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RESEARCH ENGINEER

"We use syntactic foam on many of our deep-sea vehicles. It's the white material on the outside of *Alvin*. The titanium sphere and frame are *Alvin*'s structural backbone. The foam isn't structural; it's for flotation. It's made of tiny, hollow, glass microspheres mixed with epoxy to make hard blocks. The microspheres are so small they look like talcum powder. When they are packed tightly together with minimum amounts of epoxy, they can withstand high compression and are buoyant in water. The material is put into molds, like a big bread pan, and mixed and allowed to cure, to make blocks of foam.

The new sub is bigger and has a heavier sphere, and it is designed eventually to dive to 6,500 meters. Because this is a manned submersible, we have a greater safety factor and needed the foam to go beyond 6,500 meters. So we had to get stronger foam that could go deeper, but we didn't want it to be heavier.

We worked with two different companies because the development and production were critical, and we could not afford to have one company fail to produce. They extensively tested their foam, including bringing it to the point of destruction, which is more than 14,515 psi [pounds per square inch]. That is 1.5 times the pressure at 6,500 meters, or 9,677 psi.

Instead of the usual procedure of testing small samples from random blocks, we tested all of the foam in a pressure test chamber to a minimum of 12,100 psi, which is 1.25 times 9,677 psi. We used transducers that were built to monitor microcracking on structures like bridges to 'listen' for small implosions or microcracking in the foam that would indicate that it was failing. As long as we didn't hear it start cracking, we knew it was strong enough. One hundred percent of our foam was tested, and we have great confidence in it.

We also tested the foam to ensure that it did not soak up water over time. We weighed twenty percent of the blocks, put them through a 24-hour soak under pressure, and then weighed them again to make sure that the weight gain of water was less than one percent.

These blocks were then bonded together into larger shapes. They were machined flat at joining surfaces, so that only a minimum amount of adhesive was needed to bond them. The more adhesive, the heavier the blocks get, and we also wanted to eliminate any air to get a good bond joint. Prior to this, we did bonding tests to prove both adhesive and technique. We did tension tests, where we tried to pull two blocks apart, and shear tests, where we pushed sideways on them.

The bonded blocks were then machined to make the shapes we needed. And finally, in certain areas, we added on a protective layer of fiberglass and paint. Here we are installing the upper forebody blocks of syntactic foam. The inside edges of these blocks have been shaped with a spherical curve to fit around the personnel sphere. The foam is buoyant and light in water, but in air, these pieces are 1,390 pounds each. ▲

Tom Kleindinst/WHOI