NASA Technical Memorandum TM 102789

Debris/Ice/TPS Assessment And Photographic Analysis For Shuttle Mission STS-36

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April 1990

National Aeronautics and
Space Administration

John F. Kennedy Space Center

NASA

DEBRIS/ICE/TPS ASSESSMENT
AND
PHOTOGRAPHIC ANALYSIS
OF
SHUTTLE MISSION STS-36

February 28, 1990

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

ORIGINAL PAGE
COLOR PHOTOGRAPH

ORIGINAL PAGE IS
OF POOR QUALITY

Shuttle Mission STS-36 was launched at 2:50 a.m. EST on 2/28/90

1.0 Summary

Debris and Photo Analysis Team activities for Mission STS-36 began with the pre-launch debris inspection of the launch pad and Shuttle vehicle on 20 February 1990. No major anomalies were observed on OV-104 Atlantis, BI036, or ET-33. Minor facility discrepancies, which included loose MLP deck bolts and loose debris items in the south holddown post haunches, were corrected prior to cryo loading the vehicle.

No Orbiter or SRB anomalies were detected during the Ice Inspection. Very light condensate was present on the LO2 tank with no run-on to the intertank. Frost had accumulated on the barrel section and the lower ogive from the cable tray/ pressurization line around the +Y side of the tank to the +Y-Z quadrant. There was no evidence of ice/frost in the no-ice region of +/- 30 degrees on the upper ogive. Small amounts of ice/frost had formed in the stringer valleys on the -Z side of the tank along both the LO2 and LH2 tank-to-intertank flanges. No condensate was present on the LH2 tank, but acreage ice/frost had formed on the +Y side of the tank from the cable tray/pressurization lines around approximately 190 degrees to the +Y-Z quadrant. The ice/frost was more predominant on the lower part of the tank from station XT-1600 to XT-2058. All ice/frost observed on the vehicle was predicted to be less than 1/16-inch thick and did not violate the LCC or NSTS-08303. Ten Ice/Frost console anomalies were documented and found acceptable for launch per the LCC and NSTS-08303. The hydrogen umbilical leak sensor detected no significant hydrogen during the cryo load and was removed by the Ice Inspection Team during the T-3 hour hold.

The launch was scrubbed at T-31 seconds due to a Range Safety backup computer failure. A post drain inspection/preflight pad debris inspection was performed three hours after the scrub decision. There was no visible damage to ET, SRB, or Orbiter TPS.

The vehicle was again cryo loaded on 25 February after a 24 hour scrub/turnaround. No Orbiter or SRB anomalies were detected during the Ice Inspection. Very light condensate, but no ice or frost, was present on all acreage areas of the LO2 and LH2 tanks. However, some ice had formed along the PAL ramp to acreage interface and around the ice/frost ramps. Small amounts of ice/frost had formed in the intertank stringer valleys along the -Z side of both the LO2 and LH2 tank-to-intertank flanges. Fifteen Ice/Frost console anomalies were documented. Fourteen were found acceptable for launch per the LCC and NSTS-08303. One of the anomalies (012) documented the formation of one 3-inch and two 1-1/2 inch icicles on the north GOX vent duct at 01:04 GMT and four 1-inch icicles at 06:04 GMT. The presence of the icicles was accepted for launch by LCC waiver LW-018.

The launch was scrubbed for a second time due to adverse weather. A post-drain inspection/preflight pad debris inspection was performed six hours after the scrub decision. There was no visible damage to ET, SRB, or Orbiter TPS.

The vehicle was cryo loaded for a third time on 27 February following a 48 scrub/turnaround. No Orbiter to SRB anomalies were detected during the Ice Inspection. Very light condensate, but no ice/frost, was present on acreage areas of both the LO2 and LH2 tanks. Small amounts of ice/frost had formed in the intertank stringer valleys along the -Z side of both the LO2 and LH2 tank-to-intertank flanges. Both the LO2 and LH2 ET/Orbiter umbilicals exhibited less than usual ice/frost accumulation. There were no unusual vapors emanating from the umbilicals or any evidence of leakage. Thirteen Ice/Frost console anomalies were documented. Twelve were found acceptable per the LCC and NSTS-08303. Ice/frost accumulations on the ends of the GOX vent ducts (Anomaly 005) were recorded on PR U78-0001-00-001-0539 and accepted for launch by LCC waiver LW-020.

A post launch debris inspection of Pad 39A was performed after the successful launch. No significant flight hardware or TPS material was found. Launch damage to the holddown posts was minimal. No signs indicative of stud hang-up were visible. No fragments from HDP debris containers were found. The GH2 vent line had latched properly. Overall, the facility sustained minimal damage.

A total of 116 film and video items were analyzed as part of the post launch data review. No major vehicle damage or lost flight hardware was observed that would have affected the success of the mission. No debris was visible falling from holddown posts #1 through #7 after liftoff. However, 6 pieces of debris, including 2 ordnance piecesmeasuring 3"x1/4"x1/4", fell from the HDP #8 aft skirt stud hole. There were no signs of holddown post hang-ups in any of the films. Numerous pieces of debris fell from the vehicle during ascent. Most have been identified as ice/frost particles from the ET/Orbiter umbilicals, RCS paper covers, and instafoam particles from the SRB aft skirts. The particles falling from the vehicle after Max Q are either pieces of SRB propellant or aft skirt instafoam. More than 100 chunks of SRB propellant slag/clinkers, some of which appear very large due to the burning 'blooming' effect, were visible in the SRB plumes prior to and just after separation from the External Tank. Movement of the Orbiter body flap was visible after the roll maneuver and through most of the ascent. The motion appears to have an amplitude and frequency similar to that observed on previous flights.

The Solid Rocket Boosters were inspected at Hanger AF after retrieval. Both forward skirts and frustums exhibited a total of 16 debonds and 3 areas of TPS. Three pins from the LH frustum severance ring at approximately 100, 120, and 240 degrees were missing. One of the pins was found embedded 0.75

inches into the TPS on the forward edge of the ETA ring at 175 degrees. Analysis of this pin and the adjacent TPS indicated that the impact occurred during ascent (Ref MSFC presentation on 3/9/90). All field joint closeouts were undamaged. The LH aft center segment factory joint EPDM moisture seal was unbonded at 4 locations along the trailing edge and exhibited Chemlok 205 to case failure. K5NA was missing from numerous bolt heads on the aft side of both kick rings and from all eight aft BSM nozzles. The plungers on holddown posts #1, #6, and #7 were seated but offset from their spherical washers. Three small pieces of shim material were wedged in the bore against the HDP #4 plunger. Half of a frangible nut was wedged between the HDP #8 plunger and spherical washer. HDP #2 experienced a skewed firing. Overall, the SRBs were in good condition.

A post landing inspection of OV-104 was performed on Runway 23L. The Orbiter TPS sustained a total of 81 hits, of which 19 had a major dimension of one inch or greater. The Orbiter lower surface had a total of 61 hits, of which 17 had a major dimension of one inch or greater. Based on these numbers and comparison to statistics from previous missions of similar configuration, the number of hits on the lower surface is less than average and the number of hits with a dimension one inch or greater is considered average. Laboratory analysis of samples taken from hazed Orbiter windows, streaked RCC panels, the ET/Orbiter umbilical area, and selected lower surface tiles revealed no unusual materials.

A total of 13 Post Launch Anomalies were observed during this mission assessment.

2.0 KSC ICE/FROST/DEBRIS TEAM ACTIVITIES

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

Team Activities:

1) Pre-launch Pad Debris Inspection

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

2) Launch Countdown Firing Room 2

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

3) Ice/Frost TPS and Debris Inspection

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

4) Post Launch Pad Debris Inspection

Objectives:	Locate and identify debris that could have damaged the Shuttle vehicle during launch.
Areas:	MLP deck, exhaust holes and flame trenches, FSS, pad surfaces and slopes, extension of trenches to the perimeter fence, walkdown of the beach from Playlinda to Complex 40, aerial overview of inaccessible areas.
Time:	Launch + 3 hours (after pad safing, before washdown)
Requirements:	OMRSD S00U00.010 - An engineering debris inspection team shall perform a post launch pad/area inspection to identify any lost flight or ground systems hardware and resultant debris sources. The post launch pad and area configuration shall be documented and photographed.
Documents:	OMI S0007, OMI S6444
Report:	Initial report to NTD and verbal

briefing to Level II at L+8 hours; generate PR's.

5) Launch Data Review

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

6) SRB Post Flight/Retrieval Inspection

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

7) Orbiter Post Landing Debris Damage Assessment

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

generate PR's. Preliminary report to Level II on day of landing followed by a preliminary update the next day.

8) Level II report

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

3.0 PRE-TEST BRIEFING

The Ice/Frost/Debris Team briefing for launch activities was conducted on 20 February 1990 at 1200 hours with the following key personnel present:

C. Stevenson	NASA - KSC	Chief, ET Mechanical Systems Lead, Ice/Debris Assess Team
G. Katnik	NASA - KSC	ET Mech/TPS, STI, Ice/Debris Assessment, Film Analysis
S. Higginbotham	NASA - KSC	STI, Ice/Debris Assessment
B. Speece	NASA - KSC	ET Processing, Ice Assess
B. Bowen	NASA - KSC	ET Processing, "SURFICE"
J. Rivera	NASA - KSC	ET Processing, Debris Assess
A. Oliu	NASA - KSC	"SURFICE", Debris Assess
M. Bassignani	NASA - KSC	ET Processing, Ice Assess
B. Davis	NASA - KSC	"SURFICE", Debris Assess
K. Tenbusch	NASA - KSC	"SURFICE", Debris Assess
M. Young	LSOC - SPC	ET Processing, Ice Assess
M. Jaime	LSOC - SPC	ET Processing, Ice Assess
F. Huneidi	NASA - MSFC	TPS & Ice Assessment
Z. Byrns	NASA - JSC	Level II Integration
C. Gray	MMC - MAF	ET TPS & Materials Design
S. Copsey	MMC - MAF	ET TPS Testing/Certif
K. Ely	MMC - KSC	ET Processing, LSS
T. Hamilton	RI - DNY	Vehicle Integration
T. Thorson	RI - LSS	Vehicle Integration
K. Mayer	RI - LSS	Vehicle Integration
H. Novak	USBI - PSE	SRB Processing
K. Yamasaki	USBI - EI	SRB Processing
K. Parsons	MTI - LSS	SRM Processing

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

3.1 PRE-LAUNCH SSV/PAD DEBRIS INSPECTION

The pre-launch debris inspection of the pad and Shuttle vehicle was conducted on 20 February 1990 from 1400 - 1700 hours. The detailed walkdown of Launch Pad 39A and MLP-1 also included the primary flight elements OV-104 Atlantis (6th flight), ET-33 (LWT-26), and BI036. Documentary photographs were taken of facility anomalies, potential sources of vehicle damaging debris, and new vehicle configurations.

There were no major vehicle anomalies.

Due to the continued concern over potential hydrogen leakage from the ET/ORB LH2 umbilical interface area during the cryoload/launch of STS-29R, a temporary hydrogen detector was installed at the ET/ORB LH2 umbilical until a permanent sensor can be designed and installed. The temporary detector consists of two tygon tubes that run from the LH2 umbilical area to the hazardous gas detection equipment quick disconnects located in the LH2 TSM. The tubes were attached to the vehicle by three velcro strap assemblies. A length of parachute cord attached to these assemblies enable the entire apparatus to be quickly removed from the vehicle without causing TPS damage. The hydrogen sensor is intended to remain in place during cryo loading and be removed by the Ice Inspection Team during the T-3 hour hold.

A recurring problem is loose MLP deck bolts. This inspection revealed loose MLP deck access cover bolts in the northwest deck area near the Portable Purge Unit receptacles. Grounding bolts were loose around the SSME and SRB exhaust holes and at the handrail standoff pins along the entire outer edge of the MLP deck.

One other discrepancy consisted of six unused hasps on an FSS 135 foot level weather protection system control panel cover. The hasps are loose and could be potential debris.

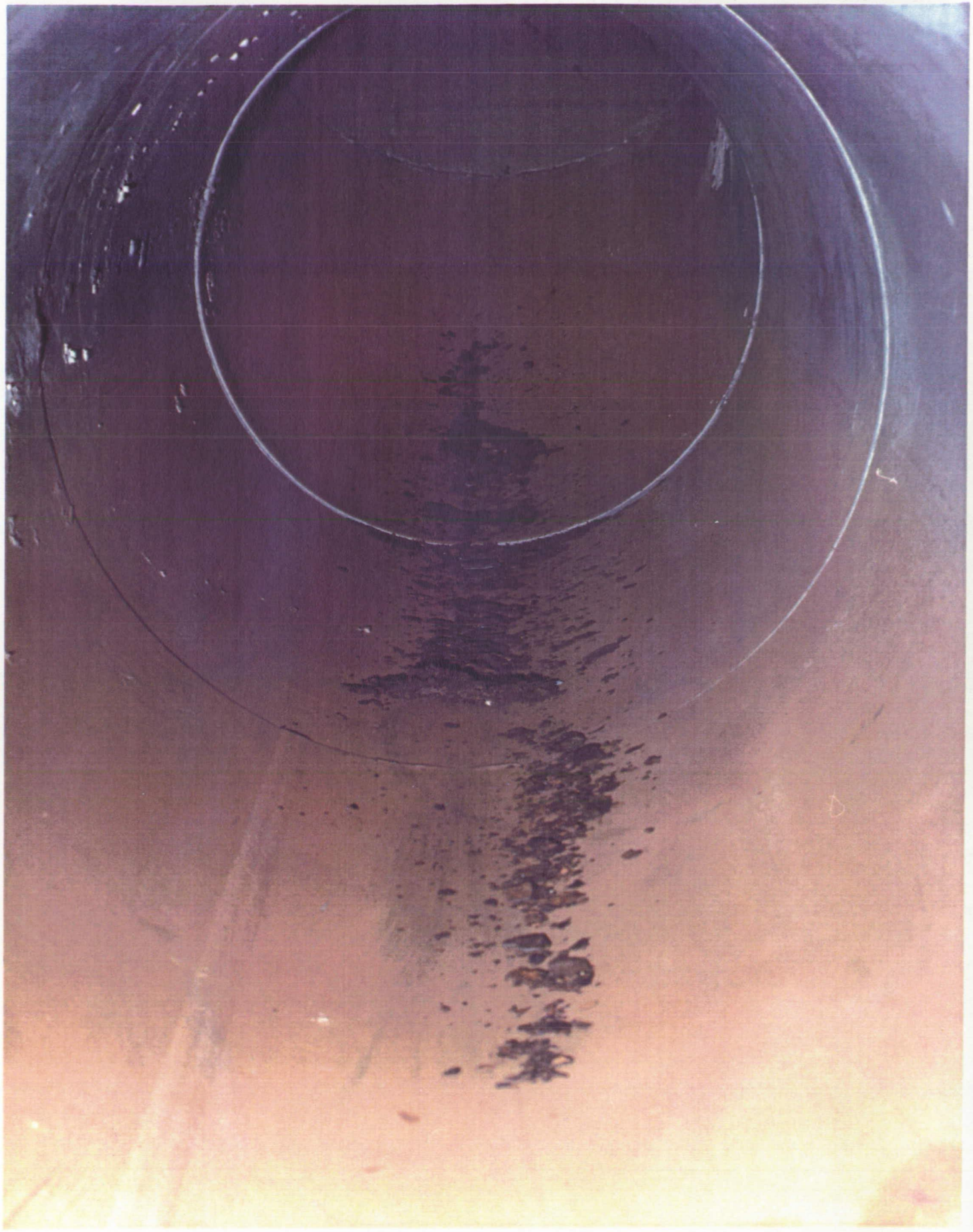
Trash and debris was visible in several areas including all south holddown post haunches. Rust flakes lay in an open sound suppression water pipe west of the SRB exhaust hole.

Cleanup of the MLP deck and pad surface was almost complete at the time of the inspection. The facility discrepancies were worked real-time or transferred to the pad leader for resolution prior to vehicle tanking.

New design of ET tumble valve cover was installed for launch

Pre-launch view of LH2 ET/ORB umbilical baggie material, which subsequently was found torn during the second vehicle cryo load

Condensate hydro diverters on the ends of the GOX vent ducts
Frost usually covers the temp sensor wiring inside the ducts



Rust flakes lay in an MLP deck sound suppression water pipe

4.0 SCRUB

The launch countdown for STS-36 was scrubbed at T-31 seconds on 25 February 1990 due to a Range Safety backup computer failure.

4.1 ICE/FROST INSPECTION

The Ice/Frost Inspection of the cryoloaded vehicle was performed on 24 February 1990 from 2000 to 2145 hours during the two hour built-in-hold at T-3 hours in the countdown. There were no violations of NSTS-08303 or the Launch Commit Criteria. Ambient weather conditions at the time of the inspection were:

Temperature:	57.0 F
Relative Humidity:	59.4 %
Wind Speed:	9.4 Knots
Wind Direction:	233 Degrees

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

4.2 ORBITER OBSERVATIONS

No Orbiter tile anomalies were observed. The average Orbiter surface temperature was recorded as 54 degrees F. The average surface temperatures of the SSME engine mounted heat shields were measured at 51 degrees F for SSME #1 (coldest 27 degrees), 46 degrees F for SSME #2 (coldest 15), and 48 degrees F for SSME #3 (coldest 35). SSME #2 had ice/frost all around the nozzle to heatshield interface except at the 10-11 o'clock position. Ice/frost had formed along the nozzle to heat shield interface of SSME #1 at 1-7 and 8-11 o'clock positions. There was no condensate or frost on the SSME #3 heatshield.

4.3 SRB OBSERVATIONS

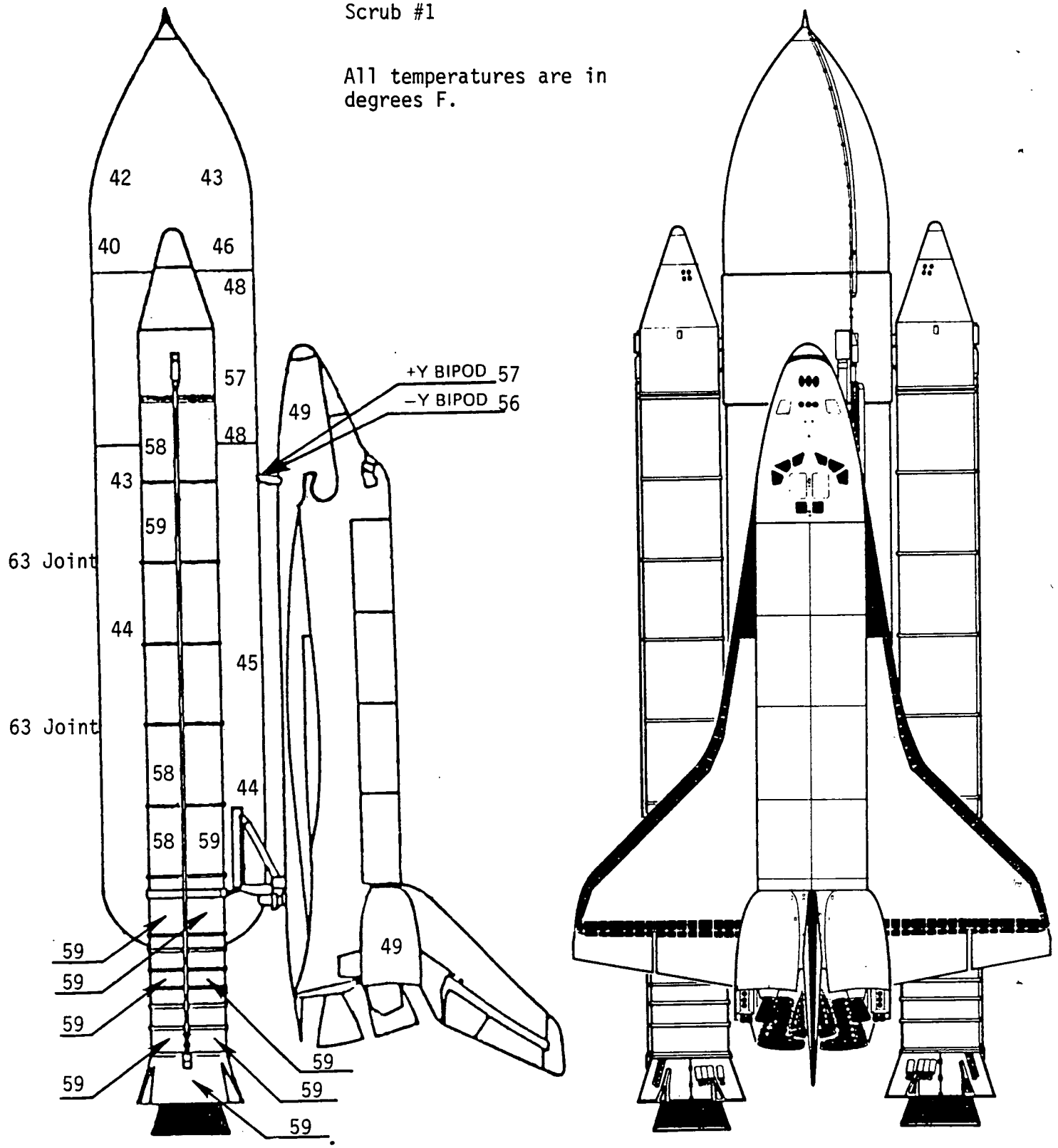
No SRB anomalies or loose ablator/cork were observed. The STI portable infrared scanner recorded RH and LH SRB case surface temperatures at 58 degrees F. Temperatures in the area of the SRB field joint heater closeouts averaged 63 degrees F. The predicted Propellant Mean Bulk Temperature (PMBT) supplied by MTI was 69 degrees F.

FIGURE 1. **INFRA RED SCANNER SSV SUMMARY DATA**

TIME: 2000-2145
DATE: 2/24/90
VEH. STS- 36

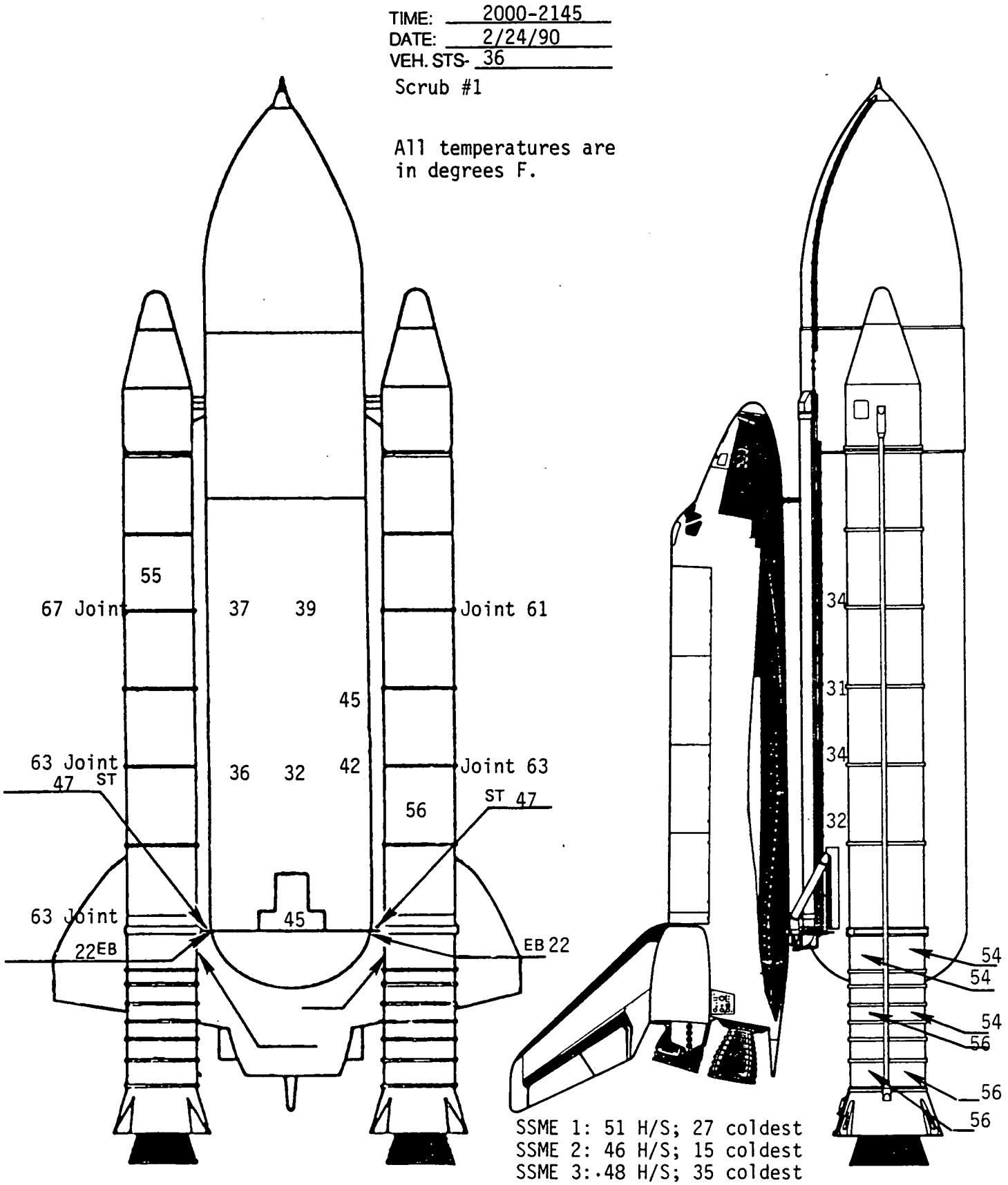
Scrub #1

All temperatures are in degrees F.



EGG/V-343D

FIGURE 2. **INFRA RED SCANNER SSV SUMMARY DATA**



4.4 EXTERNAL TANK OBSERVATIONS

The ice/frost prediction computer program was run from 1515 to 0215 hours and the results tabulated in Figures 3-8. Data from 'SURFICE' and the RSS STI is compared in Figure 9-10.

The new design of the tumble valve cover was intact. A very, very light condensate was present on the LO2 tank with no run-on to the intertank. Frost had accumulated on the barrel section and the lower ogive from the cable tray/pressurization line around the +Y side of the tank to the +Y-Z quadrant. There was no evidence of ice/frost in the no-ice region of +/- 30 degrees on the upper ogive. The surface temperature of the LO2 tank -Y side as measured by the IR scanner averaged 45 degrees F.

No run-on condensate was present on the intertank. Small amounts of ice/frost had formed in the stringer valleys on the -Z side of the tank along the LO2 tank-to-intertank flange (more accumulation) and along the LH2 tank-to-intertank flange (less accumulation). There was no ice/frost on the Orbiter side of the intertank. The average surface temperature was 57 deg F. Minor frost had formed on the GUCP, but there was no sign of leakage.

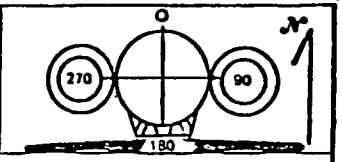
There was no condensate on the LH2 tank. Acreage ice/frost had formed on the +Y side of the tank from the cable tray/pressurization lines around approximately 190 degrees to the +Y-Z quadrant. The ice/frost was more predominant on the lower part of the tank from station XT-1600 to XT-2058. Ice/frost formation on the -Y-Z side of the lower LH2 tank had just started at the time of the Ice Team inspection. Average surface temperatures were measured as 45 degrees F on the windward side of the tank and 31 degrees F in the frost areas. Five ice areas had formed around the third hardpoint closeout along the isochem lines. One 1/2-inch ice spot formed on the aft dome siphon man hole cover leak check port closeout and another ice spot was visible on the aft dome leak check closeout.

Normal amounts of ice were present in all LO2 feedline bellows. Normal amounts of ice/frost were present in the LO2 feedline support brackets.

The LH2 ET/ORB umbilical exhibited less ice but slightly more than normal accumulations of frost. The LO2 ET/ORB umbilical exhibited less than usual ice/frost accumulations. Frost fingers had formed on the purge vents and normal venting was occurring. There were no unusual vapors emanating from the umbilicals or any evidence of leakage.

There was little frost in the LH2 feedline bellows. Both LH2 recirculation line bellows were filled with frost.

STS-36	TEST: S0007 RSS COMPUTER SCRUB					DATE: 2/24/90	T-0 TIME: DATE: 2/25/90
ORBITER	ET	SRB	MLP	PAD	LO_2 CHILLDOWN TIME: 16:29 SLOW FILL TIME: 17:08	FAST FILL TIME: 17:21 REPLENISH TIME: 0:24	LH_2 CHILLDOWN TIME: 16:30 SLOW FILL TIME: 0:24	FAST FILL TIME: 7:03 REPLENISH TIME: 22:59
OV-104	33	BI-036	1	A				



LOCAL TIME	CONDITIONS					LO_2 TANK STA 370 TO 540					LO_2 TANK STA 550 TO 852					LH_2 TANK STA 1130 TO 1380					LH_2 TANK STA 1380 TO 2058				
	TEMP. °F	REL HUM. %	DEW PT °F	WIND VEL KNTS	WIND DIR DEG	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR
1515	64.20	29.8	31.89	7	243	VI	4.13	44.59	0.0000	-.0314	VI	4.13	36.09	0.0000	-.0121	IV	2.24	27.76	0.0004	0.0134	VI	9.52	45.59	0.0000	-.0660
1530	64.80	28.6	31.48	10	240	VI	5.90	48.40	0.0000	-.0588	VI	5.90	41.28	0.0000	-.0333	V	3.20	31.66	0.0000	0.0010	VI	13.60	50.07	0.0000	-.1120
1545	64.40	27.6	30.43	8	246	VI	4.72	45.90	0.0000	-.0440	VI	4.72	37.94	0.0000	-.0189	IV	2.56	28.75	0.0002	0.0095	VI	10.88	47.27	0.0000	-.0810
1600	65.20	28.6	31.78	9	213	VI	5.31	47.85	0.0000	-.0535	VI	5.31	40.31	0.0000	-.0281	IV	2.88	30.94	0.0001	0.0037	VI	12.24	49.36	0.0000	-.0998
1615	65.20	28.4	31.63	10	217	VI	5.90	48.80	0.0000	-.0601	VI	5.90	41.65	0.0000	-.0347	VI	3.20	32.04	0.0000	0.0000	VI	13.80	50.00	0.0000	-.1144
1630	65.60	29.0	32.37	12	234	I	7.08	50.82	0.0000	-.0760	I	7.08	44.34	0.0000	-.0503	I	3.84	35.01	0.0000	-.0091	I	16.32	52.64	0.0000	-.1480
1645	65.40	27.4	31.03	12	225	VI	7.08	50.55	0.0000	-.0740	VI	7.08	44.09	0.0000	-.0484	VI	3.84	34.75	0.0000	-.0078	VI	16.32	52.42	0.0000	-.1446
1700	65.40	27.4	31.03	10	254	VI	5.90	48.92	0.0000	-.0606	VI	5.90	41.80	0.0000	-.0352	VI	4.30	36.34	0.0000	-.0131	VI	12.10	49.39	0.0000	-.0993
1715	65.20	28.4	31.63	10	242	VI	5.90	48.80	0.0000	-.0601	VI	5.90	41.65	0.0000	-.0347	VI	3.20	32.04	0.0000	0.0000	VI	13.60	50.44	0.0000	-.1143
1730	64.80	28.6	31.48	12	229	VI	7.08	50.02	0.0000	-.0719	VI	7.08	43.56	0.0000	-.0463	VI	3.84	34.22	0.0000	-.0063	VI	16.32	51.87	0.0000	-.1407
1745	64.20	31.0	32.72	10	233	I	5.90	47.95	0.0000	-.0586	I	5.90	40.80	0.0000	-.0331	III	3.20	31.68	0.0001	0.0014	I	13.60	49.54	0.0000	-.1119
1800	63.40	34.2	34.30	7	228	I	4.13	44.06	0.0000	-.0390	I	4.13	35.53	0.0000	-.0138	III	2.24	28.09	0.0006	0.0127	I	9.52	44.93	0.0000	-.0698
1815	62.00	33.8	32.88	9	216	I	5.31	44.97	0.0000	-.0454	I	5.31	37.46	0.0000	-.0201	III	2.88	29.30	0.0004	0.0100	I	12.24	46.39	0.0000	-.0863
1830	61.00	35.4	33.10	10	217	I	5.90	45.00	0.0000	-.0488	I	5.90	37.91	0.0000	-.0234	III	3.20	29.82	0.0004	0.0087	I	13.60	46.55	0.0000	-.0951
1845	59.60	40.0	34.82	8	220	I	4.72	41.84	0.0000	-.0357	I	4.72	34.16	0.0001	-.0104	III	2.56	27.18	0.0008	0.0167	I	10.88	42.93	0.0000	-.0676

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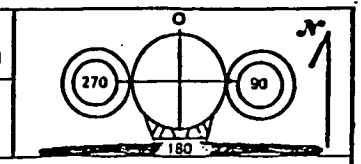
FIGURE 3. Ice/Frost Computer Predictions

STS – 36	TEST: S0007 RSS COMPUTER SCRUB	DATE: 2/24/90	T-0 TIME: DATE: 2/25/90

ORBITER	ET	SRB	MLP	PAD	LO_2				LH_2			
					CHILLDOWN TIME:	16:29	FAST FILL TIME:	17:21	CHILLDOWN TIME:	16:30	FAST FILL TIME:	7:03
OV– 104	33	BI – 036	1	A	SLOW FILL TIME:	17:08	REPLENISH TIME:	0:24	SLOW FILL TIME:	16:41	REPLENISH TIME:	0:24



LOCAL TIME	CONDITIONS					LO_2 TANK STA 370 TO 540					LO_2 TANK STA 550 TO 852					LH_2 TANK STA 1130 TO 1380					LH_2 TANK STA 1380 TO 2058				
	TEMP. °F	REL HUM. %	DEW PT °F	WIND VEL KNTS	WIND DIR DEG	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR
1900	58.80	43.8	36.46	7	231	I	4.13	40.00	0.0000	-.0300	II	4.13	33.06	0.0006	-.0047	III	2.24	25.69	0.0010	0.0203	I	9.52	40.72	0.0000	-.0555
1915	57.00	51.2	38.87	8	211	I	4.72	39.74	0.0000	-.0358	II	4.72	34.09	0.0009	-.0101	III	2.56	26.94	0.0013	0.0180	I	10.88	40.62	0.0000	-.0691
1930	57.00	56.0	41.26	5	218	II	2.95	37.50	0.0005	-.0198	III	2.95	30.86	0.0014	0.0057	III	1.60	24.60	0.0015	0.0248	II	6.80	37.46	0.0011	-.0335
1945	56.80	58.0	42.00	8	205	II	4.72	40.64	0.0003	-.0418	II	4.72	35.31	0.0014	-.0158	III	2.56	28.10	0.0016	0.0146	II	10.88	41.17	0.0004	-.0806
2000	56.80	58.0	42.00	7	210	II	4.13	39.86	0.0004	-.0348	II	4.13	34.00	0.0014	-.0089	III	2.24	26.50	0.0016	0.0186	II	9.52	40.29	0.0007	-.0654
2015	56.00	60.8	42.49	8	198	II	4.72	40.39	0.0005	-.0406	II	4.72	35.04	0.0015	-.0145	III	3.36	30.90	0.0017	0.0062	III	3.04	29.79	0.0017	0.0100
2030	56.00	61.0	42.58	8	219	II	4.72	40.43	0.0005	-.0408	II	4.72	35.08	0.0016	-.0147	III	2.56	27.83	0.0017	0.0157	II	10.88	41.00	0.0008	-.0791
2045	56.20	59.6	42.15	9	226	II	5.31	41.01	0.0003	-.0473	II	5.31	36.10	0.0014	-.0211	III	2.86	29.16	0.0017	0.0119	II	12.24	41.63	0.0003	-.0931
2100	58.20	59.8	44.19	10	247	II	5.90	43.61	0.0002	-.0663	II	5.90	39.12	0.0014	-.0397	III	3.20	31.99	0.0018	0.0001	I	13.60	44.21	0.0000	-.1303
2115	58.00	58.8	43.54	10	247	II	5.90	43.20	0.0001	-.0638	II	5.90	38.70	0.0013	-.0373	III	3.20	31.99	0.0017	0.0010	I	13.60	44.00	0.0000	-.1257
2130	57.60	57.6	42.60	12	256	I	7.08	44.02	0.0000	-.0742	II	7.08	39.50	0.0010	-.0476	II	5.16	35.92	0.0015	-.0198	I	14.52	44.24	0.0000	-.1289
2145	57.00	59.4	42.84	11	261	II	6.49	42.80	0.0000	-.0657	II	6.49	38.59	0.0012	-.0392	II	4.73	34.79	0.0017	-.0134	I	13.31	42.85	0.0000	-.1129
2200	56.00	61.4	42.75	12	260	II	7.08	42.63	0.0000	-.0687	II	7.08	38.66	0.0013	-.0422	II	5.16	35.01	0.0017	-.0153	I	14.52	42.75	0.0000	-.1200
2215	55.80	63.0	43.25	10	256	II	5.90	41.84	0.0004	-.0557	II	5.90	37.28	0.0016	-.0294	II	4.30	33.25	0.0019	-.0057	II	12.10	41.86	0.0008	-.0947
2230	56.20	63.8	43.98	10	251	II	5.90	42.40	0.0005	-.0591	II	5.90	37.86	0.0017	-.0326	II	4.30	33.81	0.0020	-.0083	II	12.20	42.42	0.0009	-.1004

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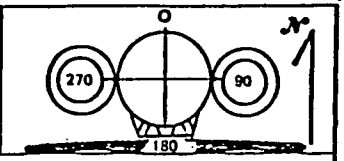
FIGURE 4. Ice/Frost Computer Predictions

STS – 36	TEST: S0007 RSS COMPUTER SCRUB					DATE: 2/24/90	T–0 TIME: DATE: 2/25/90
ORBITER OV– 104	ET 33	SRB BI–036	MLP 1	PAD A	LO_2 CHILLDOWN TIME: 16:29 SLOW FILL TIME: 17:08 FAST FILL TIME: 17:21 REPLENISH TIME: 0:24	LH_2 CHILLDOWN TIME: 16:30 SLOW FILL TIME: 16:41 FAST FILL TIME: 7:03 REPLENISH TIME: 0:24	



	CONDITIONS					LO_2 TANK STA 370 TO 540					LO_2 TANK STA 550 TO 852					LH_2 TANK STA 1130 TO 1380					LH_2 TANK STA 1380 TO 2058				
LOCAL TIME	TEMP. °F	REL. HUM. %	DEW PT °F	WIND VEL. KNTS	WIND DIR DEG	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR
2245	55.80	65.6	44.33	13	252	II	7.67	43.64	0.0003	–.0802	II	7.67	39.92	0.0016	–.0533	II	5.59	36.39	0.0020	–.0235	II	15.73	43.81	0.0004	–.1418
2300	55.40	67.4	44.67	10	252	II	5.90	42.29	0.0007	–.0584	II	5.90	37.72	0.0019	–.0319	II	4.30	33.63	0.0022	–.0075	II	12.10	42.34	0.0013	–.0996
2315	55.20	70.4	45.65	10	257	II	5.90	42.65	0.0009	–.0606	II	5.90	38.10	0.0021	–.0340	II	4.30	33.96	0.0023	–.0090	II	12.10	42.72	0.0017	–.1036
2330	55.00	73.2	46.50	9	259	II	5.31	42.39	0.0012	–.0550	II	5.31	37.45	0.0023	–.0283	II	3.87	33.12	0.0025	–.0048	II	10.89	42.39	0.0022	–.0923
2345	54.60	75.6	46.98	11	264	II	6.49	43.49	0.0012	–.0703	II	6.49	39.25	0.0025	–.0433	II	4.73	35.27	0.0027	–.0158	II	13.31	43.66	0.0022	–.1223
2400	54.80	77.4	47.82	10	253	II	5.90	43.52	0.0014	–.0660	II	5.90	38.98	0.0026	–.0390	II	4.30	34.80	0.0027	–.0127	II	12.10	43.64	0.0026	–.1132
0015	55.20	78.2	48.49	11	252	II	6.49	44.59	0.0014	–.0776	II	6.49	40.38	0.0027	–.0504	II	4.73	36.42	0.0029	–.0213	II	13.31	44.77	0.0026	–.1349
0030	55.20	77.8	48.35	11	254	II	6.49	44.51	0.0014	–.0771	II	6.49	40.31	0.0027	–.0499	II	4.73	36.34	0.0028	–.0209	II	13.31	44.69	0.0025	–.1341
0035	55.20	78.0	48.42	11	253	II	6.49	44.55	0.0014	–.0777	II	6.49	40.34	0.0027	–.0501	II	4.73	36.38	0.0028	–.0211	II	13.31	44.73	0.0026	–.1345
0040	55.20	78.8	48.70	12	255	II	7.08	45.13	0.0014	–.0864	II	7.08	41.20	0.0028	–.0590	II	5.16	37.44	0.0029	–.0277	II	14.52	45.35	0.0025	–.1520
0045	54.80	79.2	48.44	10	252	II	5.90	43.84	0.0015	–.0680	II	5.90	39.31	0.0028	–.0410	II	4.30	35.11	0.0028	–.0142	II	12.10	43.98	0.0028	–.1168
0050	54.80	80.0	48.71	10	253	II	5.90	43.99	0.0016	–.0689	II	5.90	39.45	0.0028	–.0418	II	4.30	35.25	0.0029	–.0148	II	12.10	44.13	0.0029	–.1184
0055	54.80	80.2	48.78	10	251	II	5.90	44.02	0.0016	–.0691	II	5.90	39.49	0.0028	–.0420	II	4.30	35.28	0.0029	–.0150	II	12.10	44.17	0.0029	–.1188
0100	54.80	81.0	49.05	9	245	II	5.31	43.58	0.0017	–.0618	II	5.31	38.88	0.0029	–.0348	III	2.88	31.99	0.0025	–.0027	II	12.24	44.38	0.0030	–.1222
0105	55.00	80.8	49.18	9	248	II	5.31	43.76	0.0017	–.0628	II	5.31	38.87	0.0029	–.0358	II	3.87	34.44	0.0029	–.0104	II	10.89	43.83	0.0031	–.1061

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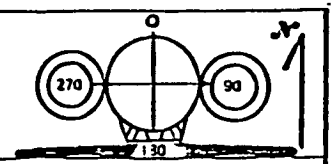
FIGURE 5. Ice/Frost Computer Predictions

STS – 36	TEST: S0007 RSS COMPUTER SCRUB	DATE: 2/24/90	T-0 TIME: DATE: 2/25/90

ORBITER	ET	SRB	MLP	PAD	LO_2			LH_2		
					CHILLDOWN TIME: 16:29	FAST FILL TIME: 17:21		CHILLDOWN TIME: 16:30	FAST FILL TIME: 7:03	
OV– 104	33	BI–036	1	A	SLOW FILL TIME: 17:08	REPLENISH TIME: 0:24		SLOW FILL TIME: 16:41	REPLENISH TIME: 0:24	



LOCAL TIME	CONDITIONS					LO_2 TANK STA 370 TO 540					LO_2 TANK STA 550 TO 852					LH_2 TANK STA 1130 TO 1380					LH_2 TANK STA 1380 TO 2058				
	TEMP. °F	REL HUM. %	DEW PT °F	WIND VEL KNTS	WIND DIR DEG	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR
0130	54.80	82.6	49.58	10	246	II	5.90	44.45	0.0018	–.0718	II	5.90	39.93	0.0030	–.0446	II	3.20	32.33	0.0026	–.0012	II	13.60	45.29	0.0031	–.1435
0145	55.00	83.6	50.10	10	252	II	5.90	44.84	0.0018	–.0742	II	5.90	40.33	0.0031	–.0470	II	4.30	36.12	0.0031	–.0188	II	12.10	45.00	0.0033	–.1277
0200	55.00	84.6	50.43	10	240	II	5.90	45.02	0.0019	–.0753	II	5.90	40.51	0.0032	–.0480	II	3.20	32.88	0.0029	–.0033	II	13.60	45.86	0.0034	–.1504
0215	54.80	85.2	50.42	9	239	II	5.31	44.32	0.0020	–.0661	II	5.31	39.44	0.0031	–.0389	III	2.88	31.99	0.0028	0.0010	II	12.24	45.15	0.0035	–.1305
AVERAGE	58.3	57.3	41.4	9.7	W			44.1					38.6					32.3					44.6		

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FIGURE 6. Ice/Frost Computer Predictions

FIGURE 7. **POSSIBLE ENVIRONMENTAL CONDITIONS**

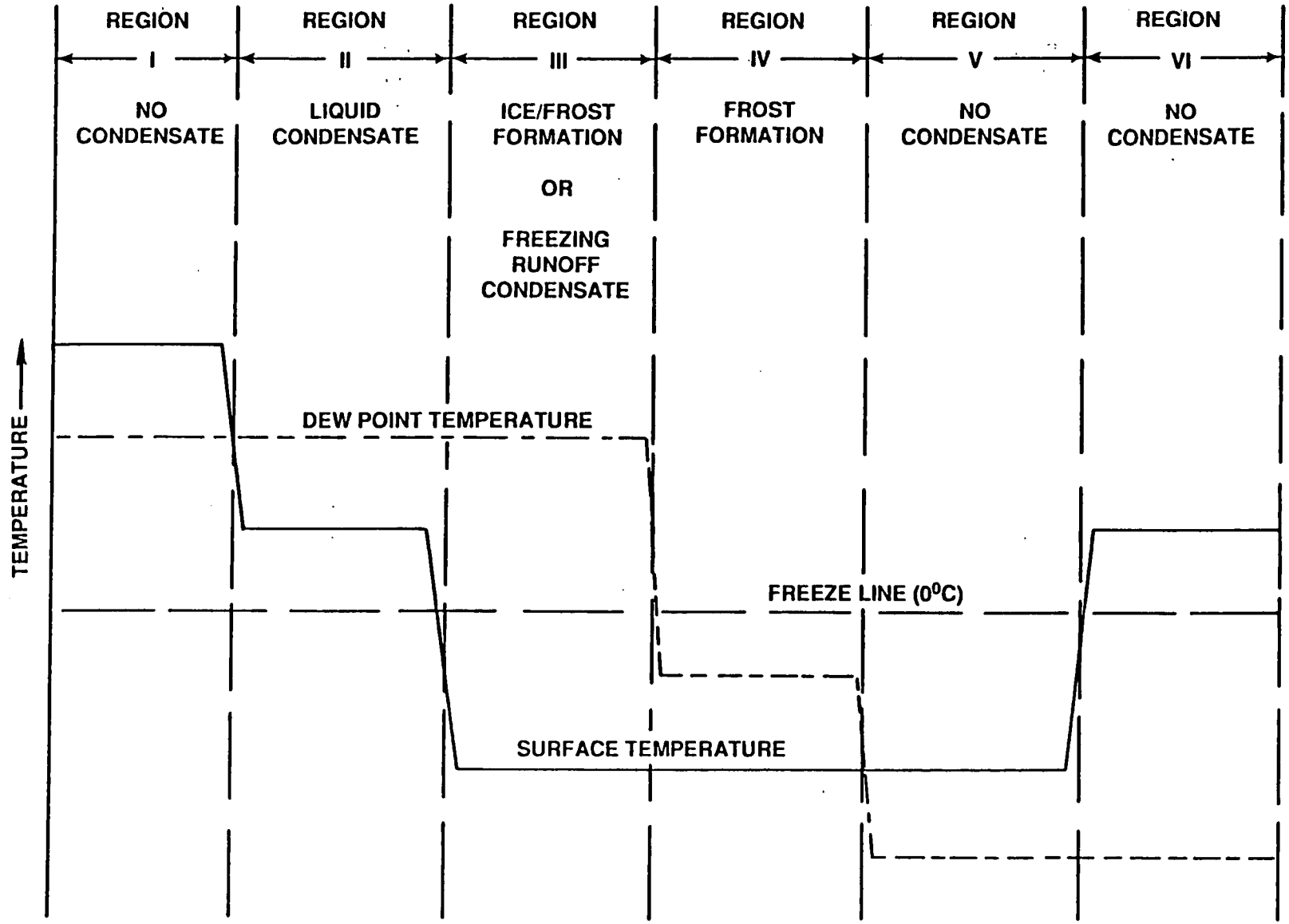


FIGURE 8. ET Surface Temperature from SurficeC

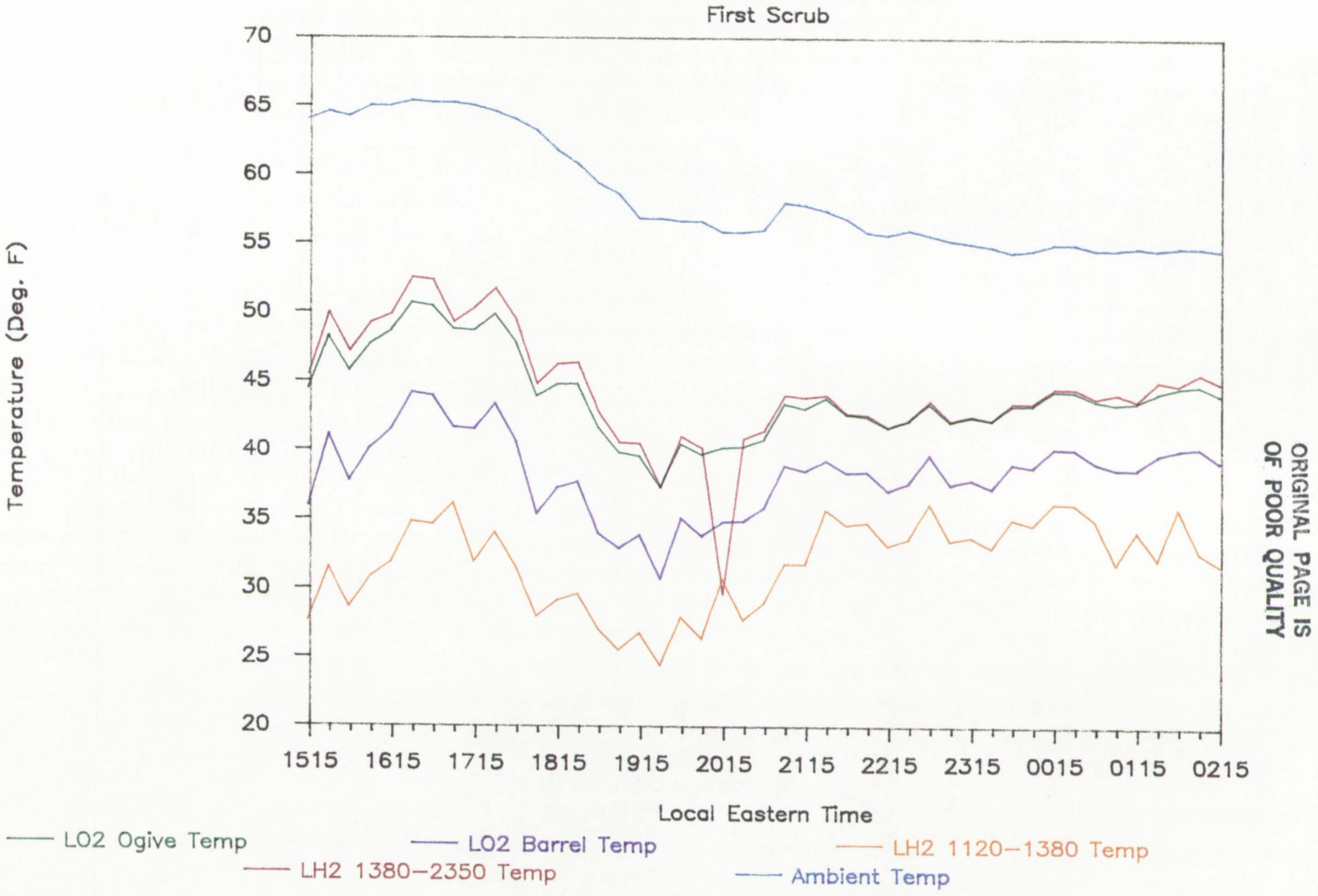


FIGURE 9. LOWER ET LH2 TANK TEMPERATURES

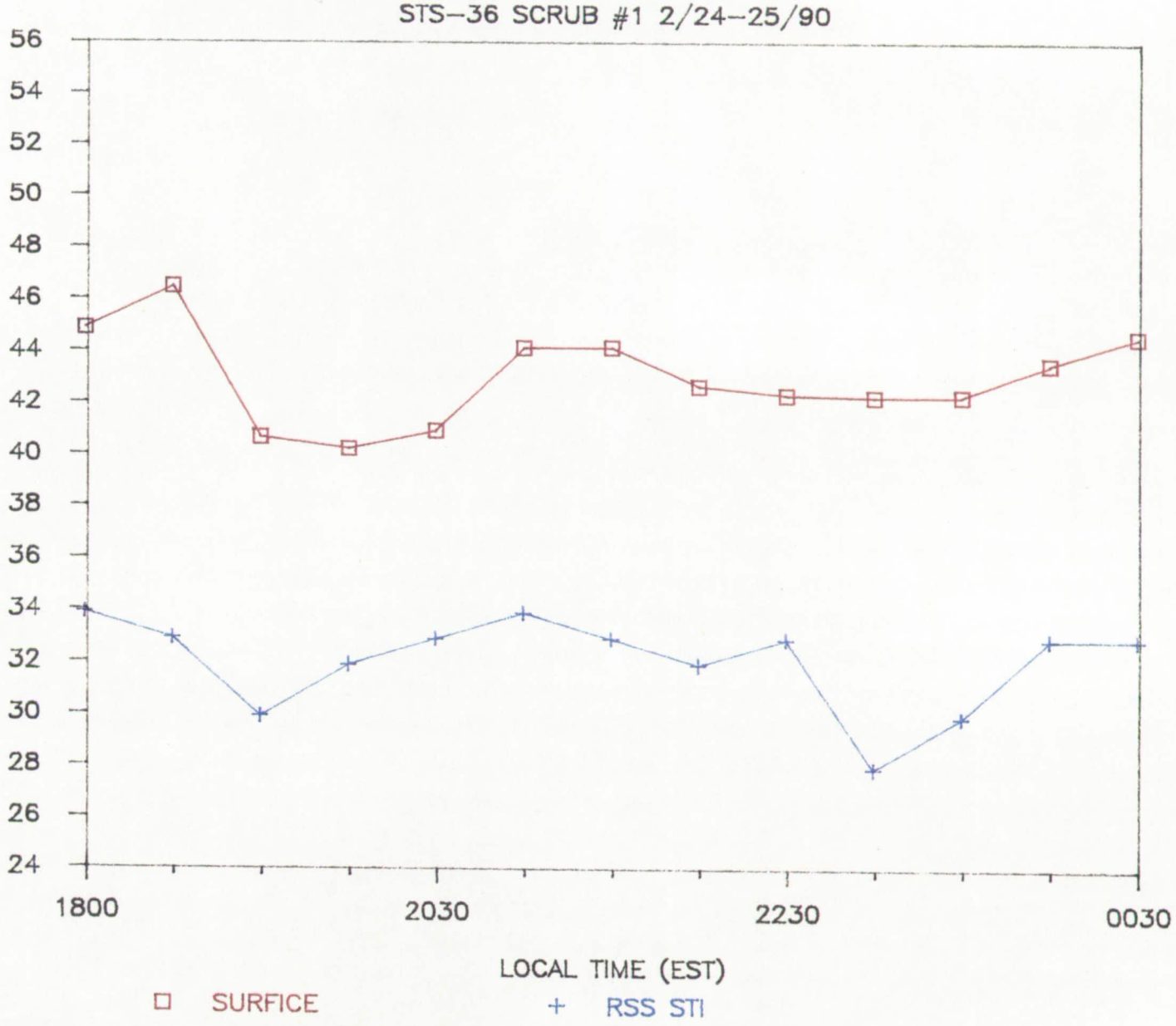
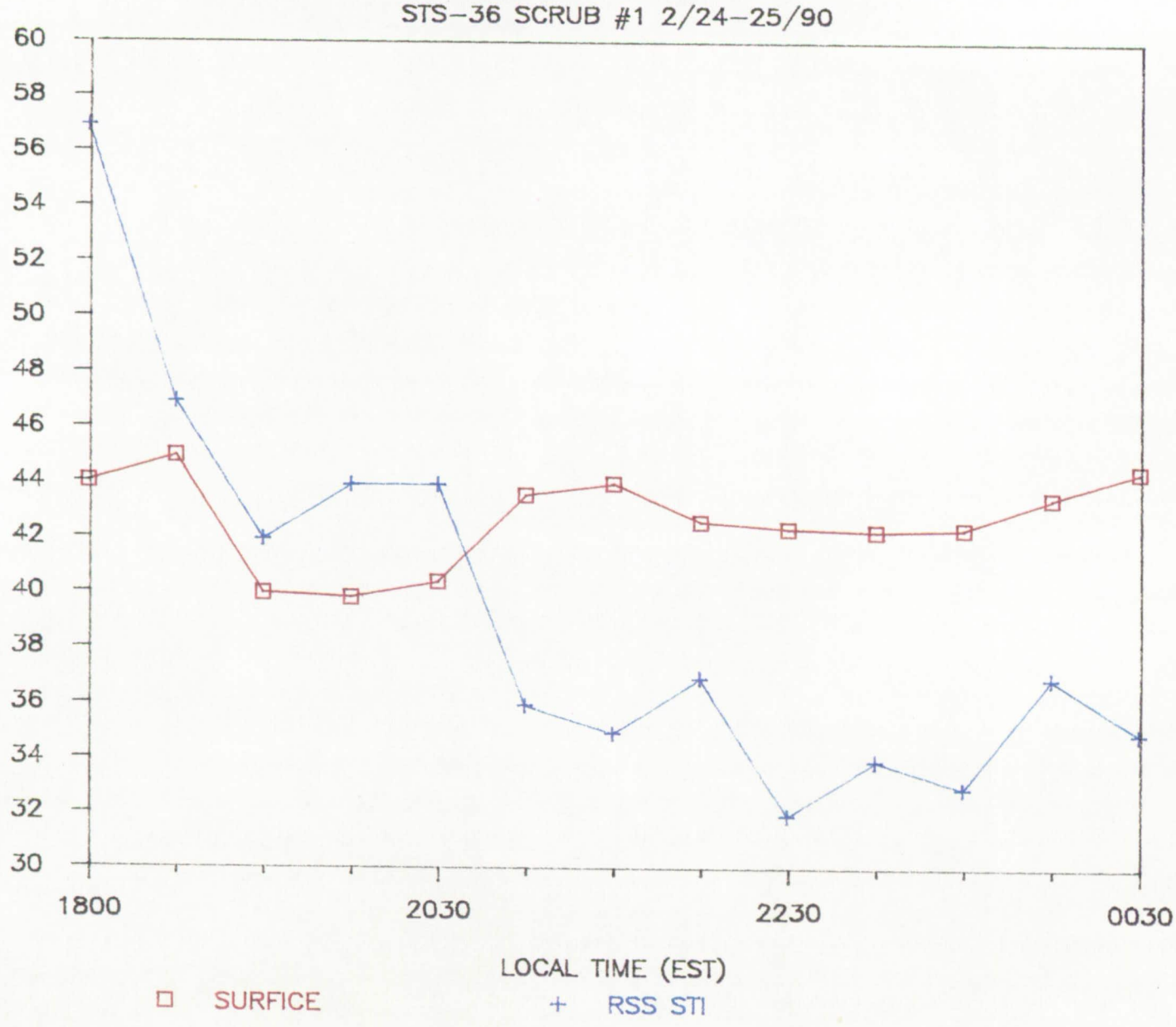


FIGURE 10. ET LO2 TANK OGIVE TEMPERATURES



Ice/Frost covered the lower EB fittings outboard to the strut pin hole with condensate on the rest of the fitting. The struts were dry and were not covered by ice.

The summary of Ice/Frost Team observation anomalies consisted of 10 OTV recorded items:

Anomaly 001 documented ice/frost accumulation in the LO2 feedline bellows. Ice/frost in the bellows was acceptable for flight per NSTS-08303.

Anomaly 002 recorded ice/frost formations along the cable tray and pressurization line ramps. These formations were acceptable per NSTS-08303.

Ice/frost growth on the third hardpoint closeout were acceptable per NSTS-08303 (Anomaly 003).

Anomaly 004, as reported by the Ice Inspection Team, was the accumulation of frost on the +Y (east) acreage of the LO2 and LH2 tanks. The frost was present on the LO2 tank from the cable tray around toward the -Z axis (approximately 120 degrees). Frost was present on the LH2 tank from the cable tray around the +Y side past the -Z axis (approximately 190 degrees). The nomographs predicted less than 1/16-inch ice. The frost did not exceed the Launch Commit Criteria and was acceptable per NSTS-08303.

Anomaly 005 recorded the appearance of frost in the intertank -Z side stringer valleys at both LO2 and LH2 tank flanges. This condition was acceptable per NSTS-08303.

An ice/frost spot on the ET aft dome +Z manhole leak check port closeout was acceptable per NSTS-08303 (Anomaly 006).

Anomaly 007 documented 3 frost spots on the +Y longeron closeout and an ice/frost formation in the longeron-to-thrust strut interface. These ice/frost formations were acceptable per NSTS-08303.

Anomaly 008 recorded a 1-inch icicle adhering to the north GOX vent duct exit. The icicle intermittently dripped liquid water. The icicle later fell off without damaging the vehicle.

Ice formed on the top surface and the outboard side of the LH2 ET/ORB umbilical. Ice/frost fingers were also present on the purge vents (Anomaly 009). This type of ice/frost accumulation typically occurs on every cryo-loading and was acceptable per NSTS-08303.

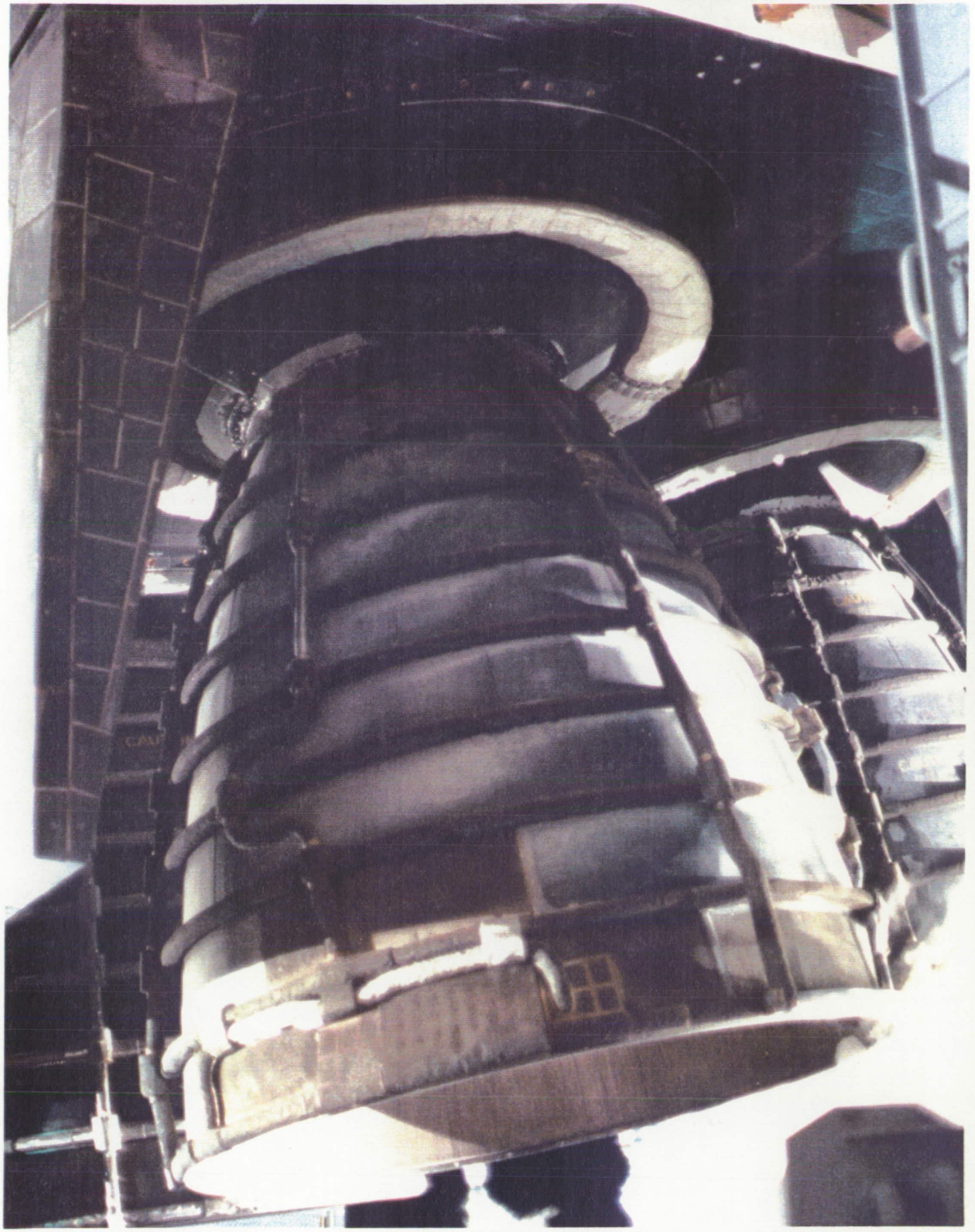
Anomaly 010 documented ice/frost fingers on the LO2 umbilical purge vents. This condition has occurred on previous launches and is acceptable per NSTS-08303.

4.5 FACILITY OBSERVATIONS

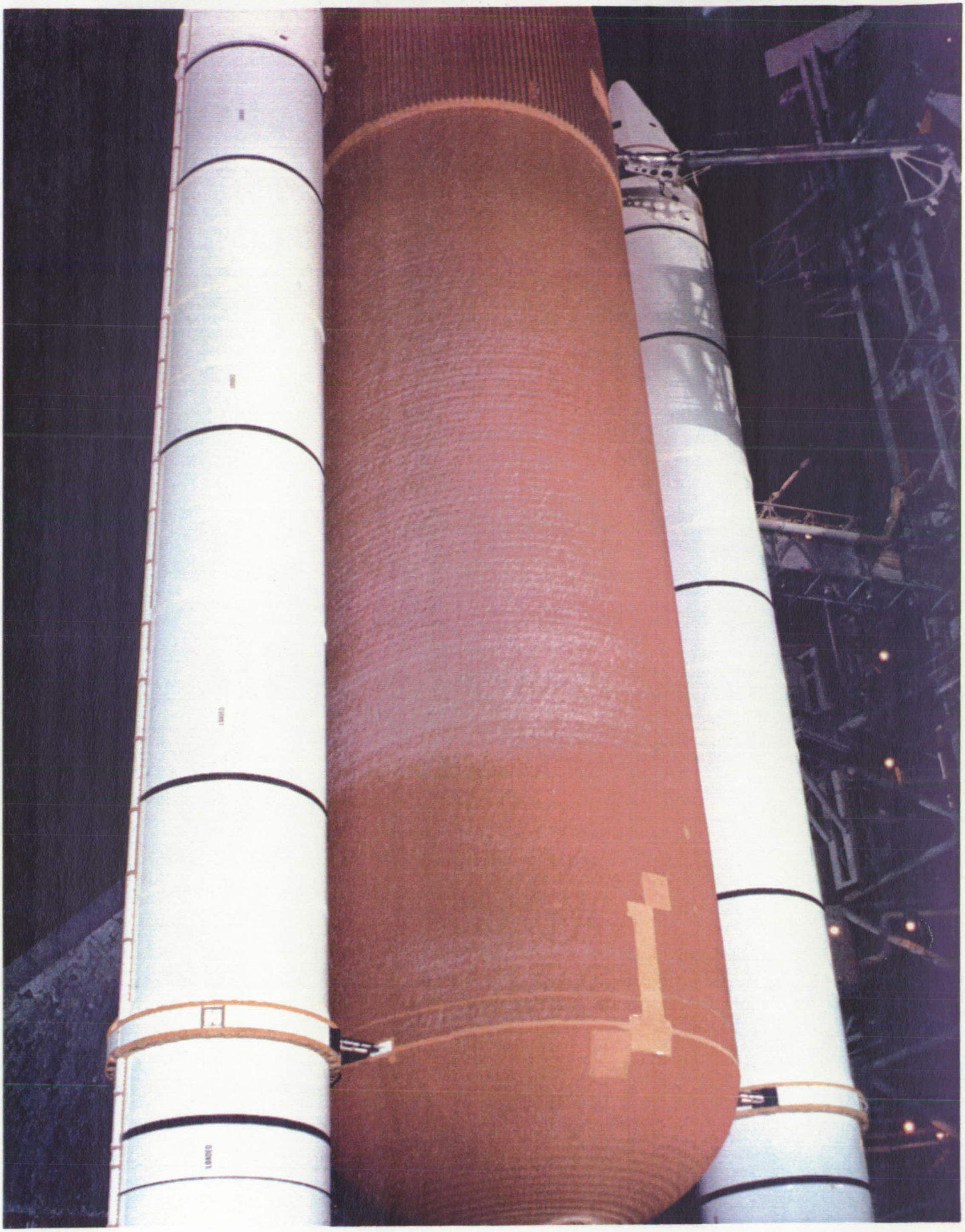
All debris concerns previously identified had been resolved prior to cryoloading and no new items were noted during the walkdown. No leaks were observed at either the LO2 or LH2 ORB T-0 umbilical carrier plates, though small amounts of ice/frost had formed. There was no apparent leakage anywhere on the GH2 vent line. The modification to the GH2 vent line prevented ice from forming but some ice/frost, which was expected, had accumulated on the GUCP legs.

Visual and infrared observations of the GOX seals confirmed no leakage. However, 4 inch icicles had formed at the end of the north GOX vent duct. Since the prevailing winds were blowing away from the vehicle, management decided there was no need to remove the icicles.

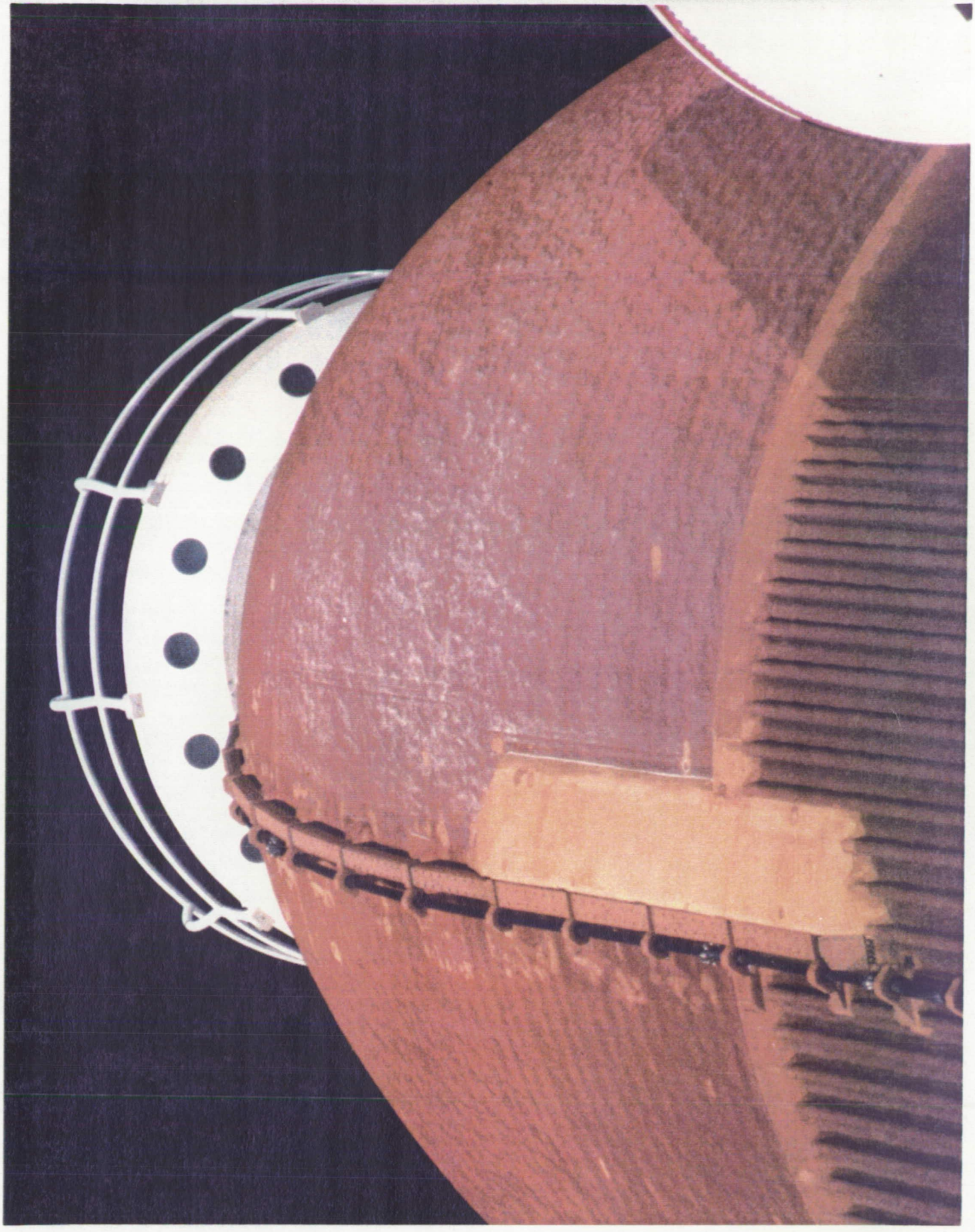
All sound suppression water troughs were full of water. The ET/ORB hydrogen detection sensor tygon tubing was removed from the vehicle without any problems. Two safety ropes inadvertently left along the crossover from the FSS 95 foot level to the MLP zero level were removed by the Ice Team.



Ice/frost accumulation on SSME #1 and #2 engine mounted heat shield-to-nozzle interface



Frost accumulation on the LH2 tank acreage -Z side at the time of the Ice Team inspection at T-3 hours

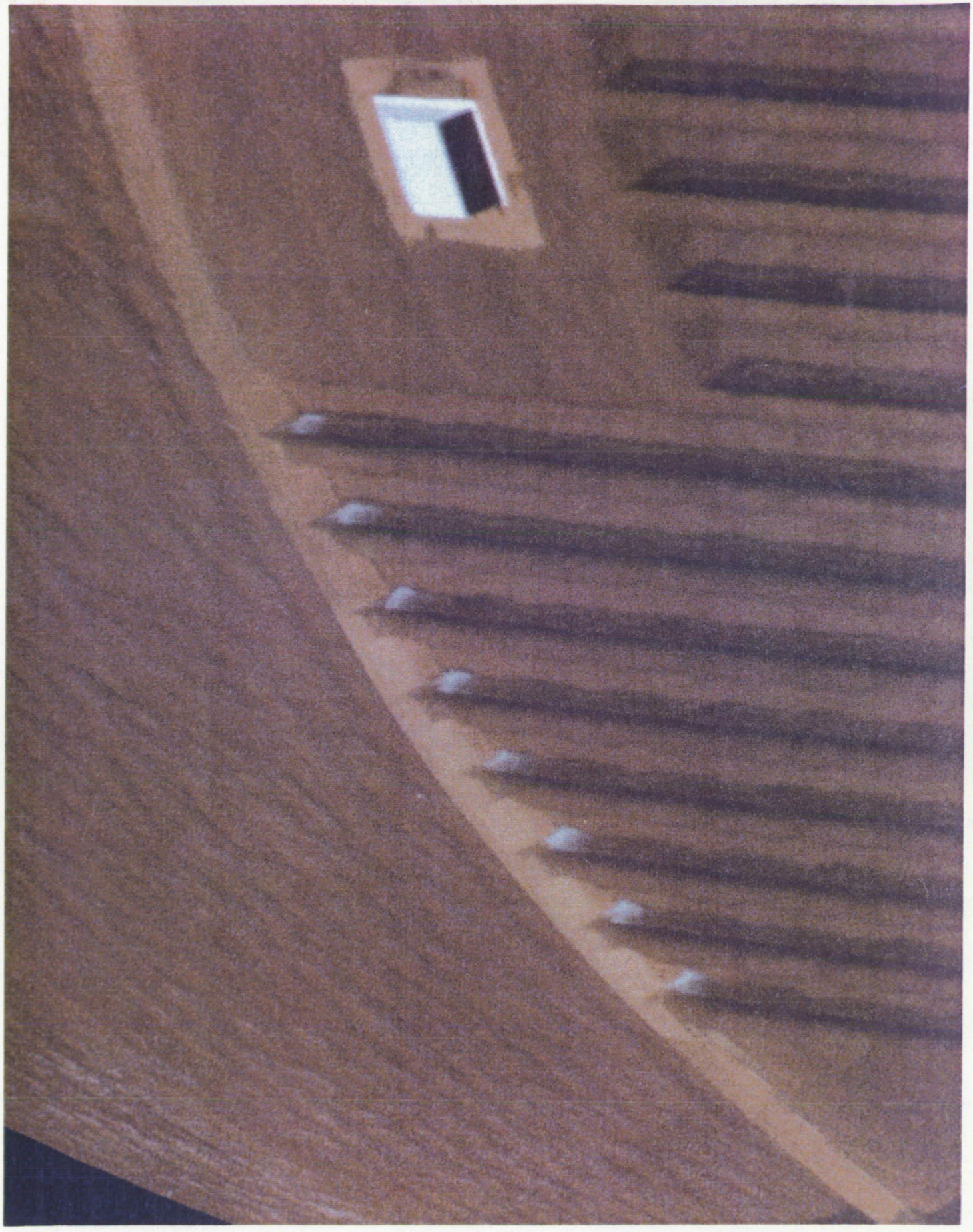


Frost accumulation on the LO2 tank barrel section acreage
+Z side at T-3 hours in the countdown

Frost accumulation on the LH2 tank acreage +Y+Z quadrant visible during the Ice Team inspection

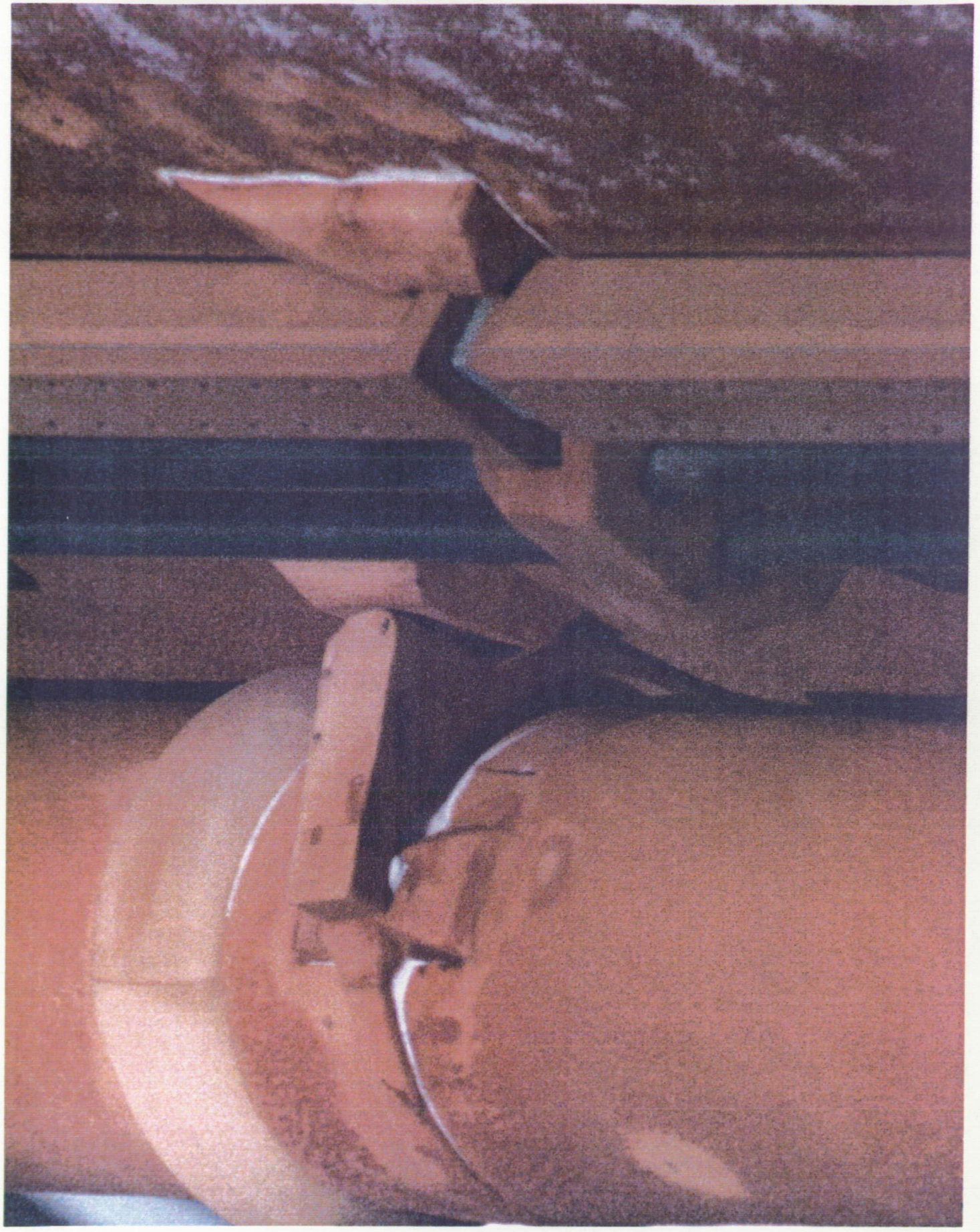
Frost accumulation along the PAL ramp-to-LH2 tank acreage interface

Close-in view of frost accumulation on the LH2 tank acreage



Ice/frost had formed in the intertank -Z side stringer valleys at the LO2 tank flange

Typical ice/frost formation in the LO2 feedline upper bellows

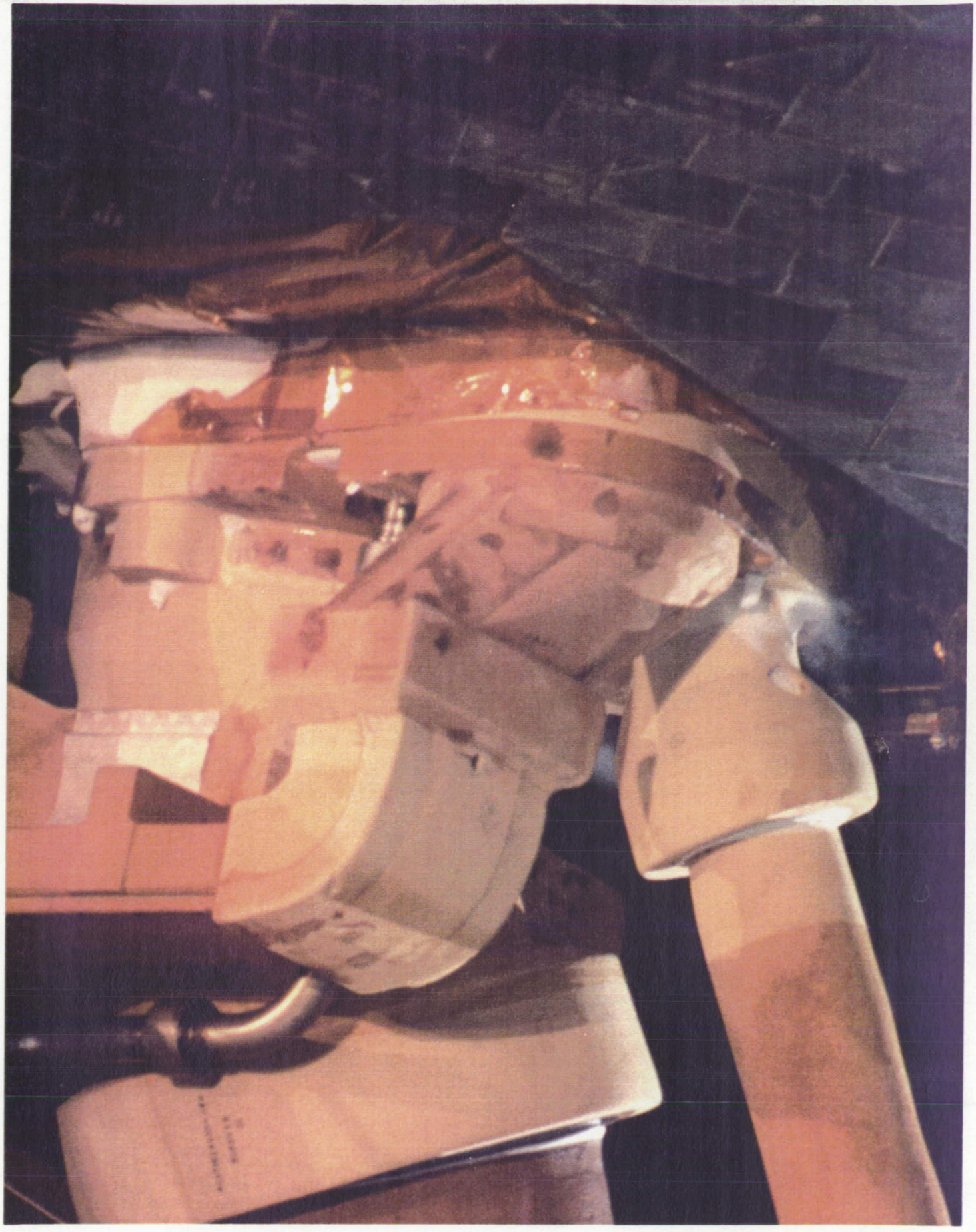


Ice/frost formed along the cable tray ramps and in the LO2 feedline support brackets

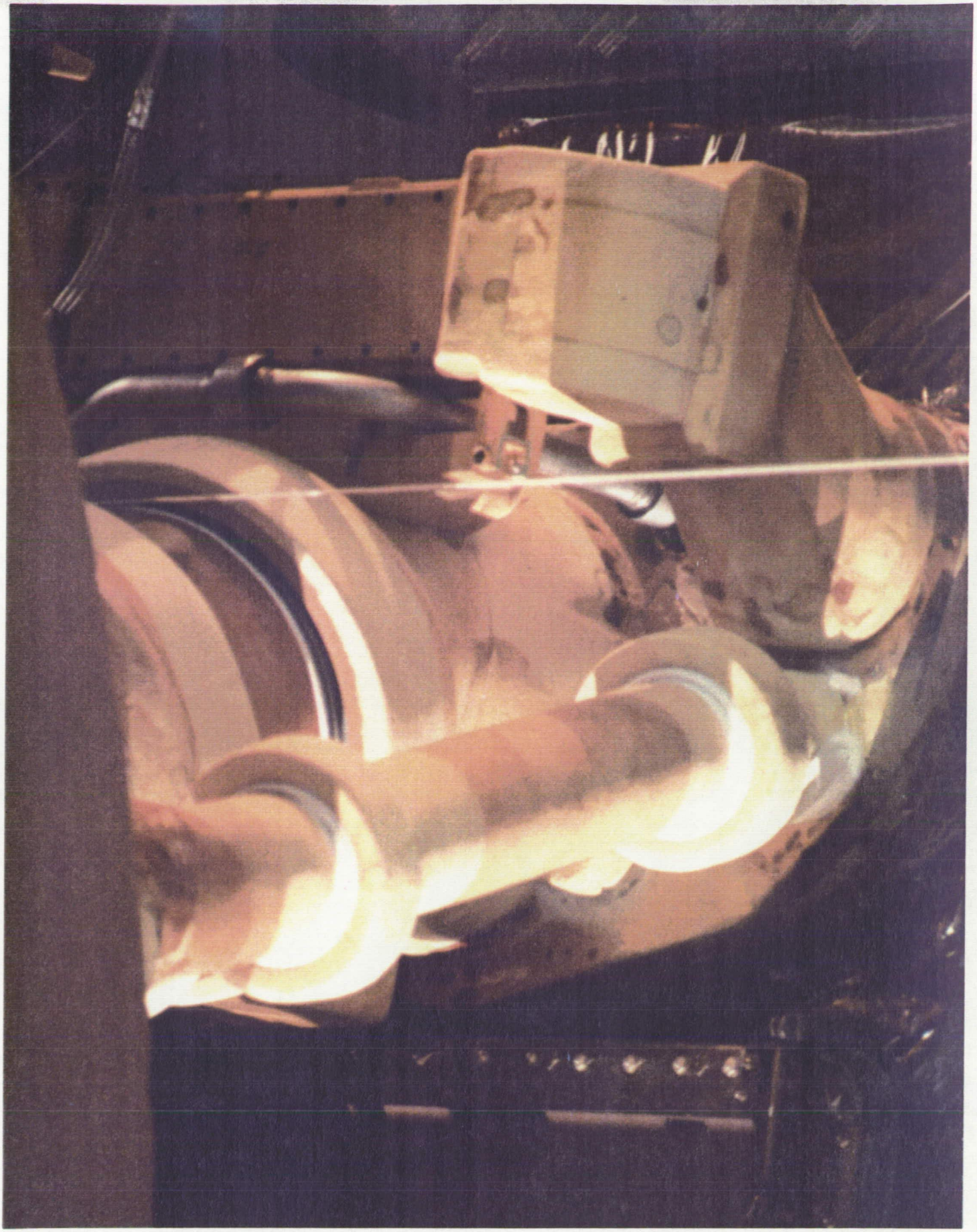
Ice/frost accumulations in the LO2 feedline lower bellows and support brackets

Light formation of ice/frost on the LO2 ET/ORB umbilical cavities, baggie material, and purge vents

Ice/frost accumulation on the LO2 ET/ORB umbilical aft and inboard sides. Note frost finger on aft purge vent.

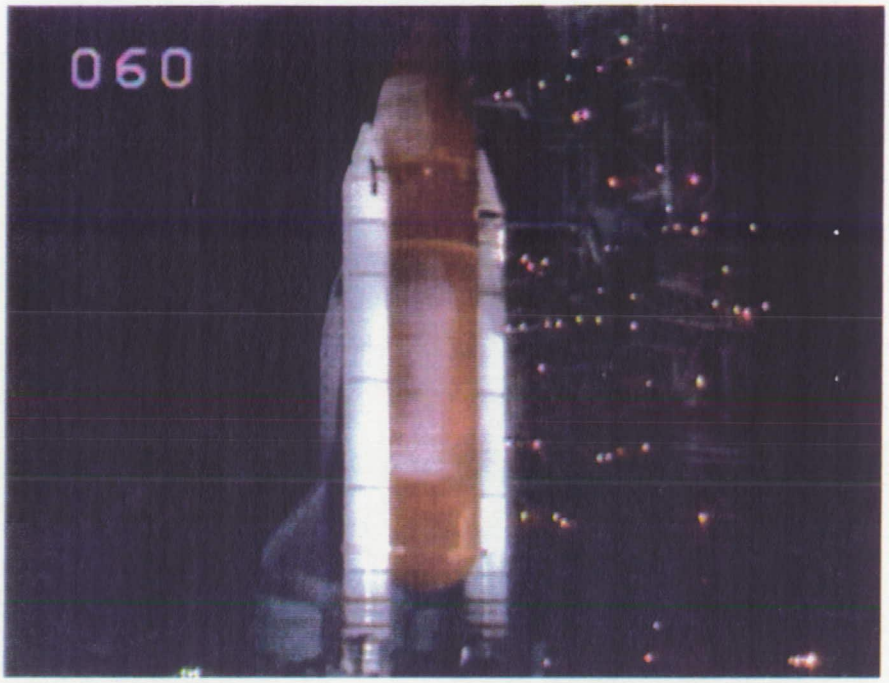


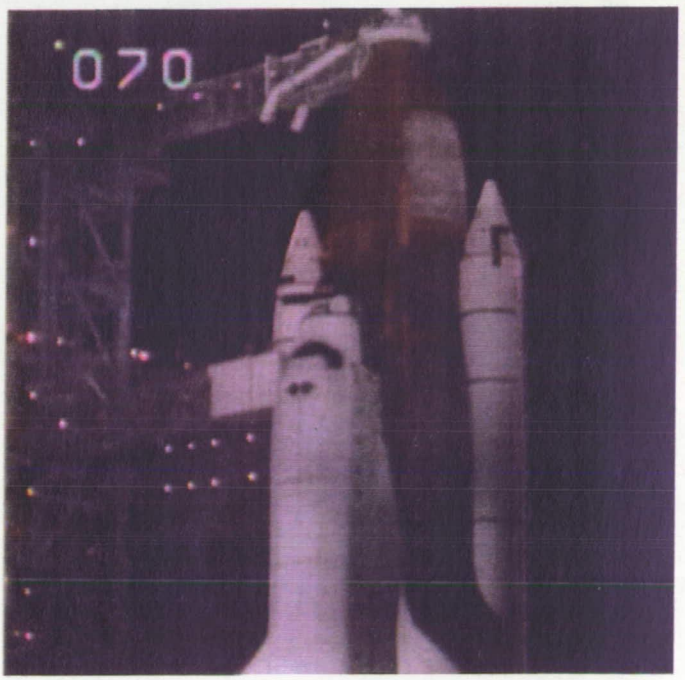
Ice/frost had formed on LH2 ET/ORB umbilical top and outboard sides. Frost fingers on purge vents are typical.



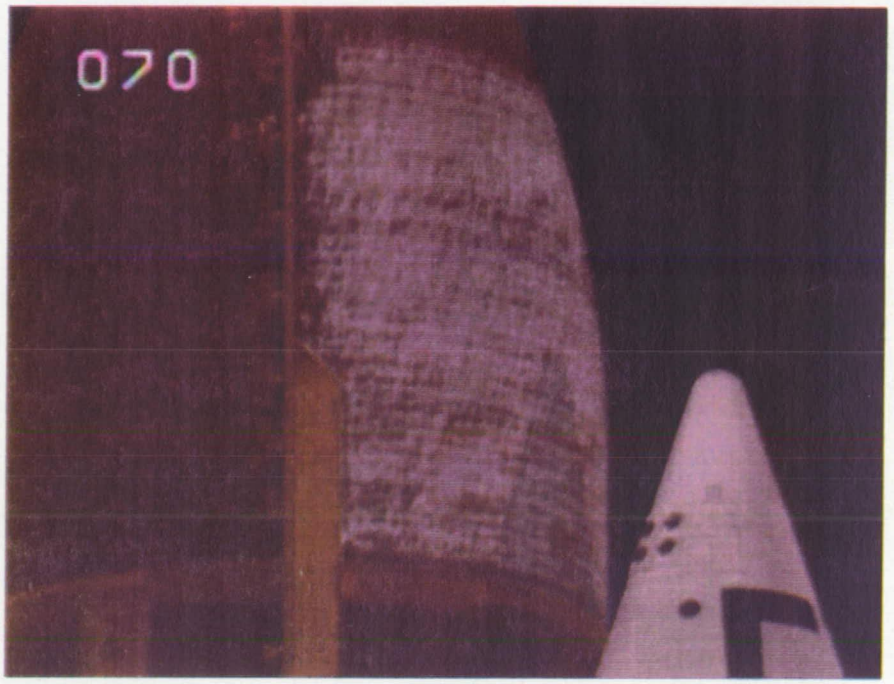
Both LH2 recirculation line bellows were filled with ice and frost, but the LH2 feedline bellows was clear

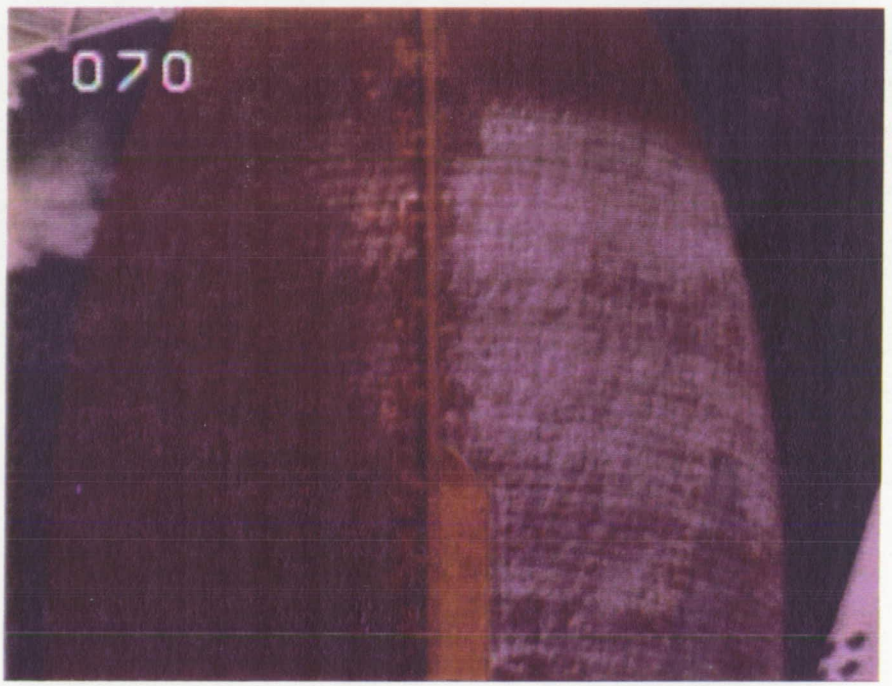
Small areas of ice/frost outline the ET third hardpoint





More frost has accumulated on the LO2 and LH2 tanks at the tartgeted T-0 time as seen on OTV cameras 070, TV-7, 060





OTV camera 070 shows the additional accumulation of frost on the +Z side of the LO2 tank during the launch window

4.6 POST DRAIN INSPECTION

The STS-36 launch was scrubbed at T-31 seconds due to a Range Safety backup computer failure. Both the LH2 and LO2 tanks had been filled to 100 percent. A post-drain inspection was performed at Pad 39A from 0530 to 0630 hours on 25 February 1990. A 24-hour Scrub Turnaround was initiated, so the SSV post drain inspection and the preflight pad debris inspection were combined.

The tumble valve cover exhibited no anomalies. No damage was visible in the -Y side nosecone footprint area. The +Y nosecone footprint area was inaccessible for inspection.

No TPS damage, such as divots or cracks on the tank acreage, was visible.

A crack 8 inches long in the +Y LH2 longeron-to-thrust strut attach point interface was filled with ice. This has typically occurred after detanking other vehicles and is acceptable per NSTS-08303.

Ice had accumulated at both LH and RH SRB cable tray-to-upper strut fairing interfaces. Ice/frost was also present around the flow restrictors of both upper and diagonal ET/SRB struts on the +Y/-Y aft fairings.

A small amount of solid ice still remained in the LH2 feedline bellows and LH2 recirculation line bellows. Both burst disks on the LH2 recirculation line were covered by ice. Solid ice (5 inches long) was attached to five of the LH2 umbilical purge vents. Ice 1 inch thick still covered EB-7 and EB-8.

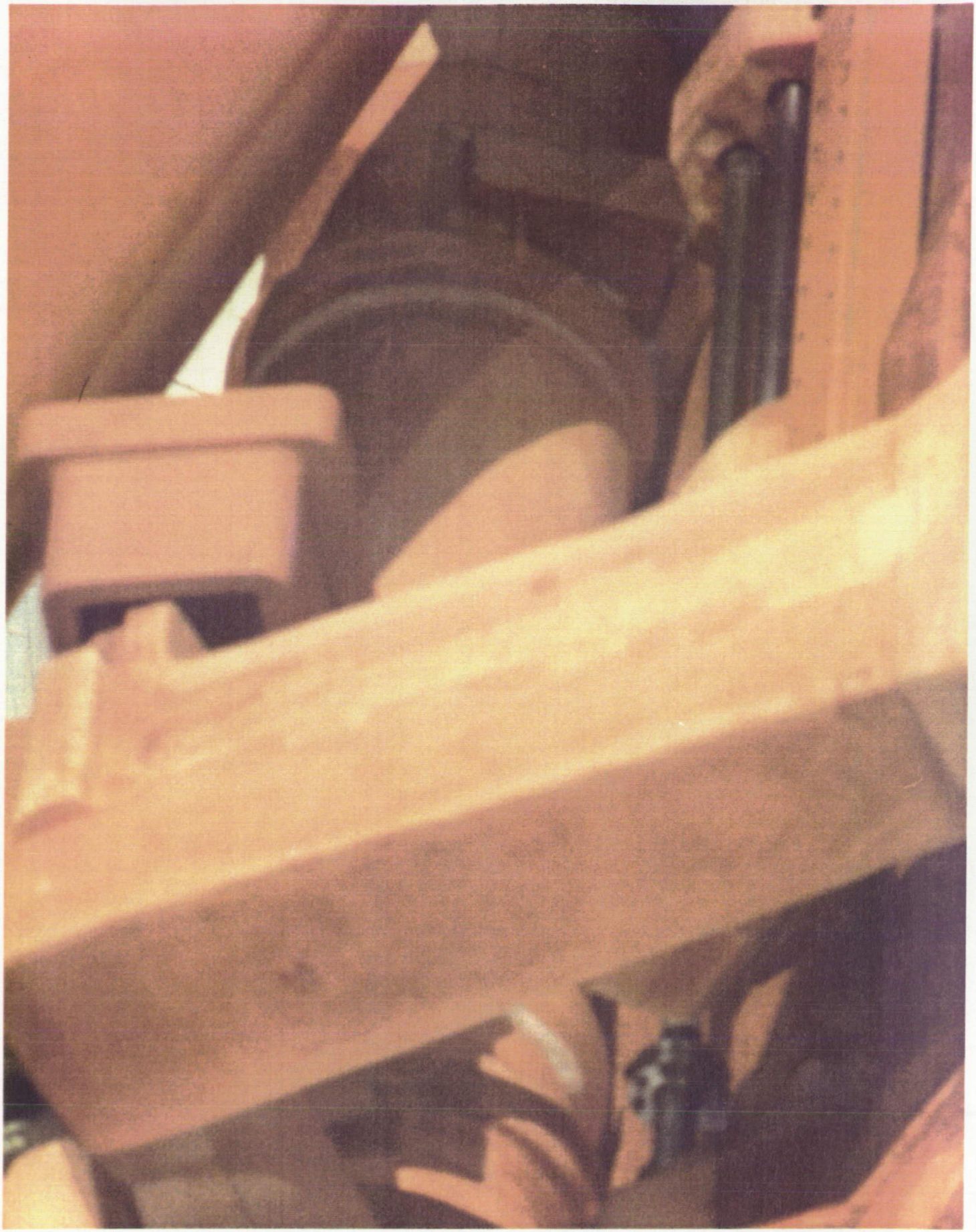
No ice/frost was visible on the LO2 ET/ORB umbilical. A solid ring of ice filled the LO2 feedline lower bellows. Less than usual amount of ice was present in all feedline support brackets. Since the RSS remained retracted the brackets could not be inspected in detail.

Ice 1 inch thick still covered EB-7 and EB-8. A small amount of ice had formed on the ET aft dome siphon manhole cover leak check port closeout.

All of this ice/frost has occurred previously on other vehicles and is acceptable per NSTS-08303.

There was no visible damage to the Orbiter or SRB TPS and the SRB sound suppression water troughs were full of water.

One Ice/Frost Team observation anomaly (#011) documented vapors emanating from the LH2 recirculation line/aft dome interface and from the SLA ablator in the area around the recirculation line burst disks. These vapors have occurred on previous detankings and were acceptable to the Ice/Frost/Debris Team.



Hard ice still remained in the LO2 feedline lower bellows and support brackets during the post drain inspection

Ice/frost covered the EB-7 and EB-8 fittings to the ET/SRB lower strut pin holes

5.0 SCRUB

The launch countdown for STS-36 was scrubbed at 0250 EST on 26 February 1990 due to adverse weather at the launch site.

5.1 ICE/FROST INSPECTION

The Ice/Frost Inspection of the cryoloaded vehicle was performed on 25 February 1990 from 1845 to 2016 hours during the two hour built-in-hold at T-3 hours in the countdown. There were no violations of NSTS-08303 or the Launch Commit Criteria. Ambient weather conditions at the time of the inspection were:

Temperature:	57.1 F
Relative Humidity:	64.2 %
Wind Speed:	17.3 Knots
Wind Direction:	343 Degrees

The portable STI infrared scanner was utilized to obtain surface temperature measurements for an overall thermal assessment of the vehicle, as shown in Figure 11 and 12.

5.2 ORBITER OBSERVATIONS

No Orbiter tile anomalies were observed. The average Orbiter surface temperature was recorded as 50 degrees F. The average surface temperatures of the SSME engine mounted heat shields were measured at 43 degrees F for SSME #1 (20 degrees coldest), 45 degrees F for SSME #2 (6 degrees coldest), and 45 degrees F for SSME #3 (23 degrees coldest). Frost, and very little condensate, had accumulated on the heatshield to nozzle interface of SSME #1 at 1-6, 7-8, and 10-11 o'clock positions. Frost was present on SSME #2 at the 9-6 o'clock position. There was no frost or condensate on SSME #3 heatshield. IPR 36RV-0182 was taken on the LH2 ET/ORB umbilical baggie material, which was torn/loose on the outboard side. The tear was located against the ET part of the umbilical and not in the purged area. The IPR was upgraded to PR MEQ-04-06-0282 and dispositioned to fly-as-is.

5.3 SRB OBSERVATIONS

No SRB anomalies or loose ablator/cork were observed. The STI portable infrared scanner recorded RH and LH SRB case surface temperatures between 47 to 51 degrees F. Temperatures in the area of the SRB field joint heater closeouts averaged 80-82 degrees F. The predicted Propellant Mean Bulk Temperature (PMBT) supplied by MTI was 66 degrees F.

FIGURE 11. **INFRA RED SCANNER SSV SUMMARY DATA**

TIME: 1845-2016
DATE: 2/25/90
VEH. STS- 36
Scrub #2

All temperatures are in degrees F.

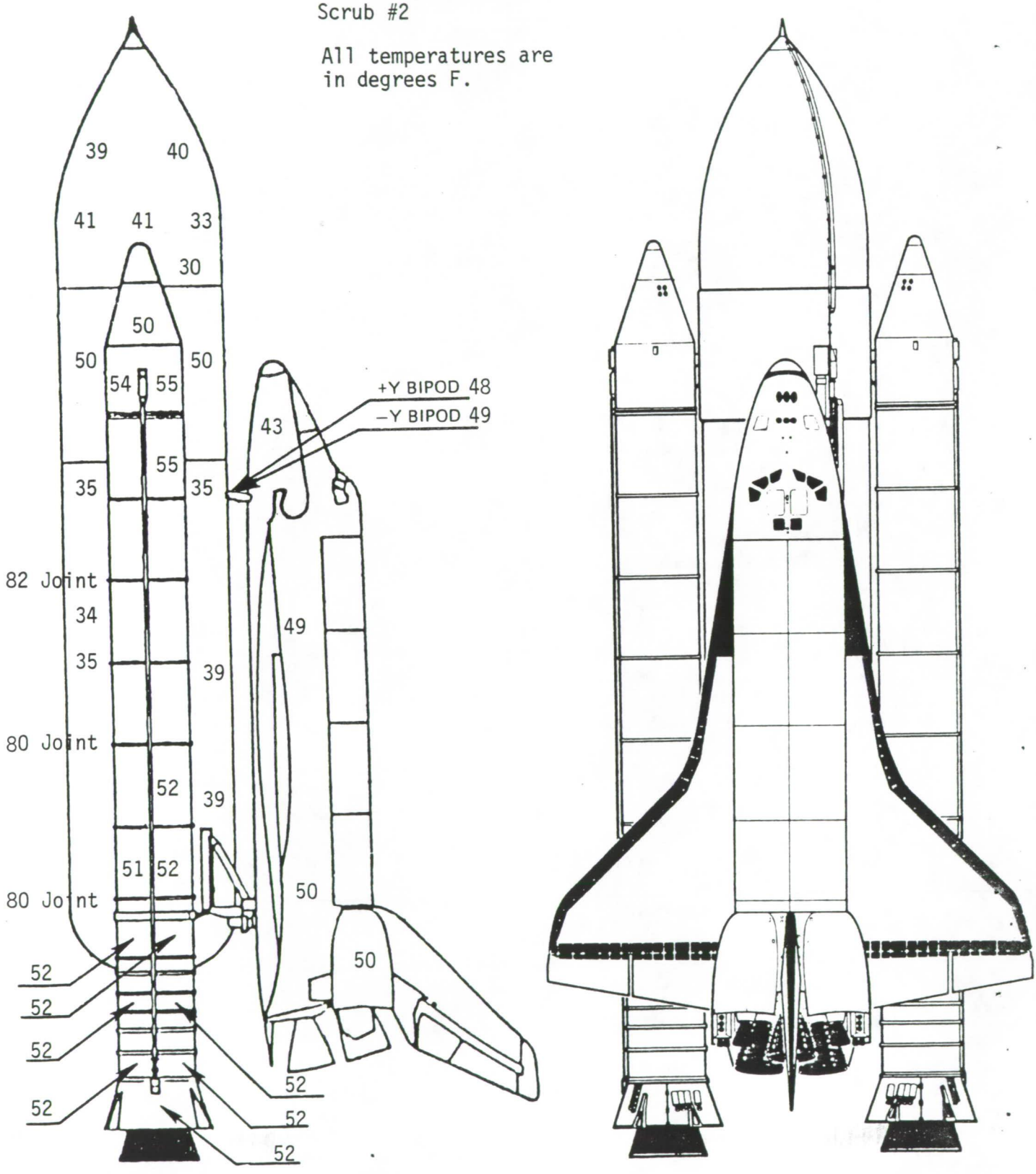
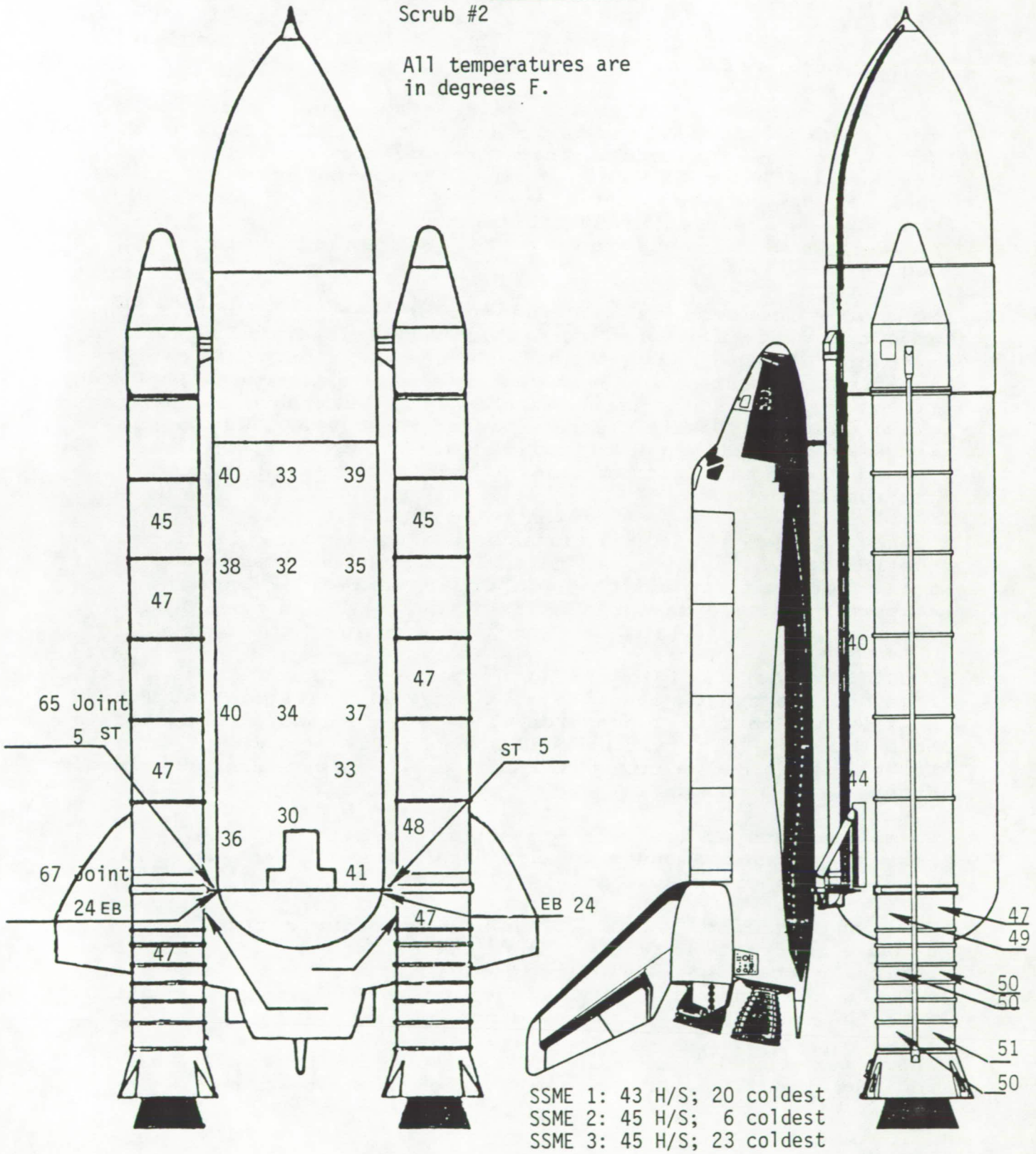


FIGURE 12. **INFRA RED SCANNER SSV SUMMARY DATA**



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5.4 EXTERNAL TANK OBSERVATIONS

The ice/frost prediction computer program was run from 1600 to 0200 hours and the results tabulated in Figures 13-16. The program predicted condensate with no ice accumulation on all TPS acreage surfaces.

The new design of the tumble valve cover was intact. A very, very light condensate was present on the LO2 tank with no run-on to the intertank. There was no acreage ice or frost. However, a frost line had formed along the edge of the PAL ramp. Frost had also accumulated under the first barrymount at the acreage ice/frost ramp. The surface temperature of the LO2 tank -Y side as measured by the IR scanner averaged 39-41 degrees F.

No run-on condensate was present on the intertank. Small amounts of ice/frost had formed in the stringer valleys on the -Z side of the tank along both the LO2 and LH2 tank-to-intertank flanges. The average surface temperature was 50 deg F. Minor frost accumulated on the GUCP, but there was no sign of leakage. A line of frost formed on the aft and outboard sides of the LH bipod closeout. Similarly, a frost line had formed along the isochem line in front of the LH bipod at the intertank closeout.

There was very little condensate and no acreage ice/frost on the LH2 tank. Some ice had formed along the PAL ramp to acreage interface and around the ice/frost ramps. Average surface temperatures were measured as 39-40 degrees F on the +Z side of the tank and 32-40 degrees F on the -Z side of the tank.

The TPS was cracked in the +Y longeron-to-thrust strut interface, but no frost was visible. A 1-1/2 inch iceball had formed halfway aft on the -Y longeron closeout. Ice had accumulated in both ET/SRB strut fairing-to-SRB cable tray joints. A line of frost had formed along the cable tray to acreage interface. Frost covered the drain holes.

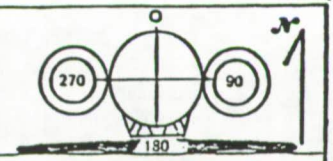
Normal amounts of ice were present in all LO2 feedline bellows. Less than usual amounts of ice/frost were present in the LO2 feedline support brackets.

Both the LH2 and LO2 ET/ORB umbilicals exhibited less than usual ice/frost accumulations. Frost fingers, smaller than typically observed, had formed on the purge vents and normal venting was occurring. There were no unusual vapors emanating from the umbilicals or any evidence of leakage.

There was little frost in the LH2 feedline bellows. Both LH2 recirculation line bellows were filled with ice/frost.

STS – 36	TEST: S0007 RTLS WEATHER SCRUB	DATE: 2/25/90	T–0 TIME: DATE: 2/26/90

ORBITER	ET	SRB	MLP	PAD	LO_2				LH_2			
					CHILLDOWN TIME:	20:28	FAST FILL TIME:	21:18	CHILLDOWN TIME:	20:28	FAST FILL TIME:	21:00
OV–104	33	BI–036	1	A	SLOW FILL TIME:	21:04	REPLENISH TIME:	23:24	SLOW FILL TIME:	20:37	REPLENISH TIME:	22:59



LOCAL TIME	CONDITIONS					LO_2 TANK STA 370 TO 540					LO_2 TANK STA 550 TO 852					LH_2 TANK STA 1130 TO 1380					LH_2 TANK STA 1380 TO 2058				
	TEMP. °F	REL HUM. %	DEW PT °F	WIND VEL. KNTS	WIND DIR DEG	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR
1600	59.20	57.4	44.06	18	346	I	10.62	48.87	0.0000	-.1305	II	10.62	43.76	0.0001	-.1029	II	7.92	41.21	0.0011	-.0638	I	17.82	47.64	0.0000	-.1878
1615	59.00	57.4	43.86	20	351	I	11.80	49.18	0.0000	-.1435	I	11.80	44.38	0.0000	-.1158	II	8.80	41.78	0.0009	-.0734	I	19.80	48.32	0.0000	-.2091
1630	59.00	57.4	43.86	17	349	I	10.03	48.07	0.0000	-.1212	II	10.03	42.23	0.0003	-.0938	II	7.48	40.57	0.0012	-.0567	I	16.83	46.94	0.0000	-.1729
1645	58.60	58.0	43.75	22	349	I	12.98	49.44	0.0000	-.1555	I	12.98	44.92	0.0000	-.1276	II	9.68	42.18	0.0007	-.0822	I	21.78	48.70	0.0000	-.2289
1700	58.20	58.6	43.64	15	350	I	8.85	46.39	0.0000	-.1019	II	8.85	41.91	0.0007	-.0747	II	6.60	38.99	0.0014	-.0420	I	14.85	45.05	0.0000	-.1424
1715	58.00	59.2	43.72	19	352	I	11.21	47.90	0.0000	-.1303	II	11.21	43.29	0.0002	-.1028	II	8.36	40.79	0.0011	-.0633	I	18.81	46.96	0.0000	-.1886
1730	57.80	57.4	42.70	16	341	I	9.44	46.43	0.0000	-.1036	II	9.44	41.88	0.0004	-.0765	II	7.04	38.86	0.0012	-.0433	I	15.84	45.25	0.0000	-.1458
1745	57.80	59.6	43.71	15	348	I	8.85	46.00	0.0000	-.1004	II	8.85	41.73	0.0008	-.0733	II	6.60	38.78	0.0001	-.0409	I	14.85	44.88	0.0000	-.1403
1800	57.40	61.2	44.03	15	343	I	8.85	45.65	0.0000	-.0999	II	8.85	41.66	0.0010	-.0728	II	6.60	38.71	0.0016	-.0404	I	14.85	44.29	0.0000	-.1397
1815	57.20	62.0	44.18	18	336	I	10.62	46.78	0.0000	-.1214	II	10.62	42.78	0.0007	-.0939	II	8.28	40.51	0.0014	-.0607	I	22.14	47.49	0.0000	-.2251
1830	57.00	63.8	44.76	21	338	I	12.39	47.67	0.0000	-.1444	II	12.39	43.82	0.0006	-.1170	II	9.24	41.47	0.0014	-.0737	I	20.79	46.82	0.0000	-.2125
1845	57.00	63.6	44.67	19	338	I	11.21	46.99	0.0000	-.1299	II	11.21	43.23	0.0008	-.1023	II	8.36	40.70	0.0016	-.0626	I	18.81	46.02	0.0000	-.1883
1900	57.00	65.0	45.26	18	341	I	10.62	46.65	0.0000	-.1255	II	10.62	43.20	0.0011	-.0979	II	7.92	40.57	0.0018	-.0593	I	17.82	45.58	0.0000	-.1808
1915	57.00	63.8	44.76	21	352	I	12.39	47.67	0.0000	-.1448	II	12.39	43.82	0.0006	-.1170	II	9.24	41.47	0.0014	-.0737	I	20.79	46.82	0.0000	-.2125
1930	57.20	63.6	44.87	17	336	I	10.03	46.41	0.0000	-.1172	II	10.03	42.76	0.0010	-.0897	II	7.82	40.40	0.0017	-.0574	I	20.91	47.06	0.0000	-.2164

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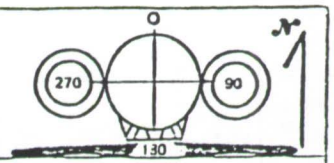
FIGURE 13. Ice/Frost Computer Predictions

STS – 36	TEST: S0007 RTLS WEATHER SCRUB	DATE: 2/25/90	T–0 TIME: DATE: 2/26/90

ORBITER	ET	SRB	MLP	PAD	LO_2	LH_2
OV–104	33	BI–036	1	A	CHILLDOWN TIME: 20:28 FAST FILL TIME: 21:18 SLOW FILL TIME: 21:04 REPLENISH TIME: 23:24	CHILLDOWN TIME: 20:28 FAST FILL TIME: 21:00 SLOW FILL TIME: 20:37 REPLENISH TIME: 22:59



LOCAL TIME	CONDITIONS					LO_2 TANK STA 370 TO 540					LO_2 TANK STA 550 TO 852					LH_2 TANK STA 1130 TO 1380					LH_2 TANK STA 1380 TO 2058				
	TEMP. °F	REL HUM. %	DEW PT °F	WIND VEL. KNTS	WIND DIR DEG	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR
1945	57.20	64.4	45.21	17	345	I	10.03	46.44	0.0000	-.1187	II	10.03	42.93	0.0011	-.0912	II	7.48	40.21	0.0018	-.0543	I	16.83	45.27	0.0000	-.1698
2000	57.20	64.2	45.12	14	342	II	8.26	45.07	0.0000	-.0960	II	8.26	41.61	0.0014	-.0688	II	6.16	38.51	0.0019	-.0373	II	13.86	44.25	0.0006	-.1330
2015	57.20	64.6	45.29	15	346	I	8.85	45.52	0.0000	-.1042	II	8.85	42.16	0.0013	-.0769	II	6.60	39.19	0.0019	-.0434	II	14.85	44.69	0.0004	-.1461
2030	57.40	65.4	45.82	16	343	I	9.44	46.22	0.0000	-.1149	II	9.44	42.95	0.0013	-.0874	II	7.04	40.11	0.0019	-.0515	II	15.84	45.36	0.0004	-.1631
2045	57.20	65.8	45.78	16	345	I	9.44	46.04	0.0000	-.1138	II	9.44	42.83	0.0014	-.0863	II	7.04	39.98	0.0020	-.0506	II	15.84	45.25	0.0004	-.1615
2100	57.60	67.6	46.90	17	349	I	10.03	46.92	0.0000	-.1285	II	10.03	43.99	0.0015	-.1008	II	7.48	41.27	0.0021	-.0617	II	16.83	46.30	0.0005	-.1846
2115	57.80	68.80	47.58	16	345	II	9.44	47.13	0.0002	-.1247	II	9.44	44.05	0.0017	-.0969	II	7.04	41.23	0.0023	-.0589	II	15.84	46.46	0.0009	-.1778
2130	57.80	70.0	48.04	20	343	I	11.80	48.25	0.0000	-.1597	II	11.80	45.63	0.0015	-.1314	II	8.80	43.21	0.0022	-.0850	II	19.80	47.68	0.0038	-.2345
2145	58.00	70.8	48.55	16	345	II	9.44	47.72	0.0005	-.1302	II	9.44	44.67	0.0020	-.1022	II	7.04	41.85	0.0025	-.0630	II	15.84	47.07	0.0013	-.1861
2200	58.20	72.4	49.35	19	354	II	11.21	48.86	0.0003	-.1609	II	11.21	46.24	0.0019	-.1325	II	8.36	43.74	0.0025	-.0860	II	18.81	48.35	0.0010	-.2354
2215	58.40	74.2	50.22	19	350	II	11.21	49.42	0.0005	-.1670	II	11.21	46.81	0.0021	-.1384	II	8.38	44.31	0.0027	-.0906	II	18.81	48.91	0.0014	-.2447
2230	58.40	74.4	50.29	20	342	II	11.80	49.63	0.0005	-.1763	II	11.80	47.13	0.0021	-.1475	II	8.80	44.73	0.0027	-.0975	II	19.80	49.16	0.0013	-.2598
2245	58.40	75.2	50.58	19	343	II	11.21	49.61	0.0007	0.1692	II	11.21	47.01	0.0023	-.1405	II	8.36	44.51	0.0028	-.0922	II	18.81	49.11	0.0016	-.2480
2300	58.60	75.8	50.99	18	346	II	10.62	49.75	0.0008	-.1635	II	10.62	47.03	0.0024	-.1349	II	7.92	44.44	0.0029	-.0881	II	17.82	49.21	0.0018	-.2385
2315	58.80	76.8	51.55	18	351	II	10.62	50.14	0.0009	-.1678	II	10.62	47.44	0.0025	-.1390	II	7.92	44.85	0.0030	-.0912	II	17.82	49.61	0.0020	-.2449

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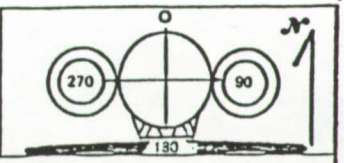
FIGURE 14. Ice/Frost Computer Predictions

STS – 36	TEST: S0007 RTLS WEATHER SCRUB					DATE: 2/25/90	T-0 TIME: DATE: 2/26/90
ORBITER OV– 104	ET 33	SRB BI–036	MLP 1	PAD A	LO_2 CHILLDOWN TIME: 20:28 SLOW FILL TIME: 21:04 FAST FILL TIME: 21:18 REPLENISH TIME: 23:24	LH_2 CHILLDOWN TIME: 20:28 SLOW FILL TIME: 20:37 FAST FILL TIME: 21:00 REPLENISH TIME: 22:59	

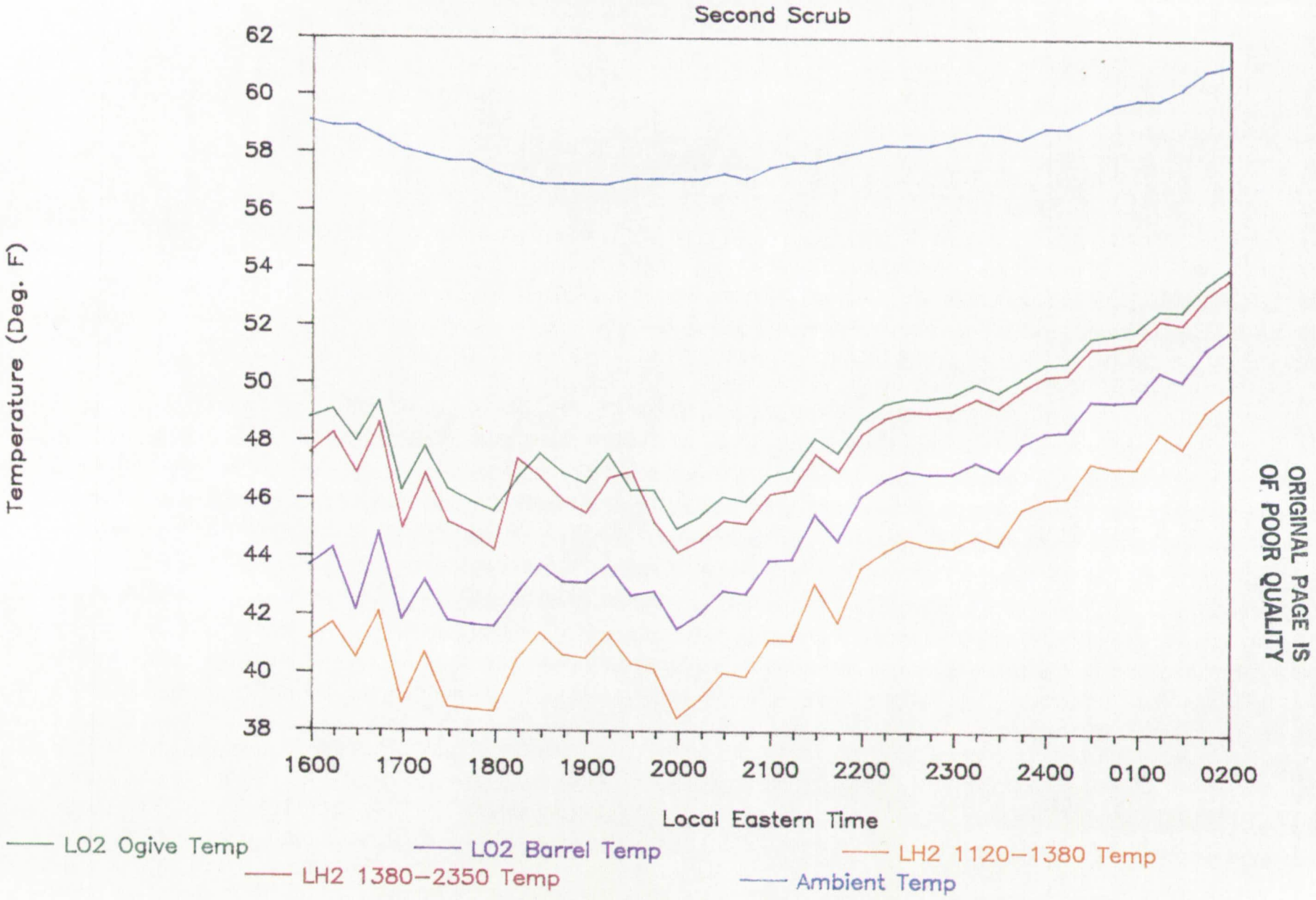


LOCAL TIME	CONDITIONS					LO_2 TANK STA 370 TO 540					LO_2 TANK STA 550 TO 852					LH_2 TANK STA 1130 TO 1380					LH_2 TANK STA 1380 TO 2058				
	TEMP. °F	REL HUM. %	DEW PT °F	WIND VEL. KNTS	WIND DIR DEG	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR
2330	58.80	75.2	50.97	18	354	II	10.62	49.83	0.0007	-.1644	II	10.62	47.11	0.0024	-.1357	II	7.92	44.53	0.0029	-.0888	II	17.82	49.29	0.0017	-.2397
2345	58.60	75.4	50.85	22	349	II	12.98	50.33	0.0004	-.1990	II	12.98	48.04	0.0021	-.1698	II	9.68	45.80	0.0028	-.1145	II	21.78	49.92	0.0012	-.2961
2400	59.00	76.6	51.67	21	345	II	12.39	50.82	0.0007	-.1976	II	12.39	48.45	0.0023	-.1684	II	9.24	46.15	0.0030	-.1136	II	20.79	50.39	0.0016	-.2931
0015	59.00	77.0	51.82	21	352	II	12.39	50.90	0.0007	-.1986	II	12.39	48.53	0.0024	-.1694	II	9.24	46.23	0.0030	-.1143	II	20.79	50.47	0.0015	-.3364
0030	59.40	77.8	52.49	23	351	II	13.57	51.73	0.0007	-.2247	II	13.57	49.56	0.0024	-.1951	II	10.12	47.42	0.0031	-.1339	II	22.77	51.36	0.0015	-.3364
0045	59.80	78.8	53.04	21	352	II	12.39	51.86	0.0010	-.2104	II	12.39	49.52	0.0027	-.1808	II	9.24	47.23	0.0032	-.1233	II	20.79	51.44	0.0020	-.3126
0100	60.00	78.4	53.30	20	346	II	11.80	52.03	0.0010	-.2043	II	11.80	49.60	0.0027	-.1748	II	8.80	47.24	0.0032	-.1189	II	19.80	51.58	0.0021	-.3023
0115	60.00	79.8	53.78	23	349	II	13.57	52.73	0.0009	-.2381	II	13.57	50.59	0.0027	-.2081	II	10.12	48.48	0.0033	-.1441	II	22.77	52.36	0.0020	-.3569
0130	60.40	79.6	54.11	20	347	II	11.80	52.68	0.0011	-.2121	II	11.80	50.26	0.0029	-.1824	II	8.80	47.92	0.0034	-.1248	II	19.80	52.22	0.0023	-.3141
0145	61.00	79.6	54.70	22	349	II	12.98	53.58	0.0010	-.2406	II	12.98	51.37	0.0028	-.2105	II	9.68	49.20	0.0034	-.1463	II	21.78	53.18	0.0021	-.3597
0200	61.20	81.8	55.58	22	355	II	12.98	54.18	0.0013	-.2487	II	12.98	51.99	0.0031	-.2184	II	9.68	49.84	0.0036	-.1524	II	21.78	53.79	0.0026	-.8722
AVERAGE	58.3	68.7	47.9	18.6	N			48.7					45.4					42.9					48.6		

EGG/V-340

FIGURE 15. Ice/Frost Computer Predictions

FIGURE 16. ET Surface Temperature From SurficeC



Ice/Frost covered the lower EB fittings outboard to the strut pin hole with condensate on the rest of the fitting. The struts were dry and were not covered by ice.

The summary of Ice/Frost Team observation anomalies consists of 15 OTV recorded items:

IPR 36RV-0182 (Anomaly 011.1) documented loose/torn baggie material on the outboard side of the LH2 ET/ORB umbilical. The IPR was upgraded to PR MEQ 04-06-0282 and accepted for flight by MRB approval.

Anomaly 012 recorded ice/frost in the intertank stringer valleys at the LO2 and LH2 flanges. The presence of ice/frost in these valleys was acceptable per NSTS-08303.

Ice/frost spots on the ET LH2 tank aft dome -Z manhole cover closeout ring and on the +Z manhole cover closeout at the interface to the aft dome (Anomaly 013) were acceptable per NSTS-08303.

Anomaly 014 documented ice/frost formations on both LH2 and LO2 ET/ORB umbilicals, which were acceptable per NSTS-08303.

Anomaly 015 recorded ice/frost in the LO2 feedline bellows and support brackets - an acceptable condition per NSTS-08303.

One frost spot on the -Y longeron foam closeout on the aft side of the vertical strut and a similar frost spot at the same location on the +Y longeron (Anomalies 016 and 017) were acceptable per NSTS-08303.

Anomaly 018 documented torn hydrogen fire detection paper at location #5. The paper was intact on the vehicle and met the criteria "intact, no more than 50 percent paper missing".

Anomaly 019 recorded ice/frost accumulations along the aft side of the cable tray ice/frost ramps and the pressurization line support ramps. This accumulation was acceptable per NSTS-08303.

Anomaly 020 was written at 01:04 GMT for one 3-inch and two 1-1/2 inch icicles on the north GOX vent duct. The icicles are 3/4-inch in diameter and approximately 20-30 pounds per cubic foot density. At 06:04 GMT, four icicles 1-inch long formed inside the duct. The presence of the icicles was accepted for launch per LCC waiver LW-018.

Ice/frost accumulation at the intersection of the cable tray PAL ramp and the LH2 tank (Anomaly 021) was acceptable per NSTS-08303.

Anomaly 022 documented small frost formations/spots on the -Z side of the LO2 and LH2 tank acreage areas near the intertank flange closeouts. These few isolated areas were acceptable per NSTS-08303.

Anomaly 023 recorded ice/frost growth aft of the -Y bipod ramp. The presence of this ice/frost was acceptable per NSTS-08303.

Ice/frost formed around the perimeter of the lower aft hard point closeout area (Anomaly 024) was acceptable per NSTS-08303

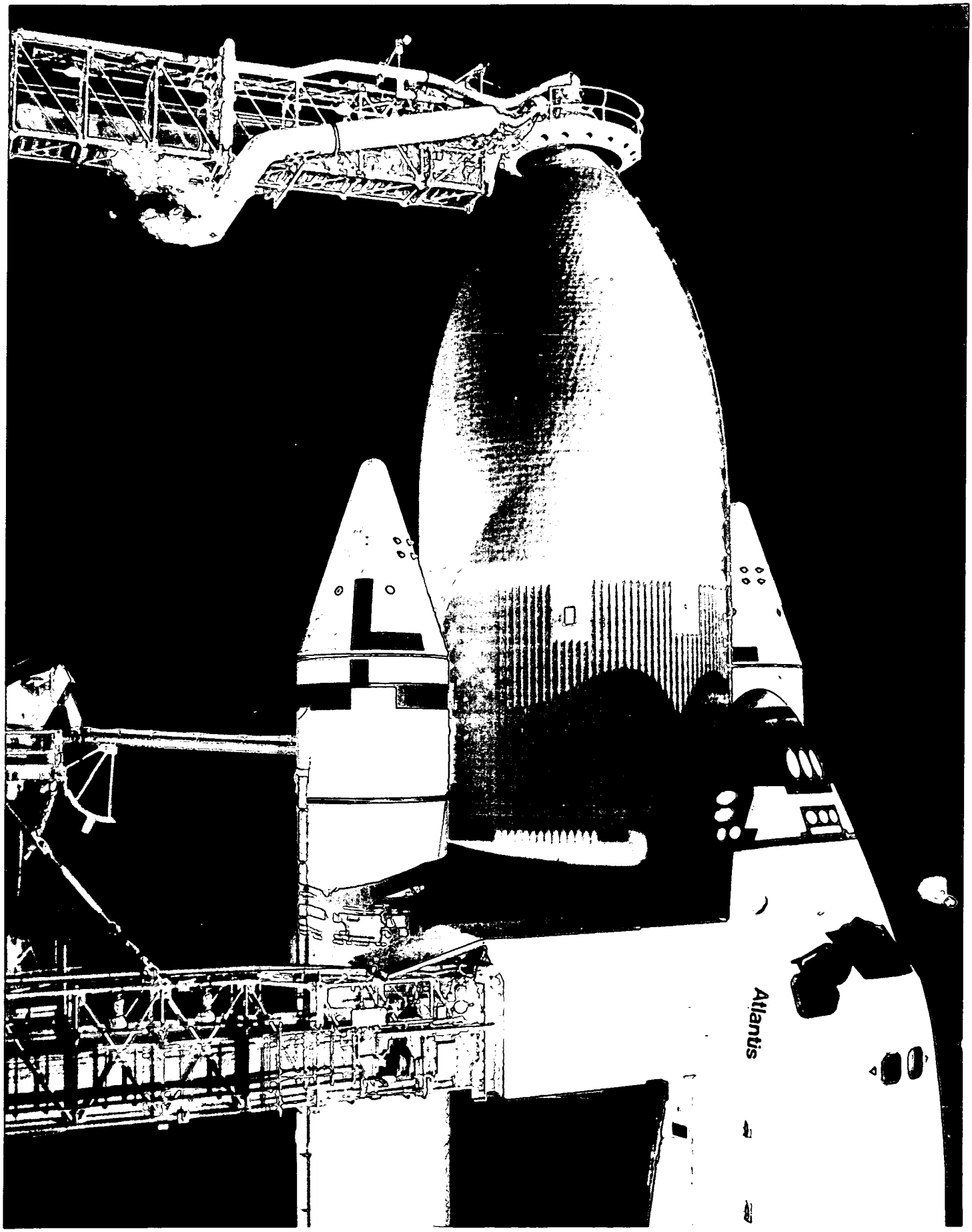
Anomaly 025 documented ice/frost formation on an apparent repair area 1 foot aft of the third hardpoint closeout. The ice formation was acceptable per NSTS-08303.

5.5 FACILITY OBSERVATIONS

All debris concerns previously identified had been resolved prior to cryoloading and no new items were noted during the walkdown. No leaks were observed at either the LO2 or LH2 ORB T-0 umbilical carrier plates, though small amounts of ice/frost had formed. The purge barrier on the LH2 TSM was loose. Ten pieces of loose tape were visible on the T-0 carrier plate lines (6 on LH2, 4 on LO2). There was no apparent leakage anywhere on the GH2 vent line. The modification to the GH2 vent line prevented ice from forming but some ice/frost, which was expected, had accumulated on the GUCP legs.

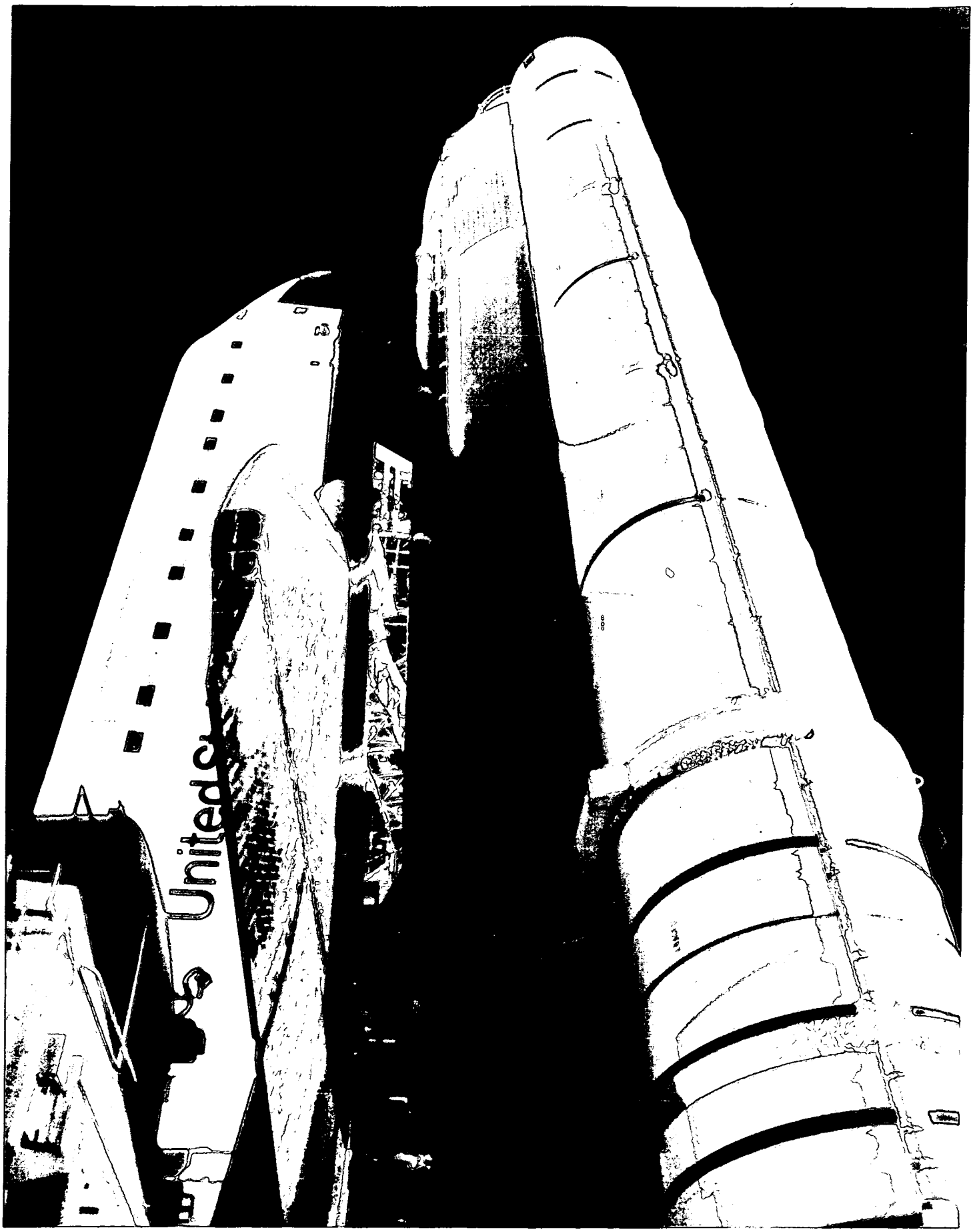
Visual and infrared observations of the GOX seals confirmed no leakage. However, one 3-inch and two 1-1/2 inch icicles had formed at the end of the north GOX vent duct. All three icicles were approximately 3/4-inch in diameter with a density of 20-30 pounds per cubic foot. The weather forecast predicted the winds would shift from the west to the north with a worst case wind at 330 degrees. According to Rockwell - Downey, a 360 degree wind would blow the smaller icicles over the LH wing. The large icicle would have a higher probability of impact. The area of possible impact would be the outer portion of the LH wing and is predicted to be a glancing blow, which in turn would result in minor TPS damage. Consequently, an IPR was taken to document the presence of the icicles and LCC Waiver LW-018 was approved as no safety of flight concern.

All sound suppression water troughs were full of water. The ET/ORB hydrogen detection sensor tygon tubing had not been reinstalled after the first scrub due to the lack of RSS access.



Weather conditions during the second cryo loading of the vehicle precluded the formation of acreage frost

ORIGINAL PAGE
COLOR PHOTOGRAPH



No acreage frost accumulated on the ET LO2 and LH2 tank +Y+Z quadrant acreage during the second cryo loading

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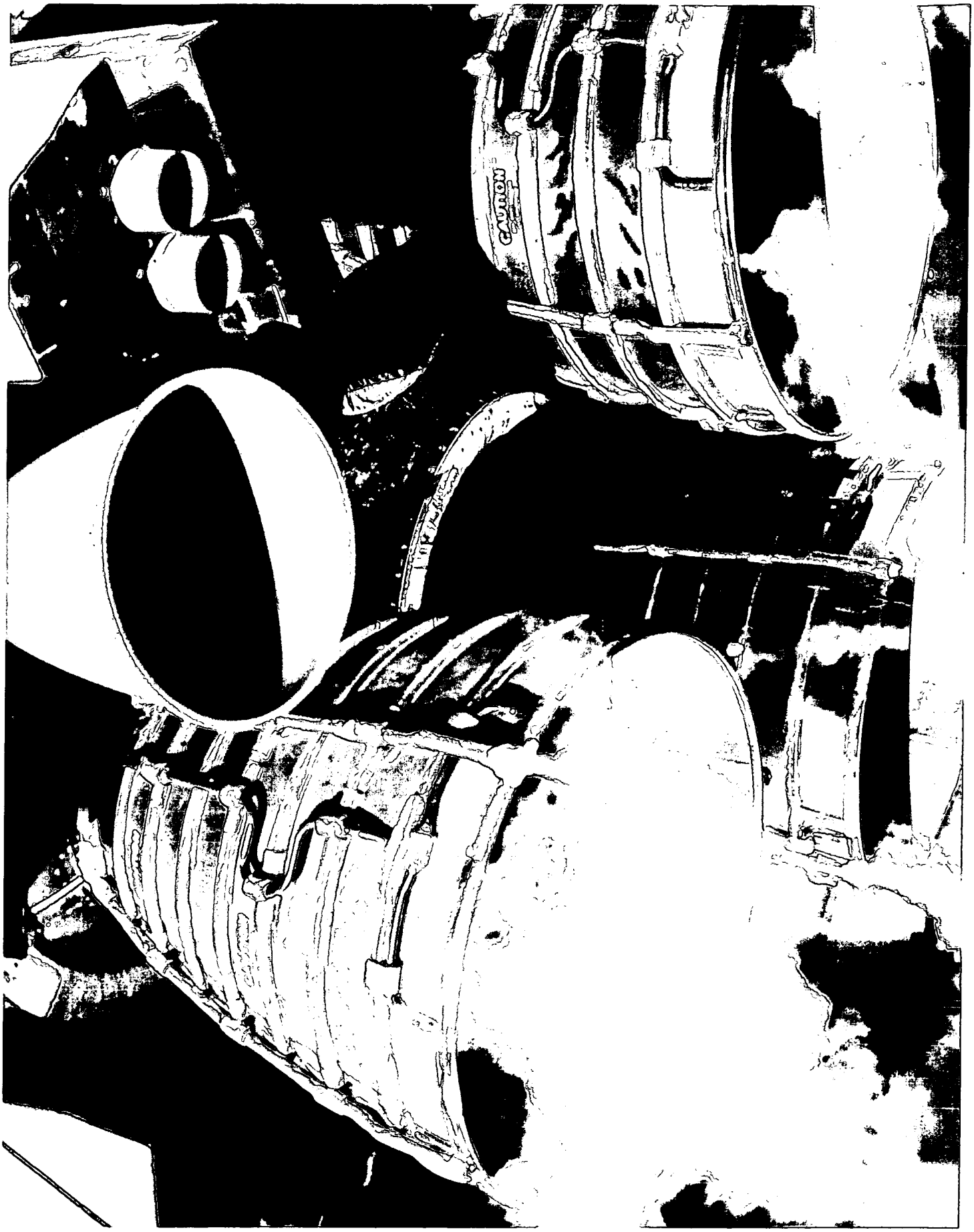
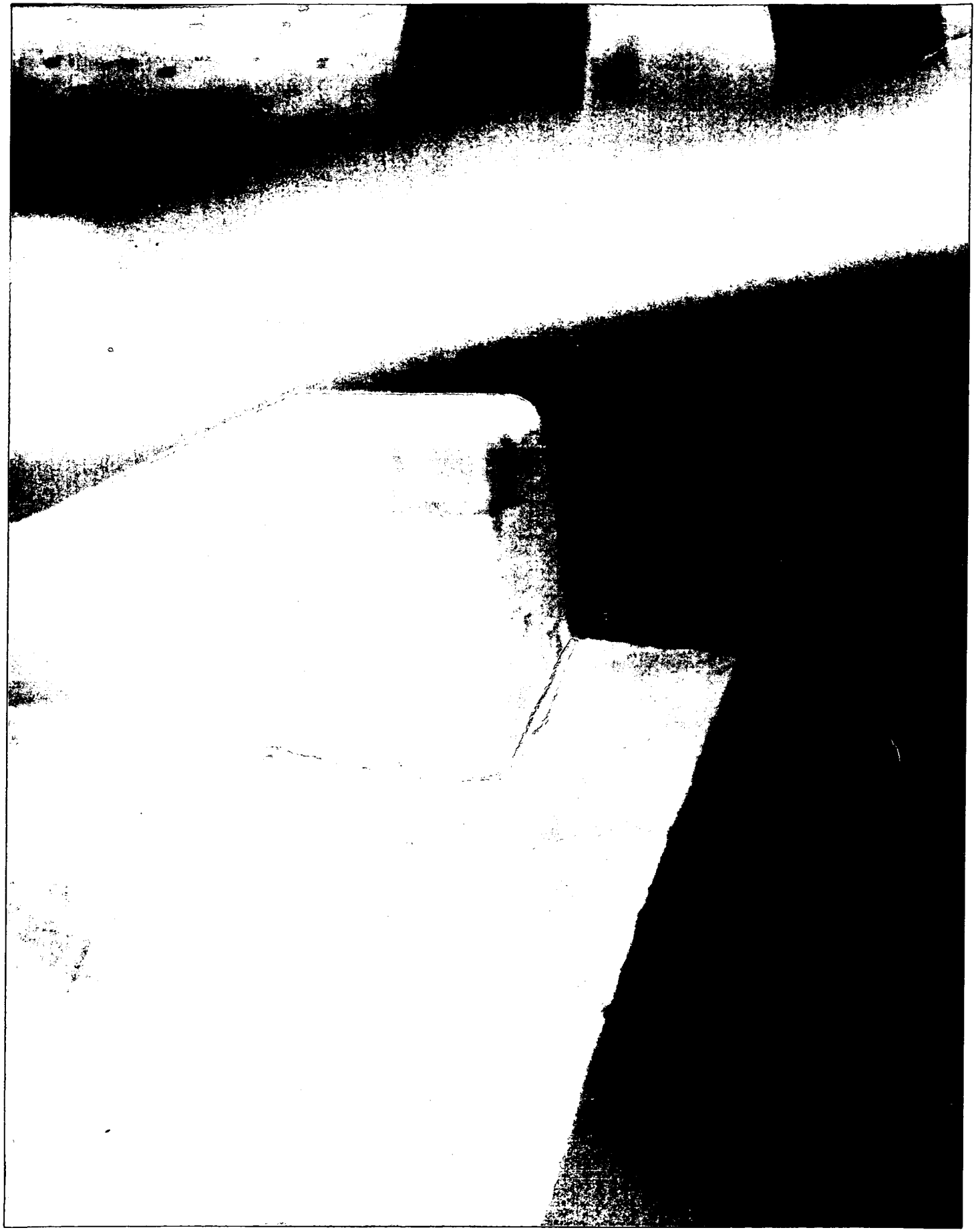
COLOR PHOTOGRAPH



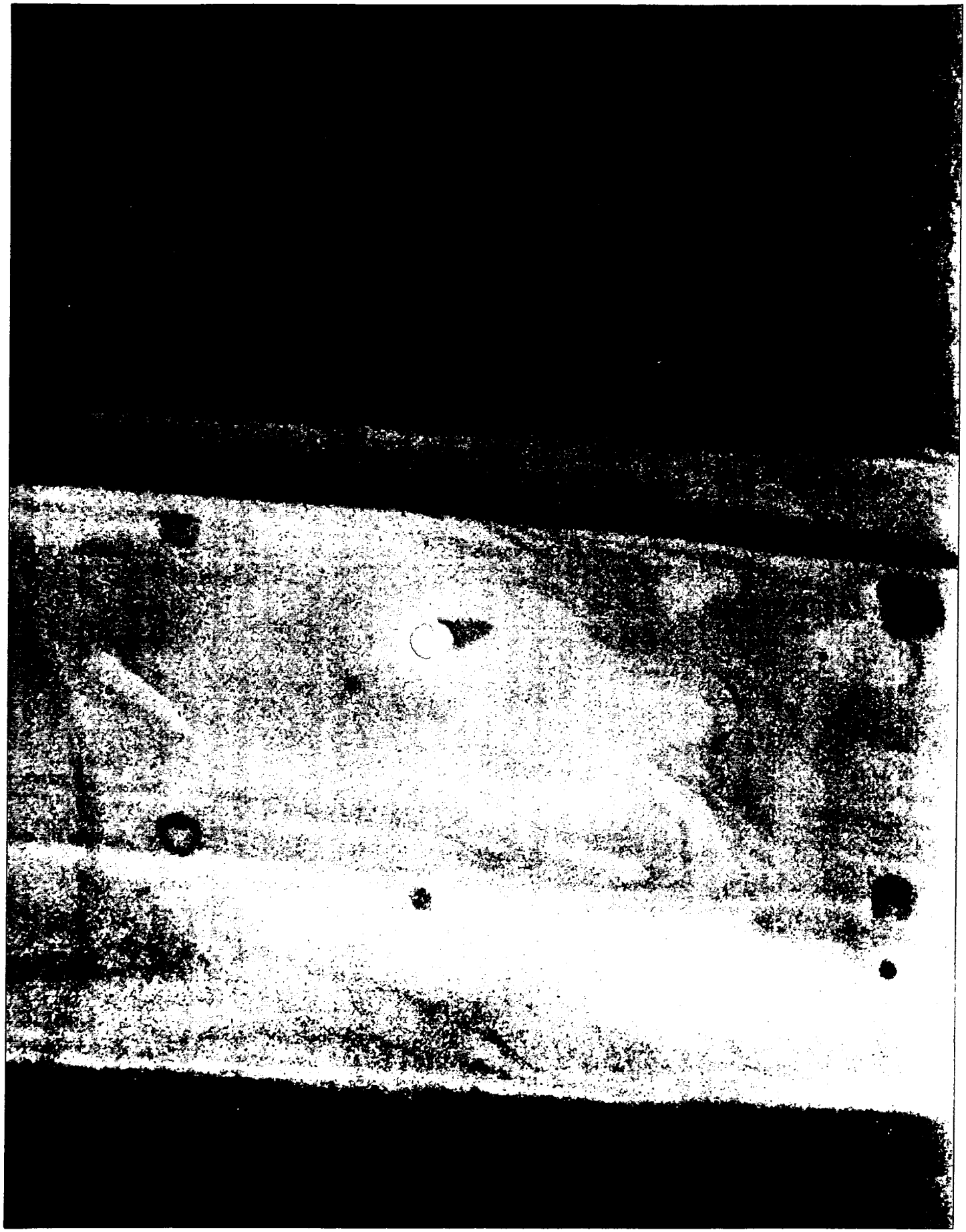
Overall view of the Main Engines shows ice/frost formation on the SSME #2 engine heat shield-to-nozzle interface

Ice/frost has formed along the SSME #1 and #2 engine mounted heat shield-to-nozzle interfaces

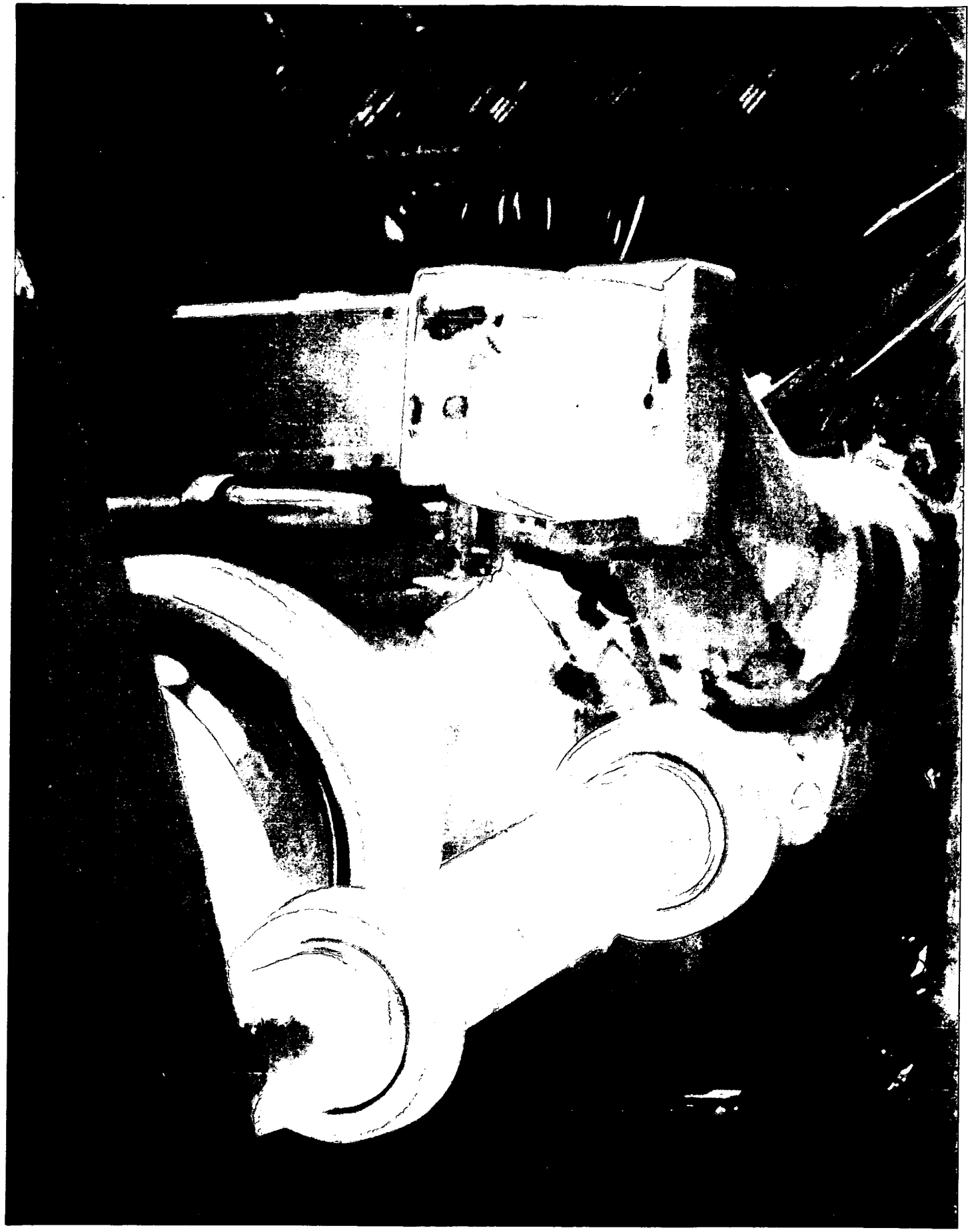
Return-to-flight modifications preclude ice formation on GH2 vent line. Light frost on GUCP leg is expected.



Frost lines formed along the aft and outboard sides of the -Y bipod closeout



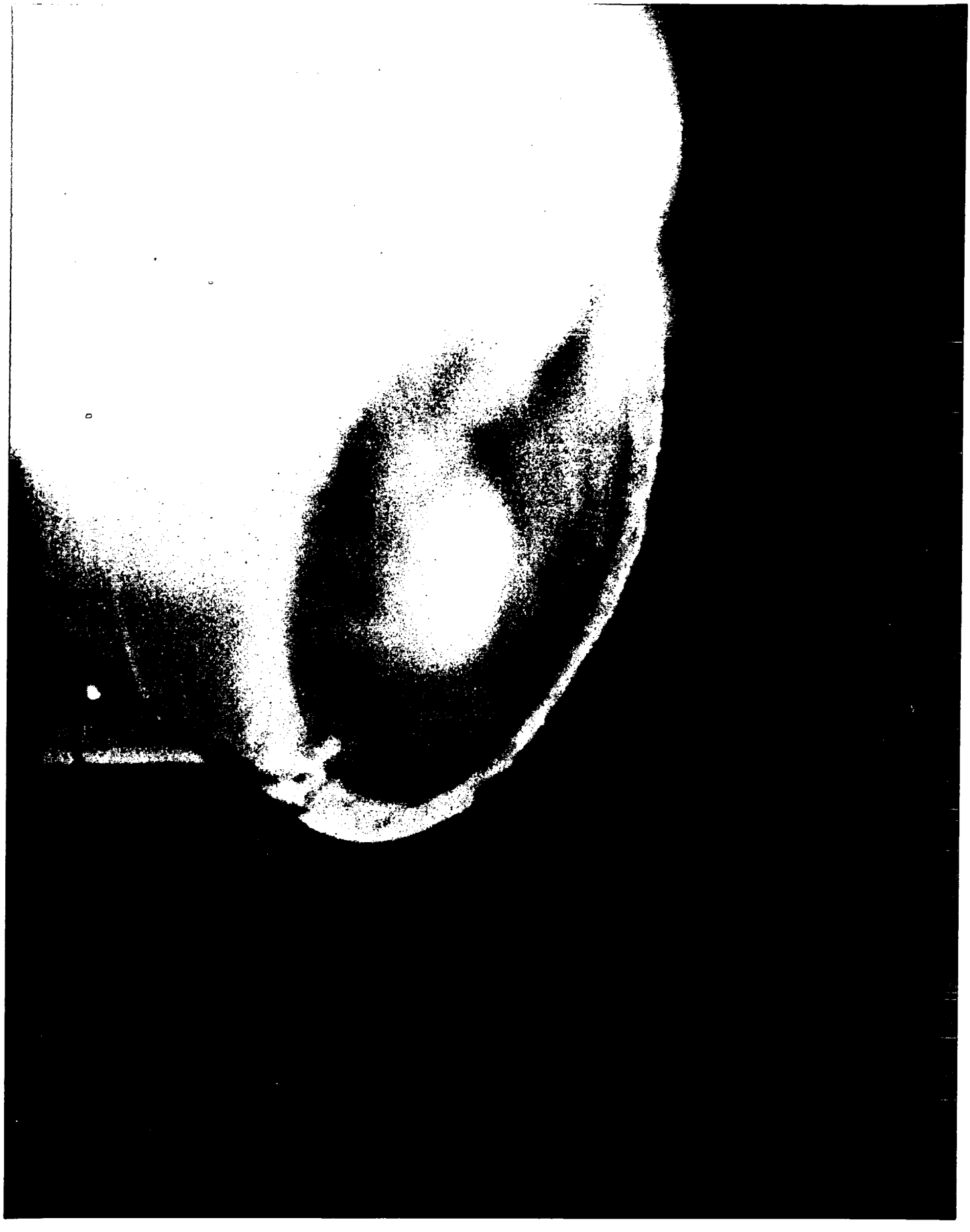
Ice/frost ball 2 inches in diameter formed on the -Y longeron closeout



LH2 feedline bellows remain clear of ice/frost, though light accumulations are present in the LH2 recirculation line bellows

Formation of ice/frost on the top and outboard sides of the LH2 ET/ORB umbilical are lighter than usual

Close-in view of tear in the LH2 ET/ORB umbilical baggie material. Tear did not affect the purged area of the umbilical



Frost-covered temperature sensor wiring, but no icicles, was visible on the end of the north GOX vent duct

5.6 POST DRAIN INSPECTION

The launch of STS-36 was scrubbed for the second time due to adverse weather. Both the LH2 and LO2 tanks had been filled to 100 percent. A post-drain inspection was performed at Pad 39A from 0800 to 0900 hours on 26 February 1990. A 48-hour Scrub Turnaround was initiated, so the post drain inspection and the preflight pad debris inspection were combined.

The tumble valve cover exhibited no anomalies. The -Y side nose cone footprint area was not damaged. The +Y side nose cone foot print area was not accessible for inspection.

No TPS damage, such as divots or cracks on the tank acreage, was visible.

An 8-inch crack in the TPS at the +Y LH2 longeron-to-thrust strut interface was not filled with ice, which had occurred during the first cryo drain the previous day. The crack has appeared before on previous vehicles and was acceptable per NSTS-08303.

Ice had accumulated at both LH and RH SRB cable tray-to-upper strut fairing interfaces. Ice/frost was also present around the SRB diagonal strut flow restrictors on the +Y/-Y aft fairings.

A small amount of solid ice still remained in the LH2 feedline bellows, in the LH2 recirculation line lower bellows, and in the -Z LH2 recirc line burst disk. Ice fingers (6 inches long) were attached to five of the LH2 umbilical purge vents. Less than usual amounts of ice covered the LH2 umbilical.

A small amount of ice remained only in the LO2 feedline upper bellows at XT-1106. Less than usual amount of ice was present in all feedline support brackets. Ice was visible between the lower bracket at XT-1978 and the tank. The LO2 feedline support brackets did not appear to have any loose foam. There was no ice/frost on the LH2 ET/ORB umbilical.

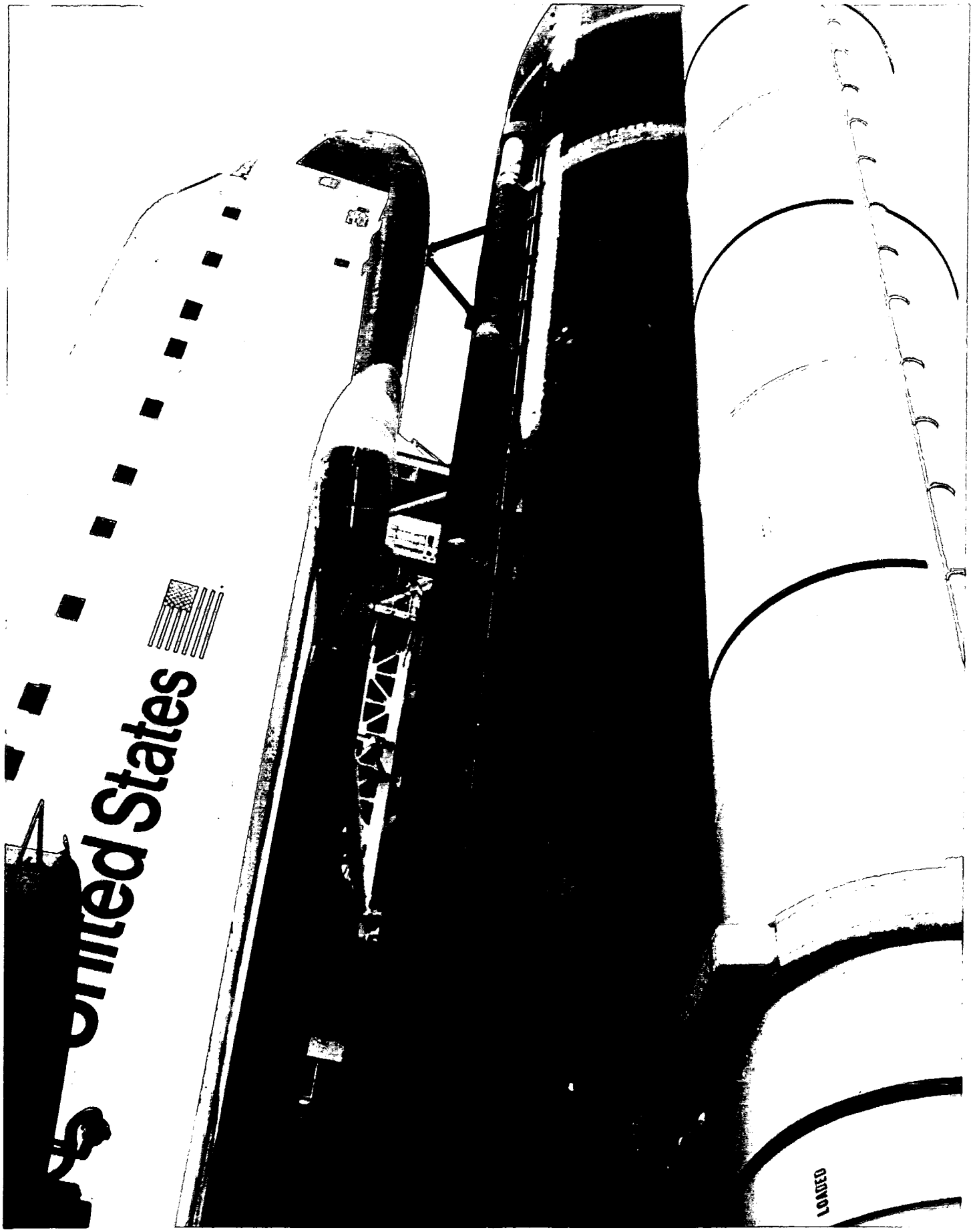
Ice 1-inch thick still covered EB-7 and EB-8. No ice was present on the ET aft dome siphon manhole leak check port closeout. However, a 1-inch diameter plug pull repair at the -Y/+Z side was covered by ice and was outgassing. After the ice had melted, there was no evidence of a broken bondline in the repair. The LH2 manhole cover BX-250 closeout exhibited 16 small areas of frost along the outer edge of the closeout. The largest frost spot measured 3"x0.5". After the frost melted, underfill gaps were visible in these areas.

All of this ice/frost has occurred previously on other vehicles and was acceptable per NSTS-08303.

There was no visible damage to the SRB or Orbiter TPS. Aft RCS paper covers on the +Z side forward nozzle of the LH stinger and the +Y side forward nozzle of the RH stinger were discolored.

The SRB sound suppression water troughs were full of water.

Icicles had formed again on the end of the north GOX vent duct. The ice formation appeared to have been caused by condensate following the GOX vent duct tip temperature indicator wiring past the condensate hydro diverter (the GVA temperature sensors had been previously removed). PR U78-0001-00-001-0539 was worked to disconnect and secure the temperature indicator wiring to the GOX vent arm walkway. Work was complete on 26 February 1990.



Overall view of the ET LH2 tank +Y+Z TPS acreage during the second post drain inspection

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6.0 LAUNCH

STS-36 was launched at 28:07:50:22 GMT on 28 February 1990.

6.1 ICE/FROST INSPECTION

The Ice/Frost Inspection of the cryoloaded vehicle was performed on 27 February 1990 from 1855 to 2030 hours during the two hour built-in-hold at T-3 hours in the countdown. There were no violations of NSTS-08303 or the Launch Commit Criteria. Ambient weather conditions at the time of the inspection were:

Temperature:	66.9 F
Relative Humidity:	58.4 %
Wind Speed:	17.7 Knots
Wind Direction:	059 Degrees

The portable STI infrared scanner was utilized to obtain surface temperature measurements for an overall thermal assessment of the vehicle, as shown in Figure 17 and 18.

6.2 ORBITER OBSERVATIONS

No Orbiter tile anomalies were observed. The average Orbiter surface temperature was recorded as 62-64 degrees F. The average surface temperatures of the SSME engine mounted heat shields were measured at 61 degrees F for SSME #1 (coldest 46 degrees), 56 degrees F for SSME #2 (coldest 18 degrees), and 64 degrees F for SSME #3 (coldest 47 degrees). A small amount of ice/frost was visible on the nozzle to heat shield interface of SSME #1 at the 5-7, 8-10 o'clock positions and 2-4, 6-9, 11-1 o'clock positions on SSME #2. No frost or condensate was present on SSME #3 heat shield. The torn LH2 ET/ORB umbilical baggie had not deteriorated since the second tanking and there were no problems with the purge in that area. There was no ice on the acreage part of the baggie.

6.3 SRB OBSERVATIONS

No SRB anomalies or loose ablator/cork were observed. The STI portable infrared scanner recorded RH and LH SRB case surface temperatures between 63-66 degrees F. Temperatures in the area of the SRB field joint heater closouts ranged from 82 to 84 degrees F. The predicted Propellant Mean Bulk Temperature (PMBT) supplied by MTI was 66 degrees F.

FIGURE 17. **INFRA RED SCANNER SSV SUMMARY DATA**

TIME: 1855-2030
DATE: 2/27/90
VEH. STS- 36

All temperatures are in degrees F.

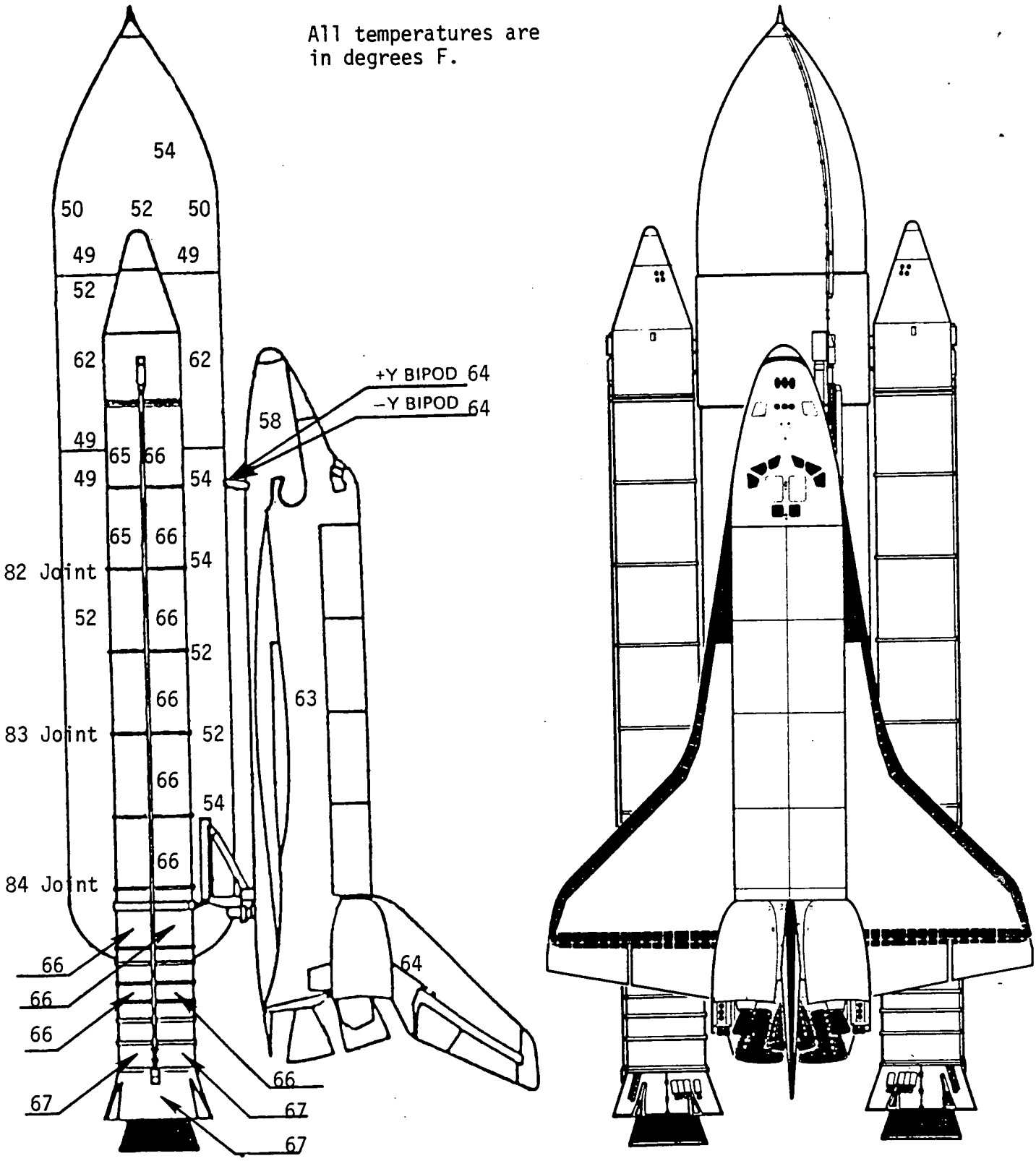
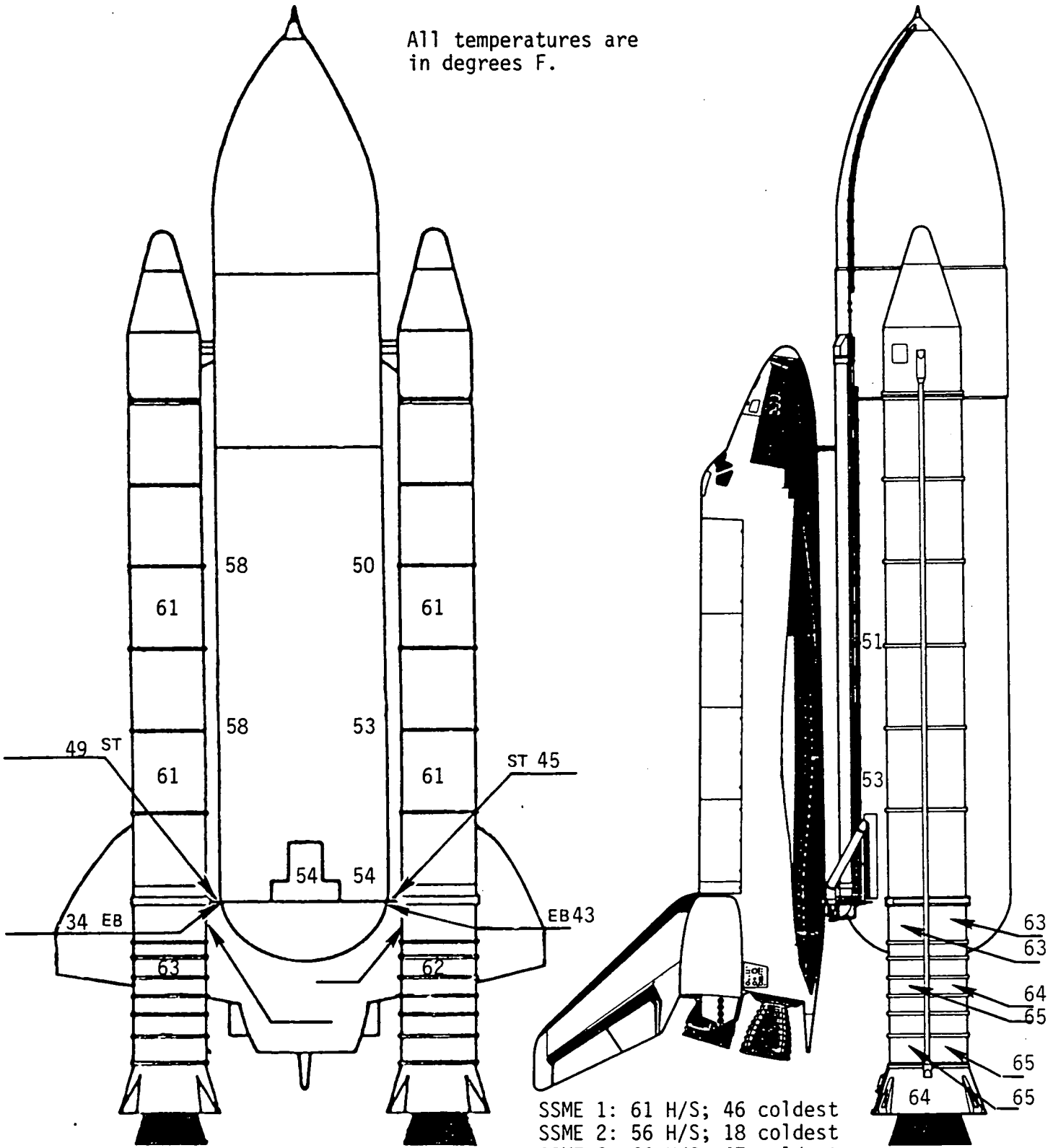


FIGURE 18. **INFRARED SCANNER SSV SUMMARY DATA**

TIME: 1855-2030
DATE: 2/27/90
VEH. STS-36

All temperatures are in degrees F.



SSME 1: 61 H/S; 46 coldest
SSME 2: 56 H/S; 18 coldest
SSME 3: 64 H/S; 47 coldest

EGG/V-343C

6.4 EXTERNAL TANK OBSERVATIONS

The ice/frost prediction computer program was run from 1545 to 0250 hours and the results tabulated in Figures 19-23. The program predicted condensate with no ice accumulation on all TPS acreage surfaces.

The new design of the tumble valve cover was intact. A very light condensate was present on the north side of the LO2 tank barrel section only with no run-on to the intertank. There was no ice/frost on the TPS acreage areas or around the PAL and ice/frost ramps. The surface temperature of the LO2 tank -Y side as measured by the IR scanner averaged 49-52 degrees F on the barrel section and 54-57 degrees F on the ogive.

No run-on condensate was present on the intertank. Small amounts of ice/frost had formed in the stringer valleys on the -Z side of the tank along both the LO2 and LH2 tank-to-intertank flanges. There was no ice/frost on the Orbiter side of the intertank. The average surface temperature was 62 deg F. Minor frost had formed on the GUCP, but there was no sign of leakage.

Very light condensate was present on the upper two-thirds of the LH2 tank -Z side. There was no acreage ice/frost. Average surface temperatures were measured as 50-54 degrees F. The bipods closeouts were clean. A total of 5 ice balls were visible on the aft sides of five pressurization line ice/frost ramps. There was no ice along the PAL ramp interface.

Normal amounts of ice/frost were present in all LO2 feedline bellows. Less than usual amounts of ice/frost were present in the LO2 feedline support brackets.

Four ice/frost spots had formed on the -Y longeron: at the forward outboard corner, at the thrust strut attach point, in the crotch area, and one 3 feet aft on the closeout.

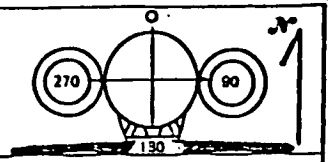
Both the LO2 and LH2 ET/ORB umbilicals exhibited less than usual ice/frost accumulation. Frost fingers had formed on the purge vents and normal venting was occurring. There were no unusual vapors emanating from the umbilicals or any evidence of leakage.

Minor amounts of ice were present on the umbilical side of the LH2 feedline bellows. Both LH2 recirculation line bellows were filled with a normal amount of ice/frost.

Ice/Frost covered the lower EB fittings outboard to the strut pin hole with condensate on the rest of the fitting. The struts were dry and were not covered by ice.

STS – 36	TEST: S0007 LAUNCH	DATE: 2/27/90	T-0 TIME: 02:50 DATE: 2/28/90

ORBITER	ET	SRB	MLP	PAD	LO_2				LH_2			
					CHILLDOWN TIME:	20:42	FAST FILL TIME:	21:33	CHILLDOWN TIME:	20:43	FAST FILL TIME:	21:16
OV-104	33	BI-036	1	A	SLOW FILL TIME:	21:19	REPLENISH TIME:	23:35	SLOW FILL TIME:	20:52	REPLENISH TIME:	23:15



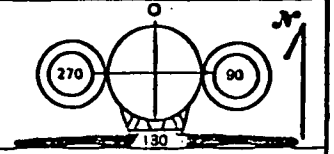
LOCAL TIME	CONDITIONS					LO_2 TANK STA 370 TO 540					LO_2 TANK STA 550 TO 852					LH_2 TANK STA 1130 TO 1380					LH_2 TANK STA 1380 TO 2058				
	TEMP. °F	REL HUM. %	DEW PT °F	WIND VEL KNTS	WIND DIR DEG	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR
1545	70.80	51.8	52.51	18	56	I	10.62	60.06	0.0000	-.2317	I	10.62	54.62	0.0000	-.2019	I	12.60	55.50	0.0000	-.2361	I	21.78	60.48	0.0000	-.4145
1600	70.20	51.2	51.61	19	64	I	11.21	59.82	0.0000	-.2348	I	11.21	54.59	0.0000	-.2052	I	13.30	55.47	0.0000	-.2401	I	22.99	60.31	0.0000	-.4224
1615	70.00	50.8	51.20	17	62	I	10.03	58.82	0.0000	-.2087	I	10.03	53.23	0.0000	-.1794	I	11.90	54.12	0.0000	-.2099	I	20.57	59.23	0.0000	-.3713
1630	70.00	51.6	51.63	15	51	I	8.85	57.92	0.0000	-.1880	I	8.85	51.89	0.0000	-.1590	I	10.50	52.78	0.0000	-.1858	I	18.15	58.19	0.0000	-.3305
1645	69.60	52.0	51.45	15	54	I	8.85	57.54	0.0000	-.1854	I	8.85	51.50	0.0000	-.1564	I	10.50	52.39	0.0000	-.1829	I	18.15	57.81	0.0000	-.3260
1700	69.20	54.2	52.20	16	58	I	9.44	57.68	0.0000	-.1990	II	9.44	52.05	0.0000	-.1698	I	11.20	52.75	0.0000	-.1986	I	19.36	57.99	0.0000	-.3527
1715	68.80	53.2	51.30	17	69	I	10.03	57.70	0.0000	-.2036	I	10.03	52.11	0.0000	-.1741	II	9.35	50.83	0.0003	-.1568	I	20.74	58.16	0.0000	-.3660
1730	68.60	54.0	51.51	16	69	I	9.44	57.07	0.0000	-.1927	II	9.44	51.41	0.0001	-.1636	II	8.80	50.48	0.0006	-.1466	I	19.52	57.47	0.0000	-.3446
1745	68.20	51.8	49.99	19	72	I	11.21	57.83	0.0000	-.2151	I	11.21	52.66	0.0000	-.1850	I	10.45	50.98	0.0000	-.1674	I	23.18	58.42	0.0000	-.3907
1800	67.80	53.0	50.23	18	67	I	10.62	57.10	0.0000	-.2038	I	10.62	51.75	0.0000	-.1747	I	12.60	52.63	0.0000	-.2049	I	21.78	57.58	0.0000	-.3554
1815	67.40	54.2	50.45	19	67	I	11.21	57.10	0.0000	-.2137	I	11.21	51.94	0.0000	-.1844	I	13.30	52.80	0.0000	-.2165	I	22.00	57.61	0.0000	-.3853
1830	67.20	54.8	50.56	18	56	I	10.62	56.55	0.0000	-.2027	I	10.62	51.19	0.0000	-.1736	I	12.60	52.07	0.0000	-.2037	I	21.78	57.01	0.0000	-.3639
1845	67.00	55.8	50.86	18	54	I	10.62	56.38	0.0000	-.2035	I	10.62	51.02	0.0000	-.1743	I	12.60	51.88	0.0000	-.2045	I	21.78	56.83	0.0000	-.3654
1900	66.80	56.4	50.96	17	60	I	10.03	55.79	0.0000	-.1924	II	10.03	50.61	0.0000	-.1633	I	11.90	51.11	0.0000	-.1917	I	20.57	56.18	0.0000	-.3437
1915	66.80	60.2	52.74	17	55	I	10.03	55.87	0.0000	-.2025	II	10.03	51.56	0.0007	-.1731	II	11.90	52.00	0.0006	-.2029	I	20.57	56.21	0.0000	-.3623

EGG/V-340

FIGURE 19. Ice/Frost Computer Predictions

STS– 36	TEST: S0007 LAUNCH	DATE: 2/27/90	T–0 TIME: 02:50 DATE: 2/28/90

ORBITER	ET	SRB	MLP	PAD	LO_2				LH_2			
					CHILLDOWN TIME:	20:42	FAST FILL TIME:	21:33	CHILLDOWN TIME:	20:43	FAST FILL TIME:	21:16
OV– 104	33	BI–036	1	A	SLOW FILL TIME:	21:19	REPLENISH TIME:	23:35	SLOW FILL TIME:	20:52	REPLENISH TIME:	23:15



LOCAL TIME	CONDITIONS					LO_2 TANK STA 370 TO 540					LO_2 TANK STA 550 TO 852					LH_2 TANK STA 1130 TO 1380					LH_2 TANK STA 1380 TO 2058				
	TEMP. °F	REL. HUM. %	DEW PT °F	WIND VEL. KNTS	WIND DIR DEG	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR
1930	67.00	57.4	51.63	15	63	I	8.85	55.10	0.0000	–.1751	II	8.85	50.36	0.0007	–.1463	II	10.50	50.82	0.0005	–.1715	I	18.15	55.35	0.0000	–.3091
1945	66.80	58.4	51.91	16	57	I	9.44	55.40	0.0000	–.1867	II	9.44	50.78	0.0007	–.1576	II	11.20	51.23	0.0005	–.1848	I	19.36	55.70	0.0000	–.3319
2000	66.80	59.4	52.37	20	62	I	11.80	56.98	0.0000	–.2335	II	11.80	52.19	0.0001	–.2038	I	14.00	52.79	0.0000	–.2391	I	24.20	57.46	0.0000	–.4237
2015	67.00	58.4	52.10	19	58	I	11.21	56.82	0.0000	–.2218	II	11.21	51.89	0.0002	–.1922	I	13.30	52.47	0.0000	–.2255	I	22.09	57.25	0.0000	–.4005
2030	67.00	58.8	52.29	20	57	I	11.80	57.16	0.0000	–.2340	II	11.80	52.24	0.0000	–.2043	I	14.00	52.98	0.0000	–.2397	I	24.20	57.65	0.0000	–.4244
2045	67.00	59.0	52.38	20	57	I	11.80	57.17	0.0000	–.2346	II	11.80	52.28	0.0001	–.2049	I	14.00	52.99	0.0000	–.2403	I	24.20	57.65	0.0000	–.4256
2100	67.00	57.4	51.63	18	60	I	10.62	56.41	0.0000	–.2080	II	10.62	51.36	0.0002	–.1786	I	12.60	51.91	0.0000	–.2096	I	21.78	56.83	0.0000	–.3736
2115	66.80	60.4	52.83	18	55	I	10.62	56.29	0.0000	–.2142	II	10.62	51.91	0.0006	–.1847	II	12.60	52.33	0.0004	–.2165	I	21.78	56.68	0.0000	–.3853
2130	67.20	58.4	52.29	19	57	I	11.21	57.01	0.0000	–.2240	II	11.21	52.08	0.0001	–.1944	I	13.30	52.67	0.0000	–.2280	I	22.99	57.46	0.0000	–.4045
2145	66.80	59.2	52.28	19	60	I	11.21	56.62	0.0000	–.2219	II	11.21	51.89	0.0003	–.1923	I	13.30	52.30	0.0000	–.2256	I	22.99	57.07	0.0000	–.4009
2200	67.20	58.0	52.11	17	62	I	10.03	56.23	0.0000	–.2007	II	10.03	51.41	0.0004	–.1714	II	11.90	51.84	0.0002	–.2010	I	20.57	56.59	0.0000	–.3587
2215	67.20	57.6	51.92	14	61	I	8.26	54.80	0.0000	–.1663	II	8.26	50.19	0.0009	–.1375	II	9.80	50.67	0.0008	–.1611	I	16.94	54.93	0.0000	–.2914
2230	67.20	58.2	52.20	15	61	I	8.85	55.33	0.0000	–.1789	II	8.85	50.76	0.0008	–.1499	II	10.50	51.22	0.0006	–.1756	I	18.15	55.55	0.0000	–.3158
2245	67.00	59.6	52.66	17	55	I	10.03	56.07	0.0000	–.2029	II	10.03	51.61	0.0007	–.1737	II	11.90	52.04	0.0005	–.2035	I	20.57	56.42	0.0000	–.3630
2300	67.20	58.4	52.29	17	58	I	10.03	56.24	0.0000	–.2019	II	10.03	51.51	0.0005	–.1725	II	11.90	51.94	0.0003	–.2022	I	20.57	56.60	0.0000	–.3607

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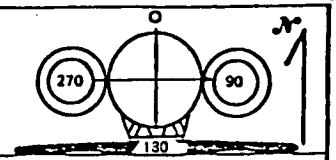
FIGURE 20. Ice/Frost Computer Predictions

STS – 36	TEST: S0007 LAUNCH	DATE: 2/27/90	T-0 TIME: 02:50 DATE: 2/28/90

ORBITER	ET	SRB	MLP	PAD	LO_2				LH_2			
					CHILLDOWN TIME:	20:42	FAST FILL TIME:	21:33	CHILLDOWN TIME:	20:43	FAST FILL TIME:	21:16
OV– 104	33	BI-036	1	A	SLOW FILL TIME:	21:19	REPLENISH TIME:	23:35	SLOW FILL TIME:	20:52	REPLENISH TIME:	23:15



LOCAL TIME	CONDITIONS					LO_2 TANK STA 370 TO 540					LO_2 TANK STA 550 TO 852					LH_2 TANK STA 1130 TO 1380					LH_2 TANK STA 1380 TO 2058				
	TEMP. °F	REL HUM. %	DEW PT °F	WIND VEL KNTS	WIND DIR DEG	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR
2315	67.20	58.0	52.11	16	56	I	9.44	55.80	0.0000	-.1896	II	9.44	51.08	0.0006	-.1605	II	11.20	51.52	0.0004	-.1881	I	16.94	56.09	0.0000	-.3369
2330	67.20	58.0	52.11	14	56	I	8.26	54.81	0.0000	-.1672	II	8.26	50.29	0.0009	-.1384	II	9.80	50.77	0.0008	-.1621	I	16.94	54.94	0.0000	-.2931
2345	67.00	57.8	51.82	15	48	I	8.85	55.12	0.0000	-.1761	II	8.85	50.46	0.0007	-.1472	II	10.50	50.92	0.0006	-.1725	I	18.15	55.35	0.0000	-.3109
0000	66.80	59.8	52.55	14	48	I	8.26	54.46	0.0000	-.1678	II	8.26	50.35	0.0011	-.1389	II	9.80	50.83	0.0011	-.1627	I	16.94	54.58	0.0000	-.2943
0015	67.00	60.4	53.02	14	49	I	8.26	54.68	0.0000	-.1709	II	8.26	50.70	0.0012	-.1419	II	9.80	51.17	0.0012	-.1662	I	16.94	54.77	0.0000	-.2999
0030	67.00	62.8	54.09	12	49	II	7.08	53.84	0.0001	-.1526	II	7.08	50.29	0.0017	-.1239	II	8.40	50.80	0.0018	-.1448	II	14.52	53.78	0.0003	-.2634
0045	67.20	61.8	53.84	13	48	I	7.67	54.36	0.0000	-.1641	II	7.67	50.78	0.0015	-.1352	II	9.10	51.27	0.0015	-.1581	I	15.73	54.32	0.0000	-.2857
0100	67.40	63.2	54.65	19	67	I	11.21	57.32	0.0000	-.2406	II	11.21	53.47	0.0009	-.2104	II	13.30	53.87	0.0007	-.2465	I	22.99	57.69	0.0000	-.4349
0115	65.80	68.4	55.26	22	61	I	12.98	56.77	0.0000	-.2718	II	12.98	53.81	0.0013	-.2412	II	15.40	54.19	0.0011	-.2831	I	26.62	57.22	0.0000	-.4982
0130	63.0	83.2	57.90	11	42	II	6.49	53.81	0.0021	-.1437	II	6.49	49.96	0.0037	-.1146	II	7.70	50.54	0.0040	-.1343	II	13.31	53.91	0.0038	-.2484
0145	63.60	82.0	58.09	8	10	II	4.72	52.64	0.0020	-.1083	II	4.72	47.74	0.0035	-.0799	II	3.52	43.67	0.0035	-.0483	II	7.92	51.15	0.0039	-.1422
0200	65.00	79.8	58.72	9	20	II	5.31	54.30	0.0019	-.1282	II	5.31	49.88	0.0034	-.0994	II	3.96	46.14	0.0036	-.0637	II	8.91	53.01	0.0037	-.1727
0215	66.40	74.4	58.16	15	53	II	8.85	56.73	0.0010	-.2094	II	8.85	53.82	0.0028	-.1793	II	10.50	54.29	0.0030	-.2096	II	18.15	56.83	0.0018	-.3722
0230	66.40	73.2	57.72	15	59	II	8.85	56.46	0.0009	-.2066	II	8.85	53.54	0.0027	-.1766	II	10.50	54.01	0.0028	-.2065	II	18.15	56.55	0.0015	-.3671
0245	66.80	70.8	57.19	20	62	I	11.80	57.22	0.0000	-.2682	II	11.80	54.93	0.0019	-.2374	II	14.00	55.33	0.0019	-.2781	II	24.20	57.54	0.0000	-.4881

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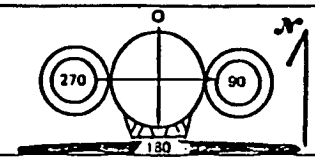
FIGURE 21. Ice/Frost Computer Predictions

STS – 36	TEST: S0007 LAUNCH	DATE: 2/27/90	T–0 TIME: 02:50 DATE: 2/28/90

ORBITER	ET	SRB	MLP	PAD	LO_2				LH_2			
OV– 104	33	BI – 036	1	A	CHILLDOWN TIME: 20:42	FAST FILL TIME: 21:33	SLOW FILL TIME: 21:19	REPLENISH TIME: 23:35	CHILLDOWN TIME: 20:43	FAST FILL TIME: 21:16	SLOW FILL TIME: 20:52	REPLENISH TIME: 23:15

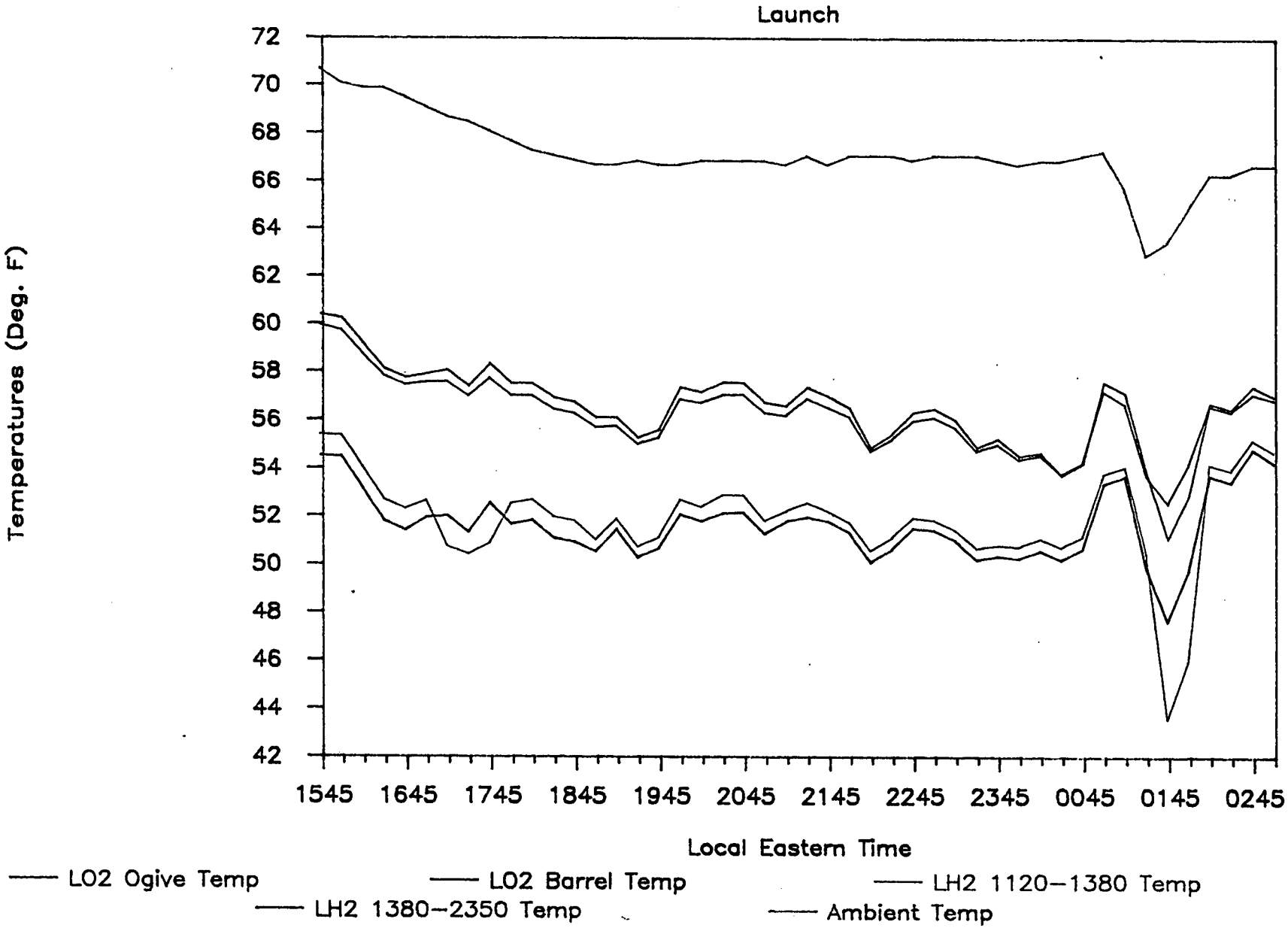


LOCAL TIME	CONDITIONS					LO_2 TANK STA 370 TO 540					LO_2 TANK STA 550 TO 852					LH_2 TANK STA 1130 TO 1380					LH_2 TANK STA 1380 TO 2058				
	TEMP. °F	REL HUM. %	DEW PT °F	WIND VEL. KNTS	WIND DIR DEG	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR
0250	66.80	71.8	57.58	17	59	I	10.03	59.96	0.0005	-.2331	II	10.03	54.34	0.0023	-.2027	II	11.90	54.78	0.0024	-.2372	II	20.57	57.07	0.0008	-.4187
AVERAGE	67.3	60.2	53	16.5	E NE			56.3					51.7					52					56.6		

EGG/V–340

FIGURE 22. Ice/Frost Computer Predictions

FIGURE 23. ET Surface Temperature From SurficeC



The summary of Ice/Frost Team observation anomalies consists of 13 OTV recorded items:

Anomaly 001 documented a 2-inch long ice/frost line along the aft bondline of the third hardpoint closeout. The ice/frost was acceptable per NSTS-08303.

Anomaly 002 recorded ice/frost formations on the ET LH2 tank aft dome manhole cover closeout perimeter. This ice/frost was acceptable per NSTS-08303.

The presence of ice/frost on the LH2 ET/ORB umbilical, on the purge vents, in the LH2 feedline bellows, and in the LH2 recirc line bellows (Anomaly 003) was acceptable per NSTS-08303.

Anomaly 004 documented ice/frost accumulation in the LO2 feed line bellows and support brackets. This condition was acceptable per NSTS-08303.

Icicles and ice/frost formations on the ends of the GOX vent ducts (Anomaly 005) were recorded on PR U78-0001-00-001-0539 and accepted for launch per LCC waiver LW-020.

Two ice/frost spots on the +Y longeron closeout (Anomaly 006) were acceptable per NSTS-08303.

Anomaly 007 documented ice/frost in the stringer valleys on the -Z side of the intertank at the LO2 tank flange. This condition was acceptable per NSTS-08303.

Anomaly 008 recorded an ice/frost spot on the aft side of the -Y bipod ramp and was acceptable per NSTS-08303.

Four ice/frost spots on the -Y longeron closeout (Anomaly 009) were acceptable per NSTS-08303.

Anomaly 010 documented ice/frost accumulation on the LO2 ET/ORB umbilical, which were acceptable per NSTS-08303.

Anomaly 011 recorded small ice/frost accumulations on the aft sides of the LH2 tank pressurization line ramps. This condition was acceptable per NSTS-08303.

Three ice/frost spots on the -Z side of the forward LH2 tank aft of the intertank access door covered 3 sanded repair areas (Anomaly 012) and were acceptable per NSTS-08303.

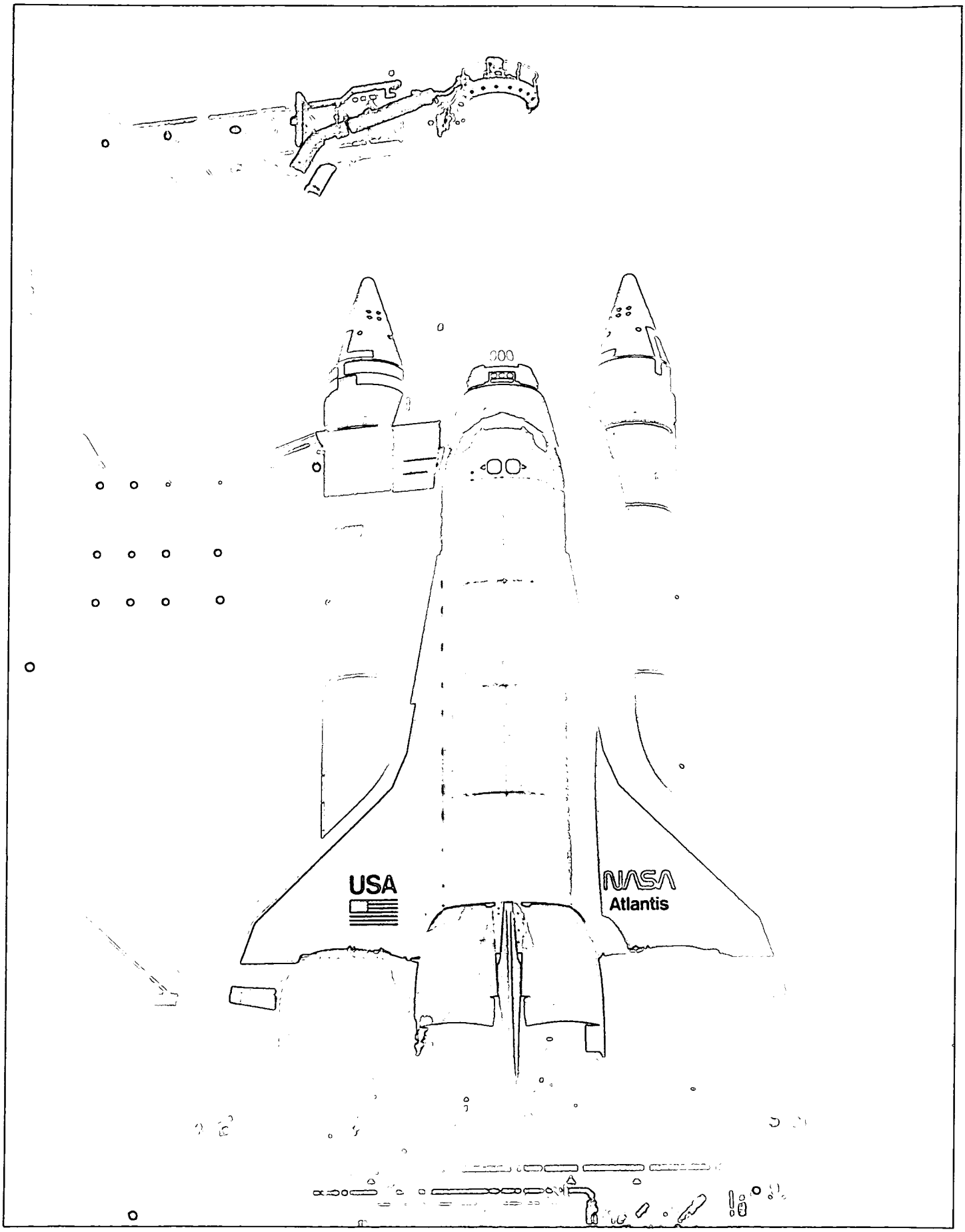
Anomaly 013 documented an ice/frost accumulation at the diagonal strut to TSE attach point, a condition acceptable per NSTS-08303.

6.5 FACILITY OBSERVATIONS

All debris concerns previously identified had been resolved prior to cryoloading and no new items were noted during the walkdown. No leaks were observed at either the LO2 or LH2 ORB T-0 umbilical carrier plates, though small amounts of ice/frost had formed. The loose purge barrier previously observed on the LH2 TSM during the second tanking had been re-attached. There was no apparent leakage anywhere on the GH2 vent line. The modification to the GH2 vent line prevented ice from forming but some ice/frost, which was expected, had accumulated on the GUCP legs.

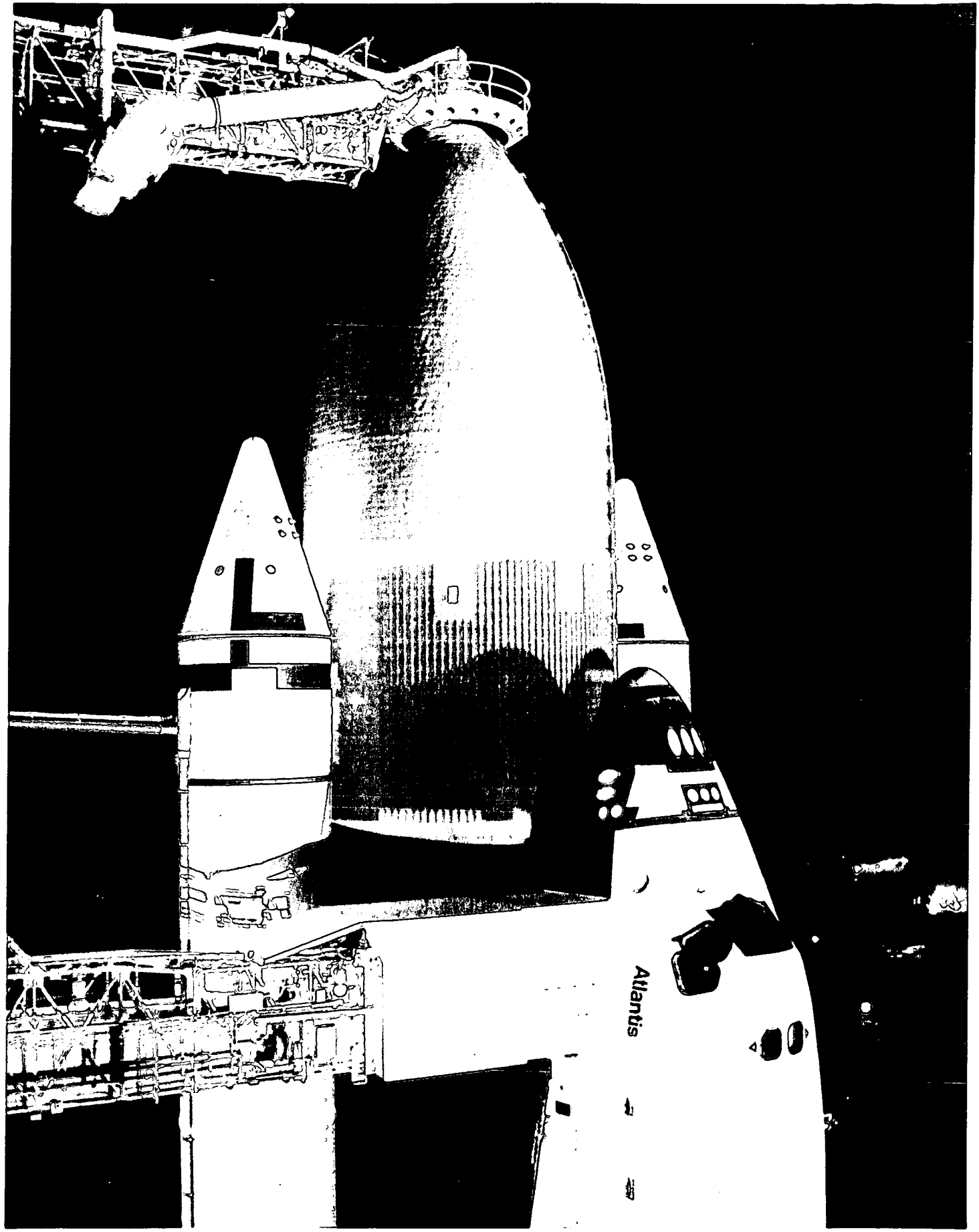
Although the GOX seals had been positioned a little high on the footprint grid, Visual and infrared observations of the seals confirmed no leakage. An icicle 1-1/2"x3/4" had formed at the end of the north GOX vent duct. The estimated density of the icicle was 20-30 pounds per cubic foot. LCC Waiver LW-020 accepted the presence of the icicle for launch based on the rationale that ice formation on the north GOX vent duct is not directly over any flight element with the GVA is extended or during retraction prior to launch. The prevailing winds, which were from the east/northeast, would carry any falling ice away from the vehicle in the event any ice should fall.

All sound suppression water troughs were full of water. The ET/ORB hydrogen detection sensor tygon tubing had not been re-installed after the first scrub.

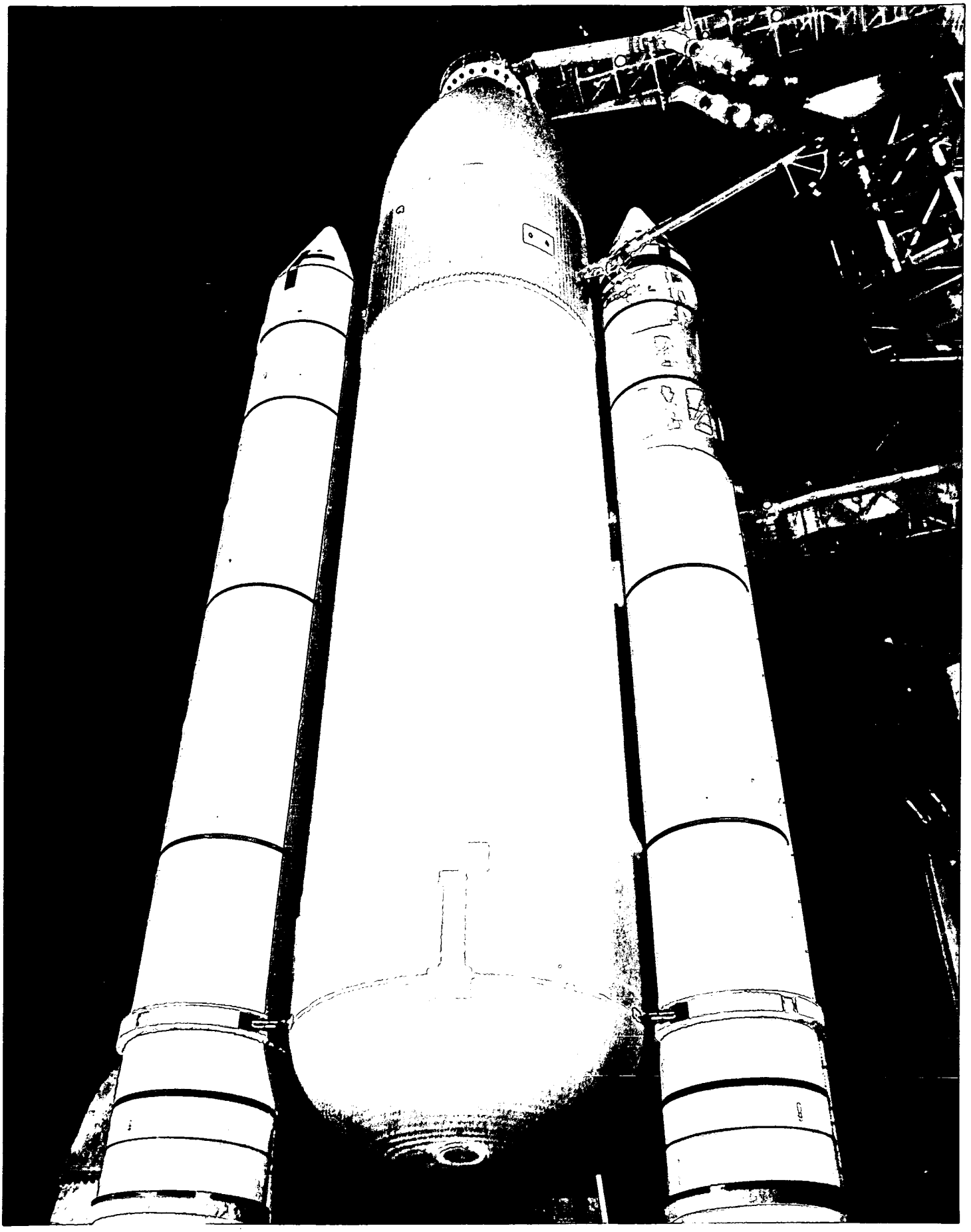


Overall view of OV-104 Atlantis, ET-33 (LWT 26), and BIO36

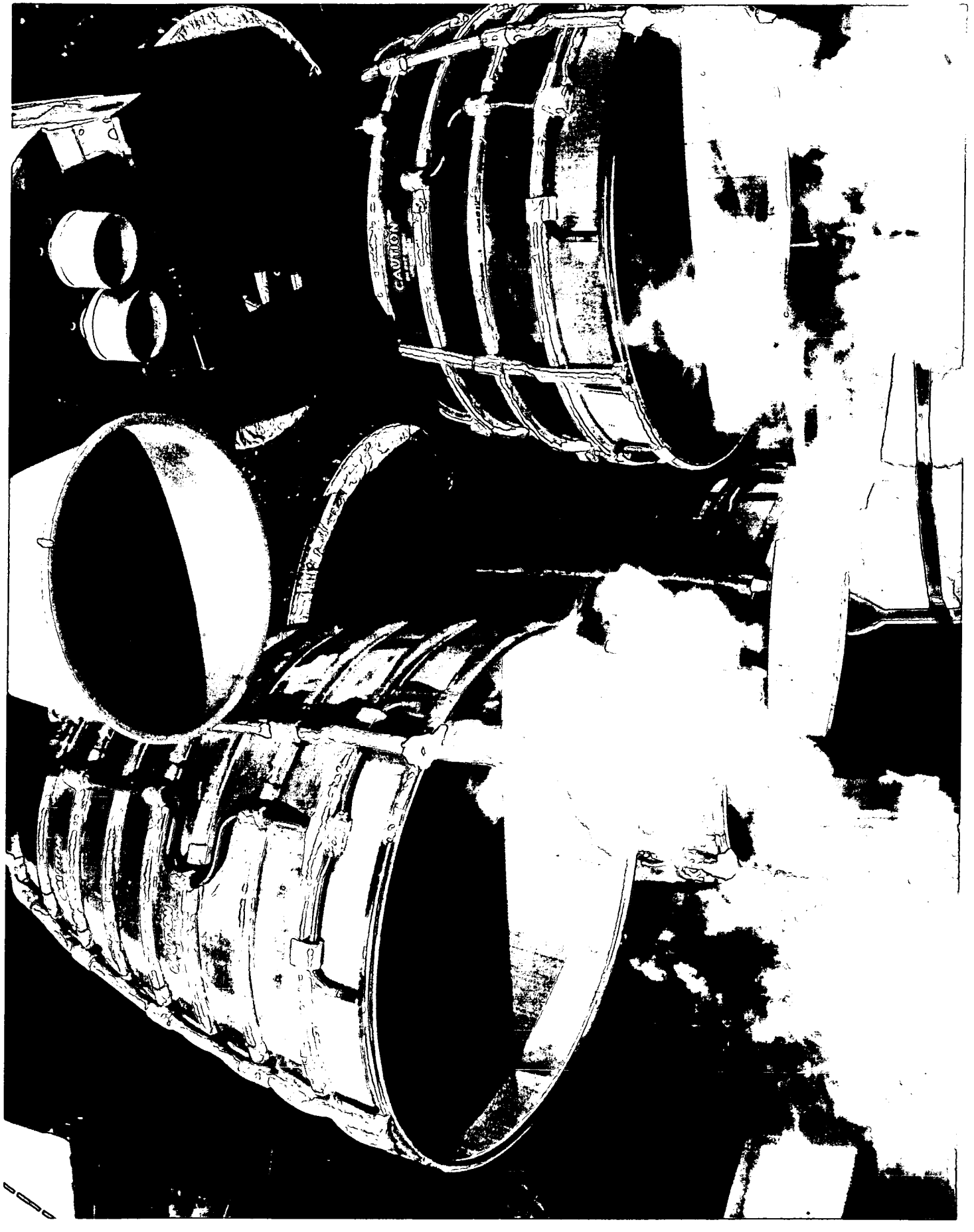
ORIGINAL PAGE
COLOR PHOTOGRAPH



Weather conditions during the third cryo loading of the vehicle precluded the formation of acreage frost



Overall view of SRB's BI036 and ET-33 -Z side



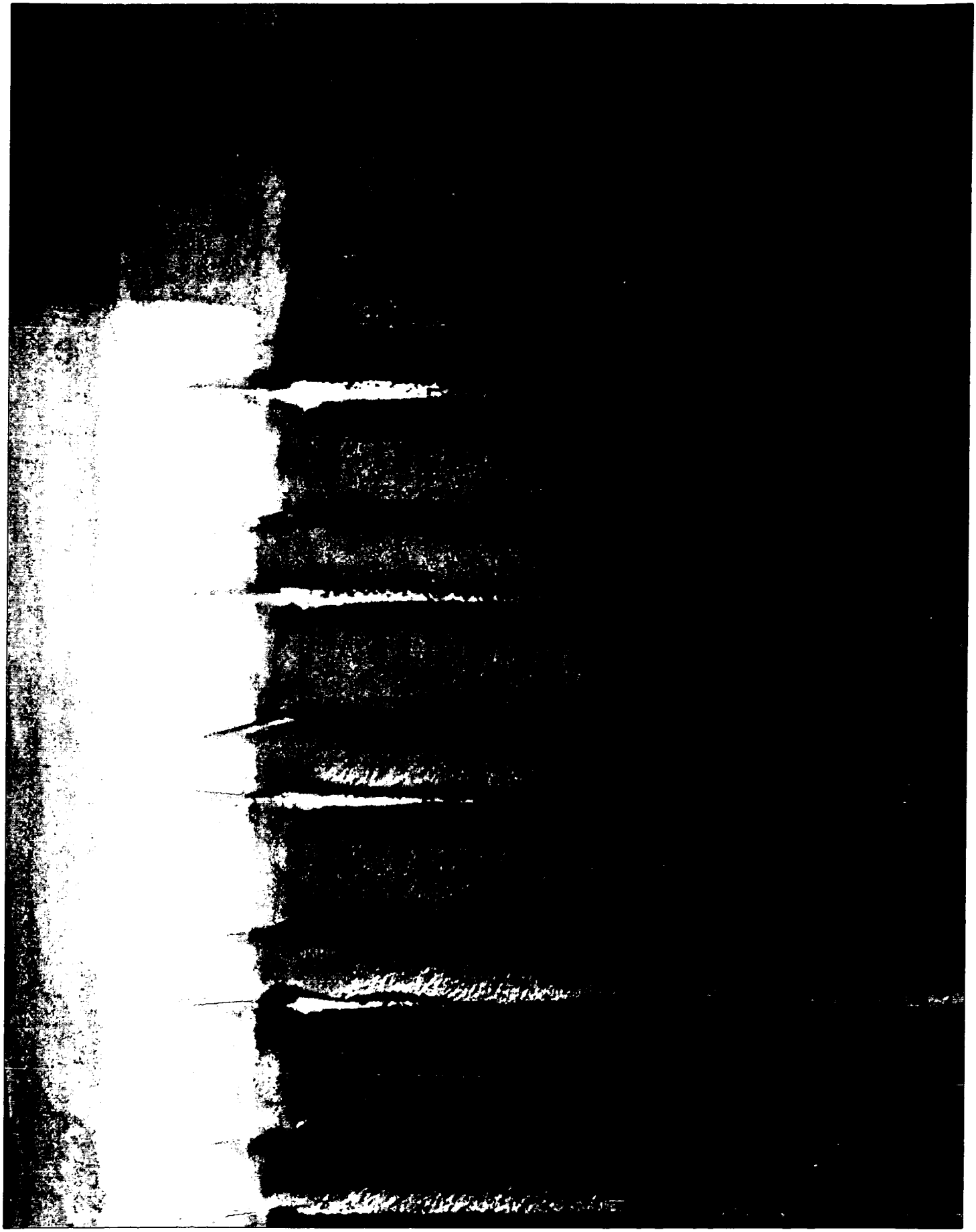
Overall view of Shuttle Main Engines shows frost along the SSME #2 engine heat shield-to-nozzle interface

ORIGINAL PAGE
COLOR PHOTOGRAPH

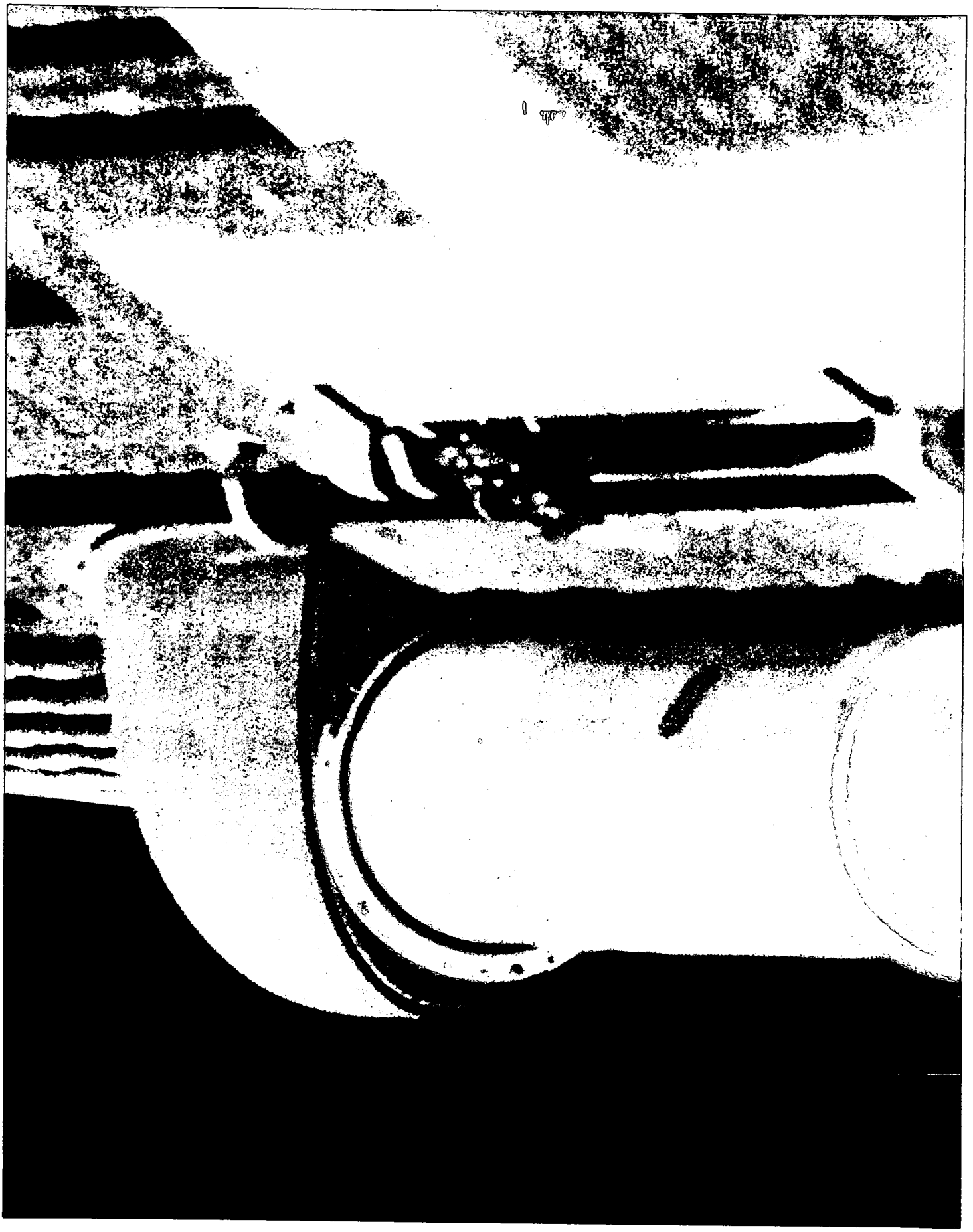
Ice/frost has formed along the SSME #1 and #2 engine mounted heat shields-to-nozzle interfaces

Overall view of RH OMS pod/RCS stinger and LO2 T-0 umbilical

Overall view of LH OMS pod/RCS stinger and LH2 T-0 umbilical



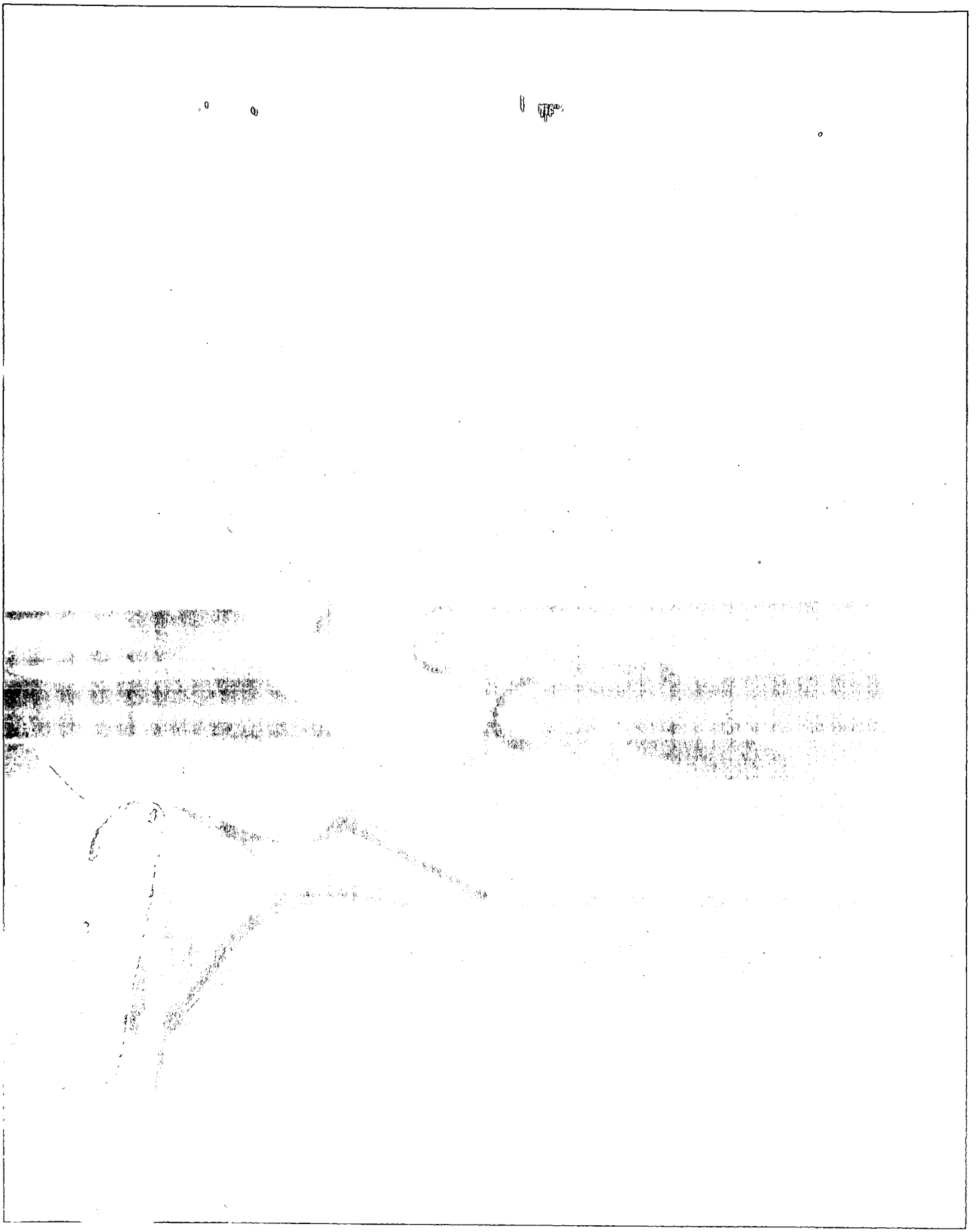
Ice/frost accumulated in the ET intertank -Z side stringer valleys at the LO2 and LH2 tank flanges



A typical accumulation of ice/frost was present in the LO2 feedline upper bellows

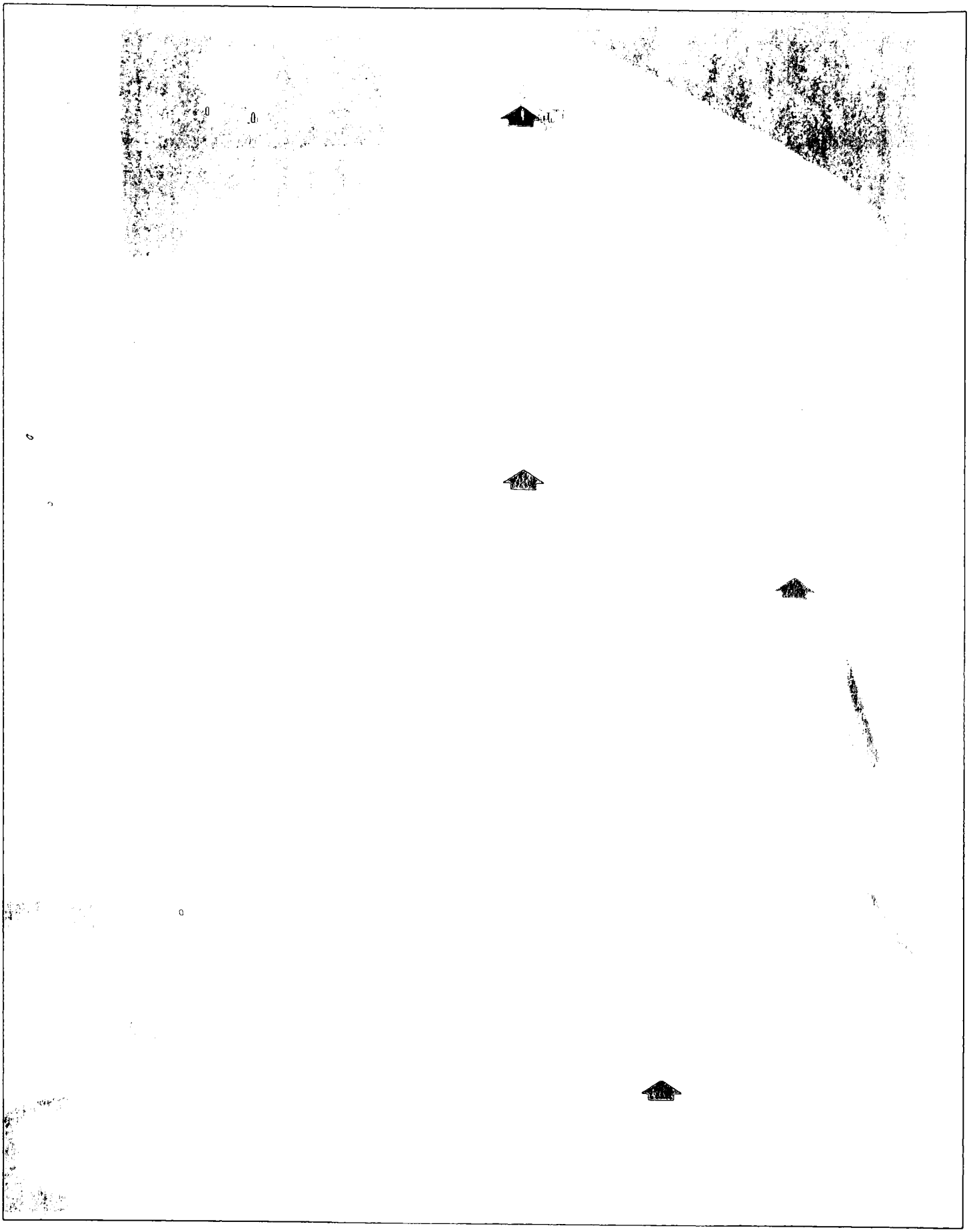
C-2

ORIGINAL PAGE
COLOR PHOTOGRAPH



Some ice/frost was visible in the LO2 feedline support brackets

A typical accumulation of ice/frost was present in the LO2 feedline lower bellows



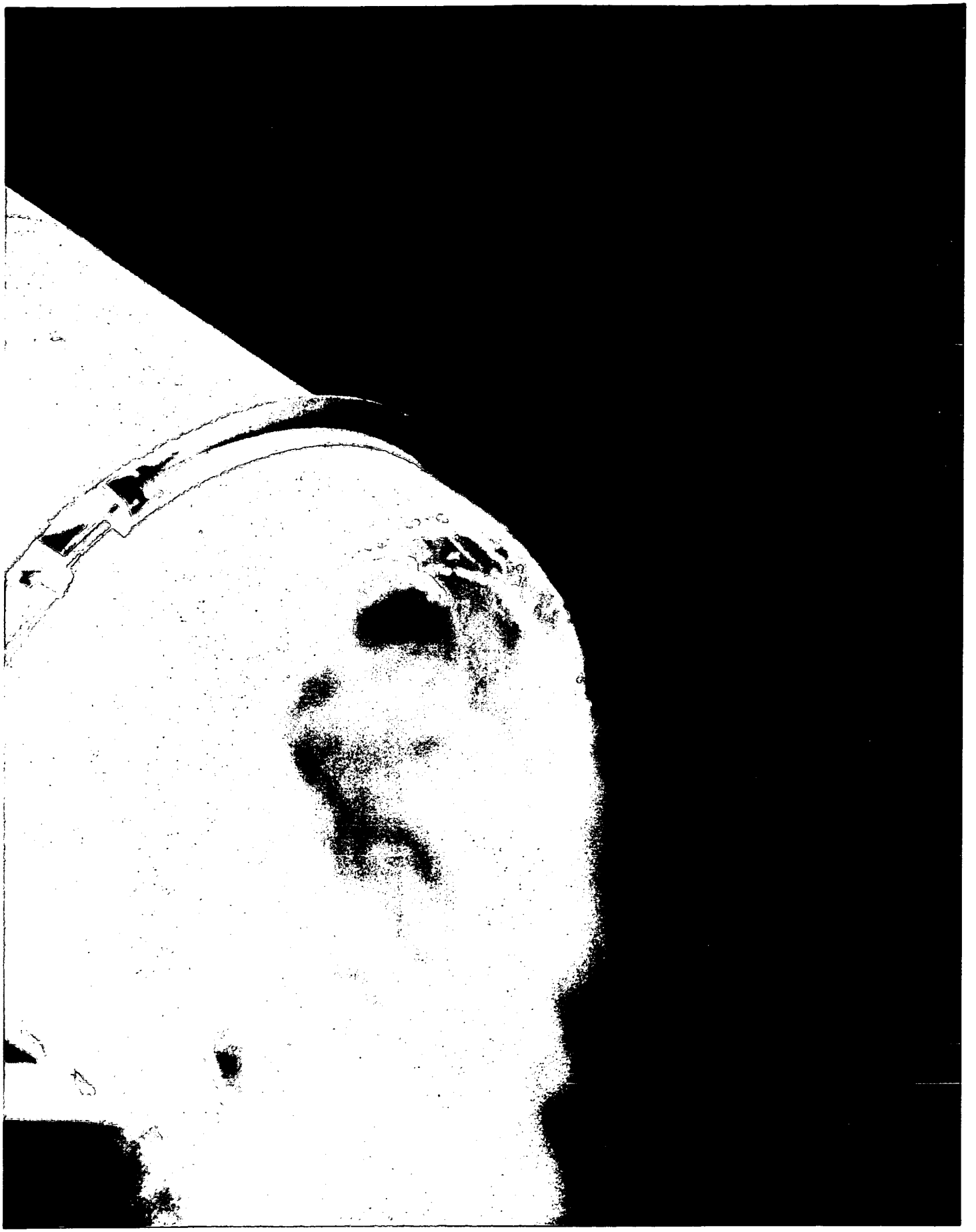
Four ice/frost spots formed on the -Y longeron closeout and thrust strut interface (arrows)

Ice/frost accumulated along the aft edge and in the splice of the ET/SRB cable tray

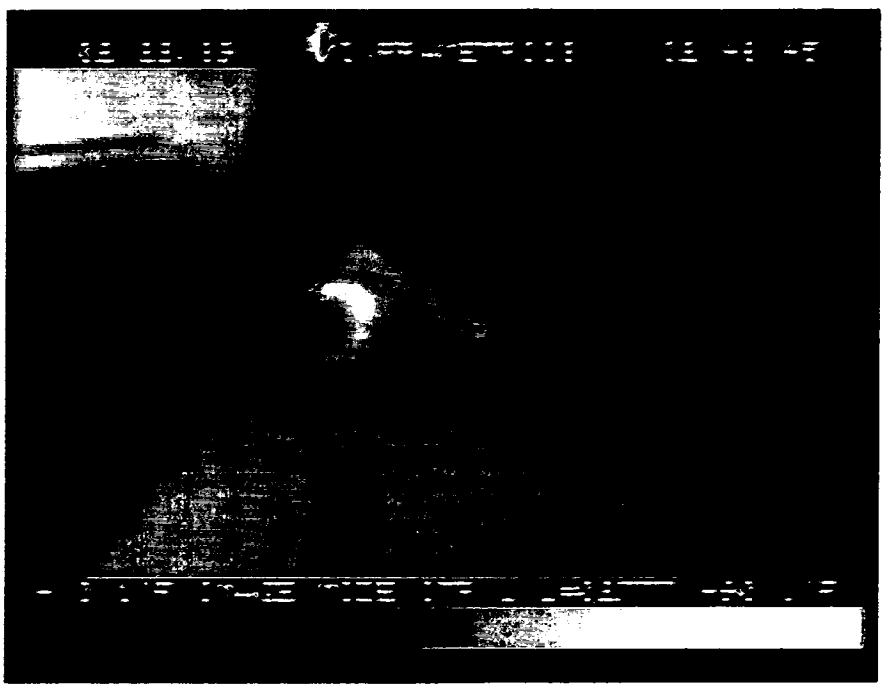
Ice/frost formation on the LO2 ET/ORB umbilical baggie material and purge vents was lighter than usual

Ice/frost formation on the top and outboard sides of the LH2 ET/ORB umbilical baggie and on the purge vents was typical

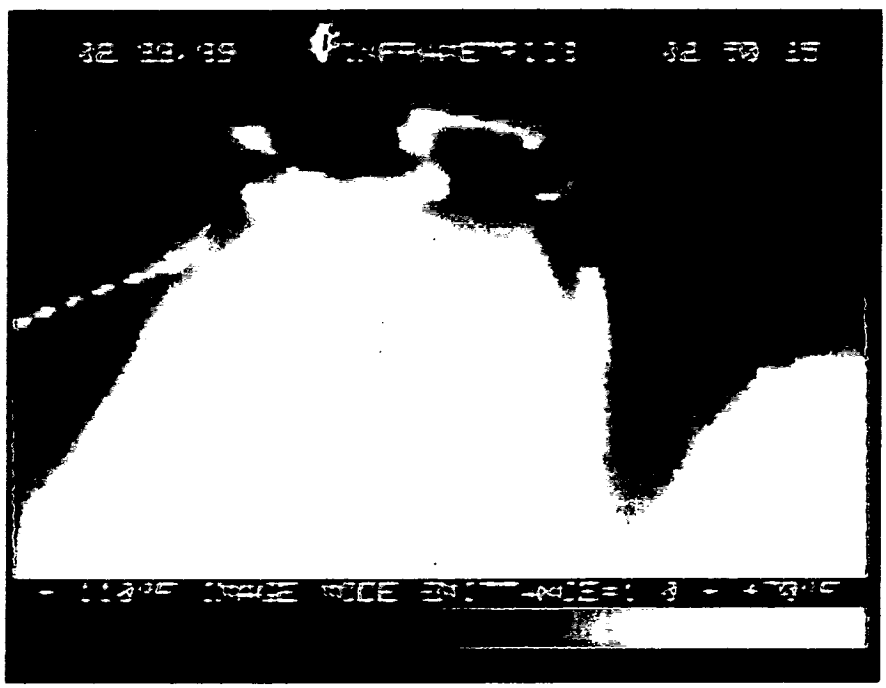
Both LH2 recirculation line bellows were covered by frost while the LH2 feedline bellows remained clear



Small icicles had formed on the end of the north GOX vent duct



Shuttle Thermal Imager on the RSS roof recorded hot APU exhaust and cool ET southwest louver prior to launch



Shuttle Thermal Imager at Camera Site #2 recorded views of the SSME's at T-0 and as the vehicle cleared the tower

7.0 POST LAUNCH PAD DEBRIS INSPECTION

The post launch inspection of the pad and surrounding area began on 28 February 1990 from launch + 2.5 to 8 hours. The MLP, FSS, pad apron, and acreage areas were inspected. No flight hardware or TPS materials were found. The usual SRB throat plug material (foam/RTV) and water trough material from the SRB exhaust holes was scattered through the field and on the pad apron.

Orbiter telemetry showed a lateral acceleration of 0.14 g just after liftoff. A value of 0.18-0.20, or above, has correctly predicted in the past the presence of an SRB stud hang-up. Although this value is below the stud hang-up range, it is higher than the expected value for a launch with no stud hang-ups. There was no external signs on any of the holddown posts to indicate that a stud hang-up had occurred.

SRB holddown post erosion was normal for this launch. All south holddown post shim material was intact, but was at least partially debonded from the shoe sidewalls/bases. Shim material was completely debonded on holddown post #2. All of the dog house blast covers on the north holddown posts were in the closed position and did not appear to be missing any parts. All doghouse blast covers exhibited more than normal erosion on the outboard corners. The doghouse blast cover on holddown post #8 appeared to have a small crack. The SRB aft skirt purge lines were in place and slightly damaged. The SRB T-0 umbilicals showed minor damage after separation.

Several pieces of facility debris were scattered to the pad perimeter. The most significant facility debris was large pieces of flame deflector found in the flame trench and north field. A loud speaker and a pad lighting fixture lay on the pad surface under the MLP north of the elevators. Two brackets holding a hot air purge duct under the 115 ft level broke loose causing the duct to sag and kink.

The GOX vent arm, OAA, and TSM's showed slight signs of damage. The GH2 vent arm was latched on the eighth tooth of the latching mechanism and no loose cables dangled from the haunch area. The GUCP showed typical signs of SRB plume heating. The GH2 vent arm retracted nominally though the north latch contacted and rode against the north saddle stabilizer. This has occurred on previous launches.

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

Overall, there was very little damage to the launch pad.

Patrick AFB and MILA radars were configured in a mode for increased sensitivity for the purpose of observing any debris falling from the vehicle during ascent. Although most of the signals registrations were very weak and often barely detectable, a total of 34 particles were imaged in the T+145 to 326 time period corresponding to vehicle altitudes between 130,000 to 375,000 feet. Eight of the particles were imaged by only 1 radar, 14 particles were imaged by two radars, and 12 particles were imaged by all three radars. One particle at T+159 seconds and another at T+175 seconds were at least 4 times the size, or had 4 times the signal strength, of the rest of the particles. Exhaust plume effects/attenuation of the signal occurred just before SRB separation in the T+120 to 125 time frame.

The debris inspection continued on 1 March 1990 and was expanded to include areas outside the pad perimeter fence. Ground teams searched the beach, railroad tracks, and the beach road from the northern KSC boundary to the Titan complex. The NASA helicopter was utilized to cover the water areas around the pad, the beach from Port Canaveral to a point 10 miles north of the pad, and the ocean area under the flight path. Although pieces of foam and K5NA/cork material were recovered from other launch vehicles, none were from this mission.

All north holddown post doghouse blast covers were closed after launch though the SRB plume had eroded some cover corners

Shim material is debonded on south holddown post #1

Shim material is debonded on south holddown post #6

8.0 FILM REVIEW SUMMARY/PROBLEM REPORT DISPOSITION

A total of 116 film and video data items, which included 33 videos, 55 16mm films, 27 35mm films, and 1 70mm film were reviewed starting on launch day.

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

Prior to SSME ignition, free burning hydrogen rises along side SSME #2 toward the base heat shield and was blown west past the LH2 TSM by the prevailing winds. Red/yellow streaks in the SSME exhaust plume were caused by pieces of aft RCS paper covers falling into the plume (E-16, 18, 19, 20, 24, 63, 77).

SSME ignition acoustics and vibration caused a small piece of tile surface coating material to shake loose from the base heat shield near the LO2 T-0 carrier plate (E-19). A heavy shower of ice/frost particles from the ET/ORB LH2 and LO2 umbilicals fell past the body flap during SSME ignition, but no tile damage was visible (E-5, 6, 25, 26, 31, OTV 9, OTV 63). A tumbling particle with a siny or translucent side, most likely a piece of ice from the GUCP area, fell into the field of view from above and may have lightly grazed the LH inboard elevon near the trailing edge. No tile damage was visible (E-31).

The weak frangible links between the DCS plungers and the holddown post studs were installed for this flight in an attempt to reduce the amount of debris lost from the Debris Containment System (DCS). No debris was visible falling from holddown posts #1 through #7 after liftoff. However, 6 pieces of debris, including 2 ordnance pieces (Figure 24) measuring 3"x1/4"x1/4", fell from the HDP #8 aft skirt stud hole (E-14, 28). There was no sign of holddown post stud hang-ups in any of the films.

A 12"x8"x4" piece of aft skirt instafoam just to the right of the holddown post #1 shoe broke away as the vehicle lifted off. The piece either stuck to the shoe when the instafoam was applied or lack of clearance with the shoe caused the piece to break away (EX1, E-8). Just after T-0, an L-shaped piece of aluminum tape or very thin sheet metal exited the SRB T-0 umbilical area and moved out of view (EX3).

The two LH FWD RCS pitch thruster covers (large) tore just after liftoff and fell from the vehicle prior to tower clear. More FWD RCS paper covers fell from the vehicle at the start of the roll maneuver and through early ascent (E-34, 40, 52, 57, 59, 62). These covers do not usually come off this early and may have been weakened by a thunderstorm and rainfall one hour before launch.

Vehicle position just after liftoff was determined from CZR data as measured from the RH SRB nozzle (Frames 25-26).

FIGURE 24. Falling Debris Particle from DCA HDP #8

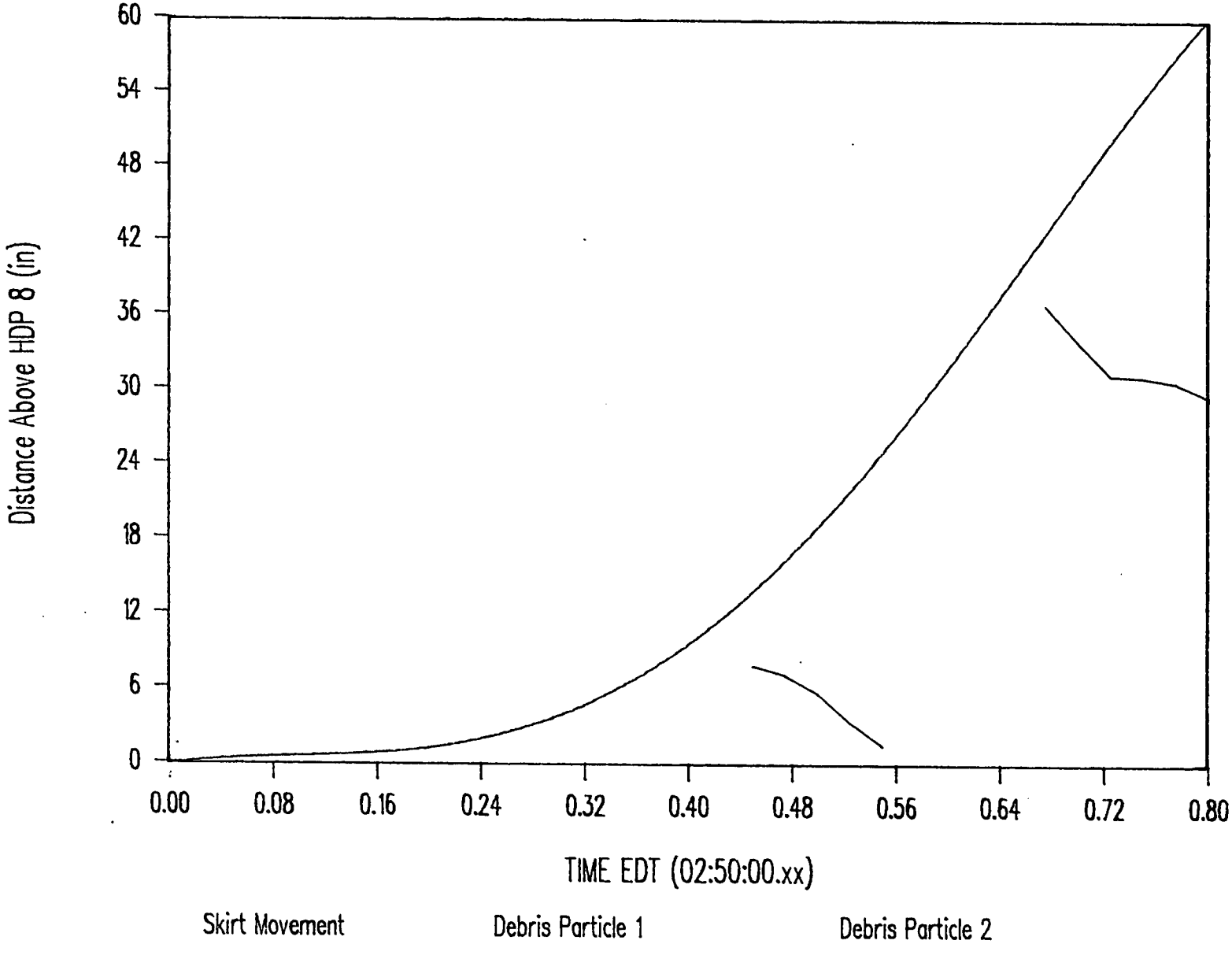


FIGURE 25. CZR Position Data
for the RH SRB Nozzle

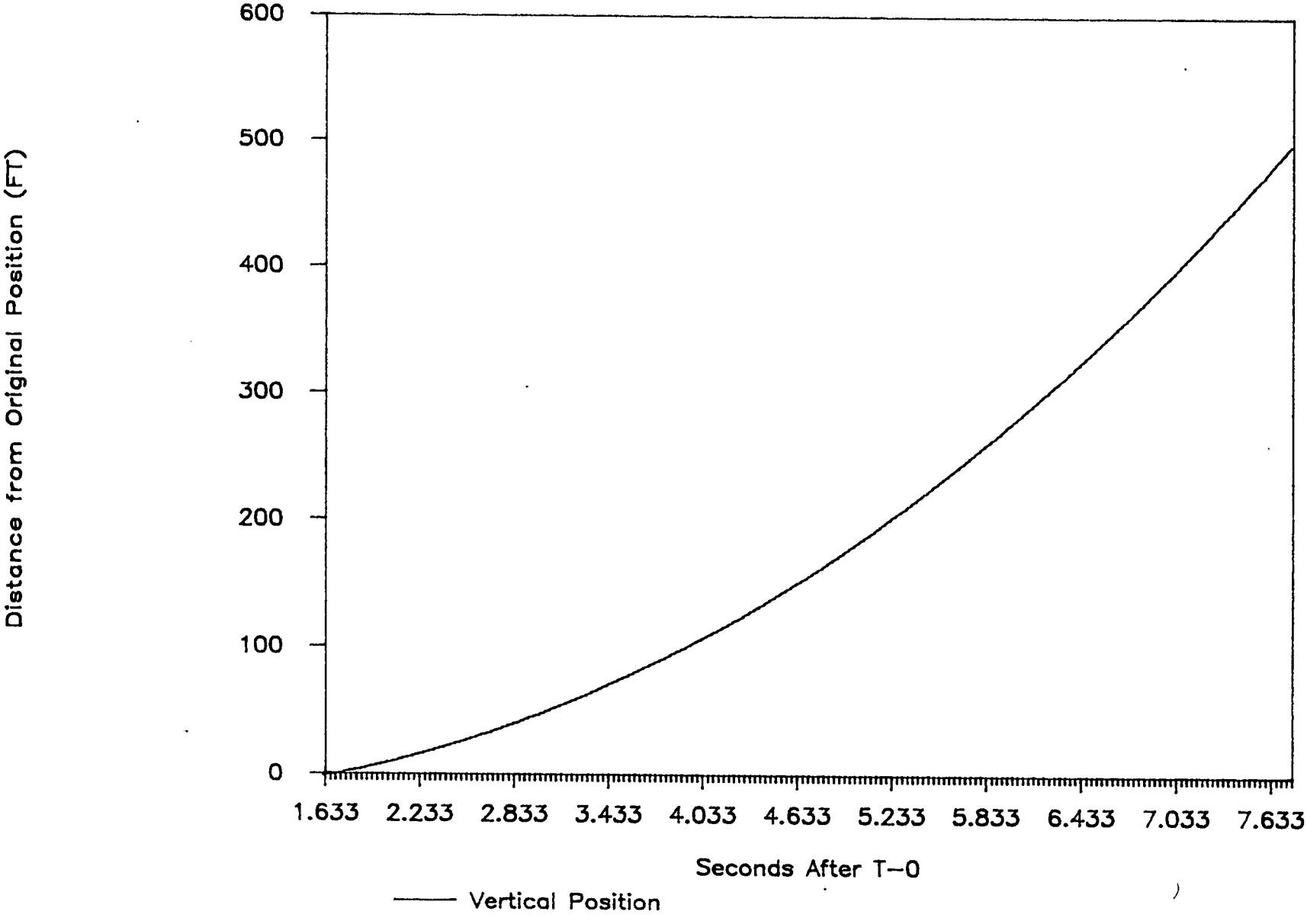
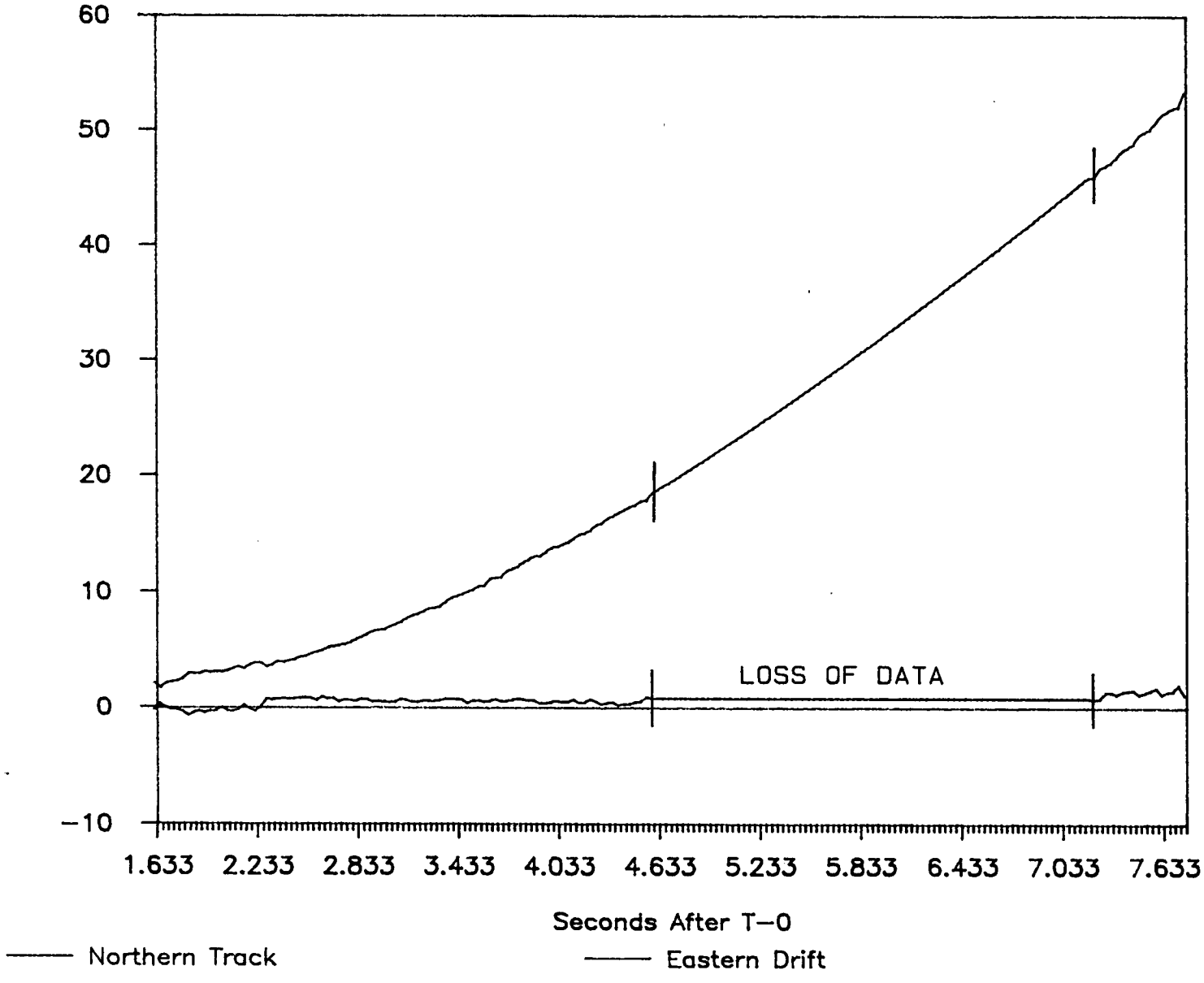


FIGURE 26. CZR Position Data
for the RH SRB Nozzle



There were no major facility anomalies. No swing arms or other pad structures contacted the vehicle during liftoff. The GH2 vent line latched properly, but excessive slack in the static retract lanyard created a loop of cable that contacted the underside of the haunch, reversed direction of travel, came around the pulley, and contacted the GUCP before full retraction of the cable was complete (E-42).

Many film and video items recorded various amounts of flying debris on the pad after the vehicle cleared the tower. This debris is SRB throat plug material and shredded sound suppression water troughs - an expected occurrence.

Movement of the Orbiter body flap after the roll program and during ascent appeared to have magnitude and frequency similar to previous flights (E-207, 213, 223).

Numerous flashes were visible in the SSME plume during ascent. Most, but not all, of the flashes could be explained by debris, such as RCS paper covers, entering the plume (E-57, 207, 211, 212, 213, 222, 223, ET-207). Plume recirculation and ET aft dome charring was normal.

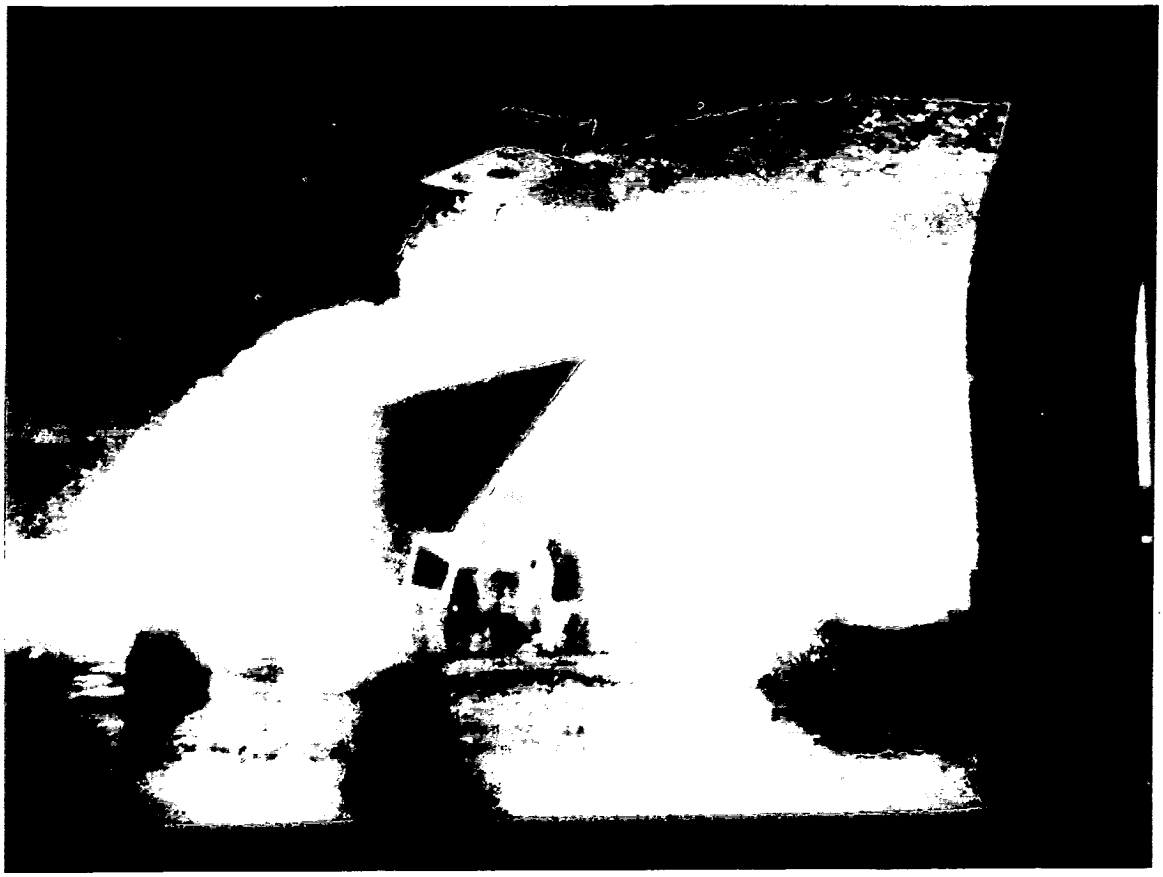
Numerous pieces of debris from the vehicle were visible during ascent. Most have been identified as ice/frost particles from the ET/ORB umbilicals and RCS paper covers from the Orbiter (E-52, 54, 57, 58, 61). A single particle fell out of the LH SRB plume at approximately T+33 seconds (E-222). Eleven particles fell out of the vehicle plume after Max Q at T+69 through 79 seconds. The particles appeared large, possibly due to the 'blooming' effect of burning chunks of propellant, slag, or inhibitor. The particles could also be pieces of aft skirt instafoam (E-223, TV-4). More than 100 chunks of SRB propellant slag/clinkers, some of which appear very large due to the burning 'blooming' effect, were visible in the SRB plumes prior to and just after separation from the External Tank (E-206, 208, TV-13, ET-206, ET-208, ET-212).

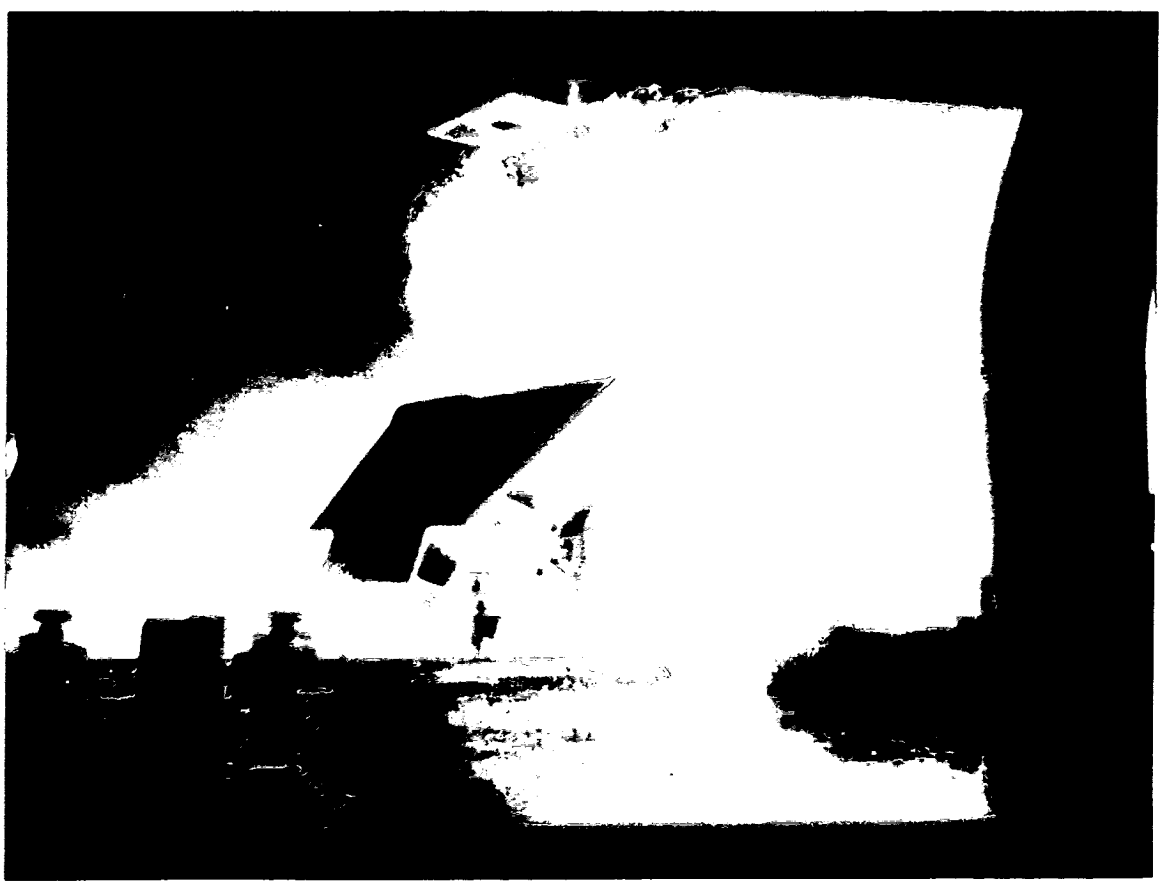
Optical phenomena/reflections, or lens effects, occur near the RH wing at the end of the roll maneuver, several times throughout ascent, and forward of the Orbiter nose just prior to SRB tailoff at T+97 and 114 seconds (E-52, 204, 207, 208, 223, ET-207).

Orbiter performance, landing gear extension, wheel touchdown, and vehicle rollout after landing at Edwards AFB was nominal.

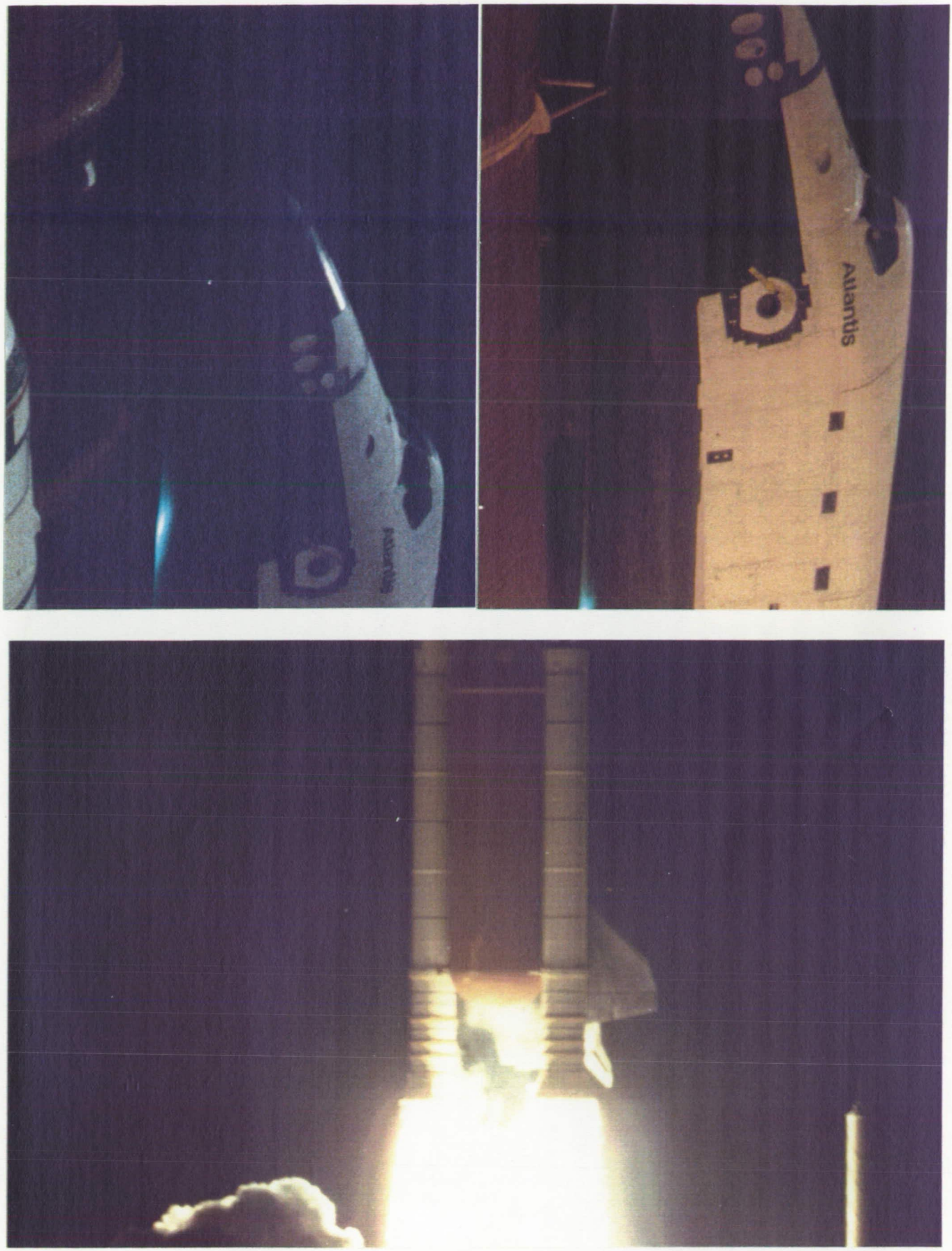
No PR's or IPR's were generated as a result of the film and video data review. However, the Post Launch Anomalies observed in the Film Review and IFA candidates were presented to the Mission Management Team, Shuttle managers, and vehicle systems engineers. These anomalies are listed in Section 12.2.

A 12"x8"x4" piece of aft skirt instafoam just to the right of the HDP #1 shoe broke away as the vehicle lifted off (EX1)

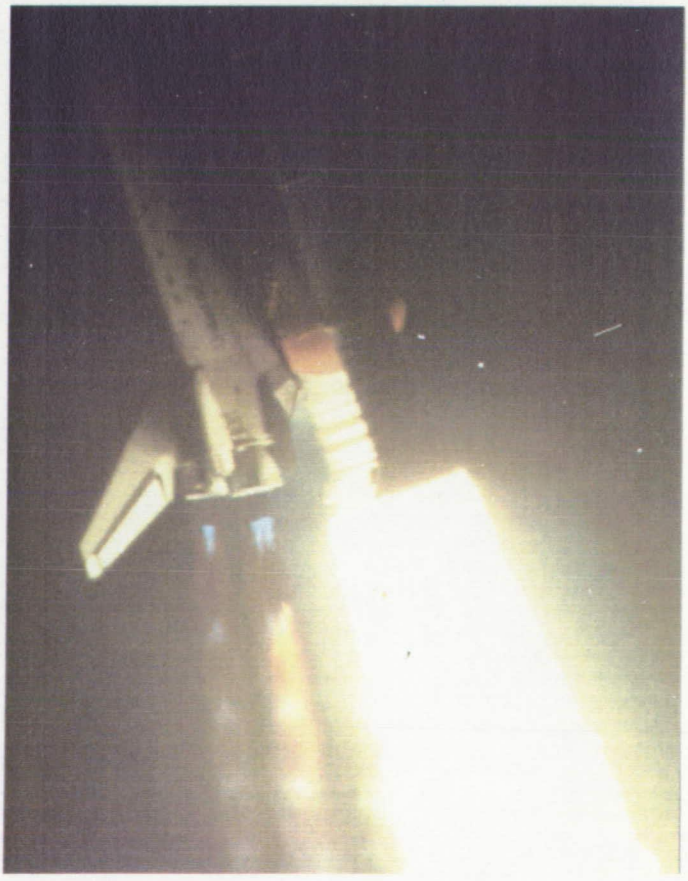




Six pieces of debris, including 2 ordnance pieces measuring 3"x1/4"x1/4", fell from the aft skirt HDP #8 stud hole (E-14)

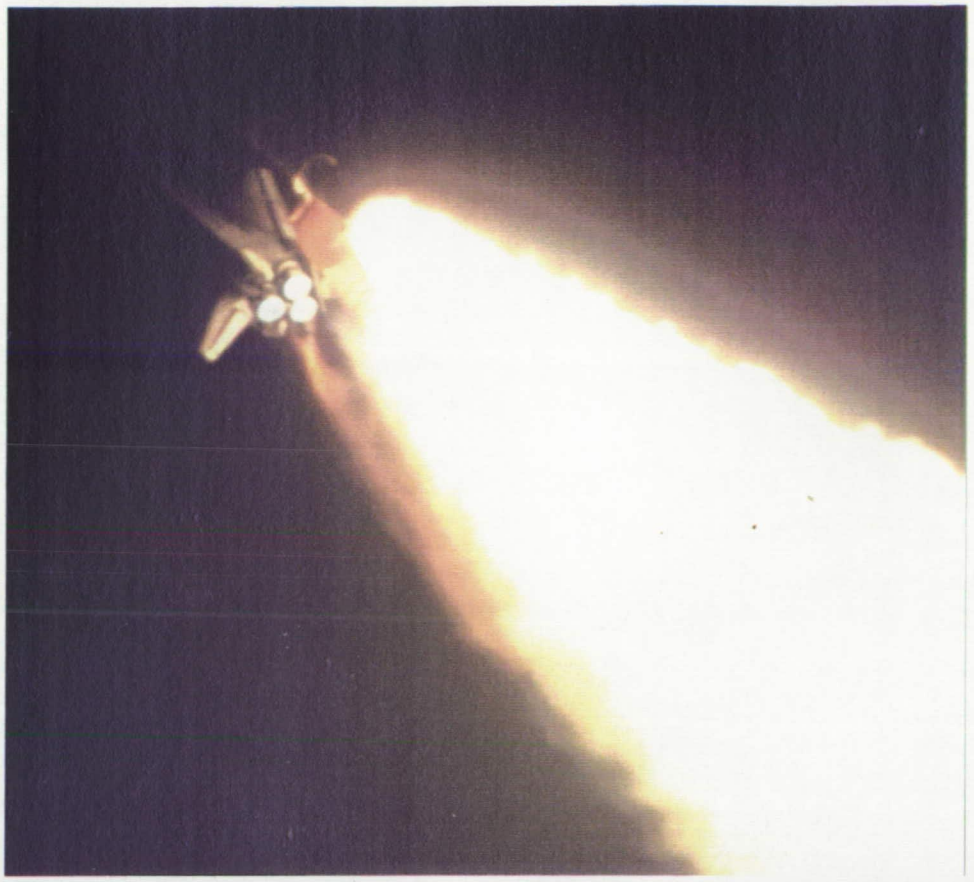


LH FWD RCS thruster paper covers tear just after T-0 and fall past the LH wing at tower clear (E-34, 223)

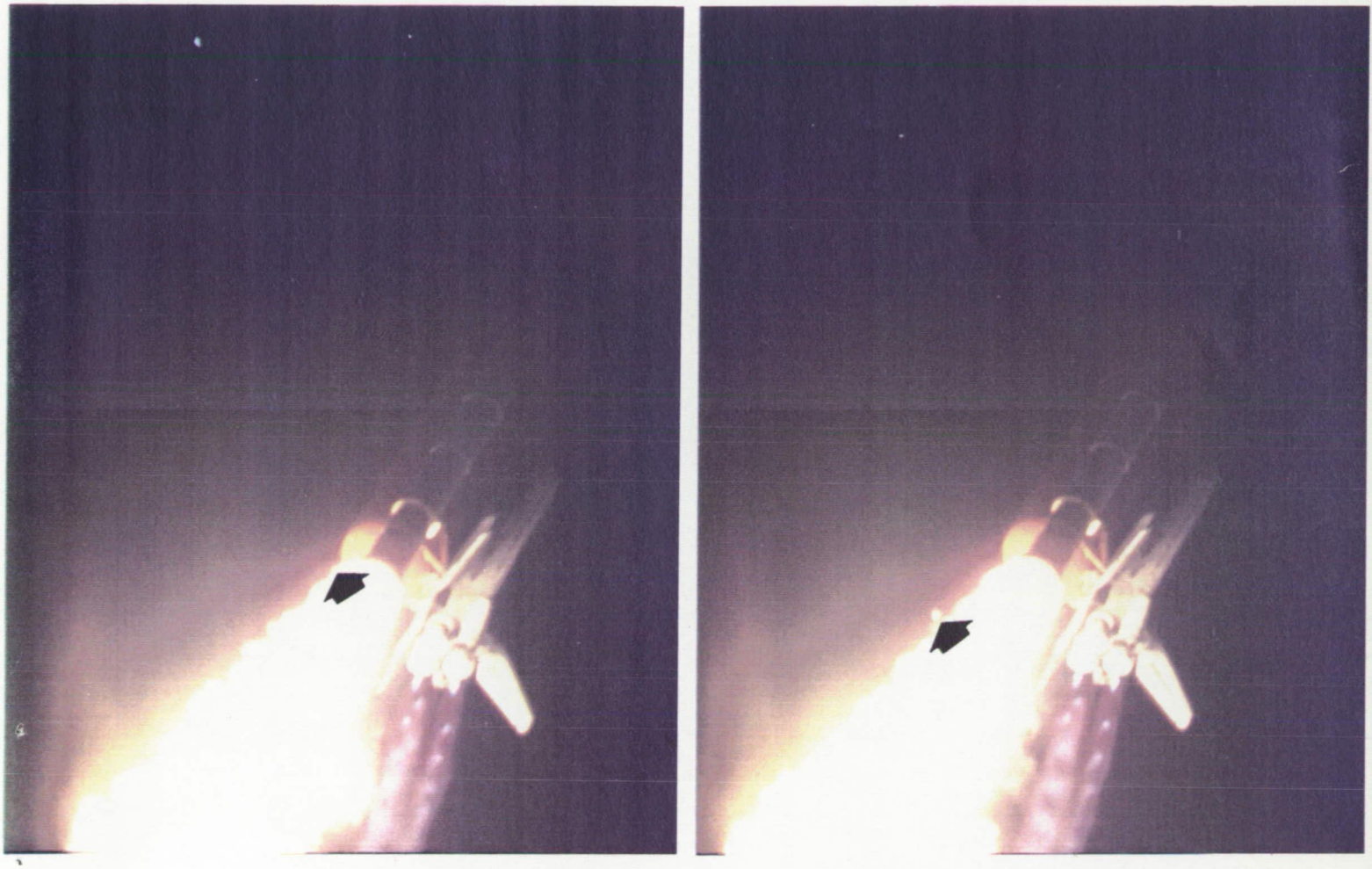


Orange streaks in the SSME plume occur throughout ascent and are caused by pieces of debris entering the plume

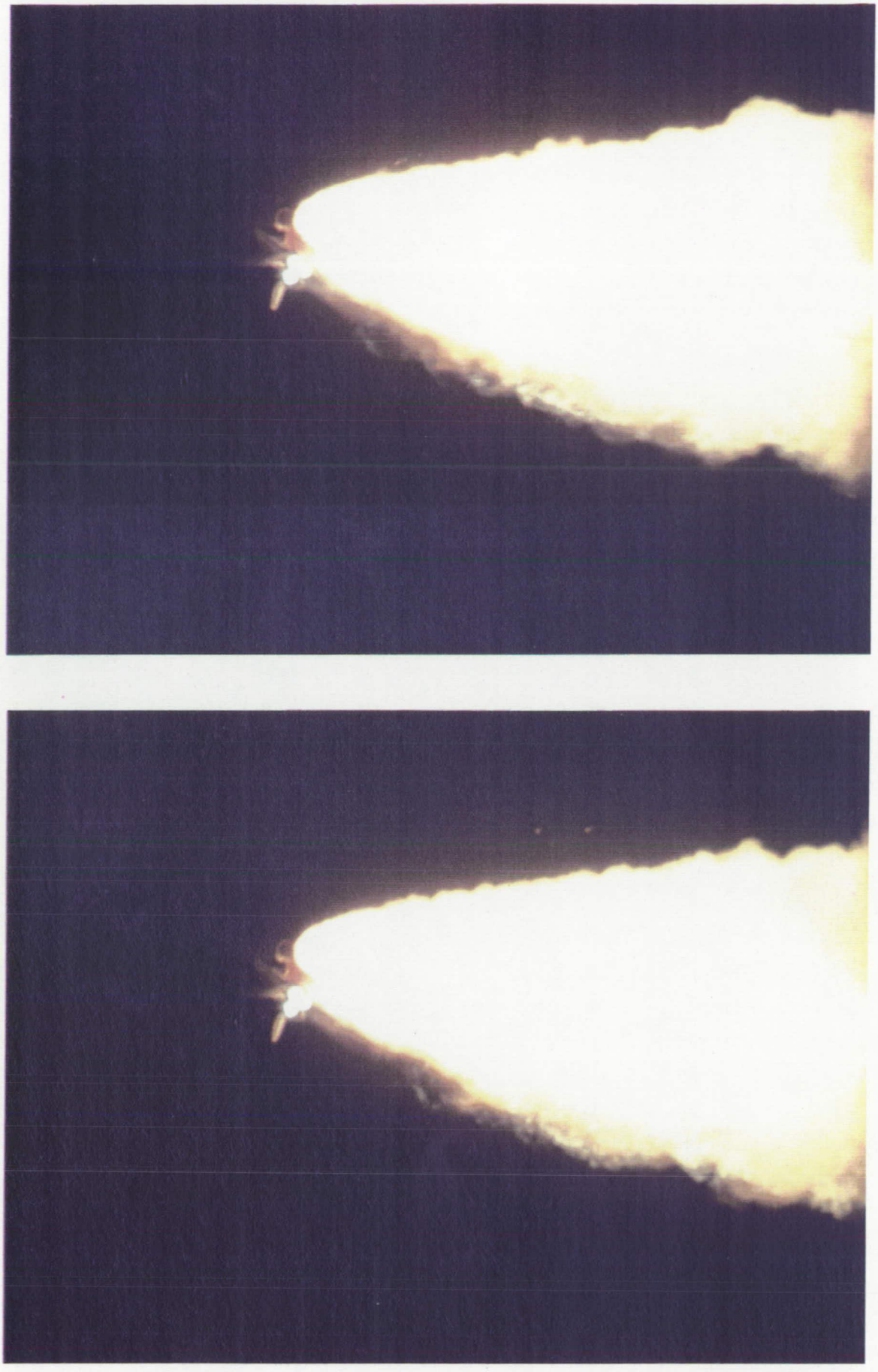
Small pockets of unburned hydrogen may cause these bright puffs in the SSME exhaust plume (E-223)



At 54 seconds MET, a large flash occurred in the exhaust plume of either SSME #2 or #3 (E-212, 223)



A bright-colored particle fell out of the LH SRB plume near the aft skirt at 33 seconds MET (E-222)



Two bright particles, believed to be pieces of SRB propellant and/or inhibitor, fall from the plume at 74 sec MET (E-223)

8.1 LAUNCH FILM AND VIDEO DATA REVIEW

FILM ITEMS

EX1
400 FPS
16mm

Camera is located on MLP deck south of RH SRB exhaust duct and looks north to view RH SRB Heater Umbilical during ignition and liftoff.

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED PRIOR TO T-0

Comments: K5NA AND INSTAFOAM TRIMMINGS MOVE AWAY FROM THE HDP AREA AFTER SSME IGNITION. NO STUD HANG-UPS ARE VISIBLE AT T-0. A 12"x8"x4" PIECE OF AFT SKIRT INSTAFOAM JUST TO THE RIGHT OF THE HDP #1 SHOE BREAKS AWAY AS THE VEHICLE LIFTS OFF. THE PIECE EITHER STUCK TO THE SHOE WHEN THE INSTAFOAM WAS SPRAYED OR LACK OF CLEARANCE WITH THE SHOE CAUSED THE PIECE TO BREAK AWAY. THE SRB T-0 UMBILICAL SEPARATED NORMALLY. TWO VERY SMALL DARK PIECES OF DEBRIS WERE VISIBLE IN THE HDP SHOE AREA JUST AFTER T-0. THE FIRST MAY BE A PIECE OF PUTTY FROM THE SHOE WHILE THE SECOND FELL VERTICALLY AS IF THE ORIGIN WAS THE AFT SKIRT STUD HOLE.

EX2
400 FPS
16mm

Camera is located on the MLP deck west of RH SRB flame duct and looks east to view SRB Heater Umbilical during ignition and liftoff.

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED PRIOR TO T-0

Comments: SEPARATION OF THE SRB T-0 UMBILICAL WAS NORMAL. T-0 CAUSES WATER IN THE SOUND SUPPRESSION WATER TROUGHS TO GEYSERS UPWARD. AFTER LIFTOFF, SMALL PIECES OF DECK DEBRIS MOVE THROUGH THE FOV.

EX3
400 FPS
16mm

Camera is located on the MLP deck east of LH SRB flame duct and looks west to view SRB Heater Umbilical during ignition and liftoff.

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED PRIOR TO T-0

Comments: T-0 CAUSES WATER IN THE SOUND SUPPRESSION WATER TROUGHS TO GEYSER UPWARD. SEPARATION OF THE SRB T-0 UMBILICAL IS NORMAL. JUST AFTER T-0, AN L-SHAPED PIECE OF ALUMINUM TAPE OR VERY THIN SHEET METAL ORIGINATES FROM THE SRB UMBILICAL AREA AND MOVES TO THE RIGHT OUT OF THE FOV. OTHER SMALL PIECES OF THROAT PLUG MATERIAL OR INSTAFOAM CROSS THE FOV.

EX4
400 FPS
16mm

Camera is located on MLP deck south of LH SRB flame duct and looks north to view LH SRB Heater Umbilical during ignition and liftoff.

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED PRIOR TO T-0

Comments: SMALL K5NA AND INSTAFOAM TRIMMINGS ARE SHAKEN LOOSE BY SSME IGNITION. EITHER AN ORANGE GSE TILE SHIM OR A VERY THIN TPS TRIMMING ENTERS THE FOV (FRAME 6725) FROM THE ORBITER SIDE AND DRIFTS PAST THE HOLDDOWN POST. ICE FALLS FROM THE ET/ORB UMBILICALS DURING SSME START-UP. NO STUD HANG-UP OCCURS AT T-0 AND NO DEBRIS FALLS FROM THE AFT SKIRT STUD HOLE. THERE IS NO APPARENT MOTION OF THE HDP SHOE SHIM THAT WOULD INDICATE DEBONDING OF THE SHIM. SEPARATION OF THE SRB T-0 UMBILICAL IS NORMAL.

E-1
400 FPS
16mm

Camera is located on the NE corner of the MLP deck and views the lower ET, SRB's, and Orbiter.

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED PRIOR TO T-0

Comments: SRB IGNITION CAUSES WATER IN SOUND SUPPRESSION WATER TROUGHS TO GEYSER UPWARD. WATER FROM A RECENT RAIN FALLS FROM THE ELEVONS DURING LIFTOFF. A FEW ICE PARTICLES FALL FROM THE ET/ORB UMBILICALS AS THE VEHICLE ASCENDS.

E-2
400 FPS
16mm

Camera is located on the SE corner of the MLP deck and views Orbiter SSME and OMS engine nozzles.

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED PRIOR TO T-0

Comments: SSME IGNITION IS NORMAL. PAPER COVERS FROM THE RCS NOZZLES AND ICE FROM THE ET/ORB UMBILICALS FALL FROM THE VEHICLE AT T-0. THE LH2 TSM DOOR CLOSES PROPERLY. RAIN WATER IN THE SRB STIFFENER RINGS VAPORIZES SHORTLY AFTER LIFTOFF.

E-3 Camera is located on the SW corner of the MLP deck
400 FPS and views Orbiter SSME and OMS engine nozzles.
16mm

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED PRIOR TO T-0

Comments: SSME IGNITION IS NOMINAL. PAPER COVERS FROM THE RCS NOZZLES AND ICE FROM THE ET/ORB UMBILICALS FALL FROM THE VEHICLE AT T-0. THE LO2 TSM DOOR REBOUNDS A FEW INCHES DURING CLOSURE.

E-4 Camera is located on the NW corner of the MLP deck
400 FPS and views lower ET, SRB's, and Orbiter.
16mm

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED PRIOR TO T-0

Comments: SSME IGNITION IS NOMINAL. ICE/FROST PARTICLES FALL FROM ET/ORB UMBILICAL DURING ENGINE START-UP. THE ET AFT DOME IS CLEAN AT LIFTOFF. A PIECE OF SRB THROAT PLUG MATERIAL FROM THE EXHAUST HOLE AREA PASSES OVERHEAD AND TO THE RIGHT OF THE CAMERA POSITION. JUST AS THE VEHICLE CLEARS THE FRAME, WATER TROUGH CORD PASSES BY THE CAMERA.

E-5 Camera is located on the east side of the MLP
400 FPS deck and views the Orbiter RH wing, body flap,
16mm and lower ET/SRB.

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED PRIOR TO T-0

Comments: WATER IS PRESENT ON LOWER PART OF CAMERA LENS. ICE PARTICLES FALL FROM LO2 T-0 UMBILICAL DURING RETRACTION. ONE PIECE OF ICE FROM THE LO2 ET/ORB UMBILICAL FALLS FROM THE VEHICLE NEAR THE TOP OF THE FRAME. NO SRB OR ET AFT DOME ANOMALIES.

E-6 Camera is located on the east side of the MLP deck
200 FPS and views the RH lower Orbiter wing, body flap, ET
16mm lower LOX feedline, and ET/Orbiter umbilical area.

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED PRIOR TO T-0

Comments: ICE/FROST FALLS FROM ET/ORB UMBILICALS DURING SSME IGNITION. ELEVONS MOVE DURING IGNITION AND LIFTOFF. A SMALL PIECE OF BAGGIE MATERIAL FALLS FROM THE UMBILICAL. NO UNUSUAL VAPORS ARE PRESENT AROUND THE ET/ORB UMBILICAL AREA.

E-7 Camera is located on the MLP deck and views the
400 FPS RH SRB northeast holddown post (HDP #4).
16mm

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED PRIOR TO T-0

Comments: THROAT PLUG MATERIAL IS EJECTED FROM THE SRB EXHAUST HOLE AT LIFTOFF. NO DEBRIS FALLS FROM THE AFT SKIRT STUD HOLE AND THE SHIM MATERIAL IS INTACT. CLOSURE OF THE HDP DOGHOUSE BLAST COVER IS NORMAL.

E-8 Camera is located on the MLP deck and views the
400 FPS RH SRB southeast holddown post (HDP #2).
16mm

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED PRIOR TO T-0

Comments: A 12"x8"x4" PIECE OF INSTAFOAM BEHIND HDP #1 FALLS INTO THE SRB EXHAUST HOLE. TWO SMALLER PIECES, 3"x1", ARE VISIBLE IN THE FOV LEFT AND RIGHT SIDES FALLING AWAY. NO DEBRIS FALLS FROM THE AFT SKIRT STUD HOLE, AND THERE IS NO SIGN OF STUD HANG UP.

E-9 Camera is located on the MLP deck and views the
400 FPS RH SRB southwest holddown post (HDP #1).
16mm

Focus : OK
F. O. V.: MUCH CAMERA SHAKE (LOOSE MOUNT?)

Exposure: OK

Comments: SOME FACILITY DEBRIS MOVES ALONG THE MLP DECK DURING SSME IGNITION. THE HDP SHOE ROCKS SLIGHTLY AT LIFTOFF. NO DEBRIS FALLS FROM THE AFT SKIRT STUD HOLE, AND NO EVIDENCE OF STUD HANG UP. RAIN WATER COMES OFF THE SRB. A SMALL OBJECT, MOST LIKELY ICE OR K5NA, PASSES THROUGH FOV UPPER RIGHT CORNER AFTER T-0.

E-10 Camera is located on the MLP deck and views the
400 FPS RH SRB northwest holddown post (HDP #3).
16mm

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED PRIOR TO T-0

Comments: A SMALL PIECE OF DEBRIS MOVES TOWARD THE HOLDDOWN POST AT LIFTOFF AND A SMALL PIECE OF INSTAFOAM IS VISIBLE NEAR THE AFT SKIRT STUD HOLE. A NORMAL AMOUNT OF SRB THROAT PLUG MATERIAL IS EJECTED UPWARD OUT OF THE SRB EXHAUST HOLE. NO DEBRIS FALLS FROM THE AFT SKIRT STUD HOLE. THE HDP DOGHOUSE BLAST COVER CLOSES NORMALLY.

E-11 Camera is located on the MLP deck and views the
400 FPS LH SRB northeast holddown post (HDP #7).
16mm

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED PRIOR TO T-0

Comments: THREE FLAKES OF MLP DECK SCALE, THE LARGEST MEASURING 2"x1", ARE IN THE FOV. JUST AFTER T-0, A HAND-SIZE PIECE OF FOAM, PROBABLY THROAT PLUG MATERIAL, ENTERS THE FOV FROM ABOVE/BEHIND THE SRB AND FALLS BEHIND THE HDP HAUNCH. A SECOND PIECE ENTERS THE FOV FROM THE LEFT AND IS APPROXIMATELY 1 INCH IN DIAMETER.

E-12 Camera is located on the MLP deck and views the
400 FPS LH SRB southeast holddown post (HDP #5).
16mm

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: SMALL PARTICLES COME OUT FROM BEHIND DCS AND SMALL TRIMMINGS MOVE ALONG THE MLP DECK DURING SSME IGNITION. MUCH ICE FALLS FROM THE ET/ORB UMBILICALS, BOUNCES ON THE MLP DECK, AND IS LATER DRAWN IN THE EXHAUST HOLE BY ASPIRATION. NO DEBRIS FALLS FROM THE AFT SKIRT STUD HOLE, AND NO EVIDENCE OF STUD HANG-UP. THE HDP SHOE BARELY ROCKS AT LIFTOFF. RAIN WATER STREAMS FROM THE SRB AFTER LIFTOFF.

E-13 Camera is located on the MLP deck and views the
400 FPS LH SRB southwest holddown post (HDP #6).
16mm

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED PRIOR TO T-0

Comments: ICE FROM THE ET/ORB UMBILICALS FALLS INTO THE FOV. A SMALL PIECE OF SRB THROAT PLUG MATERIAL ENTERS THE FOV FROM THE LEFT SHORTLY AFTER T-0. A 3"x2" PIECE OF INSTAFOAM FALLS FROM THE AFT SKIRT NEAR THE HPU EXHAUST PORT. NO DEBRIS FALLS FROM THE AFT SKIRT STUD HOLE, AND THERE IS NO SIGN OF STUD HANG-UP.

E-14 Camera is located on the MLP deck and views the
400 FPS LH SRB northwest holddown post (HDP #8).
16mm

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED PRIOR TO T-0

Comments: NUMEROUS PIECES OF SRB THROAT PLUG MATERIAL AND WATER TROUGH CORD ARE EJECTED OUT OF THE SRB EXHAUST HOLE AFTER T-0. SIX PIECES OF DEBRIS FALL FROM THE AFT SKIRT STUD HOLE: 2 MOVE SIDEWAYS FROM THE HDP SHOE AFTER THE VEHICLE HAS RISEN A FEW INCHES; A 3RD FALLS STRAIGHT DOWN FROM THE STUD HOLE AS THE FOOT CLEARS THE HDP COVER; THE 4TH AND 5TH OBJECTS ARE ORDNANCE PIECES MEASURING 3"x1/4"x1/4" FOLLOWED BY A 6TH SMALLER PIECE, POSSIBLY NSI CARTRIDGE, JUST BEFORE THE VEHICLE LEAVES THE FOV. THERE IS NO SIGN OF STUD HANG-UP AND THE SHIM IS INTACT.

E-15 Camera is located on the MLP deck and views the RH
400 FPS SRB skirt, sound suppression water troughs, and RH
16mm lower Orbiter body flap.

Focus : OK
F. O. V.: OK

Exposure: UNDEREXPOSED PRIOR TO T-0

Comments: FREE BURNING HYDROGEN IS BLOWN WEST PRIOR TO SSME START UP. ICE FROM THE UMBILICALS AND PAPER COVER PIECES FROM THE AFT RCS NOZZLES FALL DURING SSME IGNITION. WATER FROM THE SOUND SUPPRESSION WATER TROUGHS GEYSERS UPWARD AT T-0. HDP DOGHOUSE BLAST COVERS CLOSE PROPERLY. NO DEBRIS FALLS FROM THE AFT SKIRT STUD HOLES. RAIN WATER STREAMS FROM THE AFT BOOSTER.

E-16
400 FPS
16mm

Camera is located on the MLP deck and views the LH SRB skirt, sound suppression water troughs, and LH lower Orbiter body flap.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: FREE BURNING HYDROGEN RISES ALONG SIDE SSME #2. ICE FALLS FROM ET/ORB LH2 AND T-0 UMBILICALS DURING SSME IGNITION. WATER IN SOUND SUPPRESSION WATER TROUGHS DID NOT GEYSER AS MUCH AS THE RH SIDE AT T-0. A PIECE OF INSTAFOAM NEAR HDP #7 BREAKS OFF AS THE VEHICLE RISES. NO DEBRIS FALLS FROM THE AFT SKIRT STUD HOLES. THE HDP DOGHOUSE BLAST COVERS CLOSE PROPERLY.

E-17
400 FPS
16mm

Camera is located on the MLP deck and views the -Z side of the LO2 T-0 Umbilical and TSM.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: SSME IGNITION IS NOMINAL. A HEAVY SHOWER OF ICE/FROST FALLS FROM THE ET/ORB UMBILICALS DURING SSME IGNITION. SOME BODY FLAP MOTION IS VISIBLE DURING SSME START UP. T-0 UMBILICAL DISCONNECT AND RETRACTION IS NORMAL. NO TILE DAMAGE OCCURS ON THE BASE HEAT SHIELD.

E-18
400 FPS
16mm

Camera is located on the MLP deck and views the -Z side of the LH2 T-0 umbilical and TSM.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: ROFI SMOKE, SPARKS, AND FREE BURNING HYDROGEN ARE BLOWN WEST BY PREVAILING WINDS. SSME IGNITION IS NOMINAL. ICE AND FROST PARTICLES FALL FROM T-0 UMBILICAL DURING SSME START UP. DISCONNECT AND RETRACTION OF THE T-0 CARRIER PLATE IS NORMAL.

E-19
400 FPS
16mm

Camera is located on the SE side of the MLP deck and views the SSME/OMS nozzles and Orbiter aft heat shield area.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: SSME IGNITION IS NOMINAL. ICE AND RCS PAPER COVER PIECES FALL DURING SSME START UP. DISCONNECT AND RETRACTION OF THE T-0 CARRIER PLATE IS NORMAL. THE SURFACE COATING MATERIAL ON ONE BASE HEAT SHIELD TILE NEAR THE T-0 UMBILICAL IS CHIPPED JUST AFTER SSME IGNITION.

E-20
400 FPS
16mm

Camera is located on the SW side of the MLP deck and views the SSME/OMS nozzles and Orbiter aft heat shield area.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: ROFI SMOKE, SPARKS, AND FREE BURNING HYDROGEN ARE BLOWN WEST BY PREVAILING WINDS. SSME IGNITION IS NOMINAL. ICE AND RCS PAPER COVERS FALL DURING SSME START UP. DISCONNECT AND RETRACTION OF THE T-0 CARRIER PLATE IS NORMAL. THE LO2 TSM DOOR BOUNCES 2-3 INCHES DURING CLOSURE.

E-21
200 FPS
16mm

Camera is located inside the LO2 TSM and views the disconnection of the T-0 umbilical.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: DISCONNECT AND RETRACTION OF THE T-0 CARRIER PLATE IS NORMAL. THE TSM DOOR REBOUNDS 2-3 INCHES DURING CLOSURE.

E-22 Camera is located inside the LH2 TSM and views
200 FPS the disconnection of the T-0 umbilical.
16mm

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: THE PURGE BARRIER WAS INTACT PRIOR TO T-0. DISCONNECT AND RETRACTION OF THE T-0 CARRIER PLATE WAS NOMINAL.

E-23 Camera is located on the MLP deck and views the
400 FPS RH OMS engine nozzle.
16mm

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED PRIOR TO T-0

Comments: THE OMS NOZZLE FLEXES SLIGHTLY DURING SSME IGNITION. RCS PAPER COVERS TEAR AND PIECES ARE PULLED INTO THE PLUME BY ASPIRATION. DISCONNECT AND RETRACTION OF THE T-0 CARRIER PLATE IS NOMINAL. NO DAMAGE TO BASE HEAT SHIELD TILES IS VISIBLE.

E-24 Camera is located on the MLP deck and views the
400 FPS LH OMS engine nozzle.
16mm

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED PRIOR TO T-0

Comments: ROFI SPARKS ARE BLOWN WEST - SOME VERY CLOSE TO THE CAMERA LENS - BY THE PREVAILING WINDS. FREE BURNING HYDROGEN RISES TO THE BASE HEAT SHIELD AND PAST THE LH OMS POD. THE OMS NOZZLE FLEXES SLIGHTLY DURING SSME IGNITION. THE LH2 TSM PURGE BARRIER COMES LOOSE AT SSME IGNITION. DISCONNECT AND RETRACTION OF THE T-0 CARRIER PLATE IS NORMAL. NO DAMAGE TO BASE HEAT SHIELD TILES IS VISIBLE.

E-25 Camera is located on the east side of the MLP and
400 FPS views between Orbiter and ET/SRB during liftoff.
16mm

Focus : OK
F. O. V.: OK

Exposure: UNDEREXPOSED EVEN WITH SSME IGNITION

Comments: WATER DROPS ARE PRESENT ON THE CAMERA LENS. NO ICE IS VISIBLE FALLING FROM ET/ORB UMBILICALS AFTER LIFTOFF. NO VEHICLE ANOMALIES.

E-26 Camera is located on the west side of the MLP and
400 FPS views between Orbiter and ET/SRB during liftoff.
16mm

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED EVEN WITH SSME IGNITION

Comments: NO ICE IS VISIBLE FALLING FROM ET/ORB UMBILICALS AFTER LIFTOFF. NO VEHICLE ANOMALIES.

E-27 Camera is located on the MLP deck and views RH SRB
400 FPS northwest holddown post (HDP #3) blast cover.
16mm

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED PRIOR TO T-0

Comments: NO STUD HANG-UPS OR DEBRIS FALLING FROM THE AFT SKIRT STUD HOLES ARE VISIBLE. THE HDP DOGHOUSE BLAST COVERS CLOSE PROPERLY. THE SHIM MATERIAL IS INTACT ON THE AFT SKIRT HDP #3 AND #4 FEET DURING LIFTOFF.

E-28 Camera is located on the MLP deck and views LH SRB
400 FPS northeast holddown post (HDP #7) blast cover.
16mm

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED PRIOR TO T-0

Comments: NO STUD HANG-UP OCCURS ON HOLDDOWN POST #7. THE NORTH HDP DOGHOUSE BLAST COVERS CLOSE PROPERLY. THE SHIM MATERIAL IS INTACT ON THE AFT SKIRT FEET. TWO METAL SLIVERS AND A THIRD SMALLER PIECE FROM THE HDP #8 ORDNANCE FALL FROM THE AFT SKIRT STUD HOLE DURING LIFTOFF.

E-30 Camera is located on the FSS 195 foot level and
400 FPS views LH SRB and sound suppression water troughs.
16mm

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED PRIOR TO T-0

Comments: FREE BURNING HYDROGEN IS BLOWN WEST BY THE PREVAILING WINDS. SSME IGNITION CAUSES ICE/FROST TO FALL FROM THE ET/ORB UMBILICALS. NO SOUND SUPPRESSION WATER TROUGH ANOMALIES ARE VISIBLE. FACILITY DEBRIS PASSES CLOSE TO THE CAMERA LENS.

E-31 Camera is located on the FSS 95 foot level and
100 FPS views the LH Orbiter wing, body flap, and
16mm ET/Orbiter LH2 umbilical area.

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED PRIOR TO T-0

Comments: FREE BURNING HYDROGEN IS BLOWN WEST BY PREVAILING WINDS. ICE FALLS FROM THE ET/ORB UMBILICALS AND THE LH2 RECIRC LINE PAST THE BODY FLAP, BUT NO TILE DAMAGE IS VISIBLE. ELEVONS MOVE SLIGHTLY DURING SSME START UP. A TUMBLING PARTICLE WITH A SHINY OR TRANSLUCENT SIDE, MOST LIKELY A PIECE OF ICE, MOVES FROM UPPER LEFT TO LOWER RIGHT (FRAME 766) AND APPEARS TO LIGHTLY GRAZE THE LH INBOARD ELEVON NEAR THE TRAILING EDGE (FRAME 975). NO TILE DAMAGE IS VISIBLE.

E-33 Camera is located on the FSS 235 foot level and
200 FPS views the ET GH2 vent line and GUCP.
16mm

Focus : SOFT
F. O. V.: OK
Exposure: UNDEREXPOSED PRIOR TO T-0

Comments: ICE PARTICLES FALL FROM THE GUCP AFTER SSME IGNITION. GUCP SEPARATION FROM THE ET IS NOMINAL. JUST AFTER T-0, A PARTICLE APPROXIMATELY 1-INCH IN DIAMETER IS VISIBLE BELOW THE GUCP STILL IN THE INTERTANK AREA MOVING NORTH OUT OF THE FOV. THE PARTICLE APPEARS TO BE LIGHT WEIGHT AND MAY BE A PIECE OF FOAM. NO VEHICLE ANOMALIES AS THE VEHICLE CLEARS THE FRAME.

E-34 Camera is located on FSS at 255 foot level and
300 FPS views upper Orbiter tile surfaces.
16mm

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED PRIOR TO T-0

Comments: SSME IGNITION IS NOMINAL. RCS PITCH THRUSTER COVERS (LARGE) ARE ALREADY TEARING AS THE VEHICLE LIFTS OFF. NO ANOMALIES ARE VISIBLE IN THE BIPOD AREA. NO ICE FALLS FROM THE ET/ORB UMBILICALS AS THE VEHICLE ASCENDS. THERE ARE NO UNUSUAL VAPORS IN THE ET/ORB UMBILICAL AREA. RAIN WATER STREAMS FROM THE SPLIT RUDDER SPEED BRAKE NEAR THE BASE OF THE VERTICAL STABILIZER

E-35 Camera is located on the FSS 255 foot level and
300 FPS views the mid-Orbiter/ET/SRB area.
16mm

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED PRIOR TO T-0

Comments: NOT MUCH DETAIL IS VISIBLE. NO VEHICLE ANOMALIES.

E-36 Camera is located on the FSS 255 foot level and
300 FPS views lower Orbiter, ET, SRB's, and water trough.
16mm

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED PRIOR TO T-0

Comments: FACILITY WATER DELUGE ENTERS THE LEFT FOV. ROFI SPARKS AND FREE BURNING HYDROGEN ARE BLOWN WEST BY THE PREVAILING WINDS. SSME IGNITION IS NOMINAL. ICE FALLS FROM THE ET/ORB UMBILICALS DURING SSME START UP. DISCONNECT/RETRACTION OF THE T-0 CARRIER PLATE IS NORMAL. THE GH2 VENT LINE RETRACTS PROPERLY. A PIECE OF SRB THROAT PLUG MATERIAL MOVES AWAY FROM THE VEHICLE HEADED NORTH OVER THE RH SRB EXHAUST HOLE.

E-39 Camera is located on the FSS 185 foot level and
300 FPS views GH2 vent line latchback.
16mm

Focus : OK

F. O. V.: OK
Exposure: VERY UNDEREXPOSED

Comments: BY THE TIME THE SRB PLUME PROVIDES ENOUGH ILLUMINATION IN THE HAUNCH AREA, THE GH2 VENT LINE IS ALREADY LATCHED.

E-40
300 FPS
16mm

Camera is located on the FSS 275 foot level and views the ET ogive, SRB nosecone, and Orbiter tiled surfaces.

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED PRIOR TO T-0

Comments: THE TWO LARGE LH FWD RCS PAPER COVERS ARE TORN SHORTLY AFTER LIFTOFF. THE HYDROGEN FIRE DETECTION BUTCHER PAPER IS STILL INTACT ON THE ET. NO UNUSUAL VAPORS EMANATE FROM THE ET/ORB LH2 UMBILICAL AREA. ONE SMALL WHITE PARTICLE IS VISIBLE JUST ABOVE THE VERTICAL STABILIZER ROOT AS THE VEHICLE CLEARS THE TOWER.

E-41
300 FPS
16mm

Camera is located on the FSS 255 foot level and views the GH2 vent line during rotation. Also shows clearance between structure and SRB aft skirt.

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED PRIOR TO T-0

Comments: GH2 VENT LINE RELEASE, RETRACT, AND LATCHBACK IS NOMINAL. RAIN WATER ON SRB VAPORIZES SHORTLY AFTER LIFTOFF. WHILE THE VEHICLE IS STILL IN THE FOV, THREE PARTICLES FALL INTO THE FOV FROM ABOVE ON THE CAMERA SIDE OF THE ORBITER WING AND REMAIN ROUGHLY PARALLEL TO THE ET, THOUGH NOT NEAR THE VEHICLE. NUMEROUS PARTICLES AND PIECES OF PAPER ARE VISIBLE IN THE PLUME MOVING IN VARIOUS DIRECTIONS AFTER THE VEHICLE HAS CLEARED THE FRAME.

E-42
300 FPS
16mm

Camera is located on the FSS 185 foot level and views the GH2 vent line drop, deceleration, and latchback.

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED WITH LENS FLARE

Comments: RESIDUAL VAPOR VENTS FROM GUCP QD. EXCESSIVE SLACK IN STATIC RETRACT LANYARD CREATES LOOP OF CABLE THAT CONTACTS UNDER SIDE OF HAUNCH, REVERSES DIRECTION OF TRAVEL, COMES AROUND PULLEY AND CONTACTS THE GUCP BEFORE FULL RETRACTION OF THE CABLE IS COMPLETE. MANY PIECES OF FACILITY DEBRIS THAT APPEAR TO ORIGINATE FROM THE FSS MOVE IN ALL DIRECTIONS.

E-44
300 FPS
16mm

Camera is located on the FSS 155 foot level and views the LH OMS Pod leading edge tiles during ignition and liftoff.

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED PRIOR TO T-0

Comments: RESIDUAL VAPOR EMANATES FROM THE FLIGHT LH2 T-0 QD. A PARTICLE, POSSIBLY ICE, FALLS PAST THE LH OMS POD FROM TOP TO BOTTOM BUT DOES NOT STRIKE THE VEHICLE. A SECOND PARTICLE PASSES VERY CLOSE TO THE CAMERA LENS.

E-48
300 FPS
16mm

Camera is located on the FSS 215 foot level (ET Intertank access arm structure) and views the GH2 vent line during GUCP disconnection, rotation, and latchback

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: GUCP DISCONNECT AND GH2 VENT LINE RETRACTION ARE NORMAL. ICE/FROST, WHICH USUALLY FALLS FROM THE GUCP DURING DISCONNECT, IS NOT VISIBLE IN THIS ITEM. NO VEHICLE ANOMALIES.

E-50
60 FPS
16mm

Camera is located at camera site 1 at NE pad perimeter and views entire GH2 vent line and GUCP during rotation and latchback.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: VEHICLE TWANG IS NORMAL. GH2 VENT LINE SEPARATION FROM THE ET, RETRACT, AND LATCHBACK ARE NOMINAL.

E-52
96 FPS
35mm

Camera is located at camera site 2 on the east pad perimeter. Remote tracking of lower one-third of launch vehicle from ignition to 1200 feet.

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED PRIOR TO T-0

Comments: SSME IGNITION IS NOMINAL. A PIECE OF WATER TROUGH MATERIAL IS BLOWN NORTH AWAY FROM THE VEHICLE JUST ABOVE THE MLP DECK. A BIRD WEST OF THE HAMMERHEAD CRANE IS NOT NEAR THE VEHICLE DURING TOWER CLEAR. RAIN WATER STREAMS FROM THE VERTICAL TAIL. MORE RAIN WATER ON THE ET AFT DOME AND IN THE SRB STIFFENER RINGS VAPORIZES SHORTLY AFTER LIFTOFF. LH FWD RCS PAPER COVERS FALL FROM THE VEHICLE AT THE START OF THE ROLL PROGRAM. AFT RCS PAPER COVERS AND ET/ORB UMBILICAL ICE CONTINUES TO FALL FROM THE VEHICLE THROUGH EARLY ASCENT AND DURING THE ROLL MANEUVER. MORE FWD RCS PAPER COVERS FALL FROM THE VEHICLE DURING THE ROLL. AN OPTICAL REFLECTION/PHENOMENON OCCURS NEAR THE RIGHT WING AT THE END OF THE ROLL MANEUVER. CHARRING OF THE ET AFT DOME HAS BEGUN AND IS A NORMAL OCCURRENCE.

E-53
96 FPS
35mm

Camera is located at camera site 2 on the east pad perimeter. Remote tracking of middle one-third of launch vehicle from ignition to 1200 feet.

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED PRIOR TO T-0

Comments: SAME COMMENTS AS E-52, 54.

E-54
96 FPS
35mm

Camera is located at camera site 2 on the east pad perimeter. Remote tracking of upper one-third of launch vehicle from ignition to 1200 feet.

Focus : OK
F. O. V.: TRACKING LOST AFTER ROLL MANEUVER
Exposure: UNDEREXPOSED PRIOR TO T-0

Comments: FWD RCS PAPER COVERS ARE ALREADY LOOSE BY TOWER CLEAR. RAIN WATER STREAMS FROM VERTICAL STABILIZER. MORE RAIN WATER ON ET AFT DOME AND IN SRB STIFFENER RINGS VAPORIZES SHORTLY AFTER LIFTOFF. ICE REMAINS IN THE FORWARD BELLOWS WHILE THE LO2 FEED-LINE IS IN VIEW. AFT RCS PAPER COVERS FALL FROM VEHICLE THROUGH EARLY ASCENT AND ROLL MANEUVER. FWD RCS PAPER COVERS COME OFF AT 109 FT/01 FRAMES.

E-57
96 FPS
35mm

Camera is located at camera site 6 on the NW pad perimeter. Remote tracking of lower one-third of launch vehicle from ignition to 1200 feet.

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED PRIOR TO T-0

Comments: A BIRD WEST OF THE HAMMERHEAD CRANE/LIGHTNING ROD IS NOT NEAR THE VEHICLE DURING LIFTOFF. RAIN WATER ON ET AFT DOME AND IN SRB STIFFENER RINGS VAPORIZES SHORTLY AFTER LIFTOFF. FIVE PIECES OF FWD RCS PAPER COVERS FALL FROM VEHICLE AT TOWER CLEAR AND THROUGH EARLY ASCENT. PIECES OF AFT RCS PAPER COVERS FALL FROM THE VEHICLE DURING EARLY ASCENT AND THROUGH THE ROLL MANEUVER. CHARRING OF THE ET AFT DOME IS NORMAL. ONE LARGE AND TWO SMALL FLASHES OCCUR IN THE SSME PLUMES NEAR THE END OF THE ROLL MANEUVER.

E-58
96 FPS
35mm

Camera is located at camera site 6 on the NW pad perimeter. Remote tracking of center one-third of launch vehicle from ignition to 1200 feet.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: SAME COMMENTS AS E-57, 59.

E-59
96 FPS
35mm

Camera is located at camera site 6 on the NW pad perimeter. Remote tracking of upper one-third of launch vehicle from ignition to 1200 feet.

Focus : OK
F. O. V.: TRACKING LOST AFTER ROLL MANEUVER
Exposure: UNDEREXPOSED PRIOR TO T-0

Comments: LH FWD RCS PAPER COVERS COME OFF PRIOR TO TOWER CLEAR. A BIRD WEST OF THE FSS IS NOT NEAR THE VEHICLE. RESIDUAL VAPORS EMANATE FROM THE ET UMBILICAL CARRIER PLATE. FWD AND AFT RCS PAPER COVERS CONTINUE TO FALL FROM THE VEHICLE THROUGH EARLY ASCENT AND ROLL MANEUVER.

E-60
96 FPS
35mm

Camera is located on north pad perimeter at camera site 1 and views the entire launch vehicle, FSS, and MLP zero level.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: FREE BURNING HYDROGEN IS BLOWN WEST BY PREVAILING WINDS. GH2 VENT LINE RETRACT AND LATCHBACK IS NORMAL. RAIN WATER ON THE ET AFT DOME AND IN THE SRB STIFFENER RINGS VAPORIZES SHORTLY AFTER LIFTOFF. WHEN THE VEHICLE HAS RISEN APPROXIMATELY 100 FEET, A PARTICLE APPEARS TO THE NORTH OF THE FSS MOVING AWAY FROM THE VEHICLE.

E-61
96 FPS
35mm

Camera is located at camera site 2 on the east pad perimeter and views the launch vehicle, FSS, and MLP.

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED PRIOR TO T-0

Comments: FREE BURNING HYDROGEN IS BLOWN WEST. SSME IGNITION IS NOMINAL. ICE FALLS FROM ET/ORB UMBILICALS. A PIECE OF WATER TROUGH MATERIAL IS BLOWN NORTH JUST ABOVE THE MLP DECK AWAY FROM THE VEHICLE. FROST FROM FSS CRYO LINE AND NUMEROUS PIECES OF SRB THROAT PLUG MATERIAL ARE ALSO VISIBLE IN THIS AREA. A BIRD WEST OF THE HAMMERHEAD CRANE IS NOT NEAR THE VEHICLE. RAIN WATER STREAMS FROM VERTICAL STABILIZER. MORE RAIN WATER ON ET AFT DOME AND IN SRB STIFFENER RINGS VAPORIZES SHORTLY AFTER LIFTOFF.

E-62
96 FPS
35mm

Camera is located on the SE pad perimeter at camera site 3 and views entire vehicle, FSS, and MLP.

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED PRIOR TO T-0

Comments: FREE BURNING HYDROGEN IS BLOWN PAST THE LH2 TSM BY PREVAILING WINDS. EIGHT BIRDS CROSS THE FOV, BUT NONE ARE NEAR THE VEHICLE. RESIDUAL VAPORS EMANATE FROM THE TSM DISCONNECTS. SRB THROAT PLUG MATERIAL IS EJECTED FROM THE EXHAUST HOLE WELL ABOVE THE MLP DECK ON THE SOUTH SIDE OF THE VEHICLE. RAIN WATER ON THE ET AFT DOME AND IN THE SRB STIFFENER RINGS VAPORIZES

SHORTLY AFTER LIFTOFF. AFT RCS PAPER COVERS COME OFF AND TRAIL THE VEHICLE IN THE PLUME. PAPER COVERS FALL FROM THE FWD RCS THRUSTERS AS THE VEHICLE LEAVES THE FOV.

E-63
96 FPS
35mm

Camera is located on SW pad perimeter at camera site 4 and views entire launch vehicle, FSS, and MLP.

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED PRIOR TO T-0

Comments: FREE BURNING HYDROGEN IS BLOWN WEST. MOST OF THE LIFT OFF IS OBSCURED BY SSME PLUME. A LIGHT COLORED OBJECT, POSSIBLY GUCP ICE, FALLS AFT TO THE LEFT OF THE LH SRB.

E-64
96 FPS
35mm

Camera is located on NW pad perimeter at camera site 6 and views entire launch vehicle, FSS, and MLP.

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED PRIOR TO T-0

Comments: TWO BIRDS ARE IN THE FOV, BUT NOT NEAR THE VEHICLE. FROST FALLS FROM THE FSS CRYO LINE. SRB THROAT PLUG MATERIAL EJECTED UP OUT OF THE FLAME TRENCH DRIFTS BACK TOWARD VEHICLE AND MAY BE DRAWN BY ASPIRATION. RAIN WATER STREAMS FROM ET AFT DOME, SRB STIFFENER RINGS, AND VERTICAL STABILIZER.

E-65
6 FPS
16mm

Camera is located on east pad perimeter at camera site 2 and views ET LO2 feedline, ET intertank, and RH SRB as vehicle passes through the frame.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: VEHICLE 'TWANG' APPEARS NORMAL. NO ANOMALIES ON THE ET LO2 FEEDLINE.

E-76
96 FPS
35mm

Camera is located on SE pad perimeter at camera site 3 and views SSME engines #1 and #3 and the RH OMS engine nozzle.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: FREE BURNING HYDROGEN IS BLOWN WEST. A REFLECTION ON THE PURGE BARRIER IS VISIBLE NEAR THE TOP OF THE LH2 TSM. ICE AND FROST PARTICLES FALL FROM THE LO2 T-0 UMBILICAL DURING SSME IGNITION. DISCONNECT AND RETRACTION OF THE LO2 T-0 CARRIER PLATE IS NORMAL. NUMEROUS PIECES OF ICE AND RCS PAPER COVERS FALL INTO THE SSME PLUME.

E-77
96 FPS
35mm

Camera is located on SW pad perimeter at camera site 4 and views SSME engines #1 and #2 and the LH OMS engine nozzle.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: SAME COMMENTS AS E-76. FREE BURNING HYDROGEN RISES ABOVE THE LH RCS STINGER PRIOR TO SSME IGNITION. VIEW IS LATER OBSCURED BY SSME PLUME.

E-79
6 FPS
16mm

Camera is located on east pad perimeter at camera site 2 and views the ET nosecone, louver, and ogive.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: THE ET NORTHEAST LOUVER IS LIGHTLY COATED WITH FROST. VEHICLE 'TWANG' APPEARS NORMAL. NO VEHICLE ANOMALIES ARE VISIBLE.

E-201
30 FPS
70mm

UCS-9 IFLOT tracking of launch vehicle from ignition and early flight through LOV.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: RAIN WATER ON THE ET AFT DOME AND IN THE SRB STIFFENER RINGS VAPORIZES SHORTLY AFTER LIFTOFF. RCS PAPER COVERS FALL FROM THE VEHICLE DURING EARLY ASCENT AND ROLL MANEUVER. A CONTRAIL FORMS ON THE LH WING TIP AND FLASHES OCCUR IN THE SSME PLUME NEAR THE END OF THE ROLL PROGRAM. CHARRING ON THE ET AFT DOME IS A NORMAL OCCURRENCE. SRB SEPARATION IS NOMINAL.

E-204
48 FPS
35mm

PAFB IGOR tracking of launch vehicle from acquisition to SRB separation. Tracks ET/ORB after SRB separation to LOV.

Focus : SOFT DUE TO ATMOSPHERIC EFFECTS
F. O. V.: INCONSISTENT TRACKING
Exposure: OK

Comments: ET AFT DOME CHARRING IS NORMAL. AN OPTICAL PHENOMENON OCCURS AT 191 FT/09 FRAMES. PIECES OF SRB PROPELLANT SLAG JUST BEFORE AND AFTER SEPARATION IS NOT AS APPARENT AS OTHER FILM ITEMS. SRB SEPARATION IS NOMINAL.

E-205
48 FPS
35mm

Shiloh IFLOT tracking of launch vehicle from acquisition to SRB separation. Tracks ET/ORB after SRB separation to LOV.

Focus : OK
F. O. V.: TRACKING LOST SOON AFTER ACQUISITION
Exposure: OK

Comments: NO ANOMALIES ARE VISIBLE.

E-206
48 FPS
35mm

Melbourne Beach ROTI tracking of launch vehicle from acquisition to SRB separation. Tracks ET/ORB after SRB separation to LOV.

Focus : SOFT DUE TO ATMOSPHERIC EFFECTS
F. O. V.: OK
Exposure: OK

Comments: AFT DOME CHARRING IS NORMAL. PLUME RECIRCULATION IS VISIBLE AT 260 FT/00 FRAMES. SRB PROPELLANT SLAG FALLS FROM SRB PLUMES DURING TAILOFF.

E-207 UCS-10 MIGOR tracking of launch vehicle from
96 FPS acquisition to SRB separation. Tracks ET/ORB
35mm after SRB separation to LOV.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: RAIN WATER STREAMS OFF THE VERTICAL STABILIZER. RAIN WATER ON THE ET AFT DOME VAPORIZES FOLLOWED BY NORMAL CHARRING OF THE TPS. MOVEMENT OF THE BODY FLAP APPEARS TO HAVE MAGNITUDE AND FREQUENCY SIMILAR TO PREVIOUS FLIGHTS. SOME MOVEMENT OF THE SRB THERMAL CURTAINS IS ALSO VISIBLE. FLASHES OCCUR IN THE SSME PLUME AT 211 FT/08 FRAMES. OPTICAL PHENOMENA (LENS EFFECTS) OCCUR AT 227 FT/00 FRAMES, 485 FT/03 FRAMES, AND 596 FT/09 FRAMES. PLUME RECIRCULATION BEGINS AT 475 FT/00 FRAMES. SRB SEPARATION IS NOMINAL, BUT NOT MANY PIECES OF PROPELLANT SLAG OR CLINKERS ARE VISIBLE.

E-208 Cocoa Beach DOAMS tracking of launch vehicle
48 FPS from acquisition to SRB separation. Tracks ET/ORB
35mm after SRB separation to LOV.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: OPTICAL PHENOMENON (LENS EFFECT) IS VISIBLE FORWARD OF THE ORBITER PRIOR TO TAILOFF. A CLINKER FALLS FROM THE SRB PLUME PRIOR TO TAILOFF. HUNDREDS OF SLAG PARTICLES FALL FROM SRB PLUMES BEFORE AND AFTER SEPARATION. SRB SEP IS NOMINAL.

E-211 UCS-13 IFLOT intermediate tracking of forward
96 FPS portion of ORB and ET from acquisition to LOV.
35mm

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: RAIN WATER ON THE ET AFT DOME AND IN THE SRB STIFFENER RINGS VAPORIZES BY THE END OF THE ROLL MANEUVER. FLASHES OCCUR IN THE SSME PLUME AT 90 FT/10 FRAMES, 91 FT/00 FRAMES, AND 319 FT/12 FRAMES (LARGE).

E-212 UCS-23 MIGOR tracking of launch vehicle
64 FPS from acquisition to LOV.
35mm

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: RAIN WATER ON ET AFT DOME AND IN SRB STIFFENER RINGS VAPORIZES SHORTLY AFTER LIFTOFF. RCS PAPER COVERS FALL FROM THE VEHICLE DURING EARLY ASCENT. THE VEHICLE OVERSHOOTS THE ROLL AND COMES BACK TO THE CORRECT HEADING. A CONTRAIL FORMS ON THE LH WING TIP DURING THE ROLL. THREE FLASHES OCCUR IN THE SSME PLUME NEAR THE END OF THE ROLL MANEUVER. ET AFT DOME CHARRING IS NORMAL. A PARTICLE FALLS OUT OF THE LH SRB PLUME AT 244 FT/14 FRAMES. ONLY THE LARGEST PIECES OF SRB PROPELLANT SLAG ARE VISIBLE FALLING FROM THE PLUME AT SRB SEPARATION.

E-213 UCS-12 MOTS tracking of forward portion of ORB and
96 FPS ET from acquisition to LOV.
35mm

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: WATER TROUGH MATERIAL IS VISIBLE MOVING AWAY FROM THE VEHICLE RIGHT SIDE AFTER T-0. FWD RCS PAPER COVERS FALL FROM THE VEHICLE PRIOR TO TOWER CLEAR. RAIN WATER ON ET AFT DOME AND SRB STIFFENER RINGS VAPORIZES SHORTLY AFTER LIFTOFF. RCS PAPER COVERS CONTINUE TO COME OFF AND PASS BY SSME NOZZLES DURING ROLL. THREE FLASHES OCCUR IN THE SSME PLUME AT 100 FT/12 FRAMES. SLIGHT BODY FLAP MOVEMENT IS VISIBLE AFTER THE ROLL PROGRAM. CHARRING OF ET AFT DOME AND FORMATION OF A CONTRAIL ON THE LH WINGTIP IS NORMAL.

E-218 UCS-26 IFLOT intermediate tracking of
96 FPS launch vehicle from acquisition through LOV.
35mm

Focus : SOFT DUE TO ATMOSPHERIC EFFECTS
F. O. V.: TRACKING LOST SHORTLY AFTER ROLL PROGRAM
Exposure: OK

Comments: RAIN ON ET AFT DOME AND IN SRB STIFFENER RINGS VAPORIZES SHORTLY AFTER LIFTOFF. FLASHES OCCUR IN THE SSME PLUMES JUST BEFORE THE END OF THE ROLL MANEUVER. A CONTRAIL FORMS ON THE LH WING TIP. CHARRING ON THE ET AFT DOME IS NORMAL.

E-220
96 FPS
35mm

U247L116 IFLOT close-in tracking of forward portion of ORB and ET during ignition, liftoff, and early portion of flight through LOV.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: RAIN WATER ON VEHICLE VAPORIZES SHORTLY AFTER LIFTOFF. RCS PAPER COVERS FALL FROM VEHICLE THROUGH EARLY ASCENT AND ROLL MANEUVER. THE ROLL PROGRAM APPEARS NORMAL THOUGH THE VEHICLE INITIALLY OVERSHOOTS THE HEADING. A CONTRAIL FORMS ON THE LH WING TIP. CHARRING ON THE ET AFT DOME IS NORMAL.

E-222
96 FPS
35mm

Beach Road IFLOT close-in tracking of forward portion of ORB and ET during ignition, liftoff, and early portion of flight through LOV.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: RAIN WATER ON VEHICLE VAPORIZES SHORTLY AFTER LIFTOFF. RCS PAPER COVERS COME OFF THROUGH EARLY ASCENT AND DURING ROLL MANEUVER. A CONTRAIL FORMS ON THE LH WING TIP. A PARTICLE FALLS OUT OF THE LH SRB PLUME AT 201 FT/05 FRAMES. NUMEROUS FLASHES OCCUR IN THE SSME PLUMES DURING ASCENT. ONE IN PARTICULAR OCCURS AT 330 FT/12 FRAMES.

E-223
96 FPS
35mm

UCS-9 IFLOT intermediate tracking of forward portion of ORB and ET during ignition, liftoff, and early portion of flight through LOV.

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED

Comments: RAIN WATER ON ET AFT DOME AND IN SRB STIFFENER RINGS VAPORIZES SHORTLY AFTER LIFTOFF. RAIN WATER ALSO STREAMS FROM VERTICAL STABILIZER. RCS PAPER COVERS COME OFF THROUGH EARLY ASCENT AND ROLL MANEUVER. ET AFT DOME CHARRING IS NORMAL. FLASHES IN THE SSME PLUME OCCURS AT 102 FT/02 FRAMES (PAPER), 103 FT/06 FRAMES (PAPER), 104 FT/01 FRAME, 104 FT/07 FRAMES (PAPER), AND 331 FT/09 FRAMES. MOVEMENT OF THE BODY FLAP APPEARS TO HAVE MAGNITUDE AND FREQUENCY SIMILAR TO PREVIOUS FLIGHTS. PARTICLES FALL OUT OF THE SRB PLUMES AT 400 FT/00 FRAMES AND 453 FT/00 FRAMES. THESE PARTICLES ARE BELIEVED TO BE PIECES OF SRB PROPEL-

LANT SLAG/ INHIBITOR. OPTICAL PHENOMENA (LENS EFFECTS) OCCUR AT 626-632 FT AND 677 FT/14 FRAMES. SRB'S SEPARATE NOMINALLY AT 759 FT/05 FRAMES. SOME SLAG PARTICLES ARE VISIBLE.

VIDEO ITEMS

OTV 001 Views aft end of Orbiter from the FSS 255 foot
B/W M-II level.

Comments: ROFI SMOKE, SPARKS, AND FREE BURNING HYDROGEN ARE BLOWN WEST BY PREVAILING WINDS. ICE FALLS FROM THE LH2 ET/ORB UMBILICAL DURING SSME START-UP. VEHICLE 'TWANG' LOOKS NORMAL. RETRACTION OF THE T-0 UMBILICAL IS NOMINAL.

OTV 003 Views GUCP and GH2 vent line.
B/W M-II

Comments: NO ICE IS VISIBLE FALLING FROM THE GUCP DURING SSME IGNITION AND VEHICLE 'TWANG'. GUCP DISCONNECT AND GH2 VENT LINE RETRACTION IS NOMINAL.

OTV 007 Views ET/Orbiter LH2 umbilical area from the 95
B/W M-II foot level of the FSS.

Comments: WATER STILL DRIPS FROM THE RECENT RAIN SHOWER. NO UNUSUAL VAPORS ARE VISIBLE IN THE AREA OF THE ET/ORB UMBILICALS AND NORMAL PURGE VENTING IS OCCURRING. SSME IGNITION CAUSES ICE/FROST TO FALL FROM THE TOP AND SIDES OF THE UMBILICAL, THE LH2 FEEDLINE BELLOWS, AND THE LH2 RECIRCULATION LINE BELLOWS.

OTV 041 Views and tracks vehicle from camera site 2.
B/W

Comments: IMAGE IS VERY UNDEREXPOSED AND LITTLE DETAIL IS DISCERNIBLE. ROLL MANEUVER LOOKS NORMAL.

OTV 048 Launch and tracking view from camera site 6.
B/W.

Comments: WATER DELUGE ACTIVATION AND SSME IGNITION APPEAR NOMINAL. CAMERA EXPOSURE IS OVERDRIVEN AT T-0. THE ROLL PROGRAM IS LONG BUT APPEARS NORMAL.

OTV 049 Views Orbiter LO2 T-0 umbilical from MLP deck.
B/W M-II

Comments: RCS PAPER COVERS TEAR DURING SSME IGNITION. VEHICLE 'TWANG' LOOKS NORMAL. DISCONNECT AND RETRACTION OF THE LO2 T-0 UMBILICAL IS NOMINAL.

OTV 050 Views Orbiter LH2 T-0 umbilical from SW MLP deck.
B/W M-II

Comments: TSM INTERIOR CAMERA LIGHT IS ACTIVATED AT T-11 SECONDS. ROFI SMOKE AND SPARKS ARE BLOWN WEST BY THE PREVAILING WINDS. RCS PAPER COVERS TEAR DURING SSME START-UP. VEHICLE TWANG IS NORMAL. ICE/FROST FALLS FROM THE LH2 T-0 UMBILICAL DURING SSME IGNITION. T-0 UMBILICAL DISCONNECT AND RETRACTION IS NOMINAL.

OTV 051 Views main engine cluster.
B/W M-II

Comments: FREE BURNING HYDROGEN IS BLOWN SOUTHWEST PAST THE LH2 TSM. RCS PAPER COVERS TEAR AND ICE FALLS FROM THE LO2 UMBILICAL DURING SSME START-UP. SSME IGNITION IS NOMINAL. DISCONNECT AND RETRACTION OF THE LO2 T-0 UMBILICAL IS NORMAL.

OTV 054 Views ET/Orbiter LO2 umbilical and Orbiter RH wing
B/W M-II

Comments: NORMAL PURGE VENTING IS OCCURRING AT THE ET/ORB UMBILICALS. SSME IGNITIONS CAUSES ICE/FROST TO FALL FROM THE ET/ORB UMBILICALS, LH2 FEEDLINE BELLOWS, AND LH2 RECIRCULATION LINE BELLOWS. RH WING ELEVONS SHAKE AS THE VEHICLE LIFTS OFF.

OTV 055 Views RH SRB and underside of Orbiter RH wing.
B/W M-II

Comments: SSME IGNITION AND GIMBAL FOR FLIGHT IS NOMINAL. ICE FALLS FROM BOTH ET/ORB UMBILICALS DURING SSME IGNITION AND IS BLOWN WESTWARD BY THE PREVAILING WINDS. NO IMPACTS TO ORBITER TILES ARE VISIBLE.

OTV 056 Views LH SRB and underside of Orbiter LH wing.
B/W M-II

Comments: HPU EXHAUST SWIRLS ON WEST SIDE OF LH SRB. ROFI SMOKE, SPARKS, AND FREE BURNING HYDROGEN ARE BLOWN WEST PAST THE LH2 TSM. SSME IGNITION CAUSES ICE/FROST TO FALL FROM THE LH2 ET/ORB UMBILICAL, BUT NO TILE IMPACTS ARE VISIBLE.

OTV 060 Views ET nosecone and NE louver from water tower.
Color M-II

Comments: FREE BURNING HYDROGEN IS BLOWN WEST PAST LH2 TSM. SSME IGNITION IS NORMAL. CAMERA EXPOSURE IS OVERDRIVEN AT T-0.

OTV 061 Views ET nosecone and SW louver from the FSS.
Color M-II

Comments: THE LOUVER IS COVERED BY LIGHT FROST. THERE WERE NO TPS ANOMALIES ON THE NOSECONE AND OGIVE. VEHICLE 'TWANG' APPEARS NORMAL. ICE/FROST/RAIN WATER FALLS PAST THE LO2 FEEDLINE DURING ASCENT.

OTV 063 Views ET/Orbiter umbilical and Orbiter T-0
Color M-II umbilical from the FSS.

Comments: TSM INTERIOR CAMERA LIGHT IS ACTIVATED AND ILLUMINATES THE LH2 T-0 AREA. SOME SPARKS FROM THE ROFI'S DRIFT NORTH UNDER THE BODY FLAP. SSME IGNITION CAUSES ICE/FROST TO FALL FROM THE ET/ORB UMBILICALS AND RECIRCULATION LINE BELLOWS - NO TPS IMPACTS ARE VISIBLE. SOME PIECES OF ICE FALL FROM THE AFT SIDE OF THE ET/SRB CABLE TRAY. LH2 T-0 RETRACT IS NORMAL AND RESIDUAL VAPORS EXIT THE QD. WING AND ELEVON MOTION OCCURS AFTER T-0.

OTV 070 Views overall vehicle from SE direction.
Color M-II

Comments: RUSTY DELUGE WATER SPRAYS FROM THE MLP LH2 SKID. FREE BURNING HYDROGEN IS BLOWN WEST. SSME IGNITION IS NOMINAL. RCS PAPER COVERS TEAR AND ICE FALLS FROM THE LO2 T-0 UMBILICAL DURING SSME START-UP. RETRACTION OF THE T-0 UMBILICAL IS NORMAL AND RESIDUAL GOX VAPORS EXIT THE QD.

OTV 071 Views overall vehicle from SW direction.
Color M-II

Comments: FREE BURNING HYDROGEN IS BLOWN WEST. SSME IGNITION IS NORMAL. VEHICLE LIFTOFF IS OBSCURED BY SSME PLUME.

STI (C/S 2) Infrared view from camera site 2.
B/W M-II

Comments: FREE BURNING HYDROGEN IS BLOWN WEST PAST THE VERTICAL STABILIZER AND UNDER THE BODY FLAP BY PREVAILING WINDS. SSME IGNITION APPEARS NORMAL. TRACKING OF THE VEHICLE THROUGH TOWER CLEAR SHOWS NO UNUSUAL THERMAL IMAGERY OF THE ORBITER AND SRB'S.

STI (RSS) Infrared view from RSS roof.
B/W M-II

Comments: FREE BURNING HYDROGEN RISES ALONG SIDE THE LH OMS POD BEFORE DISSIPATING. SSME IGNITION IS NORMAL.

TV-2 Views entire launch vehicle from the SLF.
Color M-II

Comments: VIEW IS TOO DISTANT FOR DETAIL. NO ANOMALIES.

TV-4 Views entire vehicle from Beach Road IFLOT Site.
Color M-II

Comments: FREE BURNING HYDROGEN IS BLOWN WEST. SSME IGNITION IS NOMINAL. RAIN WATER FROM ET AFT DOME AND SRB STIFFENER RINGS VAPORIZES SHORTLY AFTER LIFTOFF. AT T+69 THROUGH 79 SECONDS, 11 PARTICLES FALL OUT OF THE PLUME. THE PARTICLES APPEAR LARGE - POSSIBLY DUE TO THE 'BLOOMING' EFFECT OF BURNING CHUNKS OF PROPELLANT, SLAG, OR INHIBITOR. BSM'S FIRE AT T+125 SECONDS. SRB SEPARATION APPEARS NORMAL.

TV-5 Views launch from VAB roof.
Color M-II

Comments: VIEW IS TOO DISTANT FOR DETAIL. NO ANOMALIES.

TV-7 Views entire launch vehicle from camera site 2
Color M-II at the pad east perimeter.

Comments: FREE BURNING HYDROGEN IS BLOWN SOUTHWEST. SSME IGNITION IS NOMINAL. VEHICLE 'TWANG' APPEARS NORMAL. A LARGE PARTICLE MOVES NORTH JUST ABOVE THE MLP DECK AFTER T-0 AND IS PROBABLY A PIECE OF SRB THROAT PLUG MATERIAL.

TV-11 Views entire launch vehicle from SLF Tower #1.
Color M-II

Comments: VIEW IS TOO DISTANT FOR DETAIL. NO ANOMALIES.

TV-13 Cocoa Beach DOAMS video. Tracks launch vehicle
Color M-II from acquisition to LOV.

Comments: VERY CLOSE-IN VIEW. AFT DOME CHARRING IS NORMAL. NUMEROUS PIECES OF SRB SLAG FALL FROM THE PLUME BEFORE AND AFTER SRB SEPARATION. SRB SEPARATION APPEARS NOMINAL.

TV-16 View from helicopter orbiting west of pad and VAB.
Color M-II

Comments: VIEW IS TOO DISTANT FOR DETAIL. NO ANOMALIES.

TV-18 Malabar ITEC video. Tracks launch vehicle from
Color M-II acquisition to LOV.

Comments: VIEW IS SOMEWHAT DISTANT - MOSTLY PLUME.

TV-21A Views entire launch vehicle from UCS-15 site
Color M-II south of Pad A.

Comments: SSME PLUME OBSCURES LIFTOFF. VIEW IS TOO DISTANT FOR DETAIL. SRB SEPARATION APPEARS NOMINAL.

ET-204 Patrick IGOR video. Tracks launch vehicle from
Color M-II acquisition to LOV.

Comments: COVERAGE IS INTERMITTENT. ONLY THE VEHICLE PLUME IS VISIBLE. NO SRB SEPARATION ANOMALIES.

ET-206 Melbourne Beach ROTI video. Tracks launch vehicle
Color M-II from acquisition to LOV.

Comments: VIEW IS SOMEWHAT DISTANT. VEHICLE ASCENT LOOKS NORMAL. NUMEROUS PARTICLES OF SRB SLAG FALL FROM THE PLUME BEFORE AND AFTER SEPARATION. SRB SEPARATION IS NOMINAL.

ET-207 UCS-10 MIGOR video. Tracks launch vehicle from
Color M-II acquisition to LOV.

Comments: RAIN WATER FROM THE ET AFT DOME AND SRB STIFFENER RINGS VAPORIZES SHORTLY AFTER LIFTOFF. THE VEHICLE OVERSHOOTS THE TARGETED HEADING DURING THE LONG ROLL MANEUVER. THREE FLASHES OCCUR IN THE SSME PLUME JUST PRIOR TO THE END OF THE ROLL PROGRAM. RAIN WATER/VAPORS APPEAR FROM THE SPLIT IN THE RUDDER SPEED BRAKE AT THE END OF THE ROLL PROGRAM. RCS PAPER COVERS ENTER THE PLUME AFTER THE ROLL. PLUME RECIRCULATION AND AFT DOME CHARRING ARE VISIBLE DURING ASCENT - A NORMAL OCCURRENCE. ANOTHER LARGE FLASH OCCURS IN THE SSME PLUME AT T+54 SECONDS. TWO OPTICAL PHENOMENA OCCUR AT T+97 AND 114 SECONDS AND APPEAR TO BE OPTICAL REFLECTIONS IN THE CAMERA LENS. BSM'S FIRE AT T+125 SECONDS. SRB SEP IS NORMAL AND SOME OF THE LARGER SRB SLAG PIECES ARE VISIBLE.

ET-208 Cocoa Beach DOAMS video. Tracks launch vehicle
Color M-II from acquisition to LOV.

Comments: ACQUISITION OCCURS LATE IN FLIGHT. CHARRING ON THE AFT DOME IS NORMAL. LATER VIEW IS MOSTLY PLUME. HUNDREDS OF PIECES OF SRB SLAG FALL FROM THE PLUME JUST BEFORE AND AFTER SRB SEP.

ET-212 UCS-23 MIGOR video. Tracks launch vehicle from
Color M-II acquisition to LOV.

Comments: TWO SMALL AND ONE LARGE FLASH OCCURS IN THE SSME PLUME PRIOR TO THE END OF THE ROLL MANEUVER. VEHICLE OVERSHOOTS ROLL TARGET AND THEN ADJUSTS BACK TO CORRECT HEADING. ASCENT COVERAGE IS INTERMITTENT DUE TO CLOUDS. THREE PARTICLES FALL OUT OF THE SRB PLUME DURING ASCENT. NUMEROUS PIECES OF SRB SLAG FALL OUT OF THE PLUME JUST BEFORE AND AFTER SRB SEPARATION.

ET-213 UCS-7 MOTS video. Tracks launch vehicle from
Color M-II acquisition to LOV.

Comments: JUST AFTER T-0, A PARTICLE MOVES NORTH AWAY FROM THE VEHICLE JUST ABOVE THE MLP DECK AND IS PROBABLY A PIECE OF SRB THROAT PLUG MATERIAL. RAIN WATER FROM THE ET AFT DOME AND SRB STIFFENER RINGS VAPORIZES SHORTLY AFTER LAUNCH. A FLASH OCCURS IN THE SSME #2 OR #3 PLUME AT T+16 SECONDS. REMAINDER OF THE IMAGERY DURING ASCENT IS OBSCURED BY THE VEHICLE PLUME.

8.2 ON-ORBIT FILM DATA REVIEW

NO ON-ORBIT PHOTOGRAPHY WAS AVAILABLE FOR THIS MISSION. OV-104 WAS NOT EQUIPPED TO CARRY UMBILICAL CAMERAS AND NO DTO'S TO PHOTOGRAPH THE EXTERNAL TANK AFTER SEPARATION BY THE FLIGHT CREW HAD BEEN SUBMITTED.

8.3 LANDING FILM DATA REVIEW

E-1002 Orbiter landing at Ames-Dryden Flight Research
16mm Facility

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: LANDING GEAR IS ALREADY EXTENDED WHEN FILM STARTS. RH MLG WHEEL CONTACTS RUNWAY FIRST FOLLOWED ALMOST IMMEDIATELY BY LH MLG. NLG STRUT FLEXURE IS MINIMAL. NO VISIBLE TILE DAMAGE.

E-1005 Orbiter landing at Ames-Dryden Flight Research
35mm Facility

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: VIEW IS SOMEWHAT DISTANT. MAIN LANDING GEAR EXTENSION, WHEEL TOUCHDOWN, AND VEHICLE ROLLOUT IS NOMINAL. NO TILE DAMAGE IS VISIBLE.

E-1006 Orbiter landing at Ames-Dryden Flight Research
16mm Facility

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: VIEW IS TOO DISTANT FOR DETAIL. NO VEHICLE ANOMALIES.

E-1007 Orbiter landing at Ames-Dryden Flight Research
16mm Facility

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: VIEW IS TOO DISTANT FOR DETAIL. NO VEHICLE ANOMALIES.

E-1008 Orbiter landing at Ames-Dryden Flight Research
35mm Facility

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: VIEW IS SOMEWHAT DISTANT. MAIN LANDING GEAR EXTENSION, WHEEL TOUCHDOWN, AND VEHICLE ROLLOUT IS NOMINAL. NO TILE ANOMALIES ARE VISIBLE.

E-1009 Orbiter landing at Ames-Dryden Flight Research
16mm Facility

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: VIEW IS TOO DISTANT FOR DETAIL. NO VEHICLE ANOMALIES.

E-1010 Orbiter landing at Ames-Dryden Flight Research
16mm Facility

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: VIEW IS TOO DISTANT FOR DETAIL. NO VEHICLE ANOMALIES.

E-1011 Orbiter landing at Ames-Dryden Flight Research
16mm Facility

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: NOT A HIGH SPEED FILM ITEM. NO VEHICLE ANOMALIES.

E-1012 Orbiter landing at Ames-Dryden Flight Research
16mm Facility

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: LH MLG DOOR OPENS FIRST. MLG EXTENSION AND WHEEL TOUCH DOWN IS NOMINAL. NLG STRUT COMPRESSION AND FLEXURE IS MINIMAL. NO TILE DAMAGE IS VISIBLE.

E-1027 Orbiter landing at Ames-Dryden Flight Research
16mm Facility

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: HEAT WAVES CAUSE WAVY IMAGE. LH MLG DOOR OPENS FIRST. MLG EXTENSION AND WHEEL TOUCHDOWN ARE NOMINAL. NLG FLEXURE IS MINIMAL. NO TILE DAMAGE IS VISIBLE.

E-1028 Orbiter landing at Ames-Dryden Flight Research
16mm Facility

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: THIS IS NOT A HIGH SPEED FILM ITEM. LH MLG DOOR OPENS FIRST. MLG EXTENSION AND WHEEL TOUCHDOWN IS NOMINAL. NLG FLEXURE IS MINIMAL. NO TILE DAMAGE IS VISIBLE.

9.0 SRB POST FLIGHT/RETRIEVAL DEBRIS ASSESSMENT

Both Solid Rocket Boosters were inspected for debris damage and debris sources at CCAFS Hangar AF on 2 March 1990 from 1200 to 1500 hours. In general, the SRB's appeared to be in good condition.

9.1 RH SOLID ROCKET BOOSTER DEBRIS INSPECTION

The nosecap was not recovered. The RH frustum was missing MTA-2 over a fastener closeout under the aft -Y BSM. The substrate was slightly sooted. There were 18 debonds total - two MSA-2 debonds over fasteners and 16 MTA-2 debonds on the ramps (Figure 27). The Hypalon paint had blistered slightly in localized areas in the visibility stripes and near the 395 ring. Some layers of MSA had adhered to the paint. The four BSM aero heatshield covers were intact and properly locked in the 180 degree open position.

The RH forward skirt exhibited no debonds or missing TPS. Separation of the forward attach fitting was nominal. However, a cable at the forward crossover was damaged. There was a 2-inch split in the cable insulation and the connector was deformed. Signs of repeated impact on the forward assembly MSA indicates the contact occurred during re-entry. K5NA closeouts had been accomplished for this flight on the inboard corners of the RSS interface cable tray. Darker than usual ascent heating scorch marks were present forward of the thrust fitting (Figure 28). The forward skirt contained 140 gallons of water.

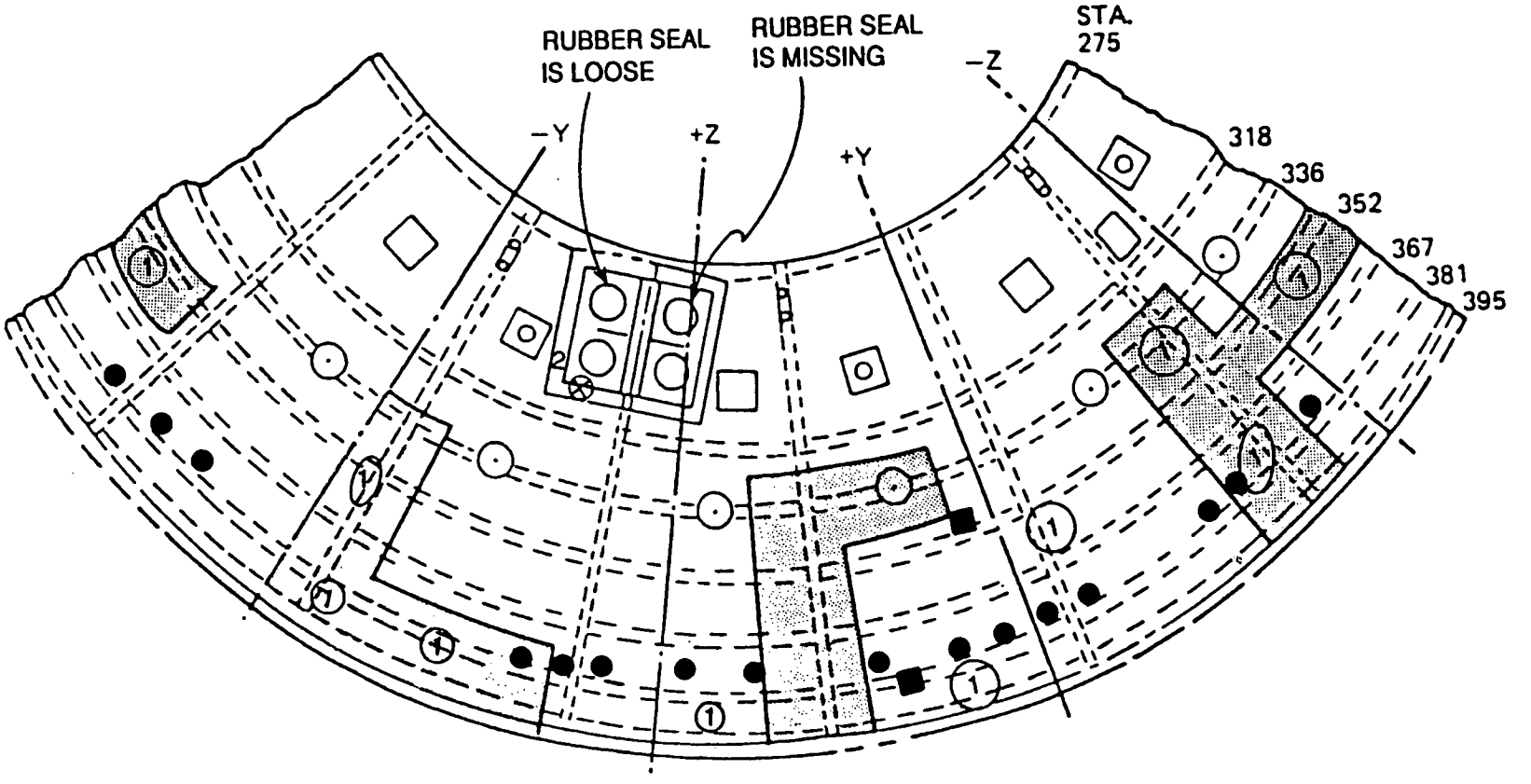
All field joint closeouts were undamaged. Minor trailing edge damage to the GEI cork runs was attributed to debris hits from nozzle extension severance.

K5NA closeouts on the IEA covers were intact, but the Hypalon paint was blistered in some areas. Some TPS was missing aft of the ETA ring. Separation of the aft ET/SRB struts was nominal. A 6-inch long piece of EPDM seal was missing from the upper strut body. The center stiffener ring web between 178-188 degrees and the aft stiffener ring web at 180 and 188 degrees was cracked due to water impact.

The TPS over the aft skirt acreage was generally in good condition (Figure 29). The TVC system appeared to be undamaged. The phenolic material on the kick ring delaminated in several locations. K5NA thermal protective domes were missing from bolt heads on the aft side of the kick ring. K5NA was missing from all four aft BSM nozzles. Instafoam was missing from the aft ring around the aft skirt feet, HPU exhaust horns, and the SRB T-0 umbilical.

There was no broaching of any post hole. HDP #1 plunger was seated but offset from the spherical washer. Some stud thread impact marks were visible in HDP #2 and #3, both of which had skewed ordnance firings. Three small pieces of shim material were wedged in the bore against the HDP #4 debris plunger.

FIGURE 27. RIGHT SRB FRUSTUM



MISSING TPS

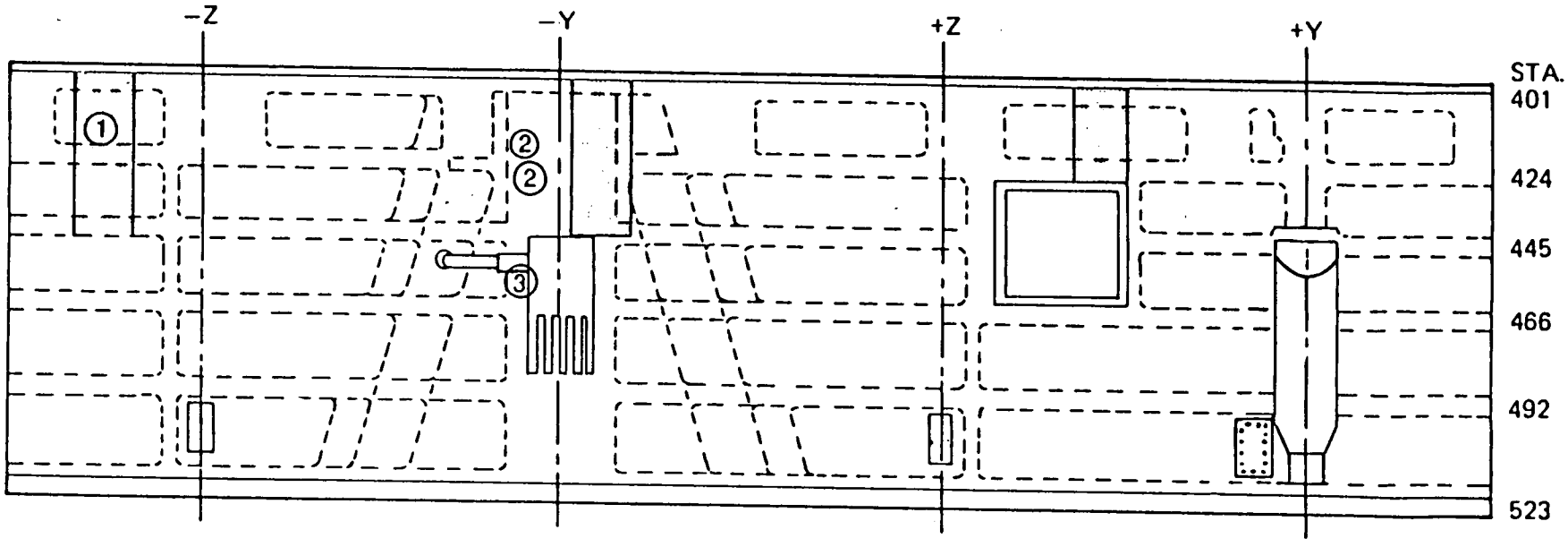
1 ⊗ CLOSEOUT OVER FASTENER MISSING

DEBONDS

16 ● MTS-2 ON RAMPS
2 ■ MSA-2 OVER FASTENERS

(1) HYPALON PAINT BLISTERING

FIGURE 28. RIGHT SRB FWD SKIRT

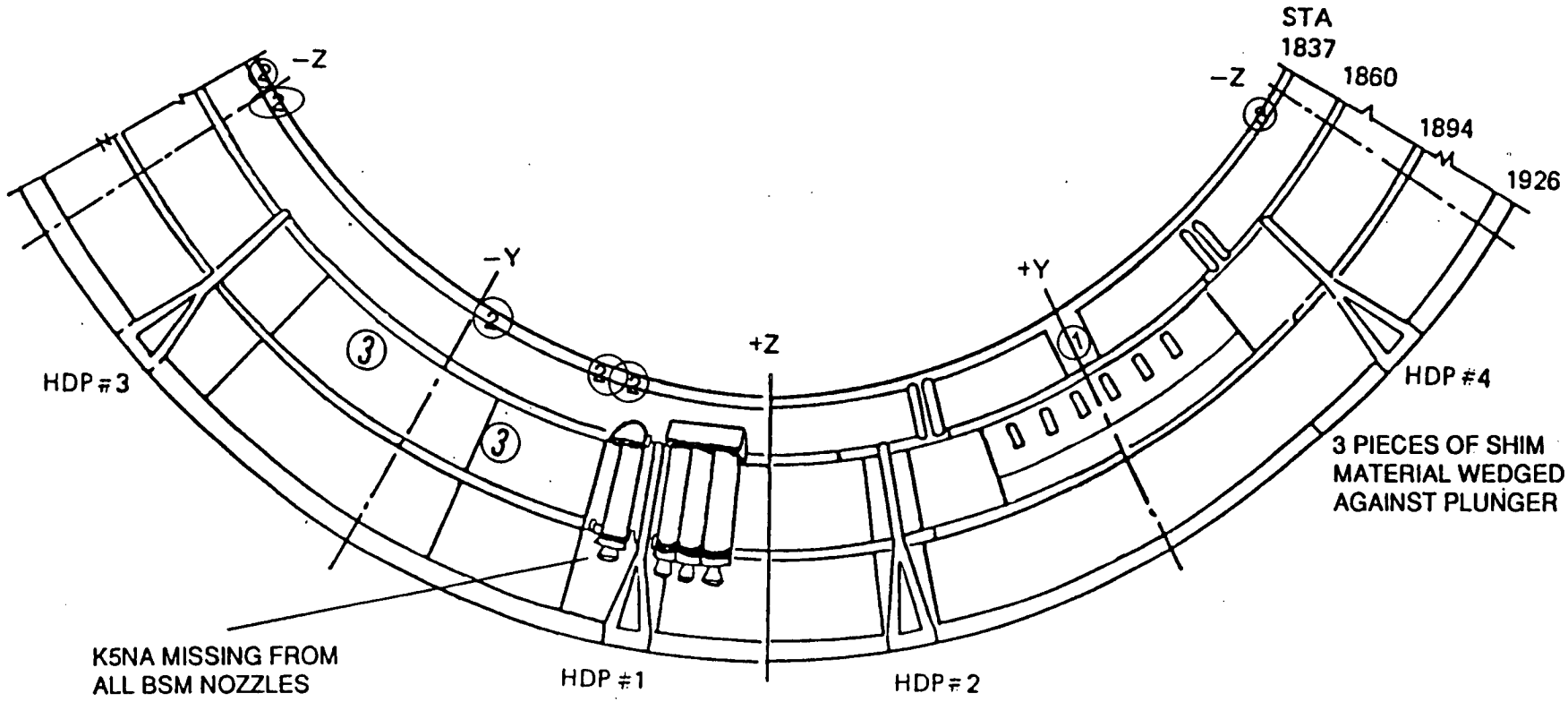


TPS MISSING
NONE

DEBONDS
NONE

1 MINOR BLISTERING OF HYPALON PAINT
2 ASCENT AEROHEATING SCORCH MARKS
3 2" SLICE IN CABLE INSULATION DAMAGED CONNECTOR

FIGURE 29. RIGHT SRB AFT SKIRT EXTERIOR TPS



① BLISTERING ON CABLE TRAY (AFT END)

② K5NA BUTTONS MISSING

③ GENERALLY MORE SCORCHING IN THIS AREA

9.2 LH SOLID ROCKET BOOSTER DEBRIS INSPECTION

The nosecap was not recovered. The LH frustum exhibited 9 MSA-2 debonds and 4 missing pieces of MTA-2 on the aft edge of the aft ramp. There was minor blistering of the Hypalon paint in localized areas near the 381 ring. Hypalon paint blistering with MSA substrate charring occurred in the visibility stripe and near the BSM's (Figure 30). The BSM aero heat shield covers were fully intact and properly locked in the 180 degree open position.

The LH forward skirt exhibited 1 debond and 2 areas of missing TPS, all of which had clean substrates and appeared to be water impact or handling damage. Darker than usual ascent heating scorch marks were visible forward of the thrust fitting. The phenolic plate on the +Z RSS antenna was delaminated and some of the material was missing (Figure 31). Three pins from the frustum severance ring (at approximately 100, 120, and 240 degrees) were missing. One of the pins was embedded 0.75 inches in the TPS on the forward side of the ETA ring at 175 degrees. Twenty-nine other pins were loose and/or protruding from the pin holes. Loss of these pins in flight is considered unacceptable. Separation of the forward attach fitting was nominal and the RSS cables separated cleanly. The K5NA closeouts had been accomplished properly on the inboard corners of the RSS interface cable tray. The forward skirt contained 2 gallons of water.

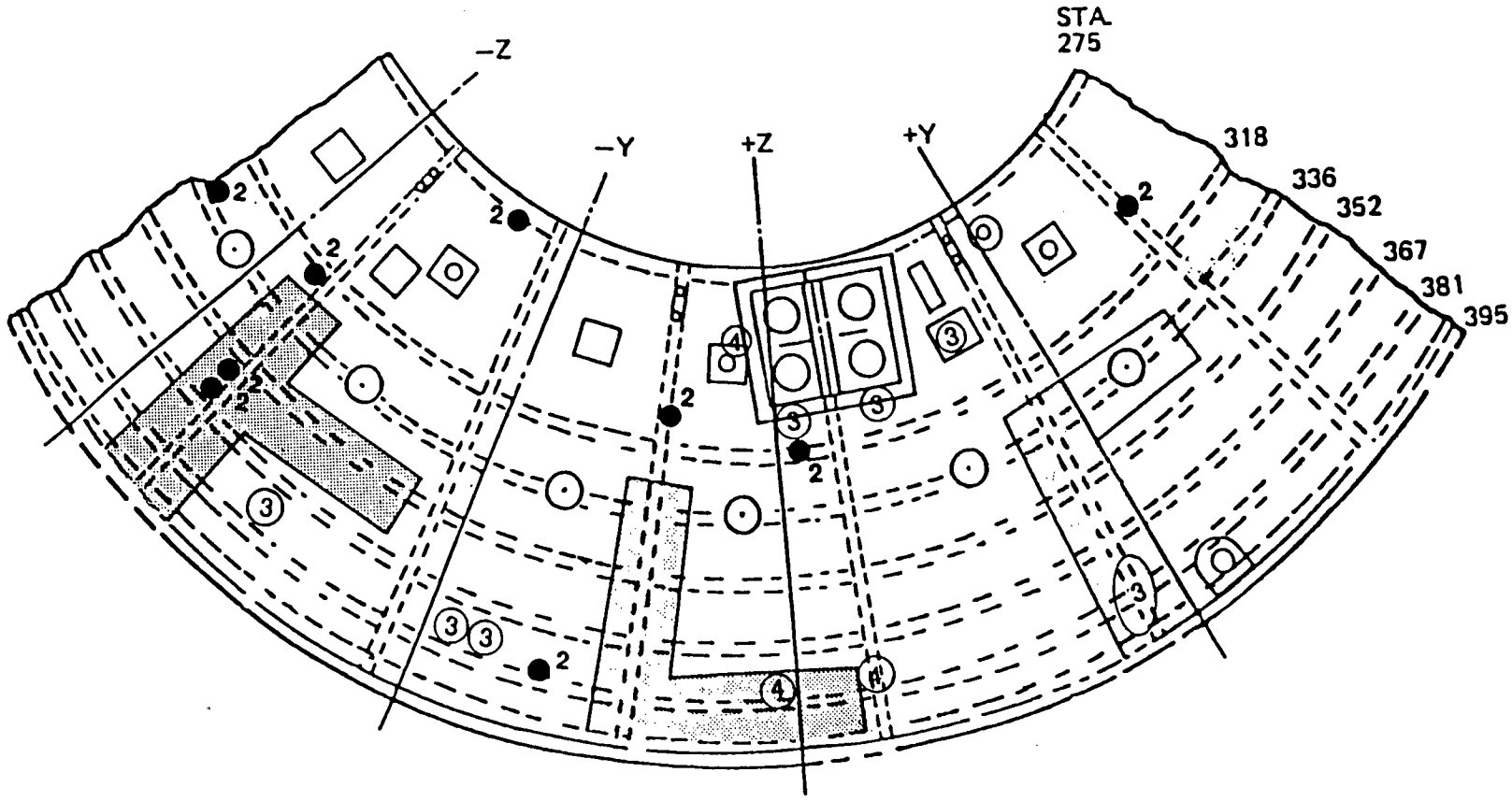
The field joint closeouts were undamaged. Trailing edge damage to the GEI cork runs was attributed to debris hits from the nozzle extension severance.

K5NA closeouts on the IEA covers were intact, but the Hypalon paint was blistered in some areas. Some TPS was missing aft of the ETA ring. Separation of the aft ET/SRB struts was nominal. The center stiffener ring web and the aft stiffener ring web were cracked at 196 and 194 degrees, respectively, due to water impact. The aft center segment factory joint EPDM moisture seal was unbonded at 4 locations along the trailing edge. The four unbonds extended to the pin retainer band and exhibited Chemlok 205 to case failure.

The TPS over the aft skirt acreage was generally in good condition (Figure 32). The TVC system appeared to be undamaged. Some K5NA protective domes were missing from bolt heads on the aft side of the phenolic kick ring. K5NA was missing from all four aft BSM nozzles. Instafoam was missing from the aft ring around the aft skirt feet, HPU exhaust horns, and the SRB T-0 umbilical.

The HDP #6 and #7 plungers were seated, but the spherical bearings were offset. Half of a frangible nut was wedged between the HDP #8 plunger and spherical washer.

FIGURE 30. LEFT SRB FRUSTUM



MISSING TPS

1) 4 MTA-2 AFT EDGE OF AFT RAMP

DEBONDS

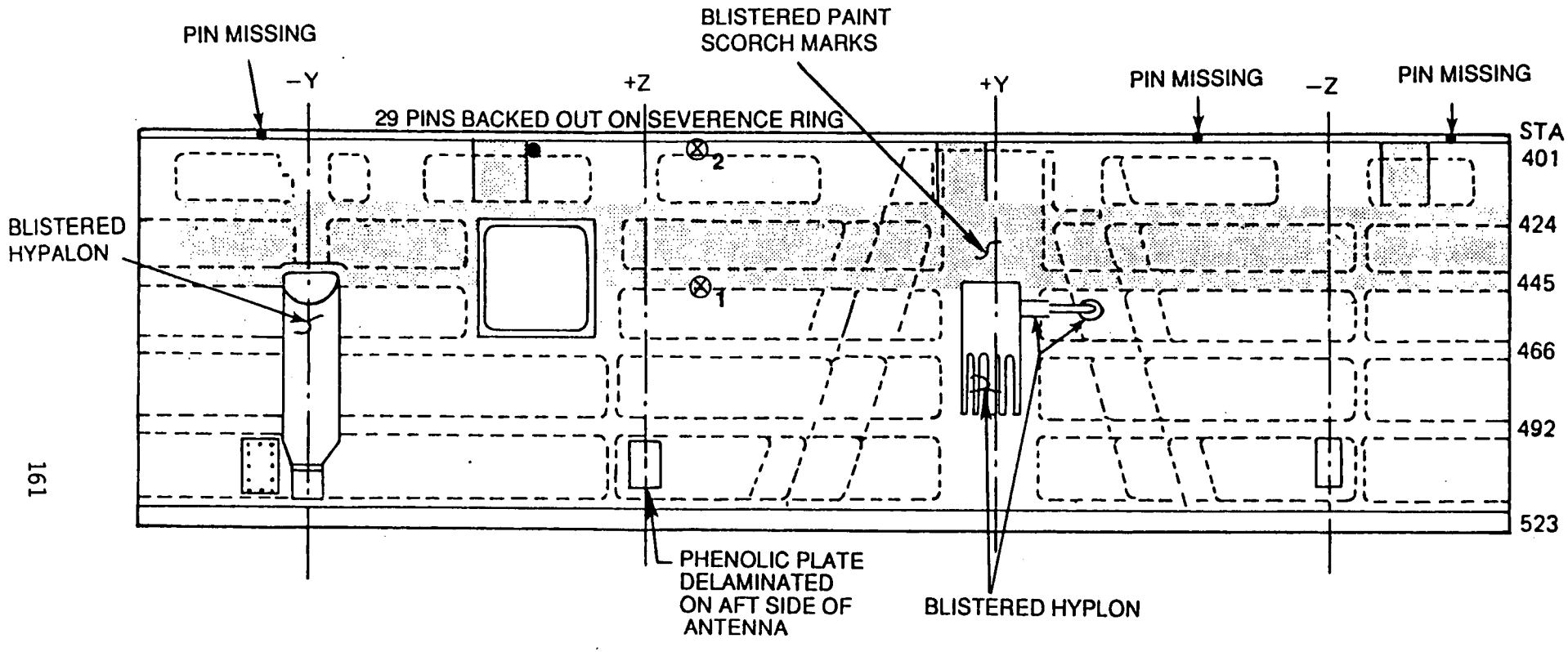
2) 9 MSA-2

3) HYPALON PAINT BLISTERING

4) HYPALON PAINT BLISTERING WITH CHARRING

EGG/V-326E

FIGURE 31. LEFT SRB FWD SKIRT



MISSING TPS

1 ⊗ 1.5" DIA CLEAN SUBSTRATE

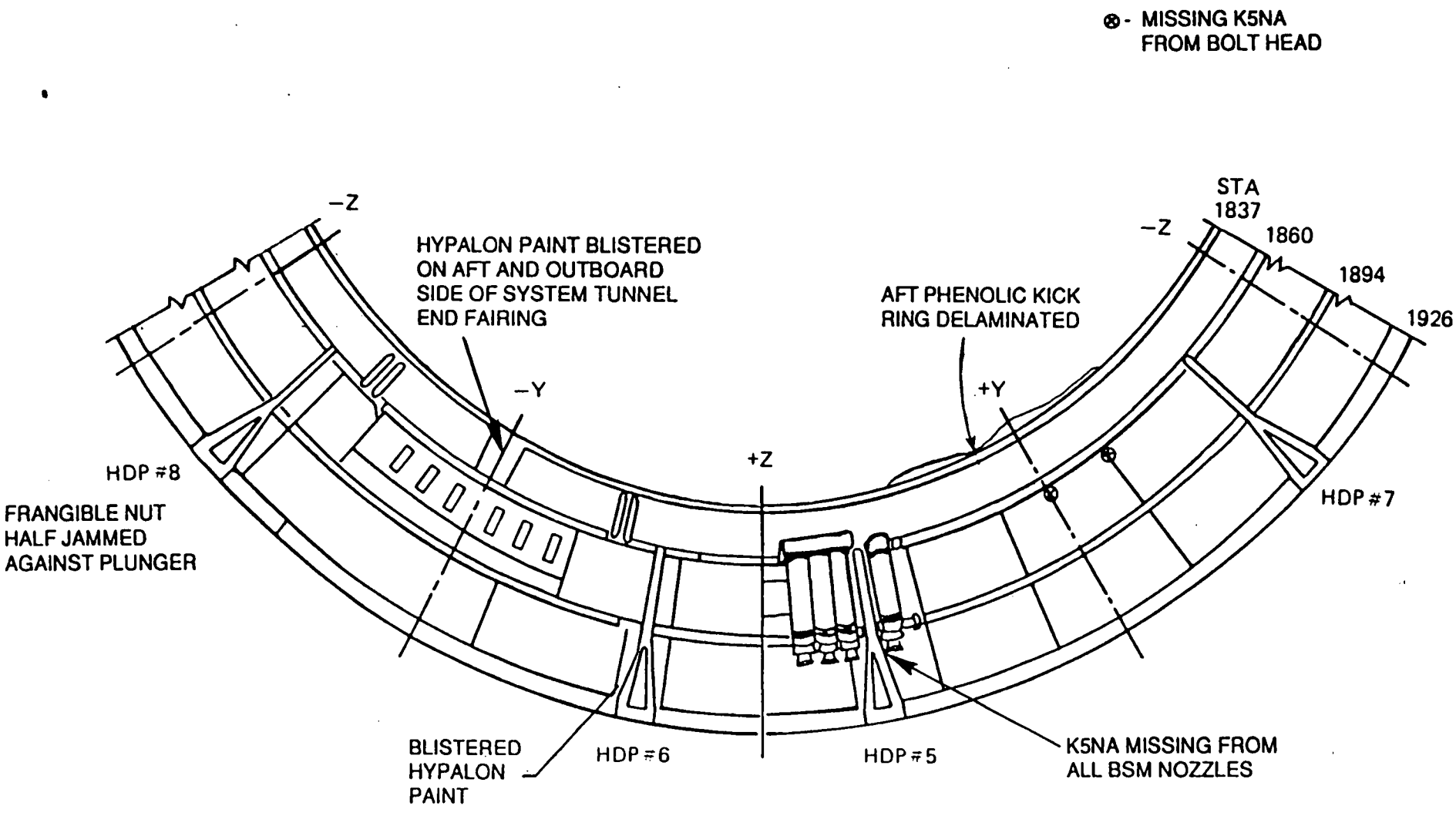
2 ⊗ 5" X 1 1/4" CLEAN SUBSTRATE

DEBONDS

1 ● 1/2 X 1/2

EGG/V-326D

FIGURE 32. LEFT SRB AFT SKIRT EXTERIOR TPS



EGG/V-326F

9.3 RECOVERED SRB DISASSEMBLY FINDINGS

Disassembly of the recovered boosters began on 1 March 1990. A piece of a phenolic shop aid (chisel) was found embedded in the K5NA ablator closeout under the RH forward assembly splice plate. This K5NA had been applied to fill the gap between the splice plate and the forward segment/forward skirt interface. During the STS-36 stacking/flow in the VAB, MRB rationale for a bolt hole nick in the original splice plate was not approved. The splice plate was subsequently replaced. Complete removal of the existing K5NA was not required during the replacement of the plate. The phenolic tool was wedged behind the remaining K5NA and never removed prior to the installation of the new splice plate. The presence of the tool was not a safety of flight issue since the chisel was buried approximately 1 inch under K5NA and was secured behind the splice plate.

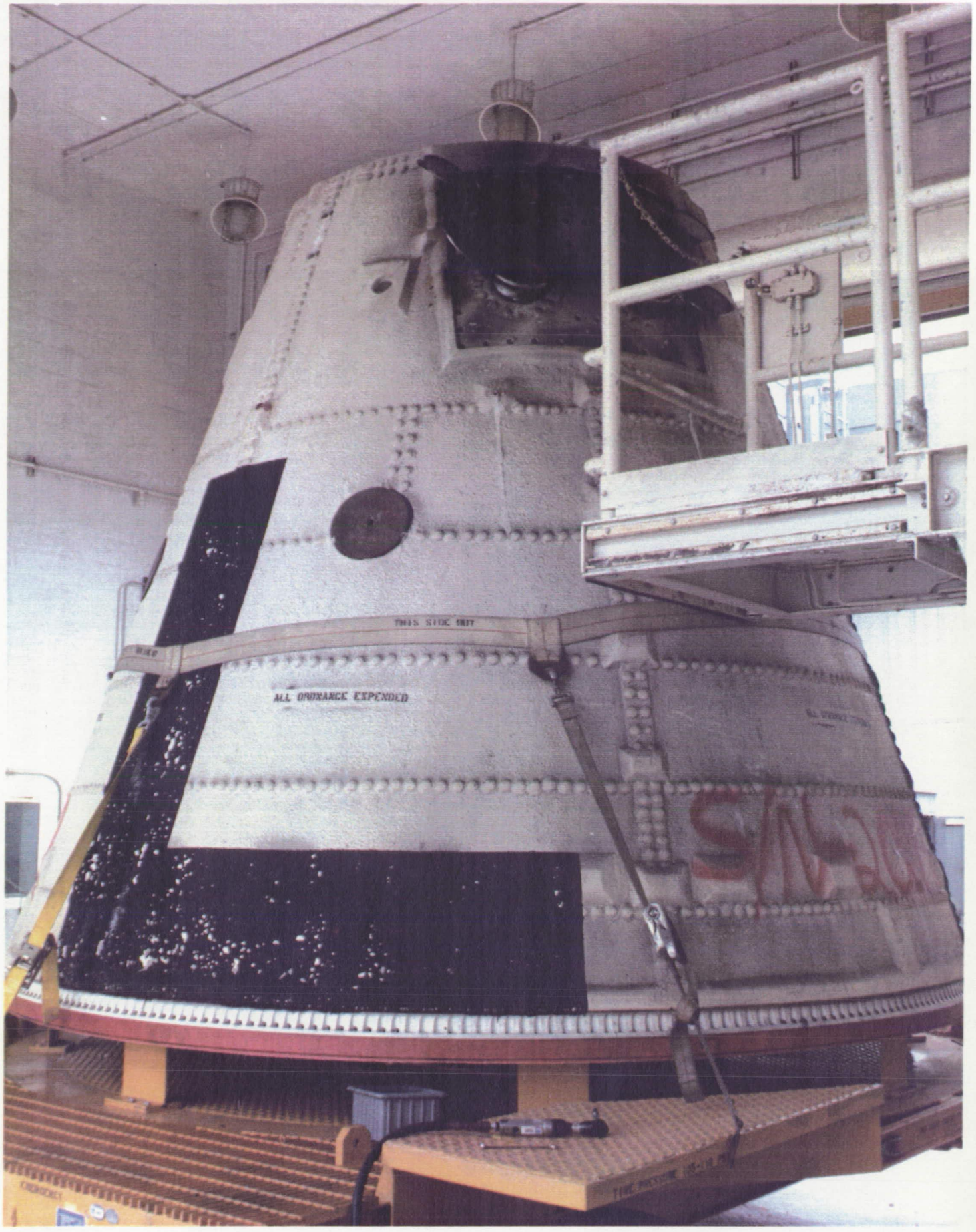
During removal of the LH igniter, the inner bolts were detorqued/removed instead of the outer bolts. This caused the igniter chamber to fall into the SRM forward segment. The forward and forward center segments were demated to allow retrieval of the igniter chamber. None of the hardware was damaged. A gas path through the putty, 2.5 inches wide at the widest point, was found in the RH igniter-to-case joint at 175 degrees. This type of blow hole has occurred on previous flights and is not anomalous according to MSFC and Thiokol. However, damage to the inner gask-o-seal cad plating, and corrosion on the forward dome boss and igniter boss occurred this time.

The A286 plunger attach stud had been installed for STS-36. Previously, this type of attach stud had been used on the first 4 flights since STS-26R. The A286 attach stud was replaced by the stronger MP35N on flights 5-7, but may have contributed to the increased occurrence of holddown post stud hang-ups. No attach stud was used on the 8th flight and an unacceptable amount of ordnance debris was lost from the DCS. USBI measured the percentage of potential debris retained in the DCS (with the A286 attach stud) for STS-36, but the total does not include the frangible nut halves:

HDP #1	98%	HDP #5	99%
HDP #2	97%	HDP #6	97%
HDP #3	96%	HDP #7	97%
HDP #4	96%	HDP #8	64%

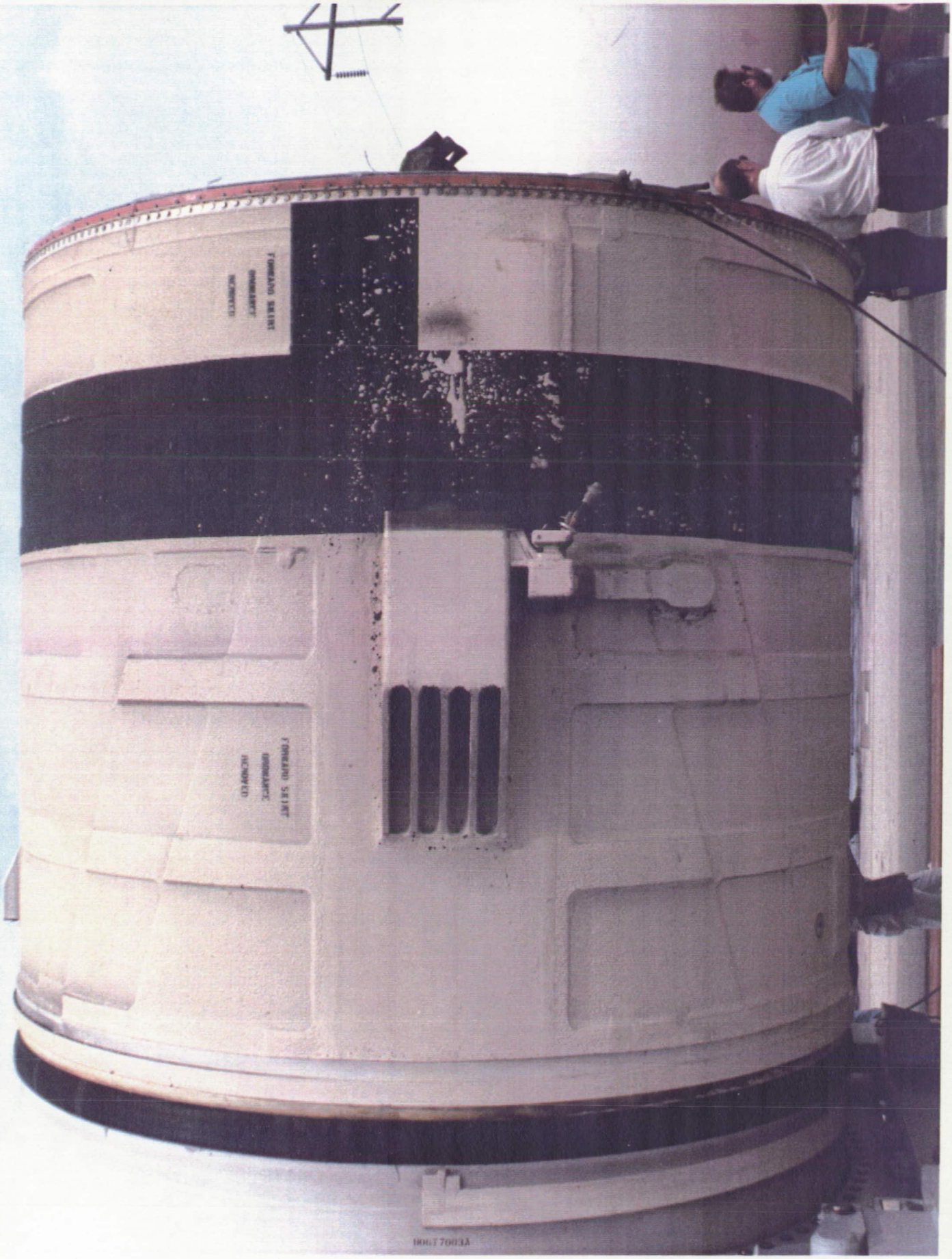
SRB Post Launch Anomalies are listed in Section 12.3.

Overall view of LH frustum with localized areas of Hypalon paint blistering in the visibility stripes

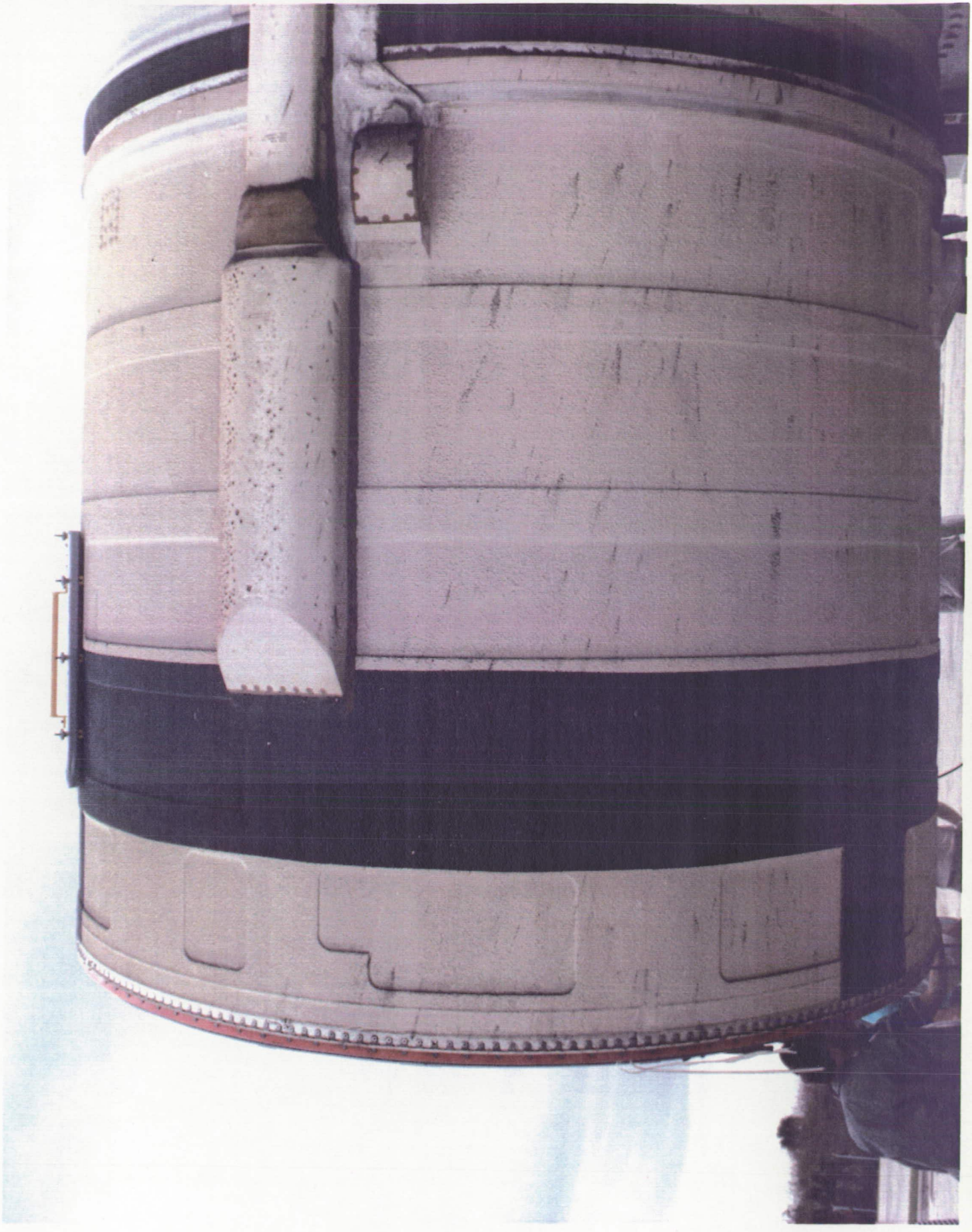


Overall view of RH frustum with localized areas of Hypalon paint blistering in the visibility stripes and 395 ring

Missing Hypalon paint with some layers of MSA-2 attached was located just above the 318 ring near the -Y axis



Overall view of LH forward skirt with Hypalon paint blistering. Note ascent aeroheating scorch mark forward of thrust fitting

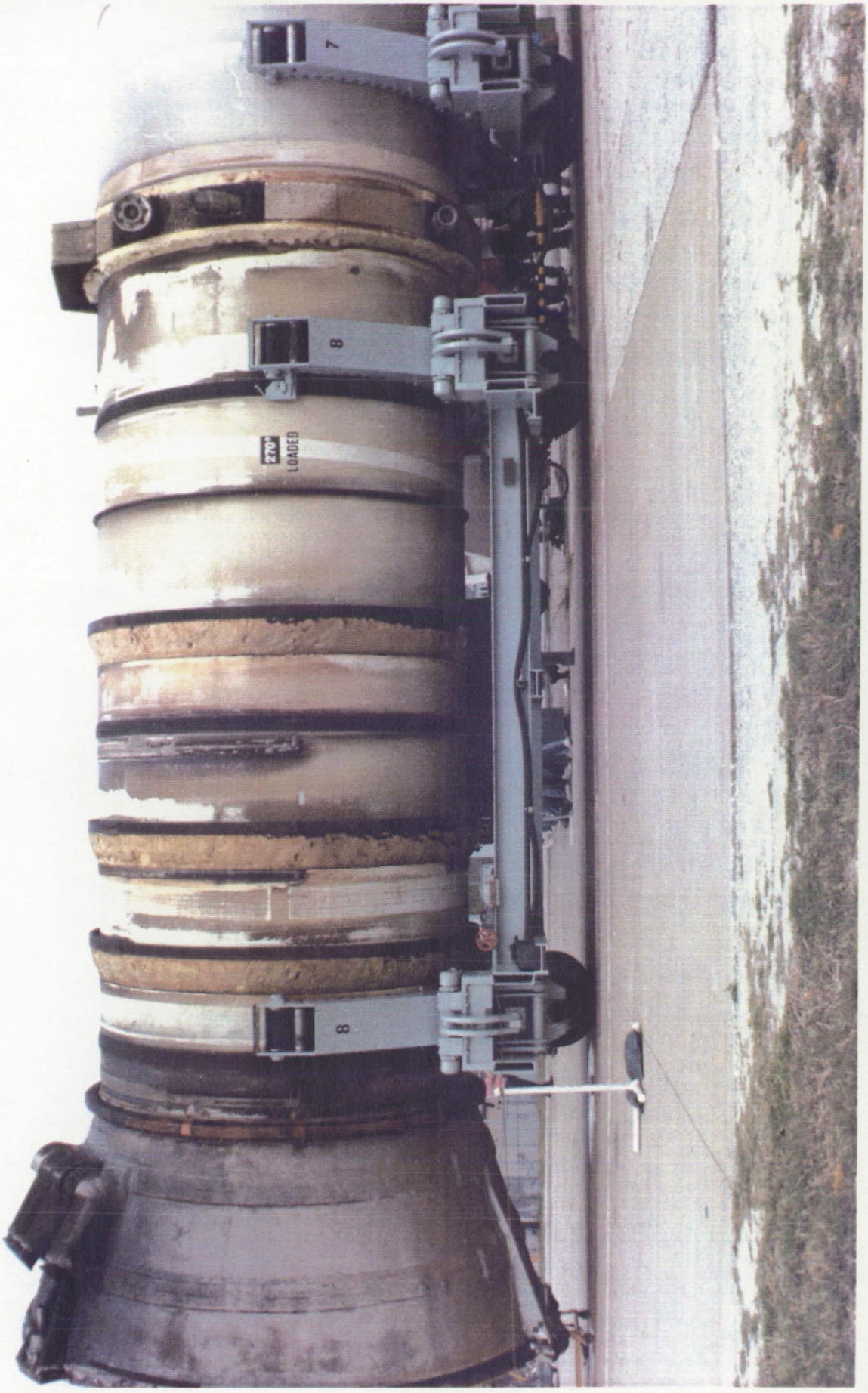


Overall view of LH forward skirt with Hypalon paint blistering on the systems tunnel cover fairing

Three pins were missing and 29 pins were backed out on the LH frustum/forward skirt severance ring

One of the missing pins from the LH frustum/forward skirt severance ring was found embedded in the ETA ring foam

The phenolic plate on the LH forward skirt +Z RSS antenna was delaminated and some of the material was missing



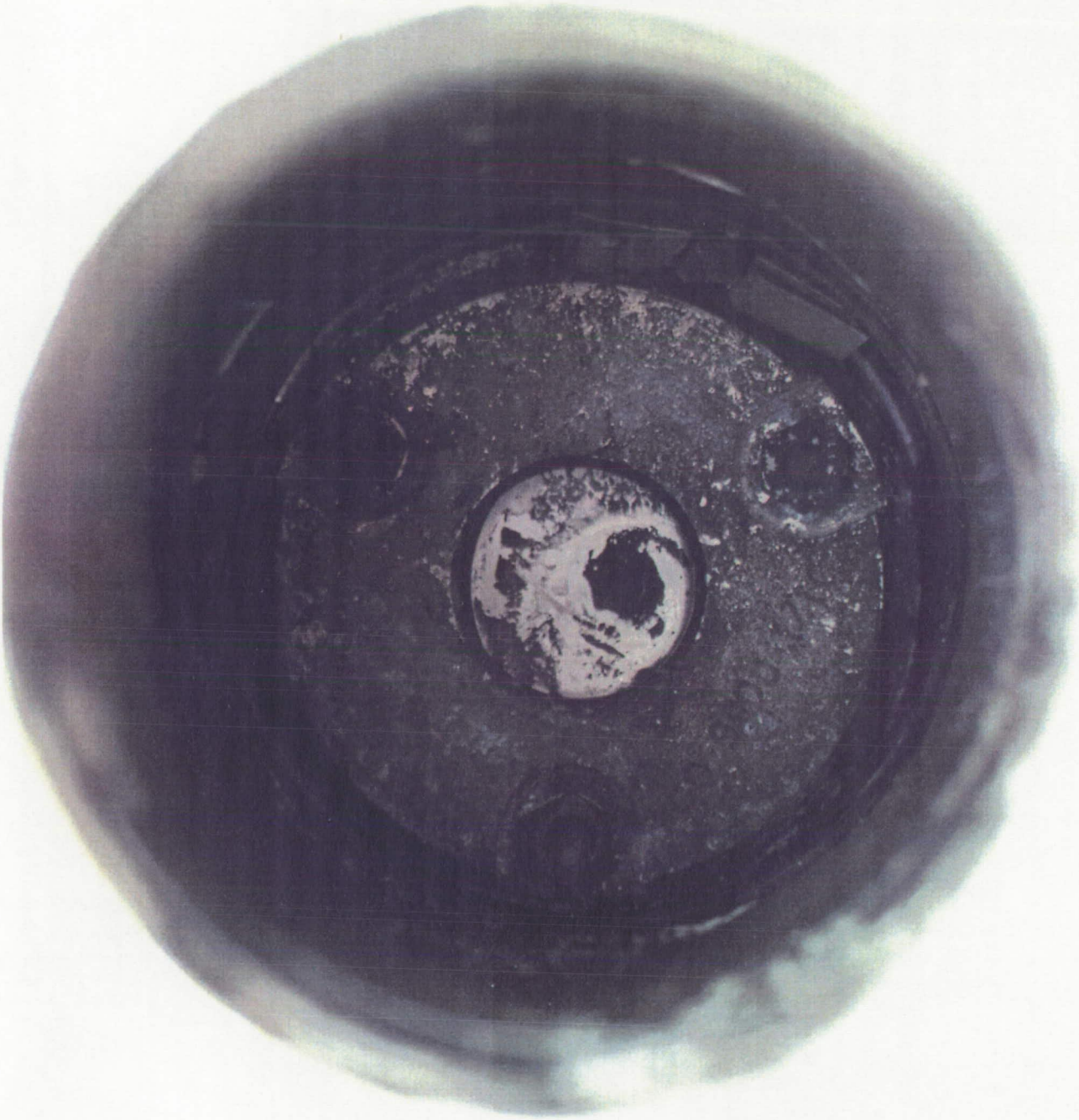
Post flight condition of the LH aft booster

EPDM seal around the ET/SRB struts was torn and the Hypalon paint on the ETA ring covers was blistered

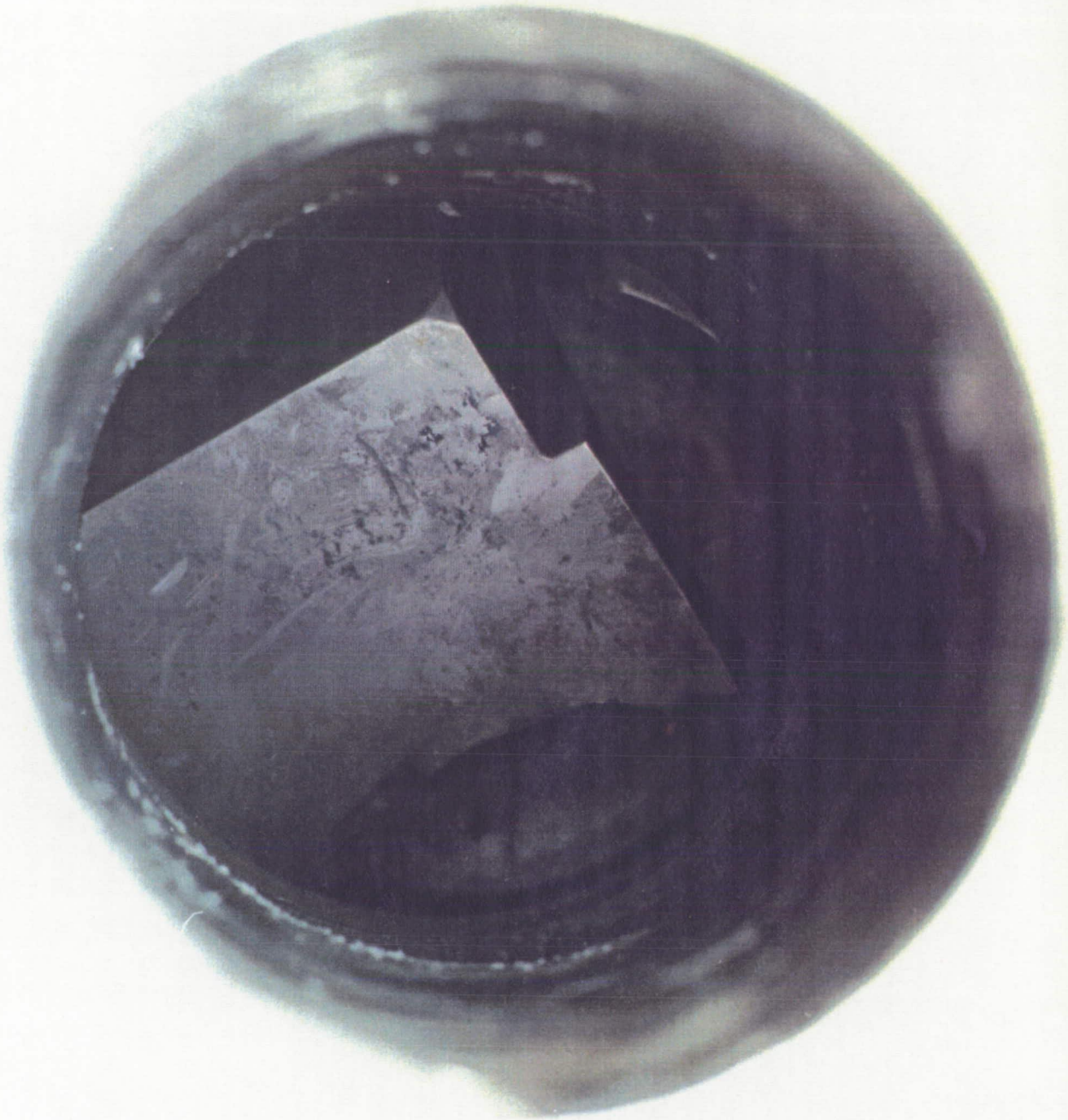
Instafoam aft of the LH IEA was lost prior to water impact

Post flight condition of LH aft skirt shows some loss of foam around aft ring prior to water impact

3"x2" piece of Epon shim material was lost prior to water impact



Three pieces of Epon shim material were wedged against the holddown post #4 DCS plunger



Half of a frangible nut prevented the holddown post #8
DCS plunger from seating

10.0 ORBITER POST LANDING DEBRIS ASSESSMENT

A detailed post landing inspection of OV-104 (Atlantis) was conducted March 4-5, 1990, at Ames-Dryden (EAFB) on Runway 23L and in the Mate/Demate Device (MDD) to identify debris impact damage, and if possible, debris sources. The Orbiter TPS sustained a total of 81 hits, of which 19 had a major dimension of one inch or greater. This total does not include the approximately 100 hits on the base heat shield.

The Orbiter lower surface had a total of 61 hits of which 17 had a major dimension of one inch or greater. A comparison of these numbers to statistics from 20 previous missions of similar configuration (excluding missions STS-24, 25, 26, 26R, 27R, and 30 which had damage from known debris sources), indicates the total number of hits on the lower surface is less than average. Based on the number of hits one inch or greater, this flight is considered to be average. Figures 33-36 show the TPS debris damage assessment for STS-36.

The majority of the damage sites larger than one inch were aft of the main landing gear. More damage sites occurred on the right side than on the left side. Four of the 17 hits larger than one inch were 3/4 to 1 inch deep. At least four areas had significant (greater than one inch) tile surface coating losses which are considered to be related to adjacent tile repairs and are not included in the damage count.

Damage to the base heat shield tiles was less than average (fewer than 100). The main engine closeout blankets had damage. SSME #1 had minor fraying of the splice area at 6 o'clock. SSME #2 splice blanket was loose at 12 o'clock. The top layer of the blanket on SSME #3 was loose from 3:30 to 4:30 o'clock, frayed at 6 o'clock, and missing from 6:30 to 10 o'clock.

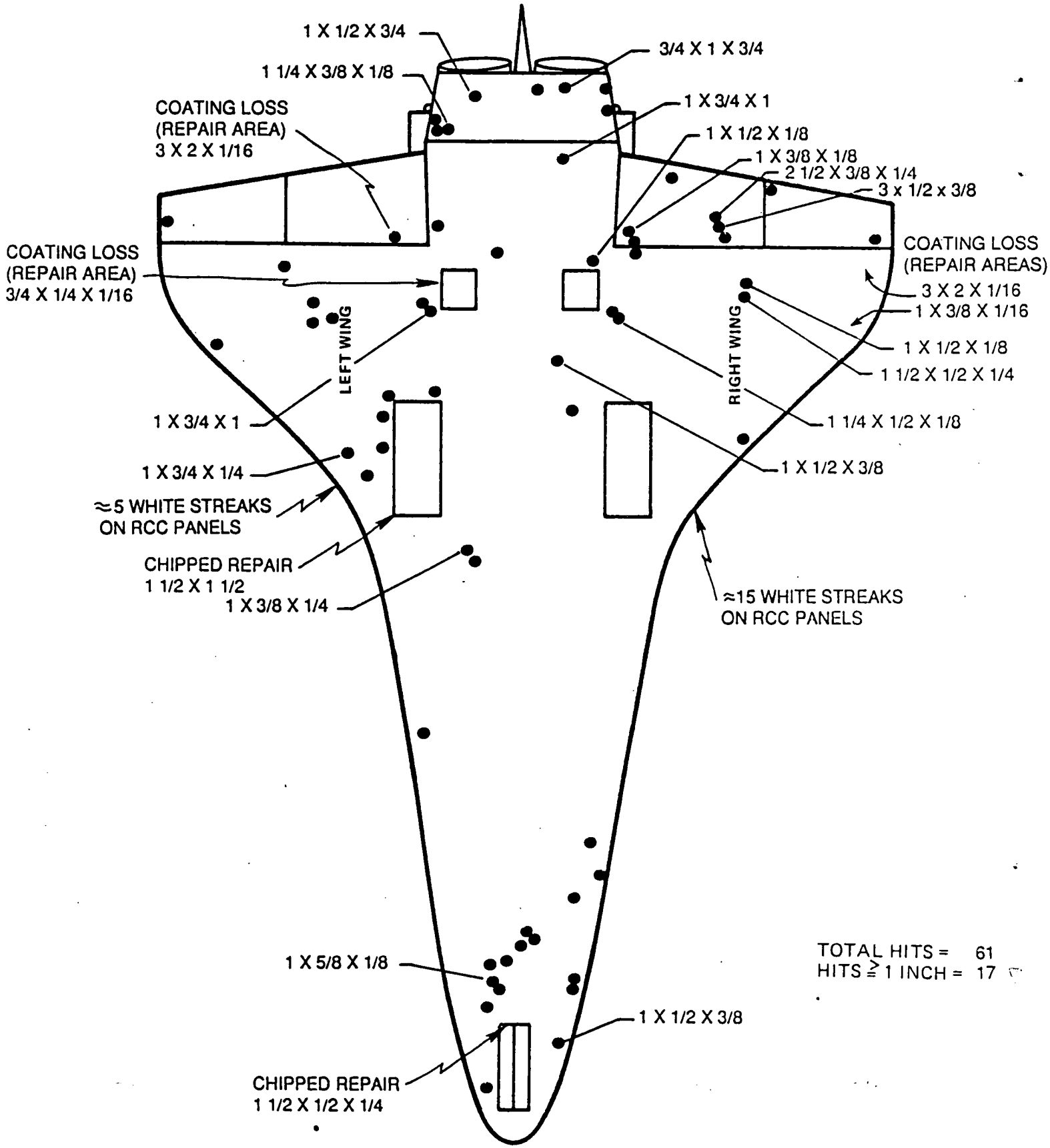
Several small pieces of gap filler sleeving material were loose on both the RH and LH OMS pods at the leading edges. No detectable damage to adjacent tiles resulted from these gap fillers.

Typical white streaks were present on the wing leading edge RCC panels. Several of the streaks had apparent significant residue. Samples of these streaks were removed for laboratory analysis.

Orbiter window #3 was heavily hazed with deposits and many streaks. Window #4 was moderately hazed with several streaks. Window #5 was lightly hazed with several streaks. Window #2 was lightly hazed. Samples for laboratory analysis were taken from all windows. In addition, samples from other selected damage sites were collected for analysis (Figures 37-38).

STS-36

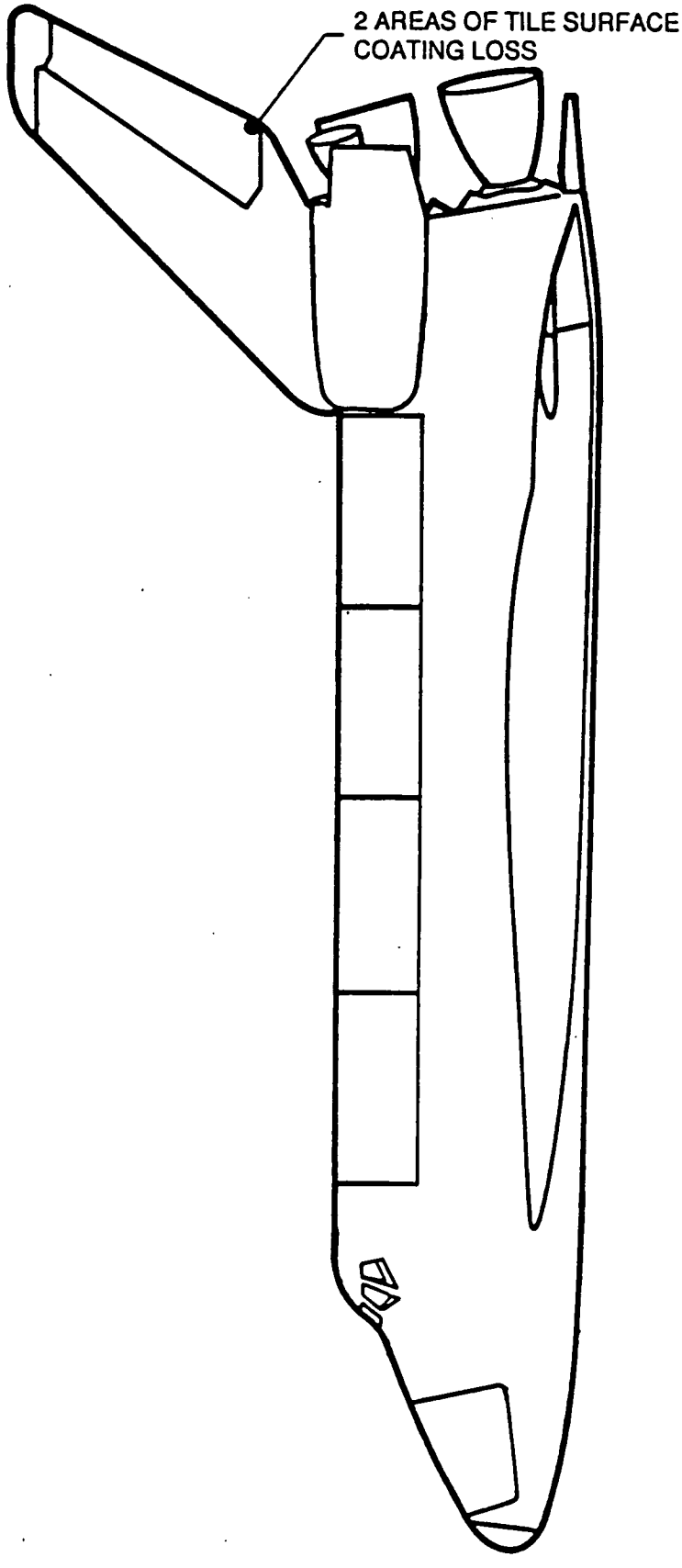
FIGURE 33. **DEBRIS DAMAGE LOCATIONS**



EGG/V-0888

STS-36

FIGURE 34. **DEBRIS DAMAGE LOCATIONS**

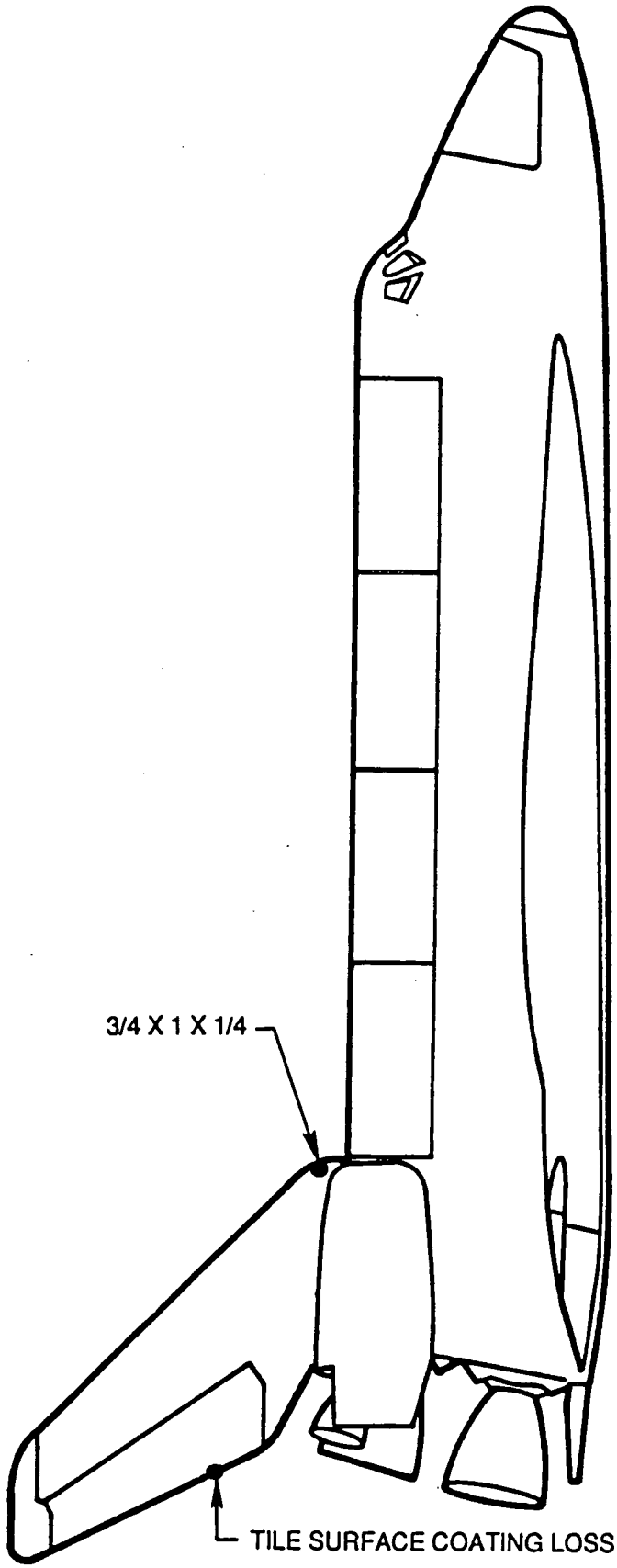


TOTAL HITS = 0
HITS ≥ 1 INCH = 0

EGG/V-088

STS-36

FIGURE 35. **DEBRIS DAMAGE LOCATIONS**

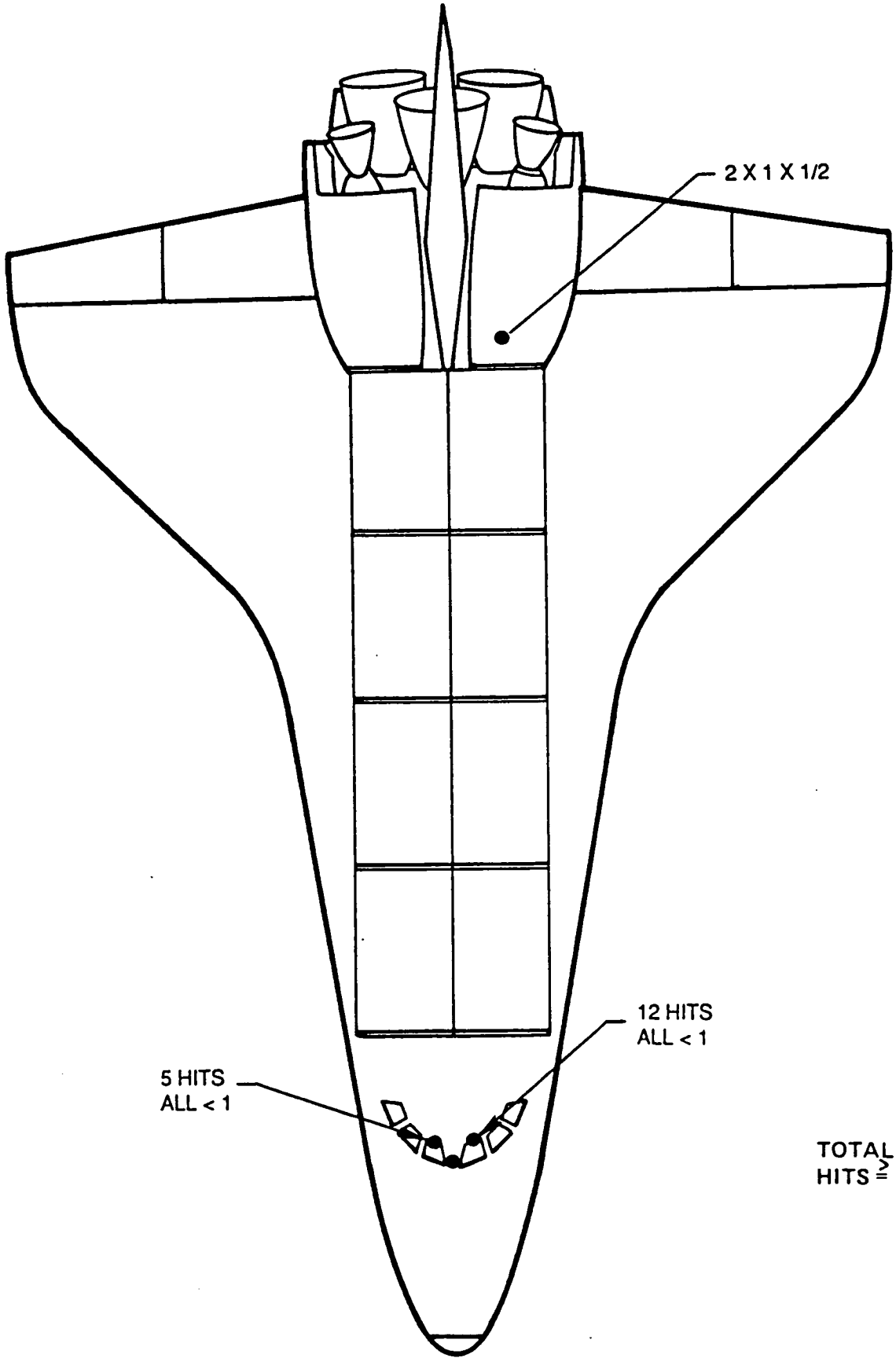


TOTAL HITS = 1
HITS ≥ 1 INCH = 1

EGG/V-088A

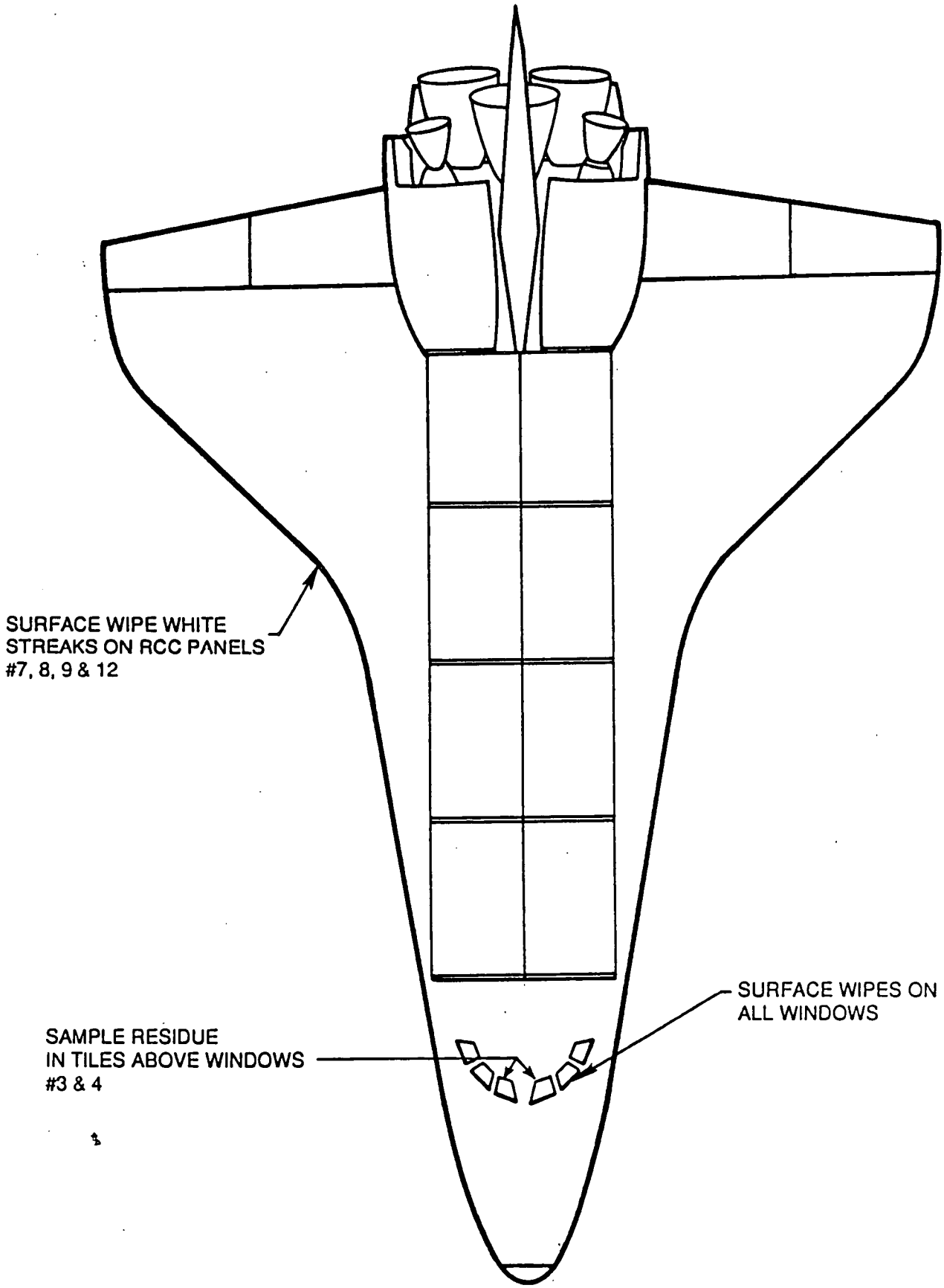
STS-36

FIGURE 36. **DEBRIS DAMAGE LOCATIONS**



STS-36

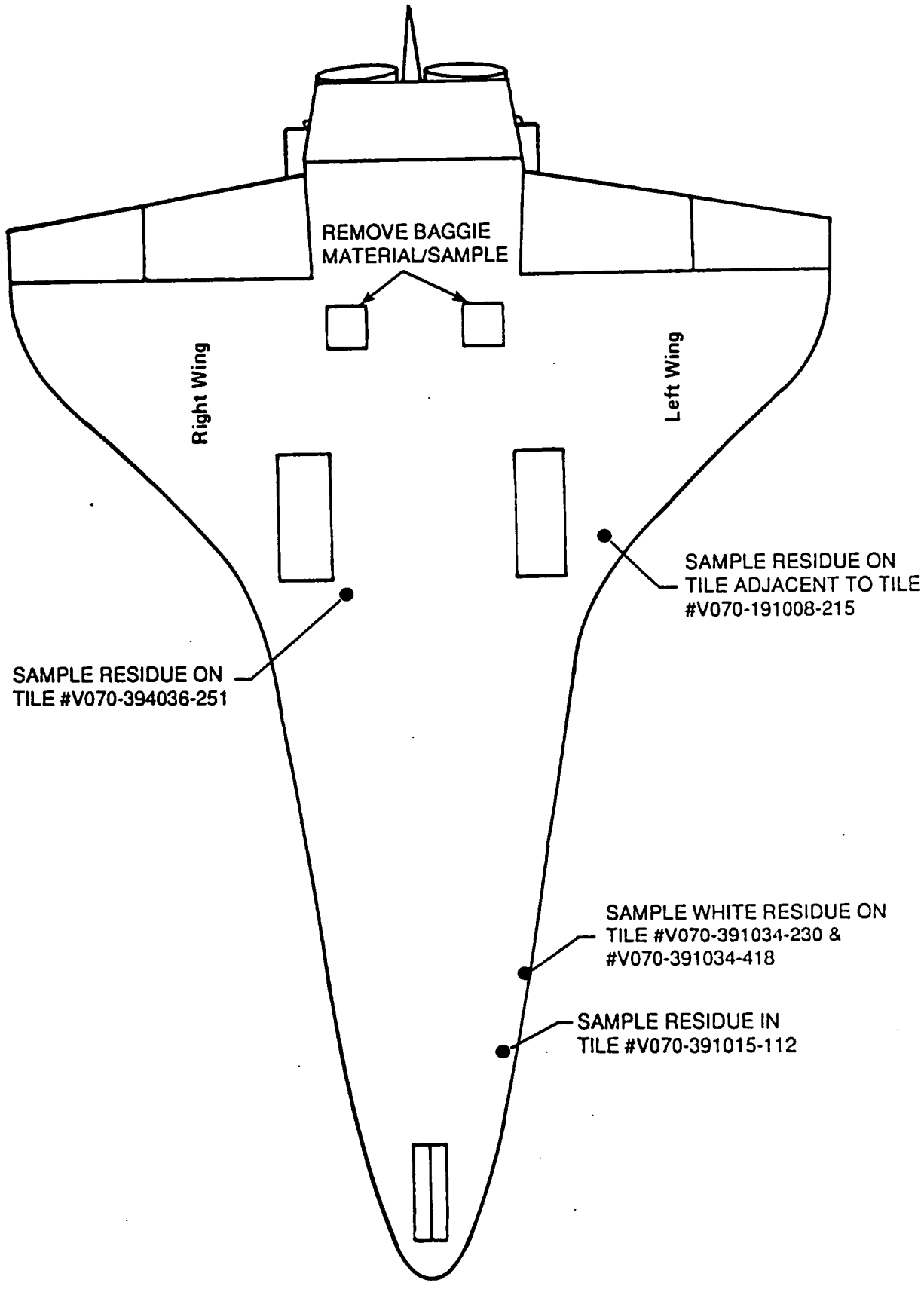
FIGURE 37. **DEBRIS DAMAGE CHEMICAL SAMPLE LOCATIONS**



EGG/V-088C

STS-36

FIGURE 38. **DEBRIS DAMAGE CHEMICAL SAMPLE LOCATIONS**



The separation ordnance devices appeared to have functioned properly. The plungers were seated on EO-2 and EO-3 and the EO-1 bipod yoke bolt was flush with the outer mold line. One of the pyro retention yokes on the LH2 side was loose in the umbilical cavity and fell to the runway upon door extension (P/N V070-4-07-0182 per PR PV-6-154071).

No TPS damage was attributed to material from the runway tires, wheels, or brakes. Aluminum tape on the inside of the MLG doors had peeled back.

The KSC Shuttle Thermal Imager (STI) was used to record the kinetic surface temperatures of several areas (Figure 39). Sixteen minutes after landing the nosecap RCC measured 137 degrees F. One hour after landing the RH wing RCC panel #9 measured 73 degrees F and the LH wing RCC panel #17 measured 78 degrees F.

Runways 17L and 23L were inspected by the Debris Team on 3 March 1990. Runway 22 was inspected and cleaned by Air Force personnel the same day. The general condition of the runways was good with very little debris found.

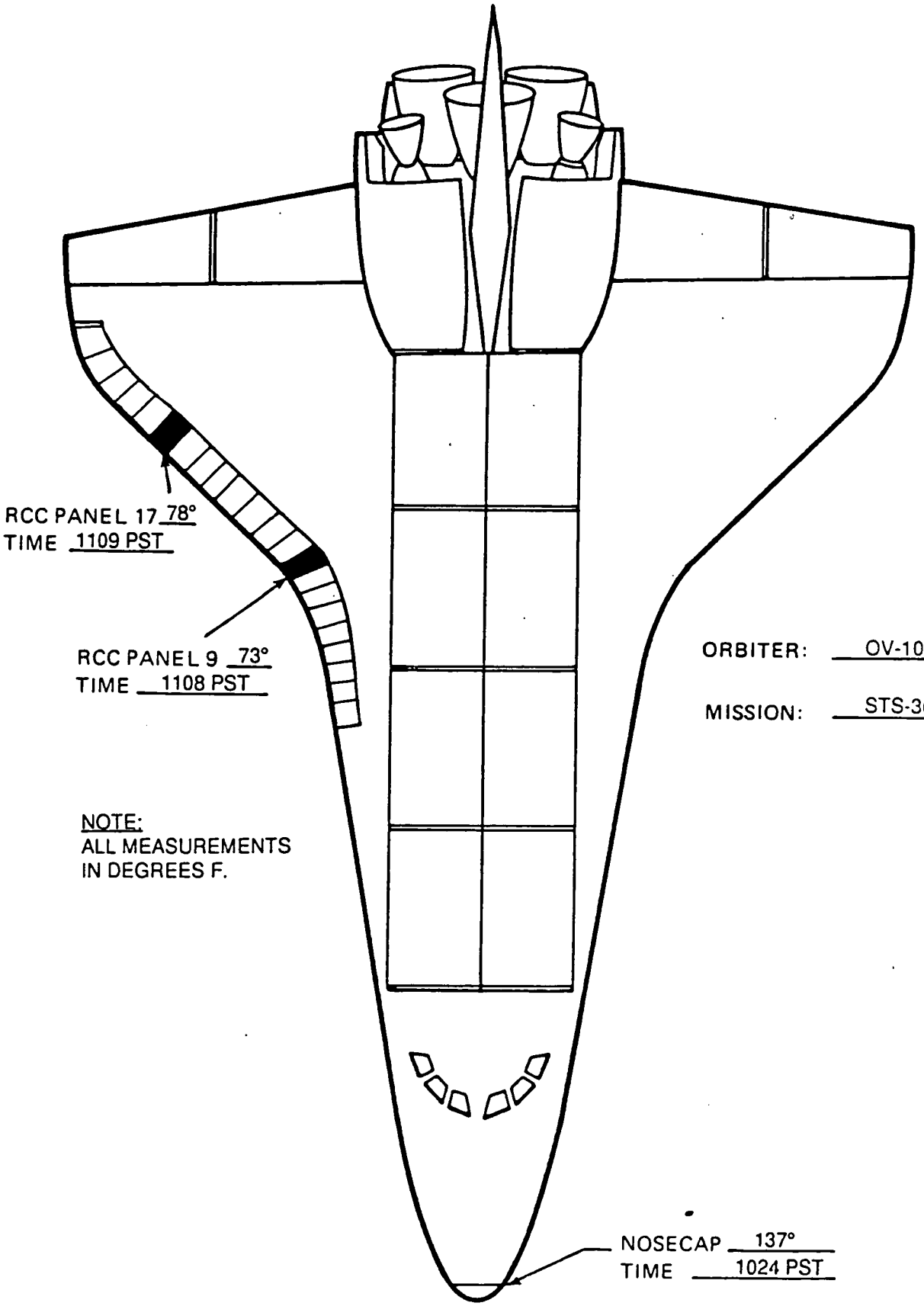
The post landing inspection of Runway 23L was performed at approximately L + 1/2 hour. Four pieces of nose landing gear door Ames gap filler were found on the runway at approximately the nose landing gear touchdown point. Runway survey markers were again detected on the runway centerline at both thresholds.

In summary, the total number of lower surface Orbiter TPS debris hits was average when compared to previous flights as shown in the comparison charts (Figure 40-41). The distribution of hits on the Orbiter does not point to a single source for ascent debris, but indicates a shedding of ice and TPS debris from random sources. The potential identification of sources of debris for mission STS-36 will be based on the laboratory analysis of TPS damage sites, inspection of the recovered SRB components, and photographic analysis.

Orbiter Post Landing Anomalies are listed in Section 12.4.

STS-36

FIGURE 39. **TEMPERATURE MEASUREMENTS**



EGG/V-088D

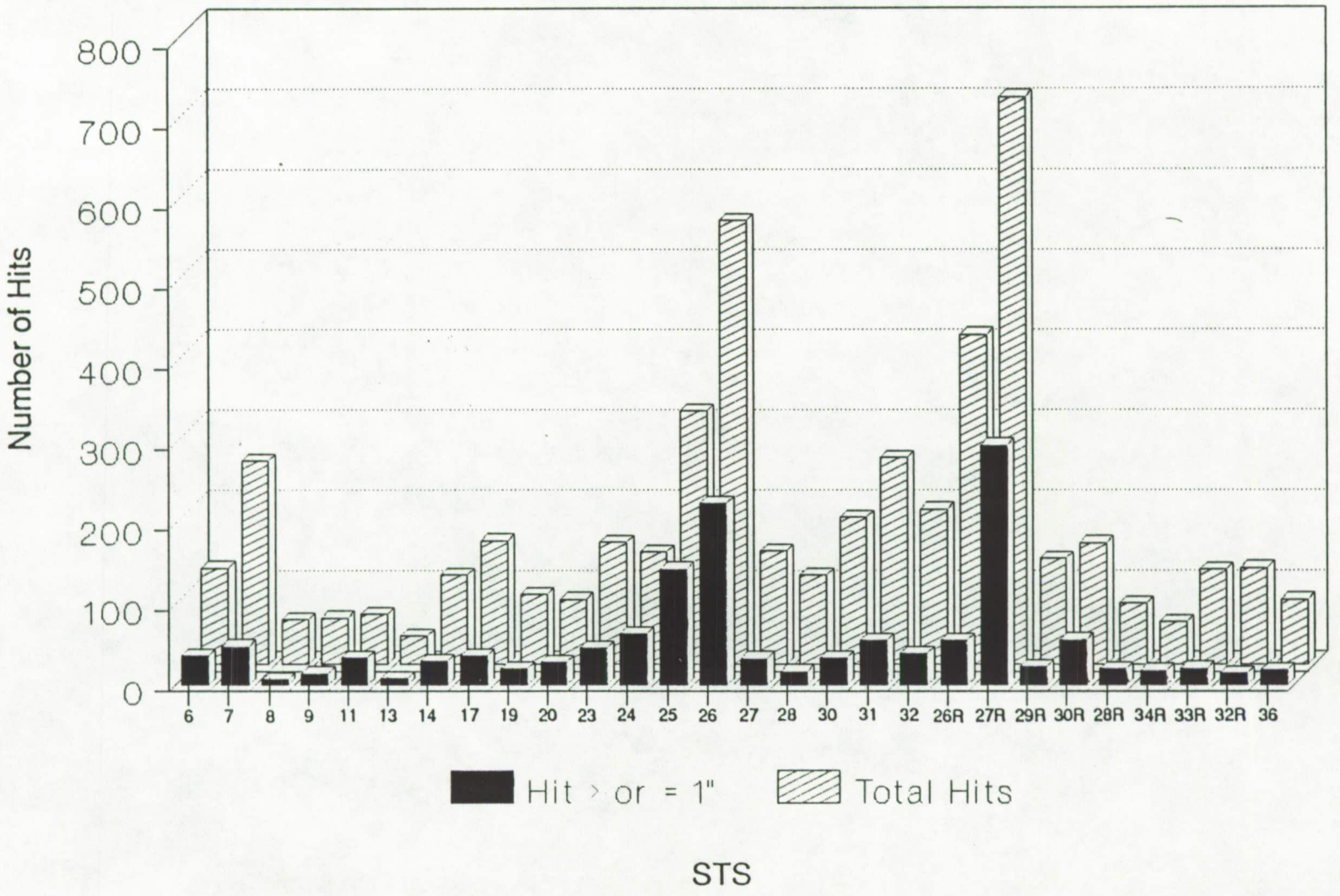
FIGURE 40. STS-36 DEBRIS DAMAGE ASSESSMENT SUMMARY

	Hits > or = 1"	Total Hits
Lower Surface	17	61
Upper Surface	0	18
Right Side	1	1
Left Side	0	0
Right OMS Pod	0	0
Left OMS Pod	1	1
TOTALS	19	81

COMPARISON TABLE

STS-6	36	120
STS-7	48	253
STS-8	7	56
STS-9 (41-A)	14	58
STS-11 (41-B)	34	63
STS-13 (41-C)	8	36
STS-14 (41-D)	30	111
STS-17 (41-G)	36	154
STS-19 (51-A)	20	87
STS-20 (51-C)	28	81
STS-23 (51-D)	46	152
STS-24 (51-B)	63	140
STS-25 (51-G)	144	315
STS-26 (51-F)	226	553
STS-27 (51-I)	33	141
STS-28 (51-J)	17	111
STS-30 (61-A)	34	183
STS-31 (61-B)	55	257
STS-32 (61-C)	39	193
STS-26R	55	411
STS-27R	298	707
STS-29R	23	132
STS-30R	56	151
STS-28R	20	76
STS-34	18	53
STS-33R	21	118
STS-32R	15	120
STS-36	19	81

FIGURE 41. # COMPARISON TABLE



No major TPS damage was visible on OV-104 Atlantis just prior to touchdown at Ames-Dryden/Edwards AFB

C-3

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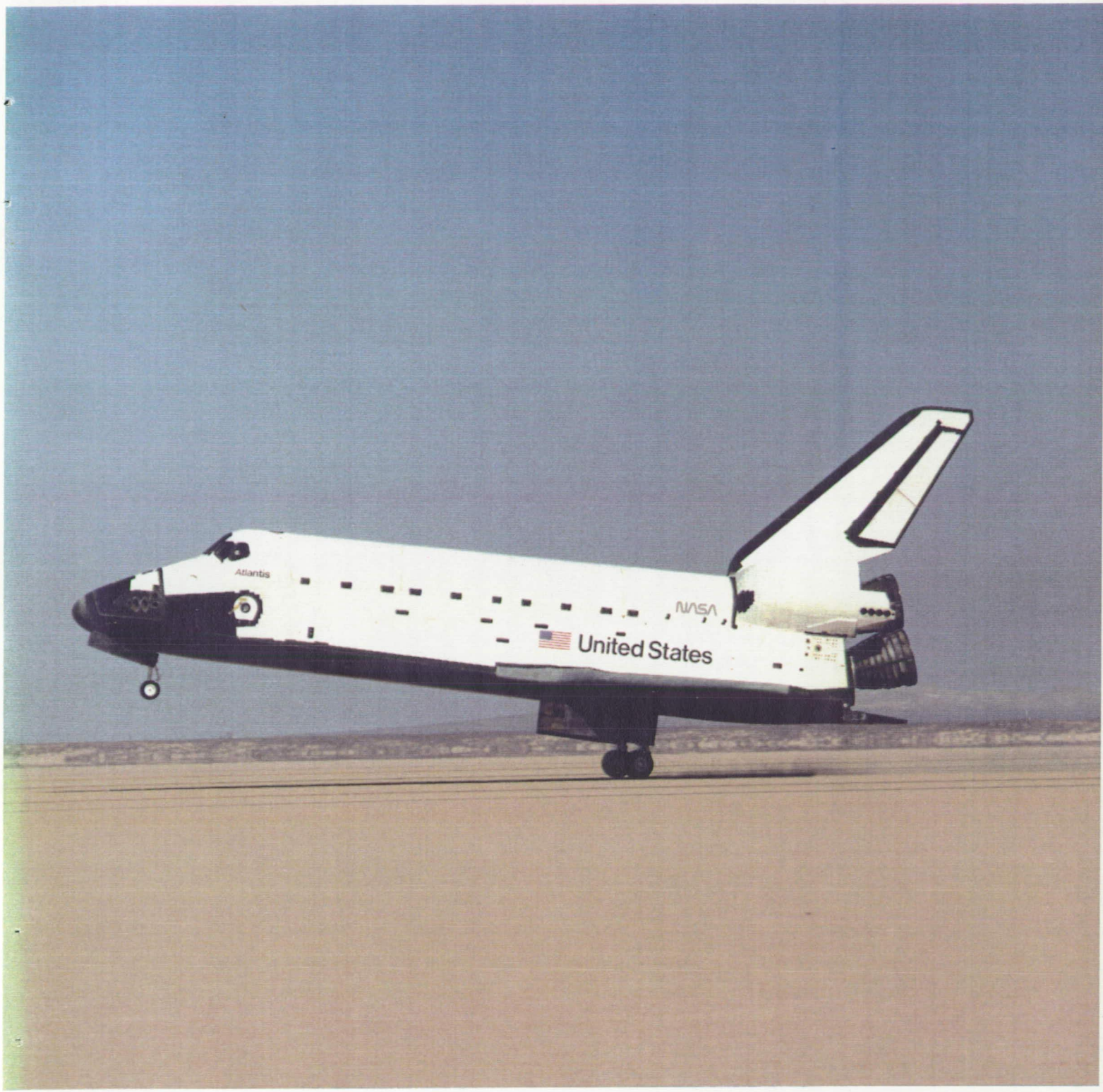

Landing of OV-104 was nominal with almost simultaneous touchdown of the main landing gear

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Concrete post runway survey marker was found near the threshold at the touchdown end of the runway

Four pieces of nose landing gear door Ames gap filler were found on the runway at the approx NLG touchdown point

Overall view of OV-104 LH side after landing

Overall view of OV-104 RH side after landing

Window #3 (forward facing) was hazed and streaked

White residue was present on LH chine lower surface tiles

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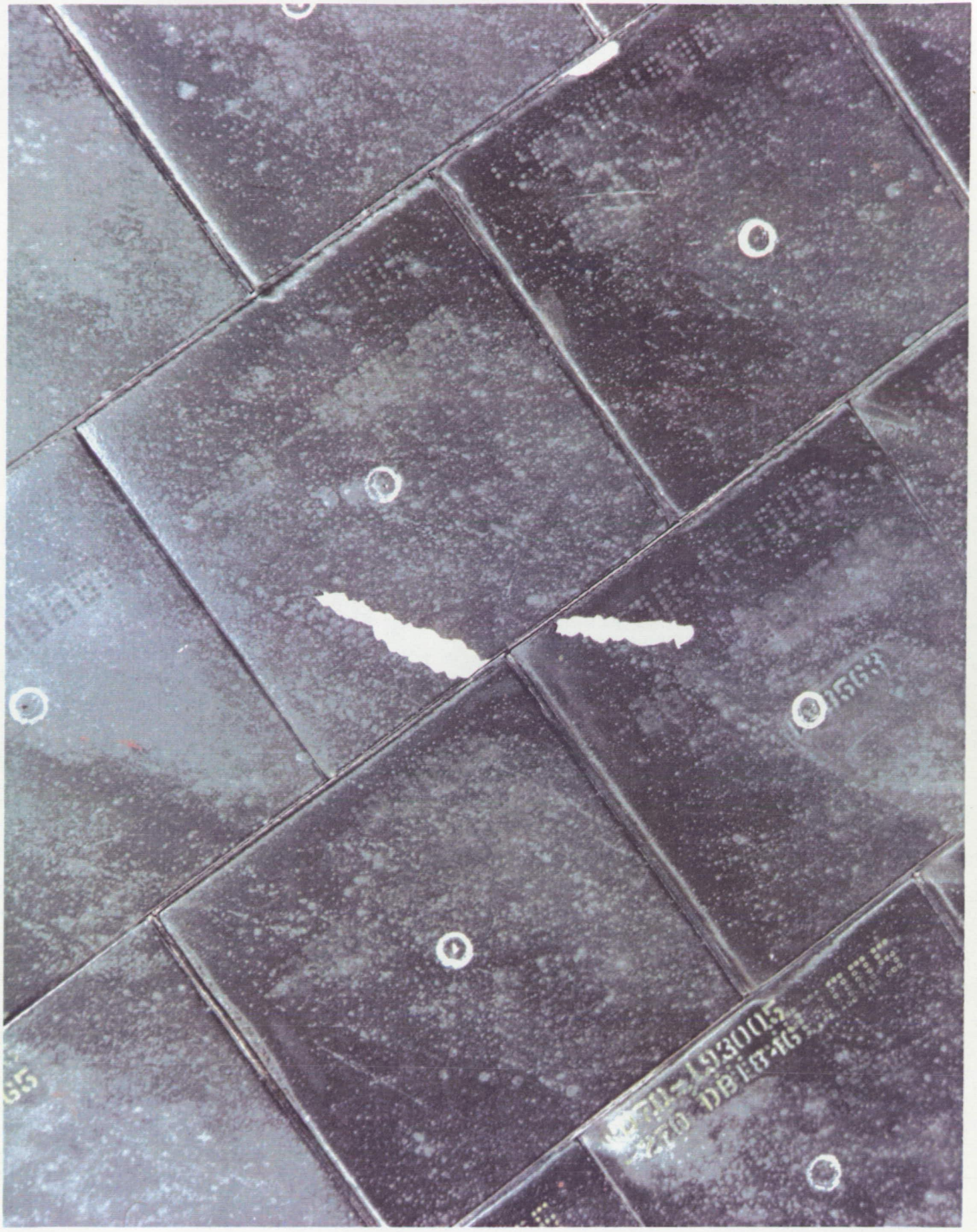
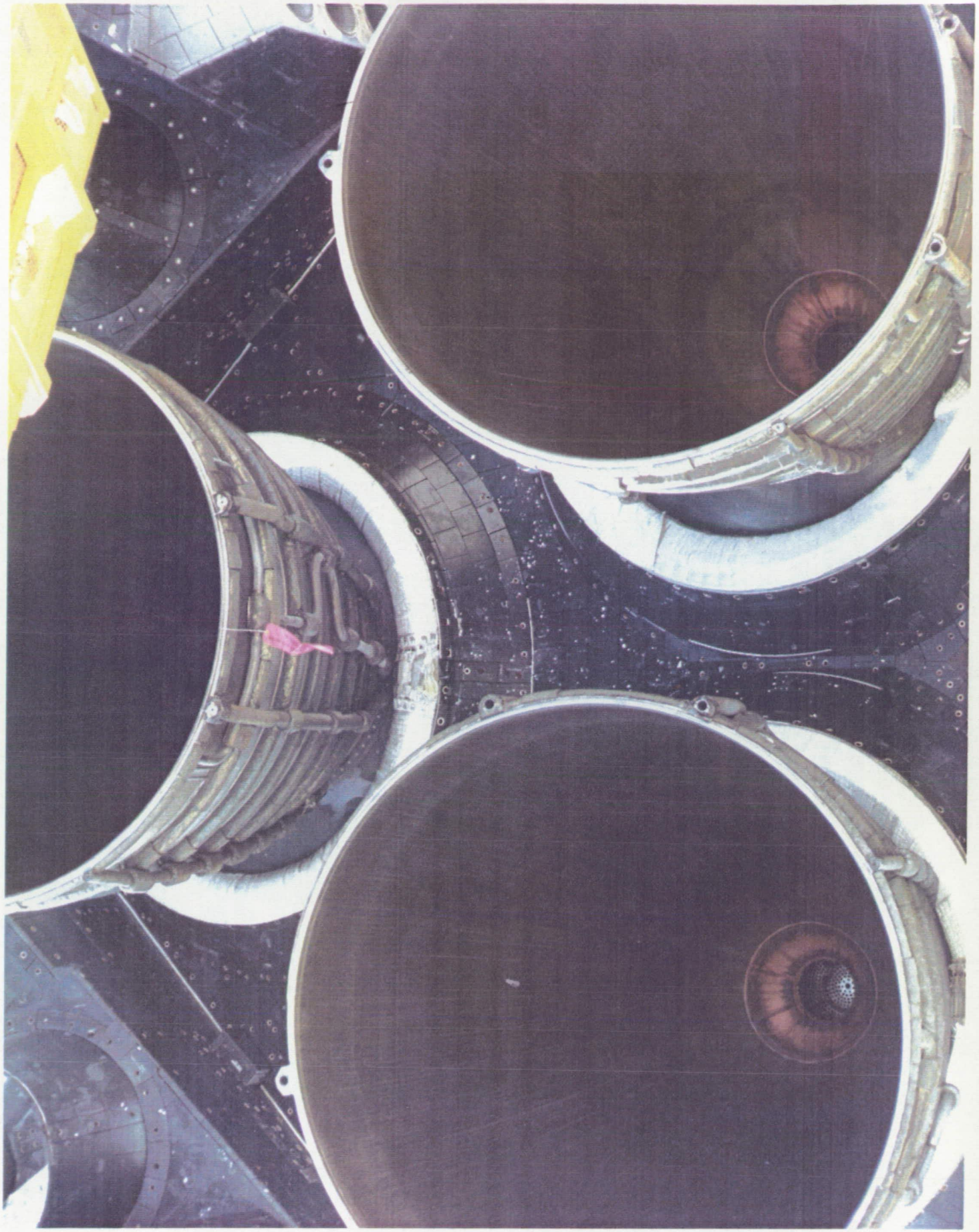


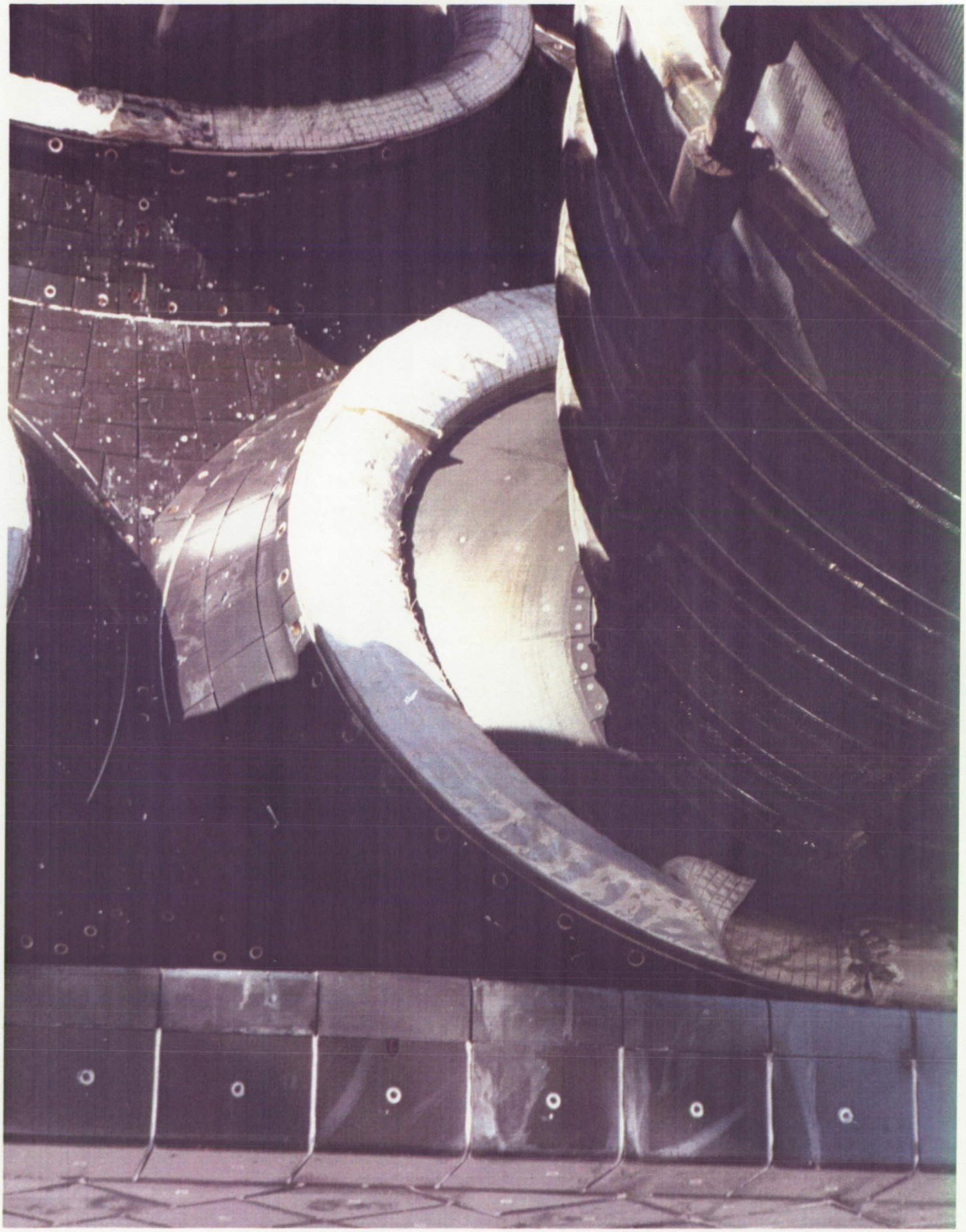
Typical tile surface coating shallow impact damage from low density debris

Typical tile surface coating impact damage from debris.
Note missing tile gap filler (arrow).



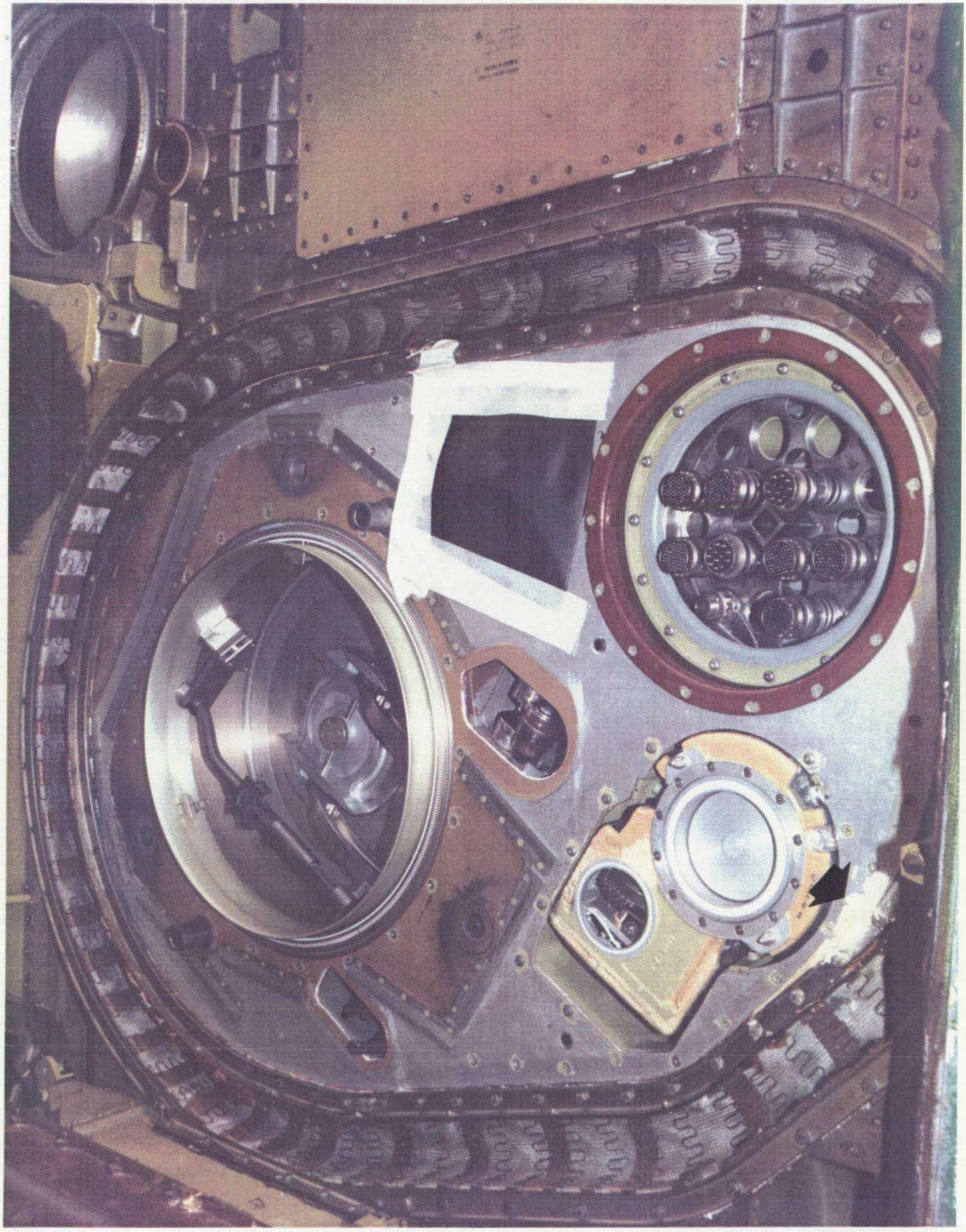
Overall view of SSME's and Orbiter base heat shield area after landing

Top layer of SSME #3 blanket was loose at 3 o'clock, frayed at 6 o'clock, and missing from the 6:30 to 10 o'clock position



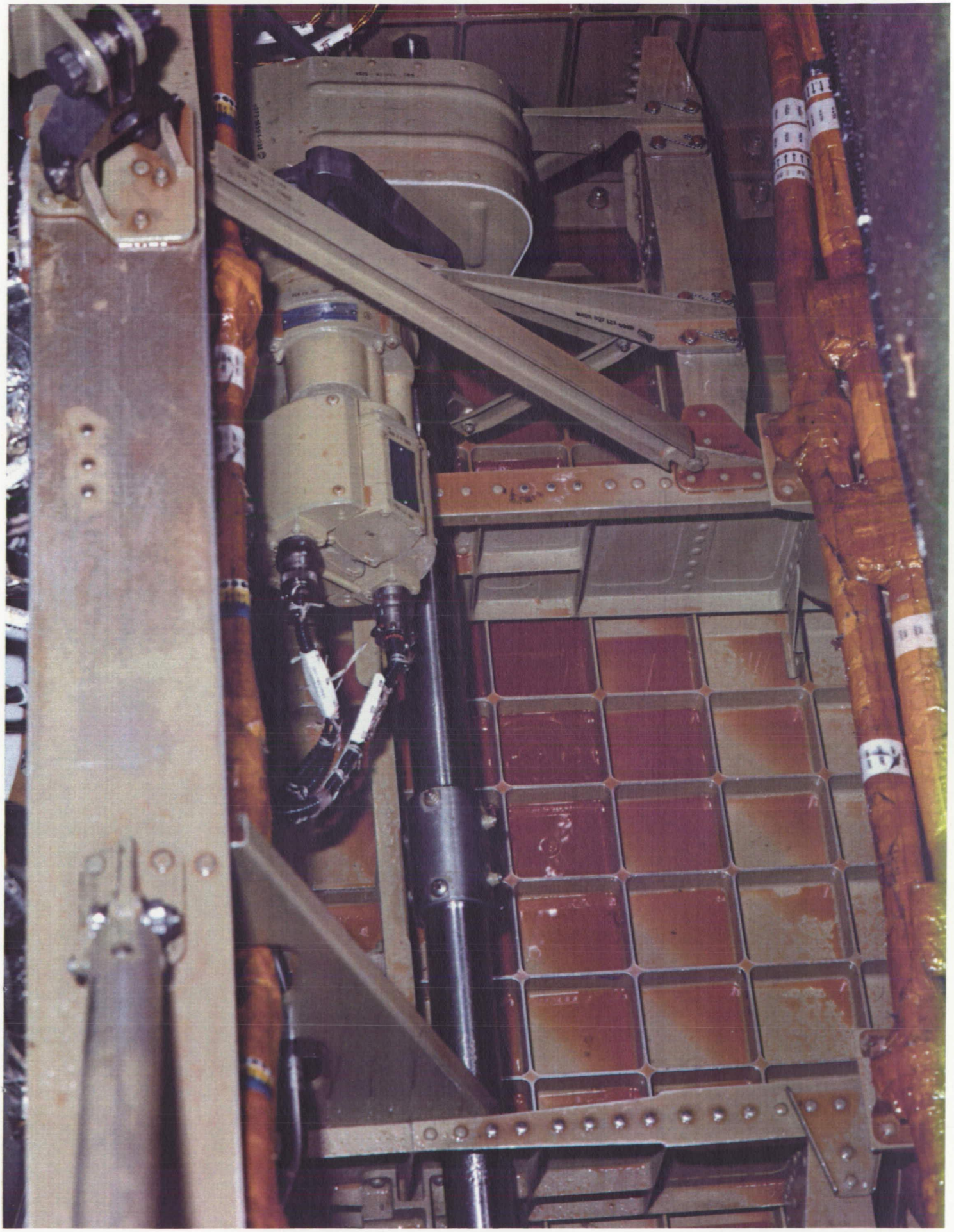
Top layer of SSME #3 beta blanket was missing from the 6:30 to 10 o'clock position

Overall view of the LO2 ET/ORB umbilical cavity. Note remnants of closeout foam intrusion along the umbilical interface



Overall view of the LH2 ET/ORB umbilical cavity. Note remnants of closeout foam intrusion near the LH2 recirc line connection

One pyro retention yoke on the LH2 side was loose in the umbilical cavity and fell onto the runway when the door opened



Leaking APU hydraulic fluid collected in low areas in the Orbiter aft compartment

Leaking APU hydraulic fluid was visible around the ET/ORB umbilicals. Some fluid was present on lower surface tiles.

Typical debris collected from the pre-landing debris walkdowns on runways 17L and 23L

11.0 DEBRIS SAMPLE LAB REPORTS

A total of 23 samples were obtained from the STS-36 Orbiter during post-landing debris assessment operations at Ames-Dryden Flight Research Facility, California. The 23 submitted samples (reference Figures 37 and 38 for locations) consisted of 8 Orbiter window wipes (W-1 thru W-8), 6 tile samples, 4 wing RCC samples, 4 ET/ORB umbilical samples, and 1 sample of window 3 and 4 RSI. All samples were analyzed by the NASA-KSC Microchemical Analysis Branch (MAB) for material composition and comparison to known STS materials. The specific elemental analysis is shown in the appended Microchemical Analysis Branch reports. Debris sample analyses are provided by Orbiter location in the following summaries. An overall summary for the mission is provided as a conclusion.

ORBITER WINDOW WIPES

Results of window wipe chemical analysis indicates the presence of the following materials:

1. Rust, dust and salt
2. Light brown flakes
3. Glass fiber

Debris analysis provides the following correlations:

1. Rust is probably an SRB BSM residue; dust and salt are probable landing site products.
2. Light brown flakes were identified an muscovite, a naturally-occurring landing site product.
3. Glass fiber composed of silicon-tile, silicon-aluminum rich high temperature insulation, and silicon-aluminum-calcium rich insulation appear to be from Orbiter thermal protection system (TPS).

ORBITER TILE

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

1. Black and white tile, RTV and Glass fiber insulation
2. Organics
3. Muscovite
4. Phenolic microballoon

Debris analysis provides the following correlations:

1. Black and white tile, RTV and Glass fiber insulation are common Orbiter thermal protection system (TPS) materials.

2. Organics may be animal or insect remains and deposits or tile waterproofing.
3. Muscovite is a naturally-occurring landing site product.
4. Phenolic microballoon is a component of ET/SRB ablators.

ORBITER WING RCC PANELS

Results of RCC sample analysis indicated the presence of the following materials:

1. White and black tile
2. Rust
3. Paint
4. Organics

Debris analysis provides the following correlations:

1. White and black tile are common to Orbiter thermal protection system (TPS).
2. Rust if probably of SRB BSM residue origin.
3. Paint particles may have originated from processing activities on the flight elements, facility, or ground support equipment.
4. Organics could be linked to animal or insect remains and deposits, or tile waterproofing.

ET-ORBITER UMBILICALS

Chemical analysis of samples from the ET-Orbiter umbilicals revealed the presence of the following materials:

1. Rust
2. Calcite
3. RTV
4. Insulation glass
5. Polyurethane foam
6. Phenolic microballoon
7. Organics

Debris analysis of these materials provides the following correlations:

1. Rust is probably of SRB BSM residue origin.
2. Calcite is a natural landing site product.
3. RTV is used as a bonding/sealant agent on the flight elements and facility/ground support equipment.
4. Insulation glass is a component of Orbiter thermal protection system (TPS).
5. Polyurethane foam is a closeout material for the umbilical.

6. Phenolic microballoon is a component of ET/SRB ablators.
7. Organics were composed of polyimide film (Kapton), polyurethane, polyvinylidine flouride copolymer (vitan) and acrylate ester; all normal umbilical closeout materials.

WINDOW REUSABLE SURFACE INSULATION (RSI) W-3 & 4

Chemical analysis of sample from the window RSI revealed the following materials:

1. Rust
2. Paint
3. Muscovite
4. White and black tile, RTV and glass fiber
5. Aluminum particles

Debris analysis provides the following correlations:

1. Rust is probably of SRB BSM residue origin.
2. Paint may have originated from processing activities on the flight elements, facility, or ground support equipment.
3. Muscovite is a natural landing site product.
4. White and black tile, RTV and glass fiber are components of Orbiter thermal protection system (TPS).
5. Aluminum particles are probably SRB BSM exhaust residue.

CONCLUSIONS

The STS-36 mission, as evidenced by the debris analysis report, was successful in minimizing damage from debris. This is also shown to be true by the chemical analysis that was performed on post-flight samples.

The Orbiter window sampling provided results that indicated exposure to SRB BSM residue, thermal protection system mateials, and landing site products.

The Orbiter tile samples indicated thermal protection system materials, landing site residue, and phenolic microballoon as in ET/SRB ablators.

The Orbiter wing RCC panel samples provided indication of paint, thermal protection system materials, organics, and SRB BSM residue.

The ET/Orbiter umbilical area continues to entrap a variety of debris particles. However, none for this mission demonstrate a debris concern.

The Orbiter widow RSI sample provided additional indication of residue as noted in other locations, and aluminum particles as from SRB BSM residue.

This mission provided no evidence of orbital debris impacts, unusual debris concerns, or unexplained debris sample analyses.

MICROCHEMICAL ANALYSIS BRANCH
DM-MSL-1, ROOM 1274, O&C BUILDING
NASA/KSC
APRIL 2, 1990

SUBJECT: Debris Samples From STS-36 Landing

LABORATORY REQUEST NO: MCB-0196-90

RELATED DOCUMENTATION: Intercenter Debris Team Requirements

1.0 FOREWORD:

1.1 REQUESTER: R. F. Speece/TV-MSD-22/7-0806

1.2 REQUESTER'S SAMPLE DESCRIPTION: The samples were from OV-104, STS-36 landing, DFRF, California, and were identified as follows:

WIPES

1. Less panels #7, 8, 9, and 12, alcohol wipe, OV-104, STS-36, 3/6/90.
2. R/H less carrier panel tile next to V070-191008-215, alcohol wipe, OV-104, STS-36, 3/6/90.
3. On R/H less carrier panel tile next to V070-191008-215, plain wipe, OV-104, STS-36, 3/6/90.
4. V07-391034-230 and V070-391034-418, alcohol wipe, OV-104, STS-36, 3/6/90.
5. Tile: V070-394036-251, dry wipe (plain), OV-104, STS-36, 3/6/90.
6. V07-391034-230 and V070-391034-418, plain dry wipe, OV-104, STS-36, 3/6/90.
7. Windows 3 and 4, RSI 4-07-067.

DEBRIS

8. R/H E.T. door baggie, OV-104, STS-36, 3/6/90.
9. R/H E.T. door material, forward side, 17 umbilical plate, OV-104, STS-36, 3/6/90.
10. L/H E.T. door baggie, OV-104, STS-36, 3/6/90.
11. L/H E.T. door sample, forward side, 17 umbilical plate, OV-104, STS-36, 3/6/90.
12. Black spec sample taken from tile V070391015-112, FWD, RH lower surface.

1.3 REQUESTED: Perform material identification and compare results to known STS materials.

2.0 CHEMICAL ANALYSIS AND RESULTS:

2.1 Procedure:

The submitted samples were analyzed by means of optical microscopy (OM), infrared spectrometry, and electron microprobe with energy dispersive spectrometry (EDS).

2.2 The particulates were classified into components on the basis of color and texture by OM. The classified components from all samples are listed in Table 1 with the possible identification of each component and elemental analysis.

Table 1

Component ID	Possible Ident.	Elemental Analysis by EDS*	
		Major	Minor
1. Metallics	Al-Particle	Al	
2. White Mtls	White Tile	Si	
3. Black Mtls	Black Tile	Si	
4. Red Rubbery	RTV	Fe,Si	
5. Wht-Grn Mtls	Paint	Ti,Si,K,Fe	Al,Mg
6. Lgt Brn Powder	Muscovite	Fe,K,Si,Al	Mg,Ti
7. Red-Blk Mtls	Rust	Fe,Cl,Si	S
8. Glass Fiber	Insulation, High Temp.Glass	Si,Al	Ca
9. Amber Sphere	Microballoon	Phenolic (?)	
10. Off-White	Calcite,Al-Si	Ca,Si,Al	K,Fe
11. Organics	Al-Si-Ca Mtls		

*: O,C,H, and B are not detectable by using this technique.

2.2.2 Table 2 lists estimated amounts of each component versus sample number.

Table 2

Sample No. / Components	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12
1. Metallics	X	X	X	X	X	X	Al	X	X	X	X	X
2. White Tile	30	68	40	80	20	48	60	X	X	X	X	X
3. Black Tile	40	30	57	20	80	50	4	X	X	X	X	100
4. RTV	X	T	T	T	X	T	T	T	X	T	X	X
5. Paint	T	X	X	X	X	X	T	X	X	X	X	X
6. Muscovite	X	X	T	X	X	X	5	X	X	X	X	X
7. Rust	10	X	X	X	X	X	1	X	2	X	X	X
8. Glass Fiber	X	T	1	T	T	2	30	10	X	10	X	X
9. Microballoon	X	X	T	X	X	X	X	T	X	T	X	X
10. Calcite	X	X	X	X	X	X	X	5	X	3	X	X
11. Organics	20	2	2	T	T	T	X	25	8	20	100	X
12. Foam	X	X	X	X	X	X	X	60	90	67	X	X
Particle Size, um	1-200	1-300	1-800	1-250	1-400	1-350	1-110	1-200	1-500	1-1000	1-1100	1-1000

30: Estimated Volume Percent.
X: Not detected.
T: Trace.

2.2.3 Figures 1 and 2 are OM photomicrograph of the off-white materials (calcite, $CaCO_3$, Si-Al rich materials and Al-Si-CA rich materials) and microballoon.

2.2.4 Figures 3 and 4 are low magnification SEM photomicrographs of black and white tiles to show the morphological features of these materials.

3.0 CONCLUSIONS:

3.1 The sample number 7 contained trace amounts of Al-metals.

3.2 The sample number 1 through 7 and 12 contained appreciable amounts of tile materials. The tiles were composed of white tile and black tile. Some particles of black tile surface show some evidence of the melted or fused appearance (Figure 3) which might have been at high temperature. No evidence of high temperature forms of mineral was noted from these particles.

3.3 The sample numbers 2, 3, 4, 6, 7, 8, and 9 contained trace amounts of RTV.

3.4 The sample number 1 and 7 contained off-white and light green-colored paint particles.

3.5 The sample number 3 and 7 contained muscovite [$KAl_2(AlSi_3O_{10})(OH)_2$] and this materials was originated from the natural environment.

3.6 The sample numbers 1, 7, and 9 contained rust materials.

3.7 The sample numbers 2, 3, 4, 5, 6, 7, 8, and 9 contained glass fibers. The glass fibers were composed of insulation type, high temperature glass fiber and Si-tile glass.

3.8 The sample numbers 3, 8, and 10 contained small amounts of phenolic microballoon (Figure 2).

3.9 The sample numbers 8 and 10 contained calcite ($CaCO_3$).

3.10 The sample numbers 1 through 6 and 8 through 11 contained organics. The organics form the sample numbers 1 through 6 were not analyzed at this time. The organics from the sample number 8 through 11 were similar in composition and were composed of polyimide film (Kapton), ether type polyurethane, polyvinylidine fluoride or polyvinylidene fluoride copolymer such as vitan with talc-like filler materials, and acrylate ester.

3.11 The sample numbers 8, 9, and 10 contained appreciable amounts of foam materials.

3.12 The particle sizes were estimated to be in the range of 1 to 1100 micrometer.

CHEMIST: H. S. Kim
H. S. Kim

APPROVED: J. F. Jones
J. F. Jones

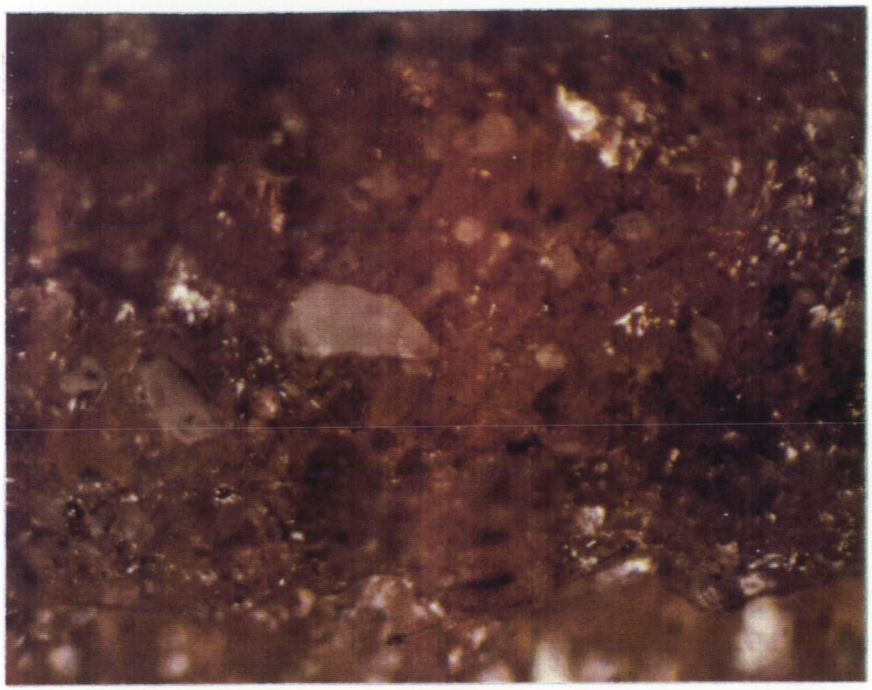


Figure 1. Low magnification optical photomicrograph of off-white materials . 45X

ORIGINAL PAGE
COLOR PHOTOGRAPH

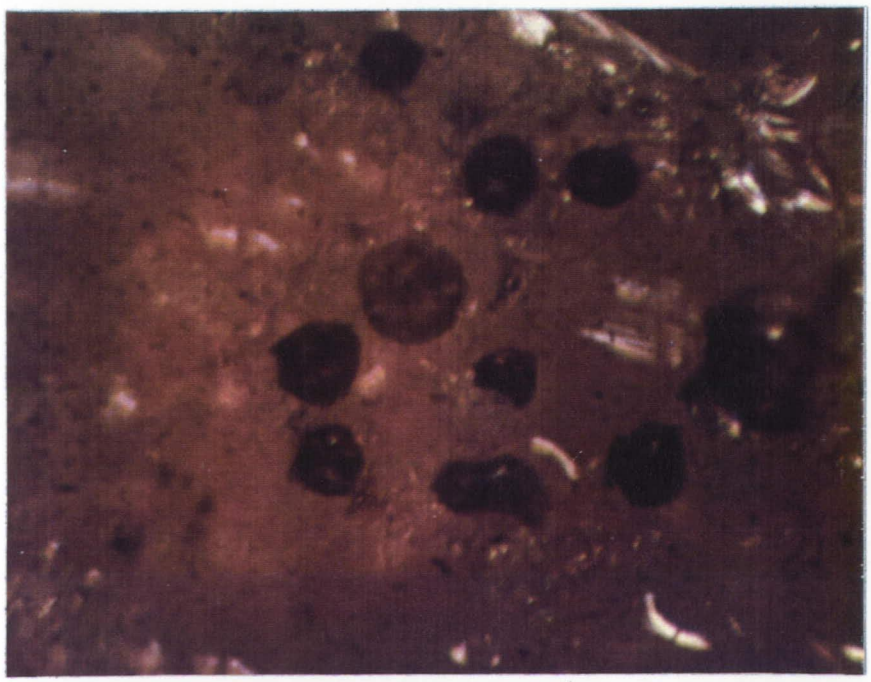


Figure 2. Low magnification optical photomicrograph of microballoon. 45X

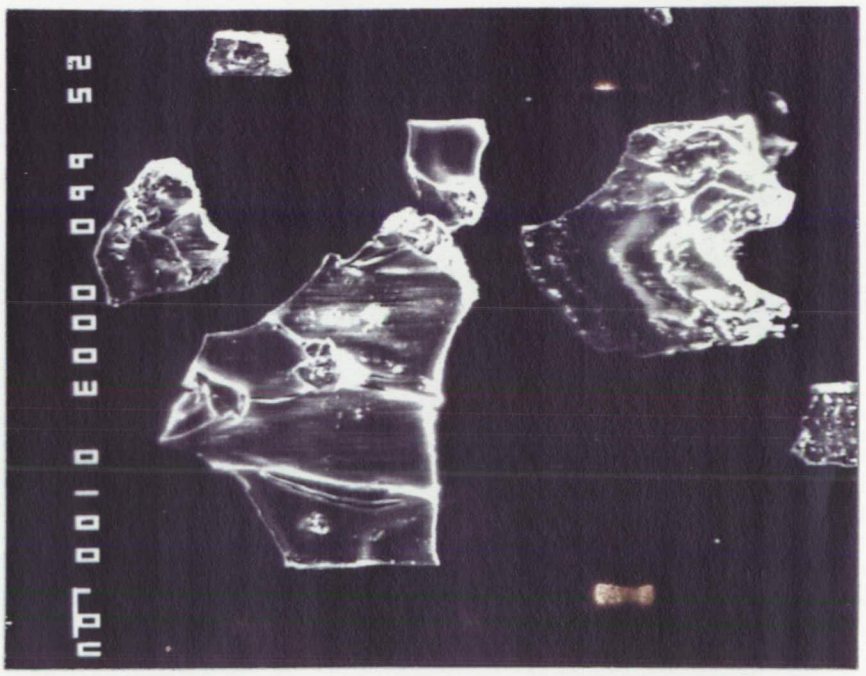


Figure 3. Low magnification SEM photomicrograph of black tile materials. 66X

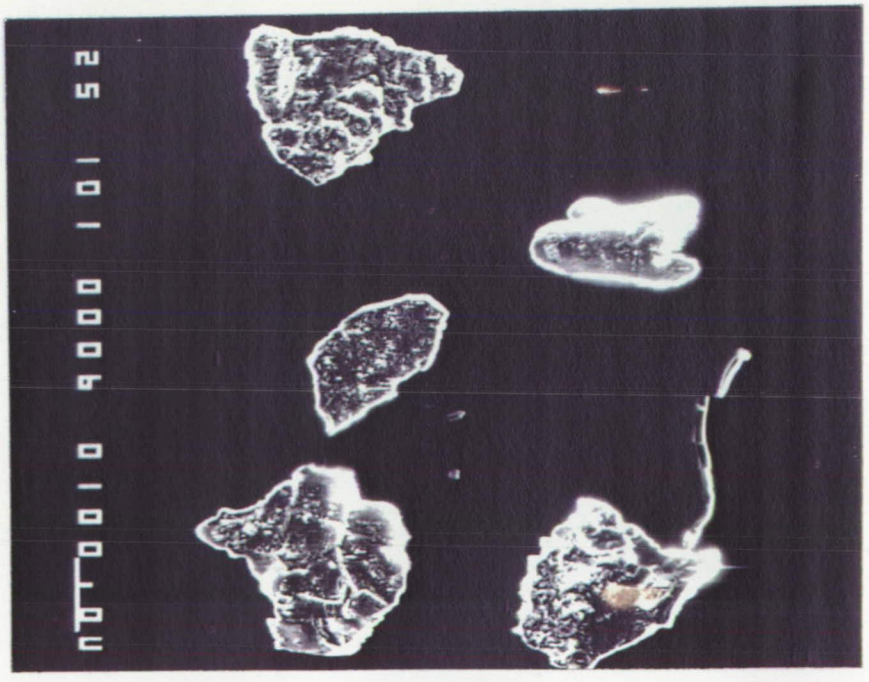


Figure 4. Low magnification SEM photomicrograph of white tile materials. 66X

MICROCHEMICAL ANALYSIS BRANCH
DM-MSL-1, ROOM 1274, O&C BUILDING
NASA/KSC
MARCH 16, 1989

SUBJECT: Window Samples (Orbiter Window)

LABORATORY REQUEST NO: MCB-0185-90

RELATED DOCUMENTATION: Intercenter Debris Team Requirements

1.0 FOREWORD:

1.1 REQUESTER: R. F. Speece/TV-MSD-22/7-0806

1.2 REQUESTER'S SAMPLE DESCRIPTION: The samples were from Orbiter window, STS-36, OV-104, DFRF, California, OMI S5022 sequence 06-000. The samples were identified as follows:

1. W-1, OV-104, 3-6-90, 0600.
2. W-2, OV-104, 3-6-90, 0600.
3. W-3, OV-104, 3-6-90, 0600.
4. W-4, OV-104, 3-6-90, 0600.
5. W-5, OV-104, 3-6-90, 0600.
6. W-6, OV-104, 3-6-90, 0600.
7. W-7, OV-104, 3-6-90, 0600.
8. W-8, OV-104, 3-6-90, 0600.

1.3 REQUESTED: Perform chemical/material identification and compare results to known STS materials.

2.0 CHEMICAL ANALYSIS AND RESULTS:

2.1 Procedure:

The submitted samples were analyzed by means of optical microscopy (OM) and electron microprobe with energy dispersive spectrometry (EDS).

2.2 The particulates were classified into components on the basis of color and texture by OM. The classified components from all samples are listed in Table 1 with the possible identification of each component and elemental analysis.

Table 1

Component ID	Possible Ident.	Elemental Analysis by EDS*	
		Major	Minor
1. Lgt Brn Powder	Dust	Ca,S,Cl,Si,Al,K	Fe,Ti,Mg,Cr,Na
2. Black Mtls	Rust, Dust	Fe,Cl,Si,K,Ca	Na,Al,Mg,Ti
3. Lgt-Brn Flake	Micaceous Mtls	Fe,K,Si,Al	Mg,Ti
4. Glass Fiber	Glass Fiber	Si,Al,Ca	

*: O,C,H, and B are not detectable by using this technique.

2.2.2 Table 2 lists estimated amounts of each component versus sample number.

Table 2

Sample No. Amt. Sample	W-1	W-2	W-3	W-4	W-5	W-6	W-7	W-8
1. Dust	94	98	98	80	97	97	98	98
2. Rust&Dust	5	2	2	5	1	1	1	1
3. Micaceous Mtls	T	T	T	15	2	2	1	1
4. Glass Fiber	1	T	T	T	T	T	T	T
Particle Size, um	1-110	1-100	1-110	1-150	1-120	1-80	1-150	1-180

3.0 CONCLUSIONS:

3.1 All samples contained dust, rust, micaceous materials and glass fibers.

3.2 The dust and rust materials appeared to be composed of Alpha-Quartz (Alpha-SiO2), calcite (CaCO3), clay minerals, micaceous materials, opaque materials, salt components (mainly NaCl) and feldspar.

3.3 The micaceous materials appeared to be composed of muscovite [KAl2(Si3Al)O10(OH,F)2].

3.4 The rust, dust, and muscovite appeared to be similar in composition to those found in lakebed soil (reference MCB-1097-89).

3.5 The glass fibers were composed of Si-tile, Si-Al rich high temperature insulation and Si-Al-Ca rich insulation glass fibers, and these glass fibers were originated from TPS.

3.6 The particle sizes were estimated to be in the range of 1 to 180 micrometer.

CHEMIST: H. S. Kim
H. S. Kim

APPROVED: J. E. Jones
J. E. Jones

12.0 POST LAUNCH ANOMALIES

Based on the debris inspections and film review, 13 Post Launch Anomalies were observed for STS-36.

12.1 POST LAUNCH PAD DEBRIS INSPECTION

1. All south holddown post shim material was at least partially debonded from the shoe sidewalls/bases. Shim material was completely debonded on HDP #2.

12.2 FILM REVIEW

1. As many as 6 pieces of debris fell from the HDP #8 aft skirt stud hole. Two of the frangible nut pieces measured approximately 3"x3/8"x3/8".

2. Although the GH2 vent arm latched properly, excessive slack in the retract lanyard caused a loop of cable to pass by the pulley, contact the underside of the haunch, snap back around the pulley in the opposite direction, and impact the GUCP. The GUCP has been damaged on previous launches when this lanyard does not retract properly.

3. A 12"x8"x4" chunk of instafoam broke away from the RH SRB aft skirt adjacent to the outboard corner of the HDP #1 shoe and fell into the SRB exhaust hole. Instafoam should remain attached to the aft skirt during liftoff and ascent.

4. A bright-colored object fell out of the RH SRB plume near the aft skirt trailing edge at approximately T+31 seconds. The object's trajectory remained close to and parallel to the plume. This object may be a piece of aft skirt instafoam, which should remain attached to the aft skirt during ascent.

12.3 SRB POST FLIGHT/RETRIEVAL INSPECTION

1. Three pins from the LH SRB frustum severance ring were missing. One of the pins was embedded in the TPS on the forward side of the ETA ring. Approximately 10 percent of the other pins were loose and protruding from the pin holes.

2. The RH frustum had 2 areas of missing TPS and 10 debonds. The LH frustum exhibited 4 MSA debonds.

3. The RSS antenna phenolic plate on the Orbiter side of the LH SRB forward skirt was delaminated and some of the material was missing.

4. The LH aft segment center factory joint EPDM moisture seal was debonded at 4 locations. Maximum depth was 2.6 inches.

5. The vehicle continues to loose K5NA from all 8 aft BSM nozzles and protective domes from the aft faces of the phenolic kick rings.

6. Half of a frangible nut was wedged between the HDP #8 plunger and spherical washer.

12.4 ORBITER POST LANDING INSPECTION

1. The top layer of the SSME #3 beta blanket was loose from 3:30 to 4:30 o'clock, frayed at 6 o'clock, and missing from 6:30 to 10 o'clock.

2. One of the pyro retention yokes was loose in the LH2 umbilical cavity and fell onto the runway when the ET/ORB umbilical doors were opened.

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Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.

4. Title and Subtitle

Debris/Ice/TPS Assessment and Photographic Analysis for Shuttle Mission STS-36

5. Report Date

April 1990

6. Performing Organization Code

7. Author(s)

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8. Performing Organization Report No.

10. Work Unit No.

9. Performing Organization Name and Address

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11. Contract or Grant No.

12. Sponsoring Agency Name and Address

13. Type of Report and Period Covered

14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

A Debris/Ice/TPS (Thermal Protection System) assessment and photographic analysis was conducted for Space Shuttle Mission STS-36. Debris inspections of the flight elements and launch pad are performed before and after launch. Ice/frost conditions on the External Tank are 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 is analyzed after launch to identify ice/debris sources and evaluate potential vehicle damage and/or in-flight anomalies. ~~This report documents~~ the debris/ice/TPS conditions and photographic analysis of Mission STS-36, and their overall effect on the Space Shuttle Program. (are documented)

17. Key Words (Suggested by Author(s))	18. Distribution Statement
STS-36 Ice Frost Debris Thermal Protection System (TPS) Photographic Analysis	Publicly Available Unclassified - Unlimited

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of pages	22. Price
Unclassified	Unclassified		

NASA FORM 1626 OCT 86