ROGERS
CORPORATION

PORON® Urethane Foams

Sealing and Gasketing

Design Guide

Sealing with PORON® Urethane Foams

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The information contained in this Design Guide is intended to assist you in designing with Rogers PORON® Urethane. It is not intended to and does not create any warranties, express or implied, including any warranty of merchantability or fitness for a particular purpose or that the results shown in this Design Guide will be achieved by a user for a particular purpose. The user should determine the suitability of Rogers PORON Urethane Foams for each application.

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Sealability

All materials are permeable to some degree. Polymeric composites, like those used in gasketing and sealing applications, consist of polymers combined with fillers, fibers and other materials to produce a composite with interconnected pores. Given enough time, all gaskets will leak under the rightconditions. Thus, there is no such thing as a perfect seal. The Society of Automotive Engineers' ***Gasket and Joint Design Manual for Engine and Transmission Systems***[1] puts it this way:

> "... the results of sealability tests cannot be considered absolute but are relative to somewhat arbitrary standards as defined by the requirements of the particular application.
>
> A seal, therefore, is described by how much the joint leaks. If it doesn't leak too much, too soon, it is considered a seal."

[1]Reprinted with permission from SAE AE-13

SEAL DESIGN REQUIREMENTS

LOAD LIMITS

An assembled housing or enclosure must ensure adequate gasket compression to provide the required level of sealing performance. Increasing the compressive force on a gasket generally improves sealing performance. This force is limited, however, by the strength of the fasteners and the structural integrity of the cover or flange that holds the gasket in place. Excessive clamp loads can snap bolts, crush mounting bosses, or cause excessive bending or creep in the cover.

The lower limit on gasket compression is generally determined by the required sealing performance. In between these upper and lower limits is the range of adequate load which will preserve acceptable sealing for the required life.

Load limits depend on the stack-up of a number of sealing design factors and tolerances:

- Flange flatness tolerance
- Gasket thickness tolerance
- Gasket load-compression behavior
- Allowance for thermal expansion
- Allowance for gasket compression set
- Allowance for flange creep

In **Figure 1**, PORON® cellular urethane is compared with solid elastomers. The PORON material has a relatively flat compression force deflection curve. This compressibility enables the load to remain within the required limits while accommodating a larger range of compressions than a solid elastomer. The tight thickness tolerance of PORON materials further widens the overall design limits. Typical compression force deflection data for a range of PORON materials are shown in **Figure 2**.

Figure 1. Compression Force Deflection
PORON® Urethane vs. Solid Elastomers

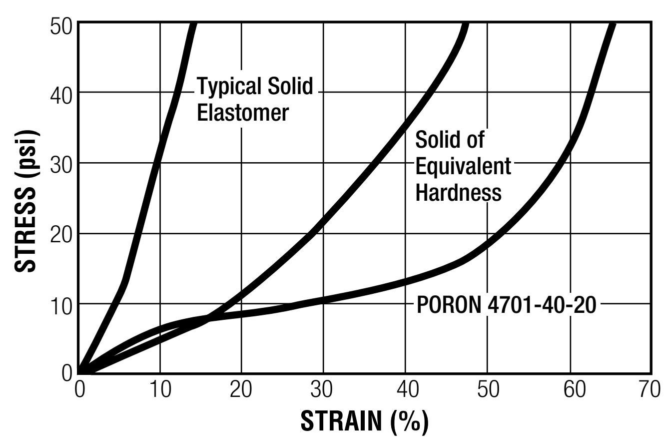
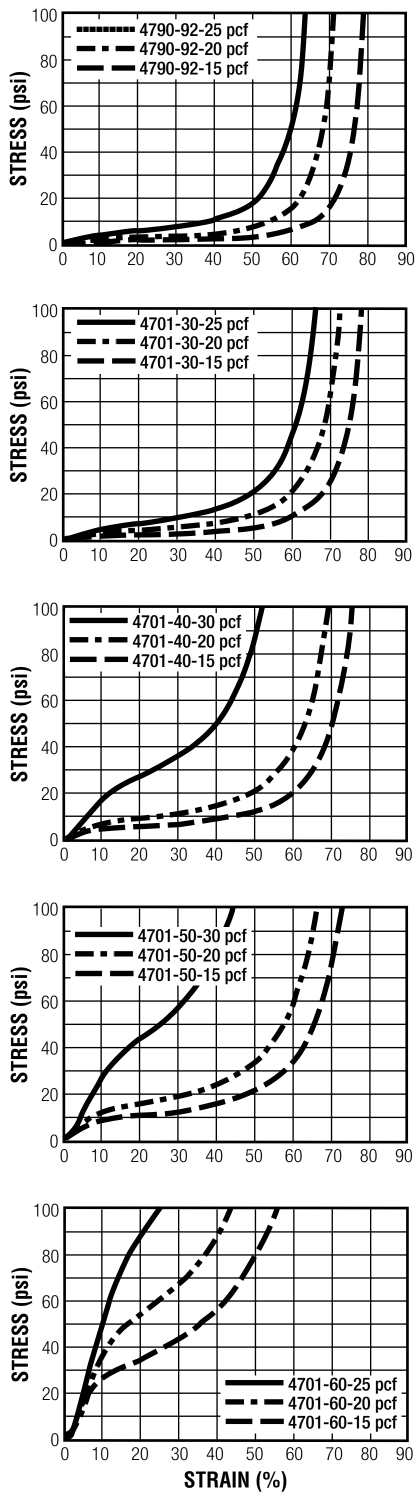


Figure 2. Typical Compression Force Deflection Curves for PORON® Urethanes

PORON cellular urethanes are available in a range of densities (15, 20, 25, and 30 lb/ft³) and a range of firmnesses.



Note: CFD strain rate is 1in/min.

BOLT PATTERN

Areas of good and poor sealing are illustrated in **Figure 3**. Bolt pattern and flange design strongly influence sealing performance. Depending on the fastener locations, the actual gasket compression can vary considerably from the nominal compression level. One small area of poor sealing can cause failure in an otherwise well-designed system.

GASKET WIDTH

At a given compression level, a wider gasket will seal better than a narrow one due to the longer path length for leakage through or around the gasket material. This sealing advantage comes at the expense of higher compression load due to the extra gasket material which needs to be compressed.

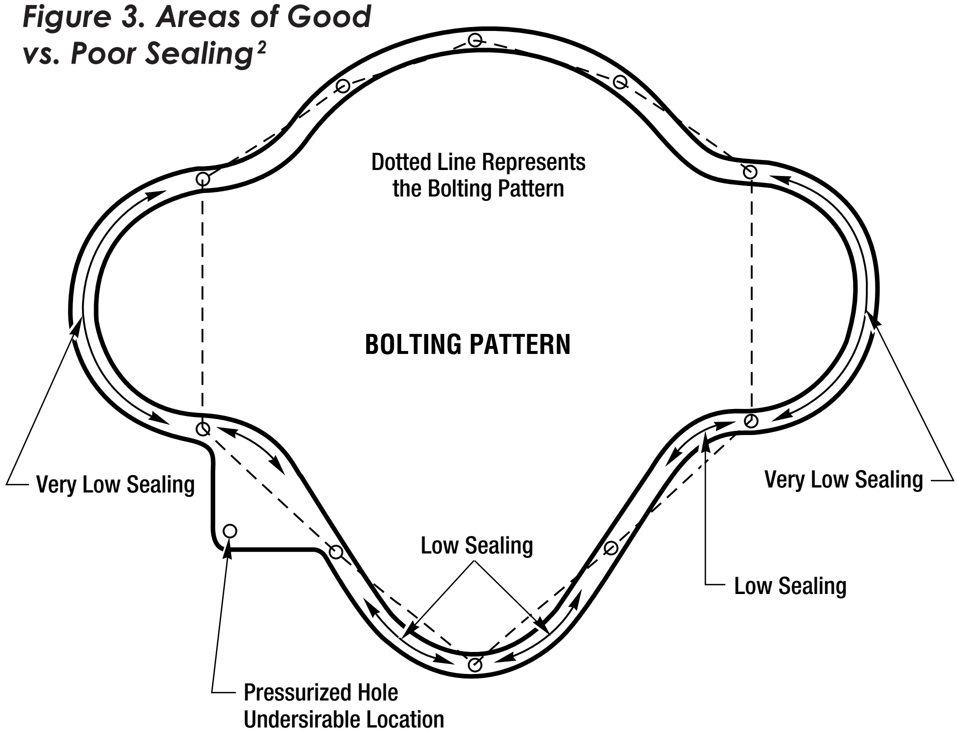
ENVIRONMENTAL FACTORS

Environmental considerations can vary tremendously depending on the application. The most common concerns include:

- Outgassing
- Chemical and solvent resistance
- High temperature load retention
- Low temperature flexibility
- Thermal conductivity
- Electrical characteristics
- Coefficient of thermal expansion

Low outgassing and good resistance to many chemicals and solvents make PORON materials suitable for a wide range of gasketing and sealing applications.

Figure 3. Areas of Good vs. Poor Sealing[2]



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GASKET MATERIAL PROPERTIES

LOAD RETENTION

The high temperature life of gasket materials is best represented by load retention. The time to 50% compressive load retention at a series of different temperatures is shown in **Figure 4**. EPDM, polyethylene, neoprene and vinyl nitrile foams perform so poorly at room temperature that performance at higher temperatures could not be measured. Note that PORON material performs as well as or better than even a premium grade silicone sponge at temperatures below 70°C (158°F). For higher temperature applications, Rogers BISCO® silicones should be considered. Because load retention testing is difficult and time consuming, most specifications are based on a related short term compression set test.

OPEN-CELL VERSUS CLOSED-CELL FOAMS

Many designers question how an open-cell material such as PORON urethane can provide an effective seal. Yet with proper design, PORON materials have been successfully used in applications requiring a water seal test at a submerged depth of 18 feet.

The photomicrographs in **Figure 5** show how an open-cell PORON material can seal. The cells in uncompressed PORON urethane are typically 100-150 μm in diameter. The openings between cells, however, are only about 20 μm in diameter. The photos in **Figure 5** show how the cells and the cell openings are deformed as the material is compressed. The openness of PORON materials, and the rate at which it closes with compression, vary with grade and density. PORON cellular

Figure 4. Load Retention of Cellular Elastomers

Time to 50% of Initial Load

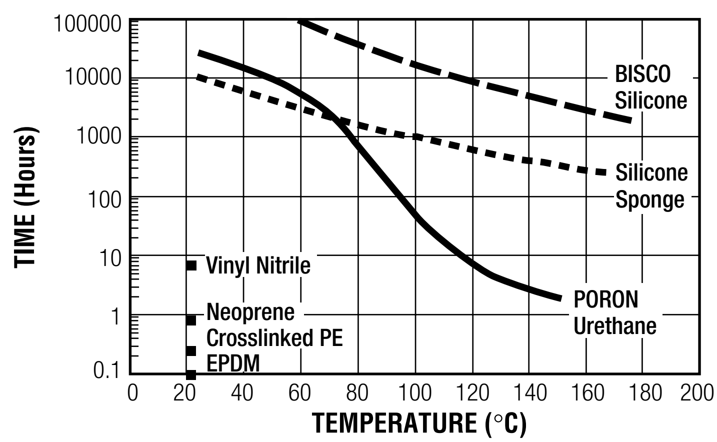
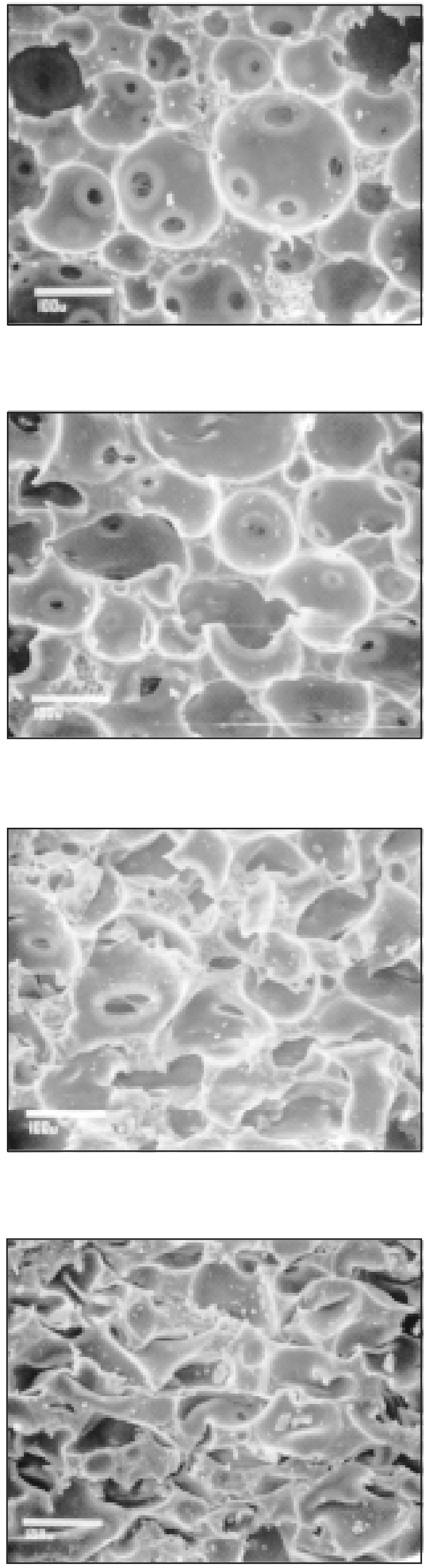


Figure 5. Cell Structure vs. Compression
Compressed PORON® Urethane @ 20 lb/ft³



0%

25%

45%

65%

urethanes are based on elastomers with densities of 70-73 lb/ft³, so the volume fraction of air in uncompressed PORON cellular urethane is:

Density (lb/ft³)	Air Volume Fraction (%)
15	79
20	72
25	65
30	58

Because closed-cell materials do not have any openings between the cells, they may provide a more effective initial seal at low compression levels. However, elastomers with a closed cell structure do have a significant disadvantage of their own. Closed cell foams derive a significant portion of their modulus from compressing the gas inside each cell. Since all elastomers are gas permeable to some degree, this pressurized gas diffuses out over time, reducing load retention. Because of this effect, the initial load needed to compress a closed cell material is higher than that required for an open celled elastomer of equivalent material modulus. Most of the materials exhibiting poor load retention shown in **Figure 4** are closed cell materials.

SEALING PERFORMANCE DATA

Most sealing or permeability tests use the same basic technique. A sample is compressed by a controlled amount. Fluid or gas pressure is generated on one side of the material, and the rate of fluid or gas flow is measured on the other side. While the basic format is the same, the tests vary tremendously due to the sample size and configuration, measurement accuracy and duration, pressure, chamber volume, and the fluid used. Measurement techniques are generally chosen to match end use application requirements as closely as possible. There is no standard test which can be used to qualify a material for all potential uses; each application must be considered individually.

The air permeability of PORON 4701-40 is shown in **Figure 6**. As expected, the permeability drops considerably as compression level increases. **Figure 7** shows typical water permeability of PORON materials based on ASTM F-37. The same relationship between compression and seal effectiveness is found.

Water vapor transmission can also be an important criterion for some applications and is usually measured on uncompressed material. In this case a Thwing Albert #68-1 vapometer is used to characterize PORON materials.

The sealing performance of a gasket material depends strongly on design factors and the application environment. PORON urethane foams have been used successfully in a wide range of sealing applications.

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Figure 6. Air Permeability of PORON® 4701-40

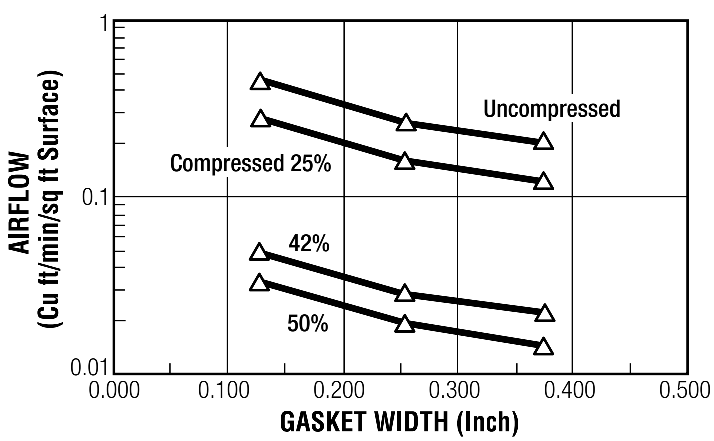
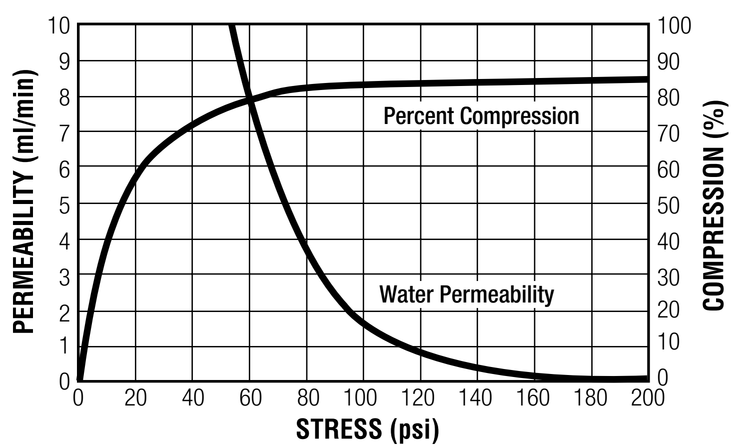


Figure 7. Water Permeability of PORON® 4701-40, *ASTM F-37 @ 7 psi*



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