ESDU 73002

Issued June 1973
With Amendments A and B
June 1976
Re-issued January 2013

Fatigue of steel spline assemblies under reversed torsion

Endorsed by
The Institution of Mechanical Engineers

ESDU Copyright material. For current status contact ESDU.

Documents
Document Sharing Hub

Full document details: ESDU 73002 B-R1 2013

ESDU DATA ITEMS

Data Items provide validated information in engineering design and analysis for use by, or under the supervision of, professionally qualified engineers. The data are founded on an evaluation of all the relevant information, both published and unpublished, and are invariably supported by original work of ESDU staff engineers or consultants. The whole process is subject to independent review for which crucial support is provided by industrial companies, government research laboratories, universities and others from around the world through the participation of some of their leading experts on ESDU Technical Committees. This process ensures that the results of much valuable work (theoretical, experimental and operational), which may not be widely available or in a readily usable form, can be communicated concisely and accurately to the engineering community.

We are constantly striving to develop new work and review data already issued. Any comments arising out of your use of our data, or any suggestions for new topics or information that might lead to improvements, will help us to provide a better service.

THE PREPARATION OF THIS DATA ITEM

The work on this particular Data Item was monitored and guided by the Stress Analysis and Strength of Components Committee first met in 1964 and now has the following membership:

Chairman	
Mr H.L. Cox	— Independent
Vice-Chairman	
Mr G.P. Smedley	— Lloyd's Register of Shipping
Members	
Mr A.J. Batchelor	— Imperial Chemical Industries Ltd
Mr C.E. Day	— Independent
Dr J.R. Dixon	— National Engineering Laboratory
Mr N.E. Frost	— National Engineering Laboratory
Dr R.B. Heywood	— A. Macklow-Smith Ltd
Mr M.J. Kemper	— A.P.V. Company Ltd
Dr L.C. Laming	— Imperial College of Science and Technology
Dr J. Spence	— University of Strathclyde
Dr C.E. Turner	— Imperial College of Science and Technology
Mr J.V. Vint	— C.A. Parsons and Company Ltd.

The construction and subsequent development of the Data Item was undertaken by

Mr M.E. Grayley — Head of Strength Analysis Group.

The ESDU Stress and Strength Series is recognised as a valuable source of validated data and methods by the Institution of Mechanical Engineers and its Structural Technology and Materials Group is involved in continually reassessing the scope and focus of the content of this Series.

ESDU Copyright material. For current status contact ESDU.

Documents
Document Sharing Hub

FATIGUE OF STEEL SPLINE ASSEMBLIES UNDER REVERSED TORSION

CONTENTS

		Page
1.	NOTATION	1
2.	GENERAL NOTES	1
3.	DISCUSSION OF DATA	2
3.1	Material Factors	2
3.2	Geometric Factors	2
3.3	Spline Surface Condition	2
3.4	Other Factors	3
4.	DERIVATION	3
5.	SPLINE ASSEMBLIES DATA	3
FIGURES 1 TO 4		5 TO 8

ESDU Copyright material. For current status contact ESDU.

Documents
Document Sharing Hub
Full document details: ESDU 73002 B-R1 2013

FATIGUE OF STEEL SPLINE ASSEMBLIES UNDER REVERSED TORSION

1. NOTATION

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

a	height of male splines	m	in
f_t	tensile strength of shaft material	N/m^2	lbf/in^2
K	stress concentration factor at root of a male spline on a shaft transmitting torsion, defined by $q_m = Kq$		
N	endurance		
q	allowable shear stress at surface of a plain shaft transmitting torsion and having diameter equal to root diameter of splined shaft	N/m^2	lbf/in^2
q_m	maximum shear stress at fillet along root of male spline on a shaft transmitting torsion	N/m^2	lbf/in^2
r	radius of fillet along root of male spline	m	in

2. GENERAL NOTES

This Item presents data on the fatigue strength of steel splines under reversed torsion applied by the female member, the shaft being free from bending or axial loading. The nominal diameter of the splines lies between 1.0 and 1.5 in (25.4 and 38.1 mm). Data on male splines manufactured from eight different steels are provided together with data on the effects of the number of splines, their shape and surface condition.

The largest body of data relates to bottom fitting assemblies having six straight-sided machine-cut splines. The splines conformed to British Standard 2059:1953, fit 1, excepting that, in order to minimise backlash, the tolerances on the spline widths were slightly reduced. The tests were made under alternating torsion of constant amplitude of sinusoidal wave form. Data on both deep and shallow standard splines are included. Figures 1 and 2 present the results of 122 fatigue tests on such assemblies. Figure 1 shows the effect of varying the spline height and root radius. Also shown is the effect of employing an assembly having tapered minor diameters. Four different steels are included on Figure 1. For deep splines, Figure 2 shows the improvements resulting from various surface condition treatments. Figure 3 shows the effect of increasing the number of splines and in addition includes involute forms having 24 splines. Figure 4 shows the effect of surface condition treatments on involute spline forms having 23 or 24 splines. Table 5.1 provides details of the sizes, materials and treatments of all the data groups.

All the fatigue failures initiated at one or more of the roots of the splines of the male member at the point where it entered the female member. The crack, or cracks, then grew on a helical path until rupture occurred. No failures or significant damage to the female splines occurred.

The female components were, in all cases, manufactured from carburised steel to British Standard BSS, En 36 or En 353. Their minimum overall diameter was 2.25 in (57.2 mm).

Issued June 1973
With Amendments A and B, June 1976
Re-issued January 2013

ESDU Copyright material. For current status contact ESDU.
Documents
Document Sharing Hub
Full document details: ESDU 73002 B-R1 2013