CRITICAL ITEMS LIST (CIL)

No. 10-02-01-18R/01

SYSTEM:	Space Shuttle RSRM 10	CRITICALITY CATEGORY:	1
SUBSYSTEM:	Nozzle Subsystem 10-02	PART NAME:	Nose Inlet-To-Throat Joint, Phenolic Components (1)
ASSEMBLY:	Nozzle and Aft Exit Cone 10-02-01		
FMEA ITEM NO.:	10-02-01-18R Rev M	PART NO.:	(See Section 6.0)
CIL REV. NO.:	M (DCN-533)	PHASE(S):	Boost (BT)
DATE:	10 Apr 2002	QUANTITY:	(See Section 6.0)
SUPERSEDES PAGE:	328-1ff.	EFFECTIVITY:	(See Table 101-6)
DATED:	6 Feb 2002	HAZARD REF.:	BN-03
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: 1.0 Thermal failure

3.0 FAILURE EFFECTS: Loss of thermal barrier resulting in break up and expulsion of the nozzle, causing loss of RSRM, SRB, crew, and vehicle

4.0 FAILURE CAUSES (FC):

FC NO.	DESCRIPTION	FAILURE CAUSE KEY
1.1	Wedge out	
1.1.1	Nonconforming fabrication of joint angle dimensions at interfaces between phenolic components	A
1.1.2	Porosity, voids, de-laminations, inclusions, or cracks	B
1.1.3	Assembly residual stresses	C
1.2	Assembly or handling damage of joint phenolics	D
1.3	Nonconforming raw material properties of carbon phenolics	E
1.4	Nonconforming manufacturing processes	F
1.5	Step discontinuities between surfaces	G

5.0 REDUNDANCY SCREENS:

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

6.0 ITEM DESCRIPTION:

1. Nose Inlet-to-Throat Inlet Joint, Phenolic Components are made up from the Nose Inlet Assembly and the Throat Inlet Assembly. Materials are listed in Table 1.

Table 1. MATERIALS

Drawing No.	Name	Material	Specification	Quantity
1U79146	Nose-Throat Assembly, Nozzle			1/motor
1U79144	Throat Inlet Assembly, Nozzle			1/motor
5U77685	Throat Inlet Phenolics			1/motor
		Glass-Cloth Phenolic	STW5-2651	163 lbs.
		Carbon-Cloth Phenolic	STW5-3279	637 lbs.
	Throat Inlet Assembly	Product Specification	STW3-3461	1/motor
1U79145	Nose-Inlet Assembly, Nozzle			1/motor
	Nose Inlet (Test)	Product Specification	STW3-9020	A/R
5U77654	Nose Cap Phenolic			1/motor
		Glass-Cloth Phenolic	STW5-2651	174 lbs.
		Carbon-Cloth Phenolic	STW5-3279	1391 lbs.
	Nose-Inlet Assembly	Product Specification	STW3-3461	1/motor
	Tapes	Cloth Phenolic, Pre-impregnated	STW5-3621	A/R

6.1 CHARACTERISTICS:

1. The nose-inlet assembly consists of an insulated and lined aluminum structure that interfaces with the throat assembly and forward end ring. The assembly forms the submerged outside diameter and inlet flow contours. Insulation liners consist of carbon-cloth phenolic on surfaces exposed to hot gases, backed by glass-cloth phenolic to protect the aluminum housing. The assembly is sealed with O-rings at each end to preclude penetration of hot, high-pressure gasses from the chamber.

2. The throat inlet assembly consists of a D6AC steel housing covered by ablative and insulative liners. It interfaces with the nose inlet, flexible bearing, and forward exit cone assemblies. The shell is convergent to contain and support the throat and throat inlet rings, preclude downstream movement, and prevent ejection loads from being transmitted into the exit cone. The throat ring has a redesigned ply angle to eliminate pocketing erosion observed at the aft end. Also, surface contour of the throat inlet ring is being modified to improve uniformity of the contour between the throat inlet and throat rings. This design thickens the part slightly, thus assuring compliance with erosion and char safety factor requirements.

3. The nose-inlet and throat-inlet joint are bolted together. The gap between phenolic components is then back filled deeper than the maximum expected char line with sealant. Gap design allows for thermal expansion of the nozzle, and tolerances in mating nozzle component contours. Sealing compound provides a high-temperature, flexible structural support for the nozzle phenolic layers that face together at the joint. Figure 1 shows the improved nozzle design for the nose inlet-to-throat inlet joint.

4. Structural analyses for nozzle bondlines using adhesives EA946 and EA913NA do not include residual stresses. For this reason, RWW0548 has been approved to waive the requirements to include residual stress in ultimate combined load structural analyses for the current nozzle structural adhesives. New analyses techniques developed for TIGA adhesive may show a negative margin of safety if same analyses were applied to EA946 and EA913NA bondlines. Extensive testing and model validation was conducted for TIGA adhesive to address residual stresses, which have not been performed on EA946

and EA913NA adhesives. Therefore, inclusion of residual stresses in the structural analyses for EA946 and EA913NA bondlines is waived.

Flight rational includes the following: 1. Nozzles are considered fully qualified with a demonstrated reliability of 0.996. 2. The 2.0 bond safety factor is meant to cover unknown conditions such as residual stress effects. 3. Process controls have been added to include monitoring and controlling of bond loads, monitoring Coeflex-shim differentials, controls on rounding forces, controls on flange mismatch, controls on transportation temperatures, improvements in grit blast, eliminated bond surface contact with black plastic, TCA-wipe prior to grit blast rather than after, and other process changes. 4. The use of improved materials include adding silane primer (adhesion promoter), virgin grit blast media for pre-bond grit blast, and incorporate the use of fresh adhesive for nozzle structural bonds.

Future incorporation of TIGA 321 adhesive on RSRM-94 will eliminate the need for waiver RWW0548. Certification analyses will include residual stresses for TIGA 321 adhesive.

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

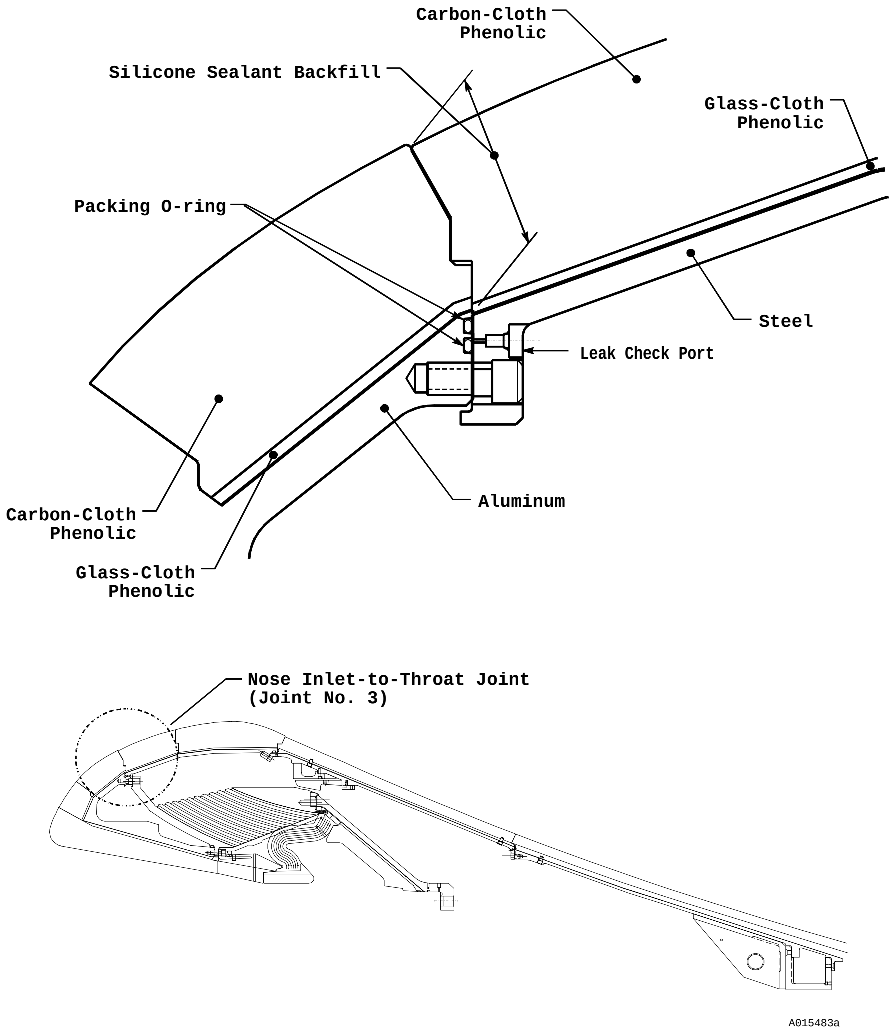

Figure 1. Nose Inlet-to-Throat Joint

9.0 RATIONALE FOR RETENTION:

9.1 DESIGN:

DCN	FAILURE CAUSES		
	A,G	1.	Phenolic components of the nose inlet assembly and throat inlet assembly are fabricated per engineering drawings.
	A,G	2.	Final machining and mandrel surface configuration provides the proper nozzle contour per engineering drawings and shop planning.
	A,C,D,G	3.	Bolt torque and tightening sequence of the nose inlet assembly to throat inlet assembly is per engineering drawings and shop planning.
533	A,B,C,E,F,G	4.	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 nose inlet assembly and the throat assembly 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.
	B,E,F	5.	Carbon-Cloth Phenolic materials function as an insulative and ablative liner in the RSRM nozzle with material characteristics per engineering.
	B,F	6.	Glass-Cloth Phenolic material is used as an insulator and is accepted per engineering.
	B,F	7.	The fabrication process for the throat inlet assembly consists of two wrappings and two machinings for the throat ring. Throat rings are first wrapped with carbon phenolic tape, hydroclave cured, and contour machined. Billets are then over wrapped with glass phenolic tape, autoclave cured, and final machined. Processes and dimensions are per engineering drawings and shop planning.
	B,F	8.	The fabrication process for the aft inlet ring portion of the nose inlet assembly consists of two tape wrappings and two machining operations. The mandrel is first wrapped with carbon phenolic tape, hydroclave cured, and contour machined. Billets are then over wrapped with glass phenolic tape, autoclave cured, and final machined. Processes and dimensions are per engineering drawings and shop planning.
	B	9.	Surface and subsurface defect criteria rationale are per TWR-16340.
	C	10.	Proper alignment of parts is controlled by tolerances established per engineering drawings and shop planning.
	C,D	11.	Joint gaps are controlled by dry fitting the nose inlet assembly and throat inlet assembly. Proper bond gaps are determined by means of shop handling equipment, bonding fixture, impression compounds, and shims. Size, number, and location of shims are per shop planning.
	C	12.	Additional testing to expand the database on design tolerances and residual stresses of nozzle phenolic joints is per TWR-16975.
	D	13.	Handling and lifting requirements for RSRM components are per TWR-13880.

Handling operations at Thiokol are per shop planning and IHM 29.

D	14.	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 ambient environments during in-plant transportation or storage are per engineering.
E	15.	Material properties of carbon phenolics are analyzed per TWR-15995.
E,F	16.	Two lots of carbon-cloth phenolic from the same supplier may be used to fabricate the nose cap of the Nose-Inlet Assembly Nozzle.
C,D	17.	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 Throat Inlet Assembly, Nozzle verify:	
	A,C,G			a.	Profile of throat inlet assembly is within tolerance	AAW055
	B			b.	Alcohol wipe phenolic surfaces after final machining	AAW010
	D			c.	Component temperatures and exposure to ambient environments during in-plant transportation or storage	BAA034
			2.		For New Throat Inlet Assembly (Test) verify:	
	B,F	(T)		a.	Compressive strength (glass and carbon)	AAW044,AAW046
	B,F	(T)		b.	Residual volatiles (glass and carbon)	AAW090,AAW089
	B,F	(T)		c.	Resin content (glass and carbon)	AAW095,AAW093
	B,F	(T)		d.	Specific gravity (glass and carbon)	AAW104,AAW102
			3.		For New Nose Inlet Assembly, Nozzle verify:	
	A,C,G			a.	Aft end profile of aft inlet ring is within tolerance	ADT100
	B			b.	Alcohol wipe phenolic surfaces	ADT019
	D			c.	Component temperatures and exposure to ambient environments during in-plant transportation or storage	BAA036
			4.		For New Nose Inlet (Test) verify:	
	B,F	(T)		a.	Compressive strength (carbon & glass)	AHO024,AHO030
	B,F	(T)		b.	Residual volatiles (carbon & glass)	AHO110,AHO116
	B,F	(T)		c.	Resin content (carbon & glass)	AHO128,AHO134
	B,F	(T)		d.	Specific gravity (carbon & glass)	AHO149,AHO156
			5.		For New Nose Inlet Assembly Phenolic Rings verify:	
	B	(T)		a.	Radiographic examination is acceptable	ADT106,ADT109,ADT115
			6.		For New Nose-Throat Assembly, Nozzle verify:	
	A,C,D,G			a.	Tightening sequence of socket head cap screws (throat inlet-to-nose inlet) per planning requirements	ADN125
	A,C,D,G			b.	Torque value of socket head cap screws in throat inlet-to-nose inlet per planning requirements	ADN127
	A,G			c.	Joint bond gap between the throat inlet and nose inlet is within specified limits	SAA009
	D			d.	Proper alignment of the throat inlet assembly to the nose inlet assembly	ADN099
			7.		For New Throat/Inlet Phenolic Rings verify:	
	B	(T)		a.	Radiographic examination is acceptable	AAW080,AAW083
			8.		For New Carbon-Cloth Phenolic verify:	
	E	(T)		a.	Cloth content--uncured	AOD017
	E	(T)		b.	Compressive strength--cured	AOD027
	E	(T)		c.	Density--cured	AOD058
	E	(T)		d.	Dry resin solids--uncured	AOD067
	E	(T)		e.	Inter-laminar shear--cured	AOD075

E	(T)	f.	Resin content--cured	AOD112
E	(T)	g.	Resin flow--uncured	AOD140
E	(T)	h.	Sodium content--uncured	AOD164
E	(T)	i.	Volatile content--uncured	AOD222
E	(T)	j.	Carbon filler content--uncured	AOF000

9. For Retest Carbon-Cloth Phenolic verify:

E	(T)	a.	Resin flow	AOD131
E	(T)	b.	Volatile content	AOD236

10. For Retest Phenolic Slit Tape verify:

E	(T)	a.	Resin flow	AOD131A
E	(T)	b.	Volatile content	AOD236A