GUIDELINES FOR BUILDING AND OPERATING A FAN-VENTILATED DARK-FIRED TOBACCO BARN

A two- or three-tier fan-ventilated dark-fired barn design has proven workable for dark-fired producers. The basic difference in this facility and conventional facilities that were 5 to 6 tiers tall is that tobacco can be put closer together on the two or three tiers and by use of one or more ventilation fans and normal curing management, equivalent curing can be accomplished with barn cost and labor savings.

Figure 1. Exterior view of fan-ventilated dark-fired barn.

The main advantages are labor savings, easier barn construction and more versatile uses of the barn. A wider or taller barn design with fan ventilation is not advised due to greater difficulties in distributing the air uniformly through the tobacco.

A special feature of this barn design is the use of one or more fans to move air through the tobacco and aid in the curing process. In the dark-fire curing procedure, air, heat and sawdust smoke are all used at one time or another in the curing process. In accordance with these factors, the fans are positioned in the top of the barn to pull air up through the tobacco and

exhaust out the top during the initial yellowing phase of the curing process (generally the first 5 to 8 days after housing). When the firing has begun, however, the fans are turned off and the bottom vents and openings at the fans are closed, or adjusted partially open depending upon the environmental conditions, to maintain a large quantity of smoke and optimize curing conditions.

Options are shown on the plan for the vent openings and door closure methods. The size of the fan has been determined based on general weather conditions that might occur during the fall, the amount of tobacco that is to be housed in the barn, and the positioning and location of the fans. Operation of the fans to achieve the desired results is also an important factor. Some suggested procedures are given in a later section. The size of the fans required for various size of facilities is given in the blueprints in terms of cubic feet per minute of air flow at a required “static pressure.” The static pressure is a rating procedure to ensure that the fan will move the required amount of air for a given resistance to flow caused by the tobacco, ventilator openings, duct work, etc. These terms are used in selecting and purchasing a fan. Any good fan supplier will understand them if you do not. When buying fans be sure these ratings are given and the fans are of good quality for this type of use. The motors should be totally enclosed and sealed ball bearing types. The fans should have sealed bearings on the shaft, and have cast aluminum or welded steel blades rather than the thin aluminum riveted blades which can become loose, cause vibration or come off completely during extended use. Direct-drive fans are usually more expensive for the high-volume of air flow required and thus belt-driven types are used. A good heavy duty V-belt drive is desirable. Variable-speed type fans are not necessary and are more costly than standard fans. A two-speed motor and fan could offer two rates of air flow. However, the low-speed rate of air flow is generally only about 1/3 less than maximum and does not offer any great advantage over a single-speed fan. An optional time clock can be used in the
wiring circuit for control of the fans to give preset times of operations, whether it be hour by hour or day/night, in accordance with how you want the ventilation to occur.

The theory and principles of air movement by fans indicate that a fan ought to be positioned to move air through an area of uniform size and with tobacco uniformly placed in this area. Therefore, it is essential during housing to space the plants uniformly on the sticks and space the sticks uniformly on the rails in accordance with the size of the tobacco. Large plants of tobacco obviously would not be placed as tightly as smaller plants due to the physical size and moisture to be removed from the different sized plants.

It is essential that the barn be filled completely with tobacco. That is, no rails, 'rooms' or portions of the barn are to be left unfilled. Air flow would “short-circuit” through any open areas to the fan rather than being moved uniformly through the tobacco. Plan your spacing of the tobacco on the rail so the barn can be completely filled with the tobacco you have or use other barn space for excess tobacco.

There is a special construction feature that is necessary for large, long barns. The fan guidelines show one fan for three to four bents, or bays, of length. For barns longer than this where more than two fans are needed, we advise that you put a partition from the roof down to the middle portion of the tobacco in order to compartmentalize the barn and provide specific sections for the fans to pull air through the tobacco. This is necessary for two reasons. First, for large barns you may not be able to cut and house tobacco every year during a one or two day period. Unfilled portions of the barn would allow the air to by-pass the tobacco and begin moisture problems due to the lack of ventilation. With the partitions every 4 to 6 bents you could cut and house one compartment of the barn in a one or two day period. Then the fans could be used to move air through that tobacco and cause the wilting and yellowing process to continue while waiting to fill the other portions of the barn. This is very critical if weather influences your operation or labor and other problems cause delays in completely filling the barn. However, firing must be delayed until all tobacco is ready. When yellowing appears on at least half of the leaf surface on the bottom tier, the fans are stopped, vents adjusted, and the firing begins for the entire barn. Because of this possible variation in housing and curing in a very large barn, separate smaller barns may be better for you.

For the two and three-tier design, a spacing of 5 ½ to 6 inches has been used for the sticks of tobacco on the rails and has proven to be quite workable during various seasons and under various people’s management. For a newly constructed barn and a producer’s first season, maybe a 6 ½ to 7 inch stick spacing ought to be used so the producer can learn the capability of the facility and management required to cure good tobacco and get a good smoke finish. Once a producer has gained experience in using the barn and understands the air movement and curing process, then the closer spacing can be used.

A word of caution is extended to producers or builders making modifications in the shape and design of the fan-ventilated barn beyond a three-tier or 28 to 32 foot wide plan as fan sizing, air movement, and curing results are unproven.
General Construction:

The barn is designed for pole-frame truss-roofed construction. This type construction requires pressure treated poles or built-up posts set into the ground 3 to 4 feet deep and the use of prefabricated trusses for the roof. This construction provides open interior space similar to and suitable for machine sheds or other facilities. For the tobacco barn, tier-rails are added for the tobacco. A minimum number of braces are required in the pole-type barn. Tier-rails can be removed at any time in the future without affecting the structural strength of the barn, provided proper pole barn 'knee' bracing and post embedment has been achieved. The former post-pier type barn, where posts are set on a concrete foundation, does not permit trusses to be used unless additional bracing is done throughout the barn. This extra bracing interferes with housing as well as preventing the interior of the barn from being removed for any future changes, modifications or other uses. Therefore, the pole-type construction is very desirable and strongly recommended for this type building. The cost is very comparable with conventional construction as far as materials are concerned. Generally, builders and carpenters that are familiar with this method can erect pole buildings as easily as conventional post-pier and rafter-type construction.

The foundation between the posts is shown as concrete. The concrete is generally formed and poured after positioning of the poles during construction. A 12 inch deep ditch between the poles is recommended to provide a footer for the concrete and as a barrier to prevent water leakage into the barn. The concrete should extend 12 to 18 inches above the ground. This concrete is desirable as a fire barrier so that any dust or wood sparks or flames during the firing process can be blocked from getting to the sidewalls of the barn. Some producers even like to go higher than 18 inches, up to 2 or 3 feet, to give added protection.

A metal plate or equal fire proof material should be put over each post on the inside at ground level to protect the wooden post from the fire hazards. Alternative foundations might be pressure treated wood with a good metal liner on the inside to likewise give the fire safety protection. Steel type metal in contact with the ground will eventually rust and not last as long as concrete.

Structural Framework:

The structural framework can be of dressed or rough lumber depending on its type and strength. Oak, Southern Yellow Pine or Douglas Fir dressed lumber is suitable. Poplar is suitable for most members but is weaker than the other species, thus a size larger member may be needed for load bearing members. In most cases the Standard Grade, No. 2, or better quality is needed in order to provide dependable structural strength. The utility grade lumber generally has so many flaws, knots, and/or splits that it is not suitable for some of the beams and would be suitable only for filler pieces or blocking. Full-dimension (2-inch thick) native sawed lumber is suitable provided defective pieces are culled at the purchase of the material or during use. Excessive warps, cracks or other defects should be culled.

The sidewall members to which the siding is nailed are 2 x 6 x 12'. The cross beams for the 28' wide barn are 2 x 10's. The tier rails are shown to be 2 x 6's on edge. Alternate sizes might be two 2x6s nailed together, 4 x 4's, 3 x 5's or similar size members. Three-by-threes
generally are to small for the heavier tobacco load that is being put on this type rail with the closer spacing. Three-by-three could undergo excessive bowing and, unless real sound lumber is used, could break and cause problems and danger during housing.

Proper nailing techniques are shown on the blueprint for nailing all wood members to each other and to the post. The number and type of nails for nailing all wood members together and, especially the wooden support beams to the post, are shown on the blueprint. These details must be followed accurately as any different type nails or fewer number could critically weaken the structure and cause danger when loading it to full capacity with fresh green tobacco as well as resisting wind and snow load strength.

Metal siding is shown as the recommended siding material. Its costs is competitive with wood and is much easier to obtain the air tight seal required for barns of this type rather than having to use battens on wooden boards. Full length siding can be used or two shorter lengths can be used and lapped. Galvanized steel or aluminum metal siding, either painted or unpainted, can be used. Be cautious about the quantity of zinc coating on some grades of galvanized metal as some brands use less than one ounce of zinc per square foot compared with the former coatings of 1.25 to 1.5 ounce per square foot. Thus, rusting will occur in just a few years under the high moisture and smoke conditions of tobacco barns. Also, the 'galvalume' type of metal surface has been observed to rust rather quickly under the moisture and smoke conditions. The heavier gages or thickness of metal are recommended in order to provide maximum resistance against physical abuse by animals, equipment, workers and other physical problems that might occur along the sidewall. Aluminum, in particular, needs a plywood backing underneath the metal up to about six foot of height to prevent puncture and damage by animals or other activity inside or outside the barn.

**Roofing Construction:**

The 28- or 32-foot span trusses can be hand-made at the site or bought commercially prefabricated. They can be lifted into position with booms, construction cranes or equivalent lift devices that comply with OSHA or local construction codes and safe practices. The trusses are anchored to the post or girder members as shown on the blueprint or equivalent means of metal anchors. This anchorage must be done properly in order to provide the strength of the facility against wind, snow and roof loads. The sheathing, or purlins, that go across the trusses are also shown on the plan. The trusses are spaced approximately 6-feet apart, or one at each post and one between the post spacing. In order to span this 6 feet between the trusses, 2 x 4's on edge are shown for the purlins. If solid wood sheathing is used, such as 1" boards or ½ inch plywood, then the trusses would have to be put closer together, (generally 2 to 3 feet apart). This closer spacing would require considerably more trusses. Or the 2 x 4 purlins would have to be installed as shown and then plywood decking or sheathing used over purlins. The reason for this variation in type of sheathing is whether you will use metal or shingle roofing.

Some types of metal roofing can cause barn condensation and barn drip. This has been experienced with galvanized metal roofing and is **not** recommended unless moisture proof insulation board material is placed between the purlins and metal roof. Some producers have found that the aluminum roofing does not cause as much condensation and is a tolerable or
acceptable roofing material. In order to completely eliminate condensation and drip, two procedures must be followed. One is to use a layer of moisture resistant insulation board over the purlins and underneath the metal roofing. A second procedure is to use wood sheathing and asphalt shingles. The type of insulation board that is moisture resistant and adequate for this method would be some of the rigid foam boards such as the extruded polystyrene materials or “closed-cell styrofoam.” The bead-board type of “styrofoam” is not moisture resistant and will allow moisture to move through insulation board, condense under the roof, and be trapped to cause excessive deterioration. The same is true with the black or gray fiberboard that is normally used in houses. Therefore, these materials are not recommended for this purpose whether on the roof or even underneath the sidewall material. The condensation at the sidewalls might occur but normally does not drip on the tobacco nor cause any tobacco damage. Usually sidewall condensation is not severe enough to cause rapid deterioration of the wooden structure but will accelerate rust formation.

The blueprint plan shows no overhang of the roof either at the sides or ends. This is done to allow easier air tight seal of the siding material against the roofing. The technique can also reduce the length of rafters or trusses and purlins needed. In order to provide air-tight sealing of leaks around the corrugations or ribbing of metal roofing and sidings, some type of foam sealer strips or other long-life materials should be used at the time of installation.

An opening is necessary in the ridge of the barn at certain spacings to provide the air outlet for the fan which pulls the air up through the tobacco and pushes it out at the roof. The size and shape of this ridge opening, or cupalo, is shown on the plan. The ends of this cupalo are closed with metal to prevent blowing rain or snow from entering the barn. The sides are open and the roof of the cupalo must extend down far enough to reduce snow and rain blowing into the barn. Even with the extension shown on the plan, however, it does not completely eliminate the blowing of rain and snow into the barn under severe weather conditions. These occasional occurrences have not been observed to be of significant damage. To completely prevent blowing in of rain and snow would require some type of closeable door or panel on the opening when it is not in use.

The tier-rails are spaced 5-feet apart vertically to prevent overlap of normal tobacco and to provide more uniform air movement and curing results. The horizontal spacing has been narrowed to 42-inches to provide a more comfortable stance for the worker and to result in a more equal square-grid spacing of plants in the cross-section area and uniformity of air flow around each plant (approximately a 5.5 x 5.5 to 6 x 6-inch plant spacing grid is desired).

One difficulty with the narrow rails has occurred when normal length sticks are used. For the outer rails of the barn, the normal 50-52-inch sticks extend several inches beyond the first rail and in the way of the next rail. When a producer has this type new barn and an older one, he generally cannot cut the sticks to length because they would get mixed up from year to year. However, for a producer that has one or more barns of this new type, he can easily cut sticks to fit the rails and thereby not have the problem of long sticks on the narrow rails. An alternative is to build the barn 32 ft. wide design with eight 4 ft wide (approximately) tier spaces.
Figure 3. Exterior view of three-tier fan-ventilated dark-fired barn during firing.

**Some barn and fan specifications and details:**

1. Capacity per bent of barn length, based on 28-ft wide barn, 11'-9" long bents, 16 tier rail spaces per bent, 5000 plants per acre.

<table>
<thead>
<tr>
<th>Plants/stick</th>
<th>Capacity of Barn in acre/bent of length, Based on stick spacing (sticks/rail)</th>
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<tbody>
<tr>
<td></td>
<td>7&quot; (21)</td>
</tr>
<tr>
<td>6</td>
<td>.41</td>
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<tr>
<td>5</td>
<td>.34</td>
</tr>
</tbody>
</table>

2. Operation and management are comparable to conventional barns (see U.K. Extension AGR 152: Harvesting, Curing and Preparing Dark-Fired Tobacco for Market). The fan can be used during yellowing and curing as required for ventilation and moisture removal and may also be used to aid in reducing mold accumulations on the tobacco following curing and prior to taking down. Proper selection and installation of the fan is important for dependable and successful operation. Sawdust firing is done as in normal barns.

3. Fans are **not** operated during the firing unless smoke and moisture need to be exhausted when the fires die down. **Important: Do not operate the fans when sparks or embers may be pulled up into the tobacco.**

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4. Recommended fan sizes:

<table>
<thead>
<tr>
<th>Barn length, No. bents</th>
<th>Fan size, C.F.M. air delivery at 0.1 inch static pressure, A.M.C.A. rated</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>6,000</td>
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<tr>
<td>3</td>
<td></td>
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<tr>
<td>4</td>
<td>8,000</td>
</tr>
<tr>
<td>5</td>
<td>10,000</td>
</tr>
<tr>
<td>6</td>
<td>Use 2 fans as for two 3-bent units</td>
</tr>
<tr>
<td>7 and larger</td>
<td>Use combination of fans and units as above</td>
</tr>
</tbody>
</table>

5. Recommended fan specifications:
   a. motors to be totally enclosed, ball bearing and thermally protected
   b. direct drive fans with narrow blades would not collect as much smoke precipitate and operate better overall for a longer period of time than wide, slow turning blade types. (Note: any fan should be cleaned before use each year to remove smoke deposits that would reduce air flow and motor cooling efficiency)
   c. fan units should be capable of long life operation in a horizontal position (bearings, mounts, etc.)
   d. For belt driven fans, check and tighten belts annually (or more often if fan air movement seems to be deficient) or replace belts when they show signs of wear.

See Plan 735-31 for barn construction details.