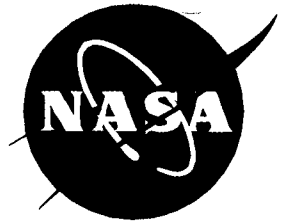
FLIGHT READINESS STATEMENT
STS-97/ET-105
EXTERNAL TANK PROJECT
PRE-FLIGHT REVIEW



EXTERNAL TANK ET-105/STS-97, AS IDENTIFIED IN THE EXTERNAL TANK PROJECT PRE-FLIGHT REVIEW DATED NOVEMBER 2, 2000, IS CONSIDERED READY TO SUPPORT FLIGHT UPON ACCEPTABLE DISPOSITION OF OPEN/PLANNED WORK AND/OR OPEN ACTIONS.

N. E. OTTE/MP31

A. A. McCOOL/MP01

J. BULLMAN/ED10

P. K. McCONNAUGHEY/ED20

P. M. MUNAFO/ED30

D. A. KROSS/ED40

A. O. GOODSON/QS01

C. E. SINGER/TD01

J. W. SMELSER/MP31, CHAIRMAN

11/02/2000

Space Shuttle
External Tank

ET Project Pre-Flight Review

STS-97/ET-105 & STS-98/ET-106

105&106PFR.4250.11/00

LOCKHEED MARTIN

Agenda

Overview ***Lynn Servay***

Prior Mission Performance Summary

- ***STS-106/ET-103***
- ***STS-92/ET-104***

Current Mission/External Tank Highlights

- ***STS-97/ET-105***
- ***STS-98/ET-106***

Mass Properties Status

Changes

Senior Management Review NCDs

Special Topics

SRM&QA Assessment

KSC Processing

Verification/Certification

Mission Unique Assessment

Readiness Statement

Appendices

Overview

This review for STS-97/ET-105 and STS-98/ET-106 includes:

- Items specific to missions STS-97 and STS-98
- First time differences and "out-of-family" non-conformances not previously flown and/or reviewed

FRR Series

- ***STS-97/ET-105***
  - ET/SRB Mate Review — 09/22/2000 (A)
  - Michoud Operations Pre-Flight Review — 10/13/2000 (A)
  - *ET Project Pre-Flight Review* — *11/02/2000*
  - Space Shuttle Vehicle FRR — 11/17/2000
  - Pre-launch Mission Management Team Review — 11/28/2000 (NET)
- ***STS-98/ET-106***
  - ET/SRB Mate Review — 11/09/2000
  - Michoud Operations Pre-Flight Review — 10/13/2000 (A)
  - *ET Project Pre-Flight Review* — *11/02/2000*
  - Space Shuttle Vehicle FRR — 01/10/2001
  - Pre-launch Mission Management Team Review — 01/16/2001

Prior Mission Performance Summary

STS-106/ET-103, 09/08/2000 Launch

System	***Performance***
• ***OMRSD/LCC***	• No ET LCC or OMRSD violations
• ***Instrumentation***	• Nominal
• ***MPS***	• Nominal
• ***ET Hazardous Gas***	• No ET violations

Prior Mission Performance Summary

STS-106/ET-103, 09/08/2000 Launch

System	***Performance***

• ***TPS***	• Ice team reported a very clean vehicle
	  • No Intertank cracks noted
	  • One crack at -Y vertical strut
	  - Acceptable per NSTS 08303

• ***Orbiter Tile Damage***	• Foam performance in-family with NCFI LWTs
	  • Lower surface hits
	  – Diameter > 1" = 17
	  – Total = 73

Post Flight Photo Review	• Crew photos from cockpit - No significant anomalies • Umbilical well photos - No significant anomalies
• ***ET Disposal***	• Nominal

Prior Mission Performance Summary

STS-92/ET-104, 10/11/2000 Launch

STS-92 scrubbed (Oct,5th) due to questions about the ET/orbiter aft attach bolt (IPR 92V-01000). The issue was resolved when it was determined that bolt protrusion is not an anomaly. In addition, the MPS #2 LO2 POGO valve PV21 indicator failed. The valve was replaced.

System	***10/10/2000*** *(First STS-92 Tanking scrubbed due to debris (4" loc-pin) on pad.)*	***10/11/2000***
• ***OMRSD/LCC***	• No ET LCC or OMRSD violations	• No ET LCC or OMRSD violations
• ***Instrumentation***	• Nominal	• Nominal
• ***MPS***	• Nominal	• Nominal
• ***ET Hazardous Gas***	• No ET violations	• No ET violations

Prior Mission Performance Summary

STS-92/ET-104, 10/11/2000 Launch (as of 10/24/2000)

System	*10/10/2000*	*10/11/2000*
• ***TPS***	• 16 Intertank/LH2 flange cracks noted. • One crack at -Y vertical strut - Acceptable per NSTS 08303	• One frost ball on the +Y longeron closeout. Acceptable per ice inspection criteria.
• ***Orbiter Tile Damage***	• N/A	• Foam performance in-family with NCFI LWTs (Data from preliminary landing report.) • Lower surface hits – Diameter > 1" = 14 – Fwd main gear >1"= 3 – Total = 85
• ***Post Flight Photo Review***	• N/A	• Crew photos from cockpit- (not available at print) • 35mm Umbilical well photos-(not available at print)
• ***ET Disposal***	• N/A	• Nominal

105&106PFR.4250.11/00

Mission/External Tank Highlights

STS-97/ET-105 (as of 11/1/2000)

Mission	***STS-97***
Launch	***11/30/2000 (NET)***
• Window	10:48 p.m. ET
• Pad	39-B
• Orbiter	Endeavour (OV-105)
• Orbital Inclination	51.6 degrees/173 nautical miles
• ET Photo Coverage	• Crew photos from cockpit window • 35mm & 16mm Umbilical well photos
Primary Payload	***International Space Station (ISS) 4A*** • Integrated Truss Structure(P6), Photovoltaic modules
Landing	***12/10/2000***
• Time	TBD
• Location	KSC
External Tank	***ET-105***
DD250 Acceptance	*07/16/1999*
Shipped to Launch Site	*08/05/1999*

105&106PFR.4250.11/00

Mission/External Tank Highlights

STS-98/ET-106 (as of 11/1/2000)

Mission	***STS-98***
Launch	***01/18/2001 (NET)***
• Window	3:36 a.m. ET
• Pad	39-A
• Orbiter	Atlantis (OV-104)
• Orbital Inclination	51.6 degrees/173 nautical miles
• ET Photo Coverage	• Crew photos from cockpit window • 35mm &16mm Umbilical well photos
Primary Payload	***International Space Station (ISS) 5A*** • 'Destiny' Lab module
Landing	***1/28/2001***
• Time	TBD
• Location	KSC
External Tank	***ET-106***
DD250 Acceptance	*12/17/1999*
Shipped to Launch Site	*02/24/2000*

105&106PFR.4250.11/00

Agenda

Overview

Prior Mission Performance Summary

Current Mission/External Tank Highlights

Mass Properties ***Rick Spring***

- ***ET-105 Status***
- ***ET-106 Status***

Changes

Senior Management Review NCDs

Special Topics

SRM&QA Assessment

KSC Processing

Verification/Certification

Mission Unique Assessment

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Mass Properties Status

STS-97 / ET-105

Specification Weight = 58,466 lbs.

ET-105 Weighing

- ET 105 was weighed at MAF on July 30, 1999 using the Intercomp platform scale weighing system

- Predicted Weight	58,390 lbs.
- As-weighed	58,547 lbs.
- Delta to Predicted	+157 lbs.

Mission Planning

- MMC-ET-SE40, ET Project - Mass Properties Weight and Balance Report, was submitted August 8, 2000 to support mission planning.
- Coordination with Level II on October 17, 2000 indicates approximately 507 LB performance margin for STS- 97

Mass Properties Status

STS-98 / ET-106

Specification Weight = 58,452 lbs.

ET-106 Weighing

- ET 106 was weighed at MAF on December 20, 1999 with the Weigh Tronix weighing system

- Predicted Weight	58,314 lbs.
- As-weighed	58,499 lbs.
- Delta to Predicted	+185 lbs.

Mission Planning

- MMC-ET-SE40, ET Project - Mass Properties Weight and Balance Report, was submitted February 14, 2000 to support mission planning.
- Coordination with Level II on October 17, 2000 indicates approximately 1062 LB performance margin for STS- 98

Mass Properties Status

MAF - ET Weighing System Comparison

Description / Requirements	***Intercomp***	***Weigh Tronix***
• *Scale Arrangement*	*8 point Compression*	*4 point Compression*
• *Requirements*	*809 3100 Document*	*809 3100 Document*
• *Scale Accuracy*	*1/10 of 1 %*	*1/10 of 1 %*
• *System Accuracy*	*+/- 126 lbs*	*+/- 126 lbs*

Process Enhancements	***Intercomp***	***Weigh Tronix***
• *Scale Set Up Time per Weighing*	*48 mh*	*20 mh*
• *Tank Weighing Time*	*4 to 8 hrs*	*2 to 4 hrs*
• *Calibration Time*	*40 hrs*	*5 hrs*
• *Physical Weight of Scale*	*160.0 lbs x 8*	*12.5 lbs x 4*
• *Weighing System Complexity*	*High*	*Low*
• *System Cost*	*High*	*Low*

105&106PFR.4250.11/00

Agenda

Overview

Prior Mission Performance Summary

Current Mission/External Tank Highlights

Mass Properties Status

Changes ***Jim McAllister***

- ***ET-106 & sub***
  - ***Redesign Vertical Strut (B02028)***

Senior Management Review NCDs

Special Topics

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Implementation of One Piece Vertical Strut

B02028

Change

- Vertical Strut redesigned to one-piece strut machined from hand forging
- Redesigned -Y vertical strut cable tray support bracket to allow clearance with new adjustable pin cap.

Background

- Vertical strut redesigned to achieve weight performance on SLWT Program
  - Redesigned strut partially offset weight impact of replacing Al2195 extruded frame chords with Al2219 extruded frame chords.
- New adjustable bushing flanges increased height of strut-to-fitting pin/cap assy .750".
  - Resulted in redesign of cable tray support bracket.

Description

	Configuration	Strut Material	End Fitting Material
ET-105	Two-Piece • Bolted Flange with Shims for length adjustment	7050-T74 Die Forging • Machined to final configuration	2219-T6 Die Forging • Machined to final configuration
ET-106	One-Piece • Eccentric bushings for length adjustment	7050-T74 Hand Forging • Machined to final configuration	7050-T74 Hand Forging integral part of one-piece strut.

Implementation of One Piece Vertical Strut

B02028

Description (continued)

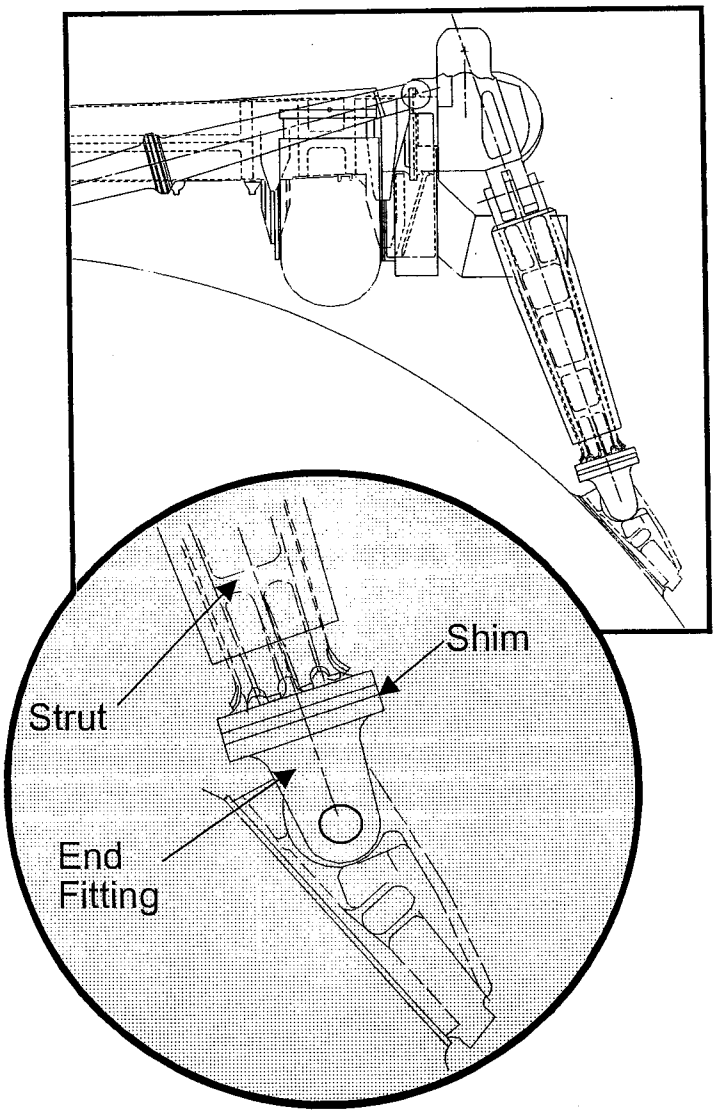
- Cable tray attachment bracket was redesigned to facilitate installation of the new strut.
  - The existing U-channel bracket was replaced with a thicker L-channel.
  - The thicker section permitted elimination of SLA.
  - New bracket closed out with SOFI.

- Elimination of bolt flanges, attachment hardware, shim and bond jumpers resulted in a total weight savings of approximately 95 lbs.

Implementation of One Piece Vertical Strut

B02028

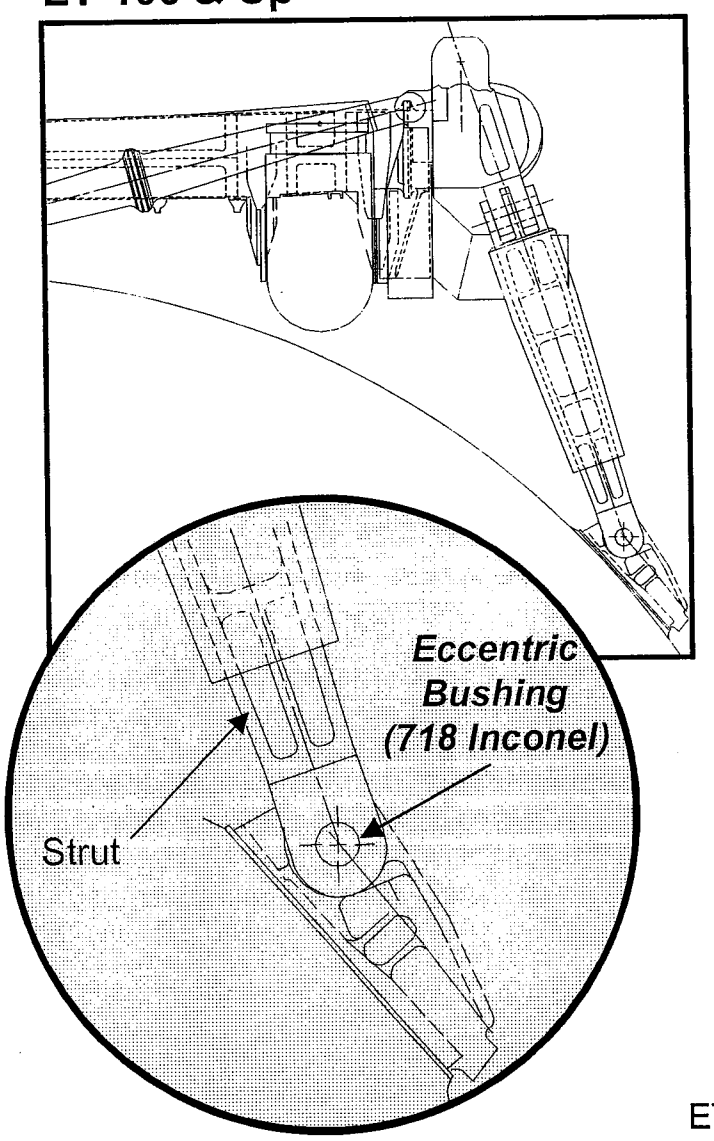
Was



+Y Shown

-Y Opposite

ET-106 & Up



Redesign Vertical Strut

B02028

Basis for Certification - Strut

- Test
  - Structural Test successfully performed at MSFC
    - Demonstrated 207% of Design Limit Load
- Analysis
  - Lower lug diameter increased to compensate for change in properties from Al2219 to Al7050
  - Stress analysis shows improved factor of safety (lower lug net tension)

Was:	1.54
Now:	1.79
Required:	1.4
- Process
  - Verification of the eccentric bushing's adjustment capability performed on test article by production personnel prior to test.

Basis for Certification - Bracket

- Analysis
  - Factor of safety greater than 2.0

Agenda

Overview

Prior Mission Performance Summary

Current Mission/External Tank Highlights

Mass Properties Status

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Senior Management Review NCDs ***Don Bolstad***

- ***ET-106 LH2 Tank Post Proof Penetrant Indications***

Special Topics

SRM&QA Assessment

KSC Processing

Verification/Certification

Mission Unique Assessment

Readiness Statement

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ET-106 LH2 Tank Post Proof Penetrant Indications

SMR 99-002

Issue

- ET-106 LH2 Barrel #1 HB1-4 weld exhibited out of family penetrant indications

Background

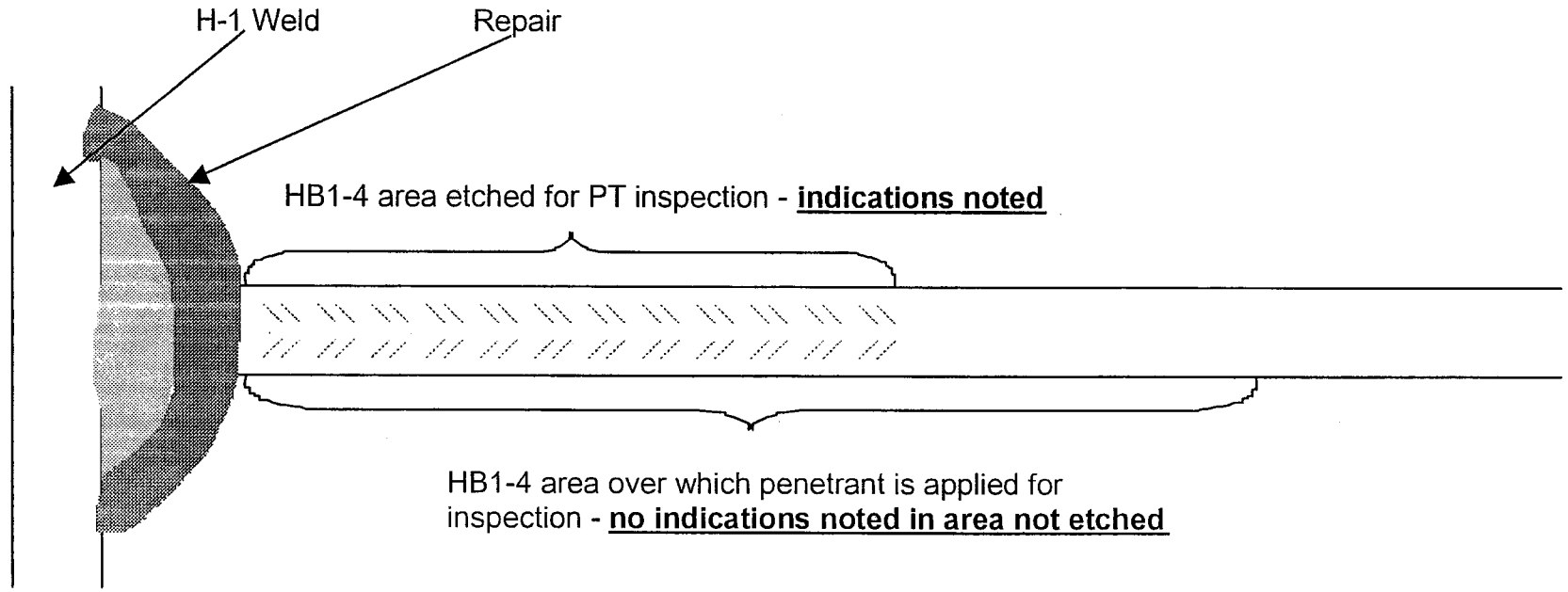
- LH2 Tank Assembly Inspection, WSA 3 (Major Weld)
  - During penetrant inspection of the adjacent H1 weld, multiple penetrant indications along HB1-4 weld were observed
    - Indications not radiographically detectable
  - Additional locations of the HB1-4 were etched and penetrant inspected to determine extent of indications

Level of Technical Coordination:

Technical coordination between LMC and NASA started immediately after this issue was identified and continued throughout the course of rework, testing, analysis, NDE and proof testing.

ET-106 LH2 Tank Post Proof Penetrant Indications

SMR 99-002



- Entire length of HB1-4 weld etched and penetrant inspected and indications detected
  - Density (number/inch) of indications consistent along length of weld
  - Orientation of indications consistent along length of weld (20° - 45° from weld direction)
  - Most indications 0.020"-0.030" long, with approximately 10% 0.040"-0.050" long
  - No longitudinal indications (along weld direction) noted
- Due to pattern, orientation, and consistency of indications, preferential etching was suspected

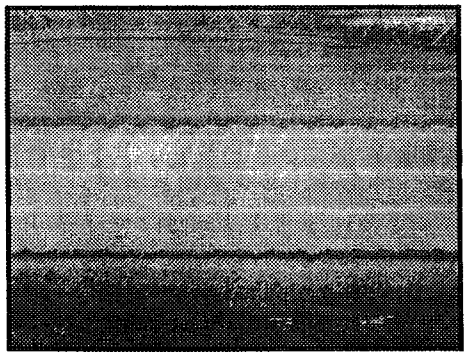
ET-106 LH2 Tank Post Proof Penetrant Indications

SMR 99-002

Discussion

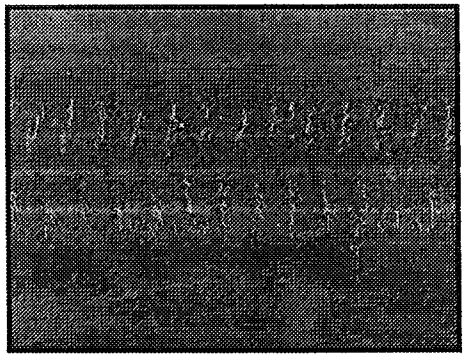
- HB1-4 penetrant indications appeared after multiple etch cycles
  - No weld x-ray indications
  - Penetrant indications can be removed by polishing
- HB1-4 manufacturing history simulated in laboratory
  - Penetrant indications duplicated
  - Root Bead Cap Pass (RBCP) grain boundaries highlighted by etching

Test Panel RBCP Weld



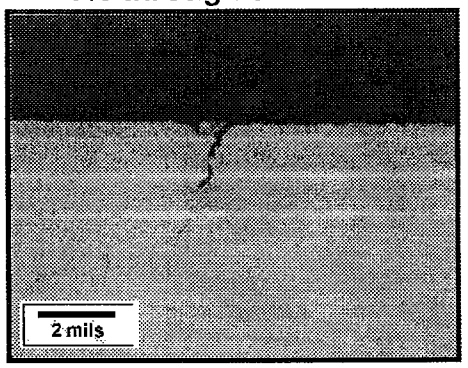
Whitelight Photo

Test Panel RBCP Weld



Blacklight Photo

Etch indications extend 1% through thickness



ET-106 LH2 Tank Post Proof Penetrant Indications

SMR 99-002

Discussion

- Pre Proof Test Assessment of Penetrant Indications
  - Due to pattern, orientation and consistency of indications, metallurgical phenomenon suspected
    - Verified by simulation panels
    - AMI repair resulted in large, columnar grains
    - Indications are preferentially etched grain boundaries
  - Evaluated options for resolving indications
    - 1) Heat repair
      - Full length, downhand AMI* repair

        *AMI: Arc Machine Incorporated
      - Welder suspended from overhead structure, 30' above factory floor
    - 2) Use as is
      - Accept indications for proof and for flight
      - No further rework
    - 3) Remove indications
      - Sand and hand polish
      - Verify removal by penetrant inspection without etch

ET-106 LH2 Tank Post Proof Penetrant Indications

SMR 99-002

Discussion

- Pre Proof Test Assessment of Penetrant Indications (continued)
  - Third (remove indications) option selected
    - Penetrant indications removed by polishing with metallurgical paper
    - Extensive test program initiated to determine as-welded mechanical and fracture properties
      - Tensile tests (room temperature and cryogenic)
      - Fracture and simulated service tests (with and without EDM* flaws)

        * EDM: Electric Discharge Machining
      - Wide panels (strength and fracture)

  - HB1-4 subsequently deemed acceptable for proof test
    - Penetrant indications removed or dispositioned
    - Mechanical and fracture properties characterized
    - Positive margins of safety calculated
    - Mission life requirements met

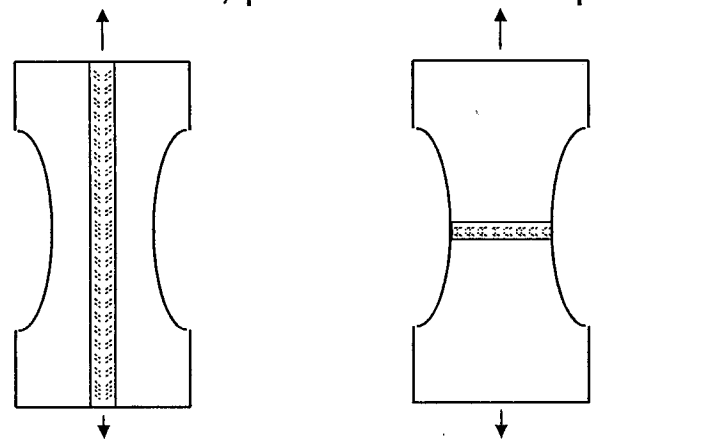
ET-106 LH2 Tank Post Proof Penetrant Indications

SMR 99-002

Basis for Certification

- Proof Test Characterization – Test Panels
  - Simulation panels, polished and without penetrant indications, proofed and reinspected

Stress / Loading Direction	Along Weld	Across Weld
20 ksi		√
25 ksi	√	√
30 ksi	√	√
35 ksi	√	



Specimen Loaded **Along** Weld Direction

Specimen Loaded **Across** Weld Direction

  - Post-proof test penetrant indications noted when stressed in either drection
    - Similar indications present, regardless of loading direction
    - 20-25 ksi along weld
    - 20 ksi across weld
  - No radiographically detectable flaws after proof test

Post-Proof Test Penetrant Indications Were Expected

105&106PFR.4250.11/00

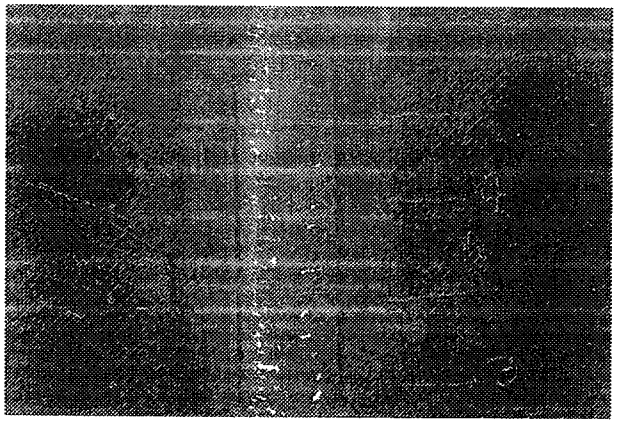
ET-106 LH2 Tank Post Proof Penetrant Indications

SMR 99-002

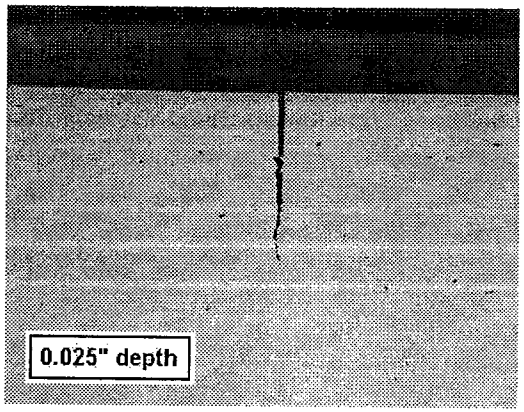
Basis for Certification

- Discussion of Tensile and Fracture results
  - All tensile / fracture panels met or exceeded design values
  - All panels developed post-proof penetrant indications
    - No x-ray indications created
    - Applied stress highlights lower strength grain boundary
  - Simulated service of natural / EDM flaws successful
    - Parent metal / weld fracture toughness unaffected
  - RBCP flaw enhancement occurred during proof test
    - Enhanced flaws are shallow, tight (no x-ray indications)
  - Orientation of RBCP penetrant indications favorable
    - Flaws transverse to weld are historically benign
    - Parent metal properties dominate (75 ksi vs. 30 ksi)

Test Panels After Proof Test



Black Light Photo



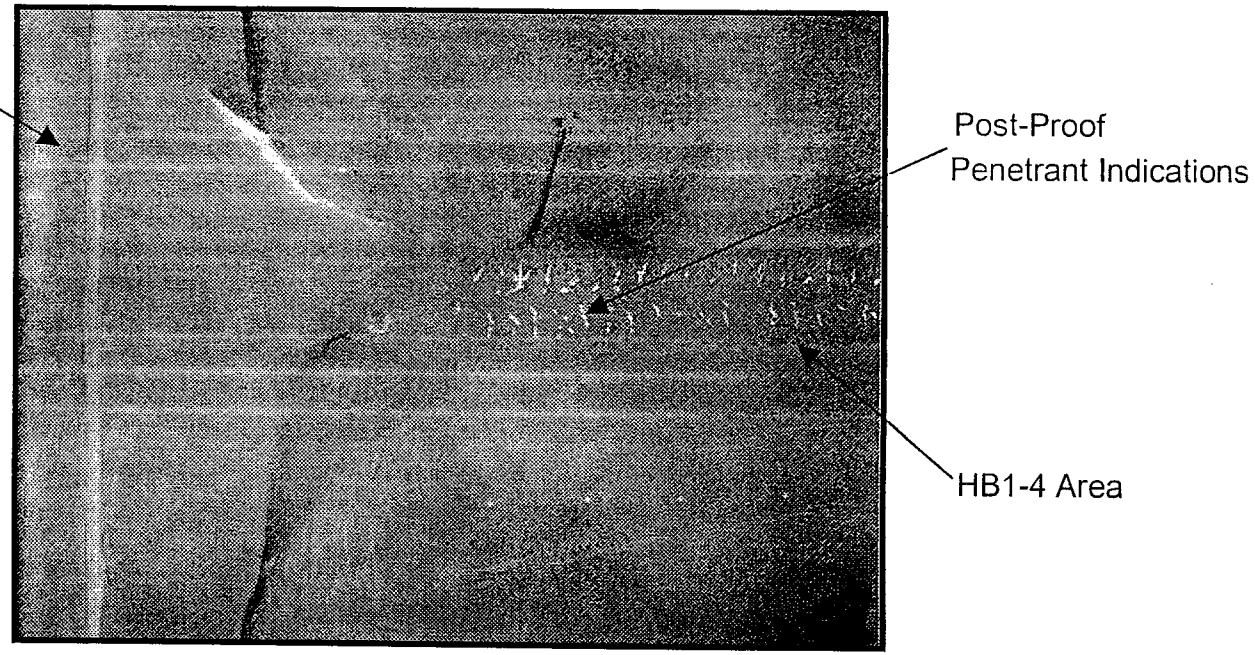
Stress Induced Flaws extend about 10% through the weld thickness

ET-106 LH2 Tank Post Proof Penetrant Indications

SMR 99-002

Basis for Certification

- Post-Proof HB1-4 Results
  - Predicted characteristic penetrant indications found full length
  - As predicted, no x-ray indications were noted
  - Penetrant indications very similar to post-proof test panels
  - Ultrasonic NDE has verified penetrant indication depth similar to test panels



ET-106 LH2 Tank Post Proof Penetrant Indications

SMR 99-002

Basis for Certification

- HB1-4 Post Proof Test Inspection
  - Significant radiography performed on the HB1-4 after proof test
    - 90° and ±35° radiographs (required for repair welds)
    - Additional informational radiographs specified by MRB
      - ±7.5° radiographs with x-ray source along weld
      - ±7.5° radiographs with x-ray source across weld
    - **No radiographically rejectable indications detected**

- Penetrant inspection performed by MRB direction
  - Numerous OSL indications detected along grain boundaries
  - Indications "in family" with those noted on test panels

- Phased array ultrasonic inspection performed by MRB direction
  - **No "out of family" indications noted**
  - Accuracy of phased array results evaluated using test panels

HB1-4 Post Proof Test Indications Are in Family With Test Panels

ET-106 LH2 Tank Post Proof Penetrant Indications

SMR 99-002

Rationale for Acceptance

- HB1-4 microstructure successfully duplicated and tested
- Mechanical properties characterized and design values exceeded
- Fracture properties characterized and mission life requirements exceeded
- HB1-4 is radiographically acceptable
- Post proof test penetrant indications duplicated and characterized
  - No strength degradation
  - No deleterious effect on mission life
- HB1-4 is adequately proof tested, less 8" aft of H2 weld
- Positive margins of safety exist for all locations of HB1-4
- Localized areas of thickness t=0.290"min. (nominal t=0.320") yielded FS=1.31 vs 1.25 reqd.

Agenda

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Prior Mission Performance Summary
Current Mission/External Tank Highlights
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Changes
Senior Management Review NCDs

Special Topics

- ***Discrepant Weld Bead Profile*** ***Don Bolstad***

SRM&QA Assessment
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Discrepant Weld Bead Profile

Issue

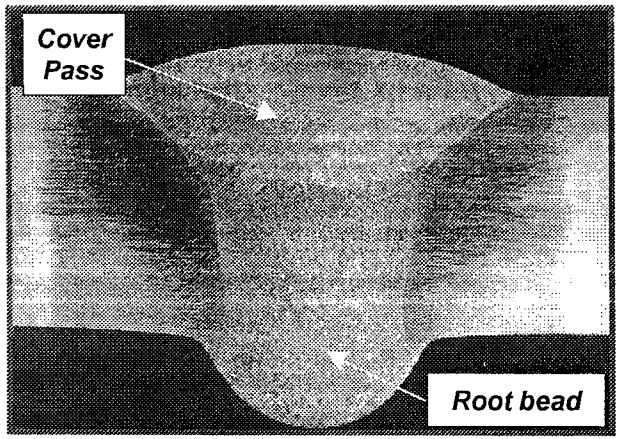
- NEQA (NASA Engineering Quality Audit) Phase 1 discrepancy/observation
  - "Dressing" (sanding/shaving) weld bead penetrant indications (porosity, inclusions and cracks) could result in unacceptable weld strength

Background

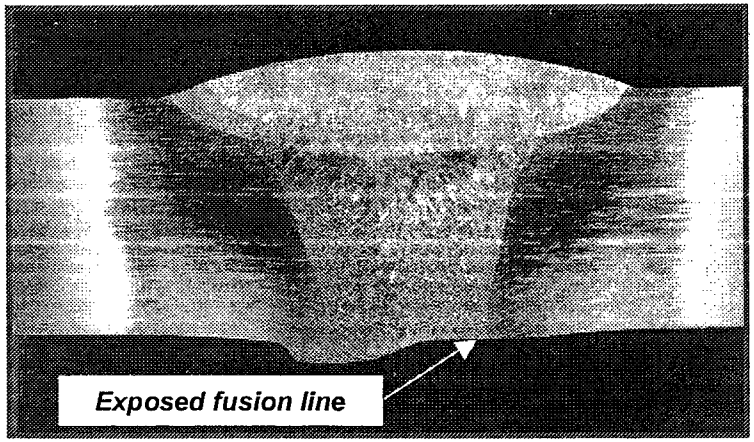
- Item was presented to the PRCB on August 1, 2000 (SR1331) to provide clearance rationale for STS-106/ET-103 in response to Action Item 92-ET/SRB-001
  - PRCB Action (S063026) was issued to report individual clearance results for ET-105 through ET-108 at the appropriate milestone review as it occurs
    - ET-105 clearance presented at the STS-97 ET/SRB Mate Milestone Review on 9/22/00
- For clearance of completed tanks, suspect condition was assumed for all welds
- Procedures allowed dressing of weld bead penetrant indications down to 0.040" minimum bead height without documentation or MRB disposition
  - Dressing was performed per written procedure, but did not meet engineering intent
- Reduction in weld strength isolated to welding of Al 2195 material
  - No strength reduction for shaving of Al 2219 material
- Fracture properties not affected
  - Allowables based on shaved flush condition

Discrepant Weld Bead Profile

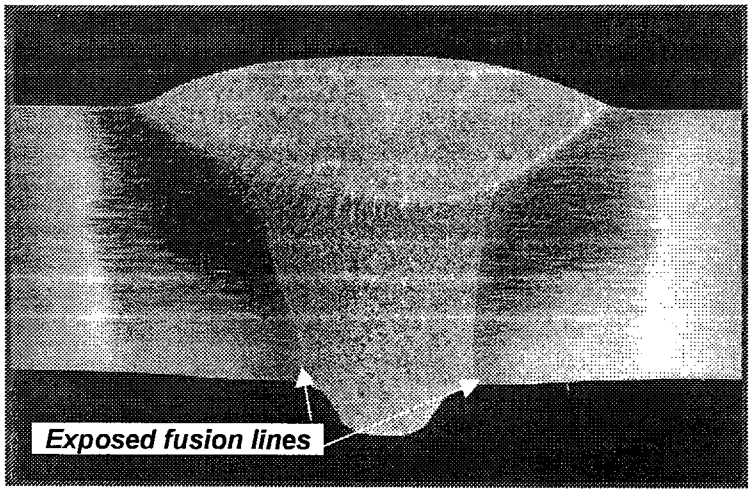
Background



As-Welded Bead



Toe sanding resulting in exposed fusion line and substantial reinforcement removal



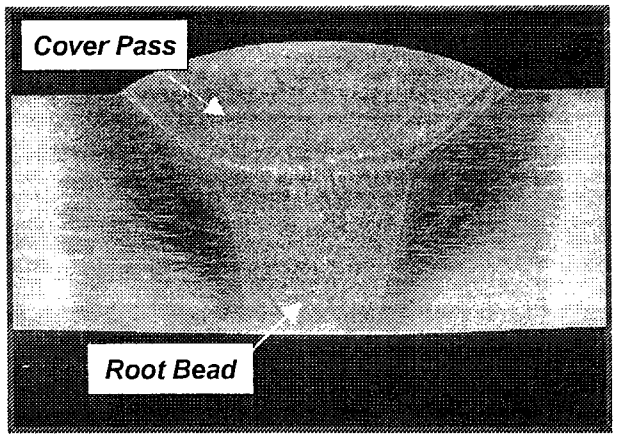
Toe sanding (both sides) resulting in both fusion lines exposed

Conditions of Concern

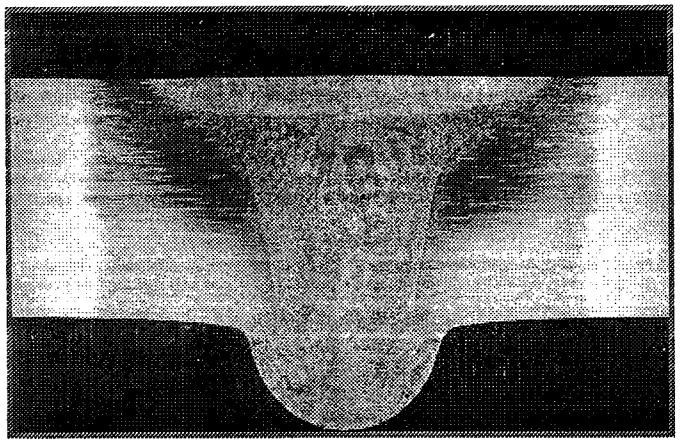
Discrepant Weld Bead Profile

STS-97/ET-105 Weld Clearance Analysis Approach

- ET-105 was evaluated using the conservative assumption that all welds have been shaved flush on one side
  - "As-built" records of peaking, mismatch, and repairs used in the analysis where needed



Root Bead Shaved Flush

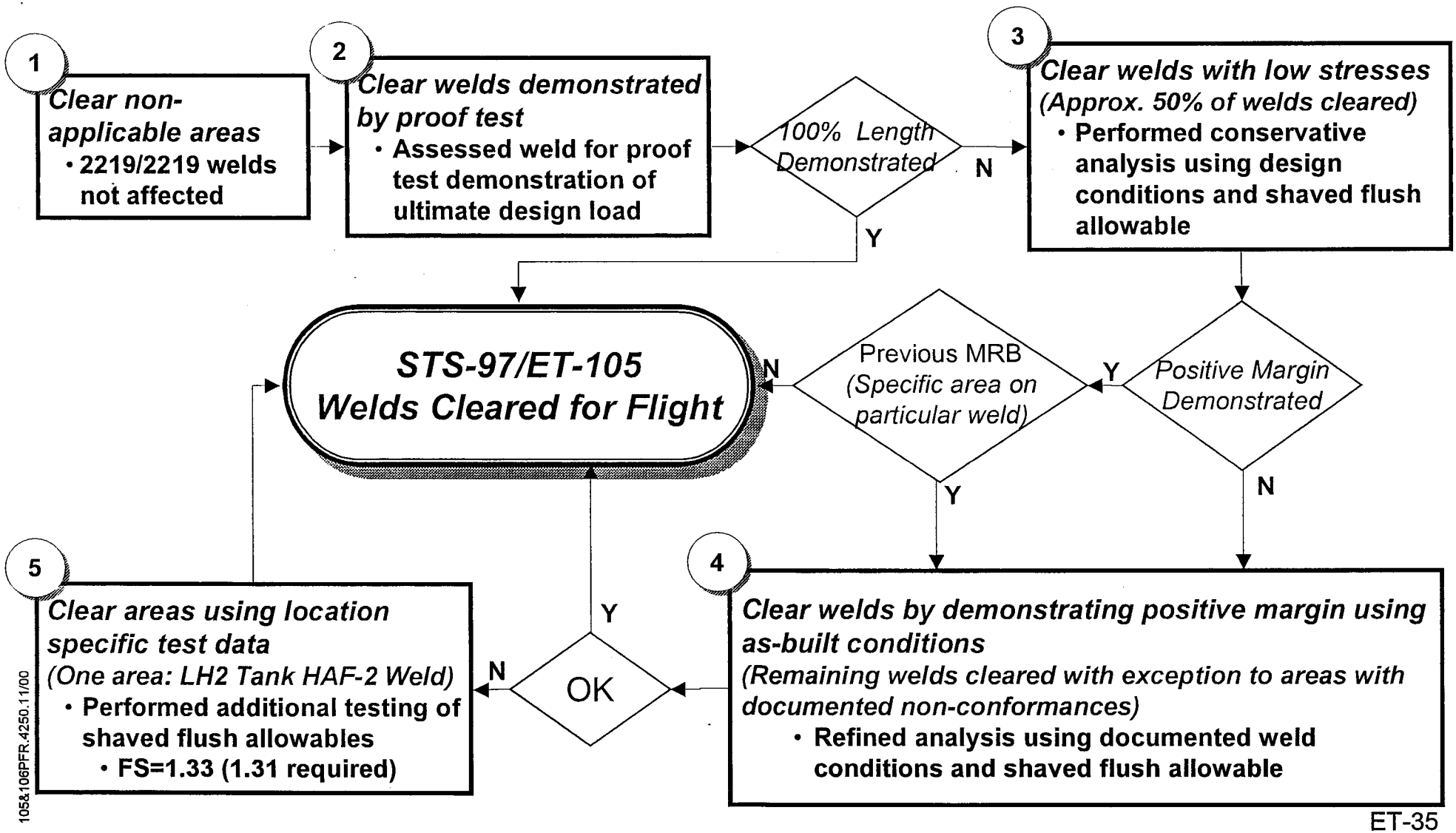


Cover Pass Shaved Flush

Conditions Assumed for Analysis

Discrepant Weld Bead Profile

STS-97/ET-105 Weld Clearance Complete



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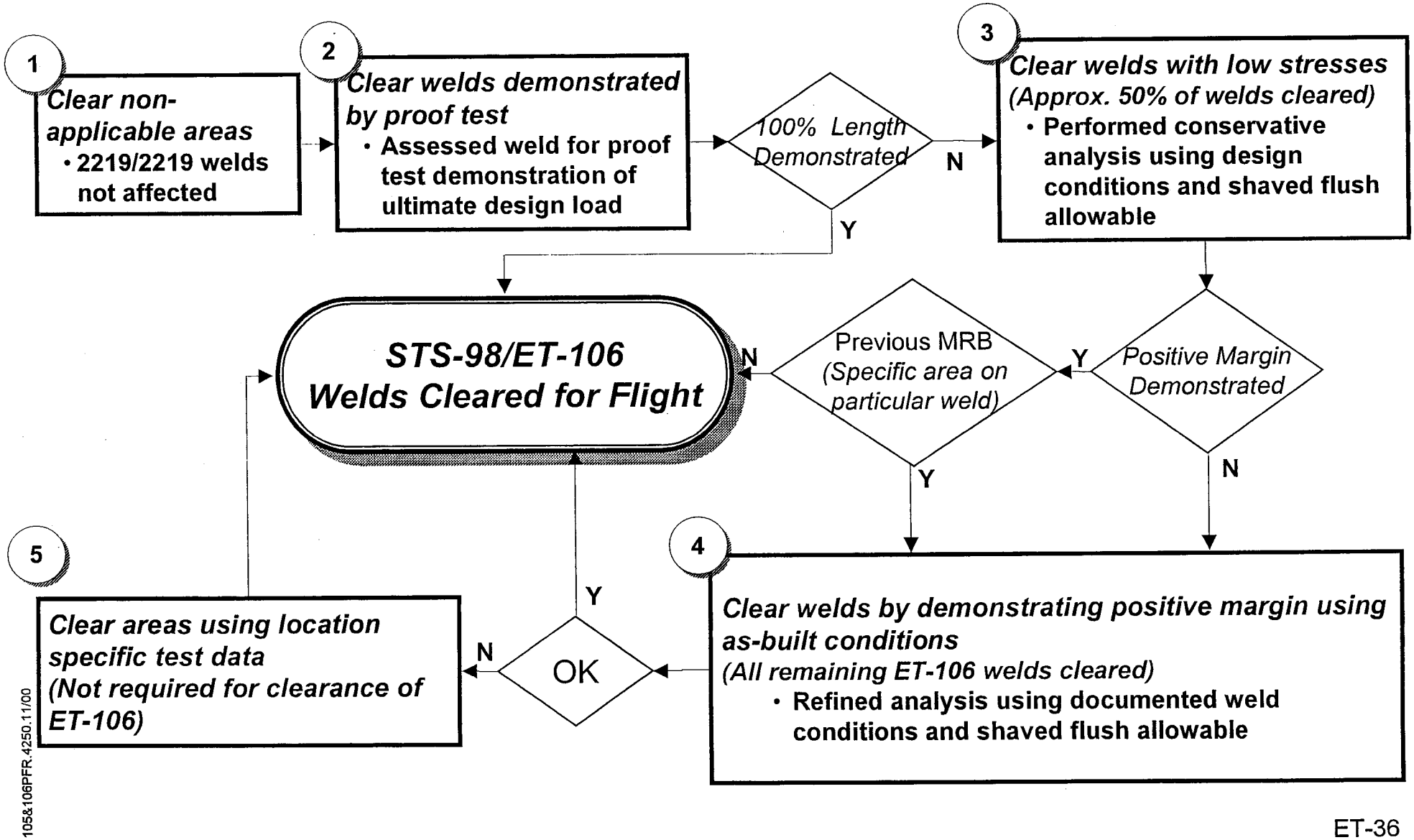
Discrepant Weld Bead Profile

STS-98/ET-106 Weld Clearance In Work



105&106PFR.4250.11/00

Discrepant Weld Bead Profile

Rationale for Acceptance

- All 2219/2319/2219 welds cleared
  - Welds meet initial weld properties with shaved flush beads
- Welds with 100% proof test demonstration of ultimate design load cleared
- Analysis/Test

  STS-97/ET-105:
  - All MRB impacts considered (As-built conditions)
  - Location specific allowables developed for shaved flush welds
  - Positive margins demonstrated
    - HAF-2 FS=1.33 (1.31 required) based on location specific assessment/test

  STS-98/ET-106:
  - Positive margins demonstrated for remaining welds using as-built conditions
    - Location specific test data not required

Agenda

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SRM&QA Assessment ***Terry McKeough***
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SRM&QA Assessment

as of 10/30/2000

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 Summary (CAPS)***	
• P-091, Leaking LO2 feedline seal on ET-111	ET-105 & ET-106 cleared - Successfully passed leak test at MAF. - CAPS in MSFC closure loop
• S-083, Post proof NDE concerns	ET-105 & ET-106 cleared for all post-proof NDE issues. - CAPS in work at MAF
• S-084, Contaminated Argon gas (Air Products) for ET welding	ET-105 & ET-106 cleared - Contaminated gas not used for ET-105 & 106 welding operations. -CAPS in MSFC closure loop
• S-085, Sanded/shaved Al 2195 welds	Presented as Special Topic. -CAPS in work at MAF
• E-169, SRB Harness Failure	ET-105 & ET-106 cleared - Passed TM04 Dielectric Withstand Voltage final acceptance test. -CAPS in MSFC closure loop
• P-092, Leaking LH2 Manhole cover seal	ET-105 and ET-106 cleared - Successfully passed leak test at MAF. - CAPS in work at MAF

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KSC Processing ***Wes Lattin***

- ***STS-97/ET-105 Status***
- ***STS-98/ET-106 Status***

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KSC Processing

as of 10/25/2000

Discrepancy Reports (DRs)/Problem Reports (PRs) Review

- PR/MRB discrepancies/dispositions similar to previously flown vehicles
  - All KSC/MRBs have been reviewed by MAF Reliability for potential SMR
  - No items were elevated to the SMR

Limited Life Component/ET Status

- All within required life through scheduled launch date plus 90 days

OMRSD Exceptions/Waivers: None

Significant Processing Anomalies: None

KSC Processing - Status

STS-97/ET-105 Status as of 10/09/2000

Changes

- ET modifications
  - Mod Kits 0
  - DC&R 0
  - Bldg 45 2
    - MPS 2" disconnect poppet inspection
    - Suspect ET weight data
      - Reweigh not performed for ET-106 based on PRCB direction
  - FEC 2
    - Intertank thrust panel and + Z stringer panel foam venting
  - OMRSD/LCC 0
  - Facility 0
  - Software 0
- Planned work changes None

SIM Launch (S0044) ***10/23/00***

SIM Load (S0056) ***11/14/00***

KSC Processing - Status

STS-98/ET-106 Status as of 10/09/2000

Changes

- ET modifications
  - Mod Kits 0
  - DC&R 0
  - Bldg 45 0
  - FEC 1
    - Intertank thrust panel and + Z stringer panel foam venting
  - OMRSD/LCC 0
  - Facility 0
  - Software 0
- Planned work changes 1
  - Intertank door closeout not required
    - ***B02049 moved flight closeout to MAF***

SIM Launch (S0044) 11/04/00

SIM Load (S0056) 12/20/00

105&106PFR.4250.11/00

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Verification/Certification

as of 10/09/2000

Item	**Status**
NSTS 07700, Volume X, Book 1, Baseline	
• Revision M, Change 267	• No issues
Certification Documentation	
• Hardware Certification Sheets (HCS)	• Complete - No issues
• Certificates of Qualification (COQ)	• No new items
Waivers/Deviations	• No new items

Mission Unique Assessment

	STS-97/ET-105	***STS-98/ET-106***
Review of MRB actions using updated loads	*ECD 11/20/2000 (UR)*	*ECD 01/08/2001 (UR)*
MPS Preflight Prediction Package	*ECD 11/20/2000 (UR)*	*ECD 01/08/2001 (UR)*

Readiness Statement

The External Tank, ET-105, is hereby certified and ready for STS-97 flight pending completion/closure of open and planned work

Ronald W. Wetmore
Vice President, External Tank Project
Lockheed Martin Space Systems Company

LOCKHEED MARTIN

Readiness Statement

The External Tank, ET-106, is hereby certified and ready for STS-98 flight pending completion/closure of open and planned work

Ronald W. Wetmore
Vice President, External Tank Project
Lockheed Martin Space Systems Company

LOCKHEED MARTIN

105&106PFR.4250.11/00

Appendices

A: Minor Changes

B: SRM&QA Assessment

- NCD Assessment Criteria

C: KSC Processing

- PR/MRB Summaries
- OMRSD Exceptions/Waivers: None
- Modification Summaries/Status
- Limited Life Component Status
- OMRSD Changes (RCNs)
- Software Changes
- Facility Modifications: None

D: Level II Waivers/Level III Deviations

Change Presentation Criteria

- Changes for Presentation
  - *Type I Documentation*
  - *Requirements*
  - *Configuration* (affects part interchangeability)
  - *Materials* (requires SE16 revision)
  - *Technical Changes to Processes* (STPs)
- Changes for inclusion in Appendix
  - *Minor configuration* (affects part interchangeability)
  - *Minor updates* - Does not affect part interchangeability, materials or processes
    - Revise point of incorporation
    - Drawing clarification
    - Non-flight hardware installation/removal
    - Datum changes
    - Update usage/List of Materials
    - Drawing incorporation errors
    - Manufacturing aid
    - Drawing errors
    - Fastener type/grip
    - Producibility
    - Update vendor list
    - Laboratory test procedures
    - Materials
- All Class I and Class II changes have been reviewed by the MSFC Resident Office
- All Class II STP/STM/Standard/Code sheet changes have been submitted to the MSFC Materials, Processes and Manufacturing Department for concurrence

Minor Change – Configuration

Change	Description	Basis for Certification
Reallocated ET-106 LO2 tank aft dome to ET-104 (B02022A/A)	Frame chord material at Sta 851 changed from Al 2195 to Al 2219 ▪ Incremental return to Al 2219 chord material	Similarity – Al 2219 extrusions previously flown at other locations on ET
Allocation of 2219 Class II Extrusion (B02022/B02022B J31158/J31195)	Frame outer chord extrusions at Sta 851, and 2058 changed from Al 2219 Class I to Al 2219 Class II ▪ Incremental return to Al 2219 chord material	Similarity – Al 2219 Class II extrusions previously flown at other locations on ET
Moved Flight Closeout of Intertank Door to MAF (B02049)	▪ Moved final close-out of the intertank door from KSC to MAF • Revision/deletion of KSC inspections and leak checks due to this change were previously implemented	Similarity – Not a configuration change; point of incorporation change only

Minor Changes

Change No.	Discipline	Description	Effectivity
H35809-440	Structural	Added serialization, traceability and fracture criticality to frame 1973 forged attach fittings.	ET-105 & sub
H35809-776	Structural	Revised xt. 2058 outer chord drawings to add outline of class II AL 2219 extrusion and machining dimension locations for clarification.	ET-106 & sub
H35809-978	Structural	Reworked xt. 2058 LH2 outer chord from class II to class I extrusion due to availability of parts.	ET-105 only
H36809-020	Structural	Reallocated LH2 Aft Dome Halves on ET-105 & ET-106 to support build schedule. Resulted in mixed class I and class II chord extrusions.	ET-105 & ET-106
H36809-021	Structural	Reworked Machined Fitting on LH2 frame at Sta 1973.5 to provide proper seating of fastener heads at installation.	ET-105 & sub
H36809-064	Structural	Corrected Fastener Orientation Callout on LH2 upper frame segment drawing to eliminate interference.	ET-106 & sub
H36809-172	Structural	Clarified drawing by defining shown and opposite on LH2 xt 1129 frame stabilizer.	ET-105 & sub
H36809-208	Structural	Revised dome weld drawing to increase tang gap from 0.020" max to 0.050" max.	ET-105 & sub
H36809-212	Structural	Added drawing flag note to permit chamfer of isolator pad (.2 max by 45° as required) to clear weld bead on LH2 tank at station 1623.	ET-106 & sub
H36809-232	Structural	Revised drawing to reflect proper ET/Orb interface cable tray fairing part numbers.	ET-105 & sub
H36809-259	Structural	Revised drawing to eliminate Epoxy Primer from in-line holes on LO2 feedline support yoke to prevent interference.	ET-105 & sub
J31193-002	Structural	Revised fasteners on stringer end caps around I/T access door.	ET-105 & sub

Minor Changes

Change No.	Discipline	Description	Effectivity
H35809-890	Structural	Revised LO2 dome splice plate installation drawing note to include STP2003 flushness requirement for countersunk fasteners.	ET-106 & sub
H36809-046	Structural	Revised Fastener (HILOK) Grip Length on I/T Panel #4 roll tie installation.	ET-106 & sub
H36809-117	Structural	Revised Weld Acceptance Manual to tighten peaking and mismatch requirements for H1 weld on Class I chord extrusions	ET-106 & sub
H36809-144	Structural	Revised Nosecone thickness from .252 +/-.018 to .234 +/-.014; previous builds met engineering requirements or were accepted on NCD	ET-106 & sub
H36809-191	Structural	Revised drawing to align bushings in one lug of the vertical strut 180° from the bushings in the adjacent lug.	ET-106 & sub
H36809-251	Structural	Revised quantity of inserts replaced on LO2 forward bulkhead brackets in final assembly prior to nosecone bracket installation.	ET-106 & sub
H36809-291	Structural	Clarified lube & adjustment requirements on vertical strut eccentric bushings.	ET-106 & sub
H36809-294	Structural	Corrected quantity of washers called out for GH2 pressline installation.	ET-106 & sub
H36809-040	Materials	Added drawing requirement to lubricate nose cone attach bolts to prevent galling. And adjusted installation torque appropriately.	ET-106 & sub
J31176-013	Prop/Mech	Document change to clarify ICD Requirements on drawings of GH2 vent/relief valve	ET-105 & sub

Minor Changes

Change No.	Discipline	Description	Effectivity
H36809-218	Prop/Mech	Change Surface Cleaning Area	ET-106 & sub
H36809-061	TPS	Revise foam trim angle and its tolerance at the intertank GUCP RF bulkhead fitting to prevent exposing adjacent stringer end cap.	ET-105 & sub
H36809-143	TPS	Add a missing foam trim dimension to the LH2 tank third hard point foam closeout trim, which was inadvertently removed by a previous change.	ET-105 & sub
H36809-175	TPS	Revise note in nose cone closeout drawing to clarify RTV sealant with respect to foam migration.	ET-105 & sub
H36809-222	TPS	Add a missing foam trim dimension to the –Y Bipod Fitting foam closeout trim which was inadvertently removed by a previous change.	ET-105 & sub
H36809-262	TPS	Revised both MAF & Offsite Acceptance Manuals to add criteria allowing atmospheric fallout type elements of SOFI/Ablator dust & foam mist over-spray particles produced during ET acreage net spray operations.	ET-106 & sub
H36809-270	TPS	Revise the sub-assembly Ablator closeout of the Aft Interface LO2 Umbilical Cable Tray to clarify graphically the actual closeout configuration and delete a dimension that serves no function at this closeout location.	ET-106 & sub
H36809-306	TPS	Take exception (NSRA 4110-2-007) not to apply epoxy primer prior to foam closeout operations on cadmium plated or titanium surfaces of the Aft Interface Vertical Strut Fitting closeout. Surfaces are Mono-ball Bushings and spotfaces in Vertical Strut Fitting. Also identified an area of foam on the Vertical Strut Fitting closeout where production could, at their option, apply this area in conjunction with SRB Cable Tray Pal Ramp closeout.	ET-106 & sub

Minor Changes

Change No.	Discipline	Description	Effectivity
H36809-322	TPS	Add foam dimensional thickness requirements to two Intertank Stringer Valleys aft of the GUCP Carrier Plate to eliminate interference with respective Launch Ground Support Hardware at installation.	ET-106 & sub

Minor Changes – STD/STM/STP/AVL

Change No.	Document	Description
H36809-240 -241 -242 -450 -455 -456	Welding STPs 5501, 5507, 5508, 5509	Revised welding specifications to address issues identified in investigation of Weld Instruction Cards. Clarification of the specifications was part of the corrective action identified to address issues.
H36809-271	L742 Polyurethane Foam	Revised STM, Code, and Addendum to delete gravimetric test and replace with GC method; added dimensional stability, hydrolytic stability, and thermal conductivity; and update entire specification in electronic format, incorporating all outstanding amendments.
H36809-430	STP2024 Screw Threads Inserts Instl	Revised STP to add tabulated data for every installation of threaded insert used on the ET for easier insert installation.
H36809-438	Y441 Argon, Welding Gas	Changed source appendix for argon gas suppliers and/or distributers to reflect those certified to supply MAF and subcontractors. Site certification of weld gas suppliers was initiated prior to shipping to MAF.
H36809-451	STP1513 Foam Poly Spray Appl	Broadened range of component A to component B average ratio to allow for acceptance of average ratio transients identified as electrical noise in the system.
H36809-452	STP1533 Polyisocyanurate Foam Appl	Broadened range of component A to component B average ratio to allow for acceptance of average ratio transients identified as electrical noise in the system.

Minor Changes – STD/STM/STP/AVL

Change No.	Document	Description
H36809-453	Y758 Anti-static Materials	Revised code sheet to allow change in vendor to Airtech International
H36809-454	K736 Ablative Coating Compound	Changed STM for test panel preparation and to code sheet, code name, addendum and source appendix to reflect supplier name change.
H36809-468	K676 High Purity Heptane	Changed vendor name and address on code sheet and appendix. No change to heptane manufacturing process or to processing location.

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-105 DR/PR/OMRSD Waiver/Exceptions

as of 10/09/2000

System	Discrepancy	Problem	MRB Items	Exceptions/ Waivers
• Electrical	0	1	0	0
• Propulsion/ Pneumatics	0	0	0	0
• Structures	0	4	1	0
• Thermal (TPS)	0	5	1	0
Total	0	10	2	0

ET-105 PR/MRBs, Thermal

PR No./Status	Title/Description	Disposition
PET-105-TS-0002	Low foam in aft hardpoint closeout.	Use-as-is Not a debris concern Will not affect rupture altitude

ET-105 PR/MRBs, Structures

PR No./Status	Title/Description	Disposition
PET-105-ST-0003	Exposed fastener on -Y Thrust panel damaged during foam machining	• Use-as-is • 1/4" Cad plating was abraded.

ET-105 KSC Modification Summary/Status

Item	***Title***	***Status***
• ***Field Engineering Changes***		
– FEC KET-0061	Intertank thrust panel foam venting	Work complete
– FEC KET-0066	Intertank +Z stringer area foam venting	Work complete
• ***Non Standard Work***		
– J5295	MPS 2" disconnect poppet inspection	Work complete
– J5297	Suspect ET weight data	Work complete

ET-105 Limited Life Components

Cycle Sensitive

Description	Part No.	Serial No.	Limit	Required	Remaining
LH2 Manhole Cover Assy	80914081488 -509	0000749870	14	2	14
LO2 Tank Mechanical Assy	80912002000 -500	0000781990	14	2	14
LH2 Tank Mechanical Assy	80914002000 -500	0000770640	14	2	14
LO2 Manhole Cover Assy	80911001205 -509	0000807690	14	2	14
LO2 Fwd Ogive Cover Plate	80911001207 -509	0000806490	14	2	14
LH2 Manhole Cover Assy -Aft	80911001444 -509	0000793600	14	2	14

ET-105 Limited Life Components

Age Sensitive

Description	Part No.	Serial No.	Limit	Initiation	Expiration
External Tank	80901000000-500	00000098	6 Yrs	7/99	7/2005

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

Description	Part No.	Lot No.	Serial No.	Latest Retest	Expiration
Separator Assy GUCP	PD5000020-059	AAH	0001153	02/24/1998	01/2002
Cartridge Assy	PD5000020-030	AAH	0001312	02/24/1998	01/2002
Cartridge Assy	PD5000020-030	AAH	0001313	02/24/1998	01/2002

ET-106 DR/PR/OMRSD Waiver/Exceptions

as of 10/09/2000

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

ET-106 KSC Modification Summary/Status

Item No.	*Title*	*Status*
• ***Field Engineering Changes***		
– FEC KET-0067	Intertank Thrust Panel and + Z Stringer Panel Foam Venting	In-Work

ET-106 Limited Life Components

Cycle Sensitive

Description	Part No.	Serial No.	Limit	Required	Remaining
LH2 Manhole Cover Assy	80914081488 -509	0000771610	14	2	14
LO2 Tank Mechanical Assy	80912002000 -500	0000806870	14	2	14
LH2 Tank Mechanical Assy	80914002000 -500	0000770640	14	2	14
LO2 Manhole Cover Assy	80911001205 -509	0000831230	14	2	14
LO2 Fwd Ogive Cover Plate	80911001207 -509	0000831330	14	2	14
LH2 Manhole Cover Assy -Aft	80911001444 -509	0000806380	14	2	14

ET-106 Limited Life Components

Age Sensitive

Description	Part No.	Serial No.	Limit	Initiation	Expiration
External Tank	80901000000 -500	00000099	6 Yrs	11/99	11/2005

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

Description	Part No.	Lot No.	Serial No.	Latest Retest	Expiration
Separator Assy GUCP	PD5000020-059	AAH	0001158	02/24/1998	01/2002
Cartridge Assy	PD5000020-030	AAH	0001324	02/24/1998	01/2002
Cartridge Assy	PD5000020-030	AAH	0001342	02/24/1998	01/2002

Level II Waivers - Baseline (ET-105 & ET-106)

Document / Requirement	Authority	Paragraph	Waiver No.	Effectivity
NSTS 07700, Volume V, Information Management Requirements				
Generic part name, type, common designation, and part manufacturer H4 code are not required for EEE parts status print out	PRCBD S000127B 06/28/88	Table C.5 Item 2SR-10	6	ETs 49 & up
Data required in limited life status report is supplied in acceptance data package	PRCBD S000127B 06/28/88	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	PRCBD S000127B 06/28/88	Table C.6 Item 2SR-7	10	ETs 49 & up

Level II Waivers - Baseline (ET-105 & ET-106)

Document / Requirement	Authority	Paragraph	Waiver No.	Effectivity
NSTS 07700, Volume X, Book 1, Space Shuttle Flight and Ground System Specification, Requirements				
Soldering, circuit boards, and connectors	PRCBD S040732M 09/09/88	3.6.15.1.1	379	ETs 23, 27-29, 31 & up
PD7400106 circuit boards	PRCBD S040732M 09/09/88	3.6.15.2.1	382	ETs 23, 27-29, 31 & up
Pressure transducer circuit boards	PRCBD S040732M 09/09/88	3.6.15.2.1	383	ETs 23, 27-29, 31 & up
Debris prevention	PRCBD S082962A 10/02/98	3.2.1.2.14	675	ETs 92, 97-105

Level II Waivers - Baseline (ET-105 & ET-106)

Document / Requirement	Authority	Paragraph	Waiver No.	Effectivity
NSTS 07700-10-MVP-01, Shuttle Master Verification Plan - Volume I, General Approach and Guidelines				
Environmental acceptance of ET components	PRCBD S002130H 03/07/89	3.7.1	13	ETs 23, 27-29, 31 & up
NSTS 08123 - Certification of Flexhoses and Bellows for Flow Induced Vibration				
LH2 feedline bellows	PRCBD S005203GR1 08/02/91	1.2	3	ETs 42-45, 47 & up

Level II Waivers - Baseline (ET-105 & ET-106)

Document / Requirement	Authority	Paragraph	Waiver No.	Effectivity
SL-E-0001 – Specification Electromagnetic Compatibility Requirement				
Wire marking is not applicable to the ET	PRCBD S040732K 09/27/89	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 feet on ground half of GUCA	PRCBD S087020L 08/17/88	3.4.2.1	21	ETs 23, 27-29, 31 & up

Level III Deviations (ET-105 & ET-106)

Document / Requirement	Paragraph	DAR No.	Effectivity
CPTO1M09A, External Tank Contract End Item Specification – Part I			
• 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	3.2.1.1.17	233	ETs 92, 97-99, 101-105 **NOTE:** Applies to ET-105 but not ET-106
• 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	3.2.1.1.17	236	ETs 106 - 108 **NOTE:** Applies to ET-105 but not ET-106