

CRITICAL ITEMS LIST (CIL)

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

SYSTEM:	Space Shuttle RSRM 10	CRITICALITY CATEGORY:	1
SUBSYSTEM:	Nozzle Subsystem 10-02	PART NAME:	Flex Bearing Assembly (1)
ASSEMBLY:	Flex Bearing Assembly 10-02-03	PART NO:	(See Section 6.0)
FMEA ITEM NO.:	10-02-03-01R 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:	347-1ff.	HAZARD REF.:	BN-06
DATED:	31 Jul 2000		
CIL ANALYST:	B. A. Frandsen		
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: 3.0 Leakage of flex bearing
- 3.0 FAILURE EFFECTS: Flex bearing burn through and loss of nozzle, causing loss of RSRM, SRB, crew, and vehicle

4.0 FAILURE CAUSES (FC):

FC NO.	DESCRIPTION	FAILURE CAUSE KEY
3.1	Bondline failure of elastomer to metal bond	
3.1.1	Bonding surfaces not properly prepared or adequately cleaned	A
3.1.2	Bonding material not properly mixed, applied, or cured	B
3.1.3	Contamination during processing	C
3.1.4	Process environments detrimental to bond strength	D
3.2	Nonconforming material properties	E
3.3	Component damage or degradation during assembly, storage, handling, or transportation	F

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5.0 REDUNDANCY SCREENS:

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

6.0 ITEM DESCRIPTION:

1. Bearing Assembly, Nozzle Flexible (Figure 1). Materials are listed in Table 1

TABLE 1. MATERIALS

Drawing No.	Name	Material	Specification	Quantity
1U52833	Aft End Ring (may be made from 1U50083)	D6AC Steel Alloy, High Strength	STW4-2709	1/motor
1U52834	Forward End Ring	D6AC Steel	STW4-2709	1/motor
1U50085	Ring, Bearing Assembly Forward	D6AC Steel	STW4-2709	1/motor
1U50097	Shim	D6AC Steel	STW4-2709	10 ea
1U51916	Cartridge (filled with Corrosion-Preventative Compound and O-Ring Lubricant)	Heavy-Duty Calcium Grease	STW5-2942	A/R
1U76888	Pressure Plug	Stainless Steel Type 303 or 304	ASTM A276	1/Flex Brng Assy
1U50228	Packing Preformed	Black Rubber	STW4-3339	1/Flex Brng Assy
AE99310E	Coupling, Bulkhead	Stainless Steel		1/Flex Brng Assy
	Rubber Compound, Natural	Natural Rubber	STW5-2943	A/R
	Adhesive Primer, Rubber-to-Metal, SRM Flex Bearing	Chlorinated Rubber	STW5-2656	A/R
	Adhesive Rubber-to-Metal, SRM Flex Bearing	Chlorinated Rubber	STW5-2657	A/R
	Cement, Natural Rubber Base	Natural Rubber	STW5-2783	A/R
	Adhesive Primer, Rubber-to-Metal	Adhesive Primer	STW5-2664	A/R
	Adhesive, Rubber-to-Metal	Chlorinated Rubber	STW5-2665	A/R
	Coatings, Epoxy-Polyamide	Epoxy and a Polyamide Resin Activator	STW5-3225	A/R
	Primer, Zinc-Rich Epoxy-Polyamide	Pigmented Epoxy Resin Base and a Polyamide Resin Activator	STW5-3226	A/R
	Sealing Compound, Temperature-Resistant, High-Adhesion	Synthetic Rubber	STW5-9072	A/R

6.1 CHARACTERISTICS:

1. The Nozzle Flex Bearing provides capability for the nozzle to vector, that controls flight direction while maintaining internal motor chamber pressures.

7.0 FAILURE HISTORY/RELATED EXPERIENCE:

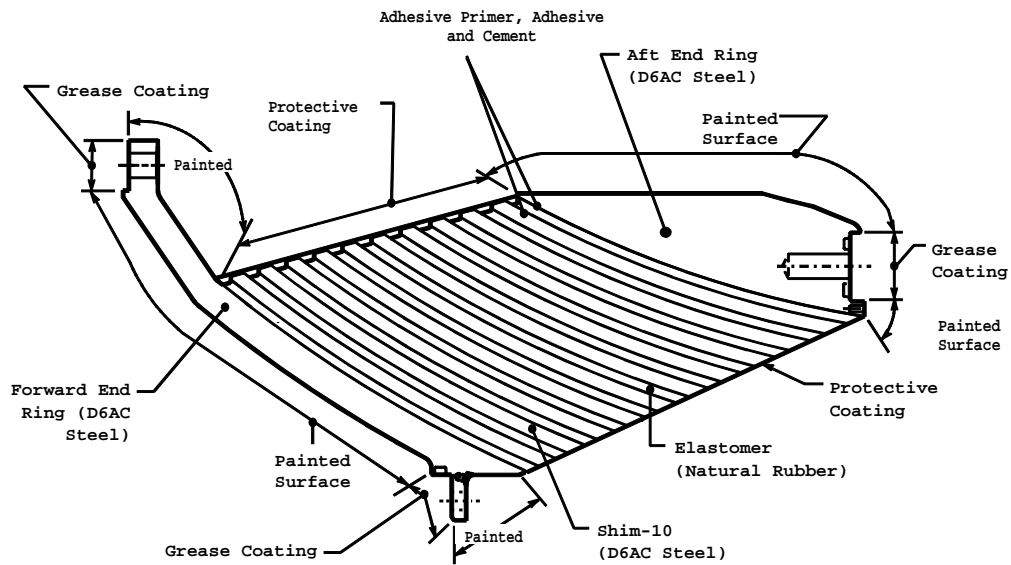
1. Current data on test failures, flight failures, unexplained failures, and other failures during RSRM ground processing activity can be found in the PRACA Database.

8.0 OPERATIONAL USE: N/A

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AD12192a

Figure 1. RSRM Flexible Bearing Assembly

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9.0 RATIONALE FOR RETENTION:

9.1 DESIGN:

DCN FAILURE CAUSES

- | | | |
|-------------|-----|---|
| A,C,D | 1. | Preparation of bonding surfaces (cleanliness and process environments) are controlled as follows: |
| A,C,D | a. | Contamination control requirements and procedures are described in TWR-16564. |
| A,C,D | b. | Preparation and cleaning of bonding surfaces are per shop planning. Surface inspection type is per shop planning. Preparation, cleaning, and inspection methods for the flex bearing protector are identified as process critical planning. |
| A,C,D | 2. | Sensitivity of natural and induced environments of the flex bearing was analyzed and the results indicated per TWR-13880. |
| A,B,C,D,E,F | 3. | Design factor of safety on the RSRM Nozzle Flex Bearing Assembly is 1.4. Analysis performed on the flex bearing showed a positive margin of safety per TWR-16975. |
| B | 4. | The following documents control the mixing, application, and curing of bonding materials: |
| B | a. | Adhesive Primer is mixed and applied per engineering drawings and shop planning. |
| B | b. | Adhesive, Rubber-to-Metal, RSRM Flex Bearing is mixed and applied per engineering drawings and shop planning. |
| B | c. | Cement, Natural Rubber Base is mixed, bonded, and cured to shims and end rings per shop planning. |
| B | d. | Elastomer is applied per engineering drawings and shop planning, and is bonded and cured to shims and end rings per shop planning. |
| B | 5. | Bonding (vulcanizing) of the rubber-to-metal to form the flex bearing is controlled by process specifications containing critical process instructions. |
| E | 6. | Rubber-to-metal adhesive primer bonds meet material engineering requirements. |
| E | 7. | Adhesive, Rubber-to-Metal, RSRM Flex Bearing meets material engineering requirements. |
| E | 8. | Cement, Natural Rubber Base meets material engineering requirements. |
| E | 9. | Elastomer meets material engineering requirements. |
| E | 10. | Qualification of material properties of the adhesive rubber-to-metal, adhesive primer, and cement-natural rubber base, was previously qualified under the initial qualification program for the flex bearing. Further testing of the flex bearing is part of the RSRM nozzle qualification program as documented in TWR-18764-10. |
| F | 11. | Transportation and handling of the Flex Bearing Assembly at Thiokol is controlled per shop planning and IHM 29. |
| F | 12. | The Flex Bearing Assembly is stored out of the nozzle in a cool, dry place. It is protected during storage prior to installation by protective coatings, and stored in a closed container to minimize corrosion, contamination, and exposure to sunlight |

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per engineering.

- F 13. Nozzle Flex Bearing components are designed for storage for 5 years after acceptance per engineering.
- F 14. The design provides for nine further flights with flex bearing reuse acceptance prior to each flight per engineering. Age tracking is provided per the TWR related to the applicable serial number.
- F 15. Bare metal surfaces are coated to provide corrosion protection during storage and useful life per engineering.
- F 16. Shipping links are used to protect and restrain the Nozzle Flex Bearing from moving during transportation as part of the aft shipping segment to the launch site per engineering drawings.
- F 17. 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.
- F 18. The nozzle assembly is shipped in the aft segment. Railcar transportation shock and vibration levels are monitored per engineering and applicable loads are derived by analysis. Monitoring records are evaluated by Thiokol to verify shock and vibration levels per MSFC specification SE-019-049-2H were not exceeded. TWR-16975 documents compliance of the nozzle with environments per MSFC specifications.
- F 19. Aging effect on Nozzle Flex Bearings was evaluated and the predicted aging factor on a 20-year service life determined per TWR-24344.
- F 20. 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 controlled per engineering.
- A 21. A Spray-in-Air cleaning system is used to clean metal components as part of the bonding surface preparation processing sequence per engineering.

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9.2 TEST AND INSPECTION:

<u>DCN</u>	<u>FAILURE CAUSES and TESTS (T)</u>	<u>CIL CODE</u>
	1. For New Bearing Assembly, Nozzle Flexible verify:	
A,C,D	a. Warm up oven is cleaned	BHU100
A,C,D	b. Overhead spray booth doors are closed during spraying operation	BHU101
A,C,D	c. Flex bearing metal parts have been grit blasted prior to assembly	AAI012
A,C,D	d. Bonding surfaces of metal parts are free of contamination prior to primer application	ADJ033
A,C,D	e. Cutting table is clean prior to rubber lay-up	ADJ048
A,B,C,D,E (T)	f. Separations prior to acceptance testing	ADJ052
A,B,C,D,E (T)	g. Separations after acceptance testing	ADJ052B
A,B,C,D (T)	h. Tensile leak test	ADJ064
A,C,D	i. Handling equipment is clean during flex bearing fabrication	ADJ073
A,C,D	j. Hydrothermograph is maintained during entire flexible bearing fabrication	ADJ076
A,C,D	k. No contamination exists on the flexible bearing mold surfaces which contact the flexible bearing and no loose contamination exists on the entire flexible bearing mold. Stains are acceptable on the entire mold	ADJ088
A,C,D	l. Overhead crane oil protection cover is in place during flex bearing fabrication	ADJ096
A,C,D	m. Overhead crane is clean during flex bearing fabrication	ADJ098
A,C,D	n. Rubber lay-up hand tools are clean prior to use	ADJ126
A,C,D	o. Spray booth is free from loose material	ADJ131
A,C,D (T)	p. Thrust relief piston axial deflection test	ADJ141
A,C,D	q. Workmanship	ANC000A
B	r. Adhesive, rubber-to-metal and adhesive primer are mixed prior to use per shop planning	ABT009,ABT010
B	s. Cement, natural rubber base are mixed prior to use per shop planning	ABT011
B	t. Adhesive materials not mixed from different lots	ABT015
B	u. Bonding materials (adhesive, cement, elastomer) used prior to shelf life expiration date	ABT016,ABT017,ABT018
B	v. Adhesive, adhesive primer, or cement is applied	ABT000,ABT001,ABT003
B	w. Cure conforms to planning requirements	ADJ047
F	x. Bearing is stored in a closed container when not in process	ADJ133
F	y. No handling damage prior to installation of bearing hardware	AAI014
F	z. No corrosion prior to assembly	AAI027
F	aa. Component temperatures and exposure to ambient environments during in-plant transportation or storage	BAA033
F	ab. Corrosion-preventive compound (grease) is properly applied to designated areas	ADJ035E
	2. For Refurbished Bearing Assembly, Nozzle Flexible verify:	
F	a. Bearing is stored in a closed container when not in process	ADJ133A
F	b. Component temperatures and exposure to ambient environments during in-plant transportation or storage	BAA033A
F	c. Corrosion-preventive compound is properly applied to designated areas	ADJ035A
	3. For New Rubber Compound, Natural, verify:	
E	a. Cure initiation time	ANP006
A,C,D	b. Cleanliness	ANP007

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E	(T)	c.	Hardness	ANP017
E	(T)	d.	Mooney viscosity	ANP023
E	(T)	e.	Shear modulus	ANP034
E	(T)	f.	Shear strength	ANP046
E	(T)	g.	Specific gravity	ANP053
4. For Re-tested Rubber Compound, Natural, verify:				
E		a.	Cure initiation time	ANP002
E	(T)	b.	Shear modulus	ANP033
E	(T)	c.	Shear strength	ANP043A
5. For New Adhesive Primer, verify:				
E	(T)	a.	Solids content	AMR059,AMR067
E	(T)	b.	Density	AMR006,AMR012
E	(T)	c.	Viscosity	AMR083,AMR092
E	(T)	d.	Peel adhesion	AMP010,AMR026,AMR022
A,C,D,E		e.	Workmanship is uniform appearance and free from visible contamination	AMR041
E		f.	Material is acceptable	AMP032
6. For New Adhesive, Rubber-To-Metal verify:				
E	(T)	a.	Peel adhesion	AMS002
E	(T)	b.	Solids content	AMS015
E	(T)	c.	Specific gravity	AMS025
E	(T)	d.	Viscosity	AMS037
A,C,D		e.	Workmanship is uniform in appearance and free from visible contamination	AMS000
7. For New Cement, Natural Rubber Base verify:				
E	(T)	a.	Solids content	ANC012
E	(T)	b.	Specific gravity	ANC016
E	(T)	c.	Peel strength	ANC004
E	(T)	d.	Shear strength	ANC008
A,C,D		e.	Workmanship	ANC000
8. For Retest Cement, Natural Rubber Base verify:				
E	(T)	a.	Solids content	ANC011
E	(T)	b.	Specific gravity	ANC015
E	(T)	c.	Peel strength	ANC003
E	(T)	d.	Shear strength	ANC007
585		9. For New Approved Solvent, verify:		
A,C,D	a.	Certificate of Conformance is complete and acceptable		AJJ007A
10. For Refurbished Shim verify:				
A,C,D		a.	Corrosion removed	ADJ037B
A,C,D		b.	Shim has no unacceptable contamination	AAI034
F		c.	Corrosion protection is per specification	ADJ035F
11. For New Ring, Bearing Assembly, Forward verify:				

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F		a.	Corrosion protection is per specification	ADF034
		12.	For Refurbished Ring, Bearing Assembly, Forward verify:	
A,C,D		a.	No unacceptable contamination	AAG032
		13.	For Refurbished Aft End Ring verify:	
A,C,D		a.	No unacceptable contamination	AAF032
F		b.	Corrosion protection is per specification	ADE005
F		c.	Corrosion protection	ADE005A
		14.	For New Adhesive, Rubber-to-Metal, SRM Flex Bearing verify:	
E	(T)	a.	Peel adhesion	AMQ007
E	(T)	b.	Viscosity	AMQ031
		15.	For Re-tested Adhesive, Rubber-to Metal, SRM Flex Bearing verify:	
E	(T)	a.	Peel adhesion	AMQ004
E	(T)	b.	Viscosity	AMQ029
		16.	KSC verifies:	
F		a.	No disengaged link (275 degree location) and no loose or disengaged link (35 and 155 degree location) when aft segment is horizontal per OMRSD, File V, Vol I, B47SG0.540	OMD112
F		b.	Flex bearing temperature readings meet specification limits prior to vectoring per OMRSD, File II, Vol I, S00GEN.680	OMD117