ATK ALLIANT TECHSYSTEMS
THIOKOL PROPULSION

CRITICAL ITEMS LIST (CIL)

No. 10-02-01-06R/02

SYSTEM:	Space Shuttle RSRM 10	CRITICALITY CATEGORY:	1
SUBSYSTEM:	Nozzle Subsystem 10-02	PART NAME:	Fixed Housing Assembly (1)
ASSEMBLY:	Nozzle and Aft Exit Cone 10-02-01	PART NO.:	(See Section 6.0)
FMEA ITEM NO.:	10-02-01-06R Rev M	PHASE(S):	Boost (BT)
CIL REV NO.:	M (DCN-533)	QUANTITY:	(See Section 6.0)
DATE:	10 Apr 2002	EFFECTIVITY:	(See Table 101-6)
SUPERSEDES PAGE:	319-1ff.	HAZARD REF.:	BN-04
DATED:	31 Jul 2000		
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: 2.0 Structural failure of the metal housing

3.0 FAILURE EFFECTS: Breakup and loss of nozzle causing loss of RSRM, SRB, crew, and vehicle

4.0 FAILURE CAUSES (FC):

FC NO.	DESCRIPTION	FAILURE CAUSE KEY
2.1	Nonconforming dimensions	
2.1.1	Initial manufacturing dimensions	A
2.1.2	Metal dimensions reduced by corrosion and/or refurbishment	B
2.2	Nonconforming material	
2.2.1	Improper heat treatment	C
2.2.2	Nonconforming voids, inclusions, or other material defects	D
2.3	Fatigue	E
2.4	Stress-corrosion cracking	F
2.5	Transportation, handling, and assembly damage	G

5.0 REDUNDANCY SCREENS:

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

6.0 ITEM DESCRIPTION:

1. Housing Assembly, Nozzle Fixed is part of the Nozzle Assembly, Final and is made of metal components (Figures 1 and 2). Materials are listed in Table 1.

TABLE 1. MATERIALS

Drawing No.	Name	Material	Specification	Quantity
1U79150	Housing Assembly, Nozzle Fixed			1/motor
1U52945	Housing, Nozzle Fixed	D6AC	STW4-2709	1/motor
1U79151	Housing and Boot Assembly, Nozzle			1/motor
1U79153	Nose-Throat-Bearing-Cowl-Housing Assembly, Nozzle			1/motor
1U77640	Segment, Rocket Motor, Aft			1/motor
	Corrosion-Preventive Compound and O-ring Lubricant	Heavy-Duty Calcium Grease	STW5-2942	A/R
	Coatings, Epoxy-Polyamide	Epoxy and a Polymide Resin Activator	STW5-3225	A/R
	Primer, Zinc-Rich Epoxy-Polyamide	Pigmented Epoxy Resin Base and a Polyamide Resin Activator	STW5-3226	A/R
	Sealant, Polysulfide	Synthetic Rubber, Polysulfide	STW5-9072	A/R

6.1 CHARACTERISTICS:

1. The nozzle Fixed Housing provides the attachment from the motor case to the nozzle assembly. It is attached between the motor case at the aft end and the bearing assembly aft end ring at the forward end.

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

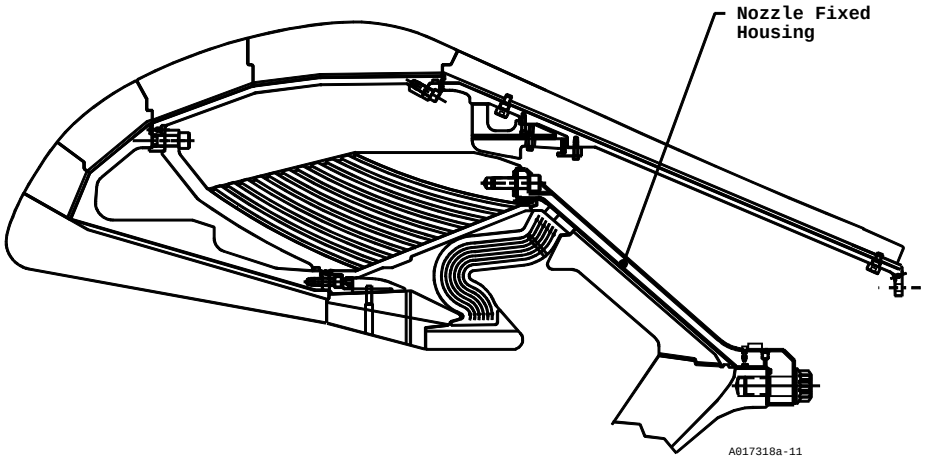

Figure 1. Nozzle Fixed Housing Location

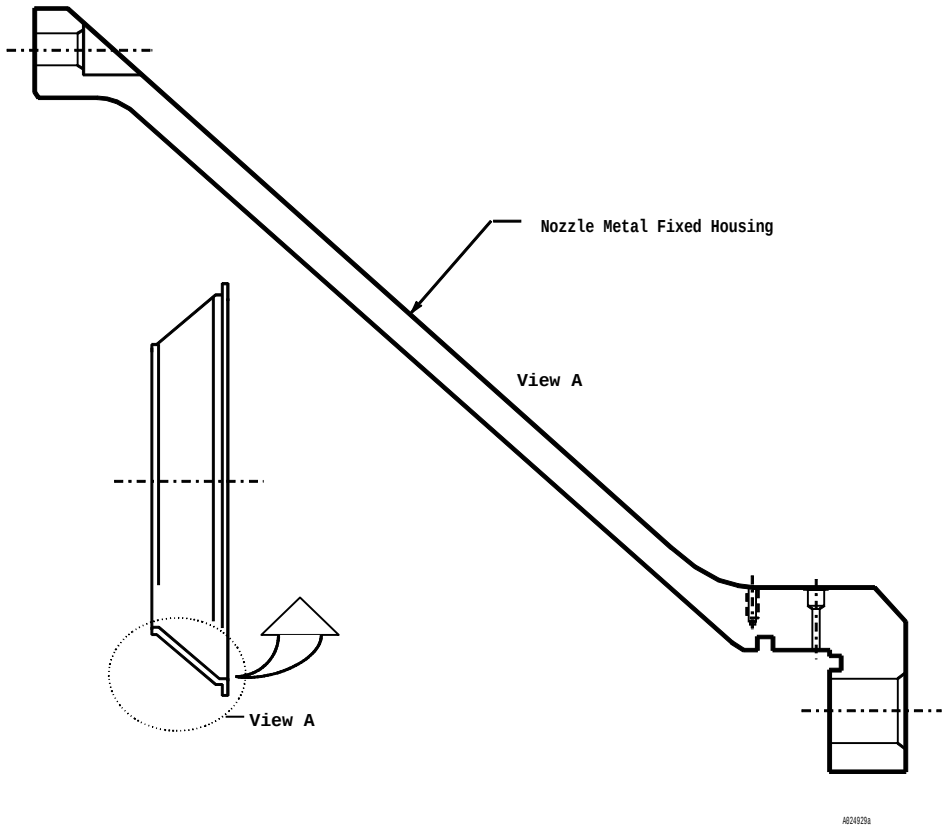

Figure 2. Nozzle Metal Fixed Housing

9.0 RATIONALE FOR RETENTION:

9.1 DESIGN:

DCN	FAILURE CAUSES	
A	1.	New Fixed Housing dimensions are per engineering drawings.
B	2.	Refurbished Fixed Housing dimensions are per engineering.
A,B,C,D,E,F	3.	Structural analyses per TWR-16975 and TWR-16873 verify that the Fixed Housing has a positive margin of safety based on factors of safety of 1.4 on ultimate and 1.1 on yield.
A,B,F	4.	The supplier provides corrosion protection to new housings per engineering drawings. Thiokol provides corrosion protection for refurbished housings per engineering.
A,B	5.	Contamination control requirements and procedures are per TWR-16564.
B	6.	To prevent corrosion, the inner surface of the Fixed Housing is primer coated and top coat painted per engineering drawings and specifications.
B,F	7.	The effects of galvanic corrosion due to dissimilar metal interaction are controlled per engineering. A Material Use Agreement is per SRM-MUA-005.
C,D,E,F	8.	The Fixed Housing is a heat treated D6AC steel forging. The first production forging of the Fixed Housing was analyzed per JSC Specifications and TWR-10719. The report concluded that the forging met all micro-cleanliness and microstructure D6AC steel specifications, mechanical properties met or exceeded all heat treatment specifications, the forging process produced a part free from re-entrant or sharply-folded flow lines that could affect the integrity of the forged component, and the principal grain flow is oriented parallel with principal stresses expected.
D	9.	Unacceptable cracks, voids, inclusions, and other material defects for new Fixed Housings are controlled per engineering.
D	10.	Unacceptable cracks and other material surface defects for refurbished Fixed Housings are controlled per engineering.
A,B,C,D,E,F	11.	Design verification analysis shows that the materials and geometry of the Fixed Housing are acceptable for flight per TWR-18764-09.
	12.	The Fixed Housing is heat treated for:
C,E		a. Ultimate strength
C,E		b. Yield strength at 0.2 percent offset
C,E		c. Fracture toughness
C,E	13.	Material type and composition of steel are controlled by the supplier per engineering. Heat treatment per engineering includes frequent logging of critical points and conditions.
E,F	14.	Fracture mechanics analysis of the Fixed Housing per TWR-16875 used the effects of sustained and cyclic stresses in the housing. The analysis verified that there is no potential crack propagation problem in the housing and the housing complies with the requirement of ensuring a potential service life greater than four times the

basic 20-use service life.

	E	15. Development and qualification motors were fired to demonstrate compliance with nozzle design parameters.
	F	16. The Fixed Housing Assembly has low-to-moderate resistance-to-stress corrosion per MSFC specifications and, therefore, requires a Material Use Agreement.
	G	17. 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.
	G	18. Handling and lifting requirements for RSRM components are similar to those for previous and current programs conducted by Thiokol per TWR-13880.
	G	19. Transportation and handling of Fixed Housing Assembly items by Thiokol is per Thiokol IHM 29.
	G	20. The Fixed Housing is covered with a protective cover and stored in a temperature-controlled building until used as a part of a larger assembly.
	G	21. 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.
	G	22. 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.
	G	23. Support equipment used to test, handle, transport, and assemble or disassemble the RSRM is certified and verified per TWR-15723.
	G	24. 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.
	G	25. Protective plugs are installed per shop planning in the leak check ports of the Fixed Housing to protect the ports from damage during handling and installation.
	E,F,G	26. 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	E,F,G	27. 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 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.

9.2 TEST AND INSPECTION:

DCN	FAILURE CAUSES and TESTS (T)			CIL CODE
		1.	For New Housing, Nozzle-Fixed verify:	
A,B		a.	Diameter	ADV057,ADV049,ADV054
A,B		b.	Height	ADV070
A,B		c.	Profile	ADV155
A,B		d.	Flatness	ADV040,ADV043
A,B		e.	Thickness	ADV035A,ADV035,ADV208,ADV205
A,B		f.	True position	ADV212A,ADV212
A,B		g.	Corrosion protection is per specification	ADV006
A,B		h.	Run out	NCC004
C,D,E,F	(T)	i.	Carburization	ADV012
C,D,E,F	(T)	j.	Decarburization	ADV044
C,D,E,F	(T)	k.	Elongation	ADV063
C,D,E,F	(T)	l.	Fracture toughness (K_{IC})	ADV073
C,D,E,F		m.	Heat treat	ADV085
C,D,E,F	(T)	n.	Hydroproof test	ADV097
C,D,E,F	(T)	o.	Magnetic particle	ADV109,ADV113
C,D,E,F	(T)	p.	Grain size	ADV133
C,D,E,F	(T)	q.	Macro structure	ADV134
C,D,E,F	(T)	r.	Inclusion rating	ADV135
C,D,E,F	(T)	s.	Reduction in area	ADV171
C,D,E,F	(T)	t.	Ultimate tensile strength	ADV213
C,D	(T)	u.	Ultrasonic	ADV222, ADV223
C,D,E,F	(T)	v.	Yield strength	ADV229
		2.	For Refurbished Housing, Nozzle Fixed verify:	
A,B		a.	Diameter	ADV050,ADV058
A,B		b.	Roundness	ADV182,ADV176,ADV180
A,B		c.	Height	ADV071
A,B		d.	Straightness	ADV152
A,B		e.	Flatness	ADV197
A,B		f.	Thickness	ADV033
A,B		g.	Bolt hole deformation	ADV009
A,B		h.	Surface defects	ADV008
A,B		i.	Deformed parts	ADV072
A,B		j.	Surfaces cleaned	ADV029
C,D,E,F	(T)	k.	Hydroproof test	ADV092
C,D,E,F	(T)	l.	Magnetic particle	ADV110
C,D,E,F		m.	Painted surfaces for heat degradation	ADV082
		3.	For the New Nozzle Fixed Housing Assembly verify:	
A,B		a.	Part is clean and free from damage, foreign material and corrosion prior to paint	ADS026
A,B		b.	Complete primer paint coverage of required surfaces	ADS033
A,B		c.	Complete topcoat paint coverage of required surfaces	ADS034
A,B		d.	Housing bonding surfaces are cleaned and free from unacceptable contamination per planning requirements	ADS024
G		e.	Clean protective cover installed and stored per planning requirements	ADS087
		4.	For New Housing and Boot Assembly, Nozzle verify:	

A,B	a.	Fixed Housing bonding surfaces are free from unacceptable contamination per planning requirements (Black light)	ABW040
	5.	For New Nose-Throat-Bearing-Cowl Housing Assembly, Nozzle verify:	
A,B	a.	Application of filtered grease to Housing, Nozzle-Fixed forward end sealing surfaces prior to assembly	ADQ015
A,B	b.	Sealing compound (polysulfide sealant) is applied around head of leak check port plug	ADQ192
A,B	c.	Sealing surfaces on Housing, Nozzle-Fixed forward end are free from corrosion and contamination prior to assembly	ADQ202
	6.	For New Nozzle Assembly, Final verify:	
A,B	a.	Fixed Housing metal surfaces are free of contamination and corrosion	ADR050
A,B	b.	Nozzle Assembly bare metal and thru-holes including the Fixed Housing are protected against corrosion per drawing	ADR085
A,B	c.	Sealing compound (polysulfide sealant) is applied to the Aft End Ring-to-Fixed Housing	ADR209
	7.	For New Segment Assembly, Rocket Motor, verify:	
A,B	a.	Fixed Housing surface by blacklight inspection for proper grease application	AGJ120
A,B	b.	Nozzle Assembly bare metal and through-holes including Fixed Housing are protected against corrosion	BHL009
A,B	c.	Sealing compound is applied around joint seam	AGJ216
G	d.	Nozzle Assembly for handling damage and protective cover is cleaned and in place	AGJ167
	8.	KSC verifies:	
G	a.	Segments and nozzle components are free of damage per OMRSD File V, Vol I, B47SG0.061	OMD079