# PORON® Orthoses Absorb Mechanical Stress

by
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Plantar foot ulceration, commonly seen in diabetes, Hansen's disease, and other neuropathic conditions, is generally caused by sensory loss and highly repetitive mechanical stresses, such as pressure stress and shear stress.[1-3] Loss of protective sensation permits injuries to develop over bony areas of high stress.[4]

The importance of protective footwear in preventing plantar ulceration has only recently begun to be appreciated by the general medical community. Footwear manufacturers are the primary source for documentation on the mechanical properties of their in-shoe materials. Most manufacturers use the American Society for Testing and Materials guidelines, which are mostly static testing methods originally established for materials used in the aerospace and automobile manufacturing industries and are of little practical value to the clinician or technician. Current research interest into the cost-effectiveness of footwear is directed at more applicable and practical information on materials.

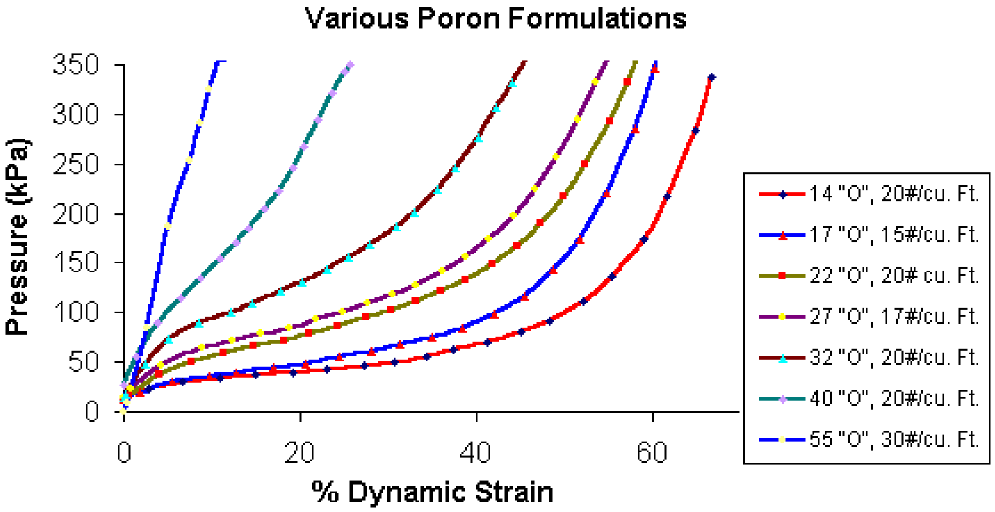
In a recent survey of podiatrists, orthotists, prosthetists, certified pedorthists, and physical therapists, the authors found that PORON was rated as one of the most popular materials used in the fabrication of foot orthoses.[5] Its popularity warrants an investigation of its strengths and weaknesses.

PORON is an open-cell polyurethane foam material commonly used as insoles or inlays in soft nonmolded orthoses, as a soft topcover for molded or functional orthoses, or as a soft sub-layer for multidensity molded orthoses.

PORON is a non-moldable material that must be backed by a moldable material to obtain a desired shape. It is available to the footwear industry in several formulations varying primarily in density, durometer, and elasticity.

Studies have shown that PORON resists bottoming out from repetitive compressive and compressive/shear stress and is superior to comparable soft materials, such as Spenco and Plastazote.[6] Materials that resist bottoming out are important for long-term protection of the neuropathic foot. Additionally, PORON has bee found to improve the durability of other soft materials when used in combination with them. Our bench studies have shown that, in combination, PORON slows the rate of bottoming out of Plastazote. PORON, however, may be less durable than Spenco or Plastazote when subjected to surface shear or elongation stresses. In clinical practice, early surface wear (appearing as a dugout in the material) can develop in PORON under the high shear stress areas of the foot (Figure1). When surface wear occurs, the material must be replaced immediately to prevent injury to insensitive tissues.

Soft materials such as PORON have been recommended for the prevention of plantar ulceration. [7-8] The material reduces pressure by distributing body weight forces over a larger area of the foot. By definition (pressure = force/area), pressure decreases as area increases, assuming the force remains unchanged. In studies using pressure platforms, soft materials including PORON, Spenco, and Plastazote have been shown to increase contact area and reduce foot peak pressure areas, but not to reduce total force in normal subjects. [9-10]




**Compression Profiles of Formulations Tested**

Footwear fit with soft orthoses reduces pressure in patients with diabetes [11] and Hansen's disease.[12] This treatment strategy can also lessen the recurrence of plantar ulcerations.[13] Studies have shown that pressure reduction is dependent on the thickness of soft materials,[14] with material thickness reaching a plateau of effectiveness at about 3/8th inch.

The issue of what degree of softness is best for effective pressure reduction has not been well studied. Complicating this is the unreliability of material hardness measurements. Durometer measurements used to determine material hardness are dependent on the technique and the durometer gauge used. We tested seven different formulations of PORON (see table) by measuring their hardness using a constant load shore "O" durometer (Rex Gauge, Buffalo Grove, IL); bench testing their dynamic pressure versus percentage of compression properties (Figure 2); and evaluating their effectiveness in reducing peak pressure in patients with diabetes who have high-risk feet by using an in-shoe pressure system (Pedar, Novel Electronics, St. Paul, MN).

One-quarter-inch thicknesses (2 x 1/8 inch, stacked) of each of the seven PORON formulations were examined using a computer-controlled cyclical compression tester at approximately 1 Hz cycle time, 350 kPa of pressure. The compression profile for each material is shown in Figure 2. This graph demonstrates that material hardness, not density, contributes most to the pressure versus percentage of compression properties of a material. The harder the material (i.e., PORON formulation 7), the less accommodating it is. It would therefore be a poor choice for a high-risk neuropathic foot condition. Conversely, a material such as PORON formulation 1 can be to soft when used for thin, single-density orthoses, producing a bottoming our effect with each step.

Results from in-shoe pressure measurement trials showed PORON materials 4 and 5 had peak pressures significantly lower than the hardest (7) and softest (1) formulations, but not statistically lower then the remaining formulations (2, 3, 6). Our studies support the use of the current PORON formulation used in footwear, which is approximately 22° shore "O" durometer and 20 lb/ft$^3$ density.

**Rogers Corporation PORON Footwear Formulations**

| Formulation | Durometer (Shore "O") | Density (lbs./ft$_3$) |
|---|---|---|
| 1) 4000-59-20125-1648 | 14 | 20 |
| 2) 4000-01-15125-1604 | 17 | 15 |
| 3) 4000-01-20125-1604 | 22 | 20 |
| 4) 4000-05-17125-1605 | 27 | 17 |
| 5) 4000-05-20125-1637 | 32 | 20 |
| 6) 4000-12-20125-1604 | 40 | 20 |
| 7) 4000-12-30125-1604 | 55 | 30 |

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*References available upon request by fax at 415/905-2235.*

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