ATK ALLIANT TECHSYSTEMS
THIOKOL PROPULSION

CRITICAL ITEMS LIST (CIL)

No. 10-02-01-05R/03

SYSTEM:	Space Shuttle RSRM 10	CRITICALITY CATEGORY:	1
SUBSYSTEM:	Nozzle Subsystem 10-02	PART NAME:	Aft Exit Cone (1)
ASSEMBLY:	Nozzle and Aft Exit Cone 10-02-01	PART NO.:	(See Section 6.0)
FMEA ITEM NO.:	10-02-01-05R 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:	316-1ff.	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 glass phenolic over wrap

3.0 FAILURE EFFECTS: Loss of aft portion of aft exit cone causing thrust reduction of SRB resulting in loss of RSRM, SRB, crew, and vehicle

4.0 FAILURE CAUSES (FC):

FC NO.	DESCRIPTION	FAILURE CAUSE KEY
3.1	Improper ply angle orientation in glass phenolic components	A
3.2	Nonconforming raw material properties	B
3.3	Nonconforming manufacturing processes	C
3.4	Nonconforming dimensions	D
3.5	Component degradation during assembly, handling, transportation, storage, or installation	E
3.6	Temperature, pressure, humidity, vibration, and shock during boost phase	F
3.7	Porosity, voids, de-laminations, inclusions, or cracks	G

5.0 REDUNDANCY SCREENS:

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

6.0 ITEM DESCRIPTION:

1. The nozzle aft exit cone sub-assembly is a structurally reinforced component using low thermal conductivity glass-cloth phenolic to over wrap the carbon-cloth liner (Figure 1). Materials are listed in Table 1.

TABLE 1. MATERIALS

Drawing No.	Name	Material	Specification	Quantity
1U79155	Exit Cone Subassembly, Aft			1/motor
5U77652	Exit Cone, Aft			1/motor
	Aft Exit Cone (Test)	Product Specification	STW3-3463	A/R
	Laminating Resin	Thermosetting Phenolic	MIL-R-9299	A/R
	Insulator	Glass-Cloth Phenolic	STW5-2651	2813 lbs.
	Ablative Liner	Carbon-Cloth Phenolic	STW5-3279	4175 lbs.
	Tape	Cloth Phenolic, Pre-impregnated	STW5-3621	A/R

6.1 CHARACTERISTICS:

1. Glass-cloth phenolic material is fiberglass-cloth reinforcement impregnated with a phenolic resin and cured with temperature, pressure, and time. The low-thermal-conductivity insulation structurally-reinforcing glass-cloth phenolic is over wrapped on the carbon-cloth phenolic ablative liner surface. After curing and final machining, it is bonded to the aluminum housing to form the aft exit cone. The portion of the glass phenolic that extends beyond the metal housing must carry structural loads. This CIL addresses the structural requirements of the glass phenolic over wrap.

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

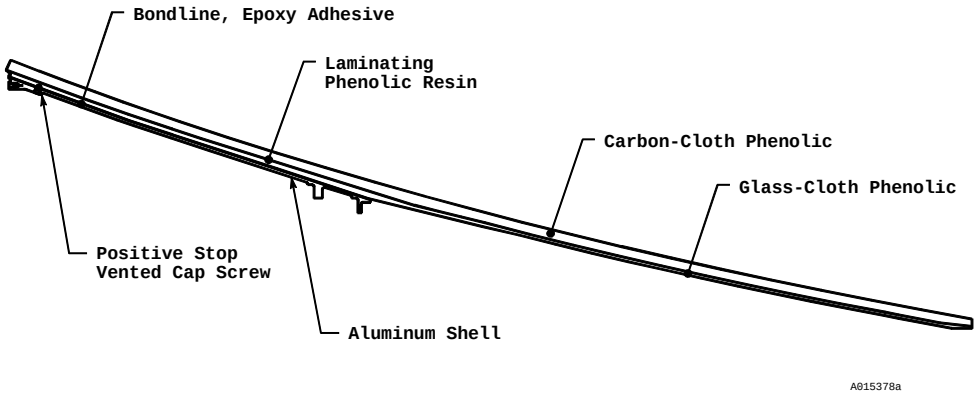

Figure 1. Aft Exit Cone Assembly

9.0 RATIONALE FOR RETENTION:

9.1 DESIGN:

DCN	FAILURE CAUSES	
A	1.	Glass-cloth phenolic is tape wrapped over carbon-cloth phenolic parallel to interfacing surfaces per engineering drawings.
A,B,C,D,F,G	2.	Thiokol analysis shows positive margins of safety based on the required thermal and structural factors of safety. Material properties are per TWR-15995.
B	3.	Glass-Cloth Phenolic material properties are per engineering.
B	4.	Intermixing of equivalent materials from different suppliers within an item is not permitted per engineering drawings.
C	5.	Glass-cloth phenolic over wrap contour is per engineering drawings.
C	6.	Preparation and cleaning methods for bonding surfaces are per shop planning. Cleanliness of bonding surfaces is determined by a combination of visual inspection and visual inspection aided by black light. Surface inspection is per shop planning. Preparation, cleaning, and inspection methods for aft exit cone bond lines are identified as process critical planning.
C,G	7.	Manufacturing processes were demonstrated on development and qualification motors per TWR-18764-11.
D	8.	Structural dimensional requirements for glass-cloth phenolic are per engineering drawings.
E	9.	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	10.	Pre-assembly mismatch causing bond line stress was shown by analysis to be within allowable limits per TWR-16975.
E	11.	Handling and lifting requirements for RSRM components are similar to those for previous and current programs as conducted by Thiokol per TWR-13880.
E		a. Proof loading of all lifting equipment is per TWR-10212.
E	12.	The exit cone and exit cone fragment shipping kit is designed for transportation of the exit cone to the launch facility and return of the recovered exit cone fragment to Thiokol per TWA-1123. The shipping kit provides an enclosed container to protect the aft exit cone from external environments.
		a. A detailed description of the shipping kit is per TWA-1189.
E	13.	The primary storage configuration for the aft nozzle exit cone assembly is on the exit cone installation fixture. Exit cones in storage are grounded and are under protection from the elements per TWA-1123.
E	14.	Transportation and handling of aft exit cone assembly by Thiokol is per IHM 29.
E	15.	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 16. Support equipment used to test, handle, transport, and assemble or disassemble the RSRM is certified and verified per TWR-15723.

E 17. 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.

E 18. Age degradation of nozzle materials was shown to not be a concern. Full-scale testing of a six-year old nozzle showed there was no performance degradation due to aging per TWR-63944. Tests on a fifteen-year old flex bearing also showed no degradation of flex bearing material properties per TWR-63806.

E 19. Thermal analyses were performed for RSRM components during in-plant transportation and storage to determine temperature and ambient environment exposure limits per TWR-50083. Component temperatures and exposure to ambient environments during in-plant transportation or storage are per engineering.

F 20. Analysis is conducted by Thiokol engineering to assess dynamic, acoustic, and vibration response of RSRM nozzle operation during the boost phase per TWR-16975.

F 21. The aft exit cone is designed not to be adversely affected when experiencing temperature, pressure, humidity, vibration, or shock environments per TWR-15723.

F 22. The environmental condition, similar to that occurring during the boost phase, was demonstrated on static firings per TWR-18764-11.

G 23. Surface and subsurface defect criteria rationale are per TWR-16340.

G 24. Aft exit cone assembly manufacturing processes are per engineering drawings and shop planning.

E,F 25. 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.

9.2 TEST AND INSPECTION:

DCN	FAILURE CAUSES and TESTS	(T)			CIL CODES
			1.	For New Exit Cone, Aft verify:	
A			a.	Proper mandrel is used	AGL001
B			b.	Environmental history of phenolic materials	AGL104,AIB027,AJG003
B			c.	Only one phenolic supplier's cloth material is used	AGL105,AGL106
C			d.	Autoclave cure of phenolic is acceptable	AIB008
C			e.	Acceptable completion of tape wrap per planning requirements	AGL078
C,G		(T)	f.	Radiographic examination is acceptable	AGL118A
C,G			g.	Alcohol wipe on phenolic	AIB003
D			h.	Outside diameter profile of glass phenolic	AGL008,AGL075
D			i.	Final surface profile of the carbon phenolic	AGL108
			2.	For New Exit Cone, Subassembly-Nozzle, Aft verify	
C,G		(T)	a.	Radiographic examination is acceptable	AGL118
D			b.	Overall length of assembly	AGL109
E			c.	Component temperatures and exposure to ambient environments	BAA026
			3.	For New Resin, Phenolic Laminating verify:	
B		(T)	a.	Specific gravity	AJG006
B			b.	Data pack is complete and acceptable	AJG022
B		(T)	c.	Viscosity	AJG037
			4.	For Retest Phenolic Slit Tape verify:	
B		(T)	a.	Resin flow	AMN103A
B		(T)	b.	Volatile content	AMN178A
			5.	For New Glass-Cloth Phenolic verify:	
B		(T)	a.	Cloth content--uncured	AMN006,AMN007
B		(T)	b.	Compressive strength--cured	AMN013,AMN014
B		(T)	c.	Density--cured	AMN037,AMN038
B		(T)	d.	Dry resin solids--uncured	AMN049,AMN048
B		(T)	e.	Inter-laminar shear strength--cured	AMN055,AMN057
B		(T)	f.	Resin content--cured	AMN086,AMN088
B		(T)	g.	Resin flow--uncured	AMN120,AMN121,AMN103
B		(T)	h.	Volatile content--uncured	AMN196,AMN195,AMN178
			6.	For New Aft Exit Cone (Test) verify:	
C		(T)	a.	Compressive strength (glass)	AGL043
C		(T)	b.	Residual volatiles (glass)	AGL140
C		(T)	c.	Resin content (glass)	AGL150
C		(T)	d.	Specific gravity (glass)	AGL174
			7.	KSC verifies:	
E			a.	Aft exit cone aft lip composites for absence of cracks and surface defects per OMRSD File V, Vol I, B47NZ0.081	OMD052