ATK ALLIANT TECHSYSTEMS
THIOKOL PROPULSION

CRITICAL ITEMS LIST (CIL)

No. 10-02-01-15R/02

SYSTEM:	Space Shuttle RSRM 10	CRITICALITY CATEGORY:	1R
SUBSYSTEM:	Nozzle Subsystem 10-02	PART NAME:	Nose Inlet-to-Forward End Ring Joint, Leak Check Port Plug O-ring, Secondary O-ring (2)
ASSEMBLY:	Nozzle and Aft Exit Cone 10-02-01		
FMEA ITEM NO:	10-02-01-15R Rev M		
CIL REV NO.:	M (DCN-533)	PART NUMBER:	(See Section 6.0)
DATE:	10 Apr 2002	PHASE(S):	Boost (BT)
SUPERSEDES PAGE:	325-1ff.	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: 2.0 Leakage of leak check port plug 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
2.1	Nonconforming O-ring splice or repair	A
2.2	Nonconforming O-ring dimensions	B
2.3	O-ring cut or damaged	C
2.4	Nonconforming O-ring voids, inclusions, or subsurface indications	D
2.5	Age degradation of O-rings	E
2.6	Moisture and/or fungus degradation of O-rings	F
2.7	O-ring gland does not meet dimensional or surface finish requirements	G
2.8	O-ring improperly installed	H
2.9	Transportation, handling, or assembly damage	I
2.10	Sealing surfaces contamination or corrosion	J
2.11	Nonconforming O-ring physical or mechanical properties	K
2.12	Leak check port plug improperly installed	L
2.13	Nonconforming plug mechanical properties	M
2.14	Nonconforming thread dimensions	N

2.15 Nonconforming plug materials O

5.0 REDUNDANCY SCREENS:

SCREEN A: Fail--The leak check port o-ring can not be verified during mission turnaround.
SCREEN B: Fail--No provision is made for failure detection by the crew.
SCREEN C: Pass--The secondary O-ring and leak check port plug o-ring can not be lost by a single credible cause.

1. The RSRM leak check port plug O-ring and the secondary O-ring form part of a redundant seal system. The leak check port plug O-ring can be pressurized even if pressure does not get past the primary O-ring. If the leak check port plug O-ring fails, the secondary O-ring will be pressurized and maintain a seal. If the leak check port plug O-ring and secondary O-ring fail, a leak path will exist and could result in loss of crew and vehicle.

6.0 ITEM DESCRIPTION:

1. There is one nose inlet-to-forward end ring joint on each RSRM, with a leak check port located between the primary and the secondary O-ring. The assembled joint is shown for the nose-throat-bearing assembly and nose-throat-bearing-cowl assembly (Figures 1 and 2). Materials are listed in Table 1.

2. The Leak Check Port Plug is also known as the RSRM Port Plug (closure screw).

TABLE 1. MATERIALS

Drawing No.	Name	Material	Specification	Quantity
1U79147	Nose-Throat-Bearing Assembly, Nozzle			1/motor
1U79149	Nose-Throat-Bearing-Cowl Assembly			1/motor
1U78676	RSRM Port Plug (closure screw)	CRES	AMS 5646	1/motor
1U50228	Packing, Preformed	Black Fluorocarbon Rubber	STW4-3339	25 1/motor
1U75150	Packing, Preformed Fluorocarbon	Black Fluorocarbon Rubber	STW4-3339	07 1/motor
1U52834	Ring, Bearing Assembly, Forward			1/motor
1U75398	Housing Assembly-Nose/Inlet, Nozzle			1/motor
1U51916	Cartridge Assembly	Heavy-Duty Calcium Grease, 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 assembly to be mated to the flex bearing assembly at Thiokol. The unit is sealed with O-rings and has one leak check port to verify there is no leakage after assembly.

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

3. The leak check port plug and its O-ring, as well as the secondary O-ring, are one-time-use items.

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. The assembled RSRM is sealed with O-rings, and must contain and direct the pressure generated by the 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

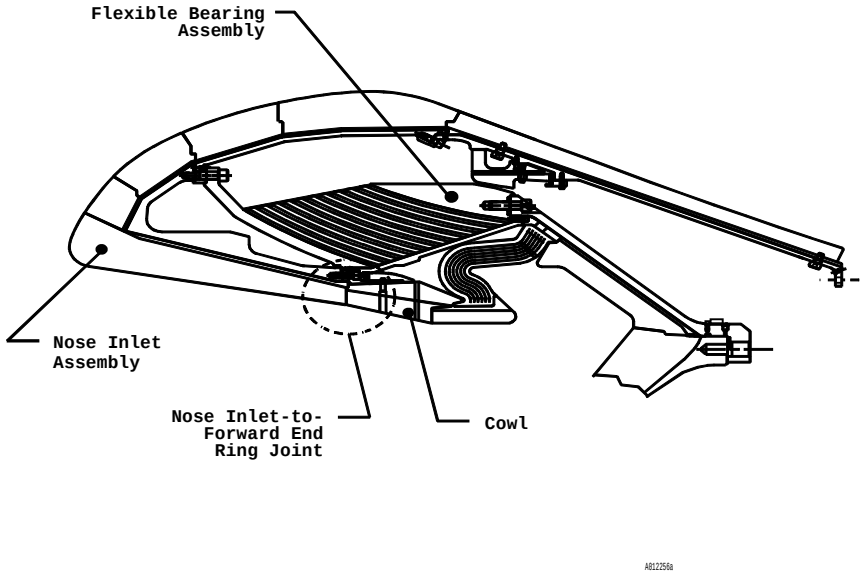

Figure 1. Nose Inlet-to-Forward Eng Ring Joint Location

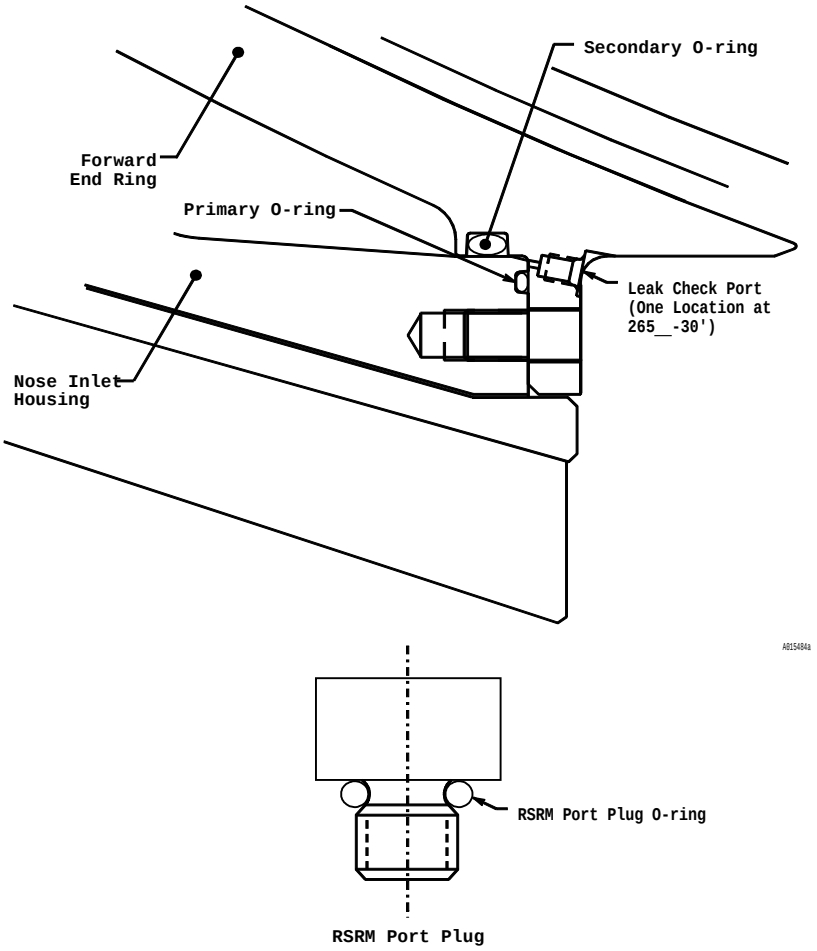

Figure 2. Nose Inlet-to-Forward End Ring Joint, Leak Check Port and Plug

9.0 RATIONALE FOR RETENTION:

9.1 DESIGN:

DCN	FAILURE CAUSES	
A	1.	Large O-rings are per engineering which 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 sizes and types of flaws that could cause sealing problems per TWR-17991.
A	4.	The leak check port O-ring is not spliced.
B	5.	Criteria for secondary O-ring dimensions is per TWR-15771.
B	6.	Both O-ring designs provide constant contact between the O-ring and mating sealing surfaces.
B,D	7.	Small and large O-rings are per engineering that establishes geometric dimensions and fabrication details.
C,H	8.	The leak check port O-ring is assembled with the RSRM Port Plug (closure screw) at Thiokol, using an O-ring installation tool.
C,H	9.	The secondary O-ring and the RSRM Port Plug (closure screw) are installed per engineering.
C,H	10.	Material selection for O-rings was based in part on resistance to damage per TWR-17082.
C,H	11.	Design development testing of O-ring twisting and its effect on performance is per ETP-0153 and TWR-17991.
E	12.	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.
C,E,H		a. O-rings are packaged and stored to preclude deterioration caused by ozone, grease, ultraviolet light, and excessive temperature.
E	13.	Small and large O-ring time duration of supplier storage and total shelf life prior to installation is per engineering.
E	14.	Aging studies of O-rings after 5 years installation life were performed. Test results are 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	15.	O-rings (RSRM Port Plug (closure screw) and secondary) are one-time-use items.
E	16.	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. Storage life under these conditions is per engineering.

E 17. 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 18. Large O-rings, small O-rings, and filtered grease are included in the aft segment life verification.

F 19. Small and large O-rings are black fluorocarbon rubber.

F 20. 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 21. Fluorocarbon rubber is a non-nutrient to fungus growth (O-ring Handbook, ORD 5700, Copyright 1982, by Parker Seal Group, Lexington, KY).

F 22. Small and large O-rings are kept dry and clean prior to packaging.

C,F,H 23. Small and large O-rings are individually packaged in an opaque, waterproof, grease-proof, and heat-sealed bag per engineering.

G 24. Secondary O-ring gland design is per engineering drawings and conforms to dimensions determined by Thiokol Design Engineering calculations for squeeze and fill per TWR-15771.

G,L,N 25. RSRM Port Plug (closure screw) design requirements are per engineering drawings and specifications.

G,N 26. Leak check port design is per the forward end ring drawing.

G 27. Design verification analysis of data from live firing tests per TWR-16534 and TWR-17563 shows that O-ring sealing surfaces are acceptable for flight use per TWR-18764-9.

G,N 28. The RSRM Port Plug (closure screw) is a one-time-use item.

G 29. Sealing surface requirements during refurbishment are per engineering drawings.

I 30. Transportation and handling of nozzle assembly items by Thiokol is per IHM 29.

I 31. The RSRM and its component parts, when protected in 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 and retrieval, and refurbishment sites.

I 32. 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 33. Support equipment used to test, handle, transport, and assemble or disassemble the RSRM is certified and verified per TWR-15723.

I 34. 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 35. 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 were not exceeded. TWR-16975 documents compliance of the nozzle with environments per MSFC Specifications

H,J,L 36. Filtered grease is applied to sealing surfaces of the nose-throat-bearing assembly and nose-throat-bearing-cowl assembly during final assembly processes.

J 37. Filtered grease filtering is per engineering to control contamination.

J 38. Surface contamination or corrosion is removed whenever contamination or corrosion is noted per engineering.

J 39. Contamination control requirements and procedures are per TWR-16564.

M,O 40. RSRM Port Plug (closure screw) material is corrosion and heat-resistant steel per Aerospace Material Specifications.

K 41. Large and small O-rings are high-temperature, low-compression set, fluid-resistant, black fluorocarbon rubber.

K 42. Temperature prior to launch is monitored for the nozzle flexible bearing and the case-to-nozzle joint and is maintained per TWR-15832. The nose inlet-to-forward end ring 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.

L 43. Torque of RSRM Port Plug (closure screw) is per engineering drawings and shop planning.

N 44. Dimensions of the threaded port in the forward end ring during refurbishment are per engineering drawings.

I 45. 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 program (super light weight tank and new liquid motors) were incorporated into TWR-16975. No significant effect on performance of the RSRM nozzle phenolic components or bolt loading where identified.

533 I 46. 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.

G, J, L, M, N, O 47. A series of thermal/flow models were evaluated for possible gas flow path to the nozzle joint 2 RSRM Port Plug (closure screw) location from the joint flame surface.

The joint gaps ranged from the minimum structural value to the maximum predicted gap opening to encompass the maximum steel and aluminum surface temperatures in the RSRM Port Plug (closure screw) vicinity. Free nominal volumes of the bolt cavities and area between the cowl inner diameter and bearing protector outer diameter were used. Based on this thermal analysis gas flow to the nozzle joint 2 RSRM Port Plug (closure screw) is not expected to result in detrimental thermal conditions at the plug head location (no heat affect to the plug head is predicted). No significant thermal effect as a result of pressurization from the boot cavity region is expected (as a result of the torturous path and benign boot cavity temperatures as measured during static tests). Any assumed leakage by the leak check plug O-ring down the torturous thread path into the joint 2 seal cavity is expected to be slow enough (if at all) that no additional heating is expected to the joint O-rings per TWR-76808.

H,J,L 48. Filtered grease is per engineering drawings, and conforms to material requirements determined by Thiokol engineering.

L,N,O 49. RSRM Port Plug (closure screw) vibration testing, documented in TWR-73485, demonstrated that a very small amount of torque from any combination of O-ring load or thread friction is sufficient to prevent loss of port plugs during flight.

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 physical and chemical properties	AEB311
A		g.	Adhesive is made from fluorocarbon rubber	AEB308,AEB311
A		h.	Splice bond integrity	AEB317,AEB319
A,D	(T)	i.	Subsurface indications	AEB354
A,C,D,F,H		j.	Surface quality	AEB388,AEB389
A,K	(T)	k.	Tensile strength	AEB401,AEB402
K	(T)	l.	Tensile strength	AEB394,AEB396
A,K	(T)	m.	Ultimate elongation	AEB442,AEB443
K	(T)	n.	Ultimate elongation	AGM408,AGW075
B		o.	Correct identification	AEB087,AEB100
C,E,F,H		p.	Packaging for damage or violation	AEB179
E,F		q.	Packaging is free of staples or other objects	LAA054
E		r.	Material is fluorocarbon rubber	AEB151,AEB141
F		s.	Clean and dry when packaged	AEB031,AEB034
K	(T)	t.	Shore A hardness	AGM304,AGM312
K	(T)	u.	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 (Primary and Secondary O-rings only, RSRM Port Plug (closure screw) O-ring is not pressure tested)	ADP049
C,H,J,L		b.	Application of filtered grease to Ring, Bearing Assembly, Forward leak check port prior to port plug installation	ADP002
C,H,J,L		c.	Application of filtered grease to RSRM Port Plug (closure screw) prior to assembly	ADP005
C,H		d.	Application of filtered grease to RSRM Port Plug (closure screw) O-ring prior to assembly	ADP005A
C,H		e.	Correct identification of RSRM Port Plug (closure screw) O-ring at time of installation	ADP018
C,H		f.	RSRM Port Plug (closure screw) O-ring is free from damage after installation onto RSRM Port Plug (closure screw)	ADP023
C,H		g.	RSRM Port Plug (closure screw) O-ring is free from damage prior to mating with RSRM Port Plug (closure screw)	ADP067
C,H		h.	Proper installation of RSRM Port Plug (closure screw) O-ring using installation tool	ADP075
C,F,H		i.	RSRM Port Plug (closure screw) O-ring packaging was not violated or damaged prior to installation	ADP069
E		j.	Shelf life of the filtered grease was not exceeded	LAA119
E		k.	RSRM Port Plug (closure screw) o-ring, shelf life is not expired	ADP076
F		l.	Ring, Bearing Assembly, Forward leak check port is free from fungus prior to installation of the RSRM Port Plug (closure screw)	ADP029
F		m.	RSRM Port Plug (closure screw) O-ring is free from fungus prior to mating with the RSRM Port Plug (closure screw)	ADP030
F		n.	Ring, Bearing Assembly, Forward leak check port is free from moisture prior to installation of the RSRM Port Plug (closure	

			screw)	ADP065
F		o.	RSRM Port Plug (closure screw) O-ring is free from moisture prior to mating with the RSRM Port Plug (closure screw)	ADP066
I		p.	Ring, Bearing Assembly, Forward leak check port is free from damage prior to installation of the RSRM Port Plug (closure screw)	ADP048
I		q.	The RSRM Port Plug (closure screw) is free from damage prior to installation	ADP064
J		r.	Ring, Bearing Assembly, Forward leak check port is free from corrosion and contamination prior to installation of the RSRM Port Plug (closure screw)	ADP046
J		s.	The RSRM Port Plug (closure screw) is free from corrosion and contamination prior to installation	ADP047
L		t.	Proper initial installation of RSRM Port Plug (closure screw) prior to final torque	ADP071
L		u.	Final torque is properly performed during installation of RSRM Port Plug (closure screw)	ADP072

3. For New Small O-ring verify:

B		a.	Correct identification	AAQ047
B		b.	Inside diameter "A"	AAQ002,AAQ003
B		c.	Cross-sectional dimension "W"	AAQ004,AAQ062
B		d.	Flash dimensions	AAQ111,AAQ112
C,D,F,H		e.	Surface quality	AAQ234,AAQ233
E,F		f.	Individually packaged and sealed in opaque bags; material is per engineering	AAQ211
E		g.	No shipping or handling damage	AAQ212
F,K		h.	Material is fluorocarbon rubber	AAQ157,AAQ117
F		i.	Dry and clean prior to packaging	AAQ023
K	(T)	j.	Shore A hardness	LAA001,LAA006,LAA011,LAA016
K	(T)	k.	Tensile strength	LAA002,LAA007,LAA012,LAA017
K	(T)	l.	Ultimate elongation	LAA003,LAA008,LAA013,LAA018
K	(T)	m.	Compression-set	LAA004,LAA009,LAA014,LAA019
K	(T)	n.	Tear strength	LAA005,LAA010,LAA015,LAA020

4. 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
C,H,J		c.	Application of filtered grease	ADO011
J		d.	Application of filtered grease	ADO006
C,H		e.	Application of filtered grease	ADO008
C,H		f.	Secondary O-ring is free from damage	ADO022A
C,H		g.	Condition of large O-ring	ADO045
E		h.	Shelf life of large O-ring	ADO052
E		i.	Shelf life of the filtered grease	LAA118
E		j.	Large O-ring packaging for damage or violation	ADO043,ADO043A
F		k.	Secondary O-ring is free from moisture	ADO042A
F		l.	Ring, Bearing Assembly, Forward aft end secondary O-ring groove is free from moisture	ADO038A
F		m.	Free from fungus	ADO041,ADO037
I		o.	Ring, Bearing Assembly, Forward aft end secondary O-ring groove is free from damage	ADO036A
I		p.	Housing Assembly-Nose/Inlet, Nozzle aft end secondary O-ring sealing surfaces are free from damage	ADO051
J		q.	Free from corrosion and contamination	ADO024,ADO025

5. For New Filtered Grease verify:

E,F,H,I,J,L	a.	Grease is received from storage unopened or resealed	ACP015
E,F,H,I,J,L	b.	The shelf life of the grease, prior to filtering	AMB018L
E,F,H,I,J,L(T)	c.	Contamination	ANO064
E,F,H,I,J,L	d.	The grease conforms to specification	LAA044
E,F,H,I,J,L	e.	The cartridge conforms to drawing	LAA046
E,F,H,I,J,L	f.	The filtered grease is capped and sealed after filling	LAA047
E,F,H,I,J,L	g.	The filtered grease is sent to storage capped and sealed (recapped and resealed)	LAA063

6. For New RSRM Port Plug (closure screw) verify:

G	a.	The O-ring groove width dimension	AAO047
G	b.	The O-ring groove surface finish	AAO037
G	c.	The O-ring groove diameter dimension	AAO025
G	d.	The plug length	AAO063
G	e.	The O-ring groove sealing surface blemishes	LAA270
J,M,O	f.	The material is corrosion and heat-resistant steel	AAO067
N	g.	Correct thread form	AAO071
N	h.	Thread surface blemishes	LAA271

7. For New Ring, Bearing Assembly, Forward verify:

G	a.	Surface finish	ADF072,ADF071
G	b.	Conformance of leak check port to specification	ADF002
N	c.	Conformance of leak check port to specification	ADF003
G	d.	O-ring groove depth	ADF077,ADF078
G	e.	O-ring groove diametric location	ADF079,ADF080
G	f.	O-ring groove surface finish	ADF081,ADF082
G	e.	O-ring groove width	ADF083,ADF084

8. For Refurbished Ring, Bearing Assembly, Forward verify:

G	a.	O-ring grooves and O-ring sealing surfaces	ADF000
N	b.	Conformance of leak check port to specification	ADF037

9. 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

10. For Refurbished Housing Assembly-Nose/Inlet Nozzle verify:

G	a.	Surface finish and surface condition	AFE148
G	b.	Dimension surface B parallelism per specification	AFE154,AFE156

11. KSC verifies:

E	a.	Life requirements for the expected launch schedule are met per OMRSD File II, Vol III, C00CA0.030	OMD019