FLIGHT READINESS STATEMENT
STS-90/ET-91
EXTERNAL TANK PROJECT
PRE-FLIGHT REVIEW

EXTERNAL TANK ET-91/STS-90, AS IDENTIFIED IN THE EXTERNAL TANK PROJECT PRE-FLIGHT REVIEW DATED FEBRUARY 4, 1998, IS CONSIDERED READY TO SUPPORT FLIGHT UPON ACCEPTABLE DISPOSITION OF OPEN/PLANNED WORK AND/OR OPEN ACTIONS.

E. C. SMITH/EB01

for G. R. WALLACE/EL01

for W. E. TAYLOR/EA01

W. R. HUMPHRIES/ED01

for A. F. WHITAKER/EH01

H. V. McCONNAUGHEY/EP01

For A. O. HARRIS/CR01

M. D. SMILES/CR70

P. V. COUNTS/SA31, CHAIRMAN

Agenda

• ***Overview***	***Jim Feeley***
• ***Prior Mission Performance Summary***	
• ***Current Mission/External Tank Highlights***	
• ET-91 Mass Properties Status	Mike Simpson
• Changes	
• Senior Management Review NCDs: None	
• SRM&QA Assessment	Terry McKeough
• KSC Processing	Juan Ramirez
• Verification/Certification	Jim Feeley
• Mission Unique Assessment	
• Readiness Statement	
• Appendices	
- A: Minor Changes	
- B: SRM&QA Assessment	
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February 4, 1998

Space Shuttle
External Tank

STS-90/ET-91
Pre-Flight Review

Prior Mission Performance Summary

STS-89/ET-90, 1/22/98

System	Performance
OMRSD/LCC	No violations
Instrumentation	• Nose cone compartment temperature and heater outlet temperatures decreased below program set point – Program set point = 60°F – Low reading = 42°F – Did not violate 37°F minimum requirement • Temperature returned to set point - No violation • Review of data showed no correlation of temperature reduction to an ET related event • Trouble shooting of primary nose cone controller pending • First use of new controller on Pad A

Overview

- Review covers changes, differences and "out of family" non-conformances not previously flown and/or reviewed

- This review for STS-90/ET-91 includes:
  - Prior mission performance summary
  - Items specific to mission STS-90
  - Details of previously presented items are included in the Appendix

- **FRR Series**

- Pre-flight Review	2/4/98
- ET/SRB Mate	2/10/98
- Space Shuttle Vehicle FRR	3/19/98
- Mission Management Team (L-2 Day)	3/31/98

Mission/External Tank Highlights

Mission	**STS-90**
• Launch	4/2/98
- Window	1319 - 1549 EST
- Pad	B
- Orbiter	Columbia (OV-102)
- Orbital inclination	39° - Insertion at 150 NM
- ET photo coverage	• Crew photos from cockpit window • Umbilical well cameras
• Primary payload	Neurolab
• Landing	4/19/98
- Time	1207 EST
- Location	KSC
External Tank	**ET-91**
• DD250 acceptance	11/14/97
• Shipped to launch site	12/4/97

Prior Mission Performance Summary

STS-89/ET-90, 1/22/98

System	Performance
MPS	First flight of Block IIA SSMEs - No issues • Performance as expected
ET Hazardous Gas	Nominal
TPS	No issues
ET disposal	Nominal
Orbiter tile damage	Lower surface, above average • Diameter > 1" = 38 • Total = 95
Post flight photo review	Not available

ET-91 Mass Properties Status

Issue: ET-91 weight status (predicted vs. actual)

Background:

- The specification weight for ET-90 is 68,560 lbs
- The control weight for LWT is 65,449 +/- 511 lbs
- ET-91 was weighed December 17, 1997

– Predicted weight	64,919 lbs
– Actual weight	64,809 lbs
– Delta	-110 lbs

Rationale for Flight: ET-91 actual (scale) weight meets specification and control weight requirements

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Changes - List

Description	Presenter
• Titanium investment casting specification (B01915)	Not presented - Included in Appendix A - Minor Changes
• **Revised Intertank foam thickness (B01982K/B02005)**	**Steve Copsey**
• **Sanded foam on Intertank thrust panels (FEC K-ET-0034)**	**Steve Copsey**
• **Revised ET nominal rupture altitude requirement (B02011)**	**Woody Widofsky**
• **ET RSS deletion, Phase III (B02010)**	**Jim Feeley**
• Revised GFP bolt catcher part number (B02017)	Not presented - Included in Appendix A - Minor Changes

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Revised Intertank Foam Thickness

B01982K/B02005

Description:

- Hardware
  - Reduced minimum Intertank foam thickness
  - Machined Intertank stringer panel foam to near minimum required thicknesses
    - Reversed fastener installation to reduce fastener head protrusion on outside panel surfaces where possible to accommodate machining
- Manufacturing
  - Implemented a new delivery system to control foam thickness to tighter tolerance and tailored thicknesses
  - Developed new machining facility with software mapping tool, cutting head and dust collection/environmental control system
- Documentation:
  - Revised HCS to reflect new TPS configuration

Revised Intertank Foam Thickness

B01982K/B02005

Change:

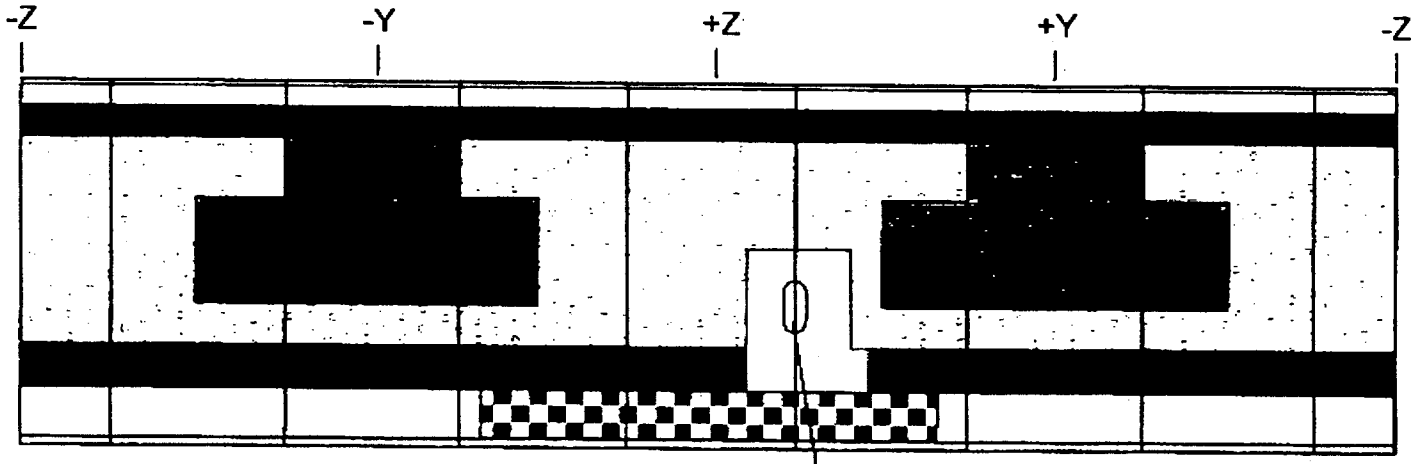
- Reduced minimum foam thickness on Intertank
- Implemented new foam delivery system for Intertank

Background/ Reason:

- Early incorporation of change on ET-91 diminishes number of first time changes for SLWT
  - Reduction of TPS average thickness provides a 150 lb weight savings

Revised Intertank Foam Thickness

STS-89/ET-90 Minimum Foam Thickness



0.30 in.

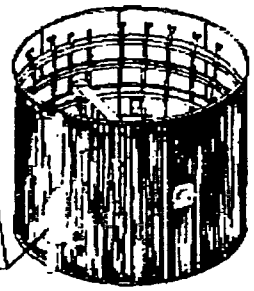
0.50 in.

Transition area
0.3–0.75 in.

0.75 in.

0.90 in.

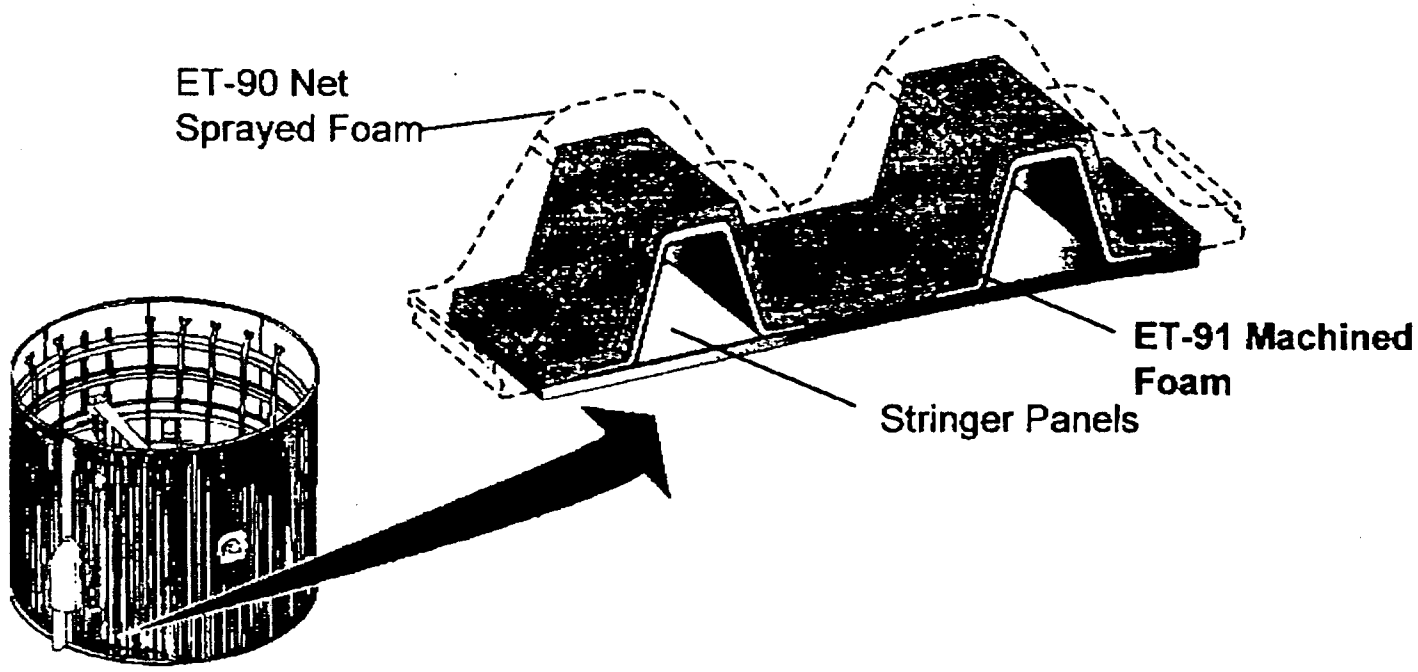
GS 213-19 ET91 FRR
213-90thickness.ai


LO2 Feedline
Fairing (Ref)

02-03-1998 14:34 5042574405 MAF/MSR P.03

Revised Intertank Foam Thickness

B01982K/B02005



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Revised Intertank Foam Thickness

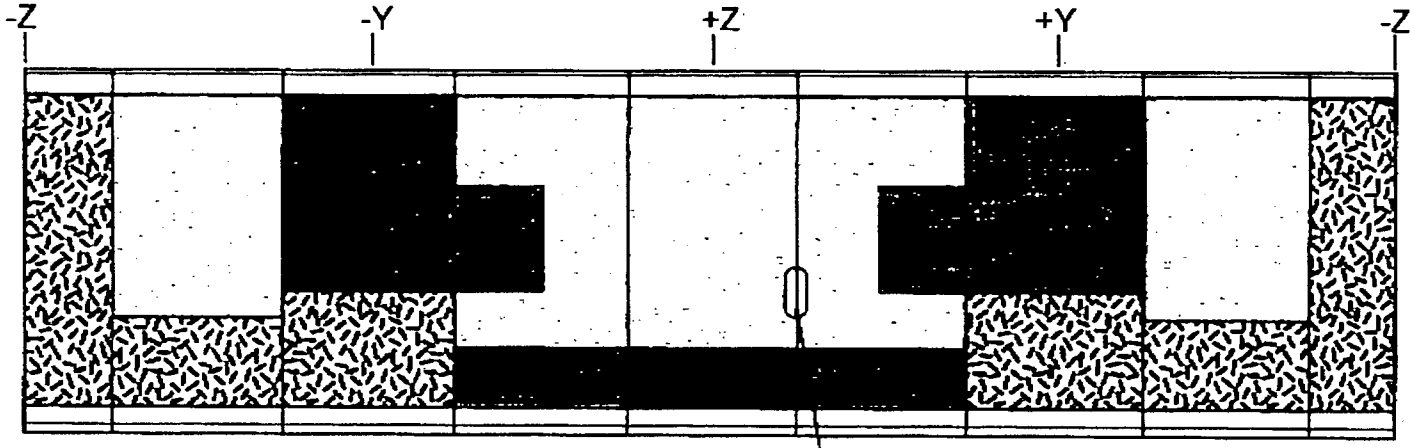
B01982K/B02005

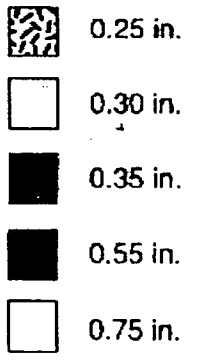
Process Development:

- New delivery system - Two validation sprays were conducted in the production cell to achieve thickness, density and strength
  - Plug pulls
    - 34.2/51.6 psi
    - 40.6 avg
  - Density
    - 2.42/2.58
    - 2.50 avg
  - Thickness: Acceptable to requirements
- Machining cell
  - Modeled (CAD) outside mold line of Intertank based on design
  - Developed program incorporating model and SOFI thickness requirements (target thickness = min + .070)
  - Verified software using bare GVTA
  - Performed machining validation on foamed areas on GVTA
  - Re-verified software on bare ET-91
  - Performed machining on ET-91 skin stringer
  - Verified machined areas meet thickness requirements

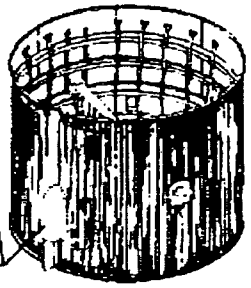
Revised Intertank Foam Thickness

STS-90/ET-91 Minimum Foam Thickness





GS 213-19 ET91 FRR
213-91thickness.ai



LO2 Feedline
Fairing (Ref)

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Sanded Foam on Intertank Thrust Panels

FEC K-ET-0034

Change:

- Reduced Intertank foam thickness on Intertank thrust panel
  - Performed plug pulls to reverify TPS strength properties

Background/ Reason:

- STS-87/OV-102 had much greater than average lower surface tile damage (109 hits > 1" on lower surface)
  - Fault tree investigation indicated TPS debris from Intertank thrust panel most probable cause of Orbiter tile damage

Revised Intertank Foam Thickness

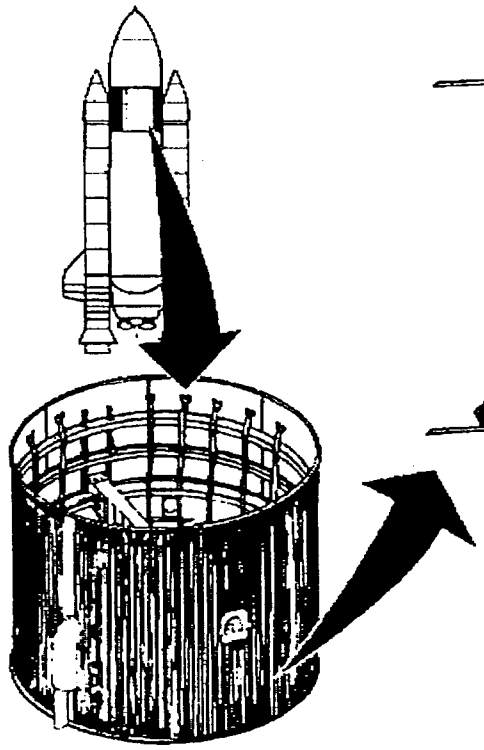
B01982K/B02005

Basis for Certification:

- Analysis
  - Stress: New configuration meets required FS of 1.10
  - Thermal: Adequate foam exists to maintain structural temperature requirements
- Inspection: Verifies proper appearance of foam
  - Lead in/lead out plus additional plug pulls
    - Required: 30 psi
    - Lead in/lead out: 64.5/58.4 psi
    - 2 additional plug pulls: 52.2/44.2
  - Lead in/lead out density
    - Required = 2.0-2.6
    - Actual = 2.39/2.38
  - Thickness met all requirements
    - Verified by ≈ 5,000 pin gage measurements

Sanded Foam Intertank Thrust Panels

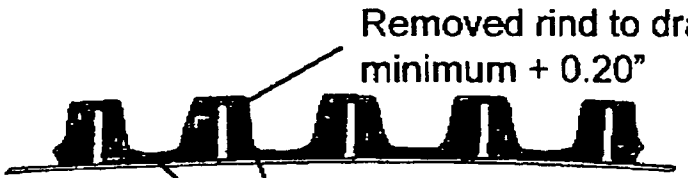
FEC K-ET-0034



GS204-41 TPS.eps

STS-90/ET-91 Net Sprayed Foam

STS-90/ET-91 Sanded Foam



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Sanded Foam on Intertank Thrust Panels

FEC K-ET-0034

Description:

- Removed foam from rib tops
  - Maintained foam minimums to + 0.20"
  - Minimums vary from 0.25" to 0.35" depending on location
  - During rind removal operations, one area of localized overtrimmed foam was accepted use as is per MRB
    - Station 912 - 914 on +Y thrust panel: Machined to 0.187" (requirement = 0.35 min.)
      - Low foam area is in non-cryogenic zone - No ascent/entry heating concern
- Removed rind material only from thrust panel valleys
  - During rind removal operations, two areas of localized overtrimmed foam were accepted use as is per MRB
    - Station 945 - 950 on -Y thrust panel: Machined to 0.28" (requirement = 0.35 min.)
      - Low foam area is in non-cryogenic zone - No ascent/entry heating concern
    - Station 894 on +Y thrust panel: Exposed two fastener heads
      - Thermal analysis of temperatures in this localized area indicates surface temperatures $\approx$ 150°F
      - Fasteners designed for use up to 450°F
- Three successful plug pulls on each thrust panel reverified material strength

Sanded Foam on Intertank Thrust Panels

FEC K-ET-0034

Basis for Certification (continued)

	Intertank Acceptance Summary Comparison			
	STS-86/ET-88	**STS-87/ET-89**	**STS-89/ET-90**	**STS-90/ET-91**
• **Tensile Strength (plug pulls)**	36.3/45 • 41.6 avg • 22.2 no test	30.1/53.3 • 40.2 avg • 16.3/22.9 No test	32.3/52.7 • 40.9 avg • 31.9/50.1 KSC retests – 43.8 avg	44.2/64.5 • 58.4 avg • 32.4/82.0 KSC retests – 55.2 avg
• **Lead-in/Lead out density**	2.53/2.33	2.09/2.32	2.57/2.50	2.39/2.39
• **Receiving inspection compression**	35	26	38	30

Sanded Foam on Intertank Thrust Panels

FEC K-ET-0034

Basis for Certification:

- Rind removal provides better TPS strain capability
- Reduced foam height reduces airload on foam from crossflow
- Removal of rind eliminates denser material layer
- Material less likely to come off in large pieces
- Material less damaging
- Reduces outer fiber bending stresses from meridonal flexure
- RAP compression and density lower than ET-90 but meets requirements
- Data review shows ET-91 tensile acceptance and KSC retests much higher than ET-89 thru ET-90

Revised ET Nominal Rupture Altitude Requirements

B02011

Change: Revised ET rupture altitude requirement

Background/ Reason:

- ET previously certified to 294,000 ft maximum rupture altitude
- More severe entry heating environments for SLWT resulted in revised rupture altitude requirement
  - Required additional TPS in local areas on Intertank and LH2 tank aft dome to satisfy rupture requirement
    - LH2 barrel foam requirements previously incorporated on ET-88 with implementation of thick/thin foam
- Early incorporation of change on ET-91 LH2 tank aft dome and Intertank diminishes number of first time changes for SLWT

Sanded Foam on Intertank Thrust Panels

FEC K-ET-0034

Basis for Certification (continued)

- Additional testing in work to verify material sprayed with NDS/TPV gun as good or better than Binks Spray used on ET-90

1	Spray planned (ECD 2/6/98)
30	Bond Tension @ RT
30	BT@ +300°F
30	Flat Wise Tension @ RT
30	FWT @ +300°F
30	Density/compression
30	Lap shear
9	Four point bend on flat panels
15	Four point bend on rib panels
1	Flat panel to MSFC for "popcorning" test

- Program ECD 2/28/98

Revised ET Nominal Rupture Altitude Requirement

B02011

Basis for Certification:

- Analysis
  - Thermal: Nominal ascent and entry heating rates predict rupture altitude below 249,000 ft
  - Stress:
    - Intertank: Configuration meets required FS of 1.10
    - LH2 tank aft dome FS (failure mode - bondline delamination)
      - Was: 2.11
      - Now: 1.57

Revised ET Nominal Rupture Altitude Requirements

B02011

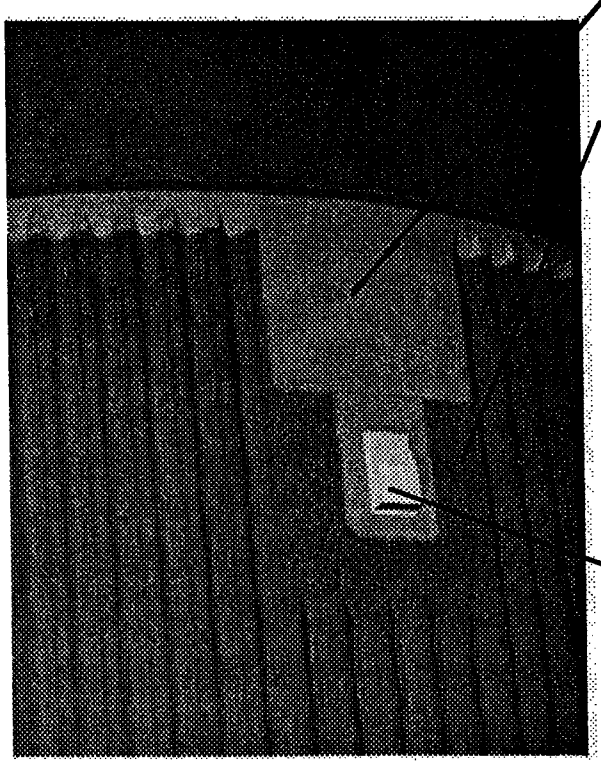
Description:

- Requirement
  - Revised ET nominal rupture altitude requirement
    - Was: Maximum rupture altitude of 294,000 ft
    - Now: Nominal rupture altitude of 249,000 ft
- Hardware:
  - Nominal foam thickness increased in local areas
    - Intertank: Increase varies from 0.19" to 0.30"
    - LH2 tank aft dome: Increase varies from 0.23" to 0.57"
- Documentation
  - Revised HCS and ICD to reflect new foam thicknesses
  - Revised EIS to reflect new rupture altitude requirement

ET RSS Deletion (Phase III)

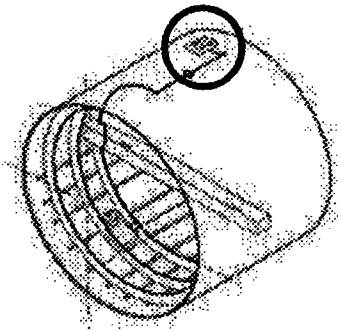
B02010

STS-89/ET-90



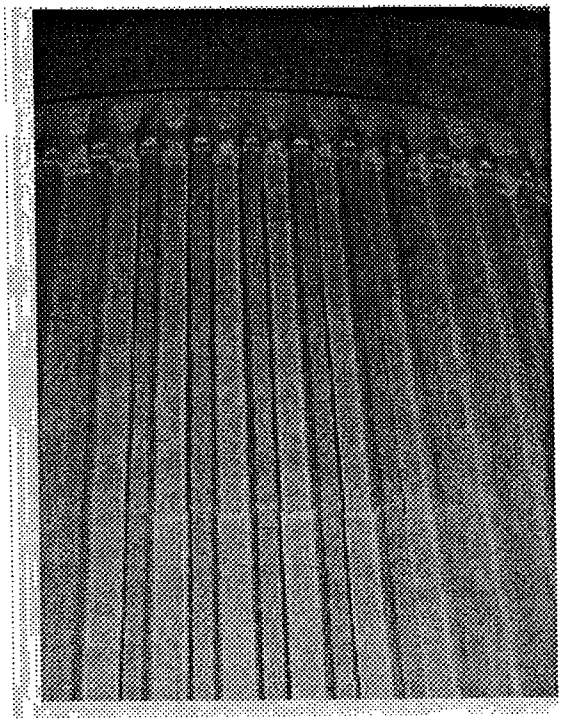
Flange Close Out Extension

Ground Plane



Antenna

STS-90/ET-91



RSS Antenna / Ground Plane deleted

ET RSS Deletion, Phase III

B02010

Change: Continued deletion of ET RSS hardware (B02011, Phase III)

Background/ Reason: PRCB approved deletion of ET RSS for STS missions with <57° orbit inclination

- Hardware has been eliminated from ET in a phased implementation

Description:

- Deleted RSS antennas, mounting brackets and cabling in LH2 tank cable trays
- Installed blank-off plate where antennas were previously mounted
  - Modified foam machining program to accommodate revised configuration
- Replaced MA25 cable trays with SLA cable trays
  - Installed rubber dams without provisions for cabling

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ET RSS Deletion, Phase III

B02010

Basis for Certification:

- Analysis
  - Dynamics: Negligible loads change due to RSS hardware deletion
  - Stress
    - Intertank: FS > 2.0, unchanged (failure mode - tension)
    - Cable tray SLA: FS > 2.0, unchanged (failure mode - strain)
  - Venting: Mass flow rates unchanged

SRM&QA Assessment

as of 2/2/98

Item	Status
• **Alerts**	None open
• **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)** - T-067PF, Loss of Intertank SOFI during ascent of STS-87/ET-89	Flight clearance - open

KSC Processing - Status

as of 2/2/98

- **Discrepancy Reports (DRs)/Problem Reports (PRs) Review**
  - All PR/MRB * discrepancies/dispositions similar to previously flown vehicles
  - 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	1 **
– OMRSD	None
– Software	None
• SIM Load	3/19/98
• SIM Launch	3/2/98

* Included in Appendix C

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** Previously discussed with Changes, Sanded foam on Intertank thrust panels

Mission Unique Assessment

as of 2/2/98

Category/Item	STS-89
• Review of MRB actions using updated loads	ECD 2/27/98
• MPS Preflight Prediction Package	ECD 3/23/98

Verification/Certification

as of 2/2/98

Item	Status
• **NSTS 07700, Volume X Baseline** - Revision L, Change 239	No constraints
• **Certification documentation** - Hardware Certification Sheets (HCS) - Certificates of Qualification (COQ)	Approved - No issues
• **Waivers/Deviations ***	Approved - No issues

* Included in Appendix D

Appendices

- **A: Minor Changes**

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

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

- **D: Previously presented items**
  - Level II Waivers
  - Level III Deviations

Readiness Statement

The External Tank, ET-91 is hereby certified and ready for STS-90 flight pending completion/closure of open and planned work

Terry L. Hibbard
Vice President, External Tank Project
Lockheed Martin Michoud Space Systems

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)

Minor Changes

Description	Reason	Basis for Certification
Added minimum mechanical properties for test bars to titanium investment casting specification (B01915) • Casting minimum design mechanical properties are unchanged	Previous specification did not account for mechanical property differences between test bars and actual castings	No change to flight hardware
Revised GFP bolt catcher assembly to add a control dimension requiring that the honeycomb be fully seated (B02017)	Eliminates potential interference between the forward separation bolt electrical cable and the honeycomb	Similarity: No change to flight hardware
Increased nominal foam thickness in local areas on 3 spray bands of LH2 tank barrel (J31178)	Producibility enhancement to assure that thickness requirements are met	Analysis: FS = 1.32, unchanged (failure mode: bondline delamination)

Class I/II or JS/DCN Changes - List, Material

Change No.	Description
H35809-835	Allow use of alternate washers on Intertank assembly due to existing washers no longer being available

Class I/II or JS/DCN Changes - List, Electrical

Change No.	Description
H35809-475	Modified drawing flag note on connector plug drawing to correct verbiage

Class I/II or JS/DCN Changes - List, Structure

Change No.	Description
H35809-474	Relax tolerance on LH2 feedline fitting installation due to limited measurement capability
H35809-545	Added vibro marking at the 0 degree location on the OMH weld to support placement of x-ray templates
H35809-552	Changes weld process from VPPA (STP-5506) to Fusion (STP-5501) for panel assembly
H35809-557	Removed lug orientation requirement on Bipod hardware installation kit assembly. Requirement is met at part level drawing and is not required at assembly level
H35809-621	Revised criteria document for LWT LH2 tank proof test. Updated max deflection requirements, established ramp rate, modified full proof pressure time envelope and add verification for minimum number of measurement devices in operation
H35809-643	Changed weld process from VPPA to GTAW for LH2 forward dome cap

Class I/II or JS/DCN Changes - List, Structure

Change No.	Description
H34809-991(A)	Revert to previous dimension on LO2 Dome Cap to prevent tool rework and to provide additional material for fabrication process
H35809-039	Redesign Ogive/Barrel T-ring to use modified extrusion shape to reduce peaking and mismatch and eliminate the use of Mag hammering
H35809-138	Implement redesign of LO2 Ogive/Barrel T-ring to reduce peaking and mismatch and to eliminate Mag hammering on SLWT
H35809-277	Revised breaker angle dimension to provide clearance for installation of splice plate. Tolerance build-up can prevent splice plate from fitting
H35809-357	Delete roundness tolerance and clarify diameter requirement of LH2 internal pipe section
H35809-383	Added fastener code callout on field of drawing
H35809-430	Moved p-clamp hole on SRB beam and web assembly to reflect LWT cable configuration

Class I/II or JS/DCN Changes - List, Structure

Change No.	Description
H35809-725	Changed weld process from VPPA (STP-5506) to GTAW (STP-5501) for forward dome assembly
H35809-794	Changed weld process from VPPA (STP-5506) to TIG fusion (STP-5501) for LH2 aft dome assembly
H35809-812	Revised ET Complete drawing to remove previously cancelled part from parts list and drawing field
H35809-840	Revised MAF and KSC ET acceptance manual to incorporate acceptance criteria to support production enhancements
H35809-858	Removed callout and flag note from drawing for lockwire on propellant feed installation drawing. Lockwire and drilled head bolts removed per previous change

fitting and manhole fitting to reduce weld defects

Class I/II or JS/DCN Changes - List, TPS

Change No.	Description
H35809-518	Added views to Intertank Foam application drawing to depict 0.25 inch minimum foam thickness on panels #6, 7, and 8 and 0.35 inch minimum foam thickness on panels #2 and 3
H35809-718	Revised LO2 tank cryoflex closeout area to show a 1.00 inch minimum foam thickness required for ET nominal rupture altitude requirements
H35809-729	Revised Intertank press line foam closeout drawing to show foam closeout bondline between two separate closeouts and clarified a flushness trim requirement
H35809-740	Revised Ice frost ramp TPS sectional view to clarify GO2 press line trim configuration

Class I/II or JS/DCN Changes - List, Systems

Change No.	Description
H35809-292	Update CIL implementation drawing to correct errors
H35809-520	Updated CIL implementation drawing to incorporate miscellaneous comments and corrections

Class I/II or JS/DCN Changes - List, TPS

Change No.	Description
H35809-823	• Revised LH2 aft dome foam application drawing for cryoflex test panel foam thickness • Changed cryoflex foam thickness to match foam thickness of surrounding foam
H35809-850	Revise PAL ramp dimension origin from cable tray slip joint cover to cable tray side

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-91 PR/MRBs - Summary, Propulsion

PR No./Status	Title/Description	Disposition
PET-91-FP-0001	Raised metal (0.010") on GO2 2" disconnect bore	Use as is • Defect not in sealing surface • Does not affect form, fit or function of seal

ET-91 DR/PR/OMRSD Waiver/Exceptions

as of 2/2/98

System	Discrepancy	Problem	MRB Items	Exceptions/ Waivers
• Electrical	0	0	**0**	0
• Propulsion/ Pneumatics	0	2	**1**	0
• Structures	3	0	**0**	0
• Thermal (TPS)	0	5	**4**	0
Total	**3**	**7**	**5**	**0**

ET-91 PR/MRBs - Summary, Thermal

PR No./Status	Title/Description	Disposition
PET-91-TS-0002	Small divot (0.15" deep) in forward ogive foam exceeds acceptable defect size (0.10" max depth) • Located approximately 3 inches aft of Station 371 and behind the LO2 cable tray	Use as is • Area not exposed to direct aero impingement • Thermal analysis indicates adequate thermal protection maintained
PET-91-TS-0004	Crushed foam on +Y aft fairing foam flow restrictor below minimum requirements • Requirement = 0.75" min. • Actual = 0.68"	Use as is • Defect is localized and will not affect flow restrictor performance

ET-91 PR/MRBs - Summary, Thermal

PR No./Status	Title/Description	Disposition
PET-91-TS-0001A	Two exposed fastener heads in valleys of Intertank thrust panels - Occurred during sanding operations	Use as is • Thermal analysis of temperatures in this localized area indicates surface temperature ≈ 150°F – Fasteners designed for use up to 450°F • Critical MS unaffected
PET-91-TS-0001B	Localized area of overtrimmed foam on Intertank thrust panel violated requirement • Worst case: 0.20" • Requirement: 0.35 min.	Use as is • Low foam areas are in non-cryogenic zones • No ice formation/ascent heating concern
PET-91-TS-0001C	Localized area of overtrimmed foam on Intertank thrust panel violated requirement • Worst case: 0.1875" • Requirement: 0.35 min.	Use as is • Low foam areas are in non-cryogenic zones • No ice formation/ascent heating concern

ET-91 Limited Life Components

Age Sensitive

Description	Part No.	Serial No.	Limit	Initiation	Expiration
External Tank	80901000000-270	00000084	6 Yrs	11/14/97	11/14/03

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

Description	Part No.	Lot No.	Serial No.	Date of Manufacture	Expiration
Separator Assy GUCP	PD5000020-059	AAG	00001130	12/13/96	12/13/00
Cartridge Assy	PD5000020-030	AAG	00001229 00001228	11/27/96 11/27/96	11/27/00 11/27/00

ET-91 Limited Life Components

Cycle Sensitive

Description	Part No.	Serial No.	Limit	Required	Remaining
LO2 Fwd Ogive Cover Plate	80911001207-029	000522590	100	1	100
LO2 Tank Mechanical Assy	80912002000-019	000456920	100	1	100
LO2 Manhole Cover Assy	80911001205-010	000559090	100	1	100
LH2 Manhole Cover Assy	80914081488-019	000510440	100	1	100
LH2 Tank Mechanical Assy	80914002000-009	000522600	100	1	100
LH2 Manhole Cover Assy (Aft Dome)	80911001444-010	000509650	100	1	100
		000549070	100	1	100

ET-91 Alternate Blowing Agent Usage at KSC

as of 2/2/98

Foam	Document	Description	Location	Size
PDL-1034	PR-TS-0001	Intertank thrust panels plug pull repairs	Sta 852-1123, 115°/245°	10 sq. in.

Level II Waivers

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

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

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
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	S005203G-R1 8/2/91	1.2	3	ETs 42 - 45, 47 & up

Level II Waivers

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 III Deviations

Document/ Requirement	Authority	Paragraph	Waiver No.	Effectivity
CPTO1M09A, External Tank Contract End Item Specification				
Potential particulate on downstream side of LH2 tank siphon screens could violate cleanliness requirement	CCBD ET3-00-9409 7/31/97	Para 3.3.10 (d)	231 R1 231 R2	ETs 87-91 ETs 96-98
MMC-ET-TMO4k-B, Space Shuttle ET Flight Acceptance Requirements				
LH2 tank proof pressure test exceeded maximum cumulative time requirement	CCBD ET3-00-9311 5/6/96 CCBD ET3-00-9329 8/1/96	Para 2.3.1.2	224 227	ET-90

Level II Waivers

Document/ Requirement	Authority	Paragraph	Waiver No.	Effectivity
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
ICD 2-12001 - Orbiter Vehicle/External Tank				
Potential particulate on downstream side of LH2 tank siphon screens could violate cleanliness requirement	S058410C 7/24/97	3.3.2	IO-1403	ETs 87-91, 96-98

FLIGHT READINESS STATEMENT
STS-90/ET-91
EXTERNAL TANK PROJECT
Δ PRE-FLIGHT REVIEW

EXTERNAL TANK ET-91/STS-90, AS IDENTIFIED IN THE EXTERNAL TANK PROJECT DELTA PRE-FLIGHT REVIEW DATED MARCH 27, 1998, IS CONSIDERED READY TO SUPPORT FLIGHT UPON ACCEPTABLE DISPOSITION OF OPEN/PLANNED WORK AND/OR OPEN ACTIONS.

for E. C. SMITH/EB01

J. L. LUSK/EE31

A. F. WHITAKER/EH01

for A. O. HARRIS/CR01

J. W. KILPATRICK/EL01

for B. E. GOLDBERG/ED01

for H. V. McCONNAUGHEY/EP01

M. D. SMILES/CR70

P. V. COUNTS/SA31, CHAIRMAN

March 27, 1998

Space Shuttle
External Tank

STS-90/ET-91
Delta Pre-Flight Review

LOCKHEED MARTIN
Michoud Space System

Agenda

• ***Overview***	***Jim Feeley***
• Changes: No new items	
• Senior Management Review NCDs: None	
• SRM&QA Assessment	Terry McKeough
• KSC Processing	Juan Ramirez
• Verification/Certification: No changes	
• Mission Unique Assessment	Jim Feeley
• Special Topic: IFA STS-87-T-01	Steve Copsey
• Readiness Statement	
• Appendices	
– A: SRM&QA Assessment	
– B: KSC Processing	

Overview

- Review covers changes, differences and "out of family" non-conformances not previously flown and/or reviewed

- This delta review for STS-90/ET-91 includes:
  - Items not previously addressed at the Pre-Flight Review (2/4/98)

- FRR Series

– Pre-flight Review	2/4/98
– ET/SRB Mate	2/10/98
– Delta Pre-Flight Review	3/27/98
– Space Shuttle Vehicle FRR	4/2/98
– Mission Management Team (L-2 Day)	4/14/98

- Launch 4/16/98

Changes

- **Changes since Pre-Flight Review:** None

- **Changes previously presented Pre-Flight Review**
  - Titanium investment casting specification (B01915)
  - Revised Intertank foam thickness (B01982K/B02005)
  - Sanded foam on Intertank thrust panels (FEC K-ET-0034)
  - Revised ET nominal rupture altitude requirement (B02011)
  - ET RSS deletion, Phase III (B02010)
  - Revised GFP bolt catcher part number (B02017)

Agenda

• Overview	Jim Feeley
• Changes: No new items	
• Senior Management Review NCDs: None	
• ***SRM&QA Assessment***	***Terry McKeough***
• KSC Processing	Juan Ramirez
• Verification/Certification: No changes	
• Mission Unique Assessment	Jim Feeley
• Special Topic: IFA STS-87-T-01	Steve Copsey
• Readiness Statement	
• Appendices	
– A: SRM&QA Assessment	
– B: KSC Processing	

SRM&QA Assessment

as of 3/26/98

Item	Status
• **Alerts**	None open
• **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)**	
– P-083, Primary seal leakage at the LH2 recirculation line and the umbilical interface	• All ETs cleared by completed/scheduled test in Final Assembly at MAF • Pending MSFC closure

- T-067PF, Loss of Intertank SOFI during ascent of STS-87/ET-89 — To be discussed as Special Topic

Agenda

• Overview	Jim Feeley
• Changes: No new items	
• Senior Management Review NCDs: None	
• SRM&QA Assessment	Terry McKeough
• ***KSC Processing***	***Juan Ramirez***
• Verification/Certification: No changes	
• Mission Unique Assessment	Jim Feeley
• Special Topic: IFA STS-87-T-01	Steve Copsey
• Readiness Statement	
• Appendices	
– A: SRM&QA Assessment	
– B: KSC Processing	

KSC Processing - Status

as of 3/26/98

- **Discrepancy Reports (DRs)/Problem Reports (PRs) Review**
  - All PR/MRB * discrepancies/dispositions similar to previously flown vehicles
  - 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

* Included in Appendix B

KSC Processing - Status

as of 3/26/98

- **Changes**
  - ET modifications
    - FEC
      - KET-0034, Reduce ET Intertank thrust panel TPS thickness ** — Discussed with Special Topic
      - KET-0035, Reduce ET Intertank thrust panel valley/sidewall TPS thickness — ↓
      - KET-0036, Install shim on -Y bipod strut at Orbiter yoke interface — Installation not required
    - Bldg 45
      - H0751, Additional weighing of ET-91 — Complete - No issues
  - OMRSD — None
  - Software — None
    - SIM Load — 4/2/98
    - SIM Launch — 3/27/98

* Included in Appendix B

** Previously discussed at Pre-Flight Review

Agenda

• Overview	Jim Feeley
• Changes: No new items	
• Senior Management Review NCDs: None	
• SRM&QA Assessment	Terry McKeough
• KSC Processing	Juan Ramirez
• Verification/Certification: No changes	
• ***Mission Unique Assessment***	***Jim Feeley***
• Special Topic: IFA STS-87-T-01	Steve Copsey
• Readiness Statement	
• Appendices	
– A: SRM&QA Assessment	
– B: KSC Processing	

Mission Unique Assessment

as of 3/26/98

Category/Item	STS-90
• Review of MRB actions using updated loads	ECD 4/1/98
• MPS Preflight Prediction Package	ECD 4/6/98

Agenda

• Overview	Jim Feeley
• Changes: No new items	
• Senior Management Review NCDs: None	
• SRM&QA Assessment	Terry McKeough
• KSC Processing	Juan Ramirez
• Verification/Certification: No changes	
• Mission Unique Assessment	Jim Feeley
• ***Special Topic: IFA STS-87-T-01***	***Steve Copsey***
• Readiness Statement	
• Appendices	
– A: SRM&QA Assessment	
– B: KSC Processing	

Special Topic - IFA STS-87-T-01

Purpose

- Update Board on status of Intertank thrust panel TPS loss investigation
  - Effects of foam loss on structural integrity and factors of safety of the Intertank thrust panels
  - Investigation findings/conclusions to date
  - Flight rationale for STS-90
  - Root cause scenario determination/discriminator test activity

Special Topic - IFA STS-87-T-01

Effects of foam loss on Intertank TPS requirements and factors of safety of the Intertank thrust panels

- Three reasons for TPS on the Intertank:
  - Prevent ice near the LO2 and LH2 tanks.
  - Maintain structural temperatures and factors of safety during ascent.
  - Maintain rupture altitude for footprint constraint.

- Minimum foam thickness requirements for the LWT thrust panel are driven by:
  - Ice/frost prevention for 12" extending from LO2 tank and 18" extending from LH2 tank
  - Ascent heating on all other acreage

Special Topic - IFA STS-87-T-01

Effects of foam (continued)

- Rationale for flight:
  - Ice
    - Minimum foam thickness required to prevent ice formation has been maintained
    - Foam loss has occurred in flight, not on the ground where ice formation is a concern
    - Inspection by the ice/frost team for launch commit
  - Structural temperatures
    - Four foam loss cases for the LWT have been assumed and analyzed

	Thermal Environment	
	Generic Certification	Mission Specific
– Foam base design configuration	FS > 2.0	FS > 2.0
– Individual divot (≤12.0")	FS > 2.0	FS > 2.0
– No foam on stringer tops and 0.125" thick foam in valleys at areas shown on STS-87	FS = 1.38	FS = 1.44
– No foam at areas shown on STS-87	FS = 1.14	FS = 1.28

Note: Factor of safety for a completely bare thrust panel would be greater than 1.0, but a more rigorous analysis and verification test is needed before a factor can be quoted

Special Topic - IFA STS-87-T-01

Effects of foam (continued)

- Rationale for flight:
  - Rupture Altitude
    - Rupture altitude requirement of < 249,000 ft. is met with a bare thrust panel
    - Photos indicate that foam loss has not been to substrate

- Conclusion:
  - Data/analysis to date indicates that the structure is being maintained at temperatures which results in required factors of safety both for ascent and reentry

Special Topic - IFA STS-87-T-01

Investigation Findings/Conclusions to Date

- NCFI foam is performing well on LH2 tank, LO2 tank and Intertank skin-stringer panels
- Foam loss is the result of interaction of NCFI material characteristics and the unique environments/configuration of the Intertank thrust panel

Effect	Intertank Thrust Panels	Intertank Stringer Panels	LH2 Tank	LO2 Tank
Substrate strain	-	-	Worst	-
Substrate flexure	**Worst**	-	-	-
Substrate vibration	-	Worst	-	-
Pyro shock	(1)	N/A	N/A	N/A
Airloads (in-plane)	**(2)**	-	-	-
Airloads (normal)	**(2)**	-	-	-
Aeroshear	-	-	-	Worst
Acoustics	**Worst**	-	-	-
Oscillating shocks	Worst	Worst	-	-
Crush pressure	-	-	-	Worst
TPS cell burst pressure	-	-	-	-
Acceleration	-	-	Worst	-
Temperature	-	-	Worst	-
Thermal gradient	-	-	Worst	-
Differential expansion	-	-	Worst	-
TPS recession	-	-	-	Worst
Residual stresses	-	-	-	-

(1) Pyro shock not involved in STS-87

(2) Airloads are unique for ribbed configuration

Special Topic - IFA STS-87-T-01

Investigation Findings/Conclusions to Date (continued)

- Uniqueness of thrust panel environment/configuration is the thrust panel flexure and ribbed configuration
- Original combined environments test for NCFI qualification did not include flexure of ribbed panel
  - Flexure test was performed as a bending test on a flat panel
  - Combined environments test performed was representative of environments/configuration of the LH2 and LO2 structure
    - Biaxial substrate strains
    - Cryogenic backface temperatures
    - Acoustics

Note: Acoustics on combined environments panels were tested at Intertank thrust panel acreage levels (170 db) - Little effect of acoustics on the foam

Special Topic - IFA STS-87-T-01

Investigation Findings/Conclusions to Date (continued)

- Major unique contributors believed to be driving failure of NCFI are:
  - Ribbed configuration
  - Flexure

- Normal ascent environments than contribute to drive the failure
  - Aeroloading
  - Vacuum
  - Heating

- Material test has failed to reveal any characteristic which would totally explain the foam loss
  - Mechanical property test
  - Hot gas test
  - Thermal vacuum test

Special Topic - IFA STS-87-T-01

Investigation Findings/Conclusions to Date (continued)

- Additional test was performed on flexure capability of NCFI, plus tests which combined flexure, ribbed panels, aeroshear loading, vacuum, and heating
  - Flexure capability was reduced by approximately 30% in the NCFI as compared to CPR
  - Current fidelity of test has failed to demonstrate failure of foam at STS environment levels

- Corrective action was taken on STS-89/ET-90 by sanding thrust panel foam
  - Test demonstrated improved flexure capability of sanded foam configuration
  - Combined environments test showed more capability with respect to aeroshear loading of rib tops
  - Removal of denser rind material

- STS-89 resulted in less extensive damage when compared to STS-86 or STS-87

Special Topic - IFA STS-87-T-01

Investigation Findings/Conclusions to Date (continued)

Conclusions

- Have not been able to demonstrate root cause with current fidelity of combined environments test
- Primary drivers are believed to be uniqueness of thrust panel configuration/environments in regards to ribbed panels, and flexure
- Corrective action taken in regards to one of the primary drivers (flexure capability) for STS-89 appears to have reduced severity of tile damage

Special Topic - IFA STS-87-T-01

Flight Rationale for STS-90

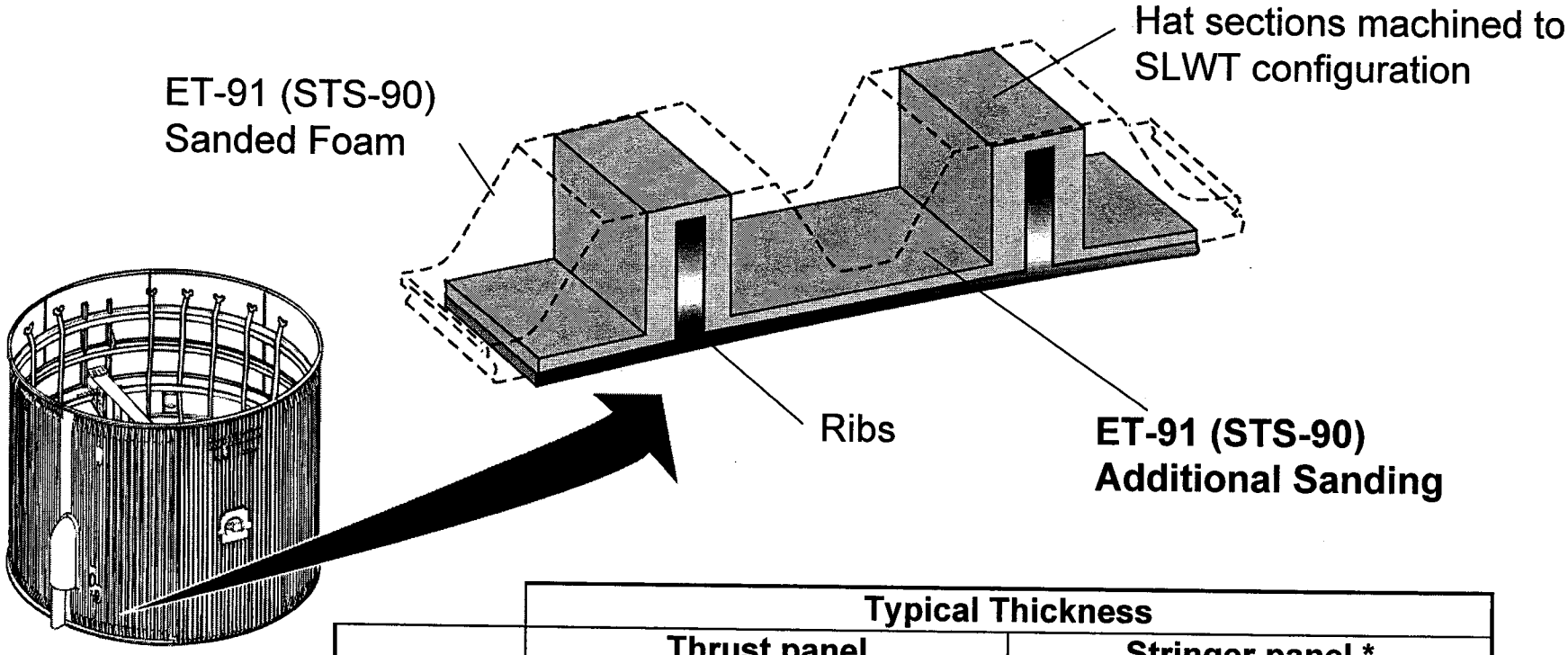
- Philosophy was to continue taking the system in the direction of goodness, as demonstrated by tests, in relationship to what is considered to be a primary failure driver

- Additional sanding was performed on STS-90 in order to further improve system in flexure

- Factor of safety for flexure = 1.51 for STS-90 vs 1.10 for STS-89

Special Topic - IFA STS-87-T-01

Flight Rationale for STS-90



	Typical Thickness			
	Thrust panel		Stringer panel *	
Location	**STS-89/ET-90**	**STS-90/ET-91**	**STS-89/ET-90**	**STS-90/ET-91**
• **Tops**	0.70"	0.50"	1.3"	0.55"
• **Valleys**	1.3"	0.50"	1.5"	0.55"

* Completely machined for STS-90/ET-91

Special Topic - IFA STS-87-T-01

Flight Rationale for STS-90

- Sanded configuration on STS-90 has been assessed for adequacy of flight
  - Baselined sand to minimum thicknesses area adequate to maintain ice formation protection and ascent/reentry structural temperature protection
  - Local over sanded areas have been assessed and positive margins of safety were maintained in all cases
  - Some differences area expected with the machined rib configuration
    - Sharp corners at top of ribs may initially erode faster than more rounded corners
      - Wind tunnel test of divots shows this recession slows to normal rate as the edges are rounded
    - Flow separation on backside of rib may cause slightly higher P from the crossflow
      - Accounted for in the rib delta P from Level II
        - Delta P for SLWT has been increased to 8.3 psi from 7.2 psi (16%) for LWT
        - Part of the increase is from higher Q for SLWT but 8.3 was considered for this LWT
      - Height of foam unsupported by the rib has been reduced by 28%
      - The increased loading coupled with the decreased area results in a net increase in the factor of safety for rib top shear off

Special Topic - IFA STS-87-T-01

Flight Rationale for STS-90

Conclusions

- Additional sanding was performed on STS-90 in order to continue to move the system in the direction of goodness
- Factor of safety against what in considered a prime driver in foam loss (flexure) has been increased
- Sanded configuration meets all ice formation protection and ascent/reentry structural temperature protection requirements
- Possible interactions of the sanded configuration to the thrust panel environments has been scrutinized and found acceptable

STS-90 is Acceptable for Flight

Special Topic - IFA STS-87-T-01

Root Cause Demonstration/Discriminator Test Activity

- Team has performed the testing that could be performed in short order
- Fidelity of testing was not sufficient to drive out root cause scenario
- Higher fidelity tests with more accurate representation and combination of environments are needed
- Activity to define and develop that test has been started
  - Further definition of environments and timelines
  - Any additional test of foam for response to individual environments
  - Combining of individual environments in a progressive manner as driven by timelines and response of foam seen in individual environments tests
- Additional test development represents a substantial technical challenge
- Project is working with Level II and the SRB Project on the possibility of placing cameras in the forward skirt of the SRBs

Special Topic - IFA STS-87-T-01

Conclusion

- Foam loss is driven by an interaction between the NCFI foam characteristics and the unique Intertank thrust panel configuration/environments
- What are believed to be the primary drivers for the thrust panel foam loss have been identified
- Current level of fidelity of test has not been sufficient to demonstrate the failure
- Interim corrective action taken on STS-89 against what is believed to be one of the primary drivers (flexure), improved the system but did not eliminate the problem
- Additional corrective action taken for STS-90 should continue to improve the system
- One of the primary drivers (flexure) will be dramatically reduced with the advent of SLWT
- Work is proceeding on the definition and development of higher fidelity combined environments test

Readiness Statement

The External Tank, ET-91 is hereby certified and ready for STS-90 flight pending completion/closure of open and planned work

Terry L. Hibbard
Vice President, External Tank Project
Lockheed Martin Michoud Space Systems

Appendices

- **A: SRM&QA Assessment**
  - NCD Assessment Criteria
  - CAPS P-063, Naflex Seal Leak

- **B: KSC Processing**
  - Alternate Blowing Agent Usage at KSC
  - Software Changes: None
  - OMRSD Exceptions/Waivers: None
  - OMRSD Changes (RCNs): None

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

CAPS P-083, Naflex Seal Leak

Issue:

- LH2 recirculation line to umbilical joint leaked at a rate of 52.00 SCCM during TP-8C101-FA leak test

Background:

- Allowable leak rate is 10.00 SCCM
- Joint disassembly revealed a piece of integrity seal adhered across the primary sealing surface of the recirculation line
- Three defects in the teflon coated primary sealing surface of the Naflex seal

Cause:

wo causes:

- Foreign material across the flange face sealing surface on LH2 recirculation line
- Defects in the teflon coating of the Naflex seal

Corrective Action:

- Foreign material on LH2 recirculation line flange
  - New integrity seals ordered that are in color contrasting to white clean gloves
  - Practitioners notified via crew meetings of importance to maintain clean
- GFP Naflex seal
  - None, GFP hardware returned to Boeing North American. This will be tracked by standard MSFC tracking for GFP problems

Clearance of Effectivities:

- All ETs successfully passed the TMO4 leak check requirements

ET-91 DR/PR/OMRSD Waiver/Exceptions

as of 3/26/98

System	Discrepancy	Problem	MRB Items	Exceptions/ Waivers
• **Electrical**	0	0	**0**	0
• **Propulsion/ Pneumatics**	0	3	**1** (1)	0
• **Structures**	3	2	**0**	0
• **Thermal (TPS)**	0	14	**10** (3)	0
Total	**3**	**19**	**11** (4)	**0**

(*) Previously discussed at Pre-Flight Review

ET-91 PR/MRBs - Summary, Propulsion

PR No./Status	Title/Description	Disposition
PET-91-FP-0001	Raised metal (0.010") on GO2 2" disconnect bore	Use as is • Defect not in sealing surface • Does not affect form, fit or function of seal

Previously discussed at Pre-Flight Review

ET-91 PR/MRBs - Summary, Thermal

PR No./Status	Title/Description	Disposition
PET-91-TS-0001A	Two exposed fastener heads in valleys of Intertank thrust panels - Occurred during sanding operations	Use as is • Thermal analysis of temperatures in this localized area indicates surface temperature ≈ 150°F – Fasteners designed for use up to 450°F • Critical MS unaffected
PET-91-TS-0001B	Localized area of overtrimmed foam on Intertank thrust panel violated requirement • Worst case: 0.20" • Requirement: 0.35 min.	Use as is • Low foam areas are in non-cryogenic zones • No ice formation/ascent heating concern
PET-91-TS-0001C	Localized area of overtrimmed foam on Intertank thrust panel violated requirement • Worst case: 0.1875" • Requirement: 0.35 min.	Use as is • Low foam areas are in non-cryogenic zones • No ice formation/ascent heating concern

Previously discussed at Pre-Flight Review

ET-91 PR/MRBs - Summary, Thermal

PR No./Status	Title/Description	Disposition
PET-91-TS-0002	Small divot (0.15" deep) in forward ogive foam exceeds acceptable defect size (0.10" max depth) • Located approximately 3 inches aft of Station 371 and behind the LO2 cable tray	Use as is • Area not exposed to direct aero impingement • Thermal analysis indicates adequate thermal protection maintained
PET-91-TS-0004	Crushed foam on +Y aft fairing foam flow restrictor below minimum requirements • Requirement = 0.75" min. • Actual = 0.68"	Use as is • Defect is localized and will not affect flow restrictor performance

Previously discussed at Pre-Flight Review

ET-91 PR/MRBs - Summary, Thermal

PR No./Status	Title/Description	Disposition
ET-91-TS-0008	Area of underfilled MBO foam on LO2 flapper valve port closeout (0.5"w x 2.0"d)	Use as is • No ice formation concerns • Surface smooth enough for acceptable fire barrier
ET-91-TS-0009	Intertank foam sanding resulted in 12 areas of low foam on the -Y thrust panel and 1 area on the +Y panel	Use as is • Low foam areas are in non-cryogenic zones • No ice formation/ascent heating/rupture altitude concerns • Spot face aft edges were beveled to 30- 45 degrees
ET-91-TS-0010	Area of crushed NCFI on LH2 tank barrel +Y side of Sta 1284, +Y • Measures 1.5W x 1.5"L x unknown depth	Use as repaired • Removed damaged foam • Primer exposed and 2.0" x 2.0" x 2.3" (triangular shape) x 0.9"D area repaired using PDL

ET-91 PR/MRBs - Summary, Thermal

PR No./Status	Title/Description	Disposition
ET-91-TS-0011	• Six corner defects noted on the +Y thrust panel rework area - All defects equal to or less than 0.25" deep	Use as is • Defects meet minimum foam thickness requirements • Defects violate the 3.0" period waiviness requirement have amplitudes .25 " or less
ET-91-TS-0012	Area of MBO foam and resin interference (.25"x .25") at the upper inboard LO2 pyro can installation port	Use of is • Area of foam/resin was removed to allow installation of tool • Small area of missing resin will not significantly affect bond strength of closeout foam

ET-91 PR/MRBs - Summary, Thermal

PR No./Status	Title/Description	Disposition
ET-91-TS-0014	Three voids and one underfilled bolt hole closeout in the +Y ET/SRB aft fairing PDL close-out	Use as repaired • Localized voids were trimmed and repaired using PDL 1034 • Additional bond lines will not affect the integrity of the close-out

ET-91 Alternate Blowing Agent Usage at KSC

as of 3/26/98

Foam	Document	Description	Location	Size
PDL-1034	PR-TS-0001	Intertank thrust panels plug pull repairs	Sta 852-1123, 115°/245°	10 sq. in.
SS-1171	T5141	Aft hardpoint closeout	Sta 1973-2076, 180°	4410 sq. in.
PDL-1034	T5249	ET/SRB aft fairing closeout	Sta 2058, 70/290°	240 sq. in.
PDL-1034	T5244	ET/Orbiter jack pad closeout	Sta1129, 15/345°	9 sq. in.

Previously discussed at Pre-Flight Review