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High Windspeed for Large Birds – Practical Considerations

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REVISED EDITION

Over the past five years, we have been seeing steep increases in windspeed requirements for large birds, from about 500 feet per minute up to 750 fpm. Why has this happened? Higher windspeed dissipates more heat from these birds, resulting in better feed conversion, faster growth rate, lower mortality, and increased yields.

As should be expected, achieving such a steep increase in windspeed requires significant additional investment in equipment, whether in upgrading an existing broiler house or building a new house to operate at the higher windspeeds. Further, limits imposed by the physical laws governing movement of air from one place to another become much more restrictive at such high windspeeds. As a result, meeting high windspeed requirements involves serious engineering and economic challenges.

This newsletter outlines the most important practical engineering and economic considerations growers and companies must understand in meeting high windspeed requirements – including real-world considerations as to exactly how windspeed is defined, determined or measured.

High Windspeed – Engineering Challenges

Key point: *As windspeed is to be increased, the increased power required at each step goes up very steeply, and not in a one-to-one proportion. For example, increasing windspeed by, say 50%, from 500 fpm to 750 fpm, requires not just half again (50%) more energy/fan power, but at least twice as much energy/fan power*.

The practical effect of this physical fact is easily seen in the chart below showing actual windspeeds measured in an empty16-fan tunnel house with six fans running and then as additional fans are turned on one by one. This is a well-designed house with identical 54-inch high-capacity fans (except for fan #1, a 48-inch), so you might expect windspeed in fpm to go up the same amount as each additional fan is turned on. But this is not what happens. Instead, the fpm gain per additional fan (at the feed line) drops from 68 fpm as fan #7 is turned on to only 35 fpm additional windspeed as fan #16 is turned on.

Fans On:	FPM at feed line	FPM at center	FPM gain at feed line	% gain at feed line	SP - Fan end	SP- Controller
#1-6	280	303			0.030	0.030
#1-7	348	387	68	24%	0.040	0.038
#1-8	396	435	48	14%	0.050	0.046
#1-9	444	490	48	12%	0.065	0.056
#1-10	495	536	51	11%	0.080	0.065
#1-11	542	588	47	9%	0.095	0.077
#1-12	582	633	40	7%	0.110	0.084
#1-13	651	667	69	12%	0.125	0.100
#1-14	708	717	57	9%	0.140	0.112
#1-15	738	747	30	4%	0.150	0.120
#1-16	773	782	35	5%	0.175	0.130

Data taken with a Kestrel 3000 windspeed meter

Real-world measurements in an actual broiler house show how physical laws of diminishing returns limit our ability to increase windspeed. Additional fans do not provide the same windspeed increase.

Adding fan #7 gives a 68 fpm increase (+24%); adding fan #16 gives only 35 fpm additional windspeed (+5%).

Understanding why additional fans do not provide the same windspeed increases requires recognition of another key point: *A fan's "capacity" in cfm (and therefore also in fpm of windspeed) depends entirely on the static pressure the fan is working against*.

That is, a fan's cfm "rating" applies only for one stated static pressure. The higher the static pressure, the lower the cfm & fpm will be.

That static pressure of course is created by the fan(s), and a higher pressure difference is required to generate higher windspeed. We add fan-power to increase the static pressure and get the higher windspeed, but at each step, each fan's resulting cfm/fpm performance drops. At 0.05 sp (what we see in the chart on page 1 at about 8 fans running), the fans in the example house are rated to produce 30,800 cfm. At 0.15 sp (15 fans running) the rated capacity is only 26,800 cfm.

The loss in cfm/fpm at higher static pressures happens because achieving – and working against – the higher static pressure involves a cost in fan rpm's. Small losses in rpm's cause large losses in cfm/fpm. The following table shows the complete BESS Lab test results for our example house fans:

BESS Lab Fan Performance Test: 54-inch Butterfly Shutter

Static Pressure (in.H2O)	Airflow (cfm)	rpm	Volts	Amps	Watts	cfm/Watt
0.00	**32500**	562	229.8	5.78	1311	**24.8**
0.05	**30800**	560	230.0	6.18	1400	**22.0**
0.10	**28900**	559	230.0	6.60	1494	**19.4**
0.15	**26800**	557	229.6	6.98	1575	**17.0**
0.20	**24600**	556	230.0	7.33	1658	**14.9**
0.25	**22300**	554	229.9	7.67	1733	**12.8**
0.30	**19800**	553	229.7	7.94	1791	**11.1**

Almost all manufacturers send fans to the BESS Lab at the University of Illinois for testing. As these test results show, operating a fan at higher pressures causes dramatic losses in airflow (cfm) and in electrical efficiency (cfm/watt).

Many fans that were acceptable for the pressure ranges needed in 500 fpm houses are not nearly as efficient at the operational pressures of 0.15 and above that are typically needed in 750 fpm houses.

Clearly, we are experiencing the law of diminishing returns. If on average it took ten 48-inch fans to achieve an average 500 fpm in a tunnel house, one might think 750 fpm could be achieved with fifteen of the same fans if the appropriate amount of cool cell and tunnel inlet were added. This is an incorrect assumption. Because of the increased pressure requirements on all fans and the resulting decreased airflow of each existing fan, it could take as many as 17-18 of the original fans to achieve the 750 fpm requirement.

As the BESS Lab testing results for the fans in our example show, these fans' output drops from 28,900 cfm at 0.10 sp to 26,800 cfm at 0.15 sp and 24,600 cfm at 0.020. The fan's operating efficiency – another important factor in grower costs – drops from 19.4 cfm/watt at 0.10 sp to 17.0 cfm/watt at 0.15 sp and only 14.9 at 0.20 sp. The truth is that many fans that were acceptable for the static pressure ranges needed in 500 fpm houses are not nearly as efficient at the operational pressures of 0.15 and above that are typically needed in 750 fpm houses.

What is the take-home point from this example? Sometimes older fans should be replaced so that the whole fan array operates well at higher static pressure levels. In all cases, whether replacing all or simply adding additional fans, the new fans should be ones that operate more efficiently at higher pressures, such as 0.15 or above.

Could adding inlet/pad area be a simple way to resolve the high windspeed engineering challenge?

Many people think additional pad area would reduce the static pressure fans have to work against, and so be a way to avoid having to add too many more fans, or having to replace existing fans with higher-cfm rating fans. This was the case in "the old days" when windspeed was 400-500 fpm and as much as two-thirds of the static pressure load was determined by the size of the inlet area. This may still be the case in houses that are experiencing inlet restrictions. However, if the inlet area is not restricted by such things as curtains being in the way or tunnel doors not opening enough, once we get to 600 fpm and try to go even higher, most of the static pressure load is created by having to physically force considerably more air through the "tunnel" of the tunnel house. Field testing in otherwise properly constructed high windspeed houses (600 fpm and above) has shown that even opening the house front doors would produce little or no increase in windspeed.

We still need inlet and pad area appropriate to the installed fan capacity; but adding extra pad area to a well-designed house may actually result in a net loss, with the extra installation and maintenance costs producing no significant increase in windspeed, but hurting flock performance by making an even larger dead spot in the front end of the house.

This is another reason why, from an engineering standpoint, the law of diminishing returns puts a definite practical limit on achieving higher and higher windspeeds. As one industry veteran recently said, "there is just so much sausage you can stuff into a casing, and a bigger funnel won't help."

High Windspeed – Real-World Measurement Challenges

What is the definition of a 600 fpm or 750 fpm house? When a company specifies that a desired windspeed is needed on a given poultry house, it is very important to know how achieving that windspeed will be determined. If it is to be determined by actual in-house measurements, we must know exactly where and how that windspeed will be measured, and all parties must understand what the measurement is actually telling them.

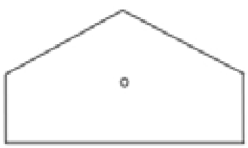
A house's design windspeed is determined by a calculation, rather than by measurement. Taking the total installed fan rated cfm's at the design static pressure and dividing by the cross-section area of the house gives a feet-per-minute number that will correspond to the expected overall average windspeed through the house. For example:

- 13 fans rated at 22,000 cfm at 0.20 sp = 286,000 total cfm's
- 40-ft wide house with 8 ft sidewall and 11 ft peak = (8+11)/2 X 40 = 380 sq ft cross-section area
- Design windspeed = 286,000 cfm divided by 380 sq ft = 752.6 fpm

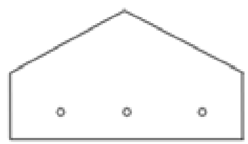
A house design windspeed number is useful – this is the way poultry houses are designed, after all – but it is not likely to match exactly to real-world field measurements, or to what is important to the birds, for two reasons:

1. Fan cfm ratings typically are derived from BESS Lab tests of brand-new fans under ideal conditions, and these are given as plus or minus 5%; in addition, actual installed fan cfm's will vary, usually downward, depending on age, maintenance conditions, and placement in the house.

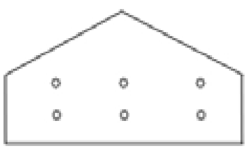
2. Real-world as-measured windspeeds will be different, often very different, depending on exactly where and how measurements are taken. The following diagrams show how this plays out with different measurement patterns:



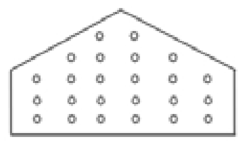
Center of House – Likely to be higher than design fpm



Three-Point Average at Bird Level – Likely to be lower than design fpm (and lowest of all)



Six-Point Average – Likely to be higher than Bird Level, lower than design fpm



Cross-Section Traverse – Likely to correspond most closely to design fpm

Company requirements for measured windspeed vary, some as simple as the Center of House pattern above, taking one reading in the center of the house 5 feet above the floor, 100 feet from the fan end. It might be an instantaneous reading or it might be obtained by allowing the wind meter to measure the average air velocity for a period of time (often 1 minute). Some companies require 3 readings, 3 feet above the floor (one reading between feed and water lines on each side of the house, and one reading in the house center). Other companies may require 6 readings (3 at 3 feet above the floor and 3 at 5 feet above the floor, between feed and water lines and in the center, 100 feet from the fan end). These multiple readings are averaged together to arrive at a single composite windspeed value for the house. Most wind meters have averaging, max-speed, and current speed modes. It is important to understand the value and the differences of these modes. Also all should be aware that windspeed meter readings may vary as much as +/- 3%.

Where and how the sample is taken, then, is critically important. In addition, in-house conditions, with or without birds, equipment up or down, etc., all affect the results. In considering either retrofitting an old house or building a new house to meet high windspeed requirements, it is very important that the grower and any design consultant understand the relationship between design and real-world windspeed, and how any particular measurement pattern or procedure that is to be followed will affect the design.

For example, in the above example house with a goal of 750 fpm, using 13 fans rated at 22,000 cfm each, based on the BESS Lab data for the fans, the +/- 5% factor means you might see anywhere from 710 to 790 fpm overall average house windspeed. If you measure at a single point in center of house 5 feet off the floor you will see higher velocity, likely in the 800-900 fpm range, depending on sidewall geometry, knee braces, deflectors, equipment, birds/no birds, etc. If you average three points 3 feet off the litter you will most likely see lower velocity, likely in the 600-700 fpm range, again depending on the side wall geometry, knee braces, deflectors, equipment, birds/no birds.

<u>The take-home point</u>: There may be no perfect method to take in-field windspeed measurements. The methods outlined here are typical. There may be others that work as well or better. It must be understood that in any case, field measured wind speed and the design wind speed derived from the calculations above will always differ, depending on chosen measuring procedures and in-house conditions. These effects must be kept in mind when deciding on what the design wind speed should be for any retrofit or new house design. Whatever method is used, it is important to strive for a repeatable, consistent technique and to understand what the gathered measurement numbers mean and how they relate to calculated design numbers as outlined above.

High Windspeed – Economic Challenges

What are the economic challenges of trying to achieve higher windspeeds, from both a grower and company standpoint? The critical questions which must be answered by both growers and companies are: 1) What are the investment and operating costs, and can they be recouped within a reasonable time frame? 2) Given the age and condition of the house, pay rates, and placement densities, does this represent a good business decision? Following is an outline of the most important factors to be considered:

Definite Added Investment Costs

1) Additional fans, installation & wiring
2) Additional cool cells, installation & wiring
3) Interest on additional borrowed capital

Potential Added Investment Costs

1) Resizing of electrical breaker box
2) Resizing wires to each house from main farm service
3) Increasing generator size or capacity
4) Increasing water line capacity
5) Increasing capacity of power utility transformer

Added Operating Costs

1) Additional annual electrical usage (kWH) of fans
2) Additional annual water expense associated with larger cool cells

Revenue Sources

1) Increased pay rate
2) Increased poundage from improved placement density
3) Increased poundage from improved performance

The Bottom Line

As a case example, if we look at a typical 8-10 year old 40x500 solid wall house with ten 48-inch fans, we would have approximately 231,000 cfm and 608 fpm design windspeed at a 0.10 sp. If we add five more of those same 48-inch fans, we will have 286,500 cfm and 754 fpm at a 0.20 sp. That five-fan increase of 150 fpm would only gain us 55,500 more cfm and an average of only 30 fpm increase per fan, yet cost around $5,000 and increase the power bill by $225/1,000 hours of operation.

Alternatively, we might add only three 54-inch fans to achieve the same 750 fpm, but their cost would still approach $5,000 and the power bill would go up by about the same amount. In either case, a $2,500 cool cell addition would be required. Therefore the cost of increasing windspeed from 600 to 750 fpm would be at least $7,500.

In any case a grower considering higher windspeed must carefully weigh the additional investment costs against projected increased income from possible increased pay rate, pounds produced and/or placement density. Only after estimating these figures can a smart business decision be made. From an industry standpoint, the facts of increasing costs with diminishing returns using current air-moving technology combined with today's placement densities suggests that new technology needs to emerge if design windspeeds increase above 750 fpm.

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