Thermal Control Replacement Materials Evaluated for Durability and Selected for the Hubble Space Telescope

During the Hubble Space Telescope (HST) second servicing mission, astronauts noticed that the outer layer of the multilayer insulation (MLI) was cracked in many locations around the telescope. The insulation's outer layer is composed of 5-mil (0.127 mm) Teflon FEP (DuPont; fluorinated ethylene propylene) with vapor-deposited aluminum (VDA) on the backside. The MLI blankets, which are used on over 80 percent of the external surface of the telescope, provide passive thermal control for equipment. Two large cracks were observed on the light shield directly above the high gain antenna. The upper light shield crack propagated from a cut placed in the blanket during installation around a handrail standoff. Two cracks propagated almost normal to each other, with the outer layer curling tightly as the cracks propagated. A second much larger vertical crack had started to curl and lift away from the telescope, as seen in the figure. MLI on the equipment bays was cracked extensively also, and in some areas it had pulled away from the bay. Continued degradation of the equipment bay insulation would potentially cause limited observations because of housekeeping boxes; for example, the data interface unit could overheat during some portions of the year, in certain sun angles.

Photograph of Hubble Space telescope taken during the second servicing mission, showing the very large, vertical light shield cracked area and the tightly curled upper light shield cracked area.

The tightly curled, cracked FEP/VDA on the upper light shield was retrieved by astronauts and found to be severely embrittled, as witnessed by ground testing. The NASA Goddard Space Flight Center organized a Hubble Space Telescope MLI Failure Review Board, which included three members from Lewis, to (1) determine the damage mechanism of the (FEP/VDA) in the telescope's orbit environment, (2) predict the condition of the MLI at the time of the next servicing mission, and (3) recommend a replacement thermal control outer layer material to be installed on the telescope during

subsequent servicing missions. The Failure Review Board chose candidate thermal control replacement materials by using a multiplicative process recommended by the NASA Lewis Research Center. Ten candidate materials were tested for environmental durability under various exposures and durations as overseen by Goddard and Lewis. Lewis conducted x-ray radiation exposure, thermal cycling under load, and large-sample thermal cycling of candidate materials. Lewis' durability testing of candidate replacement materials and involvement on the Failure Review Board had a direct impact on the choice of the replacement thermal control material to be placed on the Hubble Space Telescope during subsequent servicing missions in 2000 and 2003. The recommended replacement thermal control material chosen by the review board and adopted by the Hubble Space Telescope project office is 5-mil FEP/VDA bonded with a low-outgassing ultraviolet-durable adhesive to a Nomex (DuPont) scrim.

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