the collection vats

- *Cup rinse:* a mechanism for rinsing the receiving cup assemblies

- *Processing air:* filtered air used in contact with the product for an organoleptic inspection

Key breaking room regulatory requirements include:

1. Shell eggs must be broken in a sanitary manner and inspected for wholesomeness by smelling and visual inspection.

2. If blood, meat spots, or shell fragments accidentally fall into cups or trays, they shall be removed.

3. Whenever an inedible egg is broken, the affected breaking equipment shall be cleaned and sanitized. (§590.522(aa)(1))

4. Breaking machines must be operated at a rate to maintain complete control and accurate inspection and segregation of every egg. The cleaning frequency needs to be adequate to minimize accumulation of egg meat on the machine surface.

5. If management fails to maintain control and to segregate shell eggs entering the breaking room, the inspector must take a regulatory control action to stop breaking room operations, no matter how many machines are involved. Operations may not resume until plant management has taken appropriate corrective actions.

Liquid Egg Cooling – §590.530

- Liquid eggs will be considered satisfactorily cooled only when the entire mass reaches the required temperature.

- The temperature of previously cooled product may rise because of further processing operations such as blending, homogenizing, or reconstituting dried products. The temperature must be reduced to meet the requirements.

- Cooling and temperature requirements are specified in §590.530 Table I (see following page).

Table of Minimum Cooling and Temperature Requirements – Liquid Egg Products
Table 1 of §590.530

[Unpasteurized product temperature within 2 hours from time of breaking]

Product	Liquid (other than salt product) to be held 8 hours or less	Liquid (other than salt product) to be held in excess of 8 hours	Liquid salt product	Temperature within 2 hours after pasteurization	Temperature within 3 hours after stabilization
Whites (not to be stabilized)	55 °F. or lower	45 °F. or lower		45 °F. or lower	
Whites (to be stabilized)	70 °F. or lower	55 °F. or lower		55 °F. or lower	([1])
All other product (except product with 10 percent or more salt added)	45 °F. or lower	40 °F. or lower		If to be held 8 hours or less 45 °F. or lower. If to be held in excess of 8 hours, 40 °F. or lower	If to be held 8 hours or less, 45 °F. or lower. If to be held in excess of 8 hours, 40 °F. or lower.
Liquid egg product with 10 percent or more salt added			If to be held 30 hours or less, 65 °F. or lower. If to be held in excess of 30 hours, 45 °F. or lower	65 °F. or lower[2]	

[1]Stabilized liquid whites shall be dried as soon as possible after removal of glucose. The storage of stabilized liquid whites shall be limited to that necessary to provide a continuous operation.
[2]The cooling process shall be continued to assure that any salt product to be held in excess of 24 hours is cooled and maintained at 45 °F or lower.

(Source: http://ecfr.gpoaccess.gov/)

Defrosting Operations – §590.539

Frozen egg products should be defrosted in a sanitary manner according to the regulations.

Pasteurization – §590.570

Pasteurization is the main lethality step for destroying *Salmonella* in egg products. The principle behind pasteurization is that every particle of the product is rapidly heated to a required temperature and held at that temperature for a required minimum length of time to destroy the *Salmonella* organism.

The minimum values are set out in Table I of Section §590.570 of the regulations. (See table on following page.)

If the plant wishes to use a time-temperature combination that is not listed in Table 1, it must first get approval from the Administrator to use that process.

The main method of pasteurizing egg products is the High Temperature Short Time (HT-ST) method. The HT-ST pasteurization units may differ in configuration but there are several key pieces to this equipment, the IPP need to be familiar with the function and operation procedures for the complete pasteurization cycle.

HTST pasteurizers are available with plate and/or tubular heat exchangers (see Figure 1, page 15). The key factors are controlling the flow rate and maintaining the temperature to retain the unique properties of the final egg product while ensuring efficient pasteurization. Appendix I – Figure 2 in the Plant Familiarization section shows the flow diagram for pasteurized liquid egg products, which covers the processing, steps from receiving of shell eggs/liquid egg products through the cooler/freezer storage and shipping. We will be using this flow diagram for our discussion.

In practical terms, the HTST is a continuous process consisting of:

1. rapidly heating every particle of liquid eggs (whole eggs, whites, plain yolks, and mixtures) to a specific temperature range (125˚ - 150˚F or higher)
2. holding the product at a definite temperature for the time required by the specific product
3. rapidly cooling the product

The HT-ST process rapidly heats, holds and then cools the product. The holding time must be calculated and exactly followed to destroy the *Salmonella* pathogen.

Pasteurization Requirements[1]
Table 1 of §590.570

Liquid egg product	Minimum temperature requirements (°*F*)	Minimum holding time requirements (*Minutes*)
Albumen (without use of chemicals)	134	3.5
	132	6.2
Whole egg	140	3.5
Whole egg blends (less than 2 percent added non-egg ingredients)	142	3.5
	140	6.2
Fortified whole egg and blends (24–38 percent egg solids, 2–12 percent added non-egg ingredients)	144	3.5
	142	6.2
Salt whole egg (with 2 percent or more salt added)	146	3.5
	144	6.2
Sugar whole egg (2–12 percent sugar added)	142	3.5
	140	6.2
Plain yolk	142	3.5
	140	6.2
Sugar yolk (2 percent or more sugar added)	146	3.5
	144	6.2
Salt yolk (2–12 percent salt added)	146	3.5
	144	6.2

[1]Pasteurization of egg products not listed in this table shall be in accordance with paragraph (c) of this section.
(c) Other methods of pasteurization may be approved by the Administrator when such treatments give equivalent effects to those specified in paragraph (b) of this section for those products or other products and results in a *Salmonella* negative product.

Source: http://ecfr.gpoaccess.gov/

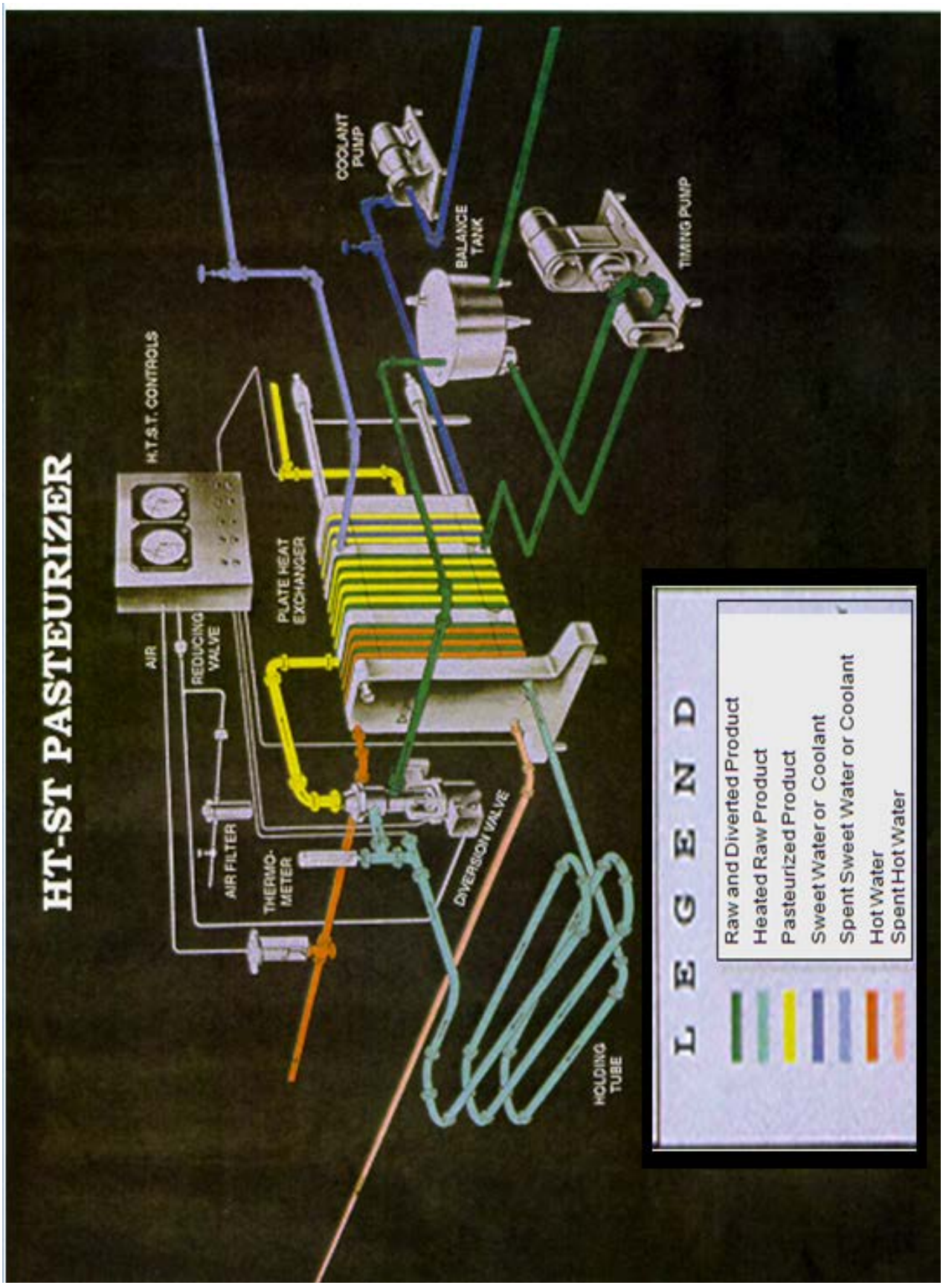


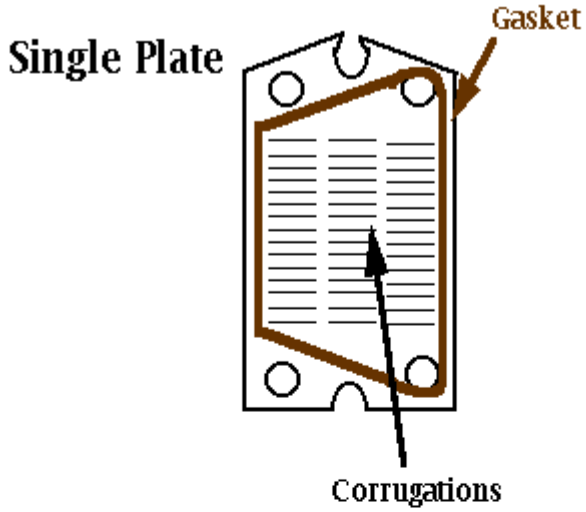
Figure 1 – Pasteurizer Equipment

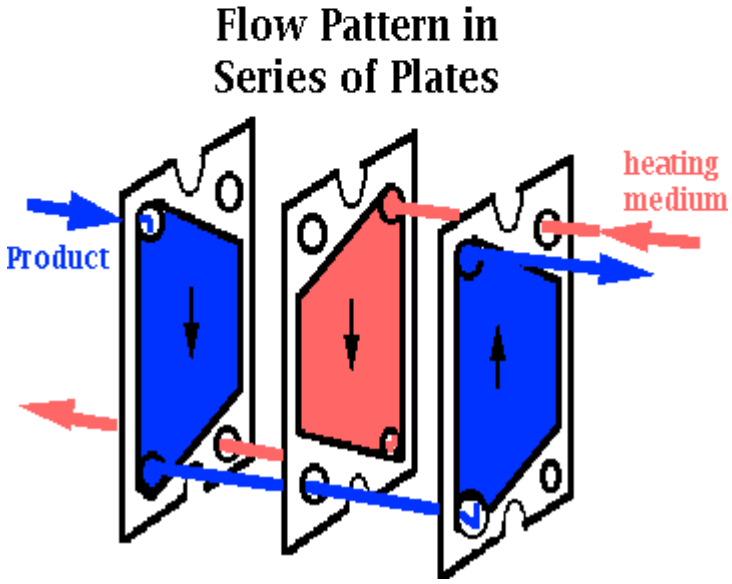
During the pasteurization method (see pages 16-18 for equipment layout and schematic heat exchangers):

- the product is rapidly heated through plates or tubes then held in holding tubes at the required temperature for a specified amount of time;
- after receding the end of the holding tubes, sensors determine and record if the time/temperature requirement has been met; and,
- as the product is run through a flow diversion valve it will be either back through the tubes or plates to be rapidly cooled if the proper time /temperature has been met. If not the product is diverted back through the heat side and reprocessed.

Records and charts are required for all egg products, thus the IPP have to verify charts and written records showing that the time/temperature requirements have been met.

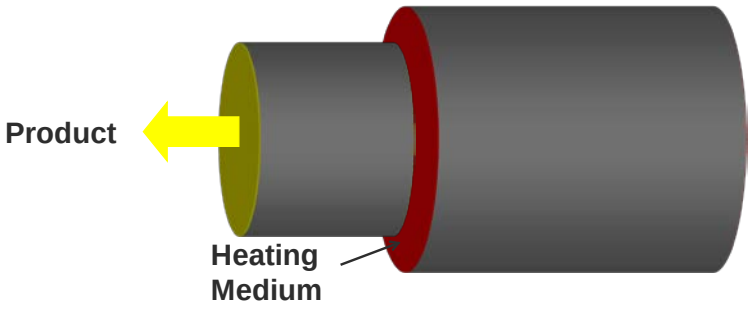
Pasteurizer with tubular heat exchanger and plate heat exchanger



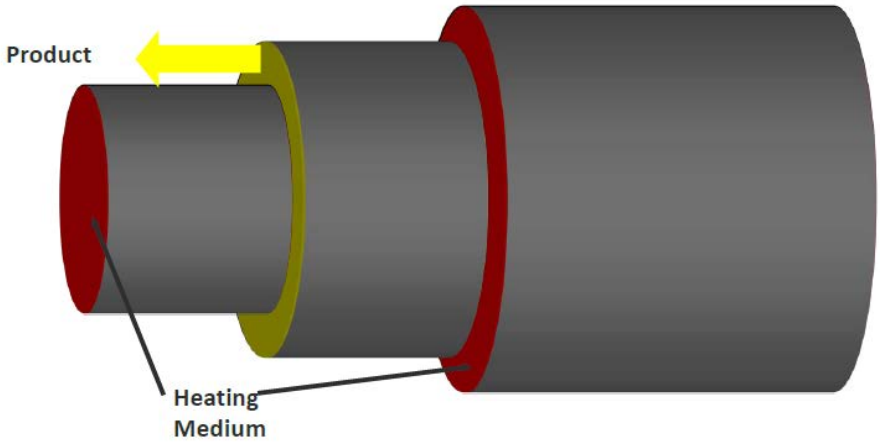


This is an example of a simple schematic flow diagram of a HTST pasteurizer along with a plate/gasket construction. The heating media represents the hot pasteurized liquid egg product from the holding tube while the product represents the raw liquid egg product coming into the pasteurizer.

Schematic Diagrams of Concentric Tube Heat Exchangers



Double Tube Heat Exchanger



Triple Tube Heat Exchanger

Concentric tube heat exchangers create a temperature driving force by passing fluid streams of different temperatures parallel to each other, separated by a physical boundary in the form of a pipe. This induces forced convection, transferring heat to/from the product.

Other pieces of equipment, which are part of the pasteurization unit:

- Indicating Thermometer - measures the temperature of the product exiting the holding tubes.

- Recording charts are required to indicate that the proper time/temperature requirements have been met. Be sure to verify that the recording paper is correct for the chart used.

- Holding tubes have several requirements that the inspector need to verify.

    1. The length of the tubes must be known to assure holding time is achieved.

    2. The holding tubes must be measured to assure proper length and must be taken from the middle of the tube to assure accuracy.

    3. The slope of the holding tubes is also a critical factor. The regulatory requirement is that the tube must have a quarter of inch incline for every inch of tubing. This must also be verified to assure proper flow in calculating the holding time.

    4. The tubes also have requirements in that they may be wrapped but no external heat may be applied.

In the pasteurization process for egg whites, Hydrogen Peroxide may be introduced as an antimicrobial (Ref: Egg Products Inspector Handbook (EPIH), Section 5 pages 36-37).

As stated previously, the holding time should be checked for each product at a frequency to insure compliance with the regulations. Following is the thought process on how to determine the holding time (Ref: EPIH Section 5, pages 24-27). The holding time gives you how many minutes the product is being held in the holding tubes.

- The first step is to calculate the flow rate (volume per unit time). Usually, the inspector collects a given amount of liquid egg product during the pasteurization operation for a measured amount of time in seconds (convert the time in seconds to one minute). The flow rate is calculated by determining the net weight of the liquid collected and converting it to pounds per minute:

    Flow Rate = weight of liquid (lbs) X time (per minute)

Example 1: It required 30 seconds to collect 40 pounds of pasteurized whole eggs. Divide 60 seconds per min by 30 seconds = 2 per min. Multiply 40 pounds by 2 per minutes = 80 pounds of liquid per minute.

- Once the flow rate is calculated and having the information of the holding tube capacity of the pasteurizer unit for a specific liquid egg product the inspector is able to calculate the holding time.

  Holding Time (min) = holding tube capacity (lbs) ÷ flow rate (lbs/ min)

  Example 2: The product that has been pasteurized is Plain Whole Eggs. The capacity of the holding tubes has been calculated at 2700 lbs for this product. The inspector determined that the product flow rate is 640 lbs/min. To determine the Holding Time divide 2790 lbs by 640 lbs/min which results in 4.35 min. Determine regulatory compliance with §590.570 & record this value along with other require information using the appropriate FSIS Form 5400-11/5400-12.

Spray Process Drying Facilities and Operations – §590.540/590.542

Industry has developed a variety of dried egg products, including dried egg white, dried plain whole egg and yolk, and specialty dried egg products.

Egg products fall under two basic categories when considering their drying characteristics:

- egg white products
- whole egg and yolk products

Before the liquid egg products go through the drying process, industry uses processing techniques to achieve the desired finished product. These techniques alter the composition of egg components by changing the lipid or sugar composition, concentrating solids, or separating egg components (e.g., lysozyme and avidin).

The following processing techniques are used in drying:

1. Some egg products plants concentrate liquid egg whites prior to drying by removing excess water. This is done in one of two ways:

   - reverse osmosis: (the most common) the albumen is forced across a membrane by applying high pressure, leaving water behind
   - ultra filtration with special membranes: large molecules (such as proteins) are separated using low pressures, leaving water behind

2. To prevent discoloration of dried egg products, some egg products plants remove glucose from the liquid prior to drying. This technique is known as desugarization or stabilization. Stabilization is done in a fermentation process where the sugar is removed by one of the following processes:

    - adding a starter bacterial culture (applicable to egg whites)
    - adding a pure yeast culture (applicable to all egg products)
    - adding an enzyme (applicable to all egg products)

    The pH is monitored during the fermentation process. Once the targeted pH is reached, the product is cooled and stored in holding tanks until the drying step.

Industry uses chemical additives to improve and keep the functional properties (whipping, coagulation, emulsification, flavor, nutrition, and color) of the final dried egg products. Examples of chemical additives include carbohydrates, whipping aids, emulsifiers, and anti-caking agents (colloidal silicon dioxide).

The methods for producing dried egg products are as follows (refer to Figure 2, page 23):

- Spray drying: This method consists of spraying the egg liquid through a number of nozzles into a stream of hot air in a drying chamber. Filtered dry air is distributed into the drying chamber where the water evaporates from the liquid droplets and they transform into powder. Built-in systems remove the powder from the drying chamber and transfer the dry product into the packaging system. Spray-drying chambers differ in the nature of their airflow and the way they collect the dried powder. Examples include the tower type, cyclone type, and box type. Yellow products are pasteurized prior to spray drying. Whites are pasteurized by heat treatment after spray drying.

- Pan drying: This method consists of drying the unpasteurized egg whites on pans to produce a flake-type material. The pan-dried egg white can also be milled to a fine powder.

The dried egg product must be handled aseptically during packaging. The advantages of dried egg products compared to their liquid frozen counterparts are shelf life, storage, and low transportation costs.

Key spray process drying facilities and operations regulatory requirements include:

1. Driers shall be of a continuous discharge type and so constructed and equipped to prevent an excess accumulation of powder in the drier, bags, and powder conveyors.

2. Driers shall be of approved construction and materials, with welded seams and the surfaces shall be smooth to allow for through cleaning.

3. Driers shall be equipped with approved air intake filters

4. Air shall be drawn into the drier from sources free from foul odors, dust and dirt

5. High-pressure pump heads and lines shall be of stainless steel construction or equivalent which will allow for thorough cleaning

6. Powder conveying equipment shall be so constructed as will facilitate thorough cleaning

7. Sifters shall be constructed of an approved metal or metal lined interior. Sifters shall be so constructed that accumulations of large particles or lumps of dried eggs can be removed continuously while the sifters are in operation.

8. The drying room shall be kept in a clean condition and free of flies, insects and rodents.

9. Low-pressure lines, high-pressure lines, high- and low-pressure pumps, homogenizers, and pasteurizers shall be clean by acceptable in place cleaning systems or dismantled and cleaned.

10. Spray nozzles, orifices, cores, or whizzers shall be cleaned immediately after cessation of drying operations.

11. Equipment shall be sanitized within 2 hours prior to resuming operations

12. Dry units, conveyors, sifters and packaging systems shall be cleaned whenever wet powder is encountered.

Drying Operations – §590.544

Key definitions for drying operations:

- **Primary powder** is the powder that is continuously removed from the primary or main drying chamber while the drying unit is in operation.

- **Secondary powder** is that powder that is continuously and automatically removed from the secondary chamber and/or bag collector chamber while the drying unit is in operation.

- **Sweep-down powder** is that powder which is recovered in the brush-down process from the primary or secondary chamber and conveyors.

- **Brush bag powder** is that powder which is brushed from the collector bags.

Figure 2. **Drying equipment**

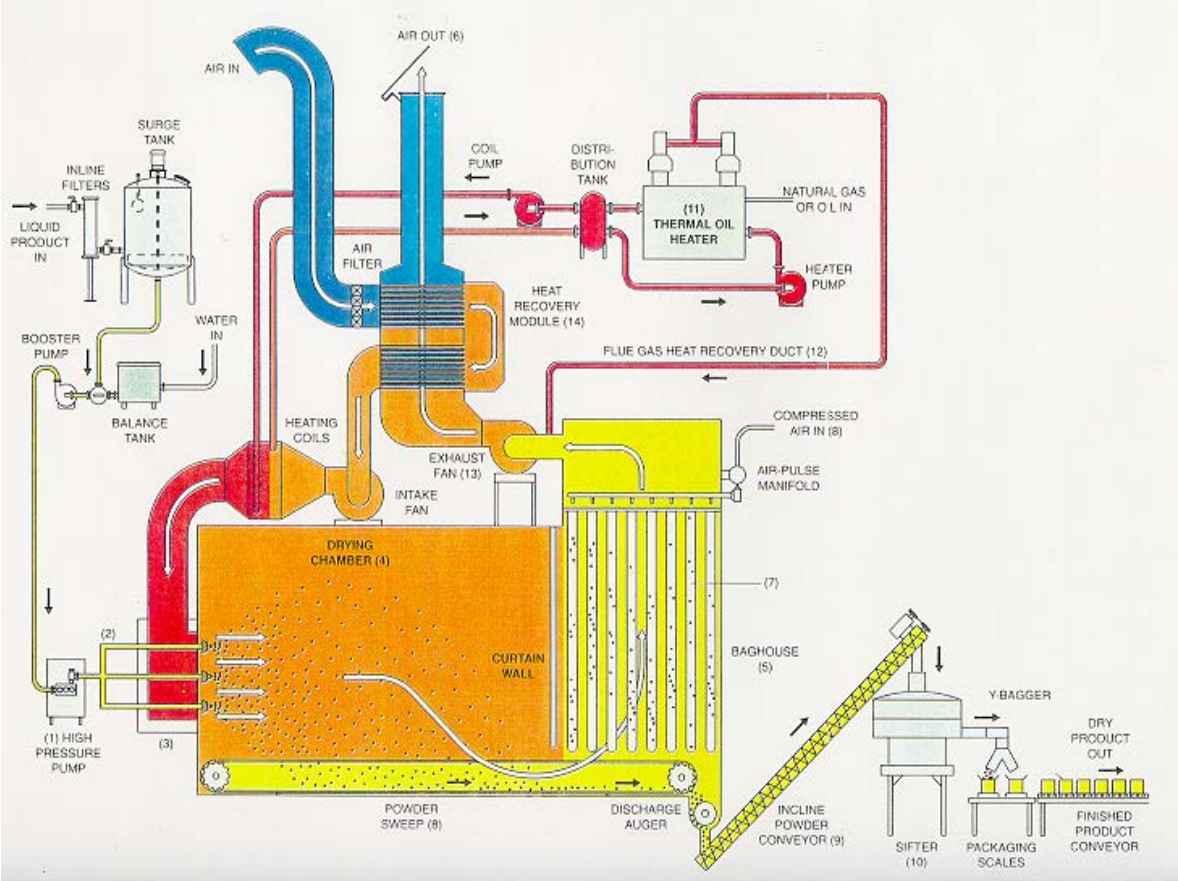


Diagram of a horizontal spray-dryer (box type)

Reconstitution

Any edible dried egg powder may be reconstituted, repasteurized, and redried in a sanitary manner, in accordance with prescribed procedures. Edible dried egg powder obtained from the sweep down, screenings, brush bag (except for brush bag powder from albumen driers) and improperly dried or scorched powder shall be reconstituted, pasteurized, and then re-dried. Powder is to be thoroughly reconstituted to at least the solids content of the original pasteurized liquid or lower. Product may be blended only in a closed system.

The following two regulations outline the requirements for the drying of albumen.

- §590.546 – Albumen flake process drying facilities
- §590.547 – Albumen flake process drying operations

Spray drying and Pan drying are two methods that may be used for the drying of albumen.

Heat Treatment of Egg Whites – §590.575

Heat treatment of dried whites is an approved method for pasteurization. The product must be heated throughout for such times and at such temperatures as will result in *Salmonella*-negative product.

1. The product to be heat treated shall be held in the heat treatment room in closed containers and shall be spaced to assure adequate heat penetration and air circulation.

2. Spray dried albumen shall be heated throughout to a temperature not less than 130º F and held continuously at such a temperature not less than 7 days and until it is *Salmonella*-negative.

3. Pan dried albumen shall be heated throughout to a temperature of not less than 125º F and held continuously at such a temperature not less than 5 days and until S*almonella*-negative.

Minimum product temperature and holding time is based on a moisture content of 6-8%. The heat resistance to *Salmonella* increases as the moisture content of the dried product decreases; thus requiring an increase in holding time and/or temperature. Recording thermometers shall be placed in product containers and shall record continuously throughout the holding process to ensure the minimum holding temperature.

- All records associated with this process must be kept for one year.

- All products must be tested and confirmed negative for *Salmonella*.

- At the time of the negative test, this product may be labeled "pasteurized."

Final Product Inspection

The final product inspection is the last chance for the inspector to determine that the product is unadulterated, wholesome, and properly labeled before the product is eligible for shipment.

The final product inspection occurs before the product is shipped and involves the following:

- Examining a minimum of two containers from each lot of each type of product category.
- Performing an organoleptic inspection.
- For frozen products, ensuring product is adequately frozen.

If the product passes this final examination, it is eligible to be shipped. If any foreign material or if any unsatisfactory odors are detected, the product is considered off condition and unacceptable for human use.

IPP will deem the odor of the product to be either satisfactory or unsatisfactory. The following describes these two classifications.

Satisfactory Odors	**Unsatisfactory Odors**
Bland	Chemical Moldy
Eggy	Fuel Oil Musty
Stale	Sour Putrid
Storage	Smoke

Final Inspection of Frozen Product for Condition and Adequacy of Freezing

Products labeled as frozen must be solidly frozen or reduced to a temperature of 10 ºF or lower within 60 hours of pasteurization. Salted or sugared egg product may not become solidly frozen. For these types of products, the internal temperature must reach 10 ºF or less.

Products are tested for adequate freezing by drilling into the frozen product and taking out samples. The sampling procedure and frequency is based upon the plant's history in successfully freezing product.

Please note that for safety purposes, FSIS requires the plant to drill the egg products. The inspector should ensure that plant personnel do not drill into samples from packages or containers that are less than 2-inches thick or that

weigh less than one pound. If containers are too small for drilling, the inspector will perform an organoleptic examination. It is recommended that product be defrosted by running cool water over the product or by any other acceptable method.

If product is not frozen after 60 hours, the inspector should do an organoleptic inspection. If the product is not off condition, the plant can propose corrective actions to ensure the product becomes adequately frozen and thus eligible for shipment.

The EPIH provides detail on how to reinspect and to retest to determine if the product is frozen.

Note: If the product is at an off-premise freezer, the company would need to determine the appropriate disposition unless the product is approved for salvage. It would then need to be returned to an official plant.

Off-Condition Product

If product is found to be off condition—for example, sour—the inspectors are to take the steps outlined below. Please note that the Documentation and Enforcement Module provides more detail on how to take and document these enforcement actions.

1. Retain the entire lot from which the off-condition product has come.

2. Inform plant management and inspection supervision of the lot amount and location of the product. Document this information on the FSIS Form 5400-12. If plant management requests re-examination of product that has failed final inspection for off condition, FSIS may grant authorization for container-by-container re-examination.

3. Assure the identification of applicable pallets.

4. Verify container-by-container segregation. If a significant number of containers are rejected, the supervisor may decide not to accept a container-by-container examination and reject the whole lot. In this case, the product would be determined ineligible for human consumption and the plant would be expected to divert the product to inedible if inspection kept it under retention.

5. Following segregation, remove or obliterate all official identification from all containers of unsatisfactory product. This product must be identified as inedible and the product must be denatured or placed under retention pending shipment as non-denatured inedible.

Shipping

Plants may also ship liquid egg products to another official egg products plant. Liquid egg products shipped to another official egg products plant must meet specific regulatory temperature requirements at the time of shipping. These temperature requirements are in 9 CFR 590.530(c) Table 1 – *Minimum Cooling and Temperature Requirements for Liquid Egg Products.*

Two factors determine the specific temperature that the egg products must meet at the time of shipping:

- The amount of time between when the product is produced or processed by the origin plant and when the receiving plant receives it. The clock begins at different times, depending on what processes the eggs undergo. Each time the product goes through a processing step, the clock resets to zero.

- Whether it has 10 percent or more salt added to the product.

Temperature Requirements for Liquid Eggs Destined for Shipping

Time Between Processing or Pasteurizing and Receipt at Receiving Plant	**Liquid Eggs with ≤10% Added Salt**	**All Other Liquid Eggs**
Less than or equal to 8 hours		45° F or less
Greater than 8 hours		40° F or less
Less than or equal to 30 hours	65° F or less	
Greater than 30 hours	45° F or less	

The equipment used to process or load product may raise the temperature of the egg products because of the friction generated by that equipment in use. Product in tankers that ship during spring and summer may have a higher temperature because of higher ambient air temperature during transportation. So, plants should consider the processing and shipping conditions when they reduce product temperature before shipping.

You will verify that the plant meets this regulatory requirement after the product is processed or pumped and before the product is shipped.

Plant Operations Quiz

Working with your group, use the handout and the appropriate regulatory references to answer these questions.

1. What might cause an egg to appear fluorescent under a black light?

2. Name two inedible egg types whose defects are difficult to see—even with the candling light—but that give off characteristic odors.

3. What action should an inspector take if he or she finds solid mold on a shell egg in the transfer room?

4. What does “ppm” stand for?

5. What are the ppm requirements for sanitizing eggs?

6. Liquid egg product has been pasteurized and is to be held for 9 hours. At what temperature must it be held?

7. What are the minimum pasteurization values for plain yolk?

8. What does reconstitution mean?

9. What are the satisfactory and unsatisfactory odors for egg products?

10. Are FSIS inspectors allowed to drill frozen product? Explain your response.

11. What steps should be taken if product is considered off condition?