### 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 <u>Eastern Sheet Metal</u> 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.



### 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



### **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		



### **More Tools**

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

easternsheetmetal.com				
CFM to Round/Flat Oval	Round to Flat Oval			
Flat Oval to Round/Flat Oval	Rectangle to Round/Flat Oval			
Input CFM and Pressure drop to determine an available round size and the available ESM flat oval size.				
* Required field				
*CFM:				
*Friction Loss{per 100ft of	duct}:			
Calculate				
Galculate				
WHY SPIRAL DUCT	~			
WHY EASTERN	~			
WHERE TO USE SPIR	RAL DUCT			

# 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 *Friction Loss{per 100ft of duct]	: 5000 : .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



## **Round to Flat Oval** Converts known round size to ESM flat oval size duct

easternsheetmetal.com				
CFM to Round/Flat Oval	Round to Flat Oval			
Flat Oval to Round/Flat Oval	Rectangle to Round/Flat Oval			
Converts a known round siz size.	e to available ESM flat oval			
* Required field				
*Round Diameter:				
CFM:				
Calculato				
Galculate				
WHY SPIRAL DUCT	~			
WHY EASTERN	~			
WHERE TO USE SPIR	RAL 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:

*Round Diameter:	50		
CFM:	10000		
	Calculate		
Friction I	Loss		Velocity FPM
0.01			733
Minor AXIS	Мајо	r 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

CFM to Round/Flat Oval       Round to Flat Oval         Flat Oval to Round/Flat Oval       Rectangle to Round/Flat Oval         Converts a known flat oval size to another available ESM flat oval size and correct round size.       *         * Required field       *         * Insert Major Axis:	t round and
Flat Oval to Round/Flat Oval         Converts a known flat oval size to another available ESM         a voal size and correct round size.         * Required field         * Insert Major Axis:         CFM:         Calculate         WHY SPIRAL DUCT         WHY CASTERN         * Insert Minor Axis:         12         * Insert Major Axis:         18         CFM:         2000         Calculate         Yassert Major Axis:         18         CFM:         2000         Calculated Hydraulic         Vavailable Spiral Diameter	t round and
Converts a known flat oval size to another available ESM flat oval size and correct round size. * Required field * Insert Minor Axis: CFM: Calculate WHY SPIRAL DUCT WHY SPIRAL DUCT WHY SPIRAL DUCT WHY EASTERN * Insert Minor Axis: 12 * Insert Minor Axis: 12 * Insert Minor Axis: 12 * Insert Major Axis: 18 CFM: 2000 Calculate Available Spiral Diameter Calculated Hydraulic Calculated Hydraulic	t round and
* Required field * Insert Major Axis: CFM: Calculate WHY SPIRAL DUCT WHY SPIRAL DUCT WHY EASTERN * Insert Minor Axis: 12 * Insert Major Axis: 12 * Insert Major Axis: 12 * Insert Major Axis: 18 CFM: 2000 Calculate Wailable Spiral Diameter Calculated Hydraulic Calculate Mydraulic Calculate Mydraulic Calculate Mydraulic Calculate Mydraulic Calculate Mydraulic Calculate Mydraulic Calculate Mydraulic Calculate Mydraulic	t round and
Insert Minor Axis:         Insert Major Axis:         CEM:         Calculate         WHY SPIRAL DUCT         WHY SPIRAL DUCT         WHY EASTERN         This option will calculate the equivalent flat oval dimensions for about five minor combinations, up to 36" minor axis, base oval size entered:         *Insert Minor Axis:       12         *Insert Minor Axis:       12         *Insert Major Axis:       18         CFM:       2000         Calculated Hydraulic       Velocity(Av         Wailable Spiral Diameter       Calculated Hydraulic	t round and
*Insert Major Axis: CFM: Calculate WHY SPIRAL DUCT WHY EASTERN This option will calculate the equivalent flat oval dimensions for about five minor combinations, up to 36" minor axis, base oval size entered: *Insert Minor Axis: 12 *Insert Major Axis: 12 *Insert Major Axis: 18 CFM: 2000 Calculate Wuilable Spiral Diameter Calculated Hydraulic Disputer Calculated Expendence Disputer Calculated Hydraulic Calculated Hydraulic Calculated Hydraulic Calculated Hydraulic Calculated Hydraulic	t round and
*Insert Major Axis: CFM: Calculate WHY SPIRAL DUCT WHY EASTERN This option will calculate the equivalent flat oval dimensions for about five minor combinations, up to 36" minor axis, base oval size entered: *Insert Minor Axis: 12 *Insert Major Axis: 18 CFM: 2000 Calculated Hydraulic Velocity(Av	t round and
CFM: Calculate WHY SPIRAL DUCT WHY EASTERN *Insert Minor Axis: 12 *Insert Major Axis: 18 CFM: 2000 Calculated Hydraulic Valiable Spiral Diameter Calculated Hydraulic Calculated Hydraulic Calculated Calculated Hydraulic Calculated Mydraulic Calculated	t round and
CFM: Calculate This option will calculate the equivalent flat oval dimensions for about five minor combinations, up to 36" minor axis, base oval size entered: *Insert Minor Axis: 12 *Insert Major Axis: 18 CFM: 2000 Calculated Hydraulic Velocity(Av	round and
Calculate  This option will calculate the equivalent flat oval dimensions for about five minor combinations, up to 36" minor axis, base oval size entered:  *Insert Minor Axis: 12  *Insert Major Axis: 18 CFM: 2000  Calculated Hydraulic Calculated Hydraulic Velocity(Av	t round and
Calculate       This option will calculate the equivalent flat oval dimensions for about five minor combinations, up to 36" minor axis, base oval size entered:         WHY EASTERN       Image: Combined to the equivalent flat oval dimensions for about five minor axis, base oval size entered:         *Insert Minor Axis:       12         *Insert Major Axis:       18         CFM:       2000         Calculated Hydraulic       Velocity(Average)         Wailable Spiral Diameter       Calculated Hydraulic	round and
WHY SPIRAL DUCT       Image of prioring thin concentrice one of prioring thin concentric one of prioring the concentering the concentering the concentric one	
WHY SPIRAL DUCT       combinations, up to 36" minor axis, base oval size entered:         WHY EASTERN       *Insert Minor Axis:         *Insert Major Axis:       12         *Insert Major Axis:       18         CFM:       2000         Calculated       Hydraulic         Vailable Spiral Diameter       Calculated Hydraulic         Friction Loss       Velocity/Av	r/major axis
WHY EASTERN       oval size entered:         *Insert Minor Axis:       12         *Insert Major Axis:       18         CFM:       2000         Calculate         Velocity(Av         Available Spiral Diameter	d on the flat
*Insert Minor Axis: 12  *Insert Major Axis: 18 CFM: 2000 Calculate Available Spiral Diameter Calculated Hydraulic Friction Loss Velocity(Av	
*Insert Major Axis: 18 CFM: 2000 Calculate Available Spiral Diameter Calculated Hydraulic Friction Loss Velocity(Av	
CFM: 2000 Calculate Calculated Hydraulic Calculated Friction Loss Velocity(Av	
CFM: 2000 Calculate Calculated Hydraulic Calculated Hydraulic Friction Loss Velocity(Av	
Calculate       Available Spiral Diameter     Calculated Hydraulic   Friction Loss	
Available Spiral Diameter Calculated Hydraulic Friction Loss Velocity(Av	
Diameter	ailable Diameter FPM
15 15.25 0.23	
Minor Axis Major Axis Velocity	1576
6 40.56 122	1576 FPM)
8 26.85 143	1576 FPM) 2
10 21.00 152	1576 FPM) 2 2
12 18.28 152	1576 FPM) 2 2 3



# Rectangle to Round/ Flat Oval

Converts rectangle size to ESM round or oval size duct

easternshe	etmetal.com				
CFM to Round/Flat Oval	Round to Flat Ov	al			
Flat Oval to Round/Flat Oval	Rectangle to Round/F	lat Oval			
Converts a rectangular size or the available ESM flat ov	to the appropriate ro al size.	ound size			
* Required field					
*Rectangular Width:					
*Rectangular Depth:					
CFM:					
Coloulata					
Calculate		This flat (	option will calcu	late the	e equivalent round and
	_		binations un to	36″ mi	nor axis based on the
		recta	angular size enter	ed:	
WHY EASTERN		$\checkmark$	5		
*Rectangula	r Width: 12				
*Rectangular	Depth: 18				
0					
	CFM: 2000				
		Calculate			
Available Spiral Dian	neter Calcu	lated Hydraulic Diameter	Friction Loss	Ve	elocity(Available Diameter) FPM
16		15.98	0.19		1435
Minor A	kis	Мајс	or Axis		Velocity(FPM)
6		43	3.70		1132
8		29	.99		1273

10

12

14

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1310

1389

1455

24.14

19.85

17.14

# Appendix

# **Equivalent Round for Rectangular**

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

Where:

 $\mathsf{D}_{\mathsf{e}}$  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

 $AR = \frac{(\pi \times aminor^2)}{4} + aminor(amajor-aminor), \text{ square inch}$  $P = \pi \times aminor + 2(mijor - aminor)$ 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<sub>h</sub> is the hydraulic diameter, in

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

Where:

A is the duct area, in<sup>2</sup>

P is the duct perimeter, inch

 $\rho$  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

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

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

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



### Where:

 $\epsilon$  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

$$Re = \frac{D_h V}{720 v}$$

Where:

v is the kinematic viscosity, ft<sup>2</sup>/s

[Total Friction Loss]

$$TF=rac{FR}{L}$$
 , in. wg

