ATK ALLIANT TECHSYSTEMS
THIOKOL PROPULSION

CRITICAL ITEMS LIST (CIL)

No. 10-01-04-01R/01

SYSTEM:	Space Shuttle RSRM 10	CRITICALITY CATEGORY:	1
SUBSYSTEM:	Case Subsystem 10-01	PART NAME:	Systems Tunnel Floor Plate Assembly Insulation (TPS) (1)
ASSEMBLY:	Thermal Protection System 10-01-04		
FMEA ITEM NO.:	10-01-04-01R Rev N	PART NO.:	(See Section 6.0)
CIL REV NO.:	N	PHASE(S):	Boost (BT)
DATE:	27 Jul 2001	QUANTITY:	(See Section 6.0)
SUPERSEDES PAGE:	221-1ff.	EFFECTIVITY:	(See Table 101-6)
DATED:	31 Jul 2000	HAZARD REF.:	BC-11
CIL ANALYST:	D. F. Bartelt		
APPROVED BY:		DATE:	
RELIABILITY ENGINEERING:	K. G. Sanofsky		27 July 2001
ENGINEERING:	V. B. Teller		27 July 2001

1.0 FAILURE CONDITION: Failure during operation (D)

2.0 FAILURE MODE: 1.0 Structural failure

3.0 FAILURE EFFECTS: Loss of TPS results in aerodynamic heating of tunnel base, possible ignition of the range safety device, loss of tunnel, loss of TVC, loss of separation capability; debris damage to adjacent STS systems, causing loss of RSRM, SRB, crew, and vehicle

4.0 FAILURE CAUSES (FC):

FC NO.	DESCRIPTION	FAILURE CAUSE KEY
1.1	Bond line failure of cork-to-paint-to-case, cork-to-cork, and cork-to-EPDM	
1.1.1	Improper application technique paint-to-primer-to-case	A
1.1.2	Improper application technique cork-to-cork	B
1.1.3	Nonconforming physical/thermal properties of cork/adhesive/EPDM	C
1.1.4	Improper application technique--cork-to-paint	D
1.1.5	Improper application technique--cork-to-EPDM	E
1.1.6	Contamination during processing	F
1.1.7	Adhesive not properly mixed, applied, or cured	G
1.1.8	Bond strength degradation during RSRM assembly, handling, storage, or transportation	H
1.1.9	Aero heating and plume radiation	I
1.1.10	Moisture or fungus degradation	J
1.1.11	Aeroshear and acoustic vibration	K
1.2	Ablative failure of cork	
1.2.1	Nonconforming materials	L

1.2.2	Nonconforming material thickness	M
1.2.3	Aeroheating and plume radiation	N

5.0 REDUNDANCY SCREENS:

SCREEN A: N/A
SCREEN B: N/A
SCREEN C: N/A

6.0 ITEM DESCRIPTION:

1. The systems tunnel floor plate insulation Thermal Protection System (TPS) is completed at the segment, rocket motor, assembly level. Materials are listed in Table 1.

TABLE 1. MATERIALS

Drawing No.	Name	Material	Specification	Quantity
1U77713	Case Assembly, Painted Forward Segment	Various		1/motor
1U77714	Case Assembly, Painted Center Segment	Various		2
1U77715	Case Assembly, Painted Aft Segment	Various		1
1U75642	Case Assembly, Painted Aft Dome	Various		1
1U77610	Segment, Rocket Motor, Forward	Various		1
1U77620	Segment, Rocket Motor, Forward Center	Various		1
1U77630	Segment, Rocket Motor, Aft Center	Various		1
1U77640	Segment, Rocket Motor, Aft	Various		1
	Top Coating (paint)	Epoxy	STW5-3225	A/R
	Primer, Zinc-rich	Epoxy	STW5-3226	A/R
	Insulation	Sheet Cork	STW4-2700	A/R
	Rubber	EPDM	STW4-2736	A/R
	Paint	Moisture and Fungus Protection Paint	STW4-9084	A/R
	Ablation Compound, Cork-filled (K5NA)	Ground Cork, Epoxy Resin, Curing Agent	STW5-3183	A/R
	Epoxy Resin Adhesive, Non-Asbestos	Epoxy Resin and Curing Agent	STW4-3218	A/R

6.1 CHARACTERISTICS:

1. Both the left and right-hand sides of the TPS consist of components and materials designed to protect external areas of the RSRM floor plate assembly from aerodynamically induced thermal loads. The system must assure that no degradation occurs on RSRM components that would compromise mission accomplishment or preclude reusability of the hardware. Additionally, the right-hand side of the protection system bonds and protects the heater cables. Figure 1 depicts the relationship between TPS bond line components for both left and right TPS components.

7.0 FAILURE HISTORY/RELATED EXPERIENCE:

1. Current data on test failures, flight failures, unexplained failures, and other failures during RSRM ground processing activity can be found in the PRACA Database.

8.0 OPERATIONAL USE: N/A

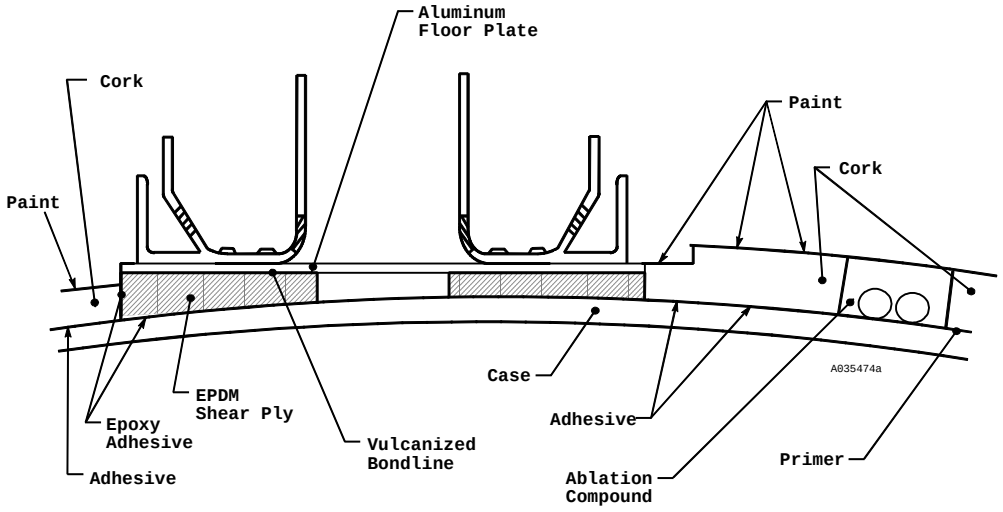

Figure 1. TPS Adjacent to Sytems Tunnel Floor Plate

9.0 RATIONALE FOR RETENTION:

9.1 DESIGN:

DCN	FAILURE CAUSES	
A	1.	Application of primer-to-case and paint-to-primer is per engineering specifications and shop planning. a. Primer-to-case--apply a primer film coat by spray application to a clean, contamination-free case segment per shop planning. The dried film is free from grit, seeds, craters, blisters, or other surface irregularity. b. Paint-to-primer--apply a topcoat film by spray application to a clean, contamination free primer coat and allow to dry to hard condition. After drying, the topcoat film must be free from blushing, streaks, blisters, coarse particles or other surface irregularities.
A,B,D,E,F,G	2.	Controlled processes and environmental requirements are per shop planning.
A,B,D,E,F,G	3.	Contamination control requirements and procedures are described in TWR-16564.
B,C	4.	Thermal analyses per TWR-19002, TWR-16517, and TWR-17243 show the adhesive bond line complies with required positive margins of safety when primer, topcoat, cork, adhesive, EPDM, and ablative compound comply with material and application requirements.
B	5.	Thermal analyses per TWR-19002 and TWR-17243 shows that TPS meets required positive margins of safety.
B,C,D,E,F,G	6.	Installation and repair processes for cork insulation are per engineering.
C,L,M,N	7.	Material properties of cork are controlled per engineering.
C	8.	Physical properties of primer are controlled per engineering.
C	9.	Physical properties of paint are controlled per engineering.
C	10.	Physical and thermal properties of cork, adhesive, and EPDM are to meet design requirements per TWR-16517 and TWR-17243.
D,E	11.	Cork is precut and identified to facilitate bonding application adjacent to the systems tunnel. Bonding includes cork-to-EPDM, cork-to-case segment paint, and cork-to-cork per engineering drawings and shop planning.
D,E	12.	Surface preparation and cleaning is per engineering.
D,E	13.	Cork is trimmed and dry fit prior to bonding with adhesive per engineering.
D,E,I	14.	Application of cork and K5NA ablation compound is per engineering drawings and shop planning.
F	15.	Contamination is removed from the case segment per shop planning.
F	16.	Each case segment primer and paint coat is uniform, continuous, and free of bubbles, wrinkles, and voids.
F	17.	Adhesive is kept free from agglomeration, foreign matter, separation, dilution, and contamination. If the bond surface was touched with bare fingers, re-cleaning with

solvent is required per engineering and shop planning.

F 18. EPDM is kept free from surface contamination such as grease, oil foreign materials, or other defects that render the thermal insulation unsuitable for the purpose intended per engineering and shop planning.

F 19. Cork sheet is uniform and free of dirt, grease, oil, excessive moisture, or any other contaminants per engineering.

G 20. Epoxy resin adhesive is mixed, applied, and cured per engineering.

H 21. A pull test is performed on the cork to verify bonding strength.

a. Storage life for the primer and paint is controlled per engineering.

H 22. Railcar transportation shock and vibration levels for the segments are monitored per engineering and loads are derived per analysis. Monitoring records are evaluated by Thiokol to verify that shock and vibration levels defined per MSFC Specifications were not exceeded.

H 23. Support equipment used to test, handle, transport, and assemble or disassemble the RSRM is certified and verified per TWR-15723.

I,L,M,N 24. TPS thermal analyses documented in TWR-19002, TWR-16517 and TWR-17243 verify that during the ascent phase the TPS maintains the temperature of critical bond lines well within design limits. All applicable internal and external heat sources were considered in the analyses. Predicted maximum at the end of ascent is also verified.

I 25. Bond line temperature capability is assured by insulation thickness and adherence to the qualified adhesive formula, which is verified by quality conformance inspections and control of bonding processes.

J 26. The following sheet cork requirements are imposed to prevent moisture or fungus damage:

a. Packaging must prevent absorption of moisture into the cork during shipment and storage. Packaging material must be capable of being resealed during use.
b. Cork material must have a minimum storage life of 2 years from date of receipt when stored at warehouse ambient temperature. Each time a container is opened, it is resealed to maintain material properties during storage. Storage life may be extended if the material passes re-tests.

J 27. When cork is used for external thermal protection, the cork is coated with a water resistant protective coating per shop planning.

J 28. After installation, all exposed cork and adhesive surfaces are coated with paint per engineering drawings. The paint specification imposes the following requirements:

a. Paint must have a low permeability to moisture and be resistant to weathering and fungus growth. Specific test methods and acceptability requirements are levied against these characteristics.
b. Conformance to requirements on accelerated weathering, fungus resistance, and permeability must be verified as part of material qualification testing.
c. Paint must have a minimum storage life of one year from date of manufacture when stored in its original container at the specified temperature.

K	29. External insulation (TPS) and joint protection system heater electrical cables are designed to withstand and are not degraded when exposed to thermal loading environments per TWR-17243.
K	30. Vibration and pressurization testing of similar Field Joint Protection Systems were performed and results are documented in TWR-17245. Testing included environmental conditioning to pre-launch natural environments consisting of high temperature, high humidity, salt, fog, rain, and low temperature. After conditioning, the test article was subjected to flight and re-entry random vibration, vehicle dynamics vibration, and water landing shock. Post-test visual inspections performed after each sub-test emphasized examinations for obvious debonds, delaminations, and any other degradation. Following testing and post-test inspections, pull tests were performed on cork discs isolated from the surrounding cork. Pull test data are used for materials and adhesives evaluation only, but these data and other test results verify the structural integrity of TPS structures, including absence of bond degradation during short-term exposure to worst-case natural environments.
L,M,N	31. As with the electrical connectors tested, heat or electrical cables performed as expected. Values for temperature in, at, and around the cables were recorded and fell within predicted tolerances. All components remained intact and showed no signs of mechanical degradation per TWR-16517 and TWR-17243.
L,M,N	32. Systems tunnel TPS cork is coated with paint that showed charring and ablation when exposed to aerothermally simulated flight environment. All other components remained intact showing no evidence of mechanical degradation per TWR-16517 and TWR-17243.
L,M,N	33. Cork and K5NA bond testing on aged TEM motors for over five years maintained a positive structural margin of safety per TWR-64178.
L,M,N	34. Cork used in the TPS meets material specifications that impose requirements on thickness, density, specific heat, and thermal conductivity.
h,I,K,N	35. TWR-66825-2 and -6 were updated to incorporate the Performance Enhancement (PE) Program. Predicted PE temperatures and aerodynamic loads for the Systems Tunnel, Systems Tunnel Cork, and GEI TPS remain essentially unchanged. Load factors were updated to include rigid body loads, but resulting effects were insignificant. Existing stresses and structural margins of safety quoted for the Generic Aero/Heating Certification are valid for PE per TWR-66825-2 & -6.

9.2 TEST AND INSPECTION:

DCN	FAILURE CAUSES and TESTS	(T)			CIL CODES
			1.	For New Case Assembly, Painted Segment (Forward, Center, and Aft) verify:	
	A		a.	Shelf life and environmental history, paint and primer	AEY035,AEY048,AEZ035, AEZ045,AFB035,AFB045
	A,F		b.	For application of paint and primer, facilities and equipment are clean	AEY037,AEZ034,AFB034
	A,F		c.	Surfaces to be primed are clean and free from contamination	AEY005,AEZ005,AFB005
	A		d.	For application of paint and primer, humidity and case temperature	AEY018,AEZ016,AFB016
	A,F		e.	Container is covered after mixing, paint, and primer	AEY034,AEY040,AEZ031, AEZ037,AFB031,AFB037
	A		f.	Full cover coat, paint, and primer	AEY014,AEY015,AEZ012, AEZ013,AFB012,AFB013
	A		g.	Runs, sags, drips, and inclusions are acceptable per specification, paint and primer	AEY033,AEY047,AEZ030, AEZ044,AFB044,FAA103
	A	(T)	h.	Dry film thickness, paint and primer	AEY025,AEY002,AEZ022, AEZ002,AFB022,AFB002
	A	(T)	i.	Adhesion strength, paint and primer	FAD005,FAD006,FAD007
			2.	For New Case Assembly, Aft Dome, Painted verify:	
	A		a.	Shelf life and environmental history, paint and primer	FAA090,FAA091
	A,F		b.	Application of paint and primer, facilities and equipment are clean	FAA092
	A,F		c.	Surfaces to be primed are clean and free from contamination	FAA097
	A		d.	For application of paint and primer, humidity and case temperature	FAA098
	A,F		e.	Container is covered after mixing, paint and primer	FAA099,FAA100
	A		f.	Full cover coat, paint and primer	FAA093,FAA094
	A		g.	Runs, sags, drips, and inclusions are acceptable per specification, paint and primer	FAA095,FAA096
	A	(T)	h.	Dry film thickness, paint and primer	FAA101,FAA102
	A	(T)	i.	Adhesion strength, paint and primer	FAD008
			3.	For New Segment, Rocket Motor (Forward, Forward Center, Aft Center, and Aft), verify:	
	B,D,E,G,I	(T)	a.	Shore D hardness of each mix of epoxy resin adhesive for cork insulation bonding	AFR036,AFS036,AFU036,AFW041
	B,D,E,G		b.	Case bonding surface temperature prior to bonding cork	FAB001,FAB005,FAB009,FAB013
	B,D,E,F		c.	Light abrasion and cleaning of all bonding surfaces prior to bonding cork	AFR009,AFS009,AFU009,AFW009
	B,D,E,G		d.	After cutting cork pieces, examine for loose or damaged areas	FAB002,FAB006FAB010,FAB014
	B,D,E,G		e.	Dry fit of cork pieces	AFR026,AFS026,AFU026,AFW024
	B,D,E,G		f.	Epoxy resin adhesive application for cork installation	AFR010,AFS010,AFU010,AFW010
	B,D,E,G		g.	Repair of defects, unbonds, voids, and gaps in cork insulation	AFR025,AFS025,AFU025,AFW023
569	B,D,E,G,I		h.	Epoxy resin adhesive for cork insulation bonding is mixed per planning requirements	AFR031,AFS031,AFU031,AFW028
	B,D,E,G,I		i.	Epoxy resin adhesive pot life for cork insulation	

			bonding	FAB003,FAB007,FAB011,FAB015
B,D,E,G,I		j.	Epoxy resin adhesive curing schedule for cork insulation bonding	FAB004,FAB008,FAB012,FAB016
B,D,E,G,I		k.	Shore A hardness of epoxy resin adhesive before removal of bonding aids for cork insulation bonding	AFR008,AFS008,AFU008,AFW040
B,D,E,G		l.	Vacuum bag pressure and application within pot life	FAA211,FAA212,FAA213,FAA214
B,D,E,H		m.	Cork insulation is free of damage, voids, or unbond conditions	FAB510,FAB511,FAB512,FAB513
B,D,E,H	(T)	n.	Pull tests for cork insulation bonding	RAA227,RAA228,RAA229,RAA230
D,E,F		o.	Entire cork bonding surface of the case is free of contamination by black light inspection	AFR015,AFS040,AFU040,AFW035
F		p.	No visible contamination of epoxy resin adhesive for cork insulation bonding before, during and after application	FAB091,FAB092,FAB093,FAB094
G		q.	Shelf life and environmental history of epoxy resin adhesive for cork insulation bonding prior to use	AFR005,AFS005,AFU005,AFW005
I		r.	Application of ablation compound	FAB022,FAB023,FAB024,FAB025
J		s.	Shelf life and environmental history of paint prior to application	FAB031,FAB034,FAB037,FAB040
J		t.	Full coverage of paint with no runs, sags, or bubbles	FAB032,FAB035,FAB038,FAB041
J		u.	No contamination of paint prior to application	FAB033,FAB036,FAB039,FAB042

4. For New Cork, Sheet verify:

C,F,L,M,N	(T)	a.	Density	ALR003,ALR004,ALR009
C,F,L,M,N	(T)	b.	Tensile strength	ALR044,ALR045
C,F,L,M,N	(T)	c.	Tensile elongation	ALR038,ALR039
C,F,L,M,N	(T)	d.	Recovery	ALR025
C,F,L,M,N	(T)	e.	Flexibility	ALR013,ALR014
C,F,L,M,N		f.	Workmanship	FAA005
I,L,M,N		g.	Thickness	ALR001
J		h.	No shipping or handling damage	ALR023
J		i.	Opened cork containers are resealed	ALR022
C,L,M,N	(T)	j.	Specific heat	ALR030,ALR035
C,L,M,N	(T)	k.	Thermal conductivity	ALR050

5. For Retest Cork, Sheet verify:

C,F,J	(T)	a.	Flexibility	ALR017

6. For New Epoxy Resin Adhesive, Non-Asbestos verify:

C,I	(T)	a.	Filler content (Part A)	AMD009,AMD013
C,I	(T)	b.	Epoxide content (Part A)	AMD002,AMD006
C,I	(T)	c.	Titratable nitrogen (Part B)	AMD035,AMD039
C,I		d.	Certificate of Conformance	FAA014
C,I		e.	Workmanship	AMD015
C,I	(T)	f.	Working life	AMD043
C,G,I	(T)	g.	Tensile adhesion steel-to-steel	AMD031

7. For Retest Epoxy Resin Adhesive, Non-Asbestos, verify:

C,G,I	(T)	a.	Tensile adhesion steel-to-steel	AMD033

8. For New Paint, Moisture and Fungus Protection verify:

J	(T)	a.	Color	ANU002
J	(T)	b.	Nonvolatile content	ANU009
J	(T)	c.	Viscosity	ANU018
J	(T)	d.	Weight per gallon	ANU025
J		e.	Certificate of Conformance	ANU015

9. KSC verifies:

H		a.	Segments and nozzle components are free of damage per OMRSD File V, Vol I, B47SG0.061	OMD079
J		b.	No fungus or contamination upon TPS surface repair per OMRSD File V, Vol I, B47GEN.070	OMD034