sile or space vehicle. This test, which involves parallel computations in the onboard computer and a checking computer of a verification parameter using a generated number sequence, has been found to be orders of magnitude more effective in detecting errors than a test using the sum of the flight constants as a verification parameter.

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# Effects of Mission Environments on the Mechanical Properties of Dacron Parachute Material

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DACRON is a candidate fabric for parachutes for planetary landers because of its high strength and heat stability.[1,2] It was used in Planetary Entry Parachute Program (PEPP),[3] which showed the feasibility of utilizing a parachute as a spacecraft decelerator, and a part of the fabric originally purchased for the PEPP parachutes was used in the present investigation. Although some investigators[4–7] have studied effects of temperature, vacuum, and/or sterilization treatments on candidate textile materials (Nylon, Dacron, Nomex, and Fiberglas), no one, to our knowledge, has determined the effects of an appropriate sequence of mission environment phases, without interruption, on the mechanical properties of Dacron. Moreover, some investigators have removed the fabrics from the environment under study in order to facilitate tensile testing, but others[8] have shown that in situ testing is necessary to assure that measurements of environmentally induced effects are valid. This investigation employs the in situ test philosophy throughout and covers the effects of exposure of Dacron to the sequence of prelaunch and flight environments that it might experience for a Mars-lander mission.

### Experimental Program

Two groups of Dacron samples were tensile-tested: 1) the control group, stored and tested at 1 atm, 75°F, and 45% relative humidity (RH); and 2) the group subjected to the mission environments in the sequence given at the top of Fig. 1, whose abscissa is elapsed time in days. Although temperatures are different for the different environments, the samples were all tensile-tested at 75°F. Initially, 45 samples were exposed to chemical sterilization by ethylene oxide (ETO), using a gas mixture of 12% ETO, 88% Freon-12 at a concentration of 500 g/l, 40% RH, and 104°F for 24 hr. At the end of this treatment, 5 samples were uniaxially tensile-tested. The remaining samples underwent dry heat sterilization (DHS) at 257°F in dry nitrogen at 570 torr for 24 hr. They were then cooled to 75°F, and five more were tensile-tested. Then the chamber was evaucated to less than $10^{-6}$ torr, and another 5 samples were tested. Other sets of 5 were tested on the 3rd, 6th, 10th, 14th, and 16th days to determine the effects of the vacuum environment over a 13-day period, with the vacuum varying between $1 \times 10^{-6}$ and $5 \times 10^{-8}$ torr. On the 16th day, the pressure was brought up to 8 torr with a simulated Martian atmosphere (MA) consisting of 74.4% $CO_2$, 12.8% $N_2$, and 12.8% Ar. After a 120-sec exposure to simulate parachute deployment on entry, 5 more samples were tensile-tested. Finally, 5 samples were tested 24 hr later (17th elapsed day) to determine whether longer MA exposure had any effect.

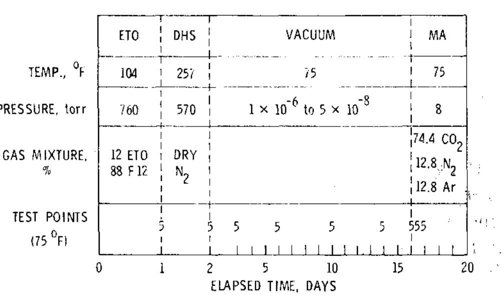


**Fig. 1 Sequence of environment phases simulated and test conditions.**

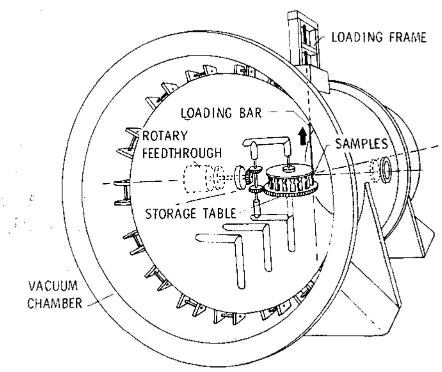


**Fig. 2 Schematic of the LRC Space Vacuum Facility with the tensile test apparatus.**

The testing took place in the 150-ft³ Space Vacuum Facility at Langley Research Center, using a carousel type, uniaxial tensile apparatus (Fig. 2).[9] The major items of interest are the storage table with samples, the rotary feed-through, the loading bar, and the loading frame. The samples were prepared in accordance with the ASTM raveling technique.[10] From the bulk cloth, a 1.25 × 10-in. sample was cut with the longitudinal axis parallel to the warp direction of the material and raveled in width to a constant strand count. It was then mounted in 2 × 2-in. stainless-steel tensile jaws to permit a 1 × 3-in. area to be free for environment exposure. The samples were then placed in the carousel, and at the time of tensile-testing they were continuously loaded at a crosshead speed of 2 in./min until failure occurred. The output of the load cell was externally recorded at a chart speed of 5 in./min.

### Discussion of Results

Figure 3 represents a typical stress-strain curve and shows how various mechanical properties may be calculated from it.

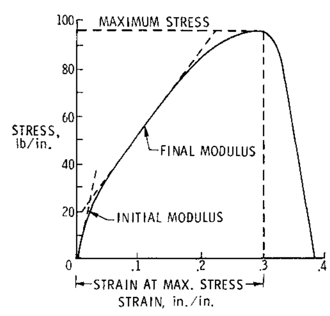


**Fig. 3 Typical stress-strain curve for ASTM type tensile test.**

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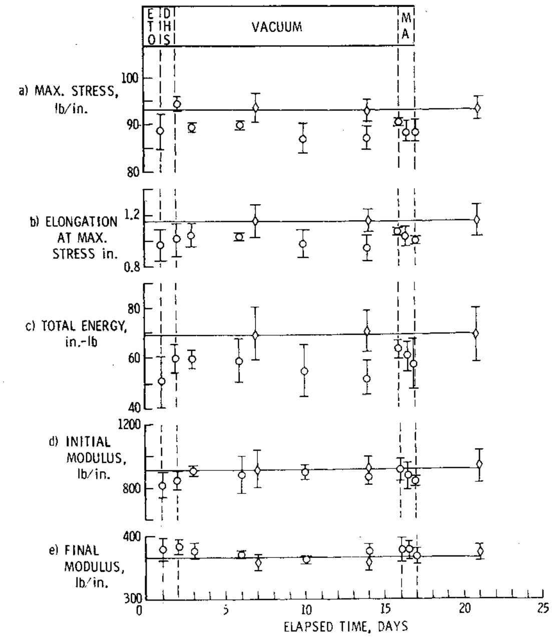


**Fig. 4 Variations in mechanical properties with time for the test sequence of Fig. 1.**

Figure 4 shows the results, using the same elapsed time scale as in Fig. 1. Each plotted point represents the average for a set of 5 samples, and the standard deviation for the set is indicated by the vertical bar. The effects of mission environments (circles) are compared to the value for the control samples (diamonds and least squares line).

Maximum stress (Fig. 4a) was 5% below the control value of 94 lb/in. after exposure to all of the mission environments. However, the changes varied from +2% after the dry heat sterilization phase (2nd day) to −8% after the vacuum phase (14th day).

Elongation at maximum stress (Fig. 4b) is the product of strain at maximum stress (see Fig. 3) and sample length (3 in.). On completion of all the environmental exposures, elongation was reduced by 13%; however, the changes varied from −18% (14th day) to −7% (16th day) from the 1.16-in. control value.

Total energy (Fig. 4c) is determined by integrating the area beneath the tensile recording. An induced change of −17% occurred after the full sequence, with variations from −24% (1st and 14th days) to −7% (16th day) from the 69-in.-lb control value.

Modulus is the ratio of stress to strain. As shown in Fig. 3, a tangent to the initial loading curve gives the initial modulus (Fig. 4d); a second tangent to the curve in the nearly constant slope region gives the "final" modulus (Fig. 4e). After exposure to all the mission environments, initial modulus was 9% lower than the 915 lb/in. control value, and final modulus was 1% above the 360 lb/in. control value. The initial modulus varied between 905 lb/in. (16th day) and 820 lb/in. (17th day), and the final modulus varied between 382 lb/in. (2nd day) and 363 lb/in. (10th day). The initial modulus had a maximum reduction of 10% after exposure to ETO, whereas the final modulus had its maximum increase of 5% after the dry heat sterilization phase.

**Table 1 Mechanical properties of Dacron on exposure to mission environments**

| Mechanical property | Control value | Induced change | |
|---|---|---|---|
| | | Maximum | End of mission |
| Maximum stress | 94 lb/in. | −8% | −5% |
| Elongation (max. stress) | 1.16 in. | −18% | −13% |
| Total energy | 69 in.-lb | −17% | −17% |
| Initial modulus | 915 lb/in. | −10% | −9% |
| Final modulus | 360 lb/in. | +5% | +1% |

Table 1 summarizes control values, the largest changes encountered during the test, and the changes induced by the complete sequence of mission environment phases investigated.

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# All Digital Guidance and Control System

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### Introduction

In the past, a typical booster utilized a digital guidance computer and an analog attitude control computer. Technological advances in the airborne digital computer field have made it practical to convert the attitude control computer to digital and use a single computer to perform both guidance and attitude control. This scheme has been used in recent flights. Further gains can be made by using digital transfer of data between information sources, control devices, and the computer, to save cable weight and eliminate the effects of noise that is induced upon analog signals when transmission lines run through a radiated noise environment. The system discussed here has these advantages; however, the main advantage of this system lies in the centralized approach to the entire airborne logic problem.

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