NASA

SECTION 29
All process changes were reviewed and none constrain STS-107

<table>
<thead>
<tr>
<th>Item Reviewed</th>
<th>STS-107 Critical Process Coverage</th>
<th>No. of Period or Effort Covered</th>
<th>No. Found To Be Critical Process Changes</th>
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<td>9</td>
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</table>

Change Review Summary
STS-107 Critical Process

Orbit: 01/09/03
Organizational/Date: Doug White
Presented: STS-107 Flight Readiness Review
output driver is individually tested with its own return

**Note:** OMRs test performed at KSC, will detect open returns since each LRU

- on all return paths
- This test will verify all inductors are installed and continuity
- Connectors J2, J3, J8 and DC returns on J9, J10
- Paragraph to measure continuity between all returns on
- Autotest test specification was revised to add new
- Autotest acceptance test procedure failed to verify
- Test at Autotest discovered 3 missing inductors
- Bump-in testing
- AMEC 28 dsc return paths

AMEC S/N 10 experienced multiple failures during SAIL

**Acceptance Test Modification (ECN-A6)**
Enhanced or Advanced Master Events Controller

**Engineering Design Change Proposal (EDCPs):**

<table>
<thead>
<tr>
<th>Organization/Date:</th>
<th>Critical Process Changes</th>
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<tbody>
<tr>
<td>Doug White</td>
<td>Presenter:</td>
</tr>
<tr>
<td>STS-107 Flight Readiness Review</td>
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</tbody>
</table>
The Zone 3 & 4 Interface

Relocated the Zone 1, 2, 2 thermostats & sensors away from

With Zones 1, 2

Reduced the number of wraps at the Zone 3 & 4 Interface

The Interface With Zones 3 & 4

Zone 1, 2 thermostats & sensors were relocated too close to

At the Zone 3 & 4 Interface with Zones 1, 2, and that the

It was determined that there were too many heater wraps

were influencing heater zones 1, 2 (doghouse)

that the OMS/RCS crossed line heater zones 3 & 4 (art)

During STS-109 post flight data review, it was determined

(ML0310-0063)

OMS/RCS Crossed Line Heater Configuration Change

Engineering Specifications:

Critical Process Changes

Orbiter 07/09/03

Organizations/Date:

Doug White

Presenter:

STS-107 FLIGHT READINESS REVIEW
CONFIGURATION CHANGES AND CERTIFICATION STATUS
Summary presented on following pages:

- Two Advanced Master Events Controllers (AMEC)
- New System Control Module (SCM) battery

First Flight Items:

- Modification certification has been processed and approved
  are in backup

Total Listing of STS-107 Modifications and Certification details

Processing Flow

18 Modifications Implemented During the STS-107

Configuration Changes and Certification Status

Table:

<table>
<thead>
<tr>
<th>Orbiter 01/09/03</th>
<th>Configuration Status</th>
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</thead>
<tbody>
<tr>
<td>Doug White</td>
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</tbody>
</table>
MCR 23061 New System Control Module Battery

Configuration Status and Certification Changes

STS-107 Flight Readiness Review
OF burn-in testings at SAL with no anomalies.
OMRS testing and have been subjected to over 1000 hours.
AMC installed in OY-102 successfully completed ATP.
- Installed in May 2001 - 1 flight
- AMEC S/N 8 in slot 2 (avionics bay 5)
- Installed in April 2002
- AMEC S/N 5 in slot 1 (avionics bay 4)
- STS-107 flight configuration:

104
- First flight of AMEC was in September 2000 (STS-106 in OV-104)
- Completed 13 missions
- AMC (single flight configuration) have successfully
- There are two MEC/EMEC/AMEC LRUs per orbiter
- First flight of two Advanced Master Controllers

<table>
<thead>
<tr>
<th>STS-107 Flight Readiness Review</th>
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<tbody>
<tr>
<td>Organizer/Date: 09/09/03</td>
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<tr>
<td>Doug White</td>
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<td>Presenter:</td>
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</tbody>
</table>

CERTIFICATION STATUS
CONFIGURATION CHANGES AND
Advanced Master Events Controller (AMEC) (cont)

- No anomalies have occurred during ground processing testing of AMECs S/N 5 and 8.

- AMEC-related issues:
  - AMEC S/N 6 and S/N 3 produced spurious non-critical outputs.
  - 2 occurrences in ~14,000 power cycles.
  - AMEC S/N 6: 2 occurrences in ~5,900 power cycles.
  - AMEC S/N 3: 0 occurrences.

- Analysis indicates that the condition is the result of the design's failure to ensure the power-on reset of non-critical command internal registers.

- Critical and Fire 3 commands are not affected.

- Condition is isolated to non-critical commands.

- Testing to date has resulted in sporadic recurrences of the condition during power up on OV-104 during the STS-98 and STS-110 flows.

- Can only occur at AMEC power-up and is not a flight constraint or concern.
David Rigby

Presenter

Topics:
- BSTRA Ball Cracks
- Liner Cracks
- OV-102 MPS LH2 Feedline Flow
Flowliner

CRES 321
OV-102

Flowliner

Inconel 718
Subs
OV-103 &

Between slots from 0.75 inches to 0.25 inches
- Roughly twice as many slots, reducing parent material in
  Material is CRES 321 instead of Inconel 718
  Similar in all details except:
  - STS-107 is 1st flight of repaired CRES Flowliners
  - STS-112 and -113
  - Inconel Flowliner weld repairs previously cleared for
    near the SSME interface
    Revealed cracks in the gimbal assembly Flowliners
    Inspections of MPS LH2 engine Feedline Flowliners

Observation:

<table>
<thead>
<tr>
<th>OV-102 MPS LH2 Feedline</th>
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</thead>
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<tr>
<td>STS-107 Flight Readiness Review</td>
</tr>
</tbody>
</table>

Orbiter 01/07/03
Organizational/Date:
David Rigby
Presenter:
Required scatter factors to determine safety margins.

Appropriate weld knockdown factor and slot-to-slot cracks on OV-102. 1 partial crack on MP TA.

Bounding known crack data in CRE 321. Flowliners:
- Derived conservative crack growth rate curve that
  - Used reverse fracture bounding analyses to estimate safety margin in cleaning repaired flowliners for flight.

Material (l.e., knockdown factor due to repair)

Determined minimum weld life relative to parent room temperature and cryogenic conditions tested fatigue life with and without repair welds at.

Tested representative of repair process MSFC completed fatigue testing of coupons configuration and to polish slots on OV-102 LH2 CRE

Developed processes to weld all detectable cracks.

Mission is the same as Inconel Flowliners.

Approach to clear weld repair of CREs Flowliners for one

Flowliner Cracks

OV-102 MPS LH2 Feedline

STS-107 Flight Readiness Review

Oriental 01/09/03
Organizational Date:
David Rigby
Presenter:
Good correlation on growth rate (slope of curve next
Superimposed on plot derived from OV-102 cracks -
Rate of crack growth observed vs. MPTA things

C rack on MPTA Feedline sectioned

Iagament in 23 missions (next page) would grow from initiation to across
Crack growth rate curve compatible with this damage
Increased stress, but inspections found no damage
After iagament fails, adjacent iagaments would have
Three locations on downstream Dowline in E2 Feedline

Inspection data from OV-102 Curve (crack length vs. missions) to bound crack
Used fracture theory to derive crack growth rate

Reverse Fracture Analysis
An undetected crack (assumed to slot-to-slot) propagation from missions 075.5 long in parent material.

Correlated by overlay of MPTA crack data and crack growth rate curve enveloping OV-102 crack data and OY-101 slot-to-slot initiation to crack growth from last 5 missions.

Weld repaired.

Flowlinecracks
OV-102 MPS LH2 Feedline

STS-107 Flight Readiness Review

Presenter: David Rigby

Orbiter 01/09/03
Organization/Date:
has insignificant effect on fatigue life
Fatigue testing confirmed this level of mean stress
prediction of approximately 25 ksi - correlated with analysis
Residual stresses measured on welded specimens

Ligament but did not change safety factor
Resulting from weld repairs across full width of
Special consideration given to residual stresses

Safety factor on life = 5.5/2 = 2.75
scatter factor of 2 for propagation
0.075 undetected flaw. Maintained standard
For ligaments with no detected cracks, assumed

Safety factor on life = 23/4 = 5.75
Maintained standard scatter factor of 4 for initiation
MFS showed no knockdown factor for welds.
For weld-repaired ligaments, material testing at

Reverse Fracture Analyses

FLOWLINE CRACKS
OY-102 MPS L2 DEADLINE

STSF-107 FLIGHT READINESS REVIEW

Orbiter 01/09/03
Organization/Date:
David Rigby
Presenter:
material property data - no issues


total: OV-102

\text{Repair Welds were represented in}

\text{dimensions such that the dimensions are correct.}

\text{Final MSFC coupon testing to assure that dimensions are correct.}

\text{Yoke welds completed with no issues}

\text{X-ray and/or boroscope of gimbal bellows and bellows to}

\text{Blended out without issue}

\text{Found during inspection}

\text{Dye penetrant inspection from shallow weld cooling cracks}

\text{Completed}

\text{Dye penetrant inspection of gimbal yoke to flange weld}

\text{Other LH2 feedline NDE inspections performed}

\text{Flowliner slots completed}

\text{Polishing of downstream and upstream gimbal}

\text{up of repairs completed}

\text{Cracks welded, post repair NDE completed & clean.}

\text{OV-102 Actions Completed:}

\text{Flowliner Cracks}

\text{OV-102 MPS LH2 Feedline

\text{STS-107 Flight Readiness Review

\text{Orbiter 07/09/03}

\text{Orbiter/Date:}

\text{David Rigby

\text{Presenter:}
Gimbal Ring: Clear for 100 plus missions analysis technique
Bellows: Clear for 51 missions using conservative proof pressure safety (above 1.4 factor of safety) at cryogenic Bellows to gimbal weld: Clear with 0.54 margin of the first BSTRA joint in the middle of the feedline BSTRA joint: Backflow dams out prior to reaching is applicable other vehicles, previous analyses and flight rationale gimbal weld, bellows, and gimbal ring is identical to All other feedline hardware (BSTRA joints, bellows to OV-102 Actions Completed (cont.):

<table>
<thead>
<tr>
<th>OV-102 Flight Readiness Review</th>
<th>Flowliner Cracks</th>
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<tbody>
<tr>
<td>STS-107 Flight Readiness Review</td>
<td>OV-102 LMS L2 Feedline</td>
</tr>
<tr>
<td>Extent 09/03</td>
<td>Extent (cont.)</td>
</tr>
<tr>
<td>Data/Flight Ready</td>
<td>Data/Flight Ready</td>
</tr>
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</table>
Conducted.

Post-flight inspections of the flowliners will be conducted.

Additional fracture test data will be gathered to develop flight rationale for future missions on OV-102.

The CRES flowliners on OV-102 for STS-107 are identified as a safety factor on the fatigue life of the structure. A coupon testing, and Fracture analyses, polishing of LH2 flowliner slots, internal flowline NDE, based on successfully completed crack repair welds.

Acceptable for STS-107 Flight:

Flowliner Cracks
OV-102 MPS LH2 Feedline

STS-107 Flight Readiness Review

[Table containing information about the inspection process]
12 inch feedlines downstream of feedline screens

17 inch feedlines upstream of feedline screens

FOD generation

In structural failure of the feedline

Lack of articulation capability of the feedline resulting

Failure of ball could result in:

Concern:

Similar design in 12 inch and 17 inch feedlines

Assembly (BSTR4A) nearest the LO2 manifold

Revealed a crack in the ball of the ball strut. The rod

OMRSD inspection of OV-103 17 inch LO2 feedline

Observation:

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<thead>
<tr>
<th>Date</th>
<th>Signatory</th>
<th>Observation</th>
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<tbody>
<tr>
<td>01/09/03</td>
<td>David Rigby</td>
<td>Rod Assembly Ball Crack</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MPS 17” Feedline Ball Strut The</td>
</tr>
</tbody>
</table>

STS-107 Flight Readiness Review
No spalling

- Crack propagation does not create FOD

FOD from cracked balls

- Binding
- Friction

Joint angle location capability not compromised

- Load margins remain positive
- Ball remains intact

Cracks must be self-limiting

Joint performance with cracked balls

---

Flight Rationale Based on Resolution of Two Issues

<table>
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<tr>
<th>Date</th>
<th>Event</th>
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<tbody>
<tr>
<td>01/09/03</td>
<td>MPS 17&quot; Feedline Ball Stut The</td>
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STS-107 Flight Readiness Review
Agenda:

- Testing Activities
- Approaches to Flight Rationale
- Build Records and Acceptance Testing of BSTRA
- Qualification Testing Summary
- Vehicle Inspection Summary
- MPS Feedline Introduction

Rod Assembly Ball Crack
MPS 17" Feedline Ball Strut Tie

ST-S-107 Flight Readiness Review
MPS Feedline Introduction:

- BSTRA joints are located in the two upstream joints of each 12 inch engine feedline and all three 17 inch feedline joints
- BSTRA provides internal structural support to feedline while allowing the joint to articulate to compensate for:
  - Cryogenic shrinkage
  - Pressure expansion
  - Dynamic loads
  - ET umbilical retract (17 inch feedline)
  - Structural deflections
<table>
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<th>Quantity</th>
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<th>Feedline Description</th>
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<td>1.25 inches</td>
<td>LH2 12 and 117 inch</td>
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<tr>
<td>6</td>
<td>1.75 inches</td>
<td>LO2 12 inch</td>
</tr>
<tr>
<td>3</td>
<td>2.24 inches</td>
<td>LO2 117 inch</td>
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</table>

Vehicle Per Ball Quantity

Feedline Descriptions:
- Vitrolube Coating
- Cobalt / Chromium / Tungsten Alloy
- Balls are manufactured from Stubby #2 718
- Cups, Hubs, and Stubs are manufactured from Inconel
- Cups are pressure carrier and a ball located inside the hub flow stream by three stubs mounted to pads on the hub.
- Each BSTRA consists of two hubs, suspended in the MPS Feedline Introduction (Cont):

MPS Feedline Introduction (Cont):

- Rod Assembly Ball Crack
- MPS 177" Feedline Ball Stut The

STS-107 Flight Readiness Review
Date: Orbiter 01/09/03

David Rigby
Reviewed:
LO2 Feedline Installation (FoamFed, OV-103 and Subs)

OBR-17.2.6

Date: 09/03

MPS 17- Feedline Ball Crank

STS-107 Flight Readiness Review

Signed by: David Rigby
LH2 Configuration Shown

Downstream Housing

(Blue)

Downstream Strut Assy

Bellows

Upstream Strut Assy (Red)

Upstream Housing

BETA Components

STS-107 Flight Readiness Review

Orbiter 01/09/03

Date:

David Rigby

Presenter:

Rod Assembly Ball Crack

MPS 17" Feeding Ball Strut Tie
### Typical BSTRA Assembly

- **Rod Assembly Ball Crack**

#### MPS 17” Feedline Ball Strut Tie

<table>
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<th>Presenter</th>
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<tbody>
<tr>
<td>Oct/1 01/90/03</td>
<td>David Rigby</td>
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</table>

**STS-107 Flight Readiness Review**
Type of borescope used

Similar indications on the ball due to access and the

Previous OMRS Inspection may not have seen

Better access to all sides of the balls / BSTRAS

Of damage from borescope

Closer inspection of balls possible due to decreased risk

Resulting in improved inspection capability

New borescope used for the first time during this inspection

Ball is not rotated during the inspection

Visual access limited to less than 25% of the surface

OMR Inspection implemented in 1995

OMR Borescope Inspection implemented in 1996

Eventually cleared as an MLF-related noise

Concerns over BSTRA binding

OV-105 "Big Bang" anomaly in mid-1990s raised

OMRS Inspection Summary

Vehicle Inspection Summary

Rod Assembly Ball Crack

STS-107 "Feeding" Ball Stunt The

Date: 09/03

Presenter: David Rigby

STS-107 Flight Readiness Review
<table>
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Vehicle Inspection Summary (cont)
OV-103 17’’ BSTRAP Ball Crack Indication

Rod Assembly Ball Crack

MPS 17’’ Feeding Ball Stud Tie

STS-107 Flight Readiness Review
design and implementation issues are resolved.

- CHIT will be brought forward to the SSP when all

- BSTRA ball
  - Rotation and inspection of the OV-103 cranked
  - Designed to unload BSTRA joint and allow full
  - Under development at JSC with KSC involvement

BSTRA Ball Inspection Tool

<table>
<thead>
<tr>
<th>Order 01/09/03</th>
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<tbody>
<tr>
<td>Date:</td>
</tr>
<tr>
<td>David Rigby</td>
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<tr>
<td>Presenter:</td>
</tr>
</tbody>
</table>

MPs 1.7“ Feedline Ball Strut The

STS-107 Flight Readiness Review
<table>
<thead>
<tr>
<th>Complete</th>
<th>Separation Test LH2 17 Inch Feedline</th>
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</thead>
<tbody>
<tr>
<td>Complete</td>
<td>MPTA LO2 17 Inch Feedline</td>
</tr>
<tr>
<td>Complete</td>
<td>MPTA LH2 17 Inch Feedline</td>
</tr>
<tr>
<td>Complete</td>
<td>Qual Unit LH2 12 Inch Engine Feedline</td>
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<tr>
<td>Complete</td>
<td>MPTA LO2 12 Inch Engine Feedline</td>
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<tr>
<td>E2, E3 Complete</td>
<td>MPTA LH2 12 Inch Engine Feedlines</td>
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<tr>
<td>E1 In-Work</td>
<td>Feedline Description</td>
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</table>

Other Feedline Assemblies

<table>
<thead>
<tr>
<th>Rod Assembly Ball Cack</th>
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<tbody>
<tr>
<td>MPS 177 Feedline Ball Strut The</td>
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</table>

STS-107 Flight Readiness Review
No cracks noted post test by metallurgical sectioning

No defects noted post test penetrant inspection

No failures occurred in test

Conclusion

Test utilized both L2 and LH2

and loading (400 cycles)

Simulated flight qualification environment thermal shock

1977 Rockwell / Arrowhead qualification testing

Qualification Test History

<table>
<thead>
<tr>
<th>ORBiter 01/09/03</th>
<th>Rod Assembly Ball Crack</th>
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</thead>
<tbody>
<tr>
<td>Date</td>
<td>Mps 17” Feedline Ball Sturt Tie</td>
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<tr>
<td>Presenter</td>
<td>STS-107 Flight Readiness Review</td>
</tr>
</tbody>
</table>
MPS 17" Feedline Ball Strut Tie
Rod Assembly Ball Crack

Qualification Test History (cont):

• 1978 MSFC testing

Stoody #2 bearings were already installed in the MPTA feedlines.

• MSFC concerns over the use of Stoody #2 in the feedlines and cost and schedule considerations made it highly desirable to not change materials.

• Tested bearings with and without cracks present.

• Test utilized both LN2 and LH2.
Steady #2 balls
ATP of the balls, the Orbiter project continued with
Due to wear capability and plans for individual cyroganic
ET project moved to inconel 718 for BSTRA balls
Program effects
Steady #2 bearings installed in MPTA ET lines
Recommedation was to continue with MPTA with
The conclusion reached was that risk of failure was low
Capability to perform intended function
No catastrophic failures and all bearings retained
Current
Penetrent inspection is unreliable as compared to eddy
Bearings may be checked on receipt
Shock
Material is prone to cracking from thermal/mechanical
Conclusions

1978 MSFC testing (cont):
Qualification Test History (cont):

<table>
<thead>
<tr>
<th>Orbiter</th>
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<tr>
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</table>

STS-107 Flight Readiness Review

MPS 17” Feeding Ball Strut The
Rod Assembly Ball Crack
Pre-existing cracks is inadequate to detect cracks

Use of dye penetrant inspection as detection method for

Inspection following LN2 thermal dunk

Acceptance test procedures perform dye penetrant

No anomalies found during search of build records

Balls

Build Records and Acceptance Testing of BSTRA

Post test inspection - no BSTRA related anomalies

100 mission qualification tests

LO2 and LH2 17" Feedline qualification tests

Qualification Test History (cont.):

<table>
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ST5-107 FLIGHT READINESS REVIEW
Approaches to Flight Rationale:

- Fly as is
- Scheduled turnaround time is prohibitive to near term flight
- Off-vehicle repair
- Accessibility issues
- Technical concerns eliminated this option due to
- On-vehicle repair
- Three options considered
- Ball is found to be inadequate
- For OV-102 / STS-107, the working assumption is that OV-102 has cracks since ATP screening of the

**Rod Assembly Ball Crack**

**MPS 17** Feedline Ball Stut The

<table>
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STS-107 Flight Readiness Review
No spalling

Crack propagation does not create FOD

FOD from cracked balls

Binding

Friction

Joint angularization capability not compromised

Load margins remain positive

Ball remains intact

Cracks must be self-limiting

Joint performance with cracked balls

Flight Rationale Based on Resolution of Two Issues

Rod Assembly Ball Crack

MPS 17” Feeding Ball Strut The

ST5-107 Flight Readiness Review
Testing Activity to Support Flight Readiness Review

STS-107 Flight Readiness Review

MPS 177 Fieldline Ball Strut The

Date: 09/03/03

Presenter: David Rigby

Orbiter 01/01/09/03

Testing: Arrest mechanism not demonstrated
- Quailification test program did not produce cracks
- Limited thermal / mechanical cycles
- Mechanism for MPTA test program
- Previous MSFC testing supported crack arrest development
- Additional testing is required to support flight rationale

Rod Assembly Ball Crack
<table>
<thead>
<tr>
<th>Size</th>
<th>Ball</th>
<th>Naturally Cracked</th>
<th>Severely Less Cracked</th>
<th>Severely Cracked</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.25&quot;</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>1.75&quot;</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.24&quot;</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- May provide some rationale that OV-103 is unique
- Thermal / load cycles
- Propagate cracks despite multiple thermal and Ball without notches did not start / (water)
- Rapid thermal cycles 212 F (boiling water) to 32 F (ice)
- 275 - 400 F (oven) to -100 F (glycol / dry ice)
- Extreme heat transfer required to crack test balls

Severe Environments Needed to Crack Test Balls

**Rod Assembly Ball Crack**

STS-107 Flight Readiness Review
through success of margin testing.

- Material property variability may be encompassed
- 1.75x Nominal Flight Profile (5 cycles minimum)
- 1.5x Nominal Flight Profile (5 cycles minimum)

Load Margin Testing

- Maximum Engine Operating Pressure (5 cycles minimum)
- Nominal Flight Profile (35 cycles minimum)
- Slow Fill (5 cycles minimum)

Cracks must be self-limiting.

Mps 177” Feedline Ball Strut Tie Rod Assembly Ball Crack

STS-107 Flight Readiness Review

Orbiter 01/10/03

Date: 01/10/03

David Rigby

Presenter:
Stress cracking can be initiated by several factors:

- Full additional cycles.
- Alternating thermal profile may speed up testing and allow showing crack arrest on 1.25 inch balls acceptable.
- Crack arrest on 2.4 / 1.75 inch balls may be able to higher load cases.
- Cycles at nominal load levels; no scatter factor on cycles at nominal load levels.
- For OV-102, ~30 million cycles would require 10 cycles.
- Factor of 4 on nominal load cycles.
- Scatter factor on cycles for margin.
- Traditional shuttle testing methodology uses scatter.

**Cyclic Margin Testing**

Cracks Must Be Self-Limiting (cont.):

<table>
<thead>
<tr>
<th>Rod Assembly Ball Crack</th>
<th>MPS 1T7 &quot;Feeding&quot; Ball Strut Tie</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orbiter 01/09/03</td>
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<tr>
<td>Date:</td>
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</tbody>
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STS-107 Flight Readiness Review
LH2 Thermal profile

* Using 287°F (oven) to -100°F (glycol / dry ice) to simulate

* 1.25 inch balls: 1/12/03
* 1.75 inch balls: 1/11/03
* 2.24 inch balls: 1/11/03

Testing ECDs

Spore balls to determine potential use for testing

Complete Eddy Current and CT scan of remaining

Full visual inspection on OV-102 to ensure no cracks

If crack fails to arrest in naturally cracked ball (1.75")

OV-103 inspection / harvest

AND/OR

Less severely cracked ball testing

If crack fails to arrest in severely cracked balls

Cracks Must Be Self-Limiting (cont.):

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STS-107 Flight Readiness Review

Rod Assembly Ball Crack

Mps 17° Feedline Ball Stuit Tie
500 micron thick interface thickness minimum
- Measured 180 microns with offset maximum
- MSFC M8P showed no issue
- Initial work on a severely cracked 2.24 inch ball by
  MSFC developing testing capability
- Will be measured
  If offset greater than vitrinite thickness actual friction
  Surfaces will be measured
  For all balls with cracks, vertical offset between
  Binding
  Friction

Joint angle & capability not compromised

---

Orbiter 01/09/03
Date:

David Rigby
Presenter:

STS-107 Flight Readiness Review

Rod Assembly Ball Crack
MPS 17" Feedingline Ball Stiff: Tie

---
the SME project

- Actions in work to determine acceptability of FOD with
  - 1.2" downstream of screen
  - 1.7" upstream of screen
  - Prevalve screen: 1000 microns
  - Hydrogen: 400 microns
  - Oxygen: 800 microns

- System design limits

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STS-107 Flight Readiness Review
<table>
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<tr>
<th>Material Parent Loss of</th>
<th>Islands Material With Cracks Branching Cracks Samples Total</th>
<th>Type of cracks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>Natural</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>Less Severe</td>
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<td>4</td>
<td>Severe</td>
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- Loss of parent material
- Material Islands
- Branching cracks
- FOD Related issues

BSTRA Ball FOD Testing (cont): Rod Assembly Ball Crack MPS 177" Feedline Ball Stunt The
- 2.24 Inch Severely Cracked Ball Shown

**BSSRA Ball Rod Testing (cont.):**

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Stress Analyses

Probabilistic Risk Assessment

FOD characterization testing

Balls to determine potential use for testing

Completely Edgy Current and CT scan of remaining spar

Less severely cracked ball testing

Completing additional testing

Metallographic analysis of the cracked balls

Investigating

and the potential associated particle size, we are

To understand the mechanism for particle generation

Testing to date has shown that the potential for FOD

BSTRA Ball FOD Testing (cont.):

Orbiter 01/09/03

Date:

David Rigby

Presenter:

STS-107 Flight Readiness Review

MPS 177 "Feeding" Ball Strut Tie

Rod Assembly Ball Crack
No spalling

- Crack propagation does not create FOD
- FOD from cracked balls
- Binding
- Friction
- Joint angulation capability not compromised
- Load margins remain positive
- Ball remains intact
- Cracks must be self-limiting
- Joint performance with cracked balls

Flight Rationale Based on Resolution of Two Issues

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PMMT Review

Final flight rationale will be presented at the STS-107.

The test program to support flight rationale is still in

Conclusions:

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not yet complete
safe flight of the potentially cracked BSTRA balls is
This test program and development of rationale for
work