

CRITICAL ITEMS LIST (CIL)

No. 10-01-02-03R/01

SYSTEM:	Space Shuttle RSRM 10	CRITICALITY CATEGORY:	1
SUBSYSTEM:	Case Subsystem 10-01	PART NAME:	Insulation (1)
ASSEMBLY:	Propellant, Liner, Insulation, Inhibitor 10-01-02	PART NO.:	(See Section 6.0)
FMEA ITEM NO.:	10-01-02-03R 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:	214-1ff.	HAZARD REF.:	BC-09, BC-10
DATED:	17 Jun 2002		
CIL ANALYST:	S. E. Rodgers		
APPROVED BY:		DATE:	
RELIABILITY ENGINEERING:	<u>K. G. Sanofsky</u>		<u>04 Feb 2003</u>
ENGINEERING:	<u>L. D. Allred</u>		<u>04 Feb 2003</u>

- 1.0 FAILURE CONDITION: Failure during operation (D)
- 2.0 FAILURE MODE: 1.0 Fails to provide thermal protection
- 3.0 FAILURE EFFECTS: Insufficient or defective internal insulation (asbestos NBR or carbon fiber EPDM) exposes the motor case to propellant combustion gas causing loss of the RSRM and SRB. Loss of TVC, detonation of the LSC, or loss of other SRB functions would result in loss of crew and vehicle

4.0 FAILURE CAUSES (FC):

FC NO.	DESCRIPTION	FAILURE CAUSE KEY
1.1	Improper handling, application, or cure cycle	A
1.2	Nonconforming material properties	B
1.3	Pin holes or ply separations	C
1.4	Voids or inclusions	D
1.5	Age degradation, storage, transportation, and handling	E
1.6	Thin spot or insufficient material thickness	F

CRITICAL ITEMS LIST (CIL)

No. 10-01-02-03R/01

DATE: 04 Feb 2003
 SUPERSEDES PAGE: 214-1ff.
 DATED: 17 Jun 2002

5.0 REDUNDANCY SCREENS:

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

6.0 ITEM DESCRIPTION:

1. Insulation (NBR and EPDM) for forward, center and aft Internal and External Insulated Segments is shown in (Figures 1, 2, and 3). Materials are listed in Table 1.

TABLE 1. MATERIALS

Drawing No.	Name	Material	Specification	Quantity
	Insulation	Acrylonitrile Butadiene Rubber (NBR)	STW4-2621	17,000 lb/Motor
	Forward Segment	Filler Extrusion (NBR)	STW4-2621 TP I	(ALTERNATE)
	Insulation	NBR Extrusion	STW4-2535	7 lb/Motor
	Insulation	NBR Extrusion	STW4-2621 TP VI	(ALTERNATE)
	Insulation	NBR Extrusion	STW4-2531	14 lb/Motor
	Insulation	NBR Extrusion	STW4-2621 TP II	(ALTERNATE)
	Insulation	NBR Extrusion	STW4-3443	14 lb/Motor
	Insulation	NBR Extrusion	STW4-2621 TP V	(ALTERNATE)
	Insulation	NBR Extrusion	STW4-3442	21 lb/Motor
	Insulation	NBR Extrusion	STW4-2621 TP IV	(ALTERNATE)
	Insulation	Carbon Fiber-Filled Ethylene Propylene Diene Monomer (EPDM) Extrusion (NBR)	STW4-2868	98 lb/Motor
	Insulation	Extrusion (NBR)	STW4-2545	2 lb/Motor
	Bonding agent	(Chemlok 236A)	STW4-2621 TP III	(ALTERNATE)
	Bonding Agent	(Chemlok 233)	STW5-2798	11 qt/Motor
	Primer	(Chemlok 205)	STW5-2712	12 gl/Motor
	Tape	Teflon	STW5-2664	8 gl/Motor
	FEP	Plastic Film	MIL-I-23594 (Type I)	8 rl/Motor
			ASTM D 3368-81 (Type II, CI I)	23 lb/Motor
1U77502	Barrel Assembly, Coated			1 ea/Motor
1U76673	Aft Dome, Insulated			1 ea/Motor

6.1 CHARACTERISTICS:

1. Primary case insulation is composed of acrylonitrile butadiene rubber (NBR) impregnated with asbestos and silicon dioxide fillers. Another insulating compound used in lesser quantities is carbon fiber-filled ethylene propylene diene monomer (EPDM). NBR material must meet engineering requirements, standards, and specifications. EPDM adhesives, primers, vacuum putty, and similar materials comply with engineering suiting their respective categories.
2. The main function of internal insulation is to protect the RSRM case from high-temperature gases and erosion created by burning propellant. Calendared raw material is available in several thicknesses. This material is supplied on rolls so it can be applied in layers to a specified depth on the inside of the case and around joint areas. This material requires vulcanization prior to propellant casting.
3. The integrity of internal insulation was demonstrated by Evaluation Test Motor ETM-1A and Development Motors DM-6 and DM-7. Insulation qualification was demonstrated by Qualification Motors QM-4 and QM-6, and flights SRM-8 through SRM-24.



CRITICAL ITEMS LIST (CIL)

No. 10-01-02-03R/01

DATE: 04 Feb 2003
SUPERSEDES PAGE: 214-1ff.
DATED: 17 Jun 2002

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

CRITICAL ITEMS LIST (CIL)

No. 10-01-02-03R/01

DATE: 04 Feb 2003
 SUPERSEDES PAGE: 214-1ff.
 DATED: 17 Jun 2002

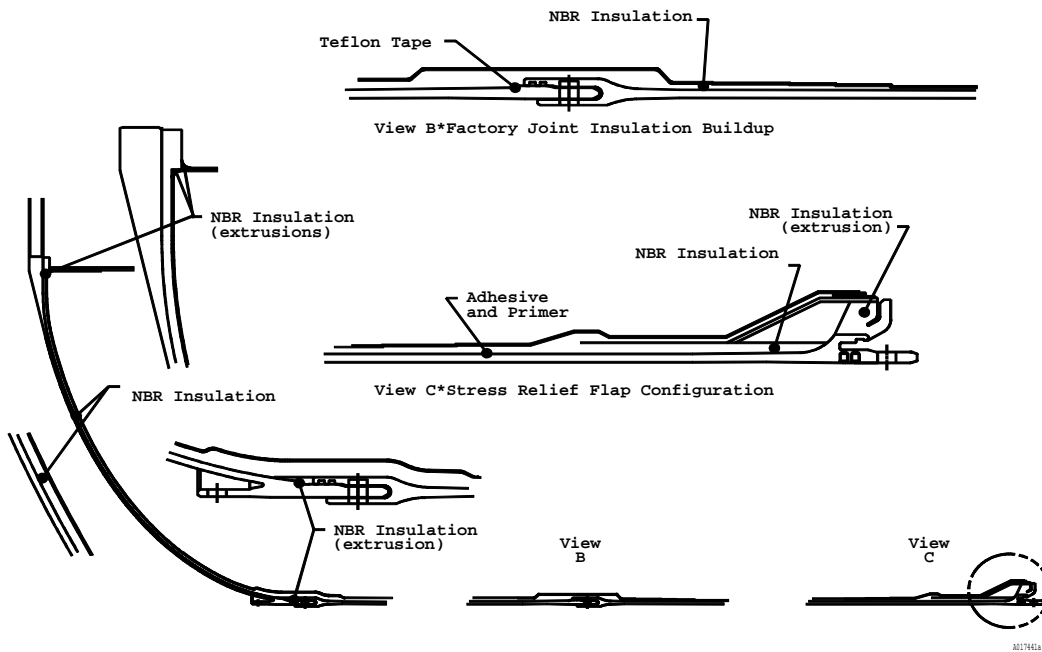


Figure 1. Forward Segment Insulation Configuration

CRITICAL ITEMS LIST (CIL)

No. 10-01-02-03R/01

DATE: 04 Feb 2003
SUPERSEDES PAGE: 214-1ff.
DATED: 17 Jun 2002

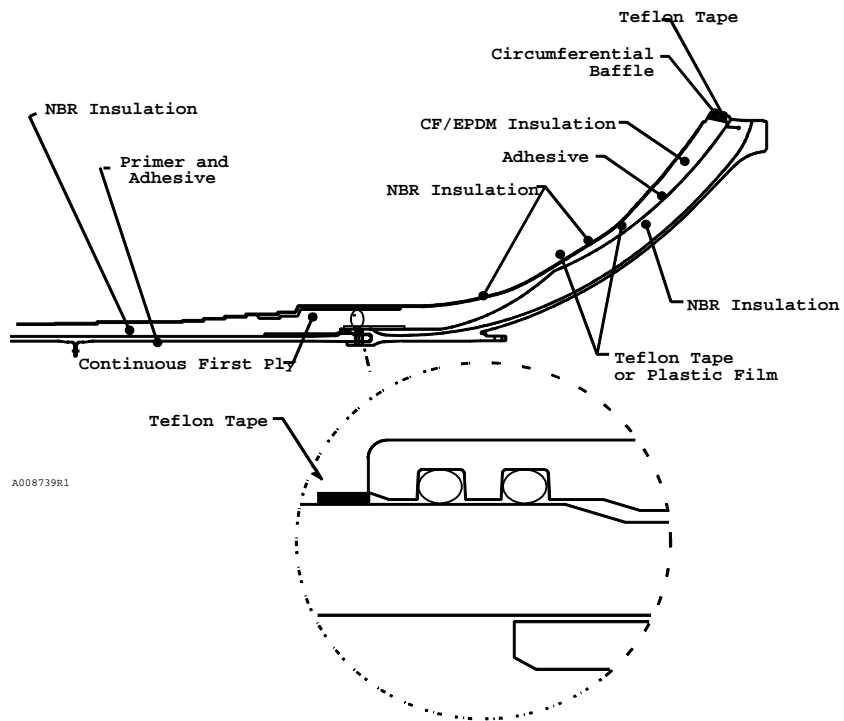


Figure 2. Aft End Insulation in Aft Segment

CRITICAL ITEMS LIST (CIL)

No. 10-01-02-03R/01

DATE: 04 Feb 2003
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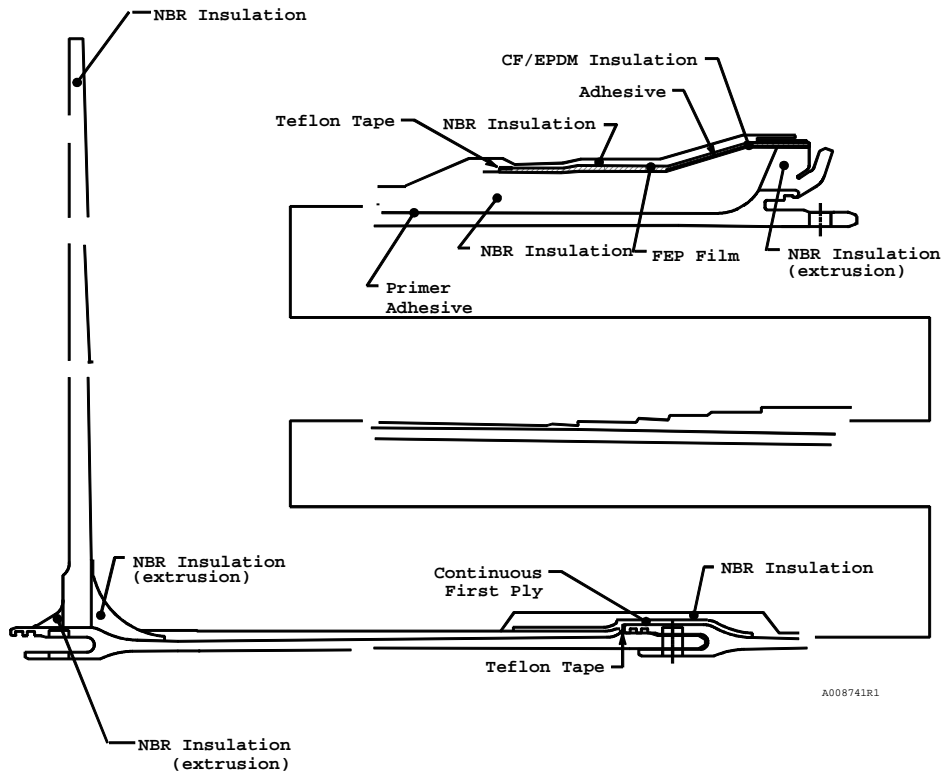


Figure 3. Center Segment Insulation

CRITICAL ITEMS LIST (CIL)

No. 10-01-02-03R/01

DATE: 04 Feb 2003
 SUPERSEDES PAGE: 214-1ff.
 DATED: 17 Jun 2002

9.0 RATIONALE FOR RETENTION:

9.1 DESIGN:

DCN FAILURE CAUSES

- | | | |
|-------|-----|--|
| A | 1. | Insulation materials received are subject to handling, storage, and use as prescribed by engineering. |
| A | 2. | Application of insulating material to the case segments is designated a "critical process" per shop planning. This provides for stricter controls during fabrication and inspection for the following: <ul style="list-style-type: none"> a. Internal case segment and aft dome insulation, including application, thickness, and number of plies, is controlled by engineering drawings. b. Engineering drawings and shop planning provide for dimensional data and configuration control of the insulation lay up in the aft dome. |
| A | 3. | 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 | 4. | Primer and adhesive application is per shop planning. |
| A,F | 5. | Contamination control requirements and procedures are described in TWR-16564. |
| A | 6. | Teflon tape is used for stress relief per TWR-17103. |
| A | 7. | Approved solvent is used on the insulation as a tackifier per engineering drawings. |
| A | 8. | Plastic film is used during insulation lay up to help create a stress relief flap per engineering drawings. |
| 598 B | 9. | Cured NBR properties are specified by engineering. |
| B | 10. | Insulation material (EPDM) properties conform to engineering drawing requirements. |
| B | 11. | Insulation adhesive primer and bonding agent material properties conform to and are qualified to engineering requirements. |
| B | 12. | Approved solvent conforms to engineering requirements. |
| B | 13. | Teflon tape conforms to engineering requirements. |
| B | 14. | Plastic film conforms to engineering requirements. |
| B | 15. | DM-8, DM-9, and QM-6 were static test fired to evaluate the performance of accepted insulation. |
| C,D,F | 16. | Internal case segment and aft dome insulation, including application, thickness, and number of plies, is controlled by engineering drawings. |

CRITICAL ITEMS LIST (CIL)

No. 10-01-02-03R/01

DATE: 04 Feb 2003
 SUPERSEDES PAGE: 214-1ff.
 DATED: 17 Jun 2002

- C,D 17. NBR insulation material specifications specify the tests to be performed to certify the quality of material procured and qualification tested for use on both case wall and forward inhibitor and documented in TWR-12646.
- C,D 18. Engineering material specifications specify tests to be performed to certify material quality for bonding agents and adhesive primers.
- C,D 19. Manufacturing drawings specify the proper lay up, number of plies, and correct dimensions of the insulation application.
- C,D 20. Acceptance criteria for insulation voids, inclusions, ply separations, and pin holes are specified by engineering drawings.
- E 21. Unvulcanized insulation material storage life and temperature limits, prior to lay up on the component, are specified by engineering. Storage life may be extended if, after retest, the material conforms to engineering.
- E 22. The RSRM and its components are protected by passive means against natural environments during transportation and handling per engineering drawings.
- E 23. Railcar transportation shock and vibration levels for the segments are monitored as required per engineering with loads derived per analyses. Monitoring records are evaluated by Thiokol to verify that shock and vibration levels defined per MSFC Specifications were not exceeded.
- E 24. 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 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.
- E 25. Cradling or support devices and tie downs that conform to the shape, size, weight, and contour of the component to be transported are used 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.
- E 26. Support equipment used to test, handle, transport, assemble, or disassemble the RSRM is certified and verified per Thiokol IHM 29.
- E 27. 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.
- E 28. Preservation and packaging of thermal insulation is to prevent exposure to direct sunlight, ultraviolet radiation, or ozone as established by engineering drawings.
- E 29. 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 30. 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.

CRITICAL ITEMS LIST (CIL)

No. 10-01-02-03R/01

DATE: 04 Feb 2003
 SUPERSEDES PAGE: 214-1ff.
 DATED: 17 Jun 2002

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| E | 31. 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. |
| F | 32. Manufacturing drawings specify the proper lay up, number of plies, and correct dimensions of insulation application. |
| A,B | 33. 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. |
| E,F | 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. |
| B | 35. All new RSRM case segments are hydroproof tested three times followed by magnetic particle inspection per engineering. The final hydroproof and magnetic particle inspection 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, F | 36. Insulation design thickness is sufficient to meet the various design criteria, including thermal safety factor requirements, per TWR-18133. |
| 598 B,F | 37. The insulation database with preflight and postflight measurements through RSRM-75 was used to determine median and M+3 sigma material decomposition depth values for the insulation per TWR-74365. |

CRITICAL ITEMS LIST (CIL)

No. 10-01-02-03R/01

DATE: 04 Feb 2003
 SUPERSEDES PAGE: 214-1ff.
 DATED: 17 Jun 2002

F A,C,D		af. Adhesive surfaces are per engineering	AFG038A,AFI110A,AFK120E
		ag. Contamination is removed from case prior to insulation lay up	AFG051,AFI057,AFK061B
		2. For New Insulated Segment Assembly (Forward) verify:	
A,B	(T)	a. Results of Chemlok-to-Forward Dome Insulation bondline integrity tests with witness panels per engineering	AOX029
		3. For New Insulated Aft Dome verify:	
A,C,D		a. 5U NBR insulation lay up is complete and acceptable	AFK145C
A		b. Solid core thermocouple leads are installed through the putty	AFK199A
A		c. Thermocouple leads are working throughout the cure cycle	AFK201A
A		d. Full coverage of adhesive primer	AFK022B
A		e. Full coverage of bonding agent	AFK024B
A		f. Full coverage of rubber-to-metal adhesive	AFK024C
A		g. Air dry of adhesive primer	AFK022C
A		h. Air dry of bonding agent	AFK024D
A		i. Air dry of rubber-to-metal adhesive	AFK024E
A		j. Blacklight inspection is performed to verify all contamination that fluoresces is removed	AFK033A
C,D		k. No unacceptable surface defects in cured NBR	AFK078C
C,D		l. Contamination is removed from dome prior to insulation lay up	AFK061A
C,D		m. All tools and in-process materials are accounted for after insulation lay up	AFK206A
E		n. Environmental history for insulation	AMX019B,AMX019D
E		o. Stock number is recorded for insulation	AMX019AC,AMX019AE
E		p. Adhesive primer is used	AMX019AF
E		q. Bonding agent is used	AMX019AG
E		r. Rubber-to-metal adhesive is used	AMX019AI
E		s. Lot number is recorded for insulation	AMX019AH,AMX019AJ
E		t. Storage life is acceptable for adhesive primer	AMX019AK
E		u. Storage life is acceptable for bonding agent	AMX019AL
E		v. Storage life is acceptable for insulation	AMX019AM,AMX019AP
E		w. Storage life is acceptable for rubber-to-metal adhesive	AMX019AN
E		x. Adhesive primer is properly mixed and acceptable for application	AFK185FJ
E		y. Bonding agent is properly mixed and acceptable for application	AFK185FK
E		z. Rubber-to-metal adhesive is properly mixed and acceptable for application	AFK185FL
A,B	(T)	aa. Results of Chemlok-to-Case Insulation bondline integrity tests with witness panels per engineering	AOX017
A,B	(T)	ab. Results of NBR insulation-to-EPDM insulation bondline integrity tests with witness panels for the Aft Dome per engineering	AOX027
A,B	(T)	ac. Results of insulation-to-insulation bondline integrity tests with witness panels for the Aft Dome per engineering	AOX028
F		ad. Primed surfaces meet spec requirements	MAA220
F		ae. Adhesive surfaces meet spec requirements	MAA221
F		af. Insulation thickness using template	AFK214AB
C,D		ag. Insulation is uniform in appearance and free of surface contamination per specifications	AFK062A
		4. For New Barrel Assembly, Coated verify:	
A		a. Full coverage of adhesive primer	AFK022A
A		b. Full coverage of bonding agent	AFK024A
A		c. Air dry of adhesive primer	AFK068
A		d. Air dry of bonding agent	AFK072A

CRITICAL ITEMS LIST (CIL)

No. 10-01-02-03R/01

DATE: 04 Feb 2003
 SUPERSEDES PAGE: 214-1ff.
 DATED: 17 Jun 2002

A		e.	Blacklight inspection to verify all contamination which fluoresces is removed	AFK033B
E		f.	Adhesive primer is used	AMR045F
E		g.	Bonding agent is used	AMX016E
E		h.	Storage life is acceptable for adhesive primer	AMR048
E		i.	Storage life is acceptable for bonding agent	AFK185F
E		j.	Adhesive primer is properly mixed and acceptable for application	AFK185FM
E		k.	Bonding agent is properly mixed and acceptable for application	AFK185FH
F		l.	Primed surfaces meet requirements	AFK120
F		m.	Adhesive surfaces meet requirements	AFK120A
5. For New Teflon Tape, verify:				
A,B		a.	Certificate of Conformance is complete and acceptable	AJC001
6. For New Approved Solvent, verify:				
A,B		a.	Certificate of Conformance is complete and acceptable	AJJ007A
7. For New Case Assembly, Painted Forward Segment, verify:				
A		a.	Air dry of adhesive primer	RAA220
A		b.	Air dry of bonding agent	RAA221
A		c.	Blacklight inspection is performed to verify all contamination that fluoresces is removed	RAA222
A		d.	Full coverage of adhesive primer	RAA225
A		e.	Full coverage of bonding agent	RAA226
E		f.	Storage life is acceptable for adhesive primer	RAA214
E		g.	Storage life is acceptable for bonding agent	RAA215
E		h.	Adhesive primer is properly mixed and acceptable for application	RAA216
E		i.	Bonding agent is properly mixed and acceptable for application	RAA217
E		j.	Adhesive primer is used	RAA218
E		k.	Bonding agent is used	RAA219
F		l.	Primed surfaces are per engineering	RAA223
F		m.	Adhesive surfaces are per engineering	RAA224
8. For New NBR verify:				
B	(T)	a.	Mooney viscosity	ALH041,ALH046
B	(T)	b.	Elongation	ALH062,ALH065
B	(T)	c.	Scorch characteristics	ALH081,ALH086
B	(T)	d.	Shore A hardness	ALH098,ALH109
B	(T)	e.	Specific gravity	ALH121,ALH126
B	(T)	f.	Tensile strength	ALH149,ALH154
9. For New EPDM, carbon fiber-filled, verify:				
B	(T)	a.	Elongation	AKZ019C,AKZ022C,ALV001
B	(T)	b.	Fiber content	ALV007
B	(T)	c.	Filler content	ALV028
B	(T)	d.	Mooney viscosity	MKL025
B		e.	Roll weight	ALV009
B	(T)	f.	Scorch characteristics	MKL024
B		g.	Shipping time and environment	ALV005
B	(T)	h.	Shore hardness	AKZ040C,AKZ045C,ALV011
B	(T)	i.	Specific gravity	AKZ046C,AKZ050C,ALV014
B	(T)	j.	Tensile strength	AKZ055C,AKZ059C,ALV021
B	(T)	k.	Volatile content	ALV031
B	(T)	l.	Weight per square foot	ALV033

CRITICAL ITEMS LIST (CIL)

No. 10-01-02-03R/01

DATE: 04 Feb 2003
 SUPERSEDES PAGE: 214-1ff.
 DATED: 17 Jun 2002

B		m.	Width of uncured stock	ALV038
		10.	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
		11.	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
		12.	For Retest NBR, verify:	
B,E	(T)	a.	Mooney viscosity	ALH049
B,E	(T)	b.	Scorch characteristics	ALH087
		13.	For New Adhesive, Rubber-to-Metal verify:	
B		a.	Solids content	AND028,AND026
B		b.	Specific gravity	AND033,AND036
B		c.	Viscosity	AND046,AND044
B		d.	Peel strength, rubber-to-steel	AND014,AND009
B		e.	Workmanship	FAA842
		14.	For New Plastic Film, verify:	
B	(T)	a.	Tensile resistance	AIN011
B	(T)	b.	Tear strength	AIN007
B	(T)	c.	Dielectric strength	AIN002
		15.	For New Loaded Segment Assembly (Forward, Center, Aft) verify:	
C,D,E	(T)	a.	Results of radiographic inspections per engineering	AFF058,AFH060,AFJ046
E		b.	Component temperatures and exposure to ambient environments during in-plant transportation or storage are acceptable	BAA008,BAA009,BAA010
		16.	KSC verifies:	
C		a.	Propellant relief flap and insulation (inboard and outboard of the flap gap) is free of defects per OMRSD, File V, Vol I, B47SG0.031.	OMD076