



**SPACE SHUTTLE PROGRAM**  
**Space Shuttle Projects Office (MSFC)**  
NASA Marshall Space Flight Center, Huntsville, Alabama



# STS-106/ET-103 Flight Readiness Review

## External Tank Project



Neil Otte  
August 29, 2000



<b>Overview</b>	Presenter Neil Otte	
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- **ET-103 Highlights**
  - Second ET to fly with full implementation of Intertank foam venting
  
- **Limited life components - All items within required life**
  
- **Change**
  - LH2 Tank Proof Test
  
- **Processing Anomalies**
  - Thrust Panel Penetrant Inspection
  - Discrepant Weld Bead Profile
    - STS-106/ET-103 clearance rationale presented to the SPRCB on August 1, 2000
  
- **Open work/paper - No constraints**



## LH2 Tank Proof Test

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- **Change**

- Implemented new proof test requirements for the SLWT LH2 tank
  - Requirements now common to LWT requirements

- **Reason/Background**

- Reliability - Increased the length of fully proofed welds by 2100 inches and correspondingly reduced post proof x-ray requirements
- Review of LH2 tank proof test requirements showed potential reduction in post proof x-ray inspection
  - Supports philosophy that it is “Better to Test than to Inspect”
  - Improved proof test and safety of flight
- Proof test loads were optimized to increase the amount of adequately proofed circumferential welds
  - Proof pressure unchanged
  - Majority of LH2 pressure wall sized for proof pressure



<b>LH2 Tank Proof Test</b>	Presenter Neil Otte	
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- **Basis for Certification**
  - Test and Inspection
    - Successful completion of LH2 Tank proof test and post-proof inspection
      - LH2 Tank common proof test implemented with increased loads
  - Analysis
    - Weld acceptance criteria document updated to reflect stress analysis results using increased proof test loads
      - Weld peaking and mismatch criteria revised to accommodate higher proof loading
      - No change to critical FS



## Thrust Panel Penetrant Inspection

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- **Issue**

- Etching and penetrant inspections were improperly performed on SLWT Thrust Panels
- Three items were identified

Item 1: Twelve areas (2 inch square) obscured by handling fixture clamps were not etched as required prior to penetrant inspection

Item 2: 2 inch areas of 18 rib tops obscured by an inspection fixture were not penetrant inspected as required

Item 3: Areas of the panel were not accessible for close black light inspection

- **Background**

- Penetrant inspection process inadequacy at sub-tier supplier discovered during a first article validation for Intertank Thrust Panels for External Tank 6th Buy
  - 5th buy parts were processed in the same manner at the same sub-tier supplier
- This is an isolated incident
  - Reviewed Etching & Penetrant Inspection processes for other large ET components
    - No other process deficiencies found



## Thrust Panel Penetrant Inspection

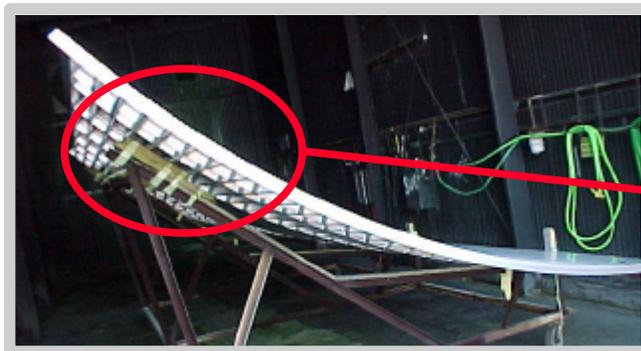
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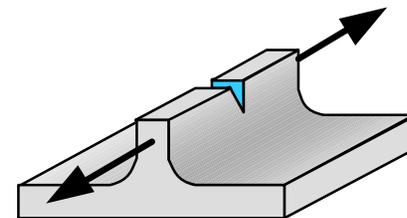
### • Item 2 Discussion

- Rib edge sections obscured by inspection fixture
  - Inspection fixture has 2" x 4" support blocks that contact OSL at six locations
    - 2 supports at forward, center, and aft sections
- Penetrant inspection not performed on 2" areas on top of 3 ribs at each support block
  - Pocket under the support block is difficult to inspect



### • Basis for Certification

- Fracture analysis results indicate all critical defects would be visually detected
  - Critical initial through flaw size greater than 1.15"
    - Through crack propagating from rib top would be visible when inspecting the pockets
    - Used single edge through crack model





## Thrust Panel Penetrant Inspection

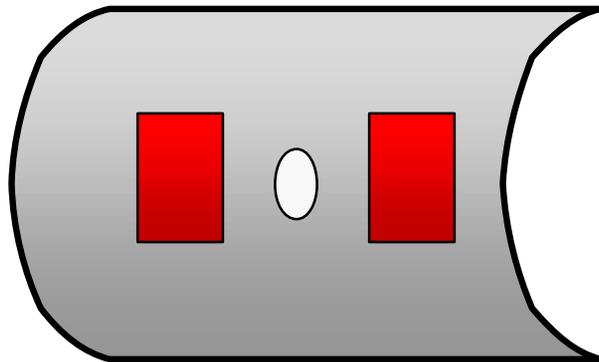
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### • Item 3 Discussion

- Areas of the panel were not accessible for close black light inspection
  - Two 2 ft x 3 ft areas of the ISL are affected
- Fixture geometry prevents inspector from standing next to inspection area
  - Level 3 POD flaw size (0.086") could be missed
    - Inspector can be 3 to 5 ft from inspection area



### • Basis for Certification

- Fracture analysis results indicate all critical defects would be visually detected
  - Critical initial through flaw size greater than 2.68"
  - Verified that surface flaw can not fail (flaw would show up on ISL)
  - Areas fully inspected on the OSL would reject critical flaw



## Discrepant Weld Bead Profile

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- **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**

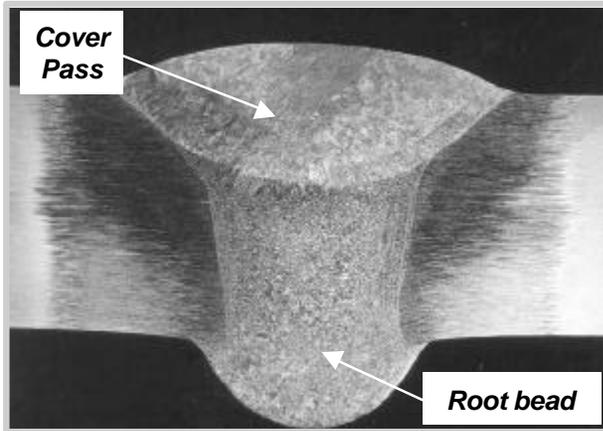
- Procedures allow dressing of weld bead penetrant indications down to 0.040” minimum bead height without documentation or MRB disposition
  - Dressing is typically performed to remove penetrant indications
  - Test data was developed and used to accept moderate dressing
  - Weld reinforcement required to transition smoothly into adjacent parent material

- Fracture properties not affected
  - Allowables based on shaved flush condition
- Rationale presented for STS-106/ET-103 (08/01/00) for continued processing at KSC

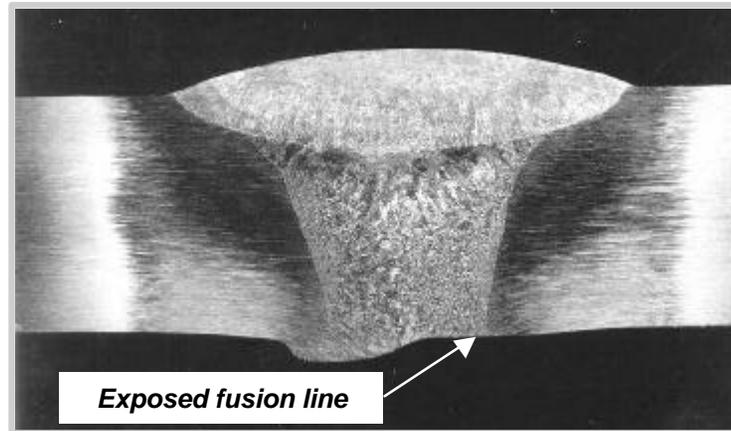


<b>Discrepant Weld Bead Profile</b>		Presenter Neil Otte	
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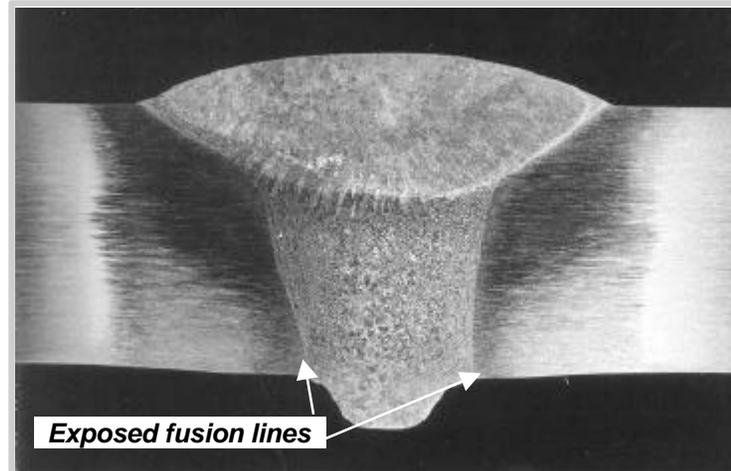
• **Background**



**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

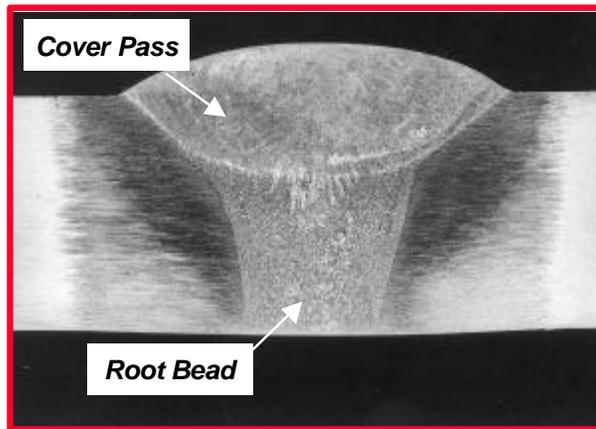
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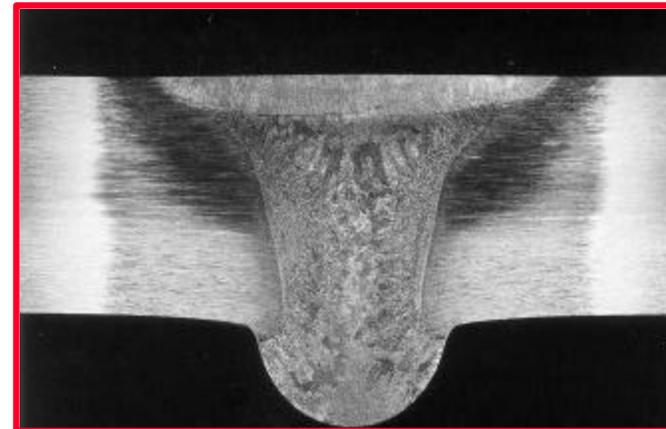
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- **STS-106/ET-103 Weld Clearance Analysis Approach**

- ET-103 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

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- **STS-106/ET-103 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
  - Location specific allowables for shaved flush welds
  - All MRB impacts considered (As-built conditions)
  - Positive margins demonstrated
    - HAF-1 FS = 1.38 (1.32 required) based on location specific assessment/test



<b>Readiness Statement</b>	Presenter Neil Otte	
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**The External Tank, ET-103, is hereby certified  
and ready for STS-106 flight pending  
completion/closure of open and planned work**