NASA Technical Memorandum TM 107542

Debris/Ice/TPS Assessment And Photographic Analysis For Shuttle Mission STS-42

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National Aeronautics and Space Administration

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DEBRIS/ICE/TPS ASSESSMENT
AND
PHOTOGRAPHIC ANALYSIS
OF
SHUTTLE MISSION STS-42

January 22, 1992

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FOREWORD

The Debris Team is continuing its effort to develop and implement measures to control damage from debris in the Shuttle operational environment and to make the control measures a part of routine processing and operations.

Shuttle Mission STS-42 was launched at 9:52 a.m. local 1/22/92

1.0 Summary

The pre-launch debris inspection of the pad and Shuttle vehicle was conducted on 21 January 1992 from 0930 - 1030 hours. The detailed walkdown of Launch Pad 39A and MLP-3 also included the primary flight elements OV-103 Discovery (14th flight), ET-52 (LWT 45), and BI-048 SRB's. There were no vehicle anomalies. Facility discrepancies were worked real-time and no items were entered into OMI S0007, Appendix K.

The vehicle was cryoloaded for flight on 22 January 1992. There were no Launch Commit Criteria, OMRS, or NSTS-08303 violations. There were no ice/frost or TPS conditions outside of the established data base. Isolated patches of frost on the External Tank TPS acreage had melted prior to launch. Light condensate covered the ET TPS acreage at the time of launch. Three Ice/Frost Team observation/ anomalies were documented and found acceptable for launch per the LCC and NSTS-08303. The LH2 umbilical leak sensor detected no significant hydrogen during the cryoload. The tubing was successfully removed from the vehicle with no TPS contact or damage.

A small amount of ice/frost had formed on the aft pyrotechnic canister bondline. Thin foam exists in this area due to an incorrect mold manufacture. The amount and location of the ice/frost was acceptable for launch per the NSTS-08303 criteria. (The problem exists through end item EI-66. The mold will be changed to add more foam for EI-67 and subs. An EI spec waiver will be issued for STS-45 and subs until existing items are expended. STS-42's umbilical was approved for use by PMRB.)

A debris inspection of Pad 39A was performed after launch. No flight hardware was found. Launch damage to the holddown posts was minimal. EPON shim material on the south holddown posts was intact, but slightly debonded at the sidewalls on HDP #1, #2, and #6. Numerous voids were visible in the EPON shim sidewall material on HDP #1 and #2. There was no visual indication of a stud hang-up on any of the south holddown posts. An SRB HDP frangible nut web (2.0 x 0.25 inches) was found laying on top of the HDP #2 stud. The GH2 vent line had latched properly. Damage to the facility overall was minimal.

A total of 132 film and video items were analyzed as part of the post launch data review. No major vehicle damage or lost flight hardware was observed that would have affected the mission. One IFA was generated as a result of the film and video data review. The on-orbit views of the External Tank showed two divots, approximately 8-12 inches in diameter, outboard of the -Y bipod ramp and forward of the LH2 tank-to-intertank flange in the -Y+Z quadrant of the intertank acreage. The intertank TPS should remain intact with no loss of material during ascent. Although there was no photographic data showing the condition of the ET TPS in the +Y+Z quadrant,

SOFI debris from the External Tank intertank and/or lower LO2 tank is the most likely cause of the excessive Orbiter tile damage.

No frangible nut/ordnance fragments was visible falling from any of the holddown post DCS/stud holes. There was no evidence of stud hang-ups on any of the holddown posts. ET aft dome charring, plume recirculation, and SRB separation were nominal. OV-103 was not equipped to carry ET/ORB umbilical cameras. Orbiter performance, landing gear extension, wheel touchdown, and vehicle rollout after landing were normal.

The Solid Rocket Boosters were inspected at Hanger AF after retrieval. Both frustums exhibited a total of 24 debonds over fasteners. The field joint protection system closeouts were in generally good condition. There was no sign of broaching in any of the stud holes. Although the HDP #3 Debris Containment System (DCS) plunger was not seated, post flight disassembly of all eight DCS housings revealed virtually no loss of frangible nut/ordnance fragments. The overall system debris retention averaged 99 percent. This was the fifth flight utilizing the optimized link. Approximately 20 percent of the HDP #3 EPON shim material was missing and the substrate was charred. The shim material appeared to have been lost during ascent.

A detailed post landing inspection of OV-103 (Discovery) was conducted on January 30-31, 1992, at Ames-Dryden (EAFB) in the Mate-Demate Device. The Orbiter TPS sustained a total of 209 hits, of which 44 had a major dimension of one inch or greater. The Orbiter lower surface had a total of 159 hits, of which 38 had a major dimension of one inch or greater. Based on these numbers and comparison to statistics from previous missions of similar configuration, both the total number of Orbiter TPS debris hits and the number of hits with a major dimension of 1 inch or larger were greater than average.

All of the tile hits on the lower surface were shallow (3/8 inch or less) relative to the surface area. This type of tile damage is indicative of impact by a low density material. As a result of this tile damage, a debris damage/source investigation was conducted. Post flight inspections of the Orbiter and recovered SRB's revealed no loss of TPS or flight hardware. The TPS on the SRB's is more dense and results in deeper penetration. A mechanism to transport ET intertank foam to the Orbiter forward lower surface area had been previously demonstrated. ET-52 was the second tank flown with the new two-gun spray process on the intertank. IFA STS-42-T-001 was taken against the loss of ET intertank foam as the probable source for the debris damage to Orbiter tiles on STS-42.

All ET/Orbiter (EO) separation ordnance device plungers appeared to have functioned properly. An ordnance connector from the LH2 umbilical outboard pyro location (Part No. NBS9GE8-2SE) fell to the runway when the ET door was opened.

The entire exterior surface (flexible insulation blanket and thermal barrier) of Orbiter RH vent door #7 exhibited a yellow-orange discoloration. The surrounding Orbiter sidewall was not similarly discolored.

A variety of residual materials were present in the post-landing Orbiter samples and indicated sources such as Orbiter TPS, SRB/BSM exhaust residue, natural landing site products, organics, and paint. This data does not indicate a single source of damaging debris as all of these materials have been previously documented in post-landing sample reports.

Additional testing performed for this mission included specially removed damaged tiles for testing at MSFC and the discolored RH vent door #7. The MSFC testing is not complete yet but the early results (non-destructive tests) do not show indications of debris particulate. KSC analysis showed the vent door discoloring was not a debris concern.

A total of ten Post Launch Anomalies, including one IFA candidate, was observed during this mission assessment.

2.0 KSC ICE/FROST/DEBRIS TEAM ACTIVITIES

Team Composition: NASA KSC, NASA MSFC, NASA JSC, LSOC SPC, RI - DOWNEY, MMMSS - MAF, USBI - BPC, MTI - UTAH

Team Activities:

1) Prelaunch Pad Debris Inspection

Objective:	Identify and evaluate potential debris material/sources. Baseline debris and debris sources existing from previous launches.
Areas:	MLP deck, ORB and SRB flame exhaust holes, FSS, Shuttle external surfaces
Time:	L - 1 day
Requirements:	OMRSD S00U00.030 - An engineering debris inspection team shall inspect the Shuttle and launch pad to identify and resolve potential debris sources. The prelaunch vehicle and pad configuration shall be documented and photographed.
Documents:	OMI S6444
Report:	Generate PR's and recommend corrective actions to pad managers.

2) Launch Countdown Firing Room 2

Objective:	Evaluate ice/frost accumulation on the Shuttle and/or any observed debris utilizing OTV cameras.
Areas:	MLP deck, FSS, Shuttle external surfaces
Time:	T - 6 hours to Launch + 1 hour or propellant drain
Requirements:	OMRSD S00FB0.005 - Monitor and video tape record ET TPS surfaces during loading through prepressurization.
Documents:	OMI S0007, OMI S6444
Report:	OIS call to NTD, Launch Director, and Shuttle managers. Generate IPR's.

3) Ice/Frost TPS and Debris Inspection

Objective:	Evaluate any ice formation as potential debris material. Identify and evaluate any ORB, ET, or SRB TPS anomaly which may be a debris source or safety of flight concern. Identify and evaluate any other possible facility or vehicle anomaly.
Areas:	MLP deck, FSS, Shuttle external surfaces
Time:	T - 3 hours (during 2 hour BIH)
Requirements:	OMRSD S00U00.020 - An engineering debris inspection team shall inspect the Shuttle for ice/frost, TPS, and debris anomalies after cryo propellant loading. Evaluate, document, and photograph all anomalies. During the walkdown, inspect Orbiter aft engine compartment (externally) for water condensation and/or ice formation in or between aft compartment tiles. An IR scan is required during the Shuttle inspection to verify ET surface temperatures. During the walkdown inspect ET TPS areas which cannot be observed by the OTV system.
Documents:	OMI S0007, OMI S6444
Report:	Briefing to NTD, Launch Director, Shuttle management; generate IPR's.

4) Post Launch Pad Debris Inspection

Objectives:	Locate and identify debris that could have damaged the Shuttle during launch
Areas:	MLP zero level, flame exhaust holes and trenches, FSS, pad surfaces and slopes, extension of trenches to the perimeter fence, walkdown of the beach from Playalinda to Complex 40, aerial overview of inaccessible areas.
Time:	Launch + 1 hours (after pad safing, before washdown)
Requirements:	OMRSD S00U00.010 - An engineering debris inspection team shall perform a post launch pad/area inspection to identify any lost flight or ground systems hardware and resultant debris sources. The post launch pad and area configuration shall be documented and photographed.
Documents:	OMI S0007, OMI S6444

Report:	Initial report to NTD and verbal briefing to Level II at L+8 hours; generate PR's.

5) Launch Data Review

Objective:	Detailed review of high speed films video tapes, and photographs from pad cameras, range trackers, aircraft and vehicle onboard cameras to determine possible launch damage to the flight vehicle. Identify debris and debris sources.
Time:	Launch + 1 day to Launch + 6 days
Requirements:	OMRSD S00U00.011 - An engineering film review and analysis shall be performed on all engineering launch film as soon as possible to identify any debris damage to the Shuttle. Identify flight flight vehicle or ground system damage that could affect orbiter flight operations or future SSV launches.
Documents:	OMI S6444
Report:	Daily reports to Level II Mission Management Team starting on L+1 day through landing; generate PR's.

6) SRB Post Flight/Retrieval Inspection

Objective:	Evaluate potential SRB debris sources. Data will be correlated with observed Orbiter post landing TPS damage.
Areas:	SRB external surfaces (Hangar AF, CCAFS)
Time:	Launch + 24 hours (after on-dock, before hydrolasing)
Requirements:	OMRSD S00U00.013 - An engineering debris damage inspection team shall perform a post retrieval inspection of the SRB's to identify any damage caused by launch debris. Anomalies must be documented/photographed and coordinated with the results of the post launch shuttle/pad area debris inspection.
Documents:	OMI B8001
Report:	Daily reports to Level II Mission Management Team. Preliminary report to SRB Disassembly Evaluation Team. Generate PR's.

7) Orbiter Post Landing Debris Damage Assessment

Objective:	Identify and evaluate areas of Orbiter TPS damage due to debris and correlate if possible, source and time of occurrence. Additionally, runways are inspected for debris/sources of debris
Areas:	Orbiter TPS surfaces, runways
Time:	After vehicle safing on runway, before towing
Requirements:	OMRSD S00U00.040 - An engineering debris inspection team shall perform a prelanding runway inspection to identify, document, and collect debris that could result in orbiter damage. Runway debris and any facility anomalies which cannot be removed/corrected by the Team shall be documented and photographed; the proper management authority shall be notified and corrective actions taken.
Requirements:	OMRSD S00U00.050 - An engineering debris inspection team shall perform a post landing runway inspection to identify and resolve potential debris sources that may have caused vehicle damage but was not present or was not identified during pre-launch runway inspection. Obtain photographic documentation of any debris, debris sources, or flight hardware that may have been lost on landing.
Requirements:	OMRSD S00U00.060 - An engineering debris inspection team shall map, document, and photograph debris-related Orbiter TPS damage and debris sources.
Requirements:	OMRSD S00U00.012 - An engineering debris damage inspection team shall perform a post landing inspection of the orbiter vehicle to identify any damage caused by launch debris. Any anomalies must be documented/ photographed and coordinated with the results of the post launch shuttle/ pad area debris inspection.
Requirements:	OMRSD V09AJ0.095 - An engineering debris inspection team shall perform temperature measurements of RCC nose cap and RCC RH wing leading edge panels 9 and 17.
Documents:	OMI S0026, OMI S0027, OMI S0028

Report: Briefing to NASA Convoy Commander and generate PR's. Preliminary report to Level II on the day of landing followed by a more detailed update the next day.

8) Level II report

Objective: Compile and correlate data from all inspections and analyses. Results of the debris assessment, along with recommendations for corrective actions, are presented directly to Level II via SIR and PRCB. Paper copy of complete report follows in 3 to 4 weeks. (Ref NASA Technical Memorandum series).

3.0 PRE-LAUNCH BRIEFING

The Ice/Frost/Debris Team briefing for launch activities was conducted on 21 January 1992 at 0830 hours with the following key personnel present:

S. Higginbotham	NASA - KSC	STI, Ice/Debris Assessment
B. Davis	NASA - KSC	STI, Ice/Debris Assessment
G. Katnik	NASA - KSC	Lead, Ice/Debris/Photo Team
B. Speece	NASA - KSC	Lead, ET Thermal Protection
B. Bowen	NASA - KSC	ET Processing, Ice/Debris
K. Tenbusch	NASA - KSC	ET Processing, Ice/Debris
P. Rosado	NASA - KSC	Chief, ET Mechanical Systems
J. Rivera	NASA - KSC	Lead, ET Structures
M. Bassignani	NASA - KSC	ET Processing, Debris Assess
A. Oliu	NASA - KSC	ET Processing, Ice/Debris
A. Biamonte	NASA - KSC	ET Processing, Ice/Debris
W. Teng	LSOC - SPC	ET Processing, Ice Assess
R. Seale	LSOC - SPC	ET Processing, Ice Assess
J. Blue	LSOC - SPC	ET Processing, Ice Assess
M. Dean	LSOC - SPC	ET Processing, Ice Assess
Z. Byrns	NASA - JSC	Level II Integration
C. Gray	MMC - MAF	ET TPS & Materials Design
S. Copsey	MMC - MAF	ET TPS Testing/Certif
J. McClymonds	RI - DNY	Debris Assess, LVL II Integ
K. Mayer	RI - LSS	Vehicle Integration
D. Denaberg	USBI - LSS	SRB Processing
J. Cook	MTI - LSS	SRM Processing

These personnel participated in various team activities, assisted in the collection and evaluation of data, and contributed to reports contained in this document.

3.1 PRE-LAUNCH SSV/PAD DEBRIS INSPECTION

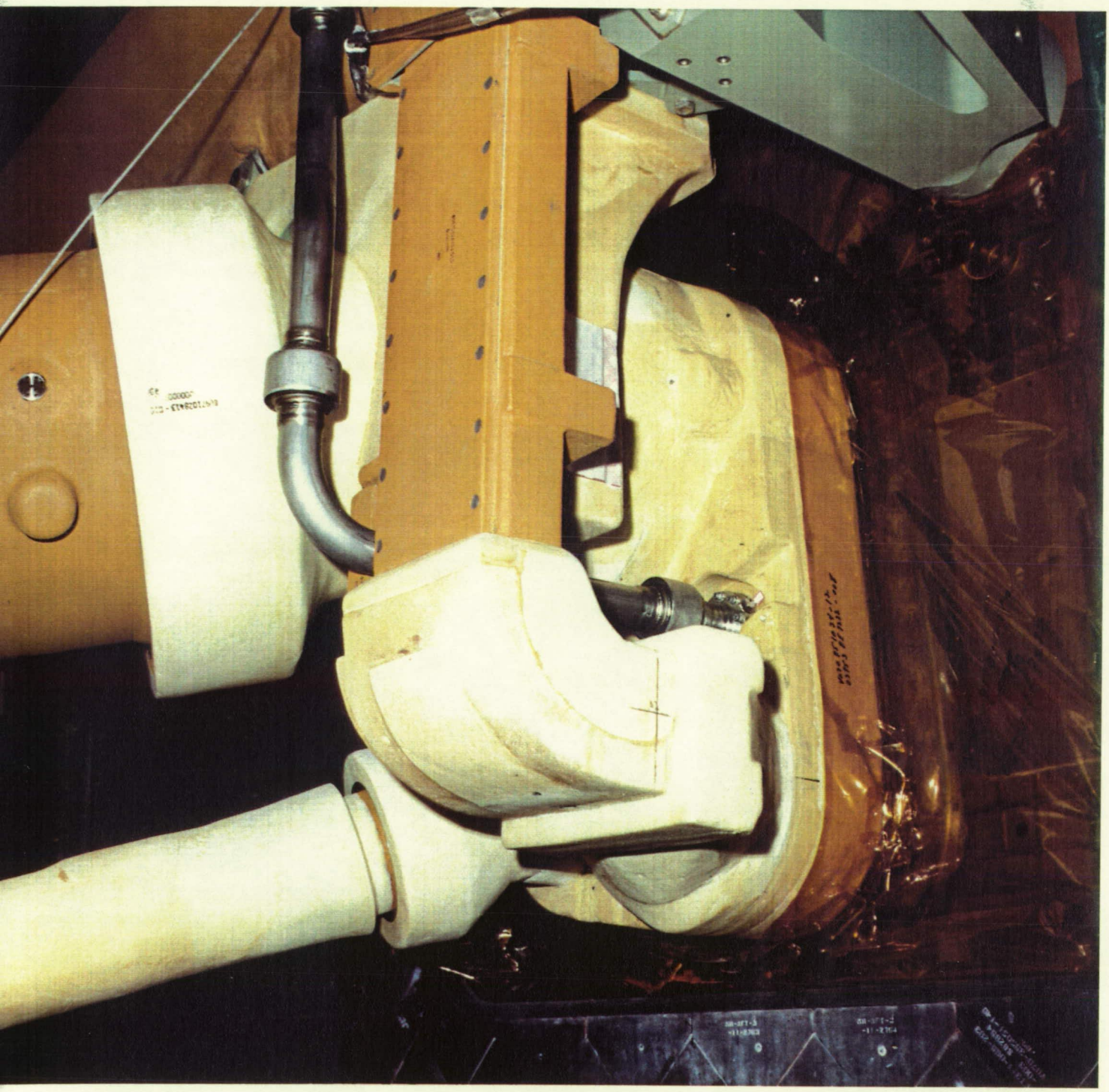
A pre-launch debris inspection of the pad and Shuttle vehicle was conducted on 21 January 1992 from 0930 - 1030 hours. The detailed walkdown of Launch Pad 39A and MLP-3 also included the primary flight elements OV-103 Discovery (14th flight), ET-52 (LWT 45), and BI-048 SRB's. Documentary photographs were taken of facility anomalies, potential sources of vehicle damaging debris, and vehicle configuration changes. Two such changes flown for the second time consisted of a new LH2 pressurization line graphite/epoxy fairing at the intertank feedthrough and the ET intertank two-gun SOFI spray process.

Due to the continued concern over potential hydrogen leakage from the ET/ORB LH2 umbilical interface area during cryoload/ launch, temporary hydrogen leak detectors LD54 and LD55 were installed at the LH2 ET/ORB umbilical until a permanent sensor could be designed and installed. The tygon tubes are intended to remain in place during cryogenic loading and be removed by the Ice Inspection Team during the T-3 hour hold.

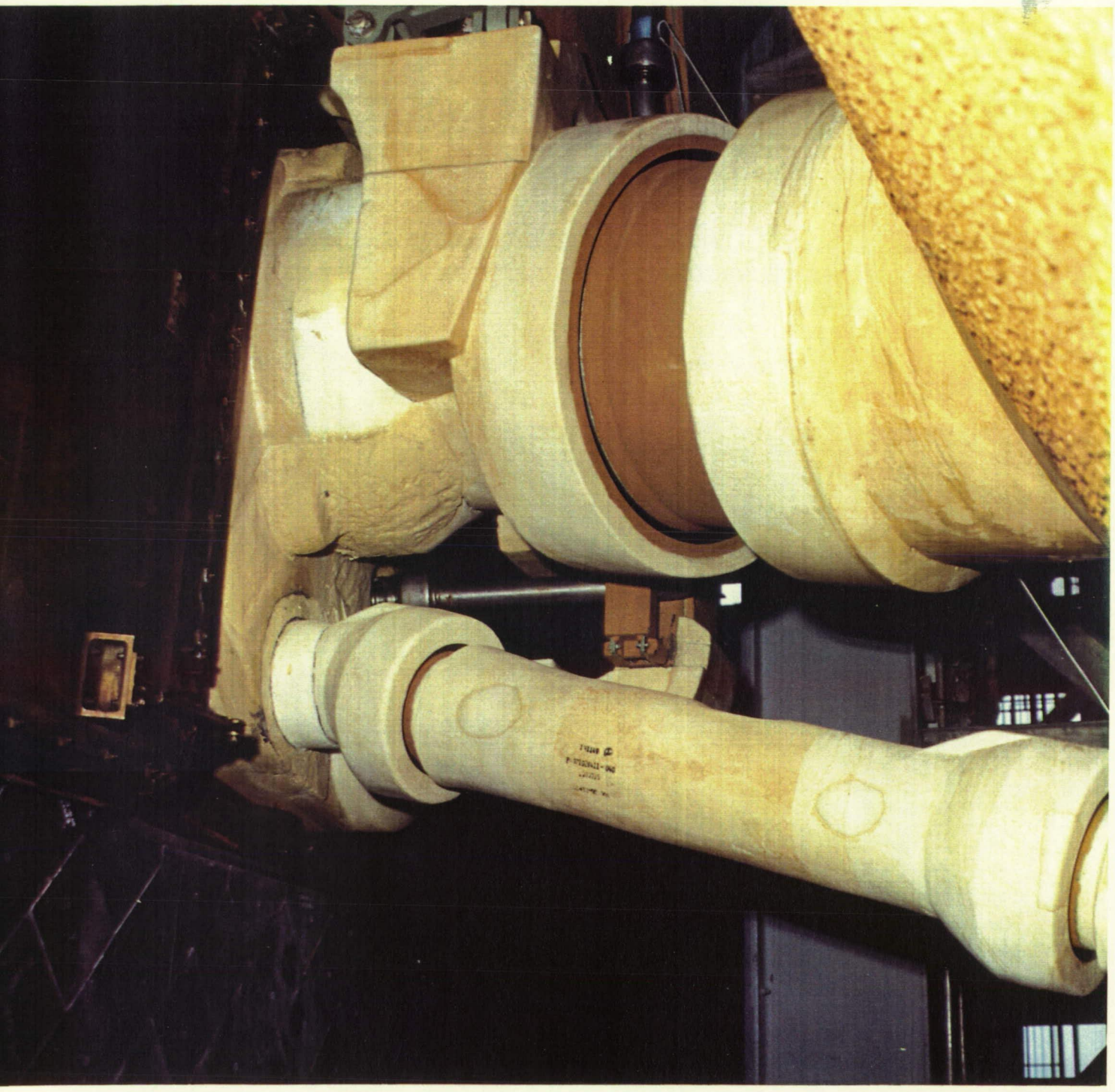
There were no vehicle anomalies. A cap on a feedthrough pipe west of the SSME exhaust hole and conduit covers in the north east corner of the MLP were loose. Round covers on the Portable Purge Unit (PPU) electrical conduit boxes were also loose.

These discrepancies were corrected real-time by Pad Operations personnel and no items were entered in S0007, Appendix K.

Pre-launch configuration of bipod jack pad closeouts.



Overall view of the LH2 ET/ORB umbilical outboard side



Overall view of the LH2 ET/ORB umbilical inboard side

Pre-launch view of the ET aft dome apex and manhole covers

4.0 LAUNCH

STS-42 was launched at 22:14:52:33 GMT (09:52:33 a.m. local) on 22 January 1992.

4.1 ICE/FROST INSPECTION

The Ice/Frost Inspection of the cryoloaded vehicle was performed on 22 January 1992 from 0435 to 0655 hours during the two hour built-in-hold at T-3 hours in the countdown. There were no Launch Commit Criteria, OMRS, or NSTS-08303 violations. There were no conditions outside of the established data base. Ambient weather conditions at the time of the inspection were:

Temperature:	57.4 F
Relative Humidity:	89.1 %
Wind Speed:	7.6 Knots
Wind Direction:	023 Degrees

The portable STI infrared scanner was utilized to obtain surface temperature measurements for an overall thermal assessment of the vehicle, as shown in Figure 1 and 2.

4.2 ORBITER

No Orbiter tile anomalies were observed. All RCS paper covers were intact and bonded to the RCS thrusters. The water spray boiler plugs were intact. The average Orbiter surface temperature was 55 degrees F. The average surface temperatures of the engine mounted heat shields were 52 degrees F for SSME #1, 44 degrees F for SSME #2, and 52 degrees F for SSME #3. Light frost coated the SSME #1 and #2 heat shield-to-nozzle interfaces along the full circumference. Some frost was present on the SSME #2 drain lines. The SSME #3 heat shield was dry. No GOX vapors originated from inside the SSME nozzles. No condensate was present on base heat shield tiles.

4.3 SOLID ROCKET BOOSTERS

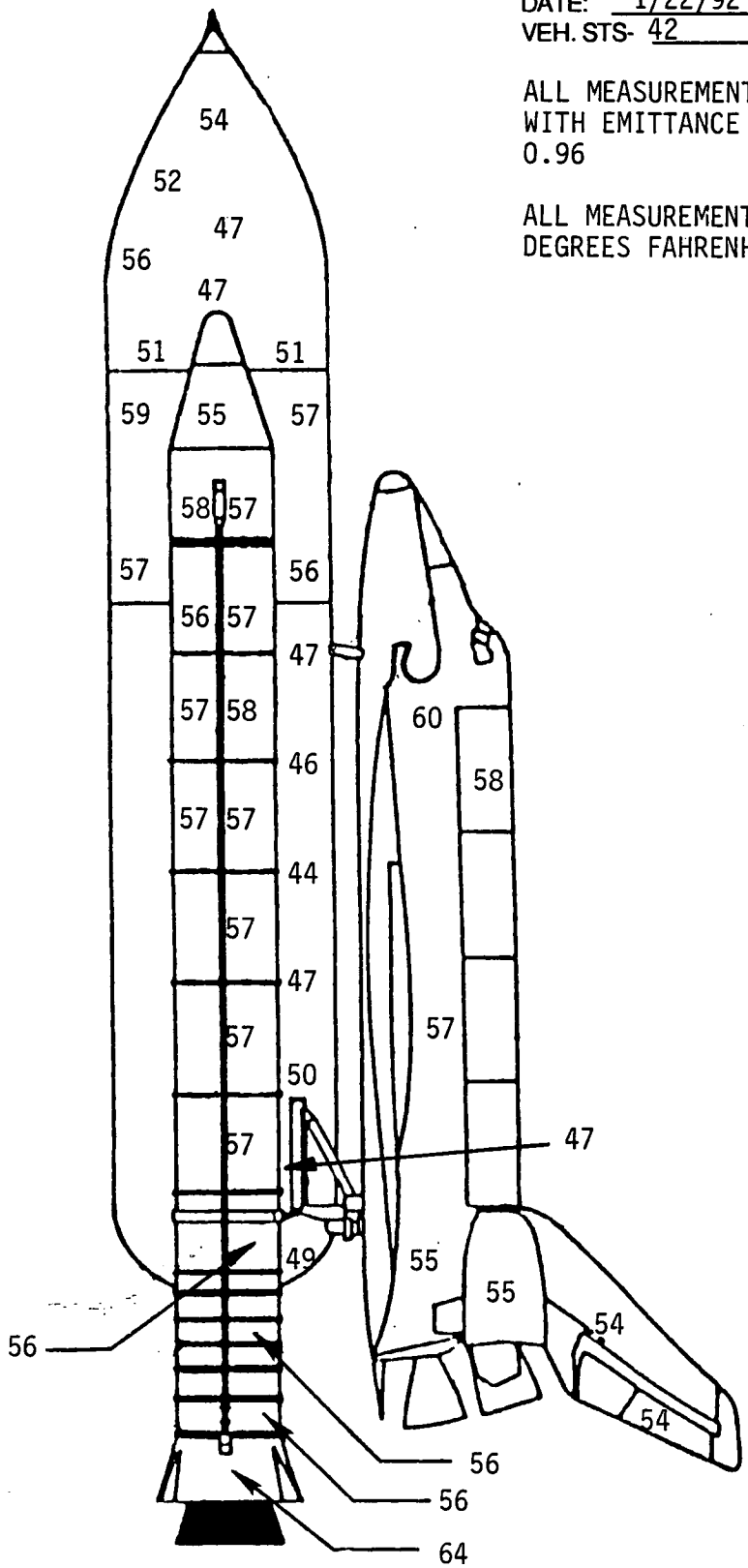
No SRB anomalies or loose ablator/cork were observed. The K5NA closeouts of the aft booster stiffener ring splice plates were intact. The STI portable infrared scanner recorded RH and LH SRB case surface temperatures between 50 and 58 degrees F. In comparison, the Cyclops radiometer measured temperatures between 54 and 59 degrees F and the GEI (Ground Environment Instrumentation) measured temperatures between 54 and 58 degrees F. All measured temperatures were above the 34 degree F minimum requirement. The predicted Propellant Mean Bulk Temperature (PMBT) supplied by MTI was 61 degrees F, which was within the required range of 44-86 degrees F.

Figure 1. **SSV INFRARED SCANNER SURFACE TEMPERATURE SUMMARY DATA**

TIME: 0430-0600
DATE: 1/22/92
VEH. STS- 42

ALL MEASUREMENTS MADE WITH EMITTANCE SET TO 0.96

ALL MEASUREMENTS IN DEGREES FAHRENHEIT



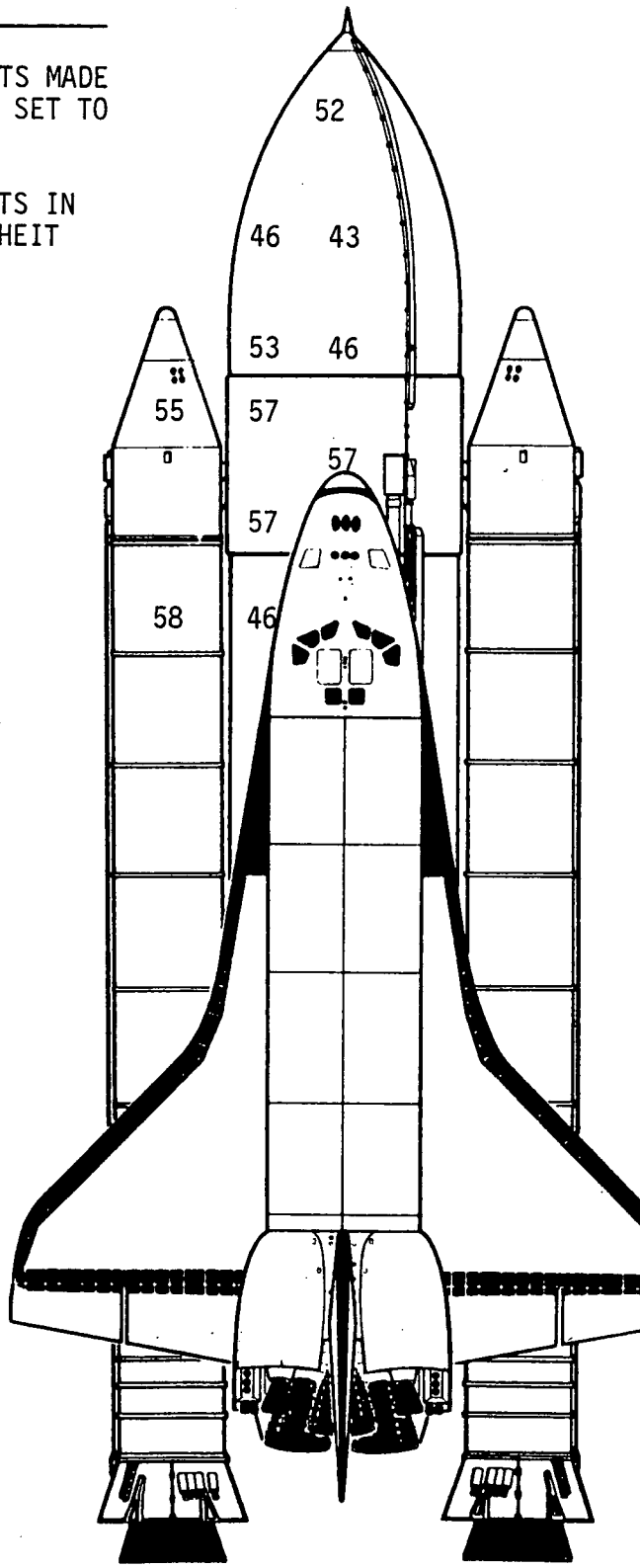
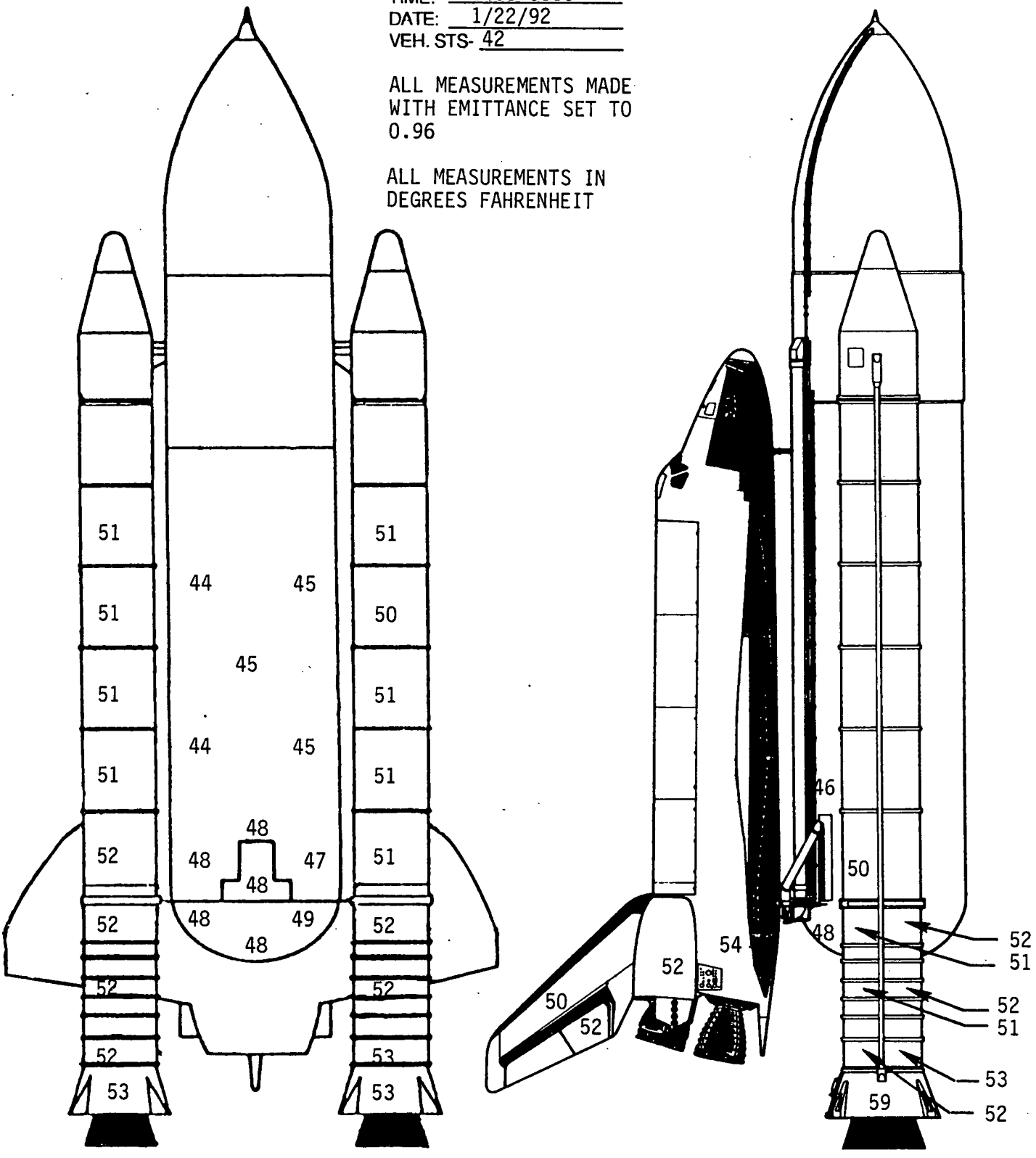


Figure 2. **SSV INFRARED SCANNER SURFACE TEMPERATURE SUMMARY DATA**



EGG/V-343C

4.4 EXTERNAL TANK

The ice/frost prediction computer program 'SURFICE' was run from 0145 to 0945 hours and the results tabulated in Figure 3. The program predicted condensate with no ice accumulation on the TPS acreage surfaces during cryoload. As the ambient temperature dropped during the night and reached a low point at approximately 0400 hours, SURFICE predicted below-freezing temperatures with ice/frost formation and/or freezing run-off condensate on the upper LH2 tank. Ice Team inspection revealed patches of frost on the +Y+Z acreage.

There was light condensate but no ice accumulation on the LO2 tank ogive and barrel sections. Small isolated frost spots on the LO2 tank +Z barrel section and LO2 tank-to-intertank flange -Y+Z closeout were visible during the Ice Team inspection, but soon melted. There were no TPS anomalies. The tumble valve cover was intact. There were no anomalies on the pressurization line and support ramps. The STI measured surface temperatures that averaged 52 degrees F on the ogive and 48 degrees F on the barrel section. In comparison, the Cyclops radiometer measured temperatures that averaged of 49 degrees F on the ogive and 45 degrees F on the barrel; SURFICE predicted temperatures of 47 degrees F on the ogive and 42 degrees F on the barrel.

The intertank TPS acreage was dry. There were no anomalies with the new intertank TPS two-gun spray configuration or the LH2 pressurization line graphite/epoxy fairing. No frost spots were present in the stringer valleys. No unusual vapors or ice formations were present on the ET umbilical carrier plate. The portable STI measured surface temperatures that averaged 57 degrees F and the Cyclops radiometer measured temperatures that averaged 56 degrees F.

There were no LH2 tank TPS acreage anomalies. Light condensate was present on the LH2 tank acreage and aft dome. There were no ice accumulations on the acreage. Isolated patches of frost on the +Y+Z quadrant acreage had melted by the end of the Ice Team inspection. Isolated frost spots on the LH2 tank-to-intertank flange -Y+Z closeout also melted. The portable STI measured surface temperatures that averaged 45 degrees F on the upper LH2 tank and 47 degrees F on the lower LH2 tank. In comparison, the Cyclops radiometer measured temperatures that averaged 44 degrees F on the upper LH2 tank and 49 degrees F on the lower LH2 tank; SURFICE predicted temperatures of 39 degrees F on the upper LH2 tank and 47 degrees F on the lower LH2 tank.

There were no anomalies on the bipods, PAL ramp, cable tray/press line ice/frost ramps, longerons, thrust struts, manhole covers, or aft dome apex. Ice/frost accumulations were present along the -Y bipod ramp closeout, the LH2 tank PAL ramp closeout, and the aft edges of the ice/frost ramps. Two small frost spots had formed on the +Y longeron and one spot on the +Z manhole cover at the 2 o'clock position. Some ice/frost was

STS- 42	TEST S0007 LAUNCH																					DATE: 22 January 1992	T-0 TIME: 09:52:32 DATE: 1/22/92	NASA KSC Ice/Frost/Debris Team		
ORBITER 103	ET 52	SRB BI-048	MLP 3	PAD A	LO2 CHILLDOWN TIME: 01:17 SLOW FILL TIME: 01:43					FAST FILL TIME: 01:58 REPLENISH TIME: 03:54					LH2 CHILLDOWN TIME: 01:06 SLOW FILL TIME: 01:15					FAST FILL TIME: 01:38 REPLENISH TIME: 03:27						
TIME (EST)	CONDITIONS					LO2 TANK STA 370 TO 540					LO2 TANK STA 550 TO 852					LH2 TANK STA 1130 TO 1380					LH2 TANK STA 1380 TO 2058				
	TEMP F	REL. HUM. %	DEW PT F	WIND VEL KNTS	WIND DIR DEG	REG	LOCAL VEL KNTS	SOFI TEMP	COND RATE IN/HR	ICE RATE IN/HR	REG	LOCAL VEL KNTS	SOFI TEMP	COND RATE IN/HR	ICE RATE IN/HR	REG	LOCAL VEL KNTS	SOFI TEMP	COND RATE IN/HR	ICE RATE IN/HR	REG	LOCAL VEL KNTS	SOFI TEMP	COND RATE IN/HR	ICE RATE IN/HR
145	55.60	90.6	52.89	7	12	II	4.13	44.60	0.0022	-0.0575	II	4.13	38.82	0.0033	-0.0304	II	3.08	34.09	0.0032	-0.0079	II	6.93	42.83	0.0040	-0.0692
200	56.00	90.4	53.23	8	3	II	4.72	45.85	0.0023	-0.0694	II	4.72	40.61	0.0035	-0.0420	II	3.52	36.17	0.0034	-0.0169	II	7.92	44.38	0.0041	-0.0878
215	56.60	89.6	53.58	8	356	II	4.72	46.37	0.0023	-0.0723	II	4.72	41.16	0.0035	-0.0448	II	3.52	36.76	0.0034	-0.0192	II	7.92	44.90	0.0041	-0.0918
230	56.00	90.0	53.11	8	10	II	4.72	45.78	0.0023	-0.0690	II	4.72	40.54	0.0035	-0.0416	II	3.52	36.11	0.0034	-0.0166	II	7.92	44.30	0.0041	-0.0872
245	56.20	90.4	53.43	7	9	II	4.13	45.24	0.0023	-0.0607	II	4.13	39.49	0.0034	-0.0334	II	3.08	34.79	0.0033	-0.0104	II	6.93	43.48	0.0041	-0.0736
300	56.40	90.4	53.63	8	13	II	4.72	46.29	0.0023	-0.0718	II	4.72	41.07	0.0035	-0.0443	II	3.52	36.66	0.0034	-0.0188	II	7.92	44.82	0.0042	-0.0912
315	52.80	90.4	50.05	7	6	II	4.13	41.42	0.0021	-0.0423	II	4.13	35.50	0.0031	-0.0156	III	3.08	31.70	0.0029	0.0044	II	6.93	39.64	0.0038	-0.0480
330	56.40	90.0	53.51	7	15	II	4.13	45.39	0.0022	-0.0614	II	4.13	39.65	0.0034	-0.0342	II	3.08	34.96	0.0033	-0.0110	II	6.93	43.63	0.0040	-0.0747
345	56.00	90.6	53.29	7	21	II	4.13	45.05	0.0023	-0.0597	II	4.13	39.29	0.0034	-0.0325	II	3.08	34.58	0.0032	-0.0096	II	6.93	43.29	0.0041	-0.0723
400	53.20	90.4	50.45	5	13	II	2.95	39.48	0.0020	-0.0272	II	2.95	32.24	0.0028	-0.0008	III	2.20	27.90	0.0026	0.0155	II	4.95	36.77	0.0035	-0.0237
415	55.00	91.6	52.60	8	28	II	4.72	44.94	0.0023	-0.0645	II	4.72	39.66	0.0035	-0.0372	II	5.60	40.34	0.0039	-0.0455	II	9.68	44.99	0.0042	-0.1074
430	55.00	91.8	52.66	8	33	II	4.72	44.97	0.0023	-0.0647	II	4.72	39.69	0.0035	-0.0374	II	5.60	40.38	0.0039	-0.0457	II	9.68	45.03	0.0043	-0.1078
445	56.60	92.0	54.31	8	32	II	4.72	46.79	0.0024	-0.0746	II	4.72	41.59	0.0036	-0.0470	II	5.60	42.27	0.0041	-0.0565	II	9.68	46.83	0.0044	-0.1242
500	57.40	90.8	54.74	7	26	II	4.13	46.66	0.0023	-0.0678	II	4.13	40.97	0.0035	-0.0403	II	4.90	41.64	0.0039	-0.0484	II	8.47	46.53	0.0043	-0.1099
515	57.80	90.2	54.96	8	26	II	4.72	47.81	0.0024	-0.0803	II	4.72	42.67	0.0036	-0.0526	II	5.60	43.33	0.0040	-0.0627	II	9.68	47.82	0.0043	-0.1334
530	57.40	89.2	54.26	7	22	II	4.13	46.38	0.0022	-0.0663	II	4.13	40.68	0.0034	-0.0389	II	3.08	36.03	0.0033	-0.0150	II	6.93	44.62	0.0041	-0.0815
545	58.00	88.0	54.48	7	19	II	4.13	46.83	0.0022	-0.0686	II	4.13	41.16	0.0034	-0.0412	II	3.08	36.55	0.0033	-0.0169	II	6.93	45.07	0.0040	-0.0846
600	58.60	87.4	54.89	8	16	II	4.72	48.19	0.0022	-0.0824	II	4.72	43.07	0.0035	-0.0546	II	3.52	38.76	0.0034	-0.0274	II	7.92	46.72	0.0041	-0.1060
615	58.00	87.2	54.23	8	17	II	4.72	47.50	0.0022	-0.0785	II	4.72	42.34	0.0034	-0.0508	II	3.52	38.01	0.0034	-0.0243	II	7.92	46.01	0.0040	-0.1004
630	57.80	87.2	54.03	8	15	II	4.72	47.27	0.0022	-0.0772	II	4.72	42.11	0.0034	-0.0496	II	3.52	37.79	0.0034	-0.0233	II	7.92	45.79	0.0040	-0.0987
645	57.80	87.6	54.16	8	27	II	4.72	47.35	0.0022	-0.0776	II	4.72	42.18	0.0034	-0.0500	II	5.60	42.85	0.0038	-0.0598	II	9.68	47.33	0.0041	-0.1288
700	57.40	88.4	54.01	7	22	II	4.13	46.23	0.0022	-0.0656	II	4.13	40.53	0.0034	-0.0382	II	3.08	35.89	0.0032	-0.0145	II	6.93	44.47	0.0040	-0.0804
715	57.20	89.8	54.24	7	24	II	4.13	46.26	0.0023	-0.0658	II	4.13	40.55	0.0034	-0.0384	II	4.90	41.23	0.0038	-0.0462	II	8.47	46.13	0.0042	-0.1065
730	57.00	90.0	54.10	8	26	II	4.72	46.89	0.0023	-0.0751	II	4.72	41.70	0.0035	-0.0475	II	5.60	42.37	0.0039	-0.0571	II	9.68	46.90	0.0043	-0.1248
745	56.00	90.4	53.23	9	26	II	5.31	46.54	0.0023	-0.0792	II	5.31	41.74	0.0036	-0.0515	II	6.30	42.40	0.0040	-0.0620	II	10.89	46.67	0.0042	-0.1343
800	58.20	90.0	55.30	8	17	II	4.72	48.22	0.0024	-0.0826	II	4.72	43.09	0.0036	-0.0548	II	3.52	38.76	0.0036	-0.0274	II	7.92	46.77	0.0043	-0.1064
815	60.00	89.6	56.96	8	10	II	4.72	50.15	0.0024	-0.0937	II	4.72	45.11	0.0038	-0.0655	II	3.52	40.86	0.0037	-0.0362	II	7.92	48.71	0.0044	-0.1220
830	59.40	90.8	56.73	8	21	II	4.72	49.70	0.0025	-0.0911	II	4.72	44.64	0.0038	-0.0630	II	3.52	40.36	0.0037	-0.0341	II	7.92	48.27	0.0045	-0.1184

Figure 3. "SURFICE" Computer Predictions

STS- 42	TEST S0007 LAUNCH															DATE: 22 January 1992					T-0 TIME: 09:52:32 DATE: 1/22/92				NASA KSC Ice/Frost/Debris Team
ORBITER 103	ET 52	SRB BI-048	MLP 3	PAD A	LO2 CHILLDOWN TIME: 01:17 SLOW FILL TIME: 01:43					FAST FILL TIME: 01:58 REPLENISH TIME: 03:54					LH2 CHILLDOWN TIME: 01:06 SLOW FILL TIME: 01:15				FAST FILL TIME: 01:38 REPLENISH TIME: 03:27						
TIME (EST)	CONDITIONS					LO2 TANK STA 370 TO 540					LO2 TANK STA 550 TO 852					LH2 TANK STA 1130 TO 1380					LH2 TANK STA 1380 TO 2058				
	TEMP F	REL. HUM. %	DEW PT F	WIND VEL KNTS	WIND DIR DEG	REG	LOCAL VEL KNTS	SOFI TEMP	COND RATE IN/HR	ICE RATE IN/HR	REG	LOCAL VEL KNTS	SOFI TEMP	COND RATE IN/HR	ICE RATE IN/HR	REG	LOCAL VEL KNTS	SOFI TEMP	COND RATE IN/HR	ICE RATE IN/HR	REG	LOCAL VEL KNTS	SOFI TEMP	COND RATE IN/HR	ICE RATE IN/HR
845	60.40	90.4	57.61	7	20	II	4.13	49.96	0.0024	-0.0849	II	4.13	44.44	0.0037	-0.0569	II	3.08	39.93	0.0036	-0.0298	II	6.93	48.25	0.0044	-0.1075
900	61.00	90.0	58.08	9	36	II	5.31	51.98	0.0025	-0.1130	II	5.31	47.42	0.0040	-0.0845	II	6.30	48.05	0.0044	-0.0992	II	10.89	52.05	0.0046	-0.1911
915	62.00	88.6	58.64	7	24	II	4.13	51.42	0.0024	-0.0927	II	4.13	45.97	0.0037	-0.0645	II	4.90	46.62	0.0041	-0.0755	II	8.47	51.23	0.0045	-0.1503
945	62.80	86.6	58.80	8	45	II	4.72	52.68	0.0023	-0.1086	II	4.72	47.77	0.0038	-0.0801	II	5.60	48.40	0.0042	-0.0936	II	9.68	52.60	0.0043	-0.1799
T-0	63.20	86.6	59.20	8	41	II	4.72	53.12	0.0024	-0.1113	II	4.72	48.23	0.0038	-0.0827	II	5.60	48.86	0.0042	-0.0965	II	9.68	53.04	0.0044	-0.1844
AVG	57.38	84.4	51.2	7.1	NNE		4.2	44.1				4.2	39.0				3.9	36.7				7.7	43.1		

Period of Ice Team Inspection

Figure 3. "SURFICE" Computer Predictions

present in the ET/SRB cable tray-to-upper strut fairing expansion joints. Ice/frost covered the lower EB fittings outboard to the strut pin hole with condensate on the rest of the fitting. The struts were dry.

Typical amounts of ice/frost were present in the LO2 feedline support brackets. Crusty, somewhat denser than usual ice/frost had formed in the LO2 feedline bellows. Although the amounts of ice/frost in the bellows were slightly greater than usual, the accumulations were acceptable per the NSTS-08303 criteria.

There were no TPS anomalies on the LO2 ET/ORB umbilical. The purge barrier (baggie) was configured properly and was holding positive purge pressure. There were no accumulations of ice/frost on the acreage areas of the umbilical. Ice/frost fingers 4 inches in length had formed on the separation bolt pyrotechnic canister purge vents. Normal venting of nitrogen purge gas had occurred during tanking, stable replenish, and launch.

Ice/frost had formed in both LH2 feedline bellows and on the straight section, in the LH2 recirculation line bellows, and on both burst disks.

Isolated ice/frost formations were present on the inboard, top, and outboard sides of the LH2 ET/ORB umbilical purge barrier. Ice/frost fingers 4-6 inches in length had formed on the pyro canister and plate gap purge vents. A small amount of ice/frost had formed on the aft pyrotechnic canister bondline. Thin foam exists in this area due to an incorrect mold manufacture. The amount and location of the ice/frost was acceptable for launch per the NSTS-08303 criteria. (The problem exists through end item EI-66. The mold will be changed to add more foam for EI-67 and subs. An EI spec waiver will be issued for STS-45 and subs until existing items are expended. STS-42's umbilical was approved for use by local PMRB.) Normal venting of helium purge gas had occurred during tanking, stable replenish, and launch. There were no unusual vapors emanating from the umbilicals nor any evidence of cryogenic drips. No ice or frost was present on the cable tray vent hole. The 17-inch flapper valve actuator access port foam plug was properly closed out with no ice/frost on the bondline.

The ET/ORB hydrogen detection sensor tygon tubing was in proper position prior to removal. The tubing was successfully removed from the vehicle with no flight hardware contact or TPS damage.

The summary of Ice/Frost Team observations/anomalies consisted of 3 OTV recorded items:

Anomaly 001 documented an ice/frost formation at the ET/ORB LH2 umbilical aft pyro canister closeout along the forward bondline. The condition was acceptable per NSTS-08303.

Anomaly 002 (documentation only) recorded ice/frost formations on the LO2 and LH2 ET/ORB umbilicals pyro canister purge vents, LH2 feedline bellows, LH2 recirculation line bellows, and LH2 purge barrier baggie. These formations were acceptable per NSTS-08303.

Anomaly 003 (documentation only) recorded ice/frost formations in the LO2 feedline bellows and support brackets. These formations were acceptable per NSTS-08303.

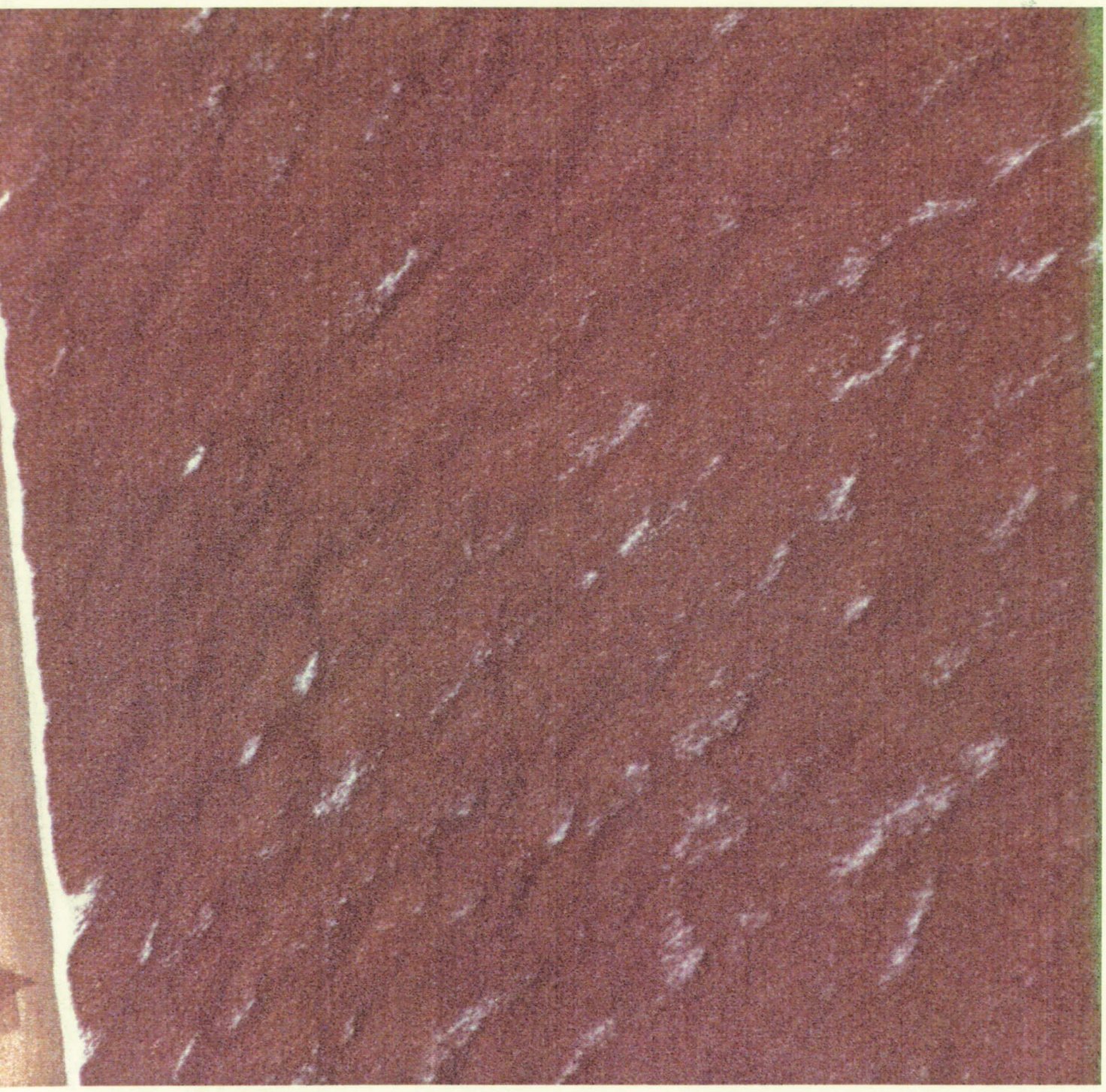
4.5 FACILITY

All SRB sound suppression water troughs were filled and properly configured for launch. There was no debris on the MLP deck or in the SRB holddown post areas.

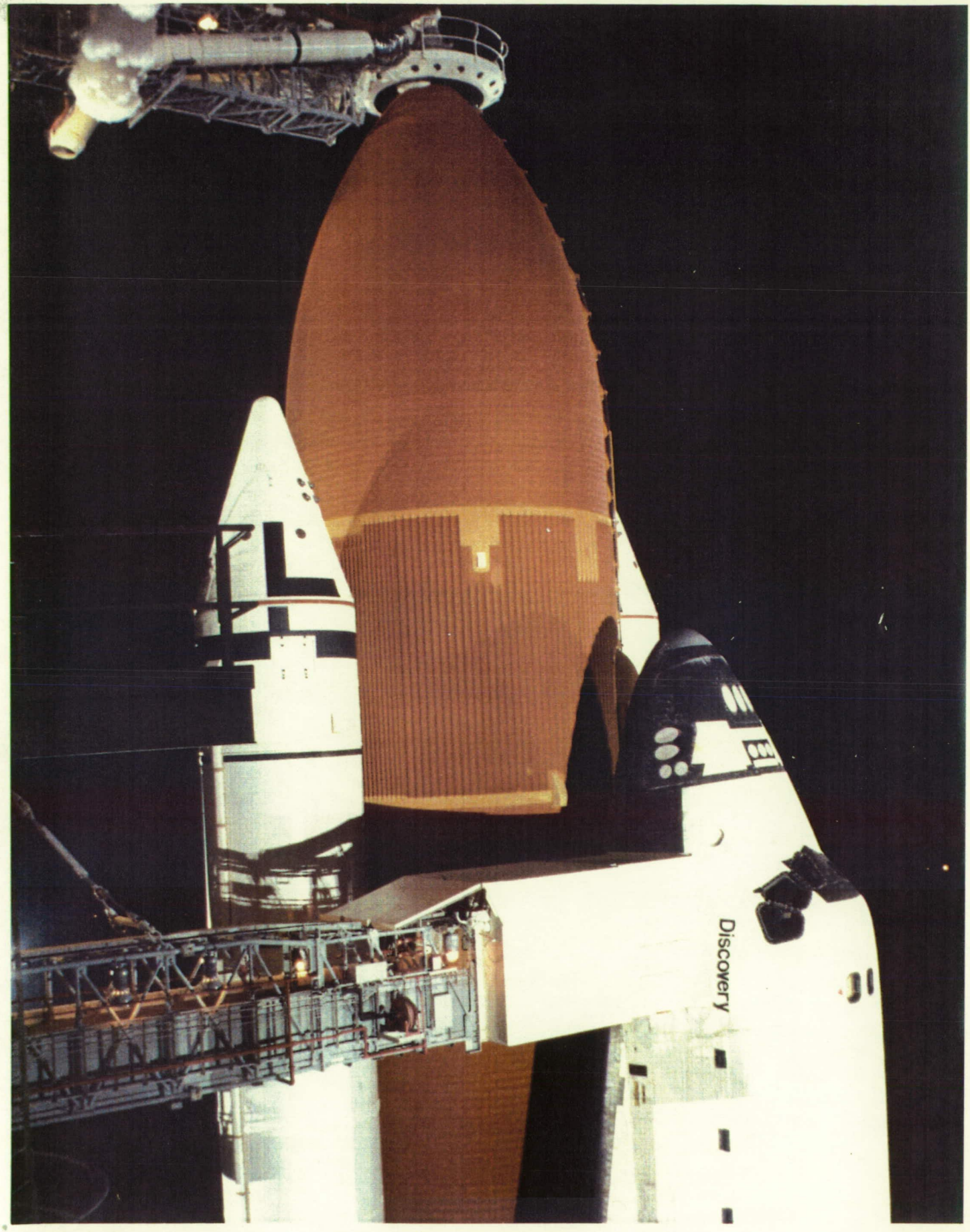
No leaks were observed on either the LO2 or LH2 Orbiter T-0 umbilicals, though typical accumulations of ice/frost were present on the cryogenic lines and purge shrouds. There was also no apparent leakage anywhere on the GH2 vent line or GUCP. The GH2 vent line modification prevented ice from forming, but some ice/frost, which was expected, had accumulated on the GUCP legs and on the uninsulated parts of the umbilical carrier plate.

Visual and infrared observations of the GOX seals confirmed no leakage. No ET nosecone/footprint damage was visible after the GOX vent hood was retracted. Small icicles less than 3/4-inch in length had formed on the north GOX vent duct during cryoload, but had melted before launch.

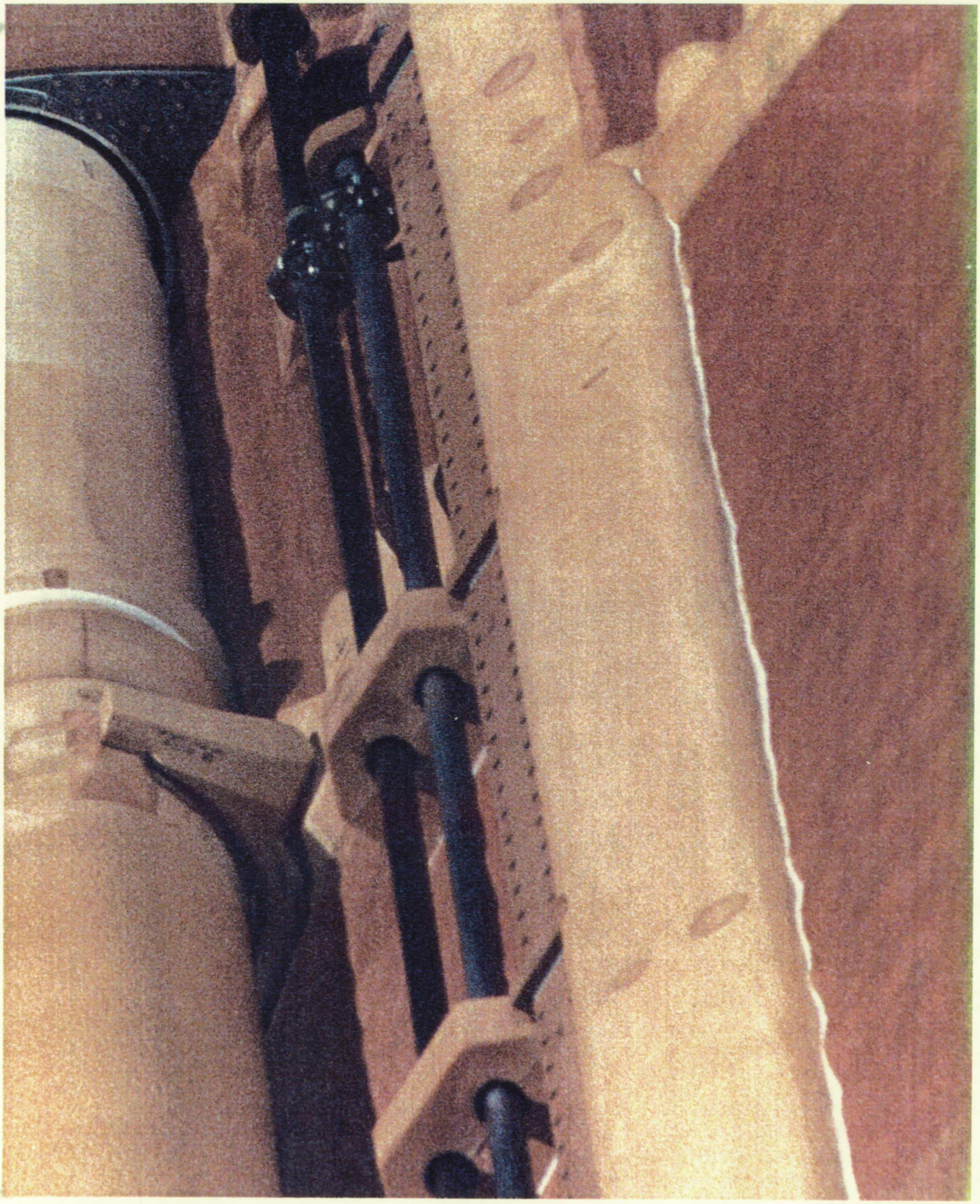
Overall view of OV-103, ET-52 (LWT 45), and BI-048 SRB's. Isolated patches of frost had accumulated on the TPS acreage of the ET LH2 tank.



Isolated patches of frost on the ET LH2 tank TPS acreage (+Y+Z quadrant) had melted prior to launch as the ambient temperature increased.

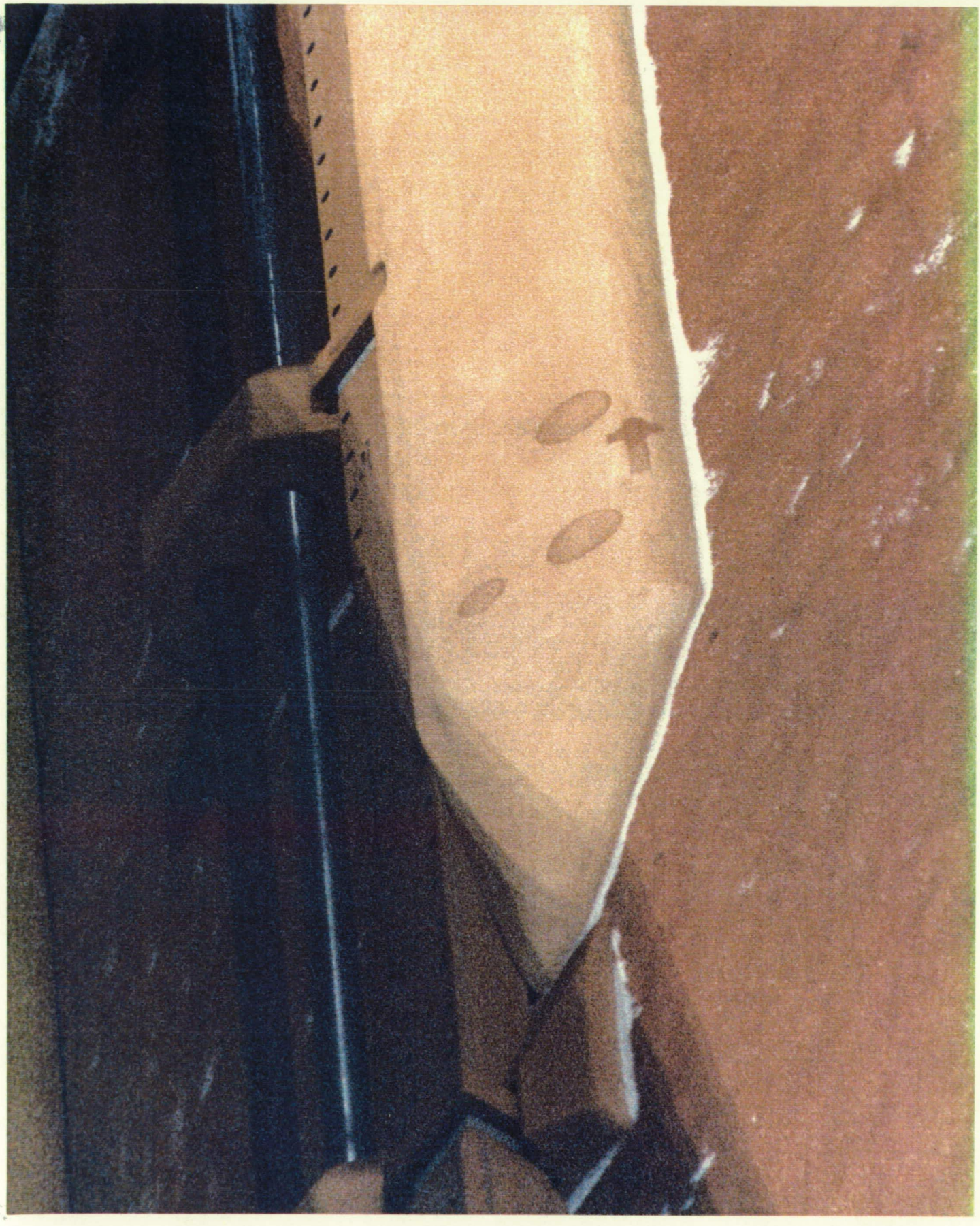


Light condensate, but no ice or frost, had accumulated on the ET LO2 tank



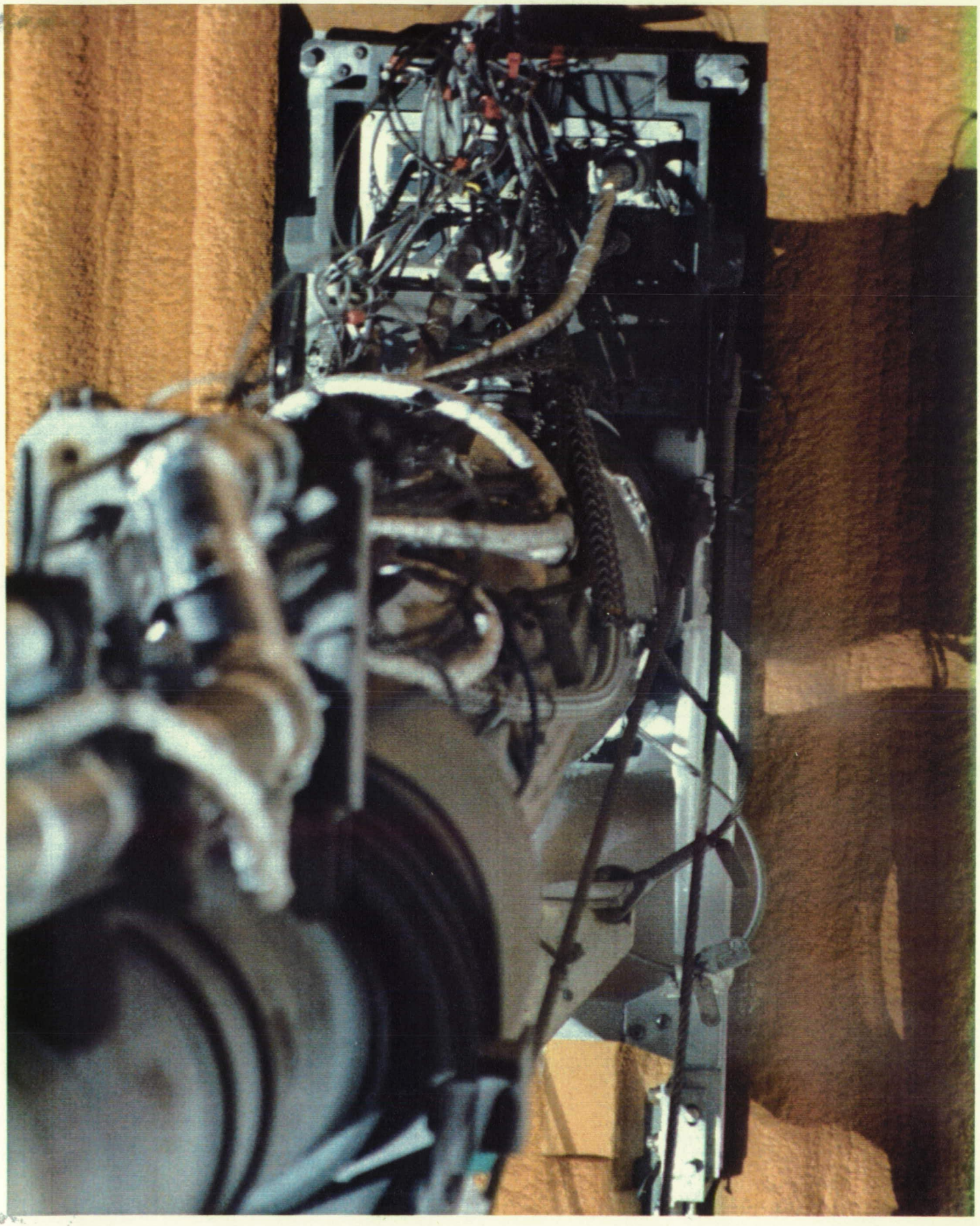
Ice/frost had formed along the bondline of the PAL ramp. Ice/frost accumulations in the LO2 feedline support bracket and upper bellows were acceptable per the NSTS-08303 criteria.

Ice/frost accumulations on the LH2 tank acreage and along the PAL ramp had melted prior to launch. Ice/frost formations in the LO2 feedline support brackets were acceptable per the NSTS-08303 criteria.



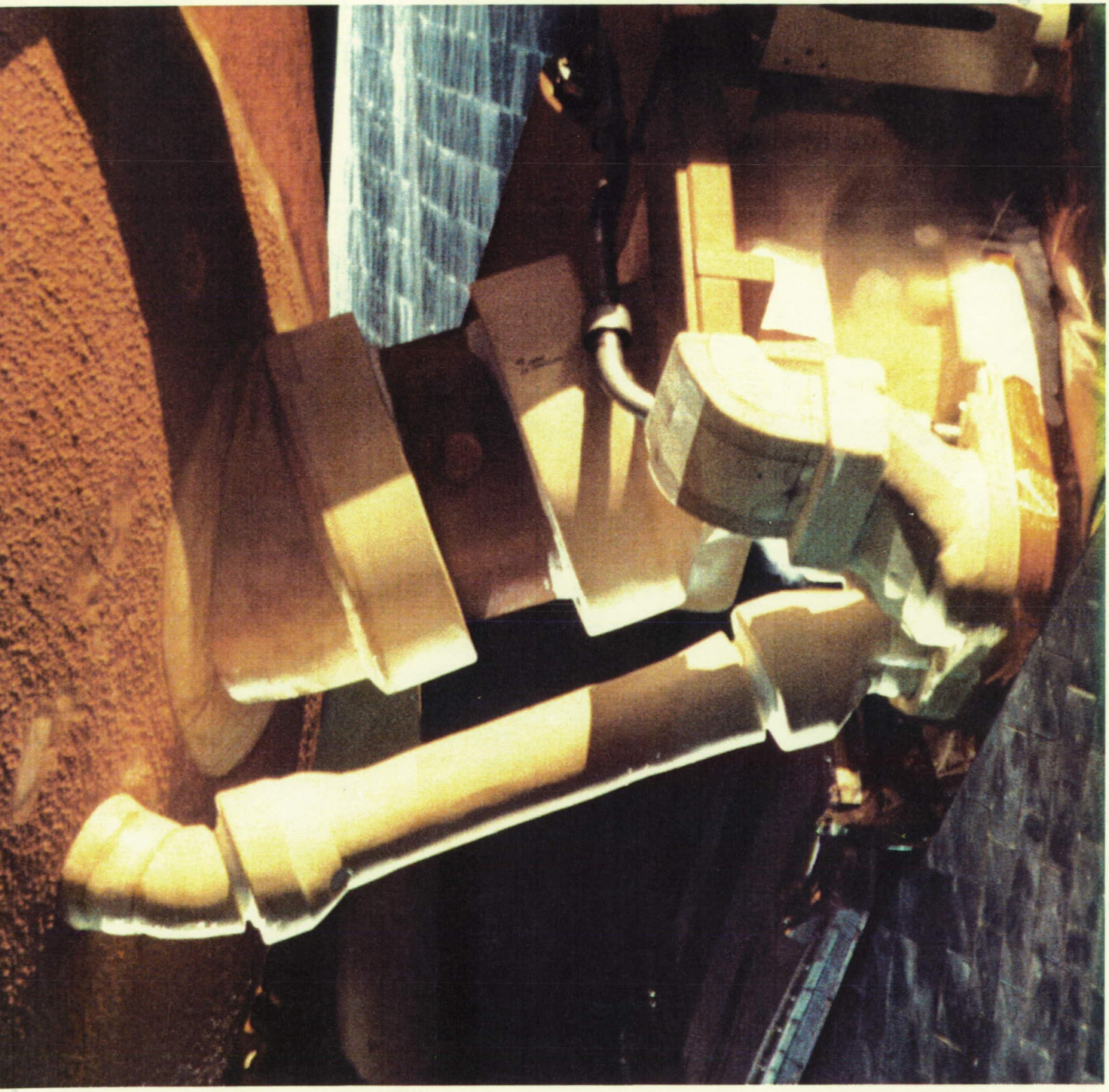
Ice/frost accumulations along the PAL ramp, cable tray ramps, pressurization line supports, and on the LH2 tank TPS acreage had melted prior to launch.

Ice/frost formation along the -Y bipod ramp closeout outboard and aft bondline was acceptable per the NSTS-08303 criteria.

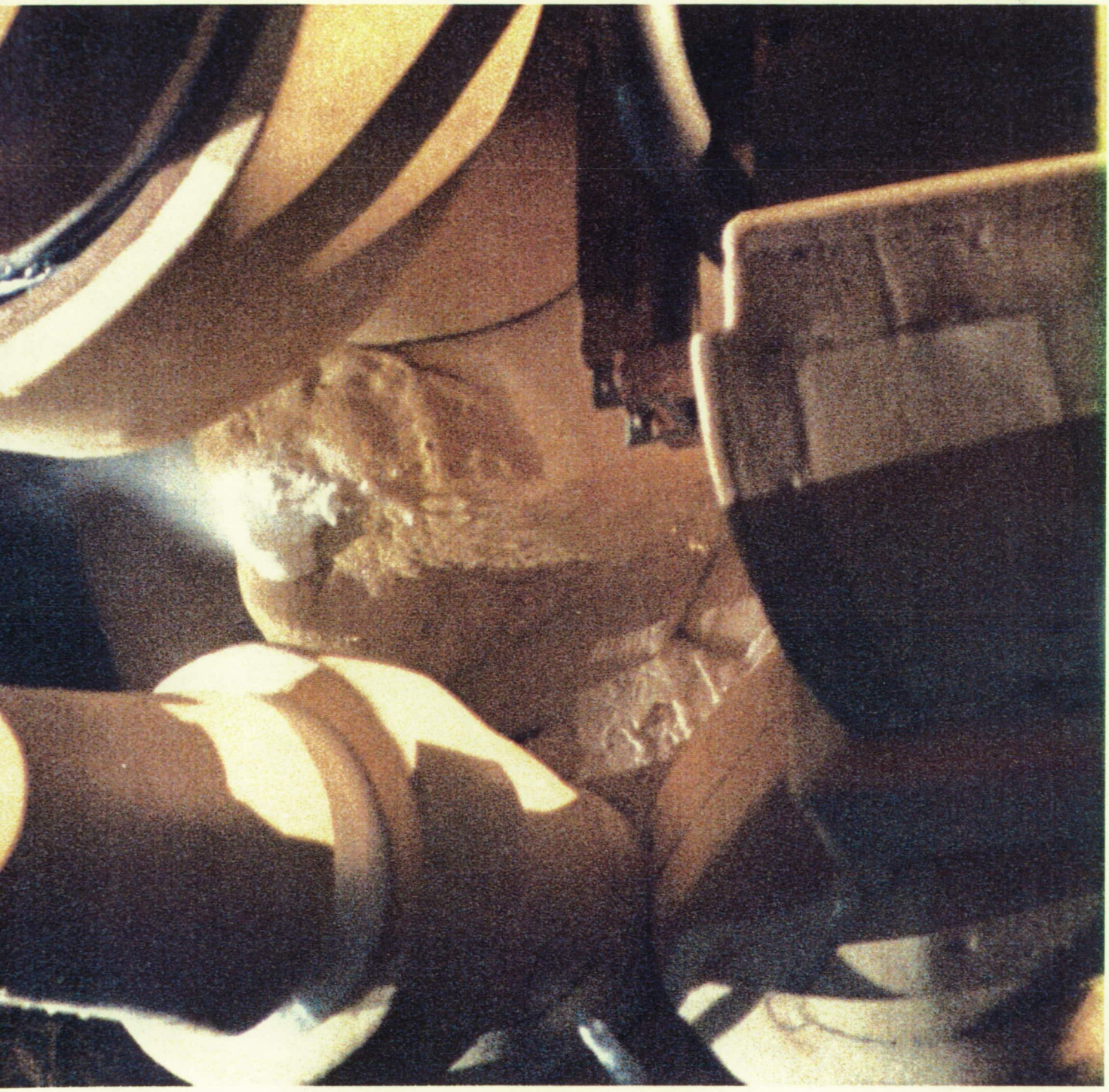


There was no apparent leakage at the GUCP. As expected, ice/ frost had formed on the GUCP legs and on the uninsulated parts of the umbilical carrier plate.

Crusty, somewhat denser than usual ice/frost had formed in the LO2 feedline bellows. Although the amounts of ice/frost in the bellows were slightly greater than usual, the accumulations were acceptable per the NSTS-08303 criteria.



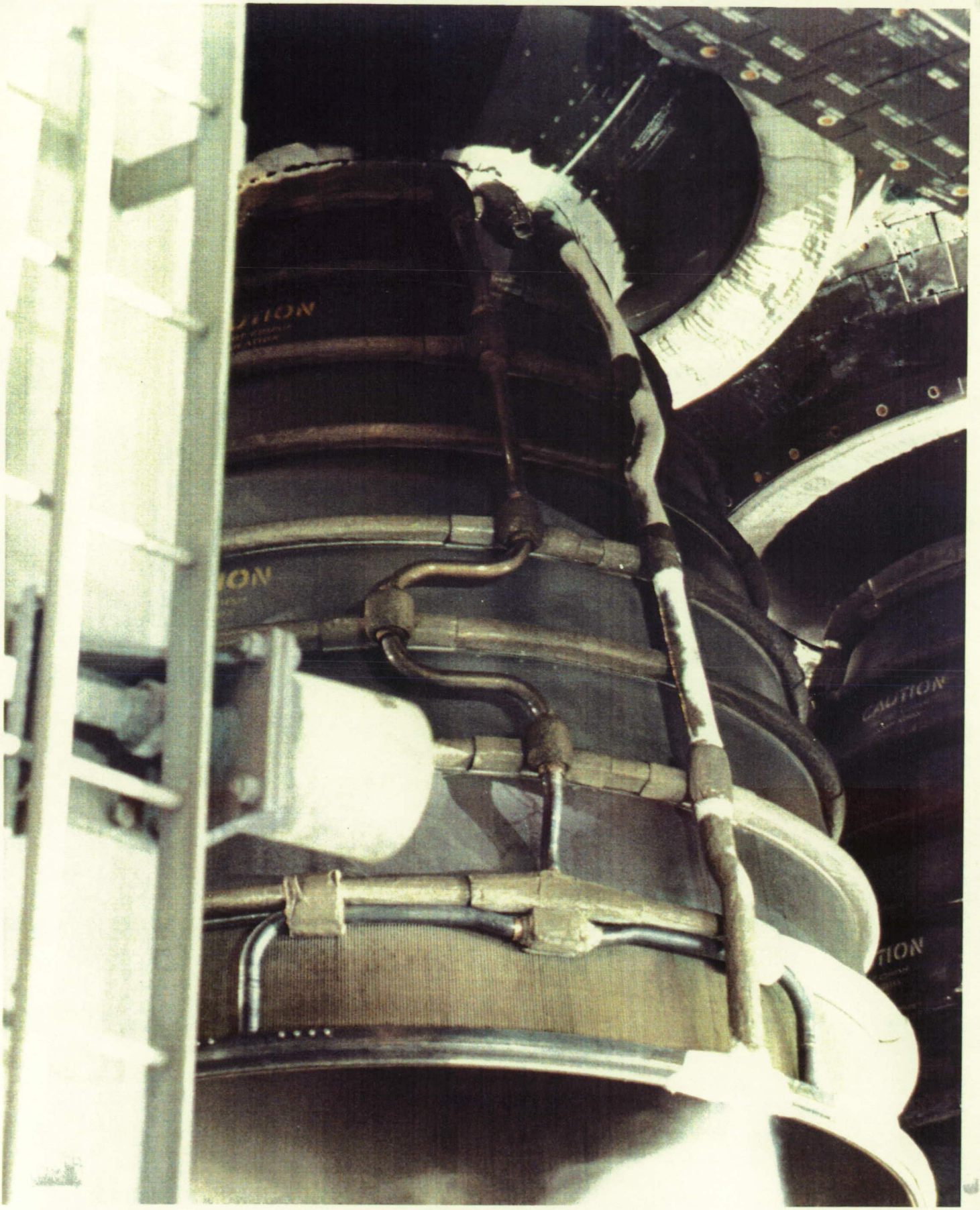
Overall view of the LH2 ET/ORB umbilical. There were no unusual vapors emanating from the umbilical nor any evidence of cryogenic drips. Ice/frost accumulations in the recirculation line bellows, on the burst disks, on the umbilical purge vents, and on the top side of the umbilical were typical.



Ice/frost formations on the lower plate gap purge vent, the aft pyro canister purge vent, and in the LH2 recirculation line bellows were typical. The cable tray vent hole and 17-inch flapper valve actuator tool access port closeout exhibited no ice or frost accumulations.

Overall view of ET aft dome apex and manhole covers

Overall view of the SSME's, RH OMS nozzle, RH RCS stinger



Frost coated the SSME #2 drain line and engine-mounted heat shield-to-nozzle interface along the full circumference. Some condensate was also present on the engine mounted heat shield.

5.0 POST LAUNCH PAD DEBRIS INSPECTION

The post launch inspections of the MLP, FSS, Pad apron, and areas within the Pad perimeter fence were conducted on 22 January 1992 from Launch+1.5 to 4 hours. No TPS materials were found. The only flight hardware recovered consisted of an SRB holddown post frangible nut web (2.0 x 0.25 inches) laying on top of the HDP #2 stud.

SRB plume erosion of the south holddown posts was typical. All south HDP EPON shim material was intact, but slightly debonded at the sidewalls on HDP #1, #2, and #6. Numerous voids were visible in the EPON shim sidewall material on HDP #1 and #2. There was no visual indication of a stud hang-up on any of the south holddown posts. All of the north post doghouse blast covers were in the closed position and exhibited minimal erosion. The SRB aft skirt purge lines were in place but slightly damaged. The SRB T-0 umbilicals and connector saver sacrificial pieces showed normal plume impingement effects.

The GOX vent arm, OAA, and TSM's showed the usual minor amount of damage. The GH2 vent arm was latched on the eighth tooth of the latching mechanism and had no loose cables (static retract lanyard). The GH2 vent line appeared to have retracted normally and showed typical signs of SRB plume impingement. The ET intertank access structure also sustained typical plume heating effects.

Damage to the facility appeared to be less than usual and included:

1. Fire brick from the SRB flame trench was scattered across the pad acreage north to the perimeter fence.
2. A metal lighting fixture was detached from a location over the stairwell and was found on the FSS 95 foot level
3. Three metal signs from the FSS 155 and 255 foot levels were found on the grating.
4. Typical amounts of facility nuts, bolts, pins, and line caps were found on the pad apron and were probably not a threat to the vehicle.

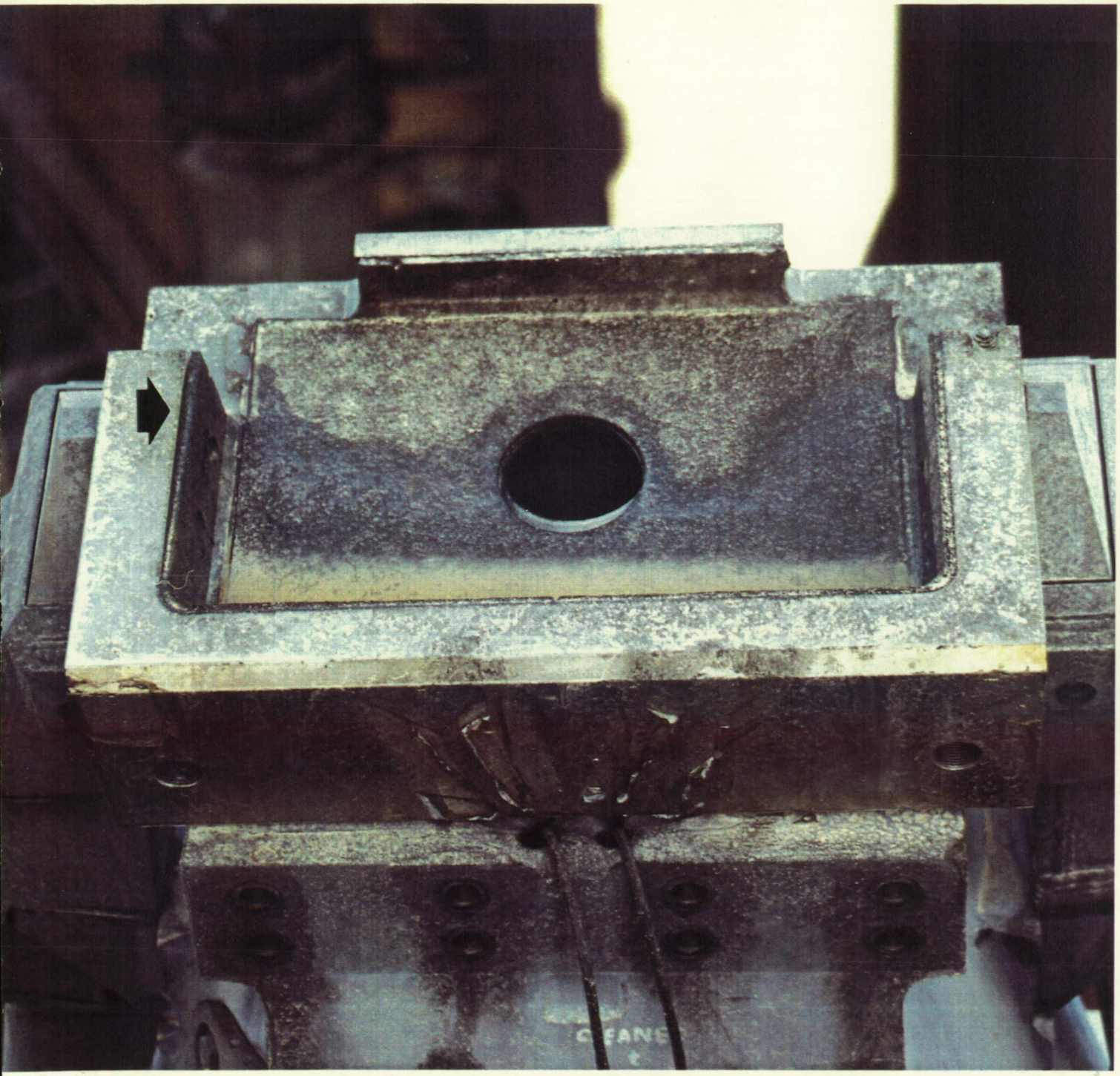
All seven emergency egress slidewire baskets were secured on the FSS 195 foot level and sustained no launch damage.

MLP-3 was configured with overpressure sensors at the top of both TSM's, at the bottom of both SRB exhaust holes, and at the bottom of the SSME exhaust hole. All sensor readings were consistent with previous launches and within nominal limits.

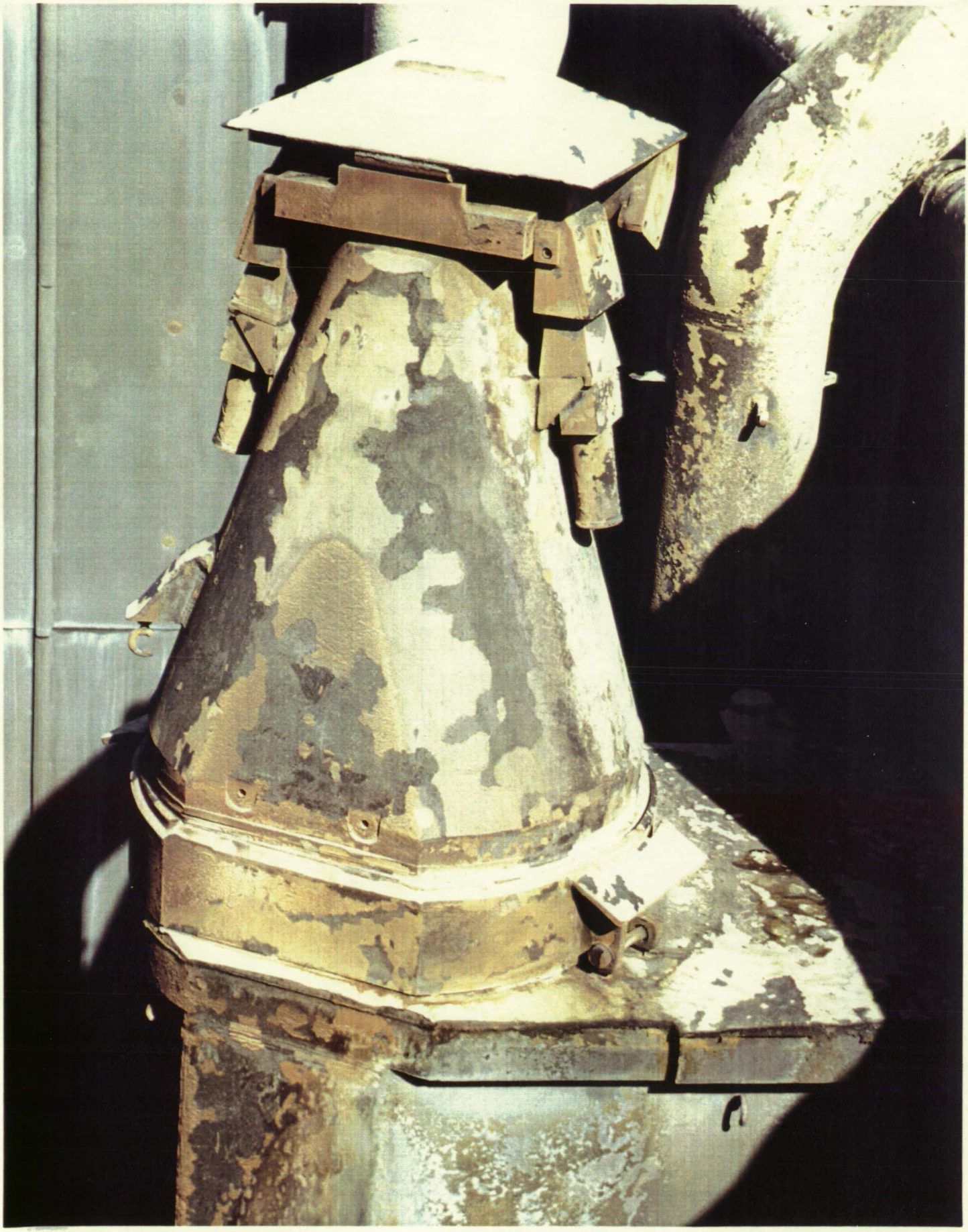
Inspection of the pad was completed on 23 January 1992 along with the areas outside the pad perimeter, railroad tracks, the beach from UCS-10 to the Titan complex, the beach access road, and the ocean areas under the vehicle flight path. No flight hardware or TPS materials were found.

Patrick AFB and MILA radars were configured in a mode for increased sensitivity for the purpose of observing any debris falling from the vehicle during ascent but after SRB separation (due to the masking effect of the SRB exhaust plume). Most of the signal registrations were very weak and often barely detectable, which generally compares with the types of particles detected on previous Shuttle flights. A total of 53 particles were imaged in the T+143 to 368 second time period. Nineteen of the particles were imaged by only one radar, 22 particles were imaged by two radars, and 12 particles was imaged by all three radars.

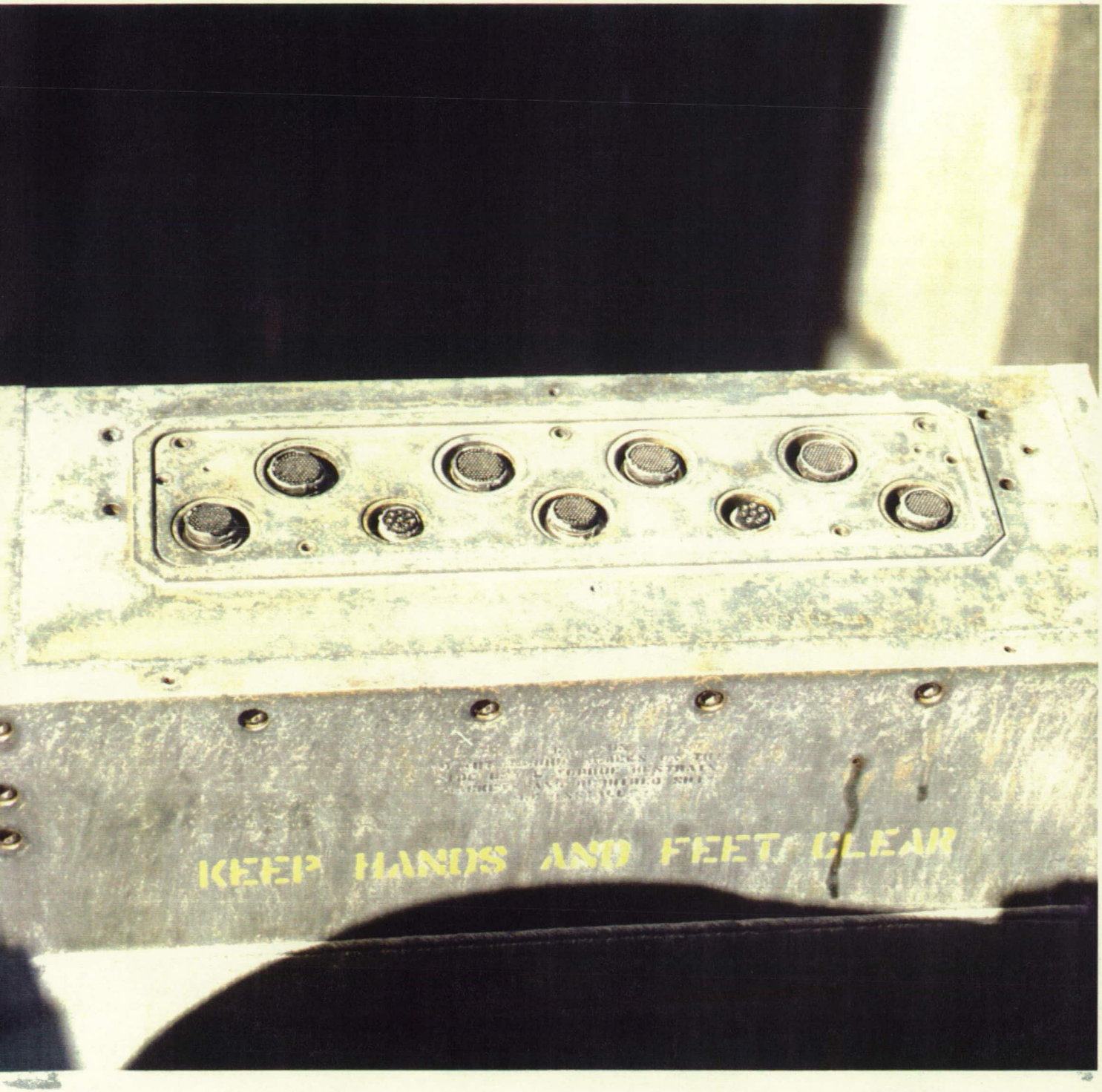
Post launch pad inspection anomalies are listed in Section 10.



Plume erosion of the south SRB holddown posts was typical. EPON shim material was intact, but slightly debonded from the holddown post shoe sidewalls on HDP #1, #2, and #6. There was no visual indication of a stud hang-up on any of the south holddown posts.



North HDP blast covers were in the closed position and exhibited typical SRB plume erosion effects



Post launch condition of the SRB T-0 umbilical carrier plate and electrical connector sacrificial pieces

Typical post launch debris included SRB holddown post frangible nut web (2.0x0.25 inches), SRB throat plug material, facility bolts and hardware, pneumatic line caps/covers, and strips of insulation.

6.0 FILM REVIEW AND PROBLEM REPORTS

A total of 132 film and video data items, which included forty-nine videos, fifty 16mm films, twenty-seven 35mm films, and six 70mm films were reviewed starting on launch day.

One IFA was generated as a result of the film and video data review. On-orbit views of the External Tank showed two divots, approximately 8-12 inches in diameter, outboard of the -Y bipod ramp and forward of the LH2 tank-to-intertank flange in the intertank acreage (-Y+Z quadrant). The intertank TPS should remain intact with no loss of material during ascent. Although there is no photographic data showing the condition of the ET TPS in the +Y+Z quadrant, SOFI debris from the External Tank intertank and/or lower LO2 tank is the most likely cause of the Orbiter tile damage.

Post Launch Anomalies observed in the Film Review were presented to the Mission Management Team, Shuttle managers, and vehicle systems engineers. These anomalies are listed in Section 10.

6.1 LAUNCH FILM AND VIDEO SUMMARY

No major vehicle damage or lost flight hardware was observed that would have affected the mission.

Helium purge vapors and ice build-up on the LH2 ET/ORB umbilical had been typical during tanking, stable replenish, flight pressurization, and launch. There were no unusual vapors or cryogenic drips (OTV 009, 054, 063).

SSME ignition and Mach diamond formation appeared normal. Free burning hydrogen drifted upward to the OMS pods and under the body flap (RSS STI, C/S-2 STI, E-2, 3, 19, 20).

SSME ignition caused numerous pieces of ice/frost to fall from the ET/Orbiter umbilicals. Some pieces of ice appeared to contact the umbilical cavity sill and were deflected outward. No damage to Orbiter tiles or ET TPS was visible (OTV 009, 054, 063, 064). Pieces of ice continued to fall from the umbilical area after liftoff.

SSME ignition vibration/acoustics caused the loss of tile surface coating material from six locations on the OMS nozzle heat shield and Orbiter base heat shield (E-23, 24).

SSME ignition caused 6-7 pieces of ice to shake loose from the uninsulated parts of the GUCP (E-35). Other film items (E-26, 4, and 12) showed light colored objects falling to the MLP deck and may be pieces of ice from the GUCP or the uninsulated GH2 vent line elbow in the ET intertank access structure. None of these objects appeared to contact the Orbiter. The light

colored object, most likely ice from the GUCP or the GH2 vent line, previously observed in film item E-12 was also visible in film item E-13. The object fell into the LH SRB exhaust hole near HDP #6.

Light frost was present in the southwest (-Y) ET GOX vent louver. There was no TPS damage to the ET nose cone acreage, footprint, or fairing (OTV 061, 062). Vehicle twang (approximately 33 inches) was typical (E-79).

Light colored mark on LH wing/elevon interface may be a piece of tape. SSME ignition appeared normal (E-76).

There were no major facility anomalies. The Orbiter LH2 and LO2 T-0 umbilicals disconnected and retracted properly (OTV 049, 050). GUCP disconnect from the External Tank was nominal (OTV 004). The GH2 vent line appeared to latch normally with no rebound (OTV 060). No swing arms or other pad structures contacted the vehicle during liftoff. Separation of the GUCP from the External Tank was nominal. The GH2 vent arm retracted and latched properly. There was no excessive slack in the static retract lanyard (E-31, 33, 41, 42, 50).

There was no evidence of stud hang-ups on any of the holddown posts. No debris fell from the DCS/stud holes. Closure of north holddown post doghouse blast covers was nominal. A small dark particle, which may have been a K5NA trimming or piece of shim putty, originated near the HDP #1 shoe and fell into the SRB exhaust hole (E-9, 12). A piece of instafoam from the LH SRB aft skirt near HDP #7 came loose after T-0 (E-28).

Separation of the SRB T-0 umbilicals from the aft skirts was nominal. The separation planes remained generally parallel during retraction. The connector savers were flush with the plate (EX2, EX3).

Six thin, rectangular, flexible objects appeared out of the SRB exhaust holes/sound suppression water troughs (three pieces near HDP #5/HDP #7 and three more pieces near HDP #6/HDP #8). Although not orange in color like the water trough material, the objects may be related to the installation of the water troughs (E-12, 16). The thin, rectangular, flexible objects in film item E-16 that appeared out of the SRB exhaust holes/sound suppression water troughs were also visible in film items E-11 and E-14. These objects may be cloth part tags from the SRB sound suppression water troughs. Cord from the water troughs appeared in film item E-10 near holddown post #3. A 6"x4" piece of instafoam broke away near the inboard edge of HDP #7 (E-11).

A white particle, probably an RCS paper cover or piece of ice, was visible near the SSME plume after the roll maneuver (TV-4). A light colored particle, appearing out of the RH SRB plume after the roll maneuver, was most likely a piece of SRB aft skirt instafoam (TV-21).

Film item E-60 confirmed that water flowed properly from all MLP rainbirds.

Flashes occurred in the SSME plume during ascent at 19 and 34 seconds MET (E-54, 213, 223, 224).

Clusters of particles falling aft of the Orbiter after completion of the roll maneuver were traced to the forward RCS thrusters and were pieces of RCS paper covers. Other pieces of RCS paper covers were visible passing over the Orbiter wings. Pieces of ET/ORB purge barrier baggie material were also visible caught in the aerodynamic recirculation and falling aft of the vehicle (E-54, 59, 212, 213, 222, 223).

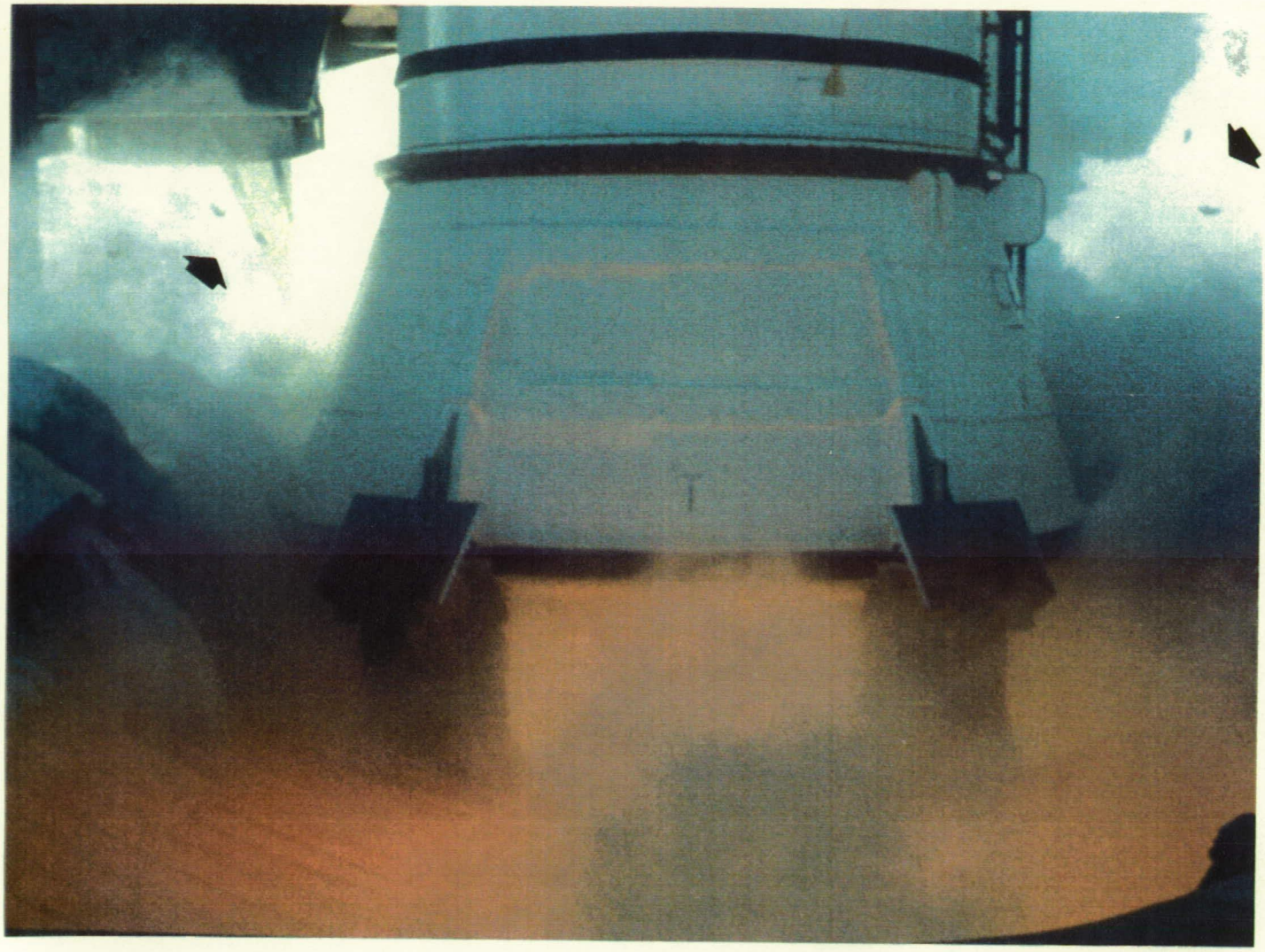
Just after the roll maneuver and during ascent, over 100 light colored particles dropped out of the SRB plume. These particles appeared to have low densities and are believed to be pieces of SRB aft skirt instafoam (E-59).

SSME closeout blankets appeared intact while in view (E-212). One piece of thermal curtain tape was loose on the LH SRB aft skirt (E-212).

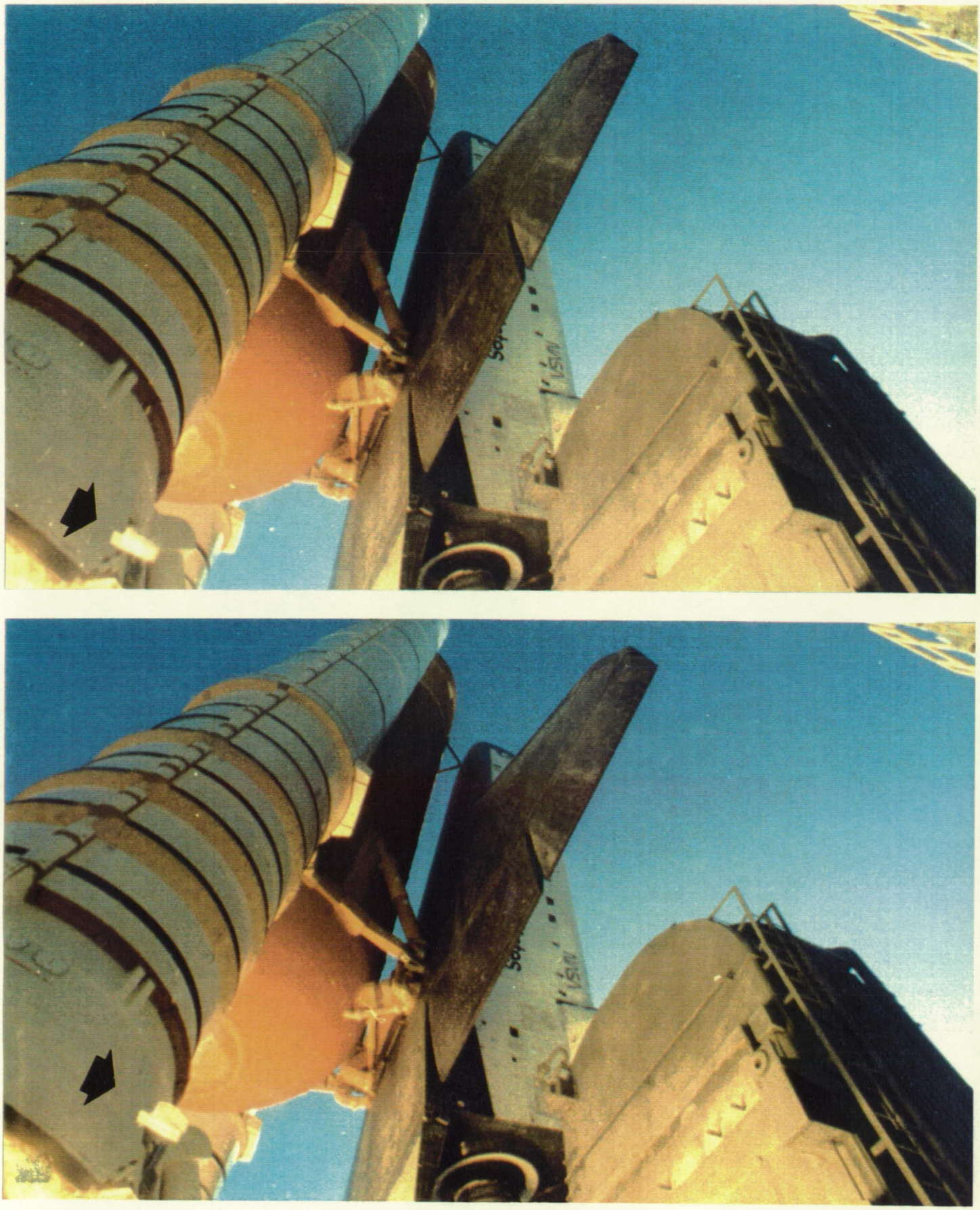
Movement of the body flap appeared similar in amplitude and frequency to that observed on previous flights (E-207, 212).

Optical linear distortions appeared in film item E-207. This phenomenon has been observed on previous flights.

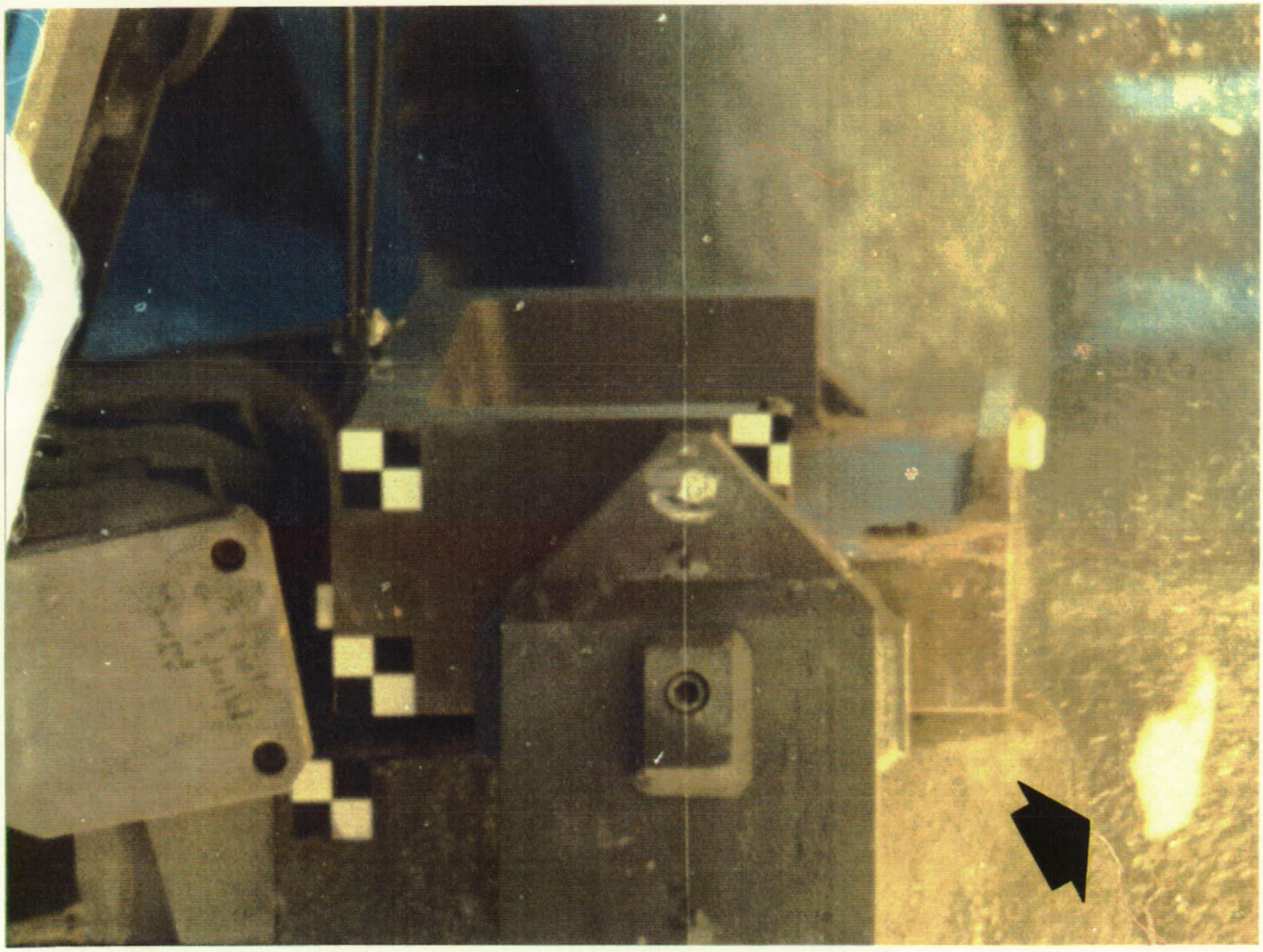
Localized flow condensation appeared on the vehicle during ascent. ET aft dome charring, exhaust plume recirculation, and SRB separation appeared nominal (E-207, E-204, 205, 206). MSFC and JSC reported apparent orange flashes near the RH SRB ET attach ring approximately 5 seconds after separation. These flashes may be the result of looking through the plume of the LH SRB. Examination of the recovered RH SRB, particularly the areas of the aft booster, ET attach ring, nozzles, and TVC revealed no hardware damage and no likely sources for the flashes.



Thin, flexible, light-colored objects appeared out of the SRB exhaust holes/holddown post haunch areas after T-0 and were identified as cloth part tags attached to the sound suppression water troughs (Film item E-16)



Thin, light-colored object with straight edges in this film item E-26 view may be one of the cloth part tags from the SRB sound suppression water troughs that were visible in film E-16.



Film item E-28 showed a piece of instafoam breaking loose after liftoff from the LH SRB aft skirt near Holddown Post #7.

6.2 ON-ORBIT FILM AND VIDEO SUMMARY

OV-103 was not equipped to carry ET/ORB umbilical separation cameras.

Review/analysis of on-orbit photography included twenty-nine 70mm still photos taken by the crew (DTO-0312). The images were generally dark and the focus was soft. In addition, 16mm motion picture footage was also taken by the crew. Camera shake prevented detail from being discernible.

No major vehicle damage or lost flight hardware was observed that would have been a safety of flight concern.

Two light spots in the intertank -Y+Z quadrant acreage outboard of the -Y bipod ramp and forward of the intertank-to-LH2 tank flange closeout appeared to be possible divots 8-12 inches in diameter.

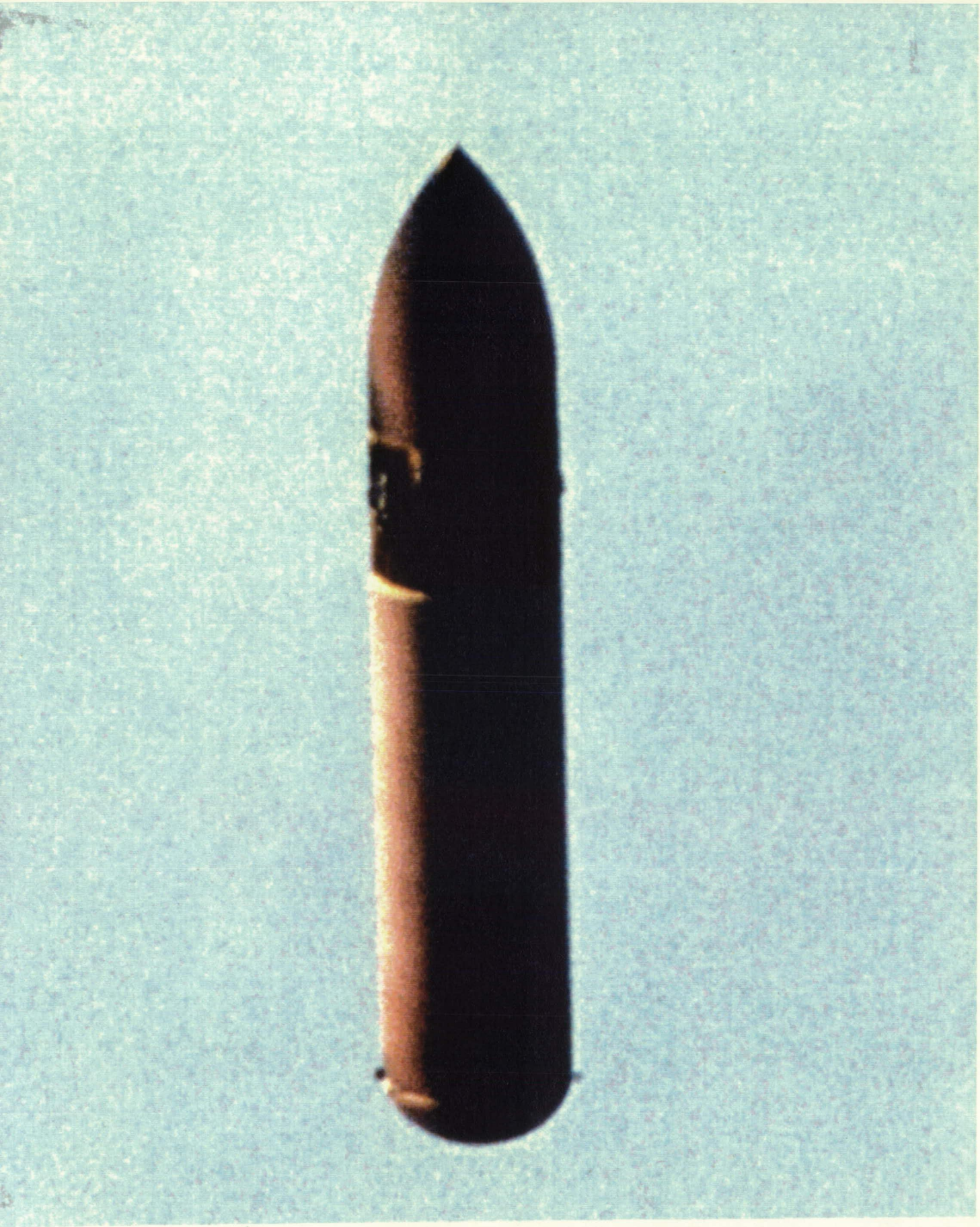
There were no apparent anomalies on the LO2 tank, LH2 tank, and aft dome TPS acreage. The BSM burn scars were typical. The nosecone, intertank access door, GH2 umbilical carrier plate, ET/SRB forward attach points, and RSS antennae were in nominal configuration.

The +Y+Z quadrant of the ET was not photographed.

6.3 LANDING FILM AND VIDEO SUMMARY

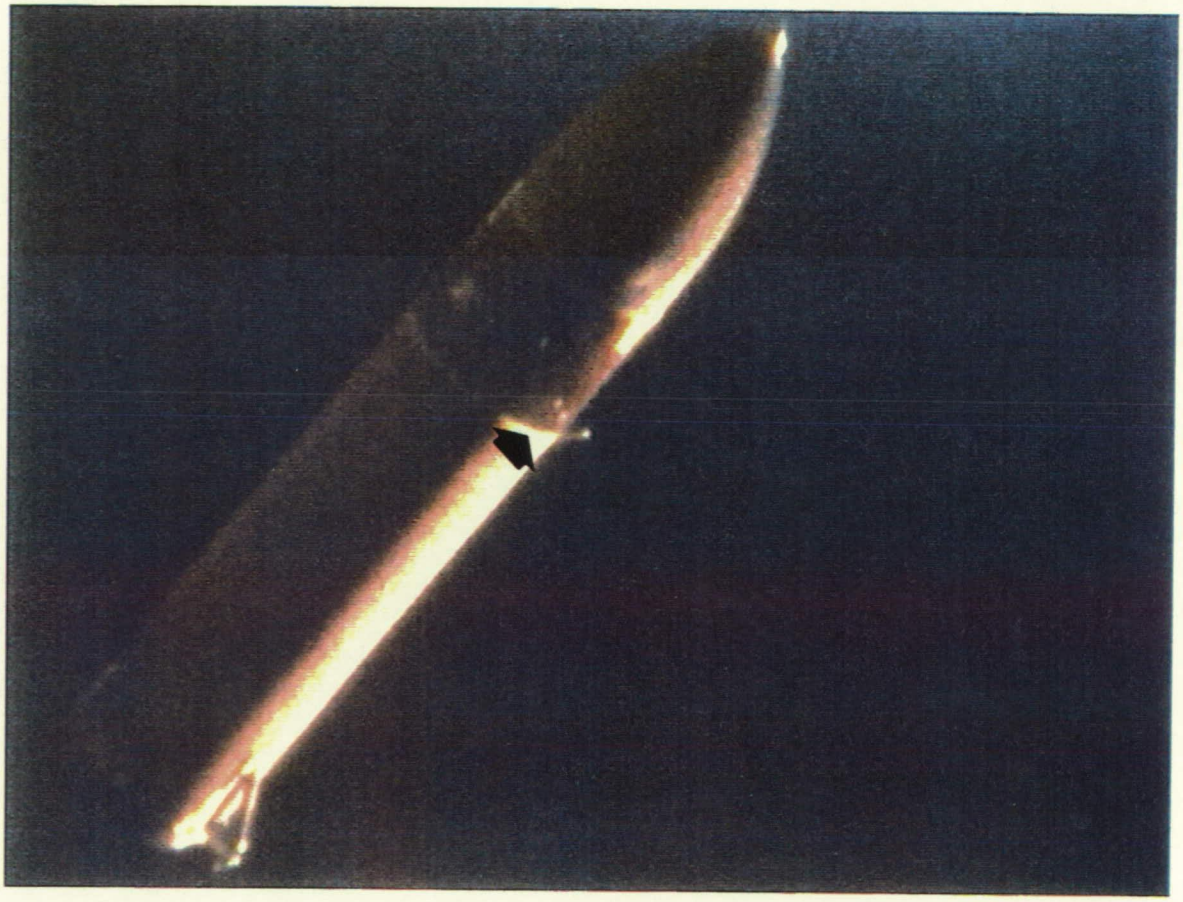
Orbiter performance in the Heading Alignment Circle (HAC) and final approach was nominal. No anomalies occurred during landing gear extension and wheel touchdown.

Both main landing gear touched down almost simultaneously with the right side slightly ahead of the left gear. Touchdown of the nose gear was smooth. There were no vehicle anomalies or unusual control surface deflections during the rollout.

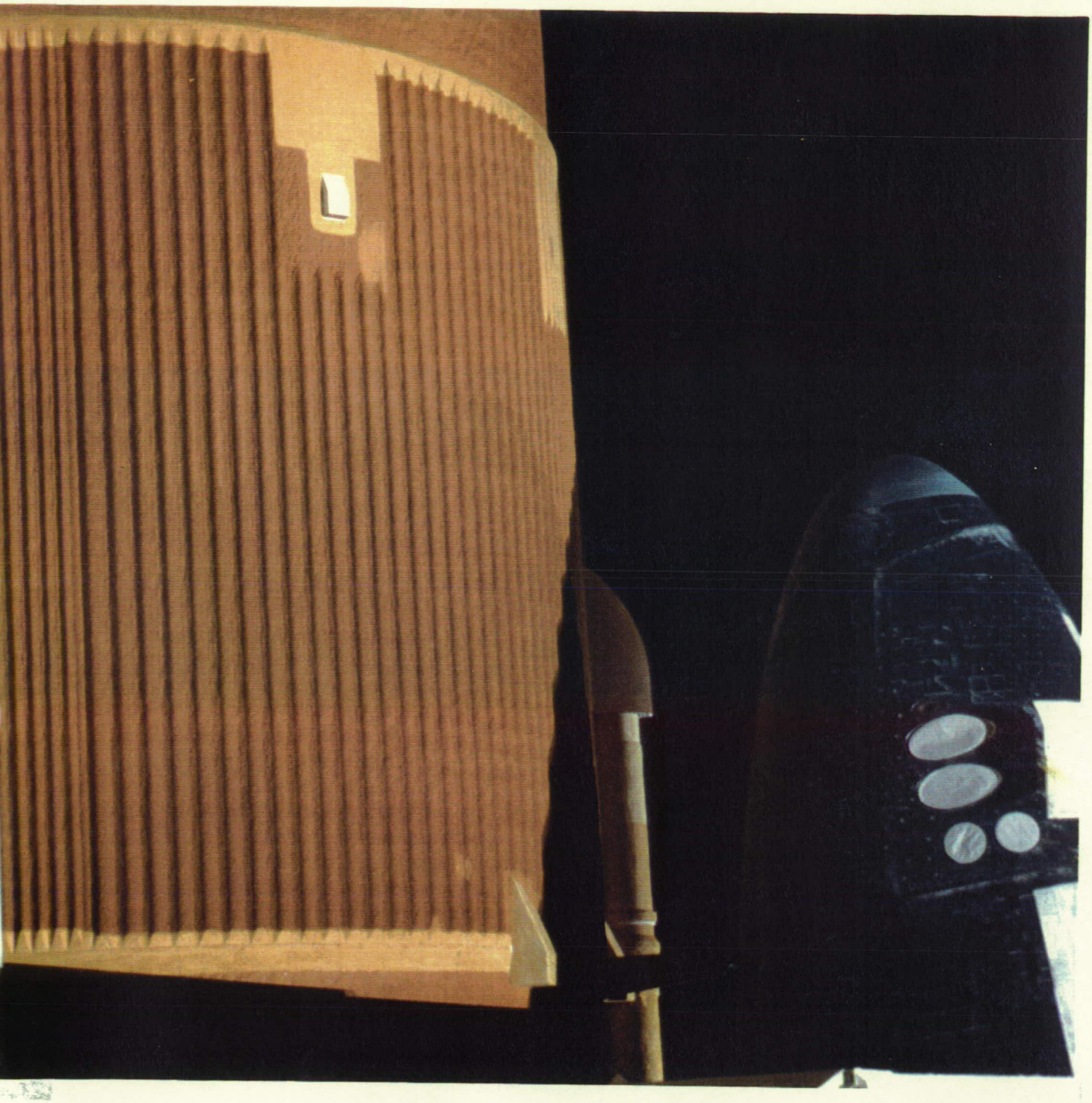


On-orbit view of the External Tank shortly after separation from the Orbiter. No major damage or lost flight hardware was observed that would have been a safety-of-flight concern.

Two light spots in the intertank -Y+Z quadrant acreage outboard of the -Y bipod ramp and forward of the intertank-to-LH2 tank flange closeout appeared to be possible divots 8-12 inches in diameter. No anomalies were visible on the nosecone or LO2/LH2 tank acreage areas.



View of External Tank -Y side showed the two divots in the intertank acreage near the bipods. Other bright features in the intertank area are the RSS antenna panel, -Y ET/SRB attach fitting, flight door, and aero vent panel.



View of External Tank -Y+Z quadrant showed no intertank TPS acreage anomalies after the vehicle had been cryoload that would account for the divots observed in the on-orbit photos.

7.0 SRB POST FLIGHT/RETRIEVAL DEBRIS ASSESSMENT

Both Solid Rocket Boosters were inspected for debris damage and debris sources at CCAFS Hangar AF on 27 January 1992 from 0800 to 1100 hours. From a debris standpoint, both SRB's were in excellent condition.

7.1 RH SOLID ROCKET BOOSTER DEBRIS INSPECTION

The RH frustum was missing no TPS but had 14 MSA-2 debonds over fasteners. There was minor localized blistering of the Hypalon paint (Figure 4). All BSM covers were locked in the fully opened position.

The RH forward skirt exhibited no debonds or missing TPS. The phenolic plates on both RSS antennae were intact. The forward separation bolt and electrical cables appeared to have separated cleanly. No pins were missing from the frustum severance ring. Minor blistering of the Hypalon paint occurred around the ET/SRB attach point and systems tunnel cover (Figure 5).

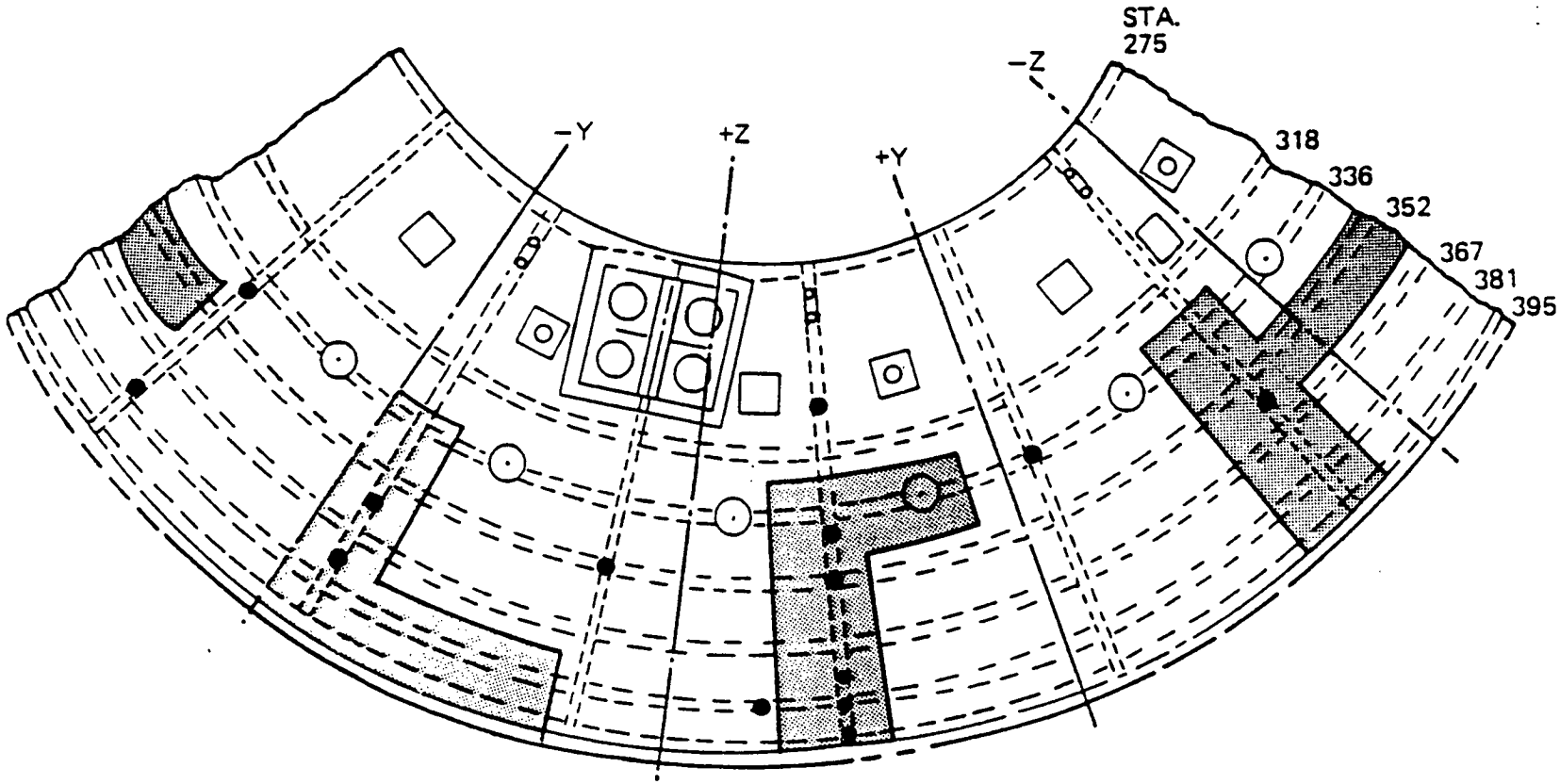
The Field Joint Protection System (FJPS) closeouts were generally in good condition. Minor trailing edge damage to the FJPS and the GEI cork runs were attributed to debris resulting from severance of the nozzle extension.

Separation of the aft ET/SRB struts appeared normal. The ET/SRB aft struts, ETA ring, IEA, and all three aft booster stiffener rings appeared undamaged. A 6"x3" area of TPS on the forward side of the upper strut fairing at the separation plane was missing and the substrate was charred. The loss of TPS in this area may have occurred during strut separation. The aft booster stiffener ring splice plate closeouts were intact and no K5NA material was missing prior to water impact.

The phenolic material on the kick ring was intact and had not delaminated. Two K5NA protective domes between HDP #1 and #3 were lost from bolt heads on the aft side of the phenolic kick ring prior to water impact (sooted substrate). The aft skirt acreage TPS was generally in good condition. K5NA was missing from all aft BSM nozzles (Figure 6).

The HDP #3 Debris Containment System (DCS) plunger was not seated. This was the fifth flight utilizing the optimized link. There was no sign of broaching in any of the stud holes. HDP #3 EPON shim was almost completely intact. None of the EPON shim material was lost from HDP #4 during ascent.

Figure 4. **RIGHT SRB FRUSTUM**



MISSING TPS

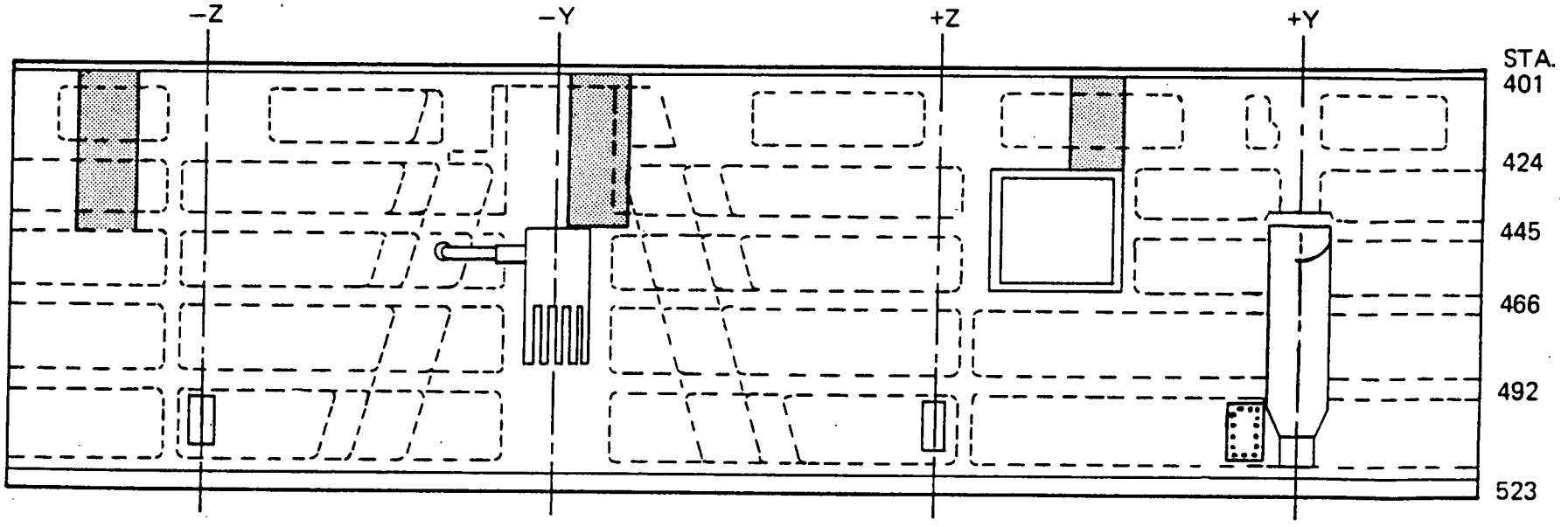
NONE

DEBONDS

● 14

ONLY MINOR BLISTERING OF HYPALON PAINT IN LOCALIZED AREAS.

Figure 5. **RIGHT SRB FWD SKIRT**



TPS MISSING

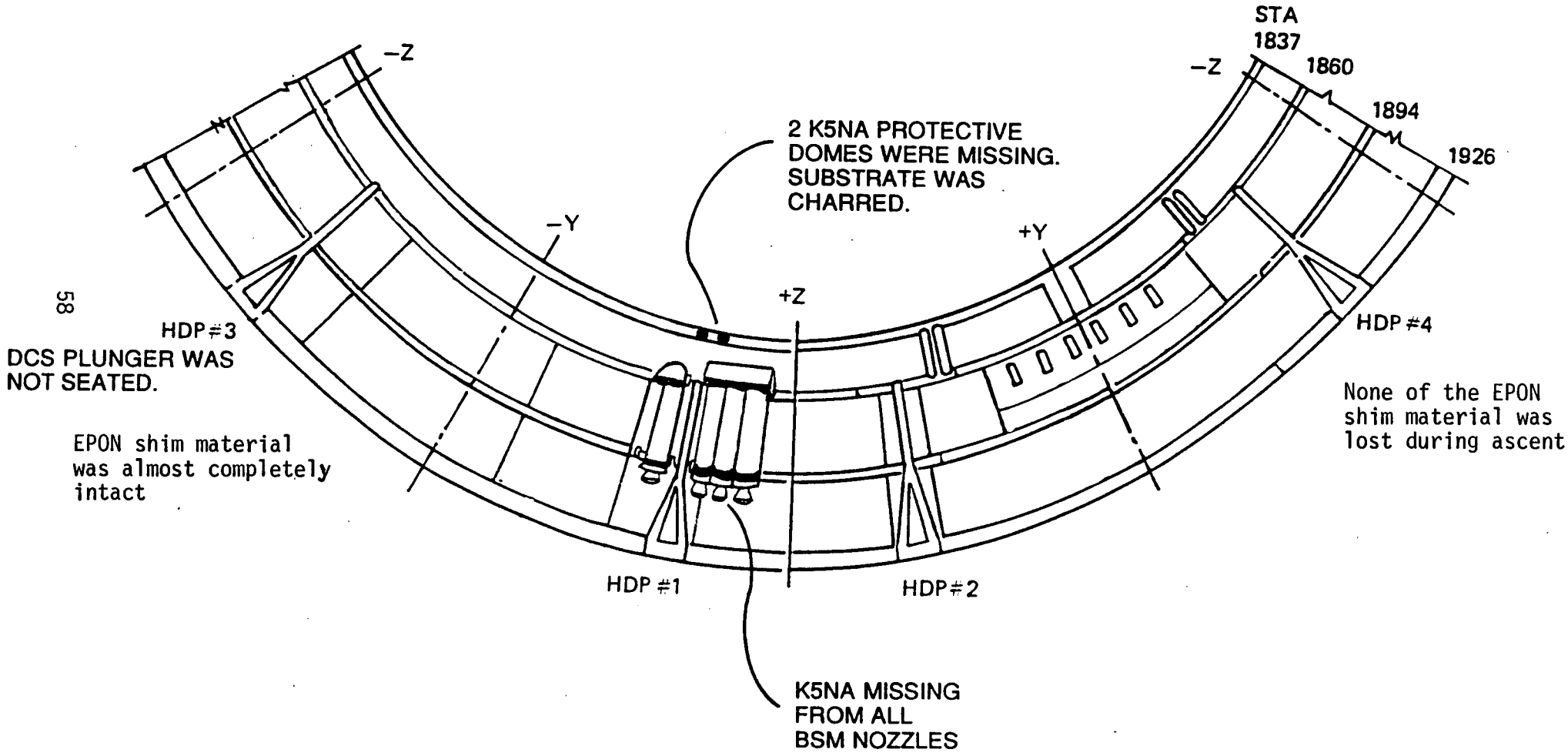
NONE

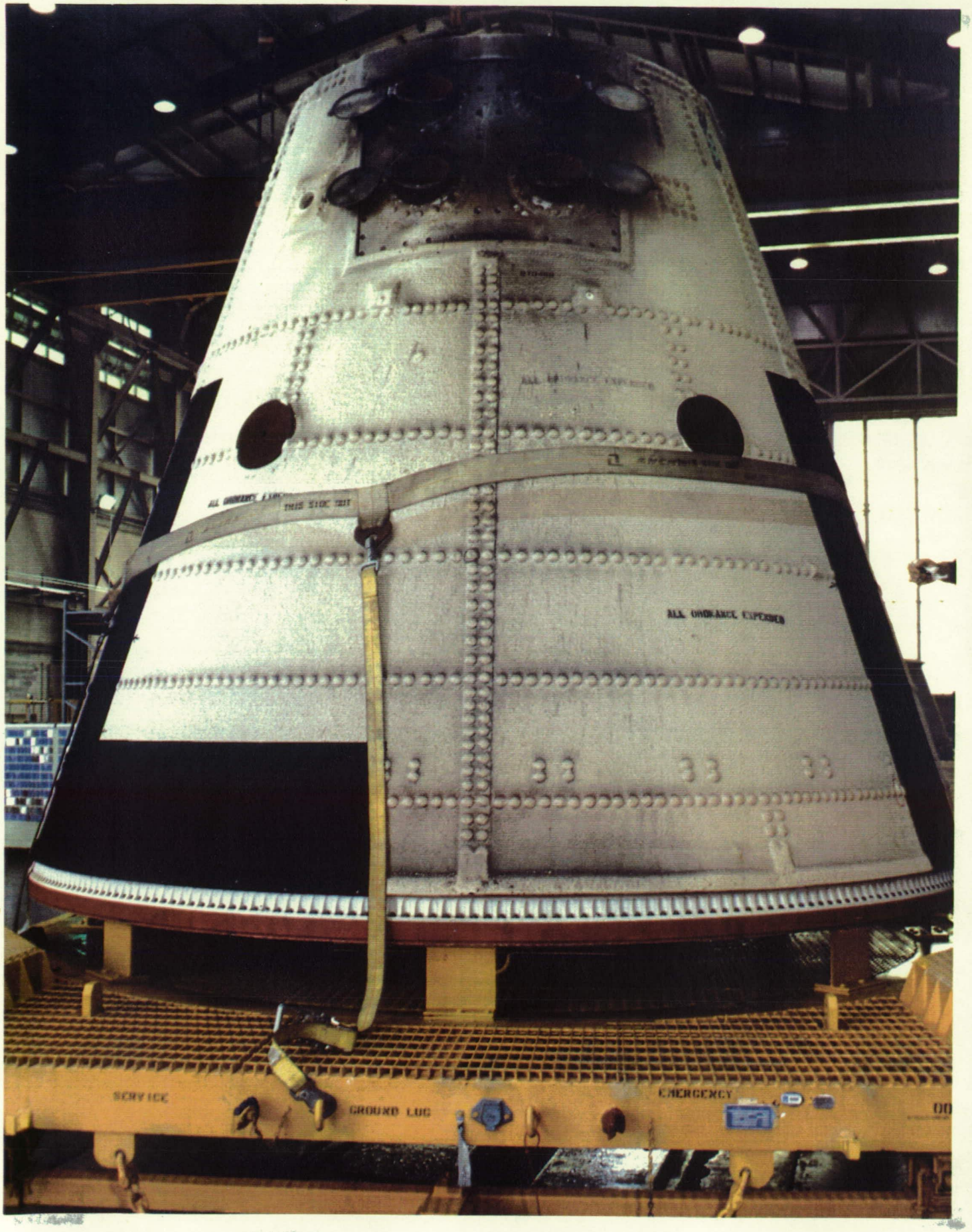
DEBONDS

NONE

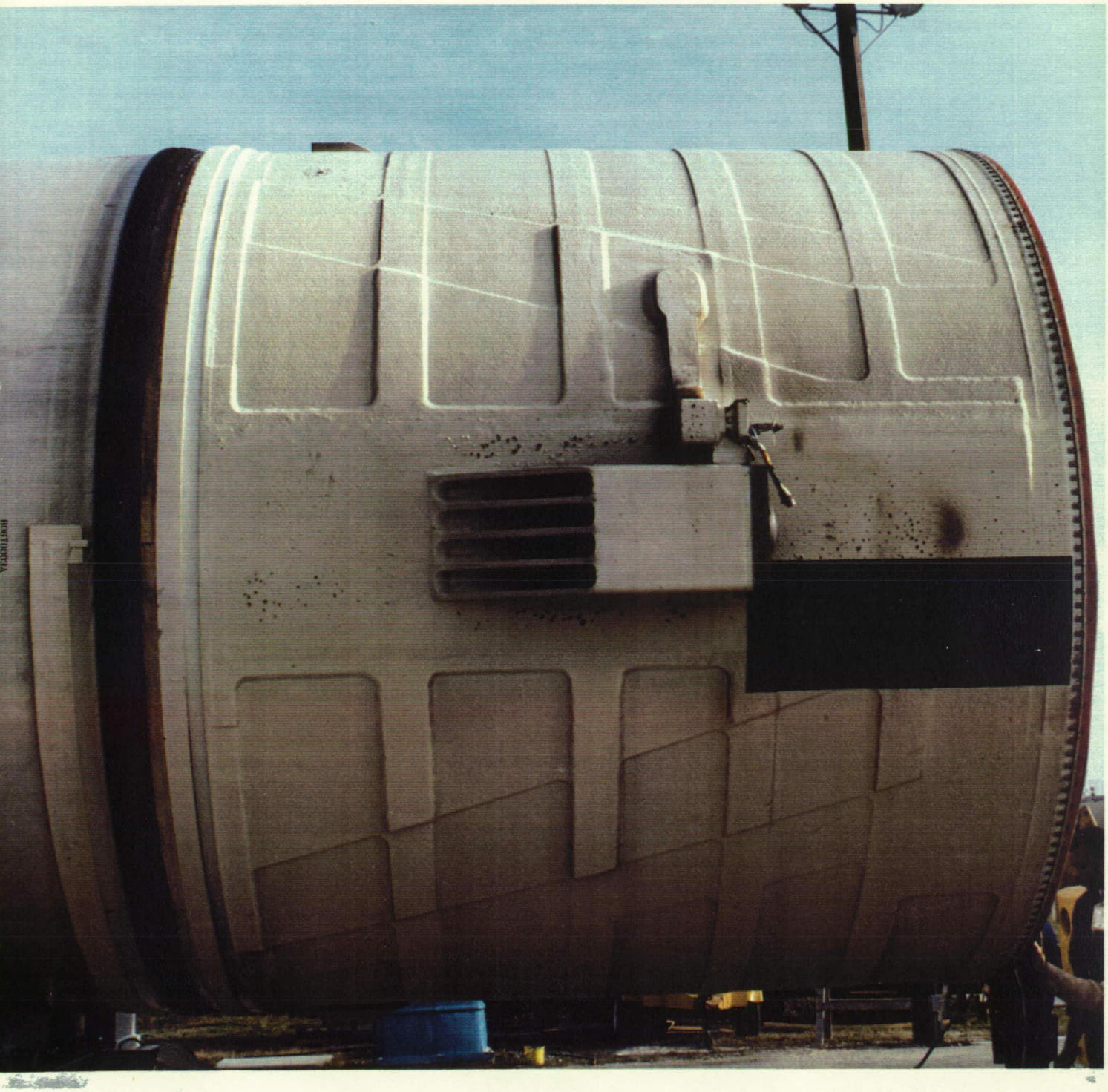
LOCALIZED BLISTERING OF THE HYPALON PAINT OCCURRED AROUND THE ET/SRB FITTING AND SYSTEMS TUNNEL COVER.

Figure 6. **RIGHT SRB AFT SKIRT EXTERIOR TPS**



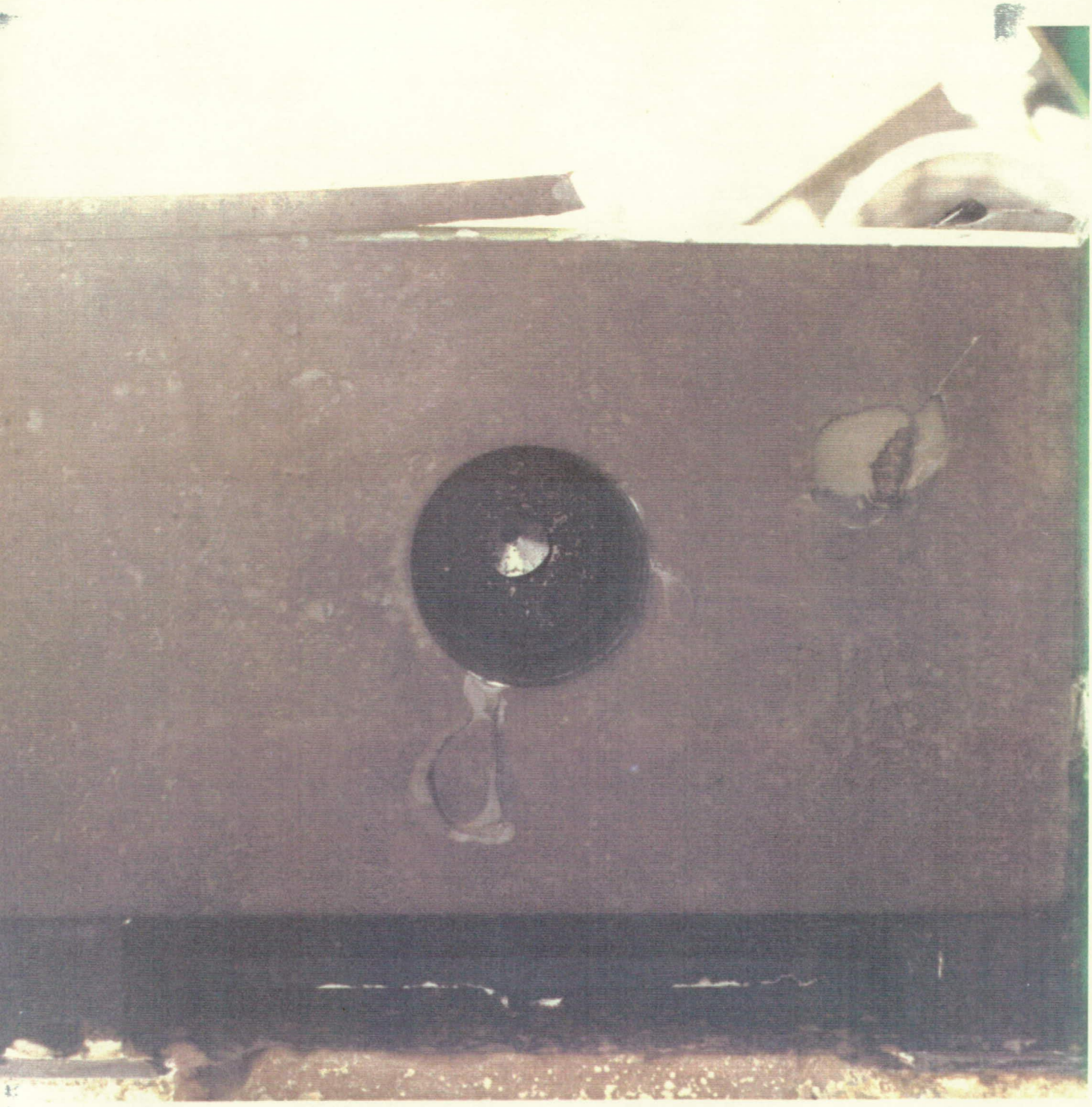


The RH frustum was missing no TPS but had 14 MSA-2 debonds over fasteners. There was minor localized blistering of the Hypalon paint.



The RH forward skirt exhibited no debonds or missing TPS. Both RSS antenna phenolic plates were intact. Minor blistering of the Hypalon paint occurred around the ET/SRB attach point.

Post flight condition of the RH aft booster. The aft skirt acreage TPS was sooted but in good condition. The ET/SRB aft struts, ETA ring, IEA, and all three aft booster stiffener rings appeared undamaged.



The HDP #3 Debris Containment System (DCS) plunger was not seated. The EPON shim material was almost completely intact.

There was no sign of broaching in any of the stud holes. None of the EPON shim material was lost prior to re-entry.

7.2 LH SOLID ROCKET BOOSTER DEBRIS INSPECTION

The LH frustum was missing no TPS but had 10 MSA-2 debonds over fasteners. There was minor localized blistering of the Hypalon paint (Figure 7). The BSM covers were locked in the fully opened position though the lower left cover attach ring was deformed and the cover bent back to the 150 degree position.

The LH forward skirt exhibited no debonds or missing TPS. The phenolic plates on both RSS antennae were intact. The forward separation bolt and electrical cables appeared to have separated cleanly. No pins were missing from the frustum severance ring. Minor blistering of the Hypalon paint occurred forward of the ET/SRB attach point and on the systems tunnel cover (Figure 8).

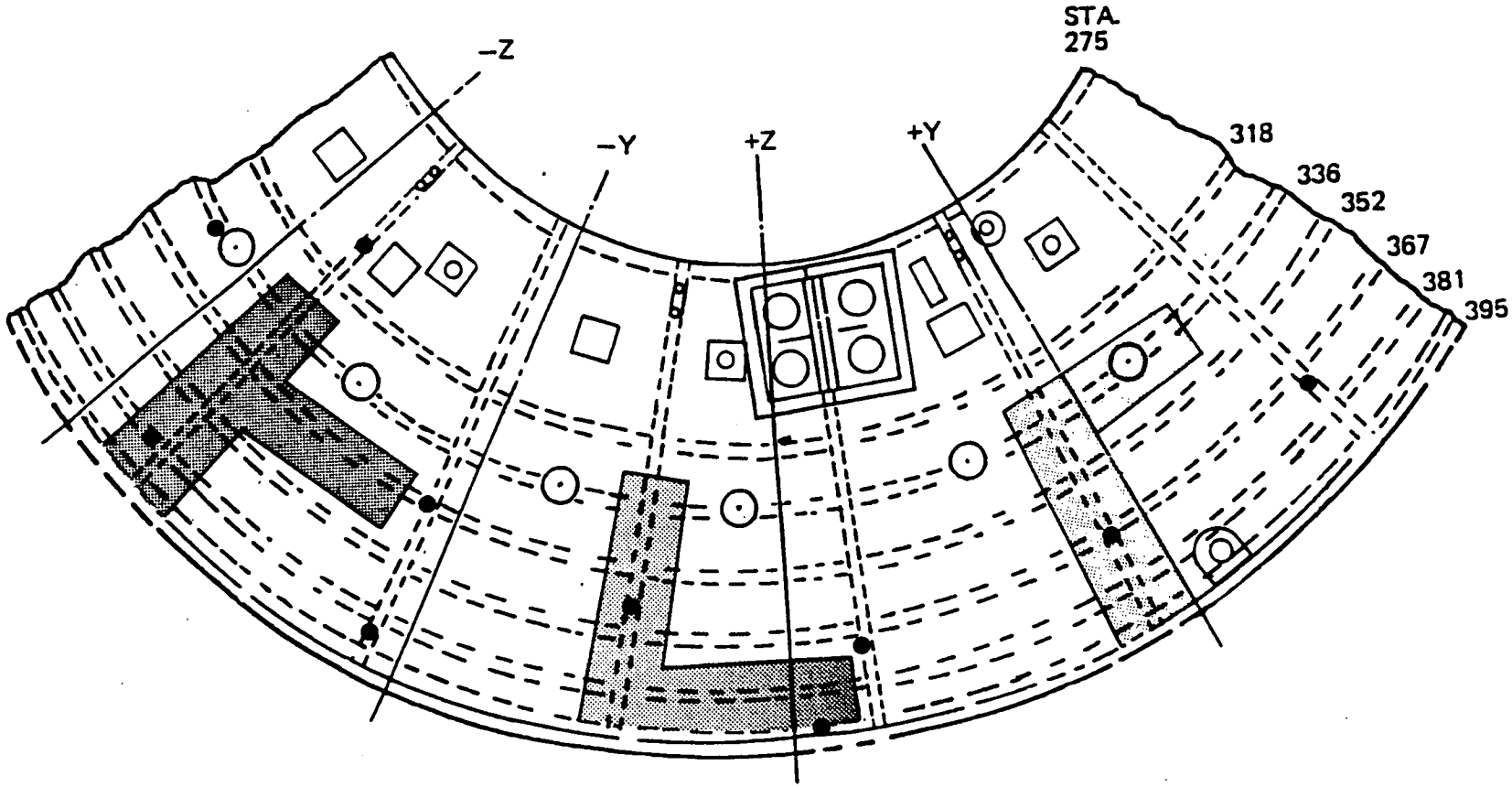
The Field Joint Protection System (FJPS) closeouts were in good condition. Minor trailing edge damage to the FJPS and the GEI cork runs were attributed to debris resulting from severance of the nozzle extension.

Separation of the aft ET/SRB struts appeared normal. The ET/SRB aft struts, IEA, ETA ring, and all three aft booster stiffener rings appeared undamaged. A 3"x1" area of TPS on the forward side of the upper strut fairing at the separation plane was missing and the substrate was charred. The loss of TPS in this area may have occurred during strut separation. The aft booster stiffener ring splice plate closeouts were intact and no K5NA material was missing prior to water impact.

One K5NA protective dome was missing from a bolt head on the aft side of the phenolic kick ring prior to water impact (charred substrate). The aft skirt acreage TPS was generally in good condition (Figure 9). K5NA was missing from all aft BSM nozzles.

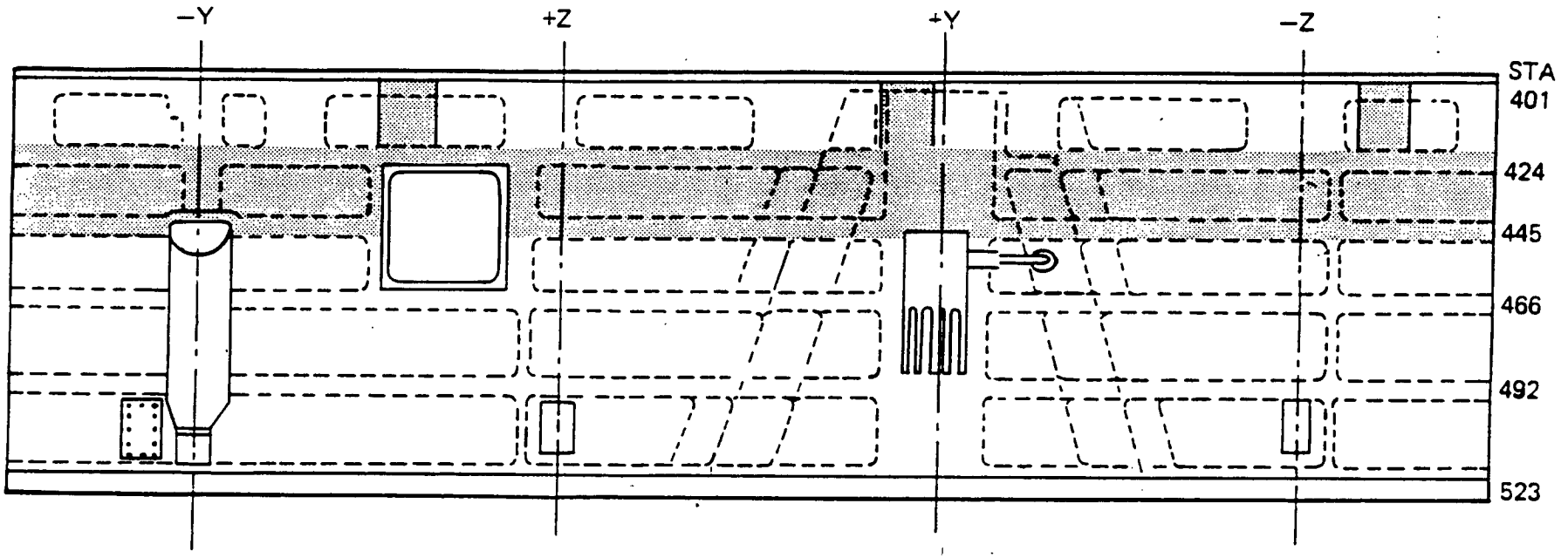
All four HDP Debris Containment System (DCS) plungers were seated. This was the fifth flight utilizing the optimized link. There was no sign of broaching in any of the stud holes. Approximately 10 percent of the HDP #7 EPON shim material was missing prior to water impact and the substrate was charred. None of the EPON shim material was lost from HDP #8 during ascent.

Figure 7. **LEFT SRB FRUSTUM**



MISSING TPS
NONE

DEBONDS
● 10

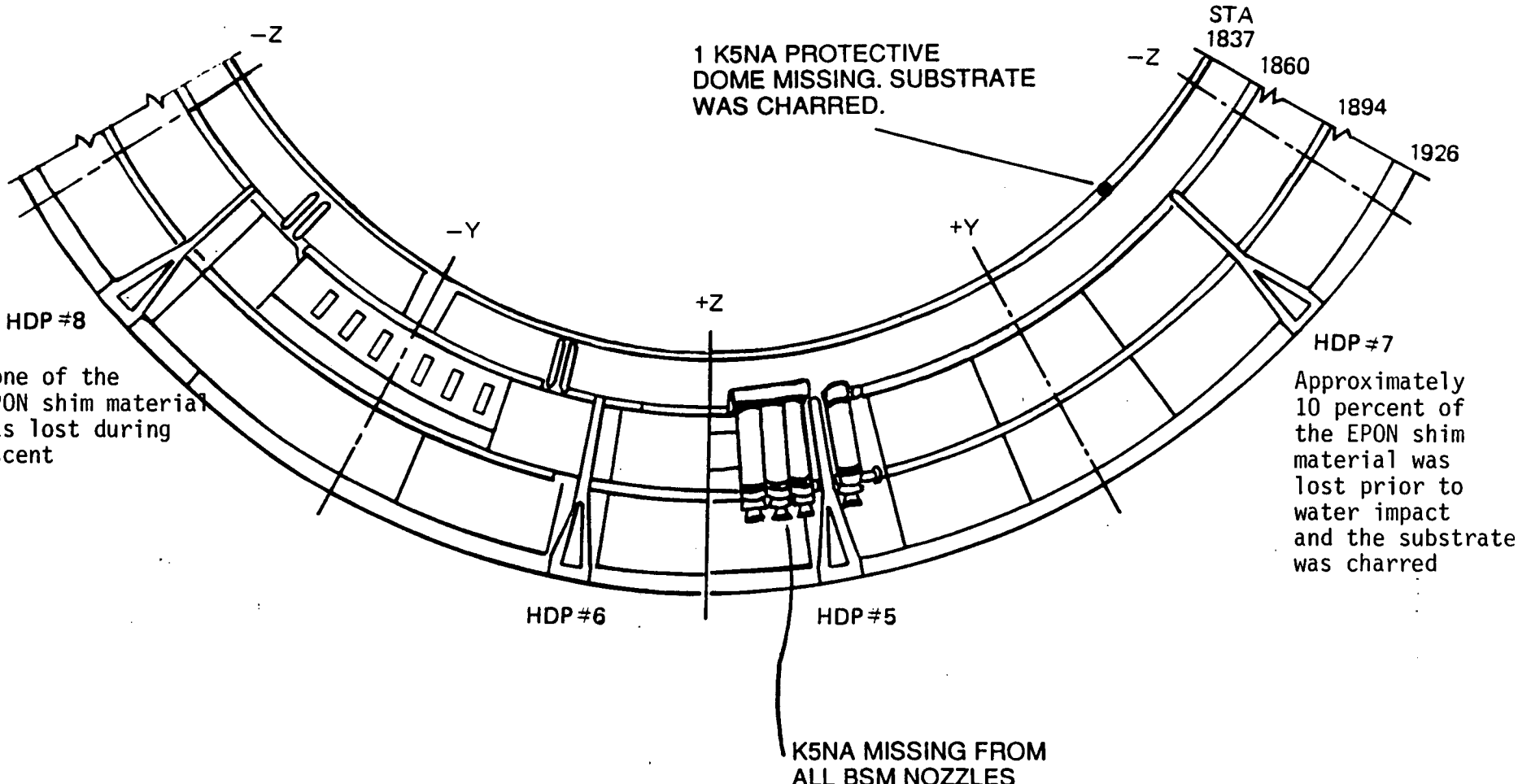


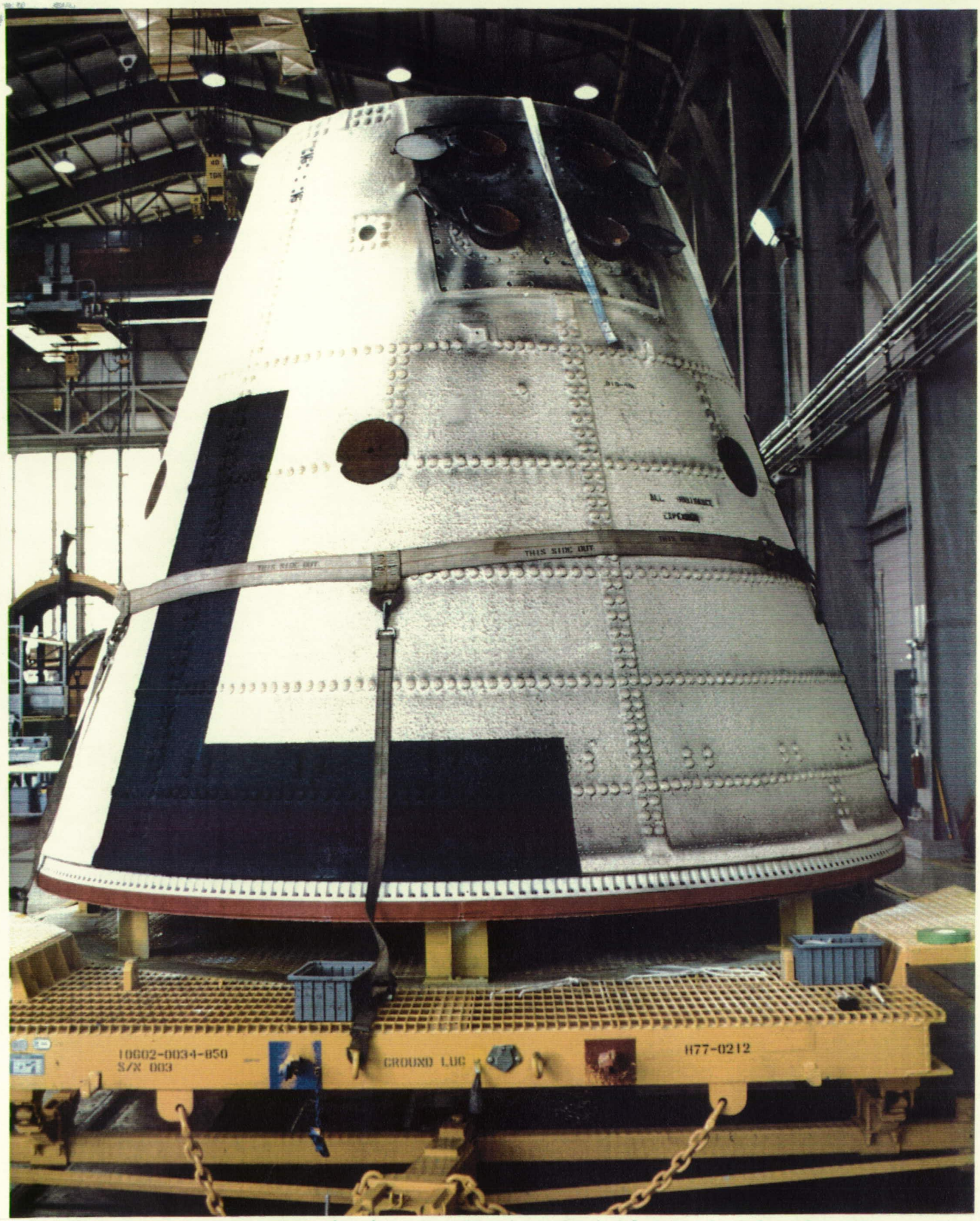
99

TPS MISSING	DEBONDS
NONE	NONE

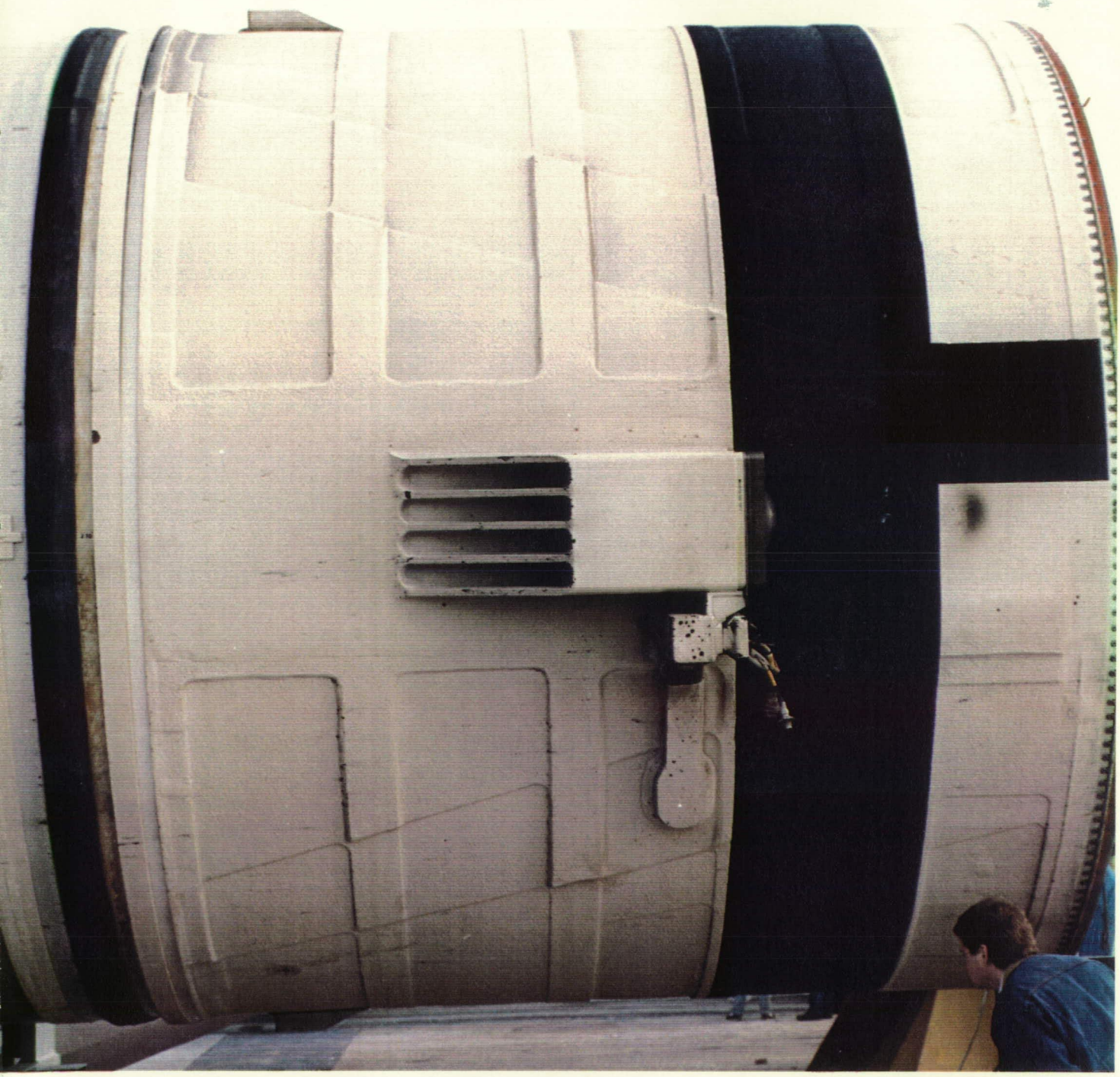
ONLY MINOR BLISTERING OF HYPALON PAINT AROUND ET/SRB FITTING AND SYSTEMS TUNNEL COVER.

Figure 9. LEFT SRB AFT SKIRT EXTERIOR TPS



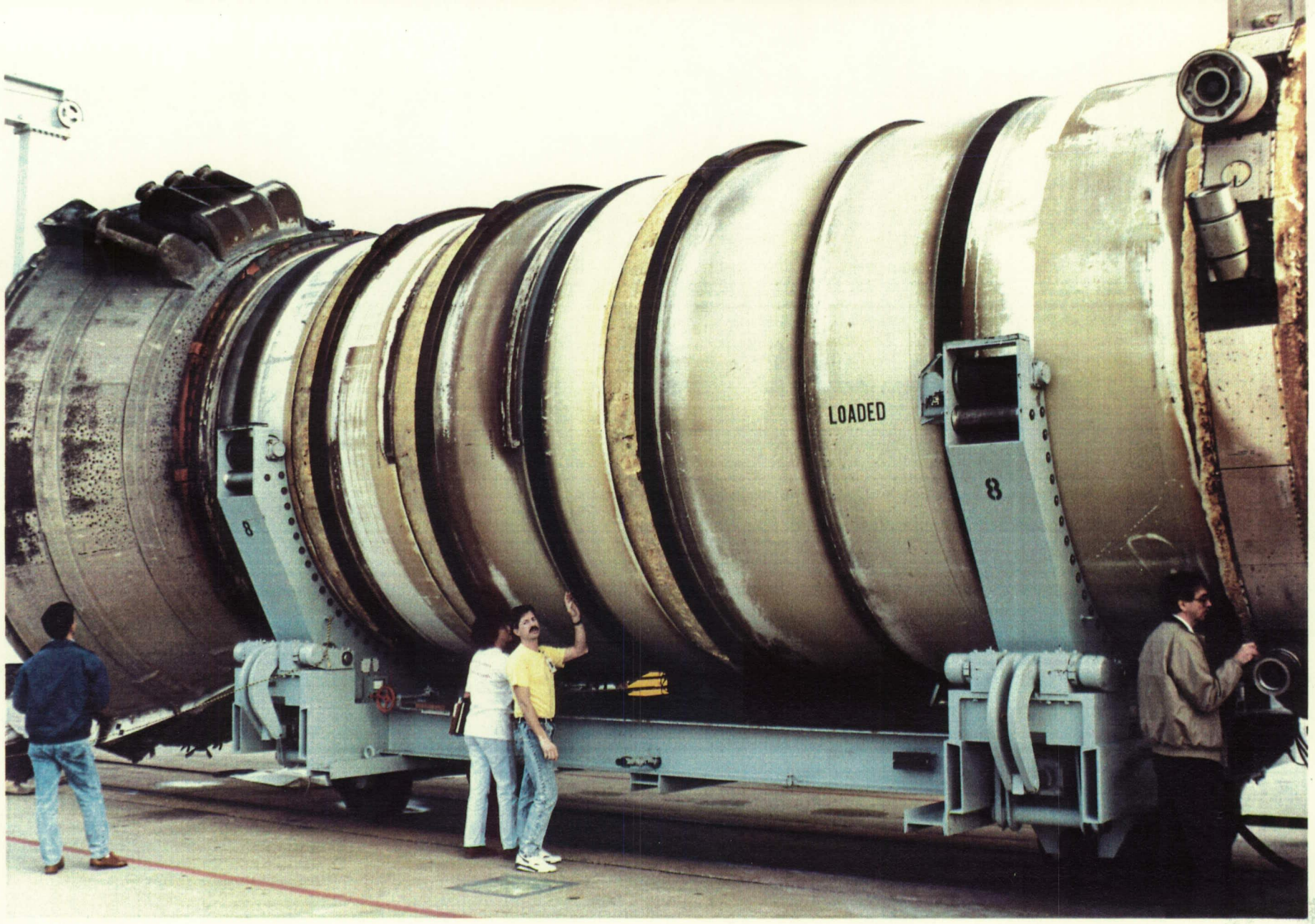


The LH frustum was missing no TPS but had 10 MSA-2 debonds over fasteners. The BSM covers were locked in the fully opened position though the lower left cover attach ring was deformed and the cover bent back to the 150 degree position.

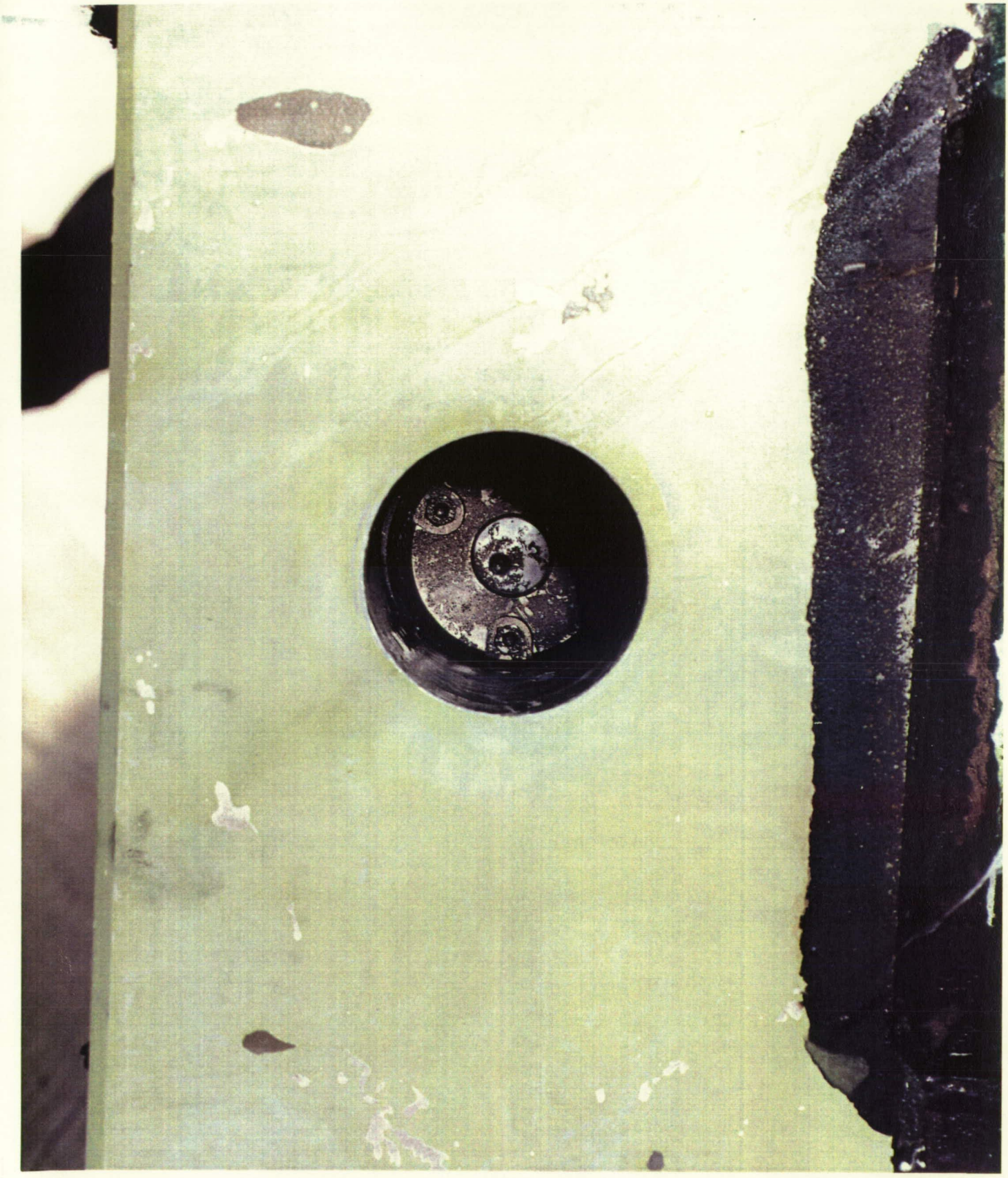


The LH forward skirt exhibited no MSA-2 debonds or missing TPS.

A 3"x1" area of TPS on the forward side of the ET/SRB upper strut fairing at the separation plane was missing and the substrate was charred. The loss of TPS in this area may have occurred during strut separation.



Post flight condition of the LH aft booster. The aft skirt acreage TPS was sooted but generally in good condition. The ET/SRB aft struts, IEA, ETA ring, and all three aft booster stiffener rings appeared undamaged.



All four HDP Debris Containment System plungers were seated. There was no sign of broaching in any of the stud holes. Approximately 10 percent of the HDP #7 EPON shim was missing prior to splashdown and the substrate was charred.

7.3 RECOVERED SRB DISASSEMBLY FINDINGS

Post flight disassembly of the Debris Containment System (DCS) housings revealed an overall system retention of 99 percent and individual holddown post retention percentages as listed:

HDP #	% of Nut without 2 large halves	% of Ordnance fragments	% Overall
1	99	93	99
2	99	91	98
3	99	96	99
4	99	99	99
5	99	97	99
6	99	98	99
7	99	95	99
8	99	95	99

STS-42 was the fifth flight to utilize the new "optimized" frangible links in the holddown post DCS's. The link was designed to increase the DCS plunger velocity and improve the seating alignment while leaving the stud ejection velocity the same. The design was intended to prevent ordnance debris from falling out of the DCS yet not increase the likelihood of a stud hang-up. According to NSTS-07700, the Debris Containment System should retain a minimum of 90 percent of the ordnance debris. Overall percentages of retention for the four previous flights utilizing the "optimized" link are:

HDP #	BI-044 STS-40	BI-045 STS-43	BI-046 STS-48	BI-047 STS-44
1	99%	98%	99%	99%
2	99%	**31%**	**88%**	99%
3	**38%**	99%	99%	99%
4	99%	99%	99%	99%
5	**23%**	99%	**58%**	99%
6	99%	99%	99%	99%
7	**62%**	99%	99%	99%
8	99%	99%	99%	99%
TOTAL	77%	90%	92%	99%
Debris Loss	58 oz	25 oz	19 oz	negl

SRB Post Launch Anomalies are listed in Section 10.

8.0 ORBITER POST LANDING DEBRIS ASSESSMENT

A post landing debris inspection of OV-103 (Discovery) was conducted on January 30 and 31, 1992, at Ames-Dryden (EAFB) on runway 22 and in the Mate/Demate Device (MDD). This inspection was performed to identify debris impact damage, and if possible, debris sources. The Orbiter TPS sustained a total of 209 hits, of which 44 had a major dimension of one inch or greater. This total does not include the numerous hits on the base heat shield attributed to engine vibration/acoustics and exhaust plume recirculation. A comparison of these numbers to statistics from 30 previous missions of similar configuration (excluding missions STS-23, 24, 25, 26, 26R, 27R, and 30R which had damage from known debris sources), indicates that both the total number of hits and the number of hits one inch or larger were greater than average. Figures 10-13 show the TPS debris damage assessment for STS-42.

The Orbiter lower surface sustained a total of 159 hits, of which 38 had a major dimension of one inch or greater. Fourteen of these hits had a major dimension of three inches or greater with 11 of these located along the forward one-third of the vehicle (Figure 10). All of these hits were shallow (3/8 inch or less) relative to the surface area. This type of tile damage is indicative of impact by a low density material. No residual debris material was observed in any of these damage sites. However, laboratory analysis was performed on selected tiles removed (intact) at KSC for replacement.

As a result of this tile damage, a debris damage/source investigation was conducted. Post flight inspections of the Orbiter and recovered SRB's revealed no loss of TPS or flight hardware. Launch films and videos showed no debris anomalies. OV-103 was not equipped to carry umbilical cameras. However, the crew photographed (70mm still photos and 16mm motion picture) the External Tank after separation. This imagery showed apparent loss of TPS (two divots 8-12 inches in diameter) in the -Y+Z quadrant of the intertank acreage outboard of the -Y bipod ramp and forward of the LH2 tank flange closeout. However, the +Y+Z quadrant of the ET was not visible in any of the photos.

The tile damage sites were large in surface area but shallow in depth, which is characteristic of low density impacts. The TPS on the SRB's is more dense and results in deeper penetration. A mechanism to transport ET intertank foam to the Orbiter forward lower surface area had been previously demonstrated. ET-52 was the second tank flown with the new two-gun spray process on the intertank. IFA STS-42-T-001 was taken against the loss of ET intertank foam as the probably source for the debris damage to Orbiter tiles on STS-42.

Figure 10. **STS-42**

DEBRIS DAMAGE LOCATIONS

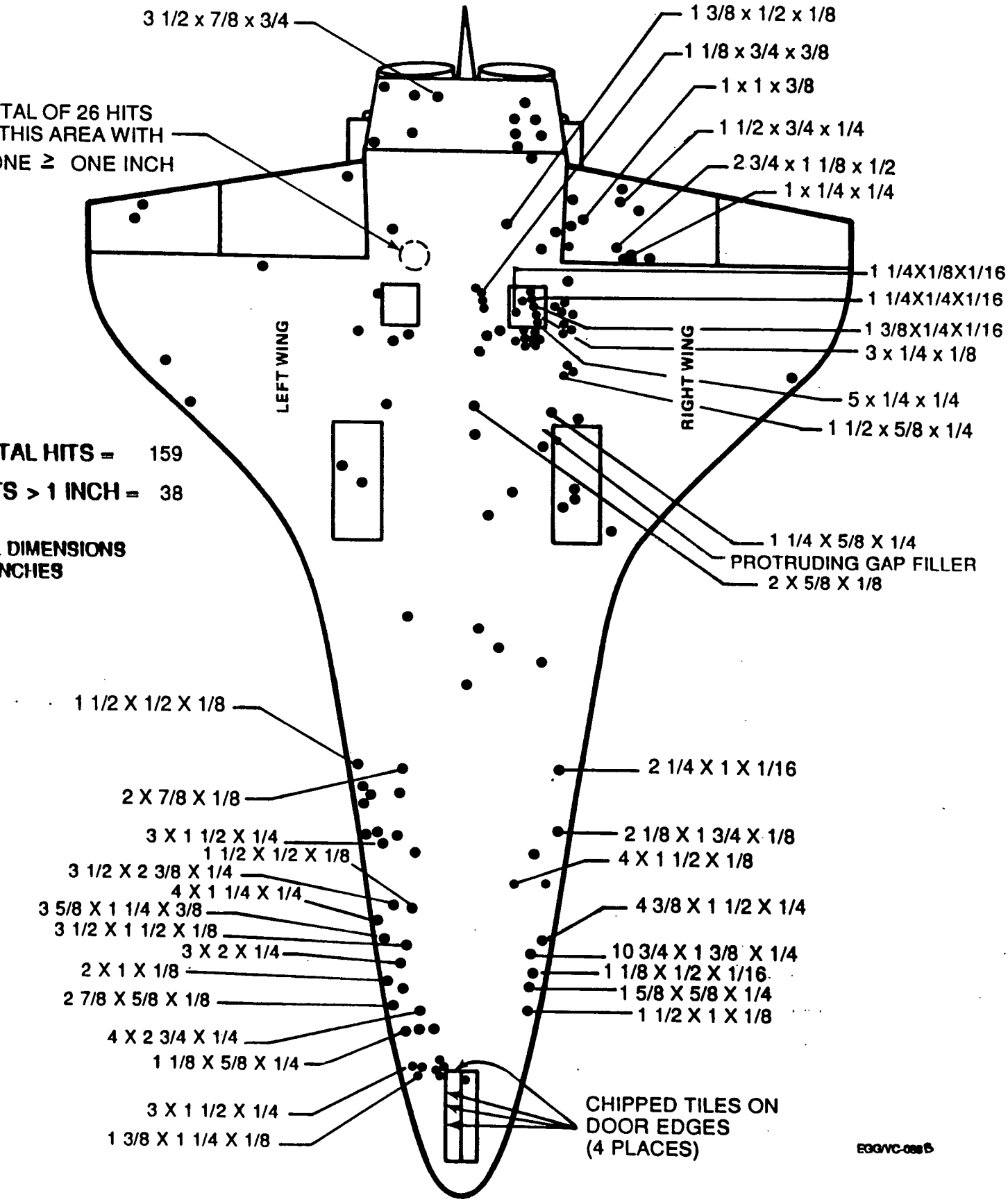
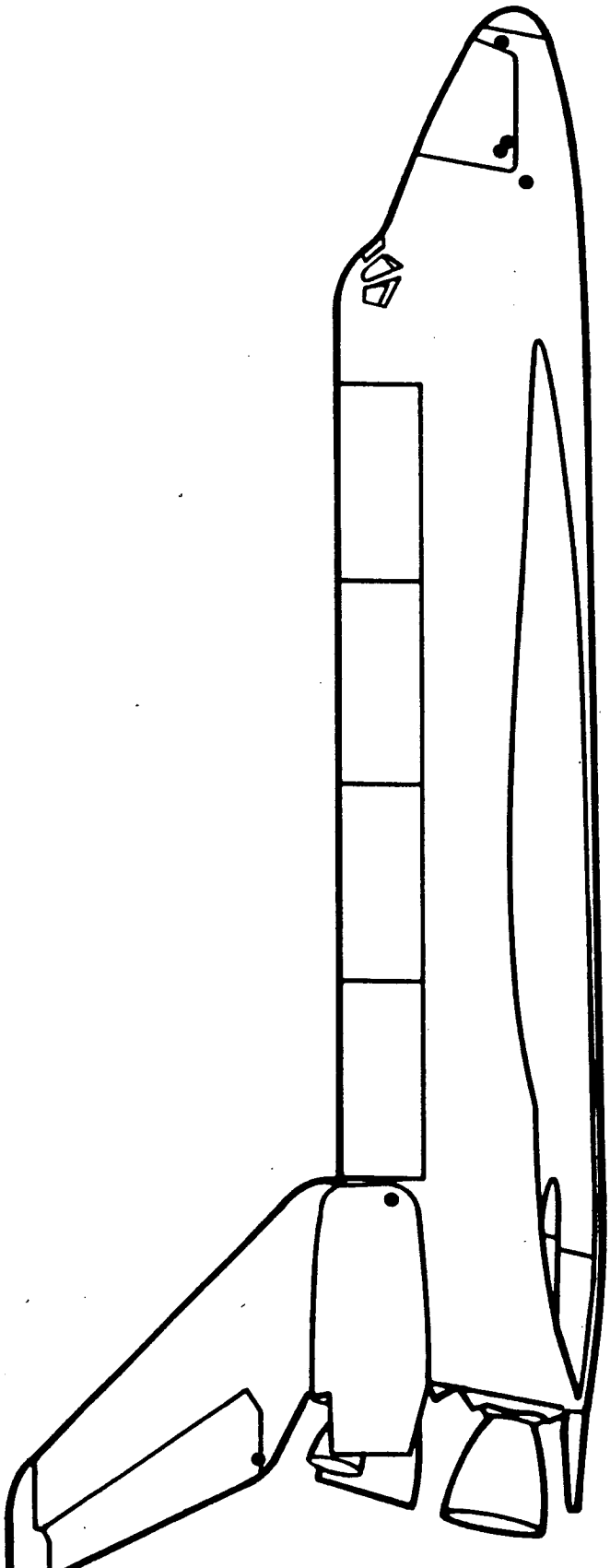


Figure 11. **STS-42**

DEBRIS DAMAGE LOCATIONS



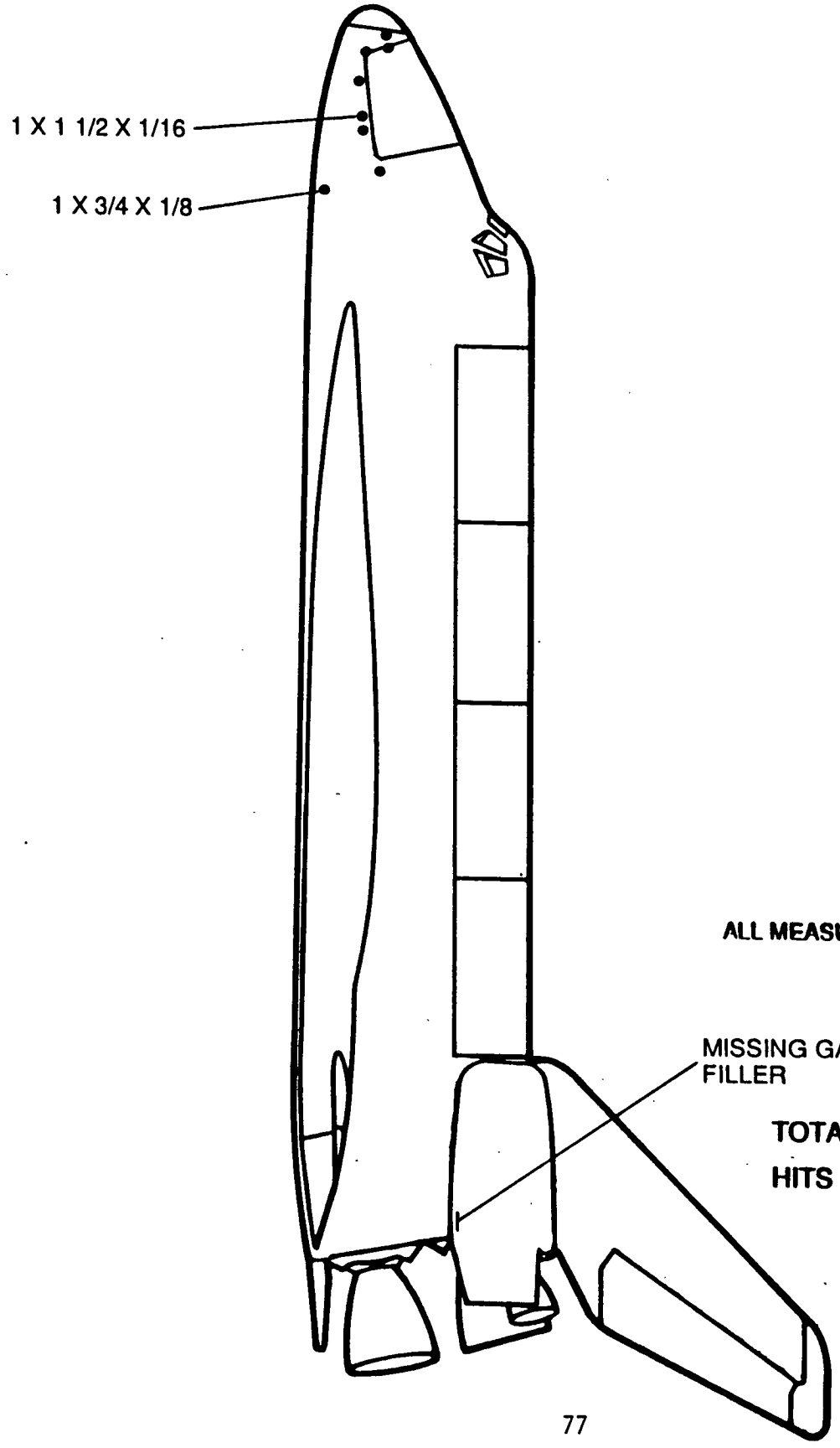
TOTAL HITS = 6

HITS > 1 INCH = 0

EG&G/VC-088

Figure 12: **STS-42**

DEBRIS DAMAGE LOCATIONS



ALL MEASUREMENTS IN INCHES

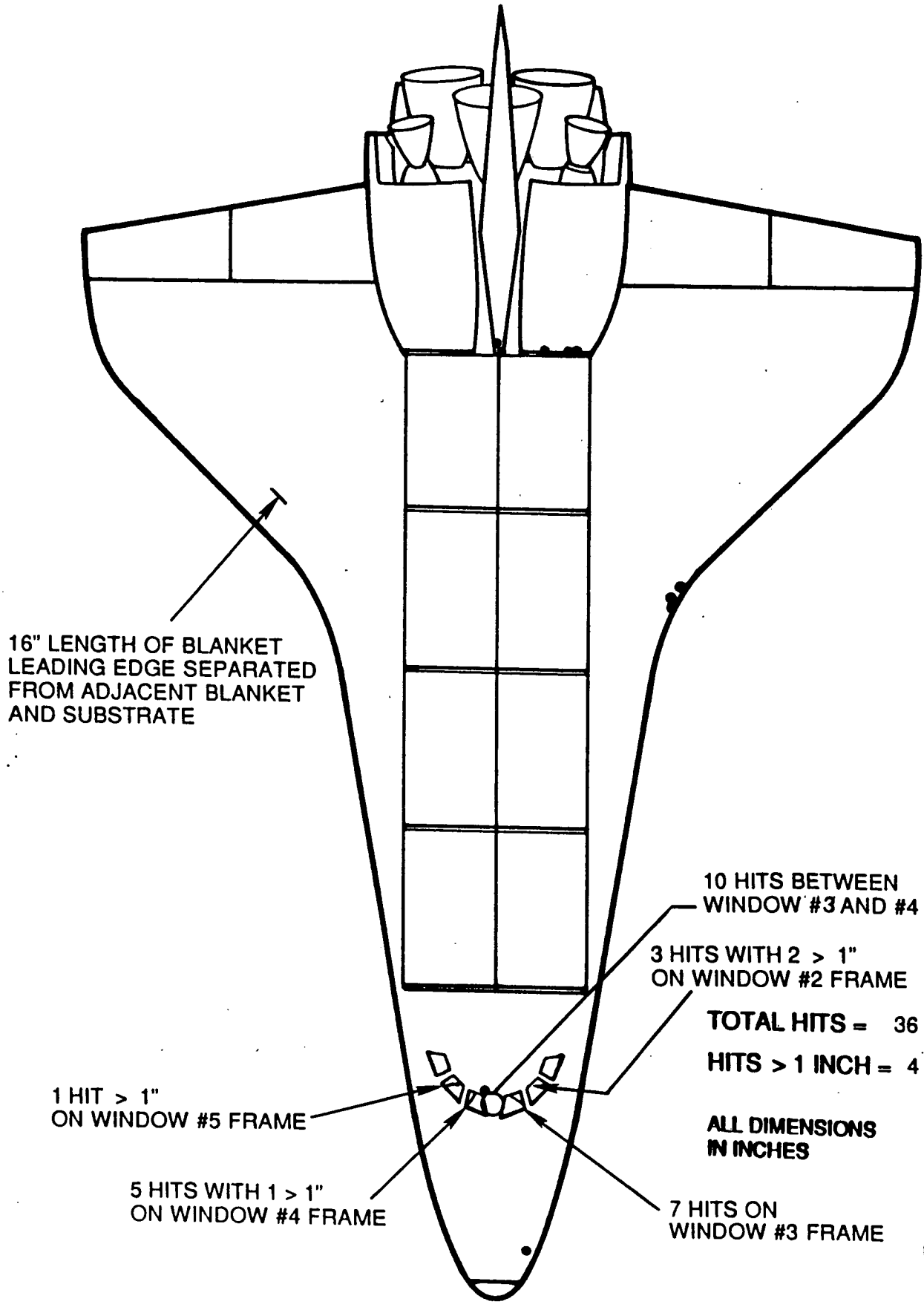
TOTAL HITS = 8

HITS > 1 INCH = 2

EGG/VC-088

Figure 13. **STS-42**

DEBRIS DAMAGE LOCATIONS



The following table breaks down the STS-42 Orbiter debris damage by area:

	HITS > 1"	TOTAL HITS
Lower surface	38	159
Upper surface	4	33
Right side	0	5
Left side	2	8
Right OMS Pod	0	1
Left OMS Pod	0	3
TOTALS	44	209

No TPS damage was attributed to material from the wheels, tires, or brakes. The main landing gear tires were considered to be in good condition for a concrete runway landing.

Five hits on the LO2 ET/Orbiter umbilical door and four hits on the Orbiter lower surface were aligned and caused by a single debris particle (most likely ice from the LO2 feedline) passing between the Orbiter lower surface and the door in the open/ latched position.

A cluster of 26 hits smaller than one inch was located just aft and inboard of the LH2 ET/Orbiter umbilical. Similar clusters of hits have been observed in this area on previous flights and are probably caused by ice/debris from the umbilical.

All ET/Orbiter (EO) separation ordnance device plungers appeared to have functioned properly. An ordnance connector from the LH2 umbilical outboard pyro location (Part No. NBS9GE8-2SE) fell to the runway when the ET door was opened. This debris was documented on PR PYR-3-14-0193. The present design of the umbilical pyro assemblies does not ensure debris retention, but a design change is in work to rectify this. The stop-bolts on the EO-1 separation assembly did not sustain any damage or bending.

Damage to the base heat shield tiles was typical. The SSME closeout blankets were generally in good condition. The only damage consisted of detached outboard edges on the SSME #1 blanket from 5:30 to 6:00 o'clock and on the SSME #3 blanket from 8:00 to 9:00 o'clock.

The coating on the LH wing leading edge RCC T-seals #7 and #8 exhibited some blistering and spalling, but was not a debris issue.

All Orbiter windows exhibited typical hazing. A few small streaks were present on windows #3 and #4. Laboratory analysis was performed on samples taken from all windows.

The entire exterior surface (flexible insulation blanket and thermal barrier) of Orbiter RH vent door #7 exhibited a yellow-orange discoloration. This anomaly was documented on PR MID-3-15-2320. The surrounding Orbiter sidewall was not similarly discolored. Wipes were taken from the exterior surface of the door and from the structure inside the door within the Orbiter for chemical analysis. The door TPS was removed after ferry flight for further laboratory analysis.

Samples were taken from other selected sites for laboratory analysis (Figure 14). The results of all laboratory chemical analyses are presented in section 9.0.

A portable infrared radiometer was used to measure the surface temperatures of three areas on the Orbiter TPS after landing (OMRSD V09AJ0.095). Approximately one hour after wheel stop the Orbiter nosecap RCC was 116 degrees F, the RH wing leading edge RCC panel #9 was 77 degrees F, and the RH wing leading edge RCC panel #17 was 76 degrees F (Figure 15).

Runway 22 was inspected and swept by Air Force personnel on January 29, 1992, and all potentially damaging debris was removed. The lakebed runways were not usable for this mission due to recent rainfall.

A post-landing inspection of runway 22 was performed approximately a half hour after landing. The only flight hardware found was a small piece of RTV rubber material from the strain gauge wires on the left hand inboard main landing gear tire.

In summary, both the total number of Orbiter TPS debris hits and the number of hits with a major dimension one inch or larger were greater than average when compared to previous flights (Figure 16-18). Based on the inspection of the recovered SRB components and analysis of film and photographic data, the loss of ET intertank foam is considered the probable cause of this greater than average debris damage to the Orbiter tiles.

Post Launch Anomalies are listed in Section 10.0.

Figure 14. **STS-42**

CHEMICAL SAMPLE LOCATIONS

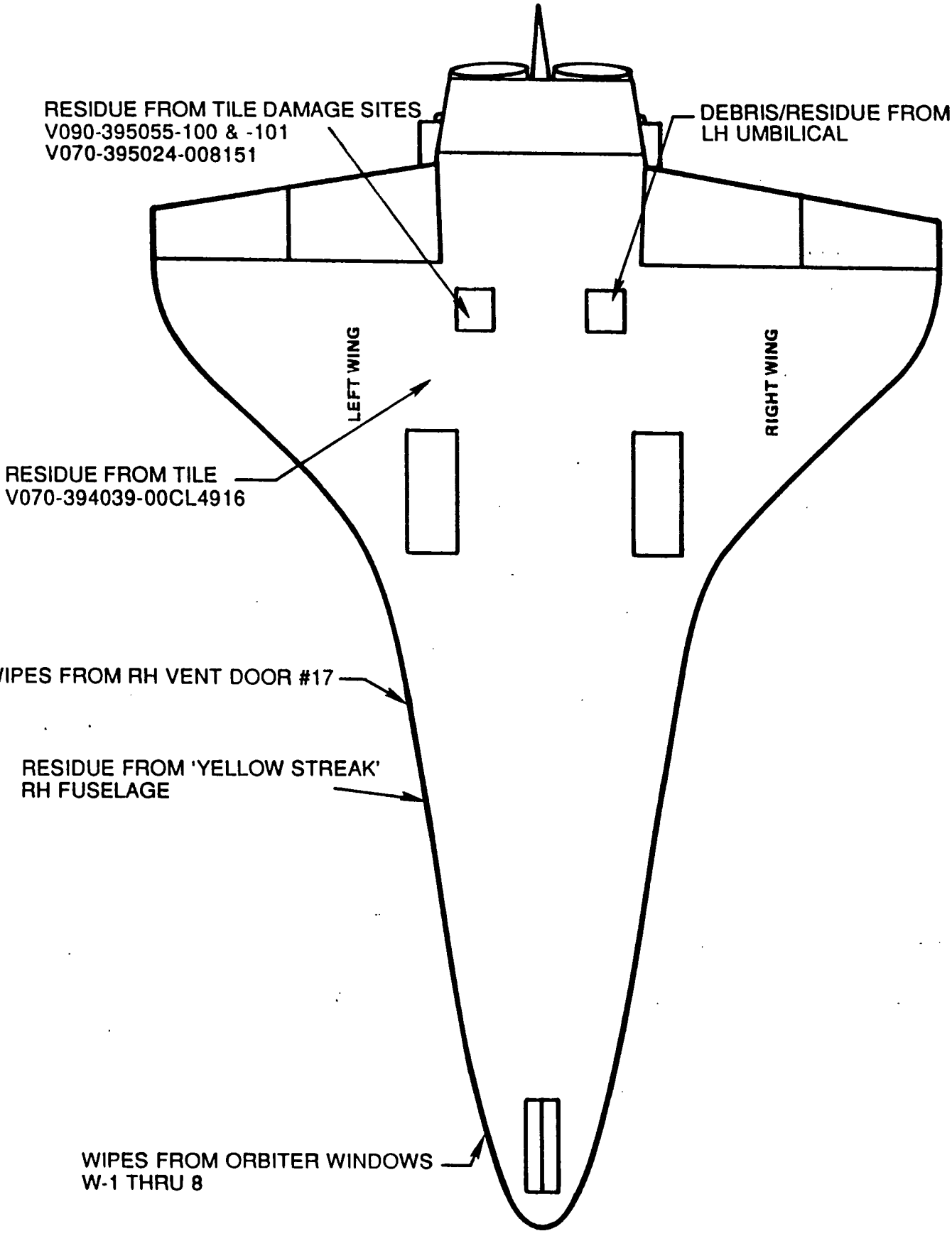


Figure 15. **STS-42 RCC TEMPERATURE MEASUREMENTS**

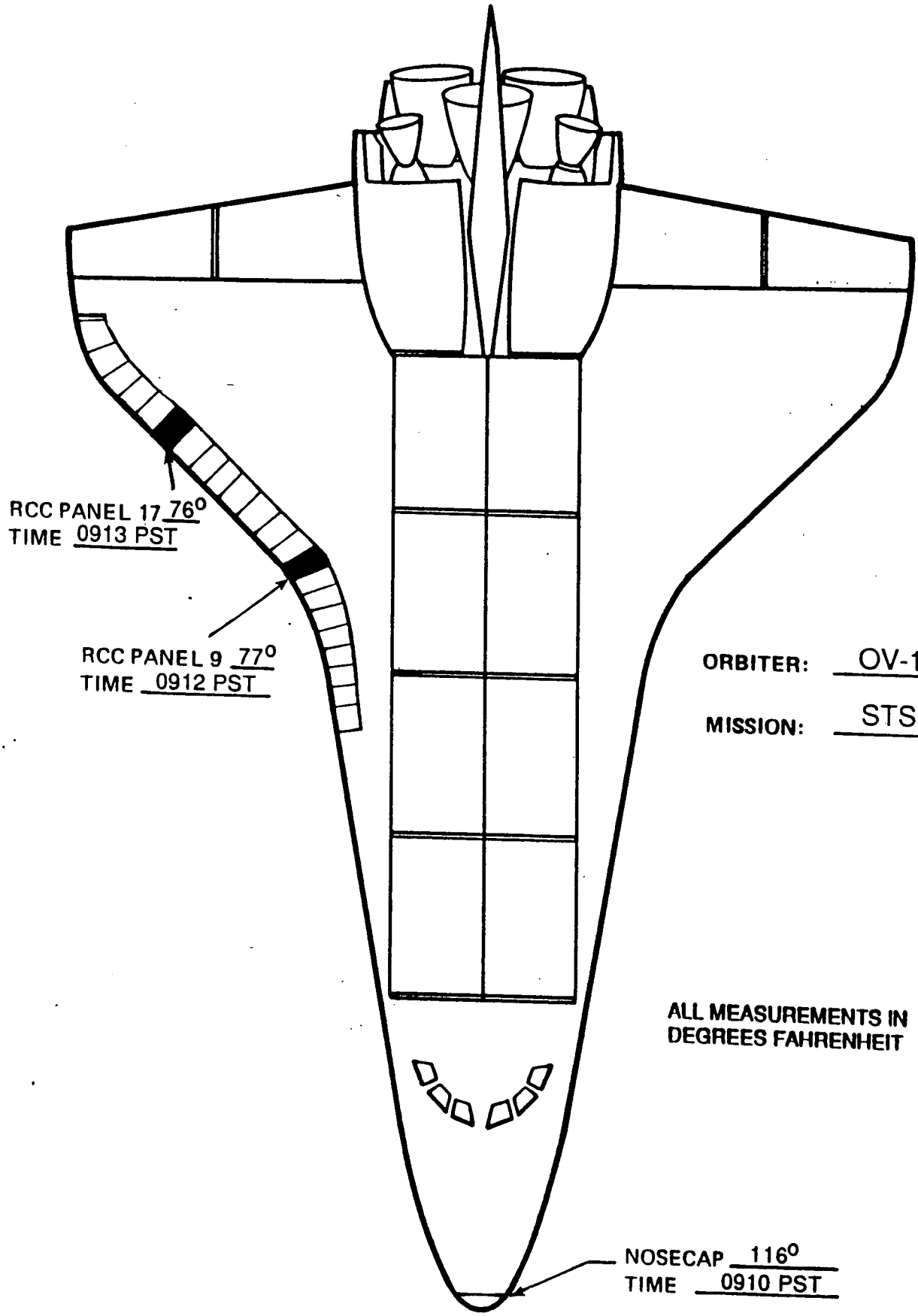


FIGURE 16: ORBITER POST FLIGHT DEBRIS DAMAGE SUMMARY

	LOWER SURFACE		ENTIRE VEHICLE	
	HITS > 1 INCH	TOTAL HITS	HITS > 1 INCH	TOTAL HITS
STS-6	15	80	36	120
STS-8	3	29	7	56
STS-9 (41-A)	9	49	14	58
STS-11 (41-B)	11	19	34	63
STS-13 (41-C)	5	27	8	36
STS-14 (41-D)	10	44	30	111
STS-17 (41-G)	25	69	36	154
STS-19 (51-A)	14	66	20	87
STS-20 (51-C)	24	67	28	81
STS-27 (51-I)	21	96	33	141
STS-28 (51-J)	7	66	17	111
STS-30 (61-A)	24	129	34	183
STS-31 (61-B)	37	177	55	257
STS-32 (61-C)	20	134	39	193
STS-29	18	100	23	132
STS-28R	13	60	20	76
STS-34	17	51	18	53
STS-33R	21	107	21	118
STS-32R	13	111	15	120
STS-36	17	61	19	81
STS-31R	13	47	14	63
STS-41	13	64	16	76
STS-38	7	70	8	81
STS-35	15	132	17	147
STS-37	7	91	10	113
STS-39	14	217	16	238
STS-40	23	153	25	197
STS-43	24	122	25	131
STS-48	14	100	25	182
STS-44	6	74	9	101
AVERAGE	15.3	87.1	22.4	118.7
SIGMA	7.3	44.7	10.9	54.9
STS-42	38	159	44	209

THIS ANALYSIS DOES NOT INCLUDE STS-23, 24, 25, 26, 26R, 27R, AND 30R
THESE MISSIONS HAD DAMAGE CAUSED BY KNOWN SOURCES

Figure 17. ORBITER TPS DEBRIS DAMAGE
STS-29 THROUGH STS-42

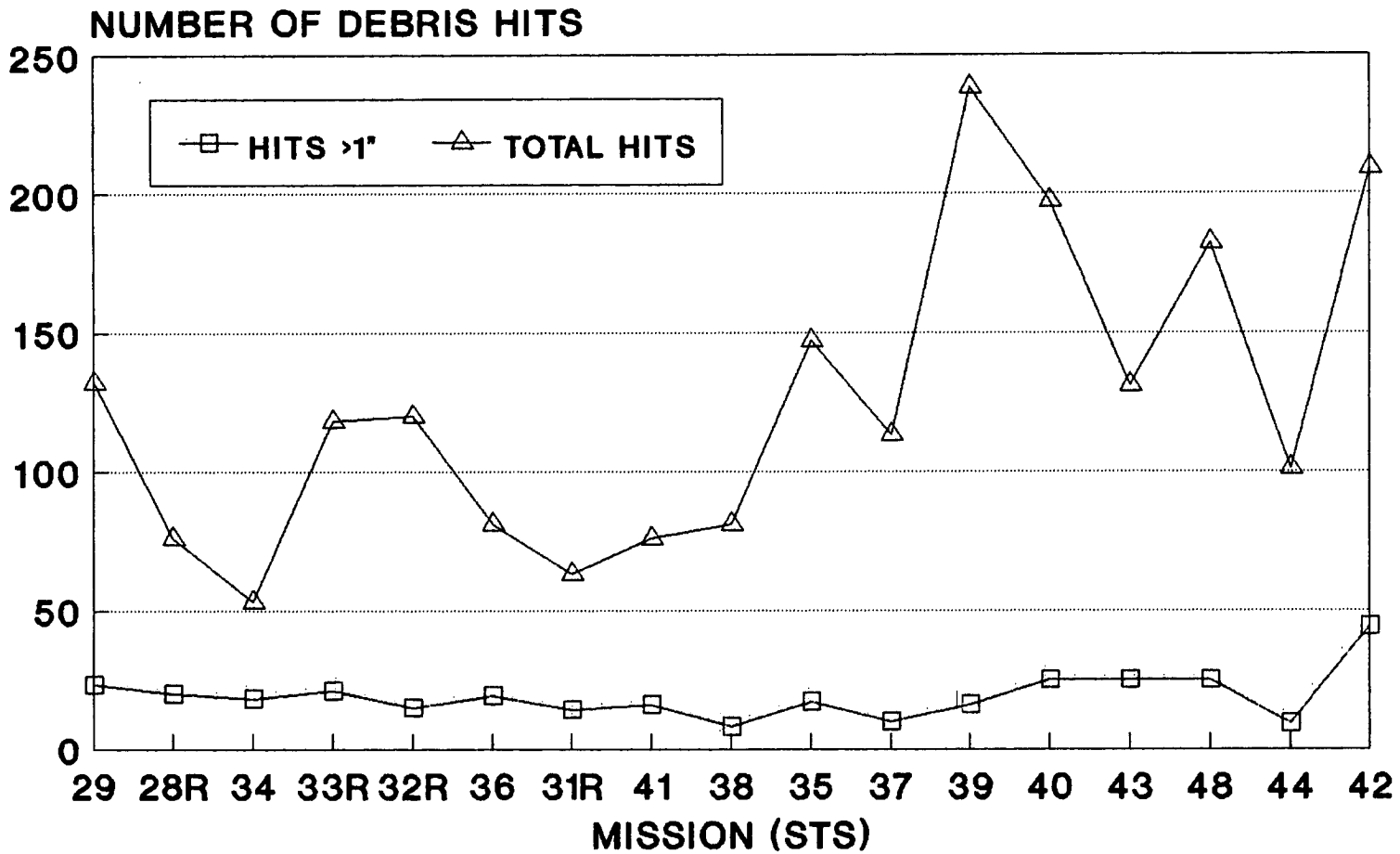
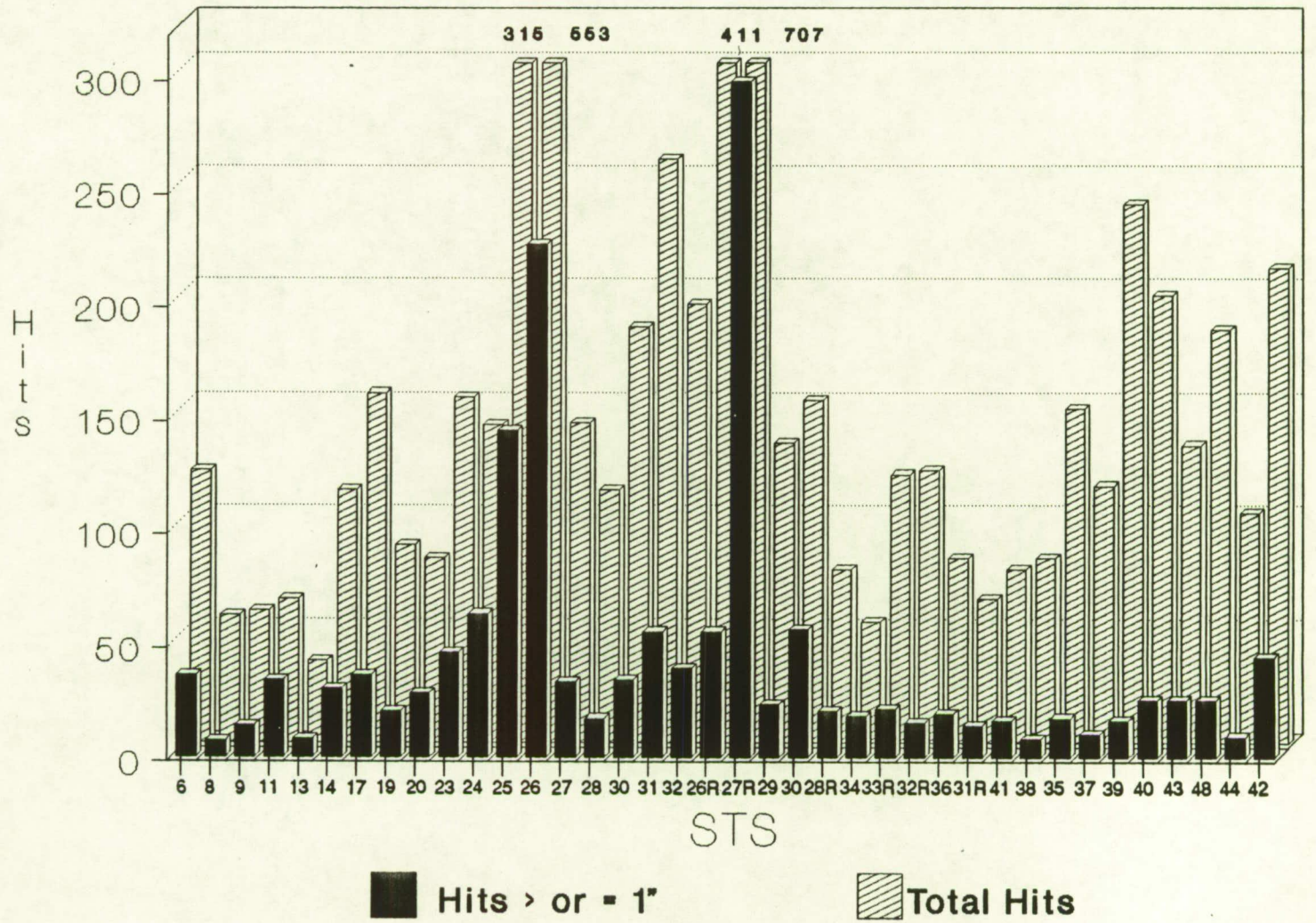
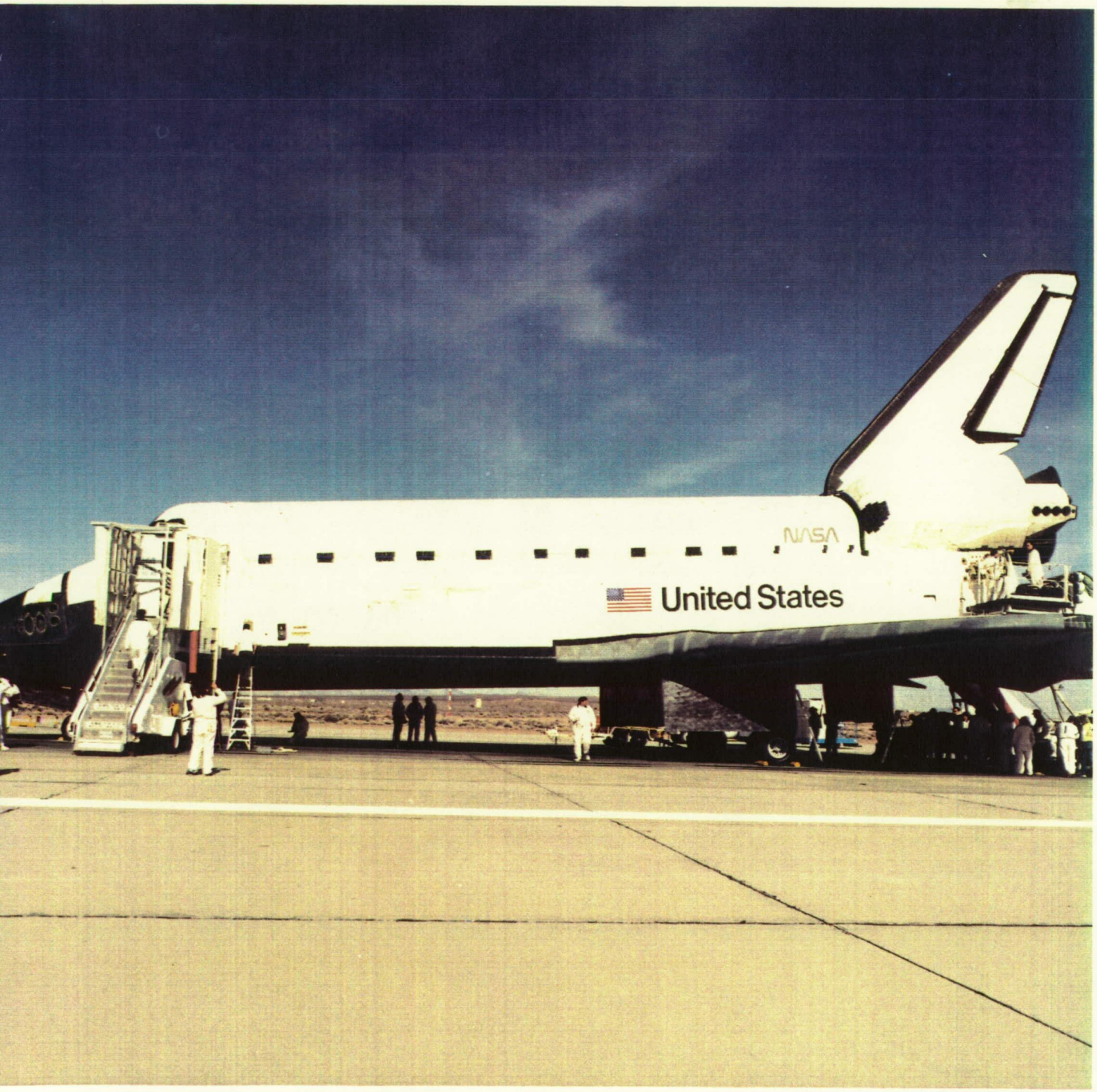
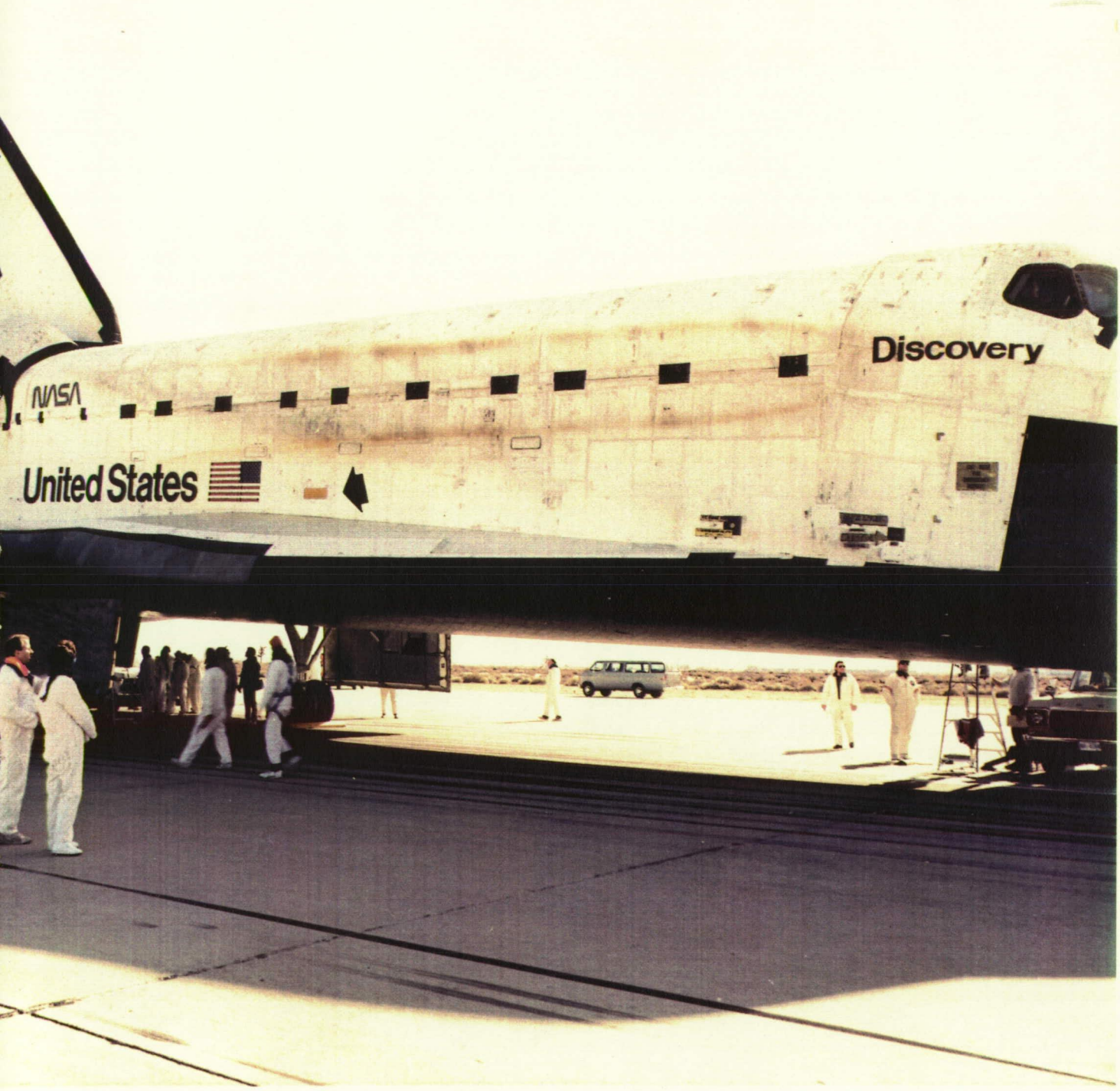


Figure 18. # COMPARISON TABLE

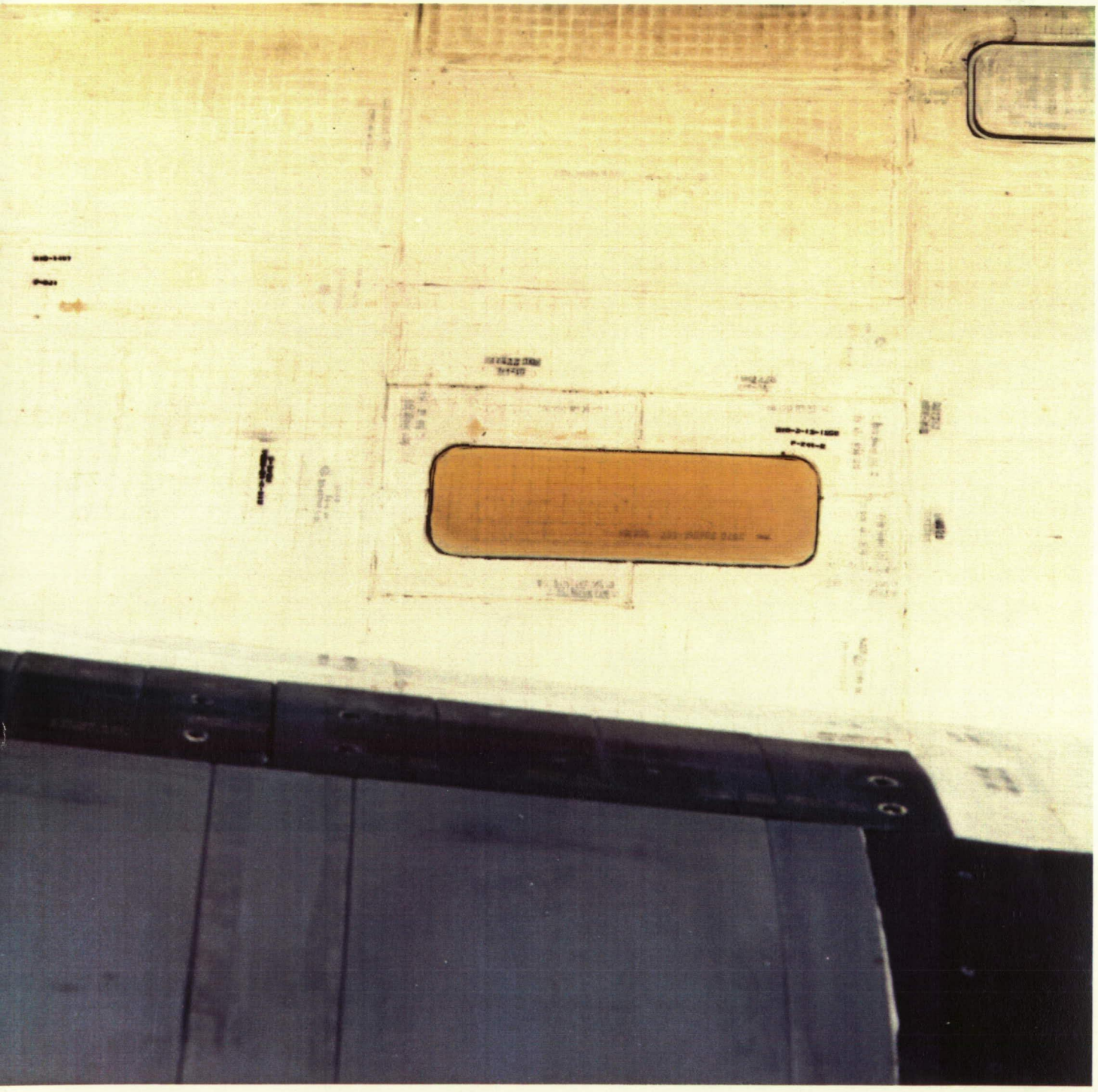




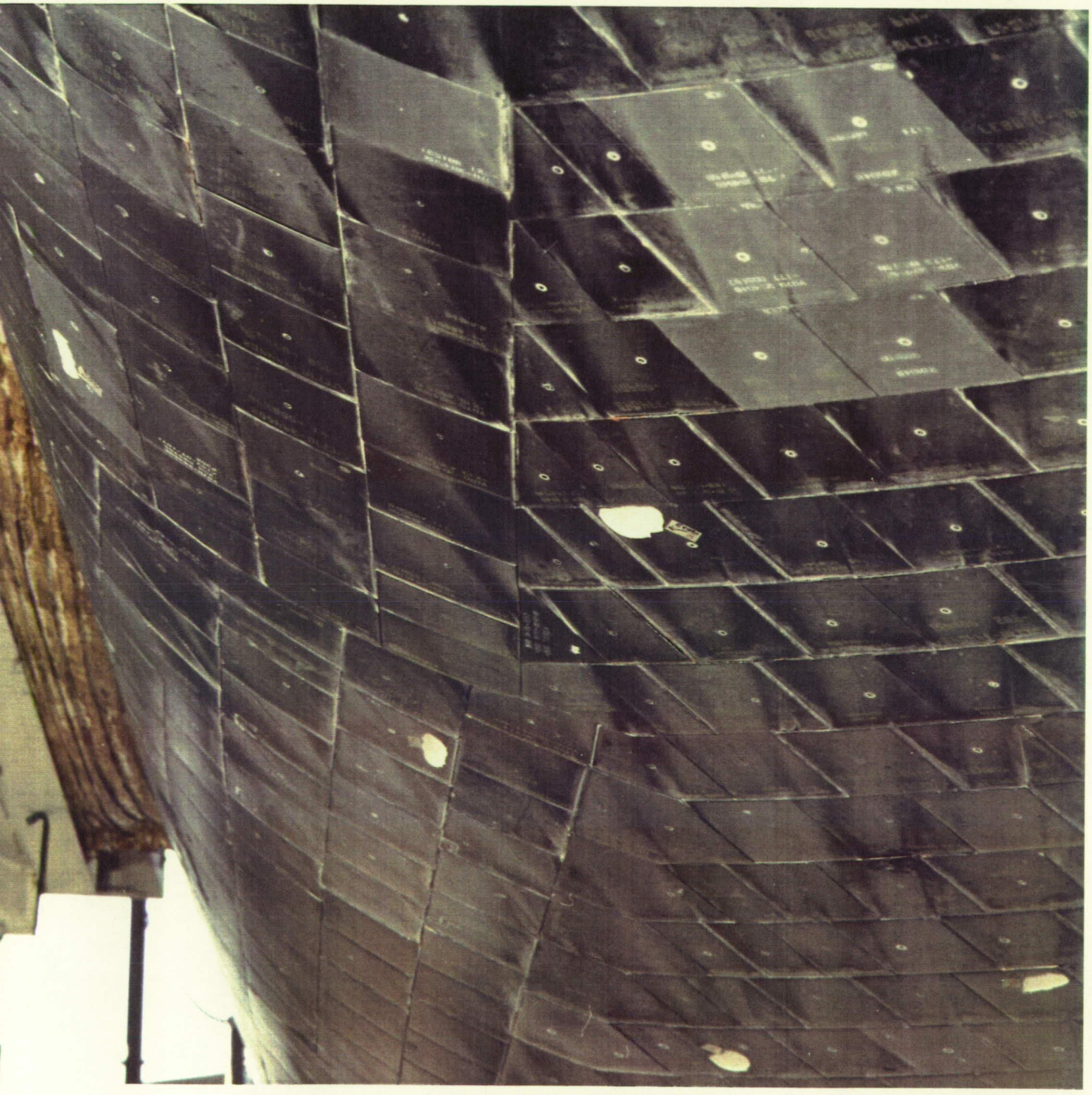
Overall view of Orbiter left side



Overall view of Orbiter right side. Streaks on payload bay door and fuselage may be related to on-orbit leak of aft RCS thruster. Note yellow discoloration of vent door #7.

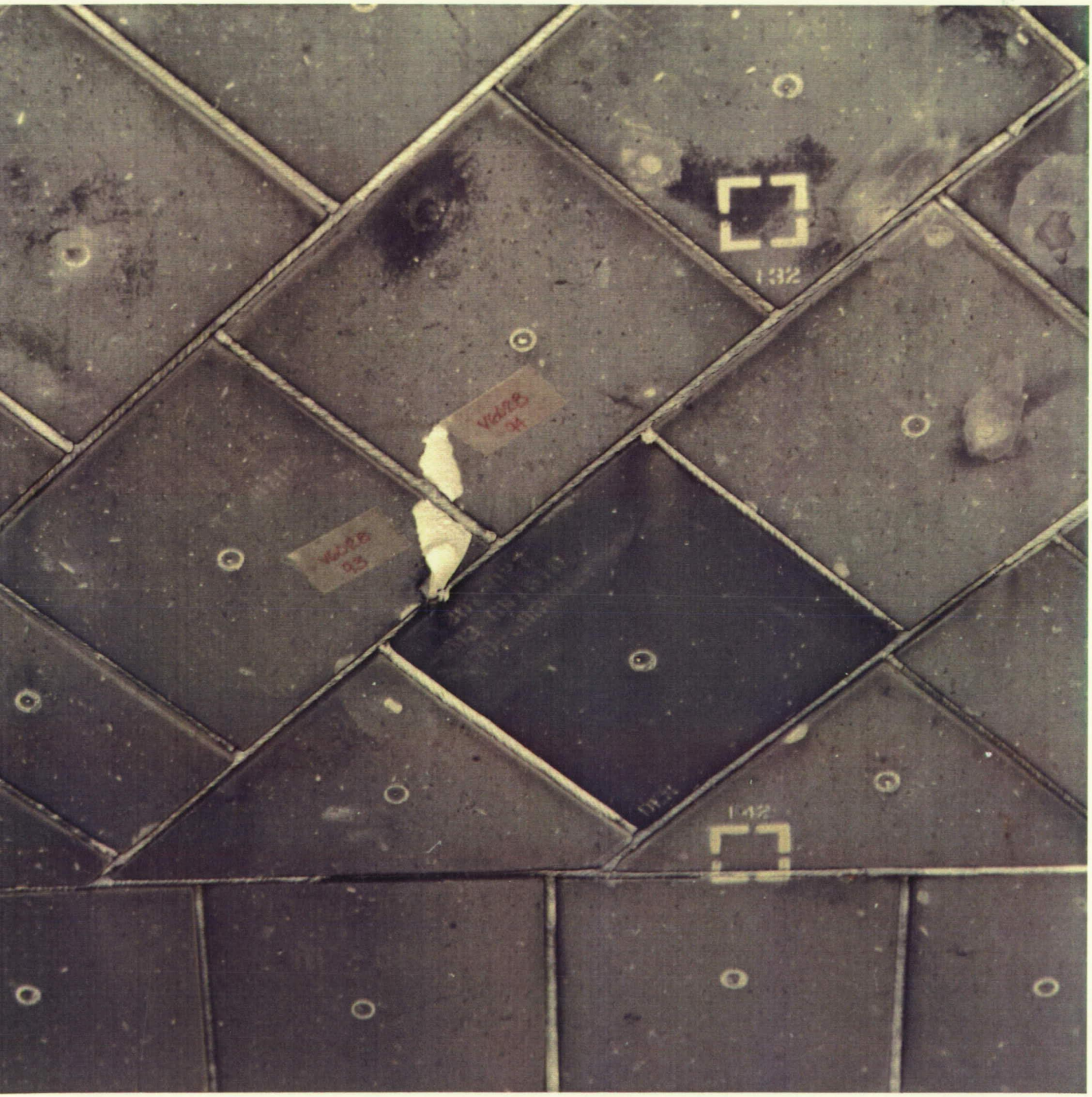


A hydraulic fluid leak was eliminated as a possible cause of the yellow discoloration on vent door #7. The most likely cause is believed to be a reaction of the RTV bonding agent through the flexible insulation blanket and thermal barrier.

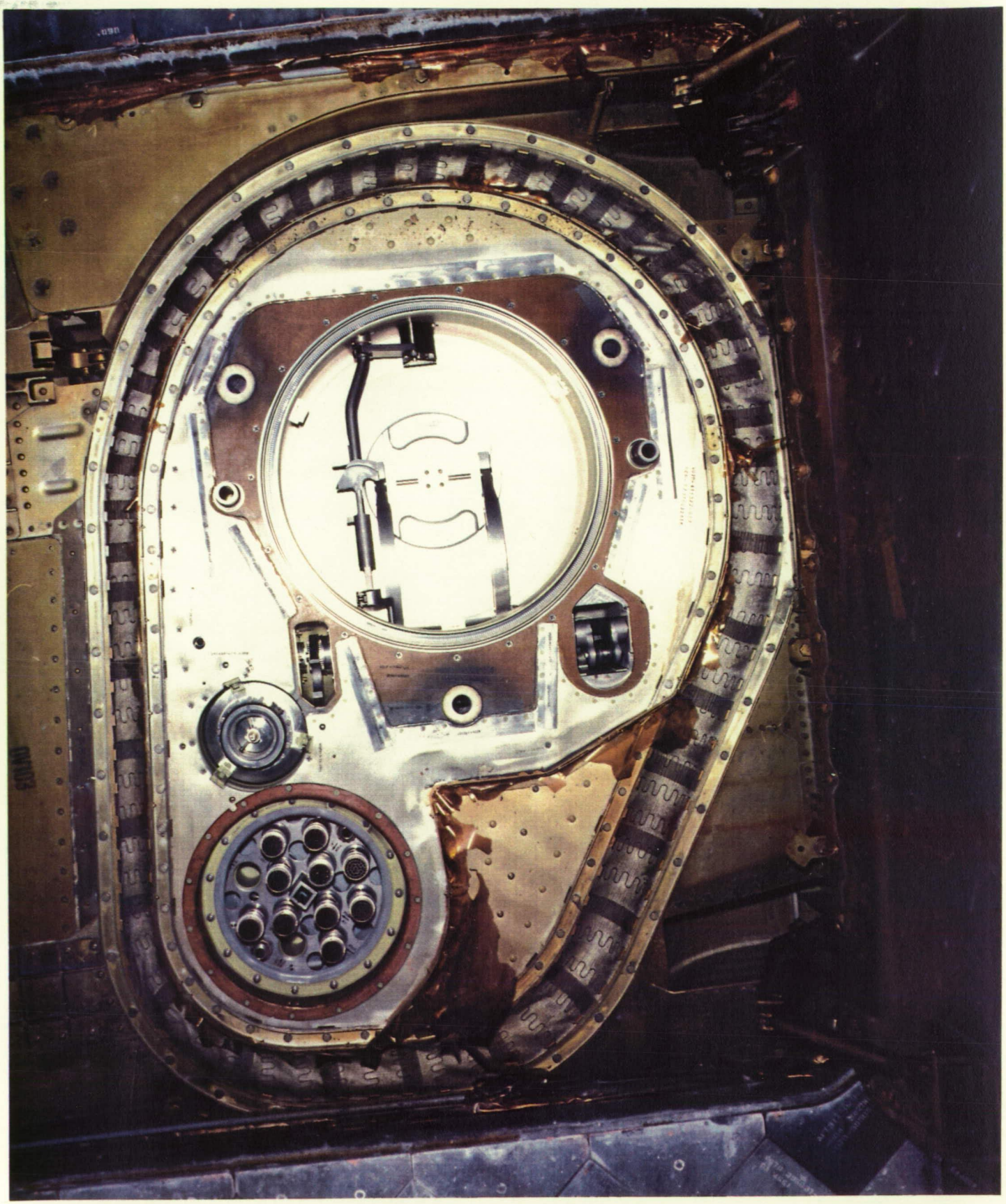


Tile damage on the lower surface near the Orbiter nose generally consisted of shallow damage sites (3/8-inch or less) relative to the surface area. This type of tile damage is indicative of impact by low density material.

The largest tile damage site (10-3/4" x 1-3/8" x 1/4") occurred on the forward right hand side of the Orbiter lower surface

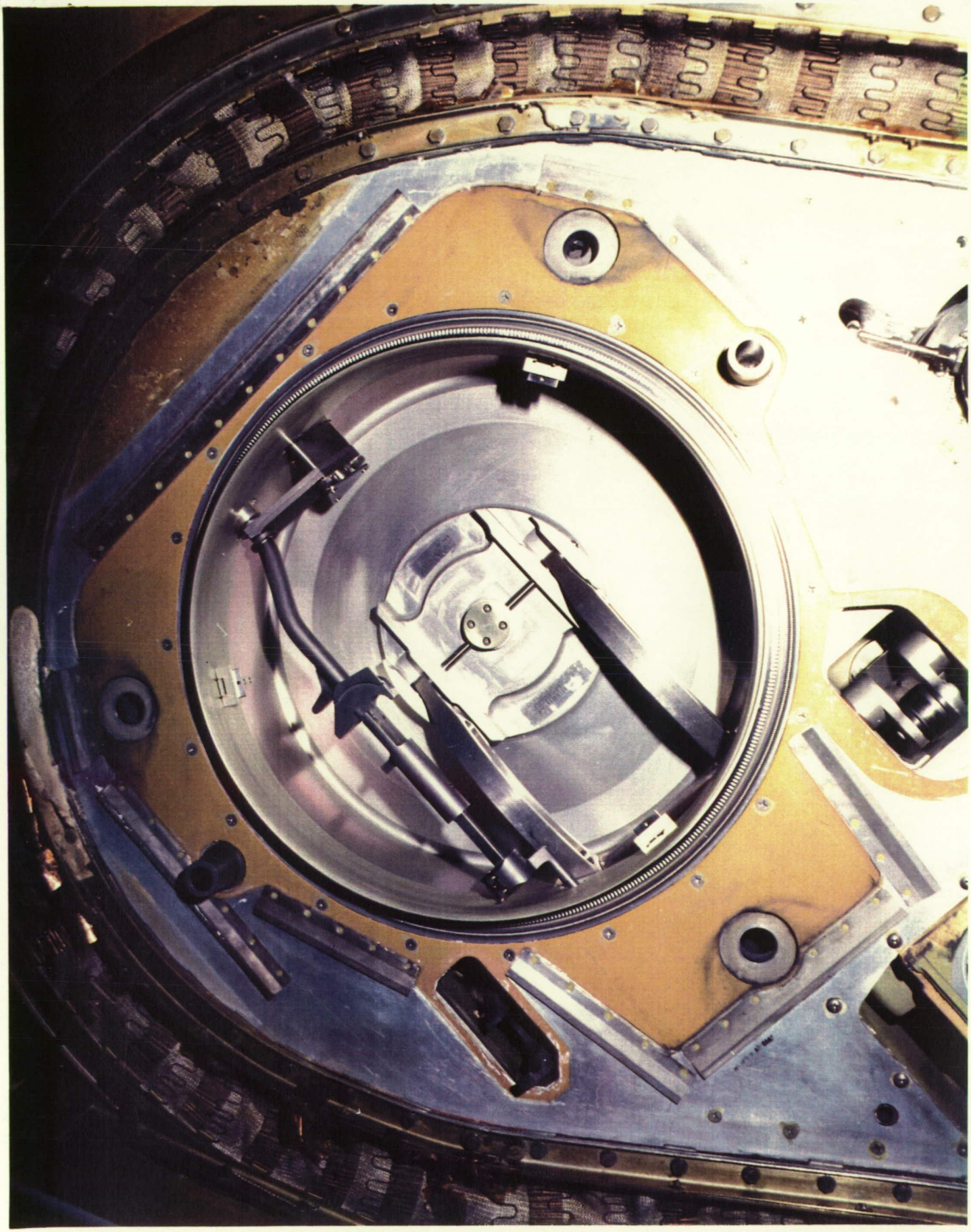


Typical tile damage on the Orbiter aft lower surface exhibited minor thermal erosion.



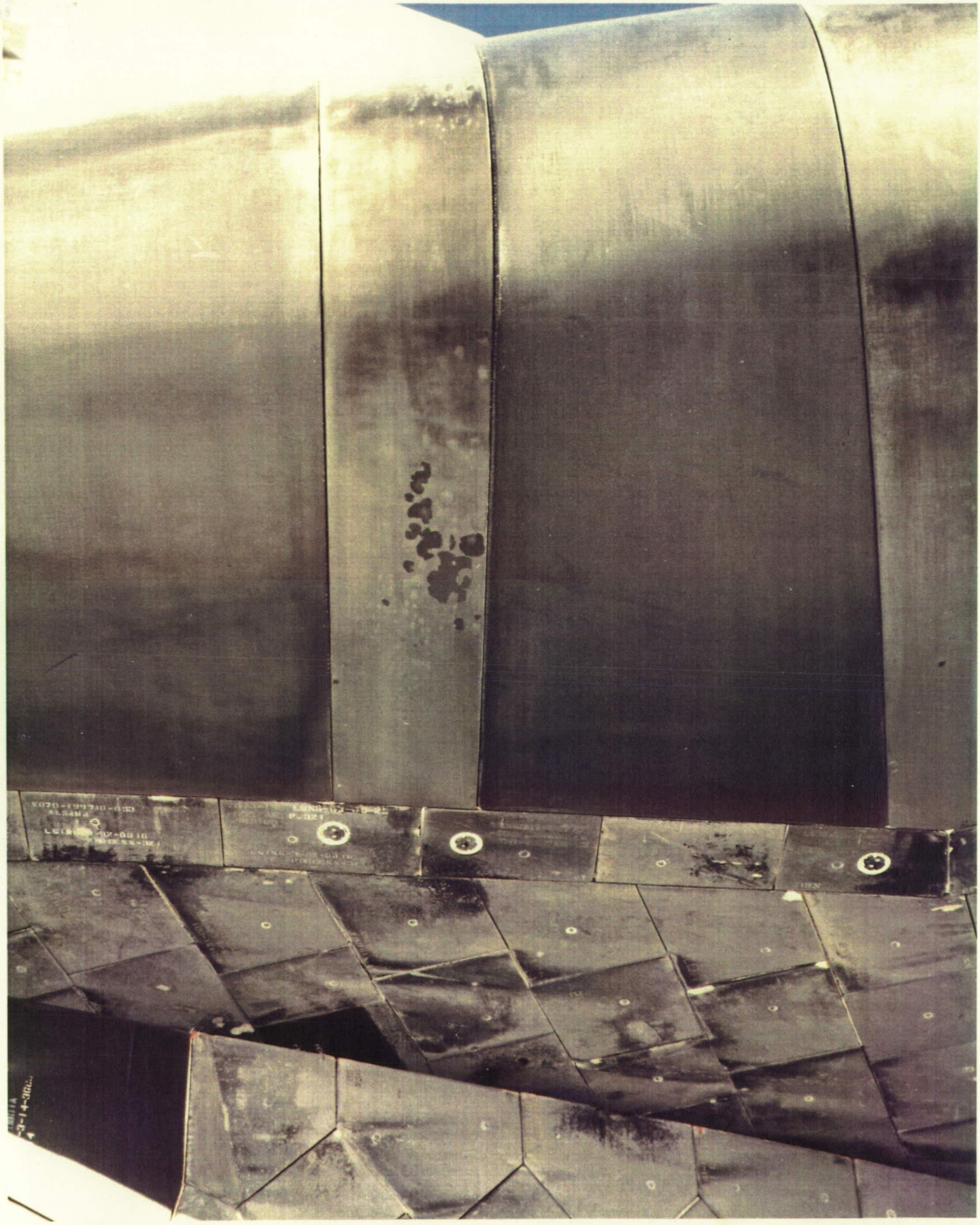
Overall view of the LO2 ET/ORB umbilical. The separation ordnance device debris plunger in EO-3 was seated and appeared to have functioned properly. Wrinkling of the interface plate, particularly near the aft separation bolt hole, was attributed to shrinkage during cryogenic chilldown.

C-2

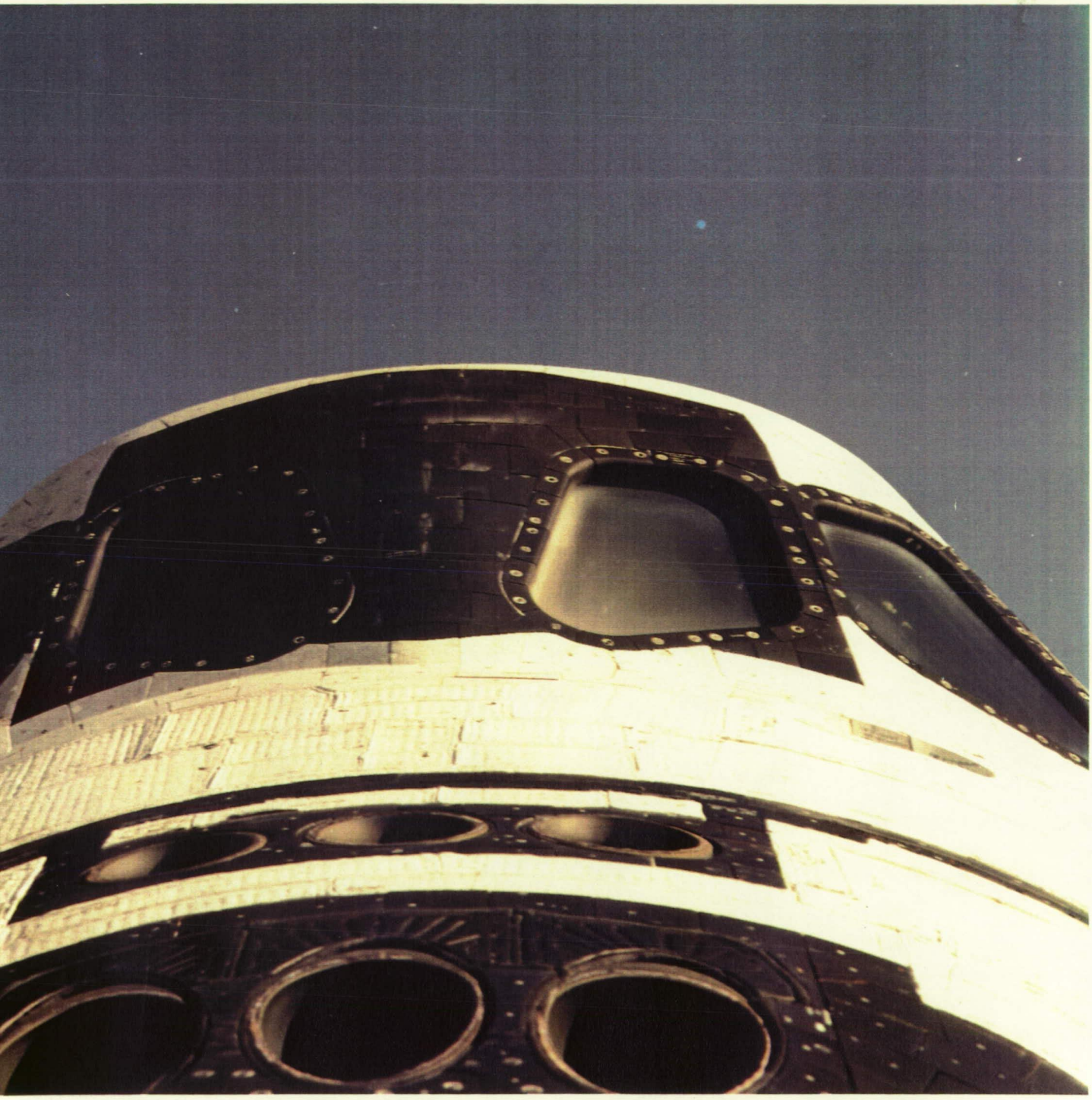


Overall view of the LH2 ET/ORB umbilical.

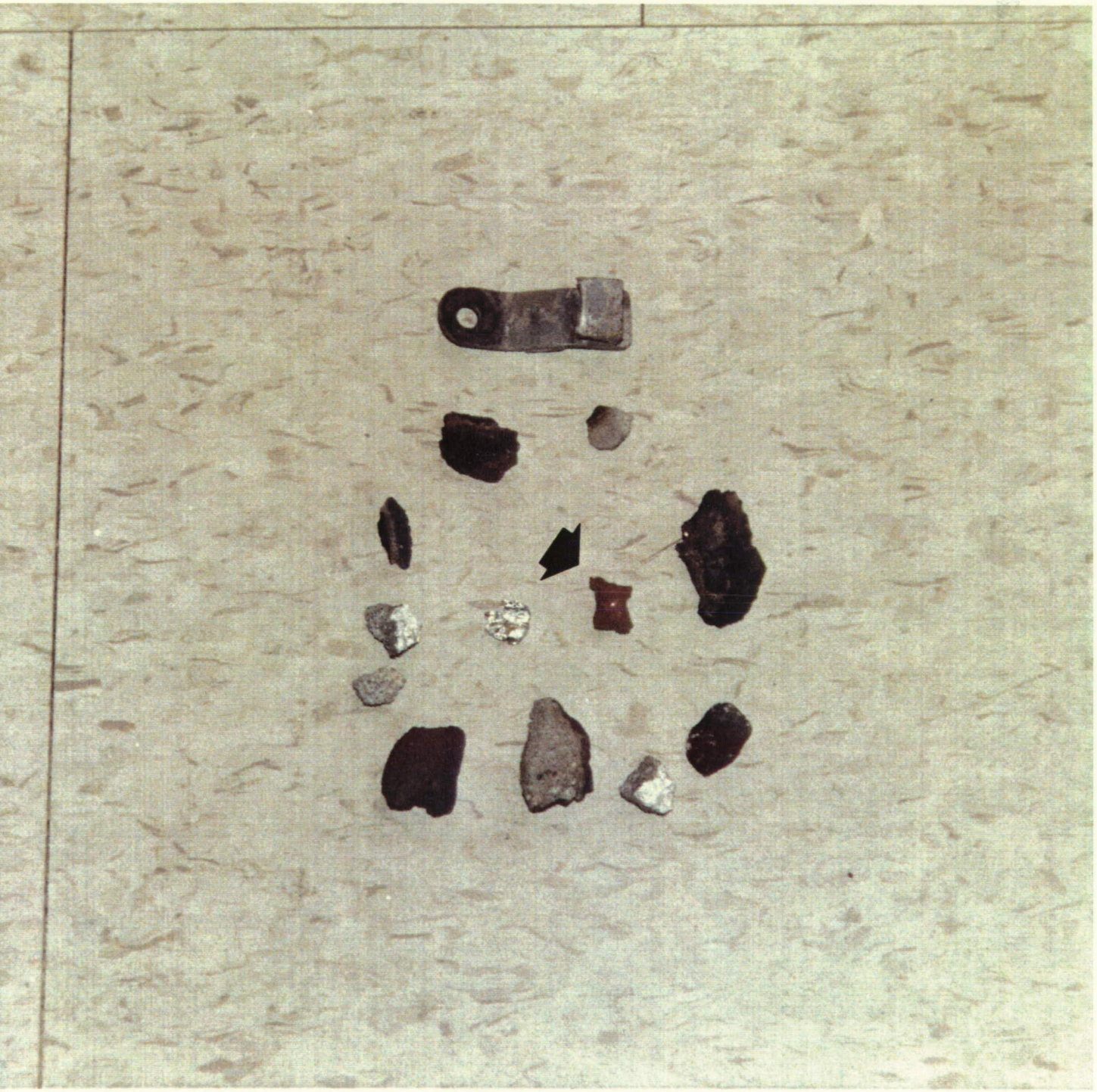
An ordnance connector from the outboard LH2 ET/ORB umbilical separation system fell to the runway when the ET door was opened.



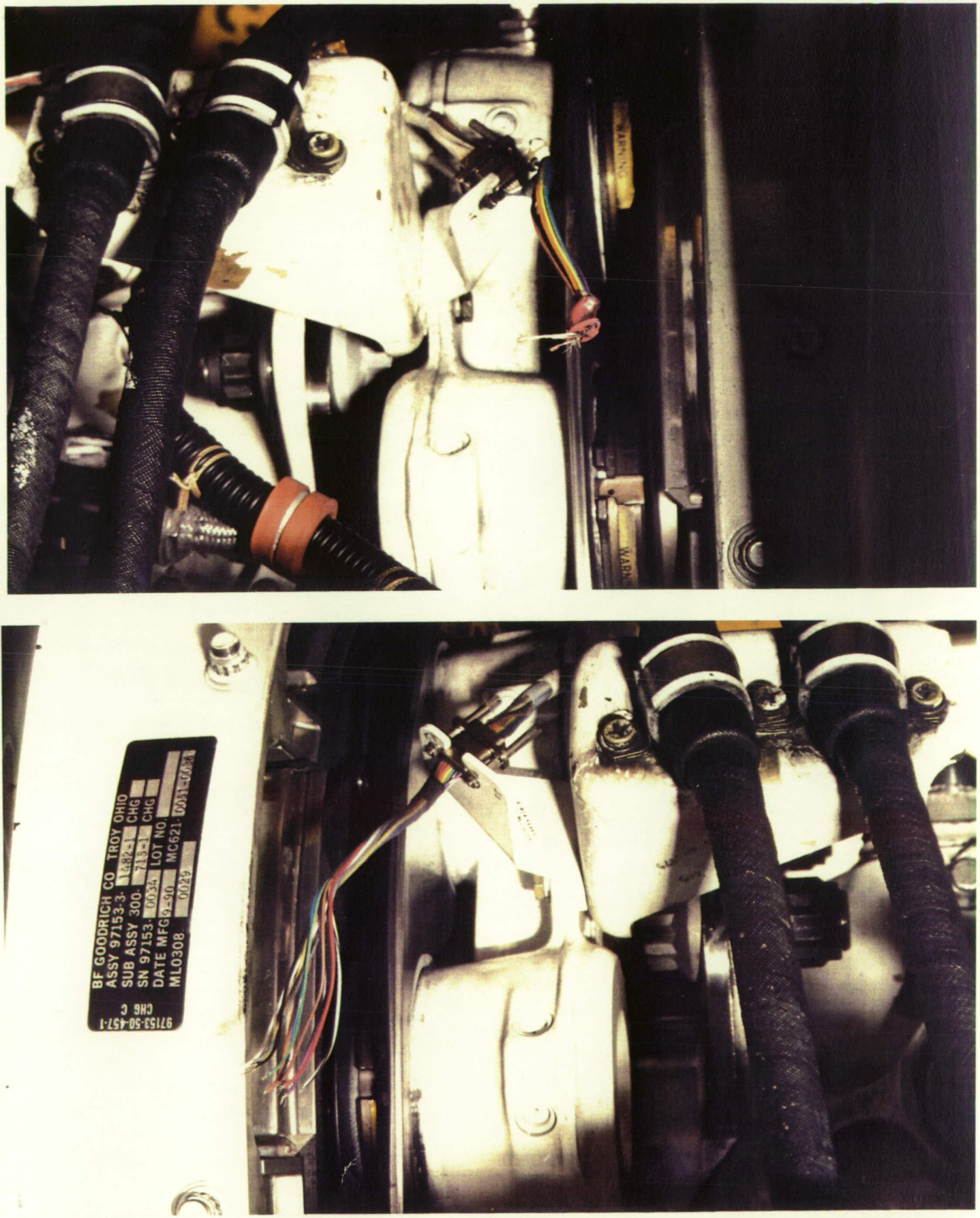
The coating on the LH wing leading edge RCC T-seals #7 and #8 exhibited some blistering and spalling, but was not a debris issue.



All Orbiter windows exhibited typical hazing. A few small streaks were present on windows #3 and #4



Typical debris found on the runway after landing. The only flight hardware recovered was a small piece of red RTV rubber material from the LH inboard main landing gear tire strain gage wire harness.



Comparative views showing small piece of RTV rubber material attached to strain gage wires (nominal configuration) and missing RTV from wires on the LH inboard main landing gear.

9.0 DEBRIS SAMPLE LAB REPORTS

Debris samples for the STS-42 mission are divided into three categories:

1. Post-landing samples
2. Orbiter RH Vent Door #7 blanket
3. Removed Tiles (damaged)-MSFC Analysis

POST-LANDING SAMPLES

A total of 13 samples were obtained from Orbiter OV-103 during the STS-42 post landing debris assessment at Ames-Dryden Flight Research Facility (ADFRF), California (Figure 14). The thirteen submitted samples consisted of 8 window wipes, 1 RH fuselage residue scraping, 3 tile samples (damage sites), and 1 residual sample from the LH2 ET/ORB umbilical plate. The samples were analyzed by the NASA KSC Microchemical Analysis Branch (MAB) for material composition and comparison to known STS materials. Debris analysis involves the identification and correlation of particles with respect to composition, thermal (mission) effects, and availability. Debris sample results and analyses are listed by Orbiter location in the following summaries.

Orbiter Windows

Results of the window sample analysis revealed the presence of the following materials:

1. Metallics
2. RTV, silica tile, tile coating
3. Glass fibers, insulation
4. Paints, dust, rust and salt
5. Organics
6. Earth compounds

Debris analysis provides the following correlations:

1. Metallic particles (nickel, aluminum, cadmium and carbon steel alloys) are common to SRB/BSM exhaust residue, but are not considered a debris concern in these quantities (micrometer) and have not generated a known debris effect

2. RTV, silica tiles, and tile coating originate from tile Orbiter TPS (thermal protection system).

3. Glass fibers and insulation materials originate from blanket insulation Orbiter TPS (thermal protection system).

4. Paint is of flight hardware/facility/GSE origin. Dust and salt are naturally-occurring landing site products. Rust is an SRB/BSM exhaust residue.

5. Organics are being analyzed by chemical fingerprint (infrared spectrometry) method; results are pending. This detailed process is more difficult due to small sample quantity (micrometer).

6. Earth compounds (muscovite, calcite, and alpha-quartz) are of landing site origin.

RH Fuselage

Results of the RH fuselage residue sample analysis indicated the presence of the following materials:

White, dense silica

Debris analysis provides the following correlations:

White, dense silica is normally observed in samples containing tile coating materials. This sample location is on insulation blanket. Comparative analysis is ongoing to further characterize this residual coating.

Orbiter Tile

Results of the tile sample chemical analysis revealed the presence of the following materials:

1. Metallics
2. Silica tile, tile coating
3. Dust and salt
4. Rust and paint

Debris analysis provides the following correlations:

1. Iron-Chromium is unique to one tile sample; the source cannot be conclusively defined (mission or sampling method contamination) due to small quantity. Aluminum alloy is common to SRB/BSM exhaust residue. Both of these particles are not considered a debris concern in this quantity and have not generated a known debris effect.

2. Silica tile and tile coating materials are used in tile Orbiter TPS (thermal protection system).

3. Dust and salt are naturally-occurring landing site products.

4. Rust is an SRB/BSM exhaust residue; paint is of flight element, ground support equipment (GSE), or facility coating origin.

LH2 Orbiter/ET Umbilical

Results of the LH2 Orbiter/ET umbilical sample revealed the presence of organic materials.

Organic materials are being analyzed by chemical fingerprint (Infrared spectrometry) method; results are pending. This detailed process is especially difficult in small sample quantities.

Conclusions

The STS-42 mission sustained Orbiter tile TPS damage to a greater than average degree. The chemical analysis results from post flight samples did not provide data that indicated a single source of damaging debris. Analysis results were consistent with previous missions in that no material or substance appeared outside of the established data base.

Orbiter window samples provided evidence of SRB/BSM exhaust residue, Orbiter TPS materials, landing site products, organics, and paint.

The Orbiter tile (damage site) samples were found to contain a variety of residuals. These residuals, including metallics, TPS materials, paint, and environmental products, do not establish a single source or debris effect. This sampling, when coupled with the MSFC analysis of removed damaged tiles, should provide a data base for corrective debris analysis.

The LH2 Orbiter/ET umbilical sample was found to contain organic materials. Specific identification analysis is pending.

RH ORBITER VENT DOOR #7 BLANKET

Post-landing observation of the unusual colored vent door blanket resulted in the sampling and subsequent removal of the blanket material. Although an initial analysis was required to complement visual observations that a vehicle/debris problem was not evident, results of detailed testing concluded the vent door discoloration was not a debris concern.

OV-103 Vent Door #7 Discoloration

After the STS-42 landing, several analyses have been performed on diverse wipe samples and the blanket specimen itself. Several sample wipes were taken at DFRF and again at KSC upon arrival. The wipe samples taken at DFRF included blanket surface and upper portion of the wing duct assembly.

The analysis performed to date included Infrared Spectrometry (IR), Energy Dispersive X-rays (EDX), Scanning Electron Microscopy (SEM), Gas Schomotography/Mass Spectrometry (GC/MS), X-ray Diffraction (XD) and X-ray Photoelectron Spectroscopy (XPS). Initial sample analysis indicated a compound similar to hydraulic fluid Mil-H-82382. Subsequent lab tests performed on a new piece of blanket material conclusively proved that the cause of the discoloration was not hydraulic fluid. Most of the analysis consistently indicated silicone type material and trace compounds of a different nature. Some of the component elements found included tin, zinc, flourine and nitrogen.

The tin is believed to originate from the catalyst used for the formulation of RTV 560 (dibutyltin dilaureate). Candidates for the presence of fluorine are Krytox, Braycote and Scotchguard. Nitrogen sources include acrylonitrile and/or heterocyclic nitrogen from the anti-oxidant in the Orbiter tires. The element zinc can originate from a primer-type material, but seems unlikely. Laboratory tests indicated minimal amounts of organic material, which may be attributed to "burn-off" during re-entry.

Several other tests have been performed in which various Orbiter compounds were coated on new blanket material and heated in a vacuum oven at elevated temperature (greater than 300 degrees C).

The test compounds included dibutyltin, Krytox and Braycote. It is interesting to note that the test panels turned brown-orange in color. No further laboratory analysis have been performed due to equipment failure (XPS unit). Additional samples that have been taken to the laboratory include Koropon paint primer, rubber specimens from the Shuttle tires, and a primed aluminum doubler. Further laboratory results are pending.

Background Information

* A similar problem occurred on OV-103 in 1984 (maiden flight). Samples were taken, but no solution was found to the problem. The blanket was coated with C-9 compound and continued to be flown until 1987 when it was replaced.

* STS-42 and STS-41D were both UV intense missions.

* The wheel well area was found to be clean with the exception of a small quantity of grease on the inboard side of the right landing gear door. This is an unexposed area when the Orbiter is in flight.

* With the exception of a red-orange stain (2" X 2") inside the wing duct vent assembly, the duct was very clean. The analysis of the stained portion revealed a silicone-type material.

* The ascent and descent relief doors on the wing duct vent assembly were in the closed position on return from flight.

* Torque tube/push rod gear box were inspected for Braycote leakage and none was observed.

* Temperature in the wheel well reached a high of 100 degrees F as reported by JSC.

Note: It is suspected that the tires outgassed into the wing duct vent assembly.

* Test samples of the removed vent door #7 blanket were sent to:

KSC lab
RI Downey
JSC - Materials lab

REMOVED TILES (DAMAGED) - MSFC ANALYSIS

As a result of the significant number of damaged tiles and the on-orbit photographs of the External Tank showing missing foam from the intertank, an STS-42 TPS Tile Damage Investigation Team was established. This team is under the direction of the MSFC material laboratory and will evaluate nine damaged tiles removed from OV-103. The current schedule for analysis depicts June 1992 as a report completion date. At this time, only external scanning of the removed tiles has been completed. The results of this non-destructive testing indicated localized dense areas in the tile damage areas along with other trace elements. Destructive testing of the removed tiles is planned and the results are pending. Full test results will be documented when available.

10.0 POST LAUNCH ANOMALIES

Based on the debris inspections and film review, 10 Post Launch Anomalies, including one IFA candidate, were observed on the STS-42 mission.

10.1 LAUNCH PAD/FACILITY

1. Fire brick from the SRB flame trench was scattered across the pad acreage north to the perimeter fence.

10.2 EXTERNAL TANK

1. Two divots, approximately 8-10 inches in diameter, were located outboard of the -Y bipod ramp and forward of the LH2 tank-to-intertank flange in the intertank acreage. The intertank TPS should remain intact with no loss of material during ascent. Although there is no photographic data showing the condition of the ET TPS in the +Y+Z quadrant, the External Tank is the most likely source for the debris that caused the Orbiter tile damage. (IFA candidate)

10.3 SOLID ROCKET BOOSTERS

1. The HDP #3 Debris Containment System (DCS) plunger was not seated when inspected at Hangar AF during the Post Flight Assessment.

2. A 2.0" x 0.25" frangible nut web lay on the holddown post #2 stud after launch. Large pieces of ordnance debris should be retained by the DCS.

3. A 6" x 4" piece of aft skirt instafoam broke away near the inboard edge of holddown post #7 during liftoff. Instafoam closeouts should remain attached to the vehicle.

4. TPS on the forward side of the upper strut fairing (a 3"x1" area on the LH SRB; a 6"x3" area on the RH SRB) at the separation plane was missing and the substrate was charred. The loss of TPS in this area probably occurred during strut separation and may have been caused by primer delamination.

5. Approximately 20 percent of the HDP #3 EPON shim material was missing and the substrate was charred. The shim material appeared to have been lost during ascent.

10.4 ORBITER

1. The Orbiter TPS sustained a total of 209 hits, of which 44 had a major dimension of 1-inch or greater. Fourteen of these hits had a major dimension of 3-inches or greater and eleven of these hits were located along the forward one-third of the vehicle. All of the hits were shallow (3/8-inch or less) relative to the surface area and are usually indicative of impacts by low density materials. A comparison of these numbers to statistics from 31 previous missions shows that both the total number of hits and the number of hits one-inch or larger were significantly greater than average. Post flight assessment of the recovered SRB's revealed no loss of MSA-2 TPS from the frustums and forward skirts. SOFI debris from the External Tank intertank and/or lower LO2 tank is the most likely cause of the tile damage.

2. SSME ignition vibration/acoustics caused the loss of tile surface coating material from six locations on the OMS nozzle heat shield and Orbiter base heat shield.

3. An ordnance connector (P/N NBS9GE8-2SE) from the LH2 umbilical outboard pyro separation system fell onto the runway when the ET door was opened.

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National Aeronautics and Space Administration

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16. Abstract

A Debris/Ice/TPS assessment and photographic analysis was conducted for Shuttle Mission STS-42. Debris inspections of the flight elements and launch pad were performed before and after launch. Ice/frost conditions on the External Tank were assessed by the use of computer programs, nomographs, and infrared scanner data during cryogenic loading of the vehicle followed by on-pad visual inspection. High speed photography was analyzed after launch to identify ice/debris sources and evaluate potential vehicle damage and/or in-flight anomalies. This report documents the debris/ice/TPS conditions and photographic analysis of Mission STS-42, and their overall effect on the Space Shuttle Program.

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