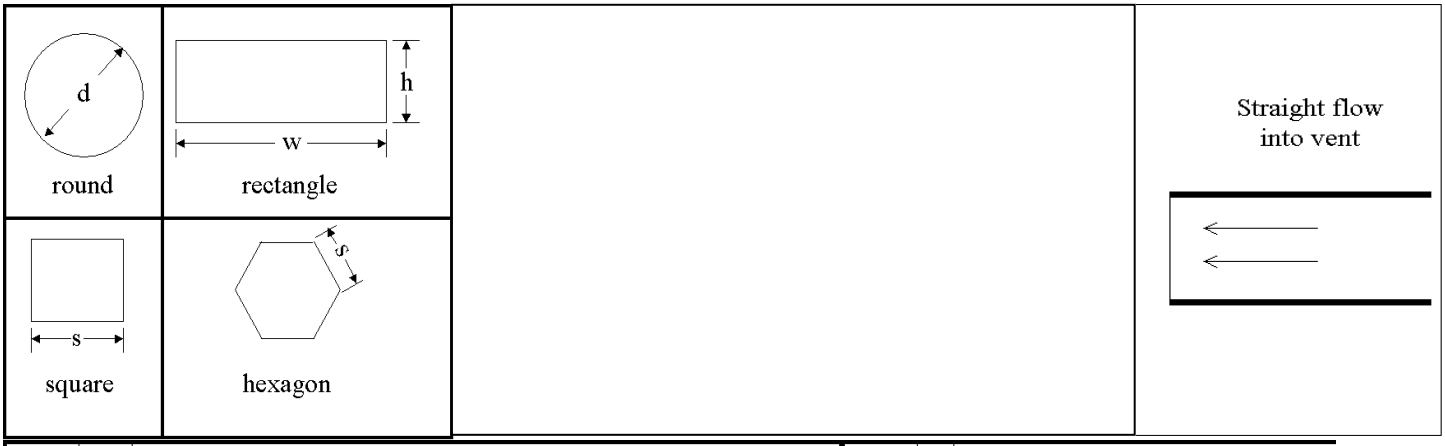
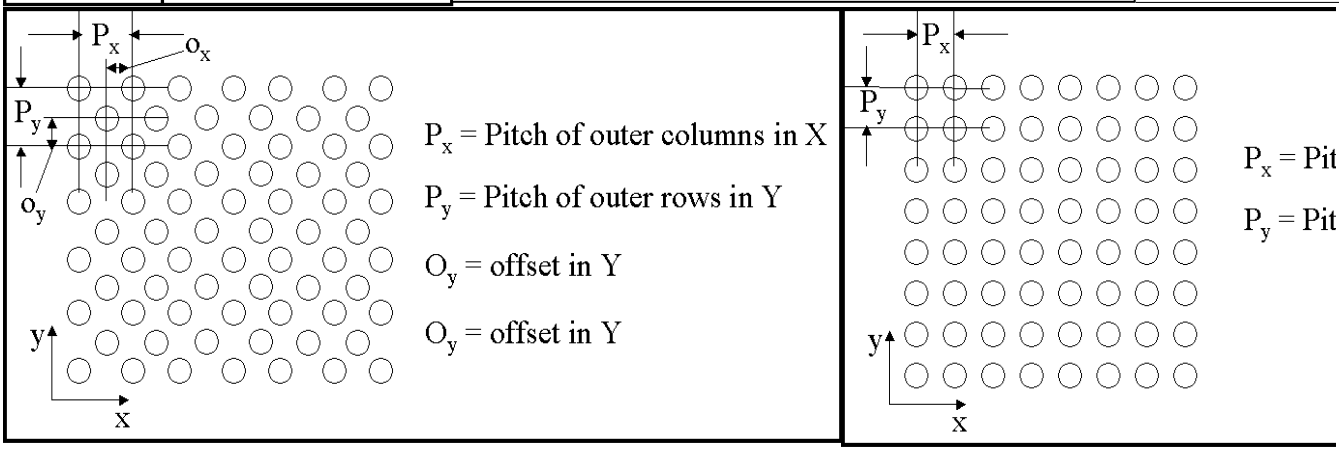




Example Hydraulic Diameter and Percent Open Area Calculation

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

Hydraulic Diameter

Dh=4A/P A = pi*D^2/4 P = pi*D Dh = 4*(pi*

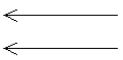
Percent Open Area

Total Hole Cross Section = 64 * pi * (4mm)^2/4 = 804mm^2

Total Panel Cross Section = (39mm) * (39mm) = 1521mm^2

Percent Open Area = (Total Hole Area) / (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.

:ch in X

:ch in Y

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

%

Correlations from Idelchik's Flow Resistance Handbook

Revision	Date	Notes
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, cros Distributed internally for feedback, prior to release to EP
0.5	9/7/00	Added instructions for calculating percent open & hydraulic diamet
0.9	2/20/01	removed inlet geometry options from the tool

s

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

ter

Panel 1 Overall Geometry

standard

Panel 1 Geometry

square

Vent Hole Geometry

round

Pattern Geometry

staggered

straight flow into vent

Panel 1 Geometry	
	Side [m]
0.1	0.12

Panel 1 Vent Hole Geometry	
Diameter [m]	
0.005	0.01
Depth [m]	
0.002	Panel 1 Name
	Case 1 Sheet Metal

TARGET PRESSURE DROP [in H2O]	0.01

Panel 1 Overall Geometry

other

Panel 1 Geometry

square

Vent Hole Geometry

round

Pattern Geometry

in-line

straight flow into vent

0.1	0.22

Panel 2 Vent Hole Geometry	
Hydraulic Diameter [m]	
0.0118	0.01
Depth [m]	
0.01	Panel 2 Name
	WG & Case 2 SM

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

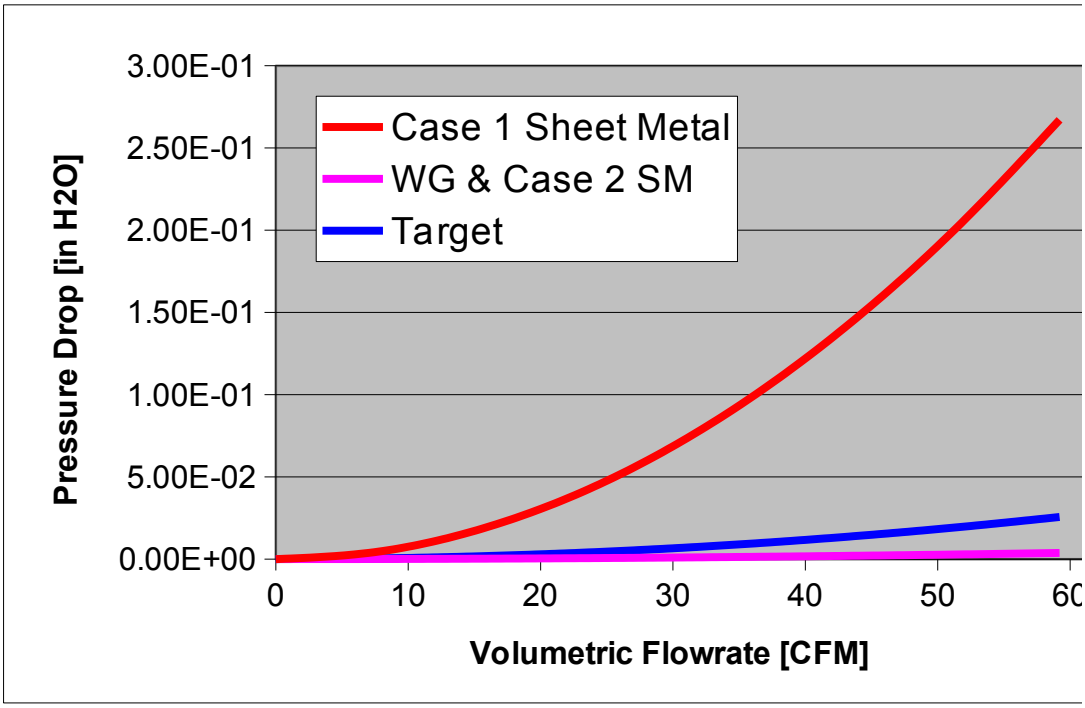
Panel 1 Loss Coefficient	Target Loss Coefficient
30.706	2.943

TARGET FLOWRATE [cfm]	37

Panel 2 Pattern Geometry	
	% Open Area
10	0.75
0.02	0.02

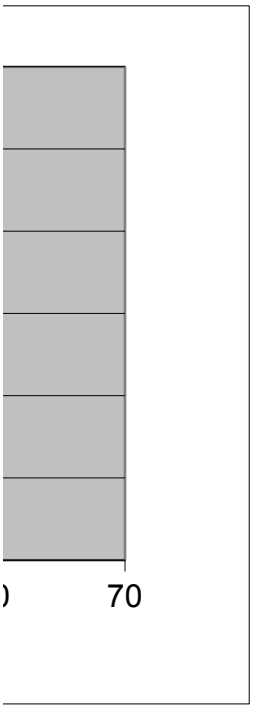
Panel 2 Loss Coefficient	Target Loss Coefficient
0.429	33.248

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



Volumetric Flowrate	Case 1 Sheet Meta	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

WG & Case 2 SM		
Loss Coefficient	0.4287	
Pressure Drop @ Target Flowrate	0.0001	in H2O
Percent Open	75.00%	

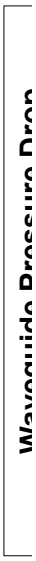


Representative Pressure Drop for wave guide vs. traditional vent hole

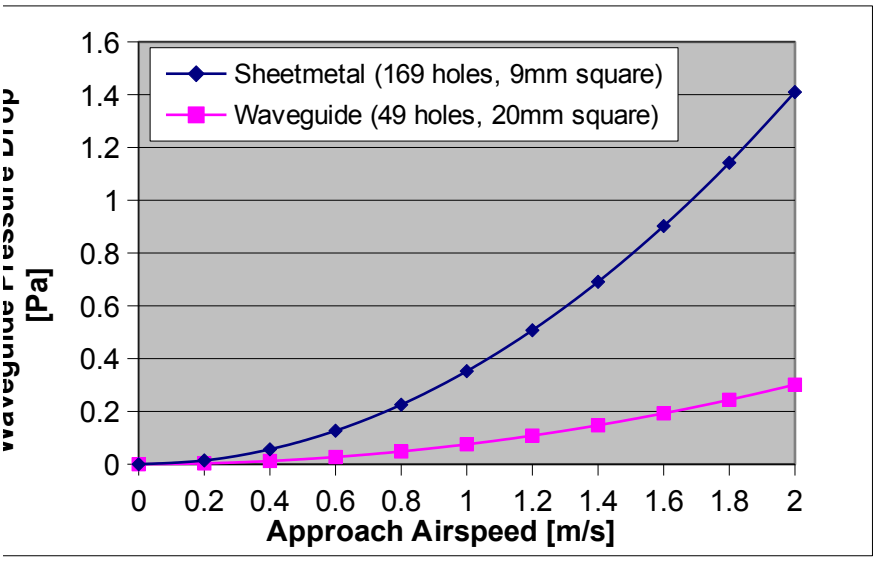
7 dB @ 7 GHz

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 s	0.613	75% open area
Waveguide (49 holes, 20mm s	0.131	88% open area



	Pressure Drop [Pa]	
Airspeed [m/s]	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



es, 20mm square)

Chassis Insert Geometry	
round	square
square	
rectangle	

Vent Hole Geometry	
round	round
square	
rectangle	
hexagon	

Vent Pattern Geometry	
staggered	staggered
in-line	

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

Overall Geometry	
standard	standard
other	

Hydraulic Diameter of Vent Hole [m]
0.00500

Chassis Insert Cross-Sectional Area [m^2]
0.0144

Total Vent Hole Open Area [m^2]
0.00340

Chassis Insert Cross-Sectional Area [m^2]
0.0144

% Open Area
23.59%

Hole Depth / Hydraulic Diameter [L/Dh]
0.4

tau
1.1

Panel 1 Geometry	
	Side [m]
0.1	0.12

Panel 1 Vent Hole Geometry	
Diameter [m]	
0.005	0.01
Depth [m]	
0.002	

Values of tau	tau interpolation

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	0.233333333333333
2	0.02	0.052
3	0	

lambda
0.02

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

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

Chassis Insert Geometry	
round square rectangle	square

Vent Hole Geometry	
round square rectangle hexagon	round

Vent Pattern Geometry	
staggered in-line	in-line

Airflow Geometry	
straight flow into vent ~~90 deg bend, from 1 side~~ ~~90 deg bend, from all sides~~ ~~vent in infinite plane~~	straight flow into vent

Overall Geometry	
standard other	other

Hydraulic Diameter of Vent Hole [m]
0.01180

Chassis Insert Cross-Sectional Area [m^2]
0.0484

Total Vent Hole Open Area [m^2]
0.00082

Chassis Insert Cross-Sectional Area [m^2]
0.0484

% Open Area
75.00%

Hole Depth / Hydraulic Diameter [L/Dh]
0.847457627118644

tau
0.293389830508475

Values of tau		tau interpolation

0.1

Panel 2 Vent H
Hydraulic Diameter [m
0.0118
Depth [m]
0.01

L / Dh	tau		
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		

lambda
0.02

Psi (Resistance Coefficient = dP/{(rho * v^2)/2}
0.428662900188324

0.22	

lole Geometry	
0.01	

Panel 2 Pattern Geometry	
	% Open Area
10	0.75
0.02	0.02
0	0