ATK
ALLIANT TECHSYSTEMS
THIOKOL PROPULSION

CRITICAL ITEMS LIST (CIL)

No. 10-02-01-01R/03

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:	307-1ff.	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: 3.0 Structural failure of the nozzle final assembly

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
3.1	Nonconforming natural frequency	A

5.0 REDUNDANCY SCREENS:

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

6.0 ITEM DESCRIPTION:

1. Nozzle Assembly, Final and Exit Cone Assembly 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

NOTE: Structural failure at nozzle subsystem individual components is addressed in respective CILs that cover such components.

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 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 located next to the exit cone compliance ring to provide nozzle deflection.

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

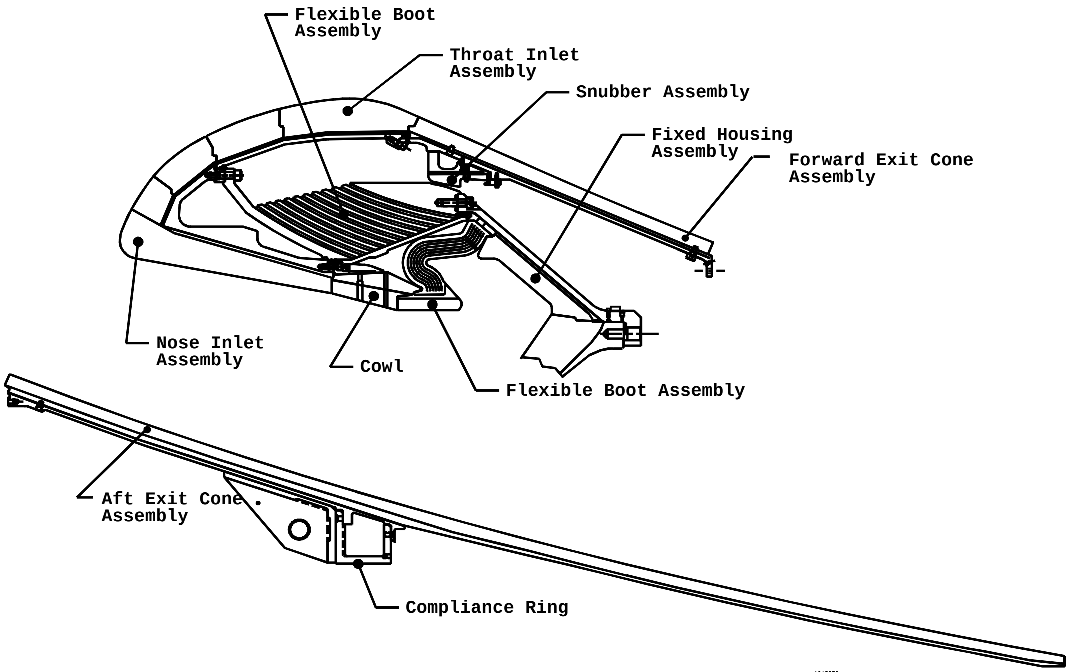

Figure 1. Nozzle Final Assembly

9.0 RATIONALE FOR RETENTION:

9.1 DESIGN:

DCN FAILURE CAUSES

A 1. Natural frequencies of the nozzle were analyzed and found to have no anticipated significant influence on motor behavior per TWR-16784.

A 2. Natural frequencies found in the analytical study per TWR-16784 were verified during the modal survey test performed on the Development Motor (DM-9) nozzle prior to motor firing per MSFC memo ET53-120-87.

A 3. Natural frequencies for the RSRM nozzle closely match those for the High Performance Motor (HPM) nozzle. Natural frequencies and corresponding mode shapes were investigated for the HPM nozzle and found to have no significant influence on motor behavior per TWR-13088.

A 4. A flutter analysis at the exit plane for the exit cone was evaluated and shows no potential for aerodynamically induced flutter per TWR-13141.

A 5. Past flight history shows that the nozzle exhibited no failures due to nonconforming natural frequency.

A 6. Nozzle assembly natural frequencies and damping coefficients expected throughout motor burn were analytically determined considering time varying and thermally degrading properties and found to have no significant influence on motor behavior per TWR-16975.

A 7. Nozzle natural frequencies and damping coefficients that were analytically determined throughout motor burn were verified from accelerometer data collected during DM-9, QM-6, and other RSRM static test firings per TWR-16975.

A 8. The nozzle assembly has a positive margin of safety with respect to induced vibration loads per TWR-16975.

A 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.

533 A 10. 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 CODE
	A	(T)	1.	No inspection or testing is performed to verify natural frequency.	