

Guide to fatigue data available in the Stress and Strength of Components Series

ESDU 20004

December 2019



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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. This Committee first met in 1964 and now has the following membership:

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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.

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GUIDE TO FATIGUE DATA AVAILABLE IN THE STRESS AND STRENGTH OF COMPONENTS SERIES

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GUIDE TO FATIGUE DATA AVAILABLE IN THE STRESS AND STRENGTH OF COMPONENTS SERIES

1. INTRODUCTION

This Data Item presents a guide to the fatigue data offered in the Stress and Strength of Components (SASC) Series at ESDU.

A useful introduction to general fatigue terms used in the fatigue-based Data Items in the SASC Series is given in ESDU 70016. ESDU 71009 summarises some general design principles that may be considered to minimise the risk of fatigue failure.

In Section 2, the fatigue data available in the SASC Series is briefly reviewed. The data presented in the SASC Series are derived from either a constant-amplitude stress-life fatigue test or from a strain-life fatigue test (see ESDU 04022 for an introduction to strain life (low cycle) fatigue). During fatigue testing it is important to consider the effect of temperature, testing environment and other factors such as fretting (see ESDU 90031) that may have a detrimental effect on fatigue strength. Furthermore, there are many approaches that can improve fatigue strength such as using surface treatments (see ESDU 89031 for further details). Most of the data summarised in this Item are from tests carried out on samples of small dimensions. However it must be remembered that the relative size and scale of the test specimens can influence fatigue strength, see ESDU 87016.

Most of the fatigue data given in the SASC Series are reported for steel and aluminium test samples but there is also a limited amount of data available regarding the fretting of titanium. A guide to the fatigue strength of welded joints is given in ESDU 86013. Once fatigue data have been obtained, ESDU 97024 can be used to plot curves through the fatigue data to aid the interpretation of the data.

A list of the Data Items offering fatigue data in the SASC Series is given in Section 3. In Section 4 a summary of the data is presented.

2. AVAILABLE DATA

2.1 General

Table 4.1 summarises the general fatigue data available in the SASC Series.

ESDU 71027 presents the results of fatigue tests on plain and notched specimens for various types of high strength steel, martensitic stainless steels, precipitation hardening martensitic stainless steels, austenitic stainless steels and maraging steels. Also, data for low-alloy steels have been correlated to show the general effect of the material tensile strength on fatigue endurance. In ESDU 74016, the results of constant amplitude fatigue tests on steel specimens with various types of stress raisers under axial loading and bending loading are given.

ESDU 75022 gives a calculation to estimate the fatigue strength of a component (not subjected to fretting) with a stress concentration, under constant amplitude cyclic loading and mean loading. The use of a fatigue strength reduction factor in place of the stress concentration factor is explained and demonstrated for various materials and stress raisers. The effect of adjacent stress concentrations, using an equivalent stress value where a combined loading or shear is applied, and the method of considering the mean stress is also explained.

The effect of surface finish on the fatigue limit as a function of the tensile strength of steel is examined in ESDU 74027. The likely value of roughness associated with various finishing techniques, and the relationship between the centre-line average roughness and the peak-to-valley roughness, is examined. In ESDU 86033, the following effects on the fatigue limit of low-alloy steel are discussed:

- chromium plating and other pre- and post plating techniques,
- shot peening before plating,
- influence of heat treatment at various temperatures, and
- effect of polishing and/or grinding.

ESDU 88008 gives data for the fatigue strength at high endurance for corrosion resistant steels which do not show a fatigue limit. Data are presented for axial, bending or torsional loading and the relationship between the fatigue limit and tensile strength is shown. For axial loading, the effect of mean stress is shown and for loading under torsion. A comparison with the prediction obtained by applying the von Mises criterion to the fatigue limit under bending is made.

In ESDU 05007, the strain-life fatigue data for type 316 austenitic stainless steels at temperatures between -269 and 816 °C (-452 and 1501 °F) and at various strain rates are given. Similarly, ESDU 05008 presents the stress-response and cyclic stress-strain fatigue data for austenitic type 316 stainless steels at temperatures between -269 and 800 °C (-452 and 1472 °F). The effect of temperature, applied strain amplitude and nitrogen content of the steels tested on the stress response is examined, as is the degree of hardening.

2.2 Effect of Fretting

Table 4.2 summaries the fatigue endurance data available from fretting fatigue tests carried out on titanium alloys.

In ESDU 88027 the detrimental effects of fretting on fatigue tests on titanium alloys carried out at room temperature in air, compared with tests carried out in salt water or at elevated temperature, are presented. The effect of clamping pad pressure and various surface coatings and treatments is also discussed.

2.3 Welded Components

Tables 4.3 and 4.4 present the available data in the SASC series for steel and aluminium alloy welds, respectively.

2.3.1 Steel Welds

ESDU 75016 presents S/N fatigue endurance data for transverse fillet and cruciform butt welds in load-carrying and non-load-carrying joints. The effect of mean stress and location of failure in such joints is also reviewed. Similarly, ESDU 76007 gives S/N curves for fatigue data obtained from longitudinal fillet welded attachments in plates with loaded and non-loaded attachments showing the likely location of failure.

ESDU 76032 gives S/N curves from fatigue tests on I-beams and T-sections under simple three or four point bending loading. In ESDU 77011, S/N curves for transverse butt welds that have been prepared with square or single or double U- or V-ends are given. The influence of weld defects is discussed as is the effect

of mean stress, residual stress and weld bead profile on fatigue endurance. ESDU 81007 presents S/N curves for structural steel I-beams with welded cover plates and different methods of attaching stiffening gussets and examines the effect of residual stress, mean stress, joint size, weld geometry and weld grinding.

ESDU 78016 discusses the methods for improving fatigue strength of longitudinal, transverse and wing-butt fillet welded attachments using post-weld heat treatments (such as grinding, compressive shot peening and stress relief). The effect of mean stress on longitudinal welds that have been stress relieved by heat treatment is compared to untreated weld data.

ESDU 78023 plots the results of constant amplitude fatigue tests carried out on plates with loaded and non loaded attachments. The effect of varying plate thickness on as-welded joints with weld toe failures and on joints with ground weld toes are given. The influence of residual and mean stresses, joint size and grinding on fatigue performance is discussed, as is the effects of leg length and weld penetration with, in that case, a graph showing their influence on location of failure.

2.3.2 Aluminium Welds

ESDU 91039 and ESDU 92017 present many S/N fatigue endurance curves for 5000, 6000, and 7000 series aluminium alloy welded joints under axial or bending loading.

In ESDU 91039, the data compares the fatigue strength of butt-welded joints in the as welded condition with those that have had a post-weld treatment applied, such as bead removal, to improve fatigue strength. A general description of the weldability and other factors affecting fatigue strength are also discussed.

In ESDU 92017 the fatigue properties of load-carrying and non-load-carrying transverse cruciform joints, load-carrying and non-load-carrying transverse and longitudinal cover plates, and single and double fillet lap welds under axial loading are discussed. The effect of mean stress is shown for cruciform and cover plate joints along with the effect of post-weld treatments (shot peening and tungsten inert gas dressing) for some cover plate joints.

2.4 Bolted Joints

A summary of the data available for steel bolted assemblies is given in Table 4.5.

ESDU 67020 presents S/N fatigue endurance curves from constant-amplitude fatigue tests carried out on axially loaded solid steel bolts with threads form-rolled before heat treatment or heat treated before being form rolled. ESDU 80028 presents S/N fatigue endurance curves for simple nut and bolt threaded assemblies showing the relatively low fatigue strength for larger nominal thread sizes equal to, or greater than, 1.5 in (38 mm) compared with threads with less than 1.0 in (25 mm) nominal diameter.

The fatigue tests presented in ESDU 84037 are carried out on externally threaded members loaded through the nut with either cut threads or with form-rolled threads indicate that the method of thread manufacture dominates the fatigue strength. Fatigue data are also presented for internally threaded components showing that such components rarely fail in fatigue, but if a thin nut is required, the risk of fatigue can be reduced by maximising material ductility.

ESDU 82022 analyses the fatigue strength of steel lugs subjected to constant amplitude loading applied by a single central clearance-fit pin. The effect of pin fit and lug size are examined as are mean stress effects and the type of treatment and/or lubrication that can be applied to the lug bore.