



AEROSPACE INFORMATION REPORT

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Designing for Long Life with Elastomers

RATIONALE

This document has been determined to contain basic and stable technology which is not dynamic in nature.

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FOREWORD

The properties of elastomers change with time and temperature; in some cases, these changes are substantial. As a result of long-term storage stability problems with some early elastomeric materials, the aerospace industry to a large extent has become accustomed to the application of age controls on O-rings, hoses, and certain other rubber products. This has proven to be very costly, time-consuming, and unwieldy. Additionally, elastomeric materials qualified for service based on the results of short-term simulation tests conducted only at service temperature extremes have not always performed adequately in the field. Accelerated tests, when required, should be performed significantly above the continuous service temperature to provide a meaningful estimate of life at reduced temperatures. However, the aging temperature must not be so high as to change the degradation mechanism and thereby give misleading results (see references 8 to 18 below).

Replacement and reassembly of parts have been found to lower reliability. Maintenance on very complex aerospace products is difficult to carry out because of compactness of these products and disassembly required to gain access to seals or other rubber goods. The reliability and cost requirements of aerospace components are very high, hence short life, unreliable elastomeric parts cannot be tolerated. Long life elastomers are available for use in aerospace designs. It, therefore, follows that designing for long life is a much more viable approach.

The designer must convey a specific requirement to all concerned that he is building critical aerospace equipment intended for long life and high reliability. This can be as straightforward as a detailed drawing note citing the life requirement in years and the expected environments. This overall requirement has to be backed up by specific elastomer material performance and mechanical property specification requirements, as well as due consideration to application requirements. Moreover, the designer cannot assume that published specifications or proprietary callouts will automatically provide elastomeric performance to meet his specific needs.

1. SCOPE

This document lists those guidelines recognized as being essential for consideration by the designer who is preparing to select an elastomer as part of an aerospace design.

1.1 Purpose

To provide guidelines to the aerospace designer in the testing and selection of elastomers so that long life service will be realized in critical components.

2. APPLICABLE DOCUMENTS

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Aerospace Technical Report.

1. F. R. Eirich, ed., "Science and Technology of Rubber", Academic Press, New York, 1978.
2. A. V. Tobolsky and H. F. Mark, ed., "Polymer Science and Materials", John Wiley and Sons, New York, 1980.
3. H. Liebowitz, ed., "Fracture - An Advanced Treatise", Vol. VII, Academic Press, New York, 1972.
4. H. F. Mark and N. G. Goryunov, N. J. Bikales, ed., "Encyclopedia of Polymer Science and Technology", Vol. 8, p. 419, Interscience Publishers, New York, 1968.
5. U. Meier, J. Kuster, and J. F. Mandel, "Rubber Chemistry and Technology", Vol. 54, 254 (1984).
6. L. P. Smith, "The Language of Rubber", Butterworth-Heinemann Ltd., Oxford, UK, 1993.
7. A.N. Gent, ed., "Engineering with Rubber – How to Design Rubber Components", 2nd Edition, HanserGardner Publications Inc., Cincinnati, Ohio, 2001.
8. K. T. Gillen, J. Wise and R. L. Ciough, "Novel Techniques Applied to Polymer Lifetime Predictions", <http://www.osti.gov/scitech/servlets/purl/10113498/>.
9. K. T. Gillen, "Modulus Profiling of Polymers", Polymer Degradation and Stability, Vol. 17, pp. 31-47, 1987.
10. J. Wise, "An Ultrasensitive Technique for Testing the Arrhenius Extrapolation Assumption for Thermally Aged Elastomers", Polymer Degradation and Stability, Vol. 49, pp. 403-418, 1995.
11. K. T. Gillen, "Extrapolation of Accelerated Aging Data – Arrhenius or Erroneous?", Trends in Polymer Science, Vol. 5 (8) pp. 250-257, August 1997.
12. M. Celina, "Oxidation Profiles of Thermally Aged Nitrile Rubber", Polymer Degradation and Stability, Vol. 60, pp. 493-504, 1998.
13. K. T. Gillen, "The Wear-Out Approach for Predicting the Remaining Lifetime of Materials", Polymer Degradation and Stability, Vol. 71, pp.15-30, 2001.
14. K. T. Gillen, M. Celina and R. Bernstein, "Validation of Improved Methods for Predicting Long-term Elastomeric Seal Lifetimes from Compression Stress-Relaxation and Oxygen Consumption Techniques", Polymer Degradation and Stability, Vol. 1, pp. 25-35, 2003; <http://www.sciencedirect.com/science/article/pii/S0141391003001509>.