ATK ALLIANT TECHSYSTEMS
THIOKOL PROPULSION

CRITICAL ITEMS LIST (CIL)

No. 10-03-04-04R/02

SYSTEM:	Space Shuttle RSRM 10	CRITICALITY CATEGORY:	1
SUBSYSTEM:	Ignition Subsystem 10-03	PART NAME:	Redesigned Igniter Insulation (1)
ASSEMBLY:	Igniter Assembly 10-03-04	PART NO.:	(See Table A-3)
FMEA ITEM NO.:	10-03-04-04R Rev N	PHASE(S).:	Boost (BT)
CIL REV NO.:	N	QUANTITY:	(See Table A-3)
DATE:	5 Aug 2002	EFFECTIVITY:	(See Table 101-6)
SUPERSEDES PAGE:	432-1ff.	HAZARD REF.:	BI-05
DATED:	27 Jul 2001		
CIL ANALYST:	S. E. Rodgers		
APPROVED BY:		DATE:	

RELIABILITY ENGINEERING: K. G. Sanofsky 5 Aug 2002

ENGINEERING: L. D. Allred 5 Aug 2002

1.0 FAILURE CONDITION: Failure during operation (D)

2.0 FAILURE MODE: 2.0 Fails to provide Igniter Adapter thermal insulation

3.0 FAILURE EFFECTS: Insulation failure would expose the Igniter Adapter to operating temperatures, causing burn through of the adapter and thrust imbalance resulting in loss of RSRM, SRB, crew, and vehicle

4.0 FAILURE CAUSES (FC):

FC NO.	DESCRIPTION	FAILURE CAUSE KEY
2.1	Nonconforming insulation or adhesive materials	A
2.2	Improper cure	B
2.3	Bondline failure of Insulation-to-Adapter	
2.3.1	Contamination of bonding materials or bond surfaces	C
2.3.2	Nonconforming bond materials application or insulation lay up	D
2.3.3	Improper surface preparation	E
2.4	Improper insulation thickness	F
2.5	Storage degradation	G
2.6	Ply separations, voids, or inclusions	H
2.7	Nonconforming sealant materials	I
2.8	Improper sealant application (Igniter Adapter-to-Igniter Initiator interface)	J

5.0 REDUNDANCY SCREENS:

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

6.0 ITEM DESCRIPTION:

1. Igniter Adapter thermal insulation (Figure 1). Materials are listed in Table 1.

TABLE 1. MATERIALS

Drawing No.	Name	Material	Specification	Quantity
1U77610	Segment, Rocket Motor, Forward	Composite of Various Components		1/motor
1U77499	Igniter Assembly	Composite of Various Components		1/motor
1U50152	Chamber Assembly, Igniter Initiator-Loaded	Composite of Various Components		1/motor
1U77451	Adapter Assembly, Igniter-Insulated	Composite of Various Components		1/motor
1U77450	Adapter, Igniter	D6AC Steel	STW4-2706	1/motor
	Insulation	Acrylonitrile Butadiene Rubber (NBR), Asbestos-Filled	STW4-2621	A/R
	Insulation	Acrylonitrile Butadiene Rubber (NBR) Silicon Dioxide-Filled	STW4-2621 TP I	(ALTERNATE)
	Sealant	Liquid Epoxy Resin, Asbestos Float-Filled	STW5-2678	A/R
	Floats	Pulp, Asbestos	STW4-2636	A/R
	Curing Agent	Polyamide Liquid Resin	STW4-2680	A/R
	Silicon Dioxide	Microfine Silicon Dioxide	STW4-2679	A/R
	Epoxy Resin	Liquid Epoxy Resin	STW4-2601	A/R
	Adhesive Primer, Rubber-to-Metal	Chlorinated Rubber-to-Metal	STW5-2664	A/R
	Adhesive Primer Bonding Agent, Rubber-to-Metal	Bonding Agent, Rubber-to-Metal (Chemlok 233)	STW5-2712	A/R
	Corrosion-Preventive Compound	Corrosion Preventive Compound	STW5-2942	A/R
	Film, Polyethylene	Film, Polyethylene, Corrosion Inhibitor Treated	STW5-3610	A/R

6.1 CHARACTERISTICS:

1. The ignition system pressure vessel consists of a main igniter chamber bolted to an Igniter Adapter. The Igniter Adapter is insulated with silica and asbestos-filled acrylonitrile butadiene rubber (NBR) to protect it during igniter firing and from temperature both during RSRM firing and subsequent heat soak during descent and recovery. The initiator assembly is insulated with the same NBR material.

2. The internal surface of the adapter is cleaned by the Spray-in Air process and grit blasted. A coat of Chemlok 205 primer is applied on the internal surface and air dried. A coat of Chemlok 233 adhesive is also applied and air dried. The adapter is inspected to verify that materials and application are acceptable. After inspection, asbestos-filled NBR is cut into rings to conform to the interior of the dome and then manually laid-up. Following this, a mold is assembled, the adapter is installed, and the assembly is placed in a heated press. The insulation is then cured at specified conditions of pressure,

heat, and time. After installation of the insulated initiator assembly to the Igniter Adapter, insulation interfaces are sealed with an asbestos float-filled, liquid epoxy resin sealant containing a polyamide curing agent and a thixotropic agent.

7.0 FAILURE HISTORY/RELATED EXPERIENCE:

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

8.0 OPERATIONAL USE: N/A

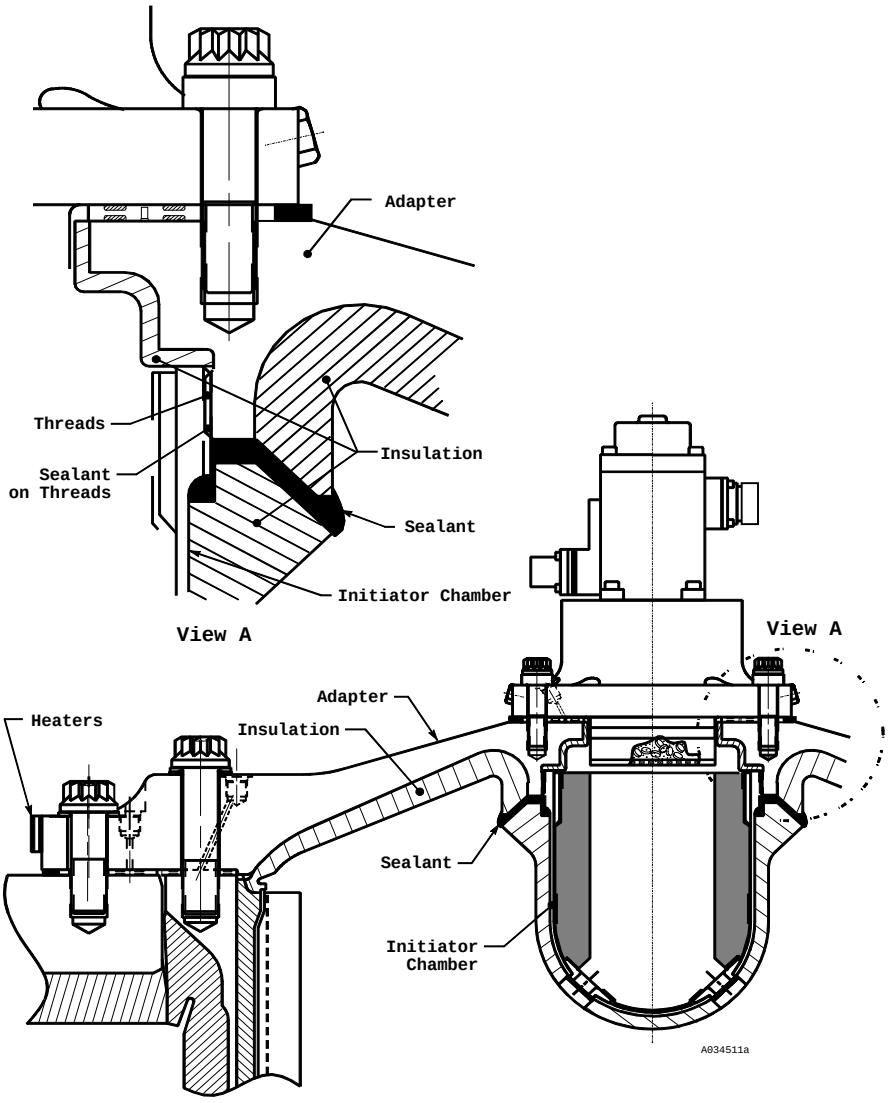

Figure 1. Insulated Adapter and Initiator Chamber

9.0 RATIONALE FOR RETENTION:

9.1 DESIGN:

DCN	FAILURE CAUSES	
A,B,H	1.	Cured NBR properties are per engineering. Margins of safety limits for erosion are per engineering drawings for the case and nozzle and TWR-12969 and TWR-16742 for the Igniter.
A,C,D,E	2.	Structural analyses determined that the Igniter Adapter-to-Insulation bondline demonstrates a positive margin of safety based on a safety factor of 2.0 per TWR-17195.
A	3.	Insulation adhesive primer and bonding agent material properties are per engineering.
A	4.	Criteria for nonmetallic material properties are per TWR-17039.
A,F	5.	Static test motors demonstrated that NBR insulation remained strongly bonded to the Igniter Adapter and that erosion was within acceptable limits. A series of igniter and RSRM static test motors qualified the insulated Igniter Adapter per TWR-18764-03.
A,F	6.	NBR insulation was qualified and tested using static test igniters. A complete study of the insulation used on the ignition system is described in TWR-63419.
B	7.	NBR insulation is cut into rings to conform to the interior of the adapter. The adapter is put into a mold, and then the adapter and mold are placed into a heated press for insulation cure per TWR-10341.
B	8.	Adapter insulation cure requirements (time, temperature, and pressure) are part of a controlled critical process per TWR-15322.
C,D,E	9.	Adhesive primers and bonding agents are mixed and applied to metal surfaces for corrosion protection and insulation bonding per engineering and shop planning.
D	10.	NBR insulation storage, handling, and lay up are per engineering and shop planning.
E,H	11.	Methyl Ethyl Ketone (MEK) is used to clean and activate the NBR surface prior to insulation lay up. MEK is allowed to completely evaporate before the NBR is used per shop planning.
E	12.	The igniter adapter is grit blasted and degreased per engineering drawings.
E	13.	Vapor degreasing contamination controls are per Process Instructions.
C,D,E	14.	To control contamination of bonding materials or bonding surfaces, primer and adhesive are stored in sealed containers. MEK is used to clean insulation and metal bonding surfaces. Clean felt is placed over metal bonding surfaces. NBR is covered with black polyethylene during process delays. Components are handled with clean, lint-free gloves. These procedures are per shop planning and include the following: a. Bonding surface preparation for the adapter and NBR is per engineering drawings. b. Contamination control requirements and procedures are per TWR-16564.

	F	15. Thickness of the Igniter Adapter Insulation is per engineering drawings. Insulation thickness is determined by the amount of NBR applied to the Igniter Adapter and mold tool configuration. Insulation application is per shop planning.
	F	16. Insulation thickness provides a positive margin of safety for erosion based on a safety factor of 1.5 per TWR-12969.
	G	17. The RSRM igniter, including Igniter Adapter Insulation, is required to have a 5-year storage life after KSC acceptance. A 64-month-old igniter was fired in Development Motor DM-6; performing satisfactorily in all aspects. It was concluded that an igniter aged up to 64 months would have no detectable performance change due to aging per TWR-13003. This igniter demonstrated the 5-year life requirements for igniters.
	G	18. Storage and retest requirements for adhesive primers and bonding agents are per engineering.
	G	19. Adhesive primer has a storage life controlled by material specifications when stored at warehouse-ambient conditions in closed containers. When material is removed from closed containers for use, it must be used within a specified time limit or be re-tested per engineering.
	G	20. Unvulcanized insulation material storage life and temperature limits prior to lay up on the component are per engineering. Storage life may be extended if, after retest, the material is per engineering.
	G	21. Corrosion protection is provided for the adapter after insulation and before storage per engineering.
	G	22. Thermal analyses were performed for RSRM components during in-plant transportation and storage to determine acceptable temperature and ambient environment exposure limits per TWR-50083. Component temperatures and exposure to ambient environments during in-plant transportation or storage are per engineering.
	G	23. Accelerated aging tests performed on the igniter PLI bond system per TWR-16106 indicate that the 90 degree peel strength of the PLI bond decreases with time, high temperature, and high humidity storage during liner cure in the test specimen. After liner cure, 90 degree peel strength stabilizes. Tensile adhesion strength of the PLI bond remains constant with time, high temperature, and high humidity storage. Accelerated aging tests indicated no degradation to the igniter PLI bond.
	G	24. The Flight Igniter is included in RSRM Forward Segment life verification.
	H	25. The insulation pressure molding and cure process minimizes ply separations and voids. The insulation lay up and molding process is per shop planning.
600	A,C,D,E,H	26. Insulation anomalies, including edge separations and inclusions, are process-finalized per engineering. Process finalization procedures and criteria are substantiated by design engineering per TR12961.
	I,J	27. Sealant is an asbestos float-filled, liquid epoxy resin sealant containing a polyamide curing agent and a thixotropic agent per engineering.
	I	28. Sealant raw material specifications are per engineering for the following materials:

a. Asbestos float
b. Liquid epoxy resin
c. Polyamide curing agent
d. Microfine silicon dioxide

I	29.	Preparation of the sealant is per shop planning.
I	30.	Acceptability of the combination of raw material lots used to manufacture sealant is demonstrated by the raw material lot combination test per engineering.
I	31.	Storage life of sealant raw materials is per engineering. Storage life of liquid epoxy resin and asbestos floats may be extended after retest per engineering.
I,J	32.	Sealant pot life is per shop planning.
I	33.	Static test motors demonstrated that the Igniter Adapter-to-Igniter Initiator interface bonded firmly. A series of igniter and RSRM static test motors qualified the insulated Igniter Adapter per TWR-18764-03.
J	34.	The Igniter Adapter and Igniter Initiator Chamber are assembled per engineering drawings and shop planning. Sealant is applied during this assembly process.
E	35.	A Spray-in-Air cleaning system is used to clean metal components as part of the bonding surface preparation processing sequence.
A	36.	The J-leg is inspected after propellant trimming to ensure it is free of liner and propellant contamination per shop planning.
A,B,C,D,E,F	38.	As a result of the RSRM Performance Enhancement (PE) Program, load factors for ignition system PLI (Propellant, Liner, and Insulation) components were updated. Structural responses to both the original and PE loads cases were analytically compared. For all conditions, there were insignificant changes in induced stresses and therefore none of the ignition system PLI structural safety factors were changed as a result of the RSRM PE program per TWR-73983.

9.2 TEST AND INSPECTION:

DCN	FAILURE CAUSES and TESTS	(T)			CIL CODES
			1.	For New NBR verify:	
A,G		(T)	a.	Elongation (calendered only)	ALH010,ALH062,ALH065
A,G		(T)	b.	Mooney viscosity (extrusions only)	ALH041,ALH046,ALH170
A,G		(T)	c.	Scorch characteristics (extrusions only)	ALH081,ALH086,ALH171
A,B,G		(T)	d.	Shore A hardness (calendered only)	ALH098,ALH102,ALH109
A,G		(T)	e.	Specific gravity (calendered only)	ALH118,ALH121,ALH126
A,G		(T)	f.	Tensile strength (calendered only)	ALH147,ALH149,ALH154
A,G			g.	Material workmanship including uniform appearance and free from contamination	ALH168
			2.	For Retest NBR, verify:	
A,G		(T)	a.	Mooney viscosity	ALH049
A,G		(T)	b.	Scorch characteristics	ALH087
			3.	For New Adhesive Primer, verify:	
C,D,G		a.		No damage to container or container seal	PDS001
A		(T)	b.	Density	AMR006,AMR012
A		(T)	c.	Peel adhesion	AMR026,AMR022
A			d.	Workmanship	AMR041
A		(T)	e.	Solids content	AMR059,AMR067
A		(T)	f.	Viscosity	AMR083,AMR092
			4.	For New Bonding Agent, Rubber-to-Metal verify:	
C,D,G			a.	No damage to container or container seal	PDS002
A		(T)	b.	Peel adhesion strength	AMX006,AMX010
A		(T)	c.	Solids content	AMX021,AMX023
A		(T)	d.	Specific gravity	AMX027,AMX029
A		(T)	e.	Viscosity	AMX039,AMX040
			5.	For New Adapter Assembly, Igniter Insulated verify:	
A,D,H			a.	No unacceptable blisters or inclusions	WJB002
E,H			b.	General workmanship and condition of part	AAL003
G			c.	Insulated adapter is properly packaged	AAL005
D,H			d.	Insulation edge separations and other anomalies conform to finalization specification	AAL010
H			e.	Insulation lay up process is complete and acceptable	AAL011
G			f.	Component temperatures and exposure to ambient environments during in-plant transportation or storage are per the handling specification	BAA011
D,E,G			g.	Environmental history for adhesive primer	PDS011
D,E,G			h.	Environmental history for bonding agent	PDS012
E			i.	Proper application of MEK to insulation and complete evaporation prior to insulation lay up	AAL013
D,G			j.	Environmental history for insulation	PDS013
B,H			k.	Insulation cure is complete and acceptable	AAL014
D,G			l.	Storage life is acceptable for adhesive primer	PDS014
D,G			m.	Storage life is acceptable for bonding agent	PDS015
D,G			n.	Storage life is acceptable for insulation	PDS016

C,D		o.	Proper application of adhesive primer	AAL018
C,D		p.	Proper application of bonding agent	AAL019
E		q.	Surface preparation is complete and acceptable prior to insulation application	AAL020
F		r.	Proper insulation mold tooling was used during insulation application	CAA023
D,E,H		s.	Tap test of adapter insulation for unbonds	AAL030
A		t.	J-leg area is free of liner and propellant after trimming	MKL043

6. For New Igniter Assembly verify:

I,J		a.	Sealant within pot life at time of application	AMU001A
J		b.	Excess sealant wiped off after torquing initiator	AEF007
G		c.	Component temperatures and exposure to ambient environments during in-plant transportation or storage are controlled per the temperature exposure limit specification	BAA015
J		d.	Proper application of sealant prior to installation of initiator	AEF035
J		e.	Adapter threads for Initiator Chamber are clean and free from contamination prior to assembly	AEF054
J		f.	Initiator Chamber threads are clean and free of contamination and surface defects per the igniter process finalization specification	AEF055
J		g.	Gap between two mating surfaces (Adapter and Initiator) is totally filled after torquing	AEF103

7. For New Segment, Rocket Motor, Forward, verify:

G		a.	Component environments during in-plant transportation or storage	BAA021

8. For New Liquid Epoxy Resin verify:

I	(T)	a.	Hydrolyzable chlorine percent	ALD009,ALD006
I	(T)	b.	Infrared spectrum	ALD030
I	(T)	c.	Moisture percent	ALD038,ALD035
I	(T)	d.	Specific gravity	ALD063,ALD061
I	(T)	e.	Viscosity	ALD085,ALD082
I	(T)	f.	Weight per epoxy	ALD101,ALD098
I		g.	Workmanship is uniform in appearance and free from visible contamination	ALD075

9. For Retest Liquid Epoxy Resin verify:

I	(T)	a.	Moisture	ALD989
I	(T)	b.	Hydrolyzable chlorine percent	ALD011
I	(T)	c.	Viscosity	ALD083
I	(T)	d.	Weight per epoxy	ALD103

10. For New Curing Agent, Polyamide Liquid Resin, verify:

I	(T)	a.	Amine value	ALQ001,AMQ006
I	(T)	b.	Ash content	AMQ015
I	(T)	c.	Color	ALQ026,AMQ028
I	(T)	d.	Specific gravity	AMQ033
I	(T)	e.	Viscosity	ALQ049,AMQ050

11. For New Floats, Asbestos verify:

I	(T)	a.	Calcination loss	ALI002
I	(T)	b.	Fiber size distribution	ALI011

I	(T)	c.	pH (aqueous extract)	ALI023
I	(T)	d.	Volatile matter	ALI051
I	(T)	e.	Wet volume	ALI053

12. For Retest Floats, Asbestos, verify:

I	(T)	a.	Volatile matter for storage life extension	ALI051A

13. For New Silicon Dioxide, verify:

I	(T)	a.	Bulk density	ALP002,ALP008
I	(T)	b.	Loss on ignition	ALP040
I	(T)	c.	Moisture	ALP058,ALP064
I	(T)	d.	pH	ALP097,ALP101

14. For New Sealant, Liquid Epoxy Resin, Asbestos Float Filled verify:

I	(T)	a.	Tensile adhesion for each raw material lot combination evaluation	AMU013
I		b.	Shelf life of sealant components at time of production mix	AMU004
I		c.	Raw material weights are correct in accordance with the production planning requirements	AMU015

15. For New Chamber Assembly, Igniter Initiator-Loaded verify:

I	(T)	a.	Shore A hardness tests of sealant	AAM077

16. KSC verifies:

G		a.	Life requirements for the expected launch schedule are met per OMRSD, File II, Vol III, C00CA0.030	OMD019