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Heat and Air Requirements for Tobacco Curing

Although the heat and air requirements for tobacco vary with the season, outside air condition, variety of tobacco, ripeness of tobacco when primed, the barn, and the type of heating system, estimations of the correct design capacities have been derived from field tests. The following table gives the computed heat uses in the typical "four room" (barns 17'-4" x 17'-4" inside, and having seven tiers) barn during 1942, a season have above average fuel requirements for this locality.

TABLE I. Itemized heat uses per hour for a typical cure. (B.t.u.)

Period	Work Done		Infiltration & Ventilation		Wall Loss	
	Insulated	Uninsulated	Insulated	Uninsulated	Insulated	Unins.
Yellowing	49,500		16,400		6,200	18,600
41 hours	68.6%	58.6%	22.7%	19.3%	8.6%	22.0%
Drying	50,300		40,900		15,400	46,200
34.6 hrs.	47.2%	36.6%	38.4%	29.8%	14.4%	33.6%
Killing	24,000		65,400		24,600	73,900
24.3 Hrs.	21.1%	14.7%	57.3%	40.0%	21.6%	45.2%

For these computations, the insulated barn was sided inside and out with three-sixteenths inch cement asbestos board with a four inch rock wool fill in the stud space. The same construction was used in the walls and roof. The uninsulated barn was sided with one half inch gypsum board on the outside and roof, ruberoid roofing was applied over the gypsum board on the roof, and the computations assumed that 3/4 inch siding was used over the gypsum board on the sides, although in the field test of this barn, no sheathing was applied over the gypsum board.

The total heat use per hour, taken as an average over the three periods of the cure are shown in table two.

TABLE II. Average heat use per hour in three periods of the cure. (B.t.u.)

Period		Insulated	Uninsulated
Yellowing	41 hrs.	72,580	85,000
Drying	34.6 hrs.	106,700	138,000
Killing	24.3 hrs.	114,000	163,000

Attention should be called to the fact that the above figures are averages for the periods of 41 to 24.3 hours. The old system of curing with wood enabled the tobacco curer to achieve flash heats, the maximum recorded being 407,000 B.t.u. per hour. Such "flash heats" are not necessary for the proper curing of tobacco, but some farmers are impatient when they can not obtain this intense heat over a short period of time. Stokers or oil burners designed to put 200,000 B.t.u. of heat in the barn in one hour will not give sharp temperature rises in the drying period. Asafe estimate of the requirement for proper curing, and one which will meet the need of critical periods is 225,000 B.t.u. per hour in the barn.

Basing the size of unit on a requirement of 225,000 B.t.u. per hour, a coal stoker operating at 45% efficiency and feeding coal with a heating value of 13,000 B.t.u. per pound should feed about 40 pounds per hour into the furnace. Actual tests indicate that this rate of feed is high, a 30 pound per hour stoker being adequate for most installations. A wick or pot type oil burner having an efficiency of 60% would be required to feed two and one-half gallons per hour, assuming the heating value of the fuel to be 150,000 B.t.u. per gallon. A pressure or gun type burner having an efficiency of 80% would handle the barn all right with a capacity of two gallons per hour. One difficulty encountered in tobacco curing is the wide range of heat requirement during the cure. The requirement for minimum heat in the barn may be as low as 30,000 B.t.u. per hour.

We are interested in just how efficiently the various systems actually operated in the field. For this study two different efficiency factors come under consideration, one, the overall efficiency of the entire system including the barn and the heating system, the efficiency ratio being the actual drying work done divided by the fuel input, and two, the efficiency of the heating system which involves the heat put into the barn divided by the heating value of the fuel used. No accurate data are available to give these efficiencies.

Using what we have, however, we arrive at the conclusion that on the average, 5,500,000 B.t.u. of drying work will be required to remove the water from a normal barn of tobacco. To achieve this quantity of work, the ordinary uninsulated barn with proper ventilation must be supplied with 12,000,000 B.t.u. of heat. Of course added efficiency may be gained by insulation, recirculation, and close control of infiltration and ventilation. The actual fuel consumptions have been measured for several different barns over a period of years with the following results:

TABLE III. Fuel input into tobacco barns in a single cure. (B.t.u.)

Barn	Yrs. Av.	Fuel input
1. Red tile	7	21,300,000 (Coal)
2. Frame	7	13,000,000 (Oil)
3. Frame	3	12,400,000 (Coal)
4. Frame	2	18,000,000 (Coal)

Barn descriptions:

1. A red tile barn has an eight inch wall up to the first tier pole with a five inch wall from there on up. Special heating system consisted of an outside heating box equipped with a stoker, approximately 100' of 10" flue pipe, and a 800 cfm blower with recirculation provision. 700 stick capacity.

2. Sheathed outside with 3/4" lumber, four inch rock wool fill in stud space, lined on two sides inside with 3/16" cement asbestos board, two sides with water proof building paper, roof similarly insulated. 600 stick capacity.

3. Sheathed inside and out with cement asbestos board. Building paper placed under inside sheathing. Four inch rock wool fill in stud space. Fired with stoker in an experimental heat converting type of flue arrangement. 700 stick capacity.

4. Sheathed outside (walls and roof) with 1/2" gypsum board. No insulation. Reflective gypsum board siding on inside up to the first tier. Almost standard flue system. 700 stick capacity.

From these data one might infer that a typical barn on the farm will use in the neighborhood of 18,000,000 B.t.u. of fuel input when burning coal in a stoker, and perhaps 15,000,000 when using the wick type oil burners.

Actual data indicate that the design efficiencies given at the top of page two are lower than they should be. The stoker-flue system seems to give an efficiency of about 67% in the conversion of heat from the fuel to the barn and an over-all efficiency of about 30%. Oil systems (wick type) appear to be about 80% efficient in converting heat from the fuel to the barn, and 37% over-all efficient. These efficiency figures are higher than those generally encountered in drying work, but may be explained in part by the fact that some "free work" is derived from the outside air. As indicated before, however, the efficiencies quoted above are little better than shrewd guesses.

Air requirements for the tobacco barn:

Air requirement for tobacco curing has been approached from two standpoints, that required to carry the moisture from the leaf, and that required to keep the CO_2 concentration down to a required minimum. (1) To reduce the CO_2, 400 cubic feet per minute is the estimated requirement for a six to seven hundred stick barn. For the proper removal of moisture, the typical cure will require a maximum of 600 c.f.m. of air entering the barn, and 700 c.f.m. leaving because of the expansion in the barn. The most extreme drying rate observed in the barns required an air change of 1420 c.f.m. entering, and 1650 c.f.m. exhaust. Just as in the heating, the extreme maximum air change in unnecessary, a design to put 600 c.f.m. in the barn being ample for even extreme conditions.

(1) State Electricity Commission of Victoria. Tobacco curing with electricity. Rural Service Section Report No. 3. Unpublished. 1932.

The most successful method of forcing air into the barn that has been tried up to this time was accomplished with a 250 c.f.m. blower controlled by a humidistat, making contact when the humidity rose above a desired level. A 750 c.f.m. blower was used continuously with a recirculation system with fair success. A 2500 c.f.m. blower with a recirculation duct proved uneconomical because of air leakage from the barn. As long as we are forced to operate in the barns as they are now built, low air movements will result in the lowest fuel costs.

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All of this information is preliminary and not for publication.