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Terms and notation for fatigue endurance data

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THE PREPARATION OF THIS DATA ITEM

The work on this particular Data Item was monitored and guided by the Fatigue Committee, which first met in 1955 and now has the following membership:

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This Item was also accepted for inclusion in the Stress and Strength Sub-series by the Stress Analysis and Strength of Components Committee, which first met in 1964 and now has the following membership:

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TERMS AND NOTATION FOR FATIGUE ENDURANCE DATA

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TERMS AND NOTATION FOR FATIGUE ENDURANCE DATA

1. INTRODUCTION

This Item defines the basic terms, notation and forms of presentation of both constant and variable amplitude fatigue endurance data. Terms and notation for statistical analysis of data are presented separately in the Data Items on statistics. The terms defined in this Item are in accordance with those used for the fatigue data presented in DEF STAN 00-932 (Reference 14) and are also broadly consistent with British and American standards.

2. NOTATION

Both SI and British units are quoted.

<i>Symbol</i>	<i>Term</i>	<i>Section giving definition or amplification of term</i>	<i>Units</i>	
D	cumulative damage ratio	6.2		
D_f	cumulative damage ratio at failure	6.2		
f_t	ultimate tensile strength		N/m ²	lbf/in ²
K_f	fatigue strength reduction factor	7.3		
K_t	theoretical elastic stress concentration factor	7.1		
N	endurance	4.1		
n	number of load cycles applied			
R	stress ratio	3.7		
S	stress in general	3.1	N/m ²	lbf/in ²
S_a	alternating stress	3.5	N/m ²	lbf/in ²
$S_{am}(N)$	fatigue strength	4.2.1	N/m ²	lbf/in ²
$S_{am}(\infty)$	fatigue limit	4.2.2	N/m ²	lbf/in ²
S_m	mean stress	3.4	N/m ²	lbf/in ²

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S_{max}	algebraic maximum stress in cycle	3.3	N/m ²	lbf/in ²
S_{min}	algebraic minimum stress in cycle	3.3	N/m ²	lbf/in ²
ΔS	stress range	3.6	N/m ²	lbf/in ²

2.1 Suffixes

1, 2 *etc.* denote various loads under variable amplitude loading

In Data Items on elastic stress concentration factors the suffix ‘*t*’ in K_t is omitted throughout for simplicity.

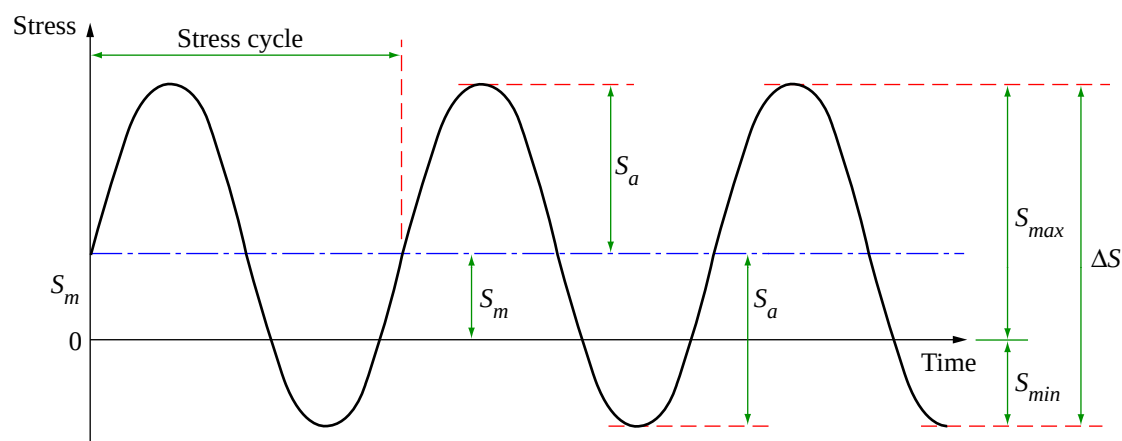
2.2 Sign Convention

Tensile stresses are positive; compressive stresses are negative.

3. FATIGUE UNDER CONSTANT AMPLITUDE LOADING

Service loadings experienced by some engineering components and structures can be represented with sufficient accuracy for most design purposes by stress cycles of constant mean stress and amplitude as illustrated in Sketch 3.1. Appropriate design data for such loadings are obtained from laboratory tests on simple smooth or notched specimens, or on commonly used joints, or sometimes on complete components, machines or structures. Basic data for individual materials in specified environmental conditions are commonly obtained from constant amplitude tests on plain specimens under axial, torsional, bending or rolling-contact loadings.

Symbols and definitions associated with fatigue under constant amplitude conditions are given below. In simple fatigue analysis, where load and stress are directly related, equivalent definitions of mean load, alternating load, *et cetera* are obtained by substituting ‘load’ for ‘stress’. In general, reference to stress in the following sections may be taken to include load and vice-versa but it should be noted that this is not always the case.



Sketch 3.1 Constant amplitude loading

3.1 Stress in General

The notation S , with various suffixes, is used in this Item to denote stress and may refer to a direct stress, shear stress, or equivalent direct stress in different applications. It is also used indiscriminately to denote the stress applied to a component in service, or to the strength of a material or component under given loading conditions. In some Data Items, for example those dealing with stress concentrations, the symbols f , f_e and q are used for direct, equivalent and shear stresses respectively in place of S .

3.2 Stress Cycle

The **stress cycle** under constant amplitude loading is illustrated on Sketch 3.1. It is the smallest section of the stress-time function which is repeated continuously and periodically.

3.3 Maximum and Minimum Stresses, S_{max} and S_{min}

The **maximum stress**, S_{max} , is the highest algebraic value of stress in a cycle. The minimum stress, S_{min} , is the minimum algebraic value of stress in a cycle. Sketch 3.1 shows S_{max} and S_{min} .

3.4 Mean Stress, S_m

The average of the algebraic values of the **maximum and minimum** stress in the cycle, that is,

$$S_m = \frac{1}{2}(S_{max} + S_{min}). \quad (3.1)$$

3.5 Alternating Stress, S_a

The amplitude of the excursion from the **mean stress**. It is one half the difference between the algebraic values of the **maximum and minimum** stress in the cycle, that is,

$$S_a = \frac{1}{2}(S_{max} - S_{min}) = S_{max} - S_m = S_m - S_{min}. \quad (3.2)$$

Under constant amplitude loading, S_a may be considered to be the variable component of the stress and S_m may be considered to be the constant component of the stress.

3.6 Stress Range, ΔS

The difference between the algebraic values of the **maximum and minimum stress** in the cycle, that is,

$$\Delta S = S_{max} - S_{min} = 2S_a. \quad (3.3)$$

3.7 Stress Ratio, R

The ratio of the algebraic **minimum stress** to the algebraic **maximum stress** in the cycle, that is,

$$R = \frac{S_{min}}{S_{max}}. \quad (3.4)$$

The values $R = 0$ and $R = -1$ are commonly used in constant amplitude fatigue testing and are referred to as described below.