ATK ALLIANT TECHSYSTEMS
THIOKOL PROPULSION

CRITICAL ITEMS LIST (CIL)

No. 10-05-04-07R/01

SYSTEM:	Space Shuttle RSRM 10	CRITICALITY CATEGORY:	1R
SUBSYSTEM:	Assembly Hardware/Interfaces 10-05	PART NAME:	Forward-to-Aft Exit Cone Joint, Primary O-ring, Leak Check Port Plug (2)
ASSEMBLY:	Fwd-to-Aft Exit Cone Interface 10-05-04		
FMEA ITEM NO.:	10-05-04-07R Rev M		
CIL REV NO.:	M (DCN-533)	PART NO.:	(See Section 6.0)
DATE:	10 Apr 2002	PHASE(S):	Boost (BT)
SUPERSEDES PAGE:	360-1ff.	QUANTITY:	(See Section 6.0)
DATED:	31 Jul 2000	EFFECTIVITY:	(See Table 101-6)
CIL ANALYST:	R. E. L. Hamilton	HAZARD REF:	BN-02
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 the joint resulting in a burn-through and loss of Aft Exit Cone causing a 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 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 cannot 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 aft exit cone to nozzle field joint on each RSRM with a leak check port located between the primary and the secondary O-ring (Figures 1 and 2). The assembled joint is per engineering drawings. 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
1U77647	Aft Booster Build-up--KSC			1/motor
1U78676	RSRM Port Plug	CRES	AMS 5646	1/ motor
1U50228	Packing, Preformed	Black Fluorocarbon Rubber	STW4-3339	1/ motor
1U75150	Packing, Preformed Fluorocarbon	Black Fluorocarbon Rubber	STW4-3339	1/ motor
1U51916	Cartridge Assembly	Heavy-Duty Calcium Grease, Filtered and Loaded in an Application Cartridge	STW7-3657	A/R
1U79152	Exit Cone Assembly, Forward Section			1/motor
1U75801	Packing, Lubricated	Black Fluorocarbon Rubber O-ring and Lubricant	STW7-2999	1/motor
1U52837	Housing, Exit Cone, Nozzle			1/motor
1U79155	Exit Cone Sub-Assembly-Nozzle, Aft			1/ motor
	Corrosion-Preventive Compound and O-ring Lubricant	Heavy-Duty Calcium Grease	STW5-2942	A/R

6.1 CHARACTERISTICS:

1. The Aft Exit Cone-to-Forward Exit Cone Joint allows the Aft Exit Cone to be mounted to the aft case segment at the launch site. The unit is sealed with an O-ring and there is one leak check port to verify that there is no leakage after assembly.

2. Seals at the Aft Exit Cone-to-Forward Exit Cone Joint are designed so that 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 primary packing, lubricated, are one-time-use items.

4. The assembled RSRM is a combustion chamber made up of segments and the nozzle. It is sealed with

an O-ring 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

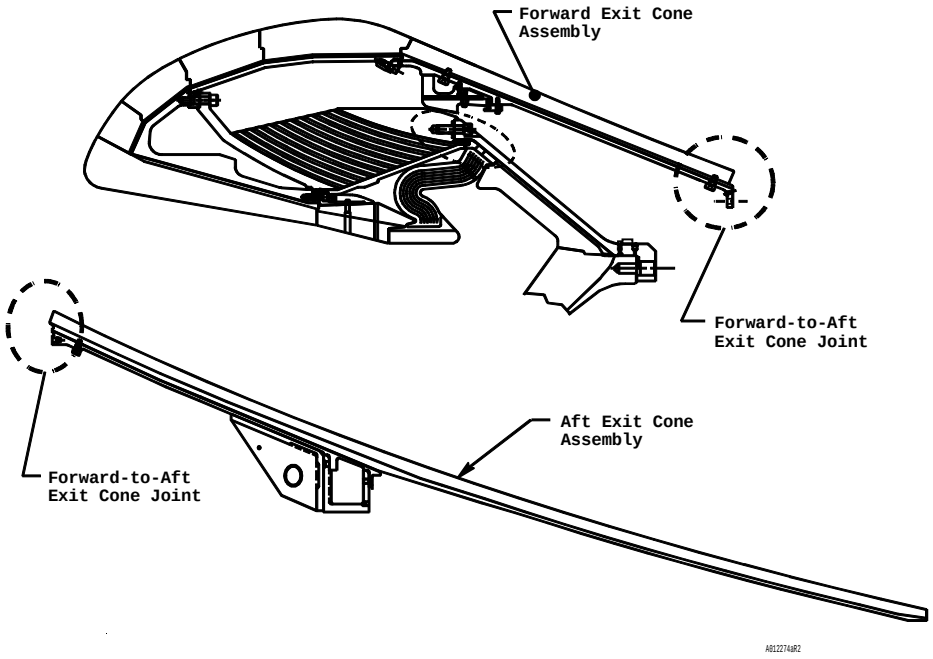

Figure 1. Forward-to-Aft Exit Cone Joint Location

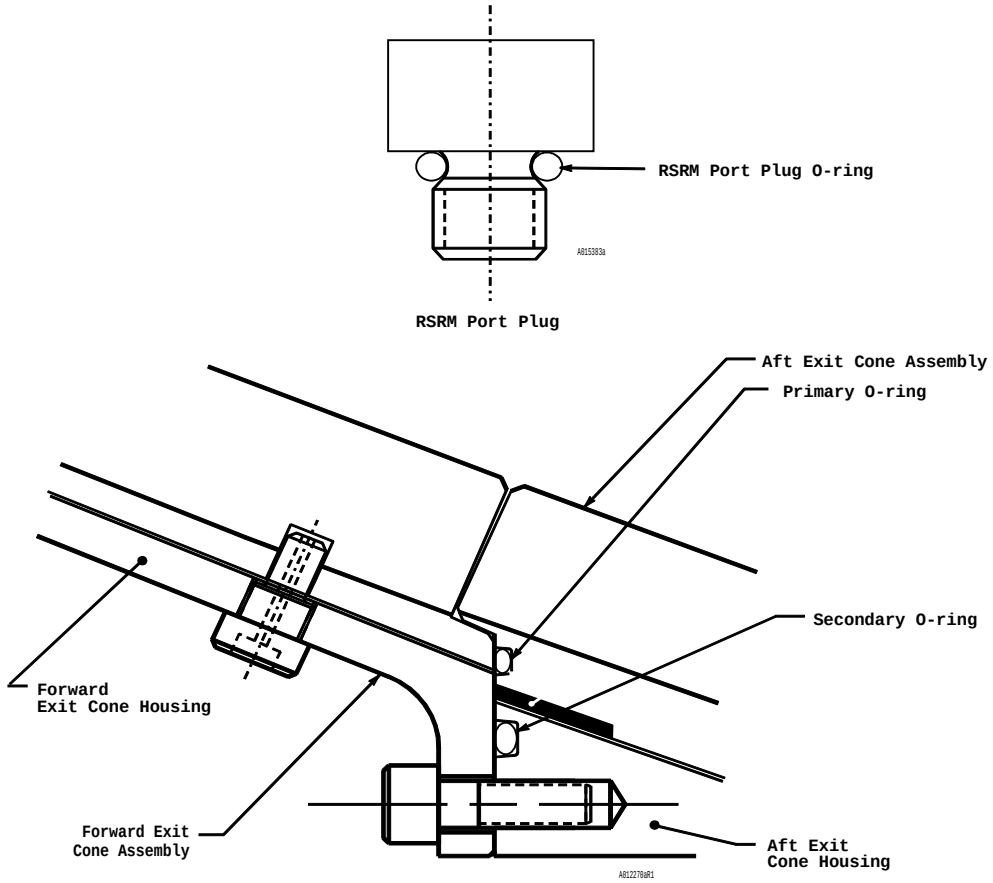

Figure 2. Forward-to-Aft Exit Cone Joint O-ring and Leak Check Port

9.0 RATIONAL 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	3.	The leak test port O-ring is a net-molded O-ring with no splices.
A,D	4.	O-rings were tested to determine size and types of flaws that could cause sealing problems per TWR-17750 and TWR-17991.
B	5.	Criteria determining primary O-ring dimensions are 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.	Large O-rings are individually packaged: a. Per engineering drawings prior to lubrication. b. Per engineering drawings after lubrication.
C	9.	Small O-rings are individually packaged per engineering.
C,H	10.	Large O-ring design allows for a minimum of stretching without damage to the O-ring per engineering.
C,H	11.	The leak check port O-ring is assembled with the RSRM Port Plug (closure screw) at KSC, using a plastic thread protector or teflon tape.
H	12.	Installation is performed after coating the O-ring with a light coat of filtered grease per engineering drawings.
C	13.	Material selection for o-rings was based in part on resistance to damage per TWR-17082.
C,H	14.	Design development testing of O-ring twisting and its effect on performance is per ETP-0153 and TWR-17991.
H	15.	To assure the correct O-ring is installed in its designated location, large O-rings are unpackaged and installed one-at-a-time.
E	16.	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 as follows: a. O-rings are packaged and stored to preclude deterioration caused by ozone, grease, ultraviolet light, and excessive temperature.

E	17.	Small and large O-ring time duration of supplier storage and total shelf life prior to installation is per engineering.
E	18.	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	19.	The O-ring (leak check port and primary) are one-time-use items.
E	20.	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	21.	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	22.	For lubricated O-rings the time duration of storage is limited after lubrication per engineering drawings.
E	23.	Large O-rings, small O-rings, and filtered grease are included in the life verification.
F	24.	Small and large O-rings are black fluorocarbon rubber.
F	25.	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	26.	Fluorocarbon rubber is a non-nutrient to fungus growth (O-ring Handbook, ORD 5700, Copyright 1982, by Parker Seal Group, Lexington, KY).
F	27.	Small and large O-rings are kept dry and clean prior to packaging.
F	28.	Small O-rings are individually packaged in an opaque, waterproof, grease-proof, and heat-sealed bag per engineering.
G	29.	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	30.	RSRM Port Plug (closure screw) design is per engineering drawings and specifications.
G	31.	Leak test port design is per engineering drawings and conforms to design criteria of MS specifications.
G,N	32.	The RSRM Port Plug (closure screw) is a one-time-use item.
G	33.	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-18764-11.
G	34.	Sealing surface requirements during refurbishment of the leak test port are per engineering drawings.

I	35.	Transportation and handling of the nozzle assembly by Thiokol is per IHM 29.
I	36.	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 and retrieval, and refurbishment sites.
I	37.	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	38.	Support equipment used to test, handle, transport, and assemble or disassemble the RSRM is certified and verified per TWR-15723.
I	39.	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	40.	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.
I	41.	Repairs to damaged phenolic sealing surfaces are performed at Thiokol per standard shop practice and shop planning.
J	42.	Filtered grease is applied to nozzle sealing surfaces at KSC during final assembly processes.
J	43.	Filtered grease filtering is per engineering to control contamination.
J	44.	Removal of surface contamination or corrosion is a standard shop practice used whenever contamination or corrosion is noted.
J	45.	Inspection for surface contamination on phenolic sealing surfaces is done at Thiokol and at KSC.
M,O	46.	RSRM Port Plug (closure screw) material is corrosion and heat-resistant steel per Aerospace Material Specifications.
K	47.	Small and large O-rings are made of high-temperature, low-compression set, fluid-resistant, black fluorocarbon rubber.
J	48.	Filtered grease is per engineering drawings and conforms to filtering specifications.
K	49.	Temperature, prior to launch, is monitored for the nozzle flexible bearing and Case-to-Nozzle Joint per TWR-15832. The Aft Exit Cone-to-Nozzle Joint is within the temperature maintained area and will benefit from temperature conditioning. Joint thermal analysis (O-ring resiliency testing) is per ETP-0276 and TWR-18597.
L	50.	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.

	L	51. Filtered grease is applied to RSRM Port Plug (closure screw) surfaces prior to installation per engineering drawings.
	N	52. Dimensions of the threaded port in the forward exit cone are per engineering drawings with design criteria per MS specifications.
	N	53. Dimensions of the threaded port in the forward exit cone during refurbishment are per engineering drawings.
	B,G,I	54. 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	B,G,I	55. 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 forward exit cone assembly and the aft exit cone 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	56. 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 CODES
		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.	Surface quality	AEB388,AEB389
A,K	(T)	i.	Tensile strength	AEB401,AEB402
A,K	(T)	j.	Ultimate elongation	AEB442,AEB443
B		k.	Correct identification	AEB100,AEB087
B		l.	Diameter	AEB018,AEB014,AEB015,AEB023
E,F		m.	Packaging is free of staples or other objects	LAA054
E,F		n.	Packaging for damage or violation	AEB179
E,F,K		o.	Material is fluorocarbon rubber	AEB141,AEB151
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 Small O-ring verify:	
B		a.	Inside diameter "A"	AAQ002,AAQ003
B		b.	Cross-sectional dimension "W"	AAQ004,AAQ062
B		c.	Flash dimensions	AAQ111,AAQ112
C,D,F		d.	Surface quality	AAQ234,AAQ233
E,F		e.	Individually packaged and sealed in opaque bags; material is per engineering	AAQ211
E		f.	No shipping or handling damage	AAQ212
F,K		g.	Material is fluorocarbon rubber	AAQ157,AAQ117
F		h.	Dry and clean prior to packaging	AAQ023
K	(T)	i.	Shore A hardness	LAA001,LAA006,LAA011,LAA016
K	(T)	j.	Tensile strength	LAA002,LAA007,LAA012,LAA017
K	(T)	k.	Ultimate elongation	LAA003,LAA008,LAA013,LAA018
K	(T)	l.	Compression-set	LAA004,LAA009,LAA014,LAA019
K	(T)	m.	Tear strength	LAA005,LAA010,LAA015,LAA020
		3.	For New O-ring, Lubricated verify:	
C,E,F		a.	O-ring packaging has not been damaged or violated	LAA103
H		b.	O-ring is cleaned and lubricated per drawing requirements	LAA104
C,H		c.	O-ring is packaged per drawing requirements	LAA105
E		d.	At least the minimum required shelf life of the filtered grease remaining prior to use	LAA255
		4.	For New Exit Cone Assembly, Forward Section verify:	
C,G		a.	Insulation-to-housing bond line is flush with surfaces adjacent	NCC005
C,G		b.	No unacceptable defects or sharp edges of adhesive bond line, aft end	NCC007
G		c.	O-ring sealing surfaces	ADI159

G			d. No unacceptable defects and surface finish of phenolic sealing surface of aft end	NCC006
		5.	For New Filtered Grease verify:	
E,F,J			a. Grease is received from storage unopened or resealed	ACP015
E,F,J			b. Shelf life of the grease, prior to filtering	AMB018L
E,F,J	(T)		c. Contamination	ANO064
E,F,J			d. Grease conforms to specification	LAA044
E,F,J			e. Cartridge conforms to drawing	LAA046
E,F,J			f. Filtered grease is capped and sealed after filling	LAA047
E,F,J			g. Filtered grease is sent to storage capped and sealed (recapped and resealed)	LAA063
		6.	For New Grease verify:	
E,F,J			a. Material received in closed containers	ANO015
E,F,J			b. Type	ANO050
E			c. No shipping or handling damage	ANO058
J	(T)		d. Penetration	LAA037
J	(T)		e. Dropping point	ANO042
J	(T)		f. Zinc concentration	LAA038
		7.	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
		8.	For New Housing, Exit Cone, Nozzle verify:	
G			a. Conformance of leak check port to specification	ADG024
N			b. VIP complete and acceptable	ADG161
N			c. Conformance of leak check port to specification	ADG024A
		9.	For Refurbished Housing, Exit Cone, Nozzle verify:	
G			a. Surface finish	ADG000
N			b. Conformance of leak check port to specification	ADG074A
		10.	For New Exit Cone, Subassembly-Nozzle, Aft verify:	
G			a. O-ring groove depth	AGL083
G			b. O-ring groove surface finish	AGL183
G			c. O-ring groove width	AGL086
G			d. O-ring groove diametric location	AGL064
		11.	KSC verifies:	
A,B,C,D, G,H,I,J	(T)		a. Leak test is performed prior to sealant backfill and the results are acceptable per OMRSD File V, Vol I, B47NZ0.110	OMD056
C,E,F			b. No damage to shipping box, shipping bag, and O-ring prior to	

		installation per OMRSD File V, Vol I, B47NZ0.052	OMD050
C,F,H,L	c.	Leak check port O-ring package for no penetrations or broken seals, use of plastic thread protector for O-ring installation, and filtered grease applied to the O-ring per OMRSD File V, Vol I, B47NZ0.090	OMD055
H,J,L	d.	Application of filtered grease on forward and aft exit cone sealing surfaces prior to installation of O-rings per OMRSD File V, Vol I, B47NZ0.120	OMD057
C,F,H,J	e.	Leak check port is free from visible contamination or corrosion and filtered grease is applied to the port prior to installation of RSRM Port Plug (closure screw) per OMRSD File V, Vol I, B47NZ0.090	OMD053
H	f.	Application of filtered grease to nozzle field joint O-rings per OMRSD File V, Vol I, B47NZ0.130	OMD058
C,J,L	g.	RSRM Port Plug (closure screw) shipping container for no damage and application of filtered grease per OMRSD File V, Vol I, B47NZ0.090	OMD054
C,H	h.	Correct parallel alignment of the nozzle field joint mating surfaces during the mating operation per OMRSD File V, Vol I, B47NZ0.060	OMD051
E	i.	Expiration date is not exceeded for materials installed at KSC per OMRSD File V, Vol I, B47GEN.160	OMD042
F,G,I,J	j.	Aft exit cone mating surfaces for damage or contamination prior to application of primer and again just prior to assembly (including black light inspection for contamination) per OMRSD File V, Vol I, B47NZ0.032	OMD048
G,I,J	k.	Forward exit cone mating surfaces prior to assembly to ensure absence of damage or contamination per OMRSD File V, Vol I, B47SG0.072	OMD080
L	l.	RSRM Port Plugs are properly torqued after the leak test per OMRSD File V, Vol I, B47GEN.130	OMD037