CRITICAL ITEMS LIST (CIL)

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

SYSTEM:	Space Shuttle RSRM 10	CRITICALITY CATEGORY:	1R
SUBSYSTEM:	Assembly Hardware/Interfaces 10-05	PART NAME:	Field Joint, Vent Port Plug (1)
ASSEMBLY:	Field Joint and Kits 10-05-01	PART NO.:	(See Section 6.0)
FMEA ITEM NO.:	10-05-01-05R Rev M	PHASE(S):	Boost (BT)
CIL REV NO.:	M	QUANTITY:	(See Section 6.0)
DATE:	31 Jul 2000	EFFECTIVITY:	(See Table 101-6)
SUPERSEDES PAGE:	224-1ff.	HAZARD REF.:	BC-01
DATED:	30 Jul 1999		
CIL ANALYST:	F. Duersch		
APPROVED BY:		DATE:	

RELIABILITY ENGINEERING: K. G. Sanofsky 31 Jul 2000

ENGINEERING: K. J. Speas 31 Jul 2000

1.0 FAILURE CONDITION: Failure during operation (D)

2.0 FAILURE MODE: 1.0 Leakage of vent port plug due to hot gas flow

3.0 FAILURE EFFECTS: Failure of the vent port seal would cause a hot gas flow path resulting in a burn through causing loss of RSRM, SRB, crew, and vehicle.

4.0 FAILURE CAUSES (FC):

FC NO.	DESCRIPTION	FAILURE CAUSE KEY
1.1	Vent port plug incorrectly installed	A
1.2	O-ring geometric deviations, cross sections too small, circumferential diameter too small	B
1.3	O-ring gland does not meet dimensional and surface finish requirements	C
1.4	O-ring cut, damaged, or improperly installed	D
1.5	O-ring voids or inclusions	E
1.6	Damage to sealing surface during transportation and handling	F
1.7	Aging degradation of O-ring	G
1.8	Sealing surface contamination	H
1.9	Moisture and/or fungus degradation of O-rings	I
1.10	Nonconforming materials	J

5.0 REDUNDANCY SCREENS:

SCREEN A: Fail--The closure plug seal cannot be verified during assembly/mission turnaround
SCREEN B: Fail--A decrease in motor chamber pressure is not detectable to the crew during boost
SCREEN C: Pass--The redundant elements can not be lost due to a single credible cause

1. The closure plug shoulder O-ring functions with the secondary O-ring to form a redundant sealing system in the event the primary O-ring fails.

2. The adjustable vent port plug features a primary and secondary O-ring seal that is verifiable. The secondary O-ring on the vent port plug will not be pressurized during flight because it is stand-by redundant to the primary O-ring. If the primary O-ring fails, the secondary O-ring (in addition to the closure plug shoulder O-ring) will be pressurized and maintain a seal. If the primary and secondary O-rings fail, a leak path will exist and could result in loss of crew and vehicle.

3. The shoulder O-ring on the closure plug that cannot be verified by leak test is not pressurized during flight because it is standby redundant to the primary O-ring. If the primary O-ring fails, the closure plug shoulder O-ring (in addition to the secondary O-ring) will be pressurized and maintain a seal. If the primary and closure plug shoulder O-rings fail, a leak path will exist and could result in loss of vehicle and crew.

6.0 ITEM DESCRIPTION:

1. There are three field joints on each RSRM (Figure 1). Each of the field joints requires a leak check port and a vent port (Figure 2). Only the vent port is addressed. The joint is assembled at KSC per engineering drawings. Figure 3 shows details of the vent port plug (either custom vent port plug or adjustable vent port plug). Materials are listed in Table 1.

2. The adjustable vent port plug and closure plug are also known as RSRM Port Plug (adjustable vent port plug) and RSRM Port Plug (closure screw) respectively.

TABLE 1. MATERIALS

Drawing No.	Name	Material	Specification	Quantity
1U77648	Assembly and Closeout, RSRM, KSC		Various	1/motor
1U52982	Case Segment	D6AC Steel	STW7-2744 or STW7-3489	2/motor
1U52983	Case Segment	D6AC Steel	STW7-2744 or STW7-3489	1/motor
1U77610	Segment, Rocket Motor, Forward		Various	1/motor
1U77620	Segment, Rocket Motor, Fwd Center	Various	1	
1U77630	Segment, Rocket Motor, Aft Center		Various	1/motor
1U77640	Segment, Rocket Motor, Aft		Various	1/motor
1U78676	RSRM Port Plug	Stainless Steel	QQ-S-763, CL316	
	(Vent Port Plug)		AMS 5648	3/motor
	(Leak Check Port Plug)	CRES	AMS 5646	3/motor
1U50228	Packing, Preformed (Primary O-ring)	Fluorocarbon Rubber	STW4-3339	3/motor
1U50228	Packing, Preformed (Secondary O-ring)	Fluorocarbon Rubber	STW4-3339	3/motor
1U50228	Packing, Preformed (Shoulder O-ring)	Fluorocarbon Rubber	STW4-3339	3/motor
1U51916	Lubricant, O-ring	Heavy-Duty Calcium Grease	STW7-3657	A/R

6.1 CHARACTERISTICS:

1. The vent port seal is a threaded port in the metal case tang end, mechanically sealed with a torqued vent port plug (Figure 3) and O-ring kit combination.

2. The vent port plug and its O-rings, as well as the closure screw and its O-ring, are one-time-use items.

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

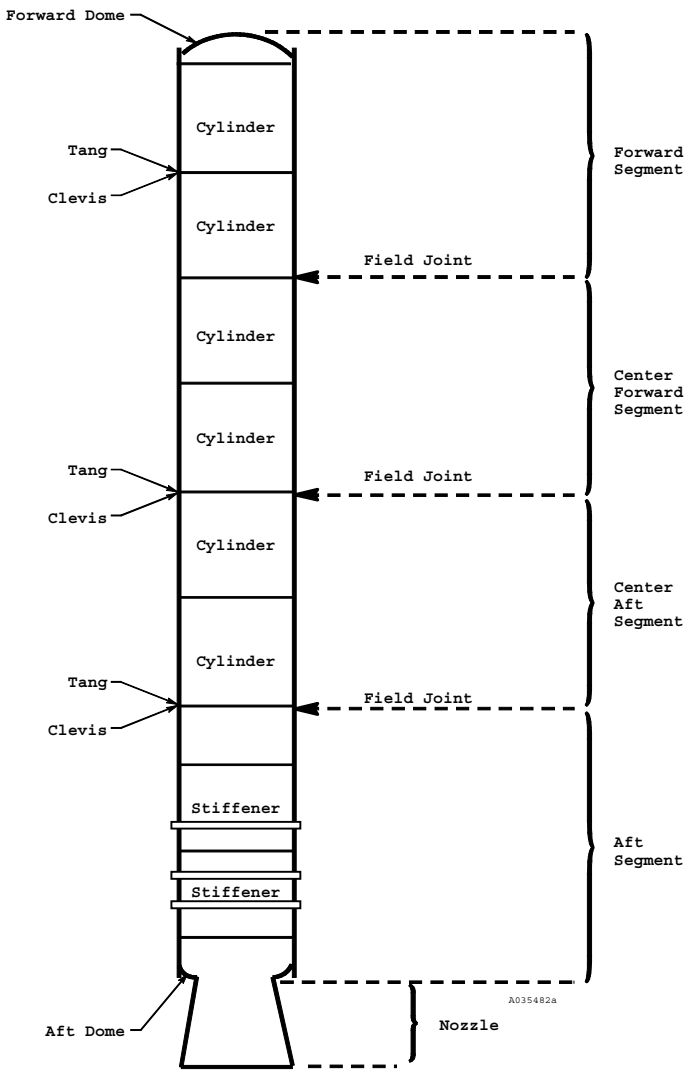

Figure 1. Field Joint Locations

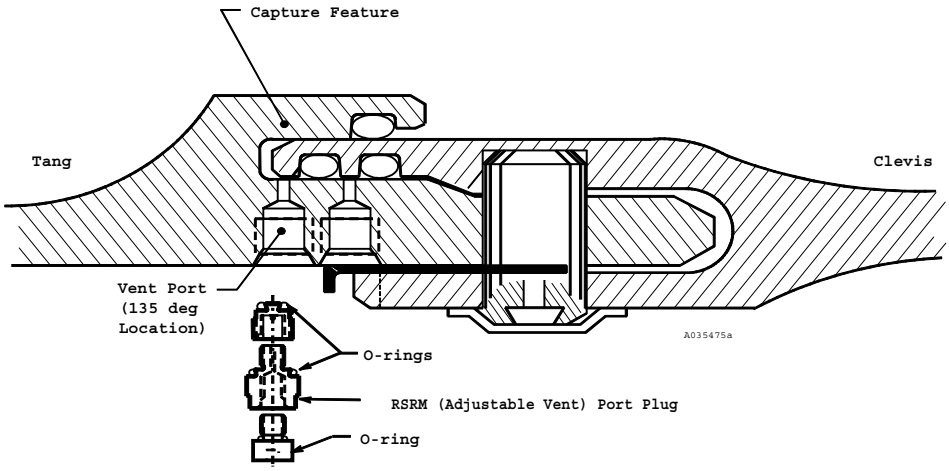

Figure 2. Field Joint Vent Port Seal

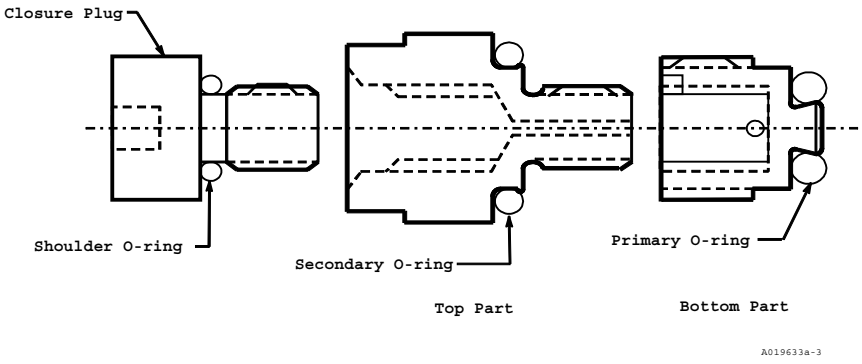

Figure 3. RSRM Port Plug (Vent Port Plug) and Seal

9.0 RATIONALE FOR RETENTION:

9.1 DESIGN:

DCN		FAILURE CAUSES
A	1.	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.
A	2.	RSRM Port Plug (adjustable vent port plug) design is per engineering drawings and specifications.
A	3.	The RSRM Port Plug (closure screw) design is per engineering drawings and specifications.
A	4.	The O-ring provides a pressure seal when seated and the RSRM Port Plug (adjustable vent port plug) is finger tight per TWR-300027.
A	5.	Design development testing for the vent port and RSRM Port Plug (adjustable vent port plug) is performed by a live firing test series per TWR-16534 and TWR-17563.
A	6.	RSRM Port Plug (adjustable vent port plug) installation into the vent port is with a light coat of filtered grease per engineering.
B,E	7.	Small O-rings are per engineering that establishes design requirements and fabrication details.
B	8.	O-ring design provides a constant contact between the O-ring and sealing surfaces.
B,E	9.	O-rings were tested to determine size and types of flaws that could cause sealing problems per TWR-17750 and TWR-17991.
C	10.	O-ring gland dimensions and sealing surfaces are per engineering for the RSRM Port Plugs (adjustable vent port plug and closure screw) and case segments.
C	11.	Qualification of sealing surface finish value is per TWR-17065.
C	12.	Sealing surface finish callout is per MS16142 and MS33649.
C	13.	The RSRM Port Plugs (adjustable vent port plug and closure screw) are one-time-use items.
C	14.	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 as reported in TWR-18764-02.
C	15.	Case segment vent port sealing surfaces are inspected during each refurbishment per engineering.
D	16.	Small O-rings are individually packaged per engineering.
D	17.	The vent port O-ring is assembled with the RSRM Port Plug (adjustable vent port plug) at KSC using an installation aid.

D 18. Installation is performed at KSC after coating the O-rings with a light coat of filtered grease per engineering drawings.

D 19. Material selection for the O-rings was based in part on resistance to damage per TWR-17082.

D 20. O-rings are installed at KSC per engineering drawings.

D 21. Design development testing of O-ring twisting and its effect on performance is per ETP-0153 and TWR-17991.

F,H 22. 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.

F,H 23. The vent port protective plug is screwed into the case port to protect the sealing surface and to keep out contaminants during transportation and handling to KSC. Installation is with a light coat of filtered grease.

F 24. Transportation and handling of case segments is per Thiokol IHM 29.

F 25. Positive cradling or support devices and tie downs that conform to shape, size, weight, and contour of the component 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 26. Support equipment used to test, handle, transport, and assemble, or disassemble the RSRM is certified and verified per TWR-15723.

F 27. Railcar transportation shock and vibration levels for the segments are monitored per engineering with loads derived per analysis. Monitoring records are evaluated by Thiokol to verify that shock and vibration levels per MSFC specifications were not exceeded.

F 28. Motor segments are protected during shipping by a segment shipping cover assembly per engineering.

G 29. 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 as follows:

a. O-rings are packaged and stored to preclude deterioration caused by ozone, grease, ultraviolet light, and excessive temperature.

G 30. Small O-ring time duration of vendor storage and total shelf life prior to installation is per engineering.

G 31. O-ring aging studies 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.

G 32. O-rings are one-time-use items.

G 33. Grease is stored at warehouse-ambient condition which is any condition of temperature and relative humidity experienced by the material when stored in an enclosed warehouse, in unopened containers, or containers which were resealed after each use. Storage life under these conditions is per engineering.

G 34. 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.

H 35. Sealing surfaces are inspected for contamination, and cleaned as necessary.

a. During processing, Thiokol takes steps to protect all case segment exposed bare metal surfaces to minimize corrosion. Superficial discoloration is allowed as long as it does not interfere with the inspection of the hardware. Corrosion is removed prior to hardware assembly per engineering.
b. During local transportation, Thiokol uses environmentally controlled shipping containers, which allow case segments to be shipped without grease per TWR-65920.

H 36. Filtered grease is applied to sealing surfaces during final assembly processes per engineering drawings.

H 37. Requirements for process environmental control for all critical process operations are per SN-C-0005.

H 38. Grease filtering is per engineering to control contamination.

I 39. Small O-rings are black fluorocarbon rubber.

I 40. 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).

I 41. Fluorocarbon rubber is a non-nutrient to fungus growth (O-ring Handbook, ORD 5700, Copyright 1982, by Parker Seal Group, Lexington, KY).

I 42. Small O-rings are kept clean and dry prior to packaging.

I 43. Small O-rings are individually packaged in an opaque, waterproof, grease-proof, and heat-sealed bag per engineering.

J 44. RSRM Port Plug (adjustable vent port plug) material is alloy steel per AMS specifications.

J 45. RSRM Port Plug (closure screw) material is corrosion and heat-resistant steel per Aerospace Material Specifications.

J 46. Small O-rings are high-temperature, low-compression set, fluid-resistant, black fluorocarbon rubber.

J 47. Filtered grease is applied during installation of the RSRM Port Plugs (adjustable vent port plug).

J 48. Temperature prior to launch is monitored for the case field joint and is maintained per TWR-15832. Joint thermal analysis (O-ring resiliency testing) is per TWR-

18757 and TWR-17991.

G 49. Small O-rings and filtered grease are included in the life verification.

H 50. Filtered grease is included in the life verification.

B,C 51. TWR-61410 was updated to include boundary conditions created by the Performance Enhancement (PE) Program. This report analyzed temperature conditions created from flight loads. PE temperatures are equal to current generic temperatures for all locations for the critical time of liftoff. For a few locations at the factory joints and case acreage during flight, temperatures rise, but only slightly, and maximum case temperatures are lower than current generic certification. For flight load events, PE temperatures are not significantly different from current generic temperatures. There is no impact on previous analyses or margins of safety for case membranes, factory joints, and field joints per TWR-61410.

A 52. RSRM Port Plug (adjustable vent port plug and 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	TESTS	(T)	FAILURE CAUSES and	CIL CODE
			1. For New RSRM Port Plug (adjustable vent port plug) verify:	
A			a. All thread forms conform to the drawing	AHB002
A			b. Thread surface blemishes	LAA276
A,C			c. All plug length dimensions	AHB017
C			d. Primary O-ring groove width dimension	AHB034
C			e. Primary O-ring groove diameter	AHB005
C			f. Primary O-ring groove surface finish	AHB028
C			g. Secondary O-ring groove width dimension	AHB034A
C			h. Secondary O-ring groove diameter	AHB005A
C			i. Secondary O-ring groove surface finish	AHB028A
C			j. Primary O-ring groove sealing surface blemishes	LAA279
C			k. Secondary O-ring groove sealing surface blemishes	LAA280
C			l. Port is per specification	NCC003
H,J			m. Material is steel alloy	AHB018
J		(T)	n. Tensile strength	AIE006
J		(T)	o. Yield strength	AIE008
J		(T)	p. Minimum elongation	AIE002
J		(T)	q. Minimum reduction of area	AIE004
			2. For New RSRM Port Plug (closure screw) verify:	
A			a. Thread surface blemishes	LAA271
A			b. Correct thread form	AAO071
C			c. O-ring groove surface finish	AAO037
C			d. O-ring groove sealing surface blemishes	LAA270
C			e. O-ring groove diameter dimension	AAO025
C			f. O-ring groove width dimension	AAO047
C			g. Plug length	AAO063
J			h. Material is corrosion- and heat-resistant steel	AAO067
			3. For New Segment, Rocket Motor (Forward, Forward Center, and Aft Center), verify:	
H			a. Vent port located at 135 degrees is free of contamination prior to installation of the vent port protective plug	AFR020,AFS019,AFU019
A			b. Filtered grease is used when installing the vent port protective plug	AFR027,AFS027,AFU027
F			c. Vent port protective plug is installed finger tight	AFR037,AFS038,AFU038
F			d. Vent port protective plug is free of any obvious damage that affects form, fit or function prior to installation	AFR048,AFS048,AFU048
			4. For New Small O-ring verify:	
B			a. Correct identification	AAQ047,AAQ037
B			b. Inside diameter "A"	AAQ002,AAQ003
B			c. Cross-sectional dimension "W"	AAQ004,AAQ062
B			d. Flash dimensions	AAQ111,AAQ112
D,E,I			e. Surface quality	AAQ234,AAQ233
I,J			f. Material is fluorocarbon rubber	AAQ157,AAQ117
I			g. Dry and clean prior to packaging	AAQ092,AAQ023

J		h.	Shore A hardness	LAA001,LAA006,LAA011,LAA016
J		i.	Tensile strength	LAA002,LAA007,LAA012,LAA017
J		j.	Ultimate elongation	LAA003,LAA008,LAA013,LAA018
J		k.	Compression-set	LAA004,LAA009,LAA014
J		l.	Tear strength	LAA005,LAA010,LAA015,LAA020

5. For New Case Segment, Capture Cylinder, Standard Weight, verify:

C		a.	Surface finish of ports	ADX025,ADX025A
		b.	Case port depth	ADX027
C		c.	Case port thread length	ADX021,ADX021A
C		d.	Diameter -D- on ports	ADX049,ADX049A
C		e.	Case port angle K	ADX137,ADX137A
C		f.	Case vent port depth	ADX027A

6. For Refurbished Case Segment, Capture Cylinder, Standard Weight, verify:

C		a.	Surface finish of ports	ADX023

7. For New Case Segment, Capture Cylinder, Light Weight, verify:

C		a.	Surface finish of ports	ADW141,ADW141A
C		b.	Case port depth	ADW022
C		c.	Case port thread length	ADW028,ADW028A
C		d.	Diameter -D- on port	ADW050,ADW050A
C		e.	Case port angle K	ADW142,ADW142A
C		f.	Case vent port depth	ADW022A

8. For Refurbished Case Segment, Capture Cylinder, Light Weight, verify:

C		a.	Surface finish of ports	ADW024

9. For New Filtered Grease verify:

H,J	(T)	a.	Contamination	ANO064

10. For New Grease verify:

J	(T)	a.	Penetration	LAA037
J	(T)	b.	Dropping point	ANO042
J	(T)	c.	Zinc concentration	LAA038

11. KSC verifies:

A,B,C,D, E,F,H	(T)	a.	Proper installation of RSRM Port Plug (closure screw) and acceptability of leak test per OMRSD File V, Vol I, B47CJ0.030	OMD028
G,H		b.	Expiration date is not exceeded for materials installed at KSC per OMRSD File V, Vol I, B47GEN.160	OMD042
A,D,F,H,I		c.	Leak check and vent 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, B47SG0.310	OMD097
A,D,F,H,I		d.	RSRM Port Plugs (adjustable vent port plug, closure screw and leak check port plug) shipping containers for no damage and application of filtered grease OMRSD File V, Vol I B47SG0.310	OMD098

A,D,F,H,I	e.	Field joint leak check and vent ports for damage, contamination, or corrosion per OMRSD File V, Vol I, B47SG0.310	OMD099
A	f.	Proper installation by the "D" dimension method of bottom RSRM Port Plug (adjustable vent port plug) and proper installation of top RSRM Port Plug (adjustable vent port plug) per OMRSD File V, Vol. I B47SG0.590	OMD114