ATK ALLIANT TECHSYSTEMS
THIOKOL PROPULSION

CRITICAL ITEMS LIST (CIL)

No. 10-01-02-04/02

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 M	QUANTITY:	(See Section 6.0)
CIL REV NO.:	M	EFFECTIVITY:	(See Table 101-6)
DATE:	17 Jun 2002	HAZARD REF.:	BC-10
SUPERSEDES PAGE:	217-1ff.		
DATED:	31 Jul 2000		
CIL ANALYST:	S. E. Rodgers		
APPROVED BY:		DATE:	

RELIABILITY ENGINEERING: K. G. Sanofsky 17 Jun 2002

ENGINEERING: P. M. McCluskey 17 Jun 2002

1.0 FAILURE CONDITION: Failure during operation (D)

2.0 FAILURE MODE: 2.0 Structural failure of the NBR inhibitor

3.0 FAILURE EFFECTS: Structural failure of NBR rubber due to stress fatigue could cause insulation cracking allowing an increase in propellant burning and causing a loss of the RSRM, SRB, crew, and vehicle

4.0 FAILURE CAUSES (FC):

FC NO.	DESCRIPTION	FAILURE CAUSE KEY
2.1	Structural failure of the NBR inhibitor	
2.1.1	Nonconforming insulation properties	A
2.1.2	Improper processing	B
2.1.3	Improper assembly	C
2.1.4	Transportation and handling damage	D
2.1.5	Age degradation	E
2.1.6	Voids or inclusions	F

5.0 REDUNDANCY SCREENS:

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

6.0 ITEM DESCRIPTION:

1. Acrylonitrile butadiene rubber (NBR) inhibitor is a continuous part of internal insulation and covers the forward surface of the propellant grain in the aft and center segments. Materials are listed in Table 1.

TABLE 1. MATERIALS

Drawing No.	Name	Material	Specification	Quantity
	Insulation	Acrylonitrile Butadiene Rubber, Asbestos Silica-Filled (NBR)	STW4-2621 STW4-2621 TP I	17,100 lb/Motor (ALTERNATE)
	Insulation	Carbon Fiber-Filled Ethylene Propylene Diene Monomer (EPDM)	STW4-2868	98 lb/Motor
	Paint	Polyethylene Chlorosulfonated, Black	STW5-9085	1.5 gal/Motor
1U76667	Segment, Insulated Center			2 ea/Motor
1U77503	Case Assembly, Aft Segment Insul			1 ea/Motor
1U76675	Segment, RSRM Loaded Center			2 ea/Motor
1U77504	Segment Assembly-Loaded, Aft			1 ea/Motor

6.1 CHARACTERISTICS:

1. NBR inhibitor is asbestos and silicon dioxide filled acrylonitrile butadiene rubber (NBR). Pre-cut layers of NBR are installed and vulcanized prior to casting the propellant grain. This acts as a thermal barrier to control RSRM propellant burn on forward grain surfaces, thus controlling motor chamber pressure and thrust.

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

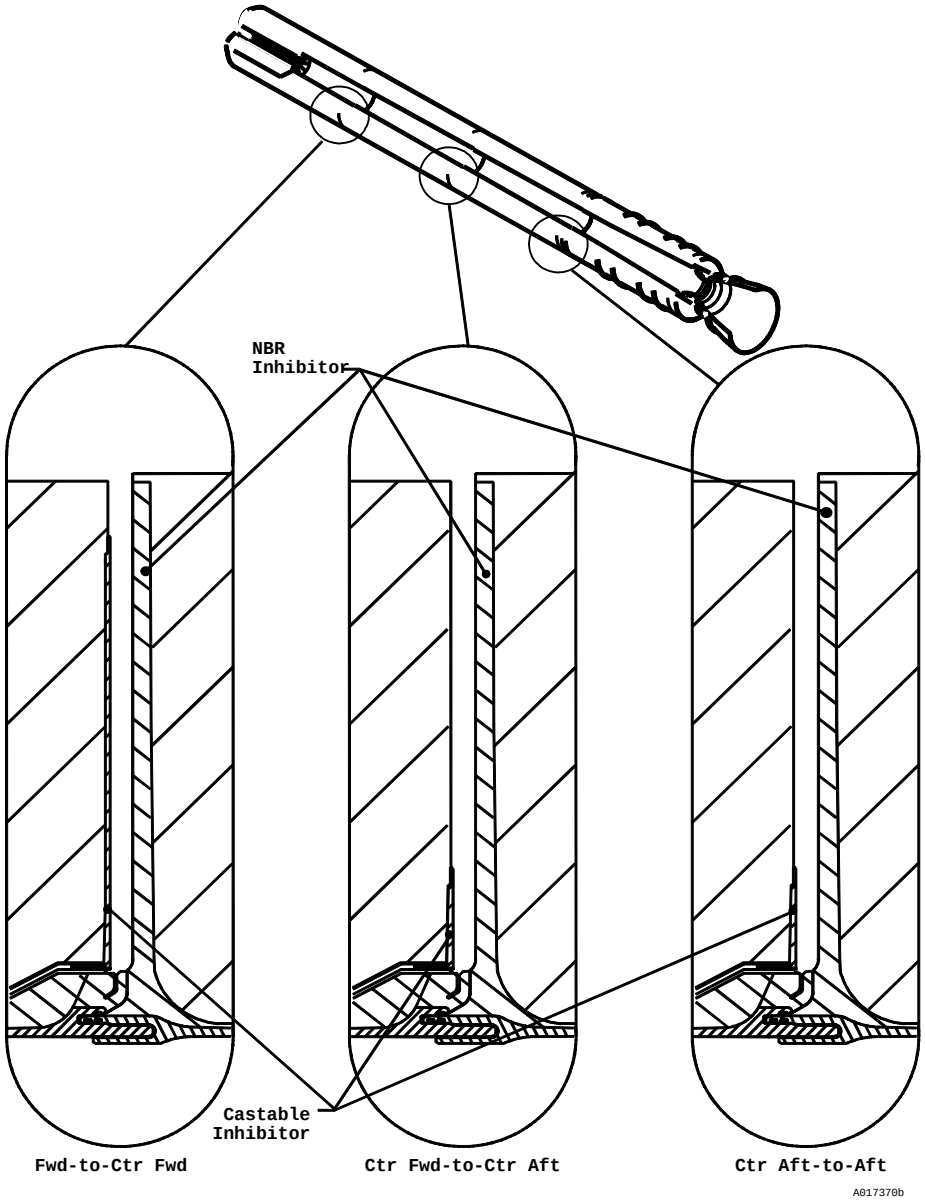
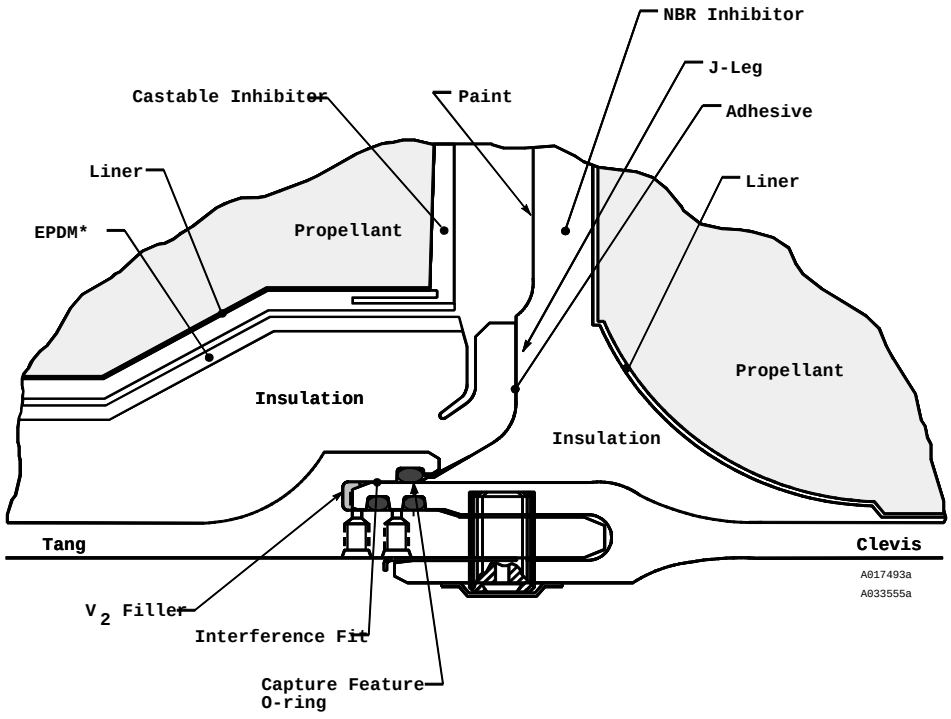


Figure 1. RSRM Castable and NBR Inhibitors



*Not used on forward segment

Figure 2. Castable Inhibitor

9.0 RATIONALE FOR RETENTION:

9.1 DESIGN:

DCN	FAILURE CAUSES	
A,B	1.	NBR insulation material specifications specify the tests to certify the quality of material procured and qualification tested for use on both case wall and forward inhibitor as documented in TWR-12646.
A,B,F	2.	Structural and thermal performance of the NBR inhibitor was successfully demonstrated in all past static tests and flight SRMs as reported in TWR-14415.
A	3.	Cured NBR properties are per engineering. Margins of safety limits for erosion are per engineering drawings for case and nozzle, and TWR-12969 and TWR-16742 for the Igniter.
A	4.	Forward facing inhibitor integrity was verified by the use of tracer salts in DM-5 per TWR-13600.
A,B,C	5.	Witness panels are cured in the autoclave with the insulated segments during the cure cycle. These panels are then tested to assure bondline integrity for primer, adhesive, insulation, liner, and propellant properties was achieved at the end of the cure cycle per engineering, TWR-17123, TWR-64433, and TWR-64923.
B	6.	NBR insulation design requirements and processing characteristics are per engineering drawings for material ingredients and shop planning for mixing and cure requirements.
B,C	7.	Thermocouples are imbedded in the NBR insulation in each segment at the time of lay up to control and verify proper cure temperature and time per engineering drawings.
B	8.	Contamination control requirements and procedures are per TWR-16564.
B	9.	Criteria for foreign (processing) material allowed on the forward face of the propellant are per engineering.
C	10.	Inhibitor and case wall insulation are laid up and cured in place in RSRM segments using uncured NBR insulation precut pattern pieces. Lay up design is per engineering drawings.
C	11.	Assembly is a controlled process per shop planning.
C	12.	Structural analysis of the inhibitor shows positive margins of safety per TWR-13040.
C	13.	Thermal analysis of NBR inhibitor verifies the design per TWR-12025.
C	14.	NBR inhibitor dimensions are per engineering drawings.
D	15.	The NBR Inhibitor Structural Analysis Report is part of TWR-12182. Analysis included effects of transportation and handling loads. In no case did the calculated factors of safety fall below 2.0.
		a. NBR inhibitor design and thermal analysis is per TWR-11271.
D	16.	Monitoring instrumentation records in transit environments. TWR-11712 describes

requirements for handling, packaging, and transportation systems for control of internal loads, stresses, or deflections in excess of the structural capability of the SRM.

D 17. Railway coupling and transportation tests were conducted on an inert forward segment per TWR-11712 to verify the adequacy of tie down provisions and to record actual g-loads during transit. Accelerations of 1.01 g longitudinal and 0.86 g vertical were measured and were less than the vibration and shock transportation target loads.

D 18. Additional tests were conducted per TWR-12079 to analyze transportation loads on the RSRM forward segment grain. This testing provides additional data for verification of vibration and shock transportation environments.

D 19. Requirements for handling RSRM components during assembly, storage, and transportation are similar to those for previous and other current programs at Thiokol. Those requirements dictate that RSRM and case segments must be handled by or near a joint to avoid damage. All lifting hooks and slings are fitted with safety hooks. Proof testing is required for all lifting and handling equipment per TWR-13880.

D 20. Positive cradling or support devices and tie downs that conform to shape, size, weight, and contour of components to be transported are provided to support RSRM segments and other components. Shock mounting and other protective devices are used on trucks and dollies to move sensitive loads per TWR-13880.

D 21. Specially designed 200-ton railroad flatcars are used to assure no damage occurs to flight hardware during transportation to the launch site per TWR-13880.

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

E 23. 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.

E 24. The RSRM and its components are protected by passive means against natural environments during transportation and handling per engineering drawings.

E 25. Preservation and packaging of thermal insulation is to prevent exposure to direct sunlight, ultraviolet radiation, or ozone per engineering drawings.

E 26. The forward surface of NBR inhibitor is protected from degradation by application of protective paint.

E 27. 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.

E 28. Evaluation of TEM-09 insulation performance and post-fire bondline integrity demonstrated that thermal safety factors and material decomposition met the requirements of HPM CEI specifications. Structural testing indicated that post fired TEM-09 internal insulation was comparable to recently fired RSRM materials per TWR-63479.

E 29. Testing of real time aged propellant/liner/insulation (PLI) samples indicated that TP-H1148 propellant and PLI bond properties were not affected by aging for up to five years per TWR-63837.

E 30. EPDM and NBR insulated segments are included in RSRM segment life verification.

F 31. NBR inhibitor material layer thickness and contamination requirements are per engineering.

F 32. Acceptance criteria for insulation voids, inclusions, ply separations, and pin holes are per engineering drawings.

F 33. NBR insulation material layer thickness and contamination requirements are per engineering.

D 34. 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	TESTS	(T)	FAILURE CAUSES and	CIL CODE
			1. For New NBR, verify:	
A			a. Certificate of Conformance	ALH006
A,B,F		(T)	b. Elongation	ALH062,ALH065
A,B,F		(T)	c. Elongation (calendered only)	ALH010
A,B,F		(T)	d. Shore A hardness	ALH098,ALH109
A,B,F		(T)	e. Shore A hardness (calendered only)	ALH102
A,B,F		(T)	f. Specific gravity	ALH121,ALH126
A,B,F		(T)	g. Specific gravity (calendered only)	ALH118
A,B,F		(T)	h. Tensile strength	ALH149,ALH154
A,B,F		(T)	i. Tensile strength (calendered only)	ALH147
A,B,F			j. Material workmanship including uniform appearance and free from contamination	ALH168
A,B,F		(T)	k. Mooney viscosity	ALH041,ALH046
A,B,F		(T)	l. Mooney viscosity (extrusions only)	ALH170
A,B,F		(T)	m. Scorch characteristics	ALH081,ALH086
A,B,F		(T)	n. Scorch characteristics (extrusions only)	ALH171
			2. For Retest NBR, verify:	
A,B,E		(T)	a. Mooney viscosity	ALH049
A,B,E		(T)	b. Scorch characteristics	ALH087
			3. For New Paint, Ozone Protection verify:	
E		(T)	a. Tests for color	DJM005
E		(T)	b. Tests for nonvolatile content	DJM006
E			c. Certificate of Conformance	DJM007
E		(T)	d. Tests for viscosity	DJM008
E		(T)	e. Tests for weight per gallon	DJM009
			4. For New Paint, Ozone Protection verify by inspection:	
E			a. Workmanship	DJM010
E			b. Adhesion	DJM011
			5. For New Insulated Segment Assembly (Center and Aft) verify:	
C			a. Correct number and position of patterns on inhibitor lay up	AHQ000,AHR000
A,B,C		(T)	b. Results of Chemlok-to-Case Insulation bondline integrity tests with witness panels per engineering	AOX015,AOX016
A,E			c. Environmental history for insulation	ALH022B,AFK086
E			d. Component temperatures and exposure to ambient environments during in-plant transportation or storage are acceptable	BAA019,BAA020
A			e. Insulation is uniform in appearance and free of surface contamination per specifications	AFK062,AFI084
C,F			f. Gaps greater than 0.05 inch are filled	AFI087,AFK094
F			g. Inhibitor ply surfaces are not contaminated during installation	AFI092,AFK102
A,E			h. Storage life is acceptable for insulation	ALH097C,AFI118
B			i. Insulation cure cycle is complete	AFI099,AFK110
C			j. Acceptable ply overlaps	AFI111,AFK121
C,F			k. All loose ply edges are reactivated and rolled in place per shop planning	AFI112,AFK122

585	C		l.	Minimal application of approved solvent to improve tack	AFI117,AFK127
	F		m.	Mold ring is cleaned	AFI121,AFK131
	C,F		n.	Trapped air bubbles in the insulation do not exceed specifications	AFI155,AFK172
	B		o.	Vacuum bags evacuated and checked for leaks	AFI160,AFK181
	C		p.	Stagger of radial overlaps	AFI165,AFK186
	B		q.	Solid core thermocouple leads are installed through the putty	AFI178,AFK199
	B		r.	Thermocouple leads are working throughout the cure cycle	AFI180,AFK201
	C,F	(T)	s.	Insulation thickness by ultrasonics	AFI186,AFK214

6. For New Loaded Segment Assembly (Center, Aft) verify:

E	a.	Component temperatures and exposure to ambient environments during in-plant transportation or storage are acceptable	BAA009,BAA010
E	b.	Full cover coat of ozone protection paint applied to inhibitor	AFH031,AFH031A

7. KSC verifies:

E	a.	Life requirements for the expected launch schedule are met per OMRSD, File II, Vol III, C00CA0.030	OMD019
D,F	b.	Forward and aft face propellant inhibitors and acrylonitrile butadiene rubber (NBR) inhibitor, liner, and propellant is free of defects per OMRSD, File V, Vol I, B47SG0.041	OMD077