Strength of Perforated Metal

This material was developed for the IPA
by O' Donnell & Associates, Inc.

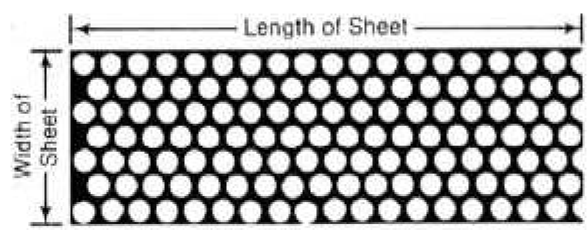
The use of perforated materials is limited by the lack of reliable strength and stiffness properties for use in design. The following information covers the strength of materials perforated with round holes in a standard staggered 60" pattern as shown in Figure (1).

Round holes arranged in a standard 60" triangular pattern ranging from .020" to 3/4" account for more than half of the perforating industry' s production. They produce the strongest pattern and are the most versatile in their application. The standard 60" staggered formation is the most popular hole arrangement because of its inherent strength and the wide range of open areas it provides. In perforating this pattern, the direction of the stagger is the short dimension or width of the sheet as illustrated. The straight row of closely- spaced holes is parallel to the long dimension or length of the sheet. This is the so-called "closed pattern." Under special order, the holes may be punched in the "open pattern." The directional properties are then reversed from those described herein. Refer to Figure (1) for the length and width directions corresponding to the directional results given in the Tables.

Equivalent Solid Material Concept

The concept of equivalent solid material is widely used for design analyses of perforated materials. As applied herein, the equivalent strength of the perforated material is used in place of the strength of the solid material. By evaluating the effect of the perforations on the yield strength of the material, the equivalent yield strength of the perforated material, (S), can be obtained as a function of the yield strength of the solid or unperforated material, S. Thus, the designer is able to determine safety margins for the perforated material for any geometry of application and any loading conditions. The S/S ratios are the same for bending and stretching of the material. Having the S /S ratios for the particular penetration pattern of interest, it is therefore easy for the designer to determine what thickness of perforated material will provide strength equal to that of the unperforated material.

Perforated material has different strengths depending on the direction of loading. Values of s* /S are given for the width (strongest) and the length (weakest) directions. The values for the length direction have been calculated conservatively.



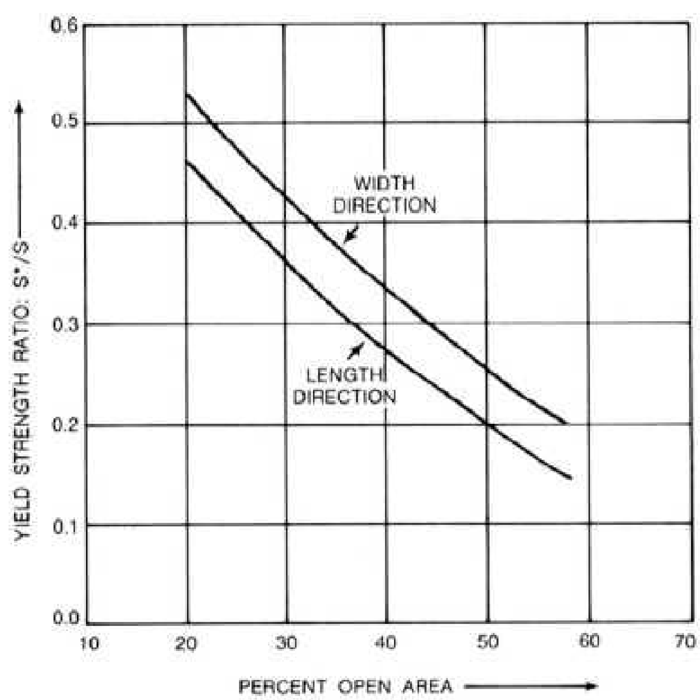
Strength of materials perforated with round holes in a standard staggered pattern:

IPA #	Perforations	Centers	Holes Per sq.in.	Open Area	S*/S= Strength[1] Width Direction	Length Direction
100	.020"	-	625	20%	.530	.465
106	1/16"	1/8"	-	23%	.500	.435
107	5/64"	7/64"	-	46%	.286	.225
108	5/64"	1/8"	-	36%	.375	.310
109	3/32"	5/32"	-	32%	.400	.334
110	3/32"	3/16"	-	23%	.500	.435
112	1/10"	5/32"	-	36%	.360	.296
113	1/8"	3/16"	-	40%	.333	.270
114	1/8"	7/32"	-	29%	.428	.363
115	1/8"	1/4"	-	23%	.500	.435
116	5/32"	7/32"	-	46%	.288	.225
117	5/32"	1/4"	-	36%	.375	.310
118	3/16"	1/4"	-	51%	.250	.192
119	3/16"	5/16"	-	33%	.400	.334
120	1/4"	5/16"	-	58%	.200	.147
121	1/4"	3/8"	-	40%	.333	.270
122	1/4"	7/16"	-	30%	.428	.363
123	1/4"	1/2"	-	23%	.500	.435
124	3/8"	1/2"	-	51%	.250	.192
125	3/8"	9/16"	-	40%	.333	.270
126	3/8"	5/8"	-	33%	.400	.334
127	7/16"	5/8"	-	45%	.300	.239
128	1/2"	11/16"	-	47%	.273	.214
129	9/16"	3/4"	-	51%	.250	.192
130	5/8"	13/16"	-	53%	.231	.175
131	3/4"	1"	-	51%	.250	.192

[1]Notes: S* = Yield strength of perforated material
S* = Yield strength of unperforated material

Length Direction = parallel to straight row of closely spaced holes (see Fig. 1)

Width Direction = direction of stagger



Elastic Properties of Perforated Metals (Stiffness)

This material was developed for the I.P.A.
by O' Donnell & Associates, Inc.

There are many potential new applications where perforated materials could be used. In many of these uses, however, the strength and stiffness properties of the perforated sheet are very important. The following information covers the stiffness properties for the standard 60" triangular penetration pattern. Since perforated materials can potentially be used in so many applications involving different geometries, materials and loading conditions, design data are given in a very general form. The ratio of the effective elastic modulus of the perforated material, E*, to the elastic modulus of the unperforated material, E, and the effective Poisson' s Ratio, v* , are given. These values are given for all the Standard IPA numbered perforations which cover round holes arranged in the standard 60" triangular pattern ranging from .020" to 1", and account for more than half of the perforating industry' s production.

Equivalent Solid Material Concept

The concept of equivalent solid material is widely used for design analyses of perforated materials. As applied herein, the equivalent stiffness of the perforated material is used in place of the stiffness of the solid material. By evaluating the effect of the perforations, the equivalent effective elastic modulus of the perforated material, E*, is obtained as a function of the elastic modulus of the solid or unperforated material, E. In addition, the effective Poisson' s Ratio, v*, of the perforated material is obtained. This Poisson' s Ratio may be used in cases where correction for load biaxiality is important.

The effective elastic constants presented herein are for plane stress conditions and apply to the in-plane loading of the thin perforated sheets of interest. The bending stiffness of such perforated sheets is somewhat greater. However, most loading conditions involve a combination of bending and stretching, and it is more convenient to use the same effective elastic constants for the combined loading conditions. The plane stress effective elastic constants given herein can be conservatively used for all loading conditions. Using these effective elastic properties, the designer is able to determine the deflections of the perforated sheet for any geometry of application and any loading conditions using available elastic solutions. It is therefore easy for the designer to determine what additional thickness of the perforated material will provide stiffness equal to that of unperforated material

Effective Elastic Properties for IPA Standard Perforations

IPA #	Perforations	Centers	Holes Per sq. in.	Open Area	E*/E
100	.020"	-	625	20%	.565
106	1/16"	1/8"	-	23%	.529
107	5/64"	7/64"	-	46%	.246
108	5/64"	1/8"	-	36%	.362
109	3/32"	5/32"	-	32%	.395
110	3/32"	3/16"	-	23%	.529
112	1/10"	5/32"	-	36%	.342
113	1/8"	3/16"	-	40%	.310
114	1/8"	7/32"	-	29%	.436
115	1/8"	1/4"	-	23%	.529
116	5/32"	7/32"	-	46%	.249
117	5/32"	1/4"	-	36%	.362
118	3/16"	1/4"	-	51%	.205
119	3/16"	5/16"	-	33%	.395
120	1/4"	5/16"	-	58%	.146
121	1/4"	3/8"	-	40%	.310
122	1/4"	7/16"	-	30%	.436
123	1/4"	1/2"	-	23%	.529
124	3/8"	1/2"	-	51%	.205
125	3/8"	9/16"	-	40%	.310
126	3/8"	5/8"	-	33%	.395
127	7/16"	5/8"	-	45%	.265
128	1/2"	11/16"	-	47%	.230
129	9/16"	3/4"	-	51%	.205
130	5/8"	13/16"	-	53%	.178
131	3/4"	1"	-	51%	.205

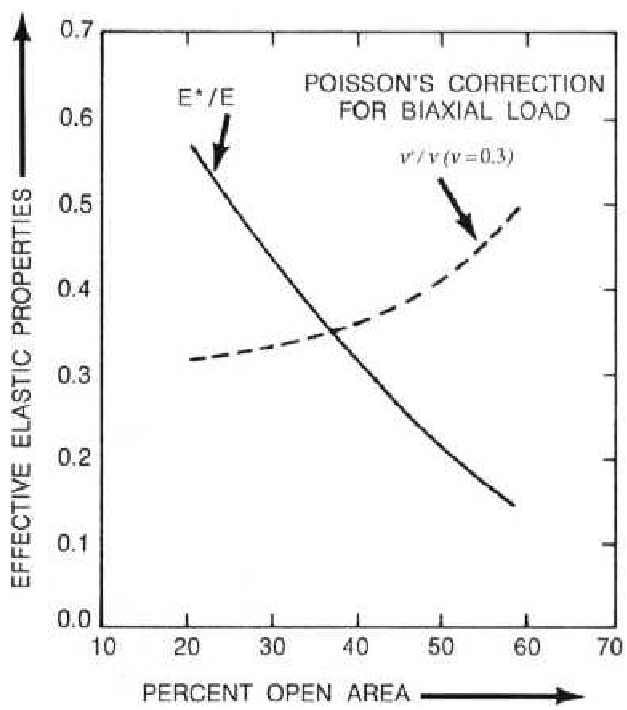


Figure 4: Effective Elastic Modulus, E*, and Poisson's Ratio, v*, vs. Percent Open Area