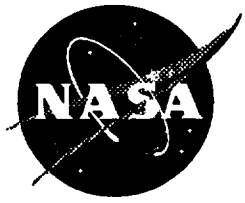
NASA Technical Memorandum TM 109201

Debris/Ice/TPS Assessment and Integrated Photographic Analysis for Shuttle Mission STS-62

May 1994



National Aeronautics and Space Administration

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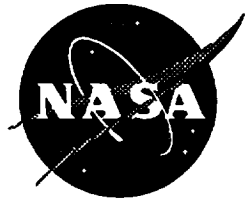

DEBRIS/ICE/TPS ASSESSMENT
AND
INTEGRATED PHOTOGRAPHIC ANALYSIS
OF
SHUTTLE MISSION STS-62

March 4, 1994

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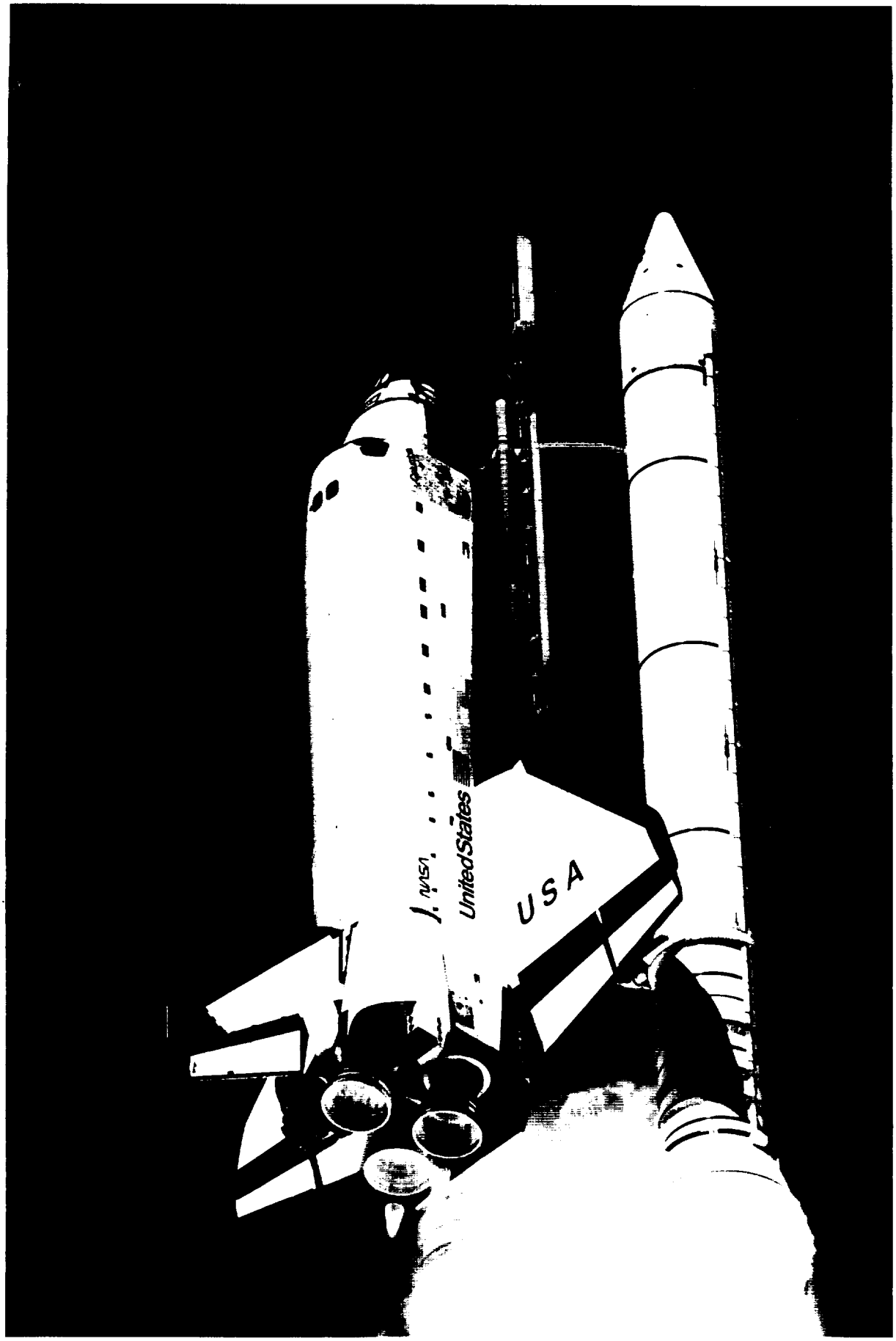
FOREWORD

The Debris Team has developed and implemented measures to control damage from debris in the Shuttle operational environment and to make the control measures a part of routine launch flows. These measures include engineering surveillance during vehicle processing and closeout operations, facility and flight hardware inspections before and after launch, and photographic analysis of mission events.

Photographic analyses of mission imagery from launch, on-orbit, and landing provide significant data in verifying proper operation of systems and evaluating anomalies. In addition to the Kennedy Space Center (KSC) Photo/Video Analysis, reports from Johnson Space Center, Marshall Space Flight Center, and Rockwell International - Downey are also included in this document to provide an integrated assessment of the mission.



Shuttle Mission STS-62 was launched at 8:53 a.m. local 3/4/94

1.0 Summary

A pre-launch debris inspection of the pad and Shuttle vehicle was conducted on 2 March 1994. The detailed walkdown of Launch Pad 39B and MLP-1 also included the primary flight elements OV-102 Columbia (16th flight), ET-62 (LWT 55), and BI-064 SRB's. There were no significant facility or vehicle anomalies.

The vehicle was cryoloaded on 4 March 1994 after a one day delay due to unfavorable weather predictions. There were no Launch Commit Criteria (LCC), OMRS, or NSTS-08303 criteria violations. There were no ice/frost conditions outside of the established data base and no IPR's were taken.

Although acreage icing on the External Tank was possible due to an ambient temperature of 45 degrees, winds averaging 8 knots and relative humidity of 81 percent caused only frost to form on a mostly condensate-free tank. Patches of frost were visible on the LO2 tank barrel section and the LH2 tank acreage.

After the 8:53 a.m. launch on March 4th, a debris inspection of Pad 39B was performed. No flight hardware or TPS materials were found. Damage to the pad overall was minimal. The GH2 vent line was latched properly, came to rest on the eighth tooth of the latching mechanism, and had no loose cables.

A total of 149 films and videos were analyzed as part of the post flight data review. No major vehicle damage or lost flight hardware was observed that would have affected the mission. No stud hang-ups occurred on any of the holddown posts. All T-0 umbilicals operated properly.

On-orbit photographs taken by the flight crew and two films from the ET/ORB umbilical cameras of the External Tank after separation from the Orbiter revealed no major damage or lost flight hardware that would have been a safety of flight concern. Intertank foam, 14 inches long by 4 inches wide, was missing from a stringer head forward of the left bipod spindle housing closeout. Approximately 3 inches of primer was exposed. A small divot appeared just aft of the left bipod spindle in the LH2 tank-to-intertank flange closeout. No other divots were visible in the flange closeout. The bipod jack pad closeouts appeared to be intact. A divot, 5 inches in diameter, occurred in the LH2 tank acreage adjacent to the +Y side of the cable tray. The divot went to substrate and exposed the primer.

Orbiter performance on final approach appeared normal. Infrared imagery of landing gear deployment showed the loss of thermal barrier from the nose gear wheel well. The missing thermal barrier material was not recovered.

The Solid Rocket Boosters were inspected at Hanger AF after retrieval. Both frustums had a combined total of 44 MSA-2 debonds over fasteners. Significant amounts of BTA had been applied to closeouts on the RH frustum, forward skirt, and aft skirt. Hypalon paint was blistered/missing over the areas were the BTA had been applied. The underlying BTA was not sooted (IFA STS-62-B-1). Investigation of this condition concluded there was insufficient heat rates to cause blistering of the Hypalon until late in the ascent phase. Testing has shown that Hypalon paint blisters burn off rather than become detached debris sources.

The LH frustum upper left BSM cover was bent backward to the 90 degree position and the attach ring had been deformed/fractured by parachute riser entanglement. The upper right BSM cover had rotated 20 degrees counterclockwise when the set screw holding the BSM in position was overloaded by parachute riser entanglement. The HDP #8 DCS plunger had been pushed back into the plunger housing, but was not obstructed by frangible nut pieces. Although launch films showed no debris falling from the DCS/stud hole at lift off, post flight disassembly of the Debris Containment System revealed a retention of only 77 percent. The ordnance fragments may have been lost at water impact.

A post landing inspection of OV-102 was conducted after the landing at KSC. The Orbiter TPS sustained a total of 97 hits, of which 16 had a major dimension of 1-inch or larger. The Orbiter lower surface had a total of 36 hits, of which 7 had a major dimension of 1-inch or larger. Based on these numbers and comparison to statistics from previous missions of similar configuration, both the total number of debris hits and the number of hits 1-inch or larger was less than average.

The largest tile damage site measured 10" x 2.5" x 0.675", involved four tiles, and was located five feet forward and five feet inboard of the RH main landing gear wheel well leading edge. The damage site was not that large initially but appears to have originated from four distinct impacts enlarged by erosion during re-entry. The remaining tile material in the damage site showed no significant glazing.

A cluster of 29 damage sites spanned three tiles on the rudder black edge tiles (left side) along the hinge line below the split in the speed brake. Six of the damage sites had a major dimension of 1-inch or larger while three of the damage sites were deep enough to expose the substrate. Three small hits occurred in this same general area on the right side of the rudder/speed brake.

Six thermal barriers, total size approximately 36" x 3" x 1.5", and one corner tile piece 4" x 4", were missing from the nose landing gear doors. Runway infrared cameras recorded these objects falling from the Orbiter when the nose landing gear doors were opened on final approach.

A search of the area under the flight path failed to recover the missing thermal barriers, which may be submerged in the large body of water south of the runway. The cause for the loss of the material was attributed to the way the substrate was prepared for bonding at the vendor.

Orbiter post landing microchemical sample results revealed a variety of residuals in the Orbiter window samples. These were attributed to SRB BSM exhaust, Orbiter TPS, window protective covers and processing, natural landing site products, and paints/primers from various sources. The residual sampling data do not indicate a single source of damaging debris and all of these materials have been documented previously in analyses for post landing sample reports. Data from residual sampling also showed no trends when compared to previous mission data.

A total of ten Post Launch Anomalies, including one IFA, were observed during the STS-62 mission assessment.

2.0 PRE-LAUNCH BRIEFING

The Ice/Debris/TPS/Photographic Analysis Team briefing for launch activities was conducted on 2 March 1994 at 0815 hours. These personnel participated in various team activities, assisted in the collection/evaluation of data, and contributed to reports contained in this document.

B. Davis	NASA - KSC	Debris, IR, Photo Analysis
G. Katnik	NASA - KSC	Shuttle Ice/Debris Systems
P. Rosado	NASA - KSC	Chief, ET Mechanical Systems
R. Speece	NASA - KSC	Lead, Thermal Protection Sys
B. Bowen	NASA - KSC	ET Processing/Ice/Debris/TPS
K. Tenbusch	NASA - KSC	ET Processing/Ice/Debris/TPS
J. Rivera	NASA - KSC	Lead, ET Structures
M. Bassignani	NASA - KSC	ET Processing, Ice/Debris
J. Blue	LSOC - SPC	ET Processing
Z. Byrns	NASA - KSC	Level II Integration
J. McClymonds	RI - DNY	Debris Assess, LVL II Integ
W. Atkinson	RI - LSS	Debris Assess, Integration
R. Hillard	MTI - LSS	SRM Processing
S. Otto	MMMSS- LSS	ET Processing
J. Burney	LSOC - SPC	Safety

3.0 LAUNCH

STS-62 was launched at 94:63:13:53:00.009 GMT (8:53 a.m. local) on 4 March 1994 after a delay of one day due to unfavorable weather predictions.

3.1 PRE-LAUNCH SSV/PAD DEBRIS INSPECTION

A pre-launch debris inspection of the pad and Shuttle vehicle was conducted on 2 March 1994. The detailed walkdown of Launch Pad 39B and MLP-1 also included the primary flight elements OV-102 Columbia (16th flight), ET-62 (LWT 55), and BI-064 SRB's.

Three areas of damaged CPR, the largest estimated at 2 inches by 1 inch by an unknown depth, were detected on the LH2 barrel -Z side near the aft hard point during the S6444 Pre-Launch L-20 Hour Debris Walkdown (PR ET-62-TS-0020). Although the damage appeared to be caused by some type of impact, possibly from a bird, lack of access at the pad precluded further assessment. The condition was accepted for flight by MRB.

A secondary sound suppression water trough missing from the RH SRB exhaust hole was replaced prior to cryoload.

3.2 ICE/FROST INSPECTION

The Ice/Frost Inspection of the cryoloaded vehicle was performed on 4 March 1994 from 0340 to 0525 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 criteria violations. There were no conditions outside of the established data base and no IPR's were taken. Ambient weather conditions at the time of the inspection were:

Temperature:	44.7 Degrees F
Relative Humidity:	81.1 Percent
Wind Speed:	8.13 Knots
Wind Direction:	260 Degrees

A portable Shuttle Thermal Imager (STI) infrared scanning radiometer was utilized to obtain vehicle surface temperature measurements for an overall thermal assessment of the vehicle, as shown in Figures 1 and 2.

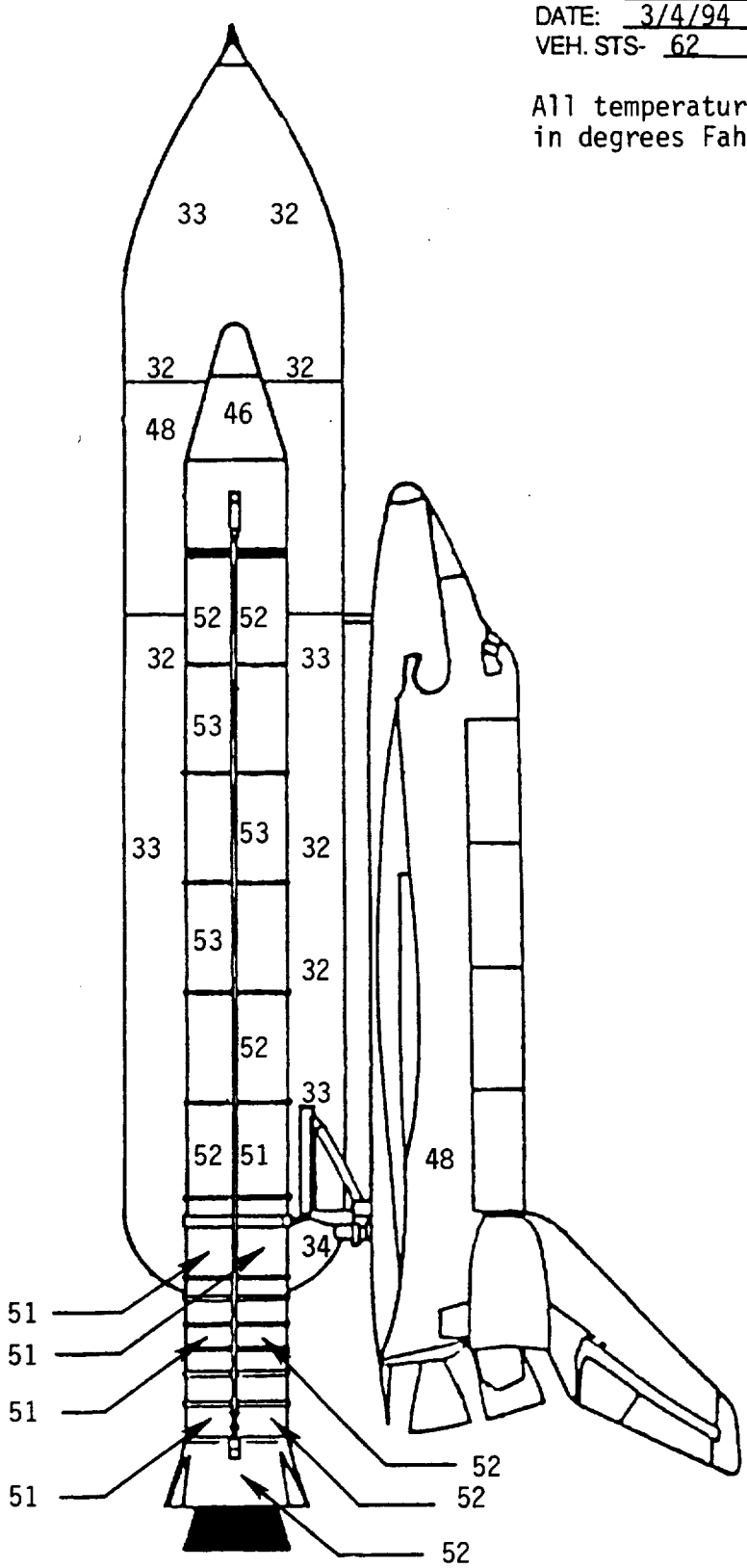
3.3 ORBITER

No Orbiter tile or RCC panel anomalies were observed. All RCS thruster paper covers were intact though the F2U cover had been wetted by internal vapors. Ice/frost accumulations were present at the SSME #1 and #2 heat shield-to-nozzle interfaces. An infrared scan revealed no unusual temperature gradients on the base heat shield or engine mounted heat shields, though a cold spot was visible inside the SSME #1 nozzle.

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

TIME: 0340 - 0525
DATE: 3/4/94
VEH. STS- 62

All temperatures are in degrees Fahrenheit



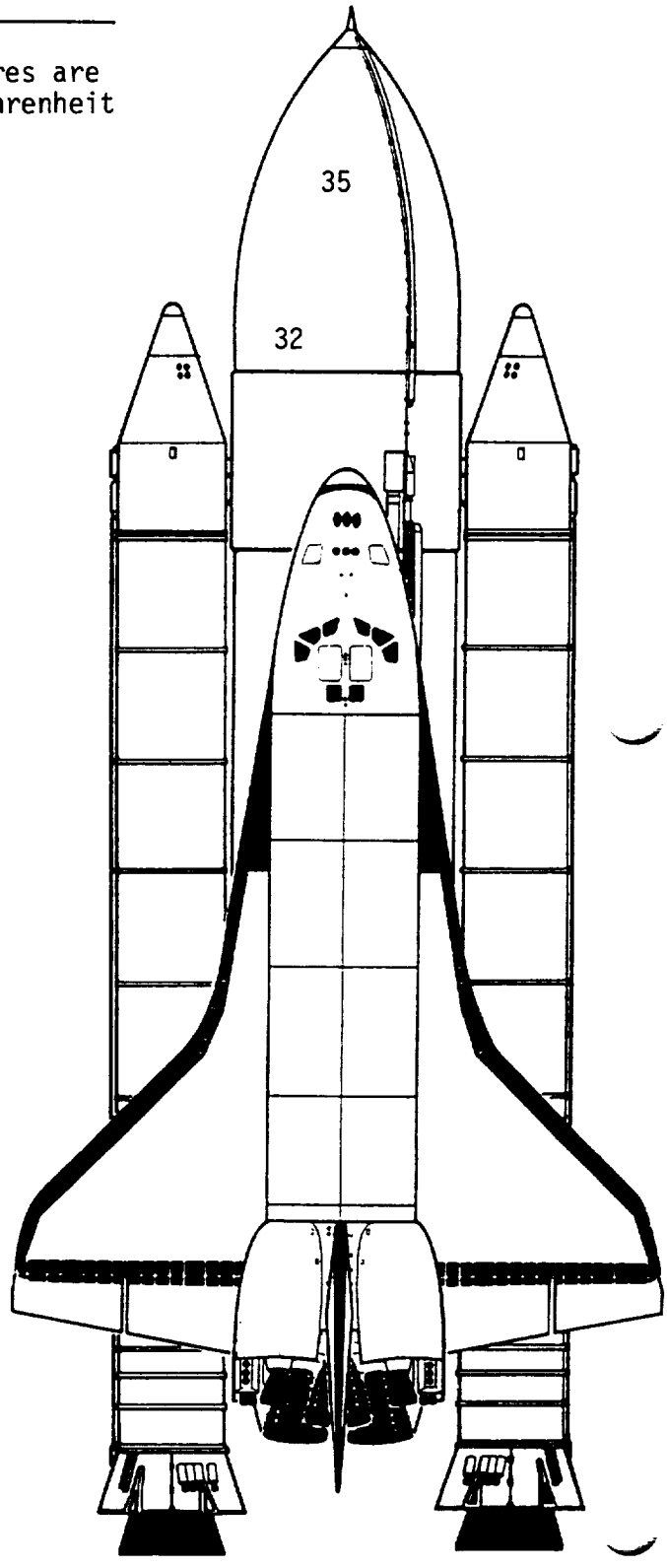
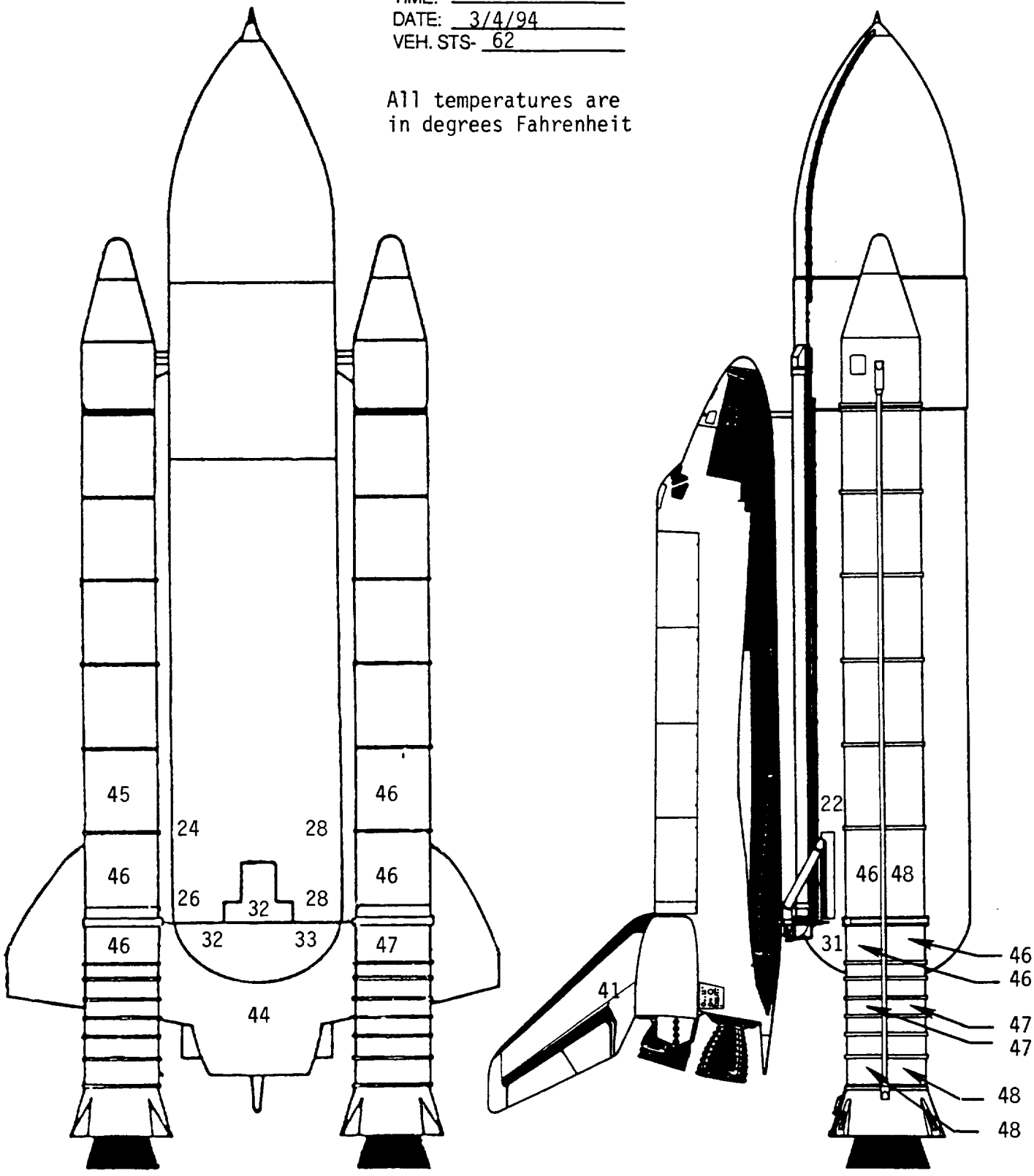


FIGURE 2. **SSV INFRARED SCANNER SURFACE TEMPERATURE SUMMARY DATA**

TIME: 0340 - 0525
DATE: 3/4/94
VEH. STS- 62

All temperatures are in degrees Fahrenheit



EGG/V-343C

3.4 SOLID ROCKET BOOSTERS

SRB case temperatures measured by the PSTI/Cyclops spot radiometer ranged from 45 to 53 degrees F. The SRB GEI measured temperatures ranging from 49 to 54 degrees F. All measured temperatures were above the 34 degrees F minimum requirement. The predicted Propellant Mean Bulk Temperature (PMBT) supplied by MTI was 66 degrees F, which was within the required range of 44-86 degrees Fahrenheit.

3.5 EXTERNAL TANK

The ice/frost prediction computer program 'SURFICE' was run from 0100 to 0845 hours and the results tabulated in Figure 3. The program predicted ice/frost formation or freezing runoff condensate (Region III) on the TPS acreage surfaces after cryoload.

The Ice Team observed no ice accumulations on the LO2 tank ogive. Frost had formed on the barrel section +Z side. There were no acreage TPS anomalies. Surface temperatures as measured by the infrared radiometer averaged 33 degrees F on the ogive and 32 degrees F on the barrel section. In comparison, SURFICE predicted temperatures of 33 degrees F on the ogive and 29 degrees F on the barrel.

The intertank acreage exhibited no TPS anomalies. Typical ice/frost accumulation, but no unusual vapor, was present on the ET umbilical carrier plate. Scattered and isolated frost spots appeared on the splice plate closeouts. The radiometer measured a surface temperature of 48 degrees F.

There were no LH2 tank acreage TPS anomalies with the exception of the three small damage areas near the aft hard point detected during the Pre-Launch Walkdown. The areas, which were small cavities believed to have been caused by a bird, were filled with ice/frost but were not an ice or debris concern due to size/location. Frost, but no ice, was present on the acreage +Z side. Heavier accumulations of ice/frost had formed over areas of thin foam, on the longerons, and along the edges of the PAL ramps, cable tray ramps, and pressurization line ramps. The portable STI measured surface temperatures averaging 32 degrees F on the upper LH2 tank and 26 degrees F on the lower LH2 tank. In comparison, SURFICE predicted temperatures of 26 degrees F on the upper LH2 tank and 34 degrees F on the lower LH2 tank.

The bipod jack pad closeouts were intact and flush with adjacent foam.

STS- 62	TEST S0007 LAUNCH															DATE: 4 March 1994					T-0 TIME: 07:53:00.009 DATE: 3/4/94				NASA KSC Ice/Frost/Debris Team
ORBITER 102	ET 62	SRB BI-064	MLP 1	PAD B	LO2 CHILLDOWN TIME: 00:28 SLOW FILL TIME: 00:53					FAST FILL TIME: 01:05 REPLENISH TIME: 03:08					LH2 CHILLDOWN TIME: 00:25 SLOW FILL TIME: 00:27				FAST FILL TIME: 01:12 REPLENISH TIME: 03:01						
TIME (EDT)	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
0100	50.00	70.0	40.39	10	298	II	5.90	37.22	0.0008	-0.0291	II	5.90	32.56	0.0019	-0.0032	III	4.60	29.69	0.0021	0.0131	II	12.30	37.47	0.0014	-0.0525
0115	51.00	69.0	40.99	8	289	II	4.72	36.74	0.0009	-0.0228	III	4.72	31.79	0.0018	0.0030	III	3.44	27.39	0.0020	0.0200	II	9.68	36.68	0.0017	-0.0372
0130	51.00	69.0	40.99	8	283	II	4.72	36.74	0.0009	-0.0228	III	4.72	31.79	0.0018	0.0030	III	3.44	27.39	0.0020	0.0200	II	9.68	36.68	0.0017	-0.0372
0145	48.80	73.2	40.41	6	264	II	3.54	33.20	0.0011	-0.0050	III	3.54	27.36	0.0020	0.0204	III	2.58	22.11	0.0019	0.0338	II	7.26	32.82	0.0022	-0.0055
0200	48.20	73.6	39.96	9	261	II	5.31	35.32	0.0011	-0.0173	III	5.31	30.81	0.0020	0.0083	III	3.87	26.52	0.0021	0.0250	II	10.89	35.44	0.0019	-0.0301
0215	46.40	75.8	38.97	6	276	III	3.54	31.48	0.0012	0.0033	III	3.54	25.21	0.0020	0.0285	III	2.58	19.80	0.0019	0.0406	III	7.26	31.22	0.0022	0.0074
0230	47.20	76.6	40.04	7	262	II	4.13	33.13	0.0013	-0.0051	III	4.13	27.83	0.0021	0.0203	III	3.01	22.85	0.0021	0.0342	II	8.47	33.02	0.0023	-0.0076
0245	45.40	78.6	38.95	6	256	III	3.54	30.88	0.0013	0.0058	III	3.54	24.56	0.0021	0.0310	III	2.58	19.08	0.0020	0.0428	III	7.26	30.66	0.0024	0.0112
0300	46.40	80.2	40.48	7	247	II	4.13	32.83	0.0014	-0.0038	III	4.13	27.53	0.0022	0.0216	III	2.24	18.53	0.0020	0.0416	II	9.52	33.64	0.0025	-0.0133
0315	44.20	83.0	39.22	7	243	III	4.13	31.33	0.0014	0.0044	III	4.13	25.60	0.0023	0.0297	III	2.24	16.27	0.0019	0.0473	III	9.52	31.99	0.0027	0.0006
0330	45.00	81.2	39.42	7	253	III	4.13	31.89	0.0014	0.0019	III	4.13	26.19	0.0022	0.0272	III	3.01	21.08	0.0022	0.0401	III	8.47	31.89	0.0025	0.0035
0345	43.40	83.6	38.61	7	242	III	4.13	30.60	0.0014	0.0077	III	4.13	24.83	0.0023	0.0328	III	2.24	15.41	0.0019	0.0496	III	9.52	31.52	0.0026	0.0065
0400	44.80	82.2	39.55	6	256	III	3.54	30.78	0.0014	0.0063	III	3.54	24.45	0.0022	0.0315	III	2.58	18.83	0.0021	0.0434	III	7.26	30.60	0.0026	0.0118
0415	45.00	80.2	39.09	9	286	II	5.31	33.02	0.0014	-0.0065	III	5.31	28.57	0.0023	0.0199	III	3.87	24.08	0.0023	0.0347	II	10.89	33.22	0.0024	-0.0110
0430	45.20	79.8	39.16	9	255	II	5.31	33.16	0.0013	-0.0062	III	5.31	28.72	0.0022	0.0192	III	3.87	24.24	0.0023	0.0340	II	10.89	33.35	0.0024	-0.0122
0445	45.20	79.2	38.96	11	266	II	6.49	34.26	0.0012	-0.0137	III	6.49	30.40	0.0022	0.0118	III	4.73	26.41	0.0024	0.0286	II	13.31	34.60	0.0022	-0.0268
0500	45.00	80.4	39.16	9	264	II	5.31	33.04	0.0014	-0.0056	III	5.31	28.60	0.0023	0.0198	III	3.87	24.11	0.0023	0.0346	II	10.89	33.24	0.0024	-0.0112
0515	44.60	81.4	39.09	7	265	III	4.13	31.51	0.0014	0.0036	III	4.13	25.79	0.0022	0.0288	III	3.01	20.65	0.0022	0.0414	III	8.47	31.52	0.0025	0.0061
0530	44.20	81.8	38.83	7	269	III	4.13	31.16	0.0014	0.0051	III	4.13	25.42	0.0022	0.0304	III	3.01	20.26	0.0022	0.0427	III	8.47	31.18	0.0025	0.0086
0545	44.40	81.6	38.96	8	274	III	4.72	31.99	0.0014	0.0002	III	4.72	27.00	0.0023	0.0258	III	3.44	22.18	0.0023	0.0392	III	9.68	31.99	0.0026	-0.0001
0600	44.60	80.8	38.90	6	275	III	3.54	30.38	0.0013	0.0079	III	3.54	24.01	0.0021	0.0330	III	2.58	18.39	0.0020	0.0446	III	7.26	30.18	0.0025	0.0143
0615	44.40	81.6	38.96	9	265	II	5.31	32.62	0.0014	-0.0033	III	5.31	28.16	0.0023	0.0220	III	3.87	23.63	0.0023	0.0364	II	10.89	32.83	0.0025	-0.0075
0615	44.40	81.6	38.96	9	265	II	5.31	32.62	0.0014	-0.0033	III	5.31	28.16	0.0023	0.0220	III	3.87	23.63	0.0023	0.0364	II	10.89	32.83	0.0025	-0.0075
0630	44.20	81.8	38.83	8	265	II	4.72	32.02	0.0014	0.0000	III	4.72	26.81	0.0023	0.0266	III	3.44	21.99	0.0023	0.0399	III	9.68	31.99	0.0026	0.0005
0645	44.40	80.8	38.70	9	259	II	5.31	32.51	0.0014	-0.0028	III	5.31	28.04	0.0023	0.0226	III	3.87	23.51	0.0023	0.0368	II	10.89	32.72	0.0025	-0.0065
0700	44.20	81.6	38.76	8	247	III	4.72	31.99	0.0014	0.0015	III	4.72	26.78	0.0023	0.0268	III	2.56	17.94	0.0020	0.0457	II	10.88	32.63	0.0025	-0.0057
0715	45.20	79.4	39.02	9	261	II	5.31	33.10	0.0013	-0.0059	III	5.31	28.66	0.0022	0.0195	III	3.87	24.18	0.0023	0.0343	II	10.89	33.30	0.0024	-0.0117
0730	45.80	78.0	39.14	8	260	II	4.72	32.78	0.0013	-0.0039	III	4.72	27.92	0.0022	0.0215	III	3.44	23.20	0.0022	0.0356	II	9.68	32.86	0.0023	-0.0071
0745	47.40	73.0	38.96	7	270	II	4.13	32.80	0.0011	-0.0036	III	4.13	27.45	0.0019	0.0217	III	3.01	22.51	0.0020	0.0352	II	8.47	32.67	0.0021	-0.0050
0800	48.80	69.2	38.91	11	284	II	6.49	36.39	0.0007	-0.0261	III	6.49	31.99	0.0018	-0.0004	III	4.73	28.61	0.0020	0.0183	II	13.31	36.63	0.0012	-0.0471
0815	50.60	65.0	39.00	9	276	II	5.31	36.35	0.0006	-0.0226	III	5.31	31.74	0.0016	0.0030	III	3.87	27.61	0.0018	0.0203	II	10.89	36.39	0.0011	-0.0382
0830	51.20	62.4	38.51	7	281	II	4.13	34.94	0.0006	-0.0130	III	4.13	29.57	0.0015	0.0123	III	3.01	24.87	0.0017	0.0270	II	8.47	34.67	0.0012	-0.0193
0845	52.40	59.0	38.18	11	284	II	6.49	38.19	0.0000	-0.0369	II	6.49	33.82	0.0011	-0.0111	III	4.73	30.44	0.0015	0.0092	II	13.31	38.40	0.0000	-0.0644
T-0	52.60	59.6	38.65	9	279	II	5.31	37.40	0.0003	-0.0280	II	5.31	32.46	0.0013	-0.0024	III	3.87	28.69	0.0016	0.0156	II	10.89	37.38	0.0005	-0.0467
AVG.	45.30	76.30	39.26	8.06	W		4.75	33.36				4.75	28.25				3.38	23.12				9.89	33.48		

Period of Ice Team Inspection

FIGURE 3. "SURFICE" Computer Predictions

A 14-inch long by 3/8-inch wide crack in the -Y vertical strut cable tray forward surface TPS near the longeron closeout interface was acceptable for flight per the NSTS-08303 criteria and required no IPR.

Typical amounts of ice/frost were present in the LO2 feedline bellows and support brackets. Frost was present on the LO2 feed line acreage.

There were no TPS anomalies on the LO2 ET/ORB umbilical. Ice/ frost covered sections of the umbilical acreage. Ice/frost fingers on the separation bolt pyrotechnic canister purge vents and cable tray drain hole were typical.

Ice/frost in the LH2 recirculation line bellows and on both burst disks was typical. The LH2 feedline bellows and portions of the feedline straight section were frost covered.

Typical amounts of ice/frost had accumulated on the LH2 ET/ORB umbilical purge barrier. Typical ice/frost fingers had formed on the pyro canister and plate gap purge vents. Ice/frost was present on the aft pyrotechnic canister closeout bondline indicating a thermal short. Ice/frost had formed from the 17-inch flapper valve actuator access port foam plug forward corner to the aft pyro canister closeout. No unusual vapors or cryogenic drips had appeared during tanking, stable replenish, and launch.

The summary of Ice/Frost Team observations/anomalies, which were all acceptable for launch per the NSTS-08303 criteria, consisted of six OTV recorded items:

Anomaly 001 documented frost accumulation on the LO2 and LH2 tank acreage with the most prominent accumulation in the +Y+Z quadrant. The frost melted after sunrise prior to T-0.

Anomaly 002 (documentation only) recorded ice/frost formations on the LO2 feedline support brackets and bellows.

Anomaly 003 (documentation only) recorded ice/frost formations on the LH2 ET/ORB umbilical, pyro can purge vents, purge barrier, and LH2 recirculation line bellows/burst discs.

Anomaly 004 (documentation only) recorded ice/frost formations on the LO2 ET/ORB umbilical, purge barrier, and pyro can purge vents.

Anomaly 005 documented a crack 14-inches long by 3/8-inch wide in the -Y vertical strut cable tray forward surface TPS. The crack exhibited no offset and was not filled with ice or frost.

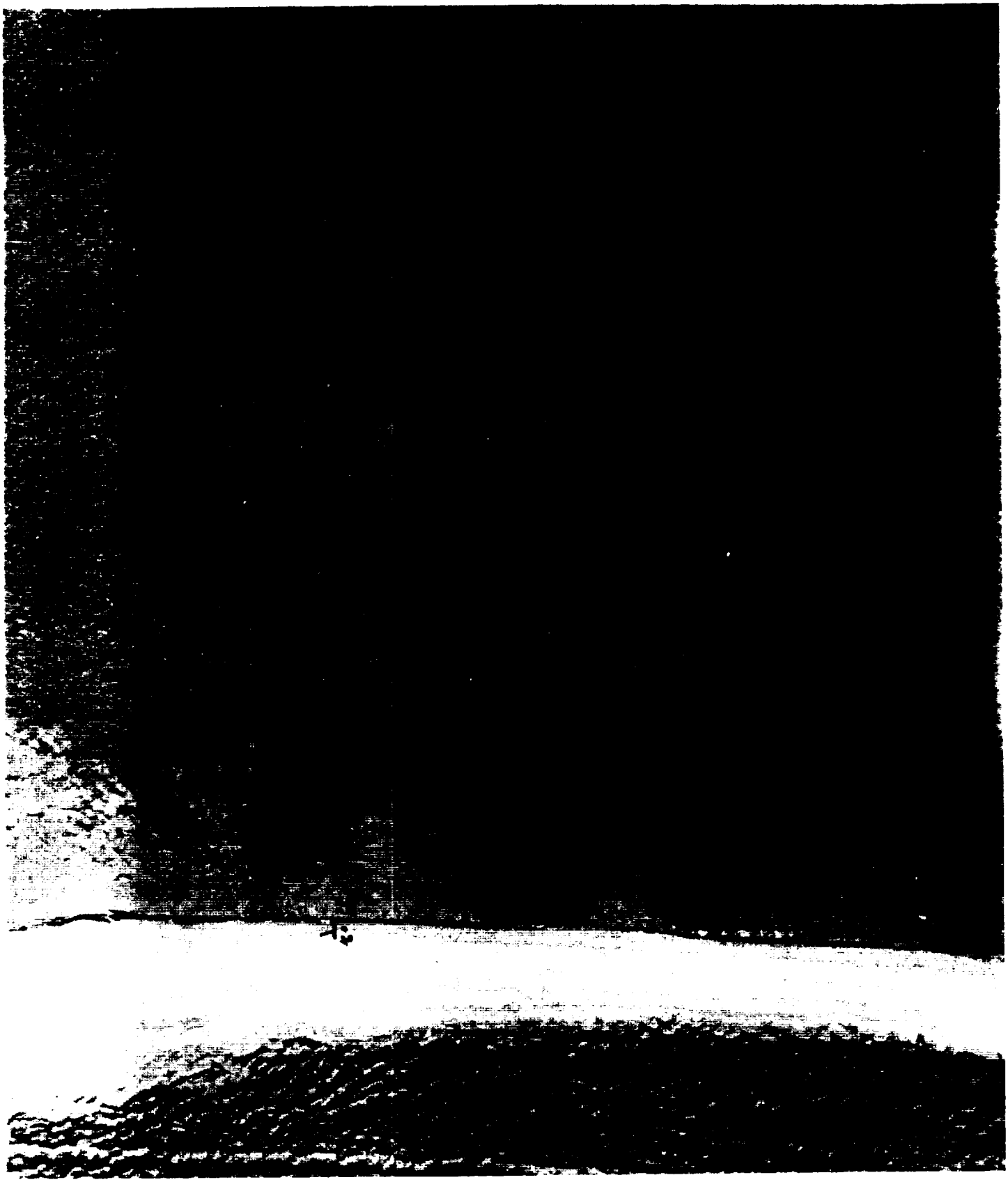
Anomaly 006 documented ice/frost accumulations in damaged foam areas adjacent to the aft hard point (PR ET-62-TS-0020).

3.6 FACILITY

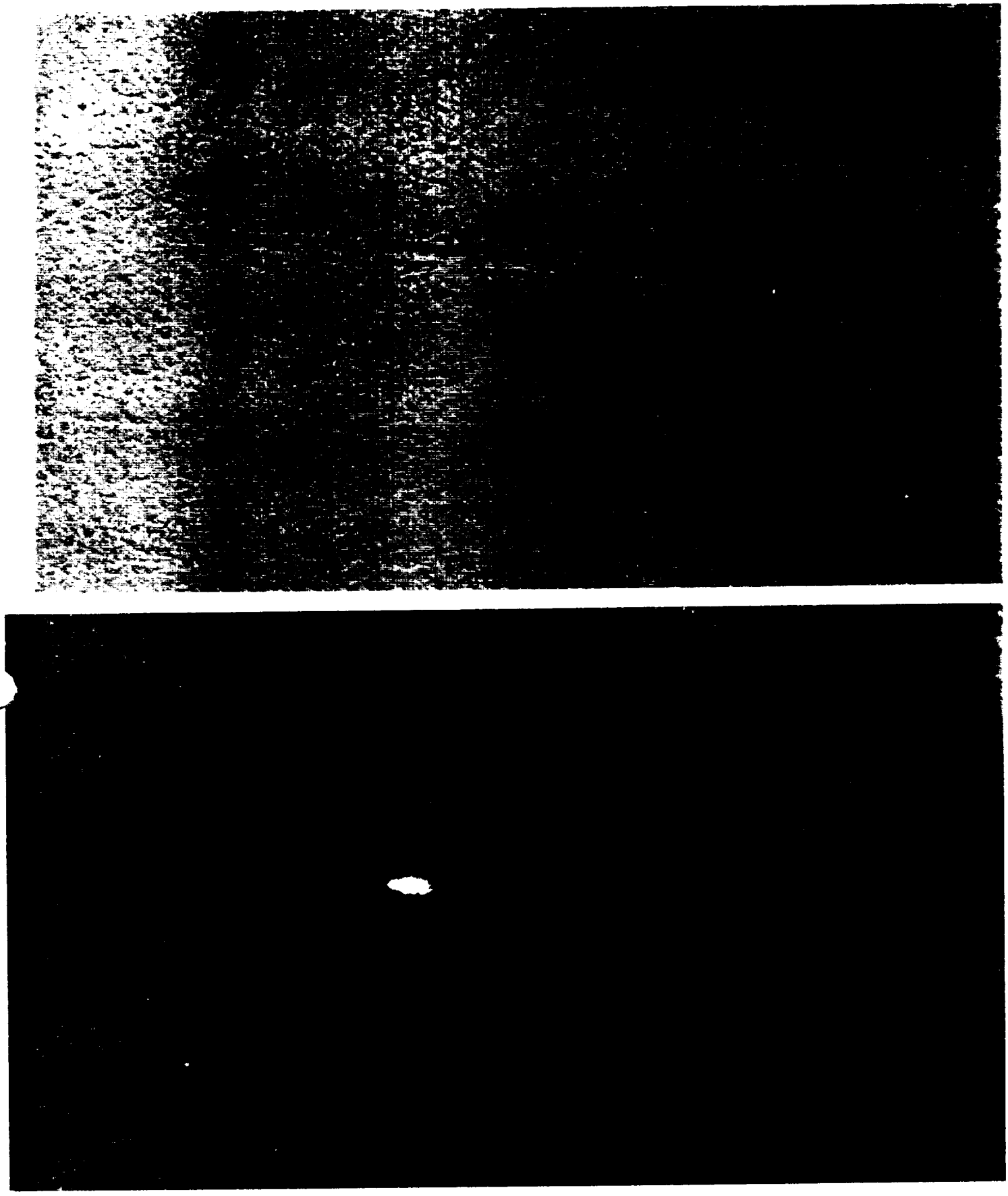
All SRB sound suppression water troughs were filled and properly configured for launch (LCC requirement).

No leaks were observed on either the LO2 or LH2 Orbiter T-0 umbilicals, the GH2 vent line, or the GUCP. Somewhat more than usual amounts of ice and frost covered the LH2 T-0 umbilical purge shroud and parts of the carrier plate.

No ET nosecone/footprint damage was visible after the GOX vent hood was retracted. No icicles had formed on the GOX vent ducts



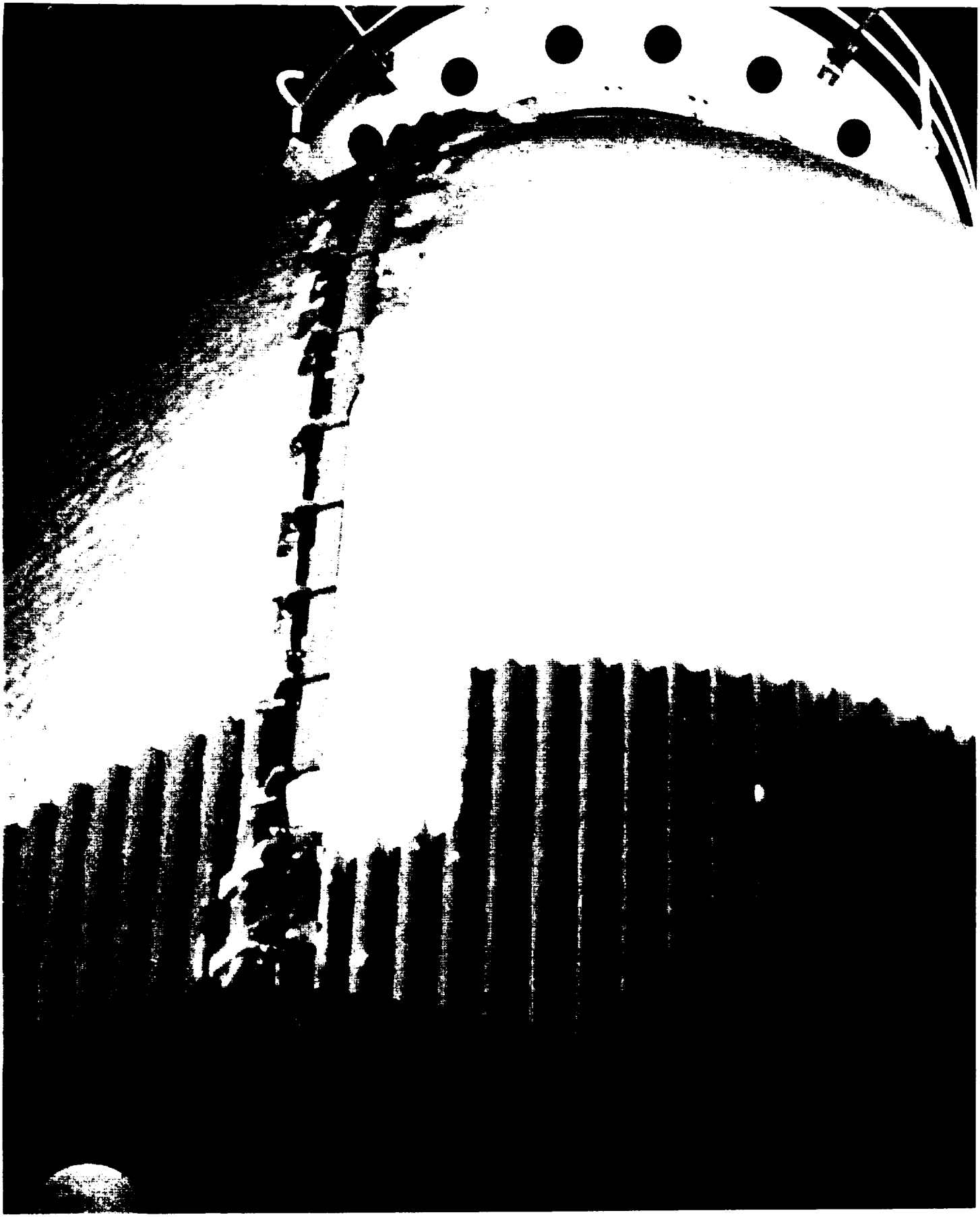
Areas of damaged/crushed CPR foam near the aft hard point were assessed and found to be no constraint for cryogenic loading and flight. The impact-type damage may have been caused by a bird while the vehicle was undergoing preparations for launch at the pad.



The largest area of damaged/crushed CPR foam, estimated to be 2 inches by 1 inch by an unknown depth, filled with ice and frost after cryogenic loading. The condition was acceptable for flight.

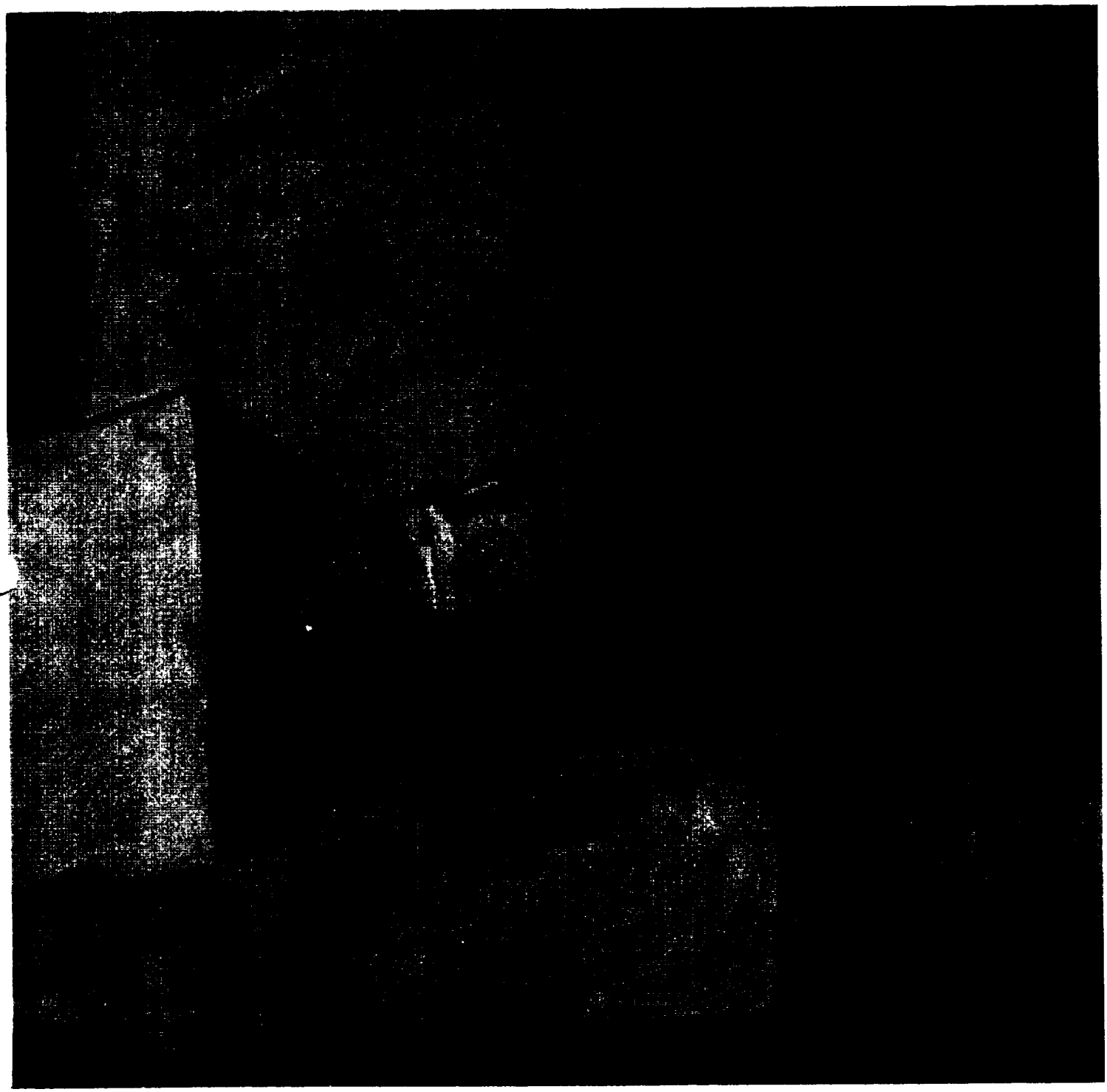
Light frost, but no ice or significant amounts of condensate, were present on the External Tank acreage after cryogenic loading. The frost melted shortly after sunrise.

Frost, but no ice, covered the acreage areas of the LH2 barrel +Y+Z quadrant, longeron closeout, LO2 feedline, and LO2 ET/ORB umbilical.



Frost, but no ice, had generally formed on the LO2 tank barrel +Y+Z quadrant. There was no ice or frost in the "No Ice" region on the nosecone and ogive.

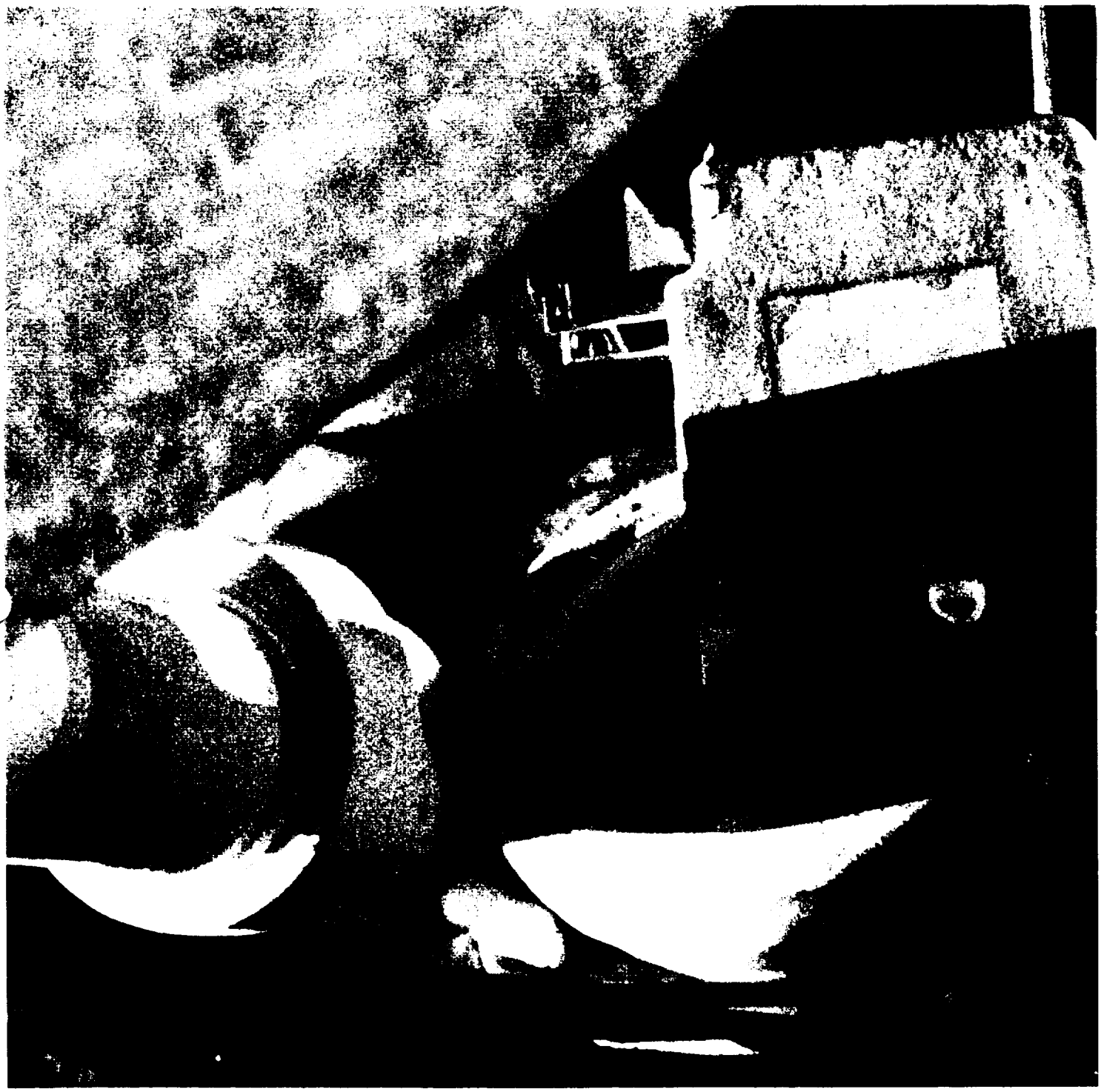
Some ice/frost had formed on the LO2 feedline support brackets. Frost also accumulated on the feedline acreage. This condition was acceptable for flight per the NSTS-08303 criteria.



A crack, 14 inches long by 3/8 inch wide, appeared in the forward surface of the -Y ET/SRB cable tray after cryoload. The crack was not filled with ice or frost and exhibited no offset.

Ice/frost covered parts of the LO2 ET/ORB umbilical acreage and the outboard side of the purge barrier (baggie). A small frost ring formed on the cable tray drain hole.

Ice/frost on the LH2 feedline and recirculation line bellows was typical. The formation of frost on the feedline straight section between the bellows was not typical. The condition was acceptable for flight per the NSTS-08303 criteria.



Typical amounts of ice/frost had accumulated on the ET/ORB LH2 umbilical including ice/frost fingers on the plate gap and pyro can purge vents. The 17-inch flapper valve access port TPS plug showed no signs of purge gas leakage or ice formations.

4.0 POST LAUNCH PAD DEBRIS INSPECTION

The post launch inspection of the Mobile Launch Platform, Fixed Service Structure and Rotating Service Structure was conducted on 4 March 1994 from Launch + 1.5 to 3 hours.

No flight hardware or TPS materials were found.

South SRB HDP erosion was typical. All south HDP shoe EPON shim material was intact. Twenty percent of the HDP #1 sidewall shim material was missing. There was no visual indication of a stud hangup on any of the south holddown posts. All of the north HDP doghouse blast covers were in the closed position. The SRB aft skirt purge lines and T-0 umbilicals exhibited typical exhaust plume damage.

A 4.5 inch long by 1 inch diameter bolt was found underneath the sound suppression pipe near the southeast corner of the LH SRB exhaust hole. A metal shim measuring 12 x 8 inches was also found under the sound suppression pipe near the north west corner of the RH SRB exhaust hole. Both items originated from the sound suppression pipe support stanchion at the north end of the LH SRB exhaust hole. Several other shim pieces were loose at this same location. Time of failure was not evident from hardware condition or film/video review.

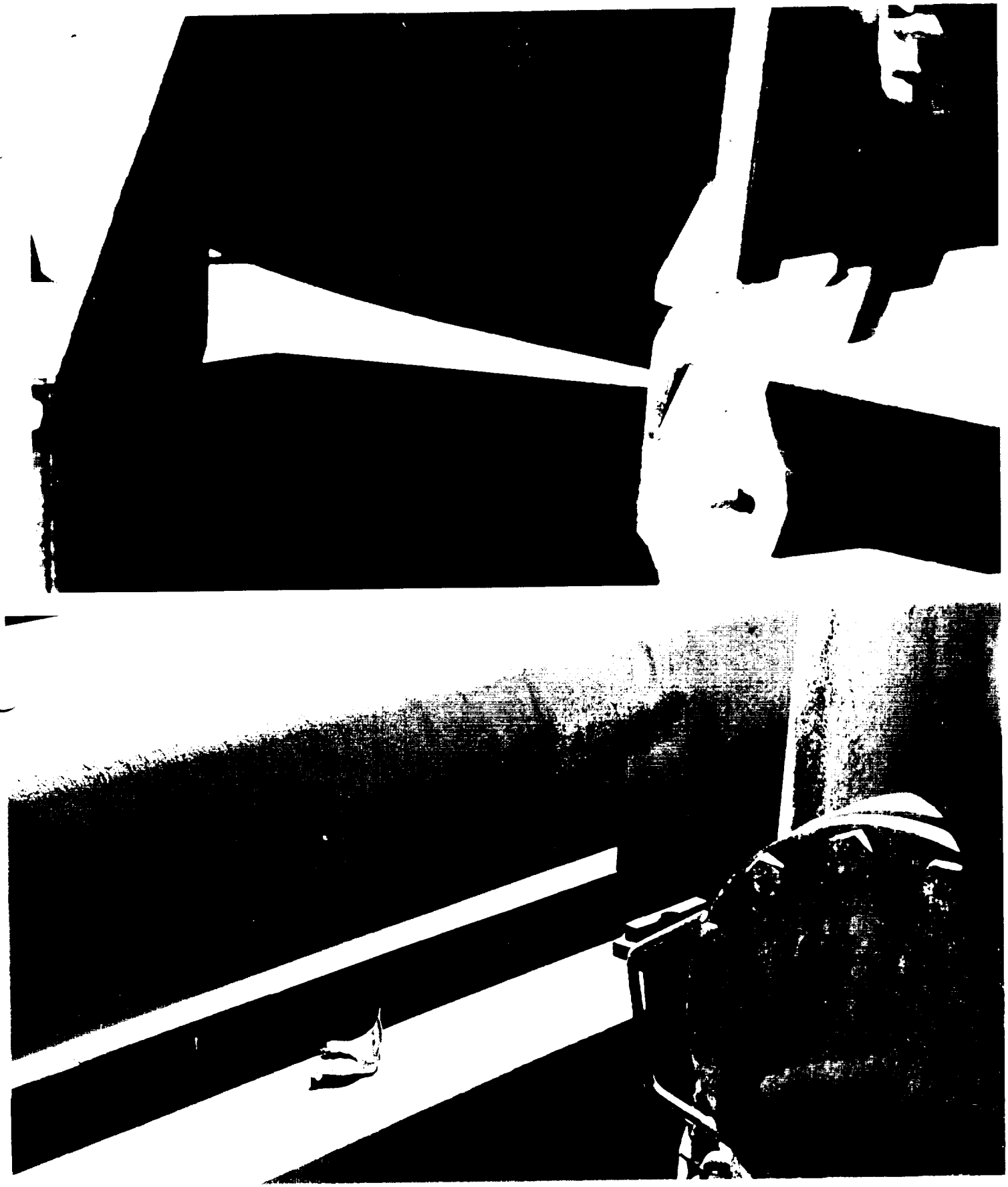
The Tail Service Masts (TSM), Orbiter Access Arm (OAA), and GOX vent arm showed only minor damage.

The GH2 vent line was latched on the eighth tooth of the latching mechanism, had no loose cables (static retract lanyard), and appeared to have latched properly with no rebound.

Damage to the facility included an unused telephone box dislodged from a mount on the FSS 95 foot level. A damaged overhead speaker on the 275 foot level was suspended only by safety cables. This damage probably occurred after the vehicle cleared the tower and is not considered a debris threat.

Debris inspections of the pad acreage, beach, and areas outside the pad perimeter were performed. No flight hardware or TPS material was found.

Post launch pad inspection anomalies are listed in Section 9.



A 4.5 inch long by 1 inch diameter bolt was found underneath the sound suppression pipe near the southeast corner of the LH SRB exhaust hole. A metal shim measuring 12 inches by 8 inches was also found near the NW corner of the RH SRB exhaust hole.

The bolt and metal shim originated from the sound suppression pipe support stanchion at the north end of the LH SRB exhaust hole.

5.0 FILM REVIEW AND PROBLEM REPORTS

Anomalies observed in the Film Review were presented to the Mission Management Team, Shuttle managers, and vehicle systems engineers. No In-Flight Anomalies were generated as a result of the film review. Post flight anomalies are listed in Section 9.

5.1 LAUNCH FILM AND VIDEO SUMMARY

A total of 106 films and videos, which included forty-one 16mm films, twenty-one 35mm films, four 70mm films, and forty videos, were reviewed starting on launch day.

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

SSME ignition, Mach diamond formation, and gimbal profile appeared normal (OTV 151, 170, 171). Ice/frost was visible at the SSME #2 nozzle-to-engine mounted heat shield interface (E-19, 26).

Fore-and-aft movement of the Orbiter base heat shield in the centerline area between the SSME cluster occurred during engine start-up. The motion was similar to that observed on previous launches (E-76, 77).

SSME ignition caused numerous pieces of ice to fall from the ET/Orbiter umbilicals. Some pieces of ice contacted the umbilical cavity sill and were deflected outward, but no tile damage was visible (OTV 109, 163).

Ice particles from the LO2 feedline upper bellows fell outboard of the EO fitting (E-5). Ice from the EB fittings impacted the RH aft BSM nozzle, but no vehicle damage was visible (E-9).

Surface coating material was lost from base heat shield tiles outboard of SSME #3 (3 places) and near SSME #2 (4 places) (E-17, 18, 20).

No stud hang-ups occurred on any of the holddown posts. No ordnance fragments or frangible nut pieces fell from any of the DCS/stud holes. A 12" x 2" piece of red tape appeared between the HDP #5 shoe and the aft skirt foam after T-0 (E-12).

The LH2 and LO2 T-0 umbilicals disconnected properly. Two thin rectangular objects fell from the LO2 T-0 umbilical prior to T-0. The first object, most likely a parts tag, appeared at 13:52:55.514 GMT. The second object, appearing at 13:52:56:446 GMT, was identified as a piece of ice (E-17, 18).

GUCP disconnect from the External Tank was nominal (E-33). The GH2 vent line appeared to latch properly (OTV 104, 160, E-41, 42, 50). There was no excessive slack in the static retract lanyard. Post launch inspection found the GH2 vent line latched on the eighth tooth of the latching mechanism.

A more than usual amount of MLP deck scale and SRB throat plug material passed in front of the camera as the vehicle was leaving the field of view (E-5, 7, 9).

Numerous light-colored debris objects, most likely SRB throat plug material, appeared out of the SRB flame trench north of the vehicle and moved in a southerly direction toward the vehicle. The objects fell back down into the flame trench well short of the MLP north side (OTV 160, E-60).

Sunlight reflected off the crew cabin windows and the LO2 tank pressurization line near the nosecone during the roll maneuver (OTV 141, TV-4B, TV-7).

The F2U thruster paper cover, which was wet prior to launch from internal vapors, tore and fell aft during the roll program. No vapors indicative of a leak were visible coming from the nozzle (E-54, 213).

Hydrogen fire detection butcher paper came off the ET vertical strut and fell past the LH2 ET/ORB umbilical at 13:53:12.919 GMT (E-57).

LO2 ET/ORB umbilical purge barrier (baggie) fell aft of the vehicle during the roll maneuver at 13:53:14.293 GMT (E-52).

One of the large, oblong paper covers from the forward RCS thrusters first appeared near SSME #1 and fell aft (E-213, frame 2128 and E-222 at T+27.985 seconds MET).

All SSME Dome Mounted Heat Shield closeout blankets appeared to be intact and missing no material.

A large flash occurred in the SSME #1 plume at approximately T+52 seconds MET (TV-4B). Numerous flashes occurred in the SSME plume during ascent (E-207, 218, 220, 222, 223).

Body flap movement (amplitude and frequency) was similar to previous flights (E-207, 220).

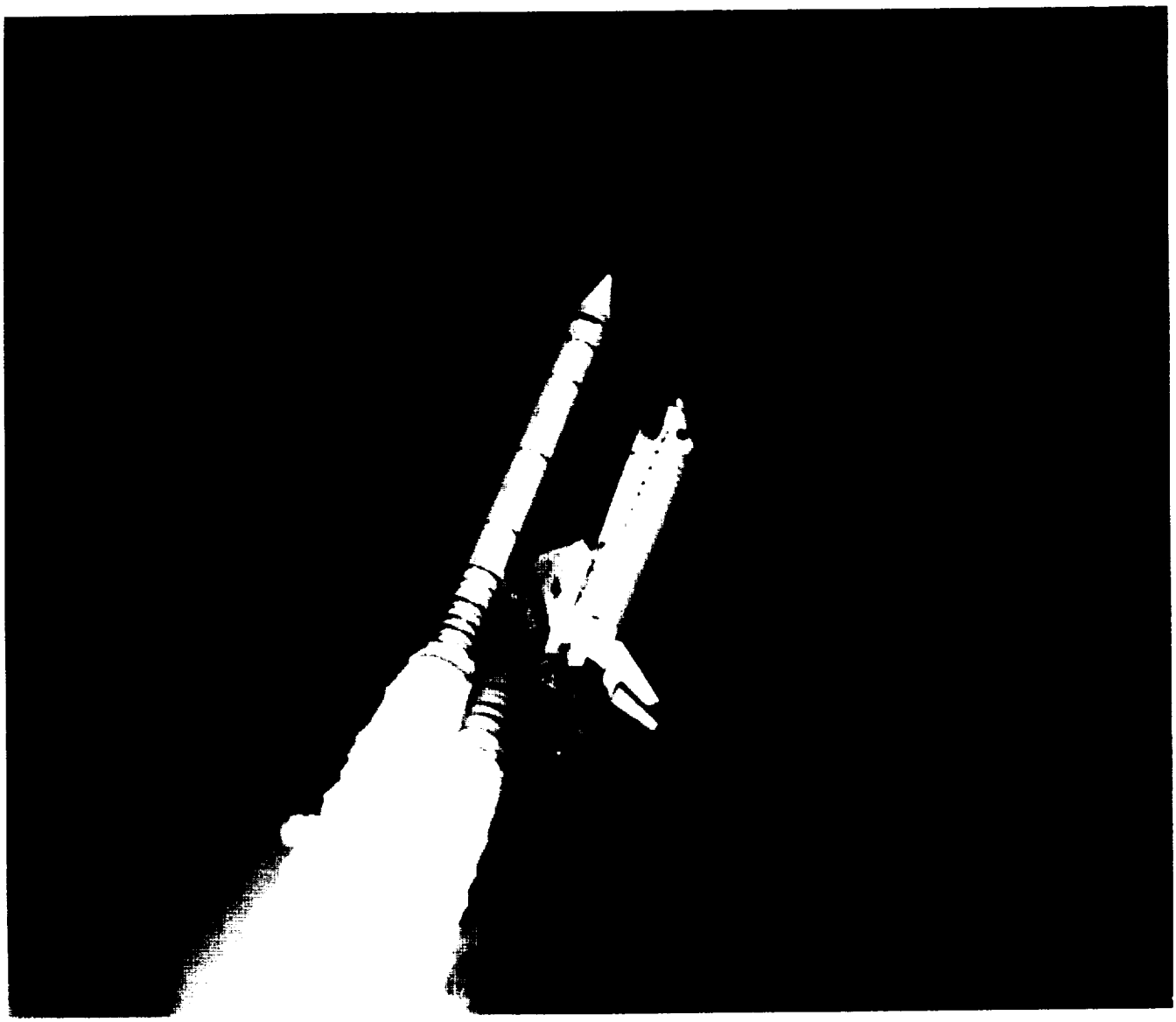
A vapor cloud near SRB plume at 13:53:56.7 GMT was associated with atmospheric conditions and was not related to vehicle performance (E-211, 224).

Numerous SRB propellant particles or pieces of aft skirt instafoam fell out of the plume during ascent (E-220, 222).

Exhaust plume recirculation and ET aft dome charring appeared typical. SRB separation from the ET was nominal. Numerous pieces of slag dropped out of the SRB plume before, during, and after separation.

The SRB frustums separated from the forward skirts properly. Parachute deployment and reefing appeared normal though a rip was visible in one main chute on the RH SRB. Function of the chute was not affected (E-301, 302).

The LO2 T-0 umbilical disconnected from the Orbiter properly. A rectangular object (arrow), most likely a parts tag, fell from the carrier plate at 13:52:55.514 GMT.



One of the large, oblong paper covers from the forward RCS thrusters passed over the wing and first appeared near SSME #1 at T+28 seconds MET. Although RCS paper covers typically tear into smaller pieces in the airflow, this cover remained intact while falling aft of the vehicle.

5.2 ON-ORBIT FILM AND VIDEO SUMMARY

DTO-0312 was performed by the flight crew. Thirty-six hand-held still images were obtained of the ET after separation from the Orbiter. OV-102 was equipped to carry umbilical cameras: 16mm motion picture with 5 mm lens; 16mm motion picture with 10mm lens; 35mm still views. The 16mm camera with the 10mm lens did not run. Data was obtained from the other two films.

No major vehicle damage or lost flight hardware was observed that would have been a safety of flight concern. Review of the on-orbit photography resulted in no IFA candidates.

External Tank intertank foam, 14 inches long by 4 inches wide, was missing from a stringer head forward of the left (-Y) bipod spindle housing closeout. Approximately 3 inches of primer was exposed. A small divot appeared just aft of the -Y bipod spindle in the LH2 tank-to-intertank flange closeout. No other divots were visible in the flange closeout (+Y+Z and -Y+Z quadrants).

At least 35 shallow "popcorn" type divots were visible on the +Z side of the intertank acreage in the vicinity of the bipods.

A divot, 5.5 inches in diameter but shallow in depth, occurred in the LH2 tank acreage just aft of the LH2 tank-to-intertank flange closeout between the +Y bipod spindle housing closeout and the LO2 feedline support bracket (XT-1129).

Both bipod jack pad closeouts were intact and appeared to be in excellent condition.

A divot, 5 inches in diameter, occurred in the LH2 tank acreage (XT-1590) adjacent to the +Y side of the cable tray. The divot went to substrate and exposed the primer.

The LO2 feedline lower support bracket splice plate closeout (XT-1973) exhibited a 4 inch by 3 inch divot.

Foam was eroded/missing from the +Y thrust strut flange closeout.

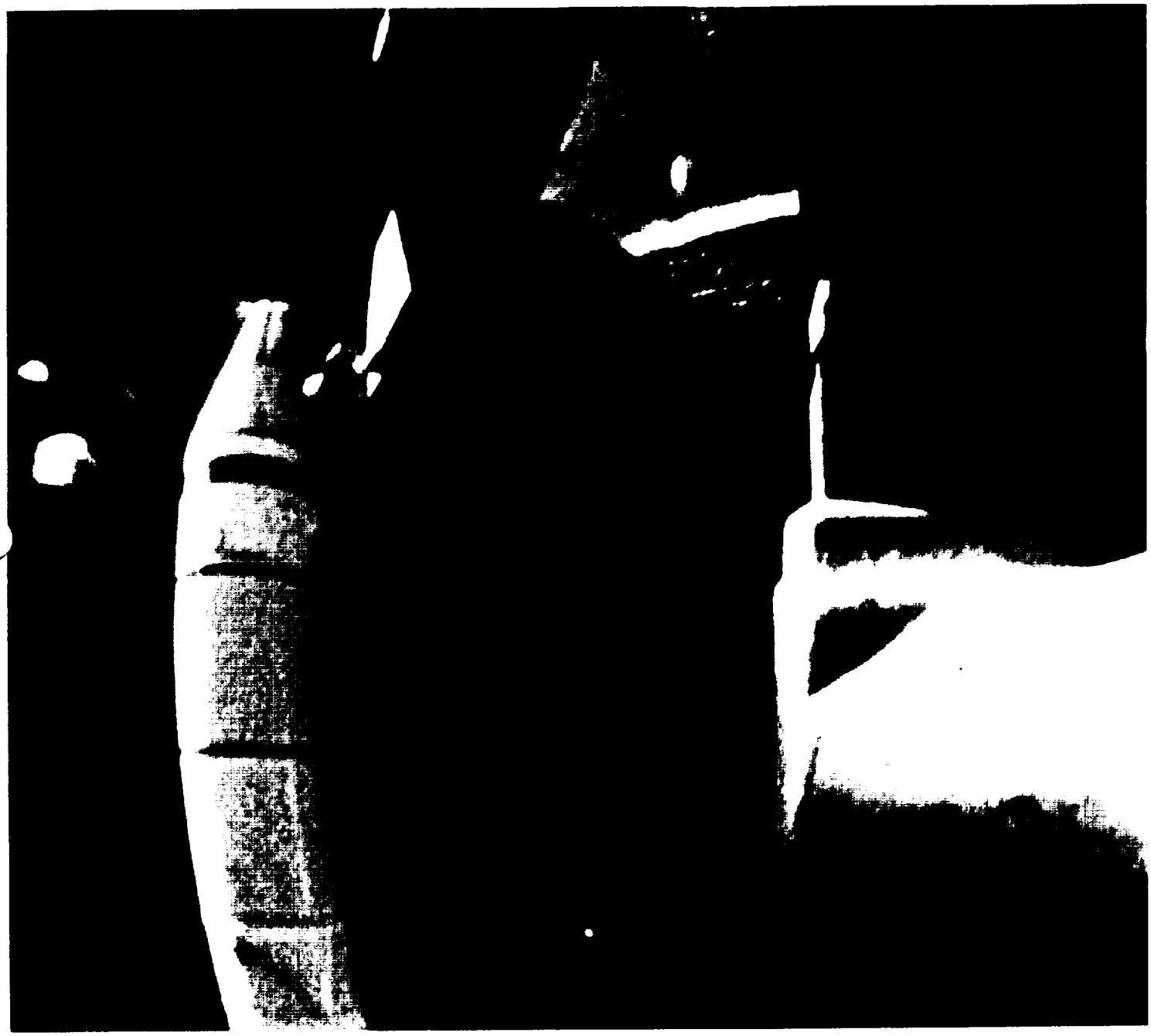
The LH2 ET/ORB umbilical appeared to be in good condition with the exception of foam peeled back on the inboard surface of the umbilical near the forward inboard pyro canister closeout. The red purge seal was intact. Blistering of the fire barrier coating was typical. Frozen hydrogen adhered to the 17-inch flapper valve. Foam was missing or eroded from the vertical section of the cable tray and the LH2 feedline outboard support bracket.

Foam on the forward inboard corner of the LO2 ET/ORB umbilical appeared slightly damaged. Numerous divots and eroded areas were visible on the horizontal and vertical sections of the cable tray. The red purge seal was intact though discolored by excess white RTV near the electrical monoball. The lightning contact strips on the umbilical were all present and intact. A debris object, possibly a shim or piece of tape, was visible inside the electrical monoball at the 2:00 o'clock position.

After ET separation from the Orbiter, a light colored, flexible, 4-6 inch long object appeared to originate from the Orbiter ET/ORB umbilical area, move past the External Tank crossbeam and LO2 ET/ORB umbilical area, and drift aft out of the field of view. The object is believed to be a piece of white RTV.

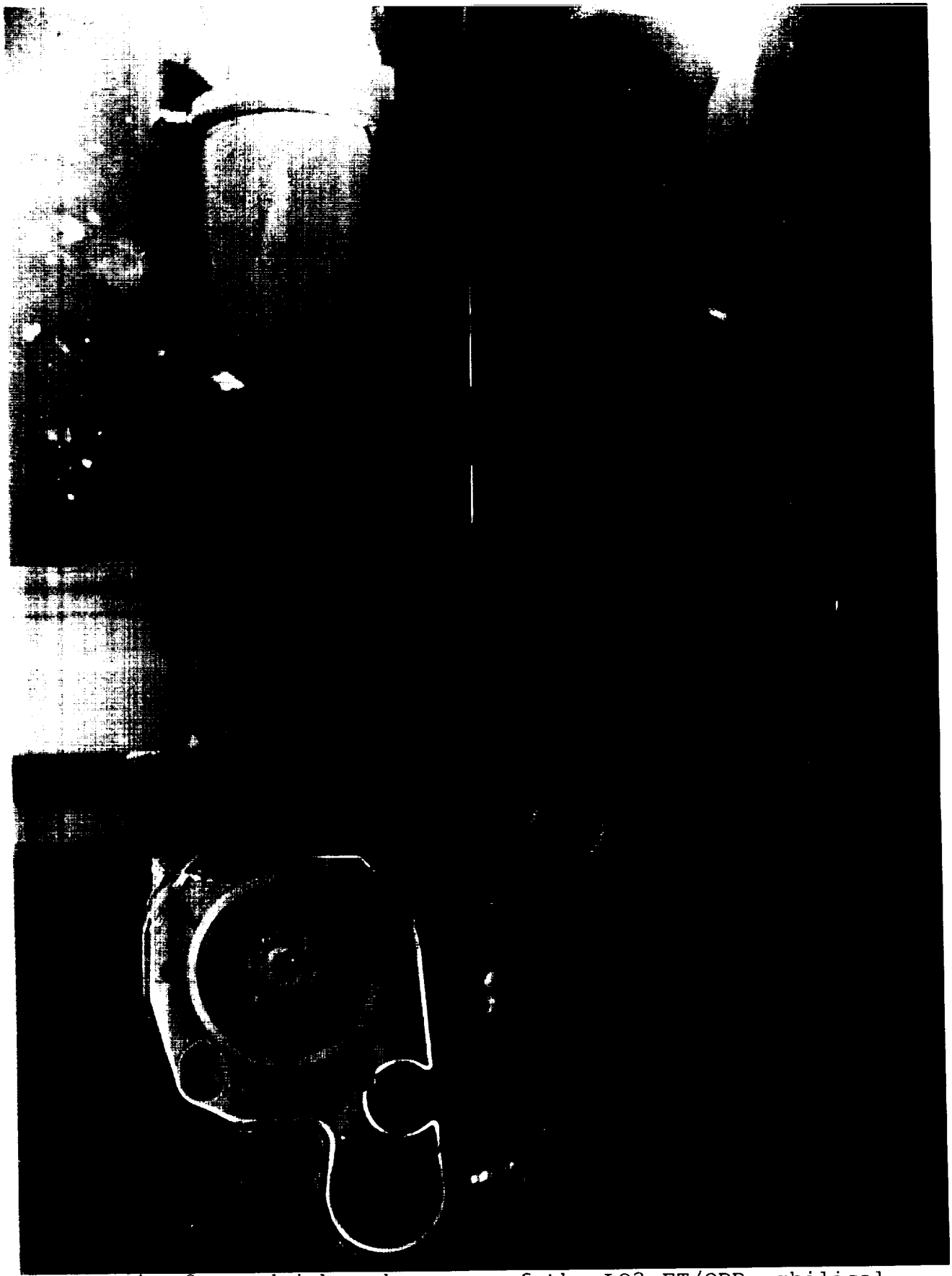
SRB separation from the ET and External Tank separation from the Orbiter were nominal.

The BSM burn scars on the LO2 tank were typical. No anomalies were observed on the nosecone, LO2 tank acreage, PAL ramps, RSS antennae, flight door, bipod ramps, LO2 feed line, and aft hard point. The aft dome NCFI acreage was charred, but showed no erosion or divots. Erosion/ablation of the manhole cover closeouts and aft dome apex, which is an expected occurrence, was also typical.

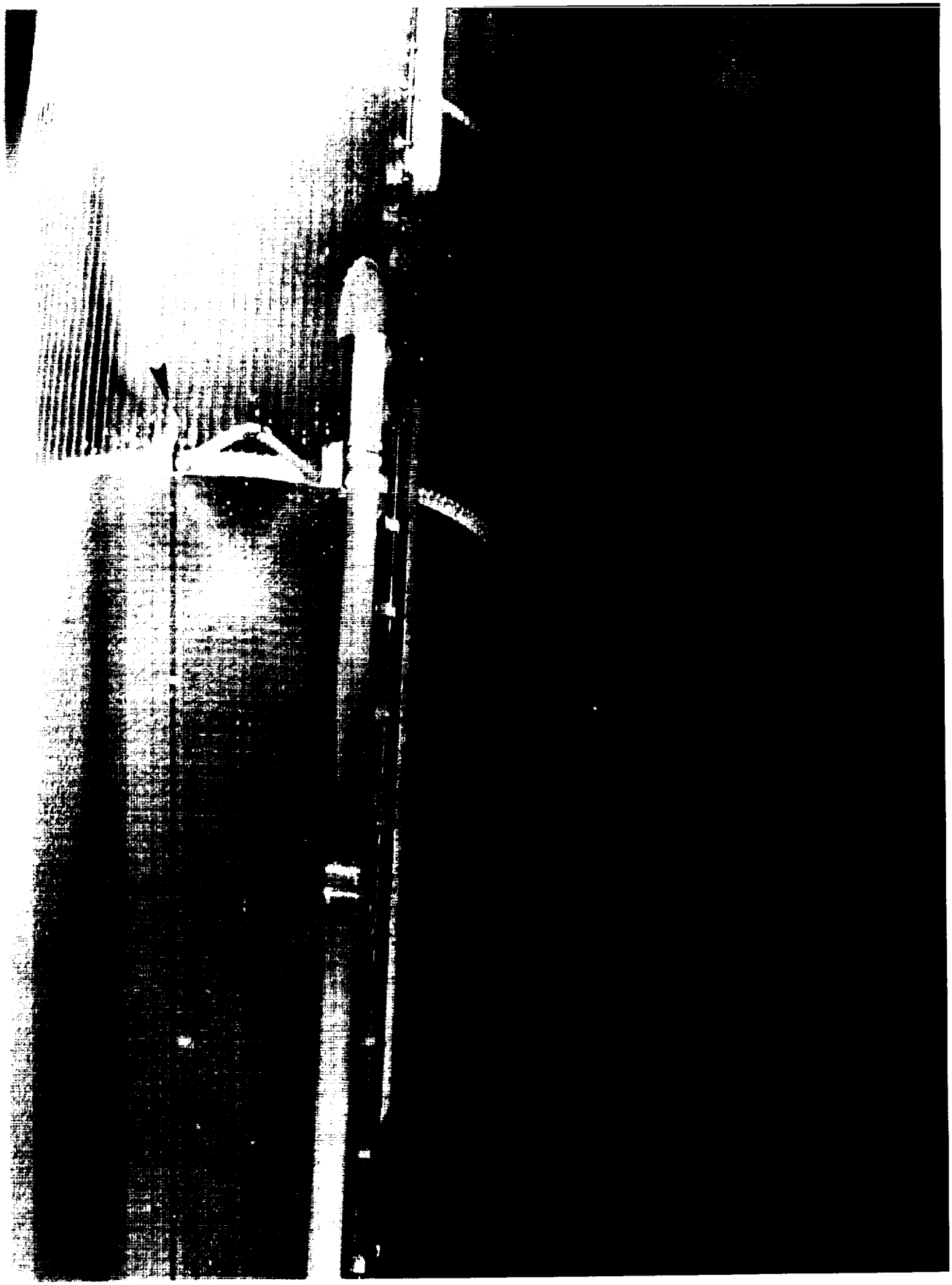


Separation of the Solid Rocket Boosters from the External Tank appeared nominal. Small pieces of foam fell aft passed the camera field of view. Erosion of TPS on the LH2 feedline support bracket and charring of the ET/SRB vertical strut aft surface was typical.

Separation of the External Tank from the Orbiter appeared normal. Foam was peeled back from the inboard surface of the LH2 ET/ORB umbilical near the forward inboard pyro canister closeout. The red purge seal appeared to be intact. Frozen hydrogen adhering to the 17-inch flapper valve was typical.



Foam on the forward inboard corner of the LO2 ET/ORB umbilical appeared slightly damaged. Numerous divots and eroded areas occurred on the horizontal and vertical sections of the cable tray. A debris object, possibly a piece of shim or tape, was visible inside the electrical monoball at the 2:00 o'clock position.



Intertank foam, 14" x 4", was missing from a stringer head forward of the left bipod spindle housing closeout. Primer was exposed. A divot appeared between the LO2 feedline and the right bipod closeout. The bipod jack pad closeouts were intact. A 5-inch diameter divot with exposed primer occurred in the LH2 tank acreage (XT-1590) next to the cable tray.

5.3 LANDING FILM AND VIDEO SUMMARY

A total of 40 films and videos, which included six 16mm films, nine 35mm films, and fifteen videos, were reviewed.

Orbiter performance on final approach appeared normal. Infrared imagery of landing gear deployment showed the loss of thermal barrier from the nose gear wheel well. The missing thermal barrier material was not recovered.

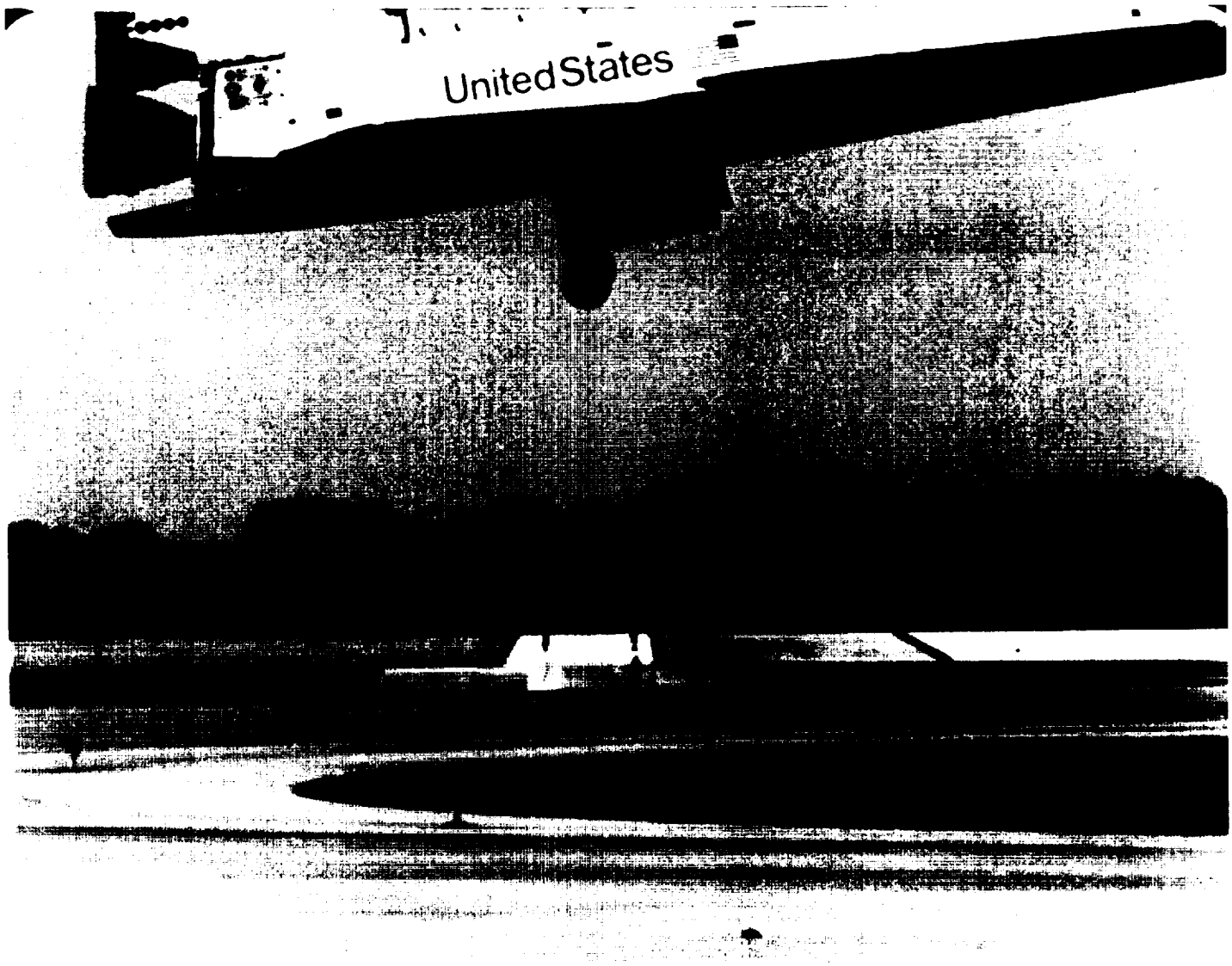
The Orbiter was slightly east of the runway centerline when crossing the threshold but drifted and appeared centered for main gear touchdown. Contact of left and right main gear was almost simultaneous. Somewhat abrupt excursions west across the runway centerline occurred twice before the drag chute was deployed. Some rudder/speed brake movement was also visible during this time.

The drag chute was deployed after breakover, but before the nose gear contacted the runway. Drag chute deployment appeared nominal. The chute was blown slightly westward (+Y side of the Orbiter) by prevailing winds.

Touchdown of the nose landing gear was smooth.

Damage to lower surface tiles near the RH MLG wheel well was visible.

A study was conducted for the astronaut office to determine the altitude of the Orbiter crossing the runway threshold using photographic means and compare the result to flight computer data. A 35mm Photosonics motion picture camera was positioned in line with Runway 33 threshold line. The camera was located at least 600 feet away from the runway centerline such that all surfaces on the Orbiter were assumed to be perpendicular to the camera. Film analysis determined the lowest point on the Orbiter (right main landing gear tire) was 28.94 feet above the runway surface. In comparison, the Orbiter flight computer showed an altitude of 23 feet above the runway when crossing the threshold line.



Film analysis determined the Orbiter right main landing gear tire was 28.94 feet above the runway surface. In comparison, the Orbiter flight computer showed an altitude of 23 feet above the runway when crossing the threshold line.

6.0 SRB POST FLIGHT/RETRIEVAL DEBRIS ASSESSMENT

Both Solid Rocket Boosters were inspected for debris damage and debris sources at CCAFS Hangar AF on 8 March 1994 from 0830 to 1030 hours. From a debris standpoint, both SRB's were in good condition.

6.1 RH SOLID ROCKET BOOSTER DEBRIS INSPECTION

The RH frustum was missing one 2" x 2" area of TPS near the BSM's and had 23 MSA-2 debonds over fasteners. Significant amounts of BTA had been applied to closeouts on this frustum. Hypalon paint was blistered/missing from areas where the BTA had been applied. The underlying BTA was not sooted except along the 395 ring aft of the BSM cluster. The soot pattern indicated some of the blisters may have formed prior to SRB separation (IFA STS-62-B-1). Investigation of this condition concluded there was insufficient heat rates to cause blistering of the Hypalon until late in the ascent phase. Testing has shown that Hypalon blisters burn off rather than become detached debris sources. The BSM aero heat shield covers had locked in the fully opened position though three of the attach rings had been bent by parachute riser entanglement (Figure 4).

The RH forward skirt acreage exhibited no debonds or missing TPS. Both RSS antennae covers/phenolic base plates were intact. Significant amounts of BTA had been applied to closeouts on this forward skirt. Hypalon paint was blistered/missing from areas where the BTA had been applied. The underlying BTA was not sooted. No pins were missing from the frustum severance ring.

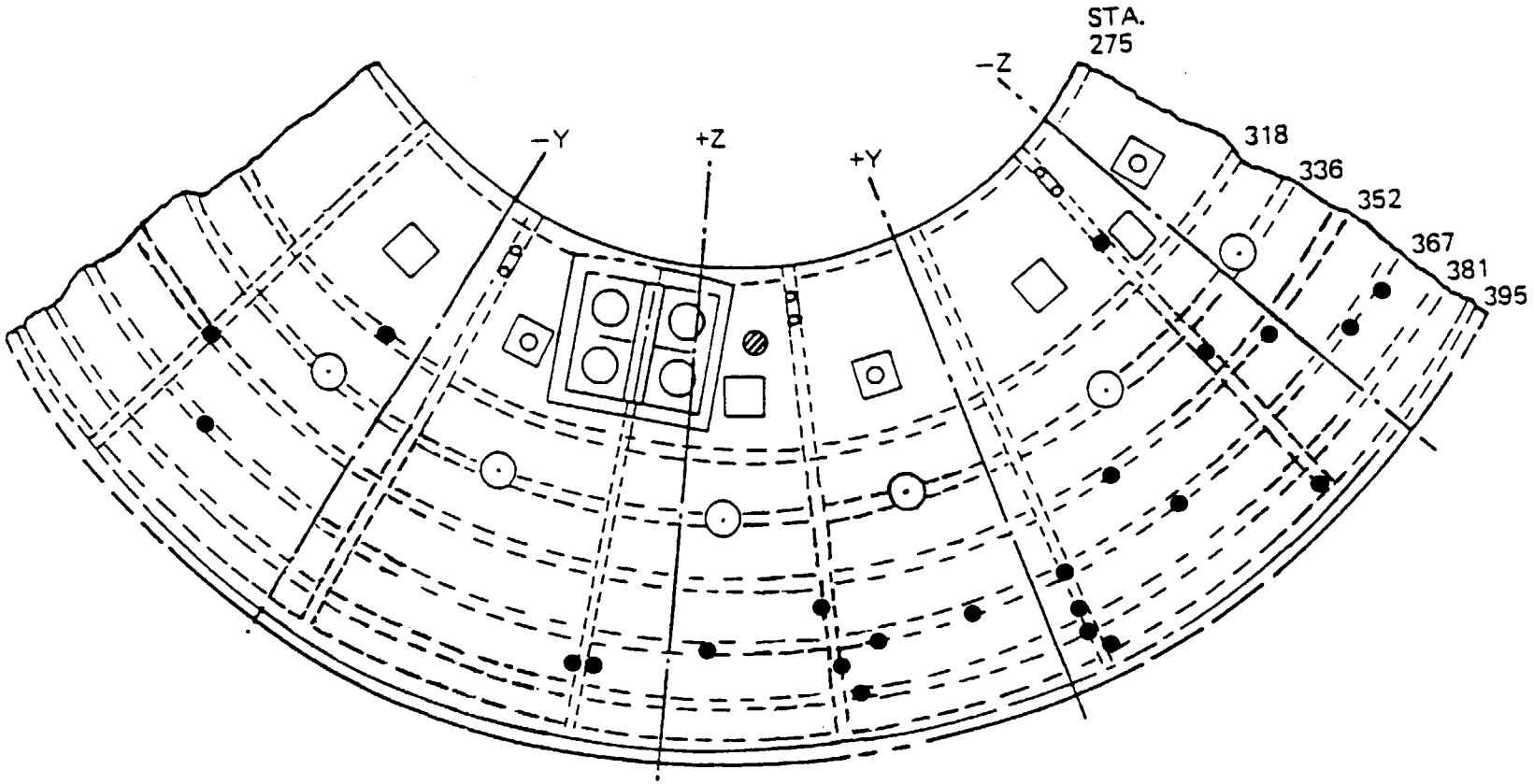
The Field Joint Protection System (FJPS) closeouts were generally in good condition. Trailing edge damage to the FJPS and the GEI cork runs were attributed to debris resulting from severance of the nozzle extension.

Separation of the aft ET/SRB struts appeared normal. The ET/SRB aft struts, ETA ring, IEA, IEA covers, and stiffener rings appeared undamaged. A 7"x1" area of K5NA was missing from the separation plane/forward side of the upper strut fairing and the substrate was sooted. The aft booster stiffener ring splice plate closeouts were intact and no K5NA material was missing.

The phenolic material on the kick ring was delaminated. Aft skirt acreage TPS was generally in good condition. Significant amounts of BTA had been applied to closeouts on this aft skirt. Hypalon paint was blistered/missing over the areas where the BTA had been applied. The underlying BTA was not sooted.

The HDP Debris Containment System (DCS) plungers were seated and appeared to have functioned properly. EPON shim material is no longer bonded to the HDP #3 and #4 aft skirt structure.

FIGURE 4. **RIGHT SRB FRUSTUM**

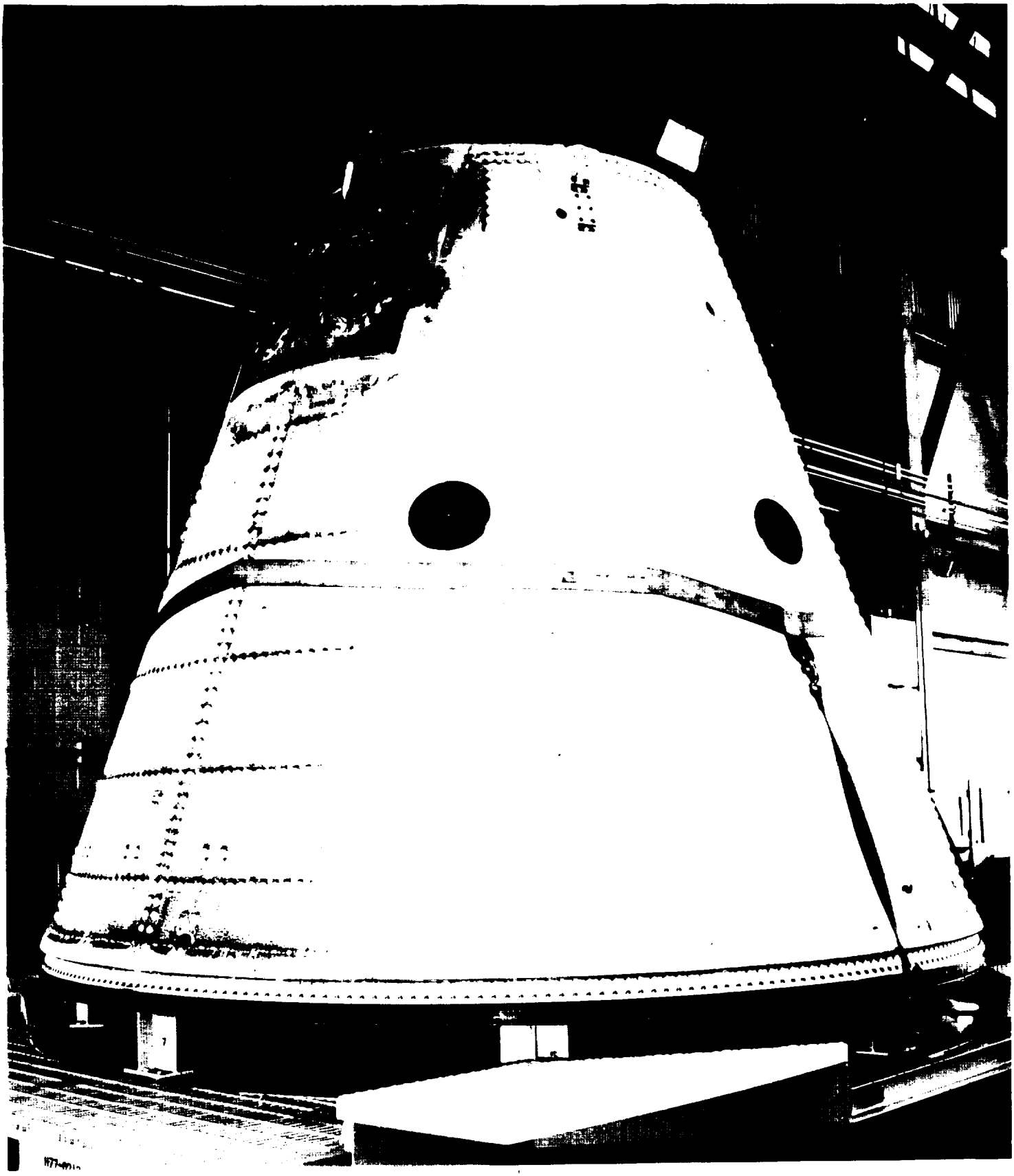


MISSING TPS

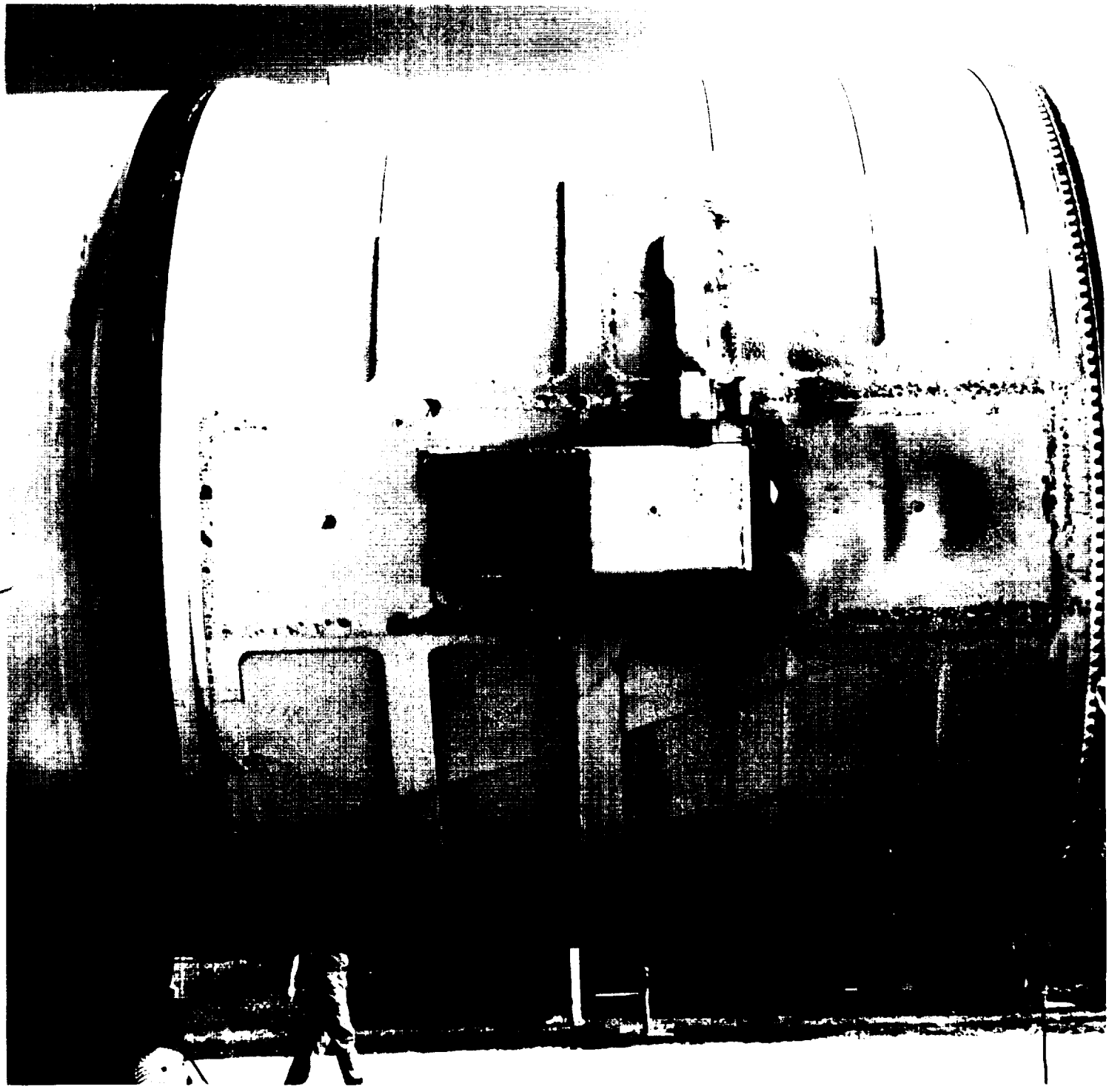
⊘ 2" x 2"

DEBONDS

● 23



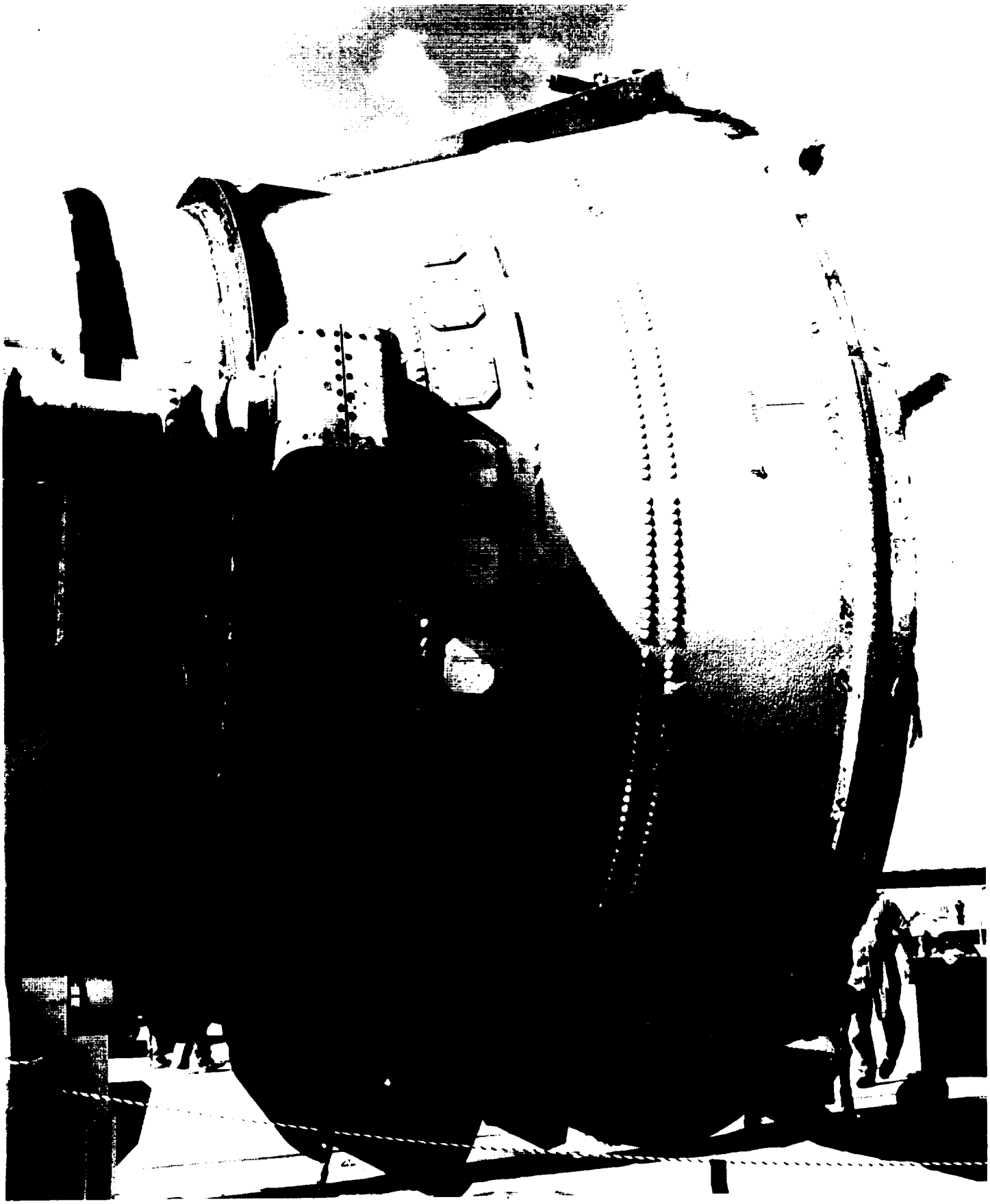
The RH frustum had 23 MSA-2 debonds over fasteners. Hypalon paint was blistered/missing from the areas where BTA had been applied. The BSM aero heat shield covers had locked in the fully opened position.



RH forward skirt acreage exhibited no debonds or missing TPS. Blistered and/or missing Hypalon paint mark the areas where BTA had been applied as a closeout material.

Significant amounts of BTA had been applied to closeouts on the right forward skirt. Hypalon paint was blistered/missing from the areas where the BTA had been used but the BTA was not sooted or charred.

Overall view of the aft booster/aft skirt. Separation of the aft ET/SRB struts appeared normal. The struts, ETA ring, IEA, IEA cover, and stiffener rings appeared undamaged.



Aft skirt acreage TPS was generally in good condition. Hypalon paint was blistered and/or missing from the areas where BTA had been used as a closeout material but the BTA was not sooted or charred.

6.2 LH SOLID ROCKET BOOSTER DEBRIS INSPECTION

The LH frustum was missing TPS in one area (3"x2") near the -Y axis/275 ring frame and had 21 MSA-2 debonds over fasteners. There was virtually no blistering of the Hypalon paint with the exception of minor localized blistering along the 395 ring. All BSM aero heat shield covers had locked in the fully opened position. However, the left covers were bent backward and the attach rings had been deformed/fractured by parachute riser entanglement. The upper right BSM had rotated 20 degrees counterclockwise when the set screw holding the BSM in position was overloaded due to parachute riser entanglement (Figure 5).

The LH forward skirt acreage exhibited no debonds or missing TPS. Both RSS antennae covers/phenolic base plates were intact, though the -Z antenna base plate had delaminated. Minor blistering of the Hypalon paint occurred near the ET/SRB attach point and on the systems tunnel cover. No pins were missing from the frustum severance ring.

The Field Joint Protection System (FJPS) closeouts were in good condition. A 1-inch debond occurred on the forward factory joint of the aft segment at 45 degrees. In general, minor trailing edge damage to the FJPS and the GEI cork runs were attributed to debris resulting from severance of the nozzle extension. Small, but more than usual, areas of missing paint on the SRM cases were most likely caused by nozzle severance debris.

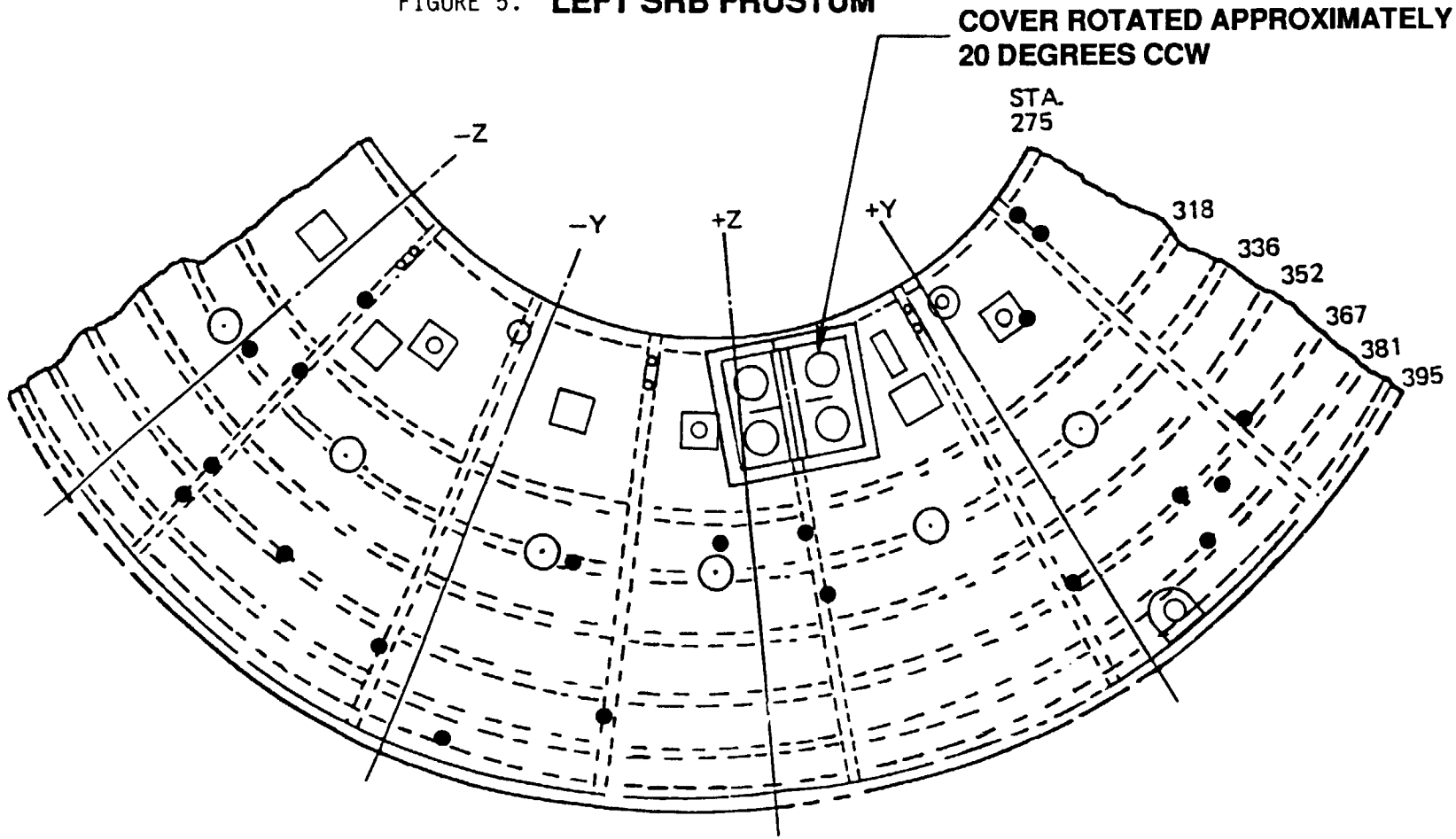
Separation of the aft ET/SRB struts appeared normal. The ET/SRB aft struts, ETA ring, IEA, IEA covers, and stiffener rings appeared undamaged. The stiffener ring splice plate closeouts were intact and no K5NA material was missing.

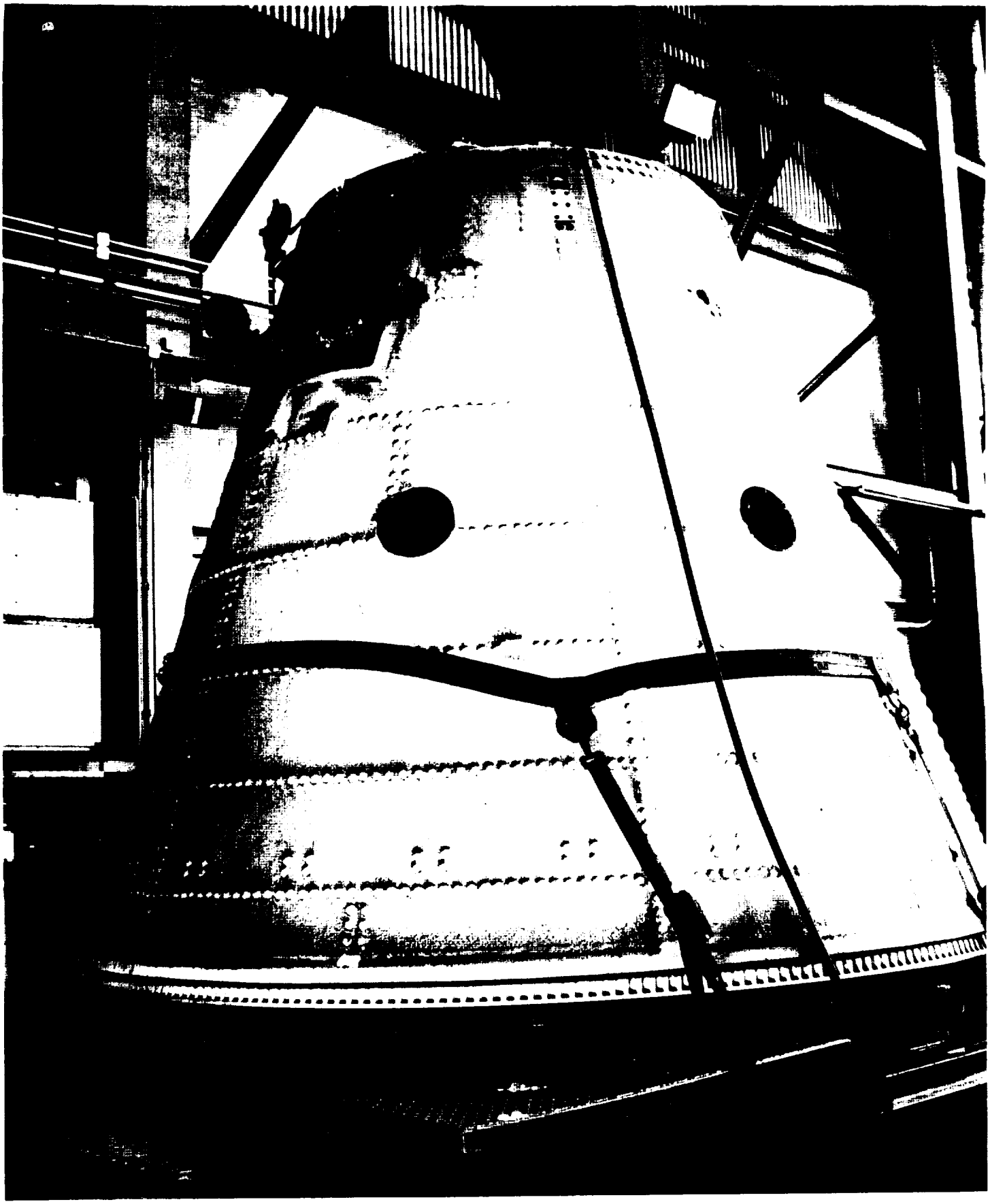
The phenolic material on the kick ring was delaminated. Aft skirt acreage TPS was generally in good condition. Hypalon paint was blistered over areas where BTA had been applied. The underlying BTA was generally not sooted.

Three of four Debris Containment System (DCS) plungers were seated and appeared to have functioned properly. The HDP #8 DCS plunger had been pushed back into the plunger housing, but was not obstructed by any frangible nut debris. Disassembly of the DCS at Hangar AF revealed a 77 percent retention. EPON shim material is no longer bonded to the HDP #7 and #8 aft skirt structure.

SRB Post Launch Anomalies are listed in Section 9.

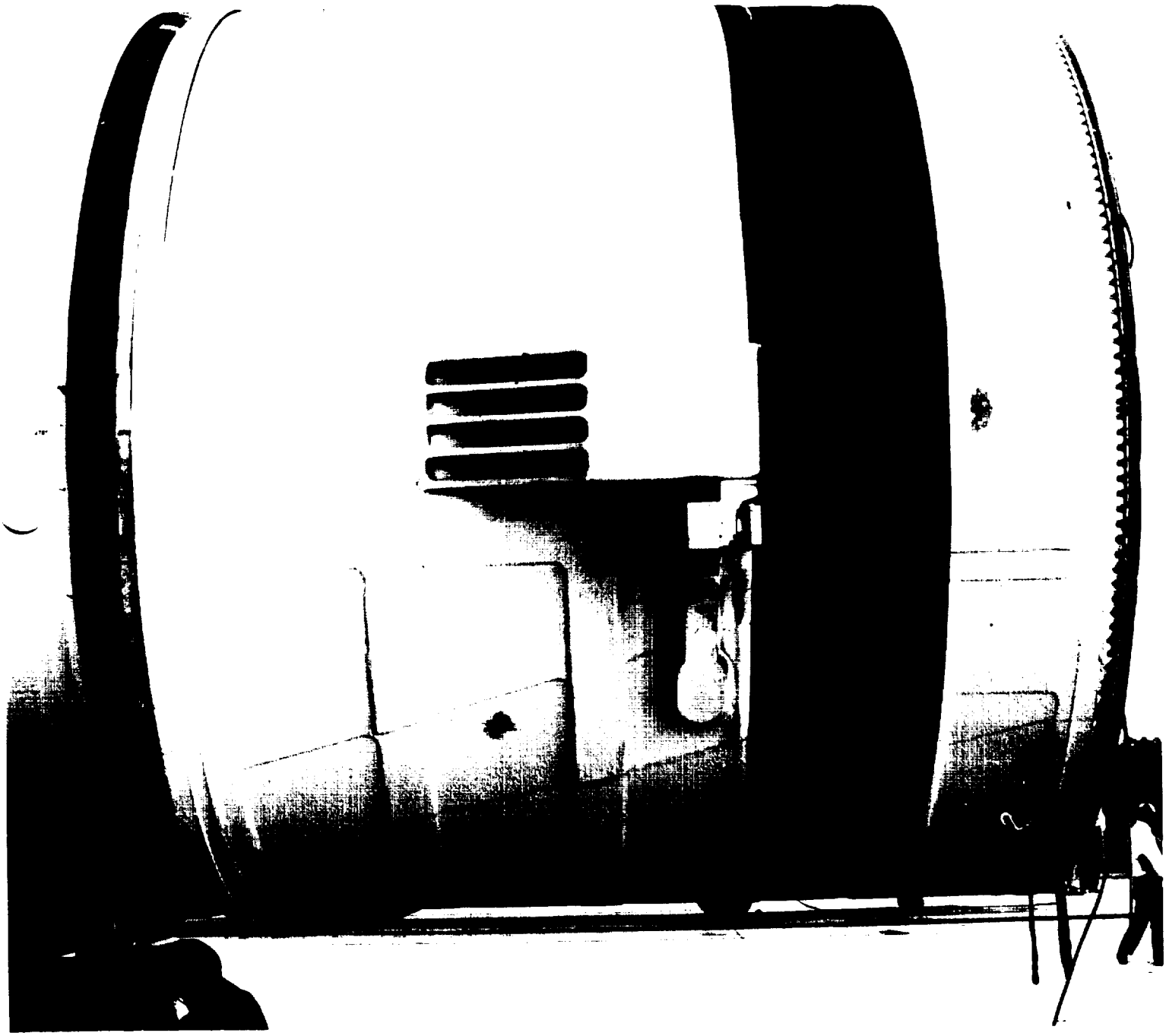
FIGURE 5. **LEFT SRB FRUSTUM**





The LH frustum had a total of 21 MSA-2 debonds over fasteners. All BSM aero heatshield covers had locked in the fully opened position, though both left cover attach rings had been bent by parachute riser entanglement.

The upper right BSM had rotated approximately 20 degrees counterclockwise. Post flight assessment revealed the set screw holding the BSM in position had been overloaded by parachute riser entanglement.



The LH forward skirt acreage MSA-2 exhibited no debonds or missing TPS. Both RSS antenna covers/phenolic base plates were intact though the -Z antenna base plate was delaminated.

Overall view of the aft booster/aft skirt. Separation of the aft ET/SRB struts appeared normal. The struts, ETA ring, IEA, IEA cover, and stiffener rings appeared undamaged.

Aft skirt acreage TPS was generally in good condition. Hypalon paint was blistered/missing from the areas where BTA had been used as a closeout material but the BTA was not sooted or charred.

7.0 ORBITER POST LANDING DEBRIS ASSESSMENT

A post landing debris inspection of OV-102 (Columbia) was conducted 18-21 March 1994 at the Kennedy Space Center on Shuttle Landing Facility (SLF) runway 33 and in the Orbiter Processing Facility bay #2. This inspection was performed to identify debris impact damage and, if possible, debris sources. The Orbiter TPS sustained a total of 97 hits, of which 16 had a major dimension of one inch or greater. This total does not include the numerous hits on the base heat shield attributed to SSME vibration/acoustics and exhaust plume recirculation. A comparison of these numbers to statistics from 45 previous missions of similar configuration (excluding missions STS-23, 25, 26, 26R, 27R, 30R, and 42, which had damage from known debris sources), indicates both the total number of hits and the number of hits 1-inch or larger was less than average (Figures 6-9).

The following table breaks down the STS-62 Orbiter debris damage by area:

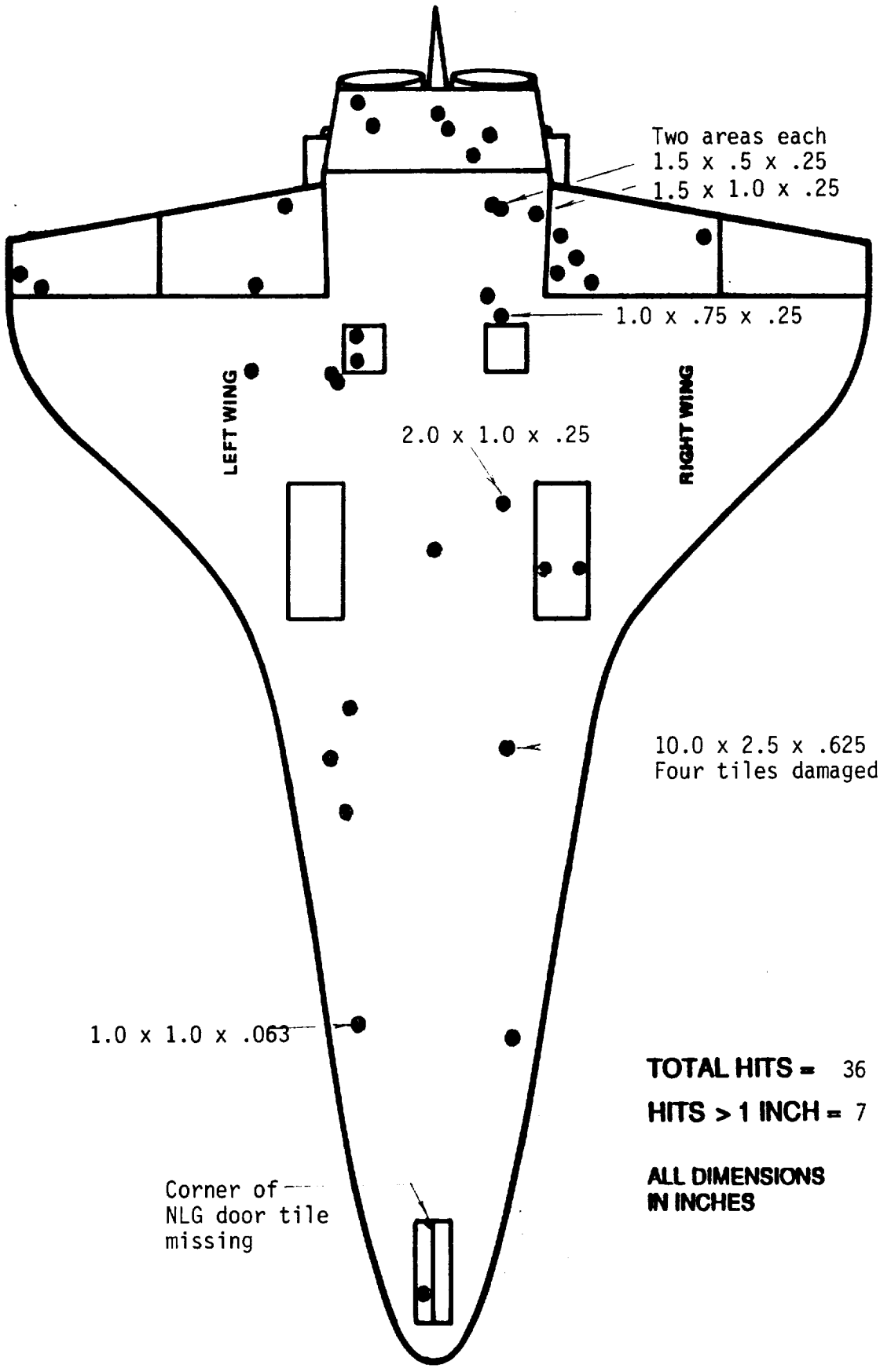
	HITS > 1"	TOTAL HITS
Lower surface	7	36
Upper surface	0	11
Right side	3	7
Left side	6	36
Right OMS Pod	0	2
Left OMS Pod	0	5
TOTALS	16	97

The Orbiter lower surface sustained a total of 36 hits, of which 7 had a major dimension of 1-inch or greater. The distribution of hits on the lower surface does not suggest a single source of ascent debris, but indicates a shedding of ice and Thermal Protection System (TPS) debris from random sources.

The largest tile damage site measured 10" x 2.5" x 0.675", involved four tiles, and was located five feet forward and five feet inboard of the RH main landing gear wheel well leading edge. The damage site was not that large initially but appears to have originated from four distinct impacts enlarged by erosion during re-entry. The remaining tile material in the damage site showed no significant glazing.

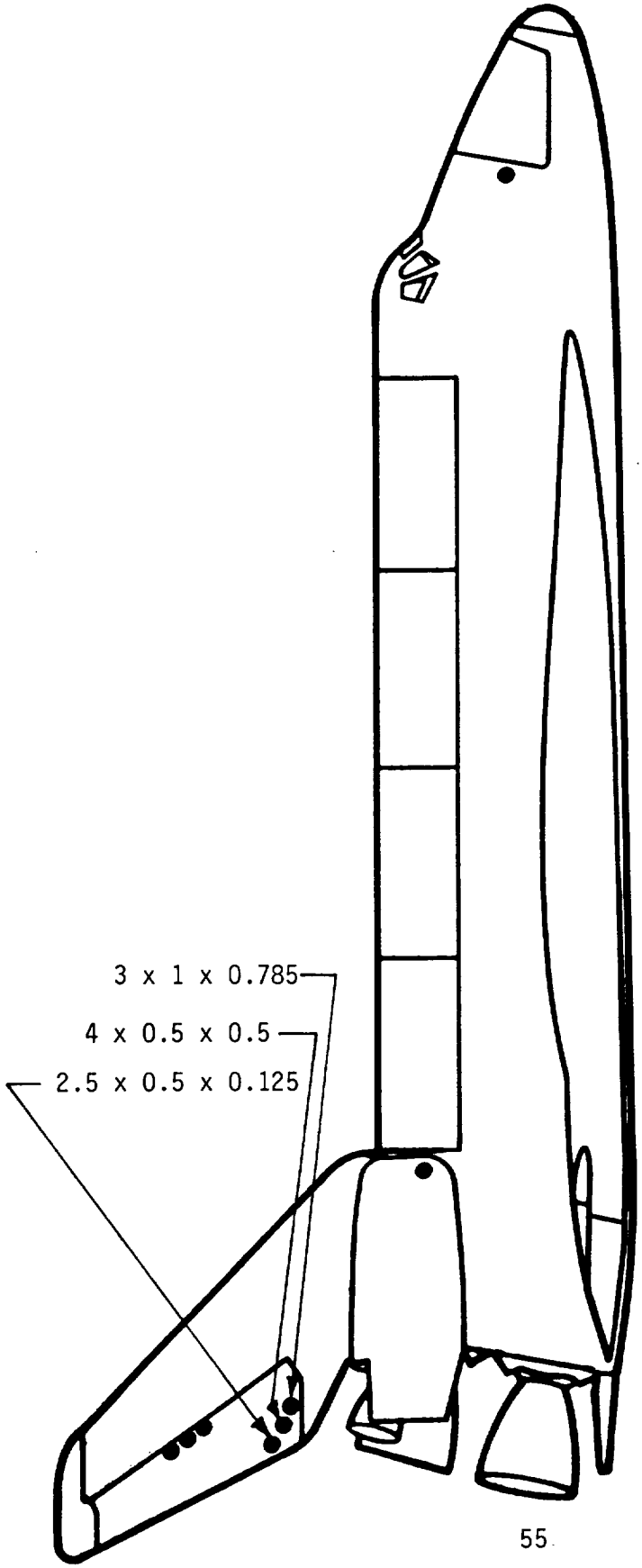
Cluster of hits aft of the LH2 and LO2 ET/ORB umbilicals are believed to be impacts from umbilical ice.

FIGURE 6. **DEBRIS DAMAGE LOCATIONS**



STS-62

FIGURE 7. **DEBRIS DAMAGE LOCATIONS**

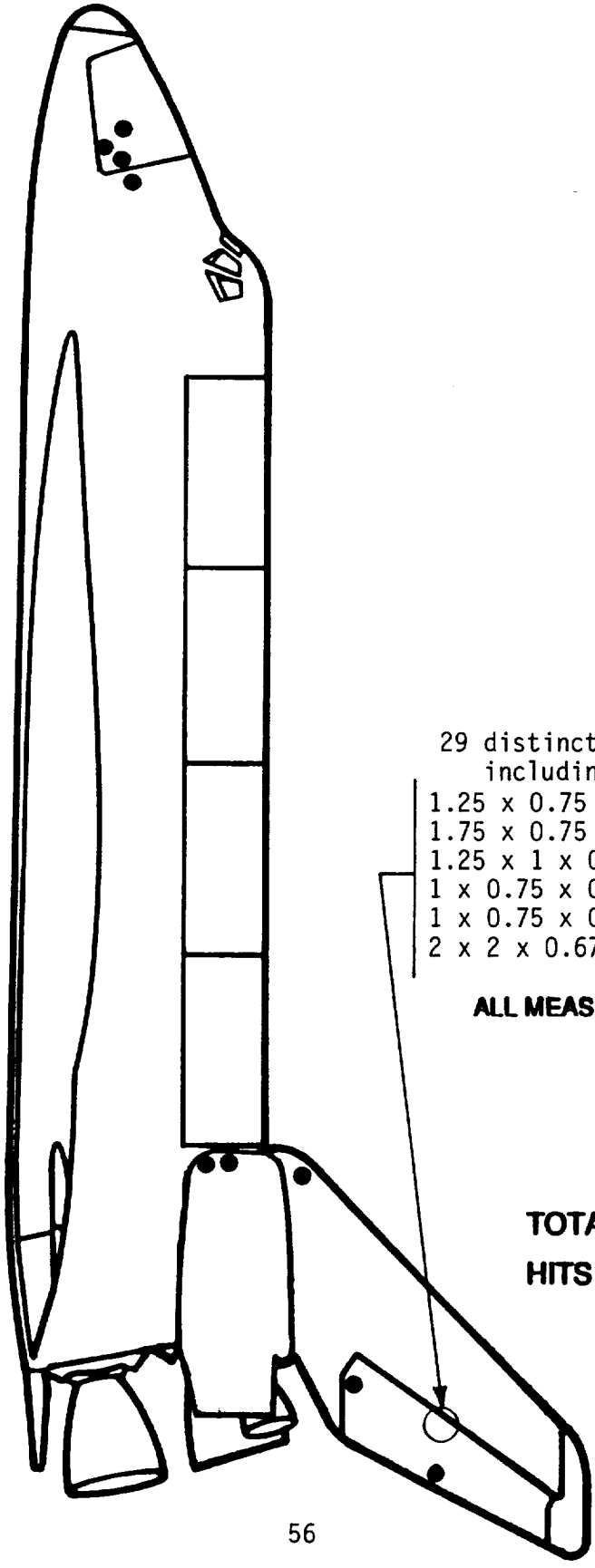


TOTAL HITS = 8

HITS > 1 INCH = 3

STS-62

FIGURE 8. **DEBRIS DAMAGE LOCATIONS**



29 distinct hits
including:
1.25 x 0.75 x 0.5
1.75 x 0.75 x 0.5
1.25 x 1 x 0.375
1 x 0.75 x 0.675
1 x 0.75 x 0.5
2 x 2 x 0.675

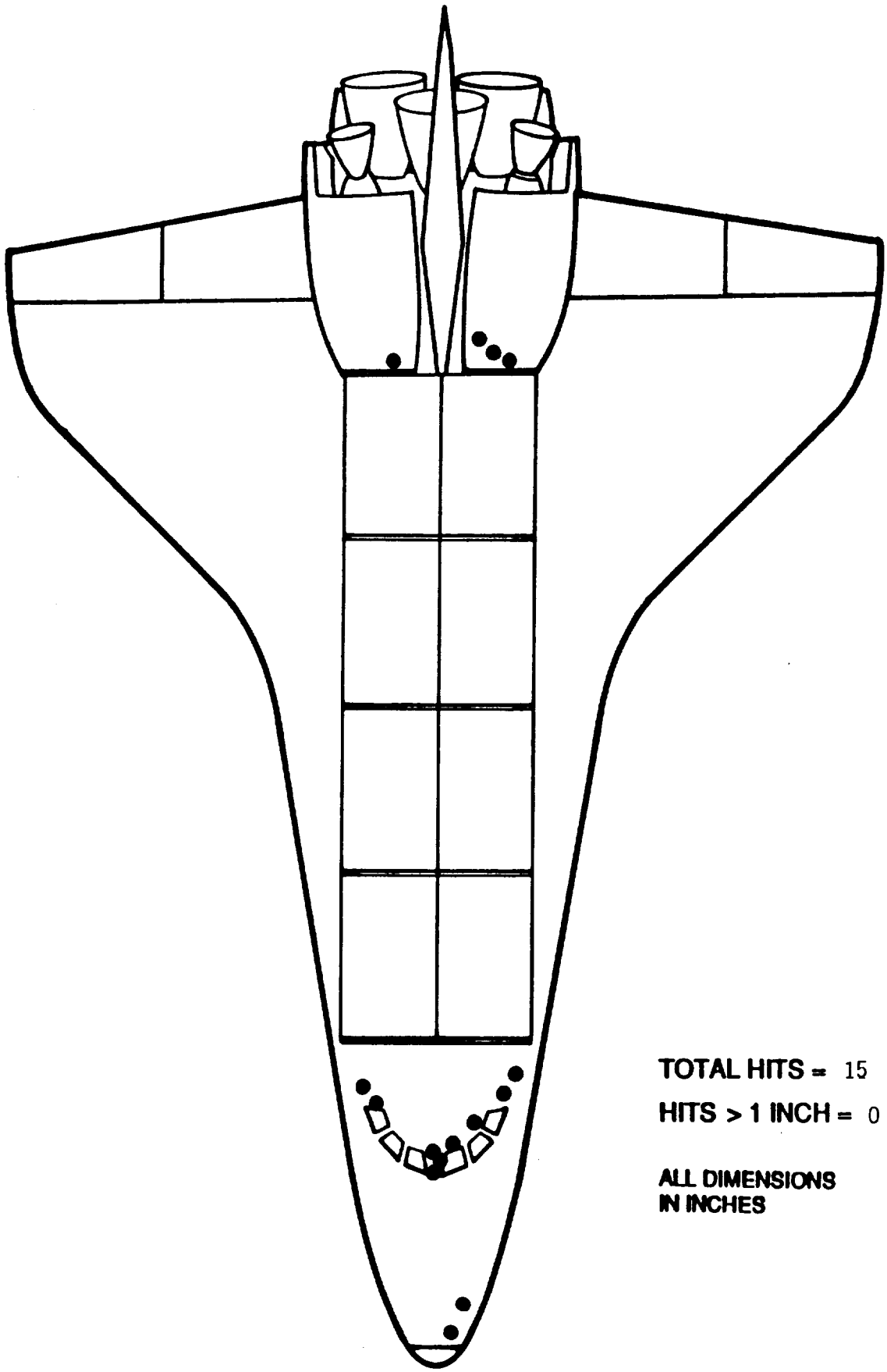
ALL MEASUREMENTS IN INCHES

TOTAL HITS = 38

HITS > 1 INCH = 6

STS-62

FIGURE 9. **DEBRIS DAMAGE LOCATIONS**



A cluster of 29 damage sites spanned three tiles on the rudder black edge tiles (left side) along the hinge line below the split in the speed brake. Six of the damage sites had a major dimension of 1-inch or larger while three of the damage sites were deep enough to expose the substrate. Three small hits occurred in this same general area on the right side of the rudder/speed brake.

Six thermal barriers, total size approximately 36" x 3" x 1.5", and one corner tile piece 4" x 4", were missing from the nose landing gear wheel well. Runway infrared cameras recorded these objects falling from the Orbiter when the nose landing gear doors were opened on final approach. A search of the area under the flight path failed to recover the missing thermal barriers, which may be submerged in the large body of water south of the runway. The cause for the loss of the material was attributed to the way the substrate was prepared for bonding at the vendor.

No tile damage from micrometeorites or on-orbit debris was identified during the inspection.

No TPS damage was attributed to material from the wheels, tires, or brakes. The tires were in good condition after a landing on the KSC runway.

ET/Orbiter separation devices EO-1, EO-2, and EO-3 functioned properly. All ET/Orbiter umbilical separation ordnance retention shutters were closed properly. No significant amounts of foam or red purge seal adhered to the LH2 ET/ORB umbilical near the 4-inch flapper valve. No debris was found on the runway beneath the ET/ORB umbilical cavities.

Charred White RTV protruded from the LH2 ET/ORB umbilical forward outboard and forward inboard pyrotechnic canister to umbilical plate interfaces.

Orbiter windows #3 and #4 exhibited moderate hazing. Only a very light haze was present on the other windows. Surface wipes were taken from all windows for laboratory analysis. Damage to the window perimeter tiles was typical. No other sites on the Orbiter were identified for chemical analysis sampling.

Tile damage on the base heat shield was also typical. The Dome Mounted Heat Shield (DMHS) closeout blankets on all three SSME's were in excellent condition and no material was missing. Tiles on the vertical stabilizer "stinger" and around the drag chute door were intact and undamaged with the exception of one 7/8-inch diameter damage site on the +Y edge of the stinger.

Runway 33 had been swept/inspected by SLF operations personnel prior to landing and all potentially damaging debris was removed.

The post landing walkdown of Runway 33 was performed immediately after landing. No unexpected flight hardware was found on the runway. All Orbiter drag chute hardware was recovered and showed no signs of abnormal operation. No organic (bird) debris was found on the runway.

The Shuttle Thermal Imager (STI) was used to measure the surface temperatures of several areas on the vehicle (per OMRSD V09AJ0.095). Eight minutes after landing, the Orbiter nosecap RCC was 224 degrees F. Twenty-two minutes after landing, the RH wing leading edge RCC panel #9 was 108 degrees F and panel #17 was 100 degrees F (Figure 10).

In summary, both the total number of Orbiter TPS debris hits and the number of hits 1-inch or larger was less than average when compared to previous missions (reference Figures 11-12). Orbiter Post Launch Debris Anomalies are listed in Section 9.

FIGURE 10. **STS- 62 RCC TEMPERATURE MEASUREMENTS AS RECORDED BY THE SHUTTLE THERMAL IMAGER**

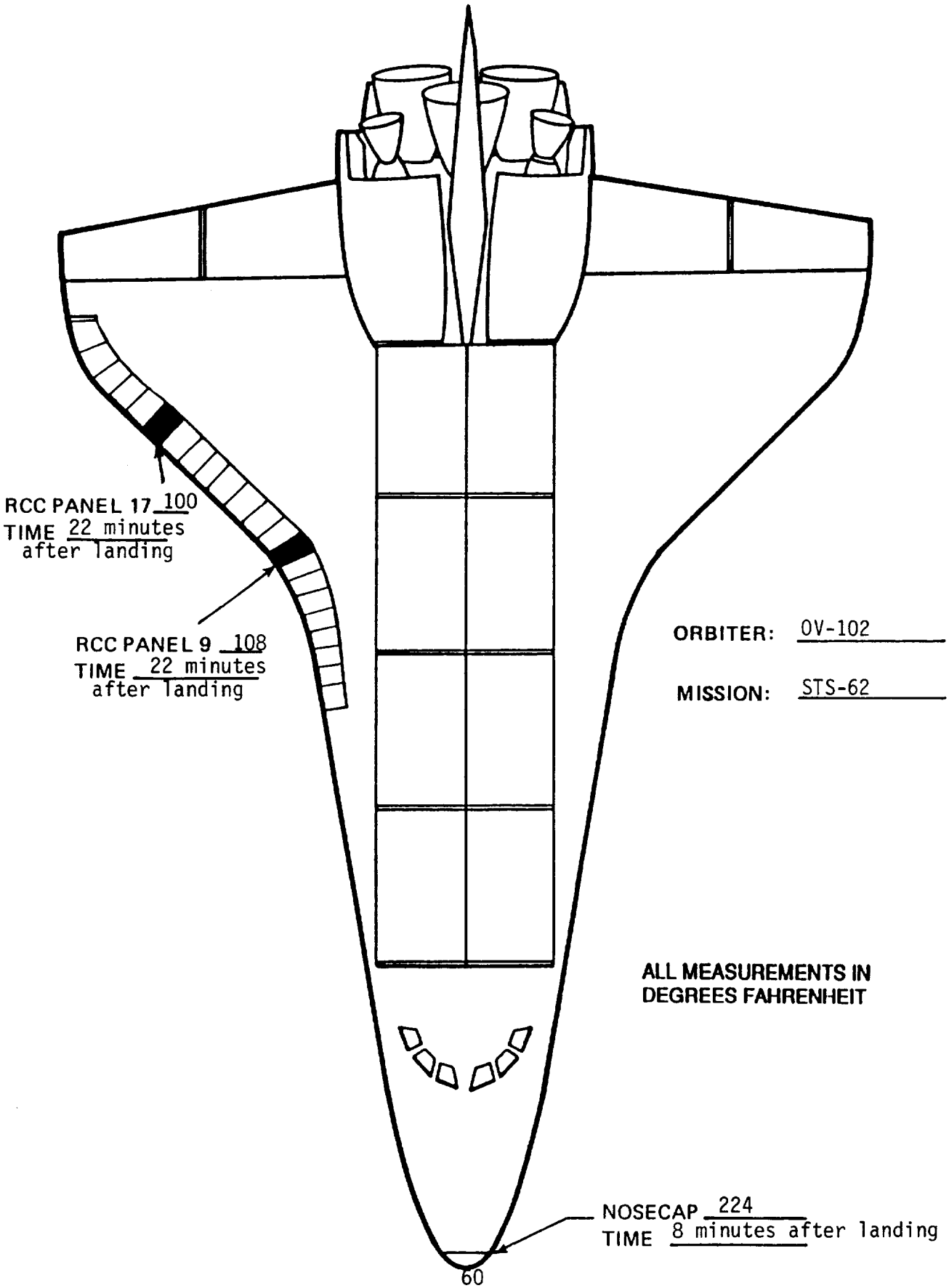
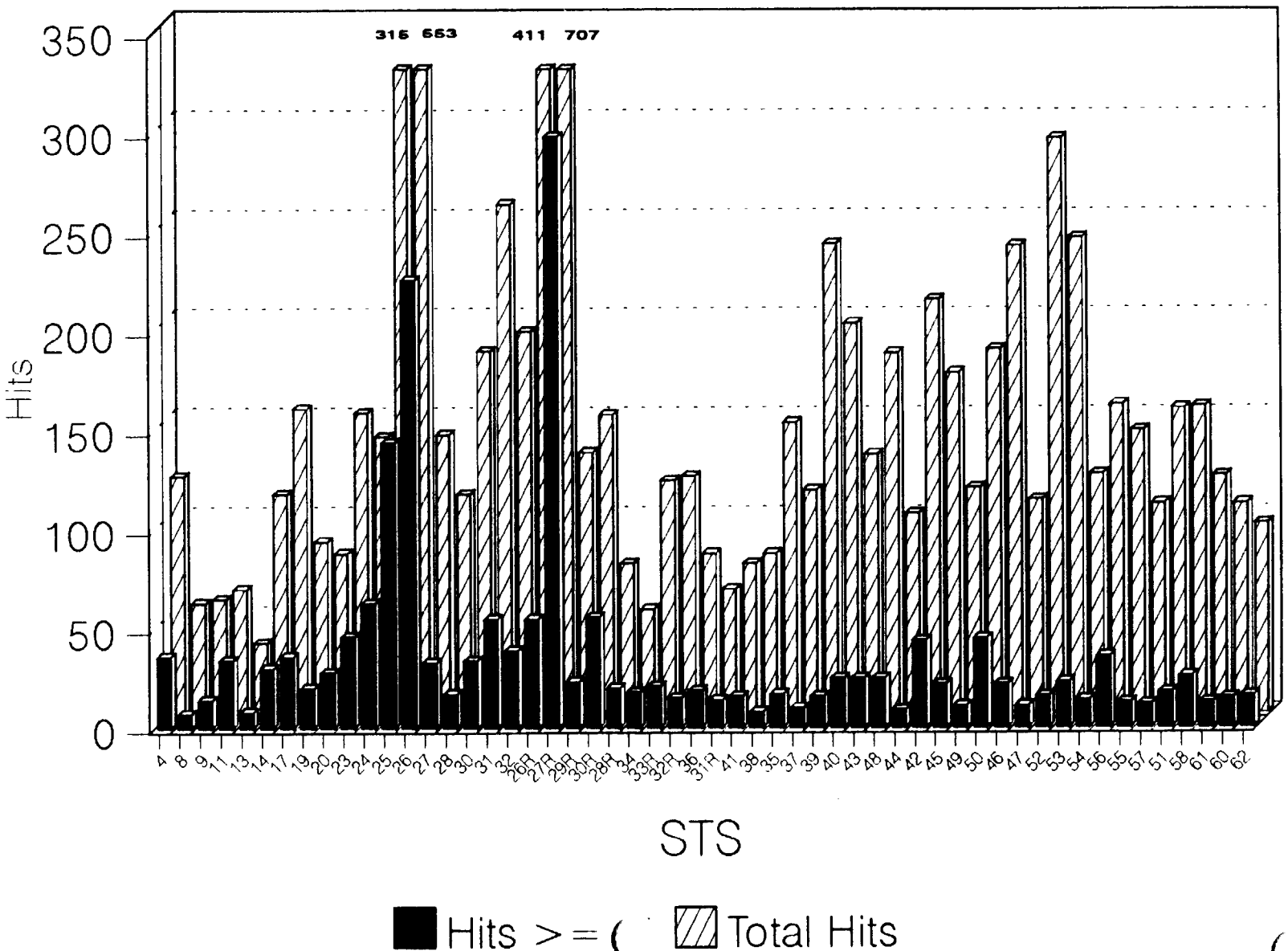


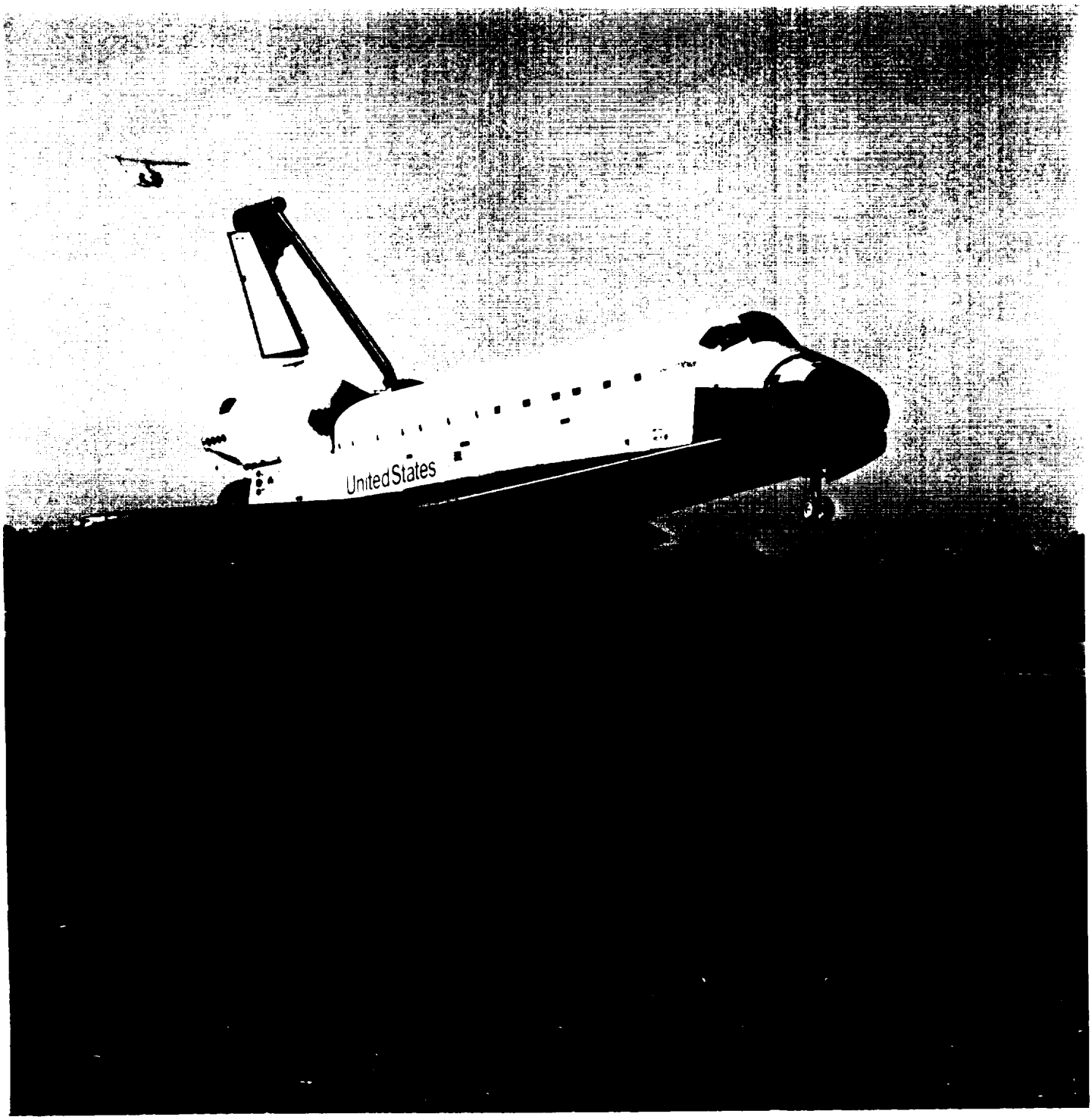
FIGURE 11 ORBITER POST FLIGHT DEBRIS DAMAGE SUMMARY

	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
STS-45	18	122	22	172
STS-49	6	55	11	114
STS-50	28	141	45	184
STS-46	11	186	22	236
STS-47	3	48	11	108
STS-52	6	152	16	290
STS-53	11	145	23	240
STS-54	14	80	14	131
STS-56	18	94	36	156
STS-55	10	128	13	143
STS-57	10	75	12	106
STS-51	8	100	18	154
STS-58	23	78	26	155
STS-61	7	59	13	120
STS-60	4	48	15	106
AVERAGE	14.2	91.6	21.5	132.8
SIGMA	7.4	44.1	10.5	58.0
STS-62	7	36	16	97

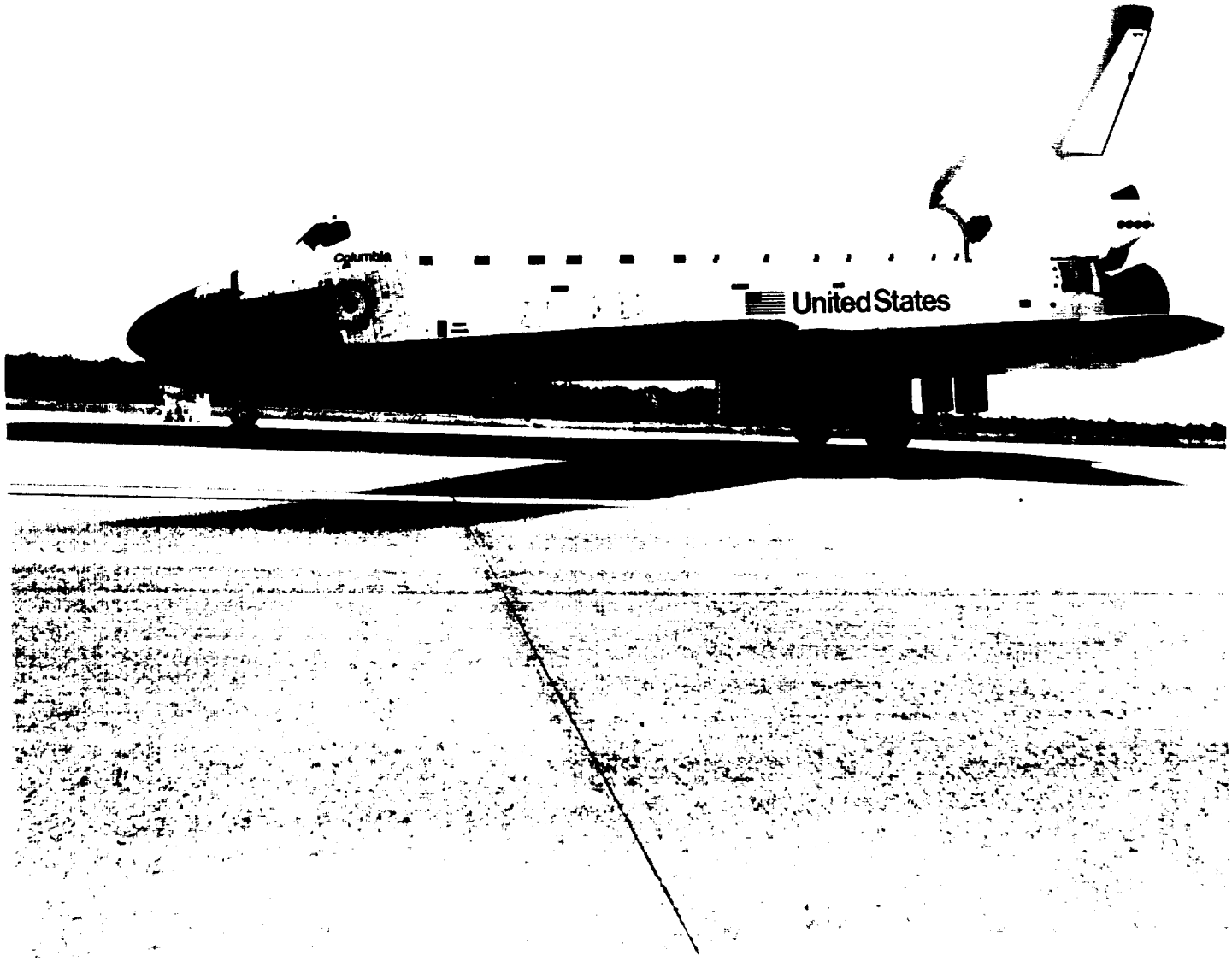
MISSIONS STS-23, 24, 25, 26, 26R, 27R, 30R, AND 42 ARE NOT INCLUDED IN THIS ANALYSIS SINCE THESE MISSIONS HAD SIGNIFICANT DAMAGE CAUSED BY KNOWN DEBRIS SOURCES

FIGURE 12. # COMPARISON TABLE



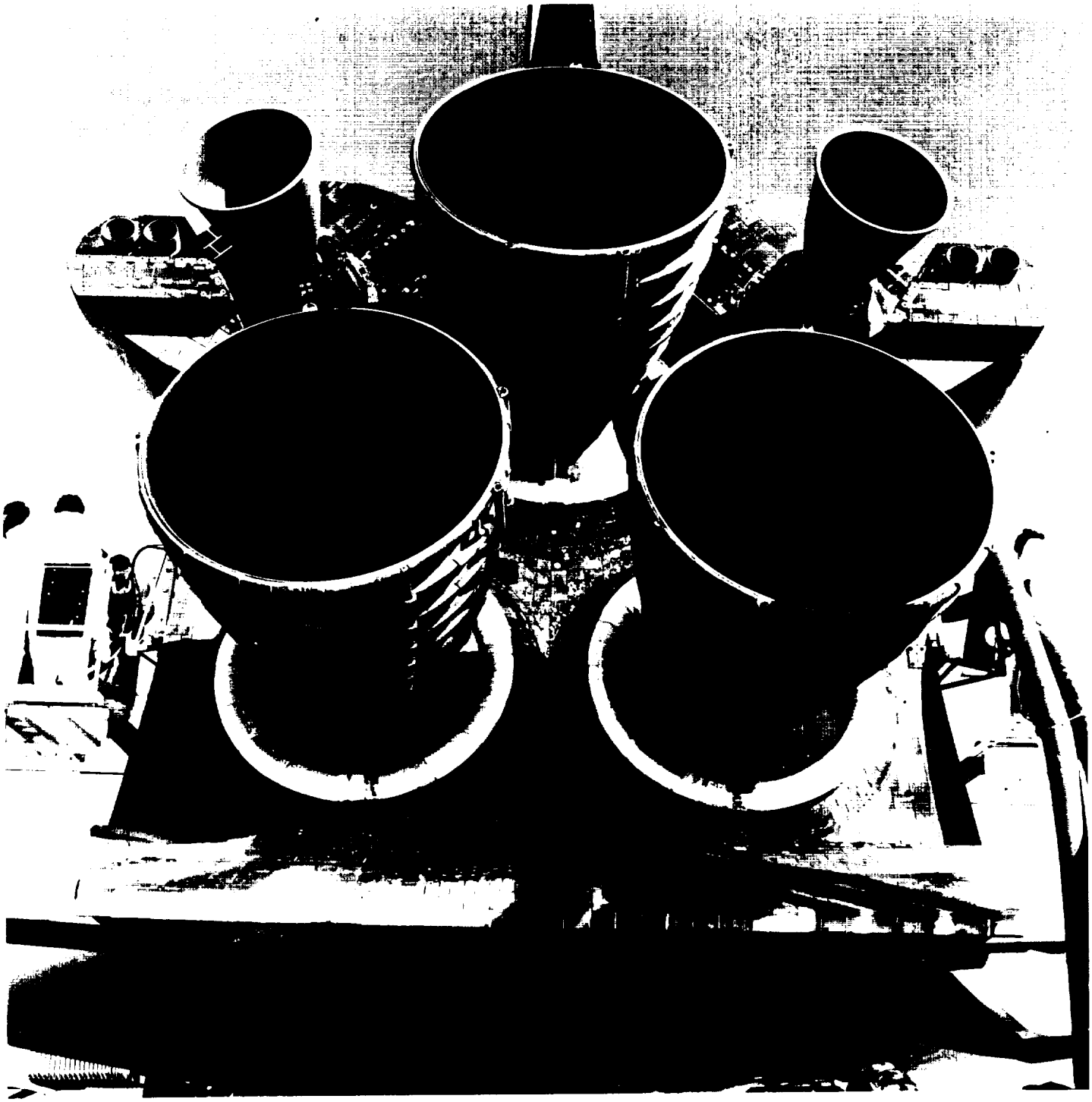


OV-102 Columbia landed on Kennedy Space Center SLF
runway 33 on 18 March 1994

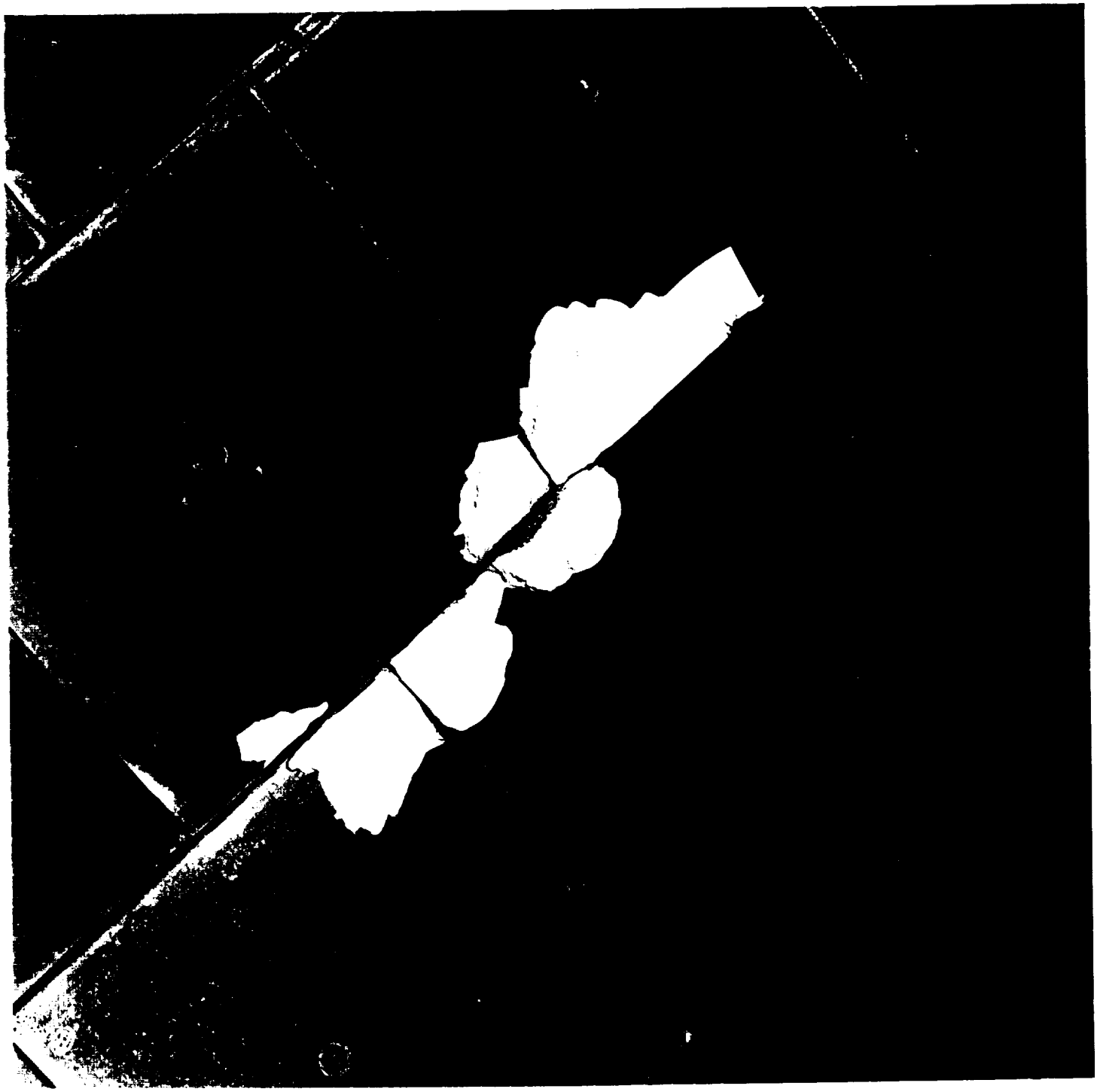


Overall view of the Orbiter left side

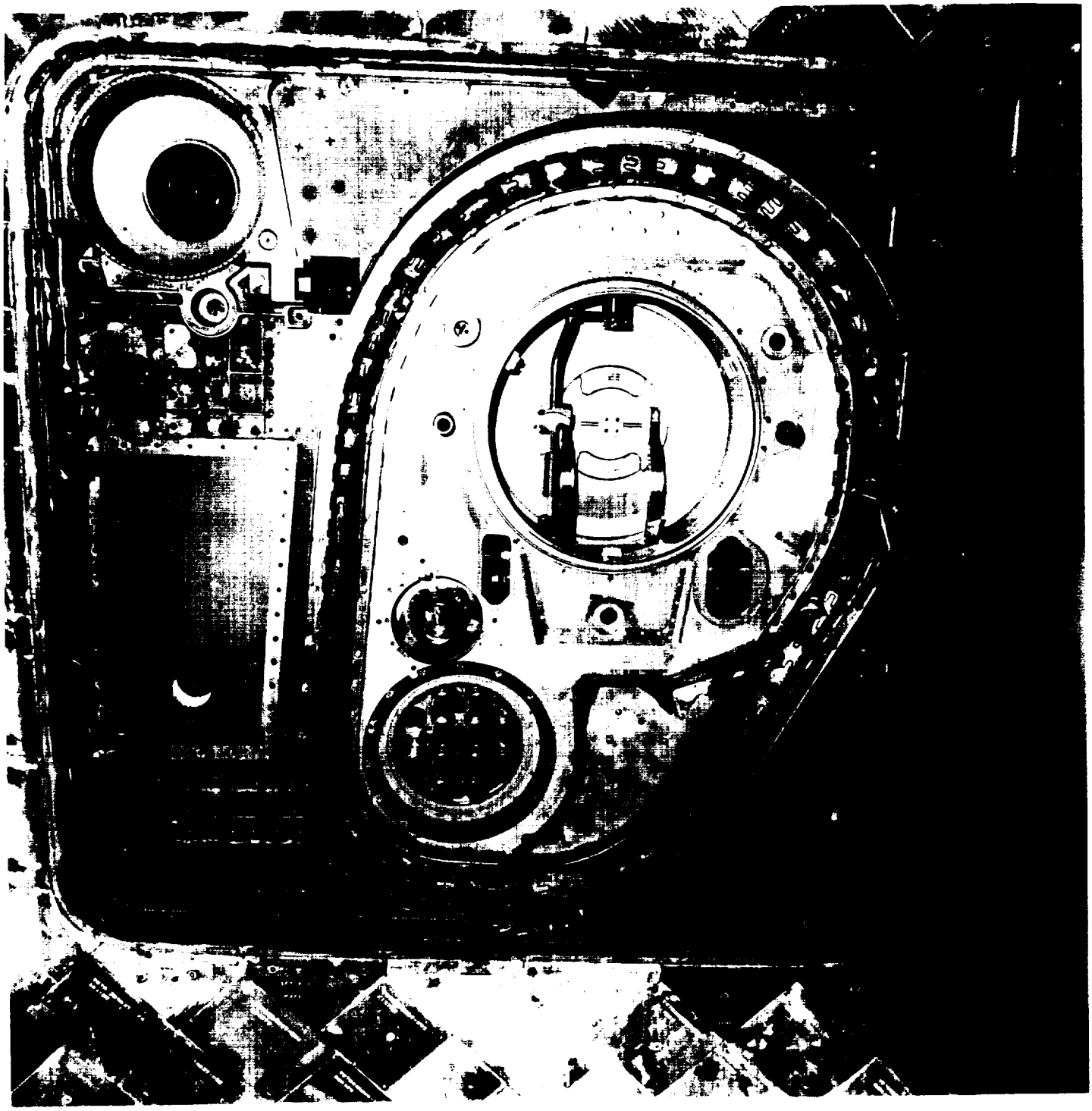
Overall view of Orbiter nose. Windows #3 and #4 exhibited moderate hazing. Only a very light haze was present on the other windows. Damage to the window perimeter tiles was typical



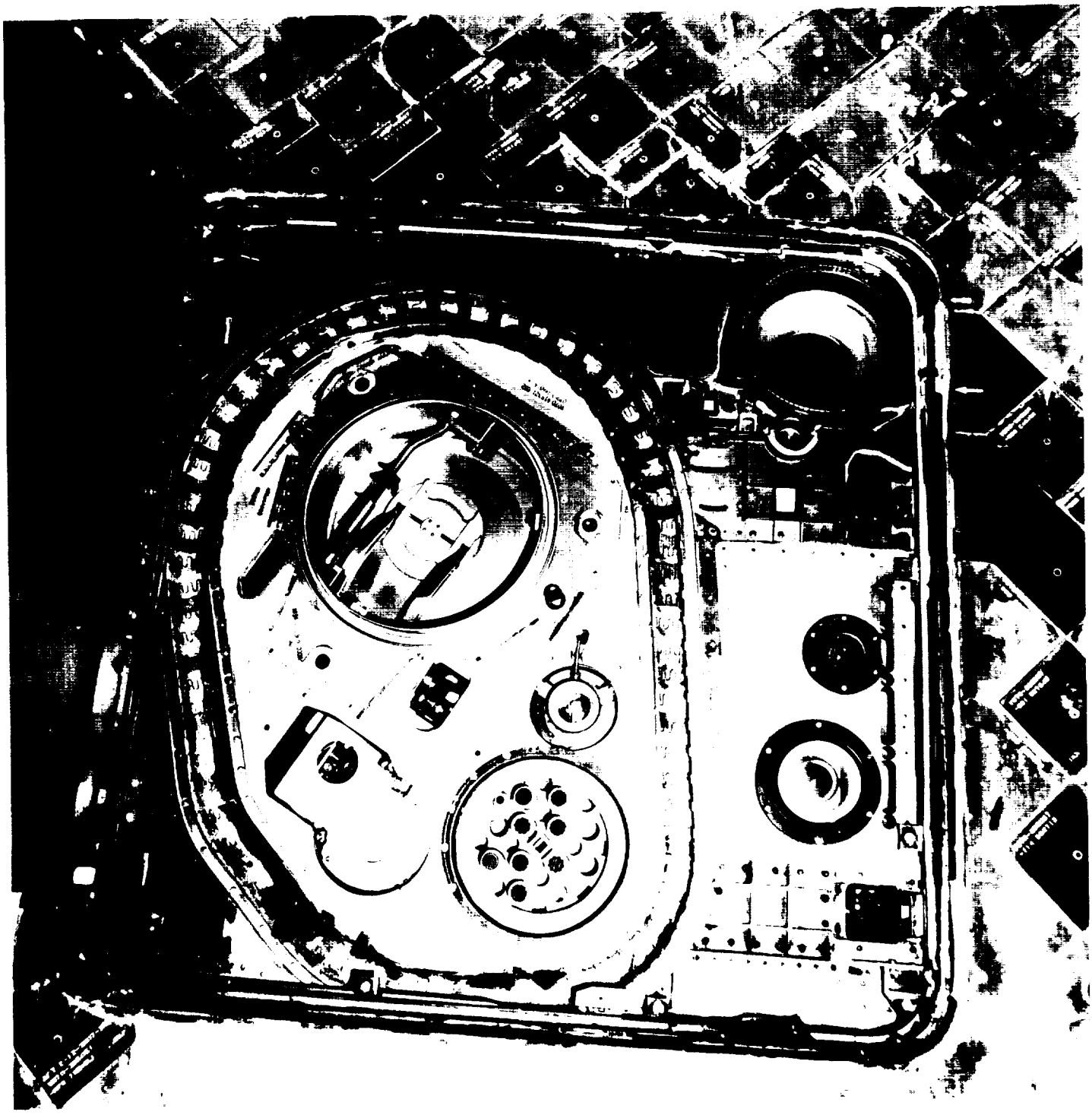
Tile damage on the base heat shield was typical. The Dome Mounted Heat Shield (DMHS) closeout blankets on all three SSME's were in excellent condition and no material was missing.



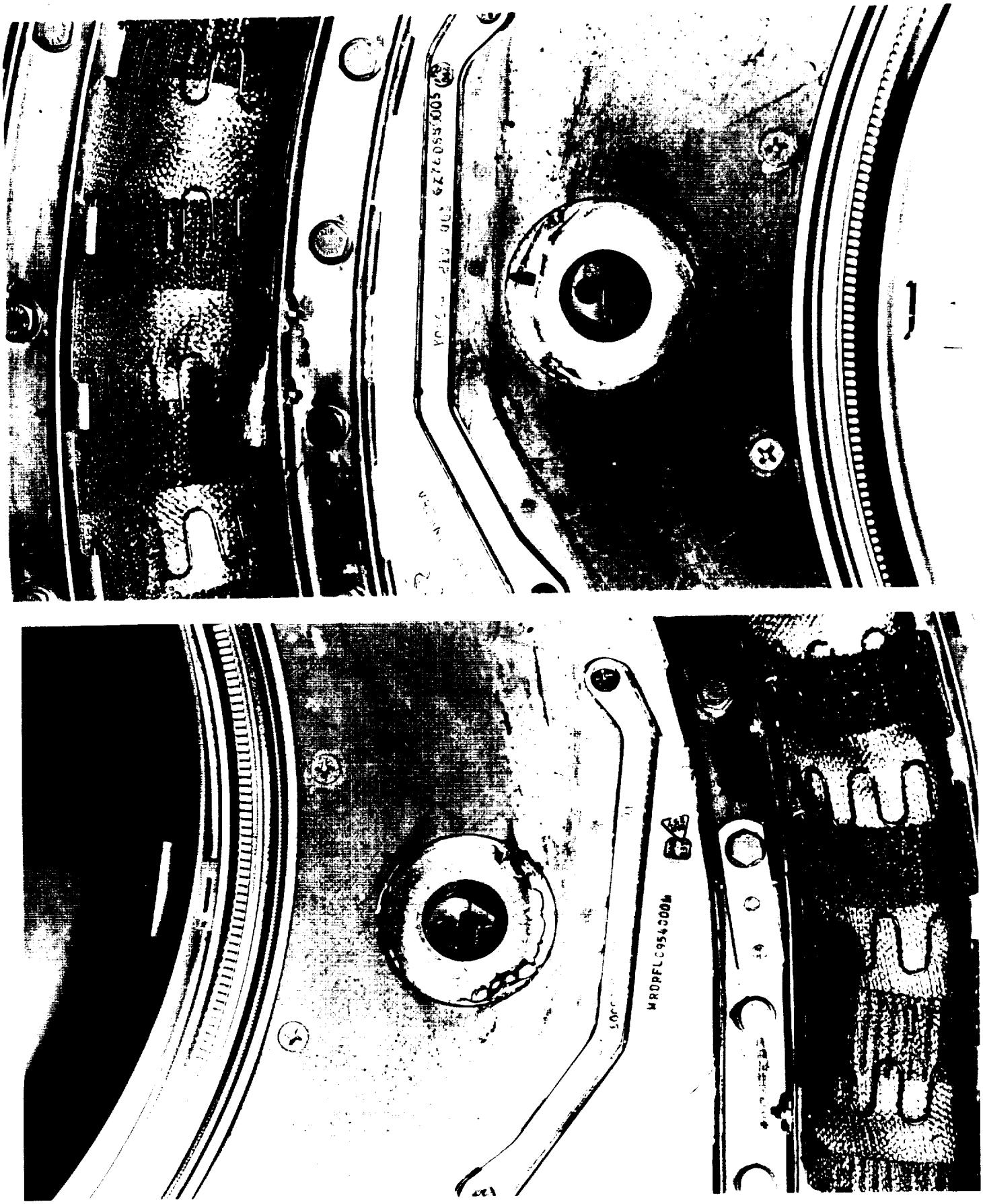
The Orbiter lower surface tiles sustained a total of 36 hits, of which 7 had a major dimension of 1-inch or greater. The largest tile damage site measured 10" x 2.5" x 0.7" and was located near the RH MLG wheel well. The damage site was not that large initially but appears to have originated from four distinct impacts enlarged by erosion during re-entry.



Overall view of the LO2 ET/ORB umbilical. All separation ordnance devices functioned properly. No flight hardware was found on the runway below the umbilical when the ET door was opened.

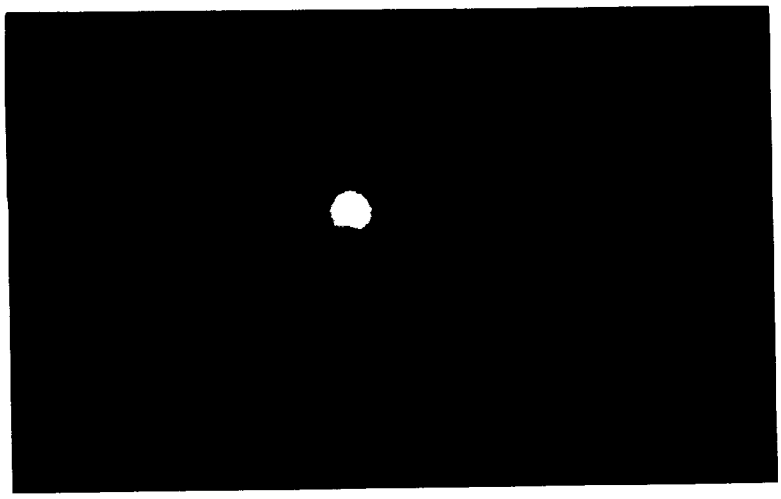


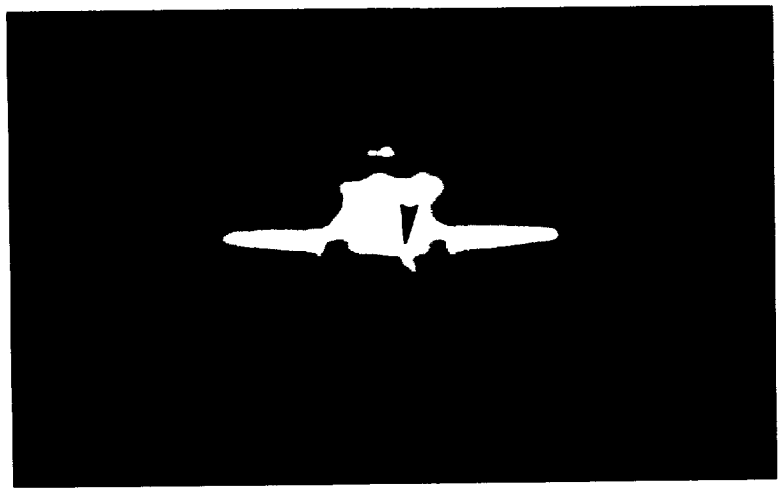
Overall view of the LH2 ET/ORB umbilical. All separation ordnance devices functioned properly. No flight hardware was found on the runway below the umbilical when the ET door was opened.

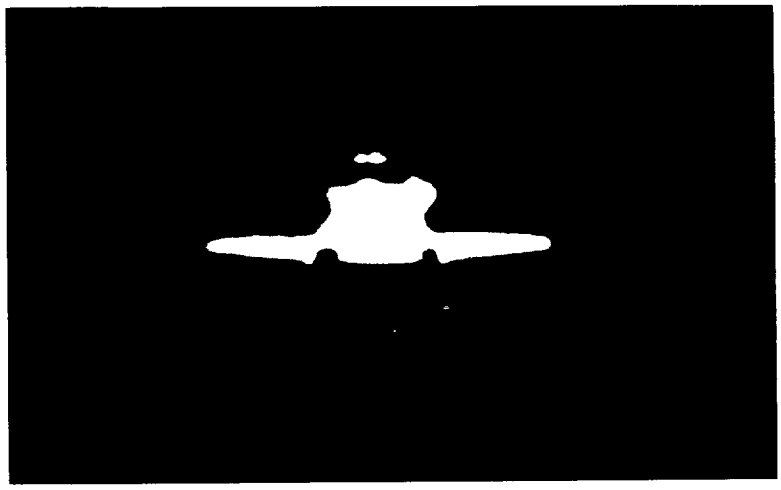


Charred white RTV protruded from the LH2 ET/ORB umbilical forward outboard and forward inboard pyrotechnic canister to umbilical plate interfaces.

Thermal barrier that fills the gap between the nose gear wheel well and the leading edges of the nose gear doors (in the closed position) was missing. The cause was attributed to the procedure for substrate preparation.







Thermal barrier, as large as 36 inches in length, fell from the Orbiter nose wheel well as the landing gear door opened on final approach. The thermal barrier, which was still at an elevated temperature from re-entry, was clearly visible in the infrared views but virtually invisible in the landing films.

A cluster of 29 damage sites spanned three tiles on the rudder black edge tiles along the hinge line below the split in the speed brake. Three hits occurred in this same general area on the right side of the rudder/speed brake.

Six of the damage sites on the rudder hinge line had a major dimension of 1-inch or larger while three of the damage sites were deep enough to expose substrate.

8.0 DEBRIS SAMPLE LAB REPORTS

A total of eight samples were obtained from OV-102 Columbia during the STS-62 post landing debris assessment at Kennedy Space Center. The samples consisted of 16 wipes (1 IPA, 1 dry for each window) from Orbiter windows #1 - #8. The samples were analyzed by the NASA KSC Microchemical Analysis Branch (MAB) for material composition and comparison to known STS materials. Debris analysis involves placing and correlating of particles and residues with respect to composition, thermal (mission) effects, and availability. Debris sample results/analyses are listed by Orbiter location in the following summaries.

ORBITER WINDOWS

Samples from the Orbiter windows indicated exposure to SRB BSM exhaust, Orbiter Thermal Protection System (TPS) materials, paints and primer from various sources, window polish residue, and natural landing site products. Building insulation fibers and carbon steel spheres were also present. All of these materials have been previously observed and occurred only in trace quantities. There was no apparent vehicle damage related to these residuals.

ORGANIC ANALYSIS

Organic analysis for this sampling provided an indication of exposure to Orbiter TPS, OMS FRCS nozzle paper cover adhesive, and window protective cover materials. A finding that has been noted previously was that of polysulfide, such as the sealant material used on the SRB forward skirt door. All of these materials have been noted in previous debris sample analyses.

STS-60 ORGANIC ANALYSIS

Organic analysis of STS-60 window samples has been completed and indicated exposure to materials from Orbiter TPS, FWD RCS nozzle paper cover adhesive, window protective covers, and polysulfide, such as that found in the SRB forward skirt flight door sealant.

NEW FINDINGS

No new findings were noted in these sample results (Figure 13). A previously documented material, polysulfide, was found in both the STS-62 and STS-60 organic analyses. This material is believed to have originated during ground processing. No vehicle damage occurred that would appear related to these residual findings.

STS	Sample Location				
	Windows	Wing RCC	Lower Tile Surface	Umbilical	Other
62	Metallics - BSM Residue (SRB) RTV, Tile, Tile filler (ORB TPS) Insulation Glass (ORB TPS) Fiber- Building insulation, wipe cloth Earth minerals (Landing site) Organics- Plastic polymer, sealant RTV-RCS thruster nozzle cover (SRB) Paint and primer				
60	Metallics - BSM Residue (SRB) RTV, Tile, Tile filler (ORB TPS) Insulation Glass (ORB TPS) Fiber - Building insulation, textile Earth minerals - (Landing site) Organics- Plastic polymers, sealant RTV-RCS nozzle thruster cover(SRB) Paint and primer				
61	Metallics - BSM Residue (SRB) RTV, Tile filler (ORB TPS) Insulation Glass (ORB TPS) Fiber - Building insulation, textile Earth minerals - (Landing site) Blue paint particles Organics - Plastic polymers, rubber RTV-RCS Nozzle thruster cover(SRB) Paint and primer				
51	Metallics - BSM Residue (SRB) - Solder (Launch Site) RTV, Tile, Tile coating (ORB TPS) Insulation Glass (ORB TPS) Glass fiber 'E-glass' Organics-Plastic polymer,filled plastic(PVC) Paint		Silica tile material Black and white paints Organics - Plastic polymer,RTV,paint		Left OMS pod- -tile,RTV,silicon carbide
57	Metallics-BSM Residue(SRB) RTV,Tile,Tile coating(ORB TPS) Insulation Glass(ORB TPS) Glass fiber-"E"-glass Calcite,Alpha-Quartz,Salt(Lndg.Site) Paint and Primer Organics-plastic polymer,RTV,paint				
55	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Glass fiber - 'E-glass' Calcite,Muscovite,Salt(Landing Site) Anhydrite (Landing Site) Paint Organics-Plastic polymer,rubber,adh.				

FIGURE 13. Orbiter Post Landing Microchemical Sample Results

STS	Sample Location				
	Windows	Wing RCC	Lower Tile Surface	Umbilical	Other
56	Metallics - BSM Residue (SRB) - Solder (Launch Site) RTV, Tile, Tile coating (ORB TPS) Insulation Glass (ORB TPS) Glass fiber 'E-glass' Organics-Plastic polymer,filled plastic(PVC) Paint		Silica-rich tile (ORB TPS) Tile coating, RTV (ORB TPS)		
54	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Calcite,Alpha-Quartz,Salt(Lndg. Site) Organics - plastic (loctite) Organics-Plastic polymer,filled plastic(PVC) Paint	Metallics - BSM Residue (SRB) Tile, Insulation Glass (ORB TPS) Calcium - Silica, Salt (Landing Site) Organics - plastic polymers Paint			
53	Metallics - BSM Residue (SRB) - Solder (Launch Site) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Calcite, Salt (Landing Site) Organics - Fibrous mat'l,RTV,Grease Organics-filled rubber,plastic polymers Paint			LO2 Umbilical Door - - Closeout Mat'l (ORB TPS) - Hydrocarbon "grease-like" sub.	RH SRB Aft Skirt Damage site - - Tile, Tile coating mat'l (ORB TPS)
52	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Calcite, Salt (Landing Site) Organics-Fibrous mat'l,red RTV Organics-filled rubber,plastic polymers Paint				HRSI Tile Damage Site- -Tile Mat'l and silicon carbide (ORB -Paints -Calcite,salts (Landing Site)
47	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Calcite, Salt (Landing Site) Window Polish Residue (ORB) Organics-Fibrous mat'l,red RTV Organics-filled rubber,plastic polymers Paint		Silica-rich Tile (ORB TPS)		
46	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Calcite,Alpha-Quartz,Salt(Lndg. Site) Organics-Adhesive,Foam,red RTV Organics-filled rubber,plastic polymers Paint				Crew Hatch Window - Metallics - BSM Residue (SRB) - Alpha-Quartz, Salt (Landing Site) - RTV, Tile (ORB TPS) - Paint - Organics

FIGURE 13. Orbiter Post Landing Microchemical Sample Results

STS	Sample Location				
	Windows	Wing RCC	Lower Tile Surface	Umbilical	Other
50	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Window Polish Residue (ORB) Mica, Calcium, Salt (Landing Site) Organics-Adhesive,Foam Organics-Plastic Polymers Paint		Silica-Rich Tile (ORB TPS)		Orbiter Vertical Stabilizer - Tile Coating (ORB TPS) - Structural Coating Glass "E-Glass"
49	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Mica, Calcium, Salt (Landing Site) Organics Paint	RTV, Tile (ORB TPS) Rust - BSM Residue (SRB) Muscovite, Salt (Landing Site) Organics Paint	RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Rust - BSM Residue (SRB) Calcium Mat'l,Salt (Landing Site Soil) Organics Paint		
45	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Calcite, Salt (Landing Site) Window Polish Residue (ORB) Organics Paint		Iron - Rich Mat'l Paint		
42	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Calcite, Salt (Landing Site) Muscovite (Landing Site) Organics Paint		Metallics - BSM Residue (SRB) Tile,Tile Coating(ORB TPS) Salt (Landing Site) Paint	Organics	RH Fuselage - Tile Coating (ORB)
44	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Calcite, Salt (Landing Site) Muscovite (Landing Site) Organics Paint			Organics Silica-Magnesium Mat'l	
48	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Calcite, Salt (Landing Site) Muscovite (Landing Site) Organics Paint			Metallics Silica - Rich Mat'l (Landing Site) Orb Umbilical C/O Mat'l (ORB) Paints	
43	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Calcite, Salt (Landing Site) Window Polish Residue (ORB) Organics Paint		RTV, Tile (ORB TPS) Metallics - BSM Residue (SRB) Salt (Landing Site) Organics Paint		Runway - FRSI Coating (ORB)

FIGURE 13. Orbiter Post Landing Microchemical Sample Results

STS	Sample Location				
	Windows	Wing RCC	Lower Tile Surface	Umbilical	Other
40	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Calcite, Salt (Landing Site) Window Polish Residue (ORB) Organics Paint	Metallics - BSM Residue (SRB) RTV, Tile (ORB) Insulation Glass (ORB TPS) Ensolite Foam (RCC Prot. Covers) Organics Paint	RTV,Tile (ORB TPS)	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Organics (ORB Umb C/O) Paint	
39		Metallics - BSM Residue (SRB) RTV, Tile (ORB) Insulation Glass (ORB TPS) Ensolite Foam (RCC Prot. Covers) Organics Paint Hypalon Paint (SRB)	Tile (ORB TPS) Insulation Glass (ORB TPS)		
37	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Calcite, Salt (Landing Site) Organics	Metallics - BSM Residue (SRB) RTV, Tile (ORB) Insulation Glass (ORB TPS) Calcite, Salt (Landing Site) Organics Paint	RTV, Tile ((ORB TPS) Insulation Glass (ORB TPS) Metallics - BSM Residue (SRB) Calcite, Salt (Landing Site) Organics		
35	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Calcite, Salt (Landing Site) Window Polish Residue (ORB) Organics Paint	Metallics - BSM Residue (SRB) RTV, Tile (ORB) Organics	RTV, Tile (ORB TPS) Metallic - Rust, Aluminum Welding Slag (Facility)		
38		RTV, Tile (ORB TPS) Hypalon Paint (SRB) Ensolite Foam (RCC Prot. Cover)	Tile (ORB TPS)		
41	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Calcite, Salt (Landing Site) Organics	Tile (ORB TPS) Salt (Landing Site)	Tile (ORB TPS)	Calcite (Landing Site) Fluorocarbon (Viton-ORB Umb) Foam (ORB C/O)	Fwd FRSI - Silicon Mat'l (ORB TPS)
31R	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Calcite, Salt (Landing Site) Organics	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Mica (Landing Site) Organics Foam Insulation (ET/SRB) Paint	RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Mica (Landing Site) Paint		
36	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Mica, Salt (Landing Site) Paint	Rust - BSM Residue (SRB) Tile (ORB TPS) Paint Organics	RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Mica (Landing Site) Organics Microballoon (ET/SRB)	Rust - BSM Residue (SRB) RTV, Insulation Glass (ORB TPS) Microballoon (ET/SRB) Calcite (Landing Site) Foam, Organics (ORB Umb C/O)	

FIGURE 13. Orbiter Post Landing Microchemical Sample Results

STS	Sample Location				
	Windows	Wing RCC	Lower Tile Surface	Umbilical	Other
32R	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Mica, Salt (Landing Site) Paint		Metallics - BSM Residue (SRB) Tile (ORB TPS) Carbon Fibers Titanium	Metallics - BSM Residue (SRB) RTV, Insulation Glass (ORB TPS) Phenolic Microballoon (ET/SRB) Quartz, Calcite (Landing Site) Organics	
33R	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Micaceous Mat'l, Salt (Landing Site) Window Polish Residue (ORB) Paint	Metallics - BSM Residue (SRB) Tile (ORB TPS) Insulation Glass (ORB TPS) Mica, Spar, Salt (Landing Site) Organics	RTV, Tile (ORB TPS)	Rust - BSM Residue (SRB) RTV, Insulation Glass (ORB TPS) Phenolic Microballoon (ET/SRB) Paint Organics	Crew Hatch Window - Rust - BSM Residue (SRB) - Alpha Quartz (TPS/Landing Site) - Paint - Organics
34	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Alpha-Quartz, Silicates, Salt (L/S) Window Polish Residue (ORB)	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Paint	RTV, Tile (ORB TPS) Stainless Steel Washer	RTV (ORB) Foam (ORB) Viton Rubber (ORB) Metallics - BSM Residue (SRB) Phenolic Microballoon (ET/SRB) Silicates, Calcium (Landing Site) Paint	
28R	Silicone (ORB FRCS Cover Adhesive)	Silicates (Landing Site) Paint Charred Silicone Brass Chip	RTV, Tile (ORB TPS) Clay, Sand, Quartz (Landing Site) Metallics - BSM Residue (SRB)	Sand, Silicates (Landing Site) Foam (ORB) RTV (ORB TPS) Koropon, Kapton (ORB) Metallics - BSM Residue (SRB)	OMS Pod - PVC Laminate (ORB TPS 'Shim')
30R	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Clay, Salt (Landing Site) Paint		Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Gap Filler (ORB TPS) Clay, Feldspar (Landing Site)		Upper Tile - Tile,Gap Filler (ORB TPS
29R	RTV, Tile (ORB TPS) Metallics - BSM Residue (SRB) Ablator, Hypalon Paint (SRB)		Tile (ORB TPS) Insulation Glass (ORB TPS) Paint Muscovite - Metallics (Landing Site)	Tile (ORB TPS) Umbilical Foam (ORB) Paint Ablator, Hypalon Paint (SRB) Metallics - BSM Residue (SRB)	Upper Tile - Tile (ORB TPS)
27R	RTV, Tile (ORB TPS)	Hypalon Paint (SRB)	RTV, Tile (ORB TPS) Ablator, Hypalon Paint (SRB)		OMS Pod - Iron Fiber - PDL Foam, FRL Paint (ET) - Ablator, Hypalon Paint (SRB)
26R			RTV, Tile (ORB TPS) Paint Rust		

Sample locations vary per mission and not all locations are sampled for every mission.
( ) - identifies the most probable source for the material.
Metallics - includes mostly Aluminum and Carbon Steel alloys

FIGURE 13. Orbiter Post Landing Microchemical Sample Results

9.0 POST LAUNCH ANOMALIES

Based on the debris walkdowns and film/video review, ten post launch anomalies, including one In-Flight Anomaly (IFA), were observed on the STS-62 mission.

9.1 LAUNCH PAD/SHUTTLE LANDING FACILITY

1. A 4.5 inch long by 1 inch diameter bolt was found underneath the MLP sound suppression pipe near the southeast corner of the LH SRB exhaust hole after launch. A metal shim measuring 12 x 8 inches was also found under the sound suppression pipe near the north west corner of the RH SRB exhaust hole. Both items originated from the sound suppression pipe support stanchion at the north end of the LH SRB exhaust hole. Several other shim pieces were loose at this same location. Time of failure was not evident from hardware condition or film/video review.

9.2 EXTERNAL TANK

1. Intertank foam, 14 inches long by 4 inches wide, was missing from a stringer head forward of the left (-Y) bipod spindle housing closeout. Approximately 3 inches of primer was exposed.

2. A small divot appeared just aft of the -Y bipod spindle in the LH2 tank-to-intertank flange closeout.

3. A divot, 5.5 inches in diameter but shallow in depth, occurred in the LH2 tank acreage just aft of the LH2 tank-to-intertank flange closeout between the +Y bipod spindle housing closeout and the LO2 feedline support bracket (XT-1129).

4. A divot, 5 inches in diameter, occurred in the LH2 tank acreage (XT-1590) adjacent to the +Y side of the cable tray. The divot went to substrate and exposed the primer.

9.3 SOLID ROCKET BOOSTERS

1. Significant amounts of BTA had been applied to closeouts on the RH frustum. Hypalon paint was blistered/missing over the areas where the BTA had been applied. The underlying BTA was not sooted except along the 395 ring aft of the BSM cluster. The soot pattern indicated some of the blisters may have formed prior to SRB separation (IFA STS-62-B-1).

2. The RH frustum was missing one 2" x 2" area of TPS near the BSM's and had 23 MSA-2 debonds over fasteners.

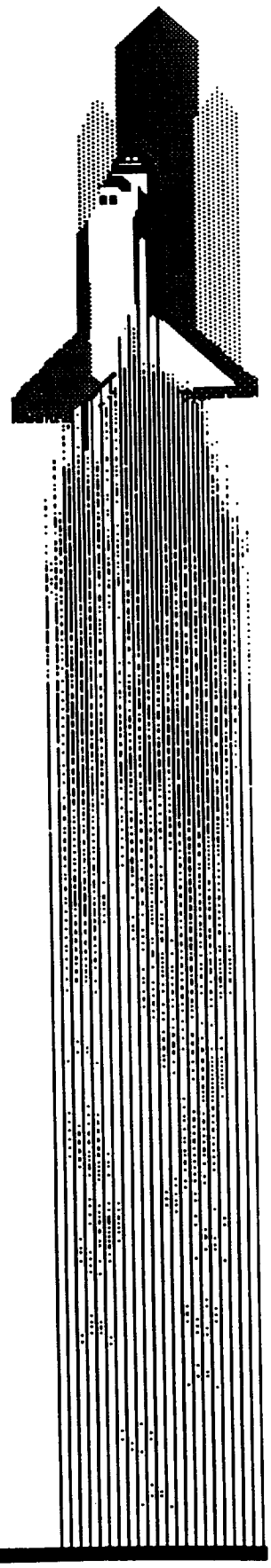
3. The LH frustum was missing TPS in one area (3"x2") near the -Y axis/275 ring frame and had 21 MSA-2 debonds over fasteners.

9.4 ORBITER

1. A cluster of 29 damage sites spanned three tiles on the rudder black edge tiles (left side) along the hinge line below the split in the speed brake. Six of the damage sites had a major dimension of 1-inch or larger while three of the damage sites were deep enough to expose the substrate. Three small hits occurred in this same general area on the right side of the rudder/speed brake.

2. Six thermal barriers, total size approximately 36" x 3" x 1.5", and one corner tile piece 4" x 4", were missing from the nose landing gear doors. Runway infrared cameras recorded these objects falling from the Orbiter when the nose landing gear doors were opened on final approach.

Appendix A. JSC Photographic Analysis Summary



Space Shuttle

Photographic and Television Analysis Project

STS-62 Summary of Significant Events

April 19, 1994

National Aeronautics and Space Administration

Lyndon B. Johnson Space Center
Houston, Texas 77058

Lockheed

ENGINEERING AND SCIENCE PROGRAM
2400 NASA Road 1, P. O. Box 58561, Houston, Texas 77258 (713) 333-5411

April 19, 1994

Greg Katnik
MC/TV-MSD-22
OSB Room 5203R
KSC, Florida 32899

Dear Greg,

The following STS-62 Summary of Significant Events report is from the Johnson Space Center Photographic and Television Analysis Project, and was completed April 19, 1994. If you have any questions or comments please contact Christine Dailey /483-5336 of the Photographic and Television Analysis Project.

Sincerely,

Christine Dailey 4/19/94

Christine Dailey
Project Specialist
Photo/TV Analysis Project

cc: Job order file

Space Shuttle
Photographic and Television
Analysis Project

STS-62 Summary of Significant Events

Project Work Order - SN-AFV

Approved By

Lockheed

C. L. Dailey, Project Specialist
Photo/TV Analysis Project

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Solar System Exploration Department

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Space and Life Sciences Directorate

National Aeronautics and
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Lyndon B. Johnson Space Center
Houston, Texas 77058

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1.0 OV-102 STS-62 Film/Video and Timing Summary

1.1 LAUNCH

Columbia (OV-102) launched on mission STS-62 from pad B at 13:53:00.019 Coordinated Universal Time (UTC) on March 4, 1994 (day 63) as seen on camera E-13. Solid rocket booster (SRB) separation occurred at 13:55:06.295 UTC as seen on camera E-211.

On launch day, 24 videos were screened. Following launch day, 55 films were reviewed.

No anomalies were observed during launch.

Detailed test objective (DTO)-0312 (photography of the external tank after separation) was performed this mission using the umbilical well cameras and a handheld Nikon camera with a 300 mm lens and 2X extender. Thirty-six handheld frames of the external tank (ET) were acquired by the astronauts. The tank appeared to be in good condition on the handheld film with the exception of a possible divot on the LH2/intertank interface on the -Z side of the ET. Video of the external tank was down linked on March 4, 1994. All sides of the external tank were imaged. Two rolls of umbilical well film were received: the 35 mm film from the LO2 umbilical and a 16 mm film (5 mm lens) from the LH2 umbilical. The 16 mm camera with the 10 mm lens did not operate. Several divots were noted on the umbilical well film including a linear shaped mark on the intertank acreage that exposed substrate primer. Numerous pieces of insulation and frozen hydrogen debris were seen during the SRB and external tank separations. A piece of white RTV debris was seen near the LO2 umbilical.

1.2 ON ORBIT

No on orbit anomalies were identified.

1.3 LANDING

Columbia landed on runway 33 at Kennedy Space Center (KSC) on March 18, 1994. Fourteen videos of the Orbiter's approach and landing were received. Four views were acquired from infrared cameras. NASA Select, which broadcasts multiple real-time views, was also received. Left main gear touchdown was at 77:13:09:40.354 UTC and right main gear touchdown occurred at 77:13:09:40.387 UTC as seen on camera KTV-33. Nose wheel touchdown occurred at 77:13:09:59.512 UTC and wheel stop was at 77:13:10:34.313 UTC as seen on camera KTV-15.

Fifteen landing films were received from KSC and no anomalies were observed.

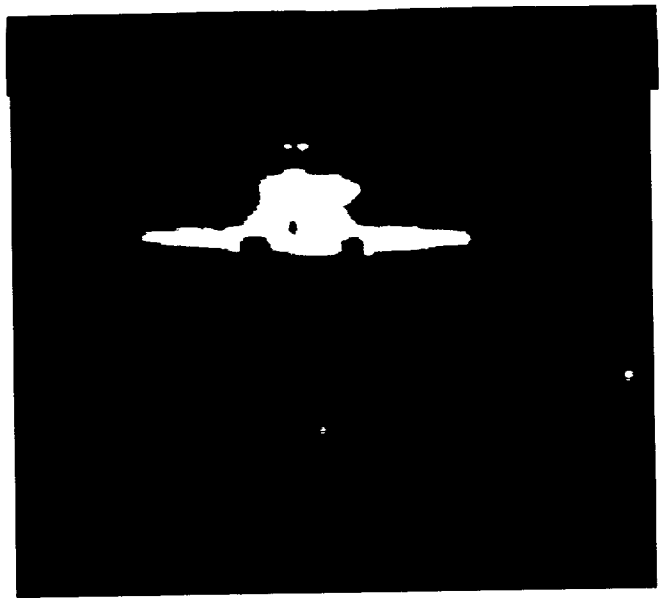


Figure 1.3 Debris at Landing Gear Deploy

Four pieces of debris fell from the vehicle at landing gear deploy as seen on infrared video views EL-17 and EL-18. Two of the items appeared to originate from the main gear doors (most visible at 77:13:09:20.991 UTC). The other two pieces appeared to originate from the nose gear area (most visible at 77:13:09:22.721 UTC). These debris items are believed to be the missing nose gear door thermal barrier material noted on the walk around video. (Debris was seen to fall from the nose gear area on infrared views of the landing gear deploy on STS-56. The STS-56 debris objects were reported by KSC to be gap fillers from the landing gear doors.)

The Orbiter was seen to deviate from the runway centerline during rollout prior to nose gear touchdown. At approximately 5 seconds after main gear touchdown, the Orbiter began to move to the right of the runway centerline. At 8 seconds, the Orbiter reached a maximum starboard distance of the runway centerline. At 11 seconds, the Orbiter reached a maximum port distance of the runway centerline. Steering changes were not visible after fourteen seconds past main gear touchdown.

The deployment of the drag chute appeared as expected. KTV-33 was used to determine drag chute initiation and pilot chute inflation. All of the remaining drag chute sequence times were obtained from KTV-15.

Drag chute initiation	77:13:09:54.634 UTC
Pilot chute inflation	77:13:09:55.502 UTC
Drag chute bag release	77:13:09:56.372 UTC
Drag chute inflation in reefed position	77:13:09:57.803 UTC
Drag chute inflation in disreefed configuration	77:13:10:00.711 UTC
Drag chute release	77:13:10:21.600 UTC

The following items were noted during the post-landing walk around: damage (bending) to the left main landing gear heat shield disks and an inboard right main landing gear heat shield disk; tile damage on the nose gear starboard door; tile damage to the left nose, underside, and right side of the vehicle; tread damage to the outboard left main tire; missing nose gear door thermal barrier material; loose string-like material on the +Y edge of the drag chute housing; slight TPS scarring near the forward ET/Orbiter attach; TPS erosion on the base heat shield.

1.4 TIMING ACTIVITIES

All launch videos had timing and film cameras E-1, E-2, E-3, E-4, E-5, E-6, E-7, E-8, E-9, E-10, E-11, E-12, E-13, E-14, E-15, E-16, E-17, E-18, E-19, E-20, E-25, E-26, E-52, E-54, E-57, E-59, E-211, E-222 and E-224 had in-frame alphanumeric timing. These videos and films were used to time specific mission events during the initial screening. Additional film from launch cameras E-40, E-79, E-204, E-208, E-212, E-220, and E-223 were used to time events using encoded film edge timing marks (IRIG-A and IRIG-B). Camera E-76 did not have timing.

All landing videos had timing except EL-17 IR, the Mobile IR, SLF North, and SLF South. All landing film cameras had timing and EL-1, EL-2, EL-3, EL-4, EL-5, EL-7, EL-8, EL-9, EL-10, EL-12, EL-15, EL-19, and EL-20 had in-frame alphanumeric timing.

2.0 Summary of Significant Events

2.1 DEBRIS

2.1.1 Debris near the Time of Space Shuttle Main Engine (SSME) Ignition

2.1.1.1 Debris Strike to RSRB aft Booster Separation Motor Nozzle
(Cameras E-5, E-9)

A large piece of white debris (ice) struck the RSRB aft BSM nozzle at T-2.16 seconds. No damage to the vehicle was observed. KSC reported that this ice was from the RSRB/ET aft attach fittings. No follow-up action was requested.

2.1.1.2 LH2 and LO2 Tail Service Mast (TSM) T- 0 Umbilical Disconnect Debris
(Cameras E-3, E-17, E-20, E-76, E-77)

Normal white (ice) debris was noted falling from the LH2 and LO2 TSM T-0 umbilical disconnect areas at SSME ignition through liftoff. A thin white rectangular piece of debris fell from the LO2 TSM T-0 umbilical lines after SSME ignition. This debris may have been a tag or a piece of tape. None of these objects were observed to strike the vehicle. No follow-up action was requested.

2.1.1.3 LH2 and LO2 ET/Orbiter Umbilical Debris
(Cameras E-5, E-6, E-15, E-17, E-18, E-19, E-25, E-26, E-31, E-65, OTV-109, OTV-154, OTV-161, OTV-163)

Normal white (ice) debris was noted falling from the LH2 and LO2 ET/Orbiter umbilical disconnect areas and aft along the body flap at SSME ignition through liftoff. White debris was seen falling from the LH2 17 inch feedline bellows during SSME ignition. None of the debris was observed to strike the vehicle. No follow-up action was requested.

2.1.2 Debris near the Time of SRB Ignition

2.1.2.1 SRB Flame Duct Debris *(Task #7)*
(Cameras E-5, E-7, E-9, E-13, E-14, E-15, E-16, OTV-163)

As on previous missions, several pieces of debris were noted originating from the SRB flame duct area after SRB ignition. On camera OTV-163, one piece of light colored debris originated from the RSRB flame duct near holddown post #M-1 at 0.415 seconds MET. The debris moved toward the mid/lower surface of the Orbiter body flap but did not appear to strike the vehicle. On camera E-5, the same debris was first seen near the base of the RSRB and traveled underneath the body flap at liftoff. True three dimensional velocity information is not available. The average horizontal velocity of the debris was determined to be 47 feet per second.

2.1.2.2 Flame Trench Debris at Liftoff
(Cameras OTV-160, E-60, E-62)

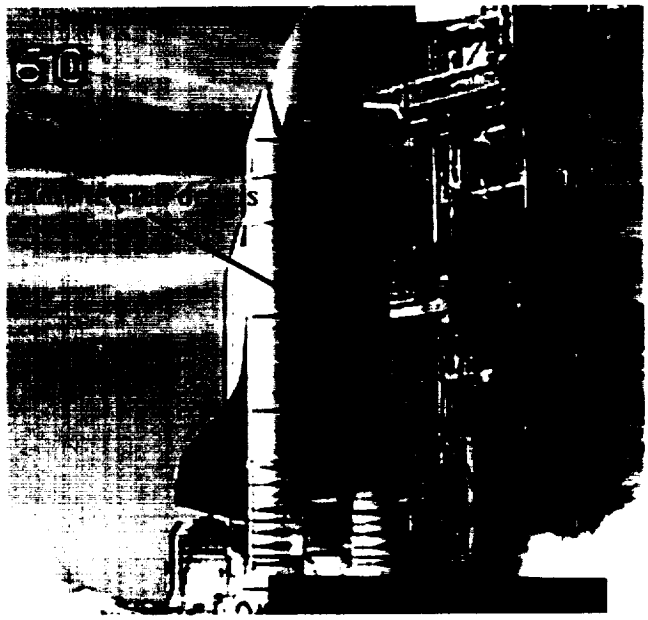


Figure 2.1.2.2 **Flame Trench Debris at Liftoff**
(Camera OTV-160)

On camera OTV-160, a light colored piece of debris was seen north of the launch pad in the exhaust cloud at 0.718 seconds MET. The debris appeared to move toward the vehicle in the OTV-160 view. This debris was not seen from other cameras so its direction of travel could not be confirmed. Additional debris was seen falling toward the flame trench on the OTV-160 view at 3.054 seconds MET and 3.54 seconds MET. The OTV-141 and OTV-148 views of the north side of the SLV were examined for debris moving toward the vehicle. No indication of debris moving toward the vehicle was found on the OTV-141 and OTV-148 views. On camera E-60, a single piece of light colored debris traveled from the SRB flame trench south toward the vehicle. On camera E-62, a single piece of SRB flame trench debris traveled away from the vehicle. None of the debris was seen to strike the vehicle. No follow up action was requested.

2.1.2.3 Debris near Holddown Posts (HDP)
(Camera E-7, E-9, E-12, E-14)

A single piece of dark debris fell aft of the RSRB holddown post #M-1 debris containment system (DCS) at 0.913 seconds MET. A thin rectangular piece of red colored debris (probably tape) fell from the LSRB aft skirt below the HDP #M-5 foot and then fell into the flame duct at liftoff. Several pieces of light colored debris were seen near the RSRB holddown post #M-4 and the LSRB holddown post #M-8 (probably flame duct debris) at liftoff. None of this debris was seen to strike the vehicle. No ordnance or frangible nut debris were seen near any of the holddown post DCS stud holes. No follow-up action was requested.

2.1.2.4 Debris Falling Along Left Inboard Elevon
(Camera E-50)

A light colored piece of debris was seen falling along the left inboard elevon at liftoff. The debris did not appear to strike the vehicle. No follow-up action was requested.

2.1.3 Debris After Liftoff
(Cameras E-40, E-50, E-52, E-54, E-57, E-59, E-65, E-79, E-207, E-212, E-213, E-220, E-222, E-223, KTV-4B, OTV-161, OTV-163)

Multiple pieces of debris were seen falling aft of the Shuttle Launch Vehicle (SLV) at liftoff, throughout the roll maneuver, and beyond on the launch tracking views. Most of the debris sightings were probably reaction control system (RCS) paper or ice from the ET/Orbiter umbilicals. During ascent, multiple pieces of debris exited the SRB exhaust plume. None of the debris was observed to strike the vehicle. No follow-up action was requested.

2.1.3.1 Debris Near ET AFT Dome During Tower Clear
(Camera E-40, E-79, OTV-161)

Figure 2.1.3.1 Debris Near ET Aft Dome During Tower Clear

Several pieces of orange colored debris were seen near the ET aft dome falling aft during tower clear. The debris had the characteristics of umbilical baggy material. The debris was timed at approximately 4.4 seconds MET on the three camera views. A multicolored piece of debris seen

aft of the ET on OTV-161 was confirmed to be the same as debris seen on E-40 and E-79 based on similar event times.

2.1.3.2 Debris during Roll Maneuver
(Camera E-57)

A small orange-colored piece of debris originated from the ET/Orbiter LH2 umbilical area during roll maneuver and fell aft at 12.86 seconds MET. KSC reported this object to be hydrogen fire detection butcher paper from the ET LH2 vertical strut. The object did not appear to strike the vehicle.

2.1.3.3 Debris between 20 and 23 Seconds MET
(Cameras E-54, E-59)

At least two pieces of debris were seen falling along the RSRB exhaust plume at 20.642 MET on Camera E-59. On camera E-54, two light colored pieces of debris were seen near the LSRB plume at 22.498 MET.

2.1.3.4 Debris at 28 Seconds MET
(Cameras KTV-4, E-222, E-213)

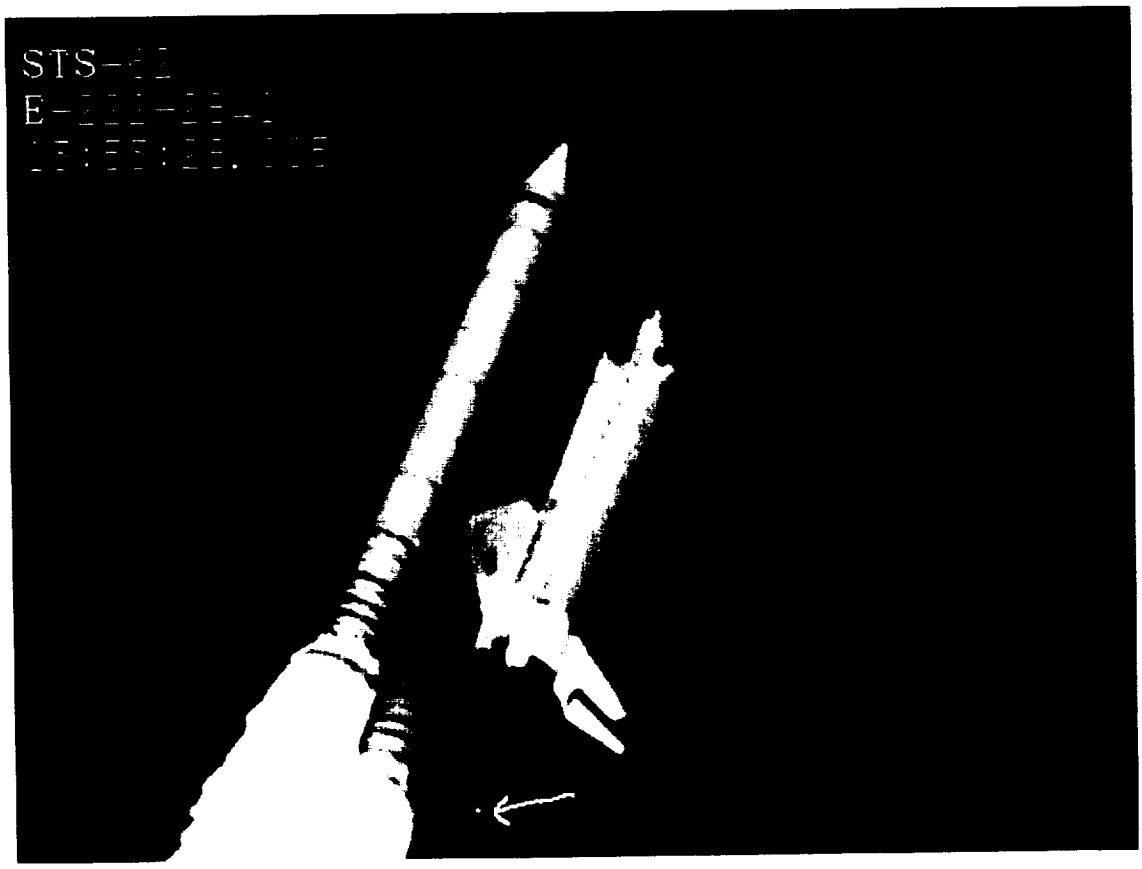


Figure 2.1.3.4 Debris at 28 Seconds MET

A fast moving light colored piece of debris first seen over the right wing and traveled aft into the SSME plume at 28.0 seconds MET. This debris was tentatively identified by KSC personnel as

an intact forward RCS cover. Smaller, red colored debris were seen falling over the right wing and near the vertical stabilizer at approximately the same time. The smaller debris was first seen by the Orbiter overhead cabin window and is believed to be forward RCS paper.

2.1.3.5 Debris between 32 to 68.5 Seconds MET
(Cameras E-212, E-213, E-220, E-222)

Numerous pieces of light colored debris traveled aft along the SRB plume during ascent. A single light colored piece of debris was seen near the LSRB nozzle and then fell aft along the SRB plume at 32 seconds MET on camera E-212. A single light colored piece of debris was seen along the SRB plume at 38.8 seconds MET on camera E-222. Multiple pieces of debris were seen falling aft along the SRB plume between approximately 57 to 68.5 seconds MET on camera E-220. In some cases the debris was seen coming from the SRB nozzle area.

2.1.3.6 Debris Reported by the Crew *(Task #10)*

The following is a written transcript of the crew debris report provided by STS-62 Commander to the Mission Control Center Capcom on March 4, 1994.

Capcom
Columbia, Houston. For John and Andy, when you get a chance can you give the debris report for your windows?

Columbia
OK, give us just a couple of minutes.

Columbia
Houston, Columbia.

Capcom
Go ahead Columbia.

Columbia
Yeah Ken, John is off com for just a couple of minutes. He will give you status on left side. On the pilot side, I would say minor smudging on the forward and the two right windows. It looks a whole lot better than my last trip.

Capcom
OK, we copy some minor smudging on the right side windows and we will stand-by for John when he gets back.

Columbia
And Ken, that was all after SRB separation as you guys probably know.

Capcom
We copy, thank you Andy.

Columbia
Houston, Columbia

Capcom
Columbia, Houston. John go ahead.

Columbia
OK, Ken. The debris report on the CDR side, some smudges, about 6 or 8 on Window 3 and a few smudges on Window 2. Looks pretty good.

Capcom
Roger, we copy, 6 or 8 smudges on Window 3 and a few on Window 2, but over all windows look in good shape.

Columbia
Very clean, maybe better than last time.

Capcom
Roger, we copy.

2.2 MLP EVENTS

2.2.1 Orange Vapor (Possibly Free-burning Hydrogen)
(Cameras E-2, E-3, E-15, E-18, E-20, E-36, E-76, E-77, OTV-163, OTV-170, OTV-171)

An orange vapor (possibly free burning hydrogen) was seen beneath the SSMEs and under the body flap prior to SSME ignition. Orange vapor was seen south of the left OMS pod on camera E-36. The amount of orange vapors visible appeared less than on many of the previous missions. No follow-up action was requested.

2.2.2 TPS Erosion
(Cameras E-18, E-20)

Two occurrences of TPS erosion were noted on the base heat shield after SSME startup. One was outboard of SSME #2 and the other was on the tip of the left RCS stinger below the L3A jet. Erosion of the base heat shield TPS has been seen on previous missions. No follow-up action was requested.

2.3 ASCENT EVENTS

2.3.1 Body Flap Motion *(Task #4)*
(Cameras E-207, E-213, E-222)

Slight body flap motion was noted during time of maximum dynamic pressure (30-90 seconds MET). The magnitude of the motion seen on the STS-62 views did not warrant further analysis.

2.3.2 **Flares in SSME plume**
(Cameras E-52, E-204, E-205, E-207,E-218, E-220, E-222, KTV-4B, KTV-21B, ET-207)

Figure 2.3.2 **Flares in SSME Plume**
(Camera ET-207)

At least nine flares were noted in the SSME plumes from 23 to 54 seconds MET. One flare, approximately 0.07 seconds in duration, was noted at 52.6 seconds MET. Flares have been observed on previous missions. No follow-up action was requested.

2.3.3 Vapor Cloud at 57 Seconds MET
(Cameras E-224, E-211, KTV-5)

Figure 2.3.3 **Vapor Cloud Near SRB Plume**
(Camera KTV-5)

A vapor cloud was seen near the SRB plume at 57.259 seconds MET. The rawinsonde data was compared to the trajectory data and it was concluded that the vapors are due to a layer of moisture at an altitude of approximately 10 km. A similar event was noted on the STS-48 mission.

2.3.4 Orange Flashes in SRB Plume Prior to SRB Separation
(Cameras ET-204, E-204, E-212)

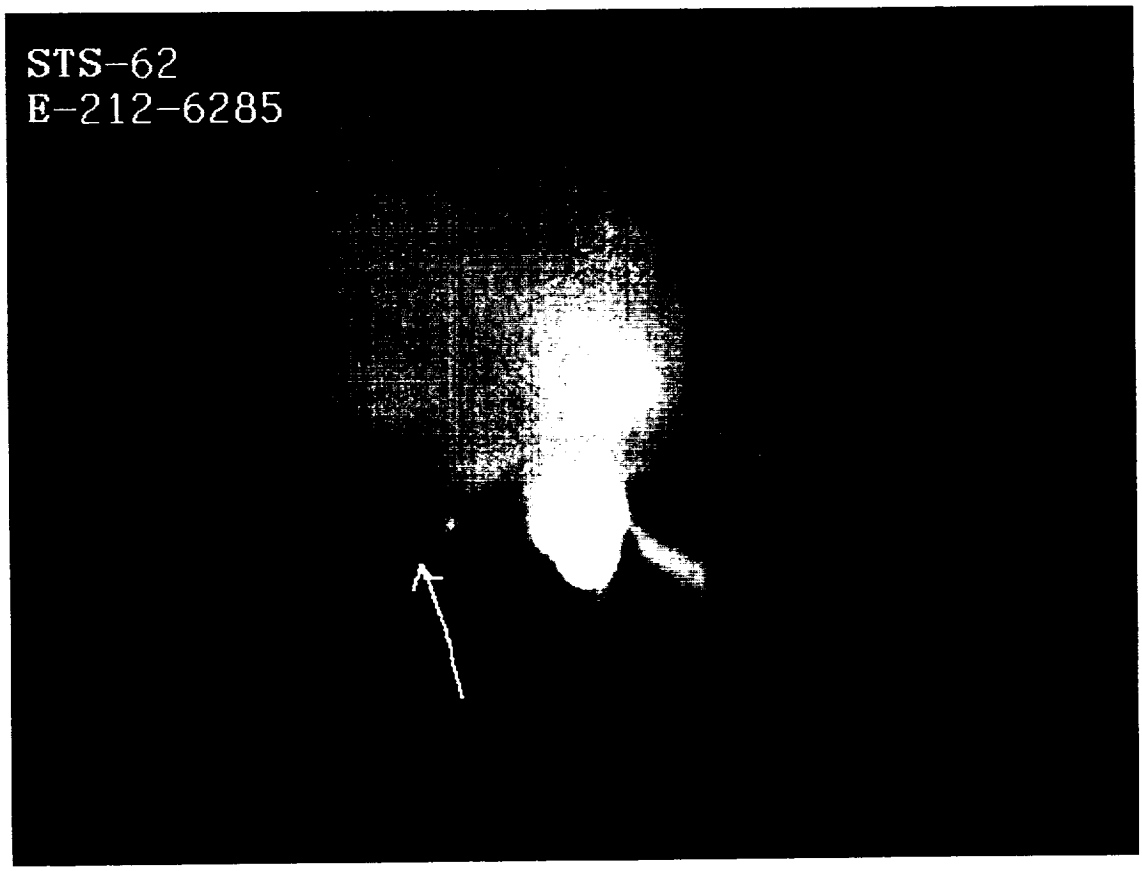


Figure 2.3.4 Orange Flashes in SRB Plume Prior to SRB Separation

Several orange flashes were noted in the SRB plume just prior to SRB separation. A orange flash was seen at the interface of the SSME and SRB plumes at approximately 115 seconds MET. An engineer from the JSC Propulsion & Power Division reviewed the films of these flashes and no follow-up action was assigned. A similar orange flash was previously identified on STS-53 and discussions with MSFC personnel at that time indicated that the event was not anomalous.

2.3.5 Linear Optical Effect
(Cameras E-207, E-212, ET-208)

Linear optical effects were seen between 62 and 108 seconds MET. The linear optical effects began at 54 seconds and ended at 57.7 seconds MET on camera E-212. Linear optical effects were seen on previous missions. No follow-up action was requested.

2.3.6 Recirculation *(Task #1)*
(Cameras E-204, ET-204)

The recirculation or expansion of burning gases at the aft end of the SLV prior to SRB separation has been seen on nearly all previous missions. The sighting of this event is dependent upon

launch inclination angle and cloud cover during ascent. For STS-62, recirculation was observed between 94 and 101 seconds MET on camera ET-204.

Cameras on which recirculation was observed for STS-62

CAMERA	START (seconds MET)	STOP (seconds MET)
ET-204*	94	101
E-204	95	98

*** BEST VIEW OF RECIRCULATION**

RECIRCULATION BY MISSION

MISSION	START (sec MET)	STOP (sec MET)	BEST VIEW	INCLIN. ANGLE
STS-26	92	112	E204	28.5°
STS-27	95	---	E205	57.0°
STS-29	92	112	E208	28.45°
STS-30	95	---	E204,E206	28.85°
STS-28	94	104	E205	57.0°
STS-34	95	---	E204	34.3°
STS-33	95	112	E206	28.45°
STS-32	100	109	E204,E206	28.5°
STS-36	93	103	E207	62.0°
STS-31	91	108	E206	28.45°
STS-41	91	112	E206	28.45°
STS-38	94	110	n/a	28.5°
STS-35	92	107	E212	28.45°
STS-37	92	107	E204	28.45°
STS-39	92	101	E205	57.0°
STS-40	---	---	---	39.0°
STS-43	94	110	E204	28.45°
STS-48	91	108	E205	57.0°
STS-44	95	113	E204	28.45°
STS-42	92	111	E205	57.0°
STS-45	97	109	E205	57.0°
STS-49	93	110	E212	28.35°
STS-50	98	110	E208	28.45°
STS-46	96	112	ET208	28.45°
STS-47	92	105	E205	57.0°
STS-52	92	113	E208	28.45°
STS-53	96	104	E207	57.0°
STS-54	94	108	E212	28.45°
STS-56	93	111	E205	57.0°
STS-55	94	110	E208	28.45°
STS-57	94	109	E204	28.5°
STS-51	94	112	E204	28.5°
STS-58	92	102	E204	39.0°
STS-61	93	113	E208	28.5°
STS-60	92	109	E205	57.0°
STS-62	94	101	ET-204	39.0°

NOTE: No recirculation was observed on STS-40 films due to cloud cover and inclination angle. Intermittent LOV prevented acquisition of specific stop times for recirculation on STS-27, STS-30 and STS-34. Best view chosen by duration and clarity of event on films.

2.4 DTO-312

2.4.1 Onboard Handheld Camera ET Analysis *(Task #6)* *(STS-62-46-01 through 36)*

Thirty-six exposures from a 35 millimeter Nikon F4 camera were taken with Ektar 100 film and a 300 millimeter lens coupled with a 2x multiplier. The photographs were taken by Marsha Ivins. The entire ET was photographed. The first photograph was taken at 14:08:31 UTC and the thirty-sixth was taken at 14:13:11 UTC, which was 15 minutes 31 seconds and 20 minutes 11 seconds MET respectively. The ET was approximately 1700 meters from the Orbiter at the time of the first photograph. The separation velocity between the ET and the Orbiter was calculated to be 5.7 meters per second. This velocity is similar to previous missions. The ET visually performed as expected and no significant TPS ablations were noted. Two separate light colored areas on the intertank acreage (-Y axis) were noted. These light colored areas are probably pre-launch closeout marks.

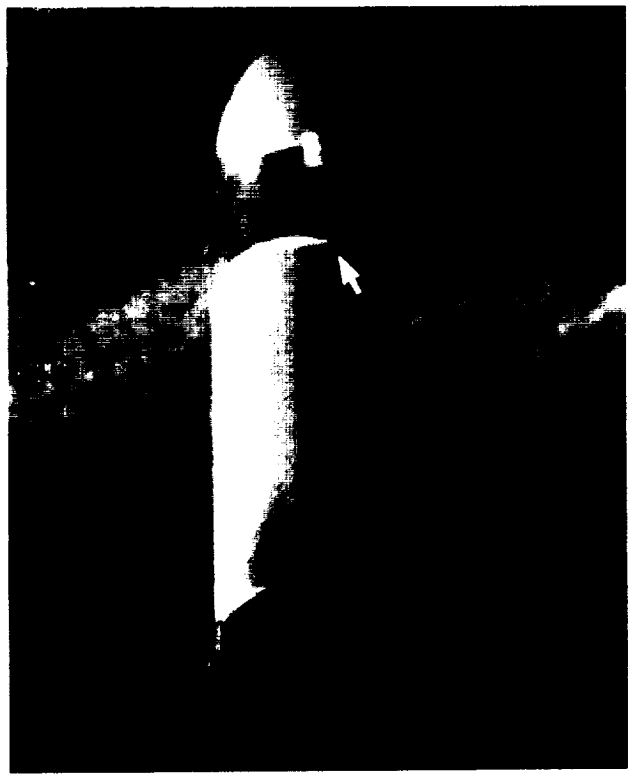


Figure 2.4.1 **Handheld Camera View of -Z Axis of External Tank**
(Camera STS-62-46-26)

A light area visible on the LH2 tank/intertank interface on the -Z axis is a possible divot.

Excellent quality video of the STS-62 external tank (after separation) was down linked on Friday March 4, 1994. A camcorder with a 2X extender and a 10 to 1 zoom lens was used to image the external tank. The ET was well tracked over nearly 13 minutes of video. The average tumble rate of the external tank was calculated to be 0.85 degrees/second. All sides of the external tank were imaged. The external tank appeared in good condition on the video views.

2.4.2 Umbilical Well Camera Analysis *(Task #5)*

2.4.2.1 16 mm Umbilical Well Camera Views of SRB and ET Separation

One 16 mm motion picture film (with a 5 mm lens) was acquired from the Orbiter LH2 umbilical camera. The 16 mm film sequence of the SRB separation is good quality. The LSRB separation and the external tank separation appeared normal. The 16 mm umbilical film sequence of ET separation has variable exposure due to sun glare. The focus is soft to good.

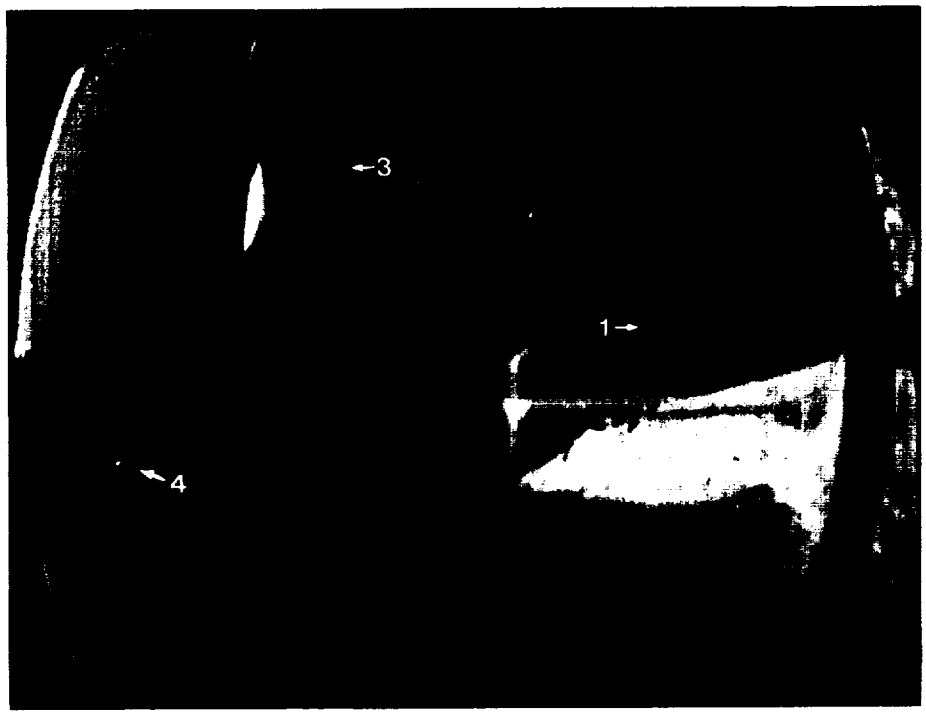


Figure 2.4.2.1a **LSRB at Separation**
(Frame STS-62-G-241-1135)

Numerous light colored pieces of debris (probably insulation) are in view throughout the SRB film sequence (1). Typical chipping and erosion of the -Y electric cable tray are visible (2). Erosion and scarring of the ET/LSRB aft attach are visible (3). A gray colored, shiny piece of top coat debris is visible in front of the LSRB approximately 0.3 seconds after SRB separation (4). A light colored piece of TPS was seen detaching from the base of the LH2 electric cable tray prior to SRB separation (frame 743). A loose piece of TPS was also seen at the side of the LH2 umbilical (frame 1061). A small dark object is visible moving from the ET side of the ET/LSRB attach toward the LSRB side of the attach point at approximately 0.06 seconds after LSRB separation (frame 1069). KSC reported that this debris is a piece of char top coat from the ET -Y vertical strut. A flat, thin, rectangular shaped piece of debris was seen in front of the electric cable tray after SRB separation. The debris is gray in color and out of focus (indicating that it is very close to the camera) (frame 1078). Several small light colored pieces of debris (probably insulation) are visible striking the top of horizontal section of the electric cable tray prior to and after SRB separation (frames 1019, 1139, 1584, 3613). A light colored piece of debris (foam)

can be seen striking the vertical section of the electric cable tray after SRB separation (frame 1684). A larger piece of white debris (frozen hydrogen) can be seen striking the top of the horizontal section of the electric cable tray prior to ET separation (frame 3788). None of these debris strikes appeared to damage the ET structure.

Figure 2.4.2.1b **LH2 Umbilical After ET Separation**
(Frame STS-62-G-241-5571)

A possible piece of detached insulation is visible on the upper right side of the LH2 umbilical after ET separation (1). Frozen hydrogen is visible in the LH2 17 inch line connection (2). A blistering of the fire barrier coating on the outboard side of the LH2 umbilical is apparent (3). A light colored area (possible frozen hydrogen) is visible on the upper left side of the LH2 umbilical above the piece of detached insulation (frame 5821). A white mark is visible below the ET diagonal strut on the -Y side of the ET LO2 umbilical (frame 6229). This mark was also seen on the 35 mm umbilical well film. A gray colored flexible debris object is visible in front of the ET cross beam near the LO2 umbilical (frames 6266 - 6496). KSC reported that this debris is a piece of white RTV from the Orbiter side of the LO2 umbilical. This debris was also seen on the 35 mm umbilical well film. A white rectangular shaped piece of debris (probably frozen hydrogen) is visible at the right side of the view well after ET separation (frame 10115).

2.4.2.2 35 mm Umbilical Well Camera Views of ET Separation

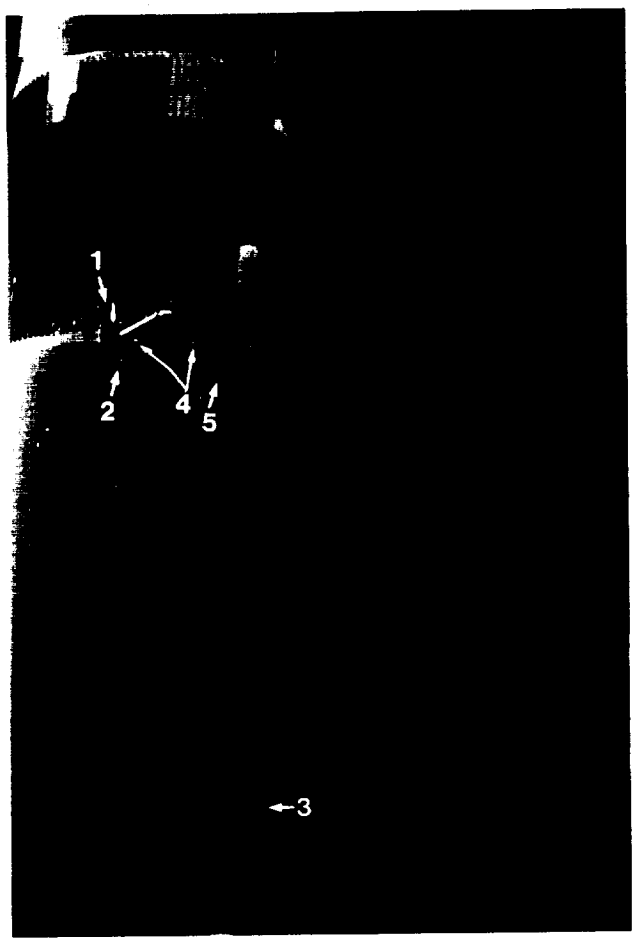


Figure 2.4.2.2a **Divot on Intertank TPS Parallel to the Stringer Heads**
(Camera STS062-64-011)

A white linear shaped mark is visible on the intertank TPS parallel to the stringer heads (1). A dark area at the aft end of this mark may be exposed primer. The divot was measured to be 19.79 inches in length. Numerous small white erosion or "pop corn" marks are visible on the intertank and the LH2 tank TPS in the vicinity of the forward ET/Orbiter attach bipod (2). A small white divot is visible on the LH2 tank TPS to the right of the electric cable tray just aft of the PAL ramp (3). A dark area at the center of the divot appears to be exposed primer. Both jack pad closeouts appeared intact (4). A shallow divot is visible in the LH2 tank acreage near the LO2 feedline and the right leg of the forward bipod (5).

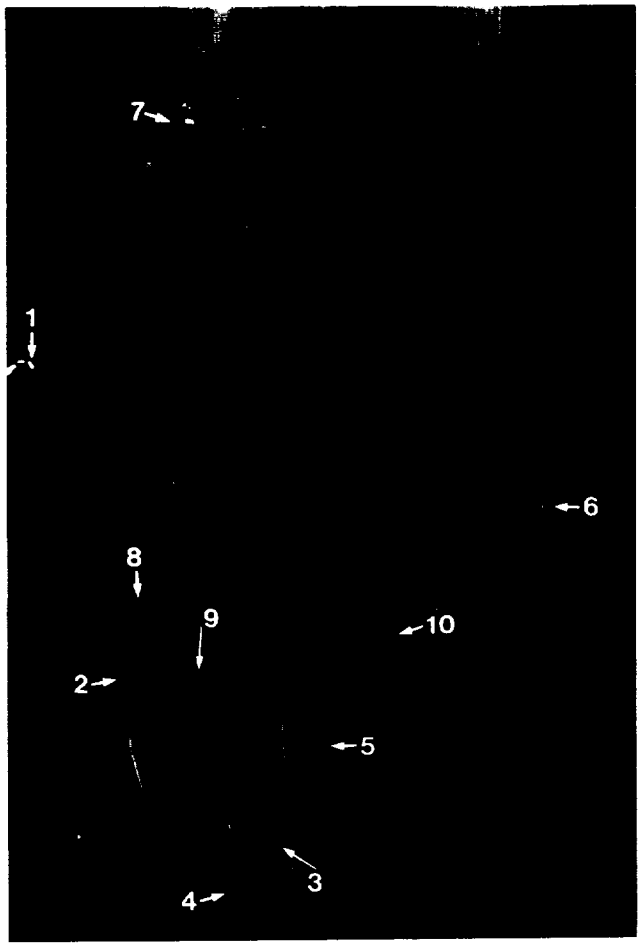


Figure 2.4.2.2b **Debris Near ET Cross Beam**
(Camera STS062-64-050)

A shiny gray colored piece of debris is visible (1). The object is longer than it is wide and is irregular in shape. The debris is first visible in front of the cross beam. The debris then moves across the top of the LO2 umbilical and falls aft. At least one smaller gray colored debris object is also visible. The larger shiny gray colored debris is also visible on the 16 mm umbilical well film in front of the cross beam near the LO2 umbilical. The object appears flexible on the 16 mm motion picture view. KSC reported that this object is probably white RTV from the Orbiter side of the umbilical.

A light colored area (probably loose foam) is visible just inboard of the LO2 umbilical at the forward left corner (2). This light colored area can be seen below the diagonal strut on the -Y side of the ET LO2 umbilical on the 16 mm umbilical well camera film. Two small light colored marks are visible in the forward right portion of the LO2 electrical monoball disconnect (3). It appears possible that a small object has lodged at this position. Previous mission views were screened and nothing similar was noted. A small section of red purge seal material appears covered over with white RTV on the LO2 umbilical near the 7 o' clock position of the electrical monoball disconnect (4). Numerous voids and eroded areas are visible on the vertical and horizontal sections of the LO2 electric cable tray (5). A white mark is visible on the +Y limb on the LH2 tank TPS above the RSRB attach area (6). This white mark appears to be a divot. TPS erosion and voids are visible on the aft LO2 feedline bellows and support bracket (7). A small

amount of TPS erosion or scarring is visible on the forward end of the +Y thrust strut. KSC reported that what appeared to be a gray to silver colored object between the cross beam and the diagonal strut just above the LO2 umbilical was not an object but a paint brush stroke (8). The LO2 lightning contact strips appear in place (9). The red seal around the EO-3 fitting appears intact (10). An out of focus rectangular shaped white colored debris object is visible between the camera and the LH2 tank TPS on frame 33. Other smaller white debris objects are visible throughout the film sequence. These white debris objects appear to be frozen hydrogen.

2.5 LANDING EVENTS

2.5.1 Landing Sink Rate Analysis Using Video *(Task #3)*

(Cameras SLF-North, SLF-South)

Camera SLF-South was used to determine the landing sink rate of the main gear. The analysis considered approximately one second of imagery immediately prior to touchdown. Data was gathered at a sample rate of 30 frames per second. An assumption was made that the line of sight of the camera was perpendicular to the Orbiter y-axis. Scaling information was determined by using the distance between the main gear struts. The vertical difference of the projected main gear point for two successive frames was multiplied by the scaling factor to find the change in height of the main gear over that interval. The main gear height above the runway was determined by assigning the frame of touchdown a height of 0 feet, and cumulatively adding the previous frames. These heights were then regressed with respect to time. Sink rate equals the slope of this regression line. The main gear sink rate was determined to be 3.3 feet per second.

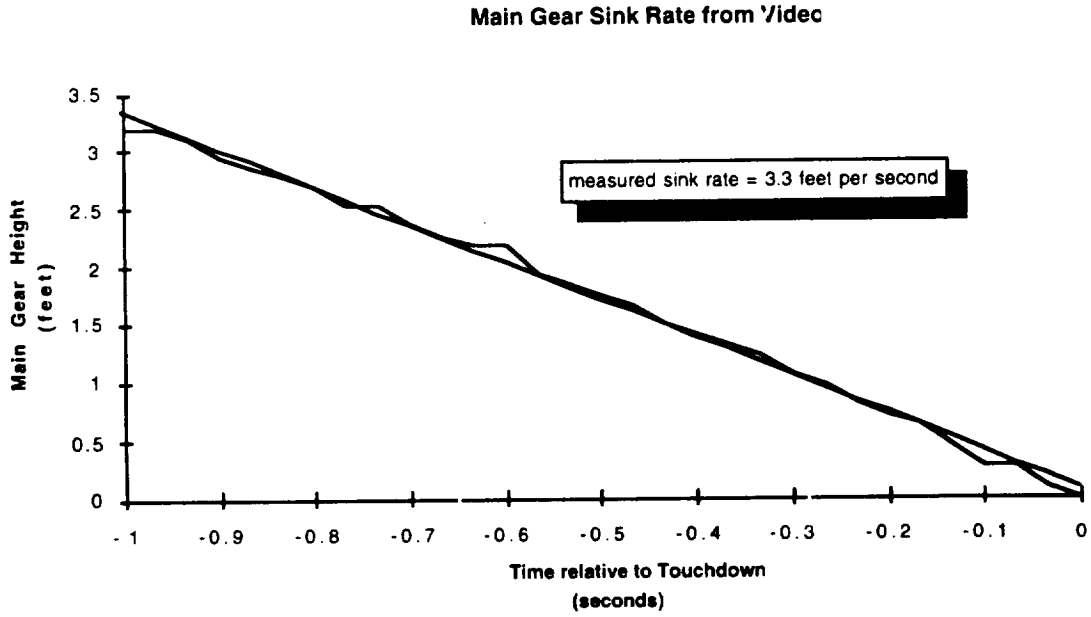


Figure 2.5.1a Graph of Right Main Gear Height Versus Time Prior to Touchdown

Camera SLF-North was used to determine the landing sink rate of the nose gear. The analysis considered approximately one second of imagery immediately prior to touchdown. Data was gathered at a sample rate of 30 frames per second. An assumption was made that the line of sight of the camera was perpendicular to the Orbiter y-axis. Scaling information was determined by using the distance between the main gear struts. The vertical difference of the digitized nose

gear point from the average of the main gear points was multiplied by the scaling factor to find the height of the nose gear for a single frame. An empirical offset correction was made to produce a calculated height at main gear touchdown of 0 feet. These heights were then regressed with respect to time. Sink rate equals the slope of this regression line. The nose gear sink rate was determined to be 2.9 feet per second.

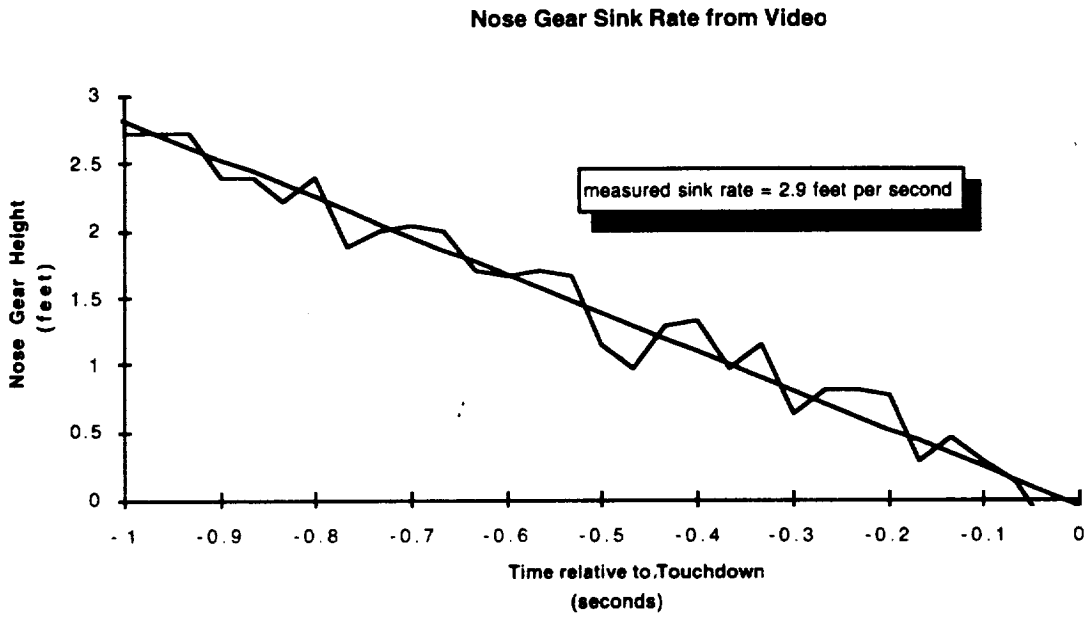


Figure 2.5.1b Graph of Nose Gear Height Versus Time During Rollout

2.5.2 Landing Sink Rate Analysis Using Film *(Task #3)* *(Cameras EL-7, EL-9)*

Camera EL-9 was used to determine the landing sink rate of the main gear. The analysis considered approximately one second of imagery immediately prior to touchdown. Data was gathered at a sample rate of 100 frames per second. An assumption was made that the line of sight of the camera was perpendicular to the Orbiter y-axis. Scaling information was determined by using the distance between the main gear struts. The vertical difference of the projected main gear point for two successive frames was multiplied by the scaling factor to find the change in height of the main gear over that interval. The main gear height above the runway was determined by assigning the frame of touchdown a height of 0 feet, and cumulatively adding the previous frames. These heights were then regressed with respect to time. Sink rate equals the slope of this regression line. The main gear sink rate was determined to be 3.2 feet per second.

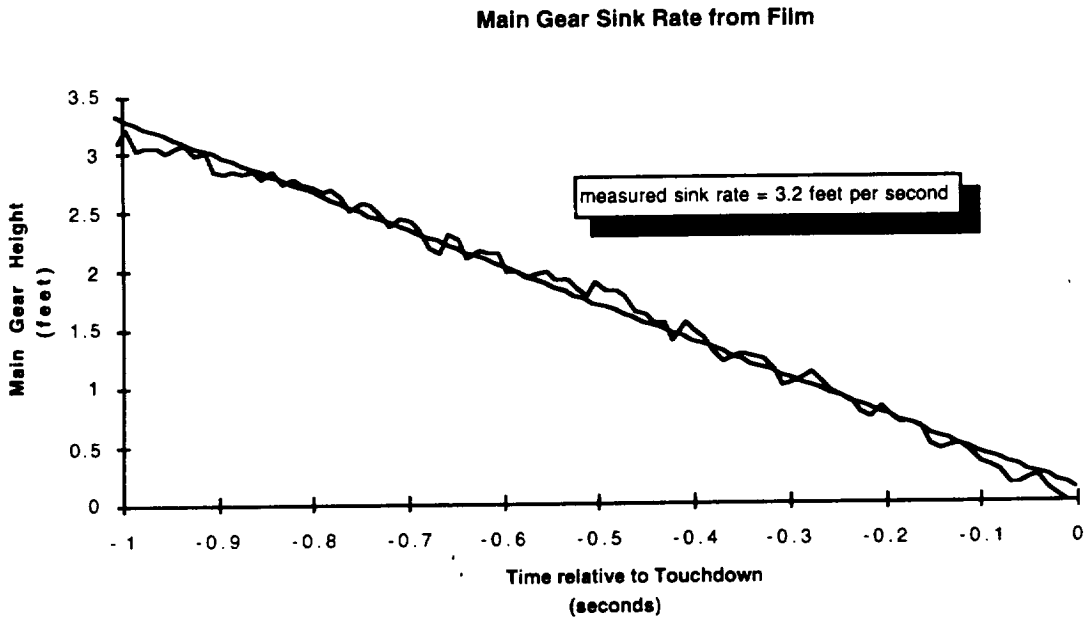


Figure 2.5.2a Graph of Right Main Gear Height Versus Time Prior to Touchdown

Camera EL-7 was used to determine the landing sink rate of the nose gear. The analysis considered approximately one second of imagery immediately prior to touchdown. Data was gathered at a sample rate of 100 frames per second. An assumption was made that the line of sight of the camera was perpendicular to the Orbiter y-axis. Scaling information was determined by using the distance between the main gear struts. The vertical difference of the digitized nose gear point from the average of the main gear points was multiplied by the scaling factor to find the height of the nose gear for a single frame. An empirical offset correction was made to produce a calculated height at main gear touchdown of 0 feet. These heights were then regressed with respect to time. Sink rate equals the slope of this regression line. The nose gear sink rate was determined to be 2.8 feet per second.

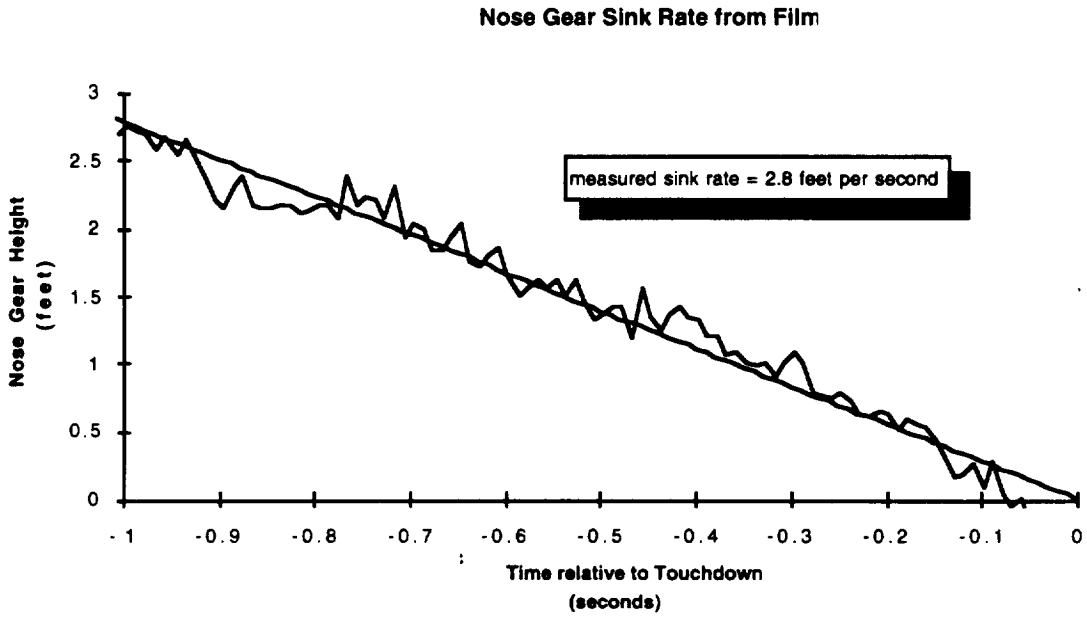


Figure 2.5.2b Graph of Nose Gear Height Versus Time During Rollout

2.5.3 Drag Chute Performance *(Task #9)*
(Cameras EL-1, EL-2, EL-3, EL-4, EL-5, EL-7, EL-9, EL-10, EL-12, EL-15, EL-19, EL-20, EL-17 IR, EL-18 IR, KTV-5L, KTV-6L, KTV-11L, KTV-15L, KTV-16L, KTV-33L, SLF North, SLF-South)

The landing of Columbia at the end of mission STS-62 marked the thirteenth deployment of the Orbiter drag chute. All components of the drag chute appeared to deploy as expected. Standard analysis of the drag chute angles as a function of time was performed using the views from the film cameras EL-7 and EL-9. This analysis is used to support the improvement of the aerodynamic math models currently in use. The maximum horizontal chute deflection was approximately 4.8 degrees. The riser angle ranged from a maximum of 6.3 degrees near chute initiation to a minimum of -4.8 degrees after disreefing. Figure 2.5.3a presents the measured heading angle versus time. Figure 2.5.3b presents the measured riser angle versus time.

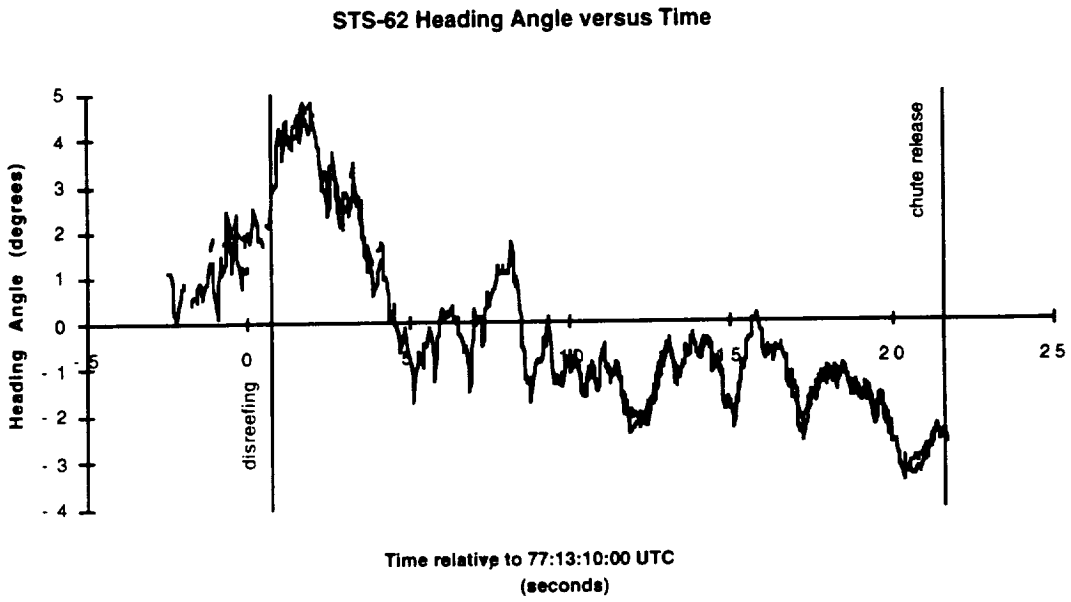


Figure 2.5.3a Graph of Drag Chute Heading Angle Versus Time During Rollout

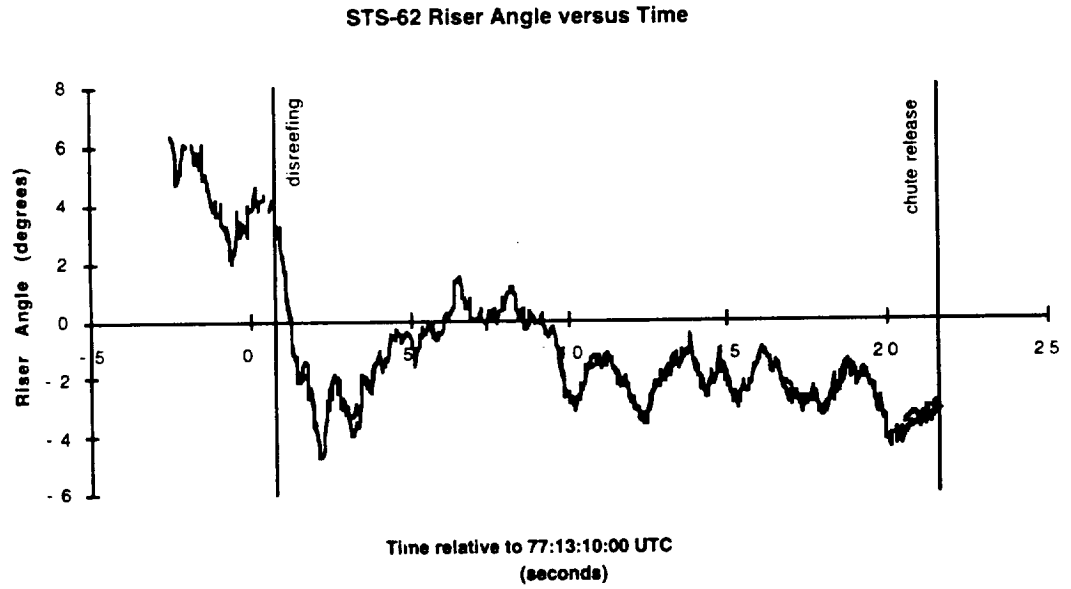


Figure 2.5.3b Graph of Drag Chute Riser Angle Versus Time During Rollout

2.6 OTHER NORMAL EVENTS

Other normal events observed include: a frost line was noted between the base of the SSME #2 bell and the base heat shield at SSME startup; DMHS vibration noted at SSME ignition; RCS paper debris after SSME ignition; frost on the ET GOX vent louvers; body flap motion noted after SSME ignition; right and left inboard and outboard elevon motion visible after SSME ignition and at liftoff; ice and vapor from the ground umbilical carrier plate (GUCP) during

SSME startup and ET GH2 vent arm retraction; ET twang; vapor from the TSM T-0 umbilical disconnect areas at liftoff; multiple pieces of light colored flame duct debris were visible at liftoff; acoustic waves were noted in the SRB exhaust cloud; debris in the exhaust cloud at the pad after liftoff; multiple light colored pieces of debris (possibly RCS paper) aft of the vehicle in the SSME plume during and after roll maneuver; ET aft dome outgassing; vapor from the SRB stiffener rings after liftoff; charring of the ET aft dome during ascent; overshoot and adjustment of roll maneuver; debris in the SSME plume from liftoff through the roll maneuver; sun glint off the Orbiter windows during roll maneuver; white flashes near the SRB plume; expansion waves; condensation around the SLV after the roll maneuver; dark puffs in SRB exhaust prior to SRB separation; SRB plume brightening; and slag debris in the SRB exhaust plume during and after SRB separation.

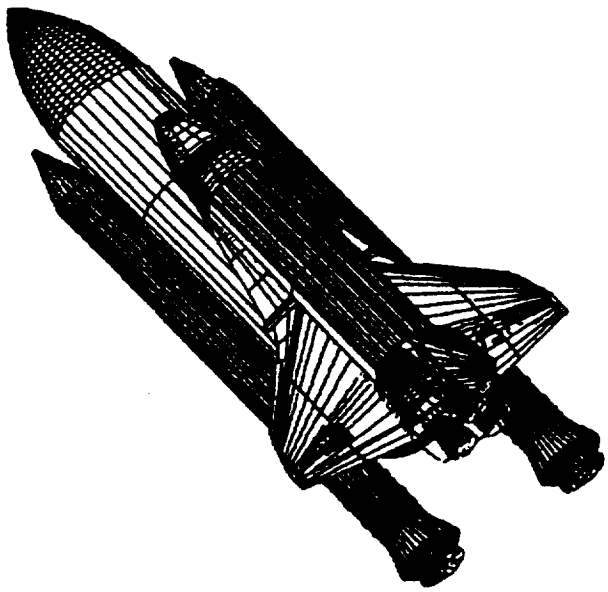
MLP events seen were fixed service structure (FSS) deluge water spray activation; mobile launch platform (MLP) water dump activation; water leak from an MLP J-pipe.

Appendix B. MSFC Photographic Analysis Summary

National Aeronautics and
Space Administration

George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

SPACE SHUTTLE
ENGINEERING PHOTOGRAPHIC ANALYSIS REPORT
STS-62



National Aeronautics and
Space Administration

George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812
AC(205)544-2121

NASA

Reply to Attn of: EP24 (94-13)

March 31, 1994

TO: Distribution

FROM: EP24/Thomas J. Rieckhoff

SUBJECT: Engineering Photographic Analysis Report for STS-62

Enclosed is the Engineering Photographic Analysis Report for the Space Shuttle Mission STS-62. For additional copies, or for further information concerning this report, contact Tom Rieckhoff at 544-7677, or Jeff Hixson, Rockwell at 544-7121.

Thomas J. Rieckhoff

Enclosure

ENGINEERING PHOTOGRAPHIC ANALYSIS REPORT

STS-62

FINAL

PREPARED BY:

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SUPERVISOR, LAUNCH OPERATIONS/ROCKWELL/HSV

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STS-62 ENGINEERING PHOTOGRAPHIC ANALYSIS REPORT

TABLE OF CONTENTS

* Photographs in the individual camera assessments are representative photographs and are not necessarily photographs taken from this particular launch.

March 31, 1994

I. INTRODUCTION

The launch of space shuttle mission STS-62, the sixteenth flight of the Orbiter Columbia occurred on March 4, 1994, at approximately 7:53 A.M. Central Standard Time from Launch Complex 39B (LC-39B), Kennedy Space Center (KSC), Florida. Extensive photographic and video coverage exists and has been evaluated to determine proper operation of the ground and flight hardware. Cameras (video and cine) providing this coverage are located on the fixed service structure (FSS), mobile launch platform (MLP), LC-39B perimeter sites, onboard the vehicle, and uprange and downrange tracking sites.

II. ENGINEERING ANALYSIS OBJECTIVES:

The planned engineering photographic and video analysis objectives for STS-62 included, but were not limited to the following:

a. Overall facility and shuttle vehicle coverage for anomaly detection
b. Verification of cameras, lighting and timing systems
c. Determination of SRB PIC firing time and SRB separation time
d. Verification of Thermal Protection System (TPS) integrity
e. Correct operation of the following:
    1. Holddown post blast covers
    2. SSME ignition
    3. LH2 and LO2 17" disconnects
    4. GH2 umbilical
    5. TSM carrier plate umbilicals
    6. Free hydrogen ignitors
    7. Vehicle clearances
    8. GH2 vent line retraction and latch back
    9. Vehicle motion

There was one special test objective for this mission:
1. DTO-0312, ET photography after separation.

III. CAMERA COVERAGE ASSESSMENT:

Film was received from fifty-six of fifty-six requested cameras as well as video from eleven of twenty-three requested cameras. The following table illustrates the camera data received at MSFC for STS-62.

Camera data received at MSFC for STS-62

	16mm	35mm	70mm	Video
MLP	22	0	0	1
FSS	7	0	0	0
Perimeter	3	3	0	1
Tracking	0	16	0	9
Onboard	3	2	0	0
Totals	35	21	0	11
Total number of films and videos received:				67

An individual motion picture camera assessment is provided as Appendix B. Appendix C contains detailed assessments of the video products received at MSFC.

a. Ground Camera Coverage:

All films of the STS-62 launch were of excellent quality. Lighting conditions at the time of launch were optimum. Little or no distortion was apparent due to the atmospheric conditions except for the extreme long-range cameras both north and south of the flight path. All requested cameras operated properly except for camera E-1 and E-15 which jammed during operation but provided the required data. Several video products from the T+45 minute engineering playbacks were not recorded at MSFC Building 4207 during the downlink. Television operations personnel have made assurances that this failure will not happen on future missions. Reports from JSC and KSC engineering photographic groups show no anomalies or issues from these cameras.

b. Onboard Camera Assessment:

Each SRB forward skirt contained a camera to record the main parachute deployment. Both cameras operated properly. The films did not record water impact. A 35mm hand-held camera was used to record film for evaluating the ET TPS integrity after ET separation. Thirty-six excellent frames of the external tank were recorded. Additionally a hand-held camcorder recorded the external tank during the same time period and acquired approximately 10 minutes of good quality video. Two 16mm

motion picture camera and one 35mm still camera were flown on this mission in the orbiter's umbilical well to record the SRB and ET separation. One 16mm camera failed to operate.

IV. ANOMALIES/OBSERVATIONS:

a. General Observations:

While viewing the film, several events were noted which occur on most missions. These included: pad debris rising and falling as the vehicle lifts off, debris north of MLP ejected from SRB blast holes, debris induced streaks in the SSME plume, ice falling from the 17 inch disconnects and umbilicals, and debris particles falling aft of the vehicle during ascent, which consist of RCS motor covers, hydrogen fire detection paper and purge barrier material. Body flap and inboard right elevon motions were noted during ascent.

An unusual debris object was noted from the left SRB main parachute camera after frustrum separation. The source of this debris is unknown. Figure 1 shows this debris from camera E-302.

b. APU Exhaust Port Dripping

Liquid drops were visible from the right SRB APU exhaust port prior to liftoff. This event occurred approximately five times. The source of this liquid is unknown. This event can be seen in Figure 2.

c. Frost on ME-2 Eyelid

Frost was observed around the ME-2 eyelid and on the LOX overboard drain line prior to engine start. This frost is visible in Figure 3. Frost around the eyelid was also visible on STS-60.

d. Glowing Debris from SRB Plume

Multiple pieces of glowing debris appeared to be ejected from the SRM plume during ascent between T+67 and T+76 seconds. This event was recorded by camera E-220 as shown in Figure 4. Typically this type debris is more visible during night sky conditions and not as evident during day time launches.

e. Main Parachute Rip

A rip in one main parachute was observed at deployment on the right SRB. No indication of the failure occurring was evident. This rip did not appear to propagate during descent. This rip can be seen in Figure 5.

f. ET TPS Divot

A long (approximately 4 x 18") divot was noted forward of the left bipod strut at the base of the ramp. Green primer is visible inside the divot. Figure 6 shows this divot as recorded by the 35mm umbilical well camera.

V. ENGINEERING DATA RESULTS:

a. T-Zero Times:

T-Zero times are determined from cameras that view the SRB holddown posts numbers M-1, M-2, M-5 and M-6. These cameras record the explosive bolt combustion products.

HOLDDOWN POST	CAMERA POSITION	TIME (UTC)
M-1	E-9	63:13:53:00.018
M-2	E-8	63:13:53:00.019
M-5	E-12	63:13:53:00.018
M-6	E-13	63:13:53:00.017

b. ET Tip Deflection:

Maximum ET tip deflection for this mission was determined to be approximately 31 inches. Figure 7 is a data plot showing the measured motion of the ET tip in both the horizontal and vertical directions. A positive horizontal displacement represents motion in the -Z direction. These data were derived from film camera E-79.

c. SRB Separation Time:

SRB separation time for STS-62 was determined to be 63:13:55:06.33 UTC as recorded by several tracking cameras.

Figure 1: Debris Object from Camera E-302

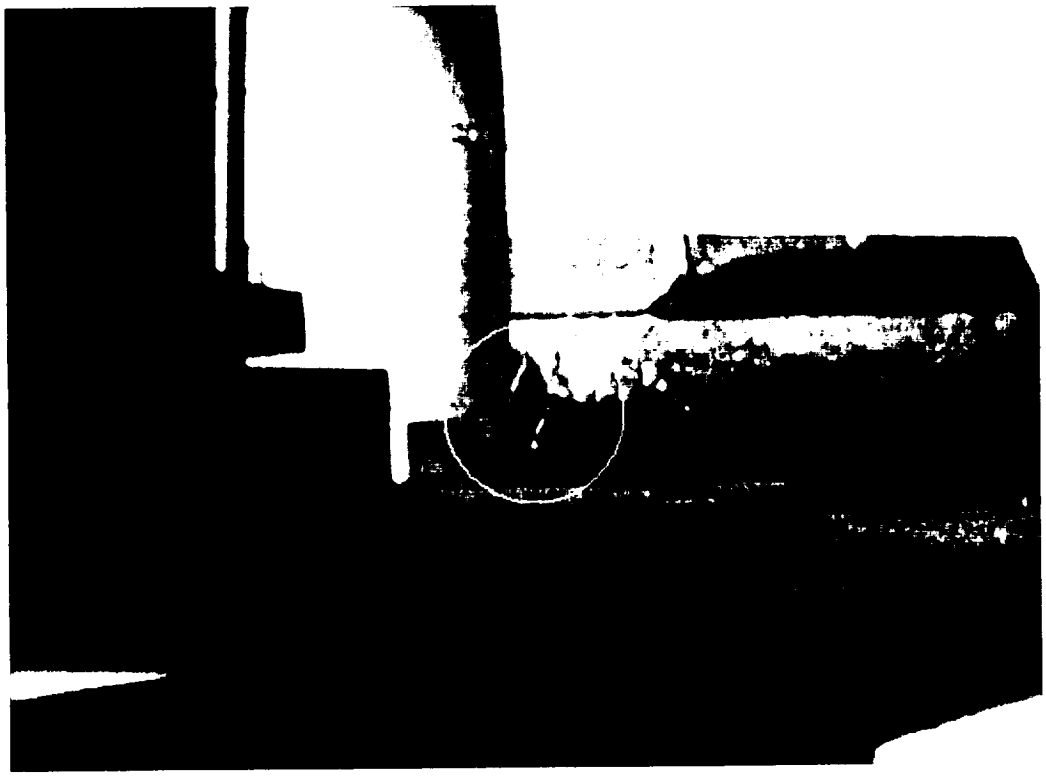

Figure 2: APU Exhaust Port Dripping

Figure 3: Frost on ME-2 Eyelid and Drain Line

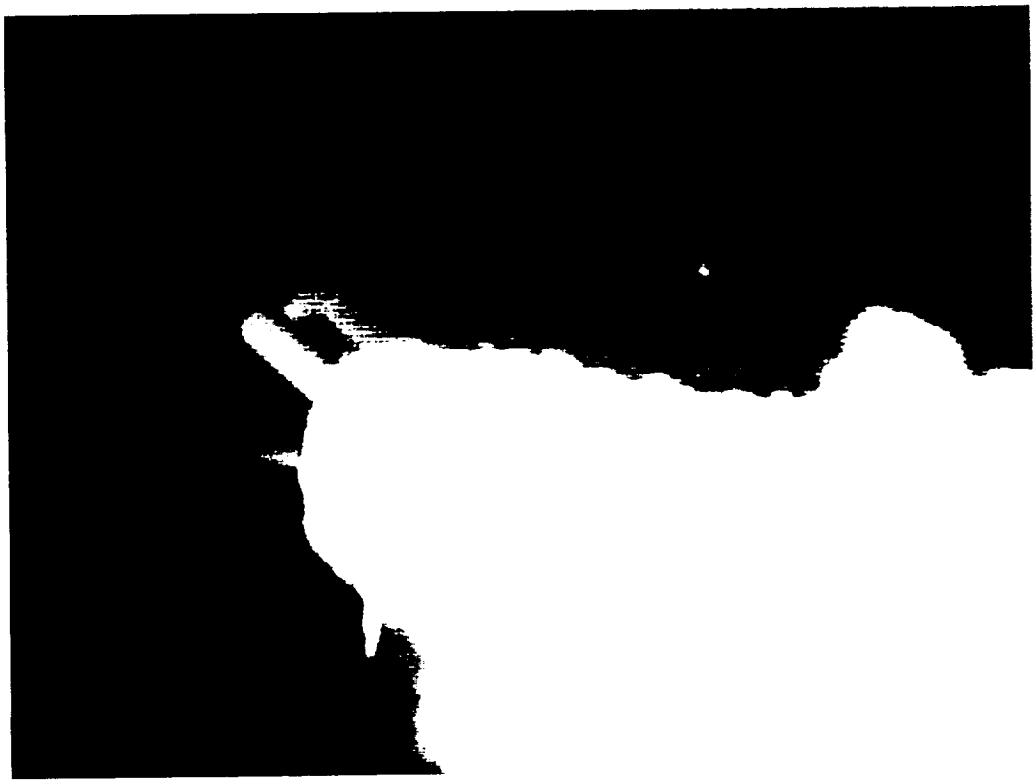

Figure 4: Glowing Debris from SRB Plume

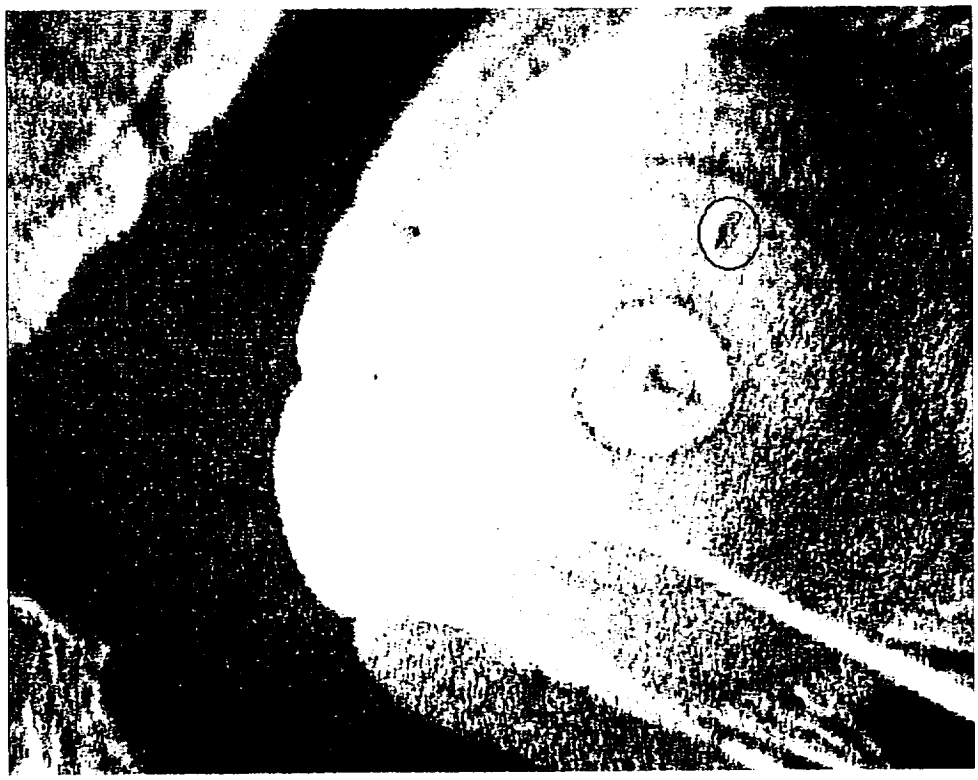

Figure 5: Main Parachute Rip

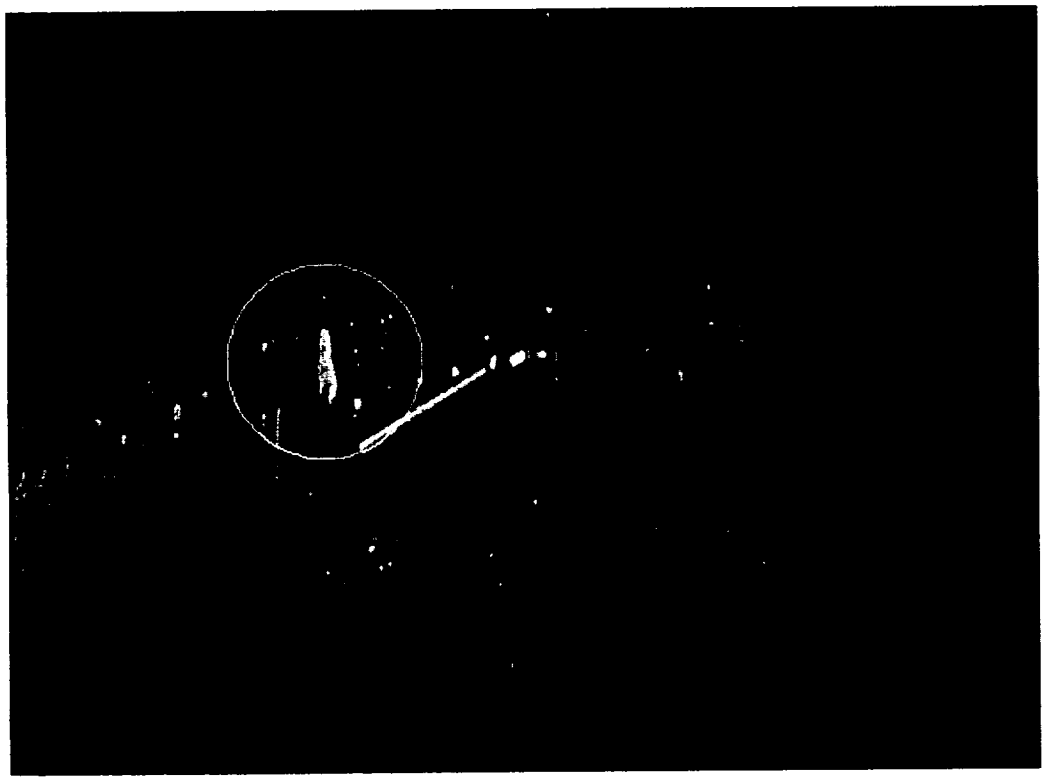

Figure 6: ET TPS Divots

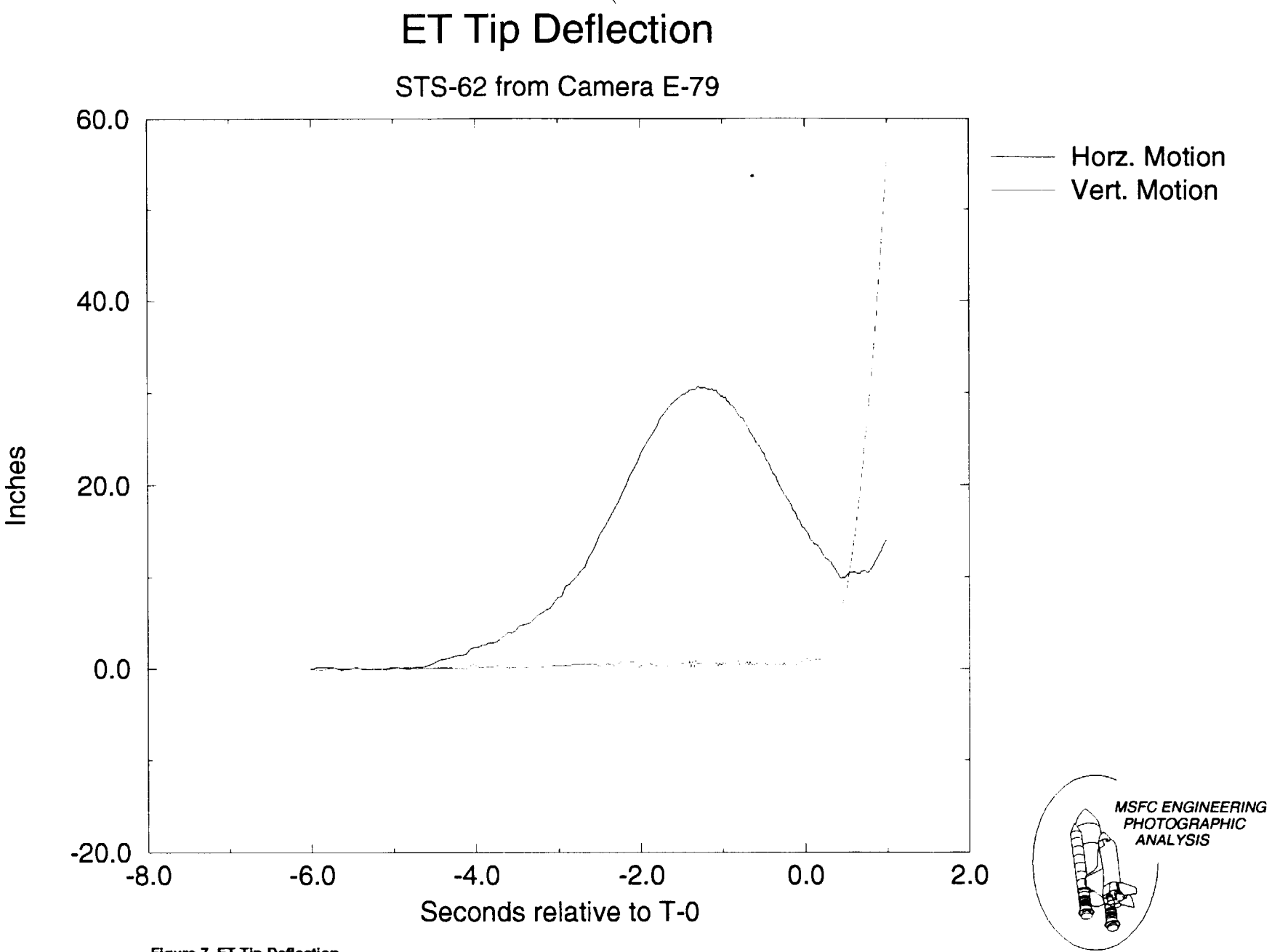

Figure 7 ET Tip Deflection

Appendix C. Rockwell Photographic Analysis Summary

ROCKWELL ENGINEERING PHOTOGRAPHIC ANALYSIS SUMMARY REPORT FOR STS-62

Extensive photographic and video coverage was provided and has been evaluated to determine ground and flight performance. Cameras (cine and video) providing this coverage are located on the Launch Complex 39B Fixed Service Structure (FSS), Mobile Launch Platform (MLP), various perimeter sites, and uprange and downrange tracking sites for the STS-62 launch conducted on March 4, 1994, at 5:53 a.m. PST/GMT 063:13:53:00.009 from the Kennedy Space Center (KSC) and for the landing on March 18, 1994 at KSC at 5:09 a.m. PST/GMT 077:13:09:41. Rockwell received launch films from 82 cameras (58 cine, 24 video) and landing films from 29 cameras (15 cine, 14 video) to support the STS-62 photographic evaluation effort.

Overall, the films showed STS-62 to be a clean flight. Several pieces of ice from the ET/Orbiter umbilical were shaken loose at SSME ignition, but no damage to the Orbiter Thermal Protection System (TPS) was apparent. The usual condensation and water vapors were seen at the ET aft dome and the SRB stiffener rings and dissipated after the completion of the roll maneuver. Charring of the ET aft dome, recirculation and brightening of the SRB plumes were normal. Booster Separation Motor (BSM) firing and SRB separation also appeared to be normal.

Nominal performance was seen for the MLP and FSS hardware. FSS deluge water was activated prior to SSME ignition and the MLP rainbirds were activated at approximately 1 second Mission Elapsed Time (MET), as is normal. All blast deflection shields closed prior to direct SRB exhaust plume impingement. Both TSM umbilicals released and retracted as designed. The ET GH_2 vent line carrier dropped normally and latched securely with a slight rebound. No anomalies were identified with the ET/ORB LH_2 umbilical hydrogen dispersal system hardware.

STS-62 was the twenty-first flight with the optimized attach link in the SRB holddown support post Debris Containment Systems (DCS's). No holddown post hangups were observed.

No major or significant events were observed or identified. Events noted by the Rockwell film/video users during the review and analysis of the STS-62 photographic items are summarized in the following comments. There events are not considered to be a constraint to next flight.

COMMENTS

1. On Cameras OTV-163, OTV-170, OTV-071, E-2, E-3, E-15, E-18, E-19, E-20, E-76 and E-77, orange vapor (possibly free burning hydrogen) was noted below the SSME bells prior to ignition. This vapor has been observed on previous flights and no follow-on work is scheduled.

2.. On cameras E-19 and E-20, a frost line was noted at the base of the SSME #2 nozzle prior to SSME ignition. Frost/ice buildup has been seen on previous flights. No follow-up action is planned.

3. A flash was observed in the SSME #1 plume at SSME ignition (camera E-3). Flashes in the SSME plumes have been seen on previous missions. No follow-up action is planned.

4. On camera E-17, a thin rectangular piece of light colored debris (possibly a parts tag) was seen falling from the L02 TSM umbilical lines after SSME ignition. the debris did not appear to strike the vehicle. No follow-up action is planned.

5. Small pieces of white debris (ET/ORB umbilical ice) noted between the SRB's traveling toward the SSME flame duct on camera's E-5 and E-9. One piece impacted the right SRB aft BSM nozzle prior to SRB ignition (T-2.15 seconds). No damage to the vehicle was visible. The KSC film analysis team reported that this piece of ice was from the right SRB/ET aft attach fittings. No follow-up action is planned.

6. On cameras OTV-109, OTV-154, OTV-163, E-5, E-6, E12,E15, E-17, E18, E-25, E-26 and E-31, normal ice debris was seen falling from the LH_2 and LO_2 ET/Orbiter umbilical disconnect area at SSME ignition through liftoff. Several of these particles contacted the LH_2 umbilical sill, but no damage was detected. No follow-up action is planned.

7. A thin rectangular piece of red colored debris (probably tape) fell from the SRB aft skirt below the holddown post M-5 foot into the flame duct at liftoff (cameras EX3 and E-12). No follow-up action has been requested.

8. Debris was observed falling aft of the Shuttle Launch Vehicle (SLV) at liftoff, during the roll maneuver and on ascent from camera's KTV-4B, OTV-161, OTV-163, E-40, E-52, E-54, E-57, E-59, E-65, E-79, E-212, E213, E-220 and E-222. Most of the debris noted were RCS paper covers or ice from the ET/Orbiter umbilicals. Other debris items observed were: 1) several pieces of orange - colored debris (probably umbilical baggie material) near the ET aft dome (OTV-161, E-40, E-79); 2) an orange - colored piece of debris from the ET/Orbiter LH_2 umbilical area falling aft (E-57) and identified by KSC as hydrogen fire detection butcher paper from the ET LH_2 vertical strut; and 3) numerous pieces of light - colored debris (probably forward RCS paper covers) falling aft along the SRB plume during ascent between

20 to 68 seconds MET (KTV-4B, E-54, E-59, E-212, E-213, E-222). None of the debris appeared to impact the vehicle. No follow-up action is planned.

9. On cameras KTV-21B, E-52, E-204, E-205, E-207, E-218, E-220, E-222 and E-223, several flares were observed in the SSME plumes during ascent. Flares have been noted on previous missions. No follow-up action is planned.

10. A white vapor cloud was seen near the SRB plume at 57 seconds MET on cameras E-211, E-222 and E-224, and was possibly caused by the vehicle traveling through a moisture layer in the atmosphere. Comparison of the rawinsonde data to the trajectory data by JSC concluded that the vapors were due to a layer of moisture at 9.9 km. A vapor cloud was noted on the STS-48 mission. No follow-up action is planned.

11. Several orange flashes were noted in the SRB plume prior to plume brightening and SRB separation (E-204, E-212, E-218). This event has previously been observed on STS-53 and MSFC personnel indicated at that time that the event was not anomalous. No follow-on work is currently scheduled.

12. The following events have been reported on previous missions and observed on STS-62. These are not of major concern, but are documented here for information only:

- Ice debris falling from the ET/Orbiter Umbilical disconnect area
- Debris (Insta-foam, water trough) in the holddown post area and MLP
- Charring of the ET aft dome
- ET aft dome outgassing after liftoff
- RCS Paper debris
- Recirculation or expansion of burning gasses at the aft end of the SLV prior to SRB separation
- Slight TPS erosion on the base heat shield during SSME start-up
- Twang motion
- Body flap motion during the maximum dynamic pressure (MAX-Q) region which appeared to have an amplitude and frequency similar to those of previous missions
- Linear optical distortion, possibly caused by shock waves or ambient meteorological conditions near the vehicle, during ascent
- Slag in SRB plume after separation
- Vapor from the SRB stiffener rings after liftoff
- Fore-and aft movement of the Orbiter base heat shield in the centerline area between the SSME cluster at engine start-up
- Condensation on the Orbiter forward fuselage, ET nose and SRB frustums during ascent.

13. Camera E33 and E41 - OMRSD File IX Vol. 5, Requirement No. DV08P.010 requires an analysis of launch pad film data to verify that the initial ascent clearance separation between the left SRB outer mold line and the falling ET umbilical structure does not violate the acceptable margin of safety.

    A qualitative assessment has been conducted and positive clearances between the left SRB and the ET vent umbilical have been verified. The films showed nominal launch pad hardware performance, and no anomalies were observed for the SRB body trajectory.

14. Cameras E7-16-OMRSD File IX Vol. 5, Requirement No. DV08P.020 requires an analysis of film data of SRM nozzle during liftoff to verify nozzle to holddown post drift clearance.

    A qualitative assessment of the launch films has been completed. No anomalies were observed for the SRM nozzle trajectory and positive clearances between the SRB nozzles and the holddown posts were verified.

15. The landing of STS-62 occurred on Runway 33 at the KSC Shuttle Landing Facility. Good video and film coverage were obtained. Main landing gear touchdown occurred at 077:13:09:41 GMT and nose landing gear touchdown occurred at 077:13:10:00 GMT with wheel stop occurring at 077:13:10:35 GMT. Review of the landing videos from the infrared cameras (EL-17, EL-18) showed four pieces of debris falling from the vehicle at nose landing gear deployment. Two of the items appeared to originate from the main gear doors and the other two items from the nose gear area. During the post landing inspection a piece of corner tile (4"x 4") and six thermal barriers (total size approximately 36"x3"x1.5") were missing from the nose landing gear doors (NLGD). These objects were probably the debris seen on the infrared views falling from the Orbiter when the NLGD were opened on final approach. No follow-up action is planned.

    The review of the landing videos and films also showed the Orbiter move to the right of the runway centerline at 5 seconds after main landing gear (MLG) touchdown and to the left of the centerline at 8 seconds. No steering changes were visible 14 seconds after MLG touchdown. No follow-up action is planned.

    The flight marked the fourteenth use of the Orbiter drag chute. The drag parachute system performed as expected. All sequenced events occurred as expected and no hardware anomalies were observed.

Any questions concerning this report should be directed to the undersigned.

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A debris/ice/thermal protection system (TPS) assessment and integrated photographic analysis was conducted for Shuttle Mission STS-62. Debris inspections of the flight elements and launch pad were performed before and after launch. Icing 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 of the launch was analyzed to identify ice/debris sources and evaluate potential vehicle damage and/or in-flight anomalies. This report documents the ice/debris/TPS conditions and integrated photographic analysis of Shuttle mission STS-62, and the resulting effect on the Space Shuttle Program.

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