
ELASTOMERIC FOAMS

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INTRODUCTION

This chapter will briefly discuss elastomeric foams (other than urethane foams). The reader will note that the emphasis of this handbook is on plastic foams (cellular plastics), but it was felt by the author that some discussion of the more well-known elastomeric foam types would be helpful.

General

Rubber products with a cellular structure have been used widely for many years. The earliest developments of these products predated World War I. The two forms of *natural rubber*—*raw rubber*, and *latex*, form the basis for different product types, one being blown dry rubber, and the other foamed and dried latex. Blown sponge and latex foam are distinctly different materials, although the end-products may appear similar and have some overlapping applications.

Sponge Rubber

In the trade, sponge rubber refers to both open- and closed-cell materials produced by sheeting, molding, and extrusion from compounded gum rubber, generally using a blowing agent. This usage is not

technically correct, because in ASTM D 1056 *sponge rubber* is defined as "cellular rubber consisting predominantly of open cells made from a solid rubber compound," and *expanded rubber* is reserved for closed-cell compounds (sometimes called unicellular rubber). Sponge rubbers are made by incorporating into the compound an inflating agent, such as sodium bicarbonate, which gives off a gas that expands the mass during the vulcanization process. Sponge rubbers are manufactured in sheet, strip, molded, or special shapes. Expanded rubbers are made by incorporating gas-forming ingredients in the rubber compound, or by subjecting the compound to high-pressure gas, such as nitrogen. Expanded rubbers are manufactured in sheet, strip, molded, and special shapes by molding or extrusion. Styrene-butadiene rubber (SBR), and natural, polyisoprene, and neoprene rubbers are the materials used in forming sponge or expanded rubber (1) (2).

Cellular Rubber

Cellular rubber is a generic term and includes latex foam produced chiefly by aeration of compounded latex, which is of necessity open-cell because water must be removed rapidly during processing (1). ASTM D 1055 defines *flexible cellular rubber* as "a cellular organic polymeric material that will not rupture within 60 seconds when a specimen 200 by 25 by 25 mm is bent around a 25-mm diameter mandrel at a uniform rate to produce 1 lap in 5 seconds in the form of a helix at a temperature between 18° and 29°C." The structure of latex foam rubbers consists of a network of open or interconnecting cells. Latex foam rubbers are made from rubber lattices or liquid rubbers. They are manufactured in sheet, strip, molded, or specific shapes (3).

Comparison of Cellular-Rubber Products

The numerous flexible and semi-rigid forms of foam rubber and sponge provide a broad spectrum of performance characteristics adaptable to consumer needs. These materials compete with cushioning or padding materials such as cloth, fiberfill polyester, hair, jute, etc., as well as urethane, polyvinyl chloride, and other plastic foams. From a performance point of view it is not always clear how to measure comfort, durability, and appearance, while parameters such as cost, weight, compression resistance, recovery, rebound, and modulus are more readily evaluated. "Feel" is therefore a factor in assessing these cellular products. *Low-density latex foam* has maintained a high quality of performance for

comfort cushioning. Good indentation-load response gives it a feel of deep comfort. This feeling comes from the fine-cell structure, the resilient nature of the rubber, and the open cells for heat and moisture transfer. Latex foam is adapted to coating applications, while *open-cell sponge*, generally made at higher densities, is not as readily processed for coatings. Nevertheless, latex foam and sponge tend to compete in a few product areas, such as automotive-seating applications. Intrinsicly, the two materials can perform essentially the same functions by proper selection of formulation variables. For this reason other factors, such as fabrication economics and design features, determine the material of choice (1).

At comparable densities sponge rubber will generally have better flex, tear, and abrasion qualities than latex foam, even at higher filler loadings, due to mastication of ingredients compared with coalescence of latex particles. Sponge rubber will usually have superior water resistance because emulsifiers are not required for processing. Latex foam has the advantage of light color and less objectionable odor. It usually recovers faster from deflection than sponge, since the rubber is not oil-modified. Closed-cell expanded rubber is different from the open-cell product. Water is sealed out in weather stripping and flotation uses. Closed cells are usually advantageous in gasketing and insulation applications (1).

TYPES OF ELASTOMERIC FOAMS

Neoprene

Neoprene, or polychloroprene, is a synthetic rubber discovered by the Du Pont Company in 1931. It is an organic polymer composed of carbon, hydrogen, and chlorine in the ratio of 55:5:40. Its relatively high chlorine content was responsible for the early recognized resistance of the polymer to burning. Practical use of this property was not developed until procedures for making foam structures from neoprene latex were developed in the 1940's. The U.S. Navy adapted the material to make neoprene foam mattresses that reduced the fire hazards in the crews' quarters of naval vessels. For many years neoprene has been the only material to meet Navy specifications for this application.

Polychloroprene begins to release hydrogen chloride (HCl) on heating to 430°F (221°C). The evolution of other gases, including carbon monoxide (CO) and carbon dioxide (CO₂), and visible smoke continues as the temperature increases to 700°F (371°C). By the time this

temperature is reached substantially only carbon residue (C) remains in the form of a rigid char. Because of the high chlorine content of the polymer neoprene has a relatively low heat of combustion (4.7 k cal/g) and a high oxygen-index value (Limiting Oxygen Index or LOI = 36). The burning characteristics of polychloroprene are altered and generally improved by the presence of fillers and chemical additives. Neoprene foam compositions generally contain antimony oxide as a flame retardant and hydrated aluminum oxide to release water vapor and thereby delay ignition. Other additives, such as char promoters and smoke retardants, may also be used (4).

In the early 1980's a neoprene-type foam (VONAR) made by Du Pont was developed specifically for use as a comfort cushioning material for critical applications where low flammability was required, such as in transport aircraft seat cushions. This material is designed for use over flame-retardant polyurethane foam and is believed to provide 50 seconds more of evacuation time in the event of a post-crash fire. VONAR has a density of 10.66 lb/ft³, compared to 7-8 lb/ft³ for standard neoprene foam, and 1.2 - 2 lb/ft³ for polyurethane foam (5).

Silicone Foams

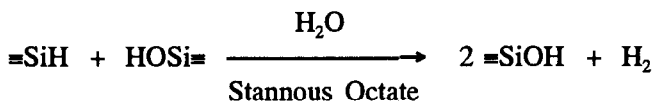
Three types of silicone foams are discussed briefly below — silicone elastomeric foams, silicone rubber sponge, and room-temperature-foaming silicone rubbers.

Silicone Elastomeric Foams: These lightweight rubbery foams are made by mixing two components. The mixing requires only 30 seconds, and the currently available materials must be poured immediately because expansion begins promptly upon blending. Negligible pressure is generated and the articles formed can be removed from the molds within five minutes, at which time the foam will have developed about 80% of its ultimate strength. Maximum strength is developed after 24 hours. When cast against glass cloth or asbestos paper the foam adheres strongly. Finished pieces can be easily bonded to each other, or to metal, by appropriate silicone adhesives (6).

Silicone Rubber Sponge: This material is prepared by blending catalysts, fillers, and blowing agents into a high-molecular-weight, linear siloxane polymer (=SiOSi=). Cure is accomplished by heating in the presence of small amounts of organic peroxides, such as dibenzoyl peroxide. The high-molecular-weight polymer is intensively mixed with high-surface-area silica fillers, plasticizers, and colorants to form the rubber base. A chemical blowing agent suitable for silicone rubber

sponge must not affect the vulcanization or the physical properties, and it must be readily dispersable in the unvulcanized rubber base. It should decompose to form a suitable gas at or near the rubber vulcanization temperature. There are two methods used for sponging and vulcanizing the silicone rubber, *cold forming* and *hot pressing*. Silicone rubber sponge can be used wherever thermally stable, flexible, cushioning-type thermal insulation is needed. It is currently used for pads in high-pressure plastic or metal-forming equipment. A soft, fine-cell silicone elastomer sponge is currently being used in localized scleral indentation treatment of retinal detachment of the eye. The product is packaged sterile, measures 8 cm. in length, and is available in either cylindrical or oval shapes. The sponge is soft, resilient, inert, and non-toxic and, therefore, exhibits minimal cellular or vascular response. It will not adhere to the ocular tissue and does not harden or break down on long-term implantation (7).

Room-Temperature-Foaming Silicone Rubbers: Liquid silicone rubber prepolymers that foam and cure at room temperature are available. These products are foamed by the liberation of hydrogen from the reaction:



Cross-linking proceeds through silanol condensation to form siloxane cross-link and water. The prepolymers generally used in this type of foam are silanol-end-blocked copolymers or mixtures of homopolymers prepared from the hydrolysis of difunctional chlorosilane monomers. Additives normally used in silicone rubbers, such as oxidation inhibitors, fillers, plasticizers and pigments, may be compounded into the prepolymer system. These foams are supplied in two-component systems. The rubber base should be well stirred just before the catalyst is added to ensure uniform color and cell structure in the finished foam. Normally about 5 to 8 parts of catalyst is mixed with 100 parts of base, using vigorous stirring. Foaming starts as soon as the catalyst is added, and the foam mixture should be poured into place within 60 seconds from the time of catalyst addition. The catalysts contain stannous octoate and may cause skin irritation. This type of catalyst gradually loses its reactivity when exposed to air, so containers should be kept tightly closed when not in use. The foam becomes tack free in 2 to 5 minutes and is firm enough to handle within 5 to 10 minutes. Maximum strength is reached after a 24-hour cure at room temperature (7).

These foams range in density from 9–20 lb/ft³ and contain about 90% open cells. Like other silicone rubber materials, RTV foams maintain their resiliency over a temperature range of –75° to 200°C (–103° to 392°F), have excellent electrical properties, and resist weathering and aging. Medical-grade RTV foams are physiologically inert. These materials are used whenever a resilient, low-density silicone rubber foam is required, such as for: (1) mechanical shock, vibration damping, or cushioning; (2) thermal insulation; (3) foam-rubber parts; and (4) lightweight electrical insulation. Silicone rubber RTV foams are used in several medical applications which require nontoxic, low-exotherm materials that foam and cure at room temperature. Useable foam rubber pads for limb prostheses were prepared by the injection of the catalyzed foam into the socket between the stump and the prosthetic device. The resilient silicone foam enables pressures to be evenly distributed over the entire distal end of the stump, resulting in an intimate, comfortable fit of the prostheses. Silicone rubber RTV foams have also been evaluated as diagnostic enemas. The catalyzed material was injected into the colon, foamed in place, and the foam allowed to expel without assistance. The silicone foam accurately recorded the shape of the colon, and surface details, such as polyps, constrictions, and lesions were reproduced on the foam surface (7).

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