



Strength of lugs under oblique load

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STRENGTH OF LUGS UNDER OBLIQUE LOAD

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STRENGTH OF LUGS UNDER OBLIQUE LOAD

1. INTRODUCTION

This Data Item provides a method to calculate the minimum load to cause either failure by rupture or maximum permissible permanent deformation of parallel-sided and tapered lugs under in-plane oblique loading applied at an angle θ to the axial (x-) direction. The method is based on the analyses presented in Derivation 1 and Derivation 1 and 4 of ESDU 91008* and ESDU 06021† respectively and is applicable to round- and square-ended lugs made of ductile metallic materials. Lugs fabricated from brittle materials are not covered by the Item.

Section 2 of this Item states the empirical interaction formula for the calculation of the load to cause failure either by rupture or maximum permissible permanent deformation of parallel-sided and tapered lugs under in-plane oblique loading. Values of the elastic stress concentration factor, K'_e , for particular lug geometries and pin/lug fits are given in ESDU 81006‡ and its significance is explained in Section 2.3.1 of ESDU 91008*.



A typical lug under oblique load
(Airbus A300 rudder hinge lug)

* ESDU 91008, "Strength of lugs under axial load".

† ESDU 06021, "Strength of lugs under transverse load".

‡ ESDU 81006, "Stress concentration factors. Axially loaded lugs with clearance-fit pins".

1.1 Notation

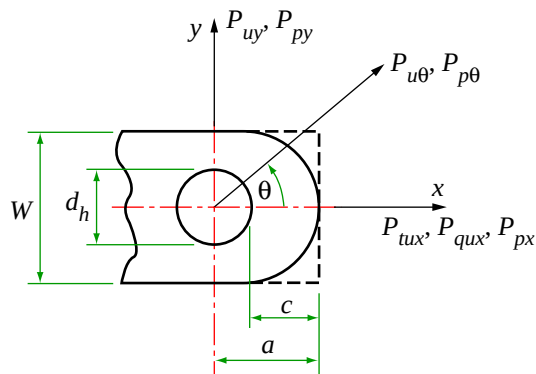
Both SI and British units are quoted but any coherent system of units may be used.

a	distance from centre of loaded hole in lug to lug end, see Sketch 1.1	m	in
d_h	diameter of loaded hole in lug, see Sketch 1.1	m	in
E	Young's modulus of lug material	N/m ²	lbf/in ²
P	load on lug or pin	N	lbf
t	thickness of lug	m	in
W	nominal width of lug (see Sketch 1.1)	m	in
x, y	coordinate system for lug (see Sketch 1.1)		
θ	angle of oblique load on lug measured from x -direction (see Sketch 1.1)	deg	deg

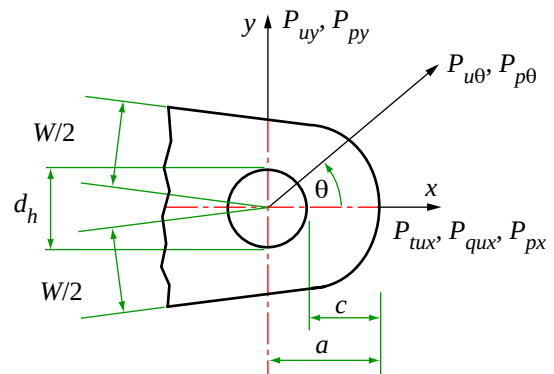
1.2 Suffixes

c	denotes material short transverse property (in plane of lug)
min	denotes minimum value of load (see Section 4.3.3)
p	denotes permanent deformation condition
q	denotes shear-bearing
t	denotes tensile
u	denotes ultimate (rupture) condition
x, y	denotes stress, load or factor in axial or transverse lug directions respectively (see Sketch 1.1)
θ	denotes load applied at angle θ to x -direction

Other notation is defined where it is used or in Items ESDU 91008 and ESDU 06021.



(a) Parallel-sided lug



(b) Shallow tapered lug

Sketch 1.1 General lug geometry and loading

2. GENERAL

The rupture of a lug under oblique loading at an angle θ to the axial (x -) direction may be estimated from the rupture loads of the lug under axial (x -direction) loading and transverse (y -direction) loading by using the following empirical interaction formula (see Derivation 1),

$$P_{u\theta} = \frac{1}{\left[\left(\frac{\cos \theta}{P_{uxmin}} \right)^{1.6} + \left(\frac{\sin \theta}{P_{uy}} \right)^{1.6} \right]^{0.625}}, \quad (2.1)$$

where P_{uxmin} is the minimum of P_{tux} and P_{qux} , obtained as detailed in Section 1.3.2 of ESDU 91008. Furthermore, the load to cause maximum permissible permanent deformation under oblique loading at an angle θ to the axial (x -) direction is estimated by replacing P_{uxmin} with P_{px} (from ESDU 91008) and P_{uy} with P_{py} (from ESDU 06021) in Equation (2.1). Sketch 2.1 represents Equation (2.1) in a graphical form for various load ratios P_{uy}/P_{uxmin} .