SUBSYSTEM: STRUCTURES AND MISCELLANEOUS ITEMS

ITEM NAME: Thermal Protection System - SRB/ET Attach Ring and Attach Ring Covers

PART NO.: 10755-0060, 0021, 0022,
10755-0055 thru -0058,
10751-0033 thru -0036,
-0059, -0060, -0070
-0093 thru -0095
10111-0041 (LH), 10112-0041 (RH)
and 10100-0061

FM CODE: A01

ITEM CODE: 60-03-10

REVISION: Basic

CRITICALITY CATEGORY: 1

REACTION TIME: Seconds

NO. REQUIRED: 1 Set

DATE: March 1, 2001 CN 042

CRITICAL PHASES: Boost

SUPERCEDES: March 31, 1998 CN 042

FMEA PAGE NO.: E-40

ANALYST: W. Keller/S. Parvathaneni

SHEET 1 OF 7

APPROVED: S. Parvathaneni CN 042

FAILURE MODE AND CAUSES: Loss of Attach Ring and Attach Ring Covers thermal protection caused by:

O Degraded thermal or physical properties due to improper constituents, formulation, mixing, application, cure or natural environments. (Degraded Properties)

O Inadequate TPS thickness. (Inadequate Thickness)

O 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 flight control or separation capability.

RATIONALE FOR RETENTION:

A. DESIGN

The Attach Ring and Attach Ring Covers (except IEA Covers) are insulated with 0.25 inch thick cork. The IEA Covers are insulated with 0.125 and 0.625 inch thick cork. The cork is bonded to the substrates with EC-2216 B/A Clear Amber adhesive. Closeout and repair are accomplished with K5NA/RT 455 (ALT.), or BTA. Final closeout is accomplished by the Shuttle Processing Contractor (SPC) with K5NA/RT 455 (ALT.) ablator. RTV-133/3-6077 sealant is used to seal faying surfaces. CN 042

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 environments, acoustic and vibration, stress and pressure 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 (e.g.: Redesign of ETA Ring allowed replacement of glass phenolic with cork and was authorized by approval of ECP-1584B2). Subsequent changes in TPS materials, thickness, configuration, 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.

Certification was performed per document SE-019-149-2H, (SRB/TPS Certification Plan). Subsequent changes in TPS materials and/or thickness or configuration will be 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	-	USA SRBE COQ A-TPS-8109
K5NA	-	USA SRBE COQ A-TPS-8108
3-6077 RTV	-	USA SRBE COQ A-TPS-8113
BTA	-	USA SRBE COQ A-TPS-8120
Hypalon	-	USA SRBE COQ A-TPS-8106
Deft	-	USA SRBE COQ A-TPS-8125
RTV 133	-	USA SRBE COQ A-TPS-8102
Zinc Primers	-	USA SRBE COQ A-TPS-8129
RT 455	-	USA SRBE COQ A-TPS-8130
Hentzen	-	USA SRBE COQ A-TPS-8131

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Attach Ring and Attach Ring Covers insulation requirements are specified on USA SRBE drawings 10755-0060, 10755-0021, 10755-0022, 10755-0055 thru -0058, 10751-0033 thru -0036, -0059, -0060, -0070, -0093 thru -0095 (Insulated Attach Ring Segments and Covers). Insulation closeout requirements are specified on USA SRBE drawings 10111-0036, (Insulation Closeout, Aft Booster Assembly) and 10100-0059 (SRB TPS Closeout Installation).

Other documents controlling Attach Ring and Attach Ring Covers insulation requirements include:

Cork/EC-2216 B/A Clear Amber Adhesive:	
10753-0009	Cork Insulation
10753-0007	Adhesive Cork Bonding

10PRC-0018	Insulation Application, Cork

Insulation Topcoat:

10PRC-0013	Paint, Chlorosulfonated Polyethylene 09463
10PRC-0028	TPS Topcoat, Application of

RTV-133:

10753-0014	Adhesive, RTV
10PRC-0025	Procedure for RTV-133, Application

RTV 3-6077:

10753-0012	Adhesive, RTV Silicone.
10PRC-0426	Procedure for RTV 3-6077

K5NA/RT 455 (ALT.):

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MSFC-SPEC-1918	Ablative Compound, Thermal
MSFC-SPEC-1919	Ablative Compound, Thermal, Application and Cure of

BTA:

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

Substrate Protective Finish:

10A00527	Sealing of Fasteners Subject to Seawater Exposure on the SRB, excluding the SRM.
10PRC-0442	Protective Finish Application for Aluminum and Steel Alloys

O Remove all TPS after every flight

B. TESTING

Testing to verify the acceptability of the USA SRBE insulation application is accomplished in accordance with the following:

O Cork application is verified per 10REQ-0021, para. 4.1.4.

- o Cork/adhesive bonding verification is accomplished by fabricating one cork panel for each day of cork application operations. The panel is processed into four flatwise tensile specimens and one test panel for topcoat analysis. (Degraded Properties/Debonding)

O BTA acceptability is verified per 10REQ-0021, para. 4.1.2

- o 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)

O K5NA/RT 455 (ALT.) acceptability is verified per OMRSD File V, Vol. I, requirement no. B09GEN.010, 10REQ-0021 para. 4.1.3 and MSFC-SPEC-1918/MSFC-SPEC-1919.

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- o To verify acceptability of K5NA/RT 455 (ALT.) constituents, formulation, mixing, application and cure for each lot of K5NA/RT 455 (ALT.) submitted for acceptance, vendor performs tests such as tensile, hardness, specific gravity and thermogravimetric analysis (TGA). (Degraded Properties)

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- o To verify acceptability of K5NA/RT 455 (ALT.) constituents, formulation, mixing application and cure for production hardware, three tensile specimens are prepared and tested from at least one batch mixed, for each day of K5NA/RT 455 (ALT.) processing. Hardness is verified for each batch and on the hardware. (Degraded Properties).

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C. INSPECTION

O Cork insulation acceptability is verified per 10REQ-0021, para. 4.1.4 including the following:

- o Preparation of surfaces to be insulated: verify that the surface is abraded, clean and dry before insulation application is made. (Debonding)

- o Proper formulation and mixing of adhesive (EC-2216 B/A): verify formulation and mixing of amber adhesive accelerator (Part A) to adhesive base (Part B). (Degraded Properties)

- o Cork thickness: verify cork thickness is in compliance with drawing requirements. (Inadequate Thickness)
- o Integrity of bonded cord: inspect bonded cork for integrity of cured bond lines, and absence of wrinkles, cracks and blisters. (Debonding)
- o Verify process control acceptance of cork bonding by flatwise tensile strength tests. (Debonding)

O K5NA/RT 455 (ALT.) acceptability is verified per 10REQ-0021, para. 4.1.3, including the following:

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- o Preparation of surfaces to be insulated: verify that the surface is abraded, clean and dry before insulation application is made. (Debonding)
- o Verification of the formulation of each lot of K5NA/RT 455 (ALT.) insulation received. (Degraded Properties)

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- o Application of K5NA/RT 455 (ALT.): verify that K5NA/RT 455 (ALT.) is applied within the application life. (Degraded Properties)

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- o Completion of cure: verify hardness meets Durometer type D 15 minimum. (Degraded Properties)
- o Thickness and integrity of application: verify K5NA/RT 455 (ALT.) applications for compliance with drawing requirements or that the K5NA/RT 455 (ALT.) thickness is equal to adjacent insulation thickness and has a smooth surface finish. (Inadequate Thickness)

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O BTA acceptability is verified per 10REQ-0021, para. 4.1.2., including the following:

- o Preparation of surfaces to be insulated: verify that the surface is abraded, clean and dry before insulation application is made. (Debonding)
- o 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)

O Topcoat (chlorosulfonated polyethylene paint) application acceptability is verifed per 10REQ-0021, para. 4.1.5.

- o Preparation of surfaces to be insulated: verify that the surface is abraded, clean and dry before insulation application is made. (Debonding)
- o Formulation of each mix of topcoat material: verify chlorosulfonated polyethylene paint/activator mix ratio by weight. (Degraded Properties)
- o Topcoat application integrity and thickness: verify dry tape test adhesion and topcoat thickness on test panel. Inspect completed topcoat application after final coat is complete for absence of overspray, blisters, sags, runs, cracking, peeling and discoloration. (Degraded Properties/Debonding)

O USA SRBE QAR verifies substrate paint system adhesion tape tests in accordance with USA SRBE SIP 1453. (Debonding)

O On repainted components, USA SRBE Quality performs surface inspections prior to application of primer and topcoat; performs topcoat inspection and verifies adhesion test, in accordance with 10SPC-0131. (Debonding)

O Shelf life, formulation, mixing, surface preparation, application, cure and physical properties of K5NA/RT 455 (ALT.) and RTV-133/3-6077 RTV are verified per OMRSD FileV, Vol. 1, requirement number B09GEN.010. (Degraded Properties/Debonding)

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O Perform TPS assessment walkdown inspection prior to rollout per OMRSD File V, Vol. 1, requirement number B09TP0.010.

- o Visually assess the TPS (Cork, K5NA/RT 455 (ALT.), SLA-220, Glass Phenolic Laminate, etc.) to identify possible degradation or damage. (Degraded Properties)

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O Visual inspection verifies the integrity of TPS and/or TPS topcoat on the SRB/ET attach ring and attach ring covers prior to rollout per OMRSD File V, Vol. 1, requirement number B09TP0.010. (Degraded Properties/Debonding)

O Perform a visual assessment of the Integrity of TPS and/or TPS topcoat on all applicable flight structures per 10REQ-0021, para., 4.1.7.1 prior to transfer to SPC.

- o Visually assess the TPS (cork, K5NA/RT 455 (ALT.), etc.) to identify possible damage or degradation prior to delivery to SPC. (Degraded Properties)

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O TPS closeout application inspection is performed after completion of K5NA/RT 455 (ALT.) cure on the SRB/ET attach ring per OMRSD File V, Vol. 1, requirement number B09TP0.020. (Degraded Properties/Debonding)

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Critical Processes/Inspections:

O Cork application per 10PRC-0018
O K5NA/RT 455 (ALT.) application per MSFC-SPEC-1919
O BTA application per 10PRC-0546 CN 042
O Insulation topcoat application per 10PRC-0028
O Substrate protective finish per 10PRC-0442
O RTV-133 application per 10PRC-0025
O 3-6077 RTV application per 10PRC-0426 and 10753-0012

D. FAILURE HISTORY

O Failure Histories may be obtained from the PRACA database.

E. OPERATIONAL USE

O Not applicable to this failure mode.