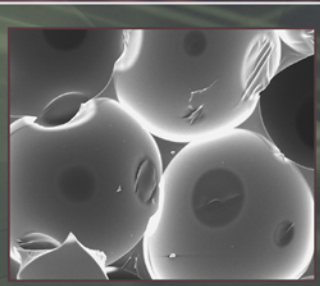
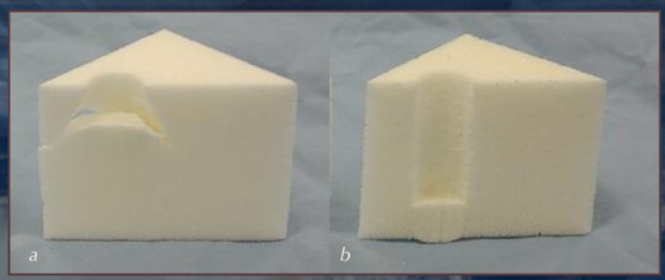
Sandia National Laboratories

TufFoam™

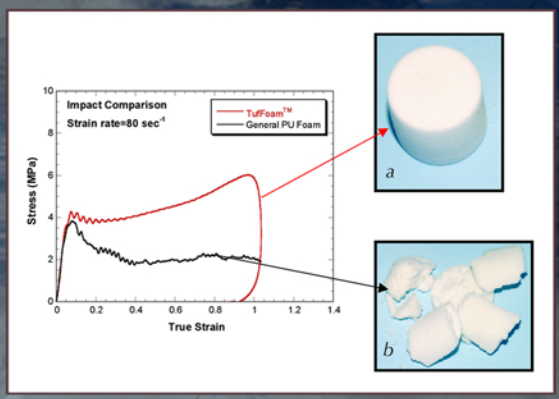
ENERGY ABSORBING FOAM



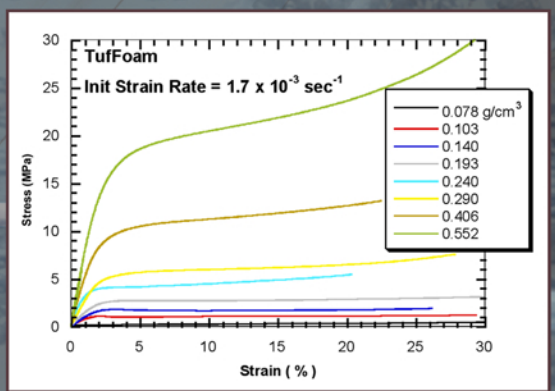
SEM image of TufFoam™ cell structure.



Samples of TufFoam™ (a) and a TDI based foam (b) after being impacted with a plunger showing how TufFoam™ is much more effective in spreading a penetrating load immediately after impact.



Impact data and samples of TufFoam™ (a) and a general polyurethane foam (b). TufFoam™ exhibits a two-fold increase in energy absorption with no tendancy to fracture.



Compression curves for TufFoam™ at densities indicated.

TufFoam™ is a *TDI-free*, water-blown, closed-cell, rigid polyurethane foam (PU) initially formulated by chemists at Sandia National Laboratories as an electronics encapsulant to mitigate the effects of harsh mechanical environments. Because it contains no TDI, the handling hazards and chemical sensitization associated with exposure during processing of common, commercially available PU foams are obviated. Beyond its original intent, it has since found use in a variety of additional applications, including as a structural material and as a thermal and electrical insulating material.

Component assemblies and structures that rely on the impact mitigating characteristics of encapsulant foams benefit from an increase in the ability of the encapsulating material to absorb energy in dynamic environments. TufFoam™ exhibits a significantly enhanced ability to withstand high-rate impact without fracture or the loss of structural integrity. These improved performance characteristics are direct result of the unique combination of monomer flexibility and functionality. TufFoam™ maintains the more conventional quasi-static design properties of the foams that it is intended to replace. As such it can be viewed as a drop-in replacement for existing applications, with no loss of performance expectations.

A patent is pending on TufFoam™. Licensees for the manufacture of kits of the resin or billets of foam are invited to contact: LeRoy Whinnery at 925-294-1215, llwhinn@sandia.gov or Laura Santos in Sandia's Business Development office at 925-294-1214, lesanto@sandia.gov.

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

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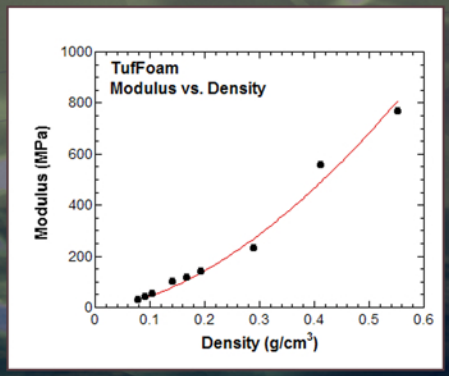
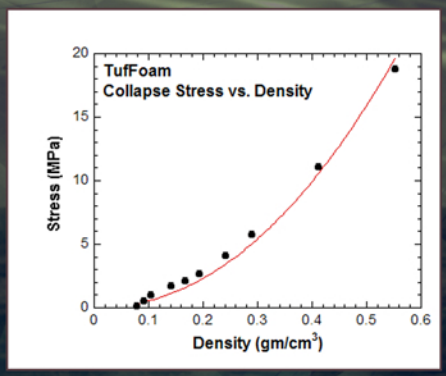
TufFoam™





Modulus and collapse strength of TufFoam™ as a function of density.

TufFoam™ encapsulant remains intact after testing at 5,000 g's.

Applications:

Structural

- Mechanical Applications
  - Impact mitigation
  - Encapsulation
  - Structural and decorative furniture
- Lightweight core materials
  - Floatation devices
  - Surfboards
  - Boat hulls

Insulation

- Household appliances
- Industrial refrigeration
- Sheathing and roofing insulation

One important attribute of TufFoam™ is that all of its constituents are commercially available in commodity quantities. TufFoam™ is currently formulated to be processed in a batch mode, but the processing schedule can be modified for machine mixing or injection molding. Batch processing schedules have been developed to prepare TufFoam™ over a range of densities from 0.032 to 0.7 g/cc (2 to 40 pcf). The optimal density will depend on the specific application requirements. The lowest density formulations make TufFoam™ attractive as a structural core material, enabling the replacement of low density TDI foams currently being restricted by regulatory agencies.

The thermal and mechanical properties of TufFoam™ result in a foam that is desirable for many applications. TufFoam™ has a uniform, fine cell structure over the entire range of density explored. Its Tg is somewhat dependant on the cure temperature, but is approximately 127°C when cured at 65°C. The coefficient of thermal expansion (CTE) is 7×10^{-5} °C^{-1}. TufFoam™ is electrically insulating with a volume resistivity of 3×10^{17} ohm-cm at a density of 0.1 g/cc. An accelerated aging study has shown no loss of ambient temperature properties after exposure to 80°C for 21 months.