CRITICAL ITEMS LIST (CIL)

No. 10-02-01-04R/01

SYSTEM:	Space Shuttle RSRM 10	CRITICALITY CATEGORY:	1
SUBSYSTEM:	Nozzle Subsystem 10-02	PART NAME:	Forward Exit Cone Assembly (1)
ASSEMBLY:	Nozzle and Aft Exit Cone 10-02-01	PART NO.:	(See Section 6.0)
FMEA ITEM NO.:	10-02-01-04R Rev N	PHASE(S):	Boost (BT)
CIL REV NO.:	N	QUANTITY:	(See Section 6.0)
DATE:	17 Jun 2002	EFFECTIVITY:	(See Table 101-6)
SUPERSEDES PAGE:	312-1ff.	HAZARD REF.:	BN-04
DATED:	10 Apr 2002		
CIL ANALYST:	B. A. Frandsen		
APPROVED BY:		DATE:	

RELIABILITY ENGINEERING: K. G. Sanofsky 17 Jun 2002

ENGINEERING: P. M. McCluskey 17 Jun 2002

1.0 FAILURE CONDITION: Failure during operation (D)

2.0 FAILURE MODE: 1.0 Thermal failure of carbon phenolic ablative liner or glass phenolic insulator components

3.0 FAILURE EFFECTS: Burn-through of forward exit cone, and breakup causing loss of nozzle causing loss of RSRM, SRB, crew, and vehicle

4.0 FAILURE CAUSES (FC):

FC NO.	DESCRIPTION	FAILURE CAUSE KEY
1.1	Carbon phenolic or glass phenolic material not manufactured to required thickness	A
1.2	Bond line failure of the glass phenolic-to-metal housing bond or glass phenolic-to-carbon phenolic bond	
1.2.1	Bonding surfaces not properly prepared or adequately cleaned	B
1.2.2	Bonding material not properly mixed, applied, or cured	C
1.2.3	Contamination during processing	D
1.2.4	Process environments detrimental to bond strength	E
1.2.5	Nonconforming material properties	F
1.2.6	Bond lines not to required thickness	G
1.3	Structural failure	
1.3.1	Improper ply angle orientation in phenolic components	H
1.3.2	Nonconforming raw material properties	I
1.3.3	Nonconforming manufacturing processes	J
1.3.4	Nonconforming dimensions	K
1.3.5	Phenolic cracks or delaminates at cap screw holes	L

1.4	Improper thermal characteristics due to nonconforming raw material properties	M
1.5	Component degradation during assembly, handling, transportation, or storage	N
1.6	Temperature, humidity, vibration, and shock during boost phase	O
1.7	Porosity, voids, de-laminations, inclusions, or cracks	P
1.8	Cap screws (shear pins) fail to hold phenolics to metal housing	
1.8.1	Cap screws improperly installed or locked	Q
1.8.2	Corrosion of cap screws	R
1.8.3	Embrittlement	S
1.8.4	Damaged threads	T

5.0 REDUNDANCY SCREENS:

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

6.0 ITEM DESCRIPTION:

Nozzle Forward Exit Cone Assembly--Insulator and Liner

1. The RSRM Forward Exit Cone Assembly is one of a series of interconnected modular nozzle components in the Nozzle Assembly (Figure 1). The Forward Exit Cone Assembly is located in the RSRM nozzle just aft of the throat inlet assembly and just forward of the aft exit cone assembly. The forward exit cone is approximately 34-inches long from flange to flange, with an inlet diameter of approximately 63 inches and an exit diameter of approximately 87 inches. Figure 2 provides an exploded sectional view of the RSRM nozzle showing the Forward Exit Cone Assembly.

2. The Forward Exit Cone Assembly consists of a truncated conic steel shell flanged on both ends. Next to the metal on the inside of the cone is a thin layer of glass phenolic resin impregnated cloth insulation, over which is laid a thicker layer of carbon phenolic impregnated cloth that acts as a liner of ablative material to the gas flow through the nozzle (Figure 3).

3. The glass phenolic layer is bonded to the steel shell with a two-part epoxy adhesive, and carbon phenolic is thermoset to the glass phenolic with a phenolic resin. The glass phenolic layer is also pinned to the steel shell using cap screws. Materials are listed in Table 1.

TABLE 1. MATERIALS

Drawing No.	Name	Material	Specification	Quantity
1U52837	Housing, Exit Cone (forward)	D6AC steel	STW4-2709	1/motor
1U76065	Screw, Cap, Socket Head-Modified	A-286 CRES 303	AMS 5737 ASTM A582	84/motor
1U77640	Segment Assembly, Rocket Motor			1/motor
1U77660	Nozzle Assembly, Final			1/motor
1U77152	Exit Cone Assembly, Fwd Section			1/motor
5U77804	Forward Exit Cone			1/motor
	Forward Exit Cone (Test)	Product Specification	STW3-3462	A/R
	Ablative Liner Material	Carbon-Cloth Phenolic	STW5-3279	616 lbs.
	Insulation	Glass-Cloth Phenolic	STW5-2651	153 lbs.
	Resin, Phenolic Laminating	Thermosetting Phenolic	MIL-R-9299	11 lbs.
	Tapes (Phenolic Slit Tape)	Cloth Phenolic, Pre-impregnated	STW5-3621	79 lbs.
	Adhesive, TIGA 321	Adhesive, Two-Part	STW5-9203	A/R
	Sealant, Polysulfide	Synthetic Rubber, Polysulfide	STW5-9072	A/R
	Adhesive	Electrically Conductive	STW4-2874	A/R
	Primer, Cyclohexane Silane	Silane Primer	STW5-9206	A/R

6.1 CHARACTERISTICS:

1. A D6AC steel housing encloses the ablative glass and carbon phenolics and provides structural shape and strength.

2. Glass-cloth pre-impregnated with phenolic resin has low thermal conductivity and is used as an insulator next to the D6AC steel shell. It also provides structural support for the ablative liner material next to it. The glass-cloth phenolic insulator is pinned with cap screws to the shell as well as being bonded with adhesive. A change in ply lay up angle (going from one material to another) is an added safety factor to slow down or stop through de-lamination.

3. Carbon-cloth pre-impregnated with phenolic resin is used as ablative liner over glass phenolic and is bonded to the glass phenolic with a thermosetting laminating phenolic resin. Carbon phenolic slowly chars away under the influence of exhaust gas at temperatures over 5600^{o}F. A cooling, localized gas layer next to the exhaust gas passageway extends the lifetime of liner material. Carbon-cloth phenolic material has a relatively high thermal conductivity compared to glass phenolic that aides the formation of the localized gas layer and spreads heat evenly to produce even charring of the surface.

4. Deviation RDW0653, (effectivity RSRM-84, RSRM-86 and subsequent) provides flight rationale for cowl station 0.3, forward exit cone, and aft exit cone not being able to meet the 1.4 Performance Factor. The Performance Factor is reduced for these components (see table below) where analysis shows a likelihood of violating the 1.4 requirement.

Component	Performance Factor
Aft Exit Cone forward 46 inches	1.3
Forward Exit Cone	1.1
Cowl, station 0.3 only	1.2

A statistical analysis performed from flight erosion and char data showed a likelihood of violating the 1.4 Performance Factor at station 0.3 on the cowl and the forward and aft exit cones (reference TWR-75135). Changing the design to add additional carbon cloth phenolic (CCP) thickness is a possible future corrective action.

The Performance Factor equation is based on the CCP thicknesses required to meet conservative thermal requirements that ensure flight safety. Failure to meet even a Performance Factor of 1.0 does not necessarily mean failure of the nozzle. In addition, phenolic components are rarely, if ever, built to the minimum allowed thickness. For more information, see TWR-75135, Justification for Nozzle Performance Margin of Safety Equation Change.

Significant burn time capability remains with the reduced Performance Factors. Extensive assessment of postflight nozzle erosion results has determined that flight safety is assured even with Performance Factors down to 1.0.

Station with Minimum Burn Time Remaining	Deviation Performance Factor	Virgin Material Remaining (inch)*	Burn Time Remaining (seconds)**
Cowl – 0.3	1.2	0.215	91
Forward Exit Cone – 4.6	1.1	0.118	39
Aft Exit Cone – 118.77	1.3	0.258	138

* Using DMMT, virgin CCP material remaining at the end of 123 seconds of motor burn before RVMR is reached.

** Time remaining after the nominal 123 second motor burn before heating the glass cloth phenolic/CCP or silica cloth phenolic/CCP interface to 600° F while maintaining all epoxy/metal bondlines at ambient temperature.

5. Waiver RWW0547R1 (effectivity 360X082 through 360X091), addresses the potential for reduced performance margin of safety as a result of pocketing. Post-test evaluation of FSM-09 nozzle throat and forward exit cone regions revealed pocketing in the throat with accompanied wash erosion in the forward exit cone. This resulted in a violation of the pocketing depth (experienced 0.38 inches vs. required 0.250 inches) and performance margin of safety requirements for the nozzle throat ring (1.9 factor of safety (FS) vs. required 2.0 FS). Due to the nature of the past pocketing events, abnormal erosion may be seen in the forward portion of the forward exit cone that may also violate the performance margin of safety (1.6 FS vs. required 1.7 FS).

   FSM-09 throat pocketing is similar in appearance to the condition that occurred in 1996 during flights STS-079 (RSRM-56) RH, STS-80 (RSRM-49) LH and RH, and in 1997 on STS-86 (RSRM-57) RH. All instances, including the most recent static test of FSM-09, determined that flight and static test safety was assured for a worst case bounding condition for Carbon Cloth Phenolic (CCP) performance. Even for the bounding case, some virgin CCP (not heat affected) liner thickness will remain at the end of burn. FSM-09 pocket depths are enveloped within pocket depths experience in the previous flight-pocketing occurrences, and therefore the statistical prediction made for the flight motor occurrences encompass FSM-09.

   To resolve the condition of manufactured ply distortion creating local ply angles approaching ninety degrees to the flow surface, new mandrel configuration, Spacer Augmented Mandrel (SAM) was implemented at STS-106 (RSRM-75) and was used for FSM-9. This corrective action resulted in machining away ply distortions created near the flow surface as demonstrated by sectioning of five throat billets manufactured with SAM. Using this manufacturing approach, nozzle throat performance was as expected for FSM-07, FSM-08 and flight sets RSRM-75 through RSRM-81 (total of 16 nozzles). Investigation as the result of FSM-09 pocketing has yielded no evidence of ply distortion in final-machined billets, but does show evidence a “steepening” by about 5 degrees of the ply angle in SAM manufactured components.

   The contribution of low fiber strength material to pocketing was not fully understood nor the exact mechanism for the resulting low fiber strengths. Extensive investigation accomplished as part of the original flight investigation and subsequent testing funded under Enhanced Sustaining Engineering Task V included Design of Experiments testing that concluded that the condition that produces materials susceptible to pocketing occurs during the carbonization process at a subtier vendor. Testing also verified the thermal analyses, which concluded that the pocketing events initiate early in motor operation. Testing also verified that the pocketing phenomenon is self-limiting for motor heat fluxes in the aft throat region.

Recent Laser Hardening Material Evaluation Laboratory (LHMEL) testing of low threshold pocketing material yielded new maximum pocketing depths for a 700 W/cm^2 heat flux. This data verified that the self-limiting behavior of the material at this heat flux (determined to be the motor flux at the forward most pocketing location). A statistical analysis determined the k-sigma pocket depth to be 1.02 inches. A bounding thermal analysis was conducted using the k-sigma pocket depth situated over the joint 4 region of the throat. Results of the analysis showed the worst case to be in the aft region of the throat ring (joint 4) and found RSRM motors have substantial remaining burn time even with the worst case ply angle and highest propensity to pocket materials.

Corrective action to help resolve this condition is being evaluated on static test motors ETM-2, FSM-10 and ETM-3.

Since certain combinations of material characteristics and manufacturing processes, the CCP forming the nozzle throat component can exhibit pocketing greater than the allowed 0.250 inches. Negative performance margins of safety on the throat and forward exit cone (FEC), including over the shear pins, CCP ablative flame front liners may be associated with this pocketing. RWW0547R1 addresses this possibility and is therefore documented in this flight hazard report. The R1 to RWW0547 is necessary for the following two reasons:

1. To change the bounding case assessment, which was previously based on a group of test results that included data from high and low threshold materials, to a grouping of data that includes low threshold materials only. The bounding case assessment has changed from 0.65 to 1.02 inches for a maximum k-sigma pocketing depth.

2. To change the rate of erosion value for pocketing regions, which are used to calculate the remaining burn time beyond normal motor operation (i.e. 123 seconds). The previous erosion rate was based on the worst-case non-pocketing erosion divided by motor operation time in seconds. The value used was 5 mils/second. The latest burn time estimate was computed using the erosion rate at the bottom of the pocket, which is less than the maximum historical erosion rate. This is due to reductions in the convective heating environment in the pocket bottom. The predicted erosion rate used was revised to 3 mils/sec, which is also the nominal erosion rate of 3 mils/sec (0.41 inch nominal erosion for 123 seconds) for the current family of CCP, and NARC HRPF, which is CCP from North American Rayon Corporation (NARC) woven at Highland Industries on a Rapier loom, carbonized at Polycarbon, and impregnated at Cytec Fiberite (HRPF).

Recognizing that throat pocketing on flight nozzles is a possibility, the following flight rationale summarizes investigation findings that support the acceptability of the risk associated with the current nozzle throat and forward exit cone phenolics:

Flight rationale:

- No out-of-family process conditions noted that would adversely impact expected CCP material performance in RSRM-82 (STS-108)
- Normal operational variation of the carbonization furnace can produce low-pocketing threshold CCP
- Low-threshold CCP with the same process pedigree as test specimens that pocketed outside of expectations has flown and pocketed [RSRM-56 (STS-79)] with adequate burn time remaining for safe flight
- If pocketing occurs, erosion and char performance of the nozzle is not expected to differ significantly from past flight and static test population
- The pocketing process is self-limiting and remaining burn time beyond 123 seconds with k-sigma bounding case pocket depth is substantial
-

6. 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

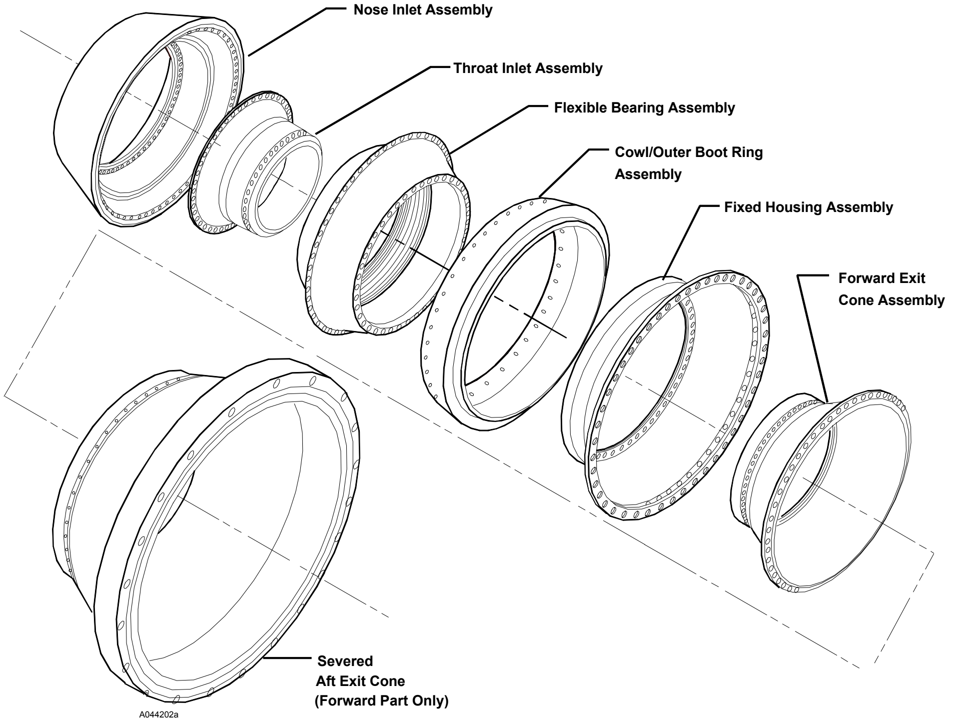

Figure 1. RSRM Nozzle Assembly Components

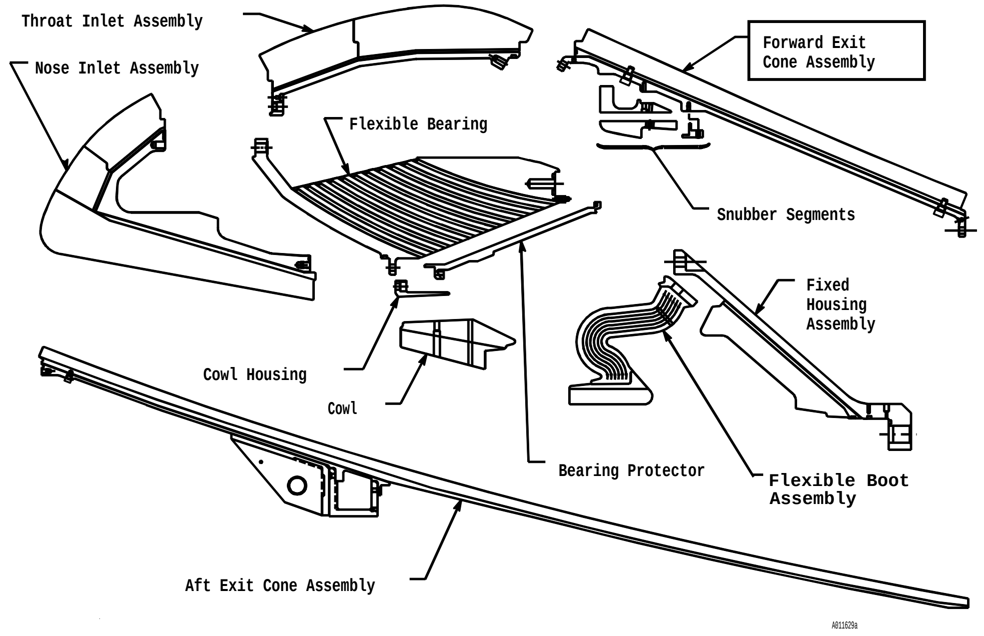

Figure 2. Exploded Section of Nozzle

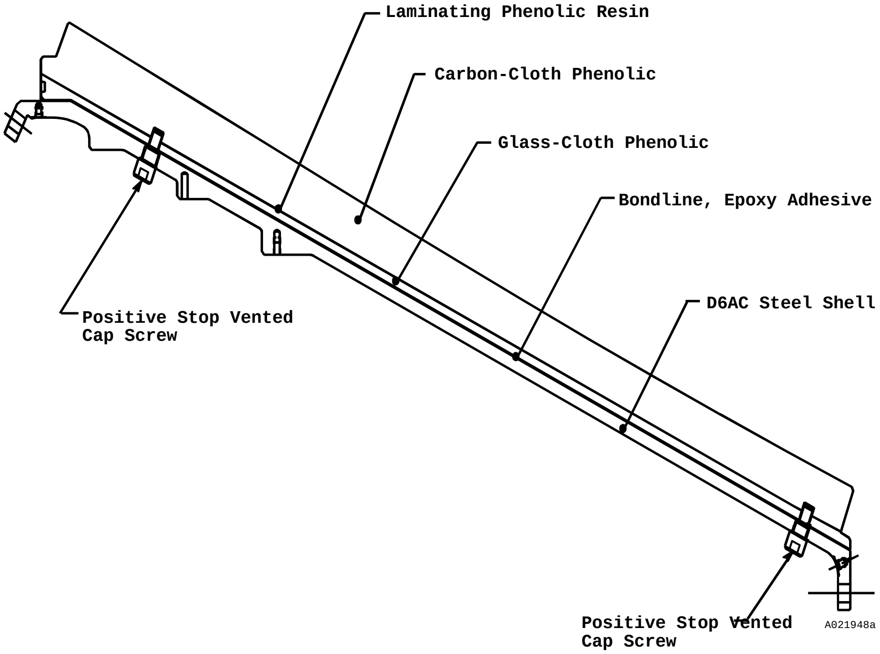

Figure 3. Forward Exit Cone Assembly

9.0 RATIONALE FOR RETENTION:

9.1 DESIGN:

DCN		FAILURE CAUSES
A,K	1.	Thickness of carbon-cloth phenolic and glass-cloth phenolic is controlled by wrapping the phenolics on the mandrel envelope per engineering drawings that was designed to generate the final inside contour of the exit cone. Phenolics are machined to reference points per engineering drawings.
A,K	2.	Assembly of the forward exit cone is per engineering drawings.
A,B,C,D,E,F,G, H,I,J,K,L,M,P	3.	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 forward exit cone 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.
A,K,G	4.	Preparation methods for bond line thickness are per shop planning. Type of surface inspection and the bonding process are per process critical planning.
A,K	5.	Thickness of the glass phenolic insulation layer is controlled by the vertical milling machine during glass phenolic tape final machining operations on the mandrel per engineering drawings. Carbon phenolic liner is cut to the proper thickness on the vertical milling machine during the carbon phenolic tape final machining operations per engineering drawings.
B,C,D,E,J	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. Conscan also verifies condition of the bonding surfaces prior to bonding. Type of surface inspection is per shop planning. Preparation, cleaning, and inspection methods for forward exit cone bond lines are identified as process critical planning.
B	7.	The effects of contamination on bond strength are per TWR-16858. Surface finish of metal parts is per TWR-31719.
B	8.	Radiographic criteria are per TWR-16340.
C	9.	Two-part epoxy adhesive is mixed, applied, and cured per shop planning and engineering drawings.
C	10.	Laminating phenolic resin is applied to the carbon phenolic surface, and the glass phenolic over wrapped composite structure is autoclave cured per shop planning and engineering drawings.
D,E	11.	Preparation and cleaning methods for bonding carbon-cloth phenolic liner, glass-cloth phenolic insulation, and the metal housing are per shop planning.

E	12. The nozzle manufacturing building is a controlled environment facility with temperature and humidity controls. There is controlled access to the building through a separate room.
F	13. Material properties for epoxy adhesive are per engineering.
F	14. Material properties for laminating phenolic resin are per government specifications for Resin, Phenolic Laminating.
F	15. Epoxy adhesive and phenolic resin are qualified and documented per TWR-18764-09.
G	16. Bond line thickness between carbon-cloth phenolic and glass-cloth phenolic is per shop planning.
G	17. Bond line thickness of the glass phenolic-to-metal housing is per engineering drawings.
G	18. Dry-fit to develop bond line shim size is done with Coe-flex per shop planning.
H	19. Carbon-cloth phenolic is tape wrapped at an angle to the mandrel centerline per engineering drawings.
H	20. Glass-cloth phenolic is tape wrapped over carbon-cloth phenolic parallel to the mandrel centerline per engineering drawings.
I,M	21. Material properties affecting structural and thermal integrity are controlled per Thiokol or government specifications for the following materials: a. Carbon-Cloth Phenolic b. Glass-Cloth Phenolic c. Resin, Phenolic Laminating d. Adhesive, LER, Silicone Filled
I,M	22. Intermixing of equivalent materials from different suppliers within the carbon phenolic components is not permitted per engineering drawings.
J,P	23. Forward Exit Cone Assembly manufacturing processes were demonstrated and qualified on development and test motors per TWR-18764-09.
L,Q,T	24. Forty-eight equally spaced flat-bottom holes are drilled and threaded around the forward end and also around the aft end of the Forward Exit cone Assembly into the glass phenolic insulator for the installation of cap screws.
L	25. Cracks or delaminates in phenolic material at the set screw holes are minimized by use of: a. Sharp drills b. Drill bushings c. Drill depth stops d. Flat bottom drills e. Drill shims
N	26. 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.

N 27. Handling and lifting requirements for RSRM components are similar to those for previous and current programs conducted by Thiokol per TWR-13880.

N 28. Transportation and handling of nozzle assembly items by Thiokol is per IHM 29.

N 29. The RSRM and its component parts are protected per TWR-10299 and TWR-11325. The nozzle, which is shipped as part of aft segment, is protected from the external environment at all times by either covers or shipping containers until assembled as part of the RSRM.

N 30. 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.

N 31. Support equipment used to test, handle, transport, and assemble or disassemble the RSRM is certified and verified per TWR-15723.

N 32. 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.

N 33. Age degradation of nozzle materials was shown to not be a concern. Full-scale testing of a six-year old nozzle showed that 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.

N 34. Pre-assembly mismatch causing bond line stresses was shown by analysis to be within allowable limits per TWR-16975.

N 35. The Forward Exit Cone Assembly is covered with a protective cover and stored in a temperature controlled building until used as a part of a larger assembly.

N 36. 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 the ambient environment during in-plant transportation or storage are per engineering.

O 37. Analysis is conducted by Thiokol engineering to assess dynamic, acoustic, and vibration response of RSRM nozzle operation during the boost phase per TWR-16975.

O 38. Structural analysis documented in TWR-16975 show that nozzle phenolic-to-metal bondlines have positive margins of safety based on a safety factor of 2.0. These analyses used standard conditions as allowed by the CEI specification.

O 39. Analysis of nozzle natural frequency and vibration response throughout motor burn is per TWR-16975.

O 40. Environmental thermal conditions, similar to those occurring during the boost phase, were demonstrated on static tests and documented per TWR-18764-09.

P 41. Forward Exit Cone Assembly manufacturing processes are per shop planning.

P 42. Surface and subsurface defect criteria are per TWR-16340.

Q 43. Prior to installation, conductive adhesive is installed in each exit cone hole and 84 vented cap screws are then installed. Adhesive secures and locks the caps crews in place. Twelve lighting protection vented cap screws are installed in holes that have electrically-conductive adhesive applied.

Q 44. Vented cap screws are torqued per engineering which seats the vented cap screw head to the metal housing surface and provides a positive stop.

Q,R 45. A continuous bead of corrosion-resistant polysulfide sealant is applied to the base of the vented cap screw heads that provides an inhibitor to corrosion and galvanic corrosion.

R,S 46. Cap screw materials for the Modified Cap Screw are fabricated of A-286 steel or 303 stainless steel that have a high resistance to stress-corrosion cracking. The forward exit cone housing is D6AC steel per engineering.

S 47. Cap screws fabricated from A-286 steel or 303 stainless steel are not subject to embrittlement.

Q 48. A vent hole is provided in the cap screw to preclude build-up of hydraulic pressure during installation.

B 49. A Spray-in-Air cleaning system is used to clean metal components as part of the bonding surface preparation processing sequence.

F,I,J,M 50. Two lots of carbon-cloth phenolic from the same supplier may be used to fabricate the Forward Exit Cone.

E,N,O 51. 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 CODE
			1.	For New Forward Exit Cone verify:	
	A,K		a.	Mandrel S/A number is the same as that recorded in first wrap CPI	AHM033
	A,K		b.	Final surface profile of the phenolic	AHM014,AHM016
	B		c.	Dry time of solvent wipe on carbon phenolic prior to resin application	AHM010
	B		d.	Solvent wipe prior to resin application to carbon phenolic	AHM035
	B		e.	Carbon phenolic is clean prior to resin application	AHM008
	C,E,J	(T)	f.	Autoclave cure of glass phenolic is acceptable	AHM005
	C,E,J	(T)	g.	Hydroclave cure of carbon phenolic is acceptable	AHM006
	C,D,G		h.	A thin, uniform coating of resin is applied to carbon phenolic	AHM029
	D,E,J	(T)	i.	Radiographic examination is acceptable	ADI136
	G,J		j.	Acceptable completion of tape wrap per planning requirements	AHM018,AHM037A
	H		k.	Proper mandrel is used	AHM020A
	I,M		l.	Only one phenolic supplier's material is used	ADI117,ADI118,ADI119
	I		m.	Environmental history of cloth phenolic material	AMN054,AOD072
	I		n.	Cloth phenolic shelf life has not exceeded expiration date	AMN157,AOD188
	J		o.	Alcohol wipe on phenolic	AHM002,AHM003
			2.	For New Exit Cone Assembly, Forward Section verify:	
	A,K		a.	Profile	ADI009,ADI085,NCC020
	K		b.	O-ring groove surface finish	ADI125
	K		c.	O-ring sealing surfaces	ADI159
	K,L		d.	Cap screw holes are per blueprint	ADI034
	B,D		e.	Free of contamination (Black light)	ADI021,ADI022
	B,D,J		f.	Grit blast	ADI093
	B		g.	Solvent dry wipe	ADI075
	B		h.	Solvent wipe down	ADI176
	B		i.	Solvent wipe dry time	ADI073A
	B,C,D,J		j.	With CONSCAN the steel housing bonding surfaces	ABA003
	B,C,D,J		k.	Primer application ends within specified time limit after CONSCAN	ABA004
	B,C,F		l.	Proper cure of primer	NCC008
	B,C		m.	Primer application on bond surfaces	NCC009
	B,C,D,E,F I,J,M,Q	(T)	n.	Witness panel results for adhesive integrity	NCC010
	C		o.	Adhesive (LER, Silicon filled) is mixed per planning requirements	ADI007
	C,E,J	(T)	p.	Bonding cure	ADI067
	C		q.	Phenolic is seated within the pot life of the adhesive	ADI102
	C,D		r.	Adhesive is applied to bonding surfaces	ADI190
	C,F,I,Q	(T)	s.	Cure-cup hardness tests	ADI063
	E		t.	Temperature of bonding surface	ADI187
	G		u.	Correct bond line-shim location	ADI052
	G		v.	Correct bond line-shim size	ADI031
	G		w.	Bond gap thickness	ADI109
	G		x.	Bonding of shims	ADI029
	I,Q		y.	Adhesive is acceptable	ANM000
	J		z.	Forward exit cone housing is bonded to the liner	ADI025
	J,P		aa.	Alcohol wipe test	SAA103
	N		ab.	Component temperatures and exposure to ambient environments during in-plant transportation or storage	BAA037
	Q,T		ac.	Cap screws are properly torqued	ADI191

Q			ad.	Cap screw installed with adhesive	ADI037
Q,R			ae.	Sealing compound application at base of fastener heads	ADI158
Q			af.	Conductive adhesive is acceptable	ALW001
Q,R			ag.	Sealing compound is acceptable	AJH003A
Q,T			ah.	Adhesive is applied to the threads of the housing	NCC018
Q			aj.	Adhesive (Conductive Adhesive) for cap screw holes is mixed per planning requirements	ADR132
		3.		For New Housing, Exit Cone, Nozzle verify:	
K			a.	Threads	ADG038E,ADG038A
585		4.		For New Approved Solvent, verify:	
B			a.	Certificate of Conformance is complete and acceptable	AJJ007A
		5.		For New Adhesive, LER, Silicone Filled verify:	
F,I			a.	Pot life	ANM025
F,I	(T)		b.	Tensile Adhesion Strength	ANM045
		6.		For New Adhesive, Modified Epoxy (Grey) verify:	
F,I,M	(T)		a.	Average molecular weight (epoxy paste)	ANL002
F,I,M	(T)		b.	Epoxide equivalent, epoxy resin	ANL029,ANL027
F,I			c.	Pot life	ANL074,ANL075
F,I,M	(T)		d.	Titratable nitrogen, curing agent	ANL159,ANL160
F,I	(T)		e.	Viscosity, epoxy resin	ANL176,ANL178
F,I,M	(T)		f.	Ingredient percentages	ANL045,ANL060
F,I	(T)		g.	Steel-to-steel tensile adhesion	ANL094
F,I,M			h.	Visual examination (workmanship)	ANL117
		7.		For New Silicon Dioxide, verify:	
F,I,M	(T)		a.	Bulk density	ALP002,ALP008
F,I,M	(T)		b.	Moisture	ALP058,ALP064
F,I	(T)		c.	pH	ALP097,ALP101
F,I,M	(T)		d.	Loss on ignition	ALP040
		8.		For New Resin, Phenolic Laminating verify:	
F,I,M	(T)		a.	Specific gravity	AJG006
F,I,M			b.	Data pack is complete and acceptable	AJG022
F,I	(T)		c.	Viscosity	AJG037
		9.		For New Carbon-Cloth Phenolic verify:	
I,M	(T)		a.	Cloth content--uncured	AOD017
I	(T)		b.	Compressive strength--cured	AOD027
I,M	(T)		c.	Density--cured	AOD058
I,M	(T)		d.	Dry resin solids--uncured	AOD067
I	(T)		e.	Inter-laminar shear--cured	AOD075
I,M	(T)		f.	Resin content--cured	AOD112
I,M	(T)		g.	Resin flow--uncured	AOD140
I,M	(T)		h.	Sodium content--uncured	AOD164
I,M			i.	Supplier data pack is acceptable and complete	AOD206
I,M	(T)		j.	Volatile content--uncured	AOD222

	I,M	(T)	k.	Carbon filler content--uncured	AOF000
			10.	For Retest Carbon-Cloth Phenolic verify:	
	I,M	(T)	a.	Resin flow	AOD131
	I,M	(T)	b.	Volatile content	AOD236
			11.	For New Glass-Cloth Phenolic verify:	
	I,M	(T)	a.	Cloth content--uncured	AMN007
	I	(T)	b.	Compressive strength--cured	AMN014
	I,M	(T)	c.	Density--cured	AMN038
	I,M	(T)	d.	Dry resin solids--uncured	AMN048
	I	(T)	e.	Inter-laminar shear strength--cured	AMN057
	I,M	(T)	f.	Resin content--cured	AMN088
	I,M	(T)	g.	Resin flow--uncured	AMN121
	I,M	(T)	h.	Volatile content--uncured	AMN195
	I,M		i.	Supplier data pack is complete and acceptable	AMN172
			12.	For Retest Glass-Cloth Phenolic verify:	
	I,M	(T)	a.	Resin flow	AMN103
	I,M	(T)	b.	Volatile content	AMN178
			13.	For Retest Phenolic Slit Tape verify:	
	I,M	(T)	a.	Resin flow	AMN103A,AOD131A
	I,M	(T)	b.	Volatile content	AMN178A,AOD236A
			14.	For New Forward Exit Cone (Test) verify:	
	J	(T)	a.	Compressive strength (glass and carbon)	AMN025,AOD040
	J	(T)	b.	Residual volatiles (glass and carbon)	AMN079,AOD095
	J	(T)	c.	Resin content (glass and carbon)	AMN097,AOD117
	J	(T)	d.	Specific gravity (glass and carbon)	AMN148,AOD175
			15.	For New Segment Assembly, Rocket Motor, verify:	
	N,P		a.	Nozzle assembly for handling damage and that protective cover is cleaned and in place	AGJ167
585	N,P		b.	Approved solvent wipe	AGJ029
	N,P		c.	Component environments during in-plant transportation or storage	BAA030
	Q,R		d.	Sealant is applied around bolt heads	AGJ215
	Q,R		e.	Polysulfide sealant is acceptable	AJH003B
			16.	For New Nozzle Assembly, Final verify:	
	N		a.	Alcohol wipe test of nozzle insulation prior to shipment to nozzle installation operation	ADI014
	N,P		b.	Component temperatures and exposure to ambient environments during in-plant transportation or storage	BAA028
			17.	For New Screw, Cap, Socket Head--Modified verify:	
	Q,T		a.	Shank length (lot sample)	AGI001A
	Q,T		b.	"A" dimension (lot sample)	AGI001B
	Q,T		c.	Shank diameter (lot sample)	AGI001C

Q,T	d.	Discontinuity limits are met (head and body, socket, threads)(lot sample)	AGI004A,AGI004B,AGI004C
Q,T	e.	Threads are acceptable (lot sample)	AGI007

18. For Nozzle Assembly, Structural Bond line Requirements For verify:

B,C,D,E, F,I,J,M,Q (T)	a.	Phenolic-to-adhesive interface checks meet specification requirements	PPC001

19. KSC verifies:

N	a.	Nozzle rigid phenolic components for no visible damage per OMRSD File V, Vol I, B47SG0.141	OMD086