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. and as the egg cools to room temperature the liquids contract more than does the shell. As the result of this contraction, the inner shell membrane separates from the outer to form the 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 air-cell gage (fig. 11). In candling, the air cell is considered by many as a relatively unimportant quality factor for determining the broken-out quality 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 as to 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 cells permitted in the various qualities is as follows:

Quality	*Depth*
AA	1/8 inch
A	3/16 inch
B	No limit

The air-cell gage 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 gage to check 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. 11).

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.

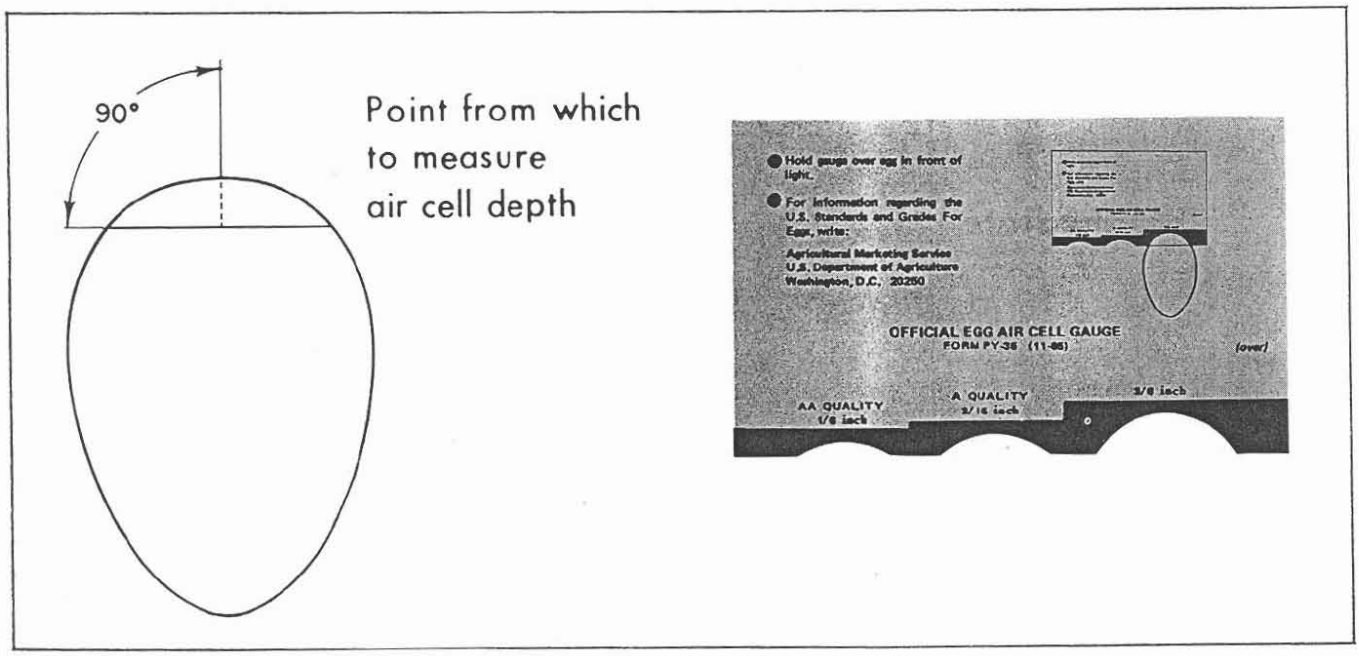

Figure 11.—Measuring depth of air cell.

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. However, there are three factors about the yolk itself that are considered in judging egg quality by the yolk. These are:

1. Distinctness of yolk shadow outline.
2. Size and shape of yolk.
3. Defects and germ development.

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

(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 of blemishes that show up before the candling light as dark shadows on the yolk, or the absence of these blemishes; and 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, therefore, 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 holding 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 for quality of 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).

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

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

Size and Shape of Yolk. The yolk in a new-laid egg is round and firm. As the yolk ages it absorbs water from the white. This increases its size 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 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, detection of them is difficult, particularly when the egg has a thick white. 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

Nearly all new-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 white. The white and yolk are very closely associated and any discussion of either factor, of necessity, involves the other. However, there are two important considerations about the white which are included in standards of quality: condition or viscosity and clarity.

The condition of the white 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 white. Thick whites permit only limited movement of the yolk and an indistinct shadow results.

The reverse is true of thin whites which permit free movement of the yolk and a distinct shadow results. The grader must judge from the behavior of the yolk, how the white will appear when the egg is broken out. Figure 9 shows the appearance of the white in broken-out eggs.

The following terms describe the white:

Clear — A white 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 — A white 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 white has a Haugh unit value of 72 or higher when measured at a temperature between 45° and 60° F. (AA quality).

Reasonably firm — A white that is somewhat less thick or viscous than a firm white. A reasonably firm white 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 white has a Haugh unit value of 60 to 72 when measured at a temperature between 45° and 60° F. (A quality).

Weak and watery — A white that is weak, thin, and generally lacking in viscosity. A weak and watery white 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 white has a Haugh unit value lower than 60 when measured at a temperature between 45° and 60° F. (B quality)

Blood spots or meat spots — Small blood spots or meat spots (aggregating not more than one-eighth inch in diameter) may be classified as B quality. If larger, or showing diffusion of blood into the white surrounding a blood spot, 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 white. Meat spots may be blood spots which have lost their characteristic red color or tissue from the reproductive organs.

Bloody white — An egg which has blood diffused through the white. Such a condition may be present in new-laid eggs. Eggs with bloody whites are classed as loss.

Loss Eggs

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

Loss — An egg that is inedible, leaker, cooked, frozen, contaminated, or containing bloody whites, large blood spots, large unsightly meat spots, or other foreign material.

Inedible eggs — Inedible eggs are described in the U.S. standards to include black rots, white rots, sour eggs, eggs with green whites, musty eggs, and moldy eggs. These types of inedible eggs are usually caused by the growth of bacteria or mold on or in the egg. Other types of inedible eggs are those showing blood rings, and those containing embryo chicks (at or beyond the blood ring stage) which result from germ development in fertile eggs. Two additional types of inedible eggs are mixed rots and eggs with stuck yolks.

The freshly laid egg is usually free of bacteria on the inside and is well protected from bacteria by the shell, shell membranes, and several chemical substances in the egg white. If subjected to warm temperatures or moisture, or both, bacteria are able to penetrate the egg and overcome the egg's defense. When bacteria grow inside the egg they may form byproducts or cause the contents of the egg to decompose, or both. These conditions result in the characteristic colors, appearance, or odors from which the rots take their name.

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

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"; later "mixed rot" or "addled egg."

Mixed rot (addled egg) 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.

Sour egg is 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.

Eggs with *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.

In early stages the *white rot* 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. This is classified as a "mixed rot."

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

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.

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.

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 at this stage the embroy dies the blood drains to the outer edge of the germ disc, causing 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.

In addition to the inedible eggs described above, eggs showing severe shell damage and the presence of large blood spots or diffused blood in the white, are classified as loss. Leakers are classified as loss.

The origin of *large blood spots and bloody whites* has already been explained. 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.

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.