

NOTES SUPPLEMENTARY TO E.07.01 ON THE FATIGUE STRENGTH OF ALUMINIUM ALLOYS

1. INTRODUCTION

Data Sheet E.07.01 gives information on the fatigue strength of aluminium alloys in bending. These notes provide additional information about the effects of axial loading, and type and condition of surface, on the fatigue strength of aluminium alloys.

2. NOTES

2.1 The Relationship between Fatigue Strengths in Bending and Under Axial Loading

Data Sheet E.07.01 states that under axial loading the unnotched fatigue strength of test specimens of aluminium alloys may be up to 20 per cent lower than in bending. This statement should be interpreted in the light of the following remarks.

The main reason for the observed difference is non-axiality of loading; an eccentricity of only about 3 per cent of the specimen width will reduce the apparent axial fatigue strength by the quoted 20 per cent. While there are other factors that produce differences in the results of tests under axial loading and in bending, they have been shown to be of secondary importance by carefully conducted tests in which the fatigue strengths of aluminium alloys were compared under the two loading systems. In Derivation 4, for example, the ratio of bending to axial fatigue strength at an endurance of 10^6 cycles was found to average 1.02, with extreme values of 0.94 and 1.08, for nine alloys.

It may be concluded that if axiality of loading is ensured, the difference between the fatigue strengths of unnotched specimens under axial loading and in bending will usually not be greater than 5 per cent and is often negligible.

In a notched specimen, failure is determined by the stress at the bottom of the notch. If this stress is correctly evaluated, there will be no difference between the two methods of testing.

The curves of E.07.01 may, therefore, be taken with little error to apply both to true axial loading and to bending. In practice, small digressions from true axial loading will reduce the fatigue strength as effectively as in the laboratory.

2.2 The Effect of Type and Condition of Surface

The curves of E.07.01 apply to specimens with smooth machined or polished surfaces. Although fatigue failures usually occur in regions of stress concentration, this is not invariably so. For this reason the effect of type and condition of surface must be considered. Some information on which to estimate the fatigue strength is tabulated below.

Surface	Ratio of mean fatigue strength to mean value in E.07.01
Smooth machined or polished	1.0
As extruded	0.4 to 0.8
As rolled (sheet)	0.8 to 1.0
Clad (sheet)	0.5 to 0.9

Where a specimen or component contains a stress concentration affecting a small region, the effect of the surface will be negligible; hence the fatigue strength indicated by E.07.01 for notched specimens of the appropriate value of K_t' will be achieved. If the stress concentration affects a large region, for example, the vicinity of an access hole, a reduction factor for the type and condition of surface must also be applied.

The fatigue strength of rolled or extruded surfaces may be improved by shot-peening or other treatments inducing residual compressive stresses in the surface.

In corrosive environments the fatigue strength of clad aluminium alloys will generally be superior to that of the same alloys unclad.

3. DERIVATION

1. Fatigue properties of light alloy sheet materials and the influence of aluminium cladding. Ministry of Aircraft Production S & T Memo 3/42, 1942.
2. ALUMINIUM LABORATORIES LTD The fatigue properties of unmachined and machined extruded sections. Ministry of Supply S & T Memo 7/52, 1952.
3. ALUMINIUM LABORATORIES LTD Large scale fatigue tests on complete sections of aluminium and magnesium alloys. Ministry of Supply S & T Memo 2/57, 1957.
4. WOODWARD, A.R.
GUNN, K.W.
FORREST, G. The effect of mean stress on the fatigue of aluminium alloys. *Proceedings of the International Conference on Fatigue of Metals*. I. Mech. E/ASME, 1958.
5. GUNN, K.W.
WOODWARD, A.R. Fatigue of unmachined aluminium alloy extrusions. *Aeronaut. Q.*, Vol. XIII, p. 271, August 1962.
6. Aerospace structural metals handbook, Vol. II, USAF ASD-TDR-63-741, 1963.
7. NORDMARK, G.E. Fatigue of aluminium with alclad or sprayed coatings. *J. Spacecraft and Rockets*. Vol. I, p. 125, Jan/Feb. 1964.