ATK ALLIANT TECHSYSTEMS
THIOKOL PROPULSION

CRITICAL ITEMS LIST (CIL)

No. 10-02-01-34R/01

SYSTEM:	Space Shuttle RSRM 10	CRITICALITY CATEGORY:	1
SUBSYSTEM:	Nozzle Subsystem 10-02	PART NAME:	Fixed Housing-to-Aft End Ring Joint, Rubber & Phenolic Components (1)
ASSEMBLY:	Nozzle & Aft Exit Cone 10-02-01		
FMEA ITEM NO.:	10-02-01-34R Rev M	PART NO.:	(See Section 6.0)
CIL REV NO.:	M (DCN-533)	PHASE(S):	Boost (BT)
DATE:	10 Apr 2002	QUANTITY:	(See Section 6.0)
SUPERSEDES PAGE:	338-1ff.	EFFECTIVITY:	(See Table 101-6)
DATED:	31 Jul 2000	HAZARD REF.:	BN-03
CIL ANALYST:	B. A. Frandsen		
APPROVED BY:		DATE:	

RELIABILITY ENGINEERING: K. G. Sanofsky 10 Apr 2002

ENGINEERING: B. H. Prescott 10 Apr 2002

1.0 FAILURE CONDITION: Failure during operation (D)

2.0 FAILURE MODE: 1.0 Thermal failure

3.0 FAILURE EFFECTS: Loss of thermal barrier. Breakup and expulsion of the nozzle causing loss of RSRM, SRB, crew, and vehicle

4.0 FAILURE CAUSES (FC):

FC NO.	DESCRIPTION	FAILURE CAUSE KEY
1.1	Porosity, voids, de-laminations, inclusions, or cracks	A
1.2	Assembly or handling damage of the flex bearing protector and inner boot ring	B
1.3	Nonconforming joint interface dimensions	C

5.0 REDUNDANCY SCREENS:

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

6.0 ITEM DESCRIPTION:

1. Fixed housing-to-aft end ring joint, rubber/phenolic components (Figure 1). Materials are listed in Table 1.

TABLE 1. MATERIALS

Drawing No.	Name	Material	Specification	Quantity
1U79153	Nose-Throat-Bearing-Cowl-Housing Assy, Nozzle			1/motor
1U79149	Nose-Throat-Bearing-Cowl Assembly, Nozzle			1/motor
1U79148	Housing Assembly, Cowl			1/motor
1U51130	Bearing Protector, Flexible			1/motor
	Flexible Bearing Protector	Product Specification	STW3-3458	1/motor
1U76608	Boot, Flexible Bearing			1/motor
1U52833	Aft End Ring			1/motor
5U76608	Boot Ring Phenolics	Glass-Cloth Phenolic	STW5-2651	40 lbs.
	Flexible Bearing Boot (Test)	Phenolic Rings	STW3-3457	2/motor
1U79151	Housing & Boot Assembly, Nozzle			1/motor
1U76609	Cowl, Nozzle			1/motor
1U79150	Housing Assembly, Nozzle Fixed			1/motor
		Glass-Cloth Phenolic	STW5-2651	265 lbs.
1U52838	Housing Assembly, Cowl, Nozzle			1/motor
		Silicone Rubber	STW5-2738	A/R

6.1 CHARACTERISTICS:

1. The fixed housing assembly consists of a conical steel shell insulated with carbon and glass cloth phenolics. It extends from the aft case to the aft end, and is the primary support structure for the nozzle assembly. The fixed housing interfaces with the aft dome boss and provides dual O-ring seals to ensure positive sealing of this critical surface. A pressure port between the two seal locations allows pressure testing of both seals after installation of the forward nozzle assembly on the aft motor segment.

2. The aft end ring is part of the flex bearing that provides omni-directional thrust-vector control capability. End rings absorb applied loads while simultaneously controlling bearing motion during vectoring.

3. The fixed housing assembly is attached to the aft end ring by a bolted joint. The joint interface is between the flex bearing protector and inner boot ring.

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

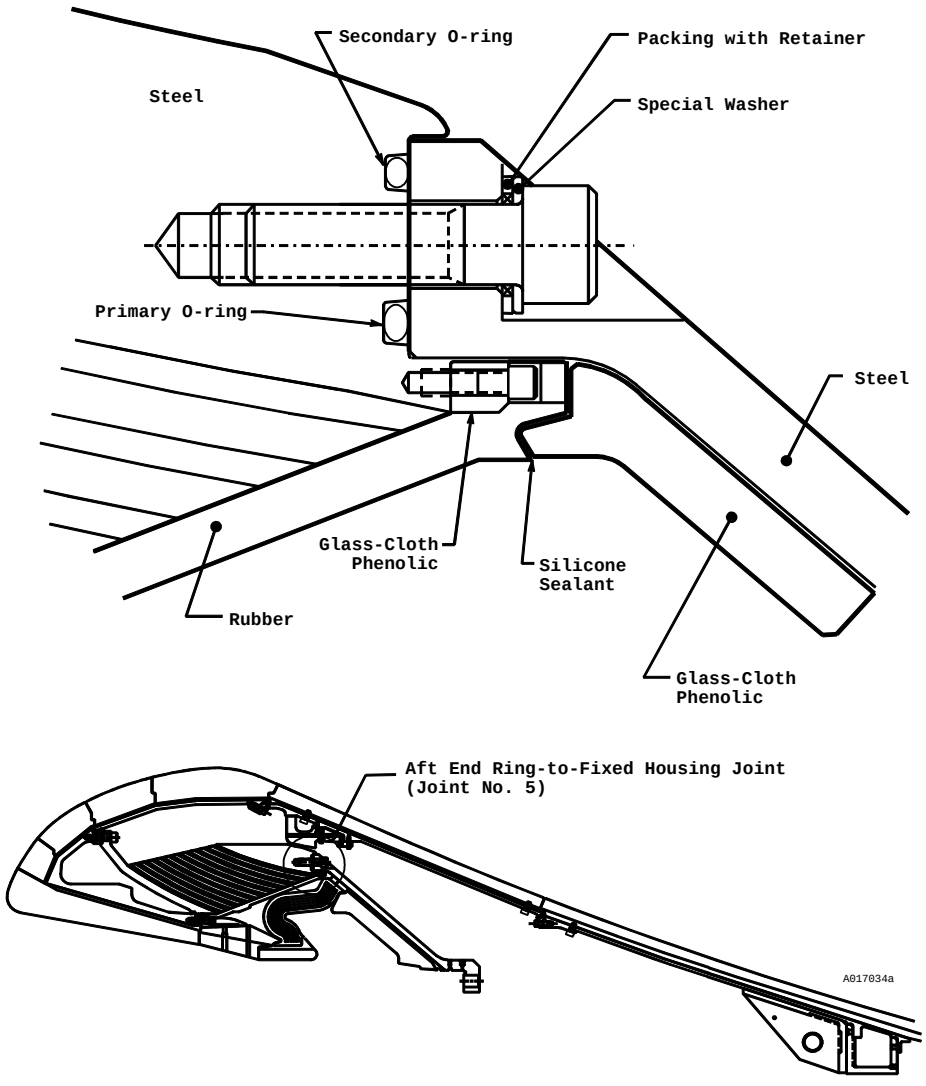

Figure 1. Fixed Housing-to-Aft End Ring Joint

9.0 RATIONALE FOR RETENTION:

9.1 DESIGN:

DCN	FAILURE CAUSES		
	A	1.	Glass-Cloth Phenolic material is used as an insulator per engineering.
	A	2.	Silicone rubber compound is used as an insulator and conforms to material specifications for Compound, Silicone per engineering.
	A	3.	The inner boot ring of the Boot, Flexible Bearing Nozzle is fabricated of glass-cloth phenolic by tape wrapping over a mandrel. After wrapping, the billet is vacuum-bagged, autoclave-cured, and final machined. Processes and dimensions are per engineering drawings and shop planning.
	A	4.	The Bearing Protector, Flexible is fabricated of silicone rubber and controlled by molding tooling per engineering drawings.
	A	5.	Surface and subsurface defect criteria rationale are per TWR-16340.
533	A,C	6.	Thermal analysis per TWR-17219 shows the nozzle phenolic meets the new performance factor equation based on the remaining virgin material after boost phase is complete. This performance factor will be equal to or greater than a safety factor of 1.4 for the fixed housing assembly per TWR-74238 and TWR-75135. (Carbon phenolic-to-glass interface, bondline temperature and metal housing temperatures were all taken into consideration). The new performance factor will insure that the CEI requirements will be met which requires that the bond between carbon and glass will not exceed 600 degree F, bondline of glass-to-metal remains at ambient temperature during boost phase, and the metal will not be heat affected at splashdown.
	B	7.	Proper alignment of parts is controlled by tolerances established per engineering drawings and shop planning.
	B,C	8.	The bond gap between the fixed housing and the inner boot ring is established using pre-cured shims made from epoxy adhesive, and installed at locations to be determined from dry-fit of mating parts per engineering drawings.
	B	9.	Joint gaps are controlled by dry-fitting the cowl housing with the cowl, flexible boot, nozzle. By means of shop handling equipment, a bonding fixture, impression compounds, and shims, proper bond gaps are determined. Size, number, and location of shims are per engineering drawings and shop planning. Joint gap between the housing assembly, cowl and the nose-throat-bearing cowl assembly is per engineering drawings.
	B	10.	Bolt torque and tightening sequence of the housing and boot assembly, nozzle and nose-throat-bearing-cowl assembly, nozzle is per engineering drawings and shop planning.
	B	11.	Requirements for handling RSRM components during assembly and transportation are similar to those for previous and other current programs at Thiokol. Proof testing is required for all lifting and handling equipment per TWR-13880.
	B	12.	Assembly and handling operations are per shop planning and IHM 29.
	B	13.	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 is per engineering.

C 14. Flex bearing protector envelope dimensions are mold controlled per engineering drawings.

C 15. The bond gap between the bearing protector, flexible and inner boot ring of the boot, flexible bearing nozzle is controlled by tolerances for dimensions, profiles, and dry-fit per engineering drawings and shop planning.

C 16. Assembly stresses are minimized as follows:

a. Mating surface flatness is controlled by inspection of machining operations.
b. Threads are cleaned and lubricated prior to assembly.
c. Assembly bolts are torqued in a pre-arranged sequence to preload values.

A,B,C 17. Analysis of carbon-cloth phenolic ply angle changes for the nozzle was performed. Results show that redesigned nozzle phenolic components have a reduced in-plane fiber strain and wedge-out potential per TWR-16975. New loads that were driven by the Performance Enhancement (PE) Program were addressed in TWR-73984. No significant effects on the performance of the RSRM nozzle were identified due to PE.

9.2 TEST AND INSPECTION:

DCN	FAILURE CAUSES and TESTS (T)			CIL CODES
		1.	For New Boot Ring Phenolics verify:	
A	(T)	a.	Radiographics for boot ring	AFM073
A		b.	Alcohol wipe of inner boot ring	AFM004
B,C		c.	Profile of inner ring	AFM001,AFM065
		2.	For New Flexible Bearing Boot (Test) verify:	
A	(T)	a.	Compressive strength (glass)	AFM023
A	(T)	b.	Residual volatiles (glass)	AFM087
A	(T)	c.	Resin content (glass)	AFM094
A	(T)	d.	Specific gravity (glass)	AFM103
		3.	For New Bearing Protector, Flexible verify:	
A	(T)	a.	Elongation stretch test results are acceptable	ABU034
B		b.	Component temperatures and exposure to ambient environments during in-plant transportation or storage	BAA032
C		c.	Acceptability of mold tooling per recycle inspection tag	ABX000
C		d.	Both sides of molded silicone rubber are free of defects after stretch test	ABU042
		4.	For New Bearing Protector Rings verify:	
A,B		a.	For Contamination and damage on ring after drilling	ABU039,ABU039A
		5.	For New Nose-Throat-Bearing-Cowl Housing Assembly, Nozzle verify:	
B		a.	Fixed housing to aft end ring screw torquing sequence	ADQ233
B		b.	Amount of torque used on each fixed housing to aft end ring screw	ADQ262
		6.	For New Boot, Flexible Bearing, Nozzle verify:	
B		a.	Component temperatures and exposure to ambient environments during in-plant transportation or storage	BAA029
		7.	For New Nozzle Fixed Housing Assembly verify:	
B		a.	Component temperatures and exposure to ambient environments during in-plant transportation or storage are per engineering	BAA035
		8.	For New Housing and Boot Assembly, Nozzle verify:	
C		a.	Bondline thickness by Coe-flex impressions	ABW007