

**STS-107 (BI116)  
FLIGHT READINESS REVIEW**

**Program**

**January 9, 2003**

**Solid Rocket Booster**

## AGENDA

Presenter:

Roger Elliott

Organization/Date:

USA-SRB/1-9-03

- Special Topic
  - Qualified New Forward and Aft Separation Bolt Vendor
- Technical Issues
  - Defective Cable Connector Sockets
  - Suspect Paint Foreign Object Debris (FOD) in Booster Separation Motors (BSMs)
- Readiness Assessment

# SPECIAL TOPIC

## NEW SEPARATION BOLT VENDOR

Presenter:

Roger Elliott

Organization/Date:

USA-SRB/1-9-03

### Topic

- First flight use of Pacific Scientific forward and aft separation bolts

### Background

- Pacific Scientific Engineering Materials Company new vendor for separation bolts
  - Previously supplied by Hi-shear and Teledyne McCormick Self
  - Pacific Scientific currently supplies 8 other SRB pyrotechnic components

### Discussion

- Hardware underwent full qualification program
  - Thermal shock, sine and random vibration, ambient and low temperature functional, stress corrosion and failure load test
- Aft bolts successfully used in tail service mast application on STS-112
- No increased risk for STS-107 and subsequent

# TECHNICAL ISSUE

## CABLE CONNECTOR SOCKETS

Presenter:

Roger Elliott

Organization/Date:

USA-SRB/1-9-03

### Issue

- Defective connector sockets on cable assemblies

### Concern

- Loss of Criticality 1R power to SRB

### Background

- Cable found with intermittent continuity during flex testing
- Cable provides Orbiter power to SRB
  - Two cables of this type per SRB (A & B buses at aft IEA)
  - Cables utilize NAS6CR24-19S/SA connector
    - Unique SRB connector design
    - Connector uses 12 gage sockets

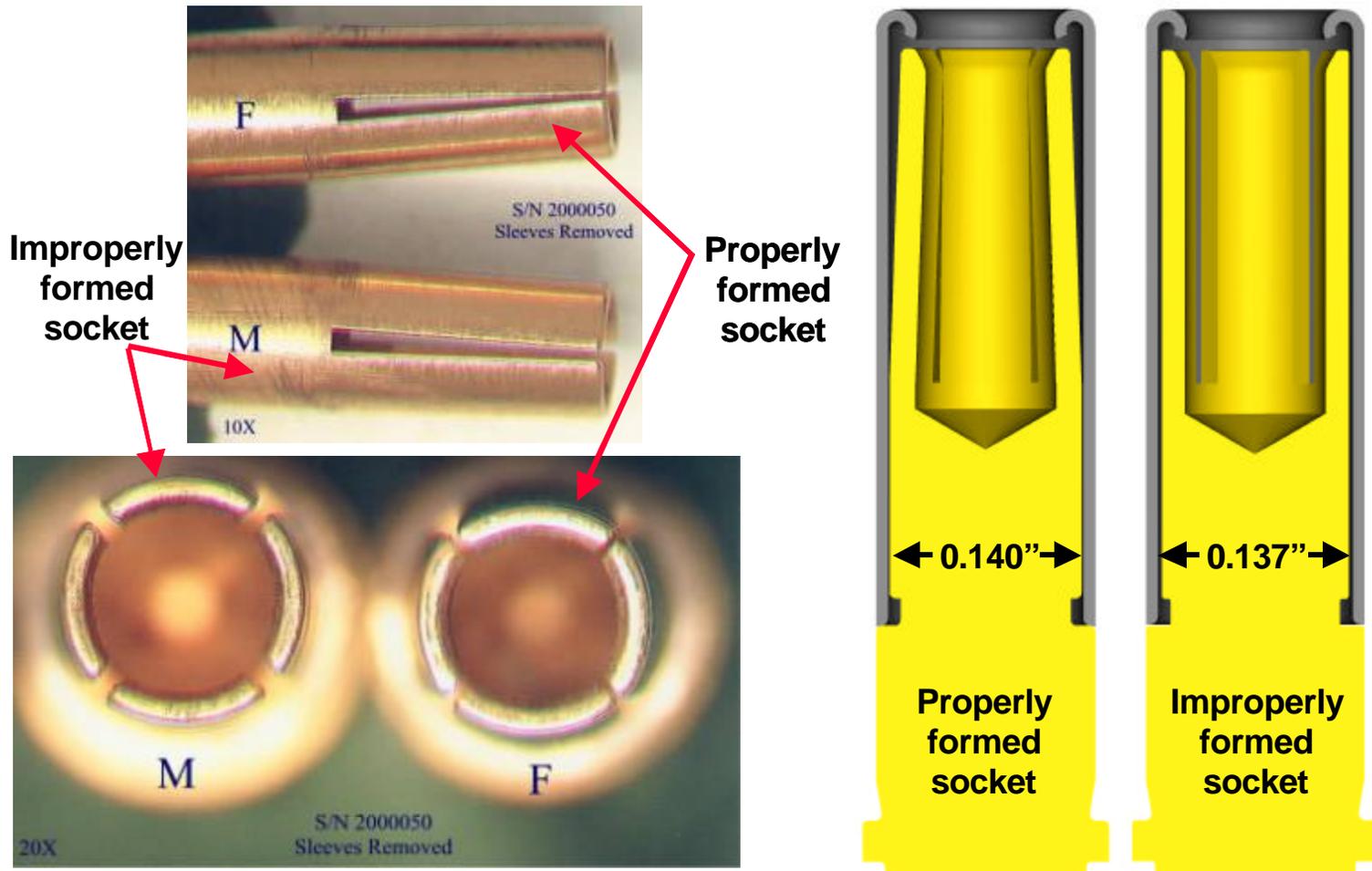
# TECHNICAL ISSUE CABLE CONNECTOR SOCKETS

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Visual Comparison of Properly and Improperly Formed Sockets

# TECHNICAL ISSUE

## CABLE CONNECTOR SOCKETS

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### Discussion

- Formed joint anomaly resolution team
  - Representatives from MSFC, USA and Amphenol
- Identified connector socket manufacturing anomaly
  - Undersized socket barrel outside diameter resulted in improper forming of socket
    - Machined by Amphenol at Sidney NY facility (October 1997)
    - In-process inspection
      - Operator required to verify six per hour (approximately 10%)
  - Contact sockets and hoods shipped to Nogales, Mexico facility for final assembly/inspection and lot acceptance testing
    - 100% burnished and gauged – manual operation
      - Required to perform separation force test on entire lot
    - Final lot acceptance testing at 1% Acceptance Quality Level (AQL)
    - First time Nogales facility used for final assembly process
      - No changes to assembly process paper
      - Language barriers existed during first time operation
        - Process paper unclear
      - On-site support not provided

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## CABLE CONNECTOR SOCKETS

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### Discussion (cont.)

- Investigation identified one additional unique connector socket utilized by SRB, NAJ-12-16
  - Manufactured using similar processes/inspections by Amphenol
  - Utilized for nose cap separation and nozzle extension severance
    - Criticality 3 functions
  - Fourteen cables and eight loose contacts inspected with no discrepant contacts identified
    - Total of 92 contacts
  - Assembled hardware not inspected
    - Criticality 3 functions
      - Nose cap separation
      - Nozzle extension severance

# TECHNICAL ISSUE

## CABLE CONNECTOR SOCKETS

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### Discussion (cont.)

- Identified improper machining of socket as primary root cause of anomaly
  - Identified quality escapes as secondary root cause
    - In-process checks – six per hour required
    - Burnish and gauge operation – 100% requirement
    - Lot acceptance tests – 1% AQL
- Completed inspection and pin retention test of all available hardware
  - No discrepancies found on STS-107, inspected 12-18-02
  - Replaced two cables on STS-114, inspected 12-16-02
  - STS-115 aft boosters still to be inspected and tested
  - Identified one unused contact on STS-116 as discrepant on 12-11-02

# TECHNICAL ISSUE

## CABLE CONNECTOR SOCKETS

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### Flight Rationale

- STS-107 NAS6CR connectors successfully passed inspection and pin retention test
- All other uses of NAS6CR connectors on future missions will be inspected and non-conformances corrected
- Investigation data supports isolated quality escapes limited to NAS6CR connector sockets
- Inspection of NAJ-12-16 sockets indicates no similar concern
  - NAJ-12-16 sockets only used in Criticality 3 applications
- All SRB system's functionality and redundancy verified before and after vehicle assembly
- Critical systems verified during pre-flight testing
- STS-107 and subsequent safe to fly

# TECHNICAL ISSUE

## SUSPECT PAINT FOD IN BSM

Presenter:

Roger Elliott

Organization/Date:

USA-SRB/1-9-03

### Issue

- Suspect paint FOD in Booster Separation Motors (BSM)

### Concern

- BSM performance
- FOD ejected during BSM firing at SRB separation

### Background

- Five small paint chips detected in propellant premix for SRB BSM propellant batch at vendor
  - Identified prior to mix operation
  - Chips loosened from painted lip of 400 gallon mix bowl when chemical addition cover removed

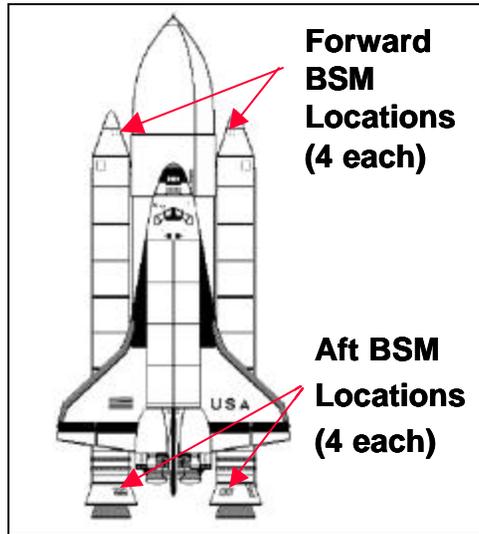
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Presenter:

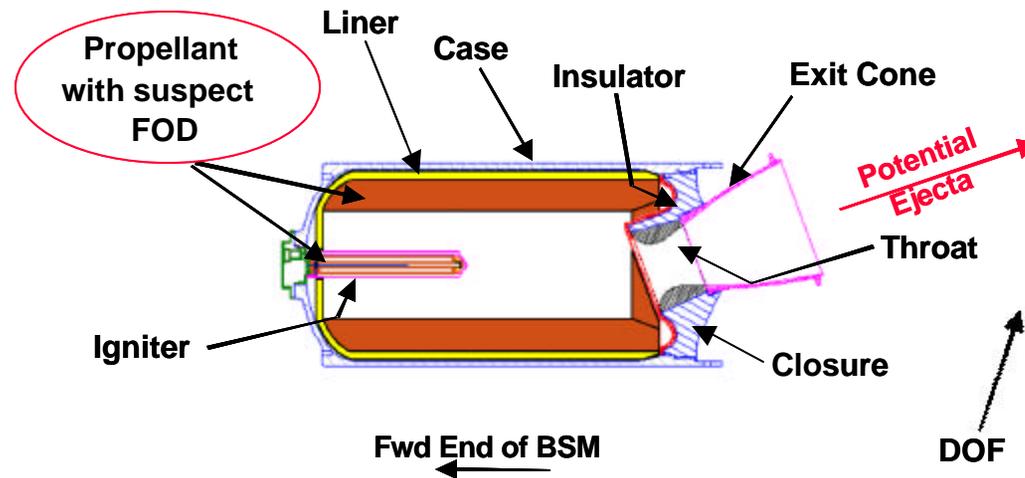
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BSM Orientation



Forward BSM Cross Section

# TECHNICAL ISSUE

## SUSPECT PAINT FOD IN BSM

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**400 Gallon Mix Bowl**



**Chemical Addition Cover  
(paint removed from rim of bowl)**

# TECHNICAL ISSUE

## SUSPECT PAINT FOD IN BSM

Presenter:

Roger Elliott

Organization/Date:

USA-SRB/1-9-03

### Discussion

- Anomaly resolution team formed
  - USA, NASA, Boeing and Pratt & Whitney Space Propulsion
  - Independent USA Chief Engineer's team formed for oversight
- All BSMs in inventory suspect
- Inspection of mix bowl showed areas of missing paint
  - Materials analysis positively identified FOD as paint from mix bowl
- Analysis reveals no affect on BSM performance
  - Structural, thermal and ignition interval
- Debris transport analysis determined BSM ejecta with similar properties as virgin paint chips would be flight concern for Orbiter windows
- Analysis alone unable to show sufficient paint consumption during BSM burn
  - Test program required

# TECHNICAL ISSUE

## SUSPECT PAINT FOD IN BSM

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### Discussion (cont.)

- Test program initiated to determine thermal effects of BSM propellant burn on imbedded paint
  - Seven successful window bomb tests performed on propellant samples
    - Window bomb testing allows high speed photography of propellant during burn
    - Propellant cast into  $\frac{1}{4}$  by  $\frac{1}{4}$  by  $\frac{1}{2}$  inch samples with paint chips inserted prior to cure
    - Paint chips inserted both horizontally and vertically to flame front
- Photographic review shows paint burning with red glow of a heated carbonized structure when released into flow stream

# TECHNICAL ISSUE SUSPECT PAINT FOD IN BSM

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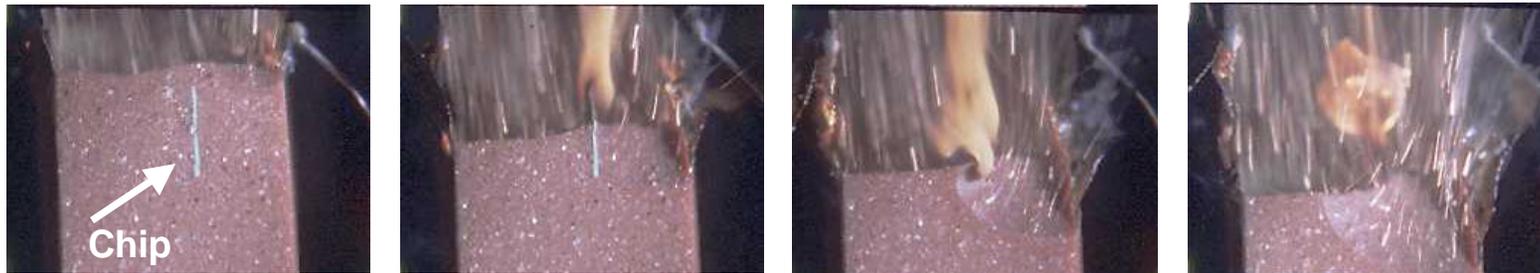
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**Window Bomb Test for Paint Chip Planar with Flame Front**



**Window Bomb Test for Paint Chip Perpendicular to Flame Front**

# TECHNICAL ISSUE

## SUSPECT PAINT FOD IN BSM

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### Discussion (cont.)

- Five of seven tests resulted in released material captured on 250 micron filter screen
  - Released material on other two tests passed through filter
  - Captured residue examined by scanning electron microscope and determined to be highly porous, fragile, carbonized structure
    - Energy Dispersive X-Ray confirms paint tint material (titanium oxide) is captured in carbonized particles
- Analysis determined that released material would not withstand forces imparted during BSM nozzle entry
  - Results in rendering particles to dust, or ash, like configuration similar to nominal BSM exhaust from combustion of propellant

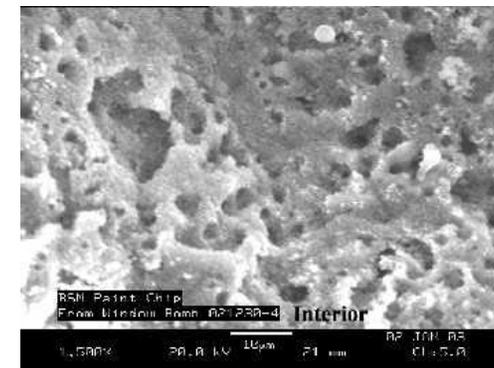
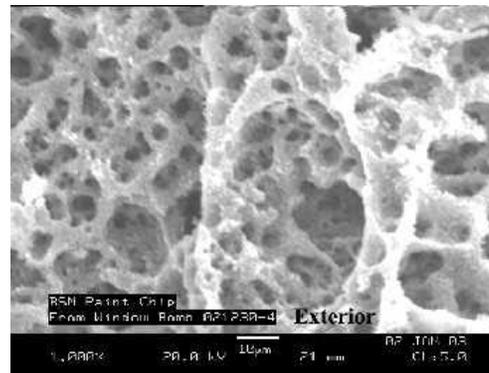
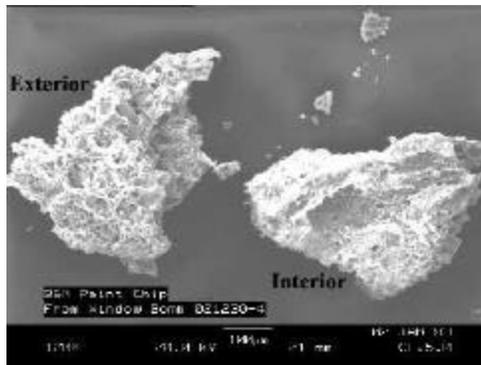
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**SEM Results for Captured Residue  
(hollow, carbonized structure)**

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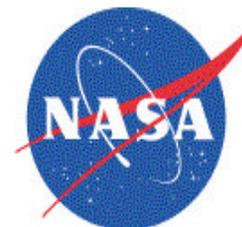
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### Flight Rationale

- BSM performance not affected by presence of paint FOD
- All Orbiter/ET debris impact concerns cleared by testing and analysis
- No increased risk to flight safety or mission success for identified paint FOD
- STS-107 and subsequent safe to fly



# ***STS-107 (BI116) Flight Readiness Review***

***Pending completion of normal operations flow,  
we certify the Booster Assembly hardware  
ready to support the launch of STS-107***

Original signed by Gordon Nielsen

**Gordon P. Nielsen  
Associate Program Manager/USA  
SRB Element**

Original signed by David Martin

**A. A. McCool  
Acting Manager,  
SRB Project Office**

