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Mars Rover Material Tested at UCSB

I was absolutely delighted when I saw that it landed, said Frederick Milstein, regarding the recent successful landing of the Mars rover, Spirit. The

professor of mechanical and environmental engineering and materials at the University of California, Santa Barbara had a special reason for his exuberance: He and his small team of researchers had made contributions NASA deemed crucial to the Mars rover landings and for which they were awarded special recognition.

His research group was chosen by NASA to test a new material designed to shield vital components of the Mars entry vehicle as it hit the Martian atmosphere. So, Milstein and his students were very pleased by the success of the landing. And they are looking forward to the touch down of the sister rover, Opportunity, expected to land on Mars on Jan. 24.

The material had to withstand both the heat of hitting the atmosphere and the shock and stress of landing. Milstein's group was tapped for its ability to test the material's structural integrity -- to be sure the material would not fall apart as the vehicle touched down. The testing took about a year to certify the materials for space-worthiness. (NASA-Ames managed the testing for the material's ability to withstand heat in its own lab.)

NASA's choice of UCSB was unusual, said Milstein, who explained that this sort of testing of components on what is called the "critical path" is usually delegated to industry. He said that NASA quality control experts visited UCSB several times to

check the test procedures and the recording and analysis of the data on the new material. Milstein has been working on materials of this sort with NASA for about five years.

NASA-Ames created the material just for the purpose of shielding the vehicle. Called SIRCA, for silicone impregnated reusable ceramic ablator, the light gray material looks like an eraser, but its density of about 15 pounds per cubic foot is only about one fourth that of water. To create the material, the NASA engineers started with silica fibers and added silicone liquid.

"When NASA first made these materials they had little idea how they would behave, and so extensive experimentation was necessary," said Milstein.

In studying compression, the UCSB researchers found that the material is highly anisotropic, which means that it has markedly different properties when stressed in different directions. Milstein compared the testing of the material to pushing down on a deck of slightly bent cards, with the cards as planes of fibers. When you push against the face of a deck of cards, there is some give at first and then the cards flatten and hold their shape and do not give any further.

In the other direction, similar to pushing on a deck of cards from end to end, the cards will buckle. Similarly, the SIRCA material breaks apart when too much stress is placed against the grain of the fibers. Milstein demonstrated with a manual stress test showing that in one direction the material becomes stiffer as it flattens, but in the other direction it eventually crumbles when enough stress is applied.

Besides compression, the scientists studied the effect of pulling the material apart. They used a laser extensometer which measures the distance between two markings to see how much deformation the material could withstand before fracturing.

Milstein said that there will likely be spin-off materials, since SIRCA is so lightweight and provides high insulation. He expects that special clothing could be one possible spin-off.

Much of the work of testing the material was performed by Milstein's students. Doctoral student Mike Gray is writing his dissertation on the work. Undergraduate Jeff Loomis also carried out measurements. Development engineer Kirk Fields was also involved.

For the work of his group, Milstein received a special certificate of recognition from NASA stating, "For outstanding performance and lasting contribution to the success of the Mars Exploration Rover Project; Entry, Descent, and Landing System."

"Landing one of these vehicles on Mars is an amazing feat," said Milstein. "There are numerous critical path parts and systems that need to be certified as flight-worthy, including the mechanical properties of the SIRCA insulation. Failure of any of these to meet specifications requires a redesign of the system, or cancellation of the flight! The recent European problems show it's not that easy to do."

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Frederick Milstein

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