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Introduction and guide to ESDU data on acoustic fatigue

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THE PREPARATION OF THIS DATA ITEM

The work on this particular Data Item which supersedes Item No. 72001, was monitored and guided by the Acoustic Fatigue Panel on behalf of the Fatigue Committee.

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INTRODUCTION AND GUIDE TO ESDU DATA ON ACOUSTIC FATIGUE

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INTRODUCTION AND GUIDE TO ESDU DATA ON ACOUSTIC FATIGUE

1. GENERAL REMARKS

Experience on many different aerospace vehicles has shown that high-frequency low-amplitude pressure fluctuations associated with random acoustic loading can cause structural fatigue or lead to unacceptable expense for maintenance and inspection. The majority of acoustic fatigue failures on aircraft to date have occurred on structure lying close to, or in the path of, the jet efflux. Similar failures have occurred in other regions of pressure fluctuation such as within the intake duct of fan engines, close to propeller tips and in regions of separated flow, for example behind airbrakes.

This introduction outlines the important factors influencing acoustic fatigue failure and gives guidance on the use of Data Items on acoustic fatigue. In the present state of knowledge a complete analytical solution to the response of a structure to acoustic loading cannot be presented, but the framework of a design procedure applicable especially to skin panels can be described. Although much of the text of this Item makes specific reference to aircraft structures, many of the data referred to are applicable to a wide range of aerospace structures.

Terms used in acoustic fatigue analysis are defined in Item No. 66013. References to relevant literature are given in the Derivation and References sections of individual Items in the Series. Also a number of references giving some background information on acoustic fatigue that will be useful are included in Section 5 of this Item.

A considerable amount of practical background information relating to the nature of the acoustic fatigue problem is given in Item No. 86025. In that Item sources of noise excitation are reviewed, information is presented on typical response behaviour and guidelines on good design practice are given.

2. OUTLINE OF THE PROBLEM

Table 2.1 summarises the important factors affecting the acoustic fatigue life of a structure subjected to jet noise. Similar considerations apply for other sources of pressure fluctuation; the factors of importance for the operating condition and noise field characteristics relevant to that source should be substituted for those under loading actions in Table 2.1. A review of acoustic and aerodynamic excitation sources is given in Item No. 86025.

TABLE 2.1

<i>Principal Items</i>		<i>Factors of Importance</i>
Loading actions	1. Operating condition	Flight plan Time duration at full thrust forward speed Use of reverse thrust Use of lift augmentation devices on STOL vehicles Occurrence of shock-cell noise
	2. Noise field characteristics	Engine characteristics Engine position Noise reflections from ground and other structure
3. Structural response		Natural frequencies Mode shapes Modal damping
4. Stress at critical points		Predominant modes Detail design (stress concentration)
5. Fatigue damage		Long life portion of $S_{rms} - N_r$ curve* under random loading Crack propagation characteristics Environment (corrosion, temperature)

* S_{rms} denotes the root mean square stress at a reference position and N_r denotes the equivalent endurance, taken as half the number of zero crossings to failure of the stress-time function.

3. DESIGN PROCEDURE

Within the ESDU Vibration and Acoustic Fatigue Series, design data are provided for skin panels and box structures typical of those used in the aerospace industry. With the advent of the use of composite materials in the manufacture of skin panels of structures and their stiffening members it is necessary to consider the noise induced response of such systems. The use of Data Items developed principally for isotropic systems can be extended to this end by the introduction of orthotropic plate stiffnesses (see Section 4.3)

The following notes are relevant to the design of skin panels and box structures.

3.1 Skin Panels

The basic type of skin design for a component subject to acoustic fatigue loading is chosen with regard to the overall noise level which may be estimated as outlined in Section 4.2 or from previous experience. Guidance on good current practice in stiffened skin design is given in Item No. 86025. The effect of variations in panel geometry may be investigated by means of the analysis outlined in Section 4.3. Use of early design charts such as those of Reference 3 has been found in many cases to lead to excessively heavy designs and it is believed that the methods discussed in this Item and in the later References are more realistic. Tests of critical sections of structure in a simulated acoustic environment that is representative of