Introduction

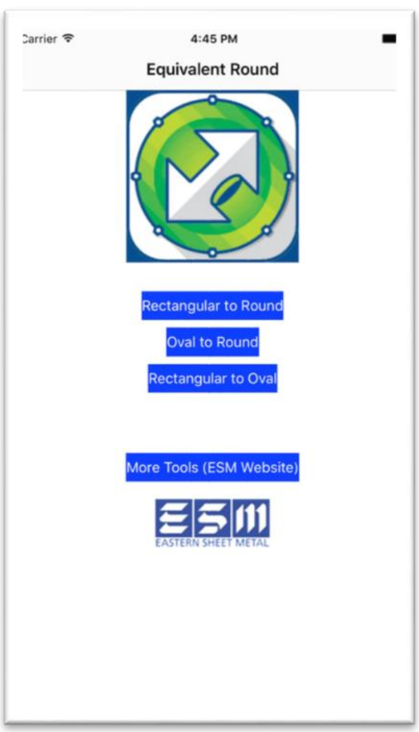
Round is the most efficient duct shape for transporting air. Round duct has less surface area, weight and fewer joints than rectangular duct. It is much easier to seal and can easily be specified to meet SMACNA Class 3 Leakage even at 10 in. wg static pressures.

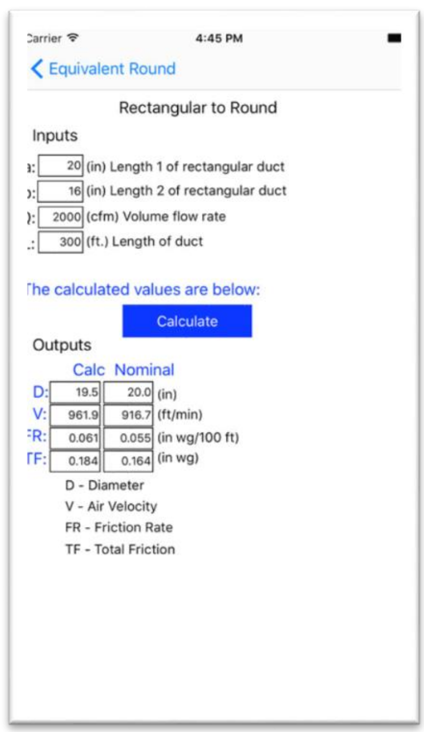
Flat Oval is the next most efficient shape and the closer the aspect ratio approaches 1, the more it approaches the efficiency of round duct. An aspect ratio of 1 is round duct.

When a designer sees rectangular duct on a drawing, they should convert it to an equivalent round size if possible. If it cannot be converted to round because of restrictions, it should be converted to an equivalent flat oval size. That will at least give the duct system many of the advantages of round, but fit within the space allocated.

Once in a while flat oval duct can be converted to the even more efficient shape of round, if the equivalent round size fits the available space.

Eastern Sheet Metal's Equivalent Duct Calculator APP does all that and will calculate the friction loss for standard air if the volume flow rate is entered. The APP is available for Apple or Android Systems. You can search for it by entering "Equivalent Round" or visit Eastern Sheet Metal to download.



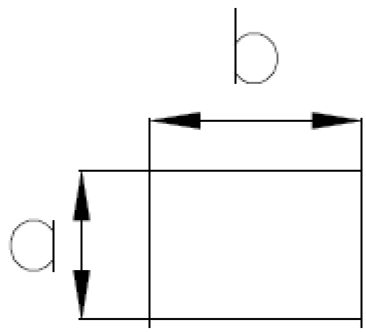


The equations used in the app are standard ASHRAE equations for equivalent round diameter, flow rate and friction loss. They are listed in this User's Guide Appendix.

FUNCTIONS OF THE APP

Rectangular to Round

Select this option when you know the rectangular dimensions that you would like to change to an efficient round size. Enter the two rectangular dimensions of the sides, side 1 is "a" and side 2 is "b". Enter these dimensions in inches.



If you want to know the friction rate (FR) in in. wg/100 ft., then enter the volume flow rate, Q, in cfm (cubic feet per minute). This is not necessary to determine the equivalent round size, but calculated if you need it. Pressure loss for a specific airflow rate can be determined by entering the length (L) in feet. Once the values are entered, press the 'Calculate" icon. The output will include:

(D) Equivalent Round Diameter (inch)

(V) Velocity (ft/min)

(FR) Friction Rate (in. wg/100 ft)

(TF) Total Friction, which is the pressure loss caused by friction along the length entered (in. wg)

Example: Rectangular to Round

Input

a = 12 inches

b = 18 inches

Q = 2000 cfm

L = 50 ft

Output

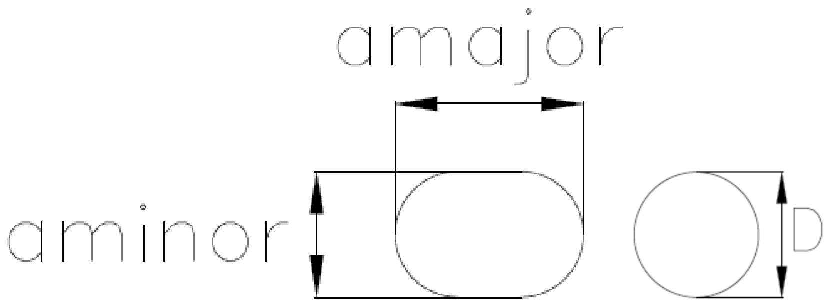
	Calculated	**Nominal**
D (inch):	16	16
V (ft/min)	1435	1432
FR (in. wg/100 ft)	0.165	0.164
TF (in. wg)	0.0823	0.0820

The calculated values are based on the exact dimension for D. The nominal values are based on the closest real world dimension available.

Eastern Sheet Metal

Oval to Round

Select this option when you know the flat oval dimensions that you would like to change to the more efficient round size. Enter the two flat oval dimensions of the sides, “aminor” is the smaller dimension or minor axis dimension and “amajor” is the larger dimension or the major axis dimension. Enter these dimensions in inches.



If you want to know the friction rate (FR) in in. wg/100 ft., then enter the volume flow rate, Q, in cfm (cubic feet per minute). This is not necessary to determine the equivalent round size, but calculated if you need it. Pressure loss for a specific airflow rate can be determined by entering the length (L) in feet. Once the values are entered, press the ‘Calculate” icon. The output will include:

(D) Equivalent Round Diameter (inch)

(V) Velocity (ft/min)

(FR) Friction Rate (in. wg/100 ft)

(TF) Total Friction, which is the pressure loss caused by friction along the length entered (in. wg)

The calculated values are based on the exact dimension for D. The nominal values are based on the closest real world dimension available.

Example: Oval to Round

Input

aminor = 12 inches

amajor = 18 inches

Q = 2000 cfm

L = 50 ft

Output

	Calculated	**Nominal**
D (inch):	15.3	15
V (ft/min)	1576	1630
FR (in. wg/100 ft)	0.208	0.226
TF (in. wg)	0.104	0.113

Eastern Sheet Metal

Rectangular to Oval

Select this option when you know the rectangular dimensions that you would like to change to the more efficient flat oval size. Enter the two rectangular dimensions of the sides, side 1 is "a" and side 2 is "b". Enter these dimensions in inches. Then enter the minor axis "aminor" of the flat oval duct that you want to fit in a space with a height restriction. If you want to know the friction rate (FR) in in. wg/100 ft., then enter the volume flow rate, Q, in cfm (cubic feet per minute). This is not necessary to determine the equivalent flat oval size, but calculated if you need it. Pressure loss for a specific airflow rate can be determined by entering the length (L) in feet. Once the values are entered, press the 'Calculate" icon. The output will include:

(D) Equivalent Round Diameter (inch)

(amajor) Major dimension of flat oval duct (in.)

(V) Velocity (ft/min)

(FR) Friction Rate (in. wg/100 ft)

(TF) Total Friction, which is the pressure loss caused by friction along the length entered (in. wg)

The calculated values are based on the exact dimension for D. The nominal values are based on the closest real world dimension available.

Example: Rectangular to Oval

Input

a = 12 inches

b = 18 inches

aminor = 12 inches

Q = 2000 cfm

L = 50 ft

Output

	Calculated	Nominal
D (inch):	16	
amajor:	19.6	20
V (ft/min)	1435	1407
FR (in. wg/100 ft)	0.165	0.157
TF (in. wg)	0.0823	0.0784

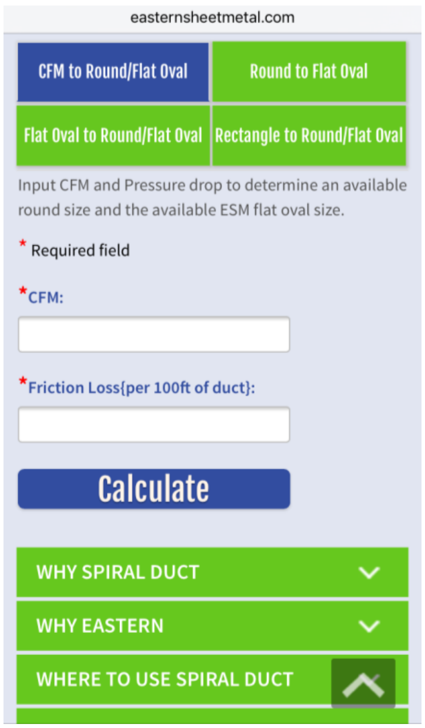
Eastern Sheet Metal

More Tools

The More Tools option gives several more types of calculations you can do from the following:

CFM to Round/Flat Oval

Convert known round size to ESM flat oval size duct



This option will calculate a round size and several equivalent flat oval dimensions in inches for about six minor/major axis combinations. For example if you want to use a 0.20 per 100 ft friction loss and 5000 cfm the program will calculate:

*CFM: 5000

*Friction Loss{per 100ft of duct}: .2

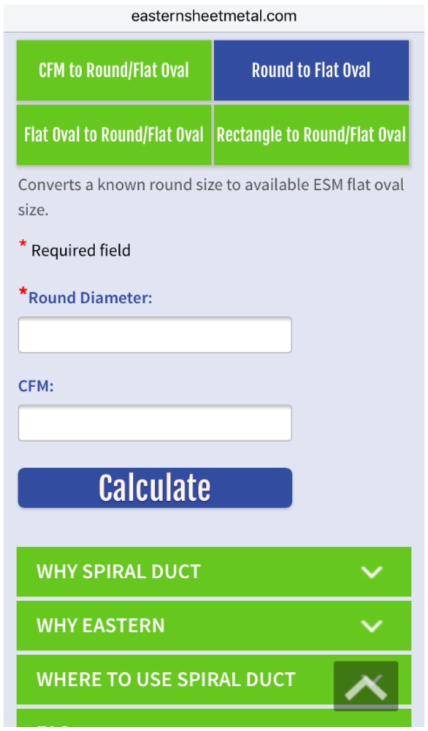
Calculate

Available Spiral Diameter	Calculated Hydraulic Diameter	Velocity(Available Diameter) FPM
22	22.26	1894

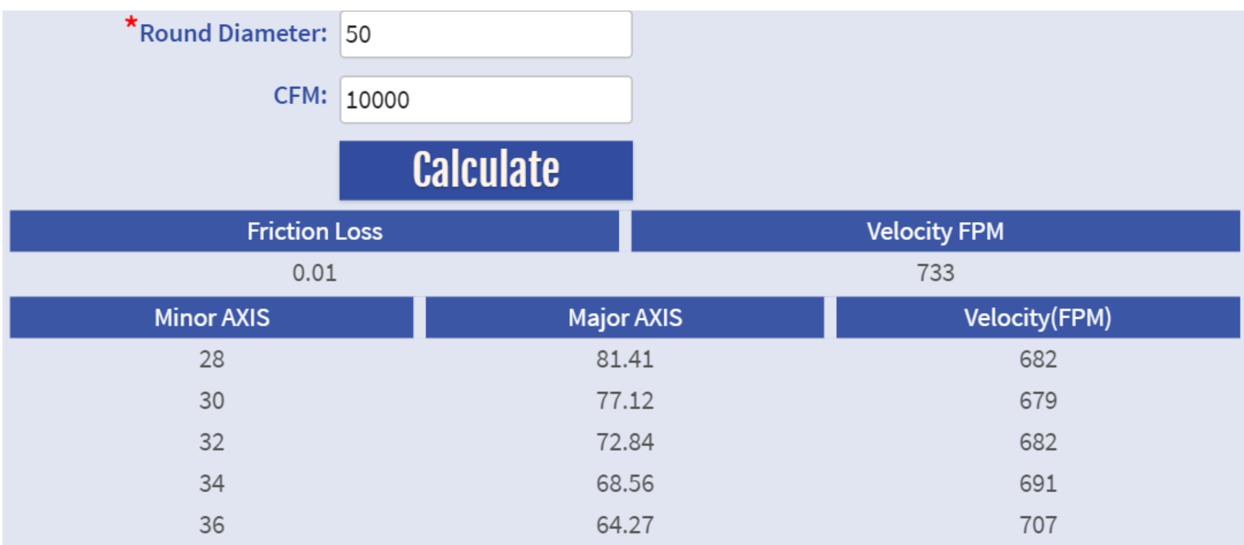
Minor Axis	Major Axis	Velocity(FPM)
8	64.55	1432
10	47.70	1581
12	38.70	1661
14	32.85	1723
16	28.57	1790
18	25.85	1819

Round to Flat Oval

Converts known round size to ESM flat oval size duct



This option will calculate the equivalent flat oval dimensions for about five minor/major axis combinations, up to 36” minor axis, based on the round size entered. It will also calculate the friction loss rate (in wg per 100 ft) if the CFM is entered:



Friction Loss	Velocity FPM
0.01	733

Minor AXIS	Major AXIS	Velocity(FPM)
28	81.41	682
30	77.12	679
32	72.84	682
34	68.56	691
36	64.27	707

Flat Oval to Round/ Flat Oval

Converts known flat oval size to ESM flat oval size and round size duct

This option will calculate the equivalent round and flat oval dimensions for about five minor/major axis combinations, up to 36” minor axis, based on the flat oval size entered:

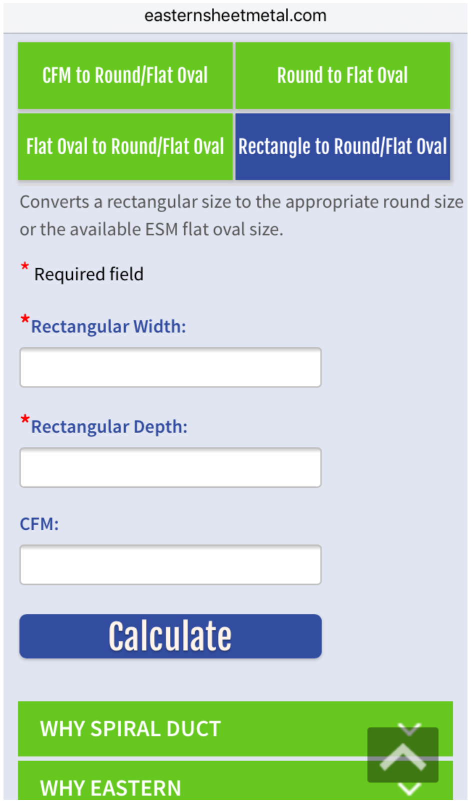
Available Spiral Diameter	Calculated Hydraulic Diameter	Friction Loss	Velocity(Available Diameter) FPM
15	15.25	0.23	1576

Minor Axis	Major Axis	Velocity(FPM)
6	40.56	1222
8	26.85	1432
10	21.00	1528
12	18.28	1528
14	15.57	1637

Eastern Sheet Metal

Rectangle to Round/ Flat Oval

Converts rectangle size to ESM round or oval size duct



This option will calculate the equivalent round and flat oval dimensions for about five minor/major axis combinations, up to 36" minor axis, based on the rectangular size entered:

*Rectangular Width: 12

*Rectangular Depth: 18

CFM: 2000

Calculate

Available Spiral Diameter	Calculated Hydraulic Diameter	Friction Loss	Velocity(Available Diameter) FPM
16	15.98	0.19	1435

Minor Axis	Major Axis	Velocity(FPM)
6	43.70	1132
8	29.99	1273
10	24.14	1310
12	19.85	1389
14	17.14	1455

Eastern Sheet Metal

Appendix

Equivalent Round for Rectangular

$$D_e = \frac{1.30\,(ab)^{0.625}}{(a+b)^{0.250}}$$

Where:

D_e is the circular equivalent of rectangular duct for equal length, fluid resistance and airflow, inch

a is the length of one side of duct, inch

b is the length adjacent side of duct, inch

Equivalent Round for Flat Oval

$$D_e = \frac{1.55AR^{0.625}}{P^{0.250}}$$

Where:

D_e is the circular equivalent of flat oval duct for equal length, fluid resistance and airflow, inch

$AR = \frac{(\pi \times aminor^2)}{4} + aminor(amajor$-aminor), square inch

$P = \pi \times aminor + 2(mijor - aminor)$

aminor is the length of the minor axis, inch

amajor is the length of the major axis, inch

Friction Loss for Round Duct

[Darcy Equation]

$$FR = \frac{100 * 12\, f\, L}{D_h}\, \rho \left(\frac{V}{1097}\right)^2$$

Where:

FR is the friction rate per 100 ft, in. wg

f is the friction factor, dimensionless

L is the duct length, ft

D_h is the hydraulic diameter, in

$$D_h = \frac{4A}{P}$$

Where:

A is the duct area, in^2

P is the duct perimeter, inch

ρ is the density, lb_m/ft^3

V is the velocity, fpm

$$V = \frac{Q}{A}$$

Where Q is the volume flow rate, cfm

The friction factor is solved directly using the Haaland Equation

$$\frac{1}{\sqrt{f}} = -1.8 \log\left[\frac{6.9}{Re} + \left(\frac{12\varepsilon}{3.7D_h}\right)^{1.11}\right]$$

This yields results identical to the Colebrook Equation, which must be solved iteratively

$$\frac{1}{\sqrt{f}} = -2 \log\left(\frac{12\varepsilon}{3.7D_h} + \frac{2.51}{Re\sqrt{f}}\right)$$

Eastern Sheet Metal

Where:

ε is the material absolute roughness factor, ft. {0.0003 ft used in this program for galvanized spiral seams with 10 ft joints}

Re is the Reynolds number

$$Re = \frac{D_h V}{720\, \nu}$$

Where:

ν is the kinematic viscosity, ft^2/s

[Total Friction Loss]

$$TF = \frac{FR}{L}, \text{ in. wg}$$