Facilities and Curing

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Conventional Barn Renovation and Remodeling

In the post-buyout era of tobacco production, curing facilities are becoming a limiting factor for producers wanting to expand their production. With the high cost of new barns, the renovation and remodeling of existing barns could be an economic advantage. Many curing barns remain that are generally in good structural condition. With some remodeling, they can often be improved to make housing easier and/or to aid the curing process. Here are a few possibilities:

Good burley curing requires lots of natural air. Be sure ventilator doors or equivalent openings equal 1/4–1/3 the barn side wall area and are positioned to permit natural ventilation air to enter and go through the hanging tobacco. Keep the vent doors in good repair so they can be opened and closed as required to regulate ventilation and manage the cure. Whenever possible, remove such obstructions as trees, bushes, and hay stacked in attached sheds that block prevailing winds.

Install full-width driveway doors to accommodate wagon access and increase housing efficiency. An amazing number of people still hand tobacco from the driveway across to the sheds and up into the barn, which takes an extra worker or two and costly labor hours.

Consider optional fans where natural ventilation is inadequate. Supplemental fan circulation and/or ventilation can help wilt big green tobacco, aid curing of tightly housed tobacco in humid weather or aid air movement in barns having poor ventilation. See available publications on the selection, installation and use of fans in tobacco barns.

Many producers have found that in older barns, where tiers are only 3–3 ½ ft apart vertically, better curing results when tobacco is housed on every other tier rail. This eliminates overlapping and produces better air movement. Sticks can usually be placed closer together when the plants do not overlap, thus compensating in barn capacity for the omitted tiers, provided the tier rails are not overloaded causing the tiers to break..

Structurally sound conventional barns can be modified for 2-3-tier air-cure housing, cable hoist, or portable frame housing for labor-saving benefits. Specific details of these procedures are contained in other publications.

What Type of Tobacco Barn or Curing Facility Should You Build?

There are several options for new tobacco barn construction as well as field curing structures. An important decision is to build the most suitable facility for present and future production methods. With labor becoming more scarce and costly, laborsaving features are a must. Rising material and construction costs continue to increase the initial investment costs. An air-cure tobacco barn (burley or dark) is the largest single investment required in the normal tobacco production system. Trends toward mechanization affect whether a facility can be modified, will become obsolete soon, or is needed at all. Partially enclosed barns and plastic covered field curing structures are alternatives for lower cost tobacco housing and curing. However, more management of field curing structures may be required for proper curing.

Producers considering a new facility should certainly not favor the historic tall, labor-intensive barns from the past era of plentiful low-cost labor and inexpensive homegrown lumber. Likewise, builders should not contend that they could only build barns of that type.

Considerations

When planning new curing facilities, producers should consider these options:

- the basic three- or four-tier barn designs, or two-tier economy designs, or one-tier field structures in which tobacco housing can be accomplished with smaller crew size and less total labor;
- alternative designs that use portable frames or cable-hoist mechanical handling and housing that can save over half the housing labor;
- structures that permit other possible farm uses of the facility during the non-curing season, such as machinery and supply storage or animal shelters; and
- future modifications for different tobacco housing and curing methods or other farm enterprises, as these methods could change significantly in the future.

Designs and Plans

Over three dozen designs and plans are currently available on the Biosystems and Agricultural Engineering Department (BAE) web site: www.bae.uky.edu/ext/tobacco. Some general groupings are:

- Three-tier and four-tier air-cure, 32, 40 or 48 ft wide, post-pier or pole-type construction, wood, or metal siding.
- Two- or three-tier forced-air, 32 or 40 ft wide, wood or metal siding, pole-type construction.
- Open-interior air-cure barn with portable curing frames handled by tractor forklift.
- Two-tier partially enclosed air-cure barn, pole-type construction.
- Cable-hoist mechanical housing system for new or modified air-cure barns.
- Thirty-foot wide machine shed with removable tier rails for small air-cure barn, pole-type construction.
- One-tier plastic-covered field curing structure with manual or mechanized housing
- Stripping rooms attached to barns or free-standing, especially layouts for the new big bale operations

Facility Design and Location

A barn should be located in an open, well-drained area with the broad side facing the direction of the prevailing wind to provide the best cross-ventilation.

The best location is on a high point on the farmstead. Width is the most important dimension affecting ventilation since width determines the distance the air must move as it passes through the facility and the amount of tobacco the air must pass through.

Most traditional barns have been 40 ft wide and as long as needed to hold the desired amount of tobacco. Other designs are 32- and 48-ft wide. Lumber of sound quality and proper strength capabilities should be used for construction as shown in typical plans. For labor saving in housing, the 'sheds' should have driveway doors so transport vehicles can pass under the tier rails for efficient handing of tobacco up into the tiers. Ventilator openings should be openable doors or panels, generally vertical in orientation, equivalent in area to at least ¼–1/3 of the side wall area. Some barns are being built with metal siding and do not have adequate side wall ventilation. Inadequate ventilation will result in 'houseburn' during humid weather or with tightly spaced tobacco.

Lower cost plastic-covered field structures can use untreated wood for reduced life or preservative treated for longer life. Various wooden and wire strung designs exist for stick harvested or notched plant hanging and curing. High tensile wire field structures are of particular importance with the plant-notching mechanical harvesters increasingly being used in larger operations because there is no practical way to use barns for hanging notched plants (see section Update on Burley Harvest Stripping Mechanization). Careless and haphazard construction, including failure to adequately anchor high tensile wire, can result in failure of these field structures when fully loaded with harvested tobacco, so it is important to build them strong.

Investment Costs and Labor Efficiency

Curing facility initial costs can range from $700-$1200 per acre capacity for simple field curing structures with plastic covers to $6000 and more per acre capacity for conventional air cure barns. Useful life of these structures can vary from 7-10 years for low cost field structures to 40-50 years or more for well-built barns. Labor requirements for hanging tobacco in these facilities (not including harvesting and hauling) can vary from approximately 12 worker-hours per acre of capacity up to 30-35 wkr-hrs/A.

The amortized value of construction cost and labor for these facilities over their useful life is estimated at approximately 8-12 cents per pound of cured tobacco per year. The annual costs per pound of cured tobacco are even greater to repay short-term construction loans.

Air Curing Burley Tobacco

One of the most important features of any tobacco curing facility is to provide for management and an environment for proper curing of the tobacco. The process of air curing burley and dark tobacco changes the tobacco leaf's chemical and physical properties from the green and yellowish stages to tan and brown aromatic leaf for processing. Most of the changes occur during the first four weeks of curing (approximately two weeks for yellowing, two weeks for browning) and alter many compounds in the green leaf.

Burley's quality is influenced by moisture and temperature conditions inside the curing facility during the curing period. For several decades the best conditions for curing burley have been cited from Jeffrey (1940) as a daily temperature range from 60–90°F and a daily relative humidity average of 65–70 percent. The study was based on an airflow of 15 feet/minute (1/6 mile per hour velocity) through the tobacco in the test chambers. These conditions were for tobacco grown and cured in the 1940s which was a very thin, buff colored leaf referred to as "white burley." The changes in varieties, fertility and cultural practices of the last couple of decades as well as buyer preferences have resulted in a darker brown to red color, thicker leaf now being favored. Recent barn and chamber studies have indicated that steady or daily average relative humidity in the 72-75 percent range produce the quality of tobacco leaves currently desired by the industry, thus a higher daily average humidity than that of the historic study.

During the normal Kentucky late August through September tobacco curing season, the outdoor temperature seldom goes above 90°F or below 60°F for any great length of time. Relative humidity can dwell near 100 percent during heavy dew or foggy nights and briefly may drop below 40-50 percent in the heat of the day, thus averaging around the 70-75 percent. The cooler October temperatures can often go below 60°F for an entire day and/or several consecutive evening periods with humidity ranging from 25-30 percent in day time to not over 70-80 percent in evening hours, resulting in daily averages of 45-55 percent. Extensive curing studies by Walton et. al. (1971, 1973) on the effect of several combinations of low and high temperatures and relative humidity on the quality of burley can be summarized as follows:

- Low temperatures result in green leaf, regardless of the relative humidity and airflow. The chemical conversions are too slow because of the low temperature. However, the drying rate does determine the degree of green cast in the leaf. The higher the drying rate, the greener the cured leaf.
- Low humidity and moderate temperature results in greenish or mottled leaf.
- Low humidity and high temperature (75°F and above) causes "pie-bald" (yellowish) leaf.
- High humidity and moderate-to-high temperature for extended periods is "house burning" weather. Houseburn results in a dark leaf with excessive loss in dry weight. The excessive weight loss is primarily caused by the action of microorganisms that cause soft rot.

Temperature determines the undesirable colors that prevail in the cured leaf during improper curing; however, it is the relative humidity (if airflow is adequate) that determines the degree of damage incurred. Walton et al. (1973) showed that the greater the departure from the optimum relative humidity range, the greater the damage to the quality of the tobacco.

The main control of the curing process is affected by spacing of the tobacco in the curing facility and management of the drying rate. Spacing can vary from 5-6 inches between plants or sticks for one and two tier facilities to 7-10 inches for 3-5 tier barns with tobacco overlapping on close tier rails. Control of the drying rate is done primarily by operating the ventilators, plastic covering, or other air control means to regulate the ventilation rates.

Barns should be located in open areas and broadside to the prevailing wind for maximum natural ventilation when ventilator doors are open. Ventilators should be sized to provide one-fourth to one-third of the wall area in openings. Fans can be used in barns to improve circulation and fresh air exchange through the tobacco for improved curing (see separate section). Also, not operating fans in a proper installation can reduce air exchange and maintain better humidity conditions during drier weather.

The conditions inside the barn generally follow the conditions outside the barn depending on the quantity of air movement and buffering action of the tobacco mass. The average temperature inside the barn will be slightly lower than outside because of evaporative cooling during drying stage and the average relative humidity inside will be higher than outside under most conditions of adequate ventilation. A good way to determine the conditions inside the barn and tobacco is to purchase a couple of commercial digital temperature and humidity instruments for $25-$39 each. Hang these up in the tobacco mass (but not directly against a moist leaf) to sense and record the environmental conditions. These instruments store maximum and minimum data readings which can be viewed to see the past cycle of conditions and reset as desired. The accuracy of relative humidity measurement is generally plus or minus 3 percent, which is reasonable for the price.

One-tier field curing structures with plastic covering normally have plentiful air movement through the tobacco, thus curing as well as the natural weather provides. Such structures should be placed downwind from fence rows or similar wooded areas to give protection from strong winds that can damage the plastic covering and tobacco. Plastic or other covering should be applied over the hanging tobacco before a significant rainfall and maintained throughout the cure for protection from rain and wind damage.

Dark Air-Cured Tobacco

Dark air-cured tobacco is cured essentially the same as burley, but because of the heavier body of dark tobacco, it is more prone to sweat, house burn, and mold. Under warm conditions (mean daytime temperatures >80°F and mean nighttime temperatures >60°F), barn doors and ventilators should be open during the early stages of curing to promote airflow through the tobacco. If warm, moist weather conditions prevail after housing, it may be necessary to use some type of heat to aid the curing process. Heat may also be necessary following late harvests if cool (mean daytime temperatures <65°F), dry conditions persist after housing. Heat sources that can be used include gas burners, coke stoves, or even small wood fires using dry sycamore wood. For dark air-cured tobacco, it is extremely important that these heat sources be virtually smoke-free so as not to leave any, or very little, smoke residue on the leaves. Barn temperatures during heating should be kept low (not exceeding 90°F), as too much heat can cause excessive drying (Bailey 2006a). Growers should be aware that the use of heat in dark air-cured tobacco can be of benefit in the situations described above, but heat in dark air curing is not a necessity that should be used in every situation.

Dark Fire-Cured Tobacco

The fire-curing process for dark tobacco can be broken down into four phases:

- Yellowing
- Color setting
- Drying
- Finishing

Yellowing. The degree of yellowing that occurs in the tobacco before fires are started will affect the color of the cured leaf. Tobacco should be allowed to yellow as much as possible without heat, managing ventilators carefully to prevent house burn and sweating. Firing should begin when yellowing is nearly complete (yellow spots appear or the majority of the leaf lamina has reached a solid yellow color). This usually occurs between five and eight days after housing. Initial fires should not exceed 100°F. Fires that are too hot too soon will cause "bluing" of the tobacco, which results in a crude, green color that will remain after curing is completed. Top ventilators are usually left open during this phase of curing and fires are mostly smoke with low heat.

Color Setting. When yellowing is completed and the entire leaf lamina is a solid yellow color, temperatures are increased with additional fires to set leaf color. Ventilators are usually closed, and temperatures should be kept between 100°F and 115°F. These conditions should be maintained until the leaf shows a solid brown color. Depending on tightness of the barn and weather conditions, this may be done with one firing or may take several firings over a 7- to 14-day period. Ventilators should be opened completely between firings to allow the tobacco to obtain some order before re-firing. When the tobacco has a clear, solid brown face and the stems are dried and browned for ½–2/3 of the way up the leaf, it is time to complete drying.

Drying. Tobacco is brought in order, ventilators opened, and heat increased until the midribs are completely dried down and darkened. Heat during the drying phase should not exceed 130°F. When drying is complete, there should be very little or no green pigment left in the stalks, tobacco should shatter when touched, and there should be no puffiness in the leaf midrib near the stalk. Puffy stems that remain after the drying phase will not easily be dried down during the final finishing phase.

Finishing. After the midribs and stalks are dried and darkened, temperatures are reduced to no more than 120°F, and smoke volume is maximized to add "finish" to the leaf surface. The finishing phase usually requires one to two slow firings over a 10- to 14-day period but may vary depending on the amount of finish desired by the buyer. Tobacco takes finish much better when in order, so ventilators should be opened for several nights prior to finishing to allow moisture to enter the barn. Finishing fires should contain minimal slabs and heavy sawdust to maximize smoke with little or no ventilation. The sawdust, barn floor, and walls may be dampened to produce a moist smoke that will help keep the tobacco in order longer to increase finish.

Firing Materials and Methods

Hardwood slabs and sawdust are the traditional firing materials used for dark fire-cured tobacco. Seasoned hardwood materials are preferable since they tend to burn more slowly and evenly than softer types of wood. Materials such as sulfur or salt should not be used in the yellowing or drying phases, and other materials such as molasses or brown sugar should not be used during the finishing phase in an attempt to increase finish in the cured leaf. Where these materials are used, the result may be tobacco that is excessively sticky and difficult to handle or not usable by the industry because of off-flavor.

Initial fires during yellowing and color-setting phases usually consist of slabs being placed in narrow rows on the floor of the barn and covered completely with sawdust, except for a small opening exposing slabs on alternating ends of each row where fires are started. Slabs should be overlapped so that fires will burn continuously to the end of each row. Later firings during the drying phase require increased heat, and slabs may be stacked higher and in wider rows or placed solid throughout the floor of the barn with sawdust covering the slabs.

Fires may be started on both ends of each row or at several locations. Finishing fires usually have minimal slabs placed either in rows or solid with increased amounts of sawdust to produce maximum smoke volume. Hardwood chips may also be used in combination with sawdust during later firings to help fires burn more slowly with increased smoke volume (Bailey 2006b).

Using Fans in Conventional Barns

High volume ventilation fans can be used in conventional barns to aid air circulation and improving curing. Here are some guidelines for using fans effectively.

When using fans to aid curing, make the air pass through the tobacco rather than just circulate around the driveway or gable space. You also need to move enough air to justify your effort in using the fans.

Most fans in the gable end of conventional barns are too small to do much more than short-circuit air through nearby wall and eave cracks. Fans at ground level in driveways or doorways need to have means (boards, etc.) to direct and/or deflect air up through the tobacco for more effective results.

The most efficient and effective method of using fans in conventional barns with numerous openings around the eave, walls and doors is to place good quality, belt-driven ventilation fans horizontally in the center, bottom rail of every other bent. This pulls any humid, stagnant air through the mass of tobacco from above and around the fan and blows it directly downward toward the ground. Thus, air is moved through the central core of the tobacco where moisture problems generally occur first. Sticks of tobacco are omitted directly above the fan and plants are moved sufficiently away from the sides to prevent damage by the fan. Leave the side ventilators or other doors open to allow the ground-level moist air to migrate out of the barn and fresh drier air to come in around the eave, through the sidewall vents and move through the tobacco.

For beneficial curing results, fan capacity should be 12,000–18,000 cu ft/minute of 0.1 inch static pressure-rated airflow for every 2 bents of 32 to 40-ft wide barn. This means good quality fans of 42 or 48-inch diameter; ½, or ¾ hp should be suitable for the above circulation method in conventional barns, depending on barn size, amount of tobacco, and the effectiveness of air movement you desire (see separate publication for more details).

Operate the fans continuously (24 hours a day) during rainy or humid weather and/or daily during the first 2 or 3 weeks of curing when the tobacco is still green or yellow and contains turgid stalks and stems. After about 3 weeks, the fans may be operated only during the day to dry the tobacco as needed and turned off at night to avoid bringing in moist air. Time clocks can be installed to automatically power the fans on and off daily.

Don't operate the fans during cool, dry weather (below 50–60°F and below 60-65 percent relative humidity) when the tobacco still has green or yellow color in the leaves, as over drying and off-colors can result.

When planning to use the electrically powered fans in conventional barns, check the existing electric wiring and service entrance components carefully. Many barns have been wired for only driveway or stripping-room lights and do not have enough electrical capacity to operate fan motors. Damaged and burned-out wiring or motors can quickly result from insufficient electrical service capacity. Have a local electrician or utility company representative help you check your electric circuits.

Tobacco Stripping Rooms

A good stripping room is very helpful for the stripping and market preparation tasks for most producers. Some producers strip early in the fall in the barn driveways using wagons for the stripping work area. Others can get by with temporarily enclosing a portion of the barn with plastic, tarps, etc., and using an improvised or fold-up work bench and portable vented heater or stove. Or, they can haul the un-stripped tobacco to a more suitable location. The advent of the big baler for burley baling requires greater space for the baler, a supply of unstripped tobacco, and accumulation of the stripped tobacco. As a baler is being filled with 500-600 lb of one tobacco grade, the additional leaf grades stripped from the plants must be accumulated. Such storage can only be avoided by operating multiple balers at a greater cost.

Heated workshops or garages can serve as temporary stripping areas. Likewise, any permanent stripping room can also serve as a workshop or storage area the rest of the year if suitably arranged and conveniently located. Features to be considered for a stripping facility include:

- Work bench of proper width and height (see below), or appropriate mechanical stripping aid;
- Overhead lighting;
- Adequate space for workers bringing in stalk tobacco, for baling equipment, and for removing the bare stalks;
- Doorways large enough to accommodate the tobacco handling and personnel passage needs;
- Heating equipment (with proper exhaust venting) for warmth in cold weather; and
- Electricity for the lights and other power equipment needs.

Blueprints are available from the BAE web site show typical construction of traditional stripping rooms. Over 20 possible layouts of larger stripping rooms for the big baler operation are also shown on the web site. Benches should be 32-36 inches high and 48-60 inches wide for one side stripping, or double width for workers on both sides. The top surface should be slatted wood or heavy wire mesh with ½-inch crack openings that allow fine particles of trash and debris to fall through.

Overhead lights should be multiple-tube fluorescent fixtures with a reflector shield, protective mesh grid and equal numbers of cool white and daylight type tubes per fixture. These tubes provide a rather good economical light source to see the tobacco color and grade qualities when stripping. Special lights with a more balanced daylight spectrum and quality of light are options.

Leaflet 293, "Improving Light Conditions for Stripping Tobacco," is a publication on the BAE web site describing various details of lighting and color features for stripping rooms. Other details of space, doorways, heating, and construction can be obtained from the blueprint plans.

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