



ESDU 71011

Issued May 1971
With Amendment A
November 2008
Supersedes in part ESDU 65004

Stresses due to interference-fit pins and bushes in plates, strips or lugs

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THE PREPARATION OF THIS DATA ITEM

The work on this particular Data Item, which supersedes in part Item No. 65004, was monitored and guided by the Stress Analysis and Strength of Components Committee. This Committee first met in 1964 and now has the following membership:

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STRESSES DUE TO INTERFERENCE-FIT PINS AND BUSHES IN PLATES, STRIPS OR LUGS

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STRESSES DUE TO INTERFERENCE-FIT PINS AND BUSHES IN PLATES, STRIPS OR LUGS

1. INTRODUCTION

This Item presents data on the elastic stresses arising in flat plates, bars, strips or lugs from the insertion of a circular interference-fit pin or bush of similar or different material. Section 3 deals with solid pins, Section 4 deals with bushes and Section 5 deals with the juxtaposition of two identical interference-fit pins or bushes.

The data are based upon two-dimensional analyses and therefore only give the average stress through the thickness of the plate or strip. Local deviations away from the average value are unlikely to be significant except perhaps where taper pins are used.

The data apply strictly to isotropic materials that obey Hooke's law, but may be used without significant error for most engineering materials. If during loading of the assembly the limit of proportionality of one (or both) of the materials is exceeded the residual stresses due to the interference-fit will be reduced. It should be noted that the degree of interference will be considerably reduced if significant creep takes place.

If the interference-fit pin or bush is additionally held, for example by means of a taper pin or a screw inserted from the side or inserted parallel to the centre line on the interface, the stress distribution will alter and the data of this Item will not be applicable.

Throughout this Item the term "bars or strips" applies to bodies having solid rectangular sections.

2. NOTATION

c	distance between centres of adjacent pins or bushes	m	in
d	diameter of unfilled hole	m	in
d_i	internal diameter of bush	m	in
e	ε/d	m/m	in/in
E	Young's modulus of lug, bar or strip or plate material	N/m ²	lbf/in ²
E_I	Young's modulus of pin or bush material	N/m ²	lbf/in ²
f	maximum tensile stress acting around boundary of hole, caused by interference	N/m ²	lbf/in ²
f_o	maximum tensile stress acting around boundary of single hole in infinite plate, caused by interference	N/m ²	lbf/in ²
k	shape factor (for bushes only, see Section 4)		
p	interface pressure	N/m ²	lbf/in ²

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q	maximum shear stress at boundary of hole, caused by interference	N/m ²	lbf/in ²
W	width of lug, bar or strip or plate	m	in
ε	interference of pin or bush with hole (pin or bush diameter is $d + \varepsilon$)	m	in
ν	Poisson's ratio of lug, bar or strip or plate material		
ν_I	Poisson's ratio of pin or bush material		

Both SI and British units are quoted but any coherent system of units may be used.

3. SOLID CIRCULAR INTERFERENCE-FIT PINS IN BARS OR STRIPS OR PLATES

For the case of an interference-fit pin in a circular hole in an infinite plate, that is $d/W = 0$, the circumferential tensile stress, radial compressive and shear stresses are equal in magnitude and constant around the hole. For a plate of finite width the stress varies around the hole and the maximum value depends upon d/W .

Figure 1 shows $q/E\varepsilon$ plotted against $E(1 - \nu_I)/E_I$ for various values of d/W and Figure 2 shows $f/E\varepsilon$ plotted against $E(1 - \nu_I)/E_I$ for various values of d/W . At points B marked on the diagram accompanying Figure 1 the tensile stress f , the shear stress q and the interface pressure p approach the values for a pin in an infinite plate. The maximum tensile and shear stresses occur at the points A although the shear stress is only slightly above its value at points B. The interface pressure is at a minimum at points A and a maximum at points B. An estimate of the interface pressure at B is given by $p/E\varepsilon = [1 - (d/W)^2]q/E\varepsilon$.

The figures are constructed for $\nu = 0.3$. Variation of ν within the range 0.25 to 0.35 does not significantly alter the maximum stress. However, for significantly different values of ν it may be advisable to calculate the stresses from the following formulae which were used to construct the curves.

$$\frac{q}{E\varepsilon} = \frac{1}{2 + \left[\frac{E(1 - \nu_I)}{E_I} - (1 - \nu) \right] \left[1 - \left(\frac{d}{W} \right)^2 \right]}$$

and

$$\frac{f}{E\varepsilon} = \frac{q}{E\varepsilon} \left[1 + \left(\frac{d}{W} \right)^2 \right].$$

These formulae relate to a pin in a ring but they represent the conditions of a pin in a strip or lug with reasonable accuracy provided that d/W is less than about 0.8.