FLIGHT READINESS STATEMENT
STS-96/ET-100
EXTERNAL TANK PROJECT
PRE-FLIGHT REVIEW

EXTERNAL TANK ET-100/STS-96, AS IDENTIFIED IN THE EXTERNAL TANK PROJECT PRE-FLIGHT REVIEW DATED APRIL, 1999, IS CONSIDERED READY TO SUPPORT FLIGHT UPON ACCEPTABLE DISPOSITION OF OPEN/PLANNED WORK AND/OR OPEN ACTIONS.

for E. C. SMITH/EB01

J. W. KILPATRICK/EL01

for J. L. LUSK/EE31

B. E. GOLDBERG/ED01

for A. F. WHITAKER/EH01

M. D. SMILES/CR70

A. O. GOODSON/CR01

P. V. COUNTS/SA31, CHAIRMAN

April 8, 1999

Space Shuttle
External Tank

STS-96/ET-100 Pre-Flight Review

CLEAR ET B CYCLE CHANGE THRU PRCB PRIOR TO S/S FRR

CLARIFY ET 100 TANK CYCLE BASIS FOR CERT

FOAM VENTING
- NEED POPCORNING VIDEO PLUS 20 SET OF TERMINAL VTR PANELS
- NEED SAMPLES FOR FRR
- MORE INFO THAN SDR CHANGE OFFERED
- STRUS PLAN FOR VENTING/NON-VENTING

CNC
- RECORD TWO AREAS
- ADD SECTIONS OF LOUVERS/DWG

GENERAL - WORK ON EXIT TEST CHARTS

Agenda

• ***Overview***	***Jim Feeley***
• ***Prior Mission Performance Summary***	
• ***Current Mission/External Tank Highlights***	
• ET-100 Mass Properties Status	Rick Spring
• Changes	
• Senior Management Review NCD	Steve Copsey
- Intertank Low Plug Pull Values	
• Special Topics	
- Nose Cone Removal and Replacement	Jim McAllister
- LH2 Tank Barrel Panel Inserts	Rob Champagne
• SRM&QA Assessment	Mike Bankester
• KSC Processing	Doug Powell
• Verification/Certification	Jim Feeley
• Mission Unique Assessment	
• Readiness Statement	
• Appendices	
- A: Minor Changes	
- B: SRM&QA Assessment	
- C: KSC Processing	
- D: Level II Waivers/Level III Deviations	

Overview

- This review for STS-96/ET-100 includes:
  - Items specific to mission STS-96
  - First time changes, differences and "out of family" non-conformances not previously flown and/or reviewed

- **FRR Series**

- ET/SRB Mate Review	03/12/1999
- Pre-flight Review	04/08/1999
- Space Shuttle Vehicle Pre-FRR	04/14/1999
- Space Shuttle Vehicle FRR	05/05/1999
- Mission Management Team (L-1 Day)	TBD

Prior Mission Performance Summary

STS-88/ET-97, 12/04/98

System	Performance
OMRSD/LCC	No Violations
Instrumentation	Nominal

Prior Mission Performance Summary

STS-88/ET-97, 12/04/98

System	Performance
MPS	• Nominal
ET Hazardous Gas	• Nominal
ET disposal	• Nominal
TPS	• Nominal
Orbiter tile damage	• Lower surface, above average - Diameter > 1" = 21 - Total = 70
Post flight photo review	• Images from hand held 35mm inconclusive - Details not discernible • Images from umbilical well cameras were dark

Mission/External Tank Highlights

STS-96/ET-100, 05/20/1999

Mission	**STS-96** 20
• Launch	05/~~24~~/1999
- Window	07:58-08:08 EDT (10 minutes)
- Pad	B
- Orbiter	Discovery (OV-103)
- Orbital inclination	51.6° - Insertion at 173 NM
- ET photo coverage	• Crew photos from cockpit window • Umbilical well cameras • SRB cameras
• Primary payload	ISS (2A.1)
• Landing	06/03/1999 6/11
- Time	03:54 EDT
- Location	KSC

External Tank	**ET-100**
• DD250 acceptance	11/25/1998
• Shipped to launch site	12/13/1998

Agenda

• Overview	Jim Feeley
• Prior Mission Performance Summary	
• Current Mission/External Tank Highlights	
• ***ET-100 Mass Properties Status***	***Rick Spring***
• Changes	
• Senior Management Review NCD	Steve Copsey
- Intertank Low Plug Pull Values	
• Special Topics	
- Nose Cone Removal and Replacement	Jim McAllister
- LH2 Tank Barrel Panel Inserts	Rob Champagne
• SRM&QA Assessment	Mike Bankester
• KSC Processing	Doug Powell
• Verification/Certification	Jim Feeley
• Mission Unique Assessment	
• Readiness Statement	
• Appendices	
- A: Minor Changes	
- B: SRM&QA Assessment	
- C: KSC Processing	
- D: Level II Waivers/Level III Deviations	

ET-100 Mass Properties Status

Subject:

- ET-100 Weight Status

Status:

- The specification weight for ET-100 is 58,470 lbs
- The nominal control weight for SLWT is 58,505±511 lbs
  - ET-100 was weighed 1/ 5/ 99 @ KSC
    - Predicted 58,330 lbs
    - As-weighed 58,356 lbs
    - Delta + 26 lbs
- ET-100 predicted weight meets specification weight requirement
- ET-100 as-weighed weight meets control weight requirement
- Per RCN KT13533M, ET 100 was the first External Tank to be weighed in the horizontal position using the compression weighing system.

Agenda

• Overview	Jim Feeley
• Prior Mission Performance Summary	
• Current Mission/External Tank Highlights	
• ET-100 Mass Properties Status	Rick Spring
• ***Changes***	
• Senior Management Review NCD	Steve Copsey
- Intertank Low Plug Pull Values	
• Special Topics	
- Nose Cone Removal and Replacement	Jim McAllister
- LH2 Tank Barrel Panel Inserts	Rob Champagne
• SRM&QA Assessment	Mike Bankester
• KSC Processing	Doug Powell
• Verification/Certification	Jim Feeley
• Mission Unique Assessment	
• Readiness Statement	
• Appendices	
- A: Minor Changes	
- B: SRM&QA Assessment	
- C: KSC Processing	
- D: Level II Waivers/Level III Deviations	

Changes List

Description	ET-99	ET-100	Presenter
Requirement			
• ***ET Pre-Launch Cycle Limit***		**STS-96 ✓**	**Don Bolstad**
Configuration			
• Redesign of LO2 Barrel Panels		X ✓	Jim McAllister
• Circumferential Rib Foam Configuration	X	✓	Steve Copsey
• Propellant Tank Reallocations		Incremental	Appendix A
• Implementation of Dual Cover Pass		Incremental	Appendix A
• Metal LO2 Feedline Fairing - Foam Closeout		X ✓	Appendix A
• RSS Deletion - SRB Beam Changes		X ✓	Appendix A
IFA Related Changes			
• Intertank Thrust Panel Foam Reduction	X	✓	Steve Copsey
• Intertank Thrust Panel Foam Venting		X ✓	Jeffery Pilet
• Installation of Intertank Thrust Panel Instrumentation		X ✓	Louis Palermo
Process			
• No Changes			

X = First Implemented
✓ = First Flown

Revised ET Pre-launch Cycle Limit

Change:

- Proposed revision to OMRS to allow additional ET Pre-Launch pressure cycles on each tank
  - Increased from 7 cycles to 13 cycles

Background:

- Invoked a more severe definition of ET Mission Life
  - Reduces potential for exceeding pre-launch pressure cycle count
- Change worked in conjunction with LH2 Tank Pre-pressurization pressure which also required Simulated Service Life Testing

Revised ET Pre-launch Cycle Limit

Discussion:

- Phased implementation test plan was used to
  - Accept higher LH2 pre-press to improve Block II Engine Life
  - Increase the predicted service life of the External Tanks
- Lot acceptance simulated service testing for 2195 plate has been revised to reflect 13 pre-launch cycles
- All SLWT weld fracture tests now include 13 cycles
- Change from 7 to 13 pre-launch cycles presented to and approved by MSFC Fracture Control Board

Revised ET Pre-launch Cycle Limit

Installation	Requirement	Test	Analysis	Similarity	Inspection
Parent Metal and Welds	Fatigue - Safe Life design shall be adopted for all major load-carrying structures. Structure shall be capable of surviving without failure one proof test cycle and 4x total mission cycles expected.	x	x		

Basis for Certification:

- **Test**
  - 38 simulated service surface flaw specimens
    - All passed imminent failure proof and 4 missions with 13 pre-launch cycles/mission
      - Parent metal, welds and weld repairs
  - 48 da/dN specimens
  - Maximum crack growth per cycle 0.0002"
    - No significant impact to critical flaw size
      - Parent metal or weld: 0.175"
      - Heat repairs: 0.130"
  - Material acceptance testing incorporates increased mission cycle requirement
- Analysis
  - FLAGRO analysis on as-built hardware and weld indications showed 13 cycles acceptable

Changes List

Description	ET-99	ET-100	Presenter
Requirement			
• ET Pre-Launch Cycle Limit		STS-96 ✓	Don Bolstad
Configuration			
• ***Redesign of LO2 Barrel Panels***		***X ✓***	***Jim McAllister***
• Circumferential Rib Foam Configuration	X	✓	Steve Copsey
• Propellant Tank Reallocations	Incremental		Appendix A
• Implementation of Dual Cover Pass	Incremental		Appendix A
• Metal LO2 Feedline Fairing - Foam Closeout		X ✓	Appendix A
• RSS Deletion - SRB Beam Changes		X ✓	Appendix A
IFA Related Changes			
• Intertank Thrust Panel Foam Reduction	X	✓	Steve Copsey
• Intertank Thrust Panel Foam Venting		X ✓	Jeffery Pilet
• Installation of Intertank Thrust Panel Instrumentation		X ✓	Louis Palermo
Process			
• No Changes			

X = First Implemented
✓ = First Flown

Redesign of LO2 Barrel Panels

J31163

Change:

- Redesigned LO2 Barrel Panels by revising the longitudinal primary and secondary weld land width and thickness and adding a tertiary weld land

Background/ Reason:

- Initial set of LO2 Barrel Panels welded for ET-96 had unacceptable oil canning after welding
- Numerous contour deviations existed along both sides of the OB-1, 2, 3 and 4 welds on the OSL panel membrane areas
- Special investigation was initiated to find the probable cause for the oil canning

SCRAP

  - Root cause for oil canning in initial ET-96 LO2 Barrel panels was determined to be a result of:
    - Narrow weld lands
    - Weld shrinkage due to
      - 0.485" thickness
      - SPAW weld process

Redesign of LO2 Barrel Panels

J31163

Description:

- To prevent oil canning the LO2 Barrel Panel design was revised as follows:
  - Weld lands resized to accommodate weld shrinkage
    - Weld thickness along OB welds reduced
  - Weld process change was revised from SPAW to VPPA for STS-91/ET-96 flight hardware

#

ADDED 30

Redesign of LO2 Barrel Panels

Installation	Requirement	Test	Analysis	Similarity	Inspection
LO2 Barrel Panel Assembly	Maintains minimum factor of safety	x	x		x
	Al 2195 Welds - Processes and quality standards shall meet updated requirements and design values for initial welds and weld repairs shall be documented	x			
	ET design shall consider presence of crack, crack-like flaws or other stress concentrations	x			

Basis for Certification:

- Test
  - Developed weld schedule for new weld thickness and weld process
    - Certified weld schedules
    - Test Program included tensile and fracture tests
    - All tests within design requirement values
  - LO2 Tank proof test
    - Provides minimum of 104% strength demonstration at OB weld land

Redesign of LO2 Barrel Panels

J31163

Basis for Certification (continued):

- Stress Analysis
  - Minimum shell strength and stability factors of safety unchanged
- Inspection
  - Measured contour along OB welds
    - No new contour issues

Changes List

Description	ET-99	ET-100	Presenter
Requirement			
• ET Pre-Launch Cycle Limit	STS-96 ✓		Don Bolstad
Configuration			
• Redesign of LO2 Barrel Panels		X ✓	Jim McAllister
• ***Circumferential Rib Foam Configuration***	***X***	✓	***Steve Copsey***
• Propellant Tank Reallocations	Incremental		Appendix A
• Implementation of Dual Cover Pass	Incremental		Appendix A
• Metal LO2 Feedline Fairing - Foam Closeout		X ✓	Appendix A
• RSS Deletion - SRB Beam Changes		X ✓	Appendix A
IFA Related Changes			
• ***Intertank Thrust Panel Foam Reduction***	***X***	✓	***Steve Copsey***
• Intertank Thrust Panel Foam Venting		X ✓	Jeffery Pilet
• Installation of Intertank Thrust Panel Instrumentation		X ✓	Louis Palermo
Process			
• No Changes			

X = First Implemented
✓ = First Flown

Circumferential Rib Foam Configuration

J31189

Change:

- Revised Intertank circumferential rib foam configuration
  - First implemented on STS-93/ET-99
    - Presented and accepted at STS-93/ET-99 ET/SRB Mate Milestone Review
  - First scheduled flight STS-96/ET-100

Background/ Reason:

- Quality of hardware improvements
  - Eliminated all exposed close-out bond lines at circumferential rib locations
  - Modified manual spray to decrease number of potential repairs
  - Significantly reduced number of exposed PDL repairs on the thrust panel
    - NCFI 24-124 completely covers SS1171/BX-250 wedges on thrust panel
    - Implemented same geometry on all SLWT circumferential ribs as was flown on LWT forward "Bathtub" ribs
  - Deleted isolated circumferential rib foam closeout
  - Reduced surface prep/foam application and trim process effort
  - Simplified (Cell "L") auto machining effort

Circumferential Rib Foam Configuration

J31189

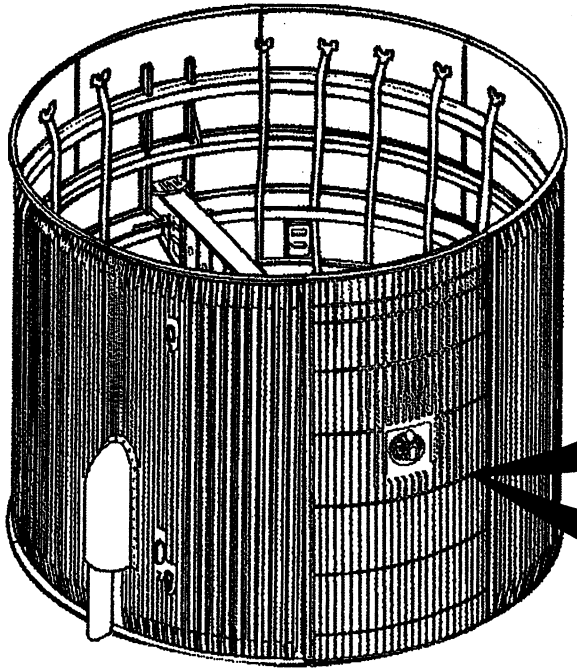
Description:

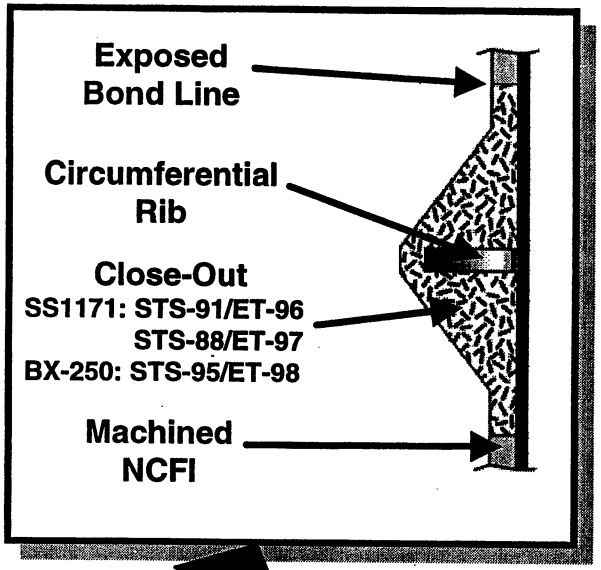
- Current configuration replaces SS1171/BX-250 isolated circumferential rib foam closeout with a wedge configuration
  - Apply SS-1171 adjacent to each circumferential rib and machine to angle of 35±5°
  - Subsequently apply NCFI 24-124 to Intertank and power machine to final configuration
- Prior rib configuration required SS1171/BX-250 close-out
- Foam configuration change reduced repairs and exposed closeouts
- Foam wedge configuration similar to configuration flown on LWT "Bathtub" on ET's 88-91

Circumferential Rib Foam Configuration

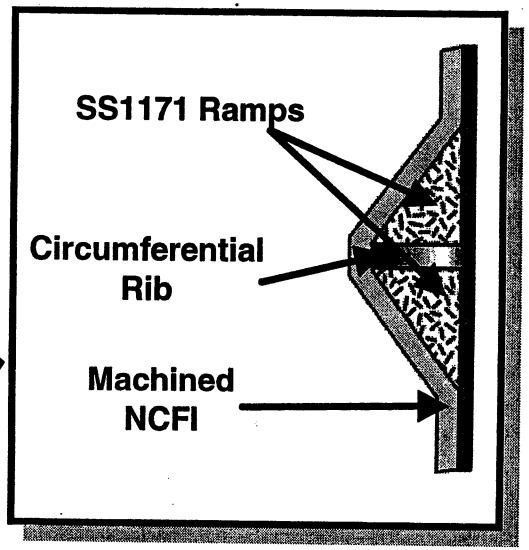
J31189

SLWT WAS



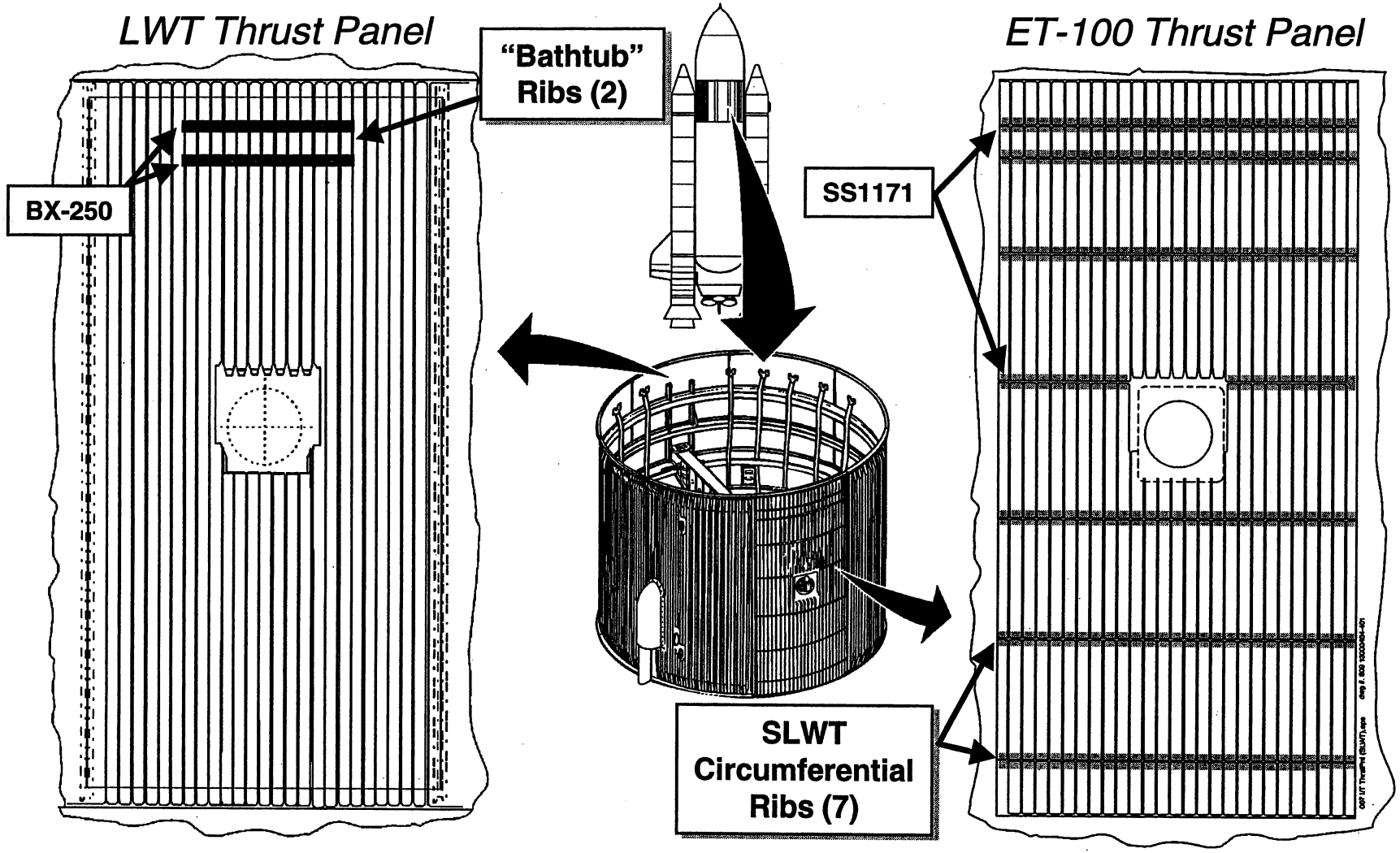


SLWT NOW



Circumferential Rib Foam Configuration

J31189



Circumferential Rib Foam Configuration

J31189 - Certification Matrix

Installation	Requirement	Test	Analysis	Similarity	Inspection
Intertank Thrust Panel	Maintain Minimum Factor of Safety		x		
	Performs after and during exposure to local temperature extremes		x		
Circumferential Rib TPS	Maintain Minimum Factor of Safety		x		
	Maintain components within acceptable temperature limits		x		
	No debris allowed from critical zone *		x	x	

* Waiver processed to accept potential violation of "debris prevention" paragraphs in Level II and Level III specifications

Basis for Certification:

- Analysis
  - Thermal
    - New configuration does not change heating rates
    - Thermal performance of new material (NCFI) is better
      - Structural temperatures lower than prior configuration
  - Structural Factor of Safety (panel buckling)

Element	*Required*	*Was*	*Now*
Thrust Panel	2.0	>2.0	>2.0

  - TPS Factor of Safety (S.T. Tension)

Element	*Required*	*FS*
BX250 Closeout (was)	1.10	2.38
NCFI over SS1171 (now)	1.10	2.04

Intertank Thrust Panel Foam Reduction

FEC KET-0047

Change:

- Reduce foam thickness in "non-automated machined" or "thick" foam area on Intertank Thrust Panel (FEC KET-0047)
- Apply grid markings using Staedtler Lumocolor marker
  - Enhances analysis in-flight photographs

Background:

- Reduced Intertank foam thickness on previous flights has demonstrated Orbiter damage less than observed on STS-87/ET-89
  - Size of potential particles is reduced by machining, resulting in less mass available to cause damage
- SLWT Thrust Panel TPS currently auto-machined with the exception of a "thick foam" area in the vicinity of ET/SRB attach fittings
- "Thick Foam" area currently hand machined to remove foam from rib tops and to remove rind from valleys
- Identical foam reduction previously performed on STS-93/ET-99

Intertank Thrust Panel Foam Reduction

FEC KET-0047

Installation	Requirement	Test	Analysis	Similarity	Inspection
Thrust Panel TPS	Maintain Minimum Factor of Safety			x	x
	Maintain components within acceptable temperature limits			x	x
	No debris allowed from critical zone *			x	

* Waiver processed to accept potential violation of "debris prevention" paragraphs in Level II and Level III specifications

Rationale for Acceptance:

- Similarity
  - Similar sanding process used at KSC on previously flown tanks
    - STS-89/ET-90 sanded in Integration Cell after Orbiter mate
    - STS-90/ET-91 sanded in Check Out Cell
  - Circumferential rib configuration similar to machining around LWT Intertank ring frame
  - SRB Camera Grid previously flown on STS-95/ET-98
    - Staedtler Lumocolor pen has been approved marking tool for foam applications throughout life of External Tank Program
- Inspection
  - Foam thickness within current design requirements

Changes List

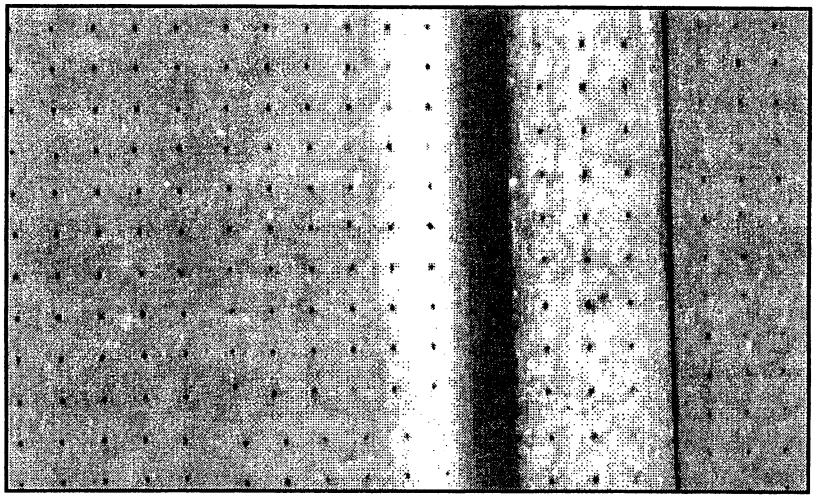
Description	ET-99	ET-100	Presenter
Requirement			
• ET Pre-Launch Cycle Limit		STS-96 ✓	Don Bolstad
Configuration			
• Redesign of LO2 Barrel Panels		X ✓	Jim McAllister
• Circumferential Rib Foam Configuration	X	✓	Steve Copsey
• Propellant Tank Reallocations	Incremental		Appendix A
• Implementation of Dual Cover Pass	Incremental		Appendix A
• Metal LO2 Feedline Fairing - Foam Closeout		X ✓	Appendix A
• RSS Deletion - SRB Beam Changes		X ✓	Appendix A
IFA Related Changes			
• Intertank Thrust Panel Foam Reduction	X	✓	Steve Copsey
• ***Intertank Thrust Panel Foam Venting***		***X*** ✓	***Jeffery Pilet***
• Installation of Intertank Thrust Panel Instrumentation		X ✓	Louis Palermo
Process			
• No Changes			

X = First Implemented
✓ = First Flown

Intertank Thrust Panel Foam Venting

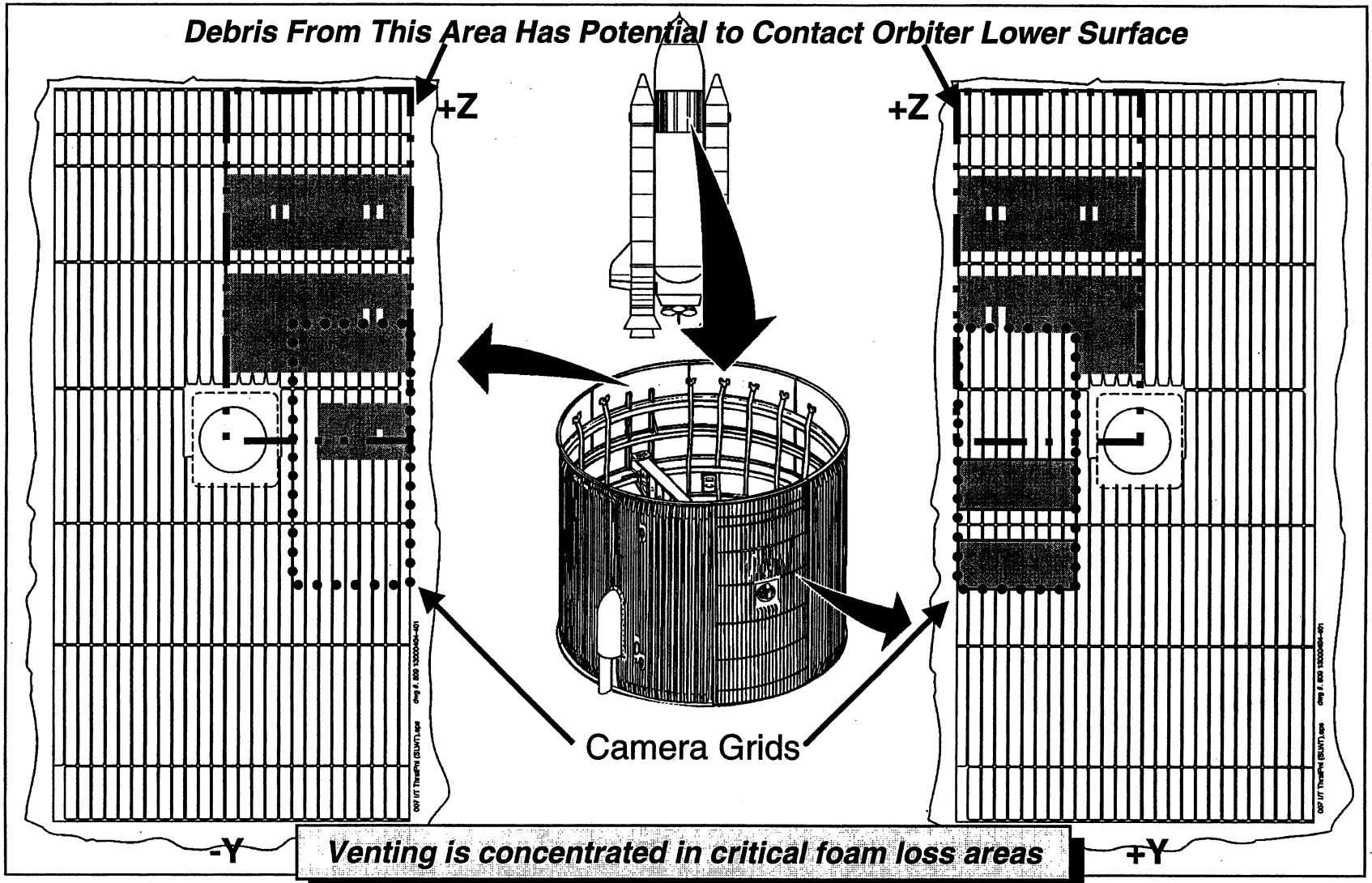
FEC KET-0049

- Change
  - Added vent holes in NCFI 24-124 foam on Intertank thrust panels in selected areas
    - 0.032" diameter pin holes spaced 0.30" apart
  - Selection of proposed vent areas involved several considerations
    - BNA-identified region of thrust panel from which debris can impact Orbiter lower surface
    - SRB camera view
    - Certification program constraints
      - Only configurations representative of those tested are included



Intertank Thrust Panel Foam Venting

FEC KET-0049



Denotes Proposed Venting Area

Intertank Thrust Panel Foam Venting

FEC KET-0049

- Background
  - Post flight inspection of STS-87 revealed out-of-family damage to the Orbiter tiles caused by foam loss from the ET Intertank Thrust Panel
    - Joint NASA/LMC team established to investigate causes of foam loss and determine corrective actions
  - Thrust panel foam divots visible from STS-95/ET-98 SRB video provided additional insight into a mechanism causing foam loss ("popcorning")
    - Timeline established – 92 secs. through SRB separation
    - Critical environments – Low heating rate and vacuum
    - Focused corrective action efforts on developing a solution to reduce "popcorning" foam loss mechanism
      - Popcorning term refers to foam loss occurring as a result of progressive cell wall rupture due to heating trapped gases until cell wall structural capability is exceeded
        - Presence of vacuum and external heating are enabling environments for popcorning foam loss
        - Foam properties, moisture, substrate geometry, spray techniques, foam machining can affect propensity to popcorn

Intertank Thrust Panel Foam Venting

FEC KET-0049

- Corrective Action Process
  - Candidate measures to reduce tendency to popcorn were investigated
    - Test beds developed to replicate popcorn phenomenon
      - Thermal/vacuum tests did replicate the popcorn phenomenon and were used to assist screening process
    - Of options available for near-term implementation, "venting" the foam showed the most promise
      - Thermal/vacuum screening tests using vented and non-vented foam showed a measurable reduction in size and amount of popcorn-type foam loss
      - Vent option approved by PRCB on 03/30/1999 for implementation on STS-93/ET-99 and STS-96/ET-100

Intertank Thrust Panel Foam Venting

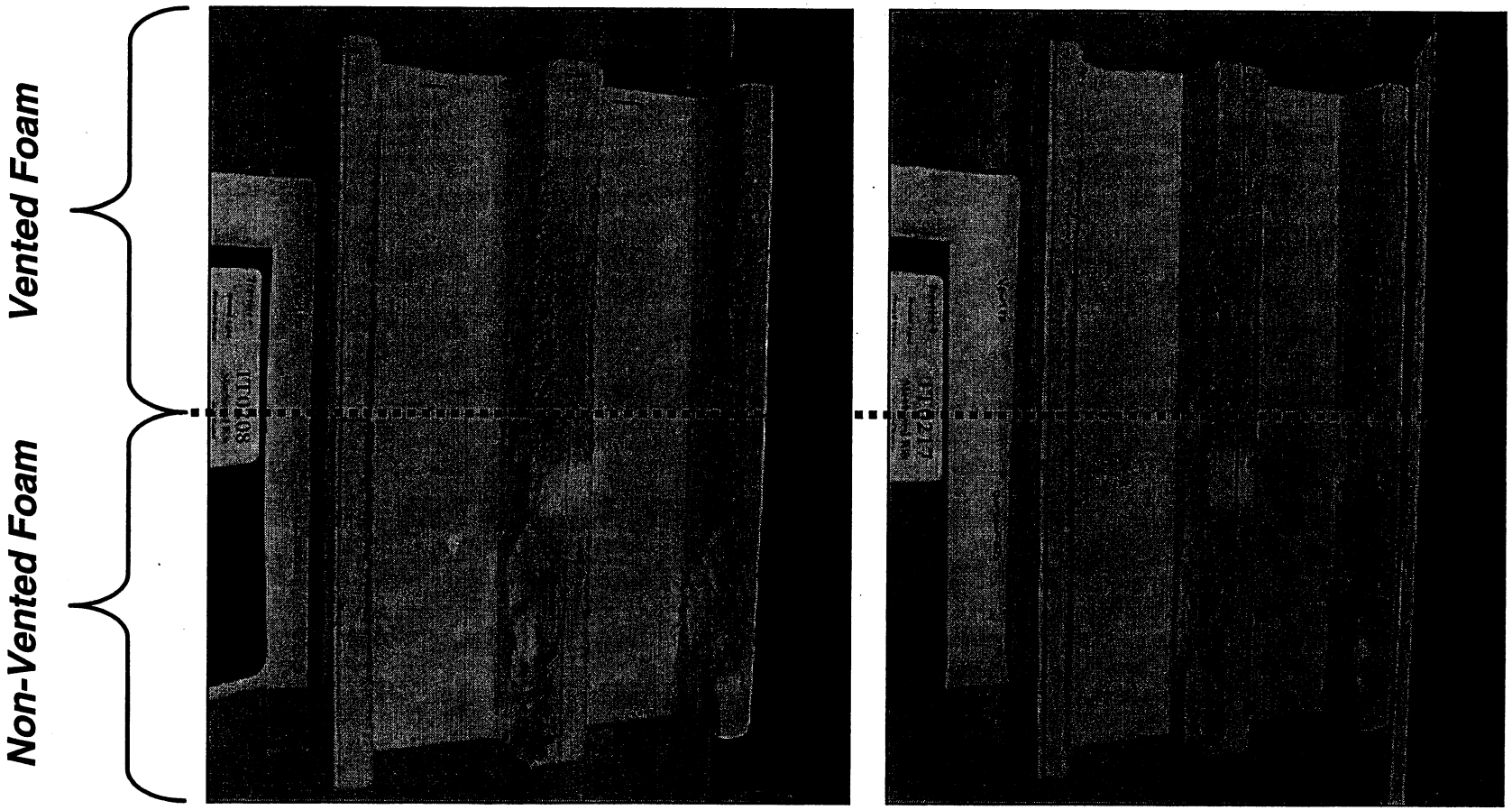
FEC KET-0049

- Certification Process for Vented Foam
  - The objectives of the certification process were to:
    - Certify no harm is done by foam venting process
    - Demonstrate that a potential to achieve a reduction in foam loss exists
  - Both vented and non-vented foam specimens were subjected to a series of tests representing enveloping combinations of environments and parameters
  - Key Discriminatory Tests
    - Hot Gas Environments Tested
      - Heating
      - Vacuum
      - Flexure
      - Aeroshear
    - Thermal Vacuum Environments Tested
      - Heating
      - Vacuum
      - Flexure

Intertank Thrust Panel Foam Venting

FEC KET-0049

- Certification Test Results - Typical Ribbed Thermal/Vacuum Test Panels



Thermal/vacuum tests demonstrated vented foam is less susceptible to popcorning foam loss mechanism

Intertank Thrust Panel Foam Venting

FEC KET-0049

- Certification Process for Vented Foam (continued)
  - Full-scale demonstration of venting techniques using Ground Vibration Test Article (GVTA)
    - Timelines established
    - Personnel, tooling and build paper certified
    - Adjacent foam not damaged
    - KSC ergonomics demonstrated
      - Replicated ET configuration and access in VAB (i.e. SRB mock-up and access/scaffolding)
  - Result from all performance testing shows that vented foam performs as well as or better than the non-vented foam configuration and measurably reduces foam loss

Intertank Thrust Panel Foam Venting

FEC KET-0049

- Certification Test Program Summary

Certification Test	No. of Tests	Test Plan	Humidity	Salt Fog
IFA/DOE "Root Cause" Testing				
Thermal Properties				
DSC (Differential Scanning Calorimetry)	21	826-2000-23F	X	X
TGA (Thermal Gravmetric Analysis)	21	826-2000-23F	X	X
Flight Verification				
Hot Gas - Rib Panels				
Net Spray DOE A	17	3917-98-004C	X	
Net Spray DOE B	36	826-2000-10		
Thermal/Vacuum				
Net Spray DOE A	24	3917-98-004C	X	
Wind Tunnel (AEDC), Machined foam	8			
F-15 Test	6	826-2000-13		
Vibro/Acoustic Test (DOE C)	11	826-2000-12	X	
Pyro Shock *	8	3917-98-002A		

* Note: Certification for Pyro Shock Phase II by analysis. Certification report documenting analysis will be provided.

Intertank Thrust Panel Foam Venting

FEC KET-0049

- Certification Test Program Summary (continued)

Certification Test	No. of Tests	Test Plan	Humidity	Salt Fog	Vented
Vented Foam Certification Testing					
Mechanical Properties/Acceptance Testing					
Density	200	826-2000-23F			X
Bond Tension	540	826-2000-23F	X	X	X
Flatwise Tension	540	826-2000-23F	X	X	X
Lap Shear	360	826-2000-23F	X		X
Plug Pulls	144	826-2000-23F		X	X
Flexure (Ribbed panels)	24	826-2000-23F	X		X
Thermal Properties					
Thermal Conductivity	24	826-2000-23F	X	X	X
Flight Verification					
Hot Gas - Flat Panels, Machined foam	20	826-2000-23F	X	X	X
Hot Gas - Rib Panels, Machined foam	63	826-2000-23F	X	X	X
Thermal/Vacuum, Flat Panels, Machined foam	40	826-2000-23F	X	X	X
Thermal/Vacuum, Single Rib Panels, Machined foam	14	826-2000-23F			X
Thermal/Vacuum, Rib Panels, Machined foam	24	826-2000-23F	X	X	X
Wind Tunnel (AEDC), Machined foam	4	826-2000-23F			X
Vibro/Acoustic Test (DOE C Addendum Testing)	6	826-2000-12(add)	X		X
Process Verification/Acceptance					
Full-Scale Process Pathfinder (GVTA)	1	826-2000-33			X

Intertank Thrust Panel Foam Venting

FEC KET-0049

- Requirements Traceability for Vented Foam

The following requirements are applicable to the ET Intertank TPS (Ref. End Item Specification Doc. No. CPT01M09A):

- ***Performance Requirements***

General ET

3.2.1.1.17	ET Debris Limits (In conjunction w/Waiver, DAR No. MMC-ET-233)

Thermal Protection Subsystem Performance

3.2.1.6.1	General - TPS Requirement
3.2.1.6.1.3	Intertank TPS
3.2.1.6.1.5	TPS Safety Factor

Operational

3.2.5	Useful Life
3.2.5.1	Pad Stay Time
3.2.9	Storage

Environments

3.2.7.1	Natural Environments
3.2.7.2	Induced Environments

- ***Design Requirements***

3.3.1.1	Materials and Processes
3.3.3.4.1	TPS Temperature

Intertank Thrust Panel Foam Venting

FEC KET-0049

- Requirements Traceability Matrix for Intertank Thrust Panel TPS

		Requirement		Method of Cert. (Non-Vented)				Method of Cert. (Vented)			
EIS Para.	Specification Title	Specification Summary	Derived	Test	Analysis	Similarity	Inspection	Test *	Analysis	Similarity	Inspection
Performance Requirements											
General ET											
3.2.1.1.17	ET Debris Limits (In conjunction w/Waiver)	No debris allowed from critical zone (popcorn allowed per waiver)	No debris (Normal ablation products acceptable)	X				5a, 9-12, 14-15	X†		
Thermal Protection Subsystem Performance											
3.2.1.6.1	General - TPS Requirement	TPS must maintain boiloff rates to meet propellant delivery requirements	Propellant requirements to meet NSTS 08209, Vol 1		X			N/A**	N/A**	N/A**	N/A**
		Prevent ice accumulation	Temps to meet reqmt's of 07700 Appen. F		X			N/A**	N/A**	N/A**	N/A**
		Maintain components with-in acceptable temp. limits	Temps to meet EIS S.F. reqmt's		X				X		
		Protect ET structure from aerodynamic and interference heating, engine and SRB exhaust heating, and SRB separation motor plume heating	Thermal Properties per 80900200102 ***	X	X			9-12, 14-15	X		

* For test ID, see chart ET-36

** Not applicable, venting will not be performed in cryogenic areas (i.e., outside of ice frost zone).

*** Thermal properties: Thermal conductivity, recession rates, etc.

† Only foam on thin ribs was tested; analysis concludes that foam on thin ribs is the bounding case and testing of foam on thick ribs is not required

Intertank Thrust Panel Foam Venting

FEC KET-0049

- Requirements Traceability Matrix for Intertank Thrust Panel TPS

		Requirement		Method of Cert. (Non-Vented)				Method of Cert. (Vented)			
EIS Para.	Specification Title	Specification Summary	Derived	Test	Analysis	Similarity	Inspection	Test *	Analysis	Similarity	Inspection
Performance Requirements (continued)											
3.2.1.6.1.3	Intertank TPS	Protect ET structure from induced environments	Thermal Properties per 80900200102 ***	X	X	X		9-12, 14-15	X	X	
3.2.1.6.1.5	TPS Safety Factor	Provide thermal protection to maintain EIS structural Safety Factor requirements	Temps to Meet EIS S.F. reqmt's	X	X			9-12, 14-15	X		
		Maintain TPS Factor of Safety of 1.1 x limit load through MECO	S.F.(TPS) ≥ 1.1	X	X			9-12, 14-15	X		
		Maintain Structural Factor of Safety of 1.0 x limit load from MECO through safe separation	S.F.(Structure) ≥ 1.0		X				X		
Operational											
3.2.5	Useful Life	Six year storage life	STP material prop. Reqm'ts ****	X			X	9-12, 15		X	X
3.2.5.1	Pad Stay Time	TPS must protect ET and withstand launch pad environments for 180 days.	STP material prop. Reqm'ts ****	X	X	X		9-12, 15	X	X	
3.2.9	Storage	Protect ET structure per EIS after exposure to storage environments	STP material prop. Reqm'ts ****	X			X	9-12, 15		X	X

* For test ID, see chart ET-36

*** Thermal properties: Thermal conductivity, recession rates, etc.

**** Vented foam certified by tests identified above in conjunction with long term storage assessment (Doc. No. 826-2045-17, -18)

Intertank Thrust Panel Foam Venting

FEC KET-0049

- Requirements Traceability Matrix for Intertank Thrust Panel TPS

		Requirement		Method of Cert. (Non-Vented)				Method of Cert. (Vented)			
EIS Para.	Specification Title	Specification Summary	Derived	Test	Analysis	Similarity	Inspection	Test *	Analysis	Similarity	Inspection
Performance Requirements (continued)											
Environments											
3.2.7.1	Natural Environments	Protect ET structure from natural environments	STP material prop. Reqm'ts ****	X	X	X		9-12, 15	X	X	
3.2.7.2	Induced Environments	Protect ET structure from induced environments	STP material prop. Reqm'ts ****	X	X	X		9-12, 15	X	X	
Design Requirements											
3.3.1.1	Material and Processes	Must use approved materials and processes per MMC-ET-SE16	Meet MMC-ET-SE16 requirements	X	X				X	X	
3.3.3.4.1	Temperature	Protect ET structure from induced environments	STP material prop. Reqm'ts ****	X	X	X		9-12, 15	X	X	

* For test ID, see chart ET-36

**** Vented foam certified by tests identified above in conjunction with long term storage assessment (Doc. No. 826-2045-17, -18)

Intertank Thrust Panel Foam Venting

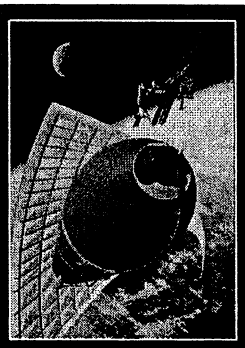
FEC KET-0049

- Peer Review
  - A thorough review of the vented foam certification process was held at Michoud Assembly Facility on March 16, 1999
  - Attendees included representatives of
    - NASA JSC
    - NASA MSFC
    - NASA KSC
    - Lockheed Martin Corporation
    - Independent consultants
  - No constraints to implementation were identified
  - The vented foam configuration was deemed acceptable

Intertank Thrust Panel Foam Venting

FEC KET-0049

- Peer Review



IFA STS-87 T-01 Peer Review
March 16, 1999

Implementation of Vented Intertank Thrust Panel Foam is Acceptable Pending Successful Completion of Planned Testing

MSFC

Parker V. Counts
Manager, External Tank Project

for Alex A. McCool
Manager, Space Shuttle Projects Office

Ann F. Whitaker
Director, Materials & Processes Laboratory

John W. Kilpatrick
Director, Systems Analysis & Integration Laboratory

Benjamin E. Goldberg
Deputy Director, Structures & Dynamics Laboratory

Joe L. Lusk
External Tank Chief Engineer

for Amanda H. Goodson
Director, Safety & Mission Assurance

Robert J. Schwinghamer
Retired Technical Director

Robert S. Ryan
Retired Deputy Director, Structures & Dynamics Laboratory

JSC

Lambert D. Austin
Manager, Space Shuttle Systems Integration

KSC

Stephen A. Minute
Director of Process Engineering

Lockheed Martin/Michoud Space Systems

Terry L. Hibbard
Vice President, External Tank

Ronald W. Wetmore
Director, Launch Support Services

Gale C. Copeland
Chief Engineer

Lockheed Martin Corporate

Ron F. Paulson
Vice President, Engineering and Technology

Arnold D. Aldrich
Director, Program Operations

Intertank Thrust Panel Foam Venting

FEC KET-0049

- Summary
  - A rigorous test program has demonstrated the potential for vented foam to dramatically reduce popcorn-type debris associated with Orbiter lower surface tile damage
  - Vented foam configuration has been certified by test and analysis to do no harm
  - Personnel, tooling and build paper was certified and demonstrated on full-scale pathfinder
  - Plan in work to certify KSC/USA personnel to perform venting operation at KSC if required

- Status
  - ET-100 to Be Vented on 04-07-1999 COMPLETE
  - ET-99 Work Scheduled to start 04-08-1999
    - KSC/USA personnel to be trained during ET-99 process

Changes List

Description	ET-99	ET-100	Presenter
Requirement			
• ET Pre-Launch Cycle Limit		STS-96 ✓	Don Bolstad
Configuration			
• Redesign of LO2 Barrel Panels		X ✓	Jim McAllister
• Circumferential Rib Foam Configuration	X	✓	Steve Copsey
• Propellant Tank Reallocations	Incremental		Appendix A
• Implementation of Dual Cover Pass	Incremental		Appendix A
• Metal LO2 Feedline Fairing - Foam Closeout		X ✓	Appendix A
• RSS Deletion - SRB Beam Changes		X ✓	Appendix A
IFA Related Changes			
• Intertank Thrust Panel Foam Reduction	X	✓	Steve Copsey
• Intertank Thrust Panel Foam Venting		X ✓	Jeffery Pilet
• ***Installation of Intertank Thrust Panel Instrumentation***		***X*** ✓	***Louis Palermo***
Process			
• No Changes			

X = First Implemented
✓ = First Flown

Installation of Thrust Panel Instrumentation

EMK-166

Change:

- Installed flight instrumentation on the ET Intertank -Y & +Y Thrust Panels

Requirement:

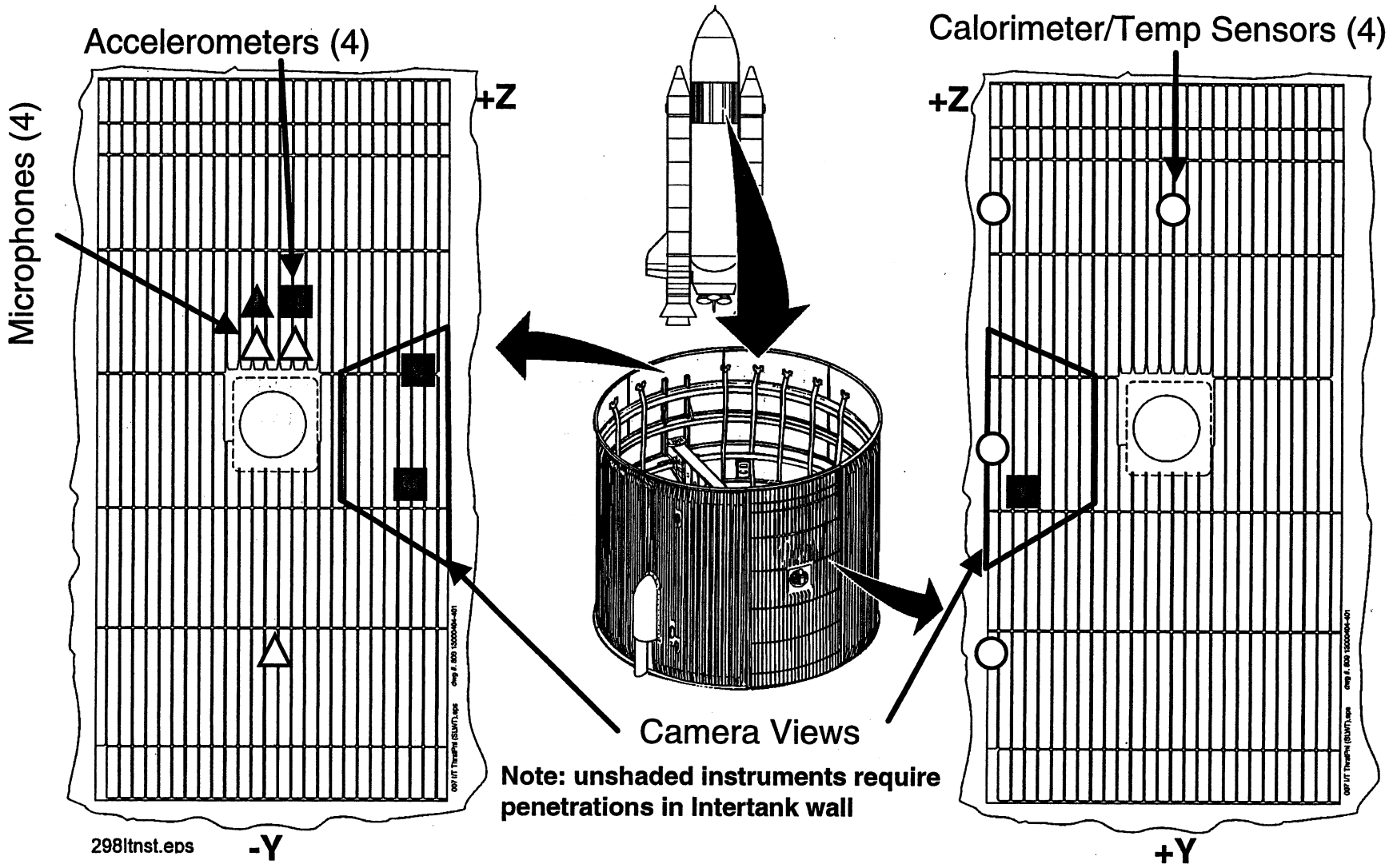
- Gather data necessary to characterize the response of the ET Intertank Thrust Panel in its flight environment to support Intertank TPS IFA root cause assessment

Background:

- Instrumentation on ET-100 is part of a planned incremental data acquisition to support the closure of the ET Intertank Thrust Panel foam loss fault tree
  - Instrument installation and connection to EDAS similar to that flown on STS-95/ET-98 and installed on STS-93/ ET-99
- Installation of cross strap cables and accelerometers approved by PRCBD S071219AR3
  - Presented to Board 02/05/1999
- Installation of calorimeters, microphones, and shock mounts approved by PRCBD S071219AR4
  - Presented to Board 02/26/1999

Installation of Thrust Panel Instrumentation

EMK-166



Installation of Thrust Panel Instrumentation

EMK-166

Description:

- Instrumentation on STS-96/ET-100 includes:
  - Four Accelerometers with Filters
    - Three on -Y Thrust Panel, one on +Y Thrust Panel
    - Accelerometers previously flown on STS-95/ET-98
  - Four Calorimeter/Temperature Sensor Assemblies
    - All on +Y Thrust Panel
    - Temperature sensor installation similar to configuration flown on SRB and installed on STS-93/ET-99
    - Calorimeters similar to calorimeters flown on SRB
      - Installation requires penetration of Intertank wall with SLA closeout to ensure sense ports remain flush with TPS
  - Four Microphones with Filters
    - All on -Y Thrust Panel
    - Installation consists of microphone port installed on the Intertank wall with flex hose connecting to microphone installed on shock mounts
    - Three of the four microphone ports require penetration of the Intertank wall with SLA closeout to ensure sense ports remain flush with TPS

Installation of Thrust Panel Instrumentation

EMK-0166 - Certification Matrix

Installation	Requirement	Test	Analysis	Similarity	Inspection
Accelerometers and Filters	Maintain Minimum Factor of Safety	x	x	x	
	Performs after and during exposure to Intertank temperature extremes			x	
	Performs after and during exposure to Vibration environment			x	
Calorimeter	Maintain Minimum Factor of Safety	x	x	x	
	Performs after and during exposure to Intertank temperature extremes		x	x	
	Performs after and during exposure to Vibration environment	x	x		
Microphones and Filters	Maintain Minimum Factor of Safety	x	x		
	Performs after and during exposure to Intertank temperature extremes		x		
	Performs after and during exposure to Vibration environment	x			
TPS (SLA Closeout)	Maintain Minimum Factor of Safety		x	x	
	Maintain components within acceptable temperature limits		x		
	No debris allowed from critical zone	x	x		

Installation of Thrust Panel Instrumentation

EMK-0166

Basis for Certification:

- Analysis
  - Thermal : Temperatures of Intertank hardware shown to remain within current design limits
  - Intertank Structure Factor of Safety (panel skin buckling)

Thrust Panel Location	*Required*	*Was*	*Now*
Calorimeter Instl.	1.40	1.69	1.69
Microphone Tube Inst.-			
Rib Valley	1.40	2.57	2.57
Rib Top	1.40	2.57	2.57
Adj. To Rib	1.40	1.93	1.93

  - Microphone Tube Factor of Safety (bending)

Element	*Required*	*Was*	*Now*
Microphone Tube.	1.40	n/a	>2.0

  - Shock Mount Installation

Installation Location	Weight (lbs.)	Fastener Description	Factor of Safety	
			Tension	Shear
Crossbeam	2	A - Plate/Rail to Isolator	>10	>10
		B - Rail to Crossbeam	>10	>10
Ring Frame	2	A - Plate/Rail to Isolator	>10	>10
		B - Rail to Ring Frame	>10	>10

  - Instrumentation Bond Factor of Safety (S.T. Tension)

Element	*Required*	*Was*	*Now*
All Bonds	1.40	n/a	>2.0

Installation of Thrust Panel Instrumentation

EMK-0166

Basis for Certification (continued):

- Test
  - Vibroacoustic tests performed on microphones, filters and shock mount hardware
    - Elements withstood ET environments
  - Hot Gas Tests performed at MSFC on sense tube installation
    - SLA closeout around sense tubes showed excellent performance
  - Adhesive bond test performed to ensure instrumentation and cabling will withstand flight environments (79 GRMS)
  - Routine functionality tests to be performed after installation
    - Function end-to-end test
    - Electromagnetic interference test to be performed with RSS powered up during S0008 following Orbiter mate
- **Similarity**
  - Accelerometer installation similar to that flown on STS-95/ ET-98
  - TPS closeouts at wall penetrations are similar to repairs previously flown and use approved materials and processes
  - Shock mounts similar to those used elsewhere on ET

Agenda

• Overview	Jim Feeley
• Prior Mission Performance Summary	
• Current Mission/External Tank Highlights	
• ET-100 Mass Properties Status	Rick Spring
• Changes	
• ***Senior Management Review NCD***	***Steve Copsey***
- ***Intertank Low Plug Pull Values***	
• Special Topics	
- Nose Cone Removal and Replacement	Jim McAllister
- LH2 Tank Barrel Panel Inserts	Rob Champagne
• SRM&QA Assessment	Mike Bankester
• KSC Processing	Doug Powell
• Verification/Certification	Jim Feeley
• Mission Unique Assessment	
• Readiness Statement	
• Appendices	
- A: Minor Changes	
- B: SRM&QA Assessment	
- C: KSC Processing	
- D: Level II Waivers/Level III Deviations	

Intertank Low Plug Pull Values

SMR-98-008

Issue:

- Suspect NCD Initiated to Evaluate STS-96/ET-100 Low Plug Pull Values
- Acceptance plug pulls resulted in low values (36.2 psi 4-measurement average) as compared to Intertank 5 flight historical values (40.2 psi multi-measurement process average)
  - Minimum required value = 30 psi
  - ET-100 minimum value = 31.7 psi

Intertank Low Plug Pull Values

SMR-98-008

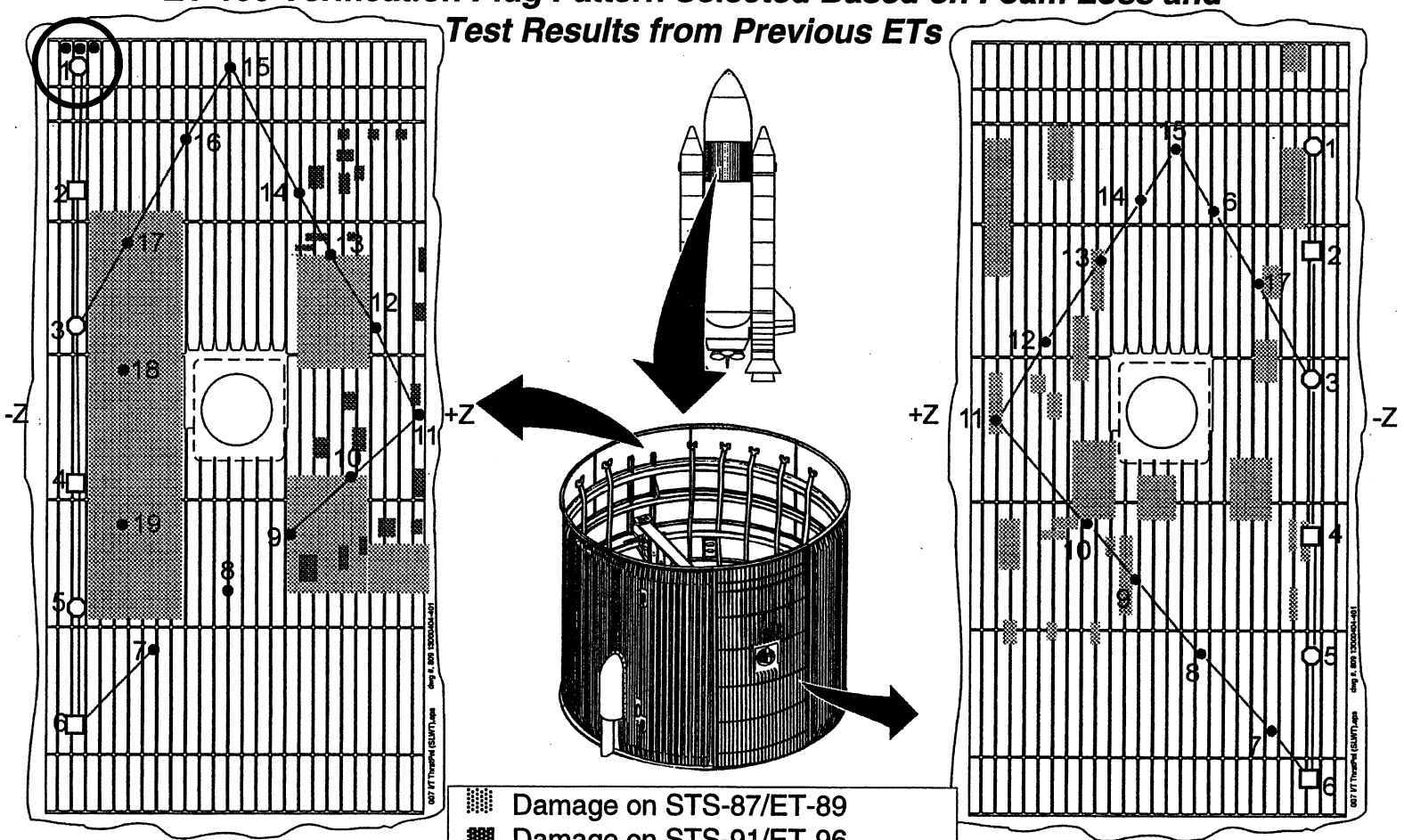
Background:

- Review of fleet material acceptance data initiated to verify acceptable material properties as part of the IFA investigation
  - Processed suspect NCD to perform verification tests for STS-96/ET-100 material property evaluations
  - Established plug pull test pattern consisting of 17 pulls on the +Y thrust panel and 19 pulls on the -Y thrust panel
    - Additional plug pulls performed on STS-89/ET-90 (15) and STS-90/ET-91 (7)
- STS-86/ET-88 and STS-87/ET-89 (first 2 flights of NCFI 24-124) had individual value results below 30 psi and had significant number of Orbiter damage locations
  - Required retest
  - Procedures specify that values below 30 psi are excluded after successful retest
    - STS-86/ET-88 = 41.6 psi average
    - STS-87/ET-89 = 40.2 psi average

Intertank Low Plug Pull Values

SMR-98-008

ET-100 Verification Plug Pattern Selected Based on Foam Loss and Test Results from Previous ETs



Intertank Low Plug Pull Values

SMR-98-008

Verification Plug Pull Results :

- Additional test effort resulted in 56.2 psi average
- Some plug pulls exhibited non-standard core height (<1")
  - Data was normalized using correlation factors developed for non-standard core height
    - Resulted in 47.2 average
  - Review of material acceptance tests indicated no evidence of anomalous material characteristics
  - Analysis of test material indicated no evidence of anomalous material characteristics
- One non-conforming value obtained on -Y thrust panel evaluation pulls (11 psi - included in averages)
  - Three additional pulls were performed in adjacent area
  - Retest pulls met required specification (36.0/38.7/41.5, lowest values within -Y thrust panel)
  - Area is outside critical debris zone

Intertank Low Plug Pull Values

SMR-98-008

Installation	Requirement	Test	Analysis	Similarity	Inspection
Circumferential Rib TPS	Maintain Minimum Factor of Safety	x		x	
	Maintain components within acceptable temperature limits			x	
	No debris allowed from critical zone *			x	

* Waiver processed to accept potential violation of "debris prevention" paragraphs in Level II and Level III specifications

Rationale for Acceptance:

- Test
  - Original (3-day) acceptance plug pulls plus additional verification tests resulted in overall value of 46.2 psi
    - Original data = 36.2 psi average (minimum=31.7 psi)
    - Verification data = 47.2 psi average

Intertank Low Plug Pull Values

SMR-98-008

Rationale for Acceptance (continued) :

- Similarity
  - Investigation noted that STS-86/ET-88, STS-87/ET-89 and STS-89/ET-90 flew with individual plug pull values equivalent to or lower than 30 psi
  - PDL repairs were performed per standard procedures
    - Approximately 100 plug pull repairs per ET
    - STS-91/ET-96 and STS-88/ET-97 each had approximately 280 repairs on circumferential rib closeout
  - Statistical assessment of entire data population indicates STS-96/ET-100 foam is in family

STS-96/ET-100 Safe to Fly

Agenda

• Overview	Jim Feeley
• Prior Mission Performance Summary	
• Current Mission/External Tank Highlights	
• ET-100 Mass Properties Status	Rick Spring
• Changes	
• Senior Management Review NCD	Steve Copsey
- Intertank Low Plug Pull Values	
• ***Special Topics***	
- ***Nose Cone Removal and Replacement***	***Jim McAllister***
- LH2 Tank Barrel Panel Inserts	Rob Champagne
• SRM&QA Assessment	Mike Bankester
• KSC Processing	Doug Powell
• Verification/Certification	Jim Feeley
• Mission Unique Assessment	
• Readiness Statement	
• Appendices	
- A: Minor Changes	
- B: SRM&QA Assessment	
- C: KSC Processing	
- D: Level II Waivers/Level III Deviations	

Nose Cone Removal and Replacement

Issue:

- ET-102 Nose cone inspected at MAF and protrusion in composite material observed
- Visual inspection of STS-96/ET-100 indicated a similar protrusion on the Composite Nose Cone at the Vent Louver location

Background:

- ET-102 Nose Cone removed at MAF and two fastener issues identified
  - Fasteners reversed on nose cone spacer installation (+Y side)
  - Fastener interference with vent horn casting due to use of improper grip length fastener
- NDE (thermography) inspection revealed localized delamination in the Nose Cone
- ET-102 Nose Cone was replaced
  - Nose cone spacer fastener installed at correct locations
  - Proper grip length nose cone louver fasteners installed
- All other installed Composite Nose Cones (ET's 99, 100 & 101) inspected for possible damage

Nose Cone Removal and Replacement

Description:

- STS-96/ET-100 Nose cone inspected at KSC and protrusion in composite material observed
- PRCBD S052923FL authorized removal, inspection, and replacement of ET-100 Nose Cone
- Nose Cone was removed and inspected
  - NDE inspection revealed a localized delamination in the Nose Cone
- New Composite Nose Cone installed
  - Nose cone spacer fasteners installed at correct locations
  - Proper grip length nose cone louver fasteners installed

Nose Cone Removal and Replacement

Rationale for Acceptance:

- No design changes were implemented in Nose Cone removal and replacement
  - Installation per existing drawing requirements
    - Better gaging technique employed for selection of Nose Cone fasteners
      - Measured individual part thickness prior to installation rather than pin gaging total stack-up after assembly
  - Composite Nose Cone Installation certified by *Test*, *Analysis*, and *Engineering Inspection*
- Vertical TPS closeout process was validated prior to implementation on STS-96/ET-100
  - PDL closeout previously validated for ET in horizontal position
  - Vertical PDL foam application has been successfully demonstrated for ETs at KSC by validation at MAF
    - Same requirements and procedures followed during horizontal and vertical validation effort

Agenda

• Overview	Jim Feeley
• Prior Mission Performance Summary	
• Current Mission/External Tank Highlights	
• ET-100 Mass Properties Status	Rick Spring
• Changes	
• Senior Management Review NCD	Steve Copsey
- Intertank Low Plug Pull Values	
• Special Topics	
- Nose Cone Removal and Replacement	Jim McAllister
- ***LH2 Tank Barrel Panel Inserts***	***Rob Champagne***
• SRM&QA Assessment	Mike Bankester
• KSC Processing	Doug Powell
• Verification/Certification	Jim Feeley
• Mission Unique Assessment	
• Readiness Statement	
• Appendices	
- A: Minor Changes	
- B: SRM&QA Assessment	
- C: KSC Processing	
- D: Level II Waivers/Level III Deviations	

LH2 Barrel Panel Insert Holes

Issue:

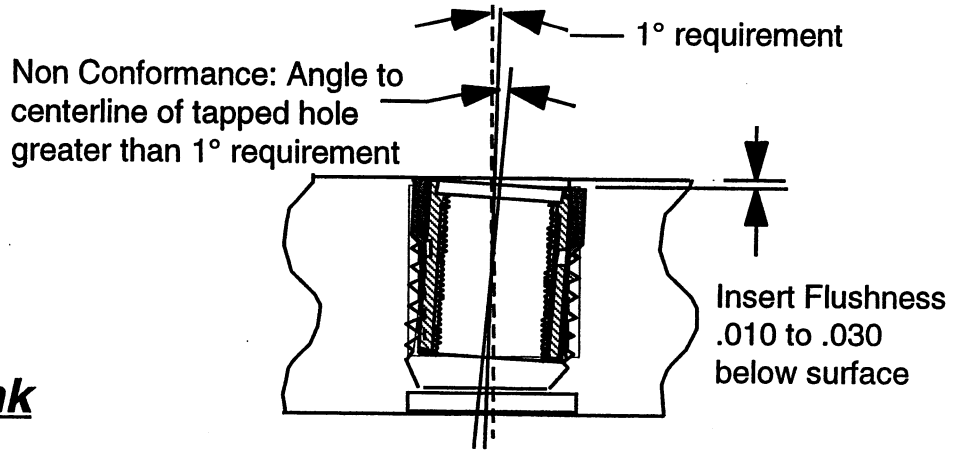
- ET-108 LH2 barrel panel had insert holes that were not tapped to the perpendicularity requirements of 1° or less
- Suspect non-conformance document was generated and dispositioned against ET-100

Background:

- Suspect non-conformance locations are on LH2 Tank
  - Internal at 1973 Frame and Frame Stabilizer fitting attach points
  - External at Cable Tray and GO2/GH2 Pressurization Line support bracket attach points
- Defect discovered during insert installation at MAF
  - Flushness requirements could not be achieved
- Holes for inserts are bored on CNC (Computer Numerical Control) machines and are not suspect
- Threads are manually tapped by vendor using a guide and are suspect
  - Tapping guide determined to have excessive wear
- Standard repair of installing oversize inserts may be used on unassembled components

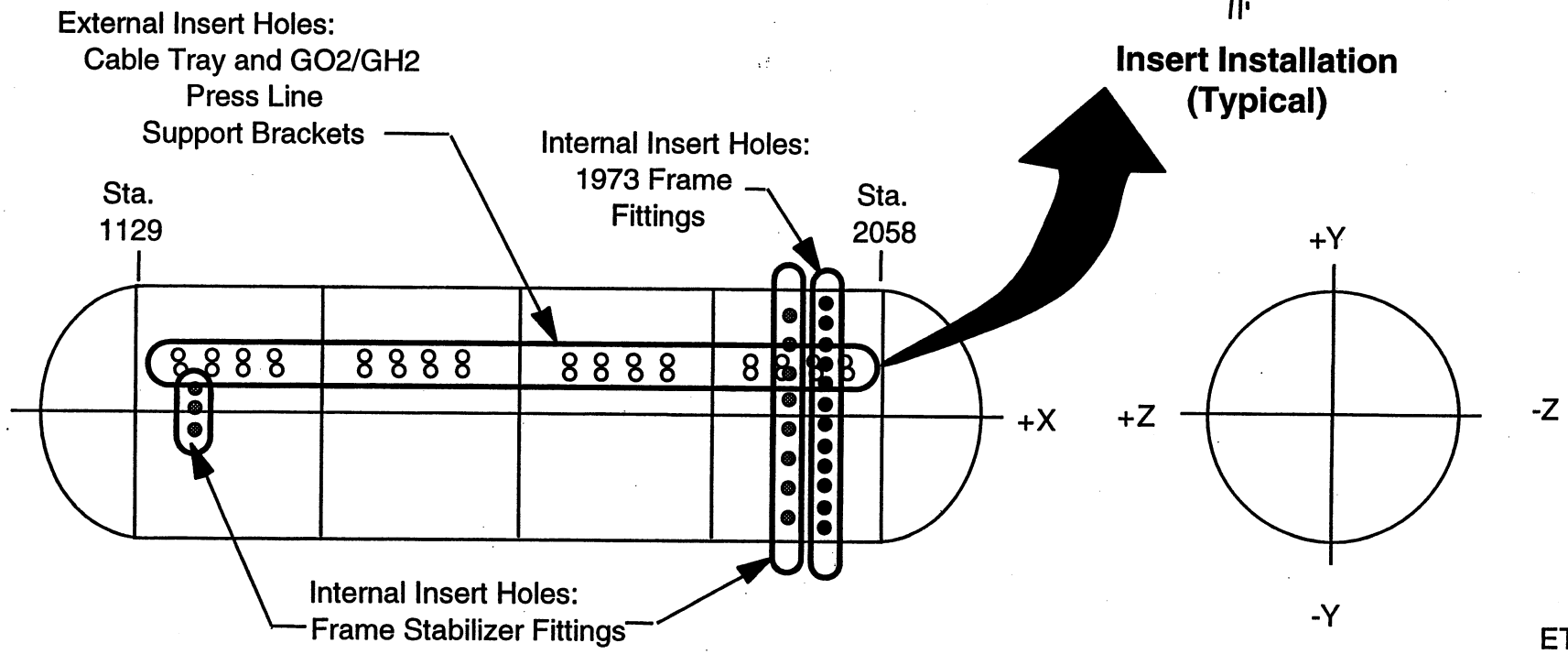
LH2 Barrel Panel Insert Holes

Perpendicularity Requirement:
Tapped Hole Perpendicular To Surface
Within .017 Inch Per Inch Along Axis.
(Approximately 1°)



Insert Installation (Typical)

Suspect Insert Locations - LH2 Tank



ET100pfr.4250.ls.04/99

LH2 Barrel Panel Insert Holes

Discussion:

- During installation of insert, lack of perpendicularity in excess of 2 - 2.5 degrees would be detected by flushness requirement
  - Top of insert must be flush to surface within .010" to .030"
    - Limits amount of angularity from perpendicular to approximately 2.5 degrees
- Lack of perpendicularity less than or equal to 1.5 degrees can be detected by inspecting bolt head gap after bolt installation
- Tests performed to determine capability of bolt/insert installation in an "out of perpendicular" condition
  - Tests performed at 70°, -320° and -423° F
  - Up to 3.5 degree "out of perpendicular" condition tested
    - Exceeds the maximum violation that could escape downstream detection
  - Test results demonstrated full capability

LH2 Barrel Panel Inserts

Installation	Requirement	Test	Analysis	Similarity	Inspection
Potentially Misaligned Insert Assembly	Maintain Minimum Factor of Safety	x			x
	Misalignment and Tolerances - Effects of misalignments shall be considered in the analysis of all loads, load distributions and structural adequecy	x			x

Rationale for Acceptance:

- Test
  - Conservative testing demonstrated that maximum potential violation would not cause reduction in design margins
- Inspection
  - Insert installations met flushness requirements
  - Bolt head gap checks were acceptable

Agenda

• Overview	Jim Feeley
• Prior Mission Performance Summary	
• Current Mission/External Tank Highlights	
• ET-100 Mass Properties Status	Rick Spring
• Changes	
• Senior Management Review NCD	Steve Copsey
- Intertank Low Plug Pull Values	
• Special Topics	
- Nose Cone Removal and Replacement	Jim McAllister
- LH2 Tank Barrel Panel Inserts	Rob Champagne
• ***SRM&QA Assessment***	***Mike Bankester***
• KSC Processing	Doug Powell
• Verification/Certification	Jim Feeley
• Mission Unique Assessment	
• Readiness Statement	
• Appendices	
- A: Minor Changes	
- B: SRM&QA Assessment	
- C: KSC Processing	
- D: Level II Waivers/Level III Deviations	

SRM&QA Assessment

as of 04/06/1999

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	- Closed pending action
- E-165, LH2 Gulton ullage pressure tranduscer failed calibration test at MAF	- All ET transducers successfully passed the calibration test - All ET transducers functionally tested at KSC during checkout

Agenda

• Overview	Jim Feeley
• Prior Mission Performance Summary	
• Current Mission/External Tank Highlights	
• ET-100 Mass Properties Status	Rick Spring
• Changes	
• Senior Management Review NCD	Steve Copsey
- Intertank Low Plug Pull Values	
• Special Topics	
- Nose Cone Removal and Replacement	Jim McAllister
- LH2 Tank Barrel Panel Inserts	Rob Champagne
• SRM&QA Assessment	Mike Bankester
• ***KSC Processing***	***Doug Powell***
• Verification/Certification	Jim Feeley
• Mission Unique Assessment	
• Readiness Statement	
• Appendices	
- A: Minor Changes	
- B: SRM&QA Assessment	
- C: KSC Processing	
- D: Level II Waivers/Level III Deviations	

KSC Processing - Status

as of 04/06/1999

- 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

KSC Processing - Status

as of 04/06/1999

- Changes
  - ET modifications

• Mod Kits	1`	- I/T Thrust Panel Instrumentation
• DC&R	0	
• Bldg 45	1	- Nose Cone Remove & Replace
• FEC	2	- Intertank Foam Reduction
		- Intertank Foam Venting
- OMRSD/LCC	2	- ET Pre-Launch Pressure Cycles
		- ET Weighing
- Software	0	

- SIM Load (S0044) 04/16/99
- SIM Launch (S0056) 05/04/99
- MMT Space Shuttle Launch Contingency SIM 05/06/99

Agenda

• Overview	Jim Feeley
• Prior Mission Performance Summary	
• Current Mission/External Tank Highlights	
• ET-100 Mass Properties Status	Rick Spring
• Changes	
• Senior Management Review NCD	Steve Copsey
- Intertank Low Plug Pull Values	
• Special Topics	
- Nose Cone Removal and Replacement	Jim McAllister
- LH2 Tank Barrel Panel Inserts	Rob Champagne
• SRM&QA Assessment	Mike Bankester
• KSC Processing	Doug Powell
• ***Verification/Certification***	***Jim Feeley***
• ***Mission Unique Assessment***	
• Readiness Statement	
• Appendices	
- A: Minor Changes	
- B: SRM&QA Assessment	
- C: KSC Processing	
- D: Level II Waivers/Level III Deviations	

Verification/Certification

as of 04/06/1999

Item	Status
• NSTS 07700, Volume X Baseline - Revision L, Change 249	No Issues
• Certification documentation	
- Hardware Certification Sheets (HCS)	Complete - No Issues
- Certificates of Qualification (COQ)	Complete - No Issues
• Waivers/Deviations	
- Potentially violates "debris prevention" paragraph in Level II and Level III specification	• Level III DAR 234 (specific to ET-100)

Mission Unique Assessment

as of 04/06/1999

Category/Item	STS-96
• Review of MRB actions using updated loads	ECD 05/10/1999
• MPS Preflight Prediction Package	ECD 05/10/1999

Readiness Statement

The External Tank, ET-100, is hereby certified and ready for STS-96 flight pending completion/closure of open and planned work

---

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

ET100pfr.4250.ls.04/99

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):

- D: Level II Waivers/Level III Deviations

Minor Changes

Change	Description	Basis for Certification
LO2 Feedline Fairing (B01775G)	▪ Created perpendicular foam closeout	▪ Similarity to previous LWT configuration
Deletion of ET Range Safety Systems (B02010)	▪ 92 holes deleted from top chord of SRB beam ▪ SRB beam stiffeners with holes for coupler wires replaced by standard stiffeners without holes ▪ Stiffener to web fastener reverts to LWT configuration	▪ Similarity to previous LWT configuration

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 Class II Changes – Electrical

Change No.	Description
NONE	

Minor Class II Changes – Propulsion/Mechanical

Change No.	Description
H35809-358	Revision to LH2 Internal Elbow weldment diameter tolerance. Delete average diameter specified on drawing
H35809-727	Revise spacing between clamps
H35809-834	Added note to LH2 Internal Feedline Instl. to pre-assemble gang channels & secure siphon screens to support frame and to vacuum all debris/particles generated when running bolts through the gang channels prior to installation into LH2 feedline
H35809-902	Relocated Lockwire installation at three test port caps; producibility change
H36809-028	Revised GO2 & GH2 Press Line Installation drawing to correct part number callout; MPP and Sheet 1 have correct part number

Minor Class II Changes – Structural

Change No.	Description
H35809-433	Revised view for underside of stringer; clarification required for primer application
H35809-524	Revised chamfer for clearance on SRB Beam Zee
H35809-613	Note specifying maximum allowable gap between bulkhead and web added to SRB Beam Assembly
H35809-670	Rotated fastener and revised shim requirement on umbilical support installation
H35809-727	Revised clamp configuration for wiring harness and sensor installation
H35809-805	Revised views of inboard chord splice on frame 2058 Segment Installation to show Hi-Loks through the splice installed with collars inboard
H35809-919	Rework DCN to replace J336B Tape on Thermal Isolator Assembly
H35809-470	Revised LO2 dome cap dimension to prevent recurring NCDs
H35809-590	Revise I/T panel shimming to avoid repetitive NCD's
H35809-670	Revise fastener head location from near side to far side and revised shim
H35809-675	Added LO2 barrel panel dimensions omitted in error at initial release. See J31163 for barrel panel redesign

Minor Class II Changes – Structural

Change No.	Description
H35809-747	Chem film changed from manual application to immersion
H35809-753	Correct drawing errors, paper changes only
H35809-754	Correct drawing errors, paper changes only
H35809-762	Increase number of allowable chem mill steps to enhance producibility
H35809-805	Producibility enhancement, Hi-Lok collars moved inboard to avoid interference
H35809-819	Revise LO2 barrel weld process from SPAW to VPPA
H35809-873	Circumference measurement moved to later assembly
H35809-929	Extend vibro marked lines on Ogive gores at supplier (was extended manually at MAF previously)
H35809-942	Clarify fastener head orientation requirements
H36809-009	Move etch coupons from machining dwg to forming dwg
H36809-023	Audit finding, added flushness requirement per STP2003
J31155-014 -015	Revised weld requirement from VPPA STP 5506 to GTAW STP 5001

Minor Class II Changes – Structural

Change No.	Description
J31188-015	Implement Dual Cover on O2 and change from SPAW to VPPA.

Minor Class II Changes – TPS

Change No.	Description
H35809-940	Remove foam rind from net sprayed foam within the "Bathtub" circumferential ribs due to reverting back to foam wedges
H35809-987	Deleted Composite Nose Cone fit check to forward Ogive interface which required changing dimensional method for Ogive/Nose Cone foam trim
H36809-019	Reduced gap between MA-25 ablator seal and Nose Cone Fairing bulkhead corner closure brackets to prevent foam erosion
H36809-071	Replaced "Great Stuff" seal application with a scheduled trim and closeout using PDL-1034 at the Composite Nose Cone/LO2 Ogive interface

Minor Class II Changes – Systems

Change No.	Description
J31176-010	Clarify ICD requirements on drawings; Add reference to ICD 2-00001 to LO2 Dome Assembly Drawing

Class Changes - STPs/STMs/STDs/AVL

Change No.	Document	Description
H35809-855	STP6508 Wiring Harness	Added allowances for wrapping and taping shield to obtain roundness and for removing excess shield slack at installation. Removed redundant requirements for maintaining shield roundness at harness fab level.
B02027-082	STP1009 Forming Al-Li 2090 Sheet	Added allowance in STP for drawing to specify penetrant inspection requirement when needed
B02034-013	EQTP1102 Al 2195 Simulated Service Acceptance Test	Modify requirements to demonstrate 13 pre-launch cycle capability
B02038-003	33L23	Release standard for gang channel nut for LH2 screen
B02043-004	33L24	Release standard for gang channel nut for LO2 screen
H35809-943	STP5006/5009 Deoxidation of Al alloy	Revise appropriate paragraphs to allow smut on welds made with 4043 weld wire after cleaning
H36809-017	STP2012 Tube Fabrication and Instl	Reduces requirement for polished surface from approximately 90% to 80% of tube flare
H36809-030	STP8002 Heat treat of 7050 Al	Clarify that hand forgings do not require first article cut-up and to replace canceled Mil-H-6088 with equivalent SAE-AMS-H6088 specification

Class Changes - STPs/STMs/STDs/AVL

Change No.	Document	Description
H36809-032	STP1006 Fab & test of 2195 chords	Clarify that only one tensile test specimen is required in the longitudinal direction when the extrusion is too small to obtain sample in the transverse direction. Specify tat this STP is also applicable to smaller chords that are formed after heat treatment.
H36809-033	M473 Adhesive cryogenic, polyurethane	Change product name due to vendor name change. Plasticizer in formulation changed to chemically equivalent, but higher purity, material.
H36809-047	STP1503 BX-250 Application	Clarify requirement to clean visibly contaminated net spray surfaces with MEK prior to adhesive application.
H36809-048	STP1536 SS-1171 Application	Clarify requirement to clean visibly contaminated net spray surfaces with MEK prior to adhesive application.
H36809-062	A659 Plastic Sheet TFE Fluorocarbon	Change Teflon from Type II, Grade 1, Class A to Type I, Grade 1, Class B (higher grade material)
H36809-067	25L6 A26 Collar (Hi-Lok)	Revise to change plating requirement (both washer and collar) to allow cadmium plate Class 2 and 3 (was 3 only)
H36809-069	26L23 Bold – Machine 12 point Head	Change heat treat requirement of 160-180 ksi to 160 ksi minimum

Class Changes - STPs/STMs/STDs/AVL

Change No.	Document	Description
H36809-070	45L9 Clamp, Saddle, Silicone Cushion	Revised cushion configuration to allow one wedge on the top and one on the bottom instead of both on top
H36809-102	B650/B650A PTFE Extrusions	Change specification from Mil-P-19468 to AMS-3656 Type 3

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-100 DR/PR/OMRSD Waiver/Exceptions

as of

System	Discrepancy	Problem	MRB Items	Exceptions/ Waivers
• Electrical	0	0	0	0
• Propulsion/ Pneumatics	1	2	0	0
• Structures	2	6	3	0
• Thermal (TPS)	2	4	2	0
Total	5	12	5	0

ET97pfrc.4250.ls 10/98

ET-100 PR/MRBs, Thermal

PR No./Status	Title/Description	Disposition
PET-100-TS-0003	Aft hard point close-out has two low areas and three voids	• Use as is for low areas and repair voids with PDL-1034 • Additional bondlines have no affect on material performance
PET-100-TS-0006	Two areas of debonded ablator in xt 1082 micro-phone tube closeout	• Repair with STP1510, Type I SLA • Repair is within standard guidelines • Additional bondlines will not affect material performance

ET-100 PR/MRBs, Structures

PR No./Status	Title/Description	Disposition
PET-100-ST-0003 Page 1B	• Alignment holes drilled in vent duct do not align with holes in new spacer	• Drill additional pilot holes - Structural capability not affected
PET-100-ST-0003 Page 1C and 1E	• After removal of closeout from xt 371 gap, closeout area exceeds drawing requirements	• Perform scheduled closeout with PDL-1034 using validated technique - Dimensional violation does not adversely affect performance
PET-100-ST-0003 Page 1D	• During CNC fit check a 34L2-5L8 Keensert in the 80911041237-008 bracket failed running torque	• Chase threads using 5/16x24 tap • Use as reworked
PET-100-ST-0003 Page 1F	• After CNC installation, J414 tape (2"x1/8") trapped between spacer and duct at bottom of -Y Louver	• Use as is - Tape is Gox compatible - Not a debris concern

ET-100 PR/MRBs, Structures

PR No./Status	Title/Description	Disposition
PET-100-ST-0005	• Holes drilled for microphone plate on -Y side of xt 1082 ring frame are too far apart	• Slot hole in plate - Structural capability not affected
PET-100-ST-0005 Page 1A	• Keensert hole drilled into -Y end of crossbeam is too deep (is 0.597, s/b 0.579 max)	• Use as is - Structural capability not affected

ET-100 Field Engineering Changes

- FEC KET-0047
- FEC KET-0049
- Intertank Foam Thickness Reduction and Camera Grid Application
- Intertank Thrust Panel Foam Venting

ET-100 Limited Life Components

Cycle Sensitive

Description	Part No.	Serial No.	Limit	Required	Remaining
LH2 Manhole Cover Assy -Fwd	80914081488 -509	0000628580	14	1	14
LO2 Tank Mechanical Assy	80912002000 -500	0000668060	14	1	14
LH2 Tank Mechanical Assy	80914002000 -500	0000666340	14	1	14
LO2 Manhole Cover Assy	80911001205 -509	0000672370	14	1	14

ET-100 Limited Life Components

Cycle Sensitive

Description	Part No.	Serial No.	Limit	Required	Remaining
LO2 Fwd Ogive Cover Plate	80911001207 -509	0000670110	14	1	14
LH2 Manhole Cover Assy -Aft	80911001444 -509	0000659490	14	1	14
LH2 Tank Siphon Closure	80911001445 -502	0000641970	14	1	14

ET-100 Limited Life Components

Age Sensitive

Description	Part No.	Serial No.	Limit	Initiation	Expiration
External Tank	80901000000 -500	00000093	6 Yrs	11/98	11/2004

ET-100 Limited Life Components

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	PD500020-059	AAH	0001143	02/24/1998	01/2002
Cartridge Assy	PD500020-030	AAH	0001287	02/24/1998	01/2002
Cartridge Assy	PD500020-030	AAH	0001288	02/24/1998	01/2002

ET-100 Alternate Blowing Agent Usage at KSC

Foam	Document	Description	Location	Size
SS-1171	T5141	Aft Hardpoint Closeout	xt 1973-2076, 180 degrees	4410 sq. in.
PDL-1034	TS-0003	Aft Hardpoint Repairs	xt 1973-2076, 180 degrees	5 sq. in.

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 print out	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	S040732G 6/18/88	Table 2.0	362	ETs 23, 27-29, 31 & up
Soldering, circuit boards, and 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				
Debris prevention	S082962A 10/2/98	3.2.1.2.14	675	ETs 92, 97-105
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 Certification of Flexible Hoses and Bellows				
LH2 feedline bellows	S005203G-R1 8/2/91	1.2	3	ETs 42-45, 47 & up

100pfrd.4250.ls.04/99

Level II Waivers - Baseline

Document / Requirement	Authority	Paragraph	Waiver No.	Effectivity
SL-E-0001 – Specification Electromagnetic Compatibility Requirement				
Wire marking is not applicable to the ET	S40732K 9/27/89	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

Level III Deviations

Document / Requirement	Paragraph	Waiver No.	Effectivity
CPTO1M09A, External Tank Contract End Item Specification			
• Photographic evidence shows a loss of foam from both +Y and –Y Intertank Thrust Panels • Analysis concluded a low probability of debris impact on Orbiter critical area	3.2.5	233	ETs 92, 97-99, 101-105