STS-113/ET-116
Flight Readiness Review

External Tank Project

October 31, 2002

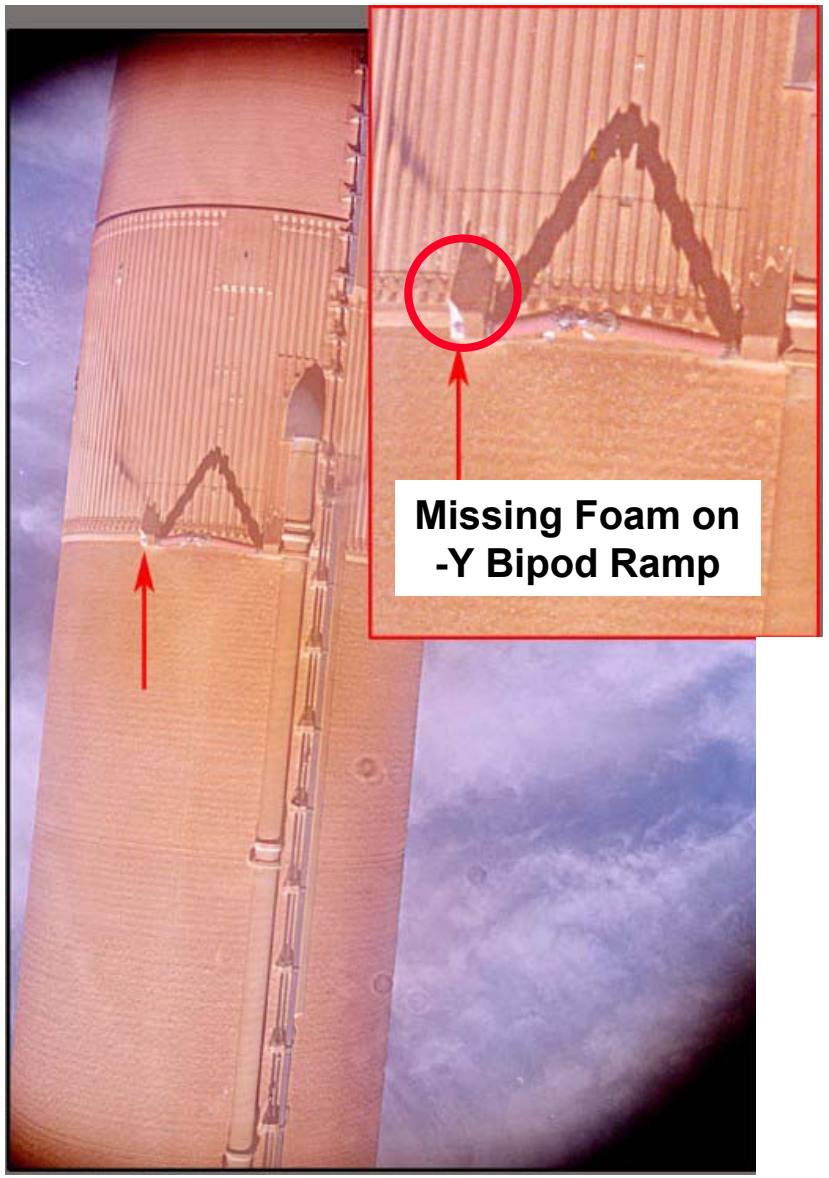
Overview

- **Limited Life Component Status**
  - All items within required life through scheduled launch date plus 90 days
- **No Significant Changes**
- **Special Topic**
  - STS-112/ET-115 Bipod Ramp Foam Loss
- **Significant Processing Anomalies**
  - LO2 Feedline Repair Using BX-265 Foam
  - Undersized Intertank Stringers
- **Readiness Statement**

STS-112/ET-115 Bipod Ramp Foam Loss

- **Issue**
  - Foam was lost on the STS-112/ET-115 -Y bipod ramp (≈ 4” X 5” X 12”) exposing the bipod housing SLA closeout

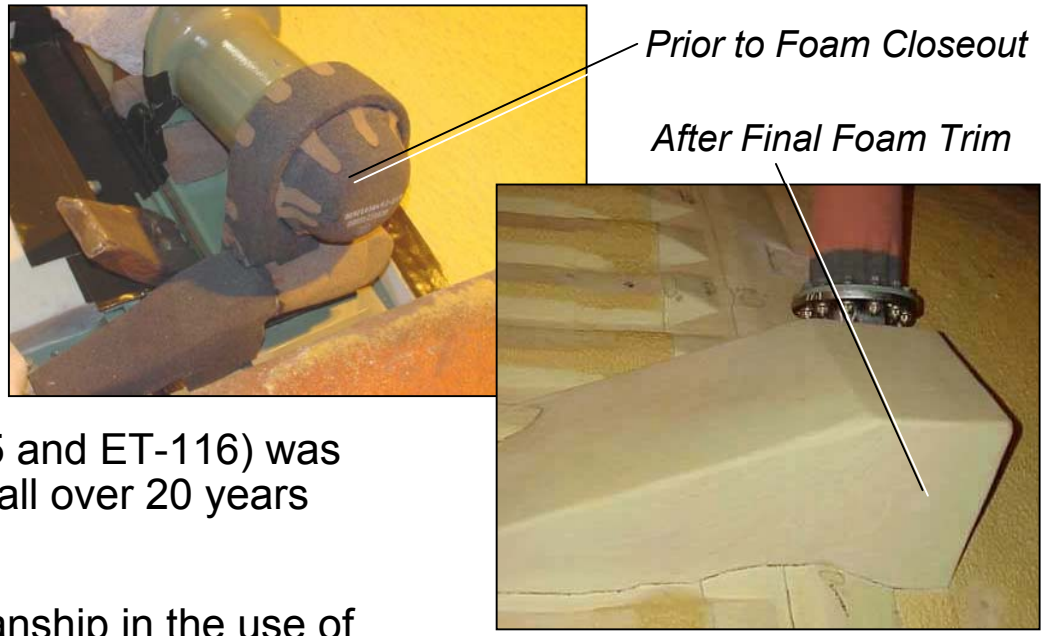
- **Background**
  - ET TPS Foam loss over the life of the Shuttle Program has never been a “Safety of Flight” issue
  - More than 100 External Tanks have flown with only 3 documented instances of significant foam loss on a bipod ramp



STS-112/ET-115 Bipod Ramp Foam Loss

Presenter Jerry Smelser, NASA/MP31

- **Rationale for Flight**
  - Current bipod ramp closeout has not been changed since STS-54 (ET-51)
  - The Orbiter has not experienced "Safety of Flight" damage from loss of foam in 112 flights (including 3 known flights with bipod ramp foam loss)
  - There have been no design / process / equipment changes over the the last 60 ETs (flights)
  - All ramp closeout work (including ET-115 and ET-116) was performed by experienced practitioners (all over 20 years experience each)
  - Ramp foam application involves craftsmanship in the use of validated application processes
  - No change in Inspection / Process control / Post application handling, etc
  - Probability of loss of ramp TPS is no higher/no lower than previous flights
  - ***The ET is safe to fly with no new concerns (and no added risk)***

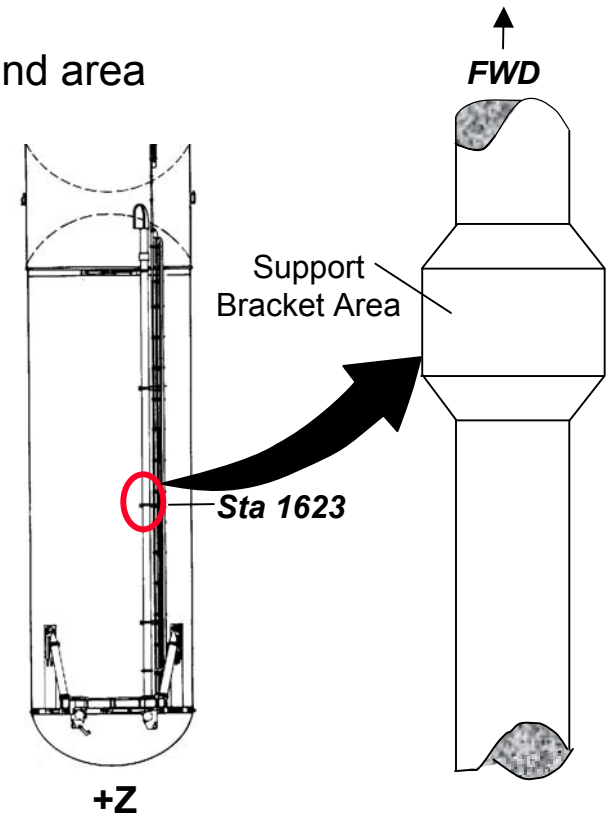


Bipod Attach Fitting

LO2 Feedline Repair Using BX-265 Foam

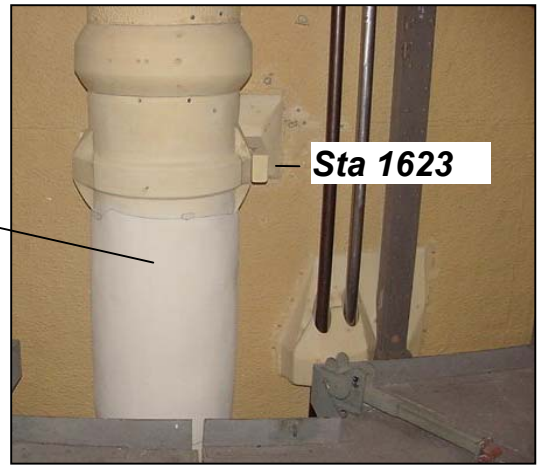
- **Issue**
  - LO2 feedline foam insulation (BX-250) debond at Sta. 1623
    - Repair required based on foam insulation bond-adhesion (plug-pull) test evaluation

- **Background**
  - Implemented inspection of all BX-250 LO2 feedlines
    - Plug pulls performed to verify foam strength or identify debond area
  - Plug pulls at 3 of 4 stations on ET-116 accepted based on
    - Measured values
    - Engineering data
    - Prior flight experience
      - Lowest value of 13.9 psi (35 psi required) at Sta. 1129 accepted based on analytical assessment and past flight performance
  - One location required repair at Sta. 1623
    - Repair accomplished using BX-265 foam
      - First time flight usage
        - Fully qualified material
        - Planned for use on ET-120



LO2 Feedline Repair Using BX-265 Foam

- **Rationale for Flight**
  - Physical and mechanical properties for BX-265 similar to BX-250 (and much greater than requirements)
    - Mechanical
      - Density, flammability, specific heat, coefficient of thermal expansion (CTE) and Poisson's ratio
      - Tensile, compressive, and shear strength, combined tension and flexure @ cryogenic temperature (cryoflex)
    - Thermal conductivity
    - Recession response
  - Production Verification
    - Cell validation
    - Full scale demonstration
  - Plug pulls on ET-116 repair area indicated strong bondline
    - Actual values: 61.9 and 41.2 psi (35 psi required)
  - ***ET-116 feedline acceptable for flight***



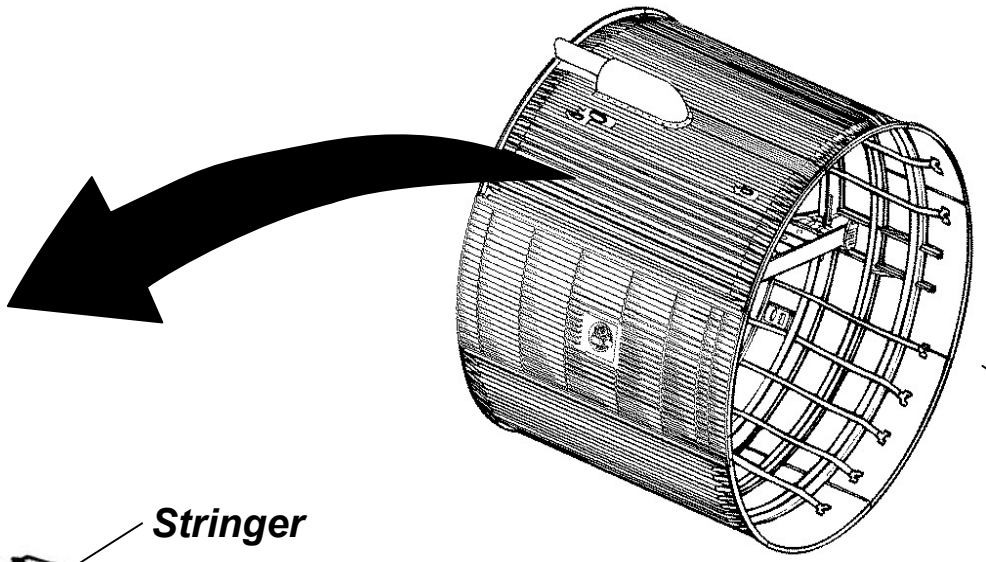
Undersized Intertank Stringers

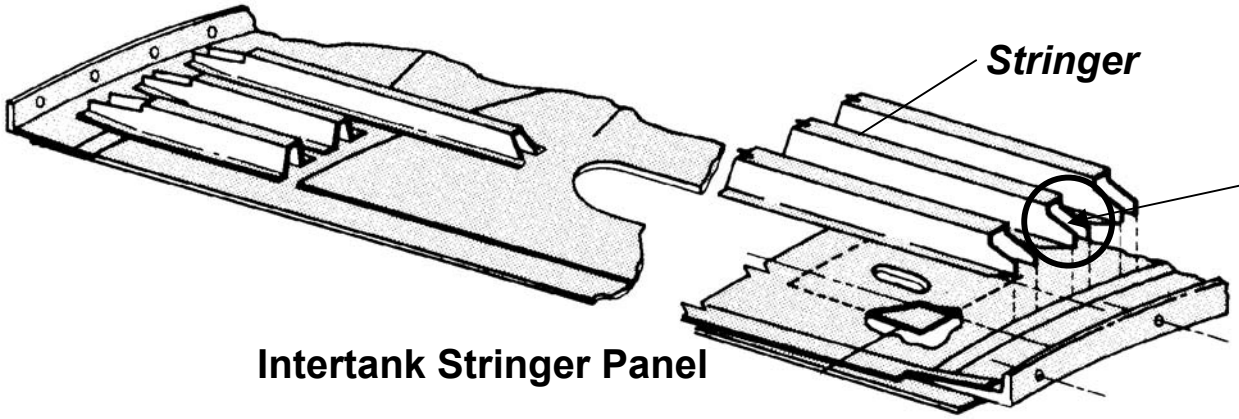
- **Issue**
  - Undersized Intertank sheet metal stringers potentially installed on completed ETs
    - Final stock material thickness verification not performed following complete part processing at Aerochem

- **Background**
  - Stringers in process flow identified at the low end or below minimum thickness tolerance
    - Stock material thickness verification performed at material receipt from Dynamic Metal Forming (DMF)
      - Stock material met receiving inspection requirement (0.061 in. min.)
    - Majority of stringers are locally chem-milled (‘pocketed’) to achieve final part thickness requirements
      - ‘Pocketed’ thicknesses are verified after final processing
      - Remaining stock material areas (non-pocketed) are chemically ‘etched’ during the cleaning and part marking process
    - ‘Non-pocketed’ stringer thicknesses were not re-verified after final processing
  - Process investigation performed and shows that the normal processing of ‘non-pocketed’ stringer regions could remove an additional 0.0028”

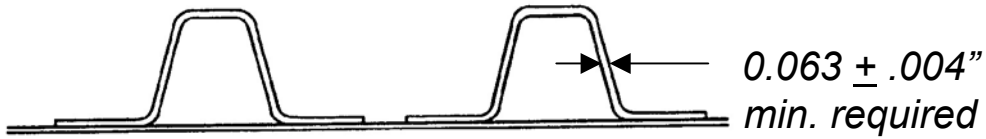
Undersized Intertank Stringers

Presenter Jeff Pilet, LMSSC-MO/4130





Intertank Stringer Panel



Stringer (X-Section)

Undersized Intertank Stringers

- **Actions Taken**
  - Initiated thickness verification of accessible stringers (≈1500 parts)
    - Stringers installed on ETs with end bays exposed and loose parts
    - Performed at least 1 measurement per stringer end
    - Thickness measurements consistent along stringer length
  - Performed statistical analysis (2070 measurements) to derive 3 sigma minimum thicknesses
    - Forward vs aft end measurements
    - 'Pocketed' vs 'non-pocketed' parts
    - Minimum measured in critical margin areas is 0.0568 in.
    - 3σ low thickness in critical margin areas is 0.0559 in.
  - Initial analysis using an assumed low bound minimum thickness (0.0530") showed local areas of negative ultimate stability margins of safety (column buckling) near the cryo 'end bay' regions
    - Low margin areas isolated to aft region of Panel 1 and the forward regions of Panels 2/3 and 6/7
    - Revisions were made to the analysis methodology to reduce conservatisms and achieve more realistic structural margins of safety for these regions

Undersized Intertank Stringers

- **Rationale for Flight**
  - Analysis
    - Analysis methodology for Panel 1 region was revised to use time consistent thermal gradient and applied vehicle loads
      - Results of analysis shows adequate structural Factor of Safety

Design	*t stringer (in.)*	*FS*	*FS required*
• Engineering requirement	0.059 min.	1.55	1.40
• 3σ Low	0.056 min.	1.48	1.40
• Lower bound	0.053 min.	1.41	1.40

    - Analysis methodology for Panel 2/3 and 6/7 regions was revised to assume the critical stringer is 'ineffective' resulting in load redistribution to adjacent structure
      - Results of analysis shows adequate structural Factor of Safety

Design	*t stringer (in.)*	*FS*	*FS required*
• Engineering requirement	0.059 min	1.54	1.29
• 3s Low	0.056 min	1.48	1.29
• Lower bound	0.053 min	1.29	1.29

  - Test
    - Column buckling analysis conservatively correlated to previous structural test results
      - Test demonstrated capability ~ 13% greater than analytical prediction

Undersized Intertank Stringers

- **Rationale for Flight - Summary**
  - Column buckling analysis methodology correlates conservatively with structural test results
  - Revised analysis methodology shows positive ultimate margins of safety using conservative lower bound stringer thickness values
  - ***ET-116 Intertank Stringers meet design requirements and are acceptable for flight***

The External Tank, ET-116, is certified and ready for STS-113 flight pending completion/closure of open and planned work