

Dark-Out Pullet Housing Design Considerations

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The need for properly designed dark out pullet housing cannot be overstated. The uniform development of the pullet flock to a healthy mature breeder flock is paramount to the economics of the integrated poultry operation. The development of tunnel ventilation has made it possible to efficiently produce pullets year-round in a wide variety of climatic conditions. However, the modern dark out pullet house using tunnel ventilation will be capable of supporting optimum bird performance only if dark out and ventilation equipment are selected with proper consideration of the special requirements imposed.

Fundamental Issues for Dark Out and Ventilation Design Choices

While poultrymen well understand the benefits of good dark out housing for their pullet operations, they may not have a full appreciation for what the dark out requirement does to the design of the ventilation system for a pullet house. Not only do light traps block light from our pullet houses, they also make it very difficult for ventilation air to be easily brought into the house. We know that air movement by the ventilation system (including evaporative cooling) is the key to temperature management of these houses both in warm and cooler weather. Therefore we must achieve good black-out designs that do not prevent the ventilation system from doing its job of keeping the flock at the comfort levels needed for best performance.

In designing a modern pullet house, two fundamental issues must be considered before any equipment can be selected:

How much light reduction is needed? The first issue that must be considered is how much total light reduction will be appropriate. Light traps are boxes typically constructed of black plastic or metal vanes which direct air entering or exiting a house through a series of short turns. Light traps take advantage of the fact that air can turn corners while light rays travel in a straight line. Each turn reduces the amount of light that makes it through the light trap.

The effectiveness of a light trap in reducing light transmission depends on a variety of factors. These include vane spacing, light trap thickness, construction materials, and the number and severity of curves the air must travel through. It is next to impossible to determine how good a job a light trap will do just by looking at it. Two light traps can

appear very similar, but slight differences in vane spacing or construction can make dramatic differences in their ability to reduce light transmission.

For acceptable dark out, light traps that have a light reduction ratio of 1,000,000 to one or better should be chosen. Traps with lower reduction factors will not provide total black out. However, if light traps are to be used in combination with six-inch cooling pads with black coating on tunnel inlets, a less than 1,000,000 to one reduction factor is acceptable, as explained below.

Along with reducing light transmission, light traps present a certain amount of resistance to air flow, which in turn has the effect of reducing the performance of the exhaust fan. That is, the number of cubic feet of air moved per minute (cfm's) by the fans will be lowered. Drawing air through an opening in the side wall is relatively easy for a fan to do. But if we put a light trap in that opening and force the air through a series of turns to exclude light, more fan energy is required. For a given area of light trap installed, more or steeper turns require more fan energy and reduce the amount of air moved by the fans. In fact, in many black-out pullet houses fan capacity is reduced 50% or more because of overly restrictive light traps. This is totally unacceptable from the standpoint of the resulting high operating costs.

Table 1 shows the light reduction achieved by various brands of commercial light traps. Figure 1 displays the static pressures that result for selected light traps at different air velocities. The air speed through the light trap (face velocity) depends directly on the area of light trap installed. What is desirable is a light trap that gives adequate light blocking while requiring less light trap area (lower cost) for lower static pressure. Usually, this involves a trade-off of desirable characteristics. Static pressure is a governing factor, however: in practice, we must design to keep static pressure drop across traps as low as possible.

The point is this: The light trap and degree of light tightness you choose affects the ability of the fans to ventilate. Thus fans must be selected that will be able to provide the needed air movement against the resistance presented by the light trap chosen. This resistance to air flow shows up in an increased static pressure which the fans must work against, and the fans must be able to provide the needed air movement (total cfm's) at the total house static pressure that results. Choosing the right light trap with due consideration of the amount of light reduction needed and the consequences for ventilation is the first key to the design of the pullet house.

Will evaporative pad cooling be used? The second fundamental issue that must be addressed in pullet house design is whether the house will include pad-type evaporative cooling. This issue also affects fan performance and overall design as well. In Alabama and all hot weather climates virtually all modern pullet houses are being tunnel ventilated and evaporatively cooled. While many pullet houses in existence use in-house fogging for air temperature reduction, the trend in hot climates is to utilize some type of recirculating pad system. These systems provide maximum real cooling of the incoming air and keep water out of the house.

Pad type evaporative cooling has become the preferred option in most modern tunnel-ventilated poultry houses, and it is pad cooling that especially impacts pullet house design in terms of both dark out and ventilation equipment selection. This is because the pads are another feature of the house that to some extent blocks light, and also presents resistance to air flow - that is, adds an additional static pressure drop to the total house static pressure which the fans must work against.

Since pads are mounted over the tunnel air inlets, they will at least partially block light from entering the house. They may actually function to block light almost as effectively as the lower-quality, least effective commercial light traps. This means that the light trap chosen for the tunnel air inlets does not need to block light as effectively as it would if no cooling pad were installed. Since in effect a lower quality light trap can be used here, a cost savings can be achieved. Also, the less-efficient light trap will present less resistance to air flow, so that the static pressure drop across the light trap will be lower, making it easier for fans to do their job of moving air through the house. In Figure 1, the Hired-Hand ProDark.5 and Munters Half-Dark traps are examples of a type of trap recently introduced onto the market which is specifically designed to be used as inlet light traps in combination with six-inch recirculating cooling pads. These traps present very low resistance to air flow (low static pressure). Specific light-reduction data for these traps was unavailable at time of publication. However, field experience has shown that the combined light-blocking action of these traps and a six-inch cooling pad gives adequate black out. They do not provide adequate black out for standalone use.

Different types of cooling pad will have different ratings for static pressure drop across the pad, and the static pressure drop for any particular pad will vary depending on the air velocity through the pad (this is often referred to as "face velocity"). For a given house total fan capacity, the air velocity through a pad will depend on the total area of pad installed. Therefore the type of pad chosen, and then the proper total area to be installed, must be carefully calculated so that the combination does not result in excessive total house static pressure.

Evaporative cooling pads can be spray-on or recirculating types. Six-inch recirculating pads are recommended, and can drop temperatures as much as 17° F, depending on conditions. Figure 2 shows static pressure/air velocity relationships for a six-inch small flute evaporative cooling pad.

Combined Effects of Pads and Traps on Fan Performance

The effect the combination of pads and traps have on fan performance cannot be overstated, and it is this effect that must be included in determining fans to be installed. The key point to keep in mind is the total static pressure the fans must work against. A good rule of thumb in designing the traps and pads for a pullet house is to keep the total combined static pressure from the evaporative pad + the inlet trap + the exhaust trap to 0.15 inches S.P. or lower. Fans must be then selected which will move the desired cfm's at that static pressure. If an insurance factor or some cushion in design is desired, the house should be designed so that total airflow will be delivered by the fans at 0.20 inches S.P.

The lower the total house static pressure can be kept the easier (and cheaper) it is for the fans to move the air through the house.

Broiler house ventilation systems are typically designed for a total house static pressure drop of 0.10 inches S.P. or less. Therefore, fan/inlet combinations that would provide adequate air flow in the broiler house situation will seriously under-ventilate a dark-out pullet house. In dark-out houses, it is especially important not only to make sure that adequate air inlet and exhaust area is provided, but to choose fans and base ventilation system designs on the fans' actual air-moving capacity *at the static pressure they will be operating against*.

Fan Characteristics

Fans vary a great deal, from manufacturer to manufacturer and from one model to another, in the performance (cfm's) they deliver at different static pressures. Typical fan performance curves from the University of Illinois Bioenvironmental and Structural Systems Laboratory for brand A and brand B 48-inch fans are shown in Figure 3. Although the two fans have the same size and horsepower rating, at 0.15 inches static pressure fan A delivers almost two times more air than fan B. Table 2 shows the performance of another good-quality 48-inch fan at different static pressures, and also displays the way fan efficiency (cfm/watt) varies. The higher the cfm/watt rating, the cheaper it is to operate the fan and deliver a given airflow.

These simple illustrations point out the importance of looking at fan performance *at the required static pressure* when choosing pullet house ventilation equipment. As a rule of thumb, fans in dark-out application should be rated *at 0.15 inches static pressure* to deliver 9000 cfm or more for a 36-inch fan and 18,000 cfm or more for a 48-inch fan. Even better fan performance would be desirable. In a particular design, fans should be selected and the number of fans to be used determined by actual calculation of the airflow cfm's needed in that particular house.

Basic Ventilation Design Considerations for Pullet Houses

As mentioned above, modern dark out pullet houses are almost always tunnel ventilated. The tunnel ventilation mode is only used when birds are larger and/or in warmer weather, when cooling is needed. Modern "tunnel houses" are typically equipped for two other modes of ventilation, minimum ventilation and transitional ventilation.

Tunnel Ventilation Mode. Tunnel is used when there is need for cooling. That is, the birds are producing more heat than can be removed from the house by air exchange alone, and wind-chill cooling and possibly evaporative cooling are needed. For effective tunnel ventilation, the minimum recommended air speed for pullet houses would be 400 fpm. Considered in terms of the air exchange rate needed, experience teaches that in hot climates the house should be designed for at least one air exchange per minute. In a house that is 400 feet long, this air exchange rate will provide an air velocity through the house of 400 fpm. If necessary, heat flow analysis can be done based on flock size, weight, building conditions, type and amount of insulation, and climate, to determine more exactly

what the proper air exchange rate should be for adequate heat removal. In milder climates, one air exchange every 1½ minutes is often sufficient. If the specific wind-chill cooling benefits of tunnel ventilation are needed, however, the system should be designed to provide at least 400 fpm air velocity.

Transitional Ventilation Mode. Transitional ventilation is used when the minimum ventilation system is no longer able to keep birds comfortable, and there is need to remove heat from the house, *but we do not want outside air to directly contact birds* because outside air is too cool, or birds are too young (or both). In a typical 8-fan pullet house, it is common to use 3 of the installed tunnel fans to draw air in through vent boxes mounted high on the sidewalls for transitional ventilation, with the tunnel curtains fully closed. Incoming air is jetted into the house above flock level, where it mixes with warmer house air in much the same way that happens in minimum ventilation. The vent boxes must be light trapped, which adds expense to the house. The number and size of vents must be calculated, depending on the particular light trap used, and the number of tunnel fans that will be used. Also, vent openings are best adjusted automatically by a static pressure sensing controller, rather than attempting to adjust openings manually as the number of fans running changes.

Minimum Ventilation Mode. Minimum ventilation is used when birds are small and/or outside weather is very cold. Most modern pullet houses will install one to two 36-inch light-trapped fans in the brood chambers to provide for initial minimum ventilation, drawing air in through sidewall vents. These fans can be omitted and minimum ventilation can be done with tunnel fans, depending on climate and owner preference. When it is no longer possible to maintain desired temperature in these houses with this setup, transitional ventilation is turned on, as explained above. In very warm climates, where winter is very mild (never goes below 50° F) the number of side wall vents has successfully been reduced and the tunnel inlet has been successfully modified (cracked) to acceptably meet minimum and transitional ventilation needs. This reduces cost of the house for the warmer climates. *This setup, however, will not work in cooler climates.*

An Example Dark Out Pullet House Design

Many of the factors that affect the design of a dark-out pullet house have been mentioned. Perhaps the best way to get a feel for what is involved in design of such a house is to take a look at a typical design. Following are the basic specifications for a typical modern pullet house. This house design is shown in Figure 4.

Sample Ventilation Design – for climate where it is very warm in summer (for example, in Alabama 100° F in summer and 20° F in winter)

40 x 400 Dark-out pullet house
11,000 birds, 4.5 lb maximum weight

Ceiling is insulated - minimum R-11, preference R-19; ceiling is dropped or can be high type. If ceiling is high type, building should be low profile. Sidewall height 8 ft, center ceiling height 11 ft; average ceiling height 9.5 ft.

Exterior Curtain sidewalls: total dark-out is desired. House to be equipped with black on white sidewall curtain with 12-inch curtain pocket installed to block light and air leaks.

Tunnel ventilation with evaporative pad cooling is desired -- minimum wind speed is 400 fpm.

Install eight 48-inch fans rated at 19,000 cfm or better at 0.15 inches S.P.

Minimum ventilation will be accomplished by use of two 36-inch fans located in brood end wall and use of additional 48-inch tunnel fans.

Minimum ventilation side wall inlets will be light trapped dark-out type equally spaced on side walls of house to allow running of 3 tunnel fans with tunnel inlet closed. Minimum ventilation inlets may be reduced or omitted for climates where it is very mild (never below 50° F). In such locations it is possible to modify tunnel inlets as minimum air inlets.

A false wall will be built on the tunnel fan end of the house to allow ease of mounting of light traps. False wall will be at least 5 ft from end wall. Maximum S.P. drop across fan trap will be no more than 0.08 inches S.P. when in full tunnel with all fans running.

Evaporative cooling will be 6-inch recirculating with sufficient pad area for maximum S.P. drop across pad to be 0.05 inches when in full tunnel operation. Design air speed through pad will be 350 fpm.

Tunnel inlet light trap will be same area and dimensions as cooling pad, using a higher light transmission trap (lower quality), since trap will be shaded by 6-inch evaporative cooling pad. Maximum S.P. drop across inlet trap will be 0.02 inches S.P. when in full tunnel operation.

Table 1. Light reduction achieved by various brands of commercial light traps*

Light Trap	Light Reduction Factor	Light Intensity Permitted (at inside face of light trap in foot candles)
Dandy Black Air	2,300	4.4
Gigola Night Air	5,000	2.0
Acme metal	8,000	1.3
Dayton	180,000	0.06
Munters Mi-T-Dark	2,100,000	0.005
Hired-Hand ProDark	2,100,000	0.005
Dandy Black Majic	3,100,000	0.003
Acme plastic	21,000,000	0.0005

Source: University of Georgia Biological and Agricultural Engineering Dept.

*Mention of manufacturers and brand names in this publication is for information purposes only; no endorsement or preference is intended or implied for one brand over another that might be suitable.

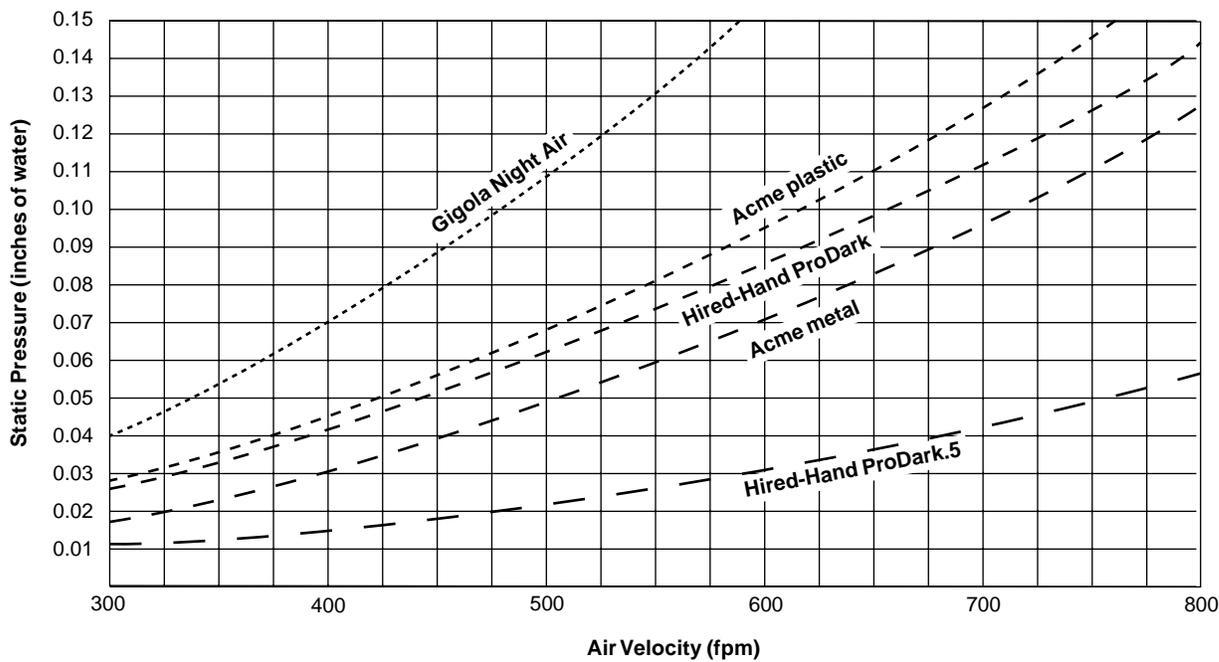
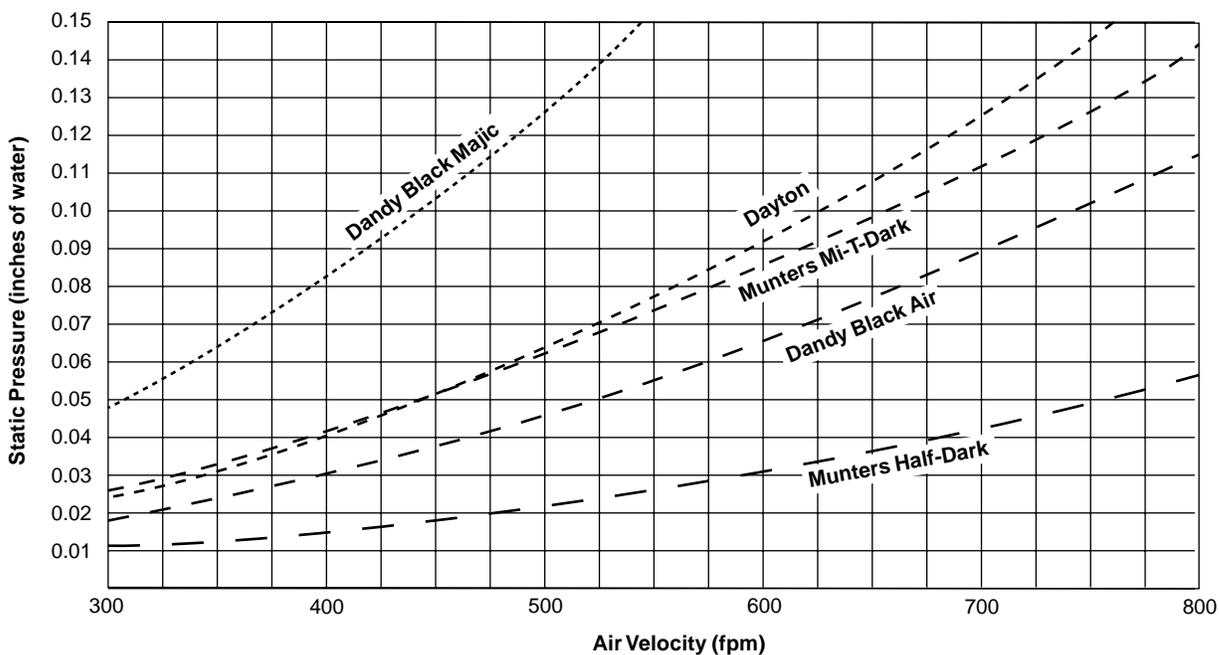
Table 2. Recommended minimum 48-inch fan characteristics for use in pullet house design

Static Pressure (inches)	Airflow (cfm)	Efficiency (cfm/watt)
0.00	23,937	23.7
0.05	22,588	21.1
0.10	21,086	18.6
0.15	19,208	16.0
0.20	17,083	13.8
0.25	13,538	10.5
0.30	5,834	4.0

48-inch fan with galvanized steel slant housing, guard, aluminum shutter and discharge cone

Source: University of Illinois Bioenvironmental and Structural Systems Lab

Figure 1. Static pressure drop at different face air velocities for selected light traps.



Source: Data provided by University of Georgia Biological and Agricultural Engineering Department and Auburn University Biosystems Engineering Department

Figure 2. Cooling efficiency and static pressure at different air velocities for a typical 6-inch small-flute recirculating cooling pad

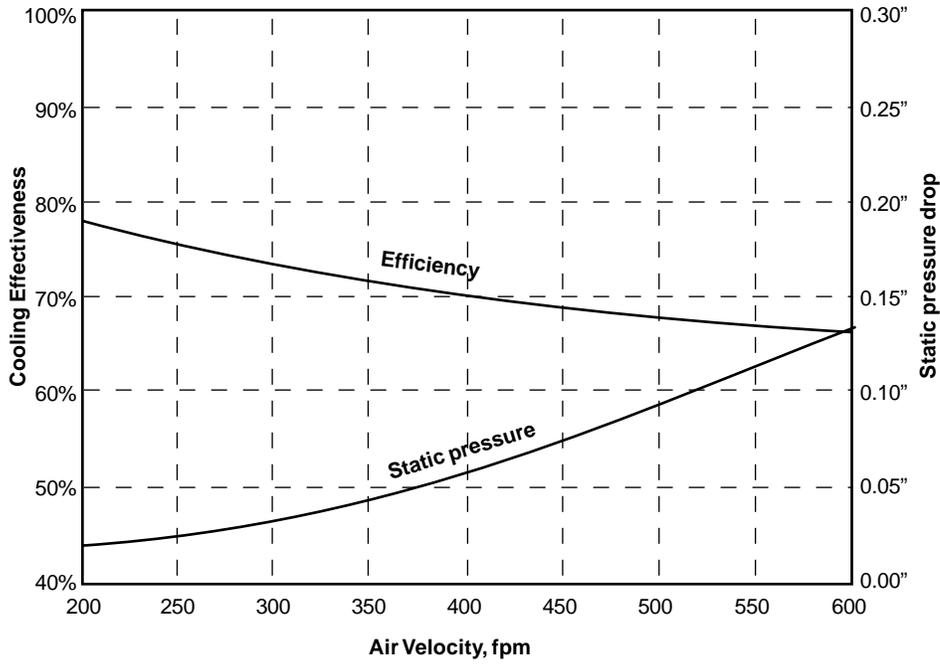


Figure 3. Performance characteristics of two similarly-rated 48-inch belt drive exhaust fans.

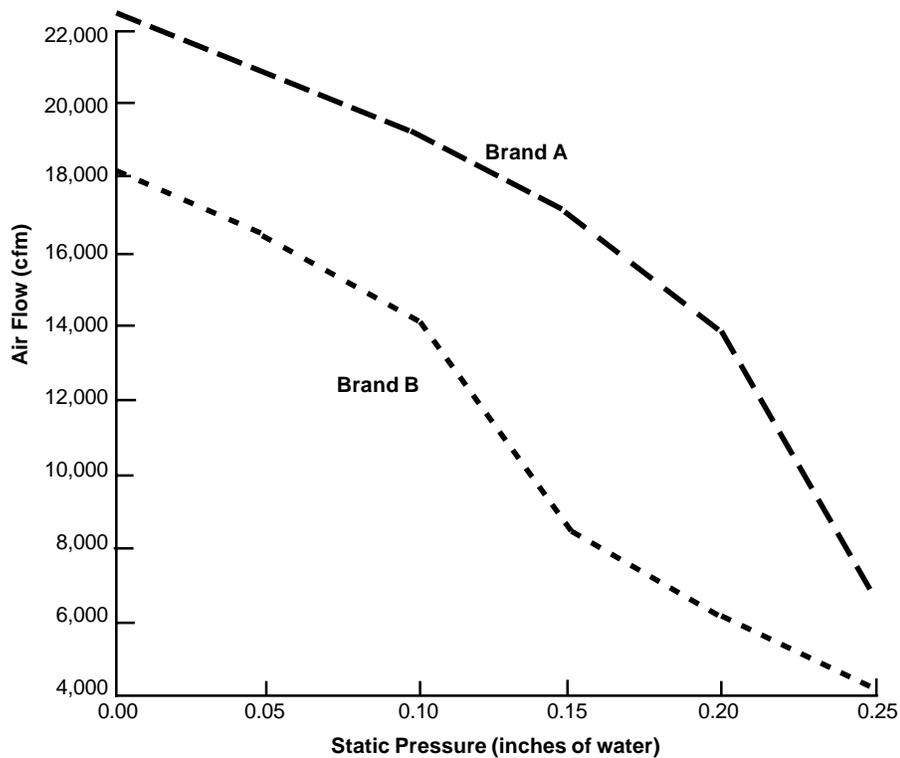
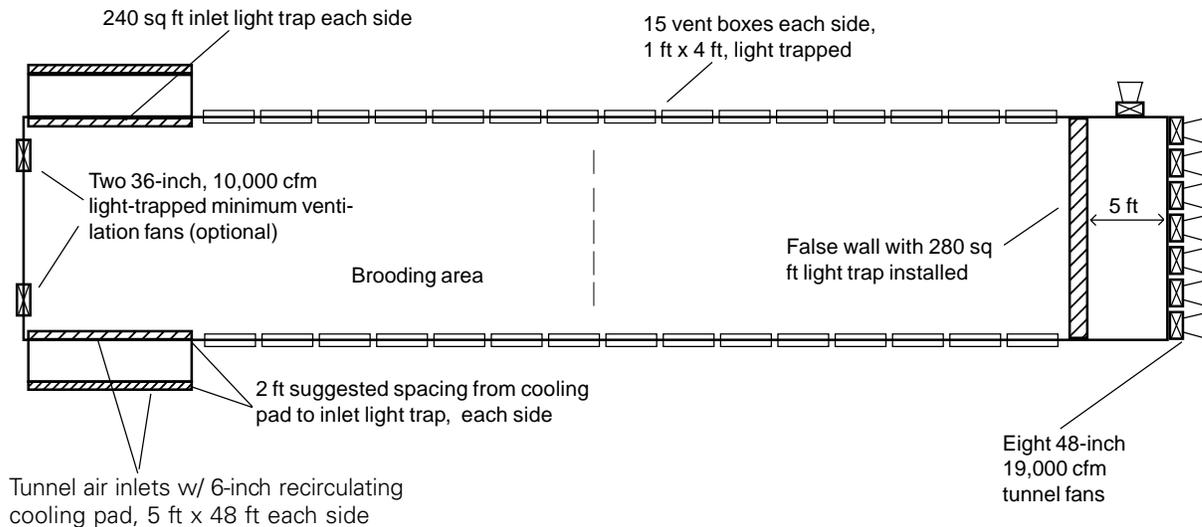


Figure 4. Recommended Typical 40 ft by 400 ft Dark out Pullet House
11,000 birds, 4.5 lbs maximum
(not to scale)



Design Calculations

1. Tunnel air speed

400 fpm desired; choose fan that will produce this at 0.15 inches S.P.

$400 \text{ ft} \times 9.5 \text{ ft} \times 40 \text{ ft} = 152,000 \text{ cu ft}$

$152,000 \text{ cfm} \div 8 \text{ fans} = 19,000 \text{ cfm}$ rating for each fan at 0.15 inches S.P. minimum requirement

2. Evaporative cooling pad determination

$152,000 \text{ cfm} \div 350 \text{ fpm face velocity} = 434 \text{ sq ft}$ needed for 0.05 inches S.P. or less drop across pad. Suggest 480 sq ft of total pad to be installed; use 5-ft pad, so 48 ft each side.

3. Inlet light trap determination

If 480 sq ft of inlet light trap is used, the face velocity will be $152,000 \text{ cfm} \div 480 \text{ sq ft} = 316 \text{ fpm}$. Suggest Hired-Hand ProDark.5, Munters Half-Dark or equivalent inlet trap, pressure drop is 0.015 inches S.P.

Using Black Air inlet trap, pressure drop would be 0.02 inches S.P.

4. Size of light trap on false wall and pressure drop on fans

Use Munters Mi-T-Dark, Hired-Hand ProDark or equivalent

False wall will hold only 40 ft x 6 ft area of light trap, or 240 sq ft unless traps are stacked

$152,000 \text{ cfm} \div 240 \text{ sq ft} = 633 \text{ fpm}$ face velocity, which produces 0.10 inches S.P. drop on fan – too high.

Suggest stacking traps to use 280 sq ft on false wall:

$152,000 \text{ cfm} \div 280 \text{ sq ft} = 542 \text{ fpm}$ face velocity, which produces 0.08 inches S.P. drop on fan

5. Total pressure check

Pads 0.05 in. + inlet traps 0.02 in. + exhaust traps 0.08 in. = 0.15 in. S.P.

When in full tunnel with 8 fans operating, we should be able to have full 6-inch recirculating pad cooling and 400 fpm tunnel wind speed operating adequately at 0.15 inches S.P. With fewer than 8 fans operating, this design will be more than adequate.

6. Number and size of minimum/transitional ventilation vent boxes

Design based on ability to run three 48-inch fans with tunnel inlets fully closed, at static pressure of 0.10 inches.

$3 \text{ fans} \times 21,086 \text{ cfm} = 63,258 \text{ cfm}$

$63,258 \text{ cfm} \div 600 \text{ fpm face velocity} = 105 \text{ sq ft}$ minimum

Suggest 120 sq ft, or 30 vents 1 ft x 4 ft on each side of house, equally spaced.