ATK ALLIANT TECHSYSTEMS
THIOKOL PROPULSION

CRITICAL ITEMS LIST (CIL)

No. 10-02-01-16R/01

SYSTEM:	Space Shuttle RSRM 10	CRITICALITY CATEGORY:	1R
SUBSYSTEM:	Nozzle Subsystem 10-02	PART NAME:	Nose Inlet-to-Forward End Ring Joint, Primary O-ring, Secondary O-ring (2)
ASSEMBLY:	Nozzle and Aft Exit Cone 10-02-01		
FMEA ITEM NO.:	10-02-01-16R Rev M		
CIL REV NO.:	M (DCN-533)	PART NO.:	(See Section 6.0)
DATE:	10 Apr 2002	PHASE(S):	Boost (BT)
SUPERSEDES PAGE:	326-1ff.	QUANTITY:	(See Section 6.0)
DATED:	31 Jul 2000	EFFECTIVITY:	(See Table 101-6)
CIL ANALYST:	B. A. Frandsen	HAZARD REF.:	BN-03
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 Leakage of primary O-ring and secondary O-ring

3.0 FAILURE EFFECTS: Failure could result in hot gas flowing through joint resulting in a burn-through, causing loss of nozzle, thrust imbalance between SRBs, and loss of RSRM, SRB, crew, and vehicle

4.0 FAILURE CAUSES (FC):

FC NO.	DESCRIPTION	FAILURE CAUSE KEY
1.1	Nonconforming O-ring splice or repair	A
1.2	Nonconforming O-ring dimensions	B
1.3	O-ring cut or damaged	C
1.4	Nonconforming O-ring voids, inclusions, or subsurface indications	D
1.5	Age degradation of O-ring	E
1.6	Moisture and/or fungus degradation of O-ring	F
1.7	O-ring gland does not meet dimensional or surface finish requirements	G
1.8	O-ring improperly installed	H
1.9	Transportation, handling, or assembly damage	I
1.10	Sealing surface contamination or corrosion	J
1.11	Nonconforming physical or mechanical properties	K

5.0 REDUNDANCY SCREENS:

SCREEN A: Pass--The leak test procedure verifies the primary O-ring and secondary O-ring seals.
SCREEN B: Fail--No provision is made for failure detection by the crew.
SCREEN C: Fail--The primary and secondary O-ring seal can be lost due to a single credible cause such as a surface defect on the sealing surface.

1. The primary and secondary O-ring together form part of a redundant seal system at the nose inlet-to-forward end ring joint when the leak check port O-ring seals. The secondary O-ring will see no pressure unless the primary O-ring fails. If the primary O-ring fails, the secondary O-ring will still maintain a seal. If both the primary and secondary O-ring fail, a leak path will exist and could result in loss of vehicle and crew.

6.0 ITEM DESCRIPTION:

1. The nose inlet-to-forward end ring joint, with primary O-ring and secondary O-ring, is shown as an assembled joint on the nose-throat-bearing assembly and nose-throat-bearing-cowl assembly drawings (Figures 1 and 2). Materials are listed in Table 1.

TABLE 1. MATERIALS

Drawing No.	Name	Material	Specification	Quantity
1U79147	Nose-Throat-Bearing Assy, Nzzle			1/motor
1U79149	Nose-Throat-Bearing Cowl Housing Assembly, Nozzle			1/motor
1U75150	Packing, Preformed Fluorocarbon	Black Fluorocarbon Rubber	STW4-3339	1/motor
1U52834	Ring, Bearing Assembly, Forward			1/motor
1U75398	Housing Assy-Nose/Inlet, Nozzle			1/motor
	Corrosion-Preventive Compound and O-ring Lubricant	Heavy-Duty Calcium Grease	STW5-2942	A/R
1U51916	Cartridge Assembly	Heavy-Duty Calcium Grease, Filtered and Placed in an Application Cartridge	STW7-3657	A/R

6.1 CHARACTERISTICS:

1. The nose inlet-to-forward end ring joint allows the nose inlet to be mounted to the forward end ring. The unit is assembled with O-rings and bolts to assure there is no leakage after assembly.

2. The primary and secondary O-rings, at the nose inlet to forward end ring joint, are designed so the O-ring maintains constant contact with its cavity at all times. Squeeze, fill, and tracking are taken into account relating to O-ring groove tolerance.

3. The O-ring is a one-time-use item.

4. The joint and seals are an important part of the assembled rocket motor case. The assembled RSRM is a combustion chamber made up of segments and the nozzle. It is sealed with O-rings and must contain and direct pressure generated by burning propellant.

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

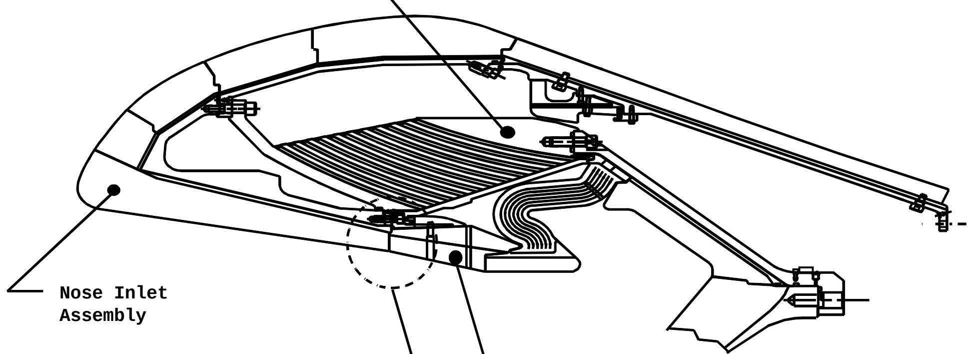

Figure 1. Nose Inlet-to-Forward Eng Ring Joint Location

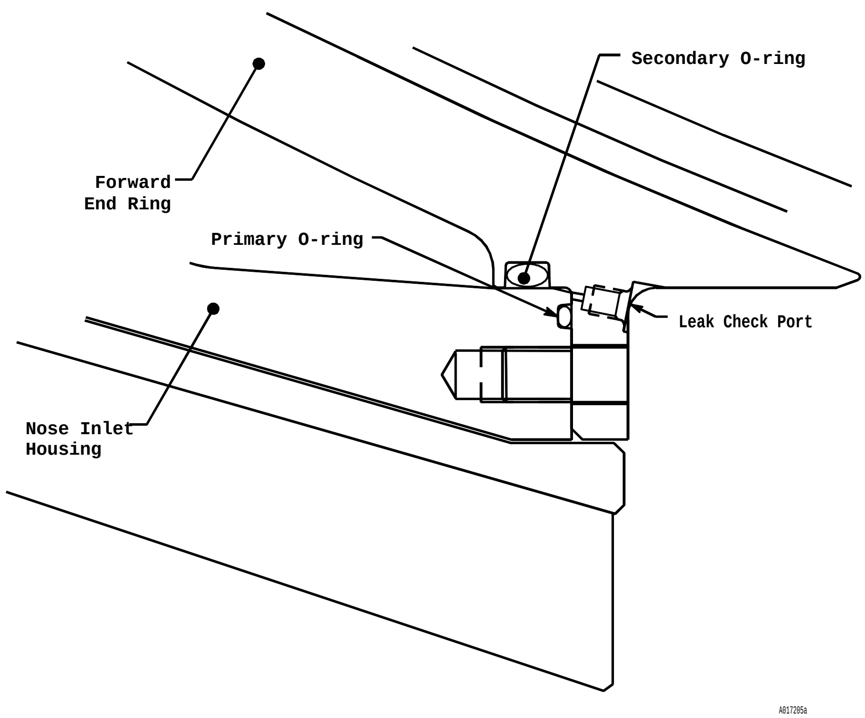

Figure 2. Nose Inlet-to-Forward Eng Ring Joint

9.0 RATIONALE FOR RETENTION:

9.1 DESIGN:

DCN	FAILURE CAUSES	
A	1.	Large O-rings are per engineering that covers process controls for fabrication of spliced joints and repairs.
A	2.	Splice joints are cut on an angle and bonded together in a mold (using 100 percent of the scarf area) using an adhesive with the same physical and chemical properties as the parent stock.
A,D	3.	O-rings were tested to determine size and types of flaws that could cause sealing problems per TWR-17750.
B	4.	Criteria for O-ring dimensions are per TWR-15771.
B	5.	Both O-ring designs provide constant contact between the O-ring and mating sealing surfaces.
B,D	6.	Large O-rings are per engineering that establishes geometric dimensions, design requirements, and fabrication details.
C,H	7.	Large O-rings are individually packaged per engineering.
C,H	8.	Large O-ring design allows for stretching without damage to the O-ring. Proper installation without over-stretching is per engineering.
C,H	9.	Material selection for O-rings was based in part on resistance to damage per TWR-17082.
C,H	10.	Design development testing of O-ring twisting and its effect on performance is per ETP-0153 and TWR-17991.
E	11.	Fluorocarbon rubber O-rings are suitable for periods of storage of up to 20 years (O-ring Handbook, ORD 5700, Copyright 1982, by Parker Seal Group, Lexington, KY). Environment and age are significant to useful seal life, both in storage and actual service.
E		a. O-rings are packaged and stored to preclude deterioration caused by ozone, grease, ultraviolet light, and excessive temperature.
E	12.	Large O-ring time duration of supplier storage and total shelf life prior to installation is per engineering.
E	13.	Aging studies of O-rings after 5 years installation life were performed. Test results are also applicable to all RSRM fluorocarbon seals. Fluorocarbon maintained its tracking ability and resiliency. Fluorocarbon was certified to maintain its sealing capability over 5 years per TWR-65546.
E	14.	O-rings are one-time-use items.
E	15.	Grease is stored at warehouse-ambient condition that is any condition of temperature and relative humidity experienced by the material when stored in an enclosed warehouse, in unopened containers or containers that were resealed after each use per engineering.

E	16.	Aging studies to demonstrate characteristics of grease after 5 years installation life were performed on TEM-9. Results showed that grease provided adequate corrosion protection for D6AC steel, and that all chemical properties of grease remained intact per TWR-61408 and TWR-64397.
E	17.	Large O-rings and filtered grease are included in the aft segment life verification.
F,K	18.	Large O-rings are high-temperature, low-compression set, fluid-resistant, black fluorocarbon rubber.
F	19.	O-ring swell is negligible unless the O-ring undergoes a long period of water immersion (O-ring Handbook, ORD 5700, Copyright 1982, by Parker Seal Group, Lexington, KY).
F	20.	Fluorocarbon rubber is a non-nutrient to fungus growth (O-ring Handbook, ORD 5700, Copyright 1982, by Parker Seal Group, Lexington, KY).
F	21.	Large O-rings are kept dry and clean prior to packaging.
G	22.	Primary and secondary O-ring glands are per engineering drawings and conform to dimensions determined by Thiokol Design Engineering calculations for squeeze, fill, and tracking per TWR-15771.
G	23.	Design verification analyses of data from live firing tests per TWR-16534 and TWR-17563 show that O-ring sealing surfaces are acceptable for flight per TWR-18764-09.
G	24.	Sealing surface requirements during refurbishment are per engineering drawings.
I	25.	Transportation and handling of nozzle assembly items by Thiokol is per IHM 29.
I	26.	The RSRM and its component parts, when protected per TWR-10299 and TWR-11325, are capable of being handled and transported by rail or other suitable means to and from fabrication, test, operational launch, recovery, retrieval, and refurbishment sites.
I	27.	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.
I	28.	Support equipment used to test, handle, transport, assemble, or disassemble the RSRM is certified and verified per TWR-15723.
I	29.	Analysis is conducted by Thiokol engineering to assess vibration and shock load response of the RSRM nozzle during transportation and handling to assembly and launch sites per TWR-16975.
I	30.	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.
J	31.	Filtered grease is applied to sealing surfaces during assembly processes.
J	32.	Filtered grease filtering is per engineering to control contamination.

J 33. Removal of surface contamination or corrosion is a standard shop practice to be used whenever contamination or corrosion is noted.

J 34. Contamination control requirements and procedures are per TWR-16564.

K 35. Filtered grease is applied per engineering drawings and conforms to engineering requirements.

K 36. Temperature prior to launch is monitored for the nozzle flexible bearing and case-to-nozzle joint and is maintained per TWR-15832. The nose inlet-to-throat joint is within the temperature maintained area and benefits from temperature conditioning. Joint thermal analysis (O-ring resiliency testing) is per ETP-0276 and TWR-18597.

H,I 37. 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.

533 H,I 38. 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 nose inlet assembly and the cowl 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.

9.2 TEST AND INSPECTION:

DCN	FAILURE CAUSES and TESTS	(T)			CIL CODE
			1.	For New Large O-ring verify:	
	A		a.	Diameter	AEB026,AEB027
	B		b.	Diameter	AEB014,AEB015,AEB018,AEB023
	A		c.	Splice is bonded over 100 percent of the scarf area	AEB133,AEB134
	A		d.	No more than five splices	AEB167,AEB169
	A		e.	Repairs	AEB265,AEB266
	A		f.	Adhesive is made from fluorocarbon rubber	AEB308,AEB311
	A		g.	Splice bond integrity	AEB317,AEB319
	A,D	(T)	h.	Subsurface indications	AEB354
	A,C,D,F,H		i.	Surface quality	AEB389,AEB388
	A,K	(T)	j.	Tensile strength	AEB401,AEB402
	K	(T)	k.	Tensile strength	AEB394,AEB396
	A,K	(T)	l.	Ultimate elongation	AEB442,AEB443
	K	(T)	m.	Ultimate elongation	AGM408,AGW075
	B		n.	Correct identification	AEB087,AEB100
	C,E,F,H		o.	Packaging for damage or violation	AEB179
	F		p.	Clean and dry when packaged	AEB031,AEB034
	E,F,K		q.	Material is fluorocarbon rubber	AEB151,AEB141
	C,E,F		r.	Packaging is free of staples or other objects	LAA054
	K	(T)	s.	Shore A hardness	AGM304,AGM312
	K	(T)	t.	Compression set	AKW006,AKW011
			2.	For New Nose-Throat-Bearing-Cowl Assembly verify:	
	A,B,C,D, G,H,I,J,	(T)	a.	Joint seals are pressure tested	ADP049
			3.	For New Nose-Throat-Bearing Assembly, Nozzle verify:	
	C,H		a.	Identification of large O-ring	ADO017
	C,H		b.	Installation and fit of large O-ring	ADO031,ADO030
	C,H		c.	Application of filtered grease	ADO006,ADO004
	C,H,J		d.	Application of filtered grease	ADO013,ADO008,ADO012,ADO011
	C,H		e.	Large O-ring unpackaged, processed, and installed one at a time	ADO044
	C,H		f.	Primary O-ring is free from damage	ADO034
	C,H		g.	Secondary O-ring is free from damage	ADO022A
	C,H		h.	Condition of large O-ring	ADO045,ADO035A
	F		i.	Ring, Bearing Assembly, Fwd aft end secondary O-ring groove is free from moisture	ADO038A
	F		j.	Primary O-ring is free from moisture	ADO042
	F		k.	Secondary O-ring is free from moisture	ADO042A
	F		l.	Housing Assembly-Nose/Inlet, Nozzle aft end primary O-ring groove is free from moisture	ADO033
	F		m.	Free from fungus	ADO037A,ADO041,ADO041A,ADO037
	E		n.	Shelf life of the filtered grease	LAA118
	E		o.	Shelf life of large O-ring	ADO052,ADO053
	E,F		p.	Large O-ring packaging for damage or violation	ADO043,ADO043A
	I		q.	Ring, Bearing Assembly, Fwd aft end primary O-ring sealing surfaces are free from damage	ADO051A
	I		r.	Housing Assembly-Nose/Inlet, Nozzle aft end primary O-ring groove free from damage	ADO036
	I		s.	Ring, Bearing Assembly, Fwd aft end secondary O-ring groove is	

				free from damage	ADO036A
I			t.	Housing Assembly-Nose/Inlet, Nozzle aft end secondary O-ring sealing surfaces are free from damage	ADO051
J			u.	Free from corrosion and contamination	ADO020,ADO024,ADO025,ADO021
		4.		For New Filtered Grease verify:	
E,F,J,K			a.	Grease is received from storage unopened or resealed	ACP015
E,F,J,K			b.	Shelf life of the grease, prior to filtering	AMB018L
E,F,J,K	(T)		c.	Contamination	ANO064
E,F,J,K			d.	Grease conforms to specification	LAA044
E,F,J,K			e.	Cartridge conforms to drawing	LAA046
E,F,J,K			f.	Filtered grease is capped and sealed after filling	LAA047
E,F,J,K			g.	Filtered grease is sent to storage capped and sealed (recapped and resealed)	LAA063
		5.		For New Grease verify:	
E,F,J			a.	Material received in closed containers	ANO015
E,F,K			b.	Type	ANO050
E			c.	No shipping or handling damage	ANO058
K	(T)		d.	Penetration	LAA037
K	(T)		e.	Dropping point	ANO042
K	(T)		f.	Zinc concentration	LAA038
		6.		For New Ring, Bearing Assembly, Forward verify:	
G			a.	Surface finish	ADF071,ADF072
G			b.	O-ring groove depth	ADF077,ADF078
G			c.	O-ring groove diametric location	ADF079,ADF080
G			d.	O-ring groove surface finish	ADF081,ADF082
G			e.	O-ring groove width	ADF083,ADF084
		7.		For Refurbished Ring, Bearing Assembly, Forward verify:	
G			a.	O-ring grooves and O-ring sealing surfaces	ADF000
		8.		For New Housing Assembly-Nose/Inlet, Nozzle verify:	
G			a.	O-ring groove depth	AFE108,AFE109
G			b.	O-ring groove diametric location	AFE110,AFE111
G			c.	O-ring groove surface finish	AFE112,AFE115
G			d.	O-ring groove width	AFE118,AFE119
G			e.	Surface finish	AFE146,AFE147
		9.		For Refurbished Housing Assembly-Nose/Inlet Nozzle verify:	
G			a.	Surface finish and surface condition	AFE148
		10.		KSC verifies:	
E			a.	Life requirements for the expected launch schedule are met per OMRSD File II, Vol III, C00CA0.030	OMD019