Selecting a suitably sized organ blower

In the second of two articles on organ winding, Stephen Lemmings explains the calculations used by BOB Stevenson Ltd to recommend the correct choice of electric blower

The British Organ Blowing Method of Ascertaining Wind Required for Organs in c.f.m. has become one of the proven methods for calculating the organ s wind requirement - *but don t forget to add on the ductwork pressure drop!*

Figure 1 is a scan of a 1950 s reprint from the original 1930 s edition of the wind calculation sheet produced by Arthur E. Fryer, the founder of British Organ Blowing Co. Ltd. Although currently under revision, it is still in use today and reinforces the reliability of the method devised all those years ago.

Consider the organ blowers shown on the Organ Blower Selection Chart , Figure 2, as you would an off the peg suit; a quick fix, an excellent price and very often more than acceptable, but please be aware that a specifically tailored organ blower can be made available for special installations.

Also be aware that the performance figures given in the selection chart are the actual performance of the blower, and make no allowance for pressure drop through the wind ducting system. This must be estimated and added to the organ s pressure requirement.

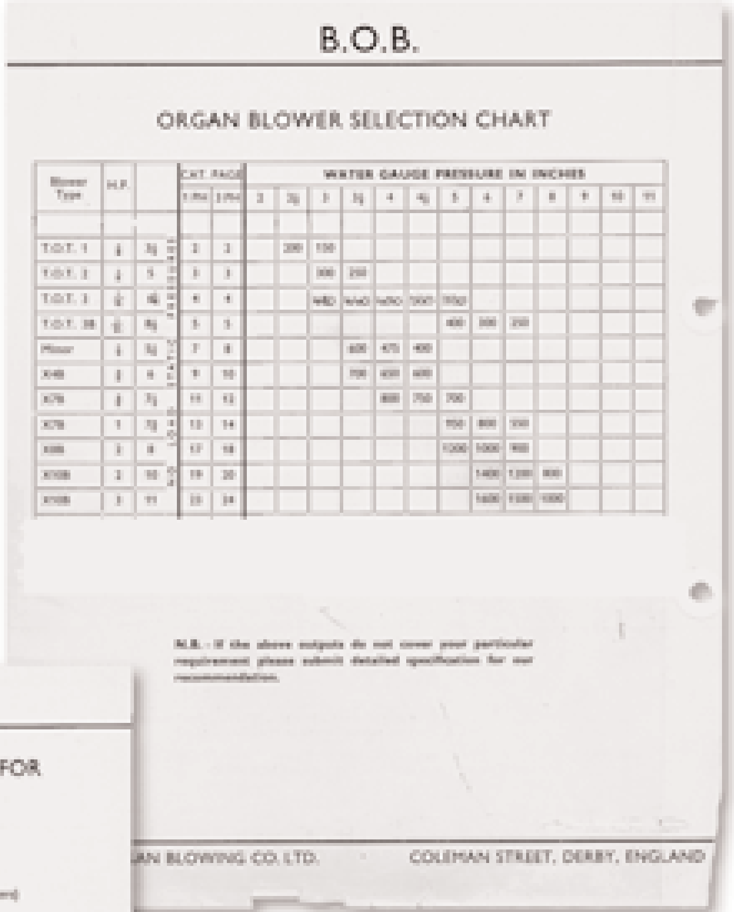

Chart: BOB Stevenson Ltd

Fig 2. Organ Blower Selection

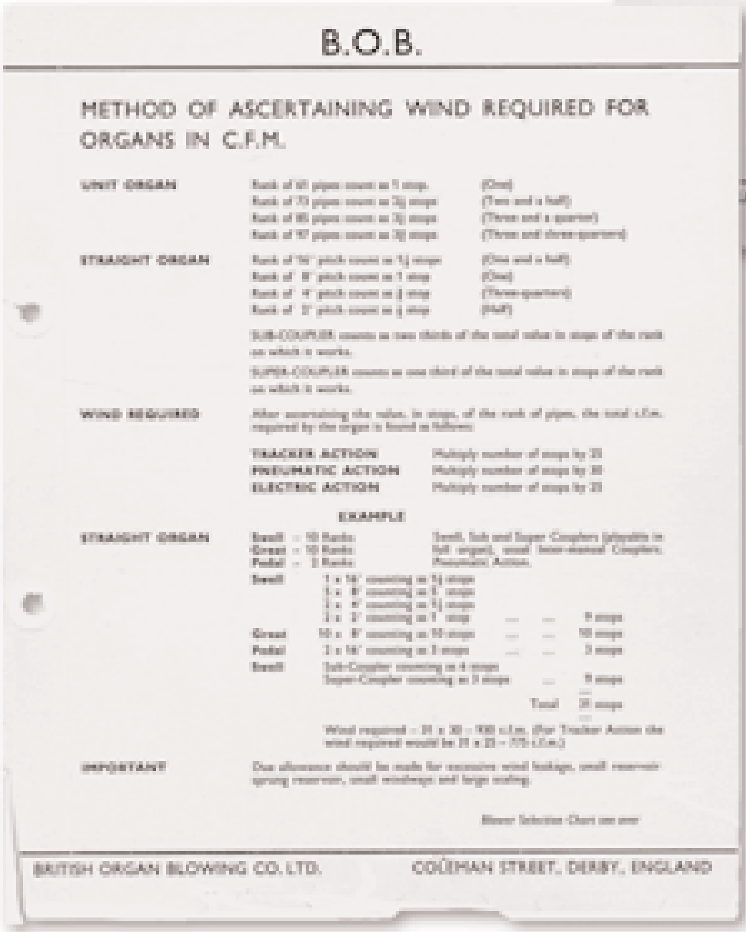

Chart: BOB Stevenson Ltd

Fig 1. Wind calculation

Although our method of ascertaining wind requirement has not changed, we are now aware that organs of more recent design and construction have different methods of wind and pressure regulation. The large area windways and large bellows capacities traditionally incorporated are not always utilised. Careful consideration must now be given to the delivery capacity of the blower, which can no longer rely on the ample reserve of air contained in the bellows, especially when full organ is held for a sustained period of, say, 15 seconds.

The Organ Blower Selection Chart shows the performance in c.f.m. against inches of water gauge pressure in tabular form, and is taken from fan performance curves that give very specific technical information.

EXAMPLE

Consider a large three-manual and pedal organ. Having calculated the wind requirement to be some 1600 cubic feet of air per minute (c.f.m.), the blower is often selected to suit the highest-pressure bellows in the organ. Assuming this is 3.5 inches water gauge pressure (w.g.p.), due consideration must also be given to the main wind duct used to convey wind from the blower to the bellows. Allowance should be made for pressure loss in the duct, especially if it has a tortuous route.

This pressure loss can be calculated. The existing wind duct from the blower in the chamber at the far end of the church is 8 inches in diameter and on its route to the bellows turns through four 90” bends and one 45” bend, and travels a total distance of 55 feet.
Cross sectional area (c.s.a) of the duct
$= \pi r^2 = \pi \times 4^2 = 50.26$ in^2

From the formula
Velocity in the duct (ft/min)
= volume flow (c.f.m.) x 144   c.s.a. (in^2)
= 1600 c.f.m. x 144   50.26 in^2
= 4584 ft/min

Symbols used in the calculations
ft/min = feet per minute
c.f.m. = cubic feet of air per minute
L = length of duct in feet.
D = diameter of duct in feet
P_T = total pressure (inches of water gauge)
P_V = velocity pressure (inches of water gauge)
P_S = static pressure (inches of water gauge)
V = velocity (ft/min)
K = factor defined for various applications
π = pi = 3.1415

Pressure loss along a straight duct $P_2 = K \times P_V$

Circular Section

$K = 0.02 \times \frac{L}{D}$

Rectangular Section of A x B feet

$K = 0.01 \times \frac{A + B}{A\,B} \times L$

Other Sections

$K = 0.005 \times \frac{\text{perimeter in feet}}{\text{area in ft}^2} \times L$

Velocity pressure

$Pv = \left[\frac{V}{3970}\right]^2$

For our example,

$Pv = \left[\frac{4584}{3970}\right]^2 = 1.33$ inches of w.g.p.

Therefore

$P_2 = 0.02 \times \frac{L}{D} \times 1.33$

$= 0.02 \times \frac{55}{0.6} \times 1.33$

= 2.2 inches of w.g.p.

Losses at change of direction $P_5 = K \times P_V$

K= 0.8 for a 90” bend
K= 0.4 for a 60” bend
K= 0.25 for a 45” bend
K= 0.16 for a 30” bend

We know that P_V = 1.33 inches w.g.p. as the velocity has not changed.

Number of bends
= 4 x 90 and 1 x 45

Therefore losses due to bends in the system
= [(4 x 0.8) + (1 x 0.25)] x 1.33 = 4.58 inches w.g.p.

Our *total* losses for the duct run (P_T)
= $P_2 + P_5$ = 2.2 inches + 4.58 inches
= 6.78 inches w.g.p.

Our pressure requirement at the bellows
= 3.5 inches w.g.p. + pressure loss in the wind trunk system
= 10.28 inches w.g.p.

Therefore the blower should be rated for 1,600 c.f.m at a minimum of 10.28 inches w.g.p.

Quite different from that which might have been selected originally! This is why it is so important to discuss and give as much detail as possible to the blower manufacturer at the initial stage.

Duct Design & Sizing

Let us go back to the example of a large three-manual and pedal organ. To ensure quiet, smooth flow of air in a duct, the air velocity should be not more than 1500 ft/min.

We know from our earlier formula that

Velocity in the duct = volume flow (c.f.m.) x 144   c.s.a. (in^2)

= 1600 c.f.m. x 144   50.26 in^2

=4584 ft/min

So we have a very high velocity and hence noisy wind duct. Fortunately, when the blower is operating at its rated capacity of 1,600 c.f.m the speaking pipes will usually mask the noise of the wind duct. However a trained ear can, and will, detect the noise and the blame will be laid at the blower.

To find the *ideal* duct size for conveying 1600 c.f.m., simply transpose the formula

Velocity in the duct (ft/min) = volume flow (c.f.m.) x 144 c.s.a. (in^2)

into

c.s.a.(in^2) = volume flow (c.f.m.) x 144   velocity in the duct (ft/min)

= 1600 x 144   1500 ft/min (ideal)

= 153.6 in^2

which equates to a 14 inch diameter duct.

This ideal sizing will allow a full organ demand of 1600 c.f.m. to raise the velocity in the duct to 1500 ft/min. Obviously when the organ is played normally the volume demand is much less and therefore the velocity in the duct drops below the 1500 ft/min, passing the air very quietly indeed. The ideal is not always attainable, but it is certainly well worth considering in a critical installation when perfection is sought.

In many installations, the original design may have been done badly, and no consideration is then given to the installation as a whole when the blower is subsequently replaced like-for-like. This is where the greatest changes and improvements can be achieved, but it does mean time must be spent assessing and considering the whole installation - i.e. blower, wind duct, surroundings and organ.

Specific Volumetric Consumption of Individual Flue Pipes

When individual stops make a large demand on the wind supply, a more accurate method of calculation is needed than that given earlier in this paper.

Much has been made in the past of the measurement of wind consumption either by mass flow calculation or velocity calculation, and whether the pipe is tuned to a particular pitch. All this calculation is unnecessary, because there is an empirical formula that states   a specific amount of air will be passed through a known cross sectional area when delivered at a known pressure .

Consider a single 32 flue pipe. The amount of air volume passed is entirely dependent upon the smallest cross sectional area (c.s.a.) which is the flue formed by the languid, not the tip hole. The amount depends on the pressure (inches of water gauge pressure) at which the air is delivered, irrespective of the tuning of the pipe, and can be measured easily with a manometer at the regulating bellows. If the duct run to the pipes is short and of adequate cross section then there will be little or no pressure loss due to friction.

In our standard calculations we would treat the 32 pipe as four 8 stops

Wind required (assuming electric action)

= 4.0 stops multiplied by 25 for the action

= 100 c.f.m. or 1.66 ft^3 per second.

A slot or flue of the pipe of 12 inches x 0.25 inch would give 3.0 in^2 c.s.a. If the air entry hole or tip of the pipe was 4 inches diameter or 12.57 in^2 c.s.a. then the air supply to the flue would not be restricted by the tip hole. Assume the pipe was sitting on a chest or soundboard of air at 6.0 inches w.g.p.

Using the following standard empirical formula, we know how much air can be passed through a known opening (open cross sectional area)

The volume flow in c.f.m. that can be passed through 1 in^2 of open area

= 27.55 x $\sqrt{P_s}$

where P_s = active static pressure in inches of water gauge.

In our example the volume per square inch of open area

= 27.55 x $\sqrt{6}$

= 67.48 c.f.m.

but we have 3 in^2 of open area in the slot so the flow through the pipe

= 3 x 67.48

= 202 c.f.m. or 3.37 ft^3 per second

But of course the note is usually only held for seconds, and the reserve of air in the bellows may be adequate. If full organ is held for an exceptionally long period, the only way to provide sufficient volume of air would be to utilise the above detailed calculation for the organ which might indicate that perhaps two or more times the wind volume would be required. Sometimes 10 to 15 seconds of full organ is specified but possibly never used in practice. I do appreciate that perhaps not all the pipes will be utilised when full organ is played, and the period will vary between composition, organist s interpretation and winding of the organ. This is a neglected subject and the organ will benefit from any input into this field, so any feedback will be greatly appreciated.

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