FLIGHT READINESS STATEMENT
STS-112/ET-115
EXTERNAL TANK PROJECT
PRE-FLIGHT REVIEW

EXTERNAL TANK ET-115/STS-112, AS IDENTIFIED IN THE EXTERNAL TANK PROJECT PRE-FLIGHT REVIEW DATED AUGUST 27, 2002, IS CONSIDERED READY TO SUPPORT FLIGHT UPON ACCEPTABLE DISPOSITION OF OPEN/PLANNED WORK AND/OR OPEN ACTIONS.

N. E. OTTE/MP31

for J. BULLMAN/ED10

for P. M. MUNAFO/ED30

A. C. ADAMS/QS20

for A. A. McCOOL/MP01

for P. K. McCONNAUGHEY/ED20

S. D. ROSE/ED40

J. S. CHAPMAN/TD01

J. W. SMELSER/MP31, CHAIRMAN

August 27, 2002

Space Shuttle
External Tank

Pre-Flight Review

STS-112/ET-115

115PFR.4250.ls.08/02

Agenda

Overview ***Lynn Servay***
Prior Mission Performance Summary
Current Mission/External Tank Highlights
ET-115 Mass Properties Status
Changes
- LO2 Tank Changes for Higher Ullage Pressure
- Intertank Access Door Revisions
- ET Shuttle Observation Camera

Senior Management Review NCD
Special Topic – LO2 Feedline Foam Repair
SRM&QA Assessment
KSC Processing
Verification/Certification
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-112/ET-115 includes:

- Items specific to mission STS-112
- First time changes, differences and "out-of-family" non-conformances not previously flown and/or reviewed

FRR Series

• ET/SRB Mate Milestone Review	06/21/2002 (A)
• Michoud Operations President's Review	08/21/2002 (A)
• *Pre-Flight Review*	*08/27/2002*
• Space Shuttle Vehicle FRR	09/17/2002 (T)
• Mission Management Team (L-2 Day)	09/30/2002 (T)

Prior Mission Performance Summary

STS-111/ET-113, 05/30/2002 - Launch Scrubbed Due to Weather Violations

System	Performance
• ***OMRSD***	• No ET violations
• ***LCC***	• No ET violations
• ***Instrumentation***	• Nominal performance
• ***MPS***	• No ET issues
• ***ET Hazardous Gas***	• No ET violations

• ***TPS***	• All observations acceptable per NSTS 08303
	  • Typical crack observed in -Y vertical strut closeout
	  • No cracks observed on Intertank stringer panels

Prior Mission Performance Summary

STS-111/ET-113, 06/05/2002 - Launch

System	Performance

• ***OMRSD***	• Min. LO2 replenish flow rate requirement violated
	  • Facility flow indication failed
	  • Waiver processed to proceed with operations using other measurements to monitor system

• ***LCC***	• No ET violations
• ***Instrumentation***	• Nominal performance
• ***MPS***	• Nominal performance
• ***ET Hazardous Gas***	• No ET violations
• ***TPS***	• Conditions noted during previous tanking unchanged • Cracks observed in +Y Longeron closeout • MR rationale provided; no impact to countdown
• ***ET Disposal***	• Nominal
• ***Film Review***	• Complete – No Issues • In post flight film review, no anomalies noted in LO2 feedline foam

Mission/External Tank Highlights

STS-112/ET-115

Mission	**STS-112**
Launch	
• Window	**10/02/2002** *(CR S072112D submitted 8/22/02)*
• Pad	10 min. (late afternoon)
• Orbiter	B
	Atlantis (OV-104)
	• 26th Flight of Atlantis
• Orbital Inclination	51.6° - Insertion at 122 NM
• ET Photo Coverage	• Crew photos from cockpit window
	• Umbilical well cameras
Primary Payload	International Space Station Flight 9A
	• 15th station flight delivers the first right-side truss segment (ITS S1) with cooling radiators and Crew and Equipment Translation Aid (CETA) Cart A
Landing	10/13/2002 at KSC
External Tank	**ET-115**
DD250 Acceptance	9/26/2001
Shipped to Launch Site	12/14/2001

115PFR.4250.ls.08/02

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ET-115 Mass Properties Status

STS-112/ET-115

ET-115 Weighing

- ET-115 was weighed at MAF on September 26, 2001 using the Weigh Tronix weighing system

– Predicted Weight	58,419 lbs.
– As-weighed	58,454 lbs.
– Delta to Predicted	+ 35 lbs.

Mission Planning

- MMC-ET-SE40, ET Project - Mass Properties Weight and Balance Report, was originally submitted September 27, 2001 and updated March 11, 2002 to incorporated the ET Camera System change in support mission planning.
- Coordination with Level II on August 22, 2002 indicates approximately 863 lbs. performance margin for STS-112

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LO2 Tank Changes for Higher Ullage Pressures

B02035

Change

- Resize of LO2 tank structure, increases to the LO2 acceptance proof test pressures, and an increase in the LO2 tank weld post-proof inspections resulting from higher flight ullage pressure requirements

Background

- SSP (Level II) requested External Tank certification to higher maximum LO2 tank ullage pressure operating range (expansion of ICD requirements)
  - Allows the Orbiter fleet to use any combination of spare GO2 fixed orifice flow control valves beginning at STS-112/ET-115

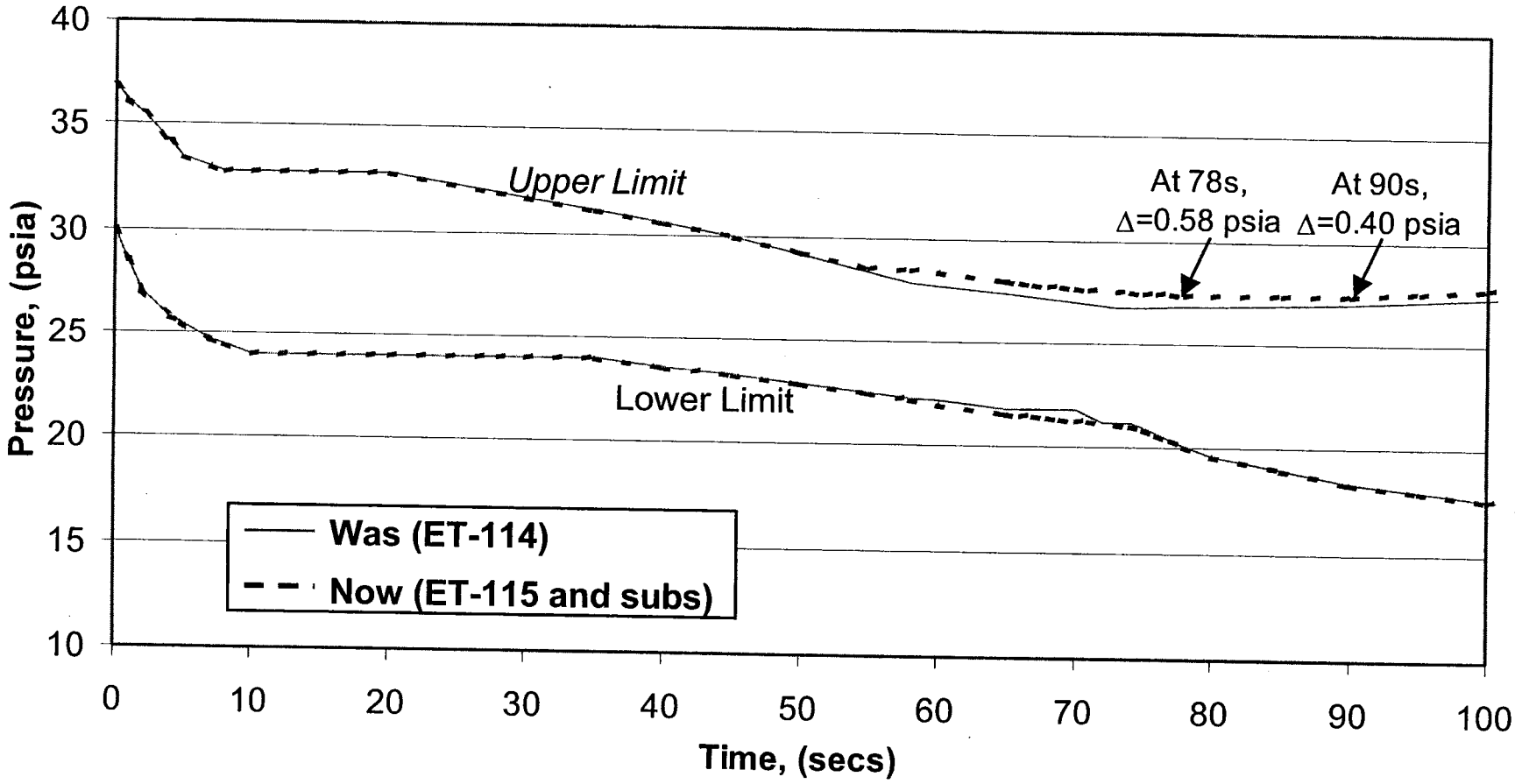
- ICD revised to reflect higher maximum pressure requirement
  - 0.58 psig max increase in pressure occurs at 78 seconds for nominal mission
    - Ullage pressure @ 78 seconds = 27.4 psig

- ET certification to the higher pressures required minor revisions to LO2 tank barrel and dome cap membrane thicknesses, LO2 tank acceptance proof test, and LO2 tank weld post-proof inspection requirements

LO2 Tank Changes for Higher Ullage Pressures

B02035

Ullage Pressure (ICD) Changes



LO2 Tank Changes for Higher Ullage Pressures

B02035

Basis for Certification

- Both the barrel and dome cap designs are certified for flight by similarity, proof test, and analysis
  - Similarity
    - Basic design configurations are unchanged from previous designs
      - Only change is increase in membrane thicknesses to maintain strength requirements
  - Test
    - Proof test demonstrates greater than design limit load (DLL) for both the barrel and dome cap
      - Barrel – 112% of DLL
      - Dome Cap – 120% of DLL
  - Analysis
    - Stress analysis shows improved Factors of Safety for the resized hardware

		Was	***Now***	***Required***	***Failure Mode***
Barrel	Proof	1.10	1.13	1.00	Yield Strength
	Flight	1.27	1.28	1.27	Ultimate Strength
Dome Cap	Proof	1.00	1.04	1.00	Yield Strength
	Flight	1.53	1.58	1.26	Ultimate Strength

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Intertank Access Door Revisions

B02067

Change

- Redesigned the Composite Intertank Access Door to mitigate material / vendor availability issues and improve producibility
  - Material changed from a PMR-15 composite material system to one using AS4/3501-6 graphite/epoxy
  - PMR-15 system not widely used; very little supplier interest in continuing production

Design Description

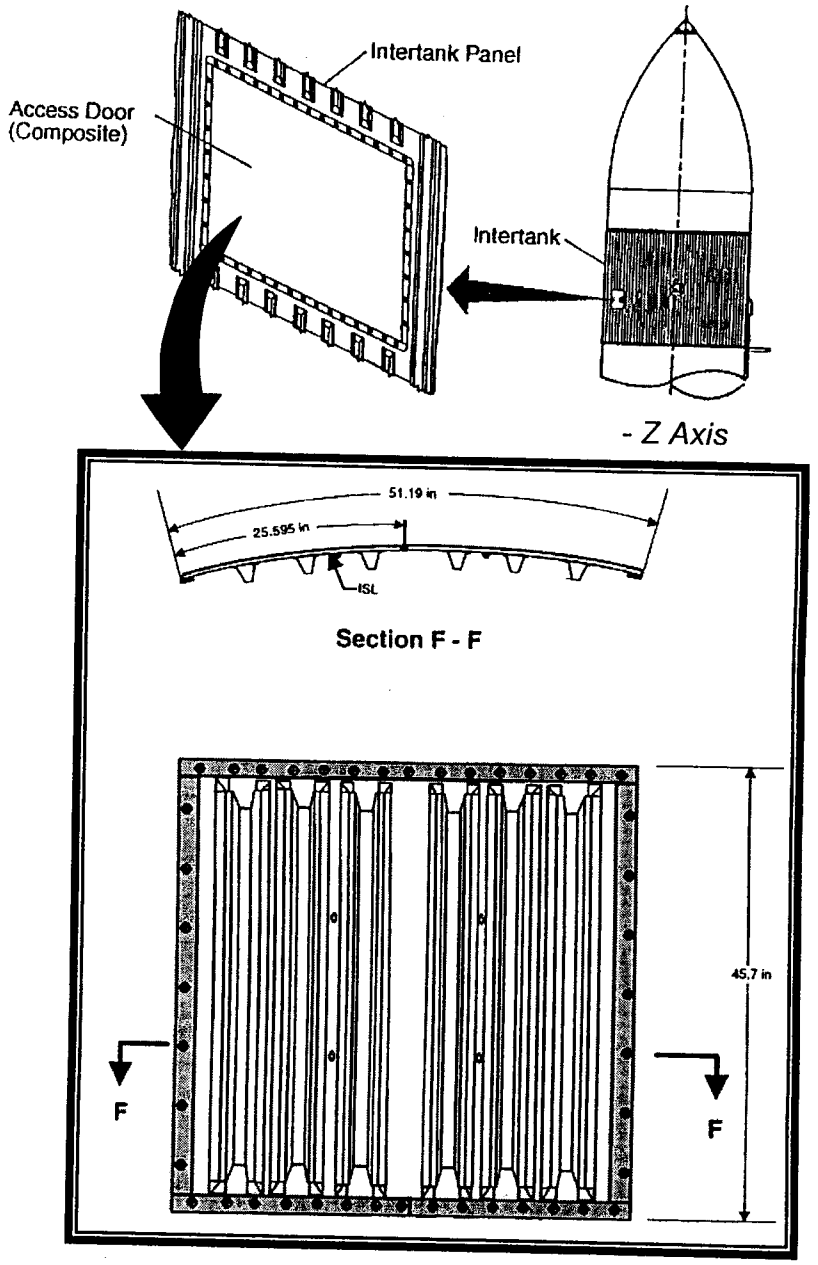
- Objective was to provide a cost effective, structurally robust, and producible design with minimal weight impacts to External Tank
  - Selected graphite/epoxy material (AS4/3501-6)
  - Common material with well documented material property database
    - Large database of mechanical property test data and material provided by NASA MSFC through the SRB nosecone project
  - Graphite/Epoxy is much easier to process than the previous material system but not as strong at elevated temperatures (>400°F)

Intertank Access Door Revisions

B02067

Design Description (continued)

- Design was optimized to incorporate graphite/ epoxy composite material system with negligible impact to the structural weight
- Basic configuration of the door is unchanged
  - Hat stiffened panel with same stiffener pitch and geometry
- Added plies around the periphery of the door (16 to 24) and hat stiffener run-outs (8 to 12)
- Removed acreage plies from stringers and skin (16 to 12)



Intertank Access Door Revisions

B02067

Basis for Certification

- Design is certified by test and analysis
  - Door is non-structural with the only applied loading resulting from a small delta pressure across the intertank wall during ascent
  - Two critical load cases drove the redesign
    - Max Temperature: ΔP_{limit} = 2.80 psig @ 120 secs. (404°F)
    - Max Delta Pressure: ΔP_{limit} = 5.92 psig @ 60 secs. (132°F)
  - Structural verification testing successfully performed for both critical design loading conditions
    - Max Temperature case demonstrated 342% (9.58 psig vs. 2.80 psig) of design limit load without failure @ 404°F
    - Max Delta Pressure case demonstrated 162% (9.58 psig vs. 5.92 psig) of design limit load without failure @ 404°F
    - Post test NDE examination showed no indications of imminent failure
  - Qualification testing performed for aerothermal environments
    - Tested to maximum heating rate and heating loads
    - Post test NDE showed no indications of delamination
  - Stress analysis shows improved minimum factor of safety for the redesigned door

Configuration	*FS*	*FS req'd*	*Failure Mode*
Now AS4/3501-6	1.57	1.40	Tsai-Hill Ply Failure
Was PMR-15	1.43	1.40	Tsai-Hill Ply Failure

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ET Shuttle Observation Camera

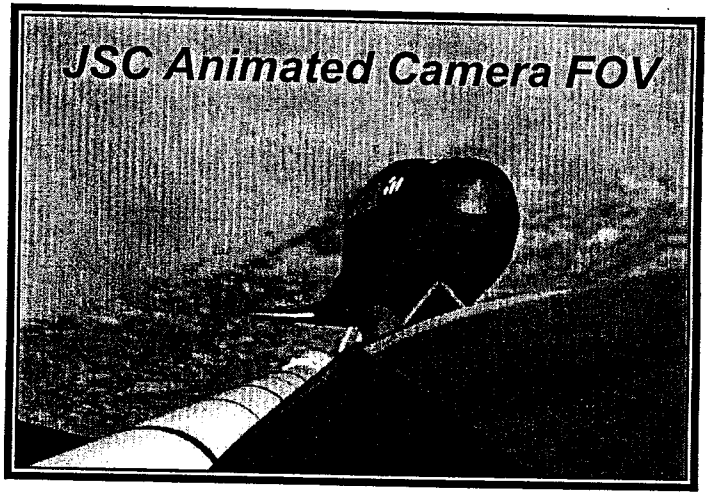
B02055 / E167

Background

- Action was assigned to JSC Shuttle Systems Integration to identify and recommend locations for a Shuttle Observation Camera

- In July 1999, a stand alone camera system on the ET was recommended and approved for the Shuttle Program

  - System was to provide real-time video from pre-launch through ET separation for high inclination Shuttle missions
  - Flight system hardware installation by mod kit to enable quick turnaround on implementation
  - Systems integration function provided by JSC



- System design and verification was completed in 4th Quarter 2000

- In December 2001, installation of a Shuttle Observation Camera was approved for STS-112/ET-115 (PRCBD S071219Y)

ET Shuttle Observation Camera

B02055 / E167

Design Philosophy

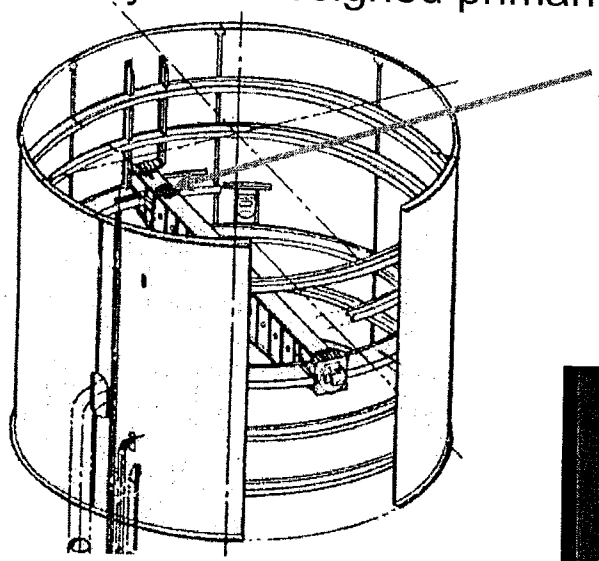
- Groundrules were developed to allow safe implementation and quick turnaround
  - Safety was identified as the highest priority in system design
    - System was designed to function independently of all other Shuttle systems
    - Factor of safety of ≥ 2.0 required for all camera system flight hardware
  - Commercial Off the Shelf (COTS) hardware was preferred to reduce system development time
    - Hardware selected had been successfully flown on Delta, Atlas, and Titan Programs
    - 5 shipsets of hardware procured, ET-115 is the only approved installation

ET Shuttle Observation Camera

B02055 / E167

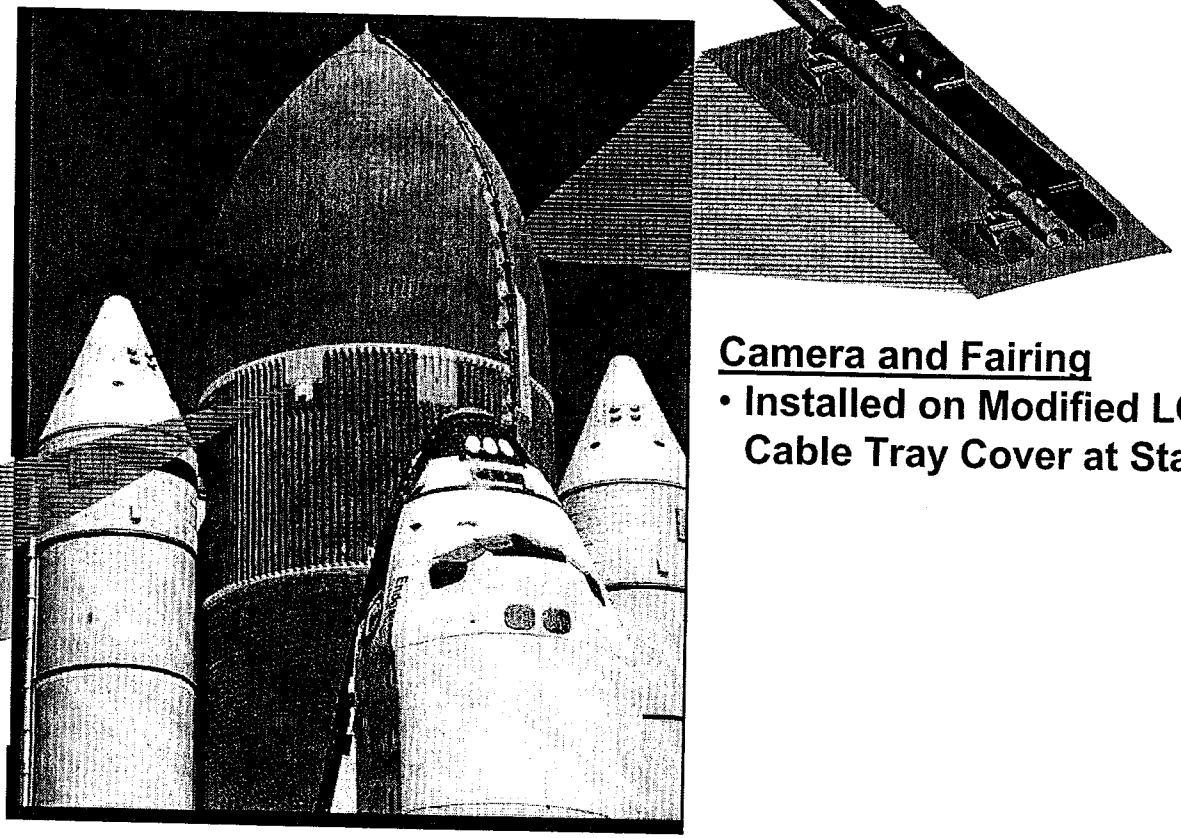
System Design Overview

- ET System designed primarily with COTS hardware flown on Delta, Atlas, and Titan



Electronics Package

- **Mounted on SRB Crossbeam**
- **Separate Battery and Electronics Compartments**
- **GUCP Connection for Battery Charging and System Activation/Deactivation**



S-band Antennas

- **Installed at Sta. 903 in Two Locations 180° Apart**

Camera and Fairing

- **Installed on Modified LO2 Cable Tray Cover at Sta. 718**

ET Shuttle Observation Camera

B02055 / E167

System Functional Description

- Camera system functions independently of other Shuttle systems and will provide real-time video of Shuttle from pre-launch and beyond ET separation
  - Activated during T-9 min hold
- System to provide telemetry through 15 min. MET
  - Frequency approval process simplified by allowing termination of signal via timer prior to over-flying foreign territories
  - G-Switch activates cut-off timer at liftoff
- System operation controlled by ground interface and on-board electronics
  - Electronics installed in Intertank used to charge batteries, monitor battery health, regulate power, and turn camera system off
  - Ground PC used for battery health monitoring, system control prior to launch, and system shut-down in the event of a scrub
- Video signal transmission parameters controlled by Interface Control Document (ICD)
  - Video downlink managed by GSFC and frequency coordinated through JSC
- High inclination launches only
  - Low inclination flights would require reactivation of Bermuda for coverage through ET separation

ET Shuttle Observation Camera

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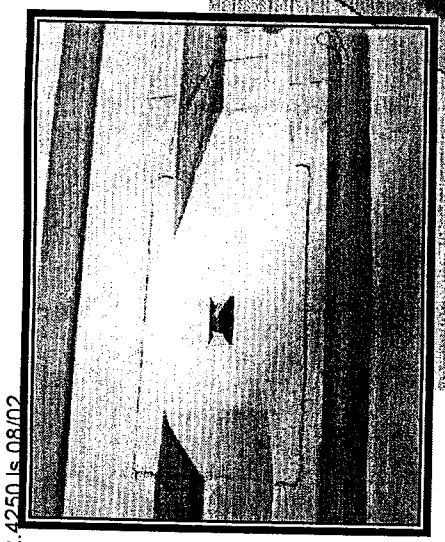
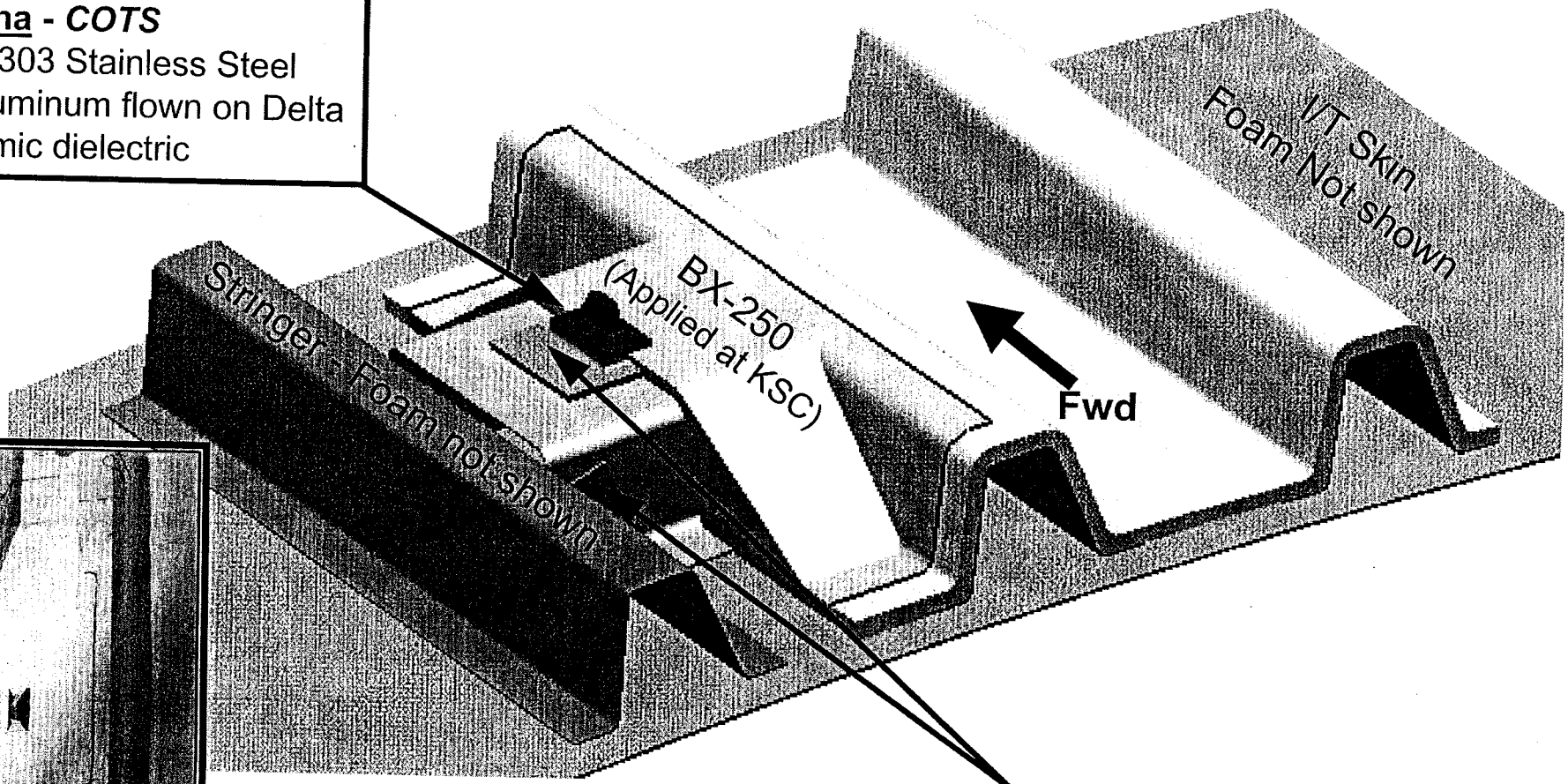
Antenna Design and Analysis

Antenna - ***COTS***
- Cres 303 Stainless Steel
  - Aluminum flown on Delta
- Ceramic dielectric



ET-115 Antenna Installation



Antenna Mounting Hardware - ***ET Unique***
- Mounting Plane F.S.=2.98 (Ult. Bending)
- Attach Fasteners F.S.>>2.0 (Ult. Tension/Shear)

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ET Shuttle Observation Camera

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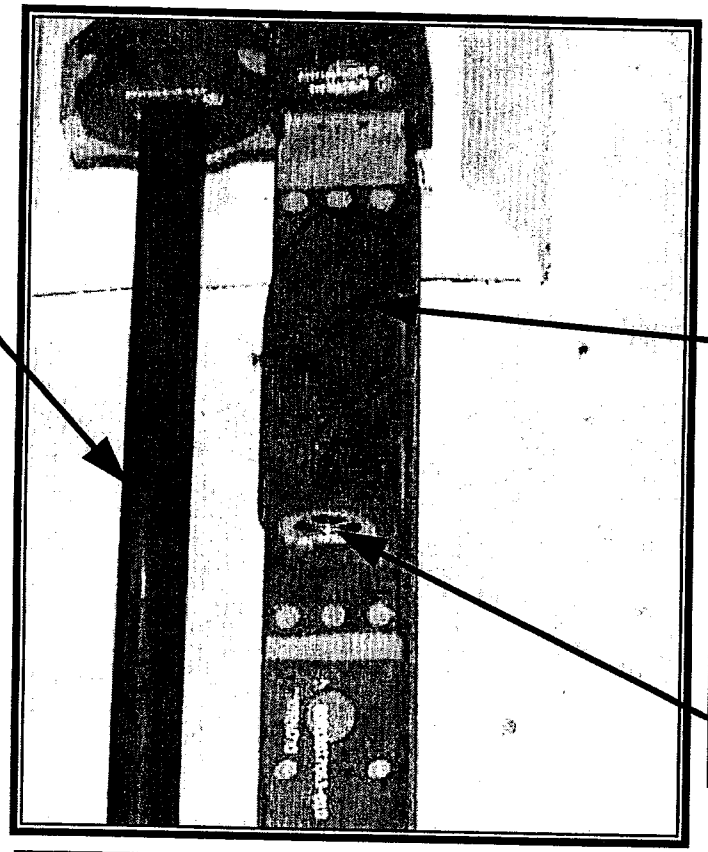
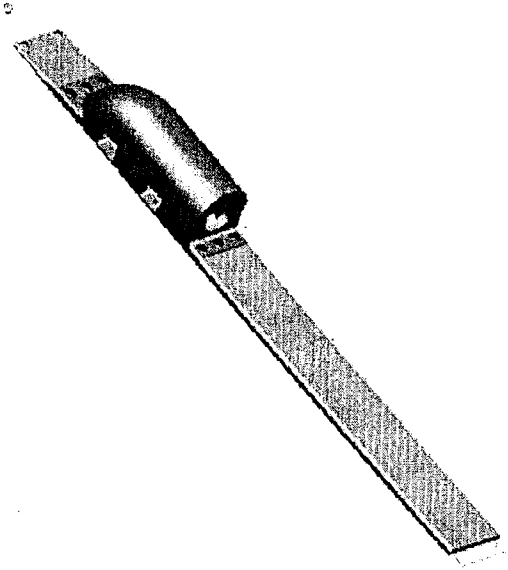
Camera/Fairing Design and Analysis

Existing GO2 Pressurization Line





Fairing Assembly

- ***COTS***
  - 1/4" thick quartz window
    - F.S.=2.32 (Ult. Bending)
    - 3/16 flown on Delta
- ***ET Unique***
  - Al 2219 Fairing
    - F.S. = 2.32 (Ult. Bending)
  - SLA for thermal protection
    - F.S.=14.9 (Substrate Strain)

Camera – *COTS*

- Flown on Delta, Atlas & Titan

Sta. 718 Modified Cable Tray Cover

ET Unique

Cabletray-to-Tank Attach Points

- Epoxy Fiberglass Flange F.S.=1.96 (Ult. Flange Bending)
  - Test Demonstrated F.S. = 2.06,
- LO2 Tank Tab Weld F.S. = 1.40 (Weld shear/tension)
  - Proof Test Demonstrates 75% of Design Limit Load

ET Shuttle Observation Camera

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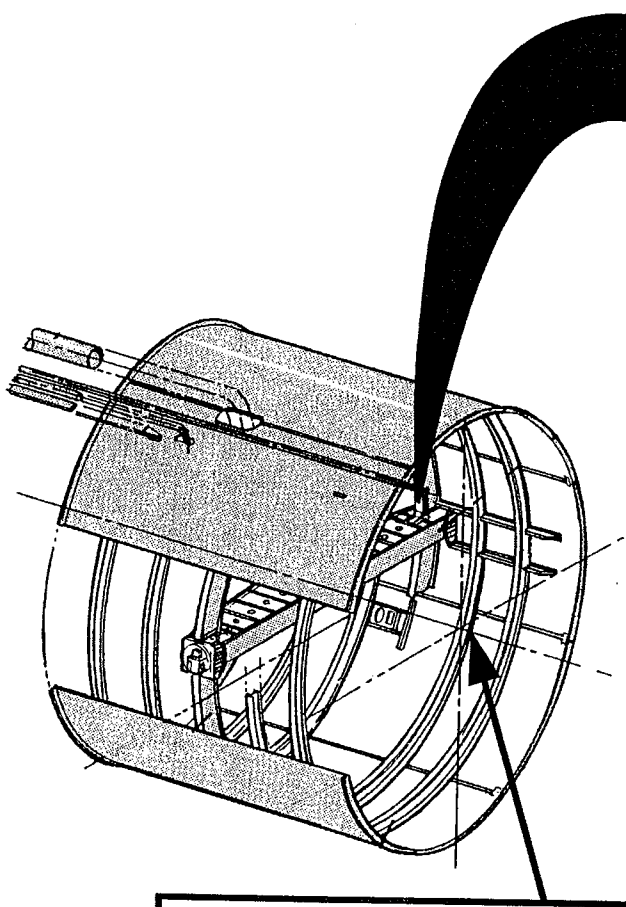
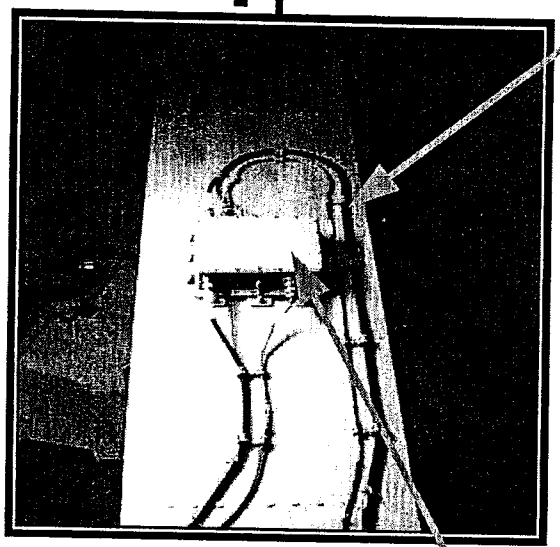
Electronics Box / Cabling Design and Analysis





Cabling
- ***COTS***
  - Video coaxial cable and connectors
  - Antenna cable
- ***ET Unique***
  - Power cable
  - Installation hardware
  - Standard, approved ET materials & processes used
  - Test demonstrated F.S.=4.78 for epoxy bonding used in Intertank

Electronics Package
- ***COTS***
  - **Electronic Components**
    - Batteries – Flown on Delta
    - 10 watt Transmitter
      - 5 watt flown on Delta
    - G-Switch, Power Splitter, PC Board, Connectors
- ***ET Unique***
  - Electronics Box
    - Lid F.S. = 4.14 (Ult. Bending)
    - Attach Fastener F.S.=2.92 (Ult. Tension/Shear)

GUCP Connection – ***ET Unique***
- For battery charging, on/off capability, and battery health monitoring
  - Existing connector used

115PFR.4250.ls.08/02

ET Shuttle Observation Camera

B02055 / E167

Camera System Design Reviews

- Design details reviewed at Technical Interchange Meeting held at MAF in 1999
  - Reviewed the design, including video downlink and ground support systems
  - Established camera system integrated design requirements
- Change Summary coordination and internal design reviews were conducted
- Design was reviewed by MSFC Technical Exchange Forum (TEF) in July 2000
  - No safety of flight issues were identified
  - TEF provided several recommendations on testing of COTS hardware
    - Perform thermal cycling, operational burn-in and proto-flight testing on camera and electronics
    - Perform antenna pattern on each unit to be flown
    - Perform electronics box corona test on design
  - Verification plan was revised to incorporate most recommendations
- Engineering drawings and test procedures for functional bench check and functional verification were coordinated and reviewed with KSC
- Environments coordinated with Level II
- System was reviewed by SSP organizations and risk of functional failure was identified
  - System Safety Review Panel, Integration Control Board, PRCB, Interface Working Group, Space Shuttle Engineering Integration Group

ET Shuttle Observation Camera

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Camera System Hardware Qualification Testing

- System Electromagnetic Interference (EMI) – SL-E-0002 requirements verified
  - Compatibility testing performed at ESTL (JSC) and Goddard – No Issues
- Fairing, Antenna, and Electronics Box vibration
- RF and corona testing*
- Electronics Box proof test*
- Electronics Box explosive environments test*

Camera System Hardware Acceptance Testing

- Functional verification of components
- Transmitter burn-in**
- Electronics Box - Proto-flight vibration*, thermal cycling*, and burn-in**
- Antenna pattern verification*
- Camera proto-flight vibration* and burn-in**

**As recommended by TEF or other review board*

***To a lesser degree than recommended by TEF, associated risk accepted*

Flight Hardware Certification Summary

Analysis of ET Camera System Complete

- Structural and thermal analysis performed for system components - *No Issues*
- Analysis performed to assess safety of camera system
  - Intertank hazardous gas analysis with battery leakage performed - *No Issue*
  - FMEA/CIL Analysis
    - FMEA analysis identified two new Aerodynamically Sensitive Items (ASI) as Criticality 1 for becoming debris (existing failure mode)
      - Camera Fairing
      - Antenna
    - Retention rationale for new Crit 1 ASI was documented in CIL and inspections added to CIL Implementation Drawing
  - Flight Camera System Safety Analysis Report was generated and reviewed

ET Camera System Certification is Complete

ET Shuttle Observation Camera

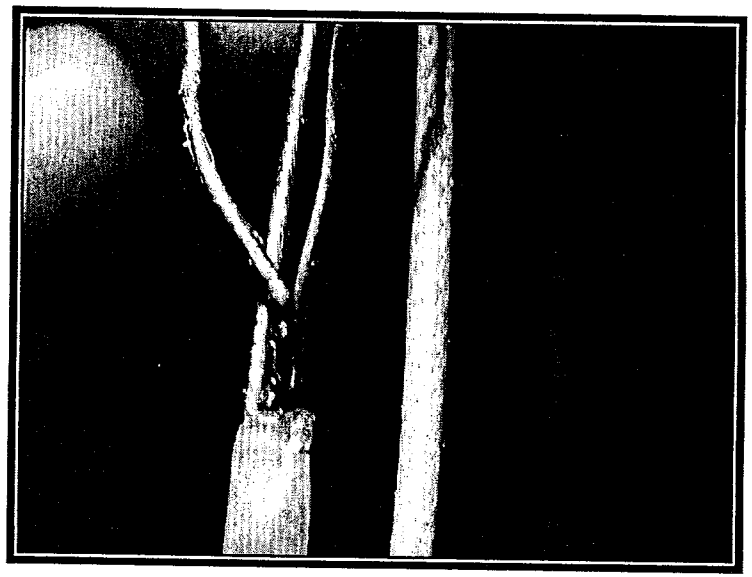
B02055 / E167

Mod Kit Preparation

- Non-standard work for installation was validated
  - Antenna TPS closeout validated at MAF and demonstrated at KSC
  - Validation of test plan performed at MAF on system hardware
- Hardware functional verification performed at MAF due to the duration of storage
  - Battery charge, camera function, transmitter function, deadfacing

Mod Kit Installation

- Mod Kit hardware delivered to KSC in March 2002 and installation completed in May 2002
- During final functional test of the system, no video was received on Video Test Set (VTS) Liquid Crystal Display or a stand alone monitor attached to VTS
- Problem was isolated to damaged insulation on video power cabling in the camera/cable tray assembly
- The entire camera and cable tray cover assembly was replaced
  - Steps were added for incremental verification of hardware during the installation



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ET Shuttle Observation Camera

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MRB Repair of Video Coaxial Cable Installation

- During installation of the new cable tray cover assembly, the cable tray video coax cable separated from the connector and MRB replacement of the entire cable length was required

- To avoid disturbing the OI bundle, the repair consisted of spot-tying new video cable to original bundle (minimum 8" spacing)

- After installation a low voltage IR test was performed on video cable center conductor/shield to ground isolation >20 MG

- A functional confidence test was run after installation of new video cable and reinstallation of cable tray tube brackets and rubber dams
  - Received good signal strength, nominal current draw, clear video

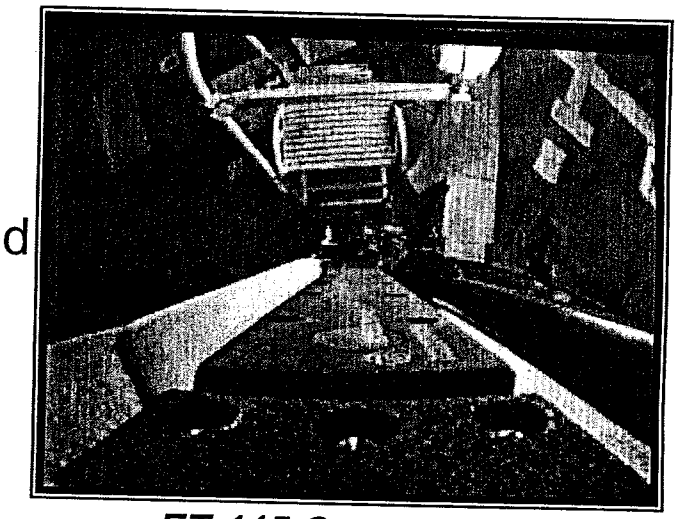
ET Shuttle Observation Camera

B02055 / E167

Summary

- ET Camera System is certified for flight

- ET-115 modification is complete and system verified
  - Prior to final closeout and acceptance, a team of experts assembled by MSFC inspected and reviewed the camera installation
  - Final functional test showed nominal performance of ET Camera System



ET-115 Camera View
(ET Checkout Cell)

- ET Camera flight hardware and software design has been adequately reviewed
  - No safety of flight issues have been identified

- CHIT defining system operational requirements approved at 5/21/02 PRCB

- Integrated functional tests are planned following rollout of the vehicle

ET-115 Camera System is Ready for Flight

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LH2 Tank Dome Damage

SMR 01-001

Issue

- Damage inside the ET-115 LH2 tank occurred when an internal wash probe disconnect pin dropped from the forward end of the tank during wash preparation

Discussion

- LH2 Internal wash probe is a two part assembly
  - Lower assembly is inserted into the tank and supported by a crossbeam above the forward tank opening
  - Upper assembly is connected to the lower assembly and secured by two disconnect pins
    - 16.5" long x 5/8" dia.
    - Weight: 2.2 lbs
- During assembly of the wash probe, the tether on one of the disconnect pins failed
  - The pin fell into the tank and dropped the full length of the tank (90 feet)

LH2 Tank Dome Damage

SMR 01-001

Damage Assessment

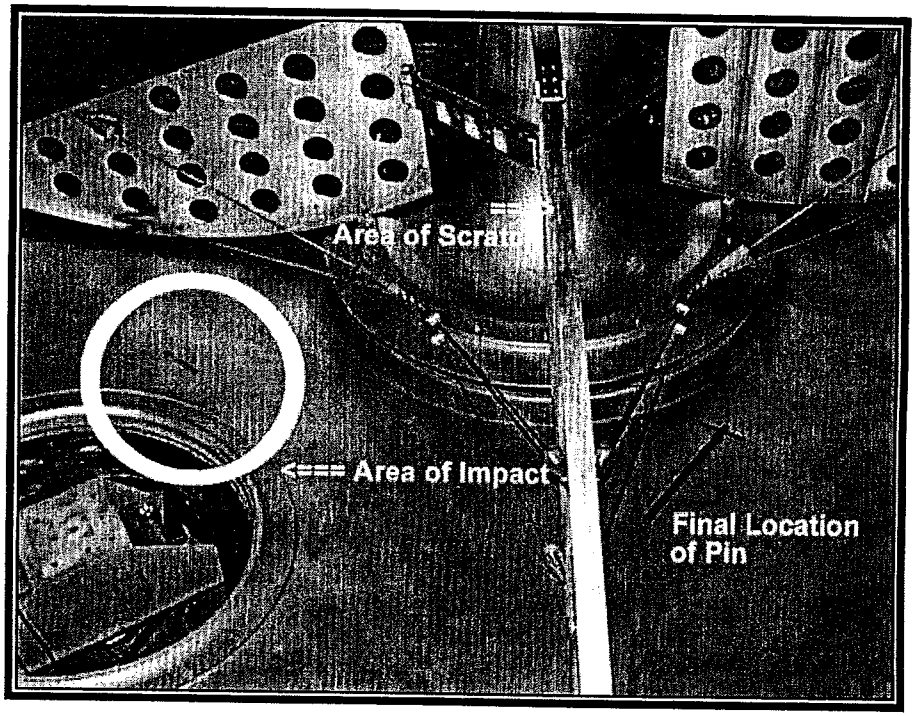
- Detailed internal inspection showed that damage was isolated to the aft dome cap and anti-vortex baffle

  Dome Cap

  - Six areas on the dome cap had indentations with measurable depth or raised metal
    - Two of these areas exhibited slight OSL protrusion
      - 0.007" offset (0.134" min. thickness)
      - 0.006" offset (0.123" min. thickness)
  - Six areas with burnish marks (no depth / no raised metal) were identified

  Vortex Baffle

  - One superficial scratch noted



- Burrs and sharp edges removed in all areas of damage
  - Remaining thicknesses (minimum) were recorded

LH2 Tank Dome Damage

SMR 01-001

Rationale for Acceptance

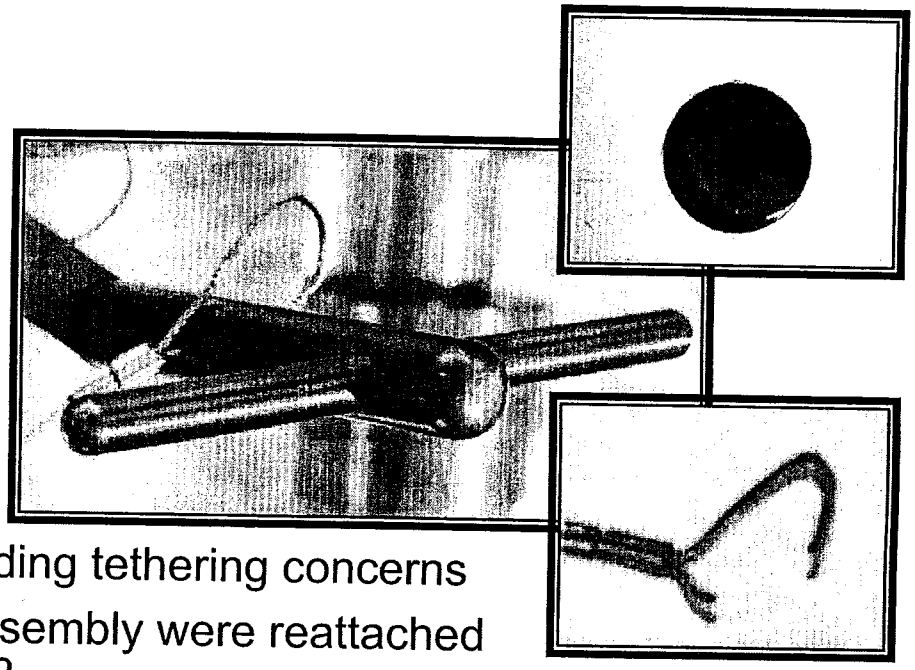
- Damage to dome cap occurred during post-proof test operations – tank internal wash
- Re-proof of the tank was not required due to the following rationale:
  - Visual inspection performed and all damage has been blended and sanded smooth
    - No downstream processing issues resulted from OSL protrusions
  - Primary damage located in the thicker portion of the dome cap and secondary weld land for cap fittings
  - Penetrant and radiographic inspection revealed no external or internal defects
    - Fracture analysis of hypothetical flaws, equal to the penetrant detectablity limit in length, shows mission life greater than 400
  - Stress Analysis shows a factor of safety of 2.04
    - Design factor of safety is 2.59 (1.26 required)
    - Failure mode is membrane tension and bending

LH2 Tank Dome Damage

SMR 01-001

Root Cause:

- Tether to pin installation was inadequate
  - Installation was not performed in accordance with STM-J-758-458, Tethering of Tooling Components



Immediate Corrective Action:

- New Safety Notice (# 283) was issued regarding tethering concerns
- Both disconnect pins from the wash probe assembly were reattached with a ring in accordance with STM-J-758-458
- All other functional areas were reviewed by Facilities for adequate tethering

Root Cause Corrective Action:

- Training requirements were updated and tether awareness training incorporated as part of the Safety Awareness Training syllabus
- Refresher training was provided to tethering and tool crib personnel
- Preventative Maintenance procedures were revised to include a step for verification of tether integrity and tether replacement as necessary
  - The revised PM also clarifies Facilities roles and responsibilities for tethering

Agenda

Overview
Prior Mission Performance Summary
Current Mission/External Tank Highlights
ET-115 Mass Properties Status
Changes
- LO2 Tank Changes for Higher Ullage Pressure
- Intertank Access Door Revisions
- ET Shuttle Observation Camera

Senior Management Review NCD
Special Topic – LO2 Feedline Foam Repair ***Philip Kopfinger***
SRM&QA Assessment
KSC Processing
Verification/Certification
Mission Unique Assessment
Readiness Statement
Appendices
- A: Minor Changes
- B: SRM&QA Assessment
- C: KSC Processing
- D: Level II Waivers/Level III Deviations

Special Topic – LO2 Feedline Foam Repair

PR ET-115-TS-0004

Issue

- Suspect foam debond condition exists on LO2 feedline sections sprayed with BX-250
  - All line sections on ET-115/STS-112 were sprayed with BX-250
  - Limited to the region near supports

Background

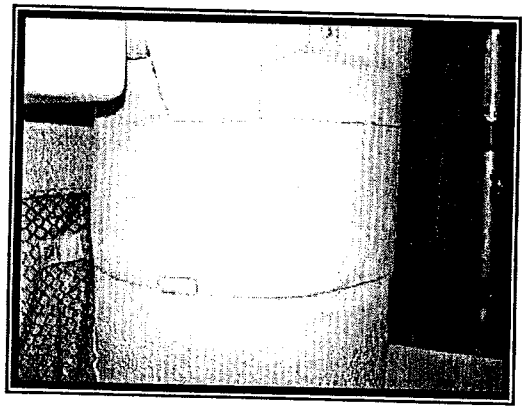
- Performed plug pulls test on all ET-115 feedline sections to establish integrity of foam
  - Sta 1377 and 1871 plug pull values met engineering process requirements (35 psi)
  - Sta 1623 low value obtained is acceptable
    - Bond adhesion strength of 33.7 psi results in FS>>2.0 at this location
    - Lower strengths were previously accepted for locations on ET-112 and ET-113
      - Review of post separation film showed no evidence of feedline foam debond
  - Sta 1129 plug pulls indicated a foam debond and required repair

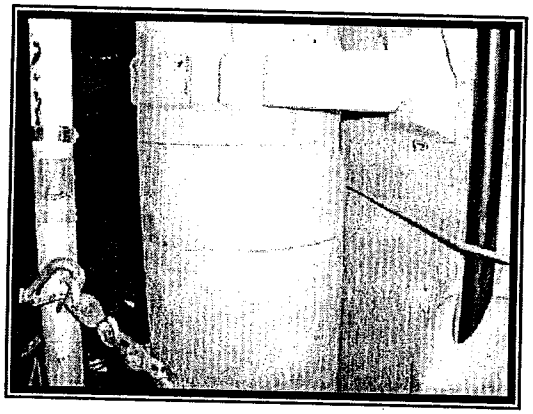
Special Topic – LO2 Feedline Foam Repair

PR ET-115-TS-0004

Discussion

- Validated a PDL repair at MAF using simulated geometry and orientation
  - Performed four PDL pours
  - Performed cryogenic and room temperature plug pulls
  - Test data was presented to NASA and approved
- Repaired Sta 1129 with PDL using the approved repair procedure
  - Repair size 8.6" long 360° circumferentially





Rationale

- PDL material will provide adequate thermal insulation for this location and repair size
  - Analysis considering flight environments shows large factors of safety
  - No increase in structural temperature during ascent or in rupture altitude
- Repair performed per MAF validated process.

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SRM&QA Assessment

as of 08/14/2002

Item	Status
ALERTS	***None***
MRB Assessment	***Complete -*** *No issues/no impact to hazard controls*
Hazard Assessment	***Complete -*** *All hazard reports were re-assessed and hazard controls verified*
CIL Retention Rationale	***CIL Update Complete*** *– No Issues* • *B02055 – ET Observation Camera* - *(Discussed with Changes)*
Corrective Action Problem Summary (CAPS)	
• **P-096, GO2 Vent/Relief Valve ATP Leak Test Failure**	• ***Clearance***- All delivered valves successfully passed ATP - Presented on subsequent charts
• **S-088, Suspect Marking of Dome and Ogive Gore Panels**	• ***Clearance***- Isolated incident - Presented on subsequent charts

115PFR.4250.ls.08/02

SRM&QA Assessment

CAPS P-096

Issue:

- External leakage of GO2 vent valve during supplier ATP

Background:

- Leak check solution applied and leaks were detected at the spring retention plug on switch housing
- New supplier, Ketema
  - 2nd valve produced, 1st valve was qualification unit that successfully passed ATP

Cause:

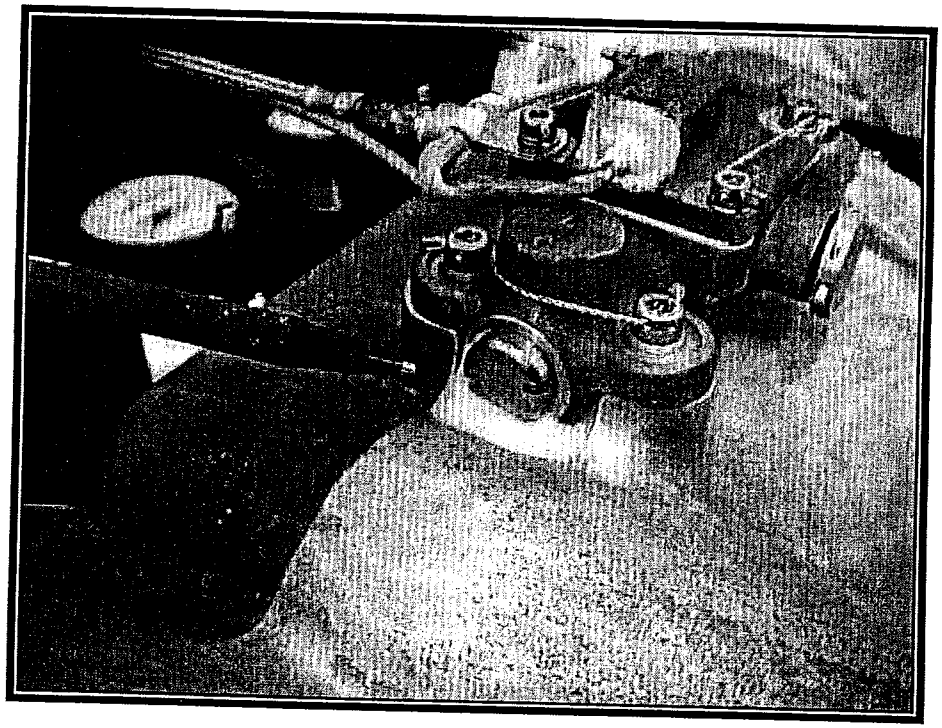
- Debris entrapment between switch housing and cap gasket

Corrective Action:

- Revised procedures to verify no debris is present prior to assembly

Clearance of Effectivities:

- All ET's cleared
  - All delivered vent valves passed ATP



Suspect Marking of Dome and Ogive Gore Panels

CAPS S-088 / SI-2002-S002

Issue

- Potential that dome and ogive gores installed on tanks were incorrectly identified and subsequently installed in incorrect location

- Action was issued at the STS-112 ET/SRB Mate Milestone Review to report the results of the ET-129 investigation of mislabeled dome panels and include flight rationale for STS-107 and STS-112.

Background

- ET-129 LH2 aft dome gores were installed at incorrect location of a welded dome assembly during operations at MAF
  - Problem identified at MAF during weld land width inspection of a completed dome
    - Weld land width verification of mislocated panel missed at ¼ dome build level

- Investigation identified incorrect part marking and inadequate part mark verification at the dome gore supplier (AHF) as cause of mismarking
  - Practitioner was marking two gores on same day, mixed the work folders, and transposed part numbers

Suspect Marking of Dome and Ogive Gore Panels

CAPS S-088 / SI-2002-S002

Investigation Actions to Isolate Issue

- Verified correct marking of all other parts marked by the practitioner responsible for mismarking ET-129 were correctly marked (40 of 42)
  - Practitioner responsible for mismarking ET-129 no longer employed by AHF
- Interviewed other AHF practitioners
  - Correct marking practice on hardware was demonstrated
    - Substantiated by LM source representative observations
- Reviewed nonconformance history to identify reported items of this type from LM source representative, AHF or MAF – No issues
  - AHF has supplied hardware to MAF since beginning of ET Program (7,407 parts)

Suspect Marking of Dome and Ogive Gore Panels

CAPS S-088 / SI-2002-S002

Investigation Actions to Isolate Issue (continued)

- Performed verifications / inspections of 2087 parts to provide confidence that occurrence is isolated – No other instances of incorrect part marking
  - Screened parts that had unique characteristics or had no opportunity for mix up
  - Reviewed LM source representative verification – *No Issues Identified*
    - 100% of the hardware installed on ET-96 thru ET-122
    - Approximately 50% of the ET-123 thru remaining inventory
  - Performed visual and/or dimensional inspection at MAF
    - Suspect aft dome gore panels on ET-94 LH2 tank (4 parts) – No issues
    - Hardware in progress (282 parts) – No issues
      - Includes parts that were verified by LM source representative (Provided dual verification)

- Performed statistical analysis
  - ET-93 and up hardware (2087 parts): Demonstrated reliability is 0.997 at 95% confidence if 2 discrepant parts are included
  - Since inception of program (7407 parts): Demonstrated reliability is 0.999 at 95% confidence if 2 discrepant parts are included

Suspect Marking of Dome and Ogive Gore Panels

CAPS S-088 / SI-2002-S002

Fleet Clearance

- ET-129 LH2 aft dome gore mislocation is an isolated case
  - Large database of supporting evidence
  - Single event resulted in the 2 misidentified panels – part numbers transposed
- Inspection of remaining parts is not required
- ET Project recommended closure of action item 112-ET/SRB-001, and presented results of the investigation to SPRCB on 8/1/2002

Corrective Actions

- Implemented interim corrective action - 100% verification by LM source representative
- Implemented long term corrective actions

  AHF

  - Revised planning to document the part marking practice that was demonstrated by practitioners during investigation interviews – To verify part number on tooling tab, part and work folder prior to final part marking
  - Implemented independent verification of part marking process
  - Revised build paper at final cleaning subtier processor (Aerochem) to verify part number on tooling tab, part and work folder

  MAF

  - Crew meetings to emphasize the importance of the inspections
  - Prepared Lessons Learned guide to educate personnel on the criticality of inspections

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Special Topic – LO2 Feedline Foam Repair
SRM&QA Assessment
KSC Processing ***Brian Knipfing***
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KSC Processing - Status

as of 08/16/2002

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

- 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

Changes to Planned Work: None

KSC Processing - Status

as of 08/16/2002

Changes

- ET modifications
  - Mod Kits — 1
  - DC&R — 0
  - Bldg 45 — 1
  - FEC — 1
  - OMRSD/LCC — 0
- Software — 0
- GSE Modifications — 2

SIM Launch (S0044) — 08/26/02

SIM Load (S0056) — 09/12/02

STS-112/ET-115

- ET Shuttle Observation Camera (E167)
- ET Shuttle Observation Camera System Operation and Test Requirements (HO783R1)
- KET-0081 – *CANCELLED* Installation of GUCP Inconel Bellows
- Pad modifications for support of ET Shuttle Observation Camera
- ET Bi-pod Heater voltage regulator

115PFR.4250.ls.08/02

Agenda

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Verification/Certification ***Lynn Servay***
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Verification/Certification

as of 08/07/2002

Item	Status
NSTS 07700, Volume X, Book 1, Baseline • Revision M, Change 285	Complete - No Issues
Waivers/Deviations	No new items

Verification/Certification

as of 08/07/2002

Item	**Status**
Certification Documentation	
• ***Hardware Certification Sheets (HCS)***	***Complete - No Issues***
- Revise Ullage Pressure Requirements (B02035)	
• S501D, LO2 Tank Assembly	
• T503S, Ice/Frost Foam (PDL 1034)	
• T504S, Closeout Foams (SS 1171)	
• T505N, Super Light Ablators (SLA 561)	
• T507S, Closeout Foams (BX 250)	
- LO2 Feedline Screen Installation Hardware (B02042)*	
• P012C, LO2 Anti-Vortex Baffles	
- Redesign of Intertank Composite Door (B02067A,D)	
• S519B, Intertank Access Door (Composite) Installation	
• ***Certificates of Qualification (COQ)***	***Complete - No Issues***
- Replace Documentation Reference for GH2 Vent Disconnect, ET Section (B02036)*	
• 27D, GH2 Vent Disconnect	
- Implement ET Observation Camera (B02055A)	
• 127A, ET Camera System Components	

** Change included in Appendix A*

Mission Unique Assessment

as of 08/16/2002

Category/Item	**STS-112**
STS-112 Liftoff Loads Environments • One LH2 tank proof test load indicator equation identified as exceeding the defined limits during the STS-112 Flight Margin Assessment - Assessment of exceedance is complete and no issues identified • Documentation issue only - no impact any as-built hardware • Equation limits were conservatively maintained to prior LH2 prelaunch 'pre-press' levels • LH2 tank was certified for increased LH2 pre-press levels at ET-101 and increased levels implemented on STS-110 / ET-114	• Equation updates are in-work and will be provided to System Integration
Review of MRB actions using updated loads • New loads or environments requiring assessment	None Identified
MPS Preflight Prediction Package	ECD 09/18/2002 (UR)

Readiness Statement

The External Tank, ET-115, is certified and ready for STS-112 flight pending completion/closure of open and planned work

Appendices

A: Minor Changes

B: SRM&QA Assessment
- NCD Assessment Criteria

C: KSC Processing
- PR/MRB Summaries
- Modification Status
- Limited Life Component Status
- Facility Modifications
- Software Changes: None
- OMRSD Exceptions/Waivers: None

D: Level II Waivers/Level III Deviations

Class II or JS/DCN Changes

- 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 enhancement
    - Update supplier 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 Changes

Change	Description	Basis for Certification
LO2 Feedline Screen Installation Changes (B02043)	• Replaced gang nut channels with standard dome gang nut channels	• Similarity - Change previously flown on LH2 Siphon Screen Installation
Hydrogen Vent Disconnect, ET Section (B02036)	• LM drawing replaced supplier drawing to allow procurement of part from new supplier • Certification document updated to reflect new drawing number	• Similarity - Documentation change - No change to design

Minor Changes

Change No.	Discipline	Description
H36809-035	Structure	Producibility - Relaxed thickness tolerance on Intertank composite door; make door radius a tool controlled dimension.
H36809-121	Structure	Producibility – Revised scribe line configuration for LO2 tank weld assembly alignment to show existing vibrator marked arrow extended to edge of the part
H36809-448	Structure	Drawing Error – Revised the specified Hi-Lok grip length on the upper frame segment assembly to accommodate material stack-up.
H36809-464	Structure	Producibility – Revised the weld acceptance manual to add a table defining the weld locations where 35° radiographic angle perspective cannot be accomplished due to configuration or thickness limitation
H36809-466	Structure	Producibility – Relax the tolerance on the Intertank composite door radius to accommodate addition of a .06 thick stainless steel slip sheet on the mold tool. Slip sheet was required to repair mold.
H36809-489	Structure	Drawing Error - Revised the post-proof weld inspection requirements to update weld inspection locations for OB weld high stress areas for heat repairs. Previously revised weld land thicknesses and stresses resulted in a decreased initial critical flaw size, requiring post proof penetrant inspection for heat repairs at any location on the OB welds. Prior builds were cleared through FCB.
H36809-655	Structure	Drawing Clarification – Revised the fit check criteria drawing to specify the stacking of washers during the Aft SRB Fairing fit check at MAF to ensure that the nut locking feature will not be engaged.
H36809-164	Propulsion	Producibility – Incorporated minor changes to the casting for the ET section of the H2 vent disconnect housing for clarification and production enhancement

Minor Changes – STD/STM/STP/AVL

Change No.	Document	Description
B02069A-110	STP6501, App. 1 Assembly of Electrical Connectors	Broadened the application of the specification to all ground test programs rather than just ALTA. – Revised the application statement of the document and revised the effectivity of the document to "FOR GROUND USE ONLY". Also corrected paragraph references in the document.
H36809-763	Scrim Cloth - H1A9, H1A9A,H226,H226A, H226AP STP6001 – Gen. Purpose Adhesive Bonding	– Revised H226 to remove vendor reference, replace I-399 silane finish scrim cloth (no longer manufactured) with commercially and chemically equivalent silane finish scrim cloth, and create H226 source appendix to identify present manufacturer. – Created H1A9 code sheet created for scrim cloth procured to AMS-C-9084, which, in turn, was added to STP 6001 for use. – MUAs 0070A and 0414A were revised to reflect changes.
H36809-766	STM11A3 – Al-Li Alloy 2297 Plate Produce	– Added flatness measurements for both T37, as well as T87, tempers – Removed chemical composition of material from the title and application statement of the document.
H36809-767	L1B3AD – BX-265 Polyurethane Foam	Clarification – L1B3AD code sheet addendum now specifies the GC/FID test method for flame retardant when performing retests for the material shelf life extension.
H36809-787	K969 – Aluminum Caustic Etch	Changed procurement information to correct the manufacturing site address for commercially available Mil-etch, and added a note permitting procurement from any manufacturing site of supplier and/or approved source of the supplier.
H36809-790	Y441AP – Argon Welding Gas	Updated code sheet appendix to add approved distributors for current approved suppliers.
H36809-793	Collar Standards: 25L5, 25L6, 25L8, 25L9	Revised standards to permit lubricant application by either spray or dip, allowing the collar manufacturer to ignore the lubricant manufacturers' recommendation.

Minor Changes – STD/STM/STP/AVL

Change No.	Document	Description
H36809-794	STP2006 – Installation of Hi-Loks	Revised process (repair only) to allow shop to sand or ream the inside diameter of repair sleeves since tolerances on pins and repair sleeves sometimes preclude assembly.
H36809-797	STML1A5 – Polyisocyanurate Foam	Added receiving acceptance testing requirement for HCFC level in the "A" component of the foam to the material specification. Requirement was inadvertently left out of specification, but performed via fingerprinting tests called out in RAP.
H36809-799	L663AP, L664AP – Silicone Rubber Compound	Revised both code sheet source appendices to allow procurement of material from approved distributors of the approved supplier.
H36809-812	AVL 33L6 – Slotted Hex Nut	Change in approved suppliers –one supplier removed from AVL.
H36809-817	N243 – Dow G-N Metal Assembly Spray	Clarified note in document to indicate that the current lubricant material shows equivalent performance functionality to lubricant material previously used (Molykote G).
H36809-822	25L6 Group – A286 Collar	Corrected typographical errors created in a previous release.
H36809-823	AVL25L31, AVL25L32	Rivet standards were revised to include the part number format for oversized rivets.
J31219-005	STP5501 – 2219 TIG Weld STP-5506 – VPPA of Aluminum Alloys	– Added requirement that all ET welds that see post-proof x-ray must have final x-ray acceptance in the as-sanded condition. Approved by FCB in March 2002.

Minor Changes – STD/STM/STP/AVL

Change No.	Document	Description
H36809-782	STP5501 – 2219 TIG Weld	– Revised minimum strength for weld thickness <.25 to be consistent with design allowable used. – Added paragraph disallowing fillet welds which penetrant through membrane, and clarify that sanding/shaving of such welds shall have MRB approval. – Updated terminology for clarification. – Deleted peaking and mismatch curves which are now located in other documents.
H36809-783	STP-5506 – VPPA of Aluminum Alloys	– Lowered qualification strength for out of position (45 & flat) welds greater than 0.330 thickness. – Deleted peaking and mismatch curves which are now located in other documents. – Updated terminology for clarification.
J31225-043	STP2001 – Installation of Rivets STP2028 – Heat Treatment of Al Rivets	Revised standards to cover the installation and the processing of new rivets that can be driven at room temperature - this prohibits heat treat of new rivets, specifies repair rivets and procedures for replacing rivets.

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-115 DR/PR/OMRSD Waiver/Exceptions

as of 8/16/2002

System	Discrepancy	Problem	MRB Items	Exceptions/ Waivers
• Electrical	0	1	1	0
• Propulsion/ Pneumatics	0	1	0	0
• Structures	0	4	1	0
• Thermal (TPS)	0	13	3	0
Total	0	19	5	0

ET-115 PR/MRBs - TPS

as of 08/16/2002

PR No./Status	Title/Description	Disposition
ET-115-TS-0004 Item 1	LO2 Feedline Foam • Two plug pull locations at XT 1129 failed	Use as repaired • Trimmed out areas of low bond adhesion • Repaired with PDL per validated process
Item 2	• One plug pull location at XT 1623 failed (33.7 psi.)	MRB approved to use as is • Analysis shows that FS to > 2.0
ET-115-TS-0011	• +Y Aft fairing lower periphery closeout has approx. 6 inch underfill at the –Z end	Use as repaired • Trim underfill to provide processed edge and repair with PDL.

ET-115 PR/MRBs - Structural

as of 08/16/2002

PR No./Status	Title/Description	Disposition
ET-115-ST-0001	Ding/Dent at 12 o' clock position on Bipod Yoke titanium flange. • Defect measures 0.010 deep X 0.012 diameter	MRB approved to use as is • Verified no crack-like defects using 10x magnification

ET-115 PR/MRBs - Electrical

as of 08/16/2002

PR No./Status	Title/Description	Disposition
ET-115-EL-0001 ITEM 3	Coaxial video cable separated from connector during adjacent operations.	Use as repaired • Removed connectors and abandoned existing cable in place • Routed new cable adjacent to old cable, securing with ties to old cable • Added a new bond jumper

ET-115 KSC Modification Summary/Status

Item	Title	Status
EMK E167	Installation of ET Shuttle Observation Camera	Complete
FEC KET-0081	Inconel bellows probe on 7" GH2 vent disconnect	Cancelled
CHIT HO783R1	ET Shuttle Observation Camera System Operation and Test Requirements	In Work

ET-115 Limited Life Components

Cycle Sensitive

Description	Part No.	Serial No.	Limit	Required	Remaining
LH2 Manhole Cover Assy	80914081488-509	0001033030	14	2	14
LO2 Tank Mechanical Assy	80912002000-509	0001033560	14	2	14
LH2 Tank Mechanical Assy	80914002000-509	0001084380	14	2	14
LO2 Manhole Cover Assy	80911001205-509	0001077740	14	2	14
LO2 Fwd Ogive Cover Plate	80911001207-509	0001038950	14	2	14
LH2 Manhole Cover Assy -Aft	80911001444-509	0001033010	14	2	14
LO2 Tank Cap Closure Siphon	80911001445-502	0001117080	14	2	14

ET-115 Limited Life Components

Age Sensitive

Description	Part No.	Serial No.	Limit	Initiation	Expiration
External Tank	80901010000-519	00000108	6 Yrs	09/26/2001	09/26/2007

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

Description	Part No.	Lot No.	Serial No.	DLAT* / Retest	Expiration
Separator Assy GUCP	PD5000020-059	AAJ	0001378	12/14/2001	12/14/2005
Cartridge Assy	PD5000020-030	AAJ	0001452	12/10/2001	12/10/2005
Cartridge Assy	PD5000020-030	AAJ	0001453	12/10/2001	12/10/2005

** Destructive Lot Acceptance Test*

Facility Modifications

TPS-SS23B-377

Description

- Modify facility to support ET/Shuttle Observation Camera
  - Command and Control via laptop computer from active Firing Room over ethernet network to pad
  - Programmable Logic Controller (PLC) and power supply located in pad PTCR rack supply power to flight electronics box via pad cabling through the GUCP
  - Battery health monitoring data from flight electronics box routed through RS-485/RS-232 digital converter and modems located on pad FSS and PTCR rack

Reason

- Implement capability to control and monitor ET/Shuttle Observation Camera system

Rationale

- GSE system validation testing successfully completed.

Facility Modifications

Pad B ET Bi-pod Heater Voltage Regulator

Description

- Replaced GSE voltage regulators and variacs that provide power to ET Bipod heaters with programmable AC voltage sources that fit into the existing rack, providing higher reliability and quicker response times
  - Upgrade previously presented for both pads, but not implemented due to schedule delays
    - Pad A: STS-111/ET-113
    - Pad B: STS-107/ET-93

Reason

- Previous equipment is obsolete and no longer supported by the original manufacturer
- The existing regulators have shown increasing signs of age by failing to meet the specified voltage recovery time after application of load

Rationale

- System validation successfully completed

Level II Waivers - Baseline

Document / Requirement	Authority	Paragraph	Waiver No.	Effectivity
NSTS 07700, Volume X, Book 1, Space Shuttle Flight and Ground System Specification, Requirements				
Electrical bonding	PRCBD S040732M 09/09/88	3.6.14	378	ETs 23, 27-29, 31 & up
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

Level II Waivers - Baseline

Document / Requirement	Authority	Paragraph	Waiver No.	Effectivity
NSTS 07700, Volume X, Book 1, Space Shuttle Flight and Ground System Specification, Requirements				
Applicability of Space Shuttle Manned Spacecraft Criteria and Standards (NSTS 08080-1)	PRCBD S061451 08/08/00	Table 2.0	683	ETs 96 & up
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
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