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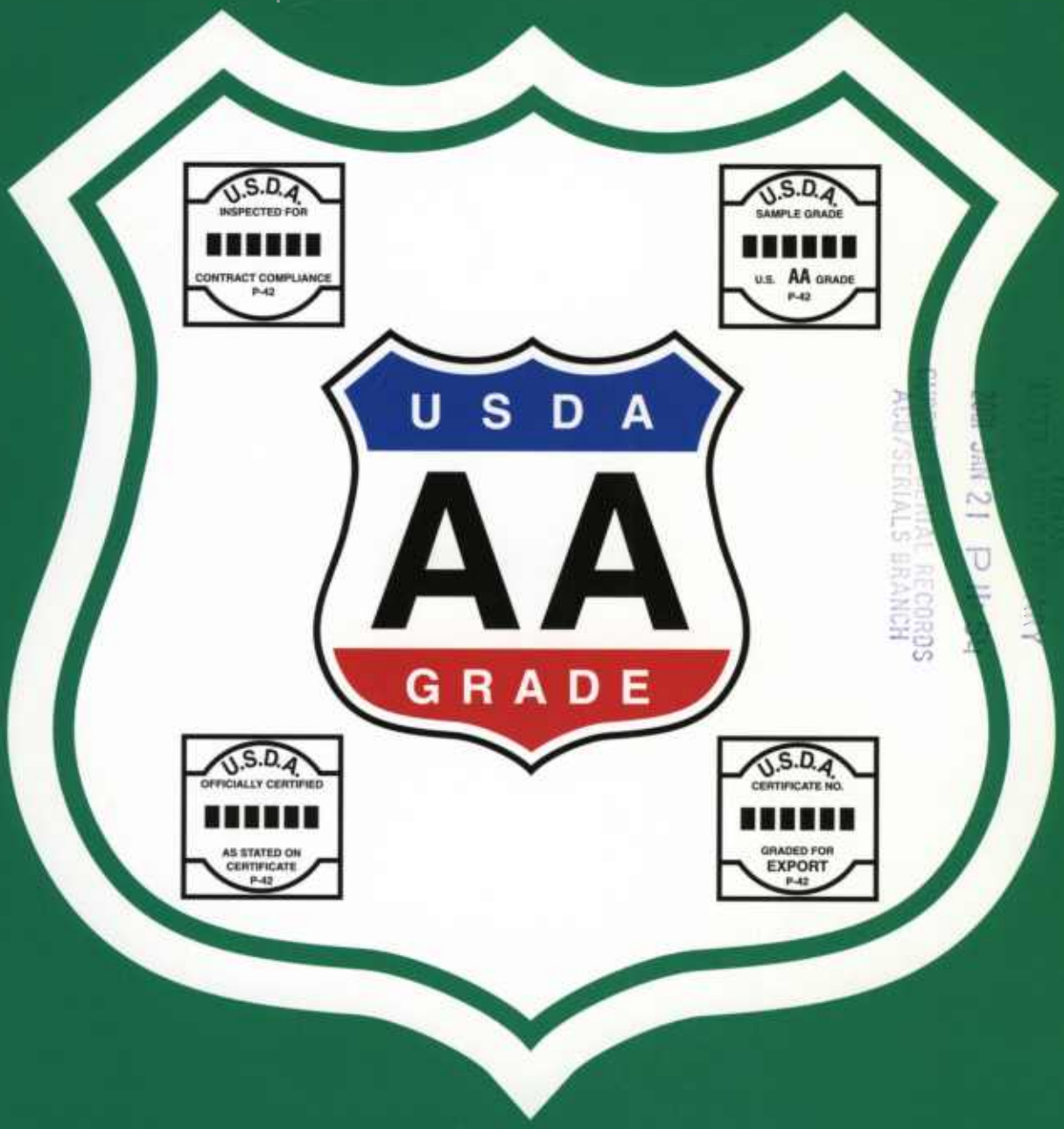
Egg-Grading Manual



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I. Introduction

This manual is an aid in teaching both beginning and experienced egg graders the correct interpretation and application of the U.S. standards, grades, and weight classes for eggs. It can serve as a guide in short courses or grading schools when supplemented with lectures, group discussions, and demonstrations. This manual should also prove useful to those teaching or working in the production, processing, and marketing of eggs.

Although some of the material in this manual is not directly related to the actual grading function, knowledge of it will help graders do a better job in handling eggs and in maintaining egg quality. Such information will give graders a better understanding of their job, and will aid them in acquiring the knowledge necessary to do their jobs well.

This manual provides graders with an understanding of egg marketing, the purpose of grading, production and processing practices, and Federal-State grading programs. An in-depth description of USDA's egg grading and certification programs is provided for use by processors, marketers, volume food buyers, and retailers to enhance their procurement and quality control activities.

Information is also included about the formation, structure, and composition of the egg. The egg is a biological structure used in nature for the reproduction of the chicken. It protects the developing chick embryo, provides it a complete diet, and serves as the principal source of nutrition for the first few days of the chick's life. The egg also serves as one of the most nutritious and versatile of human foods. Chickens produce eggs in abundance, making this source of food extremely important throughout the world, nutritionally as well as economically.

The modern trend in production is toward large, highly specialized flocks. The high-quality egg produced under this system lends itself very well to the use of machine-flash candling equipment or mass electronic scanning devices to detect checks, irregular shells, dirts, meat and blood spots, and loss eggs. For this reason, it is highly desirable for graders to have a working knowledge of these systems.

Descriptions of the various qualities of individual eggs should assist the student grader in understanding egg quality. However, it is imperative that the descriptions of the different qualities be compared with eggs before the candling light, and that the quality interpretations be checked by experienced graders.

The importance of practice in candling cannot be stressed enough. It is essential that student graders become thoroughly familiar with the descriptions of the different qualities because the final measure of their ability is the accuracy by which they interpret quality before the candling light. Occasional comparisons of broken-out appearance with candled appearance are also essential in developing grading skill.

Egg quality and grading procedures are the "what" and "how" of the job. Coupled with reasonably good judgment, practice, and guidance, graders should acquire the necessary skills to rapidly determine the proper classification of shell eggs based on official standards of quality.

II. Production and Maintenance of Egg Quality

Egg production has been, and continues to be, a major agricultural industry in the United States. In 1999, total egg production was almost 7 billion dozen. The north central area continues to lead the Nation in production, followed by the west and the middle Atlantic areas.

Producing and marketing this volume of quality eggs have been accompanied by specialization in the areas of breeding, hatching chicks, raising chickens, producing eggs, and producing poultry meat. Large vertically integrated firms that perform several or all of these functions have become most prominent. The average flock size for an operation often exceeds 75,000 layers, with many over 1 million.

Production is either "off-line" or "in-line." Off-line production refers to processing operations that are not integrated with the laying facility. Off-line eggs are gathered and shipped in from laying facilities at other locations. In-line production refers to processing operations where eggs are laid, processed, packed, and shipped from one location. Most production facilities today are large integrated in-line operations. An understanding of egg production practices will help processors and quality control personnel contend with product quality issues.

Breeding

The White Leghorn is the predominant breed of layer being raised, in part because it lays white-shell eggs. Brown-shell eggs are available in some parts of the country, but white-shell eggs are more widely demanded by consumers. Shell color and thickness, egg size, quality and quantity of thick white, quantity of eggs produced, and, to some extent, freedom from blood spots are hereditary factors that affect overall egg quality. For example, broken and cracked egg shells are directly related to shell thickness and strength, and have great economic impact on the industry. Also, a reduction in shell quality is a direct result of increased egg production. Over time, improvements in these hereditary factors have been bred into the White Leghorn. Chicks or pullets for the initial flock or flock replacement should be procured from a source that can give reasonable assurance that these factors have been carefully considered in the breeding program.

Hatching

To promote improved breeding and production qualities in poultry and to reduce losses from pullorum disease, the industry established the National Poultry Improvement Plan (NPIP) in 1935.

Today, NPIP is administered jointly by USDA's Agricultural Research Service and an official State agency in each of the cooperating States. It operates according to regulations and standards developed to provide assistance to breeders and hatcheries in producing birds free from egg-transmitted diseases. Procurement of chicks from "plan" hatcheries assists the producer in the selection of desirable young stock. In 1989, NPIP developed a *Salmonella enteritidis (Se)* control program to reduce the incidence of *Se* in hatching eggs and chicks. Participants in this program follow designated control procedures and practices at breeder farms and hatcheries.

Brooding and Raising

Some operators brood chicks and raise them to laying age, while others purchase 16- to 20-week-old birds from specialists in the pullet-raising field. The brooding period usually involves the first 6 to 8 weeks of the chick's life and is the most critical period for the bird in reaching its full potential. Temperature, feed, water, and environmental stress must be controlled and monitored continuously. A properly managed feeding program assures uniform growth and a manageable egg production schedule. The intensity and duration of light during the brooding and growout period have a dramatic effect on growth and sexual maturity. Today, most brooding and growout operations are environmentally controlled, which means the lighting and other factors can be automatically controlled for optimum development.

Years ago, many producers utilized the practice of culling flocks. Culling is the careful evaluation, either visual or physical, of a flock to remove birds that are diseased or weak and cannot reach their full level of production. Modern breeding and production technology has virtually eliminated the need for culling. Today, most layers are kept in production for a laying period of 12 to 14 months unless they are force molted.

Molting is the natural loss of feathers that generally occurs annually late in the summer. During the molting period, which usually lasts 45 to 60 days, egg production stops and the chicken's reproductive system rejuvenates. Force molting is a controlled production practice that, depending on the current economic situation, can have a significant effect on production income. Cost of feed, egg prices, and cost of layer replacements are factors that must be considered before committing to a force molting program. Force molting is usually induced by a withdrawal of feed followed by a low-protein, high-calcium diet until production resumes.

Housing

Proper housing is essential for efficient egg production. Birds that are comfortable are healthier than birds kept under improper conditions, and production costs are lower. Environmental temperature and air circulation are critical, with the optimum temperature being between 57 and 79 °F (13.9 and 26.1 °C). Temperatures outside this range affect feed conversion, egg production, egg quality, and water consumption. Waterers and feeders, whether the manual or mechanical type, should be kept clean. Dirt and dust should be held to a minimum. Controlled ventilation and, where necessary, adequate insulation should be provided to have the proper temperature and humidity conditions. Overcrowding should be avoided, and the equipment and facilities should be kept in good condition.

Currently, over 90 percent of all table eggs produced in the United States are from caged layers, primarily because of economics. Eggs produced in cages cost less to produce than those in floor systems due to much more intensive labor and floor space requirements with the latter. Most new operations are environmentally controlled multiple-level cage systems that are completely automated with mechanical feeding and watering equipment and conveyor belts that carry the eggs out of the laying house. Environmental housing also provides a method of controlling temperature, light, and humidity. Additionally, controlled housing provides protection from predators and disease-carrying rodents and pests.

Feeding

Feeding shares the limelight with breeding in the production of high-quality eggs. With recent advances in poultry nutrition and the use of computers for formulating, a dozen eggs can now be produced on less than 4

Figure 1. Typical environmentally controlled layer house. (00-CN-0601)

Figure 2. Automated multi-deck caged layer system. (CD 8202 3241 1143-89)

Large-capacity feed tanks provide a continuous supply of feed to each layer house. (CD 8202 3241 1143-96)

pounds of feed. Feed formulas with varying protein levels are adjusted based on the season, age of the birds, and the availability of specific grains.

Shell. The breaking strength of an egg shell is affected by feed, breeding, age, freedom from disease, and hot weather. Today, the average commercial feed supplemented with "grit" (calcium carbonate) usually has sufficient calcium, phosphorus, manganese, and vitamin D to produce sound shells. The source of shell trouble is more frequently found in the other factors mentioned.

Yolk. Dark pigmentation in the yolk affects the acceptability of the egg in the top qualities. Rations high in yellow grains and green feeds produce dark yellow to orange-colored yolks. Rations high in green grasses, silage, and cottonseed meal (gossypol not removed) will cause the yolks to acquire a reddish or olive color. Off-flavors may be from feed formulated with a poor-quality fish meal or other contaminants in the feed.

White (Albumen). To be of top quality, eggs must have a high percentage of thick albumen. A lack of this factor can be attributed to breeding and disease of the chickens, and to improper care of the egg after production. Low-quality whites can also be attributed to high levels of ammonia gas in the laying house due to improper ventilation.

Care of Eggs on the Farm

Immediately after it is laid, an egg begins to lose quality, even if it is removed from the nest, cooled, packed, and marketed promptly. Keeping temperature and humidity conditions at an optimum level retards this loss in quality to a large degree.

Although most eggs are produced by large in-line integrated operations, some are still produced from off-line production facilities. At off-line sites, certain steps are necessary to maintain egg quality at the highest level. Some of these steps are:

1. Gather eggs frequently (at least 3 times a day).
2. Handle the eggs carefully to prevent breakage.
3. Cool the eggs promptly and store them under the optimum temperature and humidity.
4. Pack the eggs in clean, cool packing materials.
5. Pack clean eggs separately from dirty eggs.

Egg-processing Facilities

The high-quality egg produced under today's large-scale integrated flock system lends itself well to handling and processing by automatic equipment. In fact, most new complexes are in-line systems designed to carry eggs from the hen house to the carton in one continuous operation.

Figure 4. Layers grouped in wire cages with automatic water and feed dispensing. (CD 8202 3241 1143-90)

Eggs must be handled properly throughout each phase of production, processing, and transportation to maintain quality.

Washing equipment washes, sanitizes, and dries eggs automatically. Grading equipment uses mass scanners to help operators detect and remove dirties, checks, irregular shells, meat and blood spots, and loss eggs. Automatic weighing equipment individually weighs each egg and sorts the eggs according to the official weight classes. Automatic packaging equipment places the eggs into cartons, closes the cartons, and stamps the cartons with a production code. Coolers reduce the temperature of the eggs and maintain humidity levels that minimize quality deterioration.

In addition to people doing quality control work, plants occasionally conduct quality segregation by hand-candling. In these situations, adequate facilities and equipment must be provided in order to grade eggs with maximum efficiency.

Buildings and Premises

Maintaining a sanitary food environment is an integral part of processing quality eggs. The design of the building and layout of the premises should provide suitable environmental conditions, permit adequate cleaning, minimize contamination, prevent access and breeding of pests, and provide an adequate space to accommodate the processing operation.

The premises should be clean and free of trash, debris, and old equipment and supplies to discourage and eliminate the presence of insects and pests and reduce the possibility of cross-contamination. Areas surrounding the plant should be properly graded and free of standing water, free of tall grass or weeds, and kept reasonably clean.

The floors, walls, and ceilings of buildings should be constructed of materials that are durable and smooth, and that can be kept clean, sanitary, and in good repair. Processing room floors should be properly sloped for drainage and constructed of materials that are smooth, impervious to moisture, cleanable, and resistant to chemical cleaning compounds. Doors and windows leading to the outside should be kept closed or fitted with tight-fitting screens that remain closed when not in use. Adequate ventilation is to be provided to control humidity and provide comfortable year-round working temperatures.
All rooms should be kept clean and sanitary at all times.

Figure 5. Flats of eggs are loaded onto the washing line at the off-line conveyor. (CD 8202 3241 1143-25)

Figure 6. Eggs are automatically transferred from off-line conveyor to conveyor spools going through the egg washer. (CD 8202 3241 1143-31)

Figure 7. In-line conveyor moves eggs directly from laying houses to processing area. (CD 8202 3241 1143-72)

Figure 8. Eggs from multiple in-line and off-line systems are conveyed to centralized orientation area before entering washer. (CD 8202 3241 1143-80)

Figure 9. Eggs are washed, rinsed, and sanitized using specially designed in-line equipment that will remove dirt without damaging the shells or altering quality. (00CN0048)

Figure 10. After washing, eggs are dried with a high volume of filtered air to remove excess moisture. (99-CS-1605)

Figure 11. After washing, eggs are sanitized with an approved chemical sanitizer to remove any remaining bacteria. USDA graders verify concentration of sanitizing spray. (00CN0049)

Waste collection and disposal is important in maintaining an environment free of objectionable odors and pests. Refuse containers used in the processing room should be emptied and cleaned daily. Refuse generated from the processing operation should be removed from the processing area daily, or more often if needed, and stored in covered receptacles or compactors.

Separate areas should be provided for the storage of packing and packaging materials, chemical compounds, and insecticides and rodenticides. Chemicals should be stored separately from edible food areas and properly identified to prevent any accidental contamination of the eggs. All materials should be stored away from walls to facilitate cleaning and pest control.

Washing, Grading, and Packing Operations and Equipment

Even with good farm-management practices and careful handling, a small percentage of dirty eggs will be produced. Producers must bear in mind that dirty eggs are covered with bacteria that will cause spoilage if they enter the egg. Whether conducted at the production or processing site, washing must be performed in a manner that will minimize the chances of bacterial penetration of the shell. If these important facts are forgotten, and eggs are washed carelessly, more damage can be done than by leaving the dirt on the shell. Wetting a dirty shell provides moisture in which bacteria may breed and assists their growth and penetration through the shell. A washing solution colder than the egg causes the egg content to contract and thus allows polluted water to be drawn through the shell. When washing eggs the following precautions should be followed:

1. Wash eggs with water at least 20 °F (11.1 °C) warmer than the internal temperature of the eggs and at a minimum of 90 °F (32.2 °C).
2. Select a detergent or detergent sanitizer that is compatible with the wash water and one that will not give off foreign odors that may be imparted to the egg.
3. Use only potable water with an iron content of less than 2 parts per million (p/m) for washing and keep wash water as clean as possible.
4. Rinse by spraying with water slightly warmer than the wash water.
5. Use an approved sanitizer in the spray rinse.
6. Dry the eggs to remove any excess moisture prior to packaging.

After washing, eggs should be rinsed with a warm water spray containing an approved chemical sanitizer to remove any remaining bacteria. The strength of the sanitizing spray should be no less than 50 p/m nor more than 200 p/m of available chlorine or its equivalent.

Research has shown that during the washing process, most of the outer cuticle on the egg shell is removed. Removal of this cuticle increases the rate of carbon dioxide and moisture loss of the internal egg contents. To reduce the rate of loss, spraying the eggs with a light coating of food grade mineral oil is a common practice. For best results, the entire oiling system, including spray nozzles, filters, and oil storage reservoir, should be checked frequently to assure that the equipment is functioning adequately and that the oil is free from contamination.

Most off-line eggs are packed in plastic filler flats, palletized, and transported to the processing facility. This procedure provides the most efficient method of handling and cooling off-line eggs prior to processing. Since plastic flats are used repeatedly to transport unprocessed eggs, the incidence of bacterial cross-contamination is enhanced. To avoid cross-contamination and the creation of an unsanitary condition, plastic flats

Figure 12. Food-grade mineral oil is pumped from reservoir (floor tank) to high-pressure spray nozzles to provide a light coating over each egg. (00CN0050)

Figure 14. Plant personnel segregate broken and dirty eggs after the washing cycle and prior to the candling operation. (CD 8202 3241 1143-1)

Figure 13. Automatic plastic egg flat washer washes, rinses, and stacks egg flats for drying after each use. (00CN0051)

Figure 15. During candling, a wand-type pointer electronically marks eggs that are dirty or cracked, or that contain blood spots. Newer equipment is capable of automatically removing these eggs with minimal oversight. (99-CD-1606)

Figure 16. In-line electronic scales weigh and sort individual eggs by weight classes so that they can be diverted to the proper packaging lines. (CD 8202 3241 1143-30)

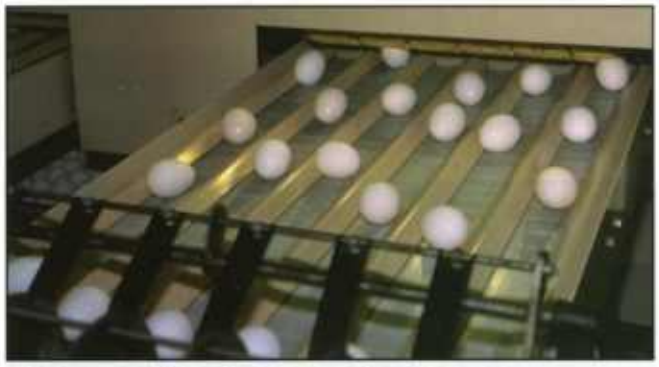

Figure 17. Eggs are automatically conveyed to packaging unit. (CD 8202 3241 1143-27)

Figure 18. Packaging unit orients eggs with small end down and gently places them into consumer cartons. (99-CS-1608)

Figure 19. Eggs gently placed into carton or other packaging material. (CD 8202 3241 1143-28)

should be thoroughly cleaned and dried after each use. To facilitate the cleaning process, modern processing plants typically install and utilize plastic flat washing and drying equipment.

All processing equipment should be designed and constructed of such materials and workmanship so as to be smooth and easily cleanable, and to preclude the adulteration of eggs with foreign materials. Egg washing, sanitizing, and oiling should be conducted according to the procedures outlined in the current Regulations Governing the Voluntary Grading of Shell Eggs (7 CFR Part 56). All equipment and processing rooms should be thoroughly cleaned at the end of each processing day and should remain reasonably clean throughout the processing shift.

The distance of processing equipment from walls and the space between equipment should be enough to provide room for cleaning, maintenance, and inspection. The space will vary greatly depending on the type of operation and capacity needed for the amount of product handled. Sufficient overhead lights should be provided to facilitate cleaning the room.

Figure 20. Packaged eggs leaving automatic packaging equipment are placed into shipped cases. (CD 8202 3241 1143-32)

Figure 21. A computer attached to the processing system monitors and controls each phase of processing. (CD 8202 3241 1143-55)

Figure 22. Unprocessed eggs from an off-line system are accumulated in cooler prior to processing. (CD 8202 3241 1143-46)

Figure 23. Processed eggs are placed in cooler in preparation for staging and final shipment. (CD 8202 3241 1143-48)

Figure 24. Packaged eggs are loaded on a clean, refrigerated transport vehicle. (CD 8202 3241 1143-34)

Figure 25. For ease of handling at retail, eggs are placed on portable shipping racks. (CD 8202 3241 1143-41)

The candling area should be darkened to the extent necessary to do an efficient job. The extent of darkness will vary depending on the type of processing equipment used. The light rays from the mass scanning area should be diverted away from the candler's eyes. On high-production machines, it is generally best for a candler to also have another type of job assignment to prevent eyestrain, break the monotony, and improve efficiency of the candling operations.

Recent advances in processing technologies have resulted in the development and use of candling equipment that can electronically remove most under grade-type eggs.

After candling, individual eggs are weighed using mechanical or electronic weighing equipment. Most modern processing equipment integrates weighing as an in-line component of the processing machine. The weighed eggs are segregated by weight classes and conveyed to the applicable size packing line.

Packaging and packing are normally carried on in conjunction with the grading operation. Clean packaging and packing materials should ensure adequate protection of the product in the handling required in the grading station, distribution channels, and the retail store. Cartons or filler flats of eggs should be placed on conveyors gently and carefully moved to the packing station to minimize any additional breakage.

Packaging materials should be new and free of mold, mustiness, or any other off-odors or conditions. Packing materials, such as wire or plastic baskets, or transport containers such as metal racks, should be reasonably clean and free of egg meat before use.

Cooling Facilities

After eggs are graded and packed in cases, they should immediately be moved to the shipping room cooler and held there until ready for distribution.

Cooler rooms should be free from objectionable odors and mold and should be maintained in a sanitary condition at all times. The coolers must be capable of maintaining the temperature and humidity necessary for the preservation of eggs. Coolers should be equipped with thermometers and hygrometers to verify and monitor temperature and humidity.

Coolers for unprocessed eggs should be capable of maintaining an ambient temperature of 60 °F (15.6 °C) or lower. Processed egg coolers must be capable of maintaining an ambient air temperature of 45 °F (7.2 °C) or lower. All coolers should be capable of maintaining a relative humidity of 70 to 85 percent.

Every reasonable precaution should be exercised to prevent "sweating" of eggs (when there is condensation or moisture on the shell) in order to avoid smearing and staining the shell and to inhibit the growth of bacteria on the shell. Egg "sweating" is usually caused when eggs are moved from a very cool environment to an environment with a moderate temperature, i.e., from the unprocessed-egg cooler to the processing room. This is why it is impractical for unprocessed eggs to be held in coolers for long periods of time with temperatures lower than 50 °F (10 °C).

Health and Cleanliness of Employees

Employees handling eggs should take every precaution to prevent cross-contamination between production and processing areas. Traffic patterns of employees should be reviewed by management to avoid cross-contamination. Employees assigned to work in production areas should not be allowed to work in processing areas unless the necessary facilities are available for cleaning and changing clothes. Clean outer garments should be worn when employees are processing eggs.

All employees should wash their hands before beginning work and upon returning to work after using restrooms, eating, smoking, or otherwise soiling their hands. Handwashing facilities should be provided in restrooms and processing areas.

Persons afflicted with, or who are carriers of, a communicable disease should not be permitted in any room where eggs are processed or otherwise handled. Persons with discharging or infected wounds, sores, or lesions on hands, arms, or other exposed portions of the body should not be allowed to work in any processing room where there is contact with eggs, processing equipment, or packing or packaging supplies.

Distribution

Wholesale. Eggs for wholesale outlets should be packed in new packaging and packing materials. The majority of shipments today are by refrigerated truck. Trucks hauling eggs must be refrigerated and well insulated on all surfaces and doors to maintain quality during warm weather. The loss of moisture during transportation can be minimized by pre-cooling the transport vehicle prior to loading and transporting the eggs. In addition, since wholesale eggs are generally packed in fiberboard boxes with few, if any, vent holes, it is extremely important to pre-cool the eggs to a uniform temperature prior to loading.

A refrigerated truck should be used for summer deliveries and a well-insulated truck for winter deliveries, equipped with a warm-air heating unit for extreme conditions. Truck beds should be equipped with racks to provide uniform air circulation around the load. Before loading, trucks should be checked to make sure that the interior is clean and free from foreign odors, and that there are no breaks in the walls, ceilings, or floor surfaces.

Retail. High-quality eggs that have been properly cared for during packing and transportation are sometimes handled carelessly by the retailer. Proper stock control and care, including volume delivery, rotation of supply, adequate refrigerated holding areas, and proper humidity, are necessary. Bulk stocks should be stored only under refrigeration in a space that is free from volatile odors of any kind. To promote consumer satisfaction, eggs should be packed in attractive cartons, be uniform in size and weight, and be of high interior quality. Improper handling at any point during distribution and marketing will result in lower overall quality and diminished consumer acceptance.

III. Structure, Composition, and Formation of the Egg

Physical Structure

An average chicken egg weighs about 57 grams or 2 ounces.

The parts of an egg are the yolk, the white, the shell membranes, and the shell (figs. 26 and 27).

Yolk (Ovum). The yolk consists of the *latebra*, *germinal disc*, concentric rings of *yolk material*, and *vitelline membrane* (a colorless membrane that surrounds and contains the yolk). The yolk constitutes approximately 31 percent of the total weight of the egg.

White (Albumen). The white consists of four distinct layers which together constitute about 58 percent of the weight of the egg.

The *chalaziferous* layer immediately surrounds the yolk and is continuous with the *chalazae* (pronounced kah-lay-za). This is a very thin, but firm, layer of white and makes up 3 percent of the total white.

The *inner thin* layer surrounds the chalaziferous layer and comprises about 17 percent of the white.

The *firm or thick* layer of white provides an envelope, or jacket, that holds the inner thin white and the yolk. It adheres to the shell membrane at each end of the egg. Approximately 57 percent of the white is firm white.

The *outer thin* layer lies just inside the shell membranes, except where the thick white is attached to the shell, and accounts for about 23 percent of the total white.

Shell Membranes. The shell membranes are tough and fibrous and are composed chiefly of a protein similar to that in hair and feathers. The *inner* membrane is thinner than the *outer*, and together they are only about 24 ten-thousandths of an inch (0.00609 mm) thick.

Shell. The shell is composed of three layers and constitutes approximately 11 percent of the egg.

The *mammillary* or *inner* layer covers the outer shell membrane. Next is the *spongy* layer, then the *cuticle*. *Pores* connect the surface and the mammilla.

The egg, as laid, normally has no *air cell*. The air cell forms as the egg cools, usually in the large end of the egg, and develops between the shell membranes. The air cell is formed as a result of the different rates of contraction between the shell and its contents.

Composition

The egg is an excellent source of high-quality protein and of certain vitamins and minerals. The chemical composition of the egg, including the shell, is summarized in table 1.

White (Albumen). The egg's protein content is complete; it contains all of the essential amino acids in well-balanced proportions. Water is the major component of albumen. The pH of albumen from a newly laid egg is between 7 and 8.5 and, due to the loss of carbon dioxide, will generally rise during storage.

The thick albumen is made up mainly of the proteins ovomucin, ovalbumin, conalbumin, ovoglobulin, and ovomucoid. Ovomucin gives structure to the thick albumen.

The thin albumen is composed mostly of the same proteins contained in the thick albumen, with the exception of ovomucin.

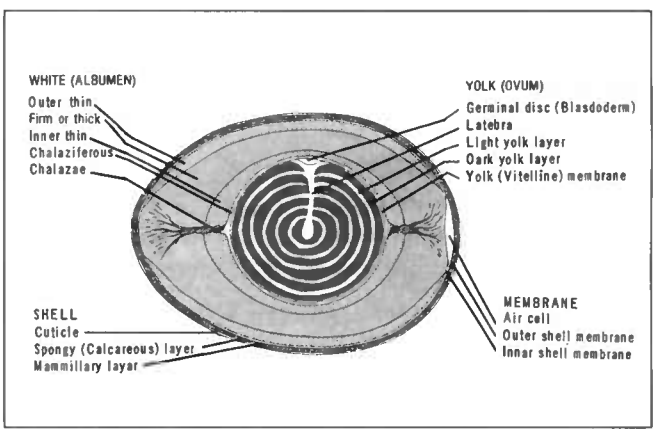

Figure 26. The parts of an egg.

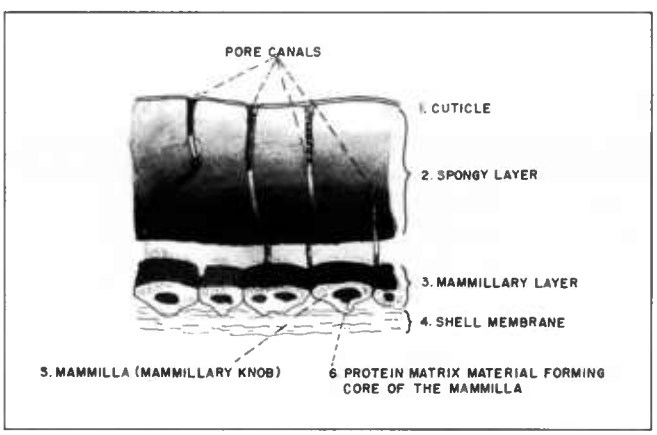

Figure 27. Magnified radial section through the egg shell.

The albumen also contains water-soluble B vitamins such as riboflavin. Riboflavin gives the greenish tint to the albumen.

Yolk. The major components of yolk are proteins and lipids (fats). The important yolk proteins are ovovitellin (about three-fourths of the yolk protein) and ovolivetin. The fatty substances of the yolk are mostly triglycerides (true fat) 65.5 percent, phospholipid 28.3 percent, and cholesterol 5.2 percent. The pH of the yolk in a freshly laid egg is generally about 6.0 but gradually increases to about 7.0 during storage. Yolk pigments (mostly xanthophyll) come from green plants and yellow corn that the birds eat.

The yolk contains most of the known vitamins with the exception of vitamin C. The vitelline membrane is composed mostly of protein similar to that found in the shell membranes and is fairly permeable to water. The higher concentration of solids in the yolk causes the yolk to increase in size and become less viscous because of the inflow of water from the white as the egg ages.

The yolk contains iron, phosphorus, sulphur, copper, potassium, sodium, magnesium, calcium, chlorine, and manganese, all of which are essential elements.

Formation

The reproductive system of the hen is divided into two main parts: Ovary and oviduct (fig. 28). Most female animals possess both a right and a left functioning ovary but in the hen, the right ovary and oviduct normally remain dormant and the left ovary and oviduct develop the egg.

Ovary. This is a cluster of developing yolks, each separate from the others, attached to the middle part of the back about midway between the neck and the tail. This organ is fully formed, although very small, when the chick is hatched. It contains approximately 3,600 to 4,000 minute ova (future yolks) each within its own sac or follicle.

TABLE 1. *Chemical composition of the egg.*

	Percent	Water	Protein	Fat	Ash
Whole egg	100	65.5	11.8	11.0	11.7
White	58	88.0	11.0	0.2	0.8
Yolk	31	48.0	17.5	32.5	2.0
		Calcium carbonate	*Magnesium carbonate*	*Calcium phosphate*	*Organic matter*
Shell	11	94.0	1.0	1.0	4.0

Oviduct. This is a long, tubelike organ lying along the backbone and attached to it loosely between the ovary and the tail. It is approximately 25 to 27 inches (63.5 to 68.6 cm) long, and may be divided into five areas which perform certain functions in completing the formation of the egg. It is here that the white, shell membranes, and shell are secreted.

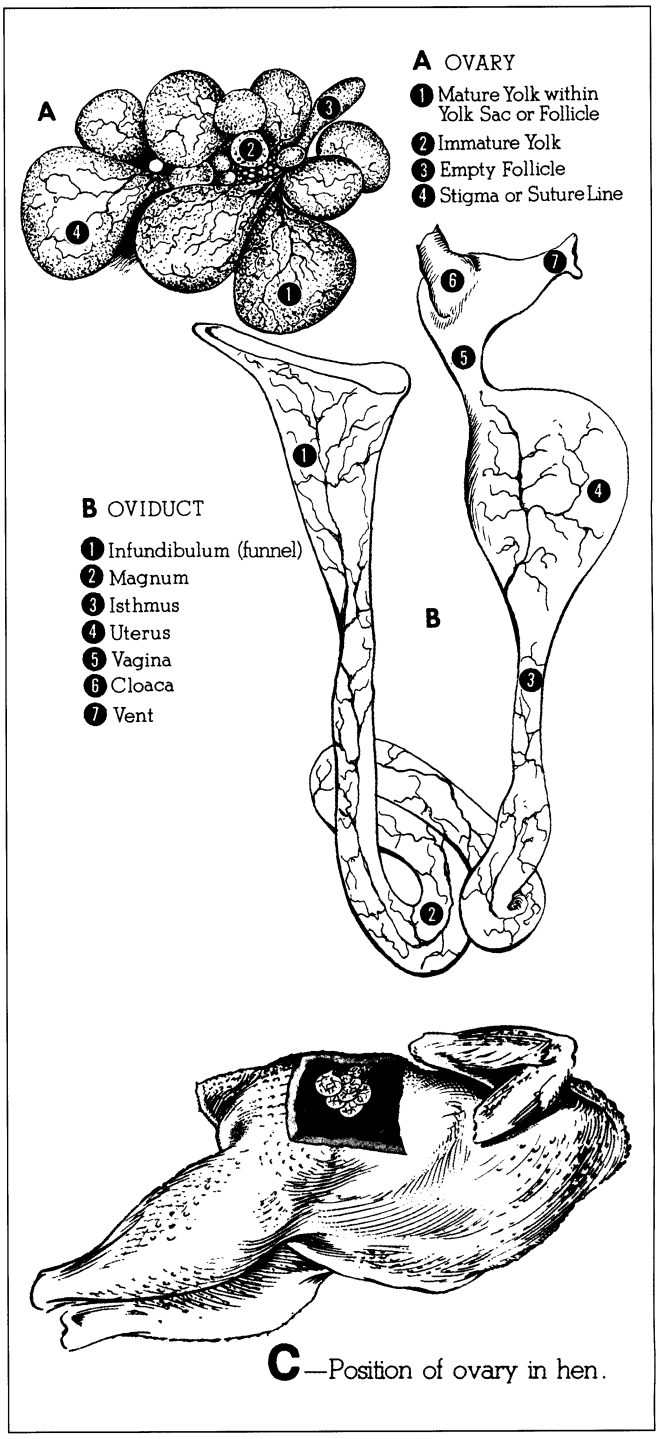

Figure 28. Enlarged drawings of a hen's reproductive system.

Formation of the Yolk

Each yolk within the ovary starts as a single cell (female reproductive cell or germ) with the vitelline membrane around it.

The yolk develops slowly at first by the gradual addition of yolk fluid. Fat-soluble pigments, normally xanthophyll, are transferred rapidly from the digestive tract to the blood stream and then to the yolk. Occasionally, what appears to be concentric layers of alternate dark- and light-colored yolk fluid may be observed. However, modern feeding and production practices have reduced the frequency of this occurrence.

The yolk matures as more yolk fluid is added. The germ stays at the surface of the yolk, leaving a tubelike structure, the latebra, extending to the center of the yolk.

An accelerated stage occurs 8 to 10 days before ovulation. This stage is initiated by the stimulating hormone of the pituitary gland. The hormones secreted by the ovary in turn stimulate the oviduct to activity. The rate of yolk secretion increases rapidly from the 9th to 2nd day before ovulation (0.5 to 2.8 grams of yolk per day) and decreases thereafter.

Ovulation is the release of a *mature yolk* (ovum) from the ovary. Each developing yolk is enclosed in a *yolk sac* in which many blood vessels are profusely distributed. These blood vessels carry yolk-building substances to the developing yolk. One particular area of the yolk sac is free of blood vessels (*stigma or suture line*) and it is normally here that ovulation or release of the mature yolk takes place. However, the rupture of the yolk sac and release of the yolk sometimes occur at sites other than the stigma, with the result that one or more blood vessels are ruptured and blood spots occur on the yolk, or the white becomes bloody.

Occasionally, reddish brown, brown, tan, or white spots, commonly known as "meat spots," may be found in the egg. It has been demonstrated that meat spots may be either blood spots which have changed in color due to chemical action, or tissue sloughed off from the reproductive organs of the hen.

Ovulation occurs again about 30 minutes after an egg is laid, during the laying clutch of a good producing hen.

Formation of the White

The first part of the oviduct, usually 3 or 4 inches (7.62 to 10.16 cm) long, is the *infundibulum*, commonly called the funnel. It opens into the body cavity. When ovulation occurs, the funnel engulfs the yolk and starts it on its way down the oviduct.

Although the main function of the funnel is to pick up the yolk, it also serves as a reservoir for male sperm which, if present, fertilize the germ and set up embryonic growth. The yolk moves through the infundibulum, or funnel, to the magnum in about 15 minutes. Movement is brought about by peristaltic action.

The *magnum* area is about 15 inches (38.1 cm) long and the time required for the yolk to travel through its length is about 3 hours. It is here that three of the four layers of the white are formed, and where practically all the protein in the white is secreted.

The white contains ovomucin, secreted by the magnum as fibers or strands, which makes the white thick. These strands draw together as the developing egg continues its spiral movement through the oviduct. From these strands the chalaziferous layer and the chalazae are formed (1st layer). The continued twisting and drawing together of these strands tend to squeeze out thin white to form the inner thin white (2nd layer). The remaining thick white is a homogeneous gel (3rd layer).

The quality of the white is largely dependent on the amount of ovomucin secreted by this part of the oviduct. The portion of the gel immediately adjacent to the yolk undergoes partial liquefaction before the egg leaves the magnum.

The *isthmus* is a constricted area of the oviduct about 4 inches (10.16 cm) long, through which the developing egg passes in about 1-1/4 hours. Here some water and mineral salts are added and the two shell membranes are deposited.

The *uterus*, a heavy-walled part of the oviduct, approximately 4 inches (10.16 cm) in length, is where the developing egg spends about 21 hours. Here, the outer thin white (4th layer) and minerals pass through the shell membranes by osmotic pressure, and the shell and shell pigment are added. The water and solids of the white ultimately become equally distributed in the various layers of the white.

Formation of the Shell Membranes

The shell membranes are added as the partly formed egg enters the *isthmus*. The membranes are a closely knit lace-like nitrogenous compound similar to that present in the chicken's toe nails.

Formation of the Shell

Calcium carbonate comprises about 94 percent of the dry shell. A hen may use as much as 47 percent of her skeletal calcium for egg shell formation. Two layers of the shell are formed in the *uterus*.

The spongy layer consists of small calcite crystals that are not arranged in any order, except in the outer portion of the layer where crystals are set at right angles to the shell surface.

Pigment, if any, is laid down in the spongy layer of the shell and is derived from the blood.

Pores are formed through the spongy layer connecting some of the space between the knoblike mammilla with the surface.

Moving finally into the *vagina*, a 2-inch (5.1 cm) area, the fully formed egg enters the *cloaca* and the *vent*, and is laid. When the egg is laid, the pores are filled by the matrix material and covered by the cuticle.

Cuticle, which is sometimes erroneously referred to as "bloom," is of a chemical composition similar to the shell membrane.

The time from ovulation to laying is usually slightly more than 24 hours. About 1/2 hour after a hen has laid an egg, she releases another yolk (ovulation), and it will, likewise, travel the length of the oviduct.

Abnormalities

Double-yolked eggs result when two yolks are released about the same time, or when one yolk is lost into the body cavity for a day and is picked up by the funnel when the next day's yolk is released.

Yolkless eggs are usually formed around a bit of tissue that is sloughed off the ovary or oviduct. This tissue stimulates the secreting glands of the oviduct and a yolkless egg results.

An egg within an egg is due to the reversal of direction of the egg by the wall of the oviduct. One day's egg is added to the next day's egg and the shell is formed around both.

Blood spots are caused by a rupture of one or more small blood vessels in the yolk follicle at the time of ovulation. Since the albumen of freshly laid eggs is usually cloudy, the detection of small blood spots during candling is difficult.

Meat spots have been demonstrated to be either blood spots which have changed in color due to chemical action, or tissue sloughed off from the reproductive organs of the hen, although most meat spots are from sources other than blood spots.

Soft-shelled eggs generally occur when an egg is prematurely laid, and insufficient time in the uterus prevents the deposit of the shell.

Thin-shelled eggs may be caused by dietary deficiencies, heredity, or disease.

Glassy- and chalky-shelled eggs are caused by malfunctions of the uterus of the laying bird. Glassy eggs are less porous and will not hatch, but may retain their quality.

Off-colored yolks are due to substances in feed that cause off-color.

Off-flavored eggs may be due to certain feed flavors or improper storage practices.

IV. Grading

Grading generally involves the sorting of products according to quality, size, weight, and other factors that determine the relative value of the product. Egg grading is the grouping of eggs into lots having similar characteristics as to quality and weight.

The grading for quality of eggs is the classifying of the individual egg according to established standards. U.S. standards for quality of individual eggs have been developed on the basis of such interior quality factors as condition of the white and yolk, size of the air cell, and the exterior quality factors of cleanliness and soundness of the shell. These standards apply to eggs of the domesticated chicken.

Eggs are also classified according to weight (or size) expressed in ounces per dozen. Although eggs are not sold according to exact weight, they are grouped within relatively narrow weight ranges or weight classes, the minimum net weight per unit being specified. When grading, eggs must meet minimum individual egg, carton, and case weight requirements.

Advantages of Grading

Grading aids orderly marketing by reducing waste, confusion, and uncertainty with respect to quality values. The egg production pattern and the marketing system in the United States are such that interstate trading and shipment occur constantly and in large volume. This situation creates a need for uniform standards throughout the country so that marketing may be facilitated and the efficiency of distribution increased.

Since eggs serve as a low-priced source of protein, the production and consumption of eggs on a global basis continues to expand. Currently, the United States is the largest producer and exporter of eggs and egg products. Grading according to uniform standards and certification for specific requirements of a purchase contract ensure importers and exporters that the product received is of the quality and condition described in the contract regardless of supplier.

Officials of USDA, and State and industry leaders, encourage the use of uniform standards and grades for eggs. Although all eggs reaching the consumer today are graded and marked according to U.S. standards and grades, only eggs packed in official USDA plants are graded by plant personnel authorized by the USDA. Additionally, the USDA grader continuously sample-grades these eggs to determine if they are eligible to be packed in cartons bearing the USDA grade shield. More information on USDA grading and certification services is provided in Sections IX through XII.

The primary advantage in using official standards and grades for eggs is that they furnish an acceptable common language in trading and marketing the product, thus making possible:

1. Impartial official grading that eliminates the need for personal inspection of the eggs by sellers, buyers, and other interested people.
2. Pooling of lots of comparable quality.

Figure 29. Individual eggs and consumer packages are check weighed by USDA graders to verify minimum weight for the designated size. (00-CN-0602)

Figure 30. Bulk packages of eggs are check weighed on platform scales to verify minimum net weight. Test weights are used to verify the accuracy of the scale. (00-CN-0603)

3. Development of improved quality at producer level through "buying on grade" programs.
4. Market price reporting in terms understood by all interested parties.
5. Negotiation of loans on generally accepted quality specifications.
6. A basis for settling disputes involving quality.
7. A basis for paying damage claims.
8. A basis for developing advertising.
9. A uniform basis for establishing brand names.
10. Establishment of buying guides for consumers.

General Application

Standards of quality have been developed as a means of classifying individual eggs according to various groups of conditions and characteristics that experience and research have shown to be desirable by producers, marketers, and consumers. The term "standardization" implies uniformity, and uniformity in interpretation will result if the same standard is used and is applied accurately in all instances.

Standards of quality are used as a basis for establishing grades. Standards of quality apply to individual eggs; grades apply to lots of eggs such as dozens, 30-dozen cases, and carloads. As egg quality is unstable and grading procedures are largely subjective, it is necessary to provide tolerances in grades for small percentages of eggs of a quality lower than that comprising the major part of the grade. The tolerances are provided to allow for errors in judgment, differences in interpretation, and normal deterioration in quality from the time of grading until the eggs are sold to the consumer.

Grades differ from standards in that they provide tolerances for individual eggs within a lot to be of lower quality than the grade name indicates. Tolerances must be within the capabilities of the industry to produce an acceptable product at reasonable prices. Without tolerances, it would not be possible to produce cartoned eggs at prices acceptable to consumers.

Once graders acquire a working knowledge of the standards of quality, accuracy in interpreting quality standards and the ability to judge correct grade classification will increase. In commercial operations, graders will make many grading decisions each day and must develop an ability to make instant decisions.

The greatest frequency of error is believed to occur in instances of repeated indecision as to the placement of individual eggs. It should be pointed out that mistakes due to oversight, minor errors in decision, and differences of opinion between graders or supervisors are factors that are taken into consideration in the U.S. grades by providing tolerances. However, errors beyond the permitted tolerances result in the incorrect grading of the entire lot of eggs. It is important that each grader's decision of egg placement be as accurate as possible.

V. Quality Factors

In acquiring skills in judging egg quality, it is helpful to break the classification process down into steps, considering separately the various quality factors affecting the shell, air cell, yolk condition, and condition of the white. Graders can concentrate with greater ease when each factor is considered separately. Later, all factors should be considered in combination.

Quality may be defined as the inherent properties of a product that determine its degree of excellence. Those conditions and characteristics that consumers want, and are willing to pay for, are, in a broad sense, factors of quality. The quality of an egg is determined by comparing a number of factors. The relative merit of one factor alone may determine the quality score of the egg, inasmuch as the final quality score can be no higher than the lowest score given to any one of the quality factors. Quality factors for eggs may be divided into two general groups: Exterior and Interior.

Exterior quality factors are apparent from direct external observation and should be the first point for evaluation.

Interior quality factors involve the contents of the egg as they appear before a candling light, or when the eggs are broken out and measured by the Haugh unit method plus visual examination of the yolk. Both methods are described in detail later in this manual.

Shell Color

Shell color does not affect the quality of the egg and is not a factor in the U.S. standards and grades. Eggs are usually sorted for color and sold as either "whites" or "browns." Eggs sell better when sorted and packed according to color than when sold as "mixed colors."

Figura 31. Eggs ara usually sorted for color and packed separately as either white or brown. (CD 8202 3241 1143-9)

For many years, consumers in some areas of the country have preferred white eggs, believing, perhaps, that the quality is better than that of brown eggs. In other areas, consumers have preferred brown eggs, believing they have greater food value. These opinions do not have any basis in fact, but it is recognized that brown eggs are more difficult to classify as to interior quality than are white eggs. It is also more difficult to detect small blood and/or meat spots in brown eggs. Research reports and random sample laying tests show that the incidence of meat spots is significantly higher in brown eggs than in white eggs.

Classification of Exterior Quality

The external factors of the egg shape, texture, soundness, and cleanliness of the shell can be determined without using the candling light, but soundness of shell should be verified by candling. The method or place where this is accomplished may vary with the type of candling and processing equipment used.

In hand candling, the examination for shell cleanliness and the removal of leakers, dented checks, and misshapen eggs will be accomplished by using the case light.

In mass scanning, the segregation for these shell factors is quite often the responsibility of a person who scans the eggs for exterior factors prior to or immediately following the candling operation. This should be done in a well-lighted area.

Exterior Quality Factors

Shell Shape and Texture. The normal egg has an oval shape with one end larger than the other, and it tapers toward the smaller end. The ends of an egg are commonly called the large end (air cell end) and the small end. Investigators measured both strength and appearance of many eggs to develop the "ideal" egg shape. This ideal egg shape is illustrated in figure 32. The shape of an egg can be considerably different from the ideal (fig. 33), but may still be considered practically normal. The grader must keep a mental picture of the normal, or usual, shape of an egg and compare each egg with that picture.

Eggs that are unusual in shape may have ridges, rough areas, or thin spots (figs. 34 and 35).

Abnormal shells may result from improper nutrition,

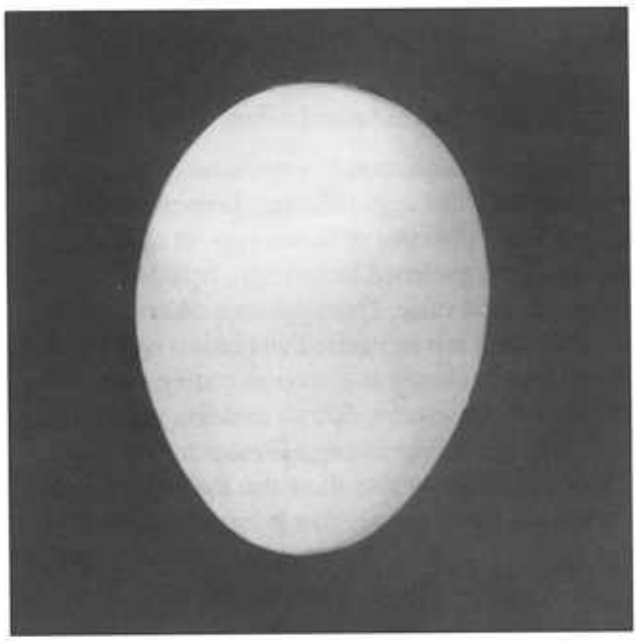

Figure 32. Ideal egg shape, usually found in AA or A quality. (BN-16548)

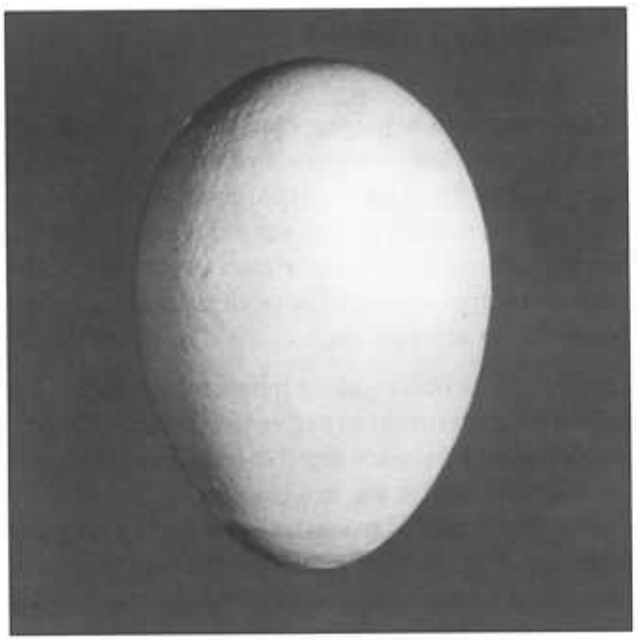

Figure 33. Practically normal shape which may be found in AA or A quality. (BN-16549)

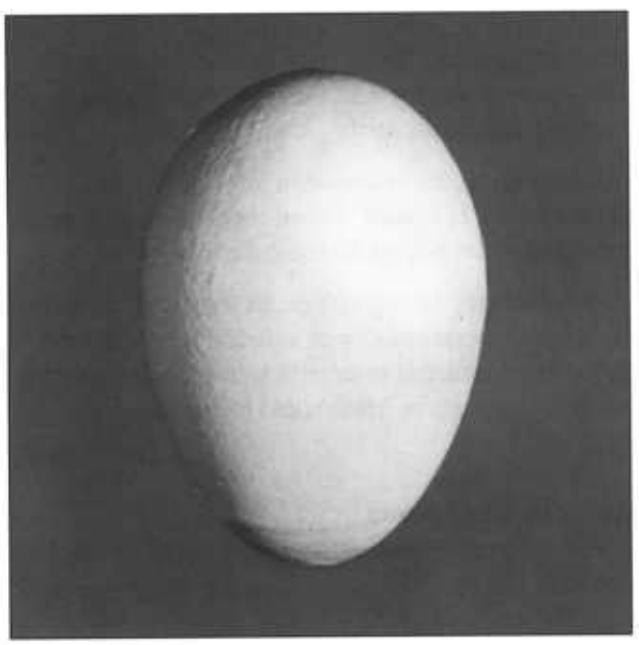

Figure 34. Practically normal shape, showing slight ridges and rough areas that do not materially affect the shape and strength of the shell and are permitted in AA or A quality. (BN-16550)

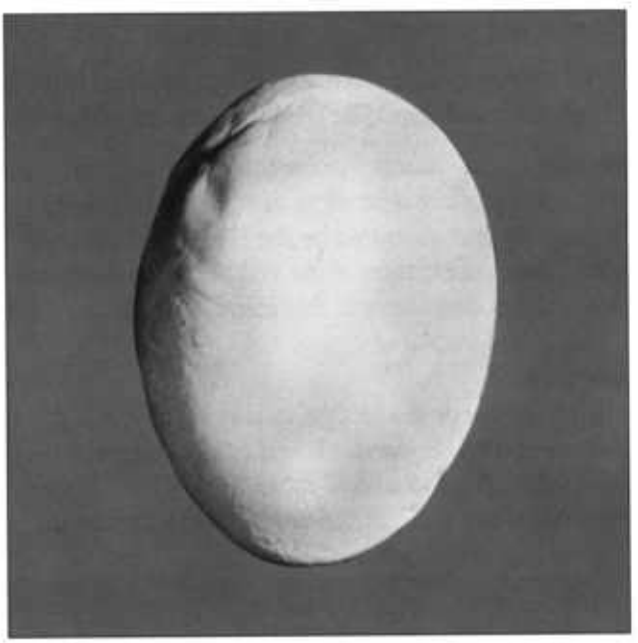

Figure 35. Abnormal shape having pronounced ridges and/or thin spots. (BN-16551)

disease, or the physical condition of the hen. Sometimes a shell is cracked while the egg is still in the body of the hen. These eggs, which are commonly referred to as "body checks," are repaired by an additional deposit of shell over the cracked area, generally resulting in a ridged area.

Shells with thin areas and some other types of defects are usually weaker than normal shells, and the danger of breakage en route to the consumer lowers the utility value of the egg. Eggs of abnormal shape also lack consumer appeal.

The specifications of the U.S. standards provide for degrees of variation:

Practically normal — A shell that approximates the usual shape and is sound and free from thin spots. Ridges and rough areas that do not materially affect the shape and

strength of the shell are permitted (AA or A quality).

Abnormal — A shell that may be somewhat unusual or decidedly misshapen or faulty in soundness or strength or that may show pronounced ridges or thin spots (B quality).

Soundness of Shell. The shell of an egg may be sound, checked or cracked, or leaking.

Following are definitions of these shell factors:

Sound — An egg whose shell is unbroken.

Check — An individual egg that has a broken shell or a crack in the shell but its shell membranes are intact and its contents do not leak.

Leaker — An individual egg that has a crack or break in the shell and shell membranes to the extent that the egg contents are exuding or free to exude through the shell. Leakers are classed as loss.

Checks are an unavoidable problem in the marketing of eggs because eggs cannot be assembled, graded, packed, transported, and merchandized without some breakage. Such eggs will not keep well or stand even moderately rough handling, and they should be diverted to immediate use or further processing.

Checks may range from eggs with plainly visible dented cracks that are removed during the grading process to very fine, hairlike cracks (blind checks) that often escape detection because they cannot be seen. While many of these checks become detectable as time passes (due primarily to contraction caused by cooling); most of the eggs will have already moved into marketing channels, reaching the retail level within 1 to 3 days after being laid.

"Blind checks" are the most common, and frequently the most difficult to detect in rapid candling, being discernible only before the candling light or by "belling." "Belling" is the practice of gently tapping two eggs together to assist in the detection of "blind checks" by sound. Hand candlers follow this practice by candling the eggs in order to verify and complete the findings arrived at by sound.

With the use of automatic processing equipment, the "belling" procedure is not used in examining the eggs for checks, although electronic check detectors are now available on new equipment. The candler must be especially attentive when these detectors are not being utilized so that all checks are removed prior to packaging. Quite often a bubbly air cell in fresh eggs indicates a "blind check".

It is necessary to remove leakers and dented checks carefully to avoid causing further damage to them and to prevent dripping liquid from the leakers onto clean eggs, onto the packaging material, or into the mechanism of the candling equipment, therefore cross-contaminating the eggs. This is necessary not only for bacteriological reasons, but for good housekeeping and appearance of the packaged product, and to keep the mechanisms of automatic weighing equipment in proper adjustment.

Shell Cleanliness. In machine processing, the examination for cleanliness is most often done immediately following the washing operation, during the mass scanning for interior quality, or after mass scanning prior to packaging. This operation should be in an area with sufficient lighting and adequate space for removing these types of eggs.

Freedom from stains and foreign material on the shell must be considered in assigning a quality designation to an individual egg. The following terms are descriptive of shell cleanliness:

Clean — A shell that is free from foreign material and from stains or discolorations that are readily visible. An egg may be considered clean if it has only very small specks, stains, or cage marks, if such specks, stains, or cage marks are not of sufficient number or intensity to detract from the generally clean appearance of the egg. Eggs that show traces of processing oil on the shell are considered clean unless otherwise soiled.

Dirty — A shell that is unbroken and has dirt or foreign material adhering to its surface, has prominent stains, or has moderate stains covering more than one-thirty-second of the shell surface if localized, or one-sixteenth of the shell surface if scattered.

The illustrations in figure 36 are intended as a guide and are not to be used as an actual measurement in grading. Graders should learn to determine the area that constitutes these measurements and then judge eggs having soiled shells against this mental picture.

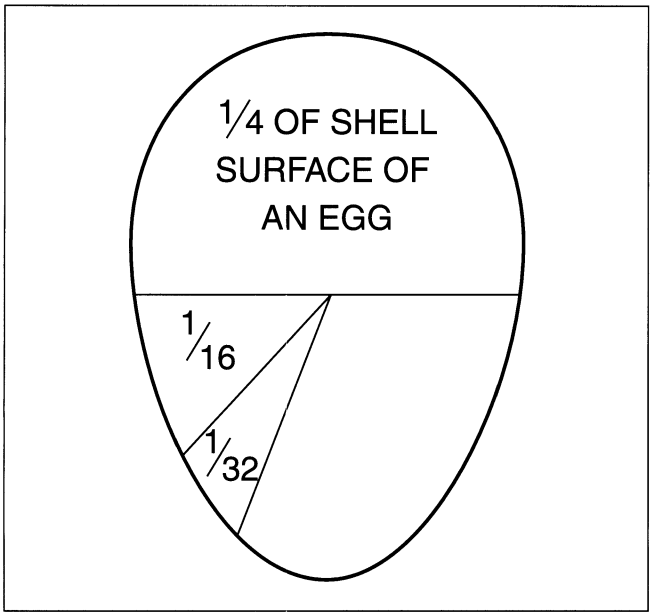

Figure 36. One thirty-second, one-sixteenth, and one-fourth of the shell surface of an egg (areas shown are approximate).

Classification of Interior Quality

Even under the most favorable conditions, egg quality is relatively unstable as the interior quality of the egg deteriorates from the time it is laid until it is consumed. Sometimes quality changes render eggs useless for food before they reach consumers. However, when eggs are properly cared for, the quality decline can be minimized. Quality decline is illustrated graphically in figure 37.

In grading eggs, and more specifically in classifying them according to internal quality, the grader is merely trying to group the eggs according to where each is located on "quality hill."

On the basis of internal quality, edible eggs are divided into three groups as shown in figure 37. All eggs whose candled characteristics fall between the top line and point 1 on the chart are in the highest quality class, or AA; those between points 1 and 2 are in the next quality, or A; and those between points 2 and 3 are in B quality. Those at and below point X are inedible or loss.

It is relatively easy to place eggs properly if they are midway between the various points on "quality hill," but judgment and skill are required to place the eggs that are at or near the quality division points in the correct group. It becomes increasingly difficult when brown eggs or mixed whites and browns are being candled. A primary objective in candling is to have a clear mental picture of the dividing line between the various quality classes, so that the eggs may be properly placed in their respective quality groups.

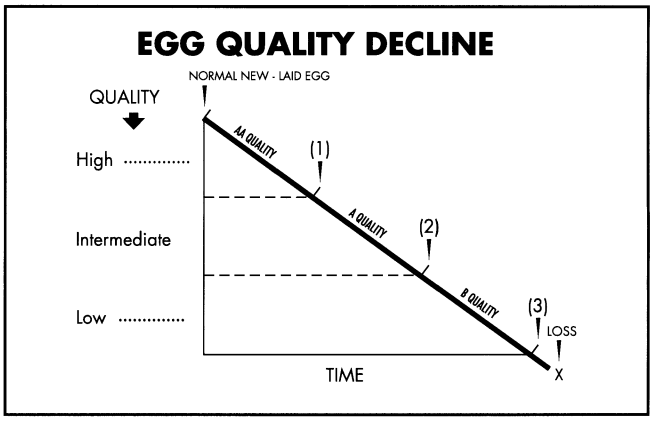

Figure 37. Chart demonstrating range of egg quality decline over time.

Good judgment in determining white and yolk condition can be developed and maintained by occasionally having graders break out an egg. Their estimate of the candled quality should be checked with the broken-out appearance as compared with (1) the chart for scoring broken-out appearance (fig. 38) and (2) the Haugh unit value of the broken-out egg. This value results from the correlation of the height of the thick white as measured by a micrometer and the weight of the egg. More information about candling eggs and Haugh units is contained in Sections VII and VIII of this manual.

Interior Quality Factors

Air Cell. As already stated, when the egg is first laid, it has no air cell at all or only a small one. Its temperature is about 105 °F (40.6 °C) and, as the egg cools, the liquids contract more than the shell. As a result of this contraction, the inner shell membrane separates from the outer to form an air space.

Further increase in the size of the air cell beyond that resulting from contraction is due to evaporation of water from the egg. The rapidity with which this takes place is due to many factors, such as age, shell texture, temperature, and humidity. The air cell is normally at the large end of the egg and is one of the first factors observed in candling.

The air cell is the easiest quality factor to evaluate, as it can be judged objectively by a simple measuring device — the

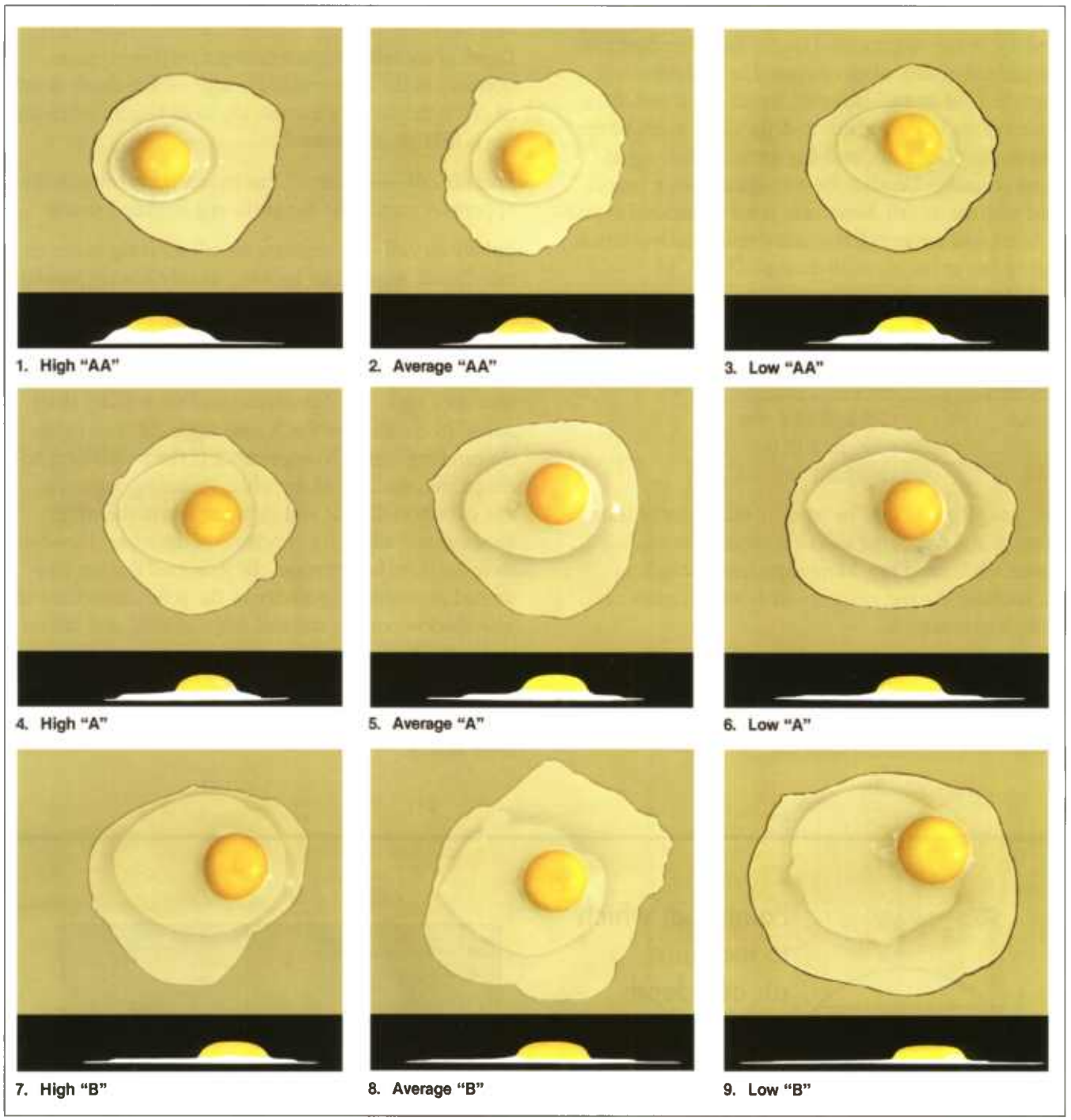

Figure 38. The pictures on this chart demonstrate the interior quality of broken-out eggs for each of the designated grades as specified in the U.S. standards with respect to white and yolk quality. Pictures 1, 2, and 3 represent the appearance of broken-out eggs of high, average, and low AA quality; 4, 5, and 6 represent high, average, and low A quality; and 7, 8, and 9 represent high, average, and low B quality. (00CN0055)

air-cell gauge (fig. 39). In candling, the air cell is considered a relatively unimportant quality factor for determining internal quality when compared to the broken-out appearance of an egg. However, the air cell is one of the factors of the U.S. standards and, therefore, it can be the determining factor in classifying the individual egg in terms of quality. Depth is the only quality factor considered with the air cell. Movement is not considered a quality factor, and the air cell may show unlimited movement and be free or bubbly in all qualities (AA, A, B).

The size of the air cell permitted in the various qualities is as follows:

Quality	Depth
AA	1/8 inch (3.2 mm)
A	3/16 inch (4.8 mm)
B	No limit

The air-cell gauge may be used by the beginner learning to judge the size of the air cell accurately at a quick glance while candling. More experienced candlers occasionally use the gauge to verify the accuracy of their determinations.

The depth of the air cell is measured at the point of greatest distance between the top of the cell and an imaginary plane passing through the egg at the lower edge of the air cell where it touches the shell (fig. 39).

The following terms are descriptive of the air cell:

Depth of air cell (air space between shell membranes, normally in the large end of the egg) — The depth of the air cell is the distance from its top to its bottom when the egg is held air cell upward.

Free air cell — An air cell that moves freely towards the uppermost part in the egg as the egg is rotated slowly.

Bubbly air cell — A ruptured air cell resulting in one or more small, separate air bubbles, usually floating beneath the main air cell.

Yolk. The appearance of the yolk as the egg is twirled in candling is one of the best indicators of the interior quality of shell eggs. The characteristics of the yolk are determined by the shadow that it casts upon the shell before the candling light. The appearance of the yolk is dependent on the condition of the white. As the egg ages, the rate of carbon dioxide and moisture loss in the white increases and affects the condition of the white. However, there are three factors about the yolk itself that are considered in judging egg quality by the yolk: distinctness of yolk shadow outline, size and shape of yolk, and defects and germ development.

Distinctness of yolk shadow outline. The distinctness of the yolk outline or shadow outline is governed by three factors:

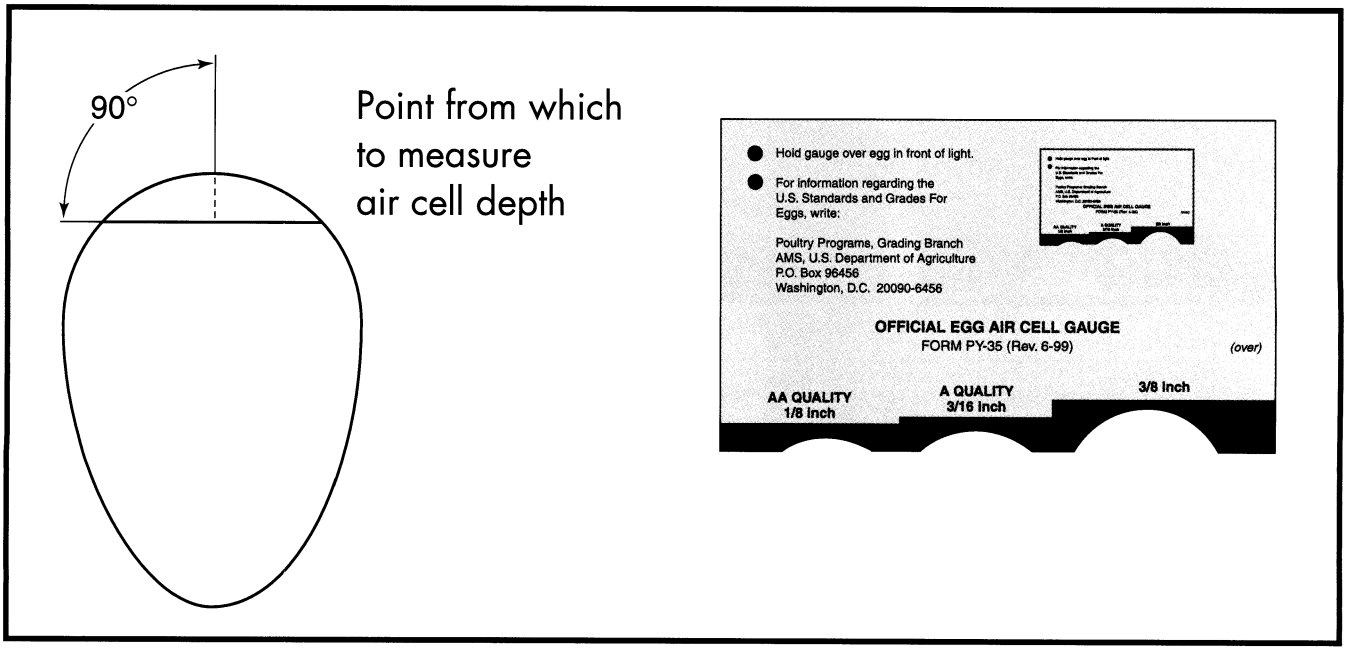

Figure 39. Official air cell gauge and method for measuring depth of air cell.

1. **The thickness and consistency of the white.** The thicker the white, the less distinct the outline appears, because the yolk is prevented from moving close to the shell.

2. **Condition of the yolk.** This condition is determined by the presence or absence of blemishes that show up before the candling light as dark shadows on the yolk, or the presence or absence of an off-colored yolk appearance which shows as a grayish or greenish shadow.

3. **Color of the yolk.** It is difficult to determine the color of the yolk before the candling light except off-color. However, extremes in yolk color may influence the candler's judgment of the egg quality. An extremely deep-colored yolk, under some conditions, would cast a darker shadow before the candling light than would a lighter yolk.

By concentrating on the yolk outline instead of the depth of the yolk shadow, the grader will minimize the influence of yolk color on quality determinations. The color of the yolk and the firmness of the white are two interacting influences affecting the distinctness of the yolk shadow outline; therefore, a grader cannot be reasonably certain which is the more important factor in any specific case.

The principle of judging distinctness of the outline rather than the depth of darkness of the shadow can be illustrated by holding a ball close to a wall so its shadow falls on the wall, and then moving it a little farther away from the wall. At the greater distance, the outline of the shadow is less distinct.

The terms used to define the three degrees of distinctness of yolk shadow outline in the U.S. Standards of Quality for Shell Eggs are:

Outline slightly defined — A yolk outline that is indistinctly indicated and appears to blend into the surrounding white as the egg is twirled (AA quality). (fig. 40)

Outline fairly well defined — A yolk outline that is discernible but not clearly outlined as the egg is twirled (A quality). (fig. 41)

Outline plainly visible — A yolk outline that is clearly visible as a dark shadow when the egg is twirled (B quality). (fig. 42)

Size and shape of yolk. The yolk in a freshly-laid egg is round and firm. As the yolk ages, the strength of the yolk membrane weakens allowing water to be absorbed from the white. This increases its size and weight and causes it to stretch and weaken the vitelline membrane and to assume a somewhat flattened shape on top and an "out-of-round" shape generally, resembling a balloon partially filled with water. Yolk size and shape are mentioned only in the lowest quality classification for eggs - B quality - where these factors become apparent. The terms used in

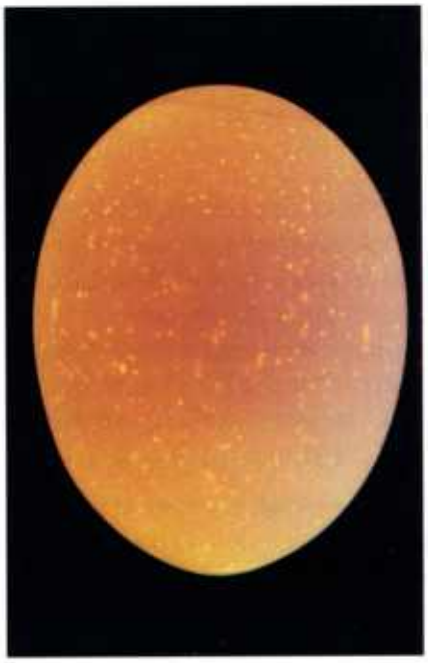

Figure 40. Yolk outline slightly defined. (99-CS-1610)

Figure 41. Yolk outline fairly well defined. (99-CS-1611)

Figure 42. Yolk outline plainly visible. (99-CS-1612)

the U.S. Standards of Quality for Shell Eggs to describe yolk size and shape are:

Enlarged and flattened — A yolk in which the yolk membranes and tissues have weakened and/or moisture has been absorbed from the white to such an extent that the yolk appears definitely enlarged and flat (B quality).

Defects and germ development. Relatively little is known about the exact causes of most yolk defects other than those due to germ development. Some of the causes which have been advanced are: irregular deposits of light and dark yolk; blemishes from rubbing; and development of accumulations or clusters of the fat and oil in droplets. The relative viscosity of the white has a direct bearing on the accurate determination of defects on the yolk before the candling light. Unless yolk defects are very prominent, it is difficult to detect them, particularly when the egg has a thick or cloudy albumen. Germ development is visible before the candling light and can generally be detected as a circular dark area near the center of the yolk shadow. If blood is visible, the egg must be rejected as inedible.

The terms used to describe yolk defects are:

Practically free from defects — A yolk that shows no germ development, but may show other very slight defects on its surface (AA and A quality).

Serious defects — A yolk that shows well developed spots or areas and other serious defects, such as olive yolks, that do not render the egg inedible (B quality).

Clearly visible germ development — Development of the germ spot on the yolk of a fertile egg that has progressed to the point where it is plainly visible as a definite circular area or spot with no blood in evidence (B quality).

Blood due to germ development — Blood caused by development of the germ in a fertile egg to a point where it is visible as definite lines or as a blood ring. Such an egg is classified as inedible.

White (Albumen). Nearly all freshly-laid eggs contain four layers of white — chalaziferous, inner thin, thick, and outer thin. The appearance of the egg before the candling light is governed largely by the relative proportions of the thick and outer thin layers of albumen. The albumen and yolk are very closely associated and any discussion of either factor, by necessity, involves the other. However, there are two important considerations about the albumen which are included in standards of quality: condition, or viscosity, and clarity.

The condition of the albumen is determined in candling by the intensity of the yolk shadow and the freedom of movement of the yolk as the egg is twirled before the candling light. These factors are related to the viscosity of the albumen. Thick albumen permits only limited movement of the yolk, and an indistinct shadow results.

The reverse is true of thin albumen, which permits free movement of the yolk, and a distinct shadow results. The grader must judge from the behavior of the yolk how the albumen will appear when the egg is broken out. Figure 37 shows the appearance of the albumen in broken-out eggs.

The following terms describe albumen:

Clear — Albumen that is free from discolorations or from any foreign bodies floating in it. Prominent chalazas should not be confused with foreign bodies such as spots or blood clots (AA, A quality).

Firm — Albumen that is sufficiently thick or viscous to prevent the yolk outline from being more than slightly defined or indistinctly indicated when the egg is twirled. With respect to a broken-out egg, a firm albumen has a Haugh unit value of 72 or higher when measured at a temperature between 45 and 60 °F (7.2 and 15.6 °C) (AA quality).

Reasonably firm — Albumen that is somewhat less thick or viscous than firm albumen. A reasonably firm albumen permits the yolk to approach the shell more closely, which results in a fairly well defined yolk outline when the egg is twirled. With respect to a broken-out egg, a reasonably firm albumen has a Haugh unit value of 60 up to, but not including, 72 when measured at a temperature between 45 and 60 °F (7.2 and 15.6 °C) (A quality).

Weak and watery — Albumen that is weak, thin, and generally lacking in viscosity. A weak and watery albumen permits the yolk to approach the shell closely, thus causing the yolk outline to appear plainly visible and dark when the egg is twirled. With respect to a broken-out egg, a weak and watery albumen has a Haugh unit value lower than 60 when measured at a temperature between 45 and 60 °F (7.2 and 15.6 °C) (B quality).

Blood spots or meat spots — Small blood spots (aggregating not more than one-eighth inch in diameter) are to be classified as B* quality. Small meat spots (aggregating not more than one-eighth inch in diameter) are to be classified as B quality. If blood spots are larger, or show diffusion of blood into the albumen surrounding them,

the egg shall be classified as loss. Blood spots shall not be due to germ development. They may be on the yolk or in the albumen. Meat spots may be blood spots which have lost their characteristic red color, or tissue from the reproductive organs. (figs. 43 and 44)

Figure 43. Small blood spot. (99-CS-1613)

Bloody white — An egg which has blood diffused through the albumen. Such a condition may be present in freshly laid eggs. Eggs with bloody albumen are classed as loss. (fig. 45)

Loss Eggs. The U.S. standards of quality also define certain eggs as "loss."

Loss — An egg that is inedible, cooked, frozen, contaminated, sour, musty, or moldy, or an egg that contains a large blood spot, large meat spot, bloody white, green white, rot, stuck yolk, blood ring, embryo chick (at or beyond the blood ring state), free yolk in the white, or other foreign material.

Cooked eggs are eggs which have been subjected to heat resulting in coagulation of the contents. Cooked eggs, when held before the candling light, may be identified by the presence of threadlike shadows in the white, indicating a slightly cooked egg, or a dark, opaque appearance, indicating complete coagulation of the contents.

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

Figure 44. Candled and broken-out appearance of a large blood spot. (99-CS-1614)

odor emanating from the egg. Sources of contamination may be a musty odor in the case or the nesting material, or the presence of this odor on the shell itself.

It is said that certain bacteria that occasionally invade the egg also give off this characteristic odor. Because this type of loss is impossible to detect by visual observation, it is important that the grader note the odor emanating from the case and packing material immediately upon opening the case.

Moldy eggs may be detected by observing mold spots on the shell or by mold growth in checked areas of the shell, or by mold growths (the odor of mold or must may or may not be present) inside the egg itself when viewed before the candling light. The use of dirty water for wash-

Figure 45. Bloody white. (99-CS-1615)

ing eggs and dirty processing oil cooler than the egg, and the storage of the egg in unusually high humidity encourage mold growth and mold penetration through the shell. Advanced stages of mold growth throughout the entire egg might have an appearance similar to that of black rot.

Large blood spots and bloody whites have already been discussed. They appear as brilliant red in color or as a dark gray in so-called meat spots, in contrast to the surrounding lemon-to-orange colored tinge of the yolk, observed before the candling light.

Green whites can be detected by experienced graders using the standard candling light. This type of loss is caused by the *Pseudomonas* group of bacteria. Like sour eggs, eggs with green whites will fluoresce under the ultraviolet light when broken out. Eggs with green whites may or may not have a sour odor.

Mixed rot occurs when the vitelline membrane of the yolk breaks and the yolk mixes with the white, resulting in a murkiness throughout the interior of the egg when viewed before the candling light. (fig. 46)

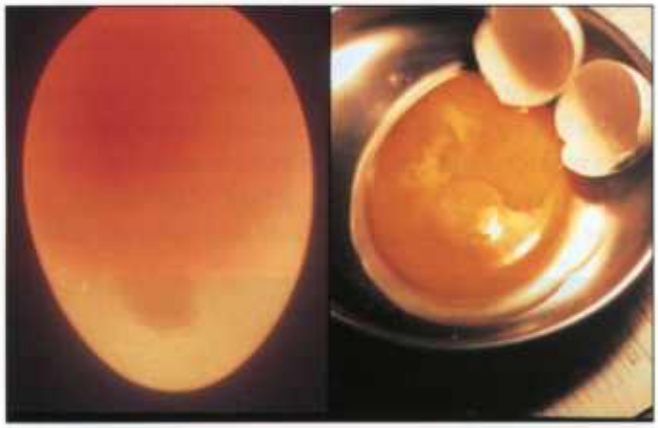

Figure 46. Candled and broken-out appearance of a mixed rot. (99-CS-1616)

A white rot, in its early stages, may be detected by the presence of threadlike shadows in the thin white. 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.

Black rots are generally opaque (with the exception of the air cell) when viewed before the candling light. When broken, the contents have a muddy brown appearance and give off a repulsive, putrid odor. The bacteria most frequently causing this type of loss belong to a group named *Proteus*. However, when any rot is at an advanced stage, it may appear "black" before the candling light.

Stuck yolk occurs when the yolk membrane becomes attached to the shell membrane. It generally occurs in storage 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. Before the candling light, the yolk appears attached to the shell and snaps back to its attached position when the twirling motion of the egg is stopped. If loosened from its position, the yolk membrane usually breaks, permitting the yolk content to seep into the white. The first stage of this condition is generally referred to as "seeping yolk," and later as "mixed rot" or "addled egg."

Blood rings and embryo chicks are caused by germ development, occurring in fertile eggs held at incubation temperatures. At a rather early stage in incubation (after 24 hours) the embryo develops a circulatory system. If the embryo dies at this stage, the blood drains to the outer edge of the germ disc and forms the blood ring. Before the candling light, it appears as a brilliant blood-red circle from one-eighth to three-eighths inch in diameter, depending on the stage of development.

If incubation temperatures are maintained for a longer period, the embryo chick is formed by about the third day, and eventually fills most of the egg. This can be observed before the candling light as an actual outline of the embryo in the early stages.

Sour eggs are often difficult to detect by standard candling methods. Generally, eggs in this condition show a weak white and murky shadow around an off-center swollen yolk. The bacteria causing sour eggs belong to a group named *Pseudomonas*. These organisms produce a material which fluoresces under ultraviolet light, giving off a green sheen. The adoption of ultraviolet light in candling (black light) has made the detection of this type of loss easier.

In addition to the eggs described above, eggs showing severe shell damage, and eggs that are leakers, are also classified as loss.

Eggs not classified as loss, but as "no grade," include eggs of possible edible qualities that have been contaminated by smoke, chemicals, or other foreign material which has seriously affected the character, appearance, or flavor of the eggs.

High concentrations of fish oil or garlic fed to hens impart their flavor to the eggs. Eggs exposed to foreign odors after they have been laid may give off these odors. Eggs stored near kerosene, carbolic acid, mold, must, fruits, and vegetables, for example, readily absorb odors from these products.

VI. U.S. Standards, Grades, and Weight Classes for Shell Eggs

The U.S. standards, grades, and weight classes for individual shell eggs are applicable only to eggs of the domesticated chicken that are in the shell.

U.S. Standards for Quality of Individual Shell Eggs

The standards described below are summarized in table 2 and are based on the candled appearance of the egg.

AA quality — The shell must be clean, unbroken, and practically normal. The air cell must not exceed one-eighth inch (3.2 mm) in depth, may show unlimited movement, and may be free or bubbly. The white must be clear and firm, so that the yolk is only slightly defined when the egg is twirled before the candling light. The yolk must be practically free from apparent defects.

A quality — The shell must be clean, unbroken, and practically normal. The air cell must not exceed three-sixteenths inch (4.8 mm) in depth, may show unlimited movement, and may be free or bubbly. The white must be clear and at least reasonably firm, so that the yolk outline is only fairly well defined when the egg is twirled before the candling light. The yolk must be practically free from apparent defects.

B quality — The shell must be unbroken, may be abnormal, and may have slightly stained areas. Moderately stained areas are permitted if they do not cover more than one-thirty-second (0.8 mm) of the shell surface if localized, or one-sixteenth (4.8 mm) of the shell surface if scattered. Eggs having shells with prominent stains or adhering dirt are not permitted. The air cell may be over three-sixteenths inch (1.6 mm) in depth, may show unlimited movement, and may be free or bubbly. The white may be weak and watery, so that the yolk outline is plainly visible when the egg is twirled before the candling light. The yolk may appear dark, enlarged, and flattened, and may show clearly visible germ development, but no blood due to such development. It may show other serious defects that do not render the egg inedible. Small blood spots or meat spots (aggregating not more than one-eighth inch (3.2 mm) in diameter) may be present.

Dirty — An individual egg that has an unbroken shell with adhering dirt or foreign material, prominent stains, or moderate stains covering more than one-thirty-second of the shell surface if localized, or one-sixteenth of the shell surface if scattered.

Check — An individual egg that has a broken shell or a crack in the shell, but its shell membranes are intact and its contents do not leak.

Leaker — An individual egg that has a crack or break in the shell and shell membranes to the extent that the egg contents are exuding or free to exude through the shell.

TABLE 2. *Summary of U.S. Standards for Quality of Individual Shell Eggs.*

SPECIFICATIONS FOR EACH QUALITY FACTOR			
Quality Factor	**AA Quality**	**A Quality**	**B Quality**
Shell	Clean Unbroken. Practically Normal.	Clean Unbroken. Practically Normal.	Clean to slightly stained.* Unbroken. Abnormal.
Air Cell	1/8 inch or less in depth. Unlimited movement and free or bubbly.	3/16 inch or less in depth. Unlimited movement and free or bubbly.	Over 3/16 inch in depth. Unlimited movement and free or bubbly.
White	Clear. Firm.	Clear. Reasonably firm.	Weak and watery. Small blood and meat spots present.**
Yolk	Outline slightly defined. Practically free from defects.	Outline fairly well defined. Practically free from defects.	Outline plainly visible. Enlarged and flattened. Clearly visible germ development but no blood. Other serious defects.

For eggs with dirty or broken shells, the standards of quality provide two additional qualities.	
Dirty	**Check**
Unbroken. Adhering dirt or foreign material, prominent stains, moderate stained areas in excess of B quality.	Broken or cracked shell, but membranes intact, not leaking.***

* Moderately stained areas permitted (1/32 of surface if localized, or 1/16 if scattered.).
** If they are small (aggregating not more than 1/8 inch in diameter).
*** Leaker has broken or cracked shell membranes, and contents leaking or free to leak.

U.S. Consumer Grades and Weight Classes for Shell Eggs

Consumer Grades. The standards for shell eggs provide for "origin" and "destination" consumer grades. "Origin grading" is defined as a grading made on a lot of eggs at a plant where the eggs are graded and packed.

Table 3 gives a summary of the consumer grades, while table 4 gives the tolerance for individual cases within a lot.

U.S. Consumer Grade AA (at origin) shall consist of eggs that are at least 87 percent AA quality. The maximum tolerance of 13 percent that may be below AA quality may consist of A or B quality in any combination, except that within the tolerance for B quality, not more than 1 percent may be B quality due to air cells over three-eighths inch (9.5 mm), blood spots aggregating not more than one-eighth inch (3.2 mm) in diameter, or serious yolk defects. Not more than 5 percent (7 percent for Jumbo size) checks are permitted and not more than 0.5 percent leakers, dirties, or loss (due to meat or blood spots) in any combination, except that such loss may not exceed 0.3 percent. Other types of loss are not permitted.

U.S. Consumer Grade AA (destination) shall consist of eggs that are at least 72 percent AA quality. The remaining tolerance of 28 percent shall consist of at least 10 percent A quality and the remainder shall be B quality, except that within the tolerance for B quality, not more than 1 percent may be B quality due to air cells over three-eighths inch (9.5 mm), blood spots aggregating not more than one-eighth inch (3.2 mm) in diameter, or serious yolk defects. Not more than 7 percent (9 percent for Jumbo size) checks are permitted and not more than 1 percent leakers, dirties, or loss (due to meat or blood spots) in any combination, except that such loss may not exceed 0.3 percent. Other types of loss are not permitted.

U.S. Consumer Grade A (at origin) shall consist of eggs that are at least 87 percent A quality or better. Within the maximum tolerance of 13 percent that may be below A quality, not more than 1 percent may be B quality due to air cells over three-eighths inch (9.5 mm), blood spots aggregating not more than one-eighth inch (3.2 mm) in diameter, or serious yolk defects. Not more than 5 percent (7 percent for Jumbo size) checks are permitted and not more than 0.5 percent leakers, dirties, or loss (due to meat or blood spots) in any combination, except that such loss may not exceed 0.3 percent. Other types of loss are not permitted.

TABLE 3. *Summary of U.S. Consumer Grades for Shell Eggs.*

U.S. consumer grade (origin)	Quality required [1]	Tolerance permitted [2]	
		Percent	Quality
Grade AA	87 percent AA.	Up to 13 Not over 5	A or B. [5] Checks. [6]
Grade A	87 percent A or better.	Up to 13 Not over 5	B. [5] Checks. [6]
Grade B	90 percent B or better.	Not over 10	Checks.

U.S. consumer grade (destination)	Quality required [1]	Tolerance permitted [3]	
		Percent	Quality
Grade AA	72 percent AA.	Up to 28 [4] Not over 7	A or B. [5] Checks. [6]
Grade A	82 percent A or better.	Up to 18 Not over 7	B. [5] Checks. [6]
Grade B	90 percent B or better.	Not over 10	Checks.

[1] In lots of two or more cases, see table 4 for tolerances for an individual case within a lot.
[2] For the U.S. consumer grades (at origin), a tolerance of 0.50 percent Leakers, Dirties, or Loss (due to meat or blood spots) in any combination is permitted, except that such Loss may not exceed 0.30 percent. Other types of Loss are not permitted.
[3] For the U.S. consumer grades (destination), a tolerance of 1 percent Leakers, Dirties, or Loss (due to meat or blood spots) in any combination is permitted, except that such Loss may not exceed 0.30 percent. Other types of Loss are not permitted.
[4] For U.S. Grade AA at destination, at least 10 percent must be A quality or better.
[5] For U.S. Grade AA and A at origin and destination within the tolerances permitted for B quality, not more than 1 percent may be B quality due to air cells over 3/8 inch, blood spots (aggregating not more than 1/8 inch in diameter), or serious yolk defects.
[6] For U.S. Grades AA and A Jumbo size eggs, the tolerance for Checks at origin and destination is 7 percent and 9 percent, respectively.

U.S. Consumer Grade A (destination) shall consist of eggs that are at least 82 percent A quality or better. Within the maximum tolerance of 18 percent that may be below A quality, not more than 1 percent may be B quality due to air cells over three-eighths inch (9.5 mm), blood spots aggregating not more than one-eighth inch (3.2 mm) in diameter, or serious yolk defects. Not more than 7 percent (9 percent for Jumbo size) checks are permitted and not more than 1 percent leakers, dirties, or loss (due to meat or blood spots) in any combination, except that such loss may not exceed 0.3 percent. Other types of loss are not permitted.

U.S. Consumer Grade B (at origin) shall consist of eggs that are at least 90 percent B quality or better, not more than 10 percent may be checks, and not more than 0.5 percent leakers, dirties, or loss (due to meat or blood spots) in any combination, except that such loss may not exceed 0.3 percent. Other types of loss are not permitted.

U.S. Consumer Grade B (destination) shall consist of eggs that are at least 90 percent B quality or better, not more than 10 percent may be checks, and not more than 1 percent leakers, dirties, or loss (due to meat or blood spots) in any combination, except that such loss may not exceed 0.3 percent. Other types of loss are not permitted.

TABLE 4. *Tolerances for individual cases within a lot.*

U.S. consumer grade	Case Quality	Origin (percent)	Destination (percent)
Grade AA	AA (min) A or B Check (max)	77 13 10	62 28 10
Grade A	A (min) B Check (max)	77 13 10	72 18 10
Grade B	B (min) Check (max)	80 20	80 20

Additional tolerances. In lots of two or more cases:

For grade AA — No individual case may exceed 10 percent less AA quality eggs than the minimum permitted for the lot average.

For grade A — No individual case may exceed 10 percent less A quality eggs than the minimum permitted for the lot average.

For grade B — No individual case may exceed 10 percent less B quality eggs than the minimum permitted for the lot average.

For grades AA, A, and B, no lot shall be rejected or downgraded due to the quality of a single egg except for loss other than blood or meat spots.

Weight Classes. The weight classes for U.S. consumer grades for shell eggs shall be as indicated in table 5, and shall apply to all consumer grades.

A lot-average tolerance of 3.3 percent for individual eggs in the next lower weight class is permitted, as long as no individual case within the lot exceeds 5 percent.

TABLE 5. *Weight classes of U.S. Consumer Grades for Shell Eggs.*

Size or weight class	Minimum net weight per dozen (ounces)	Minimum net weight 30 per dozen (pounds)	Minimum net weight for individual eggs at rate per dozen (ounces)
Jumbo	30	56	29
Extra large	27	50 1/2	26
Large	24	45	23
Medium	21	39 1/2	20
Small	18	34	17
Peewee	15	28	—

U.S. Nest Run Grade and Weight Classes for Shell Eggs

Table 6 summarizes the nest run grade described below.

U.S. Nest Run_% AA Quality shall consist of eggs of current production of which at least 20 percent are AA quality; and the actual percentage of AA quality eggs shall be stated in the grade name. Within the maximum of 15 percent that may be below A quality, not more than 10 percent may be B quality for shell shape, for interior quality (including meat or blood spots), or due to rusty- or blackish-appearing cage marks or blood stains; not more than 5 percent may have adhering dirt or foreign material on the shell one-half inch (12.7 mm) or larger in diameter; not more than 6 percent may be checks; and not more than 3 percent may be loss. Marks that are slightly gray in appearance and adhering dirt or foreign material on the shell less than one-half inch (12.7 mm) in diameter are not considered quality factors. The eggs shall be officially graded for all other quality factors. No case may contain less than 75 percent A quality and AA quality eggs in any combination.

The weight classes for the U.S. Nest Run grade for shell eggs shall be as indicated in table 7.

TABLE 7. *Weight classes for U.S. Nest Run Grade for Shell Eggs.*

Weight classes	Minimum average net weight on lot basis 30-dozen cases (pounds)
Class XL	51
Class 1	48
Class 2	45
Class 3	42
Class 4	39

Obsolete Grades and Weight Classes

Procurement grades and weight classes were eliminated in 1981. Procurement Grade I was practically identical to U.S. Consumer Grade A; thus the consumer grade standard could readily be used in place of the procurement standard. The U.S. Department of Defense was the principal user of Procurement Grade I. Procurement Grade II had not been used for a number of years.

Wholesale grades and weight classes were also eliminated as their use diminished. Almost all eggs moving in commerce today are sold on the basis of the U.S. Consumer Grades, U.S. Nest-Run Grade, company specifications, or are sold without certification. "U.S. Trades," "U.S. Dirties," and "U.S. Checks" were eliminated in 1981; "U.S. Specials," "U.S. Extras," and "U.S. Standards" in 1995.

TABLE 6. *Summary of U.S. Nest Run Grade for Shell Eggs.*

	Nest-run grade, description [1]	U.S. nest run ___ percent AA quality [2]
Minimum percentage of quality required (lot average) [3]	AA quality [4]	20
	A quality or better [5]	85
Maximum percentage tolerance permitted (15 percent lot average) [3]	B quality for shell shape, pronounced ridges or thin spots, interior quality (including blood & meat spots) or cage marks [6] and blood stains	10
	Checks	6
	Loss	3
	Adhering dirt or foreign material 1/2 inch or larger in diameter	5

[1] Stains (other than rusty or blackish appearing cage marks or blood stains) and adhering dirt and foreign material on the shell less than 1/2 inch in diameter shall not be considered as quality factors in determining the grade designation.
[2] The actual total percentage must be stated in the grade name.
[3] Substitution of eggs of higher qualities for lower specified qualities is permitted.
[4] No case may contain less than 10 percent AA quality.
[5] No case may contain less than 75 percent A quality and AA quality eggs in any combination.
[6] Cage marks which are rusty or blackish in appearance shall be considered as quality factors. Marks which are slightly gray in appearance are not considered as quality factors.

VII. Determining Interior Quality by Hand Candling

Hand candling was originally developed as a method of sorting fresh eggs from storage eggs and for the detection of incubator rejects. With the changes in production practices and processing technologies, hand candling is used very little in present commercial grading operations. Automated equipment and mass scanning devices have practically replaced these manual operations. However, hand candling is still an excellent method for teaching and demonstrating quality determination, and is used for spot checking and verifying accuracy of mass scanning personnel.

Hand Candling Booth

For purposes of quality control, there should be at least one strategically located candling booth in each grading plant. Ideally, the booth should be 8 feet (2.43 m) wide, 4 feet (1.22 m) deep, and 7 feet (2.13 m) high. The proper type of candling booth needed for check grading or quality control is illustrated in figure 47. The candling booth walls should be painted with a dark-colored flat finished paint to avoid light reflection. The booth should include an overhead light, exhaust fan, and at least two electrical outlets. Grading and candling equipment provided with the booth should include two hand candling lights, an electronic individual egg scale graduated in 1/10 ounce (1 gram) increments or less, a scale graduated in 1/4 ounce (1 gram) or less increments for verifying weights of consumer packages, a bulk scale graduated in 1/4 pound (0.1 kg) increments or less for verifying weights of shipping containers, test weights for verifying the accuracy of each scale, and breakout plates for periodic correlations of the candled versus the broken-out appearance of eggs.

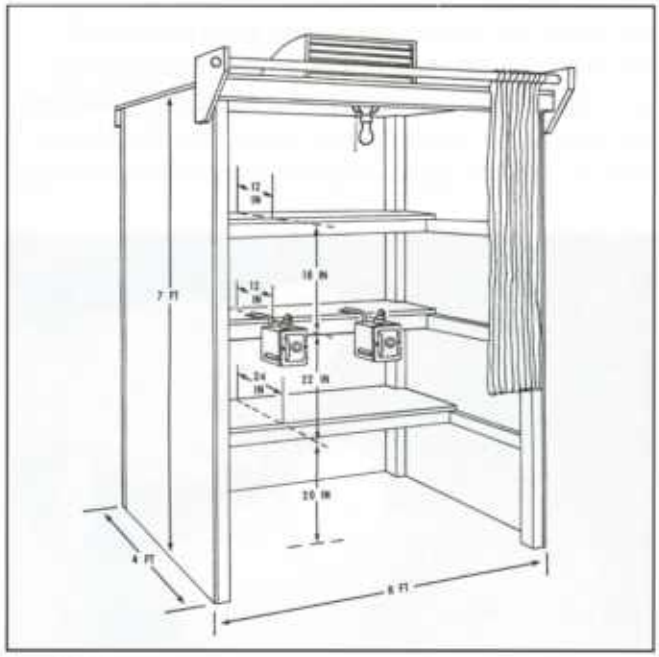

Figure 47. Dimensions and layout of an ideal candling booth.

Hand Candling Light

There are many styles and types of candling lights commercially available in which the light intensity and the size of the candling light opening vary considerably. Most of these lights are satisfactory if they are adjusted to provide comfort and proper illumination for the job. It is largely a matter of becoming accustomed to the type of light in use. The accuracy of the hand candling results can be checked by breaking out an occasional egg and comparing the broken-out quality with the candled quality.

In hand candling operations, there should be no cross beams of light between the candler and the candling light. The candling light should be properly adjusted and focused to give better and more uniform candling results. The light should be at about elbow height for the candler and placed so that the light does not shine in the candler's eyes.

Graders may adjust their quality interpretation slightly according to different types of candling lights or varied adjustments of the same light. In selecting a candling light, therefore, it is best to select one type of light and keep it

Figure 48. Typical layout of USDA grader's candling booth and work area. (99-CS-1609)

clean and properly adjusted. Once a grader has adjusted candled interpretation to a reasonably close correlation with the broken out appearance of eggs, uniform grading can be maintained with moderate supervision.

The opening that the egg is held up to for examination should be no larger than 1 1/8 inches (2.86 cm) in diameter. The opening at the bottom of the light should be no larger than necessary to provide sufficient illumination to detect dirty eggs and to observe the condition of the packing material. The light should be adjusted so that its aperture is approximately on the level of the grader's elbows. The interior of the candling light should be kept clean and free from dust to assure maximum light efficiency. If a lens and a reflector are used, they should be freed periodically of the film-like coating that tends to buildup over time. The reflector should be kept in adjustment and the silver surface should be intact.

Hand Candling Technique

Prior to actual candling, the grader should make a preliminary examination of the general appearance of the eggs to be candled at the time the container is opened or the flats are removed from the sample case. This preliminary examination is to initially segregate the eggs for cleanliness. Eggs with only very small specks, stains, or cage marks may be considered clean if such small specks, stains, or cage marks are not of sufficient number or intensity to detract appreciably from the appearance of the eggs. While the eggs are still in standing position, the grader should remove and candle the eggs with stained or dirty shells. This procedure will assist in removing dirty or stained eggs that are noticed at first glance.

The grader should remove the remaining eggs in the container, two eggs in each hand, for candling. On the way to the candling aperture, the eggs in each hand should be rotated under the light that illuminates the contents of the sample, commonly referred to as a case light. As the eggs are rotated, the grader should observe the shells for stains or dirty conditions.

This operation (rotation and observation for cleanliness) should be performed rapidly enough that the motion of the hand from the case light to the candling aperture is made in one sweeping motion. Any stained or dirty eggs that are detected at this point should be candled and segregated before the candling of clean eggs is begun. When the eggs are placed before the candling aperture, the grader should remove previously undetected dirty or stained shells.

The candling light must provide sufficient illumination to detect checks and interior defects. Light reflection from the bottom of the candling light is used to detect stained and dirty shells.

When hand candling, the grader should always have clean, dry hands to avoid staining shells. The candling aperture should be of a material that will not mark or stain the shell and will aid in minimizing breakage.

In determining interior quality by hand candling, it is customary to hold two eggs in each hand, supporting one egg by the tips of the thumb and index finger and holding the other against the palm with the other fingers. The small ends of the eggs should point toward the palm of the hand (fig. 49). After one egg in the hand has been candled, it is shifted back in a rotating motion to the palm of the hand and the second egg is brought into candling position. The eggs are viewed alternately before the light.

The uppermost egg in one hand is examined first, then the uppermost egg in the other hand, and this procedure is repeated after the position of the eggs in each hand has been shifted. After the first egg is candled and the hand is dropped slightly back and downward, the third and fourth fingers are relaxed, letting the uncandled egg roll downward slightly.

At the same time, the thumb and index and second fingers guide the candled egg into the palm of the hand. The third and little fingers then roll the uncandled egg into candling position between the thumb and index finger; meanwhile the little finger (fourth) and third finger hold the candled egg in the palm. The position of the egg

Figure 49. USDA grader demonstrates the proper way to hold eggs while candling. (00CN0052)

is changed in one hand while one of the eggs held in the other hand is being candled. During this finger-to-palm rotation, proficient candlers carefully conduct the "belling" process to detect "blind checks."

The ability to quickly rotate two eggs in each hand makes for more rapid work and should be practiced until reasonable dexterity is acquired. In manipulating eggs before the candling light, it is important that the rotation of eggs in each hand and the twirling motion before the light become mechanical. Dexterity in this rotation operation permits the grader to concentrate entirely on placing the egg before the light rather than on changing its position, on rotating the two eggs, or on concern over dropping the eggs. It also helps the grader develop a rhythm which improves uniform timing of judgment, thereby making possible greater proficiency.

In order to obtain a proper view of the egg while candling, it is necessary to have the contents spinning within the shell at the time of viewing. This can be achieved in one smooth motion when the two eggs in the one hand are being rotated and moved toward the aperture in the candling light. The contents of the egg will be set in motion by a movement of hand and wrist in an arc of about 180° (3.06 rad).

Stopping the hand motion at the end of the arc without moving the arm or body permits the contents to spin within the shell. The long axis of the egg should be at about a 45° (0.76 rad) angle to the candling aperture. The thumb and index finger should be on opposite sides of the shell without obstructing the grader's view (fig. 50). After gaining some experience in the candling operation, the grader will learn to have the egg contents spinning at the exact instant the egg is placed before the candling aperture.

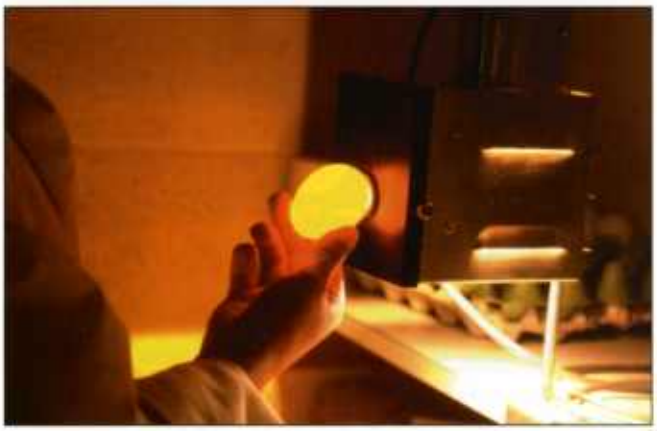

Figure 50. USDA grader demonstrating the use of a hand candling light. (CD 8202 3241 1143-14)

Speed and accuracy in hand candling should be accompanied by careful handling of the product. When eggs are returned into a carton or filler-flat, they should be placed carefully, not dropped, and always packed with the small end down.

VIII. Determining Interior Quality by the Breakout Method

The breakout method of determining interior quality is a way for graders and students to fine-tune their grading skills. It enables them to make comparisons of broken-out egg appearance with candled appearance. The most accepted and widely used method for determining albumen quality is measuring Haugh units. The Haugh unit was developed by Raymond Haugh in 1937, and consists of a correlation of the height of the thick albumen, the weight of the egg, and the internal egg temperature. At one time, this method was part of USDA's quality control program.

Quality Control Program

Research workers and breeders experimented for years on a more objective way of determining interior quality based on the measurement of the height of the thick albumen correlated with the weight of the egg. Statistical analysis of the quality variation found in eggs from flocks of uniform age managed under similar conditions showed that a small sample of eggs randomly selected from these flocks each week was highly accurate in reflecting the average quality of the lot.

Based on the extensive research and the statistical analyses, USDA implemented a quality control program in 1959. This program made possible the marketing of high-quality eggs from the controlled flocks under the fresh fancy or AA label of identification. A program to market grade A eggs under the quality control program was also made available with less stringent requirements than the fresh fancy or AA program.

A small sample of eggs was randomly selected from flocks under the programs. These eggs were then broken out, the height of the thick albumen was measured with a micrometer, and the reading was correlated with the weight of the eggs. This resulted in a Haugh unit figure used to determine the quality of the egg. The higher the Haugh unit, the higher the quality of the egg. While the programs were excellent marketing tools for high-quality eggs, their use was very limited. The fresh fancy quality program practically ceased, and the grade "A" program was not used. Special handling was required for these programs, and additional equipment and facilities were required beyond those for the regular voluntary programs. The use of these programs probably was restricted by their cost and the fact that producers and packers did not receive premiums for the product sufficient to justify the costs. Thus the programs were eliminated in 1981.

Breakout Equipment

For economy in time and preservation of the product, the following equipment should be available to persons engaged in breaking eggs for the purpose of measuring the height of the thick albumen as well as the condition of the yolk and albumen:

Figure 51. Egg breakouts are conducted on equipment which typically includes a metal stand, glass top, and reflective mirror. (CD 8202 3241 1143-11)

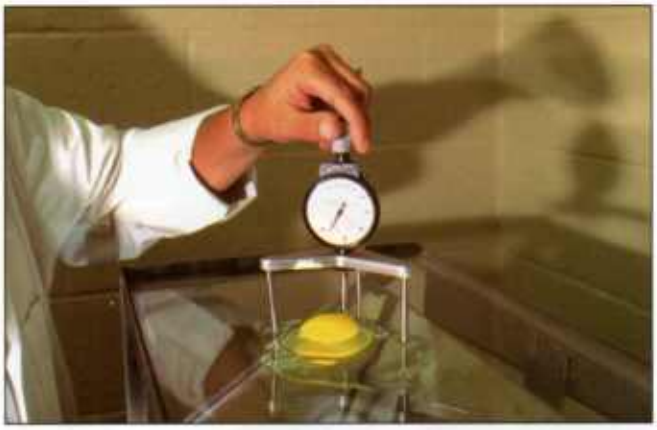

Figure 52. USDA grader demonstrating the use of a Haugh meter by measuring the height of the thick albumen. (CD 8202 3241 1143-17)

1. A flat glass surface approximately 12 by 18 inches (30.5 by 45.7 cm) or larger. The glass should be placed on a metal stand having adjustable legs for leveling. A mirror of approximately the same size as the glass is needed for observing the under side of the egg. The stand should be set on a table of such height that the dial of the micrometer will be at eye level when in use.
2. A standard individual egg scale that indicates the weight in ounces per dozen for each egg. A test weight should be used to check the scale at the start of the breaking operation and any time the scale is moved.
3. A knife and breaking tray obtained from an equipment supplier of egg-breaking equipment is very convenient for opening the eggs.
4. A Haugh meter that has a provision for setting the egg weight and provides a direct Haugh unit reading.
5. A squeegee is handy to move the broken egg from the glass surface to a suitable container.
6. Containers for collecting and holding egg shells and liquid egg contents.

Procedure

Comparable results can be obtained only if uniform procedures are used. Since eggs for top quality must have practically normal shells, the grader should select only such eggs when obtaining the sample for breakouts. The eggs must be cooled to an internal temperature between 45 and 60 °F (7.2 and 15.6 °C) . Additionally, the internal temperatures of the eggs selected for the breakout must be uniform to provide accurate and consistent results.

Care must be taken in using the breaking knife so the thick albumen is not ruptured. Consistent results can best be obtained by using a breaking knife. Blunt edges, such as a table edge, may cause the shell to splinter, with the possibility of puncturing the thick albumen. The egg should be held as near the glass as possible and the contents emptied very gently from the shell.

In some eggs, the envelope of thick albumen is rather firmly attached to the shell membrane in the small end of the egg. When this is noted, rupture of the thick albumen can generally be prevented by slowly raising the half shell. Haugh units should not be measured or recorded when the thick albumen or yolk membrane has ruptured.

The surface on which the egg contents are placed must be level. One egg at a time should be broken since it is important to measure the albumen height immediately after breaking. A delay of a few minutes can make a significant difference in the Haugh unit reading.

If a micrometer is used for measuring Haugh units, it must be checked before using. Set it on the glass and turn the measuring rod down until it touches the surface of the glass on which the broken-out egg will be placed. To be sure that the rod is actually touching the surface of the glass, push the edge of a thin sheet of paper against the intersection of the rod and the glass. The face of the micrometer is then turned so that the indicator will read zero. The procedure should be repeated from time to time during the breaking operation to be sure that the micrometer is properly adjusted.

When determining albumen quality with a Haugh meter or micrometer, select a flat area in the surface of the widest expanse of the thick albumen for measurement. Eggs with a very high albumen will not have a flat surface and in such cases a point about halfway between the yolk and the edge of the widest expanse of thick albumen should be selected. Care should be taken to avoid measuring areas over an air bubble or chalaza. The measuring rod should be rolled down slowly until it makes contact with the surface of the albumen and should be raised and cleaned before placing over the next egg to be measured.

IX. Egg Grading and Certification Services

Federal-State Grading Programs

For over 70 years, USDA in cooperation with the various States has conducted a voluntary Federal-State egg-grading service. The legislation authorizing this service provides that it be conducted on a self-supporting basis financed from fees charged to the applicants.

The grading service is based on the U.S. standards for quality of individual shell eggs and the U.S. grades and weight classes for consumer and nest run grades of shell eggs. In addition, contract purchase specifications serve as another basis for performing grading or inspection of lots of eggs tendered for delivery under purchase agreements. The various purchase specifications are, of course, based on the U.S. standards for quality of individual shell eggs.

Although the first quality standards for individual eggs were developed in 1925, the first standards for grades and weight classes were enacted under the Agricultural Marketing Act of 1946. It was during this period that the U.S. Government became involved in developing grade standards for numerous agricultural products. The application of standardized requirements for eggs became essential in fair trade and, subsequently, impacted the economical spectrum within the industry.

In the early days of the Federal-State grading service for poultry and eggs, the work consisted largely of examining eggs and poultry purchased by the U.S. Navy, to determine compliance with procurement specifications. Grading and inspection service of this type was gradually extended to other Government agencies and private institutions that purchased eggs and poultry products.

Grading offices were established at the important terminal markets along the east and west coasts, as well as in the inland terminal markets, such as St. Louis, MO., and Chicago, IL. These offices, in addition to providing grading service for eggs, poultry, and poultry products, handled the market news reporting activities which began at about the same time.

The growth of the service was slow at first, but expansion continued at a steady pace during the thirties. The most rapid expansion occurred during World War II in connection with Government buying programs for the Armed Forces, and it was during this period that resident grading programs developed into major importance.

The use of the services and the volume of products inspected and graded continued to expand after the end of hostilities. This expansion was due in part to the price-support programs that followed and to the fact that firms had previous experience with Federal-State grading and inspection programs and were continuing to use them in their processing and marketing programs.

Under these programs, a qualified USDA-licensed grader, whose duties included the grading of shell eggs in accordance with U.S. standards, was placed in the processing plant. With the advent of this "resident grader" type of service, the volume of products graded on a "fee basis" became proportionately less important, considering the overall volume officially graded. Resident services are usually performed by graders who are assigned to a specific plant on either a full-time or part-time basis.

Today, resident graders are used in the production areas, as well as in the distribution centers. Resident grading offers several advantages over the terminal market or fee type of grading service:

1. Graders are constantly available to grade and certify the pack, whether in cartons or loose.
2. Grading is likely to be more uniform because the grader is continuously available to check the accuracy of the candlers and processing equipment.
3. By constantly sampling product and monitoring the grading operation, graders can detect quality problems before large amounts of product are packed and rejected.
4. Depending on the volume of product graded, cost of resident grading service is usually substantially less per unit than intermittent fee grading.
5. Only resident plants are allowed to identify product with the USDA grade shield.

Grading service can also be provided on a "temporary plant" as-needed basis when requested by the applicant. Temporary plants must meet the same minimum facility, operating, and sanitary requirements specified in the regulations for resident service. All processing, grading, and packing of product identified with the grade shield must be completed under the supervision of the assigned grader.

Fee grading is performed when an applicant requests grading of a particular lot of eggs, often for verification of grade, size, or compliance with other contract require-

ments. Requests for this type of service are usually made on an irregular basis and the charges are based on the time needed to perform the work.

USDA's grading services for shell eggs are permissive, in that individuals, firms, or Governmental agencies that desire these services may request them on their own volition.

Application for grading service is usually made by telephoning the local USDA grading office or by contacting the Federal-State supervisor's office. Prospective applicants for egg grading services may also contact USDA in Washington, DC, regarding the availability of grading service in their areas. Services are performed on the basis of the Regulations Governing the Voluntary Grading of Shell Eggs and the U.S. Standards, Grades, and Weight Classes for Shell Eggs.

Today, voluntary egg grading and certification services are administered by the Poultry Programs, Grading Branch of USDA's Agricultural Marketing Service (AMS). Grading and certification is performed by USDA-licensed graders who are supervised by the State, regional, and national supervisors of the service. Graders may be either State or Federal employees.

Costs of Service

The legislation that authorizes Federal-State grading programs provides that the costs of the service be covered by fees charged to firms who use the service. Schedules of charges have been established to cover these costs. Included as cost items are the salaries and fringe benefits of the graders who perform the service, travel costs incurred in connection with grading activities, clerical assistance in maintaining necessary office records, supervisory costs at the field level, and administrative and overhead costs at the Washington level.

Fees for grading service performed on a resident or continuous grading basis are based on the cost to USDA of furnishing the grader or graders to the plant, plus an overhead administrative charge based on the volume of the product handled in the plant to cover supervisory and other costs. Salaries of Federal resident graders are based on the U.S. Government's General Schedule (GS) rates. The charges for grading shell eggs on a temporary plant fee basis are based on the time required to render the service. The fee schedules are updated from time to time as costs change. Whether the grading is done on a fee basis or a resident basis, the cost will generally average only a fraction of a cent per dozen eggs.

Cooperative Agreements

The Federal-State egg grading service is conducted under cooperative agreements between USDA and one or more cooperating parties within most of the States. The agreements are usually made with State departments of agriculture.

State colleges and extension services often cooperate in the educational aspects of the grading program by providing training for prospective graders and by explaining the Federal-State program to producers, handlers, and consumers.

State departments of agriculture are usually responsible for the administrative phases of the program within their States. These responsibilities may vary from State to State.

There are two main types of agreements — State Trust Fund and Federal Trust Fund. Under the State Trust Fund agreement, fees charged are collected and held in trust by the State. The applications for service are between the State and the individual firms, and the resident graders are State or Federal employees. To cover the cost of the Federal supervision of the program and Federal graders working within the State, the cooperating State periodically reimburses USDA from the State Trust Fund.

Under the Federal Trust Fund agreement, the contracts for services are between USDA and the individual firms, and the fees are collected and held in trust by USDA. The employees doing resident grading work are Federal or State employees, and the State is periodically paid an amount out of the trust fund that is in accordance with the terms of the agreement.

X. Official Grade Labeling and Identification

Several requirements must be met before packaged eggs may be grade labeled with the official grade shield:

1. The eggs must be graded by and identified under the supervision of a licensed grader. The eggs may be graded by an authorized company employee, but then must be check-graded by the supervising grader.
2. Eggs to be packed in packages and marked U.S. grade AA, U.S. grade A, or U.S. grade B must be packed from eggs of current production. Current production means that the eggs are not older than 30 days when packed.
3. Once packed and shipped for consumer sales, officially graded and identified eggs may not be regraded, repackaged, or redated.
4. Eggs must be packed in establishments meeting the facility and operating requirements set forth in the USDA regulations.

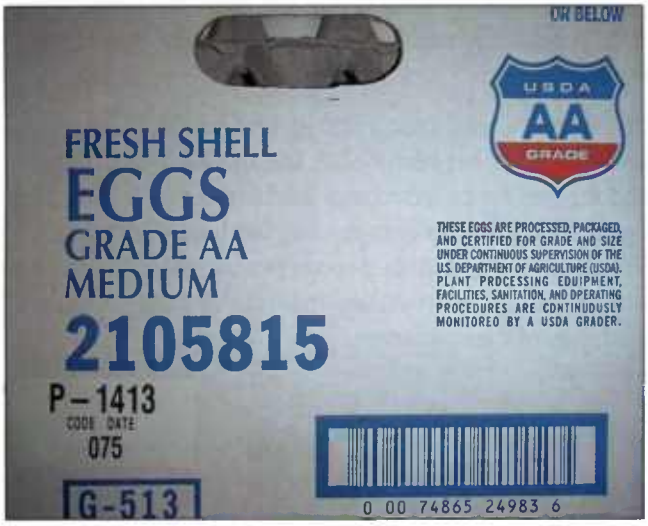

Figure 53. For marketing purposes, the official grademark may be preprinted on shipping cases. (00CN0053)

The greatest use of the grading program is in the grade labeling of individual consumer packages of eggs to inform consumers of the quality. The regulations provide for the approval of grade labels that are used in the program. The *grademark* used on officially graded product is contained in a shield design (figs. 54, 55, and 56). The shield contains the letters "USDA" and the grade. The size may also appear in the shield. The shield is usually printed in a prominent place on the consumer package.

Under the Federal-State grading program, provisions are made for the grade identification of the packaged product, whether packed bulk in 15- or 30-dozen cases, 1-dozen cartons, or other consumer-sized packages. Usually *the official grademark* is applied to cases of bulk-packed eggs by means of a rubber stamp (fig. 57). The stamp also specifies the date the eggs were graded and the plant number. When packed in cases, each case is sealed with either paper or plastic tape, and the stamp is placed on one end of the case partially on the tape and partially on the case or adjacent to the tape.

Figure 57. Official grademark applied to cases of bulk packed eggs by means of a rubber stamp. (00-CN-0604)

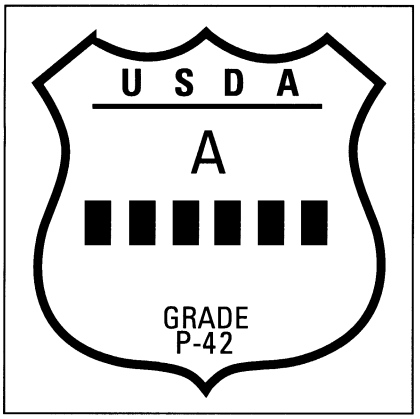

Figure 54.

Figure 55.

Figure 56.

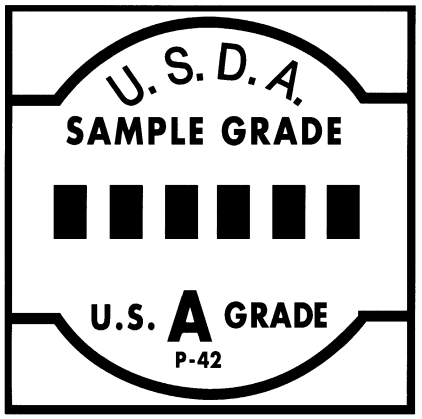

Figure 59.

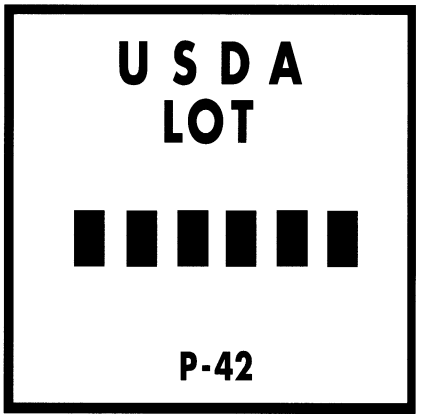

Figure 60.

Figure 61.

Figure 62.

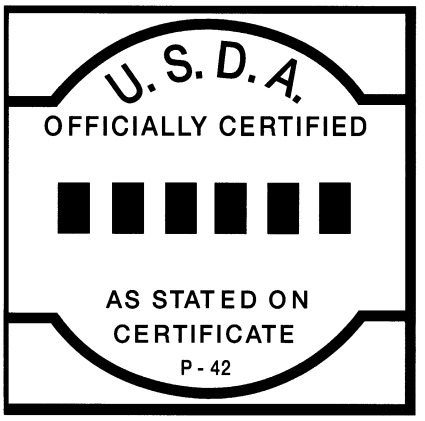

Figure 63.

Figure 64.

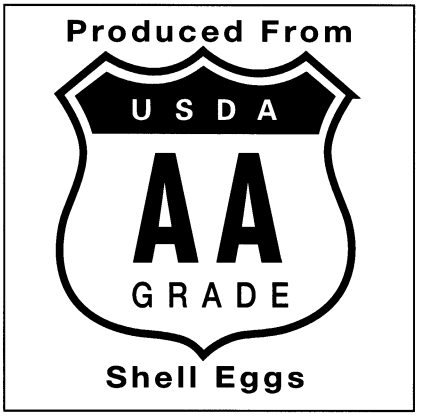

Figure 65.

When using the official grademark, the date of grading, corresponding to the consecutive calendar day of the year when the eggs were actually packed into the consumer package, must also be shown on the package. The use of expiration dates on consumer packages by the packer or retailer is optional. When used, the expiration date must bear an appropriate qualifying prefix such as "EXP" or a preprinted statement such as "Sell by," "Not to be sold after date on top or end" or "Last sale date on end" (fig. 58). All expiration dates are calculated from the date the eggs are packed into the consumer package and may not exceed 30 days, including the date of pack.

Terminology such as "Use before," "Use by," "Best before," or other similar language generally indicates the maximum time frame for expected quality. The dates associated with these prefixes must be calculated from the date the eggs are packed into the consumer package and may not exceed 45 days, including the date of pack.

Figure 58. Labeling on consumer cartons of officially identified eggs must include the lot number and official plant number. Expiration dates are optional but, if included, must be preceded by "EXP" or words of similar meaning. (CD 8202 3241 1143-8)

The ***USDA Sample Grade stamp*** (fig. 59) is used to identify shipping containers of loose-packed or cartoned eggs that were not packed under USDA supervision. The words "USDA Sample Grade" and the Grade AA, A, or B designation indicate that a representative sample of the lot meets the grade requirements. The date of grading and the number of the official plant where the product was sample-graded by USDA are also shown. If not sample-graded in an official USDA plant, the stamp will show a grader number instead of a plant number.

The ***USDA Lot stamp*** (fig. 60) is used on containers of eggs to be identified with a consumer grademark at a later date. The eggs are to be processed under continuous USDA supervision and must meet all the processing requirements outlined in the regulations. The lot number used in the stamp is the consecutive day of the year the eggs were packed. The number of the plant where the eggs have been processed is also shown.

The ***USDA Contract Compliance stamp*** (fig. 61) is used to identify shell eggs which comply with written contract or specification requirements. The eggs may or may not have been processed and graded in an official USDA plant depending on the terms of the contract. Compliance is determined on a sample-graded basis by either a resident grader or a fee grader. The date of grading or a certificate number appears in the stamp, as well as a plant or grader number. A grading certificate should accompany the eggs upon delivery.

The ***USDA Graded for Export stamp*** (fig. 62) is used to identify product packed for export shipments under the Export Enhancement Program, or for commercial export sales. The eggs may or may not have been processed and graded in an official plant depending on the terms of the contract. Compliance is determined on a sample-graded basis by either a resident grader or a fee grader. A grading certificate is provided, and should accompany the eggs upon delivery. The certificate number appears in the stamp as well as a plant or grader number.

In lieu of stamping each case, some truck shipments of officially graded consumer-packaged or loose eggs may be sealed by the grader and the seal number recorded on a grading certificate. The buyer and seller rely on the certificate to give the grade and percentages of the various qualities of the eggs in the shipment.

The ***USDA Officially Certified as Stated on Certificate stamp*** (fig. 63) is used on containers of shell eggs that have been certified as "disease free," for condition, or for other types of certifications where the grade and size are not referenced on the certificate. The certification information is recorded on a certificate, and the certificate number is shown in the stamp.

The ***USDA Certified Pasteurized stamp*** (fig. 64) is used to identify pasteurized eggs that have been processed in accordance with established pasteurization processing requirements.

The ***Produced From ____ Shell Eggs stamp*** (fig. 65) is used to identify pasteurized eggs that have been produced from officially graded eggs identified as U.S. Consumer Grade A or Grade AA.

XI. Certification to Specific Purchase Requirements

Poultry Programs provide certification services, as well as grading services. These certification services provide volume food buyers with the ability to tailor their purchase specifications to meet their unique needs. Volume food buyers include food service operators, retailers, brokers, wholesalers, and exporters. Certification involves determining compliance with the specific requirements in a purchase contract, and then issuing a contract acceptance certificate verifying compliance. Demand for this type of certification, or contact acceptance service, continues to expand.

Basically, contract acceptance involves the review and acceptance of eggs that have specific desirable attributes required by the buyer. These certification-type examinations usually include grade and other quality factors that may be specific for the intended use of the product.

These product-specific certification services are available to volume purchasers of eggs and can include:

1. Independent, third party certification of egg quality based on U.S. or other standards.
2. Certification that purchases meet contract specifications for quality, grade, weight, quantity, temperature, packaging and packing, transportation, or other desired product characteristics.
3. Assurance of product quality on a continuous basis regardless of supplier.
4. Continuous monitoring of plant facilities and processing equipment to ensure appropriate sanitary standards are met.
5. Assurance that plants use only USDA approved chemicals, compounds, insecticides, and rodenticides according to manufacturers' instructions.
6. Identification of eggs with a USDA plant number and code date to facilitate an immediate traceback, if necessary.
7. Establishment of a common language that enables buyers and sellers to communicate about egg quality and other characteristics without actually seeing the product.
8. Establishment of a basis for fair, competitive bidding between suppliers.

USDA grading specialists can help food purchasers prepare explicit egg specifications and then certify that purchases comply with these specifications. This assures purchasers that they are getting what they order, results in overall higher quality eggs, permits long-range meal planning, and eliminates controversies between the buyer and seller over compliance of the product.

Pasteurized Shell Eggs

The pasteurization of shell eggs is a recently developed process intended to destroy any harmful viable microorganisms, specifically *Salmonella enteritidis*, that may be present in the egg. In 1997, a notice published in the *Federal Register* advised that AMS will provide a voluntary certification program for pasteurized shell eggs. Once a processor's pasteurization process is reviewed and approved by the Food and Drug Administration (FDA), the processor may request that AMS provide certain official marking and identification services that would assist them in marketing their products.

Since FDA is responsible for the definitions and labeling of foods such as eggs, shell egg processors must first receive FDA authorization to use the term "pasteurized" in conjunction with their shell egg labeling. FDA's criterion for pasteurization is a 5 log reduction in total *Salmonella* count. Processors must demonstrate the effectiveness of their pasteurization process by obtaining and providing FDA with data that shows their process results in the required reduction. Additionally, they must demonstrate that, after pasteurization, product integrity can be ensured through the packaging, packing, and marketing processes.

Upon satisfying these requirements, processors are authorized to state that their products are USDA Certified Pasteurized provided that an AMS grader monitors the pasteurization process to ensure it is conducted in accordance with established requirements. For products in compliance with these requirements, the shield-shaped certified as pasteurized symbol may be placed on the packing and packaging material (fig. 64).

Processors who do not wish to have their pasteurization process monitored and certified by AMS have the option of certifying that the pasteurized eggs are produced from officially graded eggs identified as U.S. Consumer Grade A or Grade AA. (fig. 65).

XII. Plant Sanitation and Good Manufacturing Practices Program (PSGMP)

As previously noted, USDA's Agricultural Marketing Service, Poultry Programs administers a voluntary egg grading service to processors who request it. Under this service, USDA graders continuously monitor the grading and packing of eggs to ensure that they meet the applicable quality and size standards. In addition, plant processing equipment, facilities, sanitation, and operating procedures are checked and verified according to regulation requirements. By meeting these requirements, eggs packed at official plants are eligible to carry the USDA grade shield.

More emphasis is being placed on food quality, associated quality systems based on the Hazard Analysis and Critical Control Point (HACCP) system, and the International Standards Organization (ISO) 9000 quality principles. Poultry Programs has developed a sanitation and good manufacturing practices program for use by egg processors based on these principles. Facility and operational requirements for this program are more comprehensive than the basic requirements for the traditional resident grading program. Processors who consistently meet minimum program requirements are entitled to use the verification shield (fig. 68) on packing and packaging materials.

The primary objectives of the PSGMP program are as follows:

1. Provide a comprehensive sanitation and quality program for official plants that supplements the voluntary egg grading service.
2. Provide a sanitation and quality program that is universally recognized and accepted by major volume food buyers and retailers.
3. Provide participants a method to convey to customers their commitment to quality and sanitation through use of the PSGMP verification shield.

Criteria for determining initial acceptance into the program are based on good manufacturing and sanitary practices typically associated with processing eggs and quality assurance. The PSGMP program monitors over 80 prerequisite control points encompassing all phases of processing, storage, and transportation. Participating plants are required to develop and follow a quality manual that addresses each of the control points by stating how they are monitored, the frequency of monitoring, the responsible person for monitoring, and any deviation procedures.

Figure 66. USDA graders conduct pre-operational sanitation checks of equipment prior to processing. (00CN0054)

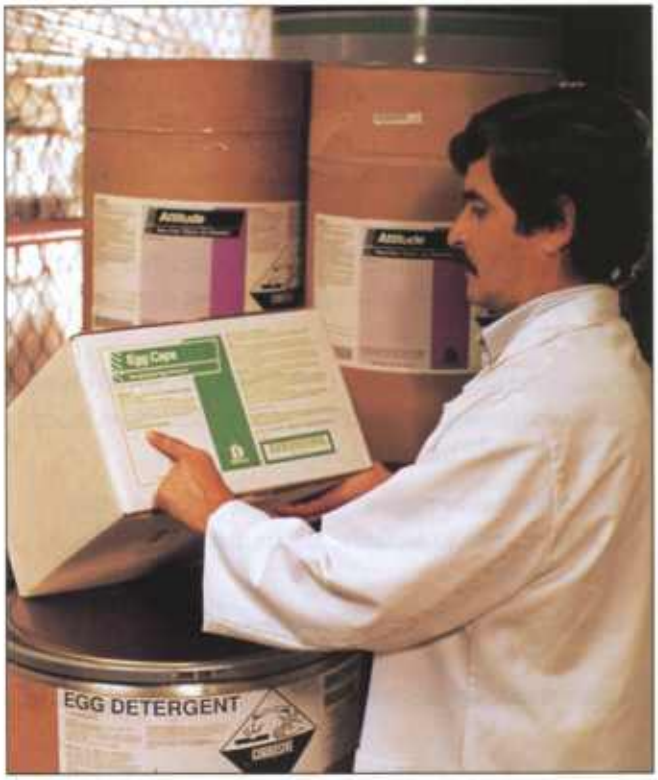

Figure 67. USDA grader verifies that chemical compounds used in official plants are approved and used according to manufacturers' instructions. (00-CN-0605)

Figure 68. The PSGMP program logo designates that the participating plant has, on a continuous basis, met all of the specified program requirements.

For participating firms, monthly audits are conducted to determine compliance with the control points listed on the Audit of Sanitation and Operating Procedures for Shell Egg Processing Plants worksheet (fig. 69). The audit includes a general sanitation inspection of premises, facilities, and equipment for cleanliness along with a review of washing, packing, cooling, and storage practices. Continued participation in the PSGMP program is contingent upon maintaining a satisfactory level of compliance.

Each area of operation is assessed to determine its level of significance, and subsequently designated either minor, major, or critical. Upon completion of each audit, USDA personnel will review the overall assessment with plant management and establish time frames for correcting non-complying items. When areas of non-compliance are found, the participant is expected to immediately address the issues and correct the deficiencies within the established time frames.

8/11/98

U.S. DEPARTMENT OF AGRICULTURE
AGRICULTURAL MARKETING SERVICE
POULTRY PROGRAMS

AUDIT OF SANITATION AND OPERATING PROCEDURES FOR SHELL EGG PROCESSING PLANTS

NAME AND ADDRESS OF PLANT (City, State, and ZIP)	DATE OF AUDIT (Month, Day, Year)		PLANT NUMBER
	PRE-AUDIT SURVEY	☐ YES	☐ NO
	REGULAR AUDIT	☐ YES	☐ NO
DESIGNATED REPRESENTATIVE	FOLLOW-UP AUDIT	☐ YES	☐ NO

This audit was completed on the date indicated by a Grading Branch representative of the USDA.
The following areas or items were checked and determined to be satisfactory or unsatisfactory in accordance with USDA's Plant Sanitation and Good Manufacturing Practices Program for Processing Eggs. All items not satisfactory are to be explained in the remarks section.

I. BUILDINGS AND PREMISES	Satis	Minor	Major	Critical	Comments:
A. Outside premises, shipping, and receiving areas clean, well maintained, and properly drained.		X			
B. Buildings of sound construction and in good repair.		X			
C. Floors constructed of washable materials.		X			
D. Use of moisture impervious materials where appropriate.		X			
E. Packing and packaging storage areas kept clean and dry.		X			
F. Adequate floor drains provided with covers.		X			
G. System for daily removal of refuse and a designated area for the accumulation of refuse provided and kept clean.		X			
H. Rodent and Pest Control					
1. An integrated rodent and pest control program is established and documented in Quality Manual.			X		
2. Records available indicating results of inspections and corrective actions.		X			
3. Records available indicating control procedures and activities.		X			
4. Pesticides used in accordance with manufacturers instructions.			X		
5. Inspection of premises and facilities indicates that the rodent and pest control program is effective.			X		
I. Handling of Inedible Product					
1. Inedible product is properly denatured, labeled, and disposed of according to established requirements.			X		
2. Inedible containers thoroughtly cleaned after use and remain reasonably clean during use in processing areas and storage.		X			
3. Inedible product stored in designated areas separate from edible food products.			X		
II. SHELL EGG WASHING, GRADING, AND PACKING OPERATIONS AND EQUIPMENT Type of water supply: Municipal _____ Well _____					
A. Potable water supply. Date tested _____.			X		
B. Water chlorinators functioning properly, if required.			X		
C. Satisfactory water supply with iron content of less than 2 parts per million. Content _____.		X			
D. Pre-Operative Sanitation Inspection					
1. Loaders, conveyers, and orienters clean and sanitary.		X			
2. Washers, nozzles, brushes, and compartments clean and sanitary.			X		
3. Plastic flat washers and dryers clean and sanitary.		X			
4. Egg drying equipment clean,sanitary, and filters regularly changed or cleaned.			X		
5. Mass scanning, scales, and packing equipment and conveyors clean and sanitary.				X	
6. Egg oiling equipment clean and sanitary and oil free of off odor or obvious contamination.				X	
7. Other product non-contact surfaces and equipment clean and sanitary.		X			

Figure 69 A.

II. SHELL EGG WASHING, GRADING, AND PACKING OPERATIONS AND EQUIPMENT (CONT'D)	Satis	Minor	Major	Critical	Comments:
E. Egg wash water temperature maintained at a minimum of 90° F and at least 20° F higher than the internal temperature of the eggs to be washed.				X	Internal egg temperature(s): _____/_____ Wash water temperature(s): _____/_____
F. Prewetting water temperature maintained at a minimum of 90° F and at least 20° F higher than the internal temperature of the eggs to be treated.			X		Prewetting water temperature(s): _____/_____
G. Waste water from washers discharged directly to drain.		X			
H. Steam and vapors generated from the washing operation continuously exhausted directly to the outside of the building.		X			
I. Sanitizer spray system functioning properly and concentration levels of not less than 50 p/m nor more than 200 p/m of chlorine or its equivalent is maintained.				X	p/m_____/_____
J. Temperature of sanitizing spray equal to, or warmer than the wash water.		X			
K. Washing, grading, and packaging equipment maintained in a clean and sanitary condition during processing operations.			X		
L. Packaging and packing materials new, clean, and free of mold, mustiness, and off odors.				X	
M. Wash water PH of >10 continuously maintained. PH levels _____/_____			X		
N. Benches, shelves, and packing tables constructed of materials that are impervious to moisture.		X			
O. Fixtures over packing and packaging areas are free from dust, dirt, and condensation.		X			
P. Lights over processing and packaging areas protected to prevent contamination in case of breakage.			X		
Q. Processing areas maintained in a clean and sanitary condition during processing operations.			X		
R. Reprocessed store and warehouse returned eggs are diverted for restricted egg disposition or packed in non-officially identified packaging material.			X		
III. SHELL EGG COOLING FACILITIES					
A. Ambient air temperature of 65° F or lower maintained in unprocessed egg coolers.		X			
B. Thermometers or recording charts provided in all unprocessed egg coolers.		X			Temperatures of each cooler: _____/_____
C. An ambient air temperature of 45° F or lower maintained in processed egg coolers.			X		Temperatures of each cooler: _____/_____
D. Thermometers or recording charts provided in all processed egg coolers.		X			
E. Relative humidity in all coolers maintained between 70 and 85%.		X			Humidity of each cooler: _____/_____/_____/_____
F. Hygrometers available for verifying the relative humidity.		X			
G. Coolers free of other food products that may produce off-odors or flavors.		X			
H. Unprocessed egg coolers maintained in a sanitary condition and free from odors and mold.			X		
I. Processed egg coolers maintained in a sanitary condition and free from odors and mold.				X	
J. All labeling bears the refrigeration statement "Keep Refrigerated".		X			
K. Packed and packaged eggs moved to coolers within 2 hours of packing.			X		
IV. HEALTH AND CLEANLINESS OF EMPLOYEES					
A. Employees in direct contact with eggs wearing clean clothes or outer garments.			X		
B. Handwashing facility provided in processing area and operating properly.			X		
C. Employees washing their hands as instructed.			X		
D. Only employees free from evidence of any communicable disease, open sores, or other similar symptoms working in processing areas.			X		
E. Employees have received proper training in food handling, disease control, and food protection principles.		X			

Figure 69 B.

V. TOILET AND HANDWASHING FACILITIES	Satis	Minor	Major	Critical	Comments:
A. Restrooms constructed of materials which are easily cleaned.			X		
B. Maintained in a clean and sanitary condition.			X		
C. Properly vented to outside of building.		X			
D. Hot and cold running water provided.			X		
E. Soap and sanitary towels provided.			X		
F. Signs posted in restrooms advising employees to wash their hands before returning to work.		X			
G. Restroom provided with a sanitary waste receptacle when required.		X			
VI. STORAGE AND USE OF CHEMICALS AND COMPOUNDS					
A. Use only approved pesticides, rodenticides, and insecticides according to manufacturer's instructions.			X		
B. Use only approved egg cleaning compounds according to manufacturer's instructions.				X	
C. Use only approved sanitizing compounds for sanitizing eggs according to manufacturer's instructions.				X	
D. Use only approved oils in shell treating operations according to manufacturer's instructions.				X	
E. Chemical compounds stored separately from edible food products.			X		
F. Use only approved inks for stamping individual eggs according to manufacturer's instructions.				X	
VII. TRANSPORTATION AND STORAGE					
A. Egg transport carriers reasonably clean and suitable for transporting food products.				X	
B. Eggs loaded and transported in a manner that prevents damage and facilitates the cooling process.		X			
C. Egg transport carriers capable of producing an air temperature of 45° F or below.			X		
D. Thermometers or recording charts available for verifying transport temperatures.		X			
VIII. RECALL AND COMPLAINT PROCEDURES					
A. Procedures for handling product recalls are documented in the Quality Manual and followed.		X			
B. Procedures for receiving, investigating, and responding to customer complaints are documented in the Quality Manual and followed.		X			
IX. QUALITY MANUAL					
A. Quality manual provided which addresses the PSGMP prerequisite requirements.			X		
B. Quality manual current and being followed.			X		
C. Control points with limits established for each prerequisite requirement.			X		
D. Procedures to monitor control points are established and followed.			X		
E. Corrective action taken when deviations are noted.				X	
F. Recordkeeping systems accurate and current.			X		
G. Procedures established to assure that equipment and rooms are thoroughly cleaned at the end of each production day.			X		
H. Procedures established to test and calibrate equipment used to monitor and control points. Tests conducted on a quarterly basis.			X		
TOTALS:					

RATING: ☐ Satisfactory ☐ Unsatisfactory

REMARKS:

GRADING REPRESENTATIVE'S SIGNATURE	DESIGNATED REPRESENTATIVE'S SIGNATURE

Figure 69 C.

Section XIII. Legislation Affecting Grading and Marketing of Eggs

Much legislation has been enacted to regulate the sale of shell eggs. The laws apply to the edibility of the product and to its quality and grade. Both Federal and State laws are applicable to eggs, but practically all of those pertaining to candling and grading have been enacted by the States.

Federal Laws

The Farm Products Inspection Act of 1917 provided the original authority for establishing grades and grading service for voluntary use. Beginning in 1925, this authority was provided each year by an act of Congress that also provided the USDA appropriations.

The Agricultural Marketing Act of 1946 contains the authority under which the present grading service is performed and authorizes the development of standards. The U.S. standards for quality of individual shell eggs serve as a basis not only for establishing U.S. grades, but also for developing State standards and grades.

The Egg Products Inspection Act (EPIA)(Public Law 91-597), which became law in 1970, provides for the uniformity of standards and grades. The Act states: "For eggs which have moved or are moving in interstate or foreign commerce, no State or local jurisdiction may require the use of standards of quality, condition, weight, quantity, or grade which are in addition to or different from the official Federal standards." This has prompted States with egg laws in which the standards and grades differ somewhat from the official Federal standards and grades to amend their laws to comply with the Federal standards. A provision on labeling prohibits States from requiring labeling on eggs from other areas to indicate the State or other geographic area of production or origin. This provision does not apply to Alaska, Hawaii, Puerto Rico, or the Virgin Islands.

The Federal Food, Drug, and Cosmetic Act, and the regulations for its enforcement, apply to all food products in interstate commerce, including shell eggs. This act is designed to prevent the shipment of adulterated and misbranded foods. In applying this act to such eggs, a small tolerance for loss eggs is permitted, as it would be rather difficult, costly, and impractical to eliminate all loss eggs from wholesale quantities of eggs.

The Federal Trade Commission has responsibility for regulating the business practices engaged in by firms marketing eggs in interstate or foreign commerce.

Surveillance Inspections

EPIA also controls the disposition of certain undergrade eggs to prevent their getting into consumer channels. These eggs are defined in the act as "restricted eggs" and include checks, dirty eggs, incubator rejects, inedibles, leakers, and loss eggs. Checks and dirties can move to official USDA egg breaking plants where they can be handled and processed properly. All other restricted eggs must be disposed of in a way that prevents their use as human food. They could be denatured with a color dye or other approved materials and be used in animal foods.

The EPIA provides for inspections of shell egg handlers to control the disposition of restricted eggs and to assure that the eggs sold to consumers contain no more restricted eggs than permitted in U.S. Consumer Grade B. Shell egg handlers include firms that grade and pack eggs for the ultimate consumer, commercial distribution, and hatcheries. Each handler is required to register with the USDA.

Under this program, quarterly visits are made to each producer/packer and yearly visits are made to hatcheries. The visits are conducted by either a State or Federal shell egg surveillance inspector to verify that shell eggs packed for consumers are in compliance, that restricted eggs are handled properly, and that adequate records are being maintained as required.

State Laws

In 1919, the first State egg laws were enacted in South Dakota, Iowa, and Illinois. The earliest regulations mainly prohibited the sale of inedible eggs. Since then, egg laws have been enacted in all of the 50 States. The laws regulate the labeling, grading, and marketing of eggs and reference the U.S. standards, grades, and weight classes. *The*

inspection of eggs at retail outlets for grade and weight compliance is basically the responsibility of State regulatory agencies under State egg laws.

New York was one of the first States to enact a law requiring that eggs be labeled by quality and size. New York egg producers hoped that proper labeling for quality, coupled with an intensive consumer education program, would cause consumers to be willing to pay more for top quality. They believed that local producers would benefit because of the higher yield of top quality eggs that packers could obtain from their eggs. Today, most States have labeling requirements and require licenses or permits for the sale of eggs.

The provisions of the EPIA concerning standards, grades, and labeling have helped to ensure the free movement of eggs in interstate commerce, and eliminate features in State egg laws that tend to act as trade barriers.

XIV. Egg Quality Schools and Training Sessions

Egg quality schools and training sessions are an effective means for students, quality control personnel, graders, and managers to learn about egg quality, standards, hand candling techniques, and egg processing practices. These sessions can be formal or informal depending on the level and extent of training desired.

Formal Training

In regards to formal training, the National Egg Quality School is one of the most extensive egg training programs currently conducted. This annual school is sponsored by United Egg Producers, State departments of agriculture, agricultural colleges and universities, and State poultry and egg associations. Curriculum covered during the 4-day session includes egg formation, abnormalities, interior and exterior quality, conserving egg quality, and HACCP development. The training includes individualized "hands-on" laboratory sessions, as well as classroom-type lectures. The instruction staff includes leading university scientists, experienced State and Federal egg graders, and qualified industry representatives. Additional information concerning this school can be obtained by contacting:

National Egg Quality School
United Egg Producers
P.O. Box 170
Eldridge, IA 52748
Telephone: (319) 285-9100
Fax: (319) 285-9109

Informal Training

Informal training can be conducted on-site at the processing plant or at other locations where the essential equipment and facilities are available and where there is sufficient space for classes and laboratory practice sessions. Informal training can be conducted by plant personnel or other outside sources. Additionally, AMS Poultry Programs offers an egg quality training service that can accommodate specific training needs of the applicant. This service is conducted by technical supervisors who are egg grading experts and whose assistance can range from developing agenda material to conducting the entire training session.

Regardless of the type or source of training, the information contained in this manual can serve as the course outline. It can be presented as a 1-day refresher course for egg graders, or expanded into a 2- to 5-day school allowing each topic to be covered in greater detail. The school should be supplemented with appropriate slides, videos, and other visual aids. Laboratory classes and hand-candling sessions are also valuable components to any egg quality school. The instructors responsible for setting up the hand-candling session should include a wide variety of qualities within the various lots of eggs candled. The selection and arrangement of the eggs for student practice and testing is important in determining the students' comprehension and will influence the overall success of the school.

In addition to hand-candling demonstrations, the laboratory session should include classification with respect to quality factors and weight classes. Each student should classify the various lots of eggs as the instructor corrects or adjusts interpretation and technique. After the student becomes reasonably accurate in interpreting each quality factor, combined lots of various qualities can be candled and graded.

Each student should also be familiar with the use of a micrometer to measure the height of the thick albumen to determine quality by the break-out method.

For further information and training aids contact:

National Supervisor, Shell Eggs
Grading Branch, Poultry Programs
USDA - AMS - STOP 0258
1400 Independence Avenue, SW
Washington, DC 20250-0258
Telephone: (202) 720-4411
Fax: (202) 690-3165

XV. Resource Materials Available

The following materials are free, unless otherwise noted. For prices and other information, call (202) 720-3506. Publications available on the Internet are marked accordingly. Send orders to:

USDA-AMS-Poultry Programs-STOP 0259
1400 Independence Avenue, SW
Washington, DC 20250-0259

Regulations Governing the Voluntary Grading of Shell Eggs, 7 CFR Part 56
www.ams.usda.gov/poultry/regulations

U.S. Standards, Grades, and Weight Classes for Shell Eggs, AMS 56
www.ams.usda.gov/poultry/standards

Egg-Grading Manual, AH-75 (for sale)
Guide to the uniform application of U.S. standards, grades, and weight classes for shell eggs. Also provides current and historical perspectives pertaining to grading, production, and the processing of eggs. Training aid for graders, students, quality control personnel, processing personnel, and volume food buyers. 2000.

U.S. Standards for Quality of Individual Shell Eggs, AMS 605 (for sale)
Photos illustrating interior and exterior quality factors used as the basis for U.S. standards and grades for shell eggs. Chart, 15x22 inches, 4 color. 1992.

Guidelines for Operating Under the Plant Sanitation and Good Manufacturing Practices (PSGMP) Program

Buy Quality Eggs with Confidence, AMS-625
Egg certification services for volume food buyers. Two-page color flyer. 1996.

Quality Eggs for Volume Buyers, AMS-626
Egg certification services for volume food buyers. 12-panel folder. 1996.

Specifications for Shell Eggs
A guide to egg certification services with detailed egg specifications for volume food buyers.

Shedding Light on the Grademark
Videos show USDA graders performing various egg grading and certification services, and processors, retailers, and volume food buyers discussing how they utilize and benefit from these services. AMS-629 outlines information presented in the videos.

Video - 7-minute VHS format (for sale)
Video - 15-minute VHS format (for sale)
AMS-629 - 12-page brochure, 1998.

How to Buy Eggs, G264
General consumer information regarding egg wholesomeness, nutritive value, standards, buying and storage tips, and safe handling. 12-page brochure. 1995.
www.ams.usda.gov/howtobuy

Photographs in this manual and about related topics are available from:

USDA, OC, STOP 1390
1400 Independence Avenue, SW
Washington, DC 20250-1390
(202) 720-4022
www.usda.gov/oc/photo/opchomea.htm

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