

**Example Hydraulic Diameter and Percent Open Area Calculation**

Assume the in-line pattern above has 4mm diameter holes, and is 39mm on a side.

Hydraulic Diameter

$$D_h = 4A/P \quad A = \pi \cdot D^2/4 \quad P = \pi \cdot D \quad D_h = 4 \cdot (\pi \cdot D^2/4) / (\pi \cdot D)$$

Percent Open Area

Total Hole Cross Section =  $64 \cdot \pi \cdot (4\text{mm})^2/4 = 804\text{mm}^2$

Total Panel Cross Section =  $(39\text{mm}) \cdot (39\text{mm}) = 1521\text{mm}^2$

Percent Open Area =  $(\text{Total Hole Area}) / (\text{Total Panel Area}) = 52.9\%$

Straight flow  
into vent

Geometry is defined for insert, the single vent hole, and the vent hole pattern. The tool calculates the number of holes in the insert from this information for geometries as shown; however, if a geometry other than one of these standards is of interest, the tool can be utilized by specifying "Other" in the **OVERALL GEOMETRY** pull down menu.

The user will then specify the **hydraulic diameter** ( $4*A / P$ ; where  $A$  is the cross-sectional area, and  $P$  is the perimeter) of the individual vent hole, the **vent depth**, and the **percent open area** (sum of all hole cross sectional areas divided by total panel cross sectional area; always will be less than 1) of the insert. The tool will then perform the analysis to calculate the flow resistance coefficient and will plot impact to airflow parameters of the waveguide design chosen.

$$D^2/4)/(\pi*D) = D$$

Correlations from Idelchik's  
Flow Resistance Handbook

<b><u>Revision</u></b>	<b><u>Date</u></b>	<b><u>Notes</u></b>
0.15	8/17/00	Thermal and waveguide tools separated into distinct analysis tools
0.35	8/17/00	Added second panel analysis capability and comparative plot, cross Distributed internally for feedback, prior to release to EP
0.5	9/7/00	Added instructions for calculating percent open & hydraulic diameter
0.9	2/20/01	removed inlet geometry options from the tool

3

ssed out inlet geometry option (not accounted for)  
G and others

ter

**Panel 1 Overall Geometry**

**Panel 1 Geometry**

**Vent Hole Geometry**

**Pattern Geometry**

**Panel 1 Geometry**

	Side [m]
0.1	0.12

**Panel 1 Vent Hole Geometry**

Diameter [m]	
0.005	0.01
Depth [m]	
0.002	<b>Panel 1 Name</b>
	<b>Case 1 Sheet Metal</b>

**TARGET PRESSURE DROP [in H2O]**

0.01

**Panel 1 Overall Geometry**

**Panel 1 Geometry**

**Vent Hole Geometry**

**Pattern Geometry**

**Panel 2 Vent Hole Geometry**

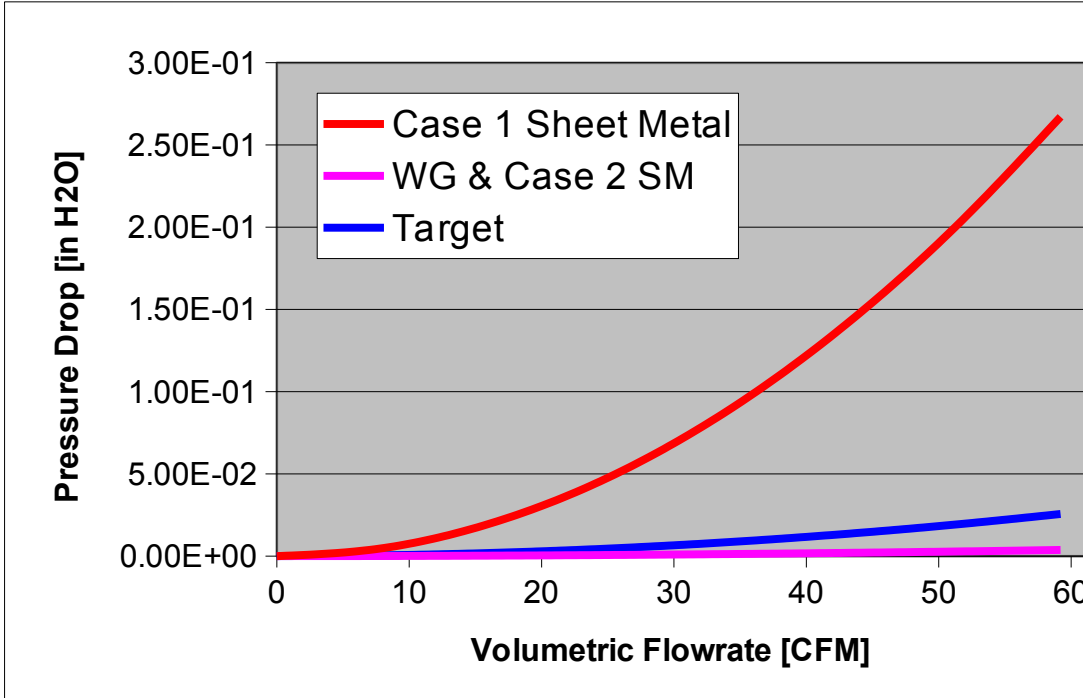
Hydraulic Diameter [m]	
0.0118	0.01
Depth [m]	
0.01	<b>Panel 2 Name</b>
	<b>WG &amp; Case 2 SM</b>

0.1

0.22

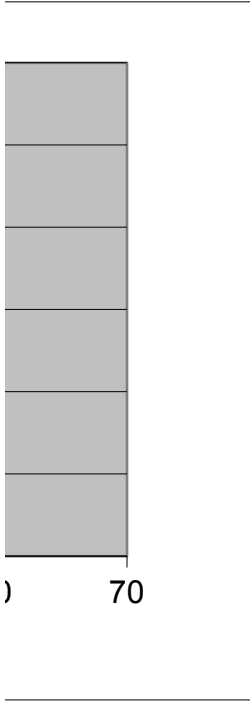
Panel 1 Pattern Geometry	
# of Outer Holes in X	# of Outer Holes in Y
12	8
Pitch of Outer Holes in X, Px [m]	Pitch of Outer Holes in Y, Py [m]
0.01	0.015
Offset in X, Ox [m]	Offset in Y, Oy [m]
0.005	0.0075
Panel 1 Loss Coefficient	Target Loss Coefficient
<b>30.706</b>	2.943
TARGET FLOWRATE [cfm]	37
Panel 2 Pattern Geometry	
	% Open Area
10	0.75
0.02	0.02
Panel 2 Loss Coefficient	Target Loss Coefficient
<b>0.429</b>	33.248

<b>Case 1 Sheet Metal</b>		
Loss Coefficient	30.7060	
Pressure Drop @ Target Flowrate	0.1043	in H2O
Percent Open	23.59%	



Volumetric Flowrate	Case 1 Sheet Metal	WG & Case 2 SM	Target
0	0.00E+00	0.00E+00	0.00E+00
7.4	4.17E-03	5.83E-05	4.00E-04
14.8	1.67E-02	2.33E-04	1.60E-03
22.2	3.76E-02	5.24E-04	3.60E-03
29.6	6.68E-02	9.32E-04	6.40E-03
37	1.04E-01	1.46E-03	1.00E-02
44.4	1.50E-01	2.10E-03	1.44E-02
51.8	2.04E-01	2.85E-03	1.96E-02
59.2	2.67E-01	3.73E-03	2.56E-02

<b>WG &amp; Case 2 SM</b>	
Loss Coefficient	0.4287
Pressure Drop @ Target Flowrate	0.0001 in H2O
Percent Open	75.00%





Representative Pressure Drop for wave guide vs. traditional vent hole

7 dB @ 7 GHz

Waveguide (49 holes, 20mm side, 20mm deep, 0.060" spacing)

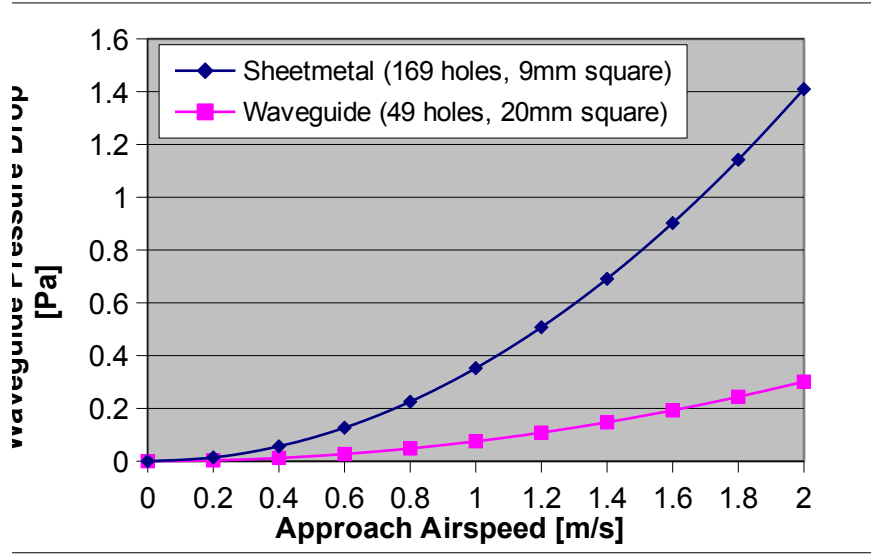
Sheet Metal (169 holes, 9mm side, 1.22mm deep, 0.060" spacing)

**Loss Coefficient**

Sheetmetal (169 holes, 9mm side, 1.22mm deep, 0.060" spacing)	0.613 75% open area
Waveguide (49 holes, 20mm side, 20mm deep, 0.060" spacing)	0.131 88% open area

Waveguide Pressure Drop

Airspeed [m/s]	Pressure Drop [Pa]	
	Sheetmetal (169 holes, 9mm square)	Waveguide (49 hole)
0	0	0
0.2	0.014099	0.003013
0.4	0.056396	0.012052
0.6	0.126891	0.027117
0.8	0.225584	0.048208
1	0.352475	0.075325
1.2	0.507564	0.108468
1.4	0.690851	0.147637
1.6	0.902336	0.192832
1.8	1.142019	0.244053
2	1.4099	0.3013



ns, 20mm square)

<b>Chassis Insert Geometry</b>		<b>Panel 1 Geometry</b>	
round	square		<b>Side [m]</b>
square		0.1	0.12
rectangle			
<b>Vent Hole Geometry</b>		<b>Panel 1 Vent Hole Geometry</b>	
round	round	<b>Diameter [m]</b>	
square		0.005	0.01
rectangle		<b>Depth [m]</b>	
hexagon		0.002	
<b>Vent Pattern Geometry</b>			
staggered	staggered		
in-line			
<b>Airflow Geometry</b>			
straight flow into vent	straight flow into vent		
90 deg bend, from 1 side			
90 deg bend, from all sides			
vent in infinite plane			
<b>Overall Geometry</b>			
standard	standard		
other			
<b>Hydraulic Diameter of Vent Hole [m]</b>			
0.00500			
<b>Chassis Insert Cross-Sectional Area [m<sup>2</sup>]</b>			
0.0144			
<b>Total Vent Hole Open Area [m<sup>2</sup>]</b>			
0.00340			
<b>Chassis Insert Cross-Sectional Area [m<sup>2</sup>]</b>			
0.0144			
<b>% Open Area</b>			
23.59%			
<b>Hole Depth / Hydraulic Diameter [L/Dh]</b>			
0.4			
<b>tau</b>			
1.1			
<b>Values of tau</b>		<b>tau interpolation</b>	

L / Dh	tau	
0	1.35	1.09
0.2	1.22	1.1
0.4	1.1	1.1
0.6	0.84	1.26
0.8	0.42	0.78
1	0.24	0.45
1.4	0.1	0.2333333333333333
2	0.02	0.052
3	0	

**lambda**  
0.02

**Psi (Resistance Coefficient =  $dP / \{(\rho * v^2) / 2\}$ )**  
30.7060120916224

<b>Panel 1 Pattern Geometry</b>	
<b># of Outer Holes in X</b>	<b># of Outer Holes in Y</b>
12	8
<b>Pitch of Outer Holes in X, Px [m]</b>	<b>Pitch of Outer Holes in Y, Py [m]</b>
0.01	0.015
<b>Offset in X, Ox [m]</b>	<b>Offset in Y, Oy [m]</b>
0.005	0.0075

<b>Chassis Insert Geometry</b>	
round	square
square	
rectangle	

<b>Vent Hole Geometry</b>	
round	round
square	
rectangle	
hexagon	

<b>Vent Pattern Geometry</b>	
staggered	in-line
in-line	

<b>Airflow Geometry</b>	
straight flow into vent	straight flow into vent
90 deg bend, from 1 side	
90 deg bend, from all sides	
vent in infinite plane	

<b>Overall Geometry</b>	
standard	other
other	

<b>Hydraulic Diameter of Vent Hole [m]</b>
0.01180

<b>Chassis Insert Cross-Sectional Area [m<sup>2</sup>]</b>
0.0484

<b>Total Vent Hole Open Area [m<sup>2</sup>]</b>
0.00082

<b>Chassis Insert Cross-Sectional Area [m<sup>2</sup>]</b>
0.0484

<b>% Open Area</b>
75.00%

<b>Hole Depth / Hydraulic Diameter [L/Dh]</b>
0.847457627118644

<b>tau</b>
0.293389830508475

<b>Values of tau</b>		
		tau interpolation

0.1

<b>Panel 2 Vent H</b>
<b>Hydraulic Diameter [m]</b>
0.0118
<b>Depth [m]</b>
0.01

<b>L / Dh</b>	<b>tau</b>		
0	1.35		0.799152542372881
0.2	1.22		0.831525423728814
0.4	1.1		0.518305084745762
0.6	0.84		0.320338983050847
0.8	0.42		0.37728813559322
1	0.24		0.293389830508475
1.4	0.1		0.173672316384181
2	0.02		0.043050847457627
3	0		

<b>lambda</b> 0.02
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<b>Psi (Resistance Coefficient = <math>dP/\{(\rho * v^2)/2\}</math>)</b> 0.428662900188324
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0.22
<b>Hole Geometry</b>
0.01



<b>Panel 2 Pattern Geometry</b>	
	<b>% Open Area</b>
10	0.75
0.02	0.02
0	0