ATK ALLIANT TECHSYSTEMS
THIOKOL PROPULSION

CRITICAL ITEMS LIST (CIL)

No. 10-05-02-04R/01

SYSTEM:	Space Shuttle RSRM 10	CRITICALITY CATEGORY:	1R
SUBSYSTEM:	Assembly Hardware/Interfaces 10-05	PART NAME:	Case-to-Nozzle Joint, Vent Port Plug (1)
ASSEMBLY:	Case-to-Nozzle Interface 10-05-04		
FMEA ITEM NO.:	10-05-02-04R 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:	353-1ff.	EFFECTIVITY:	(See Table 101-6)
DATED:	31 Jul 2000	HAZARD REF.:	BC-04
CIL ANALYST:	R. E. L. Hamilton		
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 the vent port plug

3.0 FAILURE EFFECTS: Failure of the vent port plug would result in hot gasses eroding the fixed housing creating a larger hole allowing gas to escape and motor chamber pressure to decrease. Expulsion of the nozzle could cause loss of TVC, a side thrust, thrust imbalance leading to loss of RSRM, SRB, crew, and vehicle

4.0 FAILURE CAUSES (FC):

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

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, which cannot be verified by leak test, will not be 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 is one joint on each RSRM between the aft case segment and the nozzle assembly that is designed with a vent port plug. The vent port allows air that may be trapped during the case segment and nozzle assembly mating a path of escape. The vent port also allows gaseous nitrogen, that may bypass the primary O-ring during the primary and secondary O-ring leak test, a path of escape rather than forming blow holes in the joint sealant. The assembled joint is shown in the assembly drawing and in (Figures 1 and 2). 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
1U78676	RSRM Port Plug (adjustable vent port plug)	A-286 Alloy	AMS 5737	1/motor
	(closure screw)	CRES	AMS 5646	1/motor
1U50228	Packing, Preformed	Black Fluorocarbon Rubber	STW4-3339	1/motor
1U52945	Housing, Nozzle-Fixed			1/motor
1U51916	Cartridge Assembly	Heavy-Duty Calcium Grease, Filtered and Placed in an Application Cartridge	STW7-3657	A/R
	Corrosion-Preventive Compound and O-ring Lubricant	Heavy-Duty Calcium Grease	STW5-2942	A/R
1U77640	Segment Assembly, Rocket Motor, Aft			1/motor

6.1 CHARACTERISTICS:

1. The vent port is a threaded port in the metal fixed housing, mechanically sealed with a torqued vent port plug and O-ring.

2. The vent port plug and its O-ring, 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

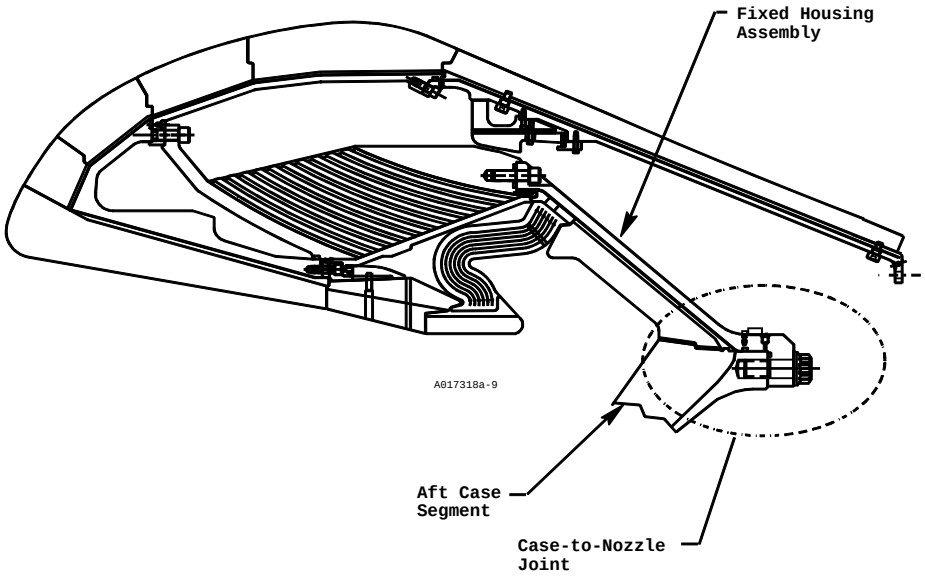
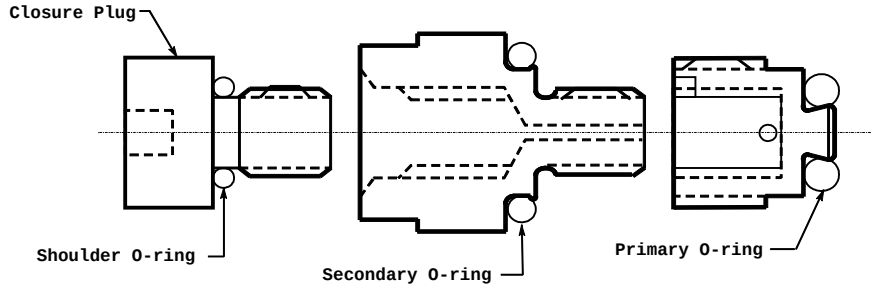


Figure 1. Case-to-Nozzle Joint Location

RSRM Port Plug
(Adjustable Vent Port Plug Assembly)



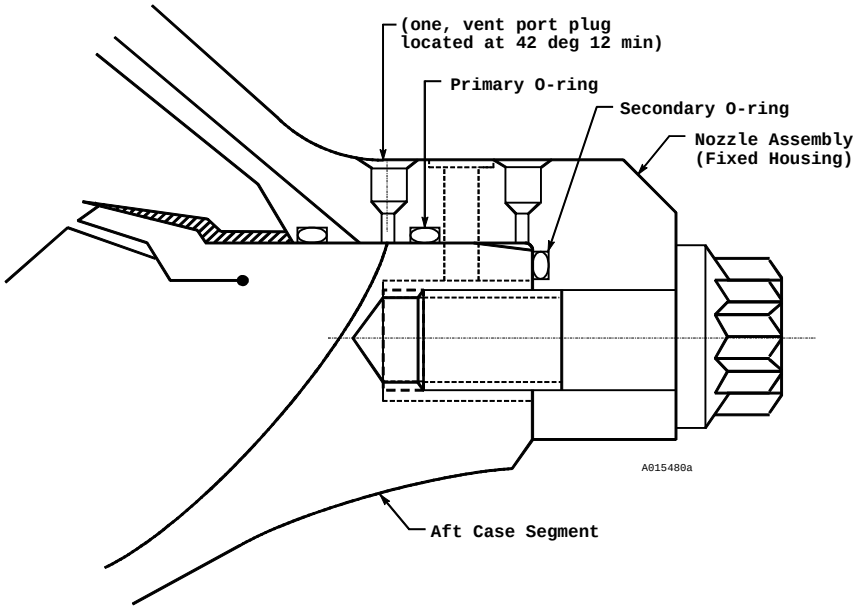


Figure 2. Case-to-Nozzle Joint RSRM Port Plug (Vent Port and Adjustable Vent Port Plug)

9.0 RATIONALE FOR RETENTION:

9.1 DESIGN:

DCN		FAILURE CAUSES
A	1.	O-ring gland dimensions and sealing surfaces are established per engineering drawings and comply with the requirements of MS specifications and engineering.
A	2.	Qualification of sealing surface finish value is per TWR-17065.
A	3.	The RSRM Port Plugs (adjustable vent port plug and closure screw) are one-time-use items.
A	4.	The design development test for O-ring sealing surfaces is qualified by live firing tests per TWR-16534 and TWR-17563.
A	5.	O-ring sealing surfaces during refurbishment are established per engineering drawings.
B,D	6.	Small O-rings conform to engineering that establishes geometric dimensions and fabrication details.
B	7.	O-ring design provides a constant contact between the O-ring and sealing surfaces.
B,D	8.	O-rings were tested to determine sizes and types of flaws that could cause sealing problems. Results are presented in TWR-17991.
C	9.	Small O-rings are individually packaged per engineering.
C	10.	The vent port shoulder O-ring is assembled with the RSRM port plug (closure screw) using an installation aid.
C	11.	Filtered grease is applied to primary, secondary, and shoulder O-rings prior to installation.
C	12.	Material selection for O-rings was based in part on resistance to damage as documented in TWR-17082.
C	13.	The small O-ring is installed with the RSRM port plugs (adjustable vent port plug and closure screw) per engineering.
C	14.	Design development testing regarding O-ring twisting and its effect on performance was performed per ETP-0153, with test results documented in TWR-17991.
E	15.	Transportation and handling of the nozzle assembly by Thiokol is detailed per IHM 29.
E	16.	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.
E	17.	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.

E 18. Support equipment used to test, handle, transport, assemble, or disassemble the RSRM is certified and verified per TWR-15723.

E 19. 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.

E 20. 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.

F 21. 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.

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

F 22. Small O-ring time duration of supplier storage and total shelf life prior to installation is limited per engineering.

F 23. 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.

F 24. The O-ring is a one-time-use item.

F 25. Grease is stored at warehouse-ambient conditions 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.

F 26. Aging studies to demonstrate characteristics of grease after 5 years of 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.

F 27. Small O-rings are included in the aft segment life verification.

G 28. Small O-rings are black fluorocarbon rubber.

G 29. 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).

G 30. Fluorocarbon rubber is a non-nutrient to fungus growth (O-ring Handbook, ORD 5700, Copyright 1982, by Parker Seal Group, Lexington, KY).

G 31. Small O-rings are kept dry and clean prior to packaging.

G 32. Small O-rings are individually packaged in an opaque, waterproof, grease-proof, and heat-sealed bag per engineering.

H	33.	Corrosion-preventative compound is applied to all sealing surfaces per engineering.
H	34.	Filtered grease is applied to all sealing surfaces per engineering.
H	35.	Filtered grease filtering is per engineering to control contamination.
H	36.	Removal of surface contamination or corrosion is a standard shop practice used whenever contamination or corrosion is noted per shop planning.
H	37.	Contamination control requirements and procedures are described in TWR-16564.
I	38.	RSRM Port Plug (adjustable vent port plug) design requirements are per engineering drawings with acceptance per engineering.
I	39.	RSRM Port Plug (closure screw) Nozzle design requirements are per engineering drawings with acceptance per engineering.
I	40.	The O-ring provides an adequate seal when it is visibly seated and the RSRM Port Plug (adjustable vent port plug) is at least finger tight per TWR-300027.
I	41.	Required torque for the RSRM Port Plug (adjustable vent port plug and closure screw) is called out per engineering drawings and specifications. The RSRM Port Plug (Closure screw) value is based on results from sealability tests documented in TWR-17364.
I	42.	Filtered grease is applied to RSRM Port Plug (adjustable vent port plug and closure screw) surfaces prior to installation per engineering.
J	43.	RSRM Port Plug (adjustable vent port plug) material is alloy steel per AMS specifications.
J	44.	RSRM Port Plug (closure screw) material is corrosion and heat-resistant steel per Aerospace Material Specifications.
J	45.	Filtered grease material requirements are per engineering.
J	46.	Temperature prior to launch is monitored for the nozzle flexible bearing and the Case-to-Nozzle Joint and is maintained to requirements per TWR-15832. Joint thermal analysis (O-ring resiliency testing) is per TWR-16818.
K	47.	RSRM Port Plug (adjustable vent port plug and closure screw) design requirements are established per engineering drawings with acceptance per engineering. RSRM Port Plugs (adjustable vent port plug and closure screw) are one-time-use items.
K	48.	Dimensions of the threaded port in the nozzle fixed housing are established per engineering drawing with design criteria per MS specifications.
K	49.	Dimensions of the threaded port in the nozzle fixed housing during refurbishment are established per engineering drawings.
A,E	50.	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 A,E

51. 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 fixed housing 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.

A,E

52. 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 the case membranes, factory joints, and field joints per TWR-61410.

I,K

53. 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	FAILURE CAUSES and TESTS (T)			CIL CODES
		1.	For New RSRM Port Plug (closure screw) verify:	
A		a.	O-ring groove width dimension	AAO047
A		b.	O-ring groove surface finish	AAO037
A		c.	O-ring groove diameter dimension	AAO025
A		d.	Plug length	AAO063
A		e.	O-ring groove sealing surface blemishes	LAA270
H,J		f.	Material is corrosion and heat resistant steel	AAO067
K		g.	Correct thread form	AAO071
K		h.	Thread surface blemishes	LAA271
		2.	For New Housing, Nozzle-Fixed verify:	
A		a.	"J" dimension	ADV156,ADV157A
A		b.	Surface finish	ADV158,ADV159A
A		c.	Minimum full thread depth	ADV160,ADV161A
A		d.	Diameter	ADV184,ADV185A
A		e.	Slope "K"	ADV193,ADV194A
K		f.	Conformance of port to specification	ADV026
		3.	For Refurbished Housing, Nozzle Fixed verify:	
A		a.	Surface finish	ADV192
K		b.	Threads	ADV101A
		4.	For New RSRM Port Plug (adjustable vent port plug) verify:	
A		a.	Primary O-ring groove width dimension	AHB034
A		b.	Primary O-ring groove diameter	AHB005
A		c.	Primary O-ring groove surface finish	AHB028
A		d.	All plug length dimensions	AHB017
A,I		e.	Secondary O-ring groove width dimension	AHB034A
A		f.	Secondary O-ring groove diameter	AHB005A
A		g.	Secondary O-ring groove surface finish	AHB028A
A		h.	Primary O-ring groove sealing surface blemishes	LAA279
A		i.	Secondary O-ring groove sealing surface blemishes	LAA280
A		j.	Port is per specification	NCC003
H,J		k.	Material is steel alloy	AHB018
I,K		l.	All the thread forms conform to the drawing	AHB002
I,K		m.	Thread surface blemishes	LAA276
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

5. For New Segment, Rocket Motor, Aft verify:

A,B,D, C,E,H,I	(T)	a.	RSRM Port Plug (adjustable vent port plug) leak test	AGJ154
C		b.	Correct identification of vent port O-rings	AGJ093,AGJ094,AGJ095
C		c.	Proper installation of vent port O-rings	LAA157,LAA171,LAA172
C,H,I		d.	Application of lubricant to RSRM Port Plug (closure screw)	AGJ045
C,H,I		e.	Application of lubricant to vent port O-rings	AGJ070,AGJ070A,AGJ046
C,H,I		f.	Application of lubricant to Fixed Housing vent port and RSRM Port Plug (adjustable vent port plug) prior to assembly	AGJ068,AGJ068A
C		g.	Vent port O-rings are free from damage	LAA168,LAA169,LAA170
C		h.	Vent port O-rings are properly installed	AGJ207,LAA173,LAA174
C		i.	Installation and fit of vent port O-rings	AGJ199,AGJ200,AGJ201
E		j.	RSRM Port Plug (closure screw) is free from damage	LAA176
E		k.	RSRM Port Plug (adjustable vent port plug) is free from damage	LAA175
E		l.	RSRM Port Plug (adjustable vent port plug) sealing surfaces are free from damage prior to installation of the RSRM Port Plug (closure screw)	LAA158
F		m.	Vent port O-rings shelf life has not expired	AGJ222A,AGJ223A,AGJ224
G		n.	Shoulder vent port O-ring is free from fungus and moisture prior to mating with the RSRM Port Plug (closure screw)	AAQ188B,AAQ189B
G		o.	Vent port O-rings are free from fungus and moisture prior to mating with the RSRM Port Plug (adjustable vent port plug)	AAQ188,AAQ189, AAQ188A,AAQ189A
G		p.	Fixed Housing aft end vent port is free from fungus and moisture prior to installation of the RSRM Port Plug (adjustable vent port plug)	AGJ241A,AGJ242A
H		q.	Fixed Housing aft end vent port is free from corrosion and contamination prior to installation of the RSRM Port Plug (adjustable vent port plug)	LAA159
H		r.	RSRM Port Plugs (adjustable vent port plug and closure screw) are free from corrosion and contamination prior to O-ring installation	LAA160,LAA161
I		s.	Correct lubricant is being used on the RSRM Port Plugs (adjustable vent port plugs)	ACP016
I		t.	Final torque is properly performed during installation of RSRM Port Plugs (adjustable vent port plug and closure screw)	AGJ090,AGJ245
I		u.	"D" dimension of the installed bottom portion of the RSRM Port Plug (adjustable vent port plug) is correct per specification	NCC012

6. 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
C,D,G		e.	Surface quality	AAQ234,AAQ233
F,G		f.	Individually packaged and sealed in opaque bags; material is per engineering	AAQ211
F		g.	No shipping or handling damage	AAQ212
G,J		h.	Material is fluorocarbon rubber	AAQ157,AAQ117
G		i.	Dry and clean prior to packaging	AAQ092,AAQ023
J	(T)	j.	Shore A hardness	LAA001,LAA006,LAA011,LAA016
J	(T)	k.	Tensile strength	LAA002,LAA007,LAA012,LAA017
J	(T)	l.	Ultimate elongation	LAA003,LAA008,LAA013,LAA018
J	(T)	m.	Compression-set	LAA004,LAA009,LAA014,LAA019
J	(T)	n.	Tear strength	LAA005,LAA010,LAA015

		7.	For New Filtered Grease verify:	
F,G,H,J		a.	Grease is received from storage unopened or resealed	ACP015
F,G,H,J		b.	Shelf life of the grease, prior to filtering	AMB018L
F,G,H,J	(T)	c.	Contamination	ANO064
F,G,H,J		d.	Grease conforms to specification	LAA044
F,G,H,J		e.	Cartridge conforms to drawing	LAA046
F,G,H,J		f.	Filtered grease is capped and sealed after filling	LAA047
F,G,H,J		g.	Filtered grease is sent to storage capped and sealed (recapped and resealed)	LAA063
		8.	For New Grease verify:	
J	(T)	a.	Penetration	LAA037
J	(T)	b.	Dropping point	ANO042
J	(T)	c.	Zinc concentration	LAA038
		9.	KSC verifies:	
I,J		a.	Temperature at the case-to-nozzle joint is acceptable prior to launch and is in compliance with Launch Commit Criteria (NSTS-16007) per OMRSD File II, Vol I, S00FA0.777.	OMD014
F		b.	Life requirements for the expected launch schedule are met per OMRSD File II, Vol III, C00CA0.030.	OMD019