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# MECHANICAL AND TEAR PROPERTIES OF FABRIC/FILM LAMINATES

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## Abstract

Films reinforced with woven fabrics are being considered for the development of a material suitable for long duration scientific balloons under a program managed by the National Aeronautics and Space Administration (NASA). Recently developed woven fabrics provide a relatively high strength to weight ratio compared to standard homogenous films. Woven fabrics also have better crack propagation resistance and rip stop capabilities when compared to homogenous lightweight, high strength polymeric films such as polyester and nylon. If joining is required, such as in the case of scientific balloons, woven fabrics have the advantage over polymeric thin films to utilize traditional textile methods as well as other techniques including hot sealing, adhesion, and ultrasonic means. Woven fabrics however, lack the barrier properties required for helium filled scientific balloons, therefore lamination with homogenous films is required to provide the gas barrier capabilities required in these applications.

Table 1: Ultimate load and elongation of selected fabrics, polyester films and their multilayer structures.

| Material | MD | | TD | |
|---|---|---|---|---|
| | Ultimate Load (KN/m) | Ultimate Elong. (%) | Ultimate Load (KN/m) | Ultimate Elong. (%) |
| 24 gauge Du Pont mylar* | 1.00(0.26) | 75.0(48.0) | 1.45(0.11) | 74.0(14.0) |
| 48 gauge Du Pont mylar | 2.56(0.26) | 82.0(15.0) | 2.22(0.37) | 58.0(26.0) |
| 6611 Fabric | 6.41(0.35) | 24.0(5.0) | 6.22(0.32) | 34.8(3.0) |
| 6611.24 | 8.04(0.91) | 20.6(4.4) | 7.16(0.77) | 17.2(4.1) |
| 6611s.48 | 10.88(0.20) | 32.0(2.0) | 1.02(0.44) | 9.9(1.1) |
| 755 Fabric | 8.97(0.21) | 31.4(1.8) | 7.83(0.19) | 42.9(2.0) |
| 755.24 | 9.61 (0.54) | 49.6(3.8) | 10.49(0.16) | 36.1(1.7) |
| 755.48 | 10.66(0.67) | 31.2(4.6) | 11.52(0.12) | 53.0(1.0) |
| 24.755.24 | 11.64(0.26) | 28.4(1.9) | 12.22(0.18) | 41.9(1.2) |
| 755.24.24 | 11.87(0.39) | 30.7(4.4) | 11.54(0.46) | 43.4(3.3) |

*Mylar is a registered trade mark of DuPont polyester.

The mechanical and tear resistance of two laminated woven fabrics were measured and compared to that of the individual layers. DP6611 is constructed of 30 denier high tenacity polyester yarn, 12 filaments per yarn; 48 yarns/cm in the warp direction compared to 42.5 in the fill direction. The fabric also has a rip stop matrix running along the warp and fill directions with 10-mm separation. The rip stop yarns were constructed of polyester in one case and spectra in another case (6611s).

DP755 is constructed in the warp direction using 30-denier high tenacity nylon yarn, 10 filaments per yarn using 53 yarns/cm. The fill direction were constructed using 40 denier high tenacity nylon yarns, 34 filaments per yarn and 41 yarn/cm. The rip stop matrix is nylon yarns separated 4 mm apart.

The uniaxial testing was accomplished according to ASTM standard test method D5035-90 (Standard Test Method for Breaking Force and Elongation of Textile Fabrics-Strip Force). The tear tests were conducted using ASTM standard test method D2261-83 (Tearing Strength of Woven Fabrics by the Single Rip Method).

The ultimate load and elongation for the laminated polyester fabric is listed in Table (1). The results indicate that the ultimate load is an additive property of the ultimate loads of the two layers; while the ultimate elongation is limited to the deformation of the less deforming member, in this case it is the fabric. For the other case as shown in Figure (1), where the rip stop yarn used is spectra instead of polyester, a premature break in these elements occurred much earlier than the ultimate break of the material. This premature failure is due to the highly oriented nature of spectra that restricts its ability to transfer the load to the other members of the multilayer material.

The effect of fabric/film arrangements was studied using the nylon fabric noted as 755. The results are also listed in Table (1). The two digits 24 and 48 represent the gauge thickness of the polyester film as well as their arrangements relative to the fabric.

In summary, this preliminary investigation highlights various aspects governing the behavior of fabric film laminates. Most important is the non-uniformity introduced by utilizing rigid members such as spectra in these multi-layer structures. The premature failure of these members can jeopardize the usefulness of these structures for membrane type applications. For applications that require high resistance to tear, the key is to maintain fabric mobility as seen by comparing the results in figure (2); fabrics laminated on both sides exhibited least resistance to tear initiation and propagation. Other factors such as fabric type, film thickness, environmental effects will also be presented.

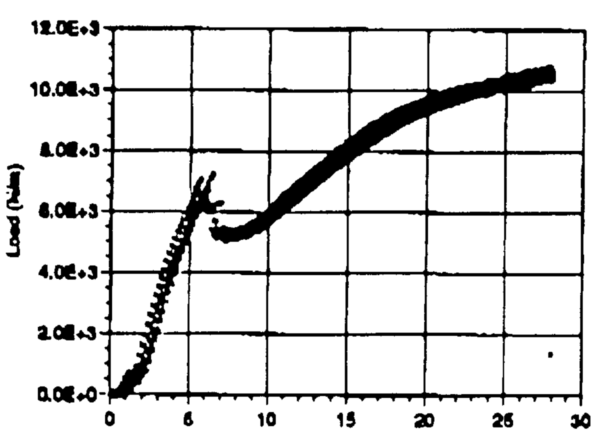


Figure (1) Behavior of fabric contains Spectra rip stop yarns

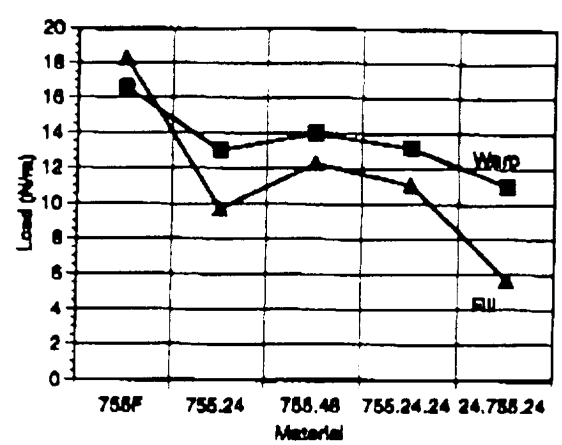


Figure (2) Effect of Layers arrangement on tear resistance