ATK ALLIANT TECHSYSTEMS
THIOKOL PROPULSION

CRITICAL ITEMS LIST (CIL)

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

SYSTEM:	Space Shuttle RSRM 10	CRITICALITY CATEGORY:	1
SUBSYSTEM:	Nozzle Subsystem 10-02	PART NAME:	Nozzle Assembly Plug (1)
ASSEMBLY:	Nozzle Assembly Plug 10-02-02	PART NO.:	(See Section 6.0)
FMEA ITEM NO.:	10-02-02-01R Rev N	PHASE(S):	Prelaunch (PL)
CIL REV NO.:	N	QUANTITY:	(See Section 6.0)
DATE:	27 Jul 2001	EFFECTIVITY:	(See Table 101-6)
SUPERSEDES PAGE:	344-1ff.	HAZARD REF.:	FN-01
DATED:	31 Jul 2000		
CIL ANALYST:	R. E. L. Hamilton		
APPROVED BY:		DATE:	

RELIABILITY ENGINEERING: K. G. Sanofsky 27 July 2001

ENGINEERING: V. B. Teller 27 July 2001

1.0 FAILURE CONDITION: Failure during operation (D)

2.0 FAILURE MODE: 1.0 Structural failure

3.0 FAILURE EFFECTS: Exposes RSRM to natural environments or premature ignition due to SSME exhaust heating causing loss of RSRM, SRB, crew, and vehicle

4.0 FAILURE CAUSES (FC):

FC NO.	DESCRIPTION	FAILURE CAUSE KEY
1.1	Temperature, vibration, and shock	A
1.2	Insufficient material thickness	
1.2.1	Material not manufactured to required thickness	B
1.2.2	Insufficient thickness of protective coating	C
1.3	Nonconforming raw material properties	D
1.4	Nonconforming dimensions	E
1.5	Component degradation during handling, assembly, storage, or transportation	F
1.6	Damage to plug during flight-readiness firing of SSMEs	G
1.7	Bond line failure	
1.7.1	Bonding surface not properly prepared or adequately cleaned	H
1.7.2	Bonding material not properly applied, mixed, or cured	I
1.7.3	Nonconforming material properties of adhesive (sealant)	J
1.7.4	Contamination during processing	K
1.7.5	Process environments detrimental to bond strength	L
1.7.6	Bondline not to required thickness	M

1.8 Improper installation of plug N

5.0 REDUNDANCY SCREENS:

SCREEN A: N/A
SCREEN B: N/A
SCREEN C: N/A

6.0 ITEM DESCRIPTION:

1. Plug, Protective, Nozzle consists of urethane foam (Figure 1). Materials are listed in Table 1.

TABLE 1. MATERIALS

Drawing No.	Name	Material	Specification	Quantity
1U51710	Billet,Foam Plug	Urethane		1/motor
1U75245	Cable Installation, Aft Segment			A/R
1U77640	Segment, Rocket Motor, Aft			1/motor
	Primer, Silicone Rubber	Silicone Rubber	STW5-3166	A/R
	Silicone Rubber, Room	Silicone Rubber, RTV-21	STW5-3154	A/R
	Sealant, Polysulfide	Synthetic Rubber, Polysulfide	STW5-9072	A/R

6.1 CHARACTERISTICS:

1. The nozzle protective plug is a flat, round, polyurethane foam plug that is approximately 6.5 inches thick and 60-inches in diameter. The top and bottom outside radial 5 inches and outside diameter surfaces of the foam plug are stiffened using a polysulfide coating. Top and bottom surfaces are covered with primer and then coated with an insulation barrier of RTV-21 silicone rubber.

2. The nozzle protective plug is bonded to the inside surface of the exit cone and is designed to function as an environmental seal after SRM assembly, and to isolate the RSRM propellant grain from the Space Shuttle Main Engine (SSME) exhaust environment prior to RSRM ignition.

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

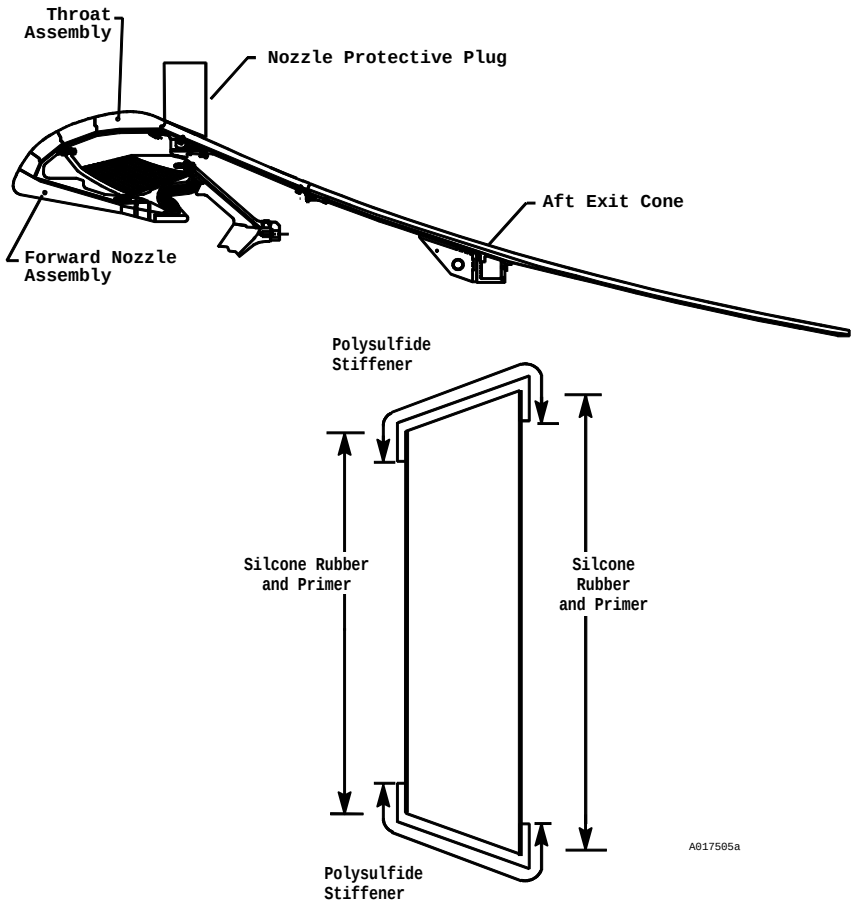

Figure 1. Nozzle Protective Plug

9.0 RATIONALE FOR RETENTION:

9.1 DESIGN:

DCN FAILURE CAUSES

A 1. An analysis was performed on the redesigned nozzle protective plug to verify the following structural requirements per TWR-16563:

a. The plug is capable of resisting an external pressure of 2.12 psi, which includes a factor of safety of 1.4 and a positive margin of safety.
b. The nozzle protective plug is capable of resisting an internal pressure of 2.0 psi, but will fail before reaching 12 psi.
c. The nozzle protective plug is capable of resisting a one-third octave band acoustic pressure environment.

A 2. A thermal analysis was performed on the redesigned nozzle protective plug to determine the thermal response of the plug when exposed to a heating load similar to the SSME exhaust environment per TWR-16538. The following conclusions were drawn:

a. RTV-21 (silicone rubber external plug surface) will stay below 400°F preventing any RTV-21 thermal and structural degradation.
b. Polyurethane foam will stay below 125°F preventing any foam shrinking and/or debonding from RTV-21.
c. Polysulfide sealant and adhesive will stay below 275°F and retain its structural integrity.

A,B,C,E 3. Testing was performed on the nozzle protective plug to determine dimensional effects due to temperature changes from 20°F to 110°F and relative humidity up to 85 percent at 110°F per ETP-0054.

A 4. Testing was performed on nozzle protective plug materials to characterize material properties at temperatures of -5°F to 165°F and relative humidity up to 95 percent per ETP-0055.

A,F 5. Thermal analyses were performed for RSRM components during in-plant transportation and storage to determine acceptable temperature and ambient environment exposure limits per TWR-50083. Component temperatures and exposure to the ambient environment during in-plant transportation or storage is per engineering.

B,C,E 6. Total thickness of the nozzle protective plug is a result of the thickness of the polyurethane foam plug plus the combined thickness of polysulfide compound, silicone rubber primer, and silicone rubber insulation barrier. Thickness is per engineering drawings as follows:

a. The polyurethane foam plug is machined from an oversized foam billet (Billet, Foam Plug) to dimensions per engineering drawings.
b. For Sealant, Polysulfide, sealing compound thickness is controlled by material weight to a nominal thickness.
c. Primer, Silicone Rubber plus Silicone Rubber, RTV insulation barrier thickness is controlled by material weight to achieve a nominal thickness.

C,E 7. Weighing of materials for nozzle protective plug fabrication is per engineering.

B,C,E 8. Conforming nozzle protective plug dimensions ensure a fit that will isolate the RSRM propellant grain from the SSME exhaust environment prior to RSRM ignition per engineering drawings.

D	9.	Raw material properties used in the nozzle protective plug are per the following material specifications: a. Sealant, Polysulfide b. Silicone Rubber, RTV c. Billet, Nozzle Foam Plug, Acceptance Criteria d. Primer, Silicone Rubber
F	10.	Transportation and handling of nozzle assembly items by Thiokol is per IHM 29.
F	11.	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.
F	12.	Support equipment used to test, handle, transport, and assemble or disassemble the RSRM is certified and verified per TWR-15723.
F	13.	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	14.	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.
F	15.	Aging and storage parameters for the nozzle plug are per TWR-15723.
F	16.	Age degradation analysis of the nozzle foam plug relative to the 5-year storage period requirement is per TWR-65282.
G	17.	A Flight-Readiness Firing (FRF) cover is placed over the aft exit cone prior to FRF. A nozzle protective plug is used for additional protection to isolate the RSRM propellant grain from the SSME exhaust environment during FRF.
H,K	18.	Requirements for installation of the nozzle protective plug are per engineering drawings.
H,K,L	19.	Surface preparation and cleanliness are per engineering drawings and shop planning.
K,L	20.	Contamination control requirements and procedures are per TWR-16564.
K,L	21.	Testing is performed on nozzle protective test plugs per TWR-16542.
H,K	22.	Preparation and cleaning methods for bonding surfaces are per engineering. Bonding surfaces are properly prepared, which includes cleaning, prior to nozzle plug installation.
I,M	23.	Mixing, application, cure, and bondline thickness of protective nozzle plug installation are per engineering drawings and shop planning.
J	24.	Material properties of polysulfide compound that is used as an adhesive in nozzle plug installation are per engineering.

N 25. Nozzle protective plug installation is performed at Thiokol per engineering drawings.

9.2 TEST AND INSPECTION:

DCN	FAILURE CAUSES and TESTS (T)			CIL CODES
		1.	For New Segment Assembly, Rocket Motor, verify:	
	A,F	a.	Component environments during in-plant transportation or storage	BAA030
	F	b.	No damage or degradation of the nozzle protective plug prior to installation	ACL004
	H,K,N	c.	Nozzle Assembly and nozzle protective plug surfaces have been properly prepared	AEV013
	M,N	d.	Measurement of bond gap during dry-fit of the nozzle protective plug	AEV003
	I,M,N	e.	Sealing compound is applied to the faying surfaces of nozzle assembly and plug	AEV014
	I,N (T)	f.	Sealing compound is cured and shore A hardness obtained	AEV008
	I	g.	Adhesive is mixed in accordance with the specifications	AEV010
	N	h.	Acceptable force is applied to nozzle protective plug for required time	AEV000
		2.	For New Plug, Protective, Nozzle verify:	
	B,C,E	a.	Required amount of polysulfide compound is evenly applied to aft surface per engineering	ACL006
	B,C,E	b.	Required amount of polysulfide compound is evenly applied to forward surface per engineering	ACL007
	C,E	c.	Required amount of polysulfide compound is evenly applied to outside diameter per engineering	ACL008
	B,C,E	d.	Full coverage coat of primer is applied to forward surface per engineering	ACL010
	B,C,E	e.	Full coverage coat of primer is applied to aft surface per engineering	ACL009
	B,C,E	f.	Required amounts of silicone rubber are evenly applied in 3 separate coats on aft surface	ACL011
	B,C,E	g.	Required amounts of silicone rubber are evenly applied in 3 separate coats on forward surface	ACL012
	B,C,E	h.	All exterior surfaces are uniform	ACL000
	B,C,E	i.	All surfaces are covered per engineering	ACL001
	C,E	j.	Forward diameter	ACL003
	E	k.	Beveled surface angle of the nozzle protective plug interface	ACL002
	B,C,E	l.	Nozzle protective plug height per planning requirements	ACL005
	D	m.	Polysulfide compound shelf life is acceptable	AJH051
	D	n.	Silicone rubber shelf life is acceptable	ANV000
	D	o.	Primer shelf life is acceptable	ANV000A
569	B,C,E	p.	Sealing compound (Sealant, Polysulfide) is mixed per planning requirements	ACL206A
		3.	For New Sealant, Polysulfide verify:	
	D,J (T)	a.	Chalking	AJH011
	D,J (T)	b.	Flow	AJH020
	D,J (T)	c.	Nonvolatile content	AJH028
	D,J (T)	d.	Peel strength	AJH030
	D,J (T)	e.	Application life	AJH035
	D,J (T)	f.	Resistance to thermal rupture	AJH037
	D,J (T)	g.	Shore A hardness	AJH058
	D,J (T)	h.	Tack-free time	AJH061
	D,J (T)	i.	Air content	AJH065A
	D,J (T)	j.	Viscosity of base compound	AJH068
	D,J (T)	k.	Viscosity of curing compound	AJH074

4. For New Silicone Rubber, RTV verify:

D	(T)	a.	Viscosity	ANV008
D	(T)	b.	Tack-free time	ANV006
D	(T)	c.	Specific gravity	ANV004
D	(T)	d.	Shore A hardness	ANV002

5. For New Billet, Foam Plug verify:

D	(T)	a.	Shear strength per material specification	ACK004
D	(T)	b.	Flexure strength per material specification	ACK002
D	(T)	c.	Density per material specification	ACK000

6. For New Primer, Silicone Rubber verify:

D	(T)	a.	Percent solids	ANW003
D	(T)	b.	Specific gravity	ANW005
D	(T)	c.	Metal-to-metal lap shear	ANW001

7. KSC verifies:

A,G		a.	Nozzle protective plug for no missing RTV, visible debonds, or visible evidence of plug movement prior to launch per OMRSD, File II, Vol I, S00FA0.800	OMD015
A,G		b.	Nozzle protective plug for no missing RTV, visible debonds, or visible evidence of plug movement prior to launch following an on-pad abort per OMRSD, File II, Vol I, S00E00.755	OMD081
F		c.	Nozzle aft exit cone for damage or contamination to metal components, cork insulation, and painted surfaces prior to assembly per OMRSD File V, Vol I, B47NZ0.020	OMD046