The great duct debate:

another view on equivalent sizing

BY JOHN GIERZAK

After reading the article in the September 2001 issue of Snips, "Taking the mystery out of equivalent sizes of duct," I felt the need to clarify some things.

The velocity in rectangular duct, 35 X 20 inches for example, is based on the duct's cross-section, not its equivalent diameter as we are led to believe in the article: "you can see that for 7,500 cfm, the velocity in 35 X 20 duct has increased to about 1,700 fpm…" Velocity does not increase in a duct unless the cross-sectional area decreases, or the volume flow rate (cfm) increases. A flow rate of 7,500 cfm will always produce 1,543 cfm in 35 X 20 duct. Perhaps the author read the velocity from the Ductulator, forgetting that it applies only to the round duct.

I think what the author was trying to convey is the following:

That even though the 35 X 20 duct has approximately the same cross-sectional area as a 30-in. duct, the friction loss is higher than the 30-in. duct. That higher friction loss equates to about 0.13-in. of water per 100 feet for the 35 X 20 rectangular duct and it would take 1,700 fpm in the 30-in. round duct to have the same friction loss. Therefore, if you use an equal area conversion from round to rectangular duct, the frictional losses are greater due to rectangular duct being less efficient than round duct in conveying air.

I would like to take an opportunity at demystifying the equivalent diameter concept. A rectangular duct and round duct that have the same pressure drop per 100 feet, are what we call equivalent. That is, they have an equivalent friction loss per unit length where the unit length is equal to 100 feet. This friction loss per 100 feet is better known as the friction loss factor. The Ductulator uses this commonality, the friction loss factor, to convert from round to rectangular and vice versa.

For any rectangular duct there is a round duct that will have the same friction loss factor. The round duct that has the same friction loss factor is called the equivalent diameter for the rectangular duct. We use equivalent diameter because round duct has the least amount of frictional losses per unit length of any shape with all else being equal; i.e. surface roughness, cross-sectional area, and air density. Therefore, equivalent diameter is the de facto standard for converting one duct shape to another. Note that equivalent diameter and equivalent round are interchangeable terms.

From *ASHRAE Fundamentals Handbook*, the following equations may be used to convert rectangular and flat oval ducts to and from round.

Rectangular ducts: $$D_{eq} = \frac{1.30(ab)^{0.625}}{(a+b)^{0.250}}$$

where a and b are duct dimensions

Flat oval ducts: $$D_{eq} = \frac{1.55AR^{0.625}}{P^{0.250}}$$

where AR is the cross-sectional area, and P is the flat oval perimeter.

Note that in both equations that for a given round duct

Continued on page 34

diameter, the dimensions for rectangular and flat oval ducts must be solved for by trial and error. Fortunately, there are conversion tables and Ductulators that make this conversion easy.

Fortunately, there are conversion tables and Ductulators that make this conversion easy.

For example, if you have a 30-in. dia. duct that is being converted to a rectangular or flat oval duct, you first decide on the minor axis you will use. Let's use 16 inches for the minor axis. Conversions can be done with the use of a Ductulator, making calculations or utilizing a conversion table. If using a table, look up the rectangular and flat oval ducts that have a 16-in. minor axis and an equivalent diameter equal to 30 inches; you may have to interpolate.

The equivalent rectangular and flat oval ducts with a 16-in. minor axis are 16 X 51 and 16 X 53, respectively. What this means is that all three ducts, 30-in. round, 16 X 61 rectangular, and 16 X 53 flat oval, will have the same friction loss for a fixed duct length for a given cfm, or simply put, all three have the same friction loss factor for a given cfm.

What happens when we put 7,500 cfm in each of these ducts? The accompanying table summarizes the properties for each duct carrying 7,500 cfm.

7,500 cfm in three ducts with same EQUIVALENT DIAMETER

Duct shape	Exact converted dimensions	Rounded dimension(s)	Cross-sectional area (sq.-ft.)	Velocity (fpm)	Friction loss (in.wg./100ft.)
Round	—	30	3.14	1592	0.10
Flat oval	16 X 52.6	16 X 53	5.51	1412	0.10
Rectangular	16 X 51	16 X 51	5.67	1362	0.10

Note that of the three ducts, the round has the smallest area and the highest velocity. Yet all three ducts have the same friction loss factor because they are equivalent (in terms of pressure drop per unit length.) Therefore, round duct is most efficient as it can handle the same amount of airflow in a smaller space. This efficiency is most evident in the table below where conversions from 30-in. round are based on equal area. Due to rounding to nearest inch, cross-sectional areas of the flat oval and rectangular ducts are not exactly equal to the 30-in. round duct.

Continued on page 36

Tech Tips

7,500 cfm in three ducts with same EQUAL AREA						
Duct shape	**Exact converted dimensions**	**Rounded dimension(s)**	**Cross-sectional area (sq.-ft.)**	**Velocity (fpm)**	**Equivalent Diameter (inches)**	**Friction loss (in.wg./100ft.)**
Round	—	30	4.91	1592	30.0	0.10
Flat oval	16 X 47.6	16 X 48	4.95	1515	28.8	0.12
Rectangular	16 X 44.2	16 X 44	4.89	1534	28.2	0.14

As you can see, when round duct is converted to flat oval or rectangular duct, using an equivalent cross-sectional area increases the frictional loss.

Therefore, when converting a round duct to flat oval or rectangular, don't use equivalent area as it will increase the pressure drop of the duct run. Use equivalent diameter. Do this if duct is the only thing you are converting – tees, laterals or crosses are another matter.

(John Gierzak has been employed with McGill AirFlow Corporation, a subsidiary of United McGill Corporation, for over 10 years working in various capacities in the Engineering Department in Westerville, Ohio. Currently he manages the airflow and acoustical product development in McGill's airflow and acoustical laboratory. An active member of ASHRAE, AMCA and ASTM, Gierzak serves as chairman of the Engineering Committee for the Acoustic Attenuation Division in AMCA and secretary for ASHRAE Technical Committee 5.2, Duct Design.)

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