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BELLCOMM, INC.
955 L'ENFANT PLAZA NORTH, S.W. WASHINGTON, D.C. 20024

SUBJECT: Comments to Multiple Docking Adapter High Performance Insulation Design - Case 620

DATE: December 20, 1968

FROM: J. W. Powers

ABSTRACT

The multi-laminar radiation barrier insulation of the Multiple Docking Adapter is located between the pressure shell and the radiator and meteroid shield outer shells. This location requires hundreds of penetrations for structural supports.

MSFC's reasons for an inside rather than outside location for that insulation adjacent to the meteroid shield are presented. A discussion of the insulation design including heat leaks through structural penetrations, decoupling of the insulation from structural penetrations, and insulation venting is presented. Fine polyurethene foam dust is intrinsic to the insulation from the spacer manufacturing process. This dust can also be caused by vibration of the space vehicle and its possible effects on the ATM experiments should be evaluated.

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(NASA-CR-100232) COMMENTS TO MULTIPLE DOCKING ADAPTER HIGH PERFORMANCE INSULATION DESIGN (Bellcomm, Inc.) 8 p

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MEMORANDUM FOR FILE

INTRODUCTION

The high performance multi-laminar radiation barrier insulation (HPI) of the Multiple Docking Adapter (MDA) is located between the pressure shell and the radiator and meteoroid shield outer shells. With this positioning the HPI surface must be perforated in hundreds of locations to accommodate the radiator and meteoroid shield fiberglass structural supports. This configuration has prompted the logical question, "Why not locate the HPI outside the structure and thus eliminate the requirement for the structural support penetrations?"*

MDA HPI DESIGN

Approximately 50% of the MDA cylindrical surface and the conical forward end are covered with meteoroid shields over HPI. The balance of the MDA cylinder is covered with a radiator, which must be the outside structure.

The reasons given by MSFC for locating the HPI under, rather than over, the meteoroid shields are as follows:**

- Protection of the insulation against reaction control system rocket exhaust plume impingement during module docking and undocking.
- Protection of the insulation during ground handling of the MDA.
- Heat flow through the many penetration areas will be relatively small compared with heat flow thru the balance of the HPI.

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* From D. A. Chisholm.

**Private Communication - J. S. Vaniman/R-P&VE-PTP, November 15, 1968.

The last reason is important and will be verified by MDA HPI penetration thermal tests, now planned to begin in early 1969. Other AAP data show large heat flows for HPI with penetrations. For example, Grumman LM HPI data show a 53% effective emissivity increase for one fiberglass standoff penetration per square foot. With a low emittance coating applied to the standoff, the increase in effective emissivity is reduced to 28%. North American Rockwell reports that approximately 25% of the CSM heat loss is through structural penetrations in the insulation. It is recognized that the crinkled, single aluminized barrier surface, spacerless LM and CSM HPI data are not directly applicable to the MDA insulation, but this and other data indicate that the heat flow through penetrations may be significant.

MSFC is using a design effective thermal conductivity ($5x10^{-4}$ Btu/Hr-Ft-°R) which is about five times greater than that measured in recent tests. This conservatism should compensate for heat losses through the structural penetrations.

MDA HPI PENETRATIONS

The highly anisotropic nature of HPI yields heat flow ratios of approximately 10^6 considering flow parallel to the plane of insulation as compared with perpendicular to the plane. For minimum heat loss any structural penetrations should be decoupled from the insulation radiation barriers. Simply leaving a gap between the structural penetration and the HPI edges is not effective for the following two reasons: radiation will enter the gap, and radiation will be transferred between the HPI barrier edges and the structural support in the area of the insulation penetration. Effective decoupling from a structural penetration is usually accomplished by the addition of an isotropic insulation material in the volume between the structural penetration and the edges of the HPI barrier layers. The MDA HPI consists of alternate layers (2.5 ft x 7.0 ft) of 1/4 mil thick double aluminized, mylar film and slightly larger area 0.03 in. thick polyurethane foam spacer sheets. These alternating layers are fabricated into blankets approximately one inch thick with fiberglass facing sheets, and dacron through threads. Decoupling will be effected by producing the penetration holes in the mylar film larger than the corresponding holes in the foam spacer sheets. To accomplish effective decoupling, this design requires the following conditions:

- Maintenance of relatively precise alignment between the respective hole patterns in the radiation barrier sheets and the foam spacer sheets. This relationship must be maintained not only during manufacture of the individual blankets but also after bonding of the blankets to the external surface of the MDA pressure shell.

- Compression or deformation of the foam spacer sheets must be accomplished at the edges of the radiation barriers at each structural penetration. This will allow the foam to cover the barrier sheet edges in the hole and thus minimize radiation exchange between the insulation barrier sheets and the structural supports. The foam spacers should also extend to the structural supports to close the penetration opening to direct radiation.

- Adhesive bonding of the blankets to the MDA pressure shell must also be accomplished so that the multiple penetration hole pattern in a blanket coincides rather closely to the structural support location pattern. Superimposed upon this dimensional requirement is positioning the blankets so that the slightly oversize foam spacer sheets will be in compression at each blanket edge butt joint to close any radiation windows.

The MDA pressure shell external lateral surface has eight equally-spaced longitudinal lands. These thickened areas which project approximately 0.17 in. above the basic shell O.D. are for meteoroid shield and radiator attachment brackets. This non-uniform surface in the vicinity of the structural penetration further complicates the fit, alignment, and attachment processes of the blankets. Maintaining the requisite poistioning accuracy during the adhesive bonding process, considering the large soft nature of the blankets, and the non-uniform external surface will be a difficult tooling and installation problem with many process variables. Structural support thermal decoupling effectiveness will thus be a variable affected by many factors.

HPI METEOROID PENETRATION CONSIDERATIONS

The additional foam spacer mass of the MDA insulation allows more efficient functioning as a meteoroid shield than a configuration with an equal number of radiation barriers but no spacers. Placement under, rather than over, the meteoroid shield protects the HPI from penetration by micrometeoroids which will impact but not penetrate the meteoroid shield. From the point of view of penetrations in the HPI caused by micrometeoroids and meteoroids, the under location is preferable.

HPI VENTING CONSIDERATIONS

For HPI to be effective, rapid evacuation of the contained atmospheric gas down to a pressure 10^{-4} torr must be accomplished. Efficient rapid gas evacuation greatly reduces the gas conduction heat transfer mode and also reduces pressure differentials across the insulation during the ascent trajectory phase. Venting of the MDA insulation is accomplished primarily through the blanket edge gaps. Very small holes on 4-inch centers for the tension tie threads between insulation facing sheets provide additional open area. The insulation penetrations also contribute to local venting, but if their centerline spacing is great compared with the radiation barrier spacing, their over-all effect may be negligible. Using only edge venting for HPI insulation is not a normal design practice and perforations are usually employed in the radiation barriers. The presence of the foam spacer sheets will tend to impede gas evacuation. The planned compression of the foam spacers at the blanket edges will further aggravate the venting problem.

MSFC has successfully conducted tests which simulate a Saturn ascent trajectory pressure differentials and the worst case of complete sealing of the edges with venting only through the nylon thread tension tie holes. The critical factor in the validity of any such proof test is the time variation profile of the internal pressure. This profile must accurately simulate the pressure differential across the insulation as a function of ascent trajectory time.

Away from the blanket edges the only structural connections maintaining the insulation thickness are single loops of 220 denier thread. These loops are on 4-inch centers through needle sized holes in the radiation barriers and knoted to the fiberglass facing sheets. A more reliable system would result if the loading condition were eliminated rather than requiring the HPI to withstand possible pressure differentials. Introducing additional broadside venting to any HPI will require a design compromise between venting speed and an increased effective thermal conducticity.

It is interesting to note that of the HPI used on the LM, ATM, CM-SM, AM, and MDA modules, only the MDA insulation utilizes separate spacers between the radiation barriers. In the other modules, the HPI radiation barriers are either crinkled or embossed allowing the radiation barriers to also function as spacers. The MDA HPI is a superior configuration relative to resisting deformation from applied loads which cause an attendant conductivity increase. This insulation also functions as a better meteoroid shield than a similar HPI configuration without spacers. The penalty is, of course, the additional foam weight required. With 27 spacers 0.03 in. thick fabricated from foam with a density of 1.7 lb/ft^3, this weight penalty is approximately 60 lbs.

Physical examination of the MDA HPI shows the presence of fine polyurethene dust. This dust is evidently caused by the manufacturing operation that produces the foam spacer thickness. Any severe vibration environment will most probably produce additional dust by causing flexing of the HPI blankets. The effects of this fine dust on the ATM and other external experiments should be evaluated since the dust is free to vent to the local atmosphere.

J. W. Powers

1022-JWP-mef J. W. Powers

Bellcomm, Inc.

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From: J.W. Powers

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