# Technical Comments

## Comments on "Vacuum Effects on Fatigue Properties of Magnesium and Two Magnesium Alloys"

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THESE Comments are offered to enlarge on the data presented by Sumsion[1] with regard to the fatigue behavior of magnesium alloys with respect to environment and protective coatings. Figures 1–4 are reproduced from Ref. 2, which is one of the most complete summations of magnesium technology recently published. (The unit tsi in these figures is tons/in.$^2$, where 1 ton = 2240 lb. The ASTM designations of these English alloys would be as follows: ZW3 = ZK31, ZRE1 = EZ33, and RZ5 = ZE41.

Figure 1 does show that water and oxygen cause drastic effects on fatigue behavior of uncoated magnesium, but it also shows effects of $H_2$ and $CO_2$, both dry and wet. Interestingly, normal air has a greater effect than wet air. Reference 2 suggests that the freshly demineralized water acted as an oxygen barrier. Note that the rubber-coated specimens had the highest fatigue strength, even higher than bare samples run in dry nitrogen. This result is similar to that suggested by Sumsion regarding the use of protective coatings.

Figure 2 shows the effect of surface finish. The subject paper[1] states that the specimens were "mechanically abraded and chemically polished." As can be readily seen, the exact description of surface finish and polish is necessary to define adequately the state of the specimens since Mg is particularly sensitive to surface preparation. Note that a protective anodizing treatment frequently used in the U.S.A. (HAE) is detrimental to fatigue life, as is a full Dow 17 treatment. It is believed that the ceramic nature of these coatings provides localized surface stress concentrations and in some cases actual surface cracks in the metal. Many people in the aerospace field are unaware of this property and often specify HAE or Dow 17 with a protective resin for maximum corrosion resistance. The benefits of the resin in excluding the environment may be more than lost by the anodizing pretreatment!

Figure 3 shows one alloy tested with various pretreatments and a protective resin compared to a polished specimen tested in air. The fluoride-anodized specimen coated with the resin is the best combination of environmental resistance and the retention of fatigue strength by minimizing corrosion fatigue. The fluoride anodizing produces a much thinner film than HAE or Dow 17 and, consequently, less irregularities in the metal surface. The effectiveness of the careful pretreatment (no HAE or Dow 17) and resin combination is shown in Fig. 4, where the endurance limits for specimens tested in air, distilled water, and a 3% NaCl solution showed no appreciable

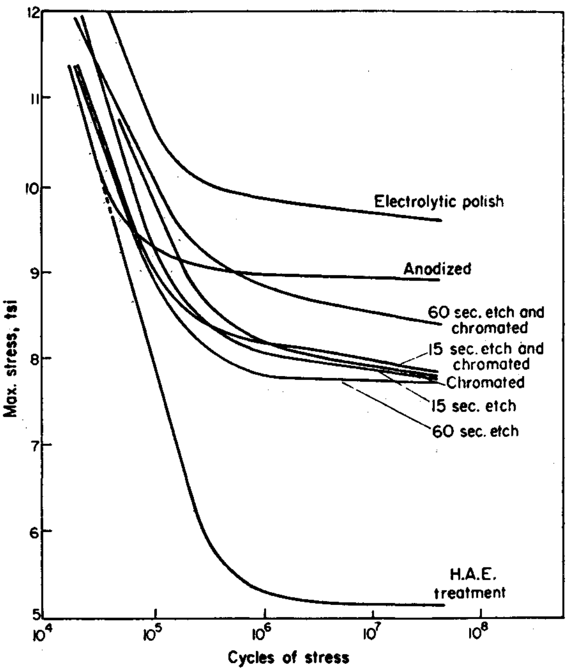


**Fig. 2 Effect of various chemical and electrochemical treatments on the fatigue endurance of extruded ZW3 and the shape of the *S/N* curve; rotating bending (Brown).**

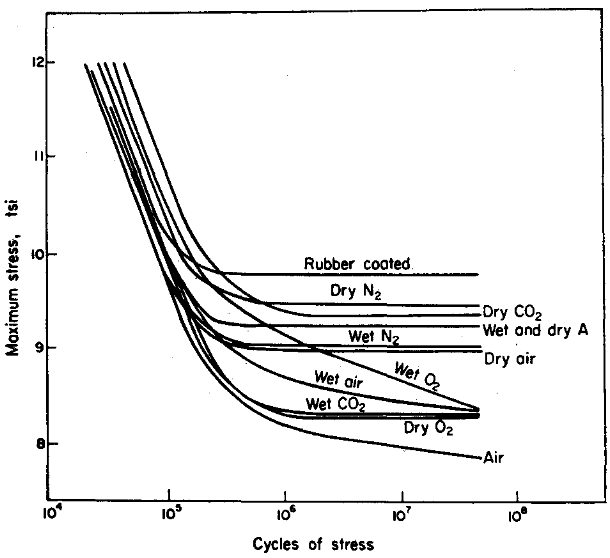


**Fig. 1 Effect of atmosphere on the fatigue strength of extruded ZW3 and the shape of the *S/N* curve; rotating bending (Brown).**

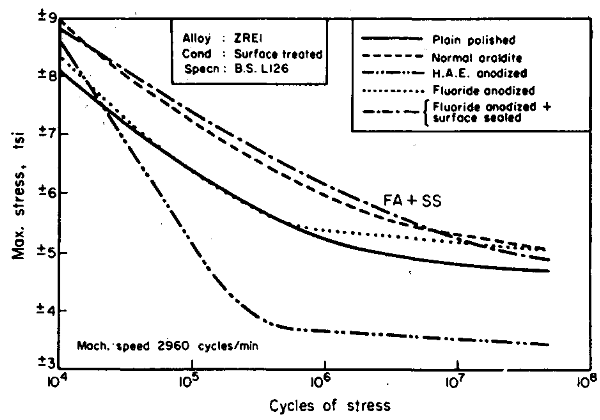


**Fig. 3 Beneficial effect of fluoride anodizing and surface sealing with Araldite 985E epoxy reson on *S/N* curves for cast ZREl (annealed); rotating bending (McDonald).**

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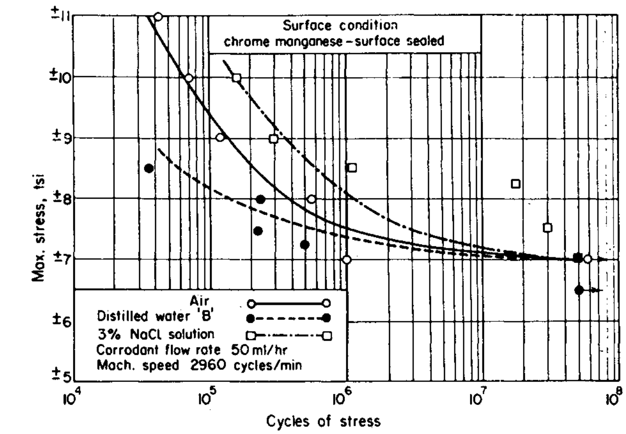


**Fig. 4 A corrosive salt environment had no measurable effect on fatigue strength of cast RZ5 (heat treated) surface-sealed with Araldite 985E epoxy resin; rotating bending (McDonald and Heaton).**

difference. Also, the endurance limits are not effected by environment, which reinforces Sumsion's conclusion that proper protection would allow inherent alloy properties to be used in design.

Figure 5[3] shows that for the Mg-Li alloy LA141A-T7, one resin (Hysol 4225) produces a notable improvement in endurance limit. Both coated specimens were fluoride-anodized prior to coating. The curves are similar to Sumsion's curves for air and vacuum testing of the same alloy. Hysol 4225 is a product of the Hysol Corporation of Olean, New York, and Laminar X-500 is a product of the Magna Chemical and Coating Corporation of Los Angeles, California.

The English resin noted in Figs. 3 and 4 (Araldite 985E) has never been available in this country, and the closest product in chemical nature (Hysol 6101J) does not seem to have quite the same properties. The Araldite resin has seen considerable use in English helicopter uses of magnesium used by their navy in such tough saline environments as typified by the Mediterranean, where aircraft are often covered white with salt just sitting on a revetment overnight.

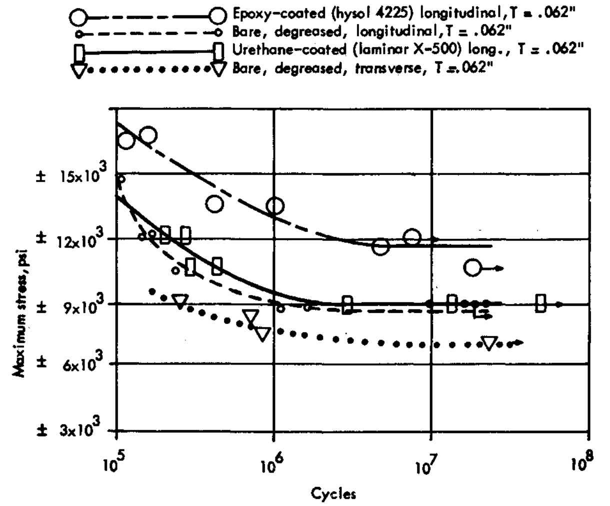


**Fig. 5 Effects of epoxy and urethane coatings on *S/N* curves for LA141A-T7 Mg-Li Krause-type specimens tested in air at 70°F by reverse bending at 33 cps. (Ultimate tensile strength, 22 ksi longitudinal, 21 ksi transverse; minimum/maximum stress ratio = 1; stress concentration factor = 1.)**

The purpose of these Comments is to add information to Ref. 1 in the area of surface protection and subsequent improvement in fatigue life. As can be seen, the pretreatment is quite important and must be taken into consideration more than it has in the past where many Federal contracts specify the use of Dow 17 or HAE for aerospace applications. Our English friends have been taking advantage of magnesium alloys in hardware by environmental protection for more than 10 years, and I believe that we, with few exceptions, have not.

### References

[1] Sumsion, H. T., "Vacuum Effects on Fatigue Properties of Magnesium and Two Magnesium Alloys," *Journal of Spacecraft and Rockets*, Vol. 5, No. 6, June 1968, pp. 700–704.

[2] Emley, E. F., *Principles of Magnesium Technology*, 1st ed., Pergamon, London, 1966, pp. 641–669.

[3] *Metalscope*, 1965.

# Notice to Subscribers

Because of a strike at the printing plant, this issue of the *Journal of Spacecraft and Rockets* is late reaching you. The next few issues also will be late until lost time can be made up.

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