

SRB CRITICAL ITEMS LIST

SUBSYSTEM: STRUCTURES AND MISCELLANEOUS ITEMS

ITEM NAME: Thermal Protection System - Aft BSM Nozzle and Nozzle Heat Seal

PART NO.: 10317-0006, 10115-0001 (LH), FM CODE: A02
10116-0001 (RH)

ITEM CODE: 60-03-04 REVISION: Basic

CRITICALITY CATEGORY: 1R REACTION TIME: Seconds

NO. REQUIRED: 4 DATE: March 31, 1998

CRITICAL PHASES: Boost SUPERCEDES: March 31, 1997

FMEA PAGE NO.: E-32A ANALYST: S. Parvathaneni

SHEET 1 OF 5 APPROVED: P. Kalia

DCN 033

DCN 033

DCN 033

FAILURE MODE AND CAUSES: Loss of Aft BSM Nozzle or Nozzle Heat Seal thermal protection caused by:

- Degraded thermal or physical properties due to improper constituents, formulation, mixing, application, cure or natural environments. (Degraded Properties)
- Inadequate TPS thickness. (Inadequate Thickness)
- Debonding due to improper application of substrate paint system, improper substrate preparation, adhesive failure or improper application of insulation topcoat. (Debonding)

FAILURE EFFECT SUMMARY: Loss of mission, vehicle and crew due to loss of required thrust at separation leading to recontact of SRB with ET or Orbiter.

REDUNDANCY SCREENS AND MEASUREMENTS

1. N/A
2. Fail - Loss of redundancy not detected by flight or ground crew.
3. Pass- No known common cause.

RATIONALE FOR RETENTION:

A. DESIGN

The Aft BSM Nozzle and Heat Seal are insulated with 0.50 inch thick cork, bonded to the nozzle cover with EC2216 adhesive, 0.38-1.00 inch thick or BTA on the nozzle and 0.62 inch minimum thickness or BTA on the Nozzle Flange/Heat Seal interface.

DCN 033

Thermal protection requirements are presented in SE-019-068-2H, SRB Thermal Design Data Book. Thermal insulation requirements were established by test and analysis.

Material properties were determined by development testing at the MSFC Modified Hot Gas Facility, AEDC and Ames wind tunnels. The range of thermal environment, acoustic and vibration, and stress loads were obtained from applicable documentation and encompassed the maximum and minimum values. Design properties derived from these tests are reported in SE-019-068-2H.

Verification testing was performed per "SRB/TPS Verification Test Plan", NASA letters EP44 (79-54), EP44 (79-79), EP44 (79-120) and EE11 (S-80-34) using analytically determined TPS material thicknesses, maximum heat loads and rates for the applicable regions, and representative model configurations. Subsequent changes in TPS materials, thickness, etc., were verified on an individual basis using current environments and loads. Subsequent changes in SRB environments were reviewed to verify that original verification parameters were not exceeded.

DCN 033

Certification was performed per document SE-019-149-2H, SRB/TPS Certification Plan. Subsequent changes in TPS materials and/or thickness were certified based on verification test results. Changes to certification requirements (environments and/or loads) are reviewed to verify that existing requirements are not exceeded.

The following Certificates of Qualification (COQs) are applicable to the TPS materials required:

Cork/EC-2216 B/A Clear Amber Adhesive - USBI COQ A-TPS-8109-1
 BTA - USBI COQ A-TPS-8120-3

DCN 033

The Aft BSM Nozzle Heat Seal is insulated with cork by the BSM vendor, UTC-Chemical Systems Division in accordance with UTC-CSD SE 2186 (Process Specification, Bonding, Adhesive, Cork-Thermal Protective Coatings). The Aft BSM Nozzle and Nozzle/Heat Seal interface insulation requirements are specified on USBI drawings 10115-0008, 10116-0008 (TPS Closeout Insulation, Aft Skirt).

Other documents controlling BSM Nozzle and Heat Seal insulation requirements include:

DCN 033

○ BTA:

10753-0032	BTA Insulation Formulation
10PRC-0546	BTA Procedure for Troweled Application

○ Substrate Protective Finish:

○ UTC-CSD B12003 Nozzle Assembly

○ Remove all TPS after every flight

B. TESTING

Testing of the vendor applied insulation is accomplished in accordance with SE2186. Testing to verify the acceptability of the USBI insulation application is accomplished in accordance with the following:

- To verify acceptability of cork/EC-2216 materials, adhesive formulation, mixing, processing and cure, porta-pull tests are performed in accordance with UTC-CSD drawing B13341 and SE2186. (Degraded Properties)

- BTA acceptability is verified per 10REQ-0021, para. 4.1.2
 - To verify acceptability of BTA constituents, formulation, mixing, application and cure, three tensile specimens and two density coupons are prepared and tested from at least one batch mixed, for each day of BTA processing. Hardness is measured on the density coupons and on the flight hardware. (Degraded Properties)

- From each group of Heat Seals bonded with an adhesive batch, one assembly is randomly selected and used for porta-pull testing to verify proper bonding in accordance with SE2186. (Debonding)

C. INSPECTION

Inspections to verify the processing and application of vendor insulation materials are accomplished in accordance with SIP 1141. (Degraded Properties)

- USBI QAR verifies Heat Seal cork installation in accordance with SIP 1141. Insulation materials are accepted on the basis of supplier certifications in compliance with SIP 1141. (Degraded Properties)
- USBI QAR verifies cork thickness, witnesses substrate paint tape test, verifies porta-pull tests, inspects test specimen for failure mode of cork bond, and inspects completed cork/heat seal bond appearance in accordance with SIP 1141. (Inadequate Thickness/Degraded Properties/Debonding)
- USBI QAR verifies acceptability of insulated Nozzle Heat Seal by verifying vendor inspection acceptance of processing and testing in accordance with SIP 1141. (Debonding)
- BTA acceptability is verified per 10REQ-0021, para. 4.1.2.
 - Preparation of surfaces to be insulated: verify that the surface is abraded, clean and dry before insulation application is made. (Debonding)
 - Formulation of each mix of BTA insulation: verify formulation and mixing of basic ingredients. (Degraded Properties)

- o Completion of cure: verify BTA material is cured and ready for subsequent operations based on three hardness tests. (Degraded Properties)
- o Finishing and Inspection: Verify that the BTA after cure is free of defects such as unacceptable sags, voids, cracks and holes. (Degraded Properties)
- o Thickness and integrity of application: verify BTA applications for compliance with drawing requirements or that the BTA thickness is equal to adjacent insulation thickness and has a smooth surface finish. (Inadequate Thickness)

DCN 033

- o Perform TPS assessment walkdown inspection prior to rollout per OMRSD File V, Vol. 1, requirement number B09TP0.020.

- o Visually assess the TPS (Cork, SLA-220, Glass Phenolic Laminate, etc.) to identify possible degradation or damage. (Degraded Properties)

DCN 031

- o Visual inspection verifies the integrity of TPS and/or TPS topcoat on the Aft BSM nozzle and nozzle heat seal prior to rollout per OMRSD File V, Vol. 1, requirement number B09TP0.010. (Degraded Properties)

- o Perform a visual assessment of the Integrity of TPS and/or TPS topcoat on all applicable flight structures per IOREQ-0021, para., 4.1.7.1 prior to transfer to SPC.

- o Visually assess the TPS (cork, etc.) to identify possible damage to degradation prior to delivery to SPC. (Degraded Properties)

DCN 033

Critical Processes/Inspections:

- o Cork application per UTC-CSD SE2186
- o BTA application per IOPRC-0546

DCN 033

D. FAILURE HISTORY

- o Failure Histories may be obtained from the PRACA database.

E. OPERATIONAL USE

- o Not applicable to this failure mode.