ATK ALLIANT TECHSYSTEMS
THIOKOL PROPULSION

CRITICAL ITEMS LIST (CIL)

No. 10-01-02-04/03

SYSTEM:	Space Shuttle RSRM 10	CRITICALITY CATEGORY:	1
SUBSYSTEM:	Case Subsystem 10-01	PART NAME:	Inhibitor (1)
ASSEMBLY:	Propellant, Liner, Insulation, Inhibitor 10-01-02	PART NO.:	(See Section 6.0)
		PHASE(S):	Boost (BT)
FMEA ITEM NO.:	10-01-02-04 Rev N	QUANTITY:	(See Section 6.0)
CIL REV NO.:	N	EFFECTIVITY:	(See Table 101-6)
DATE:	27 Jul 2001	HAZARD REF.:	BC-10
SUPERSEDES PAGE:	218-1ff.		
DATED:	31 Jul 2000		
CIL ANALYST:	F. Duersch		
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: 3.0 Burn through of the castable inhibitor

3.0 FAILURE EFFECTS: Increased burn surface resulting in increased chamber pressure causing loss of RSRM, SRB, crew, and vehicle

4.0 FAILURE CAUSES (FC):

FC NO.	DESCRIPTION	FAILURE CAUSE KEY
3.1	Nonconforming material dimension	A
3.2	Nonconforming material properties	B
3.3	Age degradation	C
3.4	Contamination of inhibitor material	D

5.0 REDUNDANCY SCREENS:

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

6.0 ITEM DESCRIPTION:

1. RSRM castable inhibitor is an HC polymer-based material filled with asbestos pulp floats that is cast and cured on the aft propellant surface of forward and center segments (Figures 1 and 2). Materials are listed in Table 1.

TABLE 1. MATERIALS

Drawing No.	Name	Material	Specification	Quantity
1U76674	Segment, RSRM Loaded Forward			1/Motor
1U76675	Segment, RSRM Loaded Center			2/Motor
	Inhibitor (Castable), RSRM, Space Shuttle Project	Composite of various materials	STW5-3223	300 lb./Motor (nominal)
		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
		Pulp Floats Asbestos	STW4-2636	Per Mix Ratio
		Iron Hexoate (2-ethyl) 6 Percent	STW4-2645	Per Mix Ratio
	Inhibitor Repair Material	Sealant, Liquid Epoxy Resin, Asbestos Float Filled	STW5-2678	A/R

6.1 CHARACTERISTICS:

1. After propellant casting, an inhibitor depression mold plate is placed on the propellant grain surface until the grain is partially cured. Upon removal of the mold plate, castable inhibitor is applied to the grain surface and cure is continued. After cure is complete, the inhibitor is inspected and repaired per engineering.

2. Castable inhibitor is a liquid polymer-based material that becomes highly cross-linked upon cure. Since propellant is also highly cross-linked upon cure, a chemical bond is formed between inhibitor and propellant per TWR-15276.

3. Castable inhibitor is similar composition to liner material. Due to the composition, inhibitor exhibits much the same properties as liner in that bond strength between inhibitor and propellant is sufficient to assure cohesive failure in the propellant before any adhesive or cohesive failure in the inhibitor.

4. A function of castable inhibitor is to control propellant burn surface area. Proper processing and material properties preclude events associated with structural failure, thus controlling propellant burn surface area. Figure 1 shows the three RSRM locations of inhibitor. Figure 2 is an expanded view showing locations of both castable and NBR inhibitors.

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

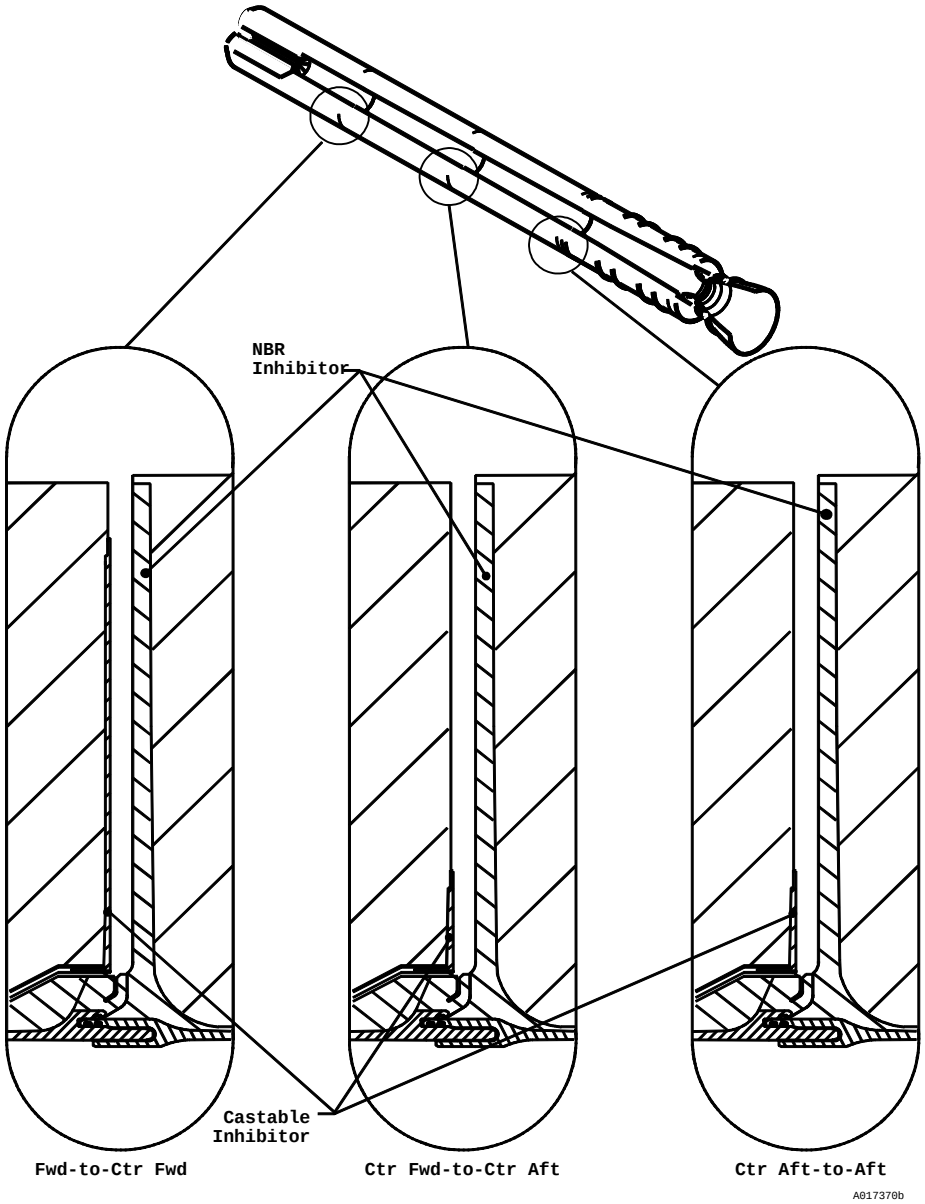

Figure 1. RSRM Castable and NBR Inhibitors

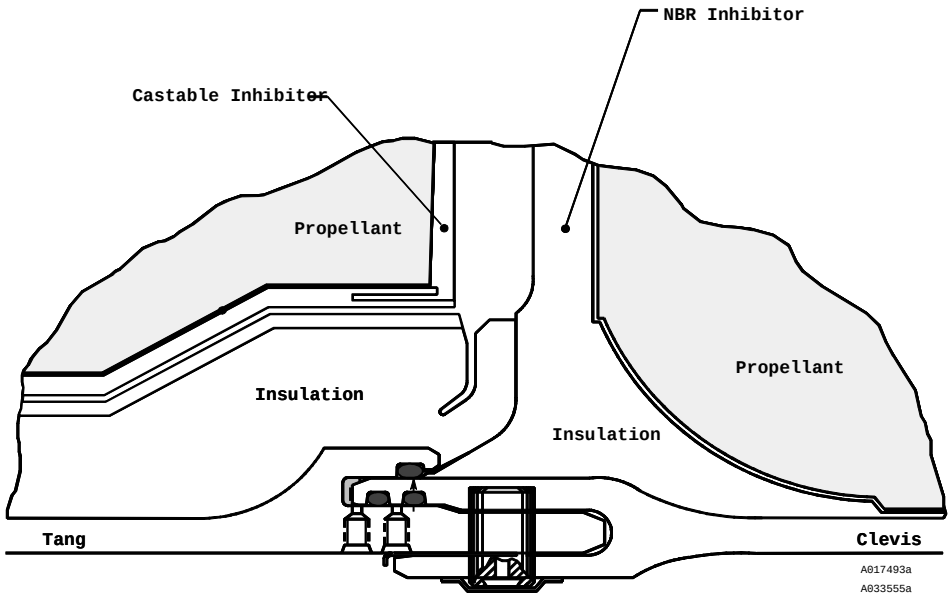

Figure 2. Castable and NBR Inhibitors

9.0 RATIONALE FOR RETENTION:

9.1 DESIGN:

DCN	FAILURE CAUSES	
A	1.	Case wall insulation is designed to withstand inhibitor failure at ignition per TWR-18133.
A	2.	Thickness dimensions of castable inhibitor for the case segment are specified per engineering drawings.
A	3.	To experience a thrust imbalance exceeding CEI requirements, the entire castable inhibitor must be lost within the first two seconds of the burn per TWR-16974. The probability of loss of the entire inhibitor is low due to adhesion properties and low bond line stresses in associated inhibitor areas.
A	4.	Depression mold plates are installed on the aft propellant face to determine castable inhibitor locations and a sweep template provides depth control per engineering drawings.
A	5.	Castable inhibitor thickness requirements are verified acceptable per Development Motors DM-8 and DM-9, and Qualification Motors QM-6 and QM-7 as reported in TWR-18764-04.
A,B	6.	Cure-cycle time and temperature are controlled per engineering drawings and shop planning.
A,D	7.	Contamination control requirements and procedures are described in TWR-16564.
B,C,D	8.	Ingredients, proportions, and mechanical properties of raw materials used in RSRM castable inhibitor are per engineering and are required to be free from visual contamination.
B	9.	Adequacy of raw material proportions related to strength in the castable inhibitor was determined by similarity to the characterization done for the liner since identical materials are used per TWR-15276.
B	10.	Thermal analyses show thermal properties and material thickness to preclude burn through per TWR-11959.
B	11.	Material properties requirements for constituents used in castable inhibitor are per engineering for the following materials: a. Liquid Polymer (HC), Polybutadiene, Carboxyl Terminated, with Antioxidant b. Tris [1-(2-Methyl) Aziridinyl] Phosphine Oxide (MAPO) c. Epoxy Resin, Medium Viscosity, Trifunction, Distilled d. Asbestos Pulp Floats e. Iron hexoate (2-ethyl) 6 percent
B	12.	Material properties for use in structural analysis are listed in TWR-17039.
B	13.	Analyses of propellant grain structural integrity for the castable inhibitor area show that factors of safety for all conditions are met per TWR-17057.
C	14.	Age and storage requirements, including retest for extending storage life for constituents used in castable inhibitor, are per engineering for the following:

a. Liquid Polymer (HC), Polybutadiene, Carboxyl Terminated, with Antioxidant
b. Tris [1-(2-Methyl) Aziridinyl] Phosphine Oxide (MAPO)
c. Epoxy Resin, Medium Viscosity, Tri-function, Distilled
d. Asbestos Pulp Floats
e. Iron Hexoate (2-Ethyl, 6 Percent)

C 15. Aging and environmental (temperature and humidity) studies were performed to qualify castable inhibitor and are summarized in TWR-12915.

C 16. 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.

C 17. Castable inhibitor meets "useful life" requirements by similarity to liner in that the composition of liner and castable inhibitor differs by only 0.2 percent asbestos floats per TWR-15278. Structural integrity of liner and castable inhibitor is greater than that of propellant and it was demonstrated that propellant meets "useful life" per TWR-17057. Post-test inspection of TEM-09 indicated no anomalous condition created by aging of hardware per TWR-63479. Premature loss of castable inhibitor would be evidenced by excessive erosion of the insulation.

D 18. Prior to segment casting, the casting pit is cleaned and verified per shop planning. Cleaning and housekeeping during processing are also controlled per shop planning.

D 19. Contamination during processing is prevented by adherence to controls per shop planning.

D 20. All tooling and equipment cleaning is controlled per shop planning.

D 21. Raw materials listed below and used in castable inhibitor are controlled per engineering.

a. Asbestos Floats
b. Iron Hexoate
c. Epoxy Resin
d. MAPO
e. Liquid Polymer

D 22. Structural analyses on propellant grain and bond lines were done to verify factors of safety for the inhibitor-to-propellant bond. These analyses show positive margins of safety for this bond as reported in TWR-16961.

A,B 23. The grain (propellant, liner, castable inhibitor and internal insulation) of the RSRM was evaluated for the Performance Enhancement (PE) Program. The grain evaluation (PLI) shows that all areas still meet required safety factors. The PLI was conservatively re-evaluated using an increased liftoff acceleration load (not part of the Performance Enhancement Program). It was concluded that structural certification was not affected per TWR-17057.

9.2 TEST AND INSPECTION:

DCN	FAILURE CAUSES and TESTS	(T)			CIL CODE
			1.	For New Loaded Segment Assembly (Forward and Center) verify:	
	D		a.	Absence of contamination on all exposed surfaces prior to casting inhibitor	AFF000,AFH002
	D		b.	Aft end of segment covered with sheet of polyethylene during core popping	AFF002,AFH004
	A		c.	Propellant/Igniter Boot terminations, after propellant trimming to a smooth contour, are acceptable per engineering	AFF003
	D		d.	Aft face of propellant is free of foreign material per engineering	AFF004,AFH006
	A		e.	Aft face of propellant is free of unacceptable anomalies after trimming to a smooth contour per engineering	AFH007,MKL033
	C		f.	Component temperatures and exposure to ambient environments during in-plant transportation or storage are acceptable	BAA008,BAA009
	A		g.	Cured aft face inhibitor surface is free from unacceptable anomalies per engineering	AFF016,AFH019
	D		h.	Cured castable inhibitor for cleanliness following core pop	AFF018,AFH020
	A		i.	Proper application of inhibitor following use of sweep template	AFF025,AFH027
	A		j.	Acceptable repair of Aft Face Inhibitor anomalies per engineering	MKL027,MKL028
	D		k.	Mold plates are clean	AFF042,AFH048
	D		l.	No foreign objects on or in the inhibitor surface after casting inhibitor per engineering	AFF044,AFH050
	A		m.	Sweep template is clean and assembled correctly prior to inhibitor application	AFF071,AFH074
	A		n.	Ultrasonic testing to verify thickness of castable inhibitor	AFF075,AFH076
			2.	For New Inhibitor, RSRM Space Shuttle Project, verify:	
	D		a.	All mixer heads and equipment are cleaned prior to mixing	ANZ001
569	B		b.	Inhibitor mixed per planning requirements	ANZ003
	B		c.	Polymer conditioned to proper temperature per shop planning	ANZ004
	D		d.	Raw materials are free of visible contamination prior to use	ANZ007
	D		e.	Raw materials are acceptable just prior to use per the accept tag and shop planning	ANZ008
	B,D	(T)	f.	Tensile adhesion of propellant to inhibitor for production batches	ANZ027
	B	(T)	g.	Tensile adhesion for standardization batches	ANZ034
	B,D	(T)	h.	Uncured inhibitor viscosity for production and /or repair batches	ANZ038
	B	(T)	i.	Uncured inhibitor viscosity for standardization batches	ANZ038B
			3.	For New Iron Hexoate, verify:	
	B,D	(T)	a.	Infrared spectrum	ALJ004,ALJ006,ALJ009
	B,D	(T)	b.	Iron content	ALJ011,ALJ013,ALJ016
	B,D	(T)	c.	Specific gravity	ALJ024,ALJ026,ALJ029
	B,D	(T)	d.	Viscosity	ALJ031,ALJ034,ALJ036
			4.	For Retest Iron Hexoate, verify:	
	C	(T)	a.	Iron content	ALJ021
			5.	For New Floats, Asbestos verify:	
	B,D	(T)	a.	Calcination loss	ALI002

B,D	(T)	b.	Fiber size distribution	ALI011
B,D	(T)	c.	pH (Aqueous extract)	ALI023
B,D	(T)	d.	Volatile matter	ALI051
B,D	(T)	e.	Wet volume	ALI053

6. For Retest Floats, Asbestos, verify:

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

7. For New Epoxy Resin verify:

B,D	(T)	a.	Hydrolyzable chlorine	ALK006
B,D	(T)	b.	Infrared spectrum	ALK014
B,D	(T)	c.	Moisture	ALK021
B,D	(T)	d.	Specific gravity	ALK034
B,D	(T)	e.	Viscosity	ALK041
B,D	(T)	f.	Weight per epoxy	ALK045

8. For Retest Epoxy Resin verify:

C	(T)	a.	Viscosity	ALK029A
C	(T)	b.	Weight per epoxy	ALK029B

9. For New MAPO, verify:

B,D	(T)	a.	Hydrolyzable chlorides	ALL004
B,D	(T)	b.	Infrared spectrum	ALL018
B,D	(T)	c.	Moisture	ALL025
B,D	(T)	d.	Reactive imine	ALL040
B,D	(T)	e.	Specific gravity	ALL050
B,D	(T)	f.	Total chlorine	ALL072
B,D	(T)	g.	Viscosity	ALL079

10. For Retest MAPO, verify:

C	(T)	a.	Reactive imine	ALL047A
C	(T)	b.	Moisture	ALL047B
C	(T)	c.	Specific gravity	ALL047C
C	(T)	d.	Viscosity	ALL047D
C	(T)	e.	Total chlorine	ALL047E
C	(T)	f.	Hydrolyzable chlorides	ALL047F

11. For New Liquid Polymer (HC), verify:

B,D	(T)	a.	AO2246 antioxidant content	AMC000,AMC002,AMC006
B,D	(T)	b.	Carboxyl equivalents	AMC009,AMC011,AMC015
B,D	(T)	c.	Infrared spectrum	AMC018,AMC020,AMC024
B,D	(T)	d.	Moisture	AMC025,AMC027,AMC031
B,D	(T)	e.	Specific gravity	AMC038,AMC040,AMC044
B,D	(T)	f.	Viscosity	AMC045,AMC047,AMC051
B,D		g.	Workmanship is uniform in appearance and free from visible contamination	FDJ001

12. For Retest Liquid Polymer (HC)), verify:

C	(T)	a.	Viscosity	AMC036A
C	(T)	b.	Carboxyl equivalents	AMC036B
C	(T)	c.	Moisture	AMC036C

13. For New Handling Kit, Forward Segment, verify:

D	a.	End cover is in place on the segment to protect the propellant grain and insulation from ultra violet degradation prior to shipping	AID000

14. For New Handling Kit, Center Segment, verify:

D	a.	End covers are in place on the segments to protect the propellant grain and insulation from ultra violet degradation prior to shipping	AID000A

15. KSC verifies:

C	a.	Forward and aft face propellant inhibitors and acrylonitrile butadiene rubber (NBR) inhibitor, liner, and propellant are free of defects per OMRSD File V, Vol I, B47SG0.041	OMD077