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N91-19007

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NASA/ASEE SUMMER FACULTY FELLOWSHIP PROGRAM

MARSHALL SPACE FLIGHT CENTER
THE UNIVERSITY OF ALABAMA

CHARACTERIZATION OF SPACE STATION MULTILAYER INSULATION DAMAGE DUE TO HYPERVELOCITY SPACE DEBRIS IMPACT

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Contract No:	NGT-01-002-099 The University of Alabama

During the course of work this summer four main tasks were accomplished which are discussed in the following sections. The first three tasks were related to the goal of measuring the degradation of the insulating capabilities of Space Station multilayer insulation (MLI) due to simulated space debris impacts at hypervelocities. The last task was associated with critically reviewing a Boeing document on the fracture characteristics of the Space Station pressure wall when subjected to a simulated hypervelocity space debris impact.

TASK 1 - Write Thermal Test Procedure for Impact Damaged MLI Specimens

To determine the effects of impact damage to MLI, damaged samples of MLI will be attached (starting 8/20/90) to a test fixture built by Boeing and tested in the MSFC Sunspot 1 Thermal Vacuum Chamber. The Boeing fixture, which is similar to the Space Station wall configuration, was built to test undamaged MLI specimens. Before any damaged MLI testing could be performed, a test procedure had to be written by the author and approved.

Writing the test procedure involved three steps: first the fabrication and use of the Boeing fixture had to be studied, then the Boeing test procedure documents had to be comprehended, and finally the operating characteristics of the Sunspot Chamber had to be understood. It was decided to write the damaged MLI test procedure in a form as close as possible to that of the Boeing undamaged MLI test plan. This allowed the test plan to be written and reviewed quickly.

The related Boeing documents and test fixture drawings, the damaged MLI test plan, and all other information related to these MLI tests have been gathered together by the author in the form of a data book for future reference.

TASK 2 - Damaged MLI Specimen Preparation

Prior to thermal testing, the MLI samples were impacted with hypervelocity particles using the MSFC light gas gun to simulate a space debris impact. It had to be determined how to prepare these samples for attachment to the Boeing fixture and insertion in the Sunspot facility. Straight from the gas gun the impacted samples consisted 12" by 12" blankets of damaged MLI covered with gun soot. The damage typically takes the form of an approximately centrally located, 2" to 4" diameter, roughly circular hole.

Firstly, it was decided to trim the specimen to the form of a circular disk to preserve radial symmetry. It was also decided to make the disks as large as possible to maximize the distance between the MLI damage and the interface between the specimen and the test fixture and thereby minimize edge effects. Thus, the final form selected for the specimens is a 12" diameter disk. The MLI specimens will be taped over a 10" diameter hole cut in the MLI blanket of the Boeing test fixture during thermal testing.

Gun soot had to be removed from the specimens for two reasons. The pump-down vacuum system of Sunspot requires reasonably clean specimens in order to function properly. Also, the gun soot may significantly affect the thermal performance of the specimens. Impacted MLI in space would of course not be contaminated with gun soot. EH52 Branch developed a cleaning procedure where the MLI was placed between two stainless steel screens (for protection) and then carefully cleaned with a soft brush using freon as a solvent.

TASK 3 - Develop Computer Program to Simulate MLI Thermal Tests

The temperature measurements obtained during the thermal testing will have to be reduced down to the form of some effective measure of MLI damage such as an equivalent hole diameter. Development of a microcomputer program

by the author for this purpose was initiated this summer. The computer program mathematically models the thermal test set up. Parameters in the model (such as the size of the hole in the MLI) can be varied until the calculated results agree with those measured. Having characterized the MLI damage, then heat transfer predictions can be made with respect to the Space Station configuration on orbit.

The computer program contains a radially-symmetric finite difference model of the pressure wall, the bumper, and all MLI layers. The program iterates until the *net* heat flux into each layer is zero (steady state) and the heat flux across the plane between each layer is equal to the heat flux supplied by the test fixture (conservation of energy). Currently, the program can accurately reproduce the experimental results obtained by Boeing for the undamaged MLI case. Work is continuing to prepare for treating the damaged MLI thermal test data.

TASK 4 - Review Boeing Document on Stressed Plate Hypervelocity Impact Testing

A significant amount of time was spent this summer by the author to review a Boeing document describing hypervelocity impact testing performed by Boeing on biaxially stressed plates. For simplicity and to control costs, most hypervelocity impact testing that has been done as part of the Space Station program has been done using unstressed plates. However, the Space Station pressure wall will be subjected to relatively high biaxial stresses, and so Boeing has done some biaxially stressed plate tests using the MSFC light gas gun.