ATK ALLIANT TECHSYSTEMS
THIOKOL PROPULSION

CRITICAL ITEMS LIST (CIL)

No. 10-02-01-09R/01

SYSTEM:	Space Shuttle RSRM 10	CRITICALITY CATEGORY:	1
SUBSYSTEM:	Nozzle Subsystem 10-02	PART NAME:	Nose Inlet-to-Forward End Ring Joint, Metal Components (1)
ASSEMBLY:	Nozzle and Aft Exit Cone 10-02-01		
FMEA ITEM NO.:	10-02-01-09R Rev M	PART NO.:	(See Section 6.0)
CIL REV NO.:	M (DCN-533)	PHASE(S):	Boost (BT)
DATE:	10 Apr 2002	QUANTITY:	(See Section 6.0)
SUPERSEDES PAGE:	322-1ff.	EFFECTIVITY:	(See Table 101-6)
DATED:	31 Jul 2000	HAZARD REF.:	BN-03
CIL ANALYST:	B. A. Frandsen		
APPROVED BY:		DATE:	

RELIABILITY ENGINEERING: K. G. Sanofsky 10 Apr 2002

ENGINEERING: B. H. Prescott 10 Apr 2002

1.0 FAILURE CONDITION: Failure during operation (D)

2.0 FAILURE MODE: 1.0 Structural failure of metal components

3.0 FAILURE EFFECTS: Seal leakage, joint deformation causing loss of nozzle, thrust imbalance between SRBs, and loss of RSRM, SRB, crew, and vehicle

4.0 FAILURE CAUSES (FC):

FC NO.	DESCRIPTION	FAILURE CAUSE KEY
1.1	Nonconforming dimensions	
1.1.1	Initial manufacturing dimensions	A
1.1.2	Metal dimensions reduced by corrosion and/or refurbishment	B
1.2	Nonconforming material	
1.2.1	Improper heat treatment	C
1.2.2	Hydrogen embrittlement of bolts	D
1.2.3	Nonconforming voids, inclusions, or other material defects	E
1.3	Stress-corrosion cracking	F
1.4	Improperly-installed bolts	G
1.5	Transportation, handling, and assembly damage	H
1.6	Fatigue	I
1.7	Improper assembly techniques	J

5.0 REDUNDANCY SCREENS:

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

6.0 ITEM DESCRIPTION:

1. Nose inlet-to-forward end ring joint is part of the Nose Throat Bearing Assembly. The nose inlet assembly consists of an aluminum superstructure that interfaces with the bearing forward end ring and cowl housing (Figures 1 and 2). Materials are listed in Table 1.

TABLE 1. MATERIALS

Drawing No.	Name	Material	Specification	Quantity
1U79324	Bearing Assembly, Nozzle Flexible			1/motor
1U79147	Nose-Throat-Bearing Assembly			1/motor
1U79149	Nose-Throat-Bearing Cowl Assy, Nozzle			1/motor
1U75398	Housing Assembly, Nose/Inlet Nozzle	7075-T73 Aluminum	STW3-3155	1/motor
1U52834	Ring, Bearing Assembly, Forward	D6AC Steel	STW4-2709	1/motor
1U52838	Housing Assembly, Cowl, Nozzle	7075-T73 Aluminum	STW3-2746	1/motor
1U77777	Bolt, Aluminum Coated, Nozzle	Alloy steel	NAS1341 FF-S-86 MIL-C-83488	60/motor
	Primer Coating, Corrosion-Resistant, Epoxy Resin	Epoxy Resin Corrosion-Resistant	STW5-2914	A/R
	Enamel Protective Coating, Epoxy Resin	Epoxy Resin, Enamel	STW5-2922	A/R
	Corrosion-Preventive Compound and O-Ring Lubricant	Heavy-Duty Calcium Grease	STW5-2942	A/R
	Coatings, Epoxy-Polymide	Epoxy and a Polymide Resin Activator	STW5-3225	A/R
	Primer, Zinc-Rich Epoxy-Polyamide	Pigmented Epoxy Resin Base & a Polyamide Resin Activator	STW5-3226	A/R
	Forgings, Mandrel and Rolled Ring Aluminum Alloy (7075), Space Shuttle Solid Rocket Motor	Aluminum Alloy (7075)	STW3-3155	A/R
	Helical Insert	CRES (AMS 7245)	MS124700 NASM124700 TT-P-1757	A/R
	Helical Insert	CRES (AMS 7245)	MS122161 NASM122161 TT-P-1757	A/R
	Conversion Coating	Chromate Film	MIL-C-5541	A/R

6.1 CHARACTERISTICS:

1. There are five main joints in the nozzle support structure. Included here is the nose inlet-to-forward end ring joint. Parts involved are the nose inlet housing, the forward end ring, and the cowl housing.

7.0 FAILURE HISTORY/RELATED EXPERIENCE:

1. Current data on test failures, flight failures, unexplained failures, and other failures during RSRM ground processing activity can be found in the PRACA Database.

8.0 OPERATIONAL USE: N/A

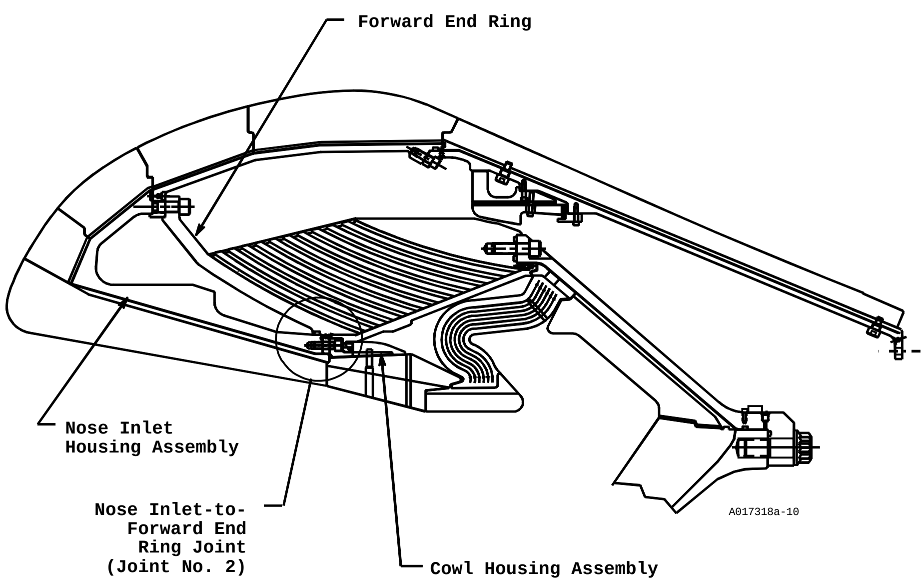

Figure 1. Nose Inlet-to-Forward End Ring Joint, Metal Components Location

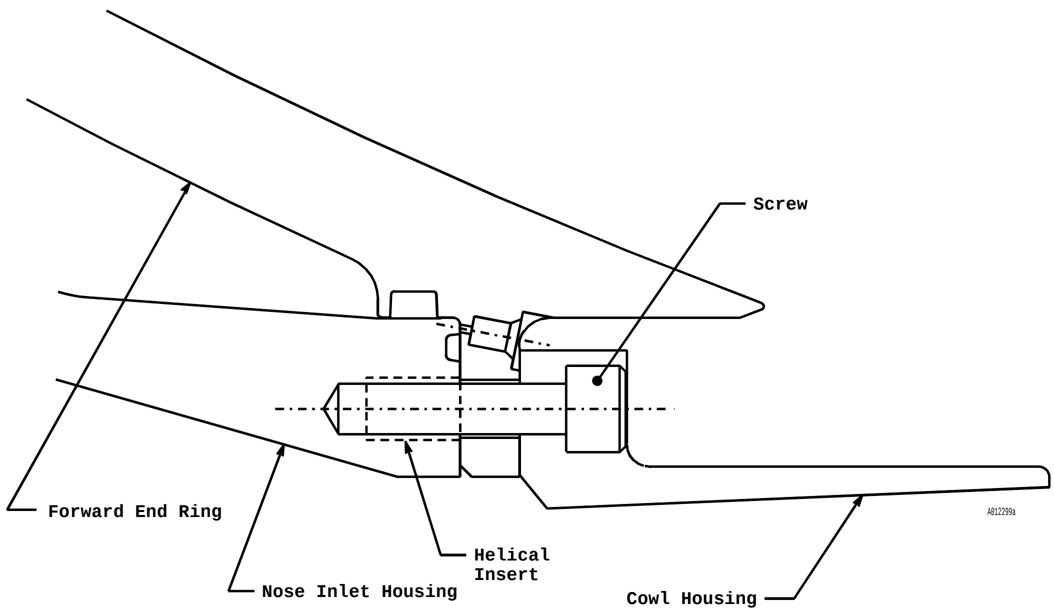

Figure 2. Nose Inlet-to-Forward End Ring Joint, Metal Components

9.0 RATIONALE FOR RETENTION:

9.1 DESIGN:

DCN	FAILURE CAUSES	
A,B	1.	Flex bearing forward end ring dimensions are per engineering drawings.
B	2.	Refurbished flex bearing forward end ring dimensions are per engineering drawings and specifications.
A,B	3.	Nose inlet housing dimensions are per engineering drawings.
B	4.	Refurbished nose inlet housing dimensions are per engineering drawings.
A	5.	Bolt dimensions are per engineering drawings. This is a one-time-use item.
A,B	6.	Cowl housing dimensions are per engineering drawings.
B	7.	Refurbished cowl housing dimensions are per engineering drawings and specifications.
A	8.	Helical insert dimensions are per engineering drawings.
C,E,F,I	9.	The flex bearing forward end ring is a heat treated D6AC alloy steel forging.
B,F	10.	Bare metal surfaces of the flex bearing forward end ring are protected from corrosion per engineering drawings.
B,F	11.	The Flex bearing forward end ring is coated with Epoxy-Polyamide Primer and top coated with Epoxy-Polyamide Coating per engineering drawings.
F,I	12.	The Flex bearing forward end ring flange and through holes, excluding the leak check port, must be magnetic particle inspected during each refurbishment.
G,J	13.	The socket head bolts joining the nose inlet assembly, forward end ring joint and cowl housing are tightened and torqued in sequence per shop planning.
C,E,F,I	14.	The nose inlet housing is a heat treated 7075-T73 aluminum alloy forging with requirements for ultimate and yield strengths and elongation per engineering.
F,I	15.	Nose inlet housing material is resistant to stress-corrosion cracking per MSFC standards.
B,F	16.	The nose inlet housing inside surface is coated with conversion coating, primer and top coating.
C,E,F,I	17.	The Housing Assembly, Cowl is an aluminum alloy forging that is heat treated per engineering.
F,I	18.	Housing Assembly, Cowl material is resistant to stress corrosion cracking per MSFC specifications.
B,F	19.	Flex bearing assembly bare metal surfaces are protected from corrosion per engineering.
B,F,I	20.	Contamination control requirements and procedures are per TWR-16564.

B,D,F,I 21. Bolts are alloy steel per Federal Specifications, and aluminum coated per MIL specifications and engineering drawings.

G,J 22. Bolts are self-locking per engineering drawings.

23. The possibility of stress corrosion or fatigue to these parts during their service life is as follows:

a. Forward end ring as follows:

F,I 1) TWR-16875 includes this part since its design was controlled by cyclic or repeated load conditions. Fatigue analysis was performed for low cycle fatigue, high cycle fatigue, and fracture mechanics. The results indicate that the forward end ring design substantially exceeds service life requirements.

E,F,I 2) The forging was evaluated per JSC Specifications and TWR-10713. The report states the micro cleanliness examination revealed the material meets all the requirements of the specification. Macro-structure examination showed that the forging process produced a part essentially free from re-entrant or sharply folded flaw lines and that all mechanical properties met or exceeded design requirements.

b. Nose inlet housing as follows:

E,F,I 1) The basic forging was analyzed per JSC Specification SE-R-0006 and reported in TWR-10711. This report shows the forging to be free of re-entrant or sharply folded lines and that the principal grain flow is oriented parallel with principal stresses expected.

F,I 2) The heat treat specification prescribes a testing procedure to assure resistance to stress-corrosion cracking for 7075 aluminum alloy with T73-series heat treat.

F,I 3) The nose inlet housing is a fracture control item per TWR-16875. TWR-16875 documents that the nose inlet housing passes the safe life requirements. Structural verification analysis per TWR-16975 shows the maximum stress obtained during operation will have a positive margin of safety using the factor of safety of 1.4 ultimate and 1.1 on yield.

c. Cowl housing as follows:

F,I 1) The basic forging was evaluated per JSC Specification SE-R-0006 and reported in TWR-10715. Result of this evaluation is that the principal grain flow pattern is parallel to the principal stresses that are considered insignificant.

F,I 2) The part is refurbished per engineering.

F,I 3) The heat treat specification prescribes a testing procedure to assure resistance to stress-corrosion cracking for 7075 aluminum alloy with T73-series heat treat.

F,I 4) The cowl housing is a fracture control item per TWR-16875. TWR-16875 documents that the cowl housing passes the safe life requirements. Structural verificationanalysis per TWR-16975 shows the maximum stress obtained during operation will have a positive margin of safety using the factor of safety of 1.4 ultimate and 1.1 on yield.

d. Bolts as follows:

F,I 1) Bolts are NAS standard alloy steel that has high resistance to stress corrosion cracking. These items are not reused.

G,J	24.	Socket head bolts must meet cleanliness requirements prior to installation per shop planning.
B	25.	Helical inserts are corrosion resistant steel. These are one-time-use items.
B,G,J	26.	Helical inserts are coated prior to installation with Federal Specification primer.
B,F	27.	Filtered grease is applied to all bare metal interfacing surfaces and all holes on the nose-throat-bearing-cowl assembly to prevent corrosion.
C,D,E,F,I	28.	Structural analyses per TWR-16975 show that all metal components of the joint have a positive margin of safety based on factors of safety of 1.4 on ultimate and 1.1 on yield.
C	29.	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, the suspect housing is analyzed. For Qualification and Production Verification motors char and eroding data were recorded per TWR-16473. For flight motors the data were recorded per TWR-50051.
D	30.	Hydrogen is inherent to the process of cadmium plating bolts and requires baking to relieve bolts of the hydrogen to preclude hydrogen embrittlement. The IVD aluminum bolt coating process does not introduce hydrogen into the bolts.
F	31.	D6AC has low-to-moderate resistance to stress corrosion per MSFC standards and the Material Use Agreement.
	32.	Assembly stresses are minimized as follows:
F,I		a. Mating surface flatness is per inspection of machining operations.
F,I		b. Threads are cleaned and lubricated prior to assembly.
F,I		c. Assembly bolts are torqued in a prearranged sequence to preload values.
G,J	33.	A coating of filtered grease is applied to all metal interfaces, helical coil inserts, holes, and underside of screw heads prior to installation of socket head cap screws per engineering drawings.
G,J	34.	Torque for the socket head bolts is per shop planning.
G,J	35.	Grease is filtered to remove unwanted contamination then loaded into a cartridge for application.
H	36.	Transportation and handling of the nozzle assembly and case segments by Thiokol is per Thiokol IHM 29.
H	37.	During assembly, care is taken to assure that threaded inserts are not damaged. Inserts that are damaged are replaced per engineering.
H	38.	Transportation and handling of the nose-throat-bearing assembly and nose throat-bearing cowl assembly, nozzle by Thiokol is per shop planning and under the direction of trained handling teams.
H	39.	Instrumentation for monitoring temperature is provided by a multi-day recording clock to record in-transit environments. Humidity control is per NASA Report TMX-64757.
H	40.	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.

H 41. If any defects are discovered in nozzle metal hardware at Thiokol during receiving inspection, processing and assembly, they are addressed per engineering.

H 42. 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.

C,D,E,F,H,I 43. Analysis of carbon-cloth phenolic ply angle changes for the nozzle was performed. Results show that redesigned nozzle phenolic components have a reduced in-plane fiber strain and wedge-out potential per TWR-16975. New loads that were driven by the Performance Enhancement (PE) Program were addressed in TWR-73984. No significant effects on the performance of the RSRM nozzle were identified due to PE.

533 C,D,E,F,H,I 44. Thermal analysis per TWR-17219 shows the nozzle phenolic meets the new performance factor equation based on the remaining virgin material after boost phase is complete. This performance factor will be equal to or greater than a safety factor of 1.4 for the nose inlet assembly per TWR-74238 and TWR-75135. (Carbon phenolic-to-glass interface, bondline temperature and metal housing temperatures were all taken into consideration). The new performance factor will insure that the CEI requirements will be met which requires that the bond between carbon and glass will not exceed 600 degree F, bondline of glass-to-metal remains at ambient temperature during boost phase, and the metal will not be heat affected at splashdown.

9.2 TEST AND INSPECTION:

DCN	FAILURE CAUSES and TESTS	(T)			CIL CODES
			1.	For New Ring, Bearing Assembly, Forward verify:	
	A,B		a.	Diameter dimension	ADF006,ADF009,ADF007,ADF010
	A,B		b.	Thickness	ADF018,ADF019
	A,B		c.	Height	ADF023,ADF024
	A,B		d.	Flatness	ADF025,ADF026
	A,B		e.	Run out	ADF060,ADF061,ADF065,ADF066,ADF068,ADF069
	A,B		f.	True position	ADF086A,ADF086,ADF087A,ADF087
	A,B		g.	Corrosion protection is per specification	ADF034
	C,D,E	(T)	h.	Ultrasonic inspection	ADF092,ADF090
	C,D,E	(T)	i.	Magnetic-particle	ADF046,ADF044
	C,D,E		j.	Heat treat	ADF033
	C,D,E	(T)	k.	Ultimate strength	ADF052
	C,D,E	(T)	l.	Yield strength	ADF052A
	C,D,E	(T)	m.	Elongation	ADF052B
	C,D,E	(T)	n.	Reduction of area	ADF052C
	C,D,E	(T)	o.	K_{IC} (fracture toughness)	ADF052D
			2.	For Refurbished Ring, Bearing Assembly, Forward verify:	
	A,B		a.	Height	ADF022
	A,B		b.	Diameter dimension	ADJ066,ADJ068
	A,B		c.	Roundness	ADJ067,ADJ069
	C,D,E,F,I	(T)	d.	Magnetic particle	ADF039
			3.	For New Housing Assembly-Nose/Inlet, Nozzle verify:	
	A,B		a.	Flatness	AFE008,AFE012
	A,B		b.	Diameter	AFE016,AFE017,AFE021,AFE022,AFE025,AFE026
	A,B		c.	Height	AFE049,AFE050
	A,B		d.	Profile	AFE123,AFE126
	A,B		e.	True position	AFE160,AFE160A,AFE161,AFE161A
	A,B		f.	Flatness	AFE009,AFE013
	A,B		g.	Alodine coating applied to designated surfaces	AFE001
	A,B		h.	Primer applied to surface	AFE120
	A,B		i.	Top coating applied to surface	AFE159
	A,B		j.	Run out	AFE136,AFE135
	C,D,E	(T)	k.	Ultrasonic	AFE166
	C,D,E		l.	Dye penetrant	AFE051
	C,D,E	(T)	m.	Elongation	AFE083B
	C,D,E,F,I		n.	Heat treat	AFE065
	C,D,E	(T)	o.	Ultimate strength	AFE083
	C,D,E	(T)	p.	Yield strength	AFE083A
	C,D,E,F,I	(T)	q.	Electrical conductivity	AFE039
	F,I		r.	Material composition	AFE080
			4.	For Refurbished Housing Assembly-Nose/Inlet Nozzle verify:	
	A,B		a.	Wall thickness	AFE168
	A,B		b.	Height	AFE048
	A,B		c.	Roundness	AFE130,AFE132
	A,B		d.	Diameter	AFE015
	A,B		e.	Straightness	AFE101,AFE103,AFE105,AFE107,AFE152

A,B		f.	Flatness	AFE154,AFE156
C,D,E,F,I		g.	Painted surfaces for indications of heat degradation	AFE097
C,D,E,F,I		h.	Dye penetrant	AFE033

5. For New Housing Assembly, Cowl, Nozzle verify:

A,B		a.	Inside diameter	ADH009,ADH008
A,B		b.	Diameter through holes	ADH010,ADH010A,ADH011,ADH011A
A,B		c.	Diameter threaded holes	ADH011B,ADH010B
A,B		d.	Position of the thru holes to Datums A and B	ADH045,ADH044
A,B		e.	Position to Datum A and Datum B	ADH044A,ADH044B,ADH045A,ADH045B
A,B		f.	Wall thickness	ADH054,ADH053
A,B		g.	Perpendicularity to Datum A of Datum B	SAA028,SAA030
C,D,E		h.	Dye penetrant after machining	ADH012
C,D,E	(T)	i.	Ultrasonic inspection	ADH046,ADH047
C,D,E,F,I	(T)	j.	Electrical conductivity	ADH017
C,D,E		k.	Heat treat	AKT003
C,D,E	(T)	l.	Tensile strength	AKT007
C,D,E	(T)	m.	Yield strength	AKT007A
C,D,E	(T)	n.	Elongation	AKT007B

6. For Refurbished Housing Assembly, Cowl, Nozzle verify:

A,B		a.	Wall thickness	ADH055
A,B		b.	Flange and housing ID roundness	ADH026

7. For New Bolt, Aluminum Coated, Nozzle, verify:

A,B		a.	By lot sample, critical dimensions	ABQ008,ABQ009,ABQ010,ABQ011
A,B,C,D,E		b.	Parts are manufactured from specified material	ABQ004
C,D,E		c.	Parts are 100% magnetic-particle inspected	ABQ005
C,D,E	(T)	d.	Tensile properties	ABQ002
C,D,E		e.	Parts are aluminum coated	ABQ001
C,D,E		f.	Lubricant application per MIL specification	ABQ006
C,D,E		g.	Locking element is per specification	ABQ007

8. For New Insert, Helical Coil, verify:

A,B		a.	Material is corrosion resistant steel	RHB001

9. For New Bearing Assembly, Nozzle Flexible verify:

A,B		a.	Corrosion-preventive compound (grease) is properly applied to designated areas	ADJ035E
A,B		b.	Epoxy-polyamide coating applied to designated surfaces	ADJ108
A,B		c.	Epoxy-polyamide primer applied to designated surfaces	ADJ110
C,D,E,F,I	(T)	d.	Tensile leak test	ADJ064

10. For New Nose-Throat-Bearing Assembly, Nozzle verify:

A,B		a.	Application of filtered grease	ADO027
G,J		b.	Free of contamination and corrosion	AOQ002
G,J		c.	Cap screws are free of visible and obvious contamination	ADO056
G,J		d.	Tightening sequence of capscrews	ADO057
G,J		e.	Torque of capscrews	ADO058

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

G,J	a.	Socket head capscrews are torqued in sequence per planning requirements, cowl assembly	ADP012
G,J	b.	Socket head capscrews are torqued to proper value, cowl assembly	ADP013
G,J	c.	Each socket head cap screw locking device is in place and acceptable	ADP027
G,J	d.	Interfacing surfaces of cowl housing are free from contamination and corrosion	ADP040
G,J	e.	Interfacing surfaces free of contamination and corrosion on nose-throat-bearing assembly	AOR001A
G,J	f.	Socket head capscrews free from contamination prior to installation	AOR006
H	g.	Finalization of parts with defects from shipping/handling damage during processing	ADP033