CRITICAL ITEMS LIST (CIL)

No. 10-01-01-08R/01

SYSTEM:	Space Shuttle RSRM 10	CRITICALITY CATEGORY:	1
SUBSYSTEM:	Case Subsystem 10-01	PART NAME:	Factory Joint, Insulator (1)
ASSEMBLY:	Case 10-01-01	PART NO.:	(See Section 6.0)
FMEA ITEM NO.:	10-01-01-08R Rev M	PHASE(S):	Boost (BT)
CIL REV NO.:	M	QUANTITY:	(See Section 6.0)
DATE:	04 Feb 2003	EFFECTIVITY:	(See Table 101-6)
SUPERSEDES PAGE:	207-1ff.	HAZARD REF.:	BC-02
DATED:	31 Jul 2000		
CIL ANALYST:	S. E. Rodgers		
APPROVED BY:		DATE:	

RELIABILITY ENGINEERING: K. G. Sanofsky 04 Feb 2003

ENGINEERING: L. D. Allred 04 Feb 2003

1.0 FAILURE CONDITION: Failure during operation (D)

2.0 FAILURE MODE: 1.0 Thermal failure

3.0 FAILURE EFFECTS: Failure of the insulator could result in hot gas flowing through the joint resulting in burn through causing loss of the RSRM, SRB, crew, and vehicle

4.0 FAILURE CAUSES (FC):

FC NO.	DESCRIPTION	FAILURE CAUSE KEY
1.1	Age degradation, storage, transportation, and handling	A
1.2	Nonconforming material properties	B
1.3	Thin spot or insufficient material thickness	C
1.4	Inclusions and presence of non-insulation material	D
1.5	Ply separations and voids	E
1.6	Improper handling, application, or cure cycle	F

5.0 REDUNDANCY SCREENS:

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

6.0 ITEM DESCRIPTION:

1. Factory joint insulators are shown as the primary internal insulation over the seven factory joints, see (Figure 1). Materials are listed in Table 1.

TABLE 1. MATERIALS

Drawing No.	Name	Material	Specification	Quantity
	FEP	Plastic Film	ASTM D 3368-81	25 lb/Motor
	Forward Segment/Dome	Filler Extrusion (NBR)	STW4-2535	7 lb/Motor
	Forward Segment/Dome Insulation	Acrylonitrile Butadiene Rubber, Asbestos Silica - Filled (NBR)	STW4-2621 Tp VI STW4-2621	7 lb/Motor 17,000 lb/Motor
		Filled (NBR)	STW4-2621 Tp I	17,100 lb/Motor
	Insulation		STW4-2868	98 lb/Motor
	Primer	(Chemlok 205)	STW5-2664	8 gl/Motor
	Bonding agent	Rubber-To-Metal (Chemlok 233)	STW5-2712	12 gl/Motor
		Teflon Tape	MIL-I-23594, Type 1	8 rl/Motor
1U77502	New Barrel Assy, Coated			1 ea/motor

6.1 CHARACTERISTICS:

1. Insulation used on the RSRM protects internal case surfaces from the heat of combustion gases during motor burn time. Insulation over the factory joint serves as the primary seal for internal pressure throughout motor burn and provides multiple-ply coverage of the factory joint after worst-case design maximum erosion was experienced. The design consistently demonstrated the seal function throughout RSRM operation even after the loss of one ply of insulation due to normal erosion. All insulation safety factors are maintained after loss of one ply.

2. Acrylonitrile butadiene rubber (NBR) is used as the primary internal insulating material throughout the RSRM case.

3. RSRM internal insulation over the factory joints was increased in thickness and number of plies. A continuous first ply over the joint replaced the butt joint method on previous configurations, precluding a leak path along a ply into a joint. Insulation minimum safety factor for each of the seven factory joints increased from 1.5 to 2.0.

4. Factory joints demonstrated reliable performance and insulation was successfully used for many years in numerous rocket motor programs, i.e., Minuteman and Poseidon (first-stage) motors, Trident, Peacekeeper, Titan IIIC, and some 156-inch experimental motors.

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

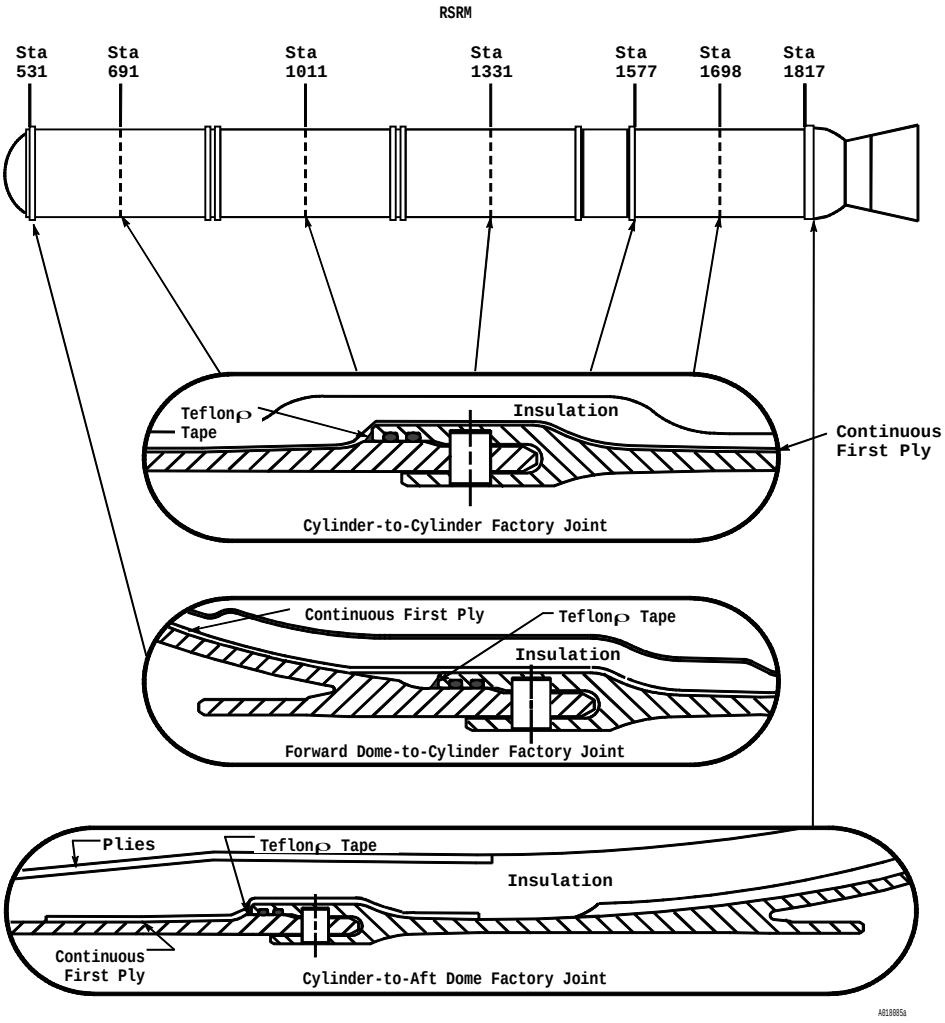

Figure 1. Factory Joints Internal Insulation

9.0 RATIONALE FOR RETENTION:

9.1 DESIGN:

DCN	FAILURE CAUSES	
A	1.	Unvulcanized insulation material storage life and temperature limits, prior to lay up on the component, are specified per engineering. Storage life may be extended if, after retest, the material conforms to engineering.
A	2.	Requirements for handling RSRM components during assembly, storage, and transportation are similar to those for previous and other current programs at Thiokol. These requirements dictate that RSRM 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.
A	3.	Cradling or support devices and tie downs that conform to shape, size, weight, and contour of the component to be transported are provided for supporting RSRM segments and other components. Shock mounting and other protective devices are used on trucks and dollies for moving sensitive loads per TWR-13880.
A	4.	Support equipment used to test, handle, transport, assemble, or disassemble the RSRM is certified and verified per TWR-15723.
A	5.	To assure that no damage occurs to flight hardware during transportation to the launch site, specially designed 200-ton railroad flatcars are used per TWR-13880.
A	6.	Railcar transportation shock and vibration levels for the segments are monitored as required by engineering with loads derived by analysis. Monitoring records are evaluated by Thiokol to verify that shock and vibration levels defined per MSFC specifications were not exceeded.
A	7.	Preservation and packaging of thermal insulation is to prevent exposure to direct sunlight, ultraviolet radiation, or ozone established per engineering drawings.
A	8.	The bonding agent and adhesive primer specified herein have a controlled storage life when stored at warehouse-ambient conditions in closed or resealed containers per engineering.
A	9.	Storage and retest requirements of adhesive primers and bonding agents are specified per engineering.
A	10.	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 the ambient environment during in-plant transportation or storage are controlled per engineering.
A	11.	Evaluation of TEM-09 insulation performance and post fire bondline integrity demonstrated that thermal safety factors and material decomposition met the requirements of the HPM CEI specification. Structural testing indicated that post-fired TEM-09 internal insulation was comparable to recently fired RSRM materials per TWR-63479.
A	12.	Testing of real time aged propellant/liner/insulation (PLI) samples indicated TP-H1148 propellant and PLI bond properties were not affected by aging for up to five years per TWR-63837.

	B	13.	Cured NBR properties are specified per engineering. Margins of safety limits for erosion are defined in engineering drawings for the case and nozzle, and TWR-12969 and TWR-16742 for the Igniter.
598	B	13.	Cured NBR properties are specified per engineering.
	B	14.	Insulation adhesive primer and bonding agent material properties conform to and are qualified per engineering requirements.
	B	15.	Teflon tape conforms to engineering requirements.
	B	16.	A series of static tests and live firings qualify the insulation materials of the RSRM per TWR-18764-06.
	B	17.	Methyl chloroform conforms to engineering requirements.
	C,E,F	18.	Internal case segment and aft dome insulation, including application, thickness, and number of plies, is controlled by engineering drawings.
	C,E	19.	Engineering drawings specify the proper lay up, number of plies, and correct dimensions of the insulation application.
	C,D,F	20.	CIL-controlled processes and environmental requirements are controlled per shop planning.
	C,D,F	21.	Contamination control requirements and procedures are described in TWR-16564.
598	C	22.	To enhance the effectiveness of the HPM factory joint insulation as a seal, several changes were made for the insulation over the RSRM factory joint including increasing the number of plies and insulation thickness over the joint. Insulation design thickness is sufficient to meet various design criteria, including a 2.0 minimum thermal safety factor, per TWR-18133.
	C,E	23.	Integrity of the factory joint insulation as a primary pressure seal is verified per TWR-16190.
	C	24.	Post-test inspection measurements of the insulation over the factory joints were performed for DM-9 per TWR-16472, Vol III. Similar inspections are performed for each flight motor per TWR-16473.
	D	25.	During insulation lay up, all personnel inside the segment are required to wear clean cotton gloves, clean coveralls, and polyethylene foot covers per shop planning.
	D	26.	All personnel inside the segment during insulation lay up are required to adhere to Hair Containment Guidelines per GS & HM 4.9 to prevent contamination of the insulation and/or bonding agents from loose hair or hair oils.
	D,E	27.	Acceptance criteria for insulation anomalies are specified per engineering.
	D	28.	Tool accountability is controlled by shop planning.
	F	29.	Design requirements and processing characteristics of NBR Insulation are established by engineering drawings and shop planning for material ingredients, mixing, and cure requirements.

	F	30. To assure no damage occurs to RSRM components during assembly and transportation, periodic proof loading of all lifting equipment is conducted to verify the integrity of the hardware. Structural support items are tested after fabrication completion. Changes to structural equipment require an additional proof test. GSE is proof loaded by Thiokol. Proof-load requirements and general equipment categories are per TWR-10212.
	F	31. A test to evaluate the effects of methyl chloroform on cured NBR was conducted by Thiokol and the results documented in TWR-18162.
	B,F	32. 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 were achieved at the end of the cure cycle per engineering, TWR-17123, TWR-64433, and TWR-64923.
	B,C	33. All new RSRM case segments are hydroproof tested three times followed by magnetic particle inspection per engineering. Final hydroproof and magnetic particle inspections ensure a four mission capability. Each refurbished RSRM case segment is hydroproofed one time to ensure a four-mission capability. The use of new tooling spools simulates joint hoop loads and therefore produces joint deflections similar to flight conditions. TWR-66845 reported test results and comparisons of measured strains to analytically predicted strains, thus verifying the analytical models. TWR-64835 analytically determined the joint stress ratios between proof test and flight meet or exceed the 1.05 proof factor requirement. TWR-16873 verifies that safe-life requirements are met. For all joint locations it was shown that safe-life is met by proof test, magnetic particle, and eddy current inspections.
598	B,C	34. The insulation database with preflight and postflight measurements through RSRM-75 was used to determine median and M+3 sigma values for insulation material decomposition depths per TWR-74365.

9.2 TEST AND INSPECTION:

DCN	FAILURE CAUSES and TESTS (T)			CIL CODE
		1.	For New Insulated Segment Assembly (Forward, Center, Aft) verify:	
A		a.	Environmental history for insulation	AFK086,AFK068A,AKZ006C,ALH022B
A		b.	Stock number is recorded for insulation	AKZ025B,ALH068AH,ALH068B,ALH068C
A		c.	Adhesive primer is used	AMR045,AMR045D,AMR045E
A		d.	Bonding agent is used	AMX016,AMX016D,AFE082N
A		e.	Lot number is recorded for insulation	ALH067A,ALH067B,ALH067C,ALH067AB
A		f.	Storage life is acceptable for adhesive primer	AFK185B,AMR048D,AMX019
A		g.	Storage life is acceptable for bonding agent	AFE082S,AFI162,AMX018
A		h.	Storage life is acceptable for insulation	AFG135H,AFI118,AKZ038C,ALH097C
A		i.	Adhesive primer is properly mixed and acceptable for application	AFK185FA,AFK185FD,AFK185FG
A		j.	Bonding agent is properly mixed and acceptable for application	AFK185FB,AFK185FE,AFK185FI
B,F	(T)	k.	Results of Chemlok-to-Case Insulation bondline integrity tests with witness panels per current engineering specification	AOX014,AOX015,AOX016
A		l.	Component temperatures and exposure to ambient environments during in-plant transportation or storage	BAA018,BAA019,BAA020
C,E,F	(T)	m.	Insulation thickness by ultrasonics	AFG171,AFI186,AFK214
C,F		n.	5U NBR insulation lay up is acceptable	AFK145B,AHP000,AHQ001
D,E,F		o.	Primed surfaces are acceptable	AFG038,AFI110C,AFK120F
D,E,F		p.	Adhesive surfaces are acceptable	AFG038A,AFI110A,AFK120E
D,E,F		q.	Contamination is removed from case prior to insulation lay up	AFG051,AFI057,AFK061B
D,E,F		r.	Insulation is uniform in appearance and free of surface contamination per specifications	AFG052,AFI084,AFK062
D		s.	No unacceptable surface defects in cured NBR	AFG067,AFI211,AFK078
D,E		t.	Blacklight inspection is performed to verify all contamination which fluoresces is removed	AFG034,AFI036,AFK033
D		u.	All tools and in-process materials are accounted for after insulation lay up	AFG006,AFI114,AFK206
E,F	(T)	v.	Insulation-to-case bond by ultrasonics in the factory joint region	AFI107A,AFI107,AFK117
E,F		w.	Trapped air bubbles in the insulation do not exceed spec requirements	AFG102,AFI155,AFK172
F		x.	Insulation cure cycle is complete and acceptable	AFG086,AFI099,AFK110
F		y.	Proper application of Teflon tape	AFG144,AFI173,AFK194
F		z.	Vacuum bags evacuated and checked for leaks	AFG177,AFI160,AFK181
F		aa.	Solid core thermocouple leads are installed through the putty	AFG147,AFI178,AFK199
F		ab.	Thermocouple leads are working throughout the cure cycle	AFG149,AFI180,AFK201
F		ac.	Black discoloration or darkening of cured NBR is acceptable	AFG002,AFI002,AFK002
		2.	For New Barrel Assembly, Coated verify:	
A		a.	Storage life is acceptable for bonding agent	AFK185F
A		b.	Bonding agent is properly mixed and acceptable for application	AFK185FH
A		c.	Adhesive primer is properly mixed and acceptable for application	AFK185FM
A		d.	Adhesive primer is used	AMR045F
A		e.	Storage life is acceptable for adhesive primer	AMR048

A		f.	Bonding agent is used	AMX016E
D,E,F		g.	Primed surfaces meet requirements	AFK120
D,E,F		h.	Adhesive surfaces meet requirements	AFK120A

3. For Retest NBR, verify:

A,B	(T)	a.	Mooney viscosity	ALH049
A,B	(T)	b.	Scorch characteristics	ALH087

4. For New Case Assembly, Painted Forward Segment, verify:

A		a.	Storage life is acceptable for adhesive primer	RAA214
A		b.	Storage life is acceptable for bonding agent	RAA215
A		c.	Adhesive primer is properly mixed and acceptable for application	RAA216
A		d.	Bonding agent is properly mixed and acceptable for application	RAA217
A		e.	Adhesive primer is used	RAA218
A		f.	Bonding agent is used	RAA219
D,E		g.	Blacklight inspection is performed to verify all contamination that fluoresces is removed	RAA222
D,E,F		h.	Primed surfaces meet the requirements per engineering	RAA223
D,E,F		i.	Adhesive surfaces meet the requirements per engineering	RAA224

5. For New NBR, verify:

B	(T)	a.	Shore A hardness (calendered only)	ALH098,ALH109,ALH102
B	(T)	b.	Elongation (calendered only)	ALH062,ALH065,ALH010
B	(T)	c.	Tensile strength (calendered only)	ALH149,ALH154,ALH147
B	(T)	d.	Specific gravity (calendered only)	ALH121,ALH126,ALH118
B		e.	Material workmanship including uniform appearance and free from contamination	ALH168
B	(T)	f.	Mooney viscosity (extrusions only)	ALH041,ALH046,ALH170
B	(T)	g.	Scorch characteristics (extrusions only)	ALH081,ALH086,ALH171
D		h.	Certificate of Conformance	ALH006

6. For New Adhesive Primer, verify:

B	(T)	a.	Solids content	AMR059,AMR067
B	(T)	b.	Density	AMR006,AMR012
B	(T)	c.	Viscosity	AMR083,AMR092
B	(T)	d.	Peel adhesion	AMR026,AMR022
B		e.	Workmanship	AMR041
D		f.	Certificate of Conformance is complete and acceptable	AMR002

7. For New Bonding Agent, Rubber-to-Metal verify:

B	(T)	a.	Specific gravity	AMX027,AMX029
B	(T)	b.	Viscosity	AMX039,AMX040
B	(T)	c.	Peel adhesion strength	AMX006,AMX010
B	(T)	d.	Solids content	AMX021,AMX023
D		e.	Certificate of Conformance is complete and acceptable	AMX000

8. For New Teflon Tape, verify:

B,D		a.	Certificate of Conformance is complete and acceptable	AJC001

9. For New Methyl Chloroform, verify:

B,D		a.	Certificate of Conformance is complete and acceptable	AJJ007

		10.	For New Loaded Segment Assembly (Forward, Center, Aft) verify:	
D,E,F	(T)	a.	Results of radiographic inspections per engineering	AFF058,AFH060,AFJ046
		11.	For New Adhesive Rubber-to-Metal, verify:	
D		a.	Certificate of Conformance is complete and acceptable	AND001