ATK ALLIANT TECHSYSTEMS
THIOKOL PROPULSION

CRITICAL ITEMS LIST (CIL)

No. 10-02-01-23R/01

SYSTEM:	Space Shuttle RSRM 10	CRITICALITY CATEGORY:	1R
SUBSYSTEM:	Nozzle Subsystem 10-02	PART NAME:	Nose Inlet-to-Throat Joint, Primary O-ring, Leak Check Port Plug (2)
ASSEMBLY:	Nozzle and Aft Exit Cone 10-02-01		
FMEA ITEM NO.:	10-02-01-23R 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:	330-1ff.	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 Leakage of primary O-ring and leak check port plug

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, 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 surfaces contamination or corrosion	J
1.11	Nonconforming O-ring physical or mechanical properties	K
1.12	Leak check port plug improperly installed	L
1.13	Nonconforming plug mechanical properties	M
1.14	Nonconforming thread dimensions	N

1.15 Nonconforming plug materials O

5.0 REDUNDANCY SCREENS:

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

1. The primary O-ring and leak check port plug form part of a redundant seal system when the secondary O-ring seals. The leak check port plug will not be pressurized unless the primary O-ring fails. If the primary O-ring fails, the leak check port plug (in addition to the secondary O-ring) will be pressurized and maintain a seal. If the primary O-ring and leak check port plug fail, a leak path will exist and could result in loss of vehicle and crew.

6.0 ITEM DESCRIPTION:

1. There is one nose inlet-to-throat joint on each RSRM, with a leak check port located between the primary and the secondary O-ring. The assembled joint is per engineering drawings (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
1U79146	Nose-Throat Assembly, Nozzle			1/motor
1U78676	RSRM Port Plug	CRES	AMS-5646	1/motor
1U50228	Packing, Pre-formed	Black Fluorocarbon Rubber	STW4-3339	1/motor
1U75150	Packing, Preformed Fluorocarbon	Black Fluorocarbon Rubber	STW4-3339	1/motor
1U75547	Housing-Throat Support, Nozzle			1/motor
1U75398	Housing Assembly-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-Throat Joint allows the Nose-Inlet Assembly to be mated to the Throat-Inlet Assembly at Thiokol. The unit is sealed with O-rings, and there is one leak check port to verify there is no leakage after assembly.

2. Seals at the Nose Inlet-to-Throat 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 tolerances.

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

4. The joint and seals are important parts of the assembled rocket motor case. The assembled RSRM is a combustion chamber made up of segments and the nozzle, sealed with O-rings that 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

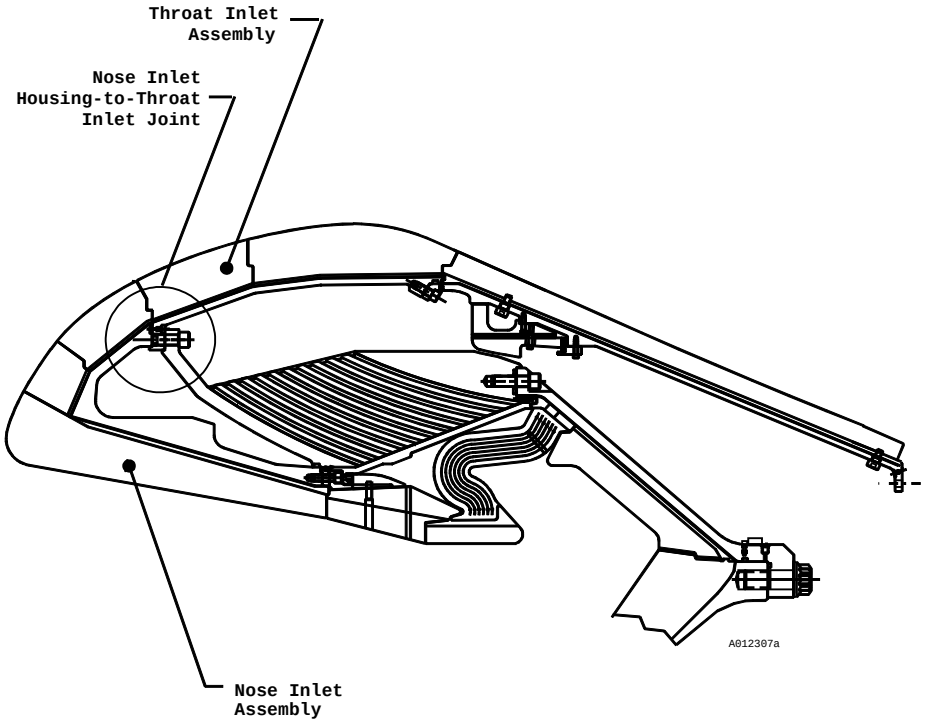

Figure 1. Nose Inlet-to-Throat Joint Location

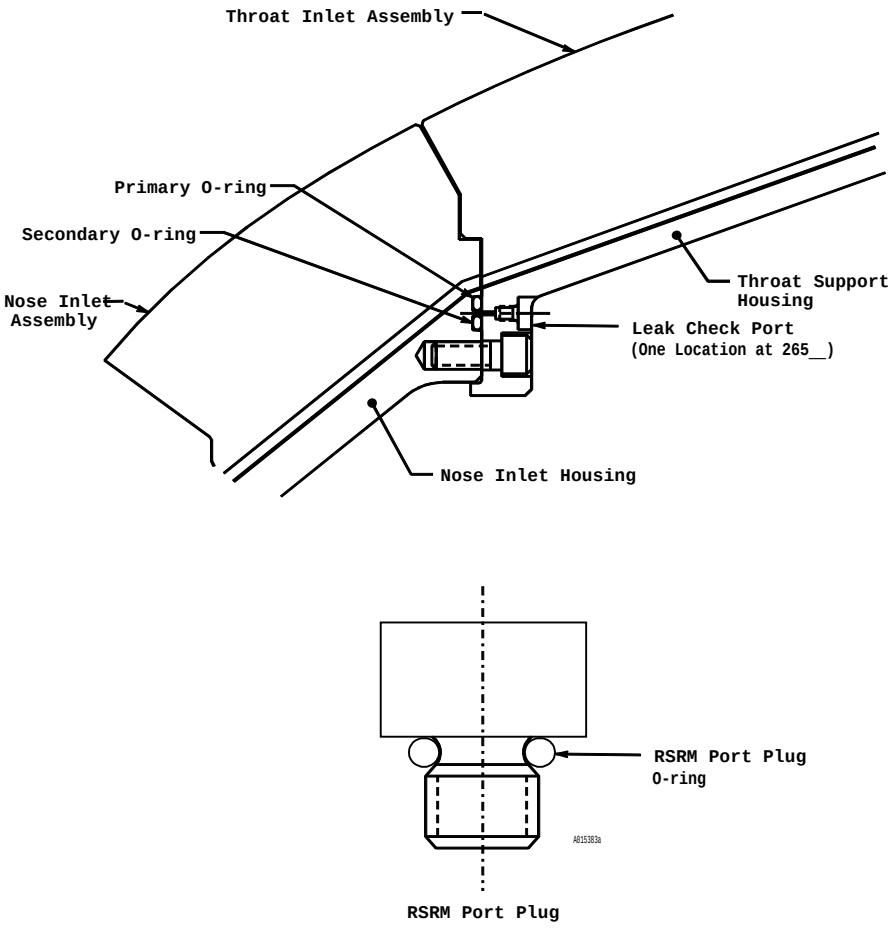

Figure 2. Nose Inlet-to-Throat Joint and RSRM Port Plug

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.
A	4.	The leak check port O-ring is not spliced.
B	5.	Criteria for primary O-ring dimensions are per TWR-15771.
B	6.	Both O-ring designs provide a constant contact between O-ring and mating sealing surfaces.
B,D	7.	Small and large O-rings are per engineering that establishes geometric dimensions, design requirements, and fabrication details.
C,H	8.	Small and large O-rings are individually packaged per engineering.
C,H	9.	Large O-ring design allows for a minimum of stretching without damage to the O-ring. Proper installation without over stretching is per engineering.
C,H	10.	The leak check port O-ring is installed on the RSRM Port Plug (closure screw) using an installation aid.
C	11.	Material selection for O-rings was based in part on resistance to damage per TWR-17082.
C,H	12.	Design development testing of O-ring twisting and its effect on performance is per ETP-0153 and TWR-17991.
E	13.	Fluorocarbon rubber O-rings are suitable for periods of storage 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	14.	Small and large O-ring time duration of supplier storage and total shelf life prior to installation is per engineering.
E	15.	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	16.	O-rings (leak check port and primary) are one-time-use items.

E	17.	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	18.	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 the grease remained intact per TWR-61408 and TWR-64397.
E	19.	Large O-rings, small O-rings, and filtered grease are included in the aft segment life verification.
F	20.	Small and large O-rings are black fluorocarbon rubber.
F	21.	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	22.	Fluorocarbon rubber is a non-nutrient to fungus growth (O-ring Handbook, ORD 5700, Copyright 1982, by Parker Seal Group, Lexington, KY).
F	23.	Small and large O-rings are kept dry and clean prior to packaging.
F	24.	Small O-rings are individually packaged in an opaque, waterproof, grease-proof, and heat-sealed bag per engineering.
G	25.	Primary O-ring gland design is per engineering drawings and conforms to dimensions determined by Thiokol design engineering calculations for squeeze, fill, and tracking per TWR-15771.
G,L,N	26.	RSRM Port Plug (closure screw) design requirements are per engineering drawings and specifications.
G	27.	Leak check port design is per engineering drawings and specifications.
G,N	28.	The RSRM Port Plug (closure screw) is a one-time-use item.
G	29.	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 per TWR-18764-09.
G	30.	Sealing surface requirements during refurbishment are per engineering drawings.
I	31.	Transportation and handling of nozzle assembly items by Thiokol is per IHM 29.
I	32.	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 or retrieval, and refurbishment sites.
I	33.	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	34.	Support equipment used to test, handle, transport, and assemble or disassemble the RSRM is certified and verified per TWR-15723.

	I	35. 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	36. 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	37. Filtered grease is applied to sealing surfaces of the nose throat assembly during final assembly processes.
	J	38. Filtered grease filtering is per engineering to control contamination.
	J	39. Removal of surface contamination or corrosion is a standard shop practice used whenever contamination or corrosion is noted per engineering.
	J	40. Contamination control requirements and procedures are per TWR-16564.
	M,O	41. RSRM Port Plug (closure screw) material is corrosion- and heat-resistant steel per Aerospace Material Specifications.
	K	42. Small and large O-rings are high-temperature, low-compression set, fluid-resistant, black fluorocarbon rubber.
	J	43. Filtered grease is specified for the nose throat assembly and conforms to material requirements per engineering.
	K,M,O	44. 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-throat joint is within the temperature maintained area and will benefit from temperature conditioning. Joint thermal analysis (O-ring resiliency testing) per ETP-0276 and TWR-18597.
	L	45. Required torque for the RSRM Port Plug (closure screw) is called out per engineering drawings and specifications. This value is based on results from sealability tests documented in TWR-17364.
	N	46. Dimensions of the threaded port in the nozzle throat support housing are per engineering drawings and MS specifications.
	N	47. Dimensions of the threaded port in the nozzle throat support housing during refurbishment are per engineering drawings.
	H,I	48. 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	D,H,I	49. 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 throat 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.

L,N,O 50. 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
A		b.	Splice is bonded over 100 percent of the scarf area	AEB133,AEB134
A		c.	No more than five splices	AEB167,AEB169
A		d.	Repairs	AEB265,AEB266
A		e.	Adhesive is made from fluorocarbon rubber	AEB308,AEB311
A		f.	Splice bond integrity	AEB317,AEB319
A,D	(T)	g.	Subsurface indications	AEB354
A,C,D,F,H		h.	Surface quality	AEB388,AEB389
A,K	(T)	i.	Tensile strength	AEB401,AEB402
A,K	(T)	j.	Ultimate elongation	AEB442,AEB443
B		k.	Diameter	AEB014,AEB015,AEB018,AEB023
B,H		l.	Correct identification	AEB087,AEB100
C,E,F,H		m.	Packaging for damage or violation	AEB179
E,F		n.	Packaging is free of staples or other objects	LAA054
E,F,K		o.	Material is fluorocarbon rubber	AEB151,AEB141
F		p.	Clean and dry when packaged	AEB031,AEB034
K	(T)	q.	Tensile strength	AEB394,AEB396
K	(T)	r.	Ultimate elongation	AGM408,AGW075
K	(T)	s.	Shore A hardness	AGM304,AGM312
K	(T)	t.	Compression set	AKW006,AKW011
		2.	For New Nose-Throat Assembly, Nozzle verify:	
A,B,C,D, G,H,I,J	(T)	a.	Joint seals are pressure tested	ADN063
C,H		b.	Correct identification of leak check port O-ring at time of installation	ADN027
C,H		c.	Correct identification of primary and secondary O-ring at time of installation	ADN029
C,H		d.	Installation and fit of primary O-ring	ADN042
C,H,J,L		e.	Application of filtered grease to Housing-Throat Support, Nozzle leak check port prior to assembly	ADN003
C,F,H		f.	Application of filtered grease to leak check port O-ring, prior to assembly	ADN006
C,F,H		g.	Application of filtered grease to primary O-ring, prior to assembly	ADN011
C,H,J		h.	Application of filtered grease to Housing Assembly-Nose/Inlet, Nozzle forward end O-ring grooves prior to assembly	ADN012
C,H		i.	Leak check port O-ring is free from damage prior to mating with RSRM Port Plug (closure screw)	ADN054
C,H		j.	Leak check port O-ring is free from damage after installation onto RSRM Port Plug (closure screw)	ADN055
C,H		k.	Primary O-ring is free from damage prior to installation	ADN088
C,F,H		l.	Primary O-ring is cleaned prior to lubrication	ADN094
C,H		m.	Condition of primary O-ring after installation into O-ring groove	ADN098
E		n.	Shelf life compliance of primary O-ring	ADN095
E		o.	Leak check port O-ring shelf life has not expired	ADN105
E		p.	Shelf life of the filtered grease has not been exceeded prior to use	LAA120
E		q.	Leak check port O-ring packaging for damage or violation just prior to installation	LAA132
F		r.	Leak check port O-ring is free from moisture prior to mating with the RSRM Port Plug (closure screw)	ADN056
F		s.	Leak check port O-ring is free from fungus prior to mating with the RSRM Port Plug (closure screw)	ADN057

F		t.	Housing Assembly-Nose/Inlet, Nozzle forward end primary O-ring groove is free from fungus prior to installation	ADN076
F		u.	Housing Assembly-Nose/Inlet, Nozzle forward end primary O-ring groove is free from moisture prior to installation	ADN082
F		v.	Primary O-ring is free from fungus prior to installation	ADN080A
F		w.	Primary O-ring is free from moisture prior to installation	ADN081A
C,G,I,J,L,N		x.	RSRM Port Plug (closure screw) is free from damage prior to installation	ADN059
C,G,I,J,L,N		y.	Housing-Throat Support, Nozzle forward end leak check port is free from damage prior to installation of the RSRM Port Plug (closure screw)	ADN062
C,G,I,J		z.	Housing Assembly-Nose/Inlet, Nozzle forward end O-ring grooves are free from damage prior to installation of O-ring	ADN075
C,G,I,J		aa.	Housing-Throat Support, Nozzle forward end O-ring sealing surfaces are free from damage prior to assembly	ADN103
J,L		ab.	Application of filtered grease to RSRM Port Plug (closure screw) prior to assembly	ADN007
J		ac.	Application of filtered grease to Housing-Throat Support, Nozzle forward end sealing surfaces	ADN013
J		ad.	Primed bonding surfaces of throat inlet assembly are free of contamination	ADN023
J		ae.	Housing-Throat Support, Nozzle forward end leak check port is free from corrosion and contamination prior to installation of the RSRM Port Plug (closure screw)	ADN053
J		af.	RSRM Port Plug (closure screw) is free from corrosion and contamination prior to installation	ADN058
J		ag.	Housing Assembly-Nose/Inlet, Nozzle forward end O-ring grooves are free from corrosion and contamination prior to assembly	ADN073
L		ah.	Proper initial installation of RSRM Port Plug (closure screw) prior to final torque	ADN060
L		ai.	Final torque is properly performed during installation of RSRM Port Plug (closure screw)	ADN061

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,H		f.	Individually packaged and sealed in opaque bags; material per engineering	AAQ211
C,D,E,F		g.	No shipping or handling damage	AAQ212
C,E,F,K		h.	Material is fluorocarbon rubber	AAQ157,AAQ117
E,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 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.	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.	Grease conforms to specification	LAA044
E,F,H,I,J,L		e.	Cartridge conforms to drawing	LAA046
E,F,H,I,J,L		f.	Filtered grease is capped and sealed after filling	LAA047
E,F,H,I,J,L		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,I,J,L		b.	Type	ANO050
E,F		c.	No shipping or handling damage	ANO058
H,I,L	(T)	d.	Penetration	LAA037
H,I,L	(T)	e.	Dropping point	ANO042
H,I,L	(T)	f.	Zinc concentration	LAA038

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

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

7. For New Housing Assembly-Nose/Inlet, Nozzle verify:

G		a.	O-ring groove depth	AFE089
G		b.	O-ring groove surface finish	AFE093,AFE092
G		c.	O-ring groove width	AFE096
G		d.	O-ring groove diametric location	AFE091

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

G		a.	Surface finish and surface condition	AFE148

9. For New Housing, Throat Support, Nozzle verify:

G,N		a.	Conformance of leak check port to specification	AFN026
G		b.	Surface finish	AFN145,AFN146

10. For Refurbished Housing, Throat Support, Nozzle verify:

G		a.	Surface finish	AFN004
G,N		b.	Conformance of leak check port to specification	AFN000A

11. KSC verifies:

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