FLIGHT READINESS STATEMENT
STS-81/ET-83
EXTERNAL TANK PROJECT
PRE-FLIGHT REVIEW

EXTERNAL TANK ET-83/STS-81, AS IDENTIFIED IN THE EXTERNAL TANK PROJECT PRE-FLIGHT REVIEW DATED DECEMBER 18, 1996, IS CONSIDERED READY TO SUPPORT FLIGHT UPON ACCEPTABLE DISPOSITION OF OPEN/PLANNED WORK AND/OR OPEN ACTIONS.

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December 18, 1996

Space Shuttle
External Tank

STS-81/ET-83
Pre-Flight Review

LOCKHEED MARTIN

Manned Space Systems

ET83PFR.4220.dd.12/96

Agenda

• ***Overview***	***Jim Feeley***
• ***Prior Mission Performance Summary***	
• ***Mission/External Tank Highlights***	
• ***Changes***	
• ***Senior Management Review NCDs***	
• SRM&QA Assessment	Terry McKeough
• KSC Processing	Bill Brandow
• Verification/Certification	Jim Feeley
• Mission Unique Assessment	
• Special Topic	John Dye
- ET-83 Welded Extrusion Assessment	
• Readiness Statement	
• Appendices	
- A: Minor Changes	
- B: SRM&QA Assessment	
- C: KSC Processing	
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Overview

- Review covers changes/differences/non-conformances not previously flown and/or reviewed

- This Delta review for STS-81/ET-83 includes:
  - Prior mission performance summary
    - Items not previously addressed at the Block 14 (ETs 81-88) ET Project FRR
    - Items specific to mission STS-81
    - Details of previously presented items are included in the Appendix

- **<u>FRR Series</u>**

- Block ET Project Review	8/14/96
- Mission Specific Reviews	
• ET/SRB Mate	11/12/96
• Pre-flight review	12/18/96
• Associate Administrator FRR	1/6/97 (S)
• Mission Management Team (L-2 Day)	1/10/97 (S)

Prior Mission Performance Summary

STS-80/ET-80, 11/19/96

System	Performance
OMRSD	No violations
LCC	LDs 23 and 25 near the GUCP indicated GH2 leak > 44,000 ppm • LCC limit = 44,000 ppm • Preplanned contingency procedure implemented - Leakage within limit for remainder of countdown (≈10,000)
Instrumentation	Nominal
MPS	Nominal
Hazardous Gas	(See LCC)
TPS	Nominal
ET disposal	Nominal
Orbiter tile damage	Lower surface, below average • >1" = 4 • Total = 34
Post flight photo review	Not available

Mission/External Tank Highlights

Mission	**STS-81**
• **Launch**	1/12/97
- Window	0417 EST
- Pad	B
- Orbiter	Atlantis (OV-104)
- Orbital inclination	51.6° - Insertion at 170 NM
- ET photo coverage	Umbilical well cameras
• **Primary payload**	• 5th MIR docking • Spacehab
• **Landing**	1/27/97
- Time	0840 EST
- Location	KSC
External Tank	**ET-83**
• DD250 Acceptance	4/25/96
• Shipped to launch site	9/18/96

Changes

- **One new item since Block 14 FRR, 8/14/96**
  - Revise aft upper ET/SRB fairing closeout (B02014)
- **Previously presented at Block 14 FRR (included in Appendix D)**
  - Move GFP umbilical test port TPS closeout from KSC to MAF (B02002/A)

Senior Management Review NCD

- **Previously presented at Block 14 FRR (included in Appendix D)**
  - LH2 aft dome cap contour deviation (T127962)

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SRM&QA Assessment

as of 12/12/96

Item	Status
• **Alerts**	None
• **MRB Assessment**	Complete - No issues/no impact to hazard controls
• **Hazard Assessment**	Complete - All hazard reports were re-assessed and hazard controls verified
• **Corrective Action Problem Summaries (CAPS)**	
- Welded extrusion cracks (S-079)	• To be discussed as Special Topic
- LH2 Gulton ullage pressure transducer failed calibration test at vendor (E-162)	• See subsequent chart

LH2 Ullage Pressure Transducer Failure

CAPS E-162

Issue:

- Gulton LH2 ullage pressure transducer failed vendor's ATP calibration accuracy test

Background:

- Output voltage lower than acceptance test requirement at applied pressures from 32 to 34 psia
- Transducer passed pre-ATP calibration test
- Output voltage shifted between pre-ATP and ATP
  - Values were lowered by same amount at all pressures
  - Indicative of internal vacuum reference reduction (leakage)

Cause:

- Undetermined - Failure analysis in progress

Corrective Action:

- Undetermined - Failure analysis in progress

Rationale for Flight:

- All ETs successfully passed ATP
- Adequate tests of transducers performed at MAF and KSC to assure performance

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KSC Processing - Status

as of 12/12/96

- **Discrepancy Reports (DRs)/Problem Reports (PRs) Review**
  - All PR/MRB * discrepancies/dispositions similar to previously flown vehicles and are within existing database
  - All MRBs have been reviewed by MAF Reliability for potential SMR

- **Limited Life Component/ET Status** *
  - All within required life through scheduled launch date plus 90 days

- **OMRSD Exceptions/Waivers:** None

- **Changes**

- ET modifications	
• Mod Kits *	3
• DC&R (Discrepancy Check and Report)	0
• Bldg 45	0
• FEC (Field Engineering Change)	0
- OMRSD	0
- Software	0
• SIM Load	12/19/96
• SIM Launch	11/4/96

* Included in Appendix C

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Verification/Certification

as of 12/12/96

Item	Status
• **NSTS 07700, Volume X Baseline** - Revision L, Change 224	No constraints
• **Certification documentation** - Hardware Certification Sheets (HCS) • T019, Revised aft upper ET/SRB fairing closeout (B02014) - Certificates of Qualification (COQ)	Approved - No issues
• **Waivers/Deviations**	Complete - No issues

Mission Unique Assessment

as of 12/12/96

Category/Item	Status
• **Review of MRB actions using updated loads**	Complete - No issues
• **MPS Preflight Prediction Package**	ECD 12/24/96

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ET-83 Welded Extrusion Assessment

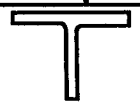
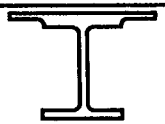
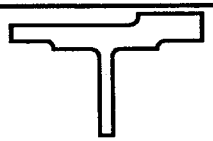
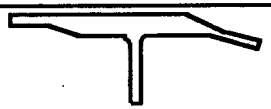
STS-81

- Extrusions on unflown ETs do not exhibit the adverse grain orientation and grain size found on ET-89 and ET-90 Station 1871 frame
- All extrusion welds have positive margins of safety using
  - "As-built" peaking and mismatch
  - Reduced weld strength from recent test program
  - Allowable methodology 99% reliability/95% confidence per Mil-Hdbk-5F
- All welds are demonstrated to 100% of limit flight loads or greater by proof test
  - Includes effect of reduced cryogenic enhancement of strength
  - Approximately 70% of weld length is demonstrated to ultimate design load (limit x SF) by proof test
- All x-rays (pre and post proof test) have been re-reviewed - No indication changes resulted
- All MRB actions re-reviewed - Positive margins are shown

Conclusions

- ET-83 meets all requirements and is acceptable for STS-81 flight

ET-83 Welded Extrusion Assessment

			Ultimate Stress (ksi)			Factor of Safety		
Location	Shape	Weld Code	Flight	Proof	Allowable Stress (ksi)	Required	Actual	Proof Test Demonstrated
744 T-ring		O3 O4	35.08 25.01	26.07 18.31	36.40 36.40	1.32 1.31	1.37 1.91	1.09 1.03
851 Dome Chord		O5 OAF	19.81 31.09	13.37 28.73	36.40 37.70	1.32 1.35	2.43 1.63	1.14 1.30
1129 Dome Chord		HFF H8	24.79 29.35	24.68 32.91	38.00 33.70	1.25 1.26	1.91 1.45	1.15 1.34
1377 & 1624 Frames		H7 H6 H5 H4	28.80 30.46 27.30 22.31	25.66 27.23 22.22 22.84	39.80 39.80 39.80 33.70	1.26 1.26 1.30 1.25	1.74 1.65 1.90 1.89	1.33 1.33 1.25 1.25
1871 Frame Chord		H3 H2	36.17 35.97	26.11 26.19	36.60 36.60	1.26 1.26	1.27 1.29	1.09 1.10
2058 Dome Chord		H1 HAF	36.36 45.27	29.12 36.52	39.80 45.60	1.26 1.31	1.37 1.32	1.12 1.18

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Readiness Statement

The External Tank, ET-83 is hereby certified and ready for STS-81 flight pending completion/closure of open and planned work

Dennis R. Deel
Vice President, External Tank Project
Lockheed Martin Manned Space Systems

Appendices

- **A: Minor Changes**

- **B: SRM&QA Assessment**
  - NCD Assessment Criteria

- **C: KSC Processing**
  - PR/MRB Summaries
  - OMRSD Exceptions/Waivers: None
  - OMRSD Changes (RCNs): None
  - Limited Life Components
  - Modification Summaries/Status
  - Software Changes: None
  - ET-83 Alternate Blowing Agent Usage at KSC

- **D: Previously presented items**
  - Changes
  - Senior Management Review NCDs
  - Level II Waivers

Class II or JS/DCN Changes

- All Class I/II JS/DCN changes have been reviewed by MSFC Resident Office
- All Class II STP/STM/Standards changes have been reviewed by MSFC M&P Lab
- These changes are acceptable for flight and summarized in this appendix (presentation not required)
  - Presentation criteria - Selection for presentation based on changes affecting:
    - Processes
    - Configuration
    - Material
    - Alternate Hardware
  - Presentation rejection criteria - All changes that do not affect configuration, material or processes
    - Revise Point of Incorporation
    - Drawing Clarification
    - Non-Flight Hardware Installation/Removal
    - Datum Changes
    - Update Usage/List of Materials (L/M)
    - Drawing Incorporation Errors
    - Manufacturing Aid
    - Drawing Errors
    - Fastener Type/Grip
    - Tolerance Change
    - Productivity
    - Minor changes taken care of by initial release of Class I Change (Same categories as above)

Class I/II or JS/DCN Changes - List

Change No.	Description	Discipline
H35809-335	Revise feedline to crossbeam foam closeout drawing to assure adequate coverage over bolts area of deleted strip heaters	TPS
H35809-368	Correct callout to apply protection to helium inject box	Systems

Class II STP/STM/Standards, List

Change No.	Document No.	Description
H35809-575	STP 7523	Graphite/Polyimide • Added: - Referenced ASTMs to industry specs and standards section - Oven and tooling requirements to equipment section - Detailed acceptance criteria to product requirements section - Witness panel requirements with acceptable properties - Minimum cure requirements and vendor qualification section • Updated material section by adding material referenced in spec • Revised mechanical and physical properties in line with actual part acceptance • Expanded fabrication control section and lay-up requirements • Made fiber volume test info only instead of hard requirement

Class II STP/STM/Standards, List

Change No.	Document No.	Description
H35809-585	CS B656	Seal, PTFE, expanded • Added oxygen compatibility batch test requirement to Skyflex seal
H35809-588	Std 41L2	Heat shield • Added requirement to perform flammability test on raw material lots used to fabricate heat shield
H35809-597	STP 2024	Installation of threaded inserts • Added clarification that keys should be installed in previous slots or be separated at least two key widths • Added requirements for 34L2-7L11 and 34L10-7L11 • Allow bare tap-drilled holes and mushrooming of driven keys

Class II STP/STM/Standards, List

Change No.	Document No.	Description
H35809-606	STP 2003	Countersinking and flushness requirements • Eliminate requirements to measure head height for counterbored holes
	STP 2014	Bolts, screws, nuts, installation of • Eliminate requirement to gage gap under 100° countersunk fastener heads in counterbored holes
H35809-628	STP 2006	Bolt and collar installation • Added figure showing sleeve length flushness requirements
	STP 2030	Installation of G/P lockbolts • Added sub-paragraph to specify hole tolerance • Added requirements for replacement of pins and collars when the collar seats on a sloped surface

NCD Assessment Criteria

- Assessment of all MRB Items
  - Adequacy of technical dispositions
  - Completeness of required repair/retest
  - First time occurrences/SMR
  - Verification of margin of safety assessment/documented
  - Review of impact to hazards
  - Engineering review for impact to loads
  - Engineering review for reduced extrusion to plate weld allowables

ET-83 DR/PR/OMRSD Waiver/Exception Summary

as of 12/12/96

System	Discrepancy Reports	Problem Reports	MRB Items *	Waivers/ Exceptions
• Electrical	0	0	0	0
• Propulsion/ Pneumatics	0	2	1	0
• Range Safety	1	0	0	0
• Structure	2	9	2	0
• Thermal (TPS)	0	9	1	0
Total	**3**	**20**	**4**	**0**

* See subsequent charts for details

ET-83 PR/MRB Summary

PR No.	Description	Disposition
Structure		
PET-83-ST-0004	Two scratches on third hardpoint -Y attach pad • 0.3" L x 0.003" D • 0.3" L x 0.002" D	• Use as repaired - Removed raised metal and restored finish - No cracks or crack-like indications - Minor defects will not affect TPS closeout
PET-83-ST-0007	Epoxy primer in EB-1/2 bores	• Use as repaired - Removed primer in bore allowing installation of the spherical washers - Iridite applied to bare metal surfaces - Remaining primer in bore does not affect part function

ET-83 PR/MRB Summary

PR No.	Description	Disposition
Propulsion/Pneumatics		
PET-83-FP-0001	Debonded resin at inboard upper edge of lightning strip on GFP LH2 umbilical	• Use as is - Function of lightning strip not affected
Thermal		
PET-83-TS-0009	Crushed foam in the -Y bipod spindle clevis PDL foam closeout that occurred during bipod strut installation	• Use as is - No discernible depth - No loose foam or offsets

ET-83 Limited Life Components

Cycle Sensitive

Description	Part No.	Serial No.	Limit	Required	Remaining
LH2 Manhole Cover Assy	80914081488-019	000222990	100	1	100
LO2 Tank Mechanical Assy	80912002000-019	000202240	100	1	100
LH2 Tank Mechanical Assy	80914002000-009	000221320	100	1	100
LO2 Manhole Cover Assy	80911001205-010	000302180	100	1	100
LO2 Fwd Ogive Cover Plate	80911001207-029	000270191	100	1	100
LH2 Manhole Cover Assy (Aft Dome)	80911001444-010	000191170	100	1	100
		000265130	100	1	100

ET-83 Limited Life Components

Age Sensitive

Description	Part No.	Serial No.	Limit	Initiation	Expiration
External Tank	80901000000-270	00000076	6 Yrs	4/96	4/2002

Age Sensitive Pyrotechnics - 10 Years Life/Requires Lot Verification Tests After 4 and 7 Years

Description	Part No.	Lot No.	Serial No.	Latest Retest	Expiration
Separator Assy GUCP	PD5000020-059	AAF	0000846	5/96	5/99
Cartridge Assy	PD5000020-030	AAF	70028	5/96	5/99
		AAF	70029	5/96	5/99

ET-83 Modification Summary

No.	Description	Status
Mod Kits		
E145/B02010	Remove ET RSS	Complete - No issues
E156/B02010	Limit GUCP RSS tear-away installation	Complete - No issues
B518/B01987A	Authorize use of PDL-1034	Complete - No issues

ET-83 Alternate Blowing Agent Usage at KSC

(PDL-1034/SS-1171)

Foam	Document	Description	Location	Size
SS-1171	T5141	Aft hardpoint closeout	Sta 1973-2076, 180°	4410 sq. in.
PDL-1034	PR-TS-0016	LH2 umbilical test ports	Sta 2070, 340°	12 sq. in.
PDL-1034	T5249	ET/SRB aft fairing closeout	Sta 2058, 40°/320°	240 sq. in.

GFP Umbilical Test Port TPS Closeout (B02002/A)

Change:

- Moved GFP LO2 and LH2 umbilical leak test port TPS closeouts from KSC to MAF for ET-83 and subs

Background/ Reason:

- Launch site work reduction
  - Leak check ports closed out at KSC with MBO foam
    - Final leaks checks performed at MAF
  - Ports not used at KSC

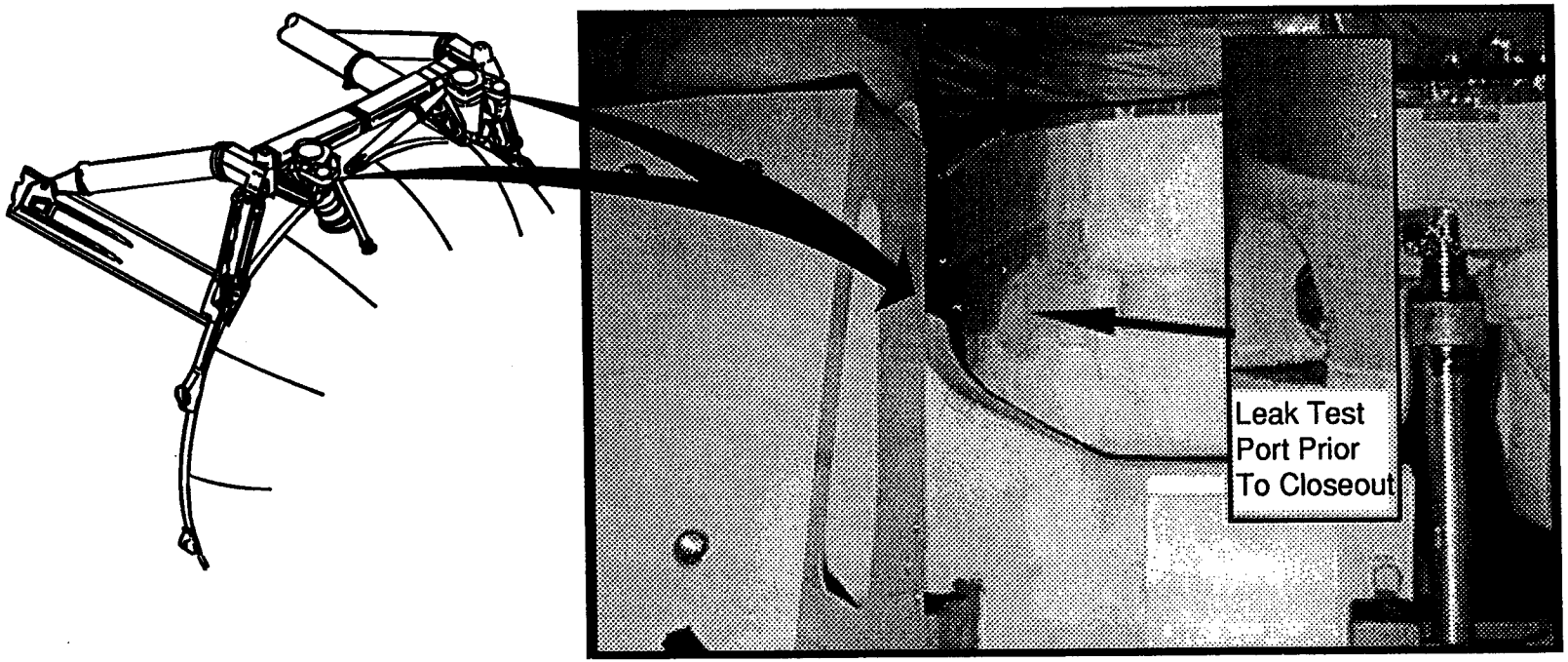
Description:

- Hardware
  - Replace MBO foam closeout of GFP umbilical leak test port with PDL foam
- Documentation
  - Revised Orbiter Vehicle to ET ICD changing closeout from KSC to MAF
  - Revise HCS to reflect material change

Basis for Certification:

- Stress analysis - PDL application to GFP hardware meets FS (1.10 required)
  - FS = 1.82
- Similar to other validated PDL applications

GFP Umbilical Test Port TPS Closeout (B02002/A)



Leak Test Port
Typical 3 locations
(1 LO2/2 LH2)

ET-83 LH2 Aft Dome Cap Contour Deviation

T127962

Issue:

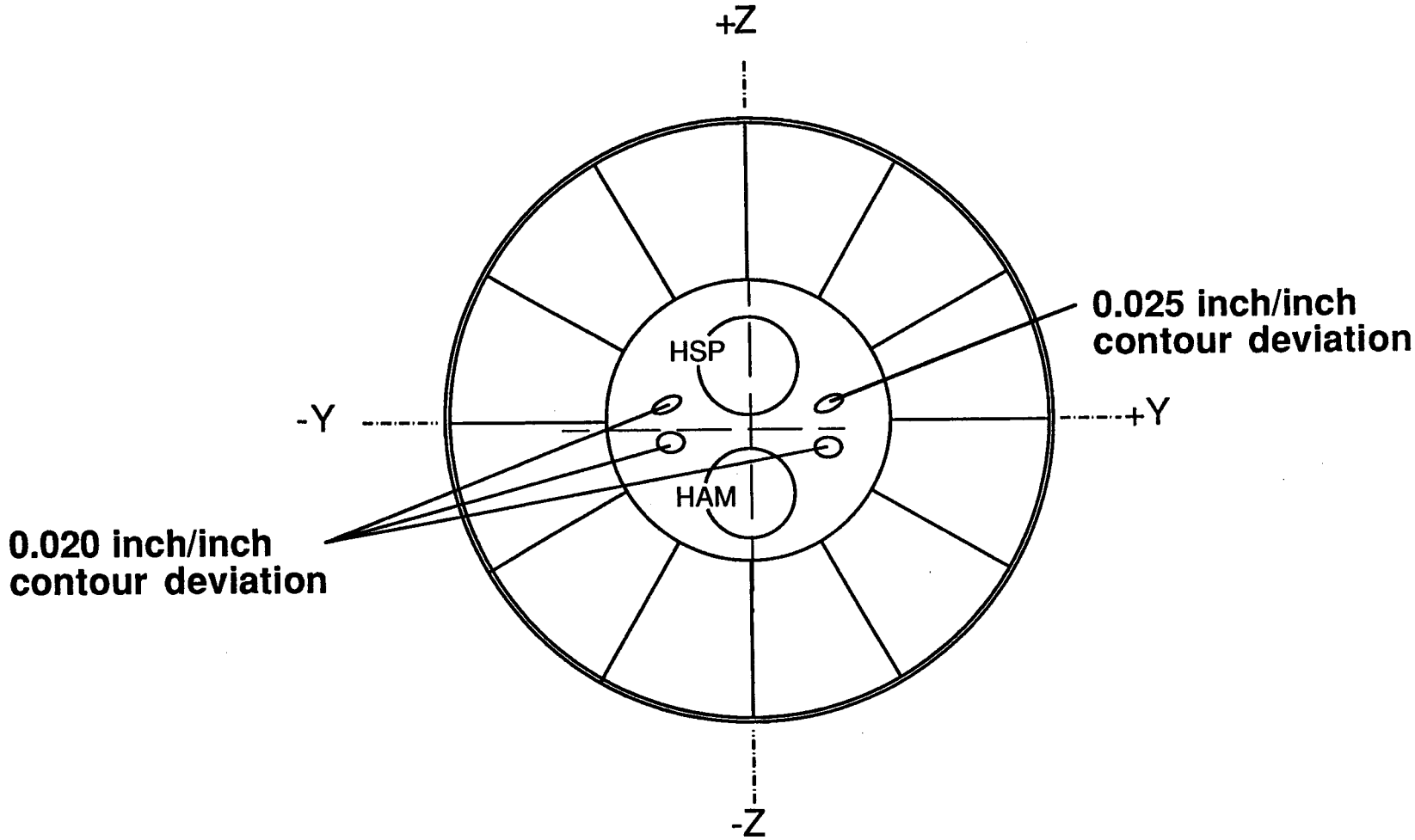
- Fansteel aft dome cap on ET-83 has four locations adjacent to manhole cover fittings with out-of-tolerance negative contours
  - Maximum allowable rate of change is 0.010 inch/inch within six inches of secondary weld land
    - Worse case contour deviation is 0.025 inch/inch

Background:

- Defects appeared after weldment of manhole cover fittings to Fansteel cap
  - Planishing utilized to reduce rate of change violation
  - Maximum allowable accumulated depth of contour deviation not violated
    - Allowable = 0.125"
    - Actual = 0.116"
  - Last remaining Fansteel LH2 aft dome cap
  - NPU'd based on manufacturing/schedule risk assessment
- Zeppelin dome caps unable to support manufacturing build schedule
  - Re-evaluated risk associated with returning NPU Fansteel cap to flight hardware
    - Determined as acceptable manpower and material risk
- HADC weldment was acceptable
  - No change of contour measurements

ET-83 LH2 Aft Dome Cap Contour Deviation

T127962



LH2 Aft Dome

ET-83 LH2 Aft Dome Cap Contour Deviation

T127962

Cause:
- Isolated case - Inherent to process

Corrective Action:
- None required - Isolated case

Disposition:
- Use as is

Rationale for Flight:
- TPS cryoflex test achieved FS = 1.13 (1.10 required)
  - Adequately proof tested
- Structural analysis of dome cap with deviation
  - FS = 1.99 (1.25 required)

Level II Waivers - Baseline

Document/ Requirement	Authority	Paragraph	Waiver No.	Effectivity
NSTS 07700 Vol. V - Information Management Requirements				
Generic part name, type, common designation, and part manufacturer H4 code are not required for EEE parts status printout	S00127B 6/28/88	Table C.5 Item 2SR-10	6	ETs 49 & up
Data required in limited life status report is supplied in acceptance data package	S00127B 6/28/88	Table C.6 Item 2SR-7	8	ETs 49 & up
Requirement to deliver element pressure vessel historical data to EPO will remain at contractor facility	S00127B 6/28/88	Table C.6 Item 2SR-7	10	ETs 49 & up

Level II Waivers - Baseline

Document/ Requirement	Authority	Paragraph	Waiver No.	Effectivity
NSTS 07700 Vol. X - Space Shuttle Flight and Ground System Specification , Book 1 Requirements				
Electrical wiring of redundant systems NSTS 08080-1, 20A/4B	S40732G 6/18/88	Table 2.0	362	ETs 23, 27-29, 31 & up
Electrical bonding per MIL-B-5087B (2)	S040732M 9/9/88	3.6.14	378	ETs 23, 27-29, 31 & up
Soldering, circuit boards & connectors	S040732M 9/9/88	3.6.15.1.1	379	ETs 23, 27-29, 31 & up
PD7400106 circuit boards	S040732M 9/9/88	3.6.15.2.1	382	ETs 23, 27-29, 31 & up
PCM MUX and pressure transducer circuit boards	S040732M 9/9/88	3.6.15.2.1	383	ETs 23, 27-29, 31 & up

Level II Waivers - Baseline

Document/ Requirement	Authority	Paragraph	Waiver No.	Effectivity
NSTS 07700 Vol. X - Space Shuttle Flight and Ground System Specification , Book 1 Requirements				
CIL fail safe and redundancy requirements	S040201E 4/3/87	3.5.1.1.1 Thru 3.5.1.1.3	401	ETs 23, 27-29, 31 & up
2058 Frame, Bearing Stress	S40793H, H-R1 11/22/88	3.2.2.1.5.2	452	ETs 23, 27-29, 31 & up
Soldering of electrical connectors	S094779C 2/21/91	3.6.15.1.1	573	ETs 37, 41 & up

Level II Waivers - Baseline

Document/ Requirement	Authority	Paragraph	Waiver No.	Effectivity
NSTS 08060, Rev. F - System Pyrotechnic Specification				
Use 40M36298 connectors	S040732F 6/24/88	3.4.1	61	ETs 23,27-29, 31 & up
Prevent adverse effects of common mode currents	S040732F 6/24/88	8.2.1	64	ETs 23, 27-29, 31 & up

Level II Waivers - Baseline

Document/ Requirement	Authority	Paragraph	Waiver No.	Effectivity
NSTS 08060, Rev. F - System Pyrotechnic Specification				
Fire circuit wiring shall be routed separately	S040732F 6/24/88	8.2.3	65	ETs 23, 27-29, 31 & up
NSTS 07700-10-MVP-01 - Shuttle Master Verification Plan				
Environmental acceptance of ET components	S002130H 3/7/89	3.7.1	13	ETs 23, 27-29, 31 & up
NSTS 08123, Rev. B - Certification of Flexible Hoses and Bellows				
LH2 feedline bellows	S0052023G-R1 8/2/91	1.2	3	ETs 42 - 45, 47 & up
SL-E-0001 - Specification Electromagnetic Compatibility Requirement				
Wire marking is not applicable to the ET	S40732K 9/27/88	3.2.5	3	ETs 23, 27-29, 31 & up
SW-E-0002 - Ground Support Equipment General Design Requirements				
Factor of safety applied to yield for GUCP leg	S87020L 8/17/88	3.4.2.1	21	ETs 23, 27-29, 31 & up