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THE NON-METALLIC MATERIALS SAMPLE ARRAY

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THE NON-METALLIC MATERIAL SAMPLE ARRAY

INTRODUCTION

This report provides the results of the evaluation of material specimens exposed to the cargo bay environment during Spacelab (SL) missions 1 and 2. The material specimens were mounted on the Non-Metallic Materials Sample Array (MSA), DWG. 42A40015, and exposed to the ambient flight environment at a location near the right-hand pallet sill just forward of the cargo bay aft bulkhead (Fig. 1). The MSA was an article of GFE provided to satisfy a portion of the materials performance evaluation requirements during the Spacelab Verification Test Program.

EXPERIMENTAL

The MSA (Figs. 2 and 3) was a 4-ft by 1-ft package, housing test samples representing three modes for performance evaluation. The majority of the "A" samples and the "C" sample on SL-2 were equipped with temperature transducers; "B" samples were designed for pre- and post-flight optical properties measurements; "C" samples represent transfer tunnel flex section materials and multilayer insulation and are suited for pre- and post-flight evaluations.

Post-flight optical properties and visual observations were recorded upon receipt of the array at MSFC. There were minor differences in the array as flown on the two missions. Samples A-13, A-17, and B-09 were changed between missions. The Deft 023-GW-3 (A-17 and B-09) had been flown uninstrumented on SL-1 but was not flown on SL-2 because the material was no longer commercially available – instead A-17 and B-09 positions were reflown with Chemglaze Z302 overcoated with RTV670. This combination was selected to evaluate the effectiveness of the silicone top coat (RTV 670) to protect the Z302 from atomic oxygen attack. For purposes of comparison A13 position was reflown with Chemglaze Z302 coating without a topcoat of silicone. The rubber system flown on SL-1 in the A13 position was not of sufficient interest to justify a second mission. The only other change between missions was that the systems tunnel flex section (Sample C) was instrumented with a temperature transducer.

The optical properties data gleaned from the MSA are summarized in Tables 1 through 3. Data from samples identified as controls represent duplicate specimens prepared simultaneously with the flight samples and stored in dust-proof containers in an area devoid of light, natural or artificial.

The physical properties data for the transfer tunnel flux section material is presented in Table 4. This data was generated by both MSFC and the Goodyear Rubber Co., the manufacturer of the flex section material (Nomex reinforced Viton).

The summary of the visual inspection is given in Table 5 for Mission SL-1. The post SL-2 examination showed no visible differences from SL-1. The RTV 670 overcoated Chemglaze Z302 was degraded more than expected.

DISCUSSION

The Non-Metallic Materials Sample Array (MSA) was successfully flown on SL-1 and SL-2 missions. Observations after each flight showed degradation of selected materials, specifically Chemglaze II A276, 3M 425 tape, Chemglaze Z306, Chemglaze Z302, Chemical Conversion Coating, and Aluminized Kapton tape. In general, exposed surfaces degraded to some extent due to both atomic oxygen attack and UV degradation.

The Chemglaze II-A276 appears to have suffered selective UV degradation on the retainer plate (Part No. 42A 40017) regions which had pre-flight contact with a silicone rubber seal which was part of the non-flight MSA cover. The selective yellowing and the maintenance of surface gloss, characteristic of UV rather than atomic oxygen degradation, was also noted on regions of sample disks adjacent to the gap in the sample retaining rings. This gap appears to function as a vent for the off-gassing products from the silicone foam cushion underneath each disk.

The off-gassing products from the silicone foam are not stable against UV degradation, as evidenced by the yellowing observed in the "vent zone" of the Z-93 and S-13GLO specimens. The extent to which this yellowing contributed to the observed yellowing of Chemglaze A-276 on the retainer plate could not be determined. The A-276 coating is known to be susceptible to UV degradation (yellowing) from ground test and previous flight results. The yellowed, glossy regions of the retainer plate were unchanged after the second mission (SL-2).

Thermal data from each disk was recorded in an attempt to determine the kinetics of the degradation. Due to the minimal changes in optical properties, no correlation to the time of change was possible.

The Chemglaze coatings A-276, Z-302, and Z-306, and 3M 401-C10, and the exposed Kapton side of the aluminized Kapton tape exhibited the typical effect of atomic oxygen attack, loss of surface gloss and/or change in visual appearance. These effects were produced during SL-1; the second mission (SL-2) produced little change.

Data from the Multilayer Insulation (MLI) and transfer tunnel flex section show little effects other than superficial yellowing of the MLI and loss of gloss of the flex tunnel section.

CONCLUSIONS

The observed changes in optical properties are quite minimal and do not indicate gross contamination from the Spacelab hardware or experiments nor from the payload bay. The contamination from the silicone material used incidentally in the MSA hardware amply demonstrates the local contamination effects possible from materials which comply with the general outgassing requirements for Shuttle payloads. The experimental coating hybrid of Chemglaze Z302 overcoated with a clear silicone, RTV670, confirm the hypothesis that silicones can inhibit the effects of atomic oxygen on underlying coatings.

Analysis of the optical properties data indicates the short duration of exposure to be generally insufficient for conclusive quantifying of space effects on these coating systems. The significance of the data must be determined for the coating of interest in conjucntion with other flight histories – the MSA experience cannot stand alone.

Data from the Multilayer Insulation (MLI) and systems tunnel flex section reveal only superficial effects of the cargo bay environment on these materials.

In summary, the Non-Metallic Materials Sample Array (MSA) was flown successfully as Verification Flight Instrumentation on SL-1 and SL-2. Valuable data was gathered on many coating systems; however, the short duration of exposure to the space environment limits the usefulness of the data. Users of this data must be cautious; other flight histories must be considered when selecting a candidate coating for the Shuttle cargo bay environment; the MSA data is not definitive.

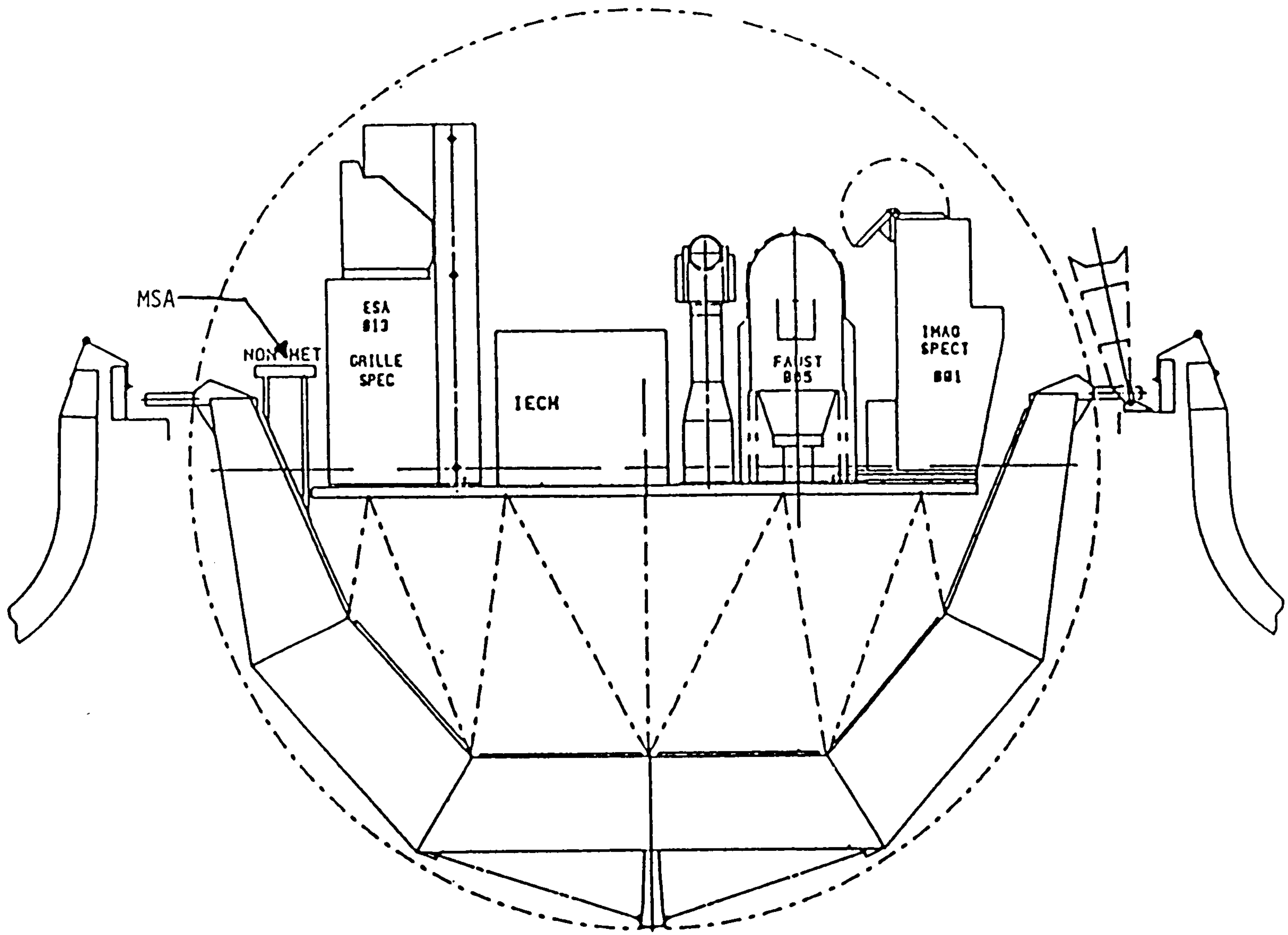
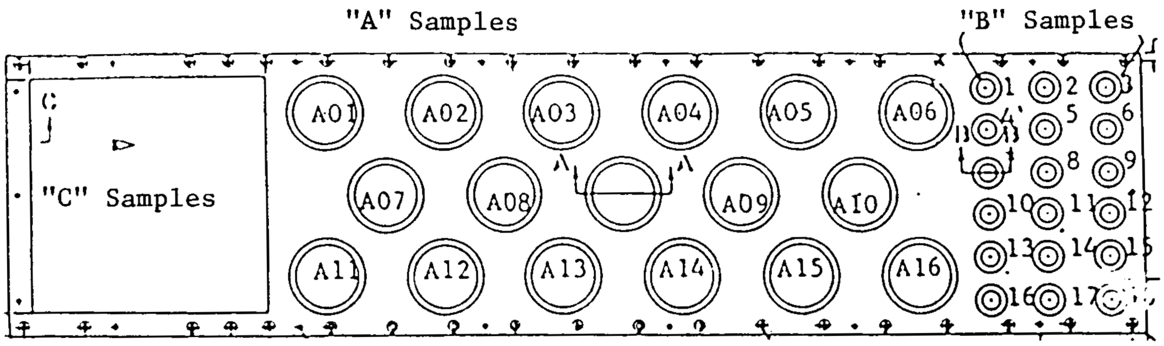
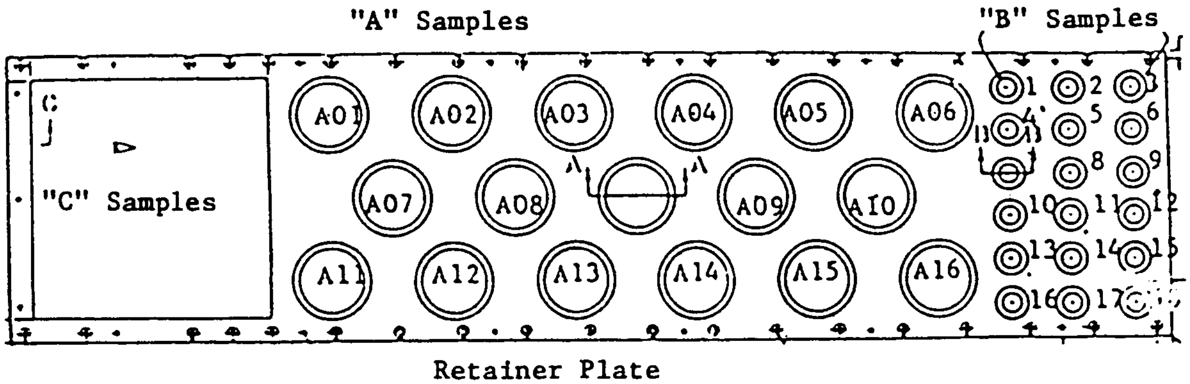


Figure 1. SL-1 pallet view C-C.



Material	Sample Position A	B	C
Z-93	01	01	
S-13GLO	02	02,14	
Chemglaze II -A276	04	03,10,7	
Chemglaze Z-306	05	04,18	
Chemglaze Z-302	06	05	
3M 401-C10	03	06,16	
Anodize	07	07	
Chemical Conversion Coating	08	08	
Deft 023-GW-3	17	09	
Tedlar Laminate	09	13	
Silverized Teflon (Sheldahl G 400300)	10	11	
Aluminized Tape Kapton	12	15	
Aluminized Tape (3M 425)	11	12	
Silicone Rubber (RA 38250)	13	-	
B-Cloth/MSFC Light Block	14	-	
B-Cloth/JSC Light Block	15	-	
B-Cloth/No Light Block	16	-	
Transfer Tunnel Flex Section			X
Multi-layer Insulation			X

Figure 2. MSA diagram and sample location guide for SL-1.



Material	Sample Position A	Sample Position B	Sample Position C
Z-93	01	01	
S-13GLO	02	02,14	
Chemglaze II -A276	04	03,10,7	
Chemglaze Z-306	05	04,18	
Chemglaze Z-302	06	05	
3M 401-C10	03	06,16	
Anodize	07	07	
Chemical Conversion Coating	08	08	
Chemglaze Z302	17	09	
Tedlar Laminate	09	13	
Silverized Teflon (Sheldahl G 400300)	10	11	
Aluminized Tape Kapton	12	15	
Aluminized Tape (3M 425)	11	12	
Chemglaze Z302/RTV670	13	-	
B-Cloth/MSFC Light Block	14	-	
B-Cloth/JSC Light Block	15	-	
B-Cloth/No Light Block	16	-	
Transfer Tunnel Flex Section			X
Multi-layer Insulation			X

Figure 3. MSA diagram and sample location guide for SL-2.

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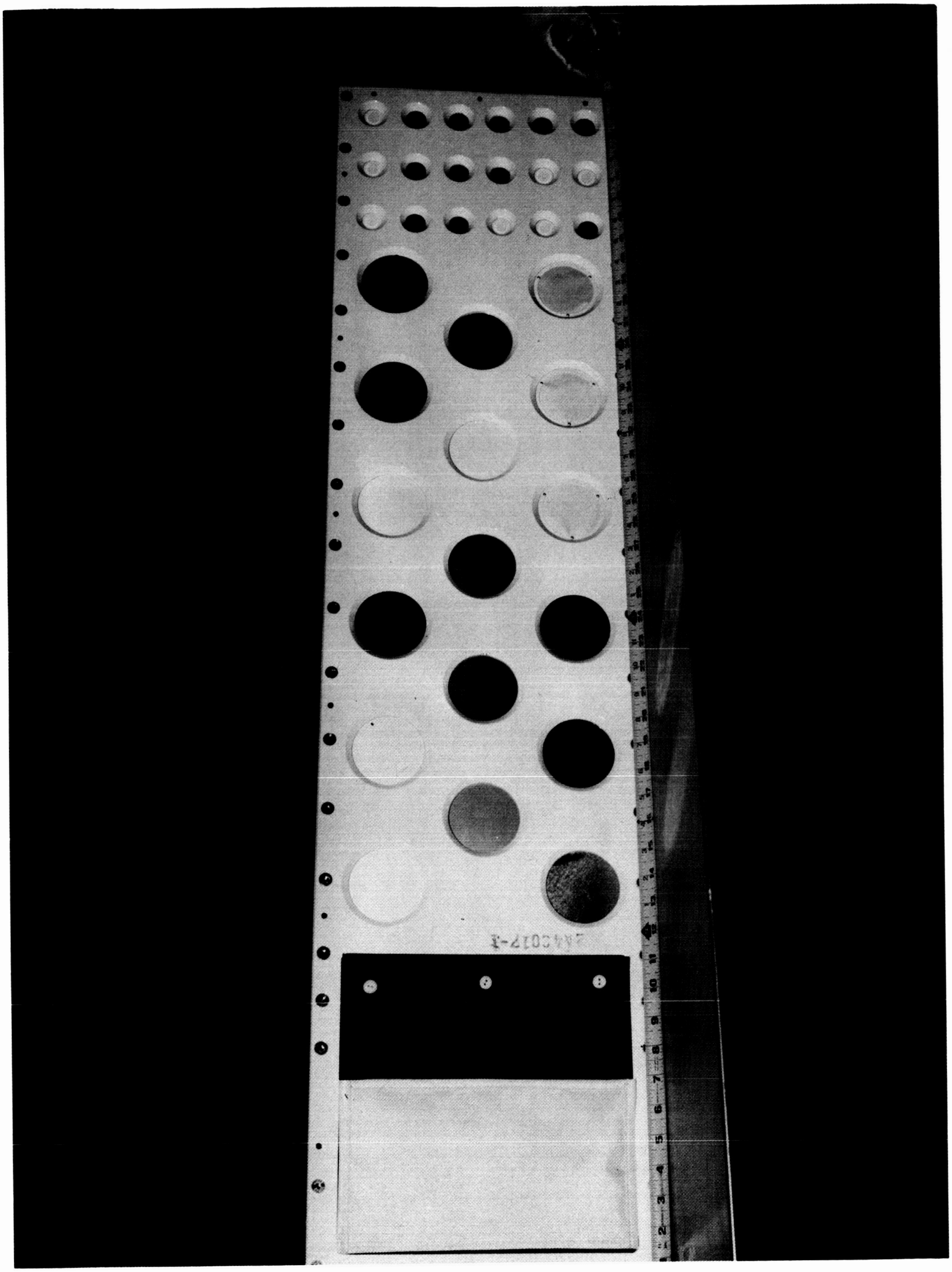

Figure 4. MSA SL-1 preflight configuration.

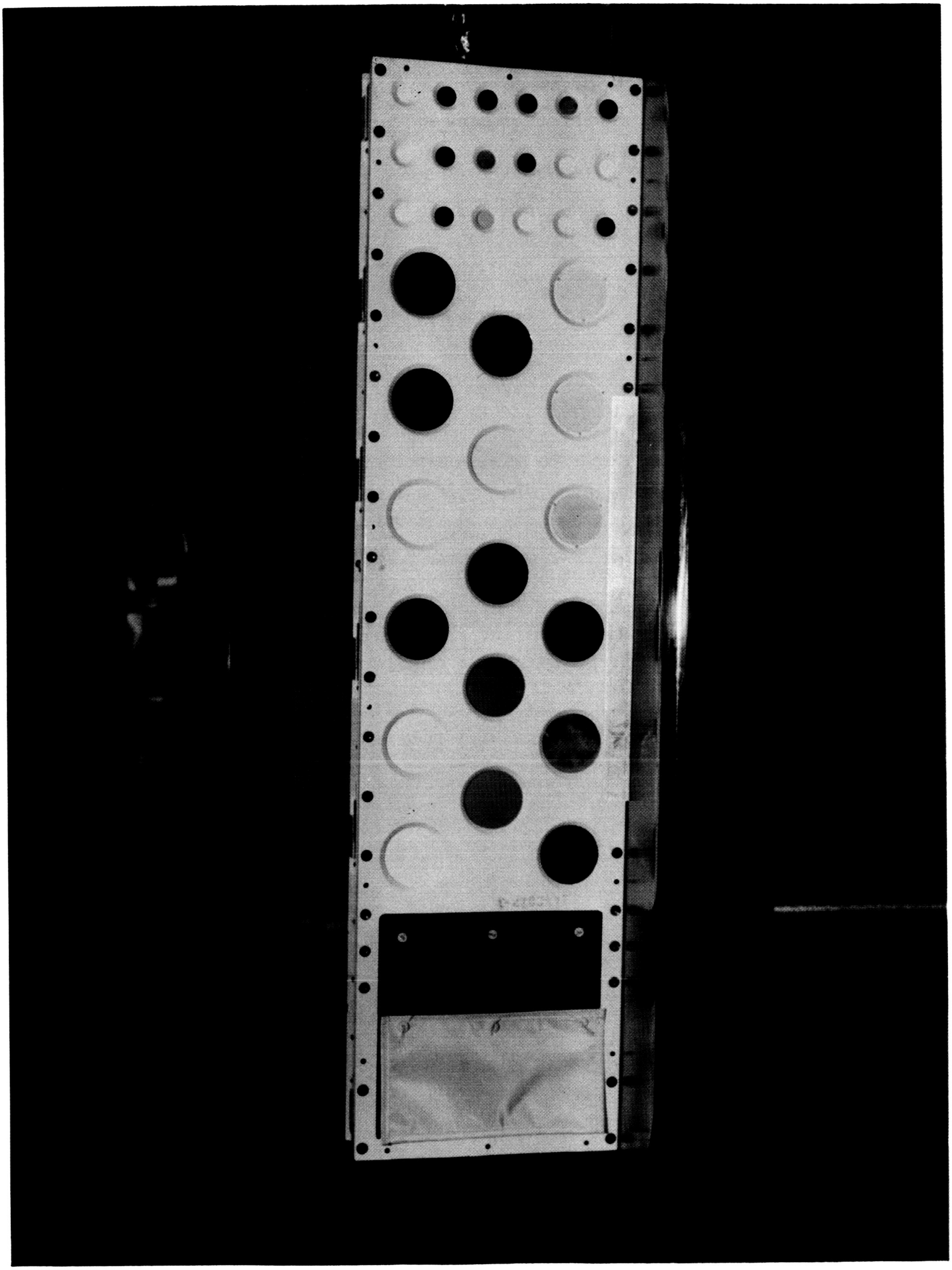

Figure 5. MSA SL-2 preflight configuration.

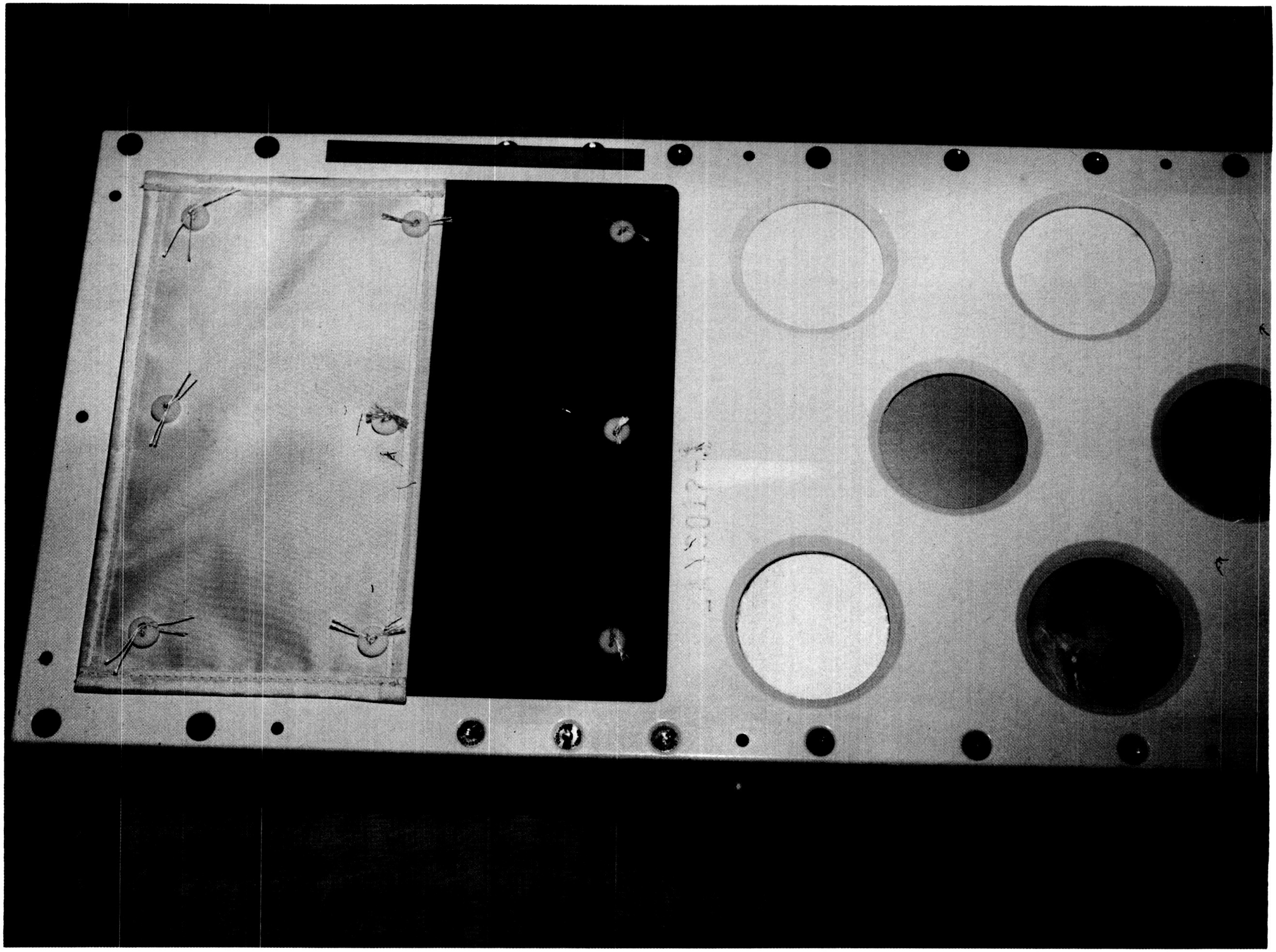

Figure 6. MSA SL-2 post flight.

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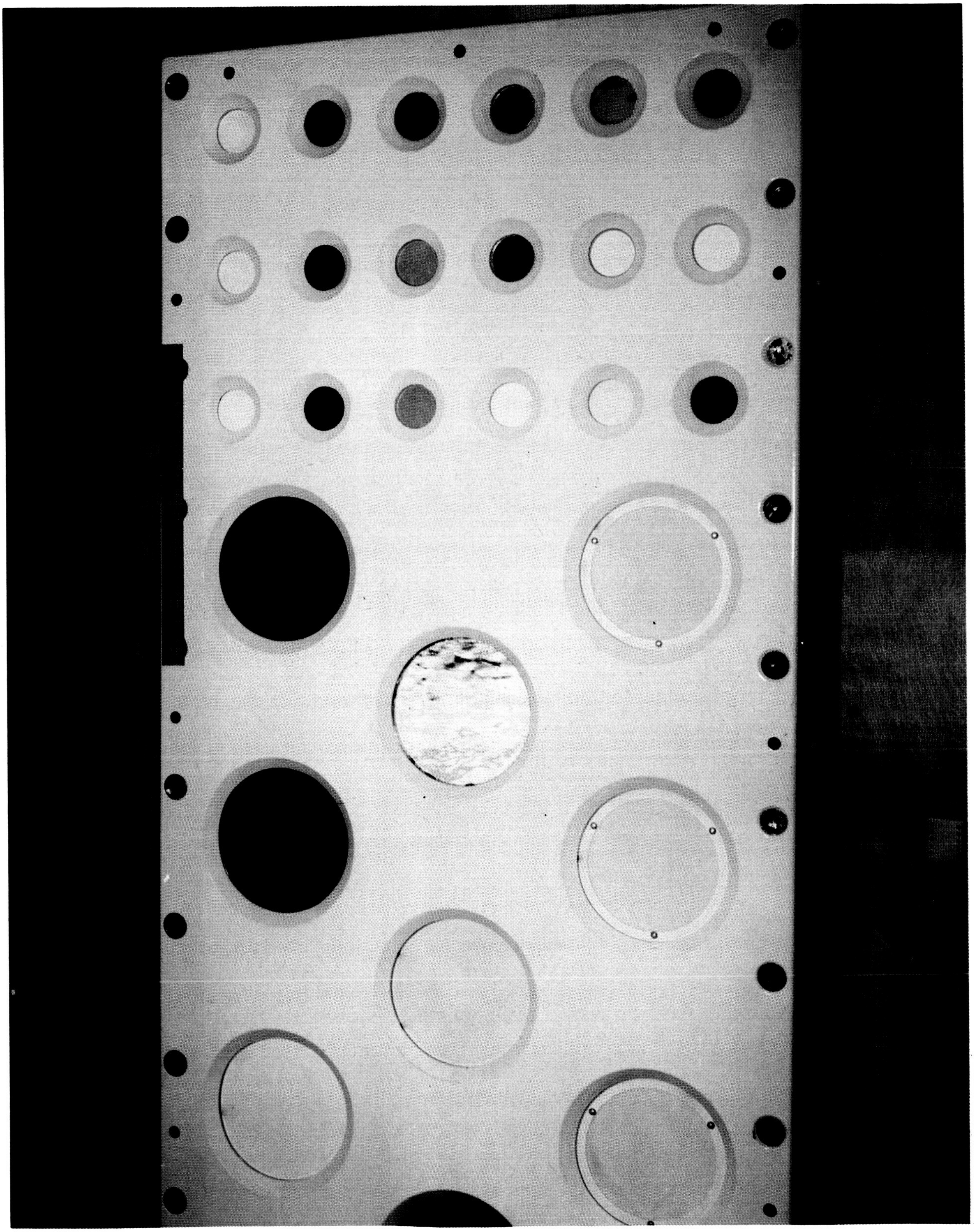

Figure 7. MSA SL-2 post flight.

TABLE 1. "B" SAMPLE OPTICAL PROPERTIES*

SAMPLE	MATERIAL	PRE-FLIGHT α	POST-FLIGHT (SL-1) α	POST-FLIGHT (SL-2) α	CONTROL α
B01	Z93	0.16	0.16	0.15	0.16
B02	S13GLO	0.18	0.18	0.19	0.18
B03	IIA276	0.25	0.25	0.27	0.25
B04	Z306	0.95	0.99	0.99	0.95
B05	Z302	0.95	0.98	0.97	0.95
B06	401C10	0.97	0.98	0.99	0.97
B07	Anodize	0.41	0.41	0.40	0.41
B08	Conversion Coating	0.42	0.40	0.40	0.42
B09	Deft	0.69	0.68	-	0.69
B10	IIA276	0.25	0.25	0.25	0.25
B11	Silverized Teflon	0.06	0.06	0.06	0.06
B12	425 Aluminized Tape	0.21	0.17	0.17	0.21
B13	Tedlar Laminate	0.24	0.24	0.26	0.24
B14	S13GLO	0.19	0.19	0.19	0.19
B15	Aluminized Kapton	0.33	0.44	0.43	0.33
B16	401C10	0.97	0.98	0.98	0.97
B17	IIA276	0.26	0.25	0.27	0.25
B18	Z306	0.96	0.98	0.99	0.96

*Data from Beckman DK2A Spectrophotometer with Gier-Dunkle Integrating Sphere

TABLE 2. "A" SAMPLE OPTICAL PROPERTIES*

SAMPLE	MATERIAL	PRE-FLIGHT ε	POST-FLIGHT (SL-1) ε	POST-FLIGHT (SL-2) ε	CONTROL ε
A01	Z93	0.92	0.91	0.91	0.91
A02	S13GLO	0.92	0.90	0.89	0.90
A03	401C10	0.91	0.91	0.90	0.90
A04	IIA276	0.90	0.89	0.88	0.89
A05	Z306	0.91	0.93	0.92	0.91
A06	Z302	0.90	0.90	0.90	0.90
A07	Anodize	0.82	0.92	0.82	0.82
A08	Conversion Coat	0.07	0.07	0.06	0.08
A09	Tedlar Laminate	0.91	0.90	0.90	0.90
A10	Silverized Teflon	0.68	0.65	0.65	0.66
A11	425 Tape	0.03	0.03	0.03	0.03
A12	Aluminized Kapton	0.54	0.50	0.53	0.51
A13	Silicone Rubber	0.90	0.91	-	0.91
A14	B-Cloth Ass'y MSFC L.B.	0.91	0.90	0.90	0.90
A15	B-Cloth Ass'y JSC L.B.	0.90	0.90	0.90	0.90
A16	B-Cloth Ass'y	0.90	0.90	0.90	0.90
A17	Deft Primer	-	0.87	-	0.67

*Data from Portable Instrumentation - Gier-Dunkle DB200

TABLE 3. MISCELLANEOUS OPTICAL PROPERTIES*

SAMPLE	PRE-FLIGHT α	PRE-FLIGHT ε	POST SL-1 α	POST SL-1 ε	POST SL-2 α	POST SL-2 ε	CONTROL α	CONTROL ε
Section C MLI	0.21	0.90	0.22	0.90	0.22	0.90	0.22	0.90
Flex Section Exposed	0.93	0.88	0.95	0.88	0.94	0.88	0.93	0.88
Flex Section Shielded	0.93	0.88	0.93	0.88	0.92	0.88	0.93	0.88
A13 (Chemglaze Z302)	0.94	0.90	-	-	0.94	0.90	0.95	0.90
A17 (Chemglaze Z302/ RTV760)	0.93	0.91	-	-	0.93	0.91	0.95	0.91
B09 (Chemglaze Z302/ RTV760)	0.96	-	-	-	0.97	-	0.96	-

*Data primarily from portable instrumentation
α Gier Dunkle MS251
ε Gier Dunkle DB200

TABLE 4. TRANSFER TUNNEL FLEX SECTION

- Physical Data -

MSFC DATA	Section A (Exposed)	Section B (Shielded)	Section C (Control)
Weight Change	-0-	-0-	-0-
Thickness Change	-0-	-0-	-0-
Shore Hardness "C"	70	72	68
SEM Results	Surface roughening of exposed tunnel section		

GOODYEAR DATA *	Control	Exposed	Shielded
Hardness ("Shore A")	90	90	88
Tensile (lbs/in)	1068	1143	1088

*This data was obtained courtesy of McDonnell Douglas Aerospace Corporation - Huntsville.

TABLE 5. VISUAL OBSERVATIONS OF SAMPLES, POST SL-1

MATERIAL	OBSERVATIONS
Z93	Visible yellowing in vent zone
S13GLO	Visible yellowing in vent zone
Chemglaze IIA276	Yellowing in silicone contaminated regions. The normally glossy coating changes to Lambertian in regions not contaminated with silicone.
Chemglaze Z306	No change in silicone contaminated regions. The remaining surface area was Lambertian, consistent with expected atomic oxygen attack.
Chemglaze Z302	No change in silicone contaminated regions; the remaining surface area was Lambertian. Extreme degradation of specular reflectance was noted.
3M 401-C10	Apparent darkening of the entire surface. No silicone effect noted.
Anodize	No visible changes noted.
Chemical Conversion Coating	Variable changes in coloration; the majority of the sample appeared to have lost coating.
Deft 023-GW3	Variable changes in coloration; the regions away from the vent zone appeared to have lost coating thickness. Degradation does not appear critical to usage in non-optically-critical areas.
Tedlar Laminate	Yellowing in the silicone vent zone; in addition, the remainder of the surface area was greyed.
Silverized Teflon	No visible changes noted.
Aluminized Tape Kapton	No change in silicone contaminated regions; the remaining surface area was Lambertian.
425 Aluminized Tape	Slight discoloration
Silicone Rubber	No changes
B-Cloth/MSFC Light Block	No significant changes
B-Cloth/JSC Light Block	No significant changes
B-Cloth/No Light Block	No significant changes
MLI	Slight yellowing of exposed side
Transfer Tunnel	No change in shielded side; the exposed side was Lambertian. Scanning Electron Microscopy at 1000X indicates a roughening of the surface of the exposed transfer tunnel material.

APPROVAL

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The information in this report has been reviewed for technical content. Review of any information concerning Department of Defense or nuclear energy activities or programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

R. J. SCHWINGHAMER
Director, Materials and Processes Laboratory

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16. ABSTRACT

The Non-Metallic Materials Sample Array (MSA) was flown as verification flight instrumentation (VFI) on both Spacelab 1 (SL-1) and Spacelab 2 (SL-2). The basis for materials selection was either previous flight history or probable flight suitability based upon analysis.

The observed changes in the optical properties of the exposed materials are, in general, quite minimal; however, this data represents the short exposure of two Space Shuttle missions, and no attempt should be made to extrapolate the long-term exposure.

The MSA was in orbit for 10 days at approximately 240 km on SL-1 and for 7 days at approximately 315 km on SL-2. The array was exposed to the solar flux for only a portion of the time in orbit.

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