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Strength of lugs under transverse load

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THE PREPARATION OF THIS DATA ITEM

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STRENGTH OF LUGS UNDER TRANSVERSE LOAD

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STRENGTH OF LUGS UNDER TRANSVERSE LOAD

1. INTRODUCTION

This Data Item provides data for use in determining the load to cause failure by rupture or maximum permissible permanent deformation of parallel-sided and tapered lugs under in-plane transverse loading*. The data are provided in the form of two figures. They are applicable to round- and square-ended lugs made of ductile metallic materials (see the note in the second paragraph of Section 2 regarding material grain direction). Lugs fabricated from brittle materials are not covered by the Item.

The data given in this Item are based on the analyses presented in Derivations 1, 2 and 4. Most of the numerical data have been obtained from both material and geometric non-linear finite element analyses supported and verified by experimental data from Derivation 3. Sections 2 and 3 of this Item describe the application and limitations of the analysis, and the calculation of the rupture and permanent deformation loads of the lug.



Airbus A300 rudder hinge lug

* For data relating to lugs under in-plane axial and oblique loading, see ESDU 91008.

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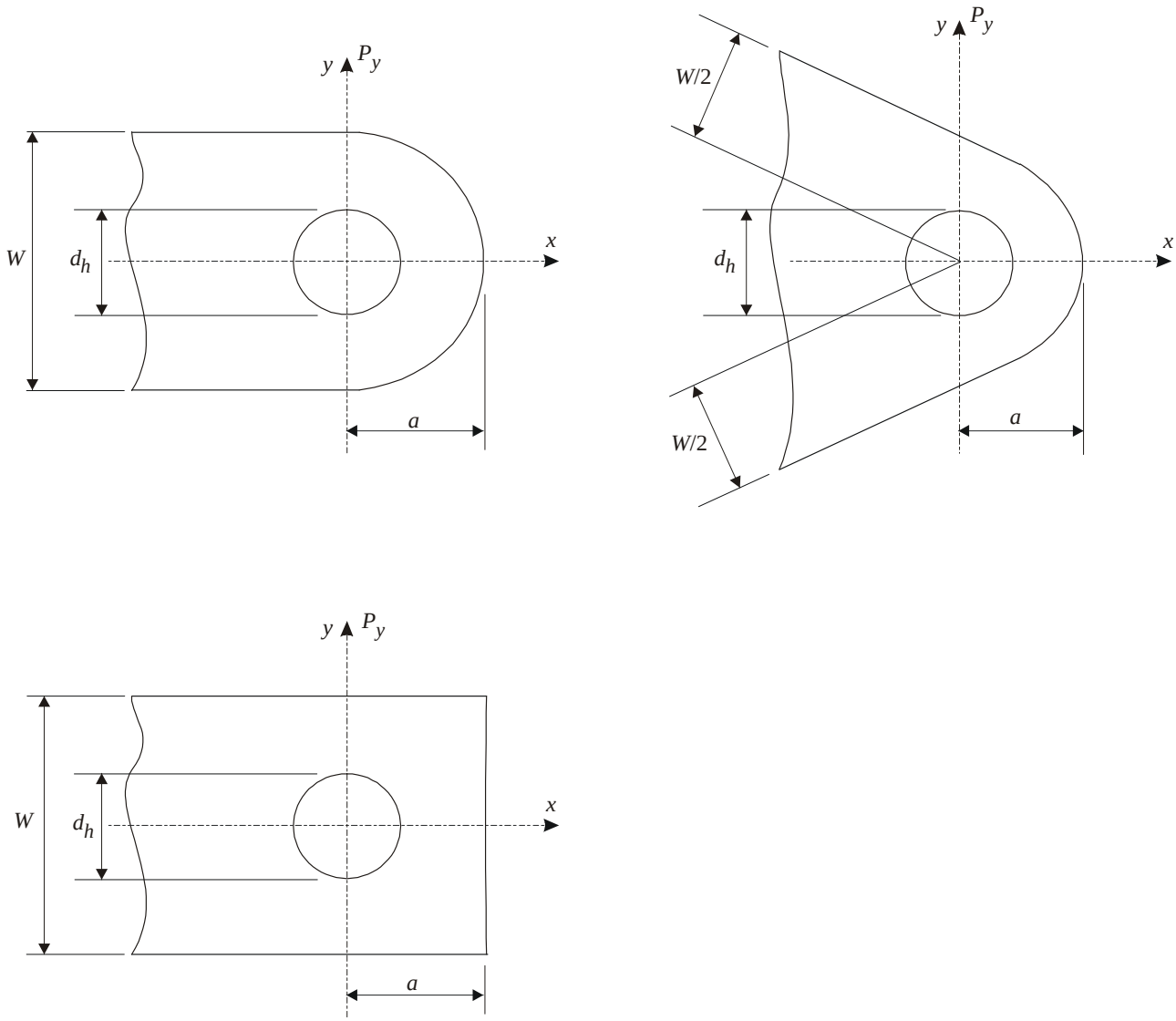
1.1 Notation

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

A_E	effective area of lug under transverse load $A_E = \dfrac{6}{\frac{3}{A_1} + \frac{1}{A_2} + \frac{1}{A_3} + \frac{1}{A_4}}$	m^2	in^2
A_1, A_2, A_3, A_4	critical areas of lug under transverse load, see Sketch 3.2	m^2	in^2
a	distance from centre of loaded hole in lug to lug end, see Sketch 1.1	m	in
C	non-dimensional parameter used in Figures 1 and 2		
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
f_t	ultimate tensile stress of lug material	N/m^2	lbf/in^2
K_{uy}	transverse rupture factor of lug		
m	material characteristic, see Reference 6		
P_{py}	load to cause maximum permissible permanent deformation of lug under transverse (y-direction) load	N	lbf
P_{uy}	transverse (y-direction) rupture load of lug	N	lbf
P_y	applied transverse (y-direction) load	N	lbf
t	thickness of lug	m	in
t_2	0.2 per cent proof stress of lug material	N/m^2	lbf/in^2
W	nominal width of lug, see Sketch 1.1	m	in
x, y	co-ordinate system for lug, see Sketch 1.1		
γ_{max}	allowable shear strain of lug material		
ε_t	ultimate total tensile strain of lug material (total tensile strain at f_t)		
ε_{ref}	total strain at 0.2 per cent proof stress, t_2, of lug material, $\varepsilon_{ref} = (t_2/E) + 0.002$.		

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Sketch 1.1 General lug geometry and loading

2. GENERAL APPLICATION AND LIMITATIONS OF THE ANALYSIS

This Item provides data that enable the loads to cause failure by rupture and maximum permissible permanent deformation to be determined for lugs under in-plane transverse (y-direction) loading. The term rupture is taken here to denote failure in the lug by fracture of the lug material in shear. The region of shear rupture is shown in Sketch 3.1. The term permanent deformation denotes that the lug material is strained beyond the elastic range (taken to be limited by the 0.2 per cent proof stress) of the lug material resulting in an irrecoverable permanent set.

The data presented may be applied to lugs fabricated from any ductile metallic material, but it should be noted that they have been obtained by finite element analyses supported and verified by experimental data from Derivation 3. For lugs fabricated from ductile metallic materials, the mode of failure under transverse (y-direction) load is likely to be rupture due to shear and bearing effects in the section of the lug receiving the pin load (see Sketch 3.1). Lugs fabricated from brittle materials with low fracture toughness generally fail in a tensile mode with fracture across the width of the lug at its end; this mode of failure is not covered

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