CRITICAL ITEMS LIST (CIL)

No. 10-02-01-08R/01

SYSTEM:	Space Shuttle RSRM 10	CRITICALITY CATEGORY:	1
SUBSYSTEM:	Nozzle Subsystem 10-02	PART NAME:	Cowl, Cowl Housing, Insulation, and Flexible Boot (1)
ASSEMBLY:	Nozzle and Aft Exit Cone 10-02-01		
FMEA ITEM NO:	10-02-01-08R Rev N	PART NO.:	(See Section 6.0)
CIL REV NO.:	N	PHASE(S):	Boost (BT)
DATE:	17 Jun 2002	QUANTITY:	(See Section 6.0)
SUPERSEDES PAGE:	321-1ff.	EFFECTIVITY:	(See Table 101-6)
DATED:	10 Apr 2002	HAZARD REF.:	BN-04, BN-06
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 cowl/cowl housing, insulation, and flexible boot

3.0 FAILURE EFFECTS: Exposure of the flex boot cavity to the motor chamber environment causes failure of the flex bearing and end ring seals resulting in breakup and loss of nozzle, causing loss of RSRM, SRB, crew, and vehicle

4.0 FAILURE CAUSES (FC):

FC NO.	DESCRIPTION	FAILURE CAUSE KEY
1.1	Cowl, inner, or outer boot rings not manufactured to required thickness	A
1.2	Boot not manufactured to required thickness	B
1.3	Bond line failure of the cowl and outer boot ring, or cowl and cowl housing, or cowl carbon phenolic and silica phenolic parts, or outer boot ring support and over wrap parts, or NBR boot and outer boot ring, or NBR boot and inner boot ring, or inner boot ring and fixed housing, or cowl housing and cowl housing insulation	
1.3.1	Bonding surfaces not properly prepared or adequately cleaned	C
1.3.2	Bonding material not properly mixed, applied, or cured	D
1.3.3	Contamination during processing	E
1.3.4	Process environments detrimental to bond strength	F
1.3.5	Nonconforming material properties	G
1.3.6	Bond lines not to required thickness	H
1.4	Temperature, vibration, and shock	I
1.5	Structural failure of the carbon, glass, or silica phenolic in the cowl, inner, or outer boot ring components	
1.5.1	Improper joint angles between cowl and outer boot ring	J

1.5.2	Improper ply angle orientation in cowl and outer boot ring components	K
1.5.3	Nonconforming raw material properties	L
1.5.4	Nonconforming manufacturing processes	M
1.5.5	Nonconforming dimensions	N
1.5.6	Ply lift of carbon-cloth phenolic	O
1.5.7	De-lamination of carbon-cloth phenolic	P
1.6	Component degradation during assembly, handling, transportation, or storage	Q
1.7	Structural failure of the NBR elastomer boot	
1.7.1	Nonconforming raw material properties of the NBR elastomer boot	R
1.7.2	Nonconforming manufacturing process	S
1.7.3	Nonconforming dimensions	T
1.7.4	Cracks, tears, or erosion of the NBR elastomer boot	U
1.8	Structural failure of the cowl housing	
1.8.1	Nonconforming initial manufacturing dimensions	V
1.8.2	Initial manufacturing material dimensions reduced by corrosion and/or refurbishment	W
1.8.3	Improper heat treatment	X
1.8.4	Nonconforming voids, inclusions, or other material defects	Y
1.8.5	Stress-corrosion cracking	Z
1.8.6	Fatigue	AA
1.9	Improper pressure equalization between motor chamber and volume between boot and flex bearing assembly	
1.9.1	Holes improperly drilled	AB
1.9.2	Blockage of vent holes	AC
1.10	Improper pressure equalization within the NBR boot layers	
1.10.1	Holes plugged	AD
1.10.2	Holes improperly drilled	AE
1.11	Spring pins fail to hold cowl to cowl housing	
1.11.1	Corrosion	AF
1.11.2	Embrittlement	AG
1.11.3	Improper installation	AH

1.12	Porosity, voids, de-laminations, inclusions, or cracks of phenolic components	AI
1.13	Improper thermal characteristics due to nonconforming raw materials in the glass, carbon, or silica phenolic	AJ
1.14	Improper thermal characteristics due to nonconforming raw materials in the NBR elastomer boot	AK
1.15	Thermal or mechanical failure of the cowl housing insulation	
	1.15.1 Nonconforming material properties	AL
	1.15.2 Nonconforming dimensions	AM

5.0 REDUNDANCY SCREENS:

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

6.0 ITEM DESCRIPTION:

1. The nozzle cowl housing assembly and flexible boot, form an insulating bridge between the fixed housing of the nozzle (bolted to the case) and the moveable parts of the nozzle. Thus, these assemblies (Figure 1) form an ablative shield for the flex bearing that is the primary attachment of the nozzle to the SRM. Materials are listed in Table 1 as follows:

TABLE 1. MATERIALS

Drawing No.	Name	Material	Specification	Quantity
1U77640	Segment, Rocket Motor, Aft			1/motor
1U52838	Housing Assembly, Cowl, Nozzle	7075-T73 Aluminum	STW3-2746	1/motor
1U79148	Housing Assembly, Cowl			1/motor
1U79150	Nozzle Fixed Housing Assembly			1/motor
1U76560	Pin, Modified			A/R
MS16562	Pin, Spring, Tubular, Slotted			A/R
1U79151	Housing and Boot Assembly, Nozzle			1/motor
1U52867	Plug			36/motor
1U79149	Nose-Throat-Bearing-Cowl Assembly, Nozzle			1/motor
1U79153	Nose-Throat-Bearing-Cowl Housing Assembly, Nozzle			1/motor
1U76608	Boot, Flexible Bearing, Nozzle	Carbon-Cloth Phenolic	STW5-3279	60 lbs.
		Glass-Cloth Phenolic	STW5-2651	40 lbs.
	Insulation	Rubber (NBR)	STW4-2621	A/R
			STW4-2621 TP I	(ALTERNATE)
	Flexible Bearing Boot (Test)	Product Specification	STW3-3457	A/R
		Phenolic Slit Tape	STW5-3621	A/R
5U76608	Boot Ring Phenolics	Fluorocarbon Plies		1/motor
1U76609	Cowl, Flexible Boot, Nozzle	Silica-Cloth Phenolic	STW5-2652	236 lbs.
		Carbon-Cloth Phenolics	STW5-3279	202 lbs.
	Cowl Insulation (Test)	Product Specification	STW3-3459	A/R
5U76609	Cowl Flexible Boot Phenolic			1/motor
	Adhesive, Epoxy, TIGA 321	Adhesive, Epoxy	STW5-9203	A/R
	Molding Compound	Silicone Adhesive (RTV)	STW5-9131	A/R
	Primer, Cyclohexane Silane	Silane Primer	STW5-9206	A/R
	Resin, Phenolic Laminating	Thermosetting Phenolic	MIL-R-9299	A/R
	Insulating Compound, Silicone		STW5-2650	A/R
	Base, Thermal		STW5-2650 (901)	A/R
	Cowl Housing Insulation	Carbon, 1200		
	Reinforcement	PPM Sodium	STW4-3184	A/R
	Thread, Splicing	Nylon	STW4-2919	A/R
	Fabric	Carbon Fabric	STW4-2871	A/R

6.1 CHARACTERISTICS:

1. The cowl assembly consists of a carbon-cloth phenolic ablative liner and silica-cloth phenolic insulator (together forming the cowl), and a structural housing. The cowl is bonded to the cowl housing and flexible boot assembly. The housing assembly, cowl is an aluminum alloy ring that serves as a structural support and bonding surface for the cowl. The aluminum housing is covered on the back side by a cowl housing insulation, made from a carbon fiber-filled thermal sealant, to protect it against the hot gases present in the flexible boot cavity. The cowl assembly is bolted to the nose inlet housing and bonded to the flexible boot assembly with silica-filled adhesive epoxy. The cowl portion of this item is a one-time-use part.

2. The Boot, Flexible Bearing Nozzle is composed of a flexible boot and two phenolic end rings to which it is attached (vulcanized). The outer boot ring is made of carbon-cloth phenolic. The outer boot ring and cowl liner join together to form the forward, rigid portion of the ablative shield. The inner boot ring is made of glass-cloth phenolic, and is bonded to the fixed housing with filled epoxy adhesive. The flexible boot itself comprises alternating layers of NBR (containing asbestos fibers and silica), carbon fabric, and Fluoroethylene Polymer (fluorocarbon film) (FEP) film to produce a pliant ablative shield for the aft portion of the flex bearing.

3. The cowl has a series of vent holes drilled through it around the circumference, allowing the cavity behind the flexible boot to pressurize at motor ignition and preventing boot collapse. There are also holes through all but one layer of the boot to equalize pressure within the boot layers. The flexible boot is a

one-time-use item.

4. Waiver RWW0533 provides flight rationale regarding the detection capability of penetrant inspection of nozzle aluminum parts. Affected nozzle aluminum parts include the Aft Exit Cone, Compliance Ring, Cowl Housing, and Actuator Bracket. Various levels of penetrant inspection performed on nozzle aluminum hardware may not reliably detect critical flaw sizes. A minimum flaw of 0.100 inches was assumed for capability of the penetrant inspection and was used in fracture mechanics analysis per TWR-16875. Recent testing of the effects of glass beaded and grit blasted bonding surfaces suggest these manufacturing processes impact crack detection capability. The waiver allows for use of the identified nozzle parts.

Nozzle Aluminum Hardware along with applicable flaw data are provided in the table below.

COMPONENT	FRACTURE CRITICAL	MINIMUM CRITICAL INITIAL FLAW SIZE	ACTUAL CRITICAL FLAW SIZE-MEOP	CRITICAL FLAW SCREENING TECHNIQUE	IS WAIVER REQUIRED
Compliance Ring	Yes	0.54 corner crack (bolt holes)	>1.2 inches	Penetrant (1)	Yes
Aft Exit Cone	Yes	0.67 through (joint 1)	>2.0 inch	Penetrant	Yes
Actuator Bracket	Yes	0.52 corner crack (bushing hole)	>1.2 inch	Penetrant	Yes
Nose Inlet Housing	Yes	0.36 through (joint 2 bolt holes)	N/A	Proof Test	No
Cowl Housing	Yes	0.42 through (holes)	N/A	Penetrant (only new parts)	Yes
Snubber	No	N/A	N/A	N/A	N/A

(1) Bolt holes are fail safe

Flight rationale is based on the following:

<u>New Hardware-Manufacturing Induced Flaws</u>

New nozzle aluminum parts are forged and ultrasonic inspected (longitudinal) to verify forging is free of sub-surface flaws. This inspection is capable of detecting internal flaws of 0.130 inches diameter or larger. Etching, per aerospace industry standards (up to 0.0004 inches), is performed and immediately followed by penetrant inspection. Penetrant inspection performed on new hardware has detected cracks as small as 0.080 inches long.

A crack missed during initial and subsequent inspections could exceed or grow to critical size during flight and/or splashdown to be of concern. The flaw would need to be "smart". To create a smart crack, a flaw would need to be generated during the new hardware fabrication and the flaw must be located in a specific critical location (circumferential and axial). In addition, smart cracks must have a specific critical orientation (longitudinal in right plane and radial in thickness). Critical flaw sizes are relatively large (>0.5 inch). Critical flaw size is based on MEOP loads, and for 3 sigma statistical flight loads critical flaw size is over twice as large. A smart crack flaw would have to be missed by all inspections (penetrant, visual, and ultrasonics). The probability of this occurring simultaneously is extremely low.

<u>Refurbishment Hardware - Water Impact Induced Cracks</u>

Nozzle aluminum parts are acceptable for reuse provided they meet requirements of STW7-2863. Dimensional checks, i.e., diameter, lengths, parallelism, etc. screen hardware that saw minor damage from water impact loads. More severe loads result in structural failure (cracks) of the parts. These cracks are easily detected during visual inspection. Aluminum parts receive penetrant inspections in addition to visual and dimensional inspection. Impact damage from debris will be detected visually.

Maximum load on nozzle hardware occurs during splashdown. Splashdown loads may cause local yielding that permanently deforms the hardware. Deformed hardware will not meet refurbishment dimensional requirements (roundness, etc.). In addition, higher splashdown loads that exceed material ultimate strength will result in localized structural failure (cracks). Post flight inspection history confirms these cracks are open and readily detectable.

The compliance ring is fail safe in bolt hole areas. Critical cracks in compliance ring bolt holes can propagate to the next hole or through the ligament and not cause failure. Critical flaw size in membrane areas is a 1.28 inch surface crack with actuator stall loads and a 1.22 inch through crack with 3-sigma flight loads (load data from 6 flights, 46.4 kip). Cracks will occur in bolt holes before cracks occur in the membrane. Compliance rings will be rejected for dimensional non-conformance before stresses are high enough to cause overload cracks due to water impact loads.

Aft exit cone critical flaw size is 0.67 inches long based on CEI design loads (i.e., stall load, MEOP, etc.). Critical flaw size based on 3 - sigma expected loads (load data from 6 flights, 46.4 kip), is 2.0 inches long. Aft exit cones will be out of round and scrapped due to dimensional non-conformance before loads are of the magnitude to initiate cracks.

Actuator bracket critical flaw size is 0.52 corner crack using CEI design loads and minimum part thickness. Critical flaw size, based on 3-sigma actuator loads is 1.2 through crack (load data from 6 flight, 46.4 kip). Water impact damage and other overload conditions create large flaws. Dimensions of actuator bracket flanges would exceed refurbishment specifications before stresses are high enough to generate cracks.

The cowl housing does not receive non-destructive examination. Damage to the forward end ring and the nose inlet housing would occur and be detected prior to or in conjunction with possible damage to the cowl housing. No visible damage to the cowl housing has ever been observed (other than corrosion). Due to low stress levels, critical initial flaw sizes for the cowl are large. Flight loads are well characterized and much less severe when compared to water impact loads. Cracks generated by water impact loading would be wide and visible.

The nose inlet is not included in this wavier. The nose inlet housing meets safe-life requirements through valid proof test.

Demonstrated reliability (with 50% confidence level) of RSRM aluminum hardware, using flight and test motors, is as follows:

Compliance Ring	--0.9960
Aft Exit Cone	--0.9960
Actuator Bracket	--0.9980
Cowl Housing	--0.9960

Effectivity for RWW0533 is RSRM 360X046, 360X047, 360X049 and 360X053 through 360X084.

5. 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.

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

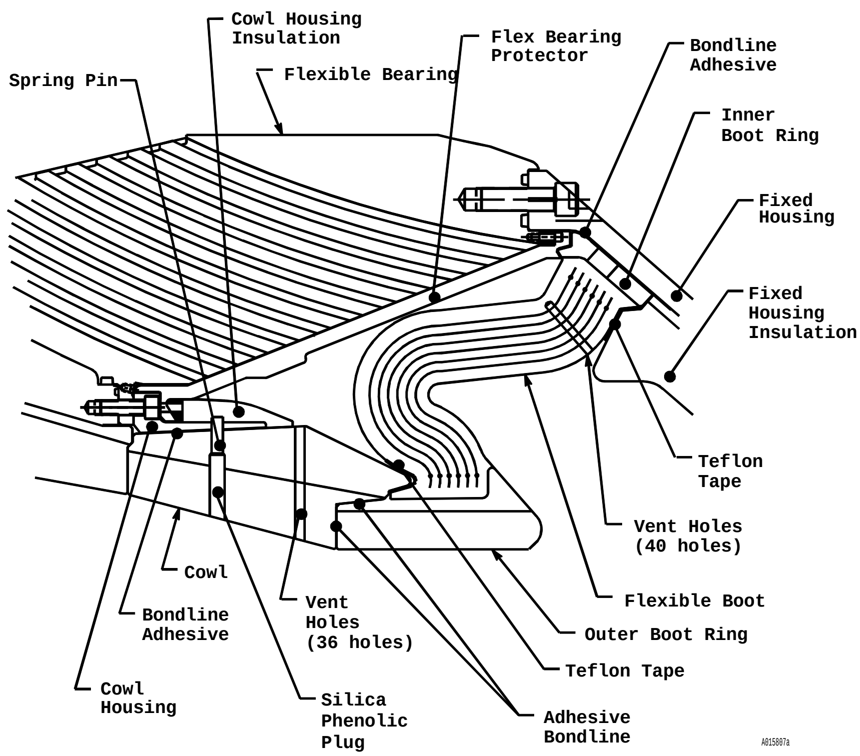

Figure 1. Redesigned Cowl and Boot

9.0 RATIONALE FOR RETENTION:

9.1 DESIGN:

DCN FAILURE CAUSES

A,J,K,L,N,
O,P,AI,AJ

1. Structural and aerothermal analyses were performed for the cowl boot phenolics, for imposed loading during motor operation. Separate margins of safety were calculated for various failure modes and associated combined stresses or thermal effects per TWR-16975 and TWR-17219. The new joint 2 assembly process changes the order of assembly for the cowl and outer boot ring. TWR-63473 states that the new assembly process does not adversely affect existing configurations of primary structure margins of safety. Margins of safety are as summarized below:

Item	Margins of Safety		Factors of Safety
Phenolics--Structural	Inter-laminar	In-Plane	
Cowl Insulation	Negative	Positive	1.4
Cowl Liner	Positive	Positive	1.4
Inner Boot Ring	Negative	Positive	1.4
Outer Boot Ring Support	Positive	Positive	1.4
Outer Boot Ring Over wrap	Positive	Positive	1.4
Adhesive Bonds/Bondlines:	Adhesive/Interface:		
Cowl and Outer Boot Ring	Positive		2.0
Bondlines	Interface		
Cowl Insulation and Liner	Positive		1.4
Outer Boot Ring Support and Over wrap	Positive		1.4

A,N

2. Glass and silica phenolics are wrapped on mandrels that were designed to generate the proper ply angles. The outer boot ring is formed by wrapping uncured carbon phenolic in two layers of differing ply angles. The carbon phenolic portion of the cowl is produced by over wrapping onto the cured and machined silica phenolic under layer. The phenolics are then cured and machined to fit reference points per engineering drawings.

A,N

3. Dimensions of the following phenolic components are per engineering drawings:

   a. Cowl
   b. Inner boot ring
   c. Outer boot ring

B,R,S,T,U,AK

4. Positive margins of safety were demonstrated by test for the flexible boot and NBR bonds to the inner and outer boot ring per TWR-14671. Positive margins of safety are demonstrated by analysis per TWR-13081 and TWR-16975. Results are summarized as follows:

Item	Margin of Safety	Factor of Safety
NBR Boot--Structural	Positive	1.4
NBR Boot--Thermal/Ablative	Positive	1.5
Bond lines:		
NBR Boot and Outer Boot Ring	Positive	1.4
NBR Boot and Inner Boot Ring	Positive	1.4

B,T 5. Structural and thermal protection value of the NBR elastomer boot is derived from the combined thickness of the NBR sheets. Consequently, thickness of the NBR sheet material is of primary importance. Care is taken in the boot fabrication process to assure correct total NBR thickness in the assembly. Layer thickness is per engineering:

Material	Verified Through
Calendared NBR Sheet Before Curing	Receiving and Process Inspections
Carbon-Cloth Thermal Layer	Supplier Certification
FEP Film	Supplier Certification

A,B,J,K,L,N,
O,P,T,AI,AJ 6. 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 cowl 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.

C,D,E,F,G,H 7. Structural analyses were performed for the bond lines of the cowl-boot assembly, for imposed loading during motor operation. Margins of safety were calculated for combined stresses and thermal effects obtained from aerothermal analysis per TWR-16975 and TWR-17219. Margins of safety were demonstrated by test for bonding of the flexible boot to the inner and outer boot rings per TWR-14671. The new joint 2 assembly process changes the order of assembly for the cowl and outer boot ring. TWR-63473 states that the new assembly process does not adversely affect the existing configurations primary structure margins of safety. Margins of safety were obtained as summarized below:

Adhesive Bonds or Bond lines	Margin of Safety	Factor of Safety
Cowl and outer boot ring	Positive	2.0
Cowl and cowl housing	Negative	2.0
Cowl insulation and liner	Positive	1.4
Outer boot ring support and over wrap	Positive	1.4
NBR boot and outer boot ring	Positive	1.4
NBR boot and inner boot ring	Positive	1.4
Inner boot ring and fixed housing	Positive	2.0

C,D,E 8. Preparation of bonding surfaces and their cleanliness are as follows:

a. Preparation and cleaning methods for bonding surfaces are per shop planning as process critical steps. Cleanliness of bonding surfaces is determined by a combination of visual inspection and visual inspection aided by black light.

CONSCAN is also used on steel housing bond lines. Surface inspection type for the following components is per shop planning:

1) Cowl and outer boot ring bond
2) Cowl and cowl housing bond
3) Cowl carbon phenolic and silica phenolic interface
4) Outer boot ring support-to-over wrap bond
5) NBR boot and outer boot ring bond
6) NBR boot and inner boot ring bond
7) Inner boot ring and fixed housing
8) Cowl housing and cowl housing insulation

b. Conscan verifies surface condition of the bonding surfaces on steel housings prior to bonding. A numerical value is obtained from the operation and is used as a process indicator to determine if changes to surface preparation took place.

C,D,E — 9. The aluminum cowl housing must be bonded within 6 hours of grit blasting per shop planning.

C,D,E,F — 10. Thiokol changed the manufacturing process that bonds the cowl-to-cowl housing before installing the outer boot assembly. This change precludes mixing of adhesive and sealant at the interface of the cowl to the nose-throat bearing assembly. This new process was static-tested on PVM-1, QM-8, TEM-6 through TEM-8, FSM-1 and FSM-2. TWR-63473 indicates that blowhole sooting and bond line voids caused by venting at assembly are eliminated or reduced in frequency and severity using the improved assembly method. The new method does not require materials or processes not used in existing methods and does not adversely affect the reliability or primary structural integrity of the nozzle.

F — 11. The nozzle manufacturing building is a controlled-environment facility with temperature and humidity controls. There is controlled access to the facility through a separate room with a card reader.

D — 12. The boot is manufactured with laid-up NBR between two phenolic rings. The inner boot ring is bonded to the fixed housing with Epoxy Adhesive. The inner and outer boot rings are vulcanized to the flexible boot using bonding material Rubber-to-Metal Adhesive. The outer boot ring is bonded to the cowl with Epoxy Adhesive. The carbon phenolic portion of the cowl is over wrapped on the silica phenolic portion after application of Phenolic Laminating Resin. The outer boot ring similarly contains a resin bond between the structural support layer and its over wrap layer. The cowl is bonded to the cowl housing with Epoxy Adhesive. Filled silicone rubber insulation is bonded to the back of the cowl housing with silicone rubber adhesive and Primer.

D — 13. At each end of the flexible boot, undesired bonding to adjacent phenolic of the cowl and fixed housing insulation is prevented by placement of Teflon tape between the phenolic and the adjacent NBR.

G — 14. Bonding material properties are per engineering for the following materials:

a. Epoxy paste adhesive is used for the following bonds:

1) Cowl-to-outer boot ring
2) Cowl-to-cowl housing
3) Inner boot ring-to-fixed housing

b. Laminating phenolic resin is used for the cowl carbon phenolic-to-silica phenolic interface and for the outer boot ring interface between the inner support layer and the outer over wrap layer of differing ply angle.

c. Silicone-rubber primer and silicone adhesive are used to bond the silicone insulation segments to the backside of the cowl housing.
d. Rubber adhesive is used to prepare phenolic surfaces for vulcanizing to the NBR plies:

1) NBR boot-to-outer boot ring
2) NBR boot-to-inner boot ring

H 15. The bond gap between the fixed housing and the inner boot ring is established using pre-cured shims made from epoxy adhesive, and installed at locations to be determined from dry-fit of mating parts per engineering drawings.

H 16. The bond gap between the cowl housing and the cowl is established using pre-cured shims made from epoxy adhesive, locations to be determined from the dry-fit of mating parts per engineering drawings.

H 17. The bond gap between the cowl and the outer boot ring is established using pre-cured shims made from epoxy adhesive, locations to be determined from the dry-fit of mating parts per engineering drawings.

H 18. Phenolic resin bond line thickness between the cowl carbon-cloth phenolic and glass-cloth phenolic and between the outer boot ring support and over wrap layers is per shop planning.

I 19. Positive margins of safety were demonstrated per structural and thermal analyses of the cowl and flexible boot assembly, including effects of vibration and shock during boost per TWR-17219 and TWR-16975.

I 20. Analysis of nozzle natural frequency and vibration response throughout motor burn is per TWR-16975.

I 21. Qualification of the nozzle assembly is per TWR-18764-09.

I,Q 22. 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.

J 23. Phenolic components of cowl and flexible boot assemblies are fabricated per engineering drawings.

J 24. Joint angle or contour is controlled by the cowl and outer boot ring. Dimensional limits of fit between the two surfaces is determined by bond gap tolerances.

J 25. Joint gaps are controlled by dry-fitting the cowl and outer boot ring. By means of shop handling equipment, a bonding fixture, impression compounds, and shims, proper bond gaps are determined. Size, number, and location of shims are per shop planning.

K 26. Cowl

a. Silica-Cloth Phenolic is tape wrapped parallel to the cowl mandrel centerline and machined to proper dimensions per engineering drawings.
b. Carbon-Cloth Phenolic is tape wrapped over the cowl silica-cloth phenolic insulation per engineering drawings.

K 27. Cowl Carbon-Cloth Phenolic material is tape wrapped to establish a new 50^{o} ply angle to insure that it will have the same ply-angle-to-flow as the adjacent outer boot ring, which does not experience ply lifting per TWR-61933.

K 28. Outer boot ring

a. Carbon-Cloth Phenolic is tape wrapped over the outer boot ring mandrel with the plies parallel to the center line to form the structural support layer, which provides strength in the axial direction and prevents through-de-lamination or cracking of the ring per engineering drawings.
b. Carbon-Cloth Phenolic is over wrapped on the structural support layer with outwardly angled plies to form the outer ablative ring per engineering drawings.

L,AJ 29. Structural and aerothermal analyses were performed for cowl phenolics, structural and thermal loading during motor operation. Margins of safety are per TWR-61933 and TWR-19047.

L,AJ 30. Material properties are presented in TWR-15995. Material specifications for the following materials stipulate requirements to which the material must comply:

a. Carbon-Cloth Phenolic
b. Silica-Cloth Phenolic
c. Glass-Cloth Phenolic
d. Resin, Phenolic Laminating

M,AI 31. The fabrication process for the cowl consists of two tape wrapping operations, two machining operations, and one drilling operation. The tape wrapping mandrel determines the inside contour of the component per engineering drawings. The mandrel is first wrapped with bias-cut silica phenolic tape, autoclave-cured, and contour machined. The billet is then over wrapped with straight cut carbon phenolic tape, autoclave-cured, and final machined. These processes are per engineering drawings and shop planning.

M,AI 32. The inner boot ring is fabricated of glass-cloth phenolic by tape wrapping over a mandrel. After wrapping, the billet is vacuum-bagged and autoclave-cured. The part is then machined and dimensionally inspected. These processes are per engineering drawings.

M,P,AI 33. The outer boot ring is formed in two separate layers of Carbon Cloth Phenolic with differing ply angles. After each tape wrapping operation, the lay up is vacuum-bagged and autoclave-cured under vacuum. The billet is then machined and inspected. Requirements are per engineering drawings and shop planning for the following operations:

a. First and second wrap phenolic cures
b. Machining of the first wrap phenolic layer
c. Machining of the second wrap phenolic layer and part completion

AI 34. Radiographic inspection is per TWR-16340.

O,P 35. Physical properties of phenolic components are per engineering that assures components with minimum potential for ply lift. Key steps in assuring a heat-stable material are:

a. Testing uncured pre-impregnated Carbon-Cloth Phenolic for volatile content per engineering for both the cowl and outer boot ring.
b. Curing under vacuum to remove volatile constituents.
c. Testing the cured product for remaining volatile material per engineering.

O 36. Packaging, storage, handling, and shipping requirements for Carbon-Cloth Phenolic are per engineering and MH&SI.

O 37. Ply lifts per TWR-19047 occur in parts wrapped parallel to the centerline (cowl, aft exit cone). Ply lifts are caused by a build-up of pore pressure at the char/virgin interface. As char thickness increases and permeability decreases late in motor burn, pore pressures can exceed the tensile strength of the char, resulting in a ply spread. Drop in motor pressure can exacerbate during motor tail off. Short plies at the aft end of the cowl are charred completely, so that they are not anchored in virgin material. This feature, in combination with ply lifts, results in char wedge outs. In addition, zero degree plies do not erode uniformly, resulting in a "ratty" appearance. Changing the ply angle to 50^{o} eliminates ply lifts, and a smooth uniform erosion pattern similar to the forward end of the outer boot ring is obtained.

P 38. The cowl is formed from a silica phenolic billet that is machined and then over wrapped with straight-cut carbon phenolic tape. The part is vacuum-bagged and autoclave-cured under vacuum, and final machined per engineering drawings.

P 39. The structural support outer boot ring design uses a parallel-to-centerline wrap in the inside-diameter portion to prevent through de-laminations from separating the boot ring from the cowl. The added structural support to the outer boot ring prevents de-lamination propagation to the boot per TWR 16295.

Q 40. Requirements for handling RSRM components during assembly and transportation are similar to those for previous and other current programs at Thiokol. Proof testing is required for all lifting and handling equipment per TWR-13880.

Q 41. Support equipment used to test, handle, transport, and assemble or disassemble the RSRM is certified per TWR-15723.

Q 42. To assure that no damage occurs to flight hardware during transportation to the launch site, specially designed and instrumented 200-ton railroad flatcars are used per TWR-13880.

Q 43. All components are inspected for damage during handling after completion. Assembly and handling operations are per shop planning and IHM 29.

Q 44. Parts are tagged "program critical hardware" to assure special handling per shop planning.

Q 45. 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.

Q 46. 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.

Q 47. 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.

R,A,K 48. The NBR elastomer boot is laid up in a mold using the following materials per engineering:

a. Calendared NBR sheet before curing
b. Carbon-cloth thermal layer
c. FEP film
d. Adhesive

S	49.	Manufacturing processes for the flexible boot are per engineering drawings and shop planning: a. The inner and outer boot rings are prepared for lay up by applying adhesive primer to bonding surfaces. The lay up mold is cleaned and the two rings are installed and secured. b. Rubber lay up is accomplished by manually placing sheets of rubber patterns into the mold to obtain the desired thickness. This boot rubber lay up consists of seven separate plies of NBR with layers of carbon-cloth and FEP film between each ply. A de-bulk operation is performed after the lay up of the fifth ply per TWR-10341. c. After lay up is complete, the upper mold ring is installed and a vacuum bag is placed over the remaining exposed rubber surfaces. The part is then placed in a press and heated to vulcanize and bond the rubber insulation to the inner and outer rings per TWR-10341. d. The flexible boot insulation is inspected for visual defects and trimmed to remove flashing. Holes for venting of the plies are then drilled.
S	50.	Critical process steps in the planning are used to control bonding operations. Included in the planning are curing processes, bonding surface preparation and cleanliness requirements, and methods and inspections to obtain required surface condition for the NBR boot and inner and outer boot ring bonds.
U	51.	The NBR elastomer boot is built up of elastomer layers. NBR material contains asbestos fibers that contribute to tear resistance.
U	52.	The flexible boot is designed as a sacrificial thermal protector for the flex bearing. NBR is filled with silicon dioxide and asbestos fibers to provide resistance to erosion by hot gases.
U	53.	NBR rubber is degraded by exposure to sunlight, ultraviolet light, and ozone, per TWR-12610. NBR elastomer layers are protected from degradation by sunlight, ultraviolet, and ozone by a coating of chemlok.
V,W,X,Y,Z, AA,AF,AG	54.	Structural analyses were performed for the cowl-boot assembly for imposed loading during motor operation. The margin of safety for the cowl housing was found to be positive for more than the planned four uses based on a 1.4 factor of safety per TWR-16975.
V,W	55.	Cowl housing dimensions for new parts are per engineering drawings and for refurbished parts per engineering.
X,Z	56.	The cowl housing is an aluminum forging, heat treated per engineering and machined per engineering drawings after heat treat.
X	57.	As part of the post flight inspection plan, char and erosion of the nozzle insulation is inspected and analyzed. If char and erosion of the insulation is determined to be such that the supporting aluminum housing was exposed to high temperature, or if heat effect is seen during post flight disassembly of the surrounding hardware, the suspect cowl housing is tested using an electrical conductivity test method. The electrical conductivity test is performed as part of the DR process to verify material condition of the housing and that heat treatment of the part was not affected.
Y	58.	Cowl housing material properties and testing is per engineering drawings. Structural flaws are minimized in the raw material by roll forming.
Y,Z	59.	The cowl housing is refurbished per engineering.

Z	60.	The possibility of stress corrosion of this part during its service life is as follows: a. Engineering prescribes a heat treat testing procedure to assure resistance to stress-corrosion cracking for 7075 aluminum alloy with T73-series heat treat for new parts. Electrical conductivity of the heat-treated forging is measured. If conductivity is 40 percent of the value before heat treat or greater, the forging is accepted. If conductivity is less than 38 percent, the material is unacceptable, and must be reheat treated. Any parts that are unable to pass the tests are rejected as being susceptible to stress-corrosion cracking.
A,B,N,T,Q,V,W,Z	61.	Assembly stresses are minimized as follows: a. Mating surface flatness is controlled by inspection of machining operations. b. Threads are cleaned and lubricated prior to assembly of the nose-throat-bearing-cowl assembly. c. Assembly bolts are torqued in a prearranged sequence to preload values. d. Dry-fit at installation assures that stresses will not be induced.
Z	62.	The forging was evaluated per JSC specifications for grain patterns and anomalies that might induce residual strain and was found to meet requirements per TWR-10715.
AA	63.	The basic forging was evaluated per JSC Specifications and TWR-10715. The result of this evaluation is that the principal grain flow pattern is parallel to principal stresses.
AB,AC	64.	The cowl has a series of vent holes drilled through it around the circumference, allowing the cavity behind the flexible boot to pressurize at motor ignition and prevent boot collapse.
AB,AC	65.	Dimensions of the cowl vent holes are per engineering drawings.
AB,AC	66.	Analysis to verify correct number and size of vent holes in the cowl is per TWR-17219.
AD,AE	67.	Vent holes are cut part way through the NBR layers to equalize pressure between the plies to retain flexibility of the boot during operation. A pilot hole is drilled and the finish hole is formed using a vent hole cutter. Each hole is checked to ensure it does not pass through the seventh rubber ply and does not contain a bottom plug per TWR-15723.
AF,AG	68.	Aluminum alloy has a high resistance to stress-induced corrosion, stress-corrosion cracking, and corrosion embrittlement per TWR-15995 and MIL-HDBK-5.
AF,AG	69.	Spring pins are steel per engineering and are cadmium plated to prevent galvanic corrosion with the aluminum surface.
AF,AG	70.	Spring pin holes are drilled into the cowl through the holes in the cowl housing. Protection is provided for the aluminum surface inside the hole by cadmium plating of the spring pins. Protection on the backside of the cowl housing is provided by cowl insulation segments.
AH	71.	Dimensions of drilled holes for the installation of cowl housing spring pins are per engineering drawings.
AH	72.	Shop planning provides instructions for drilling and installation of the spring pins.
AL,AM	73.	Aerothermal analysis of the cowl, boot, and boot cavity verified that the maximum

surface temperature of the cowl housing insulation does not exceed the allowable temperature for carbon fiber and silica-filled silicone rubber per TWR-17219. The analysis also showed that maximum temperature of the aluminum cowl housing was well below the requirement to preserve metal properties per TWR-17219. Post-fire inspection of QM-7 determined there was no thermal degradation or other damage to the cowl housing or cowl housing insulation per TWR-17271.

AL,AM 74. Cowl housing insulation is molded silicone rubber. This silicone rubber is highly sensitive to contamination and many process materials are not compatible with the curing catalyst. Therefore, shop materials and cleanliness are strictly monitored during the mixing and molding operation per shop planning and engineering drawings.

AL,AM 75. The silicone rubber mix is passed through a de-aeration assembly to prevent bubbles in the rubber. Surface voids are repaired after casting by cutting open and filling.

AM 76. Cowl housing insulation dimensions are controlled by the mold fixture. Mold envelope dimensions are per engineering drawings.

AM 77. Cowl housing insulation segments are joined lengthwise to form a complete ring of insulation. Segments are cast with excess length and manually trimmed to fit.

C 78. A Spray-in-Air cleaning system is used to clean metal components as part of the bonding surface preparation processing sequence.

G,K,L,M,AI,AJ 79. Carbon-cloth phenolic material from a single supplier and the same lot may be used in each of the separate wrap angles to fabricate the Outer boot ring. Intermixing of equivalent materials from different suppliers within each separate wrap angle is not permitted.

F,Q,AA,AJ 80. 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 performance of the RSRM nozzle were identified due to PE.

F,Q,AA,AJ 81. TWR-17219 was revised to include updated boundary conditions as part of the Generic/Performance Enhancement (PE) aero/plume heating environment certification effort. Comparison of resulting temperatures showed the generic environment analysis to be slightly higher than PE in all areas of the nozzle. Margins of safety still meet CEI requirements for char and erosion when using either generic or PE environments.

9.2 TEST AND INSPECTION:

DCN	FAILURE CAUSES and TESTS	(T)			CIL CODE
			1.	For New Cowl, Flexible Boot, Nozzle verify:	
	N,H		a.	Forward end flatness after final machine	AFL023
	Q		b.	Surface condition for handling damage after final machine	AFL029
	AB		c.	Diameter of vent through holes	AFL018
			2.	For New Cowl Flexible Boot Phenolic verify:	
	H,N		a.	Aft end profile	AFL000
	A,N		b.	Silica outside diameter profile	AFL020
	H,J,N		c.	Forward end surface profile after final machine	AFL021
	A,N		d.	Outside carbon surface profile	AFL033
	C,D,E,H		e.	Resin application prior to over wrapping	AFL045
	D,M,O,P,AI		f.	Autoclave cure is complete and acceptable (carbon)	AFL005
	D,M,AI		g.	Autoclave cure is complete and acceptable (silica)	AFL017
	K		h.	Proper mandrel is used	AFL050
	AI		i.	Material for phenolic tape is acceptable	AFL008,AFL052
	M,AI		j.	Tape wrapping is complete and acceptable	AFL009,AFL058
	P,AI	(T)	k.	Radiographic examination of cowl is acceptable	AFL037
	P,AI		l.	Alcohol wipe phenolic surfaces	AFL001
	O		m.	Shelf life of phenolic material	AOP013B,AOP017A
	O		n.	Environmental history of phenolic material	AOP014B,AOP020
			3.	For New Boot, Flexible Bearing, Nozzle verify:	
	B,E,S,T,U		a.	Lay up is complete and acceptable	AFM054,AFM055,AFM056
	B,T		b.	Overall average thickness of the NBR layers	AFM067
	C,E		c.	Cleaning of phenolic and NBR bonding surfaces is performed per planning requirements, including solvent wipe down, dry wipe and drying time	AFM040
	C,D,E		d.	A full coat of bonding material is applied to both phenolic surfaces after cleaning and prior to lay up	AFM007
	C,D,E,F, C,D,E,F,G	(T)	e.	Witness panel results for NBR to glass phenolic bonds	SAA034
	I,Q		f.	Component temperatures and exposure to ambient environments during in-plant transportation or storage	BAA029
	Q		g.	Handling damage	AFM046,AFM047,AFM048
	R,AK		h.	Raw material is from one supplier	AFM078,AFM079,AFM080,AFM081
	R,AK		i.	Raw material is acceptable by review of accept tag	AFM082,AFM083,AFM084,AFM085
	R,AK		j.	Elastomer shelf life	ALH095
	S,U		k.	Flex boot cure is complete and acceptable	AFM014
	S,U		l.	No unflowed conditions	AFM059
	S,U		m.	No voids at interface joints	AFM062
	AE		n.	Diameter of NBR boot vent holes	AFM038
	AD,AE		o.	Hole depth of NBR boot vent holes (remove 6 of 7 layers)	AFM049
	AD,AE		p.	Distance from inner boot for vent holes	AFM057
	B,T		q.	Boot thickness after cured	DJM014
	C,D,E,F,G	(T)	r.	Witness panel results for NBR to carbon phenolic bonds	SAA035
			4.	For New Boot Ring Phenolics verify:	
	A,H,N		a.	Profile of inner ring	AFM044,AFM065,AFM001
	A,N		b.	Aft radius of outer ring	AFM003
	J,N,T		c.	Forward surface flatness of outer boot ring	AFM043

A,N		d.	Profile of outer boot ring	AFM050,AFM064
A,H,J,N		e.	Profile of outer boot ring	AFM051
A,N		f.	Inside surface radius	AFM052,AFM053
A,N		g.	Width at aft end of outer ring	AFM117
N		h.	Overall axial length--outer ring	SAA031
C,E		i.	Clean billet prior to resin application for over wrap	AFM019
C,D,E,H		j.	Resin application outer ring prior to over wrapping	AHY004
M,AI		k.	Cure cycle is complete and acceptable	AFM032,AHV001
D,M,O,P,AI		l.	Cure per process instructions for outer boot ring	AFM033
K		m.	Proper mandrel is used for outer boot ring	AHX002
AI		n.	Acceptable phenolic cloth for over wrap by review of accept tag	AFM009,AFM045
AI		o.	No intermixing of supplier's lots of carbon-cloth in a single wrap angle	AFM030
M,AI		p.	First and second tape wrap (outer boot ring) per process critical instructions	AFM109,AIA000
M,AI		q.	Tape wrap is completed per shop planning--inner boot ring	AFM111
AI	(T)	r.	Radiographics for boot ring (inner)	AFM073
P,AI	(T)	s.	Radiographics for boot ring (outer)	AFM075
AI		t.	Alcohol wipe of inner boot ring (inner)	AFM004
P,AI		u.	Alcohol wipe of inner boot ring (outer)	AFM006
O		v.	Shelf life is acceptable for phenolic material	AOP013,AOP013A
O		w.	Environmental history is acceptable for phenolic material	AOP014,AOP014A

5. For New NBR, verify:

B,T		a.	Certificate of conformance	ALH006
B,T		b.	Uncured thickness (calendered only)	ALH002,ALH165,ALH166
R	(T)	c.	Shore A hardness (calendered only)	ALH098,ALH102,ALH109
R	(T)	d.	Elongation (calendered only)	ALH010,ALH062,ALH065
R	(T)	e.	Tensile strength (calendered only)	ALH147,ALH149,ALH154
R	(T)	f.	Specific gravity (calendered only)	ALH118,ALH121,ALH126
R	(T)	g.	Mooney viscosity (extrusions only)	ALH041,ALH046,ALH170
R,A,K	(T)	h.	Scorch characteristics (extrusions only)	ALH081,ALH086,ALH171
R,AK		i.	Material workmanship including uniform appearance and free from contamination	ALH168

6. For Retest NBR, verify:

R	(T)	a.	Mooney viscosity	ALH049
R,AK	(T)	b.	Scorch characteristics	ALH087

7. For New Housing and Boot Assembly, Nozzle verify:

C,E		a.	Primer application begins within specified time limit after CONSCAN	ABA008
C,D,E		b.	Silane primer application on bond surfaces with minimum overlap	ABW004
C,E		c.	Cleaning of bonding surfaces is performed per planning requirements	ABW014
C,E		d.	CONSCAN of the steel housing bonding surfaces prior to bonding	ABA007
C,E		e.	Fixed housing bonding surfaces are free from unacceptable contamination per planning requirements (Black light)	ABW040
C,D,E,F,G	(T)	f.	Witness panel results for adhesive integrity	SAA036
D		g.	Proper cure of silane primer	ABW001
D		h.	Cure is complete and acceptable per planning requirements	ABW024
D		i.	Parts are seated within pot life of adhesive	ABW045
D		j.	Adhesive (Two-part Epoxy) is mixed per planning requirements	AOE005
D		k.	Adhesive is applied to bonding surface per planning requirements	ABW000
D		l.	Unbond gap between flex boot and fixed housing is maintained by application of Teflon tape	ABW048
D,G	(T)	m.	Cure cup hardness for process finalization of inner boot ring to fixed housing	AOE008
D,G		n.	Cure cup specimen preparation is complete and acceptable	ABW002

H		o.	Bondline thickness by Coe-flex impressions	ABW007
H		p.	Shim size and location from dry-fit of mating parts	ABW058
D,E,F,G	(T)	q.	Witness panel tests for radial bond lines	AOE072

8. For New Nose-Throat-Bearing-Cowl Assembly verify:

C,D,E		a.	Application of primer to bonding surfaces	ADP007
C,E		b.	Cowl housing bonding surfaces are cleaned per planning requirements, including solvent wipe down, air dried, and drying time	ADP015
D,AL		c.	Adhesive (Silicone Adhesive) is mixed per planning requirements	ADP000,AMM005
D		d.	Cure cup specimen preparation, for silicon adhesive	ADP020
D	(T)	e.	Shore A hardness test is complete and acceptable, for silicone adhesive	ADP022
D		f.	Voids in cured adhesive do not exceed allowable	ADP088
D,AM		g.	Butt joint gaps between cowl segments are within allowed limits	AMM000
D,AM		h.	Aft OD surfaces of segments are within tolerance to cowl housing assembly	AMM007
D,AL,AM		i.	Unbonds or voids in cowl segment butt joints or bond lines are within allowed limits	AMM020
Z		j.	Socket head cap screws are torqued in sequence per planning requirements, cowl assembly	ADP012
Z		k.	Socket head cap screws are torqued to proper value, cowl assembly	ADP013
Z		l.	Cowl housing is correctly aligned	ADP070
Z		m.	Cowl housing mating surfaces and holes are cleaned	ADP083
AL		n.	Cast room is clean and no incompatible materials are used (cowl segment build)	AMM001
AL,AM		o.	Part meets acceptance criteria and that necessary repairs are complete and acceptable (cowl segment build)	AMM004
AL,AM		p.	Acceptability of mold tooling per attached accept tag and mold is clean (cowl segment build)	AMM009
AL		q.	That uncured silicone rubber is within its shelf life limits (cowl segment build)	AMM010
AL	(T)	r.	Material has reached minimum Shore A hardness requirement (cowl segment build)	AMM014

9. For New Nose-Throat-Bearing-Cowl Housing Assembly, Nozzle verify:

C,E		a.	Bonding surfaces of cowl and outer boot ring are free from contamination (black light)	ABV008
C,E		b.	Cleaning of bonding surfaces is performed per planning requirements, including solvent wipe own, dry wipe and drying time	ABV007
C,D,E,F,G	(T)	c.	Witness panel results for adhesive integrity	SAA040
D		d.	Adhesive (Two-part, Epoxy) is mixed per planning requirements	AOE002
D,G		e.	Cure cup specimen is prepared per planning and specification requirements for adhesive void repair	ABV001
D		f.	Cure is complete and acceptable per planning requirements for adhesive bond	ABV010
D		g.	Outer boot ring is seated to cowl within pot life of adhesive	ABV018
D		h.	Adhesive is applied per planning requirements	ABV000
D		i.	Unbond gap is maintained between flex boot and cowl by application of Teflon tape	ABV019
D,G	(T)	j.	Shore D hardness of cure cup specimens for adhesive void repair	ABV021
D,G		k.	Cure cup specimen preparation is complete and acceptable for silicone sealant	ADQ007
D		l.	Cure is complete and acceptable per planning requirements for silicone sealant	ADQ055
H		m.	Shims are installed in the same degree location as at dry-fit	ADQ218
H,J		n.	Bond gap between cowl and outer boot ring by Coe-flex impressions	ABV004

AC		o.	Holes are free of adhesive obstruction after completion of cure	ABV016
585		10.	For New Approved Solvent, verify:	
C,E		a.	Certificate of Conformance is complete and acceptable	AJJ007A
		11.	For New Housing Assembly, Cowl verify:	
C,D,E,F,G	(T)	a.	Witness panel results for adhesive integrity	SAA037
C,E		b.	Grit blast	ADP032
C,E		c.	Proper adhesive application (cowl and cowl housing)	ADQ006
C,E		d.	Bonding surfaces of cowl and cowl housing are free from unacceptable contamination, (black light)	ADQ039
D,F		e.	Proper cure of silane primer	SAA047
C,D,E		f.	Silane primer application on bond surfaces with minimum overlap	SAA048
D		g.	Adhesive (Two-part Epoxy) is mixed per planning requirements	AOE001
D,G		h.	Adhesive mix specimen preparation (cowl-cowl housing) for cure cup hardness	SAA020
D,G	(T)	i.	Adhesive mix specimen tests (cowl-cowl housing) cure cup hardness	SAA021
D		j.	Primer application starts after grit blast within time limits	SAA022
AH		k.	Depth of spring pin holes	ADQ056
AH		l.	Diameter of spring pin holes	ADQ057
AH		m.	Installation of spring pins is acceptable	ADQ081
		12.	For New Housing Assembly, Cowl, Nozzle verify:	
H,V,Z		a.	Bonding surface line profile to Datum B	ADH001
V,Z		b.	Countersink of mounting holes	ADH003,ADH003A
V,Z		c.	Counter bore of mounting holes	ADH006,ADH006A
V,Z		d.	Diameter through holes	ADH011,ADH011A
V,Z		e.	Diameter threaded holes	ADH011B,ADH010B
V,Z		f.	Position of the through holes to Datums A and B	ADH045
V		g.	Position to Datum A and Datum B	ADH045B,ADH045A
V,Z		h.	Run out of housing inside diameter	SAA029
V,Z		i.	Perpendicularity to Datum A of Datum B	SAA028
X,Z,AA	(T)	j.	Electrical conductivity	ADH017
X,AA	(T)	k.	Chemical composition	AKT001
X,AA	(T)	l.	Heat treat	AKT003
X,AA	(T)	m.	Tensile strength	AKT007
X,AA	(T)	n.	Yield strength	AKT007A
X,AA	(T)	o.	Elongation	AKT007B
Y,Z,AA	(T)	p.	Dye penetrant after machining	ADH013,ADH012
Y,AA	(T)	q.	Ultrasonic test before final machining	ADH047
		13.	For Refurbished Housing Assembly, Cowl, Nozzle verify:	
H,W,Z		a.	A-to-B dimension straightness	ADH027
W,Z		b.	Wall thickness	ADH055
W,Z		c.	Flange and housing ID roundness	ADH026,ADH032
Y,AA		d.	Visual inspection for damaged parts	ADF095
		14.	For New Adhesive, Epoxy verify:	
G		a.	Pot life (adhesive)	AOE043,AOE046
G	(T)	b.	Epoxy paste viscosity	AOE083,AOE086
G	(T)	c.	Amine as nitrogen (curing agent)	AOE096,SAA045
G	(T)	d.	Epoxide equivalent (epoxy paste)	SAA044,SAA046
G	(T)	e.	Fracture toughness (adhesive)	AOE015
G	(T)	f.	Average molecular weight (epoxy paste)	AOE020
G	(T)	g.	Ingredient percentages	AOE023,AOE028

G	(T)		h.	Tensile adhesion strength	AOE062
G	(T)		i.	Visual examination (workmanship)	AOE099
		15.	For New Resin, Phenolic Laminating verify:		
G,L,P,AJ	(T)		a.	Specific gravity	AJG006
G,L,P,AJ			b.	Data pack is complete and acceptable	AJG022
G,L,P	(T)		c.	Viscosity	AJG037
		16.	For New Adhesive, Rubber-To-Metal verify:		
G	(T)		a.	Peel adhesion	AMS004,AMS002
G	(T)		b.	Solids content	AMS017,AMS015
G	(T)		c.	Specific gravity	AMS027,AMS025
G	(T)		d.	Viscosity	AMS039,AMS037
		17.	For New Primer, Silicone Rubber verify:		
G	(T)		a.	Percent solids	AMZ004,AMZ006
G	(T)		b.	Specific gravity	AMZ008,AMZ010
G	(T)		c.	Viscosity	AMZ012,AMZ014
G	(T)		d.	Infrared spectrum	AMZ002
		17.	For New Primer, Cyclohexane Silane verify:		
G	(T)		a.	Percent solids	AMZ004,AMZ006
G	(T)		b.	Specific gravity	AMZ008,AMZ010
G	(T)		c.	Viscosity	AMZ012,AMZ014
G	(T)		d.	Infrared spectrum	AMZ002
		18.	For New Molding Compound, Silicone Rubber, RTV verify:		
G	(T)		a.	Elongation	AMY001,AMY003
G	(T)		b.	Shore A hardness	AMY005,AMY007
G	(T)		c.	Tear strength	AMY009,AMY011
G	(T)		d.	Tensile strength	AMY013,AMY015
		19.	For New Segment, Rocket Motor, Aft verify:		
I,Q			a.	Component environments during in-plant transportation or storage meet requirements	BAA030
Q,U,AC			b.	Nozzle assembly for handling damage and protective cover is cleaned and in place	AGJ167
		20.	For the New Nozzle Fixed Housing Assembly verify:		
I,Q			a.	Component temperatures and exposure to ambient environments during in-plant transportation or storage are per engineering	BAA035
		21.	For New Carbon-Cloth Phenolic verify:		
L,P,AJ	(T)		a.	Cloth content--uncured	AOD017
L,O,P	(T)		b.	Compressive strength--cured	AOD027
L,O,P,AJ	(T)		c.	Density--cured	AOD058
L,P,AJ	(T)		d.	Dry resin solids--uncured	AOD067
L,O,P	(T)		e.	Inter-laminar shear--cured	AOD075
L,O,P,AJ	(T)		f.	Resin content--cured	AOD112
L,O,P,AJ	(T)		g.	Resin flow--uncured	AOD140
L,P,AJ	(T)		h.	Sodium content--uncured	AOD164
L,O,P,AJ	(T)		i.	Volatile content--uncured	AOD222

L,P,AJ	(T)	j.	Carbon filler content--uncured	AOF000
P	(T)	k.	Carbon reinforcement	AOD012
P	(T)	l.	Phenolic laminating resin	AOD088
P	(T)	m.	Resin filler	AOD126
P	(T)	n.	Pre-batch mix filler content	AOE057

22. For Retest Carbon-Cloth Phenolic verify:

L,O,P,AJ	(T)	a.	Resin flow	AOD131
L,O,P,AJ	(T)	b.	Volatile content	AOD236

23. For New Silica-Cloth Phenolic verify:

L	(T)	a.	Inter-laminar shear strength--cured	AMN027
L,AJ	(T)	b.	Volatile content--uncured	AMN027A
L,AJ	(T)	c.	Dry resin solids--uncured	AMN027B
L,AJ	(T)	d.	Silica filler content--uncured	AMN027C
L,AJ	(T)	e.	Cloth content--uncured	AMN027D
L,AJ	(T)	f.	Resin flow--uncured	AMN027E
L,AJ	(T)	g.	Density--cured	AMN027F
L,AJ	(T)	h.	Resin content--cured	AMN027G
L	(T)	i.	Compressive strength--cured	AMN027H

24. For Retest Silica-Cloth Phenolic verify:

L,AJ	(T)	a.	Resin flow	AMO020
L,AJ	(T)	b.	Volatile content	AMO028

25. For New Glass-Cloth Phenolic verify:

L,AJ	(T)	a.	Cloth content--uncured	AMN007
L	(T)	b.	Compressive strength--cured	AMN014
L,AJ	(T)	c.	Density--cured	AMN038
L,AJ	(T)	d.	Dry resin solids--uncured	AMN048
L	(T)	e.	Inter-laminar shear strength--cured	AMN057
L,AJ	(T)	f.	Resin content--cured	AMN088
L,AJ	(T)	g.	Resin flow--uncured	AMN121
L,AJ	(T)	h.	Volatile content--uncured	AMN195,AMN196

26. For Retest Glass-Cloth Phenolic verify:

L,AJ	(T)	a.	Resin flow	AMN103
L,AJ	(T)	b.	Volatile content	AMN178

27. For New Phenolic Slit Tape verify:

AI		a.	Correct thread used at sewing operation	AMO006
AI		b.	Slit width is acceptable	AMN001
AI		c.	No damaged edges on bias sheets	AMN068
AI		d.	By lot sample, no contamination during rewind	AMN067

28. For Retest Phenolic Slit Tape verify:

L,AJ	(T)	a.	Resin flow (glass and silica)	AMN103A,AMO020A
L,O,P,AJ	(T)	b.	Resin flow (carbon)	AOD131A
L,AJ	(T)	c.	Volatile content (glass and silica)	AMN178A,AMO028A
L,O,P,AJ	(T)	d.	Volatile content (carbon)	AOD236A

29. For New Flexible Bearing Boot (Test) verify:

M,AI (T)		a.	Compressive strength (glass)	AFM023
M,O,P,AI (T)		b.	Compressive strength (carbon)	AFM026
M,AI (T)		c.	Residual volatiles (glass)	AFM087
M,O,P,AI (T)		d.	Residual volatiles (carbon)	AFM091
M,AI (T)		e.	Resin content (glass)	AFM094
M,O,P,AI (T)		f.	Resin content (carbon)	AFM095
M,AI (T)		g.	Specific gravity (glass)	AFM103
M,O,P,AI (T)		h.	Specific gravity (carbon)	AFM104
	30.	For New Cowl Insulation (Test) verify:		
M,AI (T)		a.	Compressive strength (silica)	AMO004
M,O,P,AI (T)		b.	Compressive strength (carbon)	AOD038
M,AI (T)		c.	Residual volatiles (silica)	AMO017
M,O,P,AI (T)		d.	Residual volatiles (carbon)	AOD093
M,AI (T)		e.	Resin content (silica)	AMO019
M,O,P,AI (T)		f.	Resin content (carbon)	AOD116
M,AI (T)		g.	Specific gravity (silica)	AMO025
M,O,P,AI (T)		h.	Specific gravity (carbon)	AOD173
	31.	For New Pin, Modified verify:		
AF,AH		a.	Length	ADV062C
	32.	For New Pin, Spring, Tubular, Slotted verify:		
AF,AH		a.	Diameter	ADV062A
AF,AG		b.	Correct material (CRES 420 or carbon steel per engineering)	AJR001
AF,AG		c.	Chemical properties	AJS000
AF		d.	Mechanical properties	AJS002
	33.	For New Insulation Compound Silicone, Thermal verify:		
AL (T)		a.	Elongation--cured	AMM002
AL (T)		b.	Shore A hardness--cured	AMM012
AL (T)		c.	Specific gravity--cured	AMM015
AL (T)		d.	Tensile strength--cured	AMM017
AL (T)		e.	Viscosity, mixed--uncured	AMM021
AL (T)		f.	Viscosity of silicone resin base--uncured	AMM023
AL (T)		g.	Working life--uncured	AMM029
	34.	For Nozzle Assembly, Structural Bond line Requirements For verify:		
C,D,E,F,G (T)		a.	Phenolic-to-adhesive interface checks meet specification requirements	PPC001
	35.	KSC verifies:		
I		a.	Flex bearing was maintained at the minimum average temperature or thermally conditioned prior to launch per OMRSD File II, Vol I, S00FA0.776	OMD013