



CRITICAL ITEMS LIST (CIL)

No. 10-01-02-04/04

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)
FMEA ITEM NO.:	10-01-02-04 Rev M	PHASE(S):	Boost (BT)
CIL REV NO.:	M	QUANTITY:	(See Section 6.0)
DATE:	17 Jun 2002	EFFECTIVITY:	(See Table 101-6)
SUPERSEDES PAGE:	219-1ff.	HAZARD REF.:	BC-10
DATED:	31 Jul 2000		
CIL ANALYST:	S. E. Rodgers		
APPROVED BY:		DATE:	
RELIABILITY ENGINEERING:	<u>K. G. Sanofsky</u>		<u>17 Jun 2002</u>
ENGINEERING:	<u>P. M. McCluskey</u>		<u>17 Jun 2002</u>

- 1.0 FAILURE CONDITION: Failure during operation (D)
- 2.0 FAILURE MODE: 4.0 Burn through of the NBR inhibitor
- 3.0 FAILURE EFFECTS: Increased burn surface resulting in increased chamber pressure and loss of RSRM causing loss of SRB, crew, and vehicle

4.0 FAILURE CAUSES (FC):

FC NO.	DESCRIPTION	FAILURE CAUSE KEY
4.1	Nonconforming material dimension	A
4.2	Nonconforming material properties	B
4.3	Age degradation	C
4.4	Contamination of inhibitor material	D

5.0 REDUNDANCY SCREENS:

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

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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	Ozone Protection 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). Precut 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:

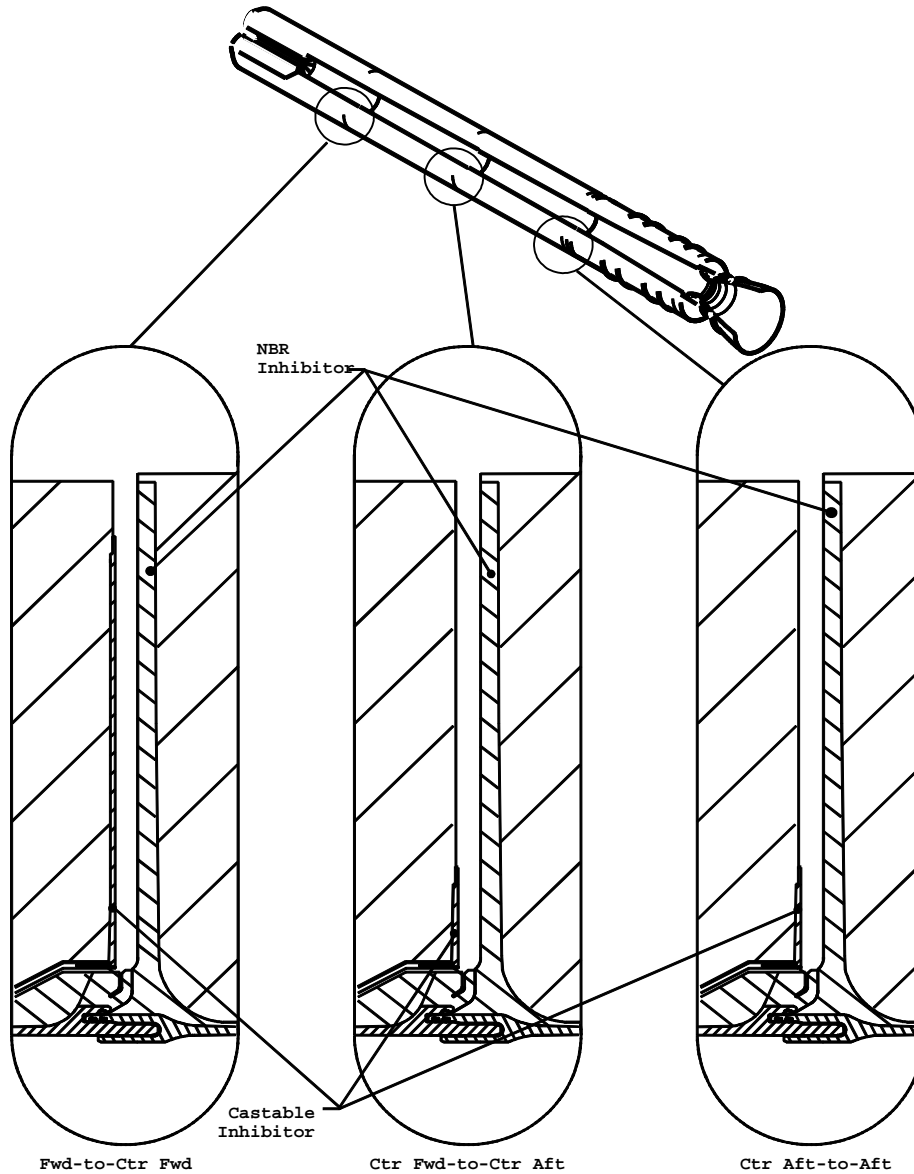
1. Current data on test failures, flight failures, unexplained failures, and other failures during RSRM ground processing activity can be found in the PRACA Database.

8.0 OPERATIONAL USE: N/A

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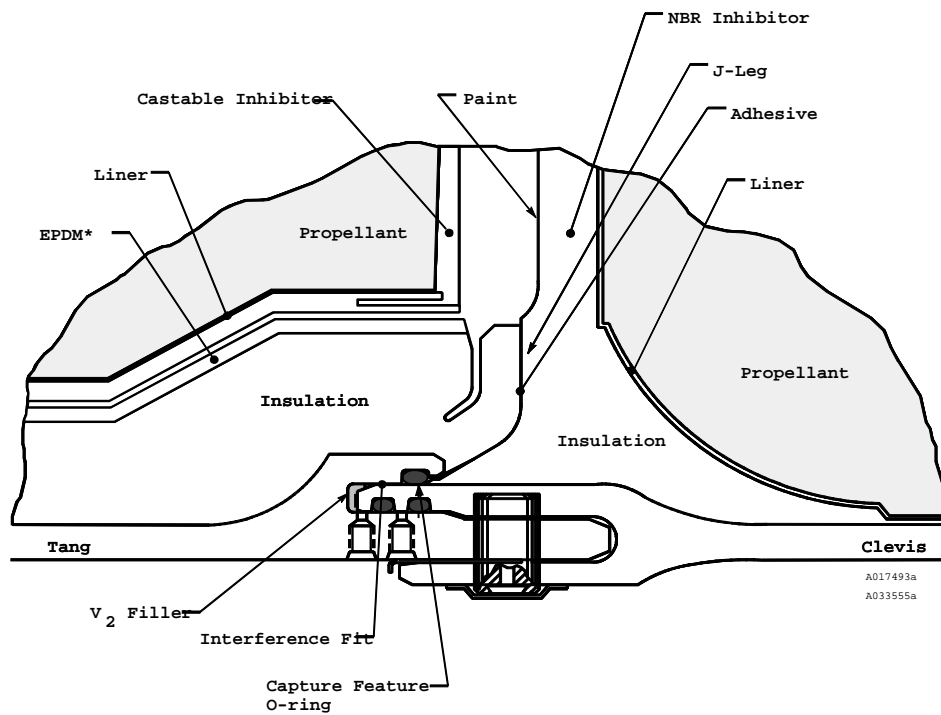
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Figure 1. RSRM Castable and NBR Inhibitors

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*Not used on forward segment

Figure 2. NBR and Castable Inhibitors

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9.0 RATIONALE FOR RETENTION:

9.1 DESIGN:

DCN FAILURE CAUSES

- | | |
|-----|---|
| A | 1. Inhibitor thickness is per engineering drawings. |
| A | 2. NBR inhibitor layer thickness and contamination requirements are per engineering. |
| A | 3. 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. |
| A | 4. Assembly is a controlled process per shop planning. |
| A | 5. 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. |
| A | 6. Structural analysis of the inhibitor shows positive margins of safety per TWR-13040. |
| A | 7. Thermal analysis of NBR inhibitor verifies the design per TWR-12025. |
| B | 8. 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. |
| B | 9. Structural and thermal performance of the NBR inhibitor material was successfully demonstrated in all past static tests and flight RSRMs as reported in TWR-14415. |
| B | 10. Mechanical and thermal properties of NBR are listed in TWR-17009. |
| B | 11. Forward facing inhibitor integrity was verified by the use of tracer salts in DM-5 per TWR-13600. |
| B,D | 12. 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. |
| C,D | 13. 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. |
| C | 14. The RSRM and its components are naturally protected by passive means against natural environments during transportation and handling per engineering drawings. |
| C | 15. Preservation and packaging of thermal insulation is to prevent exposure to direct sunlight, ultraviolet radiation, or ozone per engineering drawings. |
| C | 16. The forward surface of NBR inhibitor is protected from degradation by application of protective paint. |
| C | 17. 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 |

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exposure to ambient environments during in-plant transportation or storage are controlled per engineering.

- C 18. 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.
- C 19. Testing of real time aged propellant/liner/insulation (PLI) samples indicated TP-that H1148 propellant and PLI bond properties were not affected by aging for up to five years per TWR-63837.
- C,D 20. EPDM and NBR insulated segments are included in RSRM segment life verification.
- D 21. NBR insulation is cleaned using approved solvents per shop planning.
- D 22. Primer and adhesive are stored in sealed containers to control contamination of bonding materials and bonding surfaces. Approved solvent 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 controlled per shop planning.
- D 23. Contamination control requirements and procedures are per TWR-16564.
- A,B 24. 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.

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9.2 TEST AND INSPECTION:

FAILURE CAUSES and				
DCN	TESTS	(T)		CIL CODE
			1. For New NBR, verify:	
A			a. Uncured thickness (calendered only)	ALH002,ALH165,ALH166
B			b. Certificate of conformance	ALH006
B,D	(T)		c. Elongation (calendered only)	ALH010
B,D	(T)		d. Mooney viscosity	ALH041,ALH046
B,D	(T)		e. Elongation	ALH062,ALH065
B,D	(T)		f. Scorch characteristics	ALH081,ALH086
B,D	(T)		g. Shore A hardness	ALH098,ALH109
B,D	(T)		h. Shore A hardness (calendered only)	ALH102
B,D	(T)		i. Specific gravity (calendered only)	ALH118
B,D	(T)		j. Specific gravity	ALH121,ALH126
B,D	(T)		k. Tensile strength (calendered only)	ALH147
B,D	(T)		l. Tensile strength	ALH149,ALH154
B,D	(T)		m. Material workmanship including uniform appearance and free from contamination	ALH168
B,D	(T)		n. Mooney viscosity (extrusions only)	ALH170
B,D	(T)		o. Scorch characteristics (extrusions only)	ALH171
			2. For Retest NBR, verify:	
B,C,D	(T)		a. Mooney viscosity	ALH049
B,C,D	(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 & Aft) verify:	
A			a. Correct number and position of patterns on inhibitor lay up	AHQ000,AHR000
B,D	(T)		b. Results of Chemlok-to-Case Insulation bondline integrity tests with witness panels per engineering	AOX015,AOX016
C			c. Component temperatures and exposure to ambient environments during in-plant transportation or storage are acceptable	BAA019,BAA020
B,C,D			d. Environmental history for insulation	ALH022B,AFK086
D			e. Black light inspection is performed to verify all contamination that fluoresces is removed	AFK033,AFI036
B			f. Insulation is uniform in appearance and free of surface contamination per specifications	AFK062,AFI084
A			g. Gaps greater than 0.05 inch are filled	AFI087,AFK094
D			h. Inhibitor ply surfaces are not contaminated during installation	AFI092,AFK102
B,C,D			i. Storage life is acceptable for insulation	ALH097C,AFI118
A			j. Acceptable ply overlaps	AFI111,AFK121

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	A		k.	All loose ply edges are reactivated and rolled in place per shop planning	AFI112,AFK122
585	A		l.	Minimal application of approved solvent to improve tack	AFI117,AFK127
	A		m.	Trapped air bubbles in the insulation do not exceed specification requirements	AFI155,AFK172
	A		n.	Stagger of radial overlaps	AFI165,AFK186
	A,D	(T)	o.	Insulation thickness by ultrasonics	AFI186,AFK214
	D		p.	Mold ring is cleaned	AFI121,AFK131
			6.	For New Loaded Segment Assembly (Center and Aft) verify:	
	C		a.	Component temperatures and exposure to ambient environments during in-plant transportation or storage are acceptable	BAA009,BAA010
	D	(T)	b.	Results of insulation-to-liner-to-propellant bondline integrity tests with witness panel engineering	AOX019,AOX020
	C		c.	Full cover coat of ozone protection paint applied to inhibitor	AFH031,AFH031A
			7.	KSC verifies:	
	C,D		a.	Life requirements for the expected launch schedule are met per OMRSD, File II, Vol III, C00CA0.030	OMD019
	D		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