CRITICAL ITEMS LIST (CIL)

No. 10-03-03-03/01

SYSTEM:	Space Shuttle RSRM 10	CRITICALITY CATEGORY:	1
SUBSYSTEM:	Ignition Subsystem 10-03	PART NAME:	Initiator Liner (1)
ASSEMBLY:	Initiator Assembly 10-03-03	PART NO.:	(See Table A-3)
FMEA ITEM NO.:	10-03-03-03 Rev M	PHASE(S):	Boost (BT)
CIL REV NO.:	M	QUANTITY:	(See Table A-3)
DATE:	31 Jul 2000	EFFECTIVITY:	(See Table 101-6)
SUPERSEDES PAGE:	423-1ff.	HAZARD REF.:	BI-05
DATED:	30 Jul 1999		
CIL ANALYST:	F. Duersch		
APPROVED BY:		DATE:	

RELIABILITY ENGINEERING: K. G. Sanofsky 31 Jul 2000

ENGINEERING: S. R. Graves 31 Jul 2000

1.0 FAILURE CONDITION: Failure during operation (D)

2.0 FAILURE MODE: 1.0 Adhesive/cohesive failure of the liner

3.0 FAILURE EFFECTS: Would create debris and damage Igniter Chamber/Nozzle causing loss of RSRM, SRB, crew, and vehicle

4.0 FAILURE CAUSES (FC):

FC NO.	DESCRIPTION	FAILURE CAUSE KEY
1.1	Contamination	A
1.2	Incorrect liner mixing proportions and methods	B
1.3	Nonconformance to temperature control during curing of liner	C
1.4	Improper insulation surface preparation	D
1.5	Improper Initiator Chamber surface preparation	E
1.6	Liner coverage not uniform or complete	F
1.7	Improper liner cure time	G
1.8	Storage degradation	H
1.9	Nonconforming materials	I

5.0 REDUNDANCY SCREENS:

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

6.0 ITEM DESCRIPTION: RSRM insulated initiator chamber liner.

1. Liner is an HC polymer-based, asbestos float-filled adhesive used to line the RSRM Initiator Chamber (Figure 1). Materials are listed in Table 1.

TABLE 1. MATERIALS

Drawing No.	Name	Material	Specification	Quantity
1U77610	Segment, Rocket Motor, Fwd	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
	Liner, Solid Rocket Motor, Space Shuttle Project	Composite of various Materials	STW5-3224	A/R
		Liquid Polymer (HC), Polybutadiene, Carboxyl Terminated, with Antioxidant	STW4-3152	Per mix ratio
		Tris [1-(2-Methyl) Aziridinyl] Phosphine Oxide (MAPO)	STW4-2647	Per mix ratio
		Epoxy Resin, Medium Viscosity, Trifunction, Distilled	STW4-2646	Per mix ratio
		Floats, Pulp, Asbestos Thixotropic Powder	STW4-2636	Per mix ratio
		Modified Castor Oil	STW4-2648	Per mix ratio
		Iron Hexoate (2-ethyl) 6 Percent	STW4-2645	Per mix ratio
	TP-H1178 Propellant, RSRM Igniter, Space Shuttle Project	Composite of various Materials	STW5-2833	1.5 lb/initiator (nominal)

6.1 CHARACTERISTICS:

1. Liner provides bonding between TP-H1178 propellant and the initiator chamber and insulation. Liner is a liquid polymer-based material that promotes cross-linking and propellant is also a highly cross-linking polymer-based material. A chemical bond is formed between liner and propellant. Liner processing is per TWR-10341.

2. Liner functions as a bonding agent and was developed to ensure liner bond strength to the initiator chamber, insulation, and propellant is sufficient to assure cohesive failure in the propellant before any failure in the liner. Thus, the propellant is the weak link in the system.

7.0 FAILURE HISTORY/RELATED EXPERIENCE:

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

8.0 OPERATIONAL USE: N/A

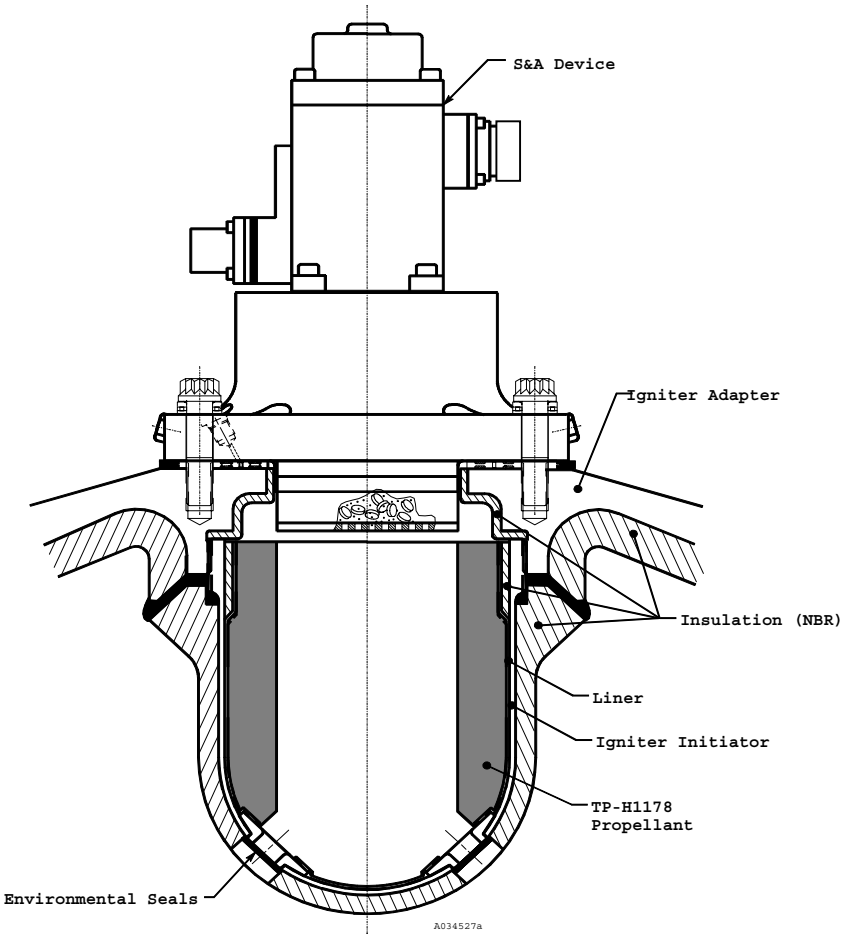

Figure 1. Liner in Loaded Igniter Initiator

9.0 RATIONALE FOR RETENTION:

9.1 DESIGN:

DCN	FAILURE CAUSES	
A,I	1.	Physical properties and contamination requirements for raw materials used in liner are per engineering.
A,I	2.	Liner constituents are required to be free from visual contamination per engineering.
A,I	3.	Contamination controls during liner mixing are per shop planning.
A,B,C,D,E,F,G,H,I	4.	Structural analysis on igniter grain materials was done to verify factors of safety for the insulation-to-liner bond and the liner-to-propellant bond. This analysis shows compliance with CEI requirements for these bonds per TWR-17195.
A,I	5.	Preparation of bonding surfaces and their cleanliness is controlled as follows: a. Bonding surface preparation for the NBR and liner is per engineering drawings. b. CONSCAN verification tests to determine cleanliness of bonding surfaces were developed and are controlled per Thiokol engineering. Data collection and analyses were evaluated for qualification per TWR-18229. c. Contamination control requirements and procedures are per TWR-16564.
B	6.	Proportions of raw materials used in liner are per engineering.
B	7.	Standardization batches are formulated to determine the amount of thixotropic powder required for production batches per engineering.
B	8.	Proportions of asbestos floats and iron hexoate are fixed, thixotropic powder is standardized, and the remaining constituents are determined by equivalents per engineering.
B	9.	Raw material weighing is per engineering drawings and specifications.
B	10.	Raw material addition sequence, mix time, temperature of mix, and housekeeping are per shop planning.
B	11.	Adequacy of raw material proportions related to liner strength was verified in a characterization analysis per TWR-15276.
C,G	12.	The maximum acceptable time period (pot life) between liner mixing and application is per shop planning.
C,G	13.	Maximum acceptable liner use life from end of cure to start of preheat for propellant casting is per engineering.
C,G	14.	Ambient temperature liner pre-cure after liner application is performed per shop planning.
C,G	15.	Liner cure temperature is per engineering.
C,G	16.	Allowable temperature excursions are per shop planning.

C,G	17.	Temperatures below the allowable minimum cure temperature are compensated by extending the cure time by an amount equal to the total excursion time below minimum cure temperature per shop planning.
C,G	18.	Time and temperature constraints for liner cure to prevent liner bubbling during chamber preheat and casting are per testing reported in TWR-14203.
C,G	19.	Liner cure time and temperature requirements were designed to provide optimum adhesion. These processes and requirements were analyzed and verified in TWR-15276.
C,G	20.	Liner cure is completed during propellant cure per engineering.
D	21.	Prior to liner application, the insulation surface is scrubbed with solvent per shop planning.
D	22.	The insulated igniter chamber is preheated to provide optimum liner adhesion per shop planning.
E	23.	Prior to lining, the Initiator Chamber is grit blasted to remove contaminants and to prepare the surface for liner application per shop planning.
E	24.	Prior to lining the Initiator Chamber, the chamber is scrubbed with solvent per shop planning.
E	25.	The insulated Initiator Chamber is preheated to provide optimum liner adhesion per shop planning.
F	26.	The Initiator Chamber is coated with liner material using a hand brush application. Thickness is controlled by applied weight and careful rationing of materials as described in TWR-10341. Liner processing and application is controlled per shop planning.
F	27.	Liner viscosity is per engineering and controlled by shop planning.
H	28.	Liner is designed with enough strength to assure cohesive failure in the propellant making the propellant the weak link. An analysis was performed to characterize the liner formula to provide optimum strength per TWR-15276.
H	29.	Mechanical properties requirements of liner are per engineering.
H	30.	Shelf life requirements for liner constituents are per engineering.
H	31.	Storage life requirements for liner were analyzed and testing was performed to study aging and humidity effects on liner performance. This analysis was a comparison of HC Polymer with two different types of antioxidants (PBNA and A02246). Polymer containing A02246 antioxidant exhibited better peel strength, less degradation in high humidity, better strain capabilities, and lower uniaxial stress per TWR-15278.
H	32.	Analysis of aged igniters was done and, through aging up to 64 months, there was no apparent degradation to the igniter systems or degradation of performance verifying 5 year storage life requirements per TWR-13003.
H	33.	Accelerated aging tests performed on the igniter PLI bond system per TWR-16106

indicated that 90 degree peel strength of the PLI bond decreases with time, high temperature, and high humidity storage during curing of the liner in the test specimen. Once the liner is cured, 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.

H 34. 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 controlled per engineering.

H 35. The Flight Igniter is included in the RSRM Forward Segment life verification.

D 36. A Spray-in-Air cleaning system is used to clean metal components as part of the bonding surface preparation processing sequence.

A,B,C,D,E,F 37. 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 CODE
			1.	For New Iron Hexoate, verify:	
A,I		(T)	a.	Infrared spectrum	ALJ004,ALJ006,ALJ009
A,I		(T)	b.	Iron content	ALJ011,ALJ013,ALJ016
A,I		(T)	c.	Specific gravity	ALJ024,ALJ026,ALJ029
A,I		(T)	d.	Viscosity	ALJ031,ALJ034,ALJ036
			2.	For New Floats, Asbestos verify:	
A,I		(T)	a.	Calcination loss	ALI002
A,I		(T)	b.	Fiber size distribution	ALI011
A,I		(T)	c.	pH (aqueous extract)	ALI023
A,I		(T)	d.	Volatile matter	ALI051
A,I		(T)	e.	Wet volume	ALI053
			3.	For Retest Floats, Asbestos, verify:	
A,I			a.	Volatile matter for storage life extension	ALI051A
			4.	For New Epoxy Resin, verify:	
A,I		(T)	a.	Hydrolyzable chlorine	ALK006
A,I		(T)	b.	Infrared spectrum	ALK014
A,I		(T)	c.	Moisture	ALK021
A,I		(T)	d.	Specific gravity	ALK034
A,I		(T)	e.	Viscosity	ALK041
A,I		(T)	f.	Weight per epoxy	ALK045
			5.	For New Mapo, verify:	
A,I		(T)	a.	Hydrolyzable chlorides	ALL004
A,I		(T)	b.	Infrared spectrum	ALL018
A,I		(T)	c.	Moisture	ALL025
A,I		(T)	d.	Reactive imine	ALL040
A,I		(T)	e.	Specific gravity	ALL050
A,I		(T)	f.	Total chlorine	ALL072
A,I		(T)	g.	Viscosity	ALL079
			6.	For New Thixotropic Powder verify:	
A,I		(T)	a.	Density	ALM002
A,I		(T)	b.	Hydroxyl number	ALM016
A,I		(T)	c.	Melting point	ALM023
A,I		(T)	d.	Moisture	ALM030
A,I		(T)	e.	Particle size	ALM037
			7.	For New Liquid Polymer (HC), verify:	
A,I		(T)	a.	AO2246 antioxidant content	AMC000,AMC002,AMC006
A,I		(T)	b.	Carboxyl equivalents	AMC009,AMC011,AMC015
A,I		(T)	c.	Infrared spectrum	AMC018,AMC020,AMC024

A,I	(T)	d.	Moisture	AMC025,AMC027,AMC031
A,I	(T)	e.	Specific gravity	AMC038,AMC040,AMC044
A,I	(T)	f.	Viscosity	AMC045,AMC047,AMC051
A,I		g.	Workmanship is uniform in appearance and free from visible contamination	FDJ001

8. For New Liner, verify:

B		a.	Mix times per shop planning	AOA010
A,I		b.	Thixotropic powder is free of contamination	ALJ020
A,I		c.	MAPO is free of contamination	ALJ020A
A,B,H,I		d.	Thixotropic powder is acceptable	ALJ020AA
A,B,H,I		e.	Epoxy resin is acceptable	ALK025
A,B,H,I		f.	Asbestos is acceptable	ALK025A
A,B,I	(T)	g.	Peel strength (cured) standardization	AOA032
A,B,H,I		h.	Liquid polymer is acceptable	AMC032
A,I		i.	Liquid polymer is free of contamination	AMC034
A,I		j.	Asbestos is free of contamination	ALI035
A,B,H,I		k.	MAPO is acceptable	ALL036
A,B,H,I		l.	Iron hexoate is acceptable	ALL036D
B		m.	Polymer conditioned to proper temperature per shop planning	AOA038
A,I		n.	Iron hexoate is free of contamination	ALL038
A,I		o.	Epoxy resin is free of contamination	ALM046
B		p.	Raw materials are weighed per shop planning	AOA048A
B		q.	Required inspection buy offs of mix per shop planning	AOA054
B		r.	Sequence of material addition per shop planning	AOA057
H		s.	Shelf life of liner materials not exceeded	AOA061
A,B,I	(T)	t.	Steel-to-steel tensile adhesion strength (cured) standardization	AOA077
B		u.	Temperature for each constituent mixed per shop planning	AOA078
B		v.	Mix temperature of liner batch per shop planning	AOA081
A,B,F,I	(T)	w.	Viscosity of production batches	AOA094
A,B,I	(T)	x.	Viscosity (uncured) standardization	AOA117

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

H		a.	Component temperatures and exposure to ambient environments during in-plant transportation or storage are per the in-plant exposure limit and transportation specification	BAA012
A,D,E		b.	Tooling and initiator chamber surfaces are clean and dry prior to liner application	AAM014
F		c.	Complete coverage of liner	AAM015
C,G		d.	Liner cure is complete and acceptable	AAM019
A,E		e.	Drying time of solvent on internal surface prior to liner application	AAM022
A,C,G,I		f.	Pot life between liner mixing and application not exceeded	AOA044
A,I		g.	Liner mix acceptable prior to application	AAM049
C,G		h.	Pre-cure acceptable	AAM061
D,E		i.	Preheat within required temperature range	AAM063
E		j.	Grit blasting is complete and acceptable	AAM063A
C,G		k.	Use life from end of liner pre-cure to start of propellant casting not exceeded per the liner specification	AAM085
B,F		l.	Weight of liner applied to Initiator Chamber	AAM092
D		m.	Insulation installation is complete and acceptable	AAM097A

10. For New Igniter Assembly verify:

H		a.	Component temperatures and exposure to ambient environments	

			during in-plant transportation or storage are per the temperature exposure limit specification	BAA015
A,B,C, G,H,I	(T)	b.	Initiator LAT for proper propellant burn time and pressure per the igniter specification	AKU021
		11.	For New Segment, Rocket Motor, Forward, verify:	
H		a.	Component environments during in-plant transportation or storage	BAA021
		12.	KSC verifies:	
H		a.	Life requirements for the expected launch schedule are met per OMRSD, File II, Vol III, C00CA0.030	OMD019