ATK ALLIANT TECHSYSTEMS
THIOKOL PROPULSION

CRITICAL ITEMS LIST (CIL)

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

SYSTEM:	Space Shuttle RSRM 10	CRITICALITY CATEGORY:	1
SUBSYSTEM:	Nozzle Subsystem 10-02	PART NAME:	Nozzle Final Assembly (1)
ASSEMBLY:	Nozzle and Aft Exit Cone 10-02-01	PART NO.:	(See Section 6.0)
FMEA ITEM NO.:	10-02-01-01R 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:	306-1ff.	HAZARD REF.:	BN-06
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 Failure to provide required thrust or meet vectoring or thrust vector requirements

3.0 FAILURE EFFECTS: No effect on RSRM. Failure to achieve desired trajectory causing loss of SRB, crew, and vehicle

4.0 FAILURE CAUSES (FC):

FC NO.	DESCRIPTION	FAILURE CAUSE
2.1	Nonconforming response to actuator stroke	A
2.2	Nonconforming dynamic thrust vector	B
2.3	Nonconforming nozzle thrust performance	C
2.4	Snubber interferes with nozzle vectoring	
2.4.1	Improper installation	D
2.4.2	Nonconforming dimensions	E

5.0 REDUNDANCY SCREENS:

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

6.0 ITEM DESCRIPTION: Nozzle Final Assembly

1. Nozzle Assembly, Final consists of structural steel and aluminum members protected against erosive, thermal, and pressure environments by carbon, silica, and glass phenolic liners (Figure 1). Materials are listed in Table 1.

TABLE 1. MATERIALS

Drawing No.	Name	Material	Specification	Quantity
1U77090	Nozzle Assembly, Final	Various		1/motor
1U79324	Bearing Assembly, Nozzle, Flexible			1/motor
1U52842	Shell, Exit Cone, Aft			1/motor
1U75756	Screw, Fastener	Cadmium-Plated	STW3-1553	128/motor
		Nylon	MIL-F-18240	64/motor
	Corrosion-Preventive Lubricant	Calcium Grease Compound and O-Ring	STW5-2942	A/R
	Carbon-Cloth Phenolic, Pre-impregnated	Carbon Cloth Reinforcement with Phenolic Resin	STW5-3279	A/R
	Sealant, Polysulfide	Synthetic Rubber, Polysulfide	STW5-9072	A/R

6.1 CHARACTERISTICS:

1. The RSRM nozzle assembly is a partially submerged, convergent-divergent movable design containing an aft pivot point flexible bearing as the vector mechanism. The assembly has an omni directional Thrust Vector (TVC) deflection capability of 8 degrees in a free state, but is constrained by two actuators to approximately 6.5 degrees. Dual-action, hydraulic-powered actuators are attached to the aft skirt below the kick ring and to the RSRM actuator attach brackets next to the exit cone compliance ring to provide nozzle deflection.

2. The snubber assembly is attached to the forward exit cone and consists of the ring, snubber support attached with socket head cap screws, snubber segments attached with socket head cap screws, and retainer shims attached with socket head cap screws. Snubber segments are positioned using axial and radial shims. The snubber assembly reduces water impact loads on the flexible bearing and prevents excessive forward motion of the nozzle upon impact. Failure modes and effects for the flexible bearing are addressed in the flexible bearing CILs.

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

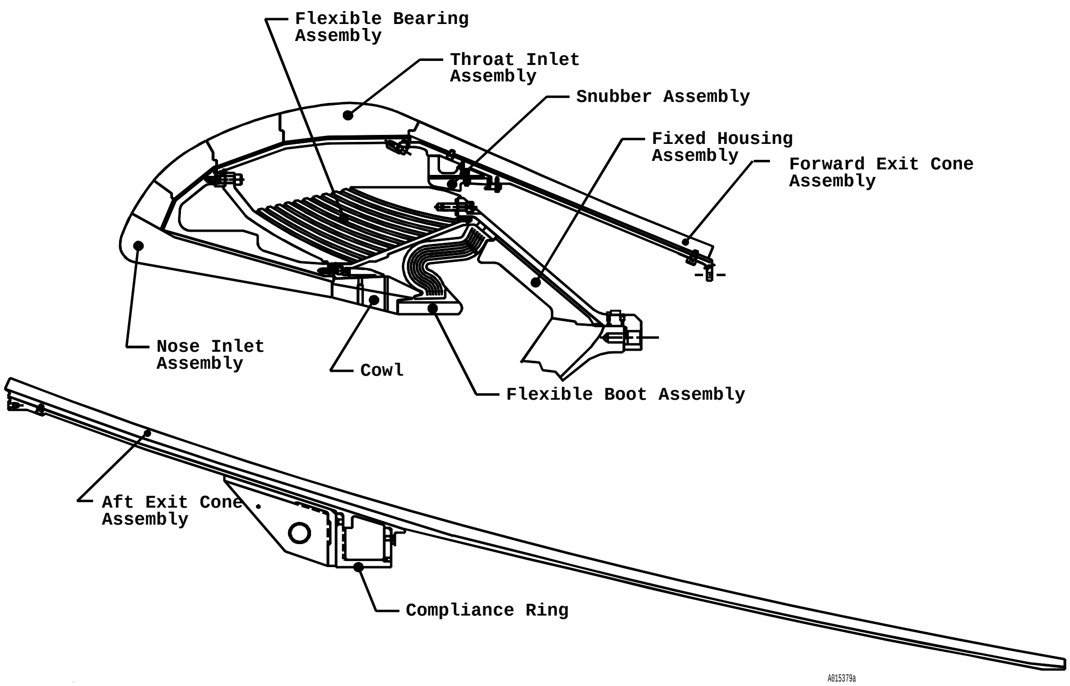

Figure 1. Nozzle Final Assembly

9.0 RATIONALE FOR RETENTION:

9.1 DESIGN:

DCN FAILURE CAUSES:

A 1. Nozzle omni-axial vectoring capability is qualified and documented per TWR-18764-09, 10, and 11.

A 2. Testing of a full-scale flex bearing defines the effects of temperature on torque and axial deflection per TWR-16831.

A 3. Load characterizations of the boot at various temperatures during nozzle vectoring are per TWR-17588.

A 4. Nozzle flex bearing components are designed for storage for 5 years after acceptance per engineering.

B,C 5. Engineering drawings control the nozzle configuration.

B,C 6. Dynamic thrust vector and nozzle thrust performance are demonstrated and certified through demonstration and qualification static motor firings per TWR-18764-09, 10, and 11.

B,C 7. Ablative material is limited to Carbon-Cloth Phenolic with low sodium and ash content to minimize erosion per engineering.

B,C 8. Carbon-cloth phenolic ply angles of the nozzle reduce fiber tensile strain and eliminate pocketing erosion. A series of sub scale static tests for evaluating ply angle design were performed. Results showed smooth, uniform erosion distributed over the entire nose, inlet, and throat regions per TWR-14746.

B,C 9. 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.

B,C 10. Machining and tooling provide the proper nozzle contour per TWR-10341.

B,C 11. Ballistic history demonstrates that dynamic thrust vector and nozzle throat performance are within limitations per TWR-14415.

B,C 12. Nozzle ablative surfaces are protected from environmental contamination and damage during storage and shipping by a foam nozzle plug, storage containers, and specially designed railcars per TWR-16563 and TWR-13880.

D 13. The installation procedure for the snubber assembly onto the final nozzle assembly is per engineering and shop planning.

D 14. A light coating of filtered grease is applied to all metal interfaces and holes prior to mounting and assembling the snubber ring, snubber segments, and retainer shims. Polysulfide sealant is used around screw heads to prevent corrosion.

D 15. All socket head cap screws used in final assembly of the snubber are self-locking and installed and torqued per shop planning.

	D	16.	Screws are cadmium plated alloy steel, baked to prevent hydrogen embrittlement.
	D,E	17.	Thiokol Quality Assurance visually verifies the bearing and throat cavity below the snubber assembly is free of foreign objects, contamination, and debris.
	E	18.	Nozzle axial shims and radial shims are used to obtain proper clearance between the flex bearing aft end ring and nozzle snubber segment.
	E	19.	The snubber assembly is designed to prevent damage to the flex bearing from axial movement at water impact and is a passive structure during boost. The proper movement of the nozzle was demonstrated and is documented per TWR-18764-09, 10, and 11.
	E	20.	An analytical study demonstrated that the snubber does not adversely affect vectoring capability. The distance between the snubber and the flex bearing aft ring provides ample clearance per TWR-17311.
533	B,C	21.	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 nozzle phenolics 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 CODES
			1.	For New Bearing Assembly, Nozzle Flexible verify:	
	A	(T)	a.	Torque test of bearing	ADJ147
	A	(T)	b.	Pivot point characterization	ADJ149B
	A	(T)	c.	Flat plate axial deflection test	ADJ029A
	A	(T)	d.	Tensile leak test	ADJ064
	A	(T)	e.	Thrust relief piston axial deflection test	ADJ141
			2.	For Refurbished Bearing Assembly, Nozzle Flexible verify:	
	A	(T)	a.	Pivot point characterization test	ADJ111
	A	(T)	b.	Torque test of bearing	ADJ147A
			3.	For New Nozzle Assembly, Final verify:	
	D,E		a.	Axial shims installation	ADR034
	D		b.	Filtered grease applied to noted metal interfaces per drawing requirements	ADR046
	D		c.	Filtered grease applied to the snubber components	ADR047
	D,E		d.	Radial shims installation	ADR199
	D,E		e.	Retainer installation	ADR200
	D		f.	Sealing compound (polysulfide sealant) application at base of fastener heads	ADR211
	D,E		g.	Snubber ring installation	ADR237
	D,E		h.	Snubber segments installation	ADR239
	D		i.	All socket head cap screws are installed and seated in the proper location	ADR242
	D		j.	Torque of screws for snubber assembly installation	ADR267
	D,E		k.	Bearing and throat cavity below the snubber assembly is free of foreign objects, contamination and debris per planning requirements	HHH028
	B,C		l.	Marking is applied per drawing requirements	ADK071
	E		m.	Clearance between snubber and aft end ring of flex bearing	ADR054
	E		n.	Run out to Datum A of the forward exit cone, nozzle	SAA008
			4.	For New Housing, Exit Cone, Nozzle verify:	
	E		a.	Run out	ADG115,ADG116
	E		b.	Diameter	ADG118,ADG119
			5.	For Refurbished Housing, Exit Cone, Nozzle verify:	
	E		a.	Diameter	ADG035,ADG040
	E		b.	Roundness	ADG117,ADG127,ADG128