

## Weapon Foam Accelerated Aging Using Dynamic Mechanical Analysis

Peter B. Rand and Bradley G. Hance

Sandia National Laboratory - New Mexico

102 11 883

Rigid polyurethane foams are used to make structural supports and as encapsulants for electronic assemblies in almost all weapon systems. The urethane polymers, which form the matrix of these foams, are stable environmentally resistant materials. Their main weakness is poor resistance to ultraviolet radiation (sunlight). Because of their stability, very little has been done to establish their longevity in the weapon environment. In essence we have no answer to the obvious question: How long are these foams going to last? As the age of our weapons increases along with requests to extend their useful lifetimes to 50 years, real data on longevity is necessary. Interestingly, when the former Soviet Union did a design review on a nuclear material storage cask we are designing for them, one of their requests was accelerated aging data on the foams. Data from the storage cask aging study will also be presented.

Three foams were selected as representative of the foams in the current and future enduring stockpile. They are BKC-44402-4, BKC-44307-14, and BKC-44320-4. BKC-44402 is a toluene diisocyanate based foam used for encapsulation applications since the 1960's. BKC-44307 is a polymeric isocyanate based foam used to make structural supports in several weapons. BKC-44320 is a new foam, polymeric isocyanate based, intended to replace the BKC-44402 encapsulation foams. All foams were supplied by Allied Signal, KCP, as no cost samples. Where possible the foams were made using production equipment.

For this study we have evaluated the mechanical properties of the foam using dynamic mechanical analysis. The tests are run using a rectangular specimen in a Rheometrics Dynamic Spectrometer (RDS-II). A new data reduction scheme has been developed to obtain the glassy and rubbery moduli, and the glass transition temperature ( $T_g$ ). These techniques were motivated by new data collection and reduction software for the mechanical spectrometer and the helpful guidance of Doug Adolf, SNL/NM. The scheme is illustrated in Figure 1. In the "ramp" or scanning technique the temperature is ramped up at a rate of  $4.0^{\circ}\text{C}/\text{minute}$  over the temperature range. Many data points are obtained over the temperature range. This gives us the storage modulus and loss modulus of the specimen as a function of temperature. A minimum of three specimen are run at each test condition. The  $T_g$  is defined by the onset of a rapid decrease in the storage modulus, shown in the storage modulus versus temperature curve. The glassy modulus is defined as the modulus at a temperature  $30^{\circ}\text{C}$  less than the  $T_g$ . The rubbery modulus is defined in a similar manner except the value is taken at a temperature  $30^{\circ}$  above the offset temperature. We feel this will give values more sensitive to any changes in the polymer. We also plan to report any shift in the glass transition temperature caused by aging. A typical data set, giving the storage and loss modulus as a function of temperature for one of the three foams, is presented in Figures 2. These data are typical. Specimen are being aged at room temperature,  $40^{\circ}\text{C}$ ,  $60^{\circ}\text{C}$ , and  $80^{\circ}\text{C}$ . The zero time data set will be presented. Our current plan is to test every year. The one year data set will be run in August 1996.

Rigid polyurethane foams are used as an energy absorber and fire protection material in the Russian Fissile Material Container (AT-400R). Aging tests are also being run to assure the long term performance of the foam. The foams being tested are a) North Carolina Foam Industries NCFI-24-125, b) Premium Polymers Uremold 100, and c) General Plastics Last-a-Foam FR-3725. The foams are being aged at  $40$ ,  $50$ , and  $60^{\circ}\text{C}$ . Data from this study will also be presented. There was no significant change in the glass transition temperature, glassy modulus, or rubbery modulus for any of these foams after one year of aging.

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Figure 1  
**Shear Modulus Versus Temperature  
 For A Rigid Polyurethane Foam**

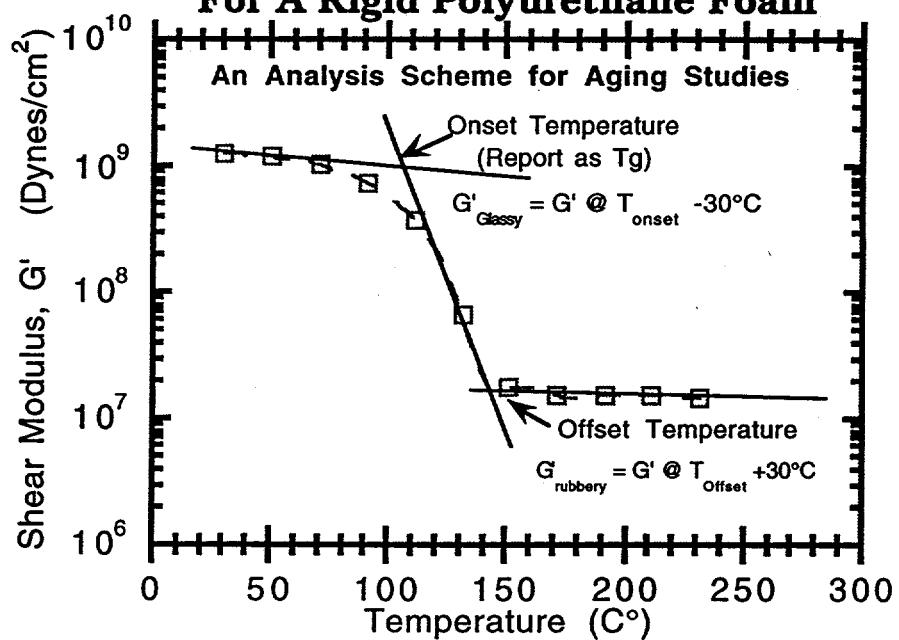
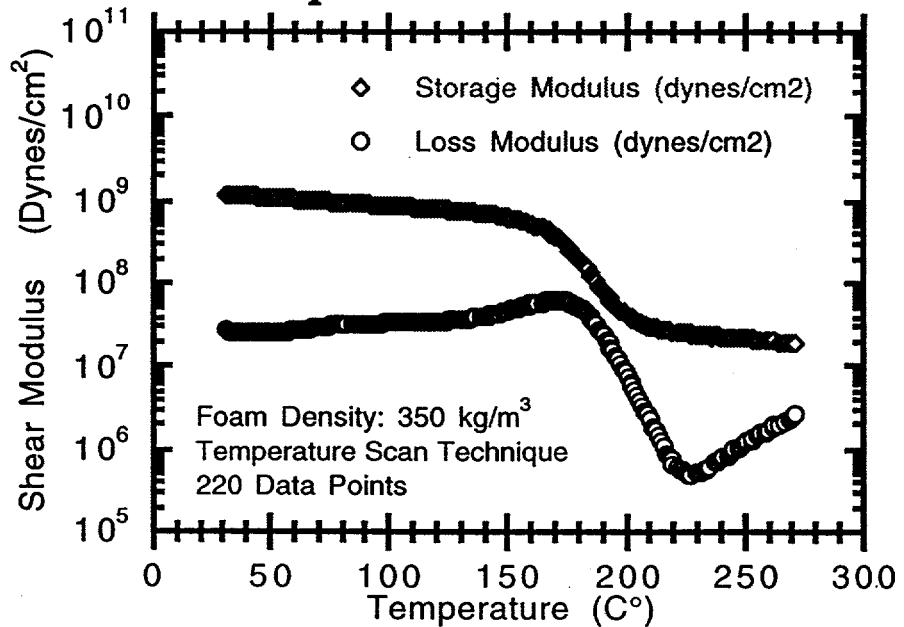


Figure 2  
**Storage and Loss Moduli Versus  
 Temperature - BKC-44307-14**



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