November 30, 1964

SUBJECT: Evaluation of R/V Debris

The following discussions and conclusions are presented based upon Structural Mechanics evaluation of the R/V debris. The two main areas evaluated are the aft skirt of the shield and the magnesium ring.

SHIELD

1. In the center portion of Figure 1, there is an area where the phenolic nylon is completely ablated away in a local crater shape. The phenolic nylon is separated from the phenolic glass liner underneath the crater type formation. This type of formation is probably the result of a local unbonded region between the phenolic nylon and the phenolic glass liner. Either due to elevated temperatures in orbit or during a shallow re-entry, the hoop and axial compressive thermal loading in the phenolic nylon would produce a bubble which ablate more than the surrounding area until the entire phenolic nylon ablates through in the center. Subsequent ablation can produce the crater type erosion. The unbonded area is estimated to be about 2 inches in diameter. Local unbonded areas of this size, however, can be tolerated without effecting the over-all mission capability of the shield system.

2. In Figure 2, a local bond separation at the edge of the saw cut is evident, with the phenolic nylon curled up on the free edges. The virgin nylon thickness tapers off as the saw cut edge is approached.

The curling phenomena can occur during the hot portion of the orbit environment or during a shallow re-entry. It is caused by the difference in thermal expansion between the unrestrained phenolic nylon (unbonded) and the adjacent phenolic nylon restrained by the bond to the liner. However, sufficient time and temperature are required to permit inelastic creep deformation to occur.

During the orbit environment, where the local high temperature reaches 250°F many orbits would be required to produce this effect, as the temperature is relatively low. During reentry, when the phenolic nylon reaches temperatures around 700°F a much shorter time will produce the same effect; however, a steep reentry is felt to be too short a time. Of the two environments, reentry is considered to be the predominant one due to the circumferential symmetry of the curl. Once the curling phenomena has occured, subsequent ablation will even off the local protrusion giving the tapered shape seen in Figure 2.

The local bond separation at the saw cut is probably the result of edge effects early in the environment. However, neither this nor the curling is considered detrimental to the over-all flight capability of the system.

3. The random cracks seen in Figure 3 were probably produced after re-entry when the phenolic nylon cooled down. During re-entry when the phenolic nylon is above 500 F it deforms plastically in compression so that a sudden cooling after re-entry would produce tensile cracks. This is substantiated by the fact that most of the cracks near the free edge of the phenolic nylon are meridional in direction because of high hoop compression during re-entry with very low axial compressive stresses. Most of the cracks in the hoop direction are away from the free edges where the axial compression stresses are equal or higher than the hoop compression stresses.

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MAGNESIUM RING

1. The end tabs of the capsule guides extending between the magnesium ring and the aft shield ring were bent at each location around most of the circumference of the shield (see Fig. 2 for one of the bent guides). In addition the dowel pin hole elongations extend in the aft direction indicating the magnesium ring moved aft relative to the glass liner. The large guide adjacent to the piston in Quad I also had a permanent impression of the raised pad on the magnesium ring, again indicating an aft movement of the ring. The conclusion reached from this is that the shield structure and magnesium ring failed at impact, the capsule structure forcing the magnesium ring aft relative to the glass liner. In addition, the magnesium ring was intact up to the point of impact since, during impact, a uniform circumferential bending of the tabs occured. This also accounts for the many small pieces of ring since a failure would be expected near each contact point between the magnesium ring and the guides.

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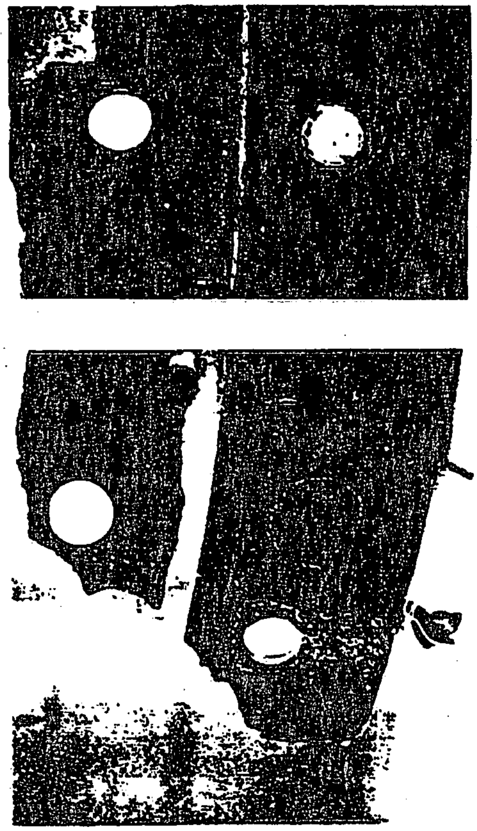

Fig 1

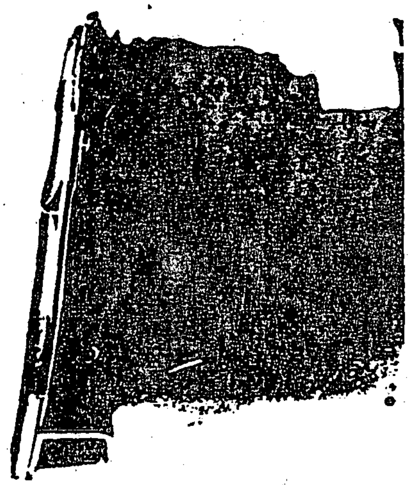

Fig 2

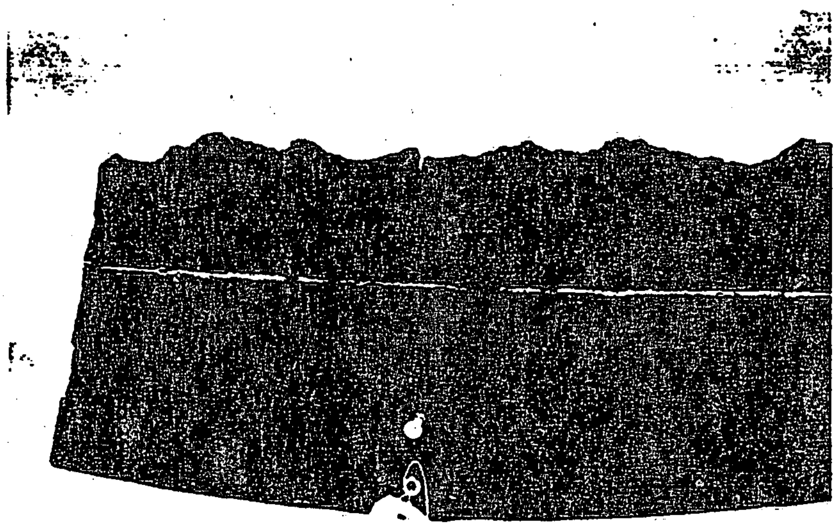

Fig 3