

CRITICAL ITEMS LIST (CIL)

No. 10-02-01-25R/01

SYSTEM:	Space Shuttle RSRM 10	CRITICALITY CATEGORY:	1
SUBSYSTEM:	Nozzle Subsystem 10-02	PART NAME:	Throat Inlet-to-Forward Exit Cone
ASSEMBLY:	Nozzle and Aft Exit Cone 10-02-01		Joint, Metal Components (1)
FMEA ITEM NO.:	10-02-01-25R Rev N	PART NO.:	(See Section 6.0)
CIL REV NO.:	N (DCN-533)	PHASE(S):	Boost (BT)
DATE:	10 Apr 2002	QUANTITY:	(See Section 6.0)
SUPERSEDES PAGE:	332-1ff.	EFFECTIVITY:	(See Table 101-6)
DATED:	27 Jul 2001	HAZARD REF.:	BN-03
CIL ANALYST:	B. A. Frandsen		
APPROVED BY:		DATE:	
RELIABILITY ENGINEERING:	<u>K. G. Sanofsky</u>		<u>10 Apr 2002</u>
ENGINEERING:	<u>B. H. Prescott</u>		<u>10 Apr 2002</u>

- 1.0 FAILURE CONDITION: Failure during operation (D)
- 2.0 FAILURE MODE: 1.0 Structural failure of the metal components
- 3.0 FAILURE EFFECTS: Seal leakage and joint deformation causing loss of nozzle, TVC, 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, or assembly damage	H
1.6	Fatigue	I
1.7	Improper assembly techniques	J
1.8	Damage to threads	K

CRITICAL ITEMS LIST (CIL)

No. 10-02-01-25R/01

DATED: 10 Apr 2002  
 SUPERSEDES PAGE: 332-1ff.  
 DATED: 27 Jul 2001

5.0 REDUNDANCY SCREENS:

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

6.0 ITEM DESCRIPTION:

1. Metal components of the Throat Inlet-to-Forward Exit Cone joint are a part of the Nozzle Assembly, Final. This assembly step joins the aft end of the throat inlet housing with the forward end of the forward exit cone assembly (Figures 1 and 2). Materials are listed in Table 1.

TABLE 1. MATERIALS

Drawing No.	Name	Material	Specification	Quantity
1U79144	Throat-Inlet Assembly, Nozzle			1/motor
1U52837	Housing, Exit Cone, Nozzle	D6AC Steel	STW4-2709	1/motor
1U78784	Forging, Forward Exit Cone, Nozzle	D6AC Steel	STW4-2709	1/motor
1U75547	Housing Throat Support, Nozzle	D6AC Steel	STW4-2709	1/motor
1U78785	Forging, Throat Housing, Nozzle	D6AC Steel	STW4-2709	1/motor
1U75756	Screw	Alloy Steel	STW3-1553 FF-S-86 QQ-P-416	143/motor
1U79152	Exit Cone Assy, Forward Section			1/motor
1U76757	Nozzle Assembly, Aft Segment			1/motor
8U50800	Shipping Kit-Segment			
	Corrosion-Preventive Compound and O-ring Lubricant	Heavy-Duty Calcium Grease	STW5-2942	A/R
	Paint	Epoxy and a Polyamide Resin Activator	STW5-3225	A/R
	Primer	Pigmented Epoxy Resin Base and a Polyamide Resin Activator	STW5-3226	A/R
	Sealant, Polysulfide	Synthetic Rubber, Polysulfide	STW5-9072	A/R
	Steel, Alloy, High Strength, D6AC	D6AC Steel	STW4-2606	A/R

6.1 CHARACTERISTICS:

1. The throat inlet-to-forward exit cone joint is one of five main joints in the nozzle assembly. The joint contains two O-ring seals and is held together by 143 self-locking, cadmium-plated, socket head cap screws. Interfacing housings are made of D6AC low-alloy steel and all interfacing metal surfaces are coated with a thin film of filtered grease to inhibit corrosion. Bolts are tightened in a predetermined pattern to minimize stress within the joint. Internal surfaces of the two housings are treated with a layer of primer and top-coating to inhibit corrosion in salt water. Sealant is applied at the inside interface of the two housings and at the base of socket head cap screws to prevent salt water penetration and corrosion.

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

CRITICAL ITEMS LIST (CIL)

No. 10-02-01-25R/01

DATED: 10 Apr 2002  
SUPERSEDES PAGE: 332-1ff.  
DATED: 27 Jul 2001

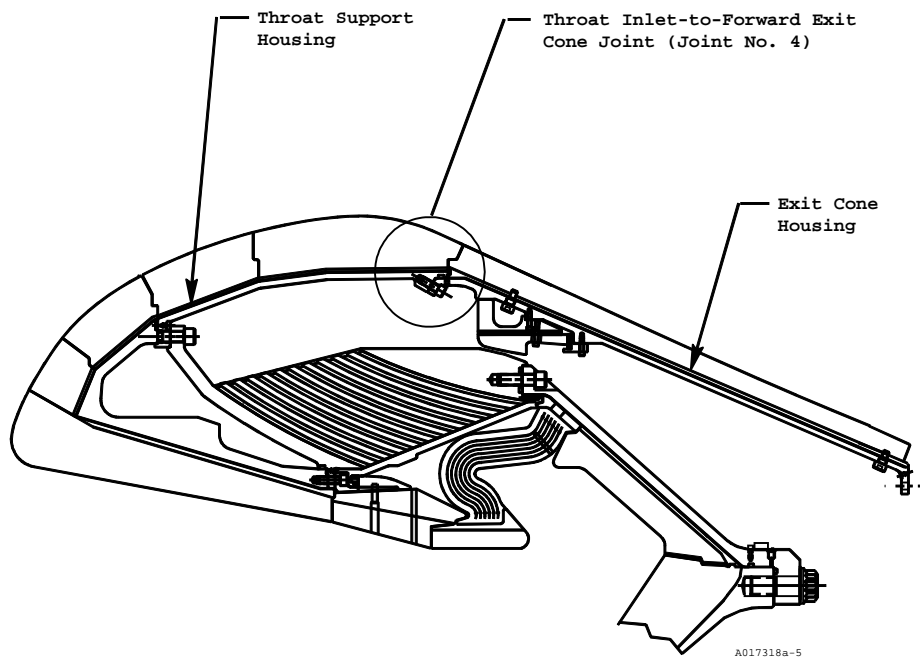


Figure 1. Throat Inlet-to-Forward Exit Cone Joint, Metal Components Location

CRITICAL ITEMS LIST (CIL)

No. 10-02-01-25R/01

DATED: 10 Apr 2002  
SUPERSEDES PAGE: 332-1ff.  
DATED: 27 Jul 2001

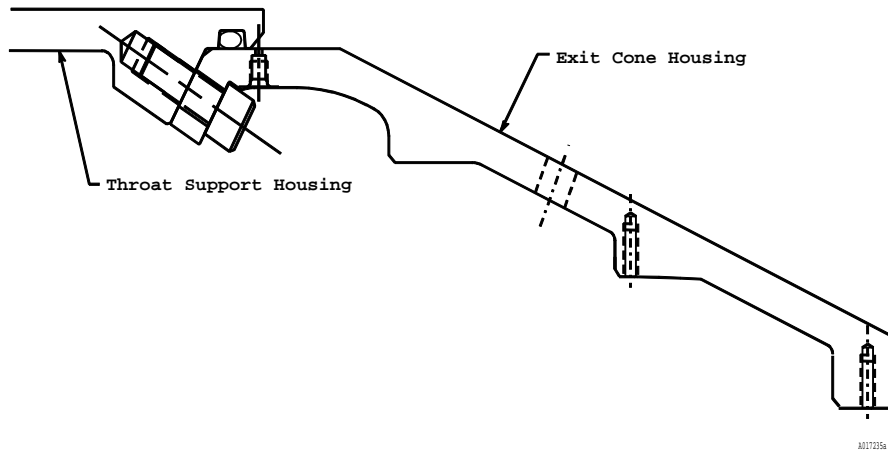


Figure 2. Throat Inlet-to-Forward Exit Cone Joint, Metal Components

CRITICAL ITEMS LIST (CIL)

No. 10-02-01-25R/01

DATED: 10 Apr 2002  
 SUPERSEDES PAGE: 332-1ff.  
 DATED: 27 Jul 2001

9.0 RATIONALE FOR RETENTION:

9.1 DESIGN:

DCN FAILURE CAUSES

- |       |     |   |
|-------|-----|---|
| A     | 1.  | Forward exit cone housing dimensions are per engineering drawings.  |
| B     | 2.  | Refurbished forward exit cone housing dimensions are per engineering drawings and specifications.   |
| A,B   | 3.  | Surfaces of the forward exit cone housing are protected from corrosion per engineering.   |
| A,B   | 4.  | Primer and top coating are applied to the outer surface of the exit cone housing to prevent corrosion.  |
| A     | 5.  | Throat support housing dimensions are per engineering drawings.   |
| B     | 6.  | Refurbished throat support housing dimensions are per engineering drawings and specifications.  |
| A,B   | 7.  | Surfaces of the throat inlet housing are protected from corrosion per engineering.  |
| A,B   | 8.  | Primer and top coating are applied to the inner surface of the throat housing to prevent corrosion per engineering drawings.  |
| A     | 9.  | Attach hardware screws meet the dimensions of engineering drawings and are one-time-use items.  |
| B     | 10. | Filtered grease is applied to joint bare metal surfaces of the nozzle at the time of assembly to prevent corrosion.   |
| A,F   | 11. | Contamination control requirements and procedures are per shop planning and TWR-16564.  |
| A     | 12. | Design dimension tolerances are per TWR-15995 to assure proper operational clearance.   |
| A,C,E | 13. | Structural analysis per TWR-16975 verifies the throat support housing has a positive margin of safety based on factors of safety of 1.4 on ultimate and 1.1 on yield. |
| C,I   | 14. | The forward exit cone housing is a heat treated D6AC steel forging.   |
| C,I   | 15. | The throat support housing is a heat treated D6AC steel forging.  |
| D     | 16. | Screws are cadmium plated alloy steel, baked to prevent hydrogen embrittlement.   |
| F     | 17. | Surfaces of D6AC steel are protected against corrosion per engineering.   |
| F,I   | 18. | Screws are protected from corrosion by cadmium plating per engineering and are a one-time-use item.   |
| F     | 19. | D6AC steel has low-to-moderate resistance to stress corrosion per MSFC-Specifications and the Material Use Agreement.   |
| F     | 20. | The nozzle throat support housing and exit cone housing are heat treated D6AC steel forgings with low-to-moderate resistance to stress corrosion per MSFC             |

CRITICAL ITEMS LIST (CIL)

No. 10-02-01-25R/01

DATED: 10 Apr 2002  
 SUPERSEDES PAGE: 332-1ff.  
 DATED: 27 Jul 2001

standards.

- 21. Assembly stresses are minimized as follows:
  - F a. Mating surface flatness is per inspection of machining operations.
  - F b. Threads are cleaned and lubricated prior to assembly.
  - F c. Assembly bolts are torqued in a prearranged sequence to preload values.
- G,J 22. Socket head capscrews joining the forward exit cone and throat support housing assemblies are tightened and torqued in a predetermined pattern per engineering drawings and shop planning.
- G,J 23. Screws used in assembling the forward exit cone and throat support housing are self-locking per engineering.
- G 24. Prior to installation, all socket head capscrews must be clean per shop planning.
- H 25. Analysis was 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.
- H 26. Handling and lifting requirements for SRM components are similar to those for previous and current programs conducted by Thiokol per TWR-13880.
- H 27. Transportation and handling of nozzle assembly items by Thiokol is per the Thiokol IHM 29.
- H 28. The RSRM and its component parts, when protected per TWR-10299 and TWR-11325, are capable of being handled and transported by rail or other suitable means to and from fabrication, test, operational launch, recovery or retrieval, and refurbishment sites.
- H 29. 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 30. Support equipment used to test, handle, transport, and assemble or disassemble the RSRM is certified and verified per TWR-15723.
- H 31. 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.
- 32. The possibility of fatigue damage to these parts during their service life is as follows:
  - a. Throat support housing:
    - F,I 1) The throat support housing is a fracture control item per TWR-16875. TWR-16875 documents that after passing surface inspection, any undetectable flaw will not propagate to a critical size in four additional missions before the next inspection. 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.

CRITICAL ITEMS LIST (CIL)

No. 10-02-01-25R/01

DATED: 10 Apr 2002  
 SUPERSEDES PAGE: 332-1ff.  
 DATED: 27 Jul 2001

- |           |     |   |
|-----------|-----|---|
| F,I       | 2)  | The basic forging was evaluated per JSC specification SE-R-0006 and reported in TWR-10717. Analysis shows the forging to be free from re-entrant and sharply folded lines. Mechanical properties met or exceeded design requirements.   |
|           | b.  | Forward exit cone assembly:   |
| F,I       | 1)  | The forward exit cone housing is a fracture control item per TWR-16875. The TWR verifies that the forward exit cone 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.   |
| F,I       | 2)  | The basic forging was evaluated per JSC specification SE-R-0006 and reported in TWR-10707. The 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.   |
| G,J       | 33. | A light coating of filtered grease is applied to interfacing metal surfaces prior to installation of socket head cap screws on the nozzle final assembly.   |
| J         | 34. | Torque for socket head cap screws is per engineering drawings.  |
| K         | 35. | New throat support housing threads are per engineering drawings. Refurbished throat support housings must satisfy thread requirements of engineering.   |
| K         | 36. | Threads are visually inspected for surface contamination, damage, and surface defects. Threads will have no damage or defects greater than called out in engineering.   |
| K         | 37. | All thread damage repair requires DR and MRB action. Thiokol SRM-MUA-005 covers the use of helical inserts in D6AC steel. Thiokol performs tests to assure twenty-use requirement and structural capability of helical inserts in D6AC steel per TWR-18555.   |
| F,I,J     | 38. | 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 F,I,J | 39. | 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 throat assembly and the forward exit cone 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. |

CRITICAL ITEMS LIST (CIL)

No. 10-02-01-25R/01

DATED: 10 Apr 2002  
 SUPERSEDES PAGE: 332-1ff.  
 DATED: 27 Jul 2001

9.2 TEST AND INSPECTION:

FAILURE CAUSES and			
DCN	TEST (T)		CIL CODE
1. For New Housing, Exit Cone, Nozzle verify:			
A		a. Flatness	ADG029,ADG030
A		b. Diameter	ADG038,ADG039,ADG042,ADG043
A		c. Flange thickness	ADG047,ADG047A,ADG048,ADG048A
A,F		d. Corrosion protection is per specification	ADG058
A		e. Profile	ADG103,ADG104,ADG106,ADG107
A		f. Run out	ADG131,ADG132,ADG133,ADG134
A		g. True position	ADG151,ADG151A,ADG151B,ADG151C ADG152,ADG152A,ADG152B,ADG152C
A		h. Wall thickness	ADG165,ADG166
C		i. Heat treat	ADG066
C,E,F,I	(T)	j. Magnetic particle	ADG078
2. For Refurbished Housing, Exit Cone, Nozzle verify:			
B		a. Wall thickness	ADG005
B		b. Diameter	ADG041
B		c. Flange-to-flange height	ADG049
B		d. Flatness	ADG142
B		e. Roundness	ADG108,ADG113
B		f. Profile	ADG143
B		g. Straightness	ADG053
C,E,F,I	(T)	h. Magnetic particle	ADG076
E,F		i. Painted surfaces for indications of heat degradation	ADG100
3. For New Exit Cone Assembly, Forward Section verify:			
A,B		a. Complete primer coverage of required surfaces	ADI042
A,B		b. Complete topcoat paint coverage of required surfaces	ADI043
A,B		c. Absence of corrosion	ADI059
4. For New Housing, Throat Support, Nozzle verify:			
A,F		a. Corrosion protection is per specification	AFN007
A		b. Flatness	AFN030,AFN031
A		c. Diameter	AFN043,AFN044,AFN047,AFN048
A		d. Profile	AFN129,AFN130
A		e. Run out	AFN140,AFN141,AFN142,AFN143
A		f. Profile	AFN160,AFN161
A		g. Minimum full thread	AFN164,AFN165
A		h. Minor diameter max depth	AFN171,AFN172
A		i. True position	AFN175,AFN175A,AFN175B,AFN176,AFN176A,AFN176B
A		j. Thickness	AFN197,AFN198,AFN200,AFN201
E,F,I,K	(T)	k. Magnetic particle	AFN107
C	(T)	l. Elongation	AFN162B
C	(T)	m. Yield strength	AFN162A
C	(T)	n. Reduction in area	AFN121C
C	(T)	o. Ultimate strength	AFN121
C	(T)	p. Decarburization	AFN033
C	(T)	q. Carburization	AFN019
K		s. Minimum full thread	AFN165
K		t. Minor diameter max depth	AFN172
K		u. True position	AFN176,AFN176A,AFN176B



CRITICAL ITEMS LIST (CIL)

No. 10-02-01-25R/01

DATED: 10 Apr 2002  
 SUPERSEDES PAGE: 332-1ff.  
 DATED: 27 Jul 2001

5. For Refurbished Housing, Throat Support, Nozzle verify:

B	a.	Diameter	AFN046,AFN042
B	b.	Roundness	AFN135,AFN132
B	c.	Height	AFN058
B	d.	Straightness	AFN126,AFN127,AFN128
B	e.	Flatness	AFN156,AFN157
B	f.	Thickness	AFN199,AFN196
C,E,F	g.	Heat damage	AFN077
C,E,F,I,K (T)	h.	Magnetic particle	AFN096

6. For New Throat Inlet Assembly, Nozzle verify:

A,B	a.	Absence of corrosion on the throat support housing	AAW003
A,B	b.	Primer applied to outside diameter surface of throat support housing	AAW071
A,B	c.	Top coating applied to outside diameter surface of throat support housing	AAW113

7. For New Screw, verify:

A	a.	Length from bottom of screw head to end of screw	AFZ024
A	b.	Screw lot number	AFZ062
A	c.	Thread form diameter (major diameter, pitch)	AFZ041
C,D,E,F	d.	Baking per engineering	AFZ004
C,D,E,F	e.	Certificate of Conformance that parts are cadmium-plated per engineering	AFZ013
C,D,E (T)	f.	Stress durability per engineering	AFZ070
C,D,E (T)	g.	Tensile properties per engineering	AFZ058
C,D,E (T)	h.	Sockets are free from chips or loose metal pieces	AFZ066
C,D,E,F	i.	Baking	AFZ004
C,D,E,F	j.	Certificate of Conformance that parts are cadmium-plated	AFZ013
C,D,E (T)	k.	Stress durability	AFZ070
C,D,E (T)	l.	Tensile properties	AFZ058

8. For New Nozzle Assembly, Final verify:

A,B,F,G	a.	All metal and plastic interfacing surfaces of the forward exit cone are cleaned prior to installation	ADG007
A,B,F,G	b.	Throat support housing is cleaned prior to assembly	ADR051
A,B	c.	Sealing compound (polysulfide sealant) application at base of fastener heads	ADR211
F	d.	Solvent wipe is complete prior to primer application to forward exit cone	ADR253
F,J	e.	Tightening sequence of socket head capscrews (throat inlet-to-forward exit cone joint) per planning requirements	ADR264
F,G,J	f.	Torque value of socket head capscrews in throat inlet-to-forward exit cone joint per planning requirements	ADR268
G	g.	All socket head capscrews are installed and seated in the proper location	ADR242
G	h.	Socket head capscrews locking device acceptable at installation	ADR243
G	i.	Socket head capscrews are free of visible contamination or corrosion	ADR244
G	j.	Housing-Throat Support, Nozzle aft end mating surface is free from corrosion and contamination prior to assembly	ADR261
G	k.	Housing, Exit Cone, Nozzle forward end mating surface is free from corrosion and contamination prior to assembly	ADR077
G	l.	Lubricant is used in the form of preloaded cartridge	ADR096

CRITICAL ITEMS LIST (CIL)

No. 10-02-01-25R/01

DATED: 10 Apr 2002  
 SUPERSEDES PAGE: 332-1ff.  
 DATED: 27 Jul 2001

G	m.	Throat inlet-to-forward exit cone socket head cap screws are identified per drawing requirements	ADR163
H	n.	Exit Cone Assembly, Forward Section forward end O-ring groove is free from damage prior to installation of primary O-ring	ADR063
H	o.	Exit Cone Assembly, Forward Section forward end O-ring sealing surface is free from damage prior to installation of secondary O-ring	ADR064
H	p.	Housing-Throat Support, Nozzle aft end O-ring sealing surfaces are free from damage prior to assembly	ADR066
H	q.	Forward exit cone sealing surfaces are free of contamination at time of assembly	ADR073
H	r.	Throat support housing sealing surfaces are free of foreign material prior to O-ring installation	ADR075
H	s.	Housing-Throat Support, Nozzle aft end O-ring groove is free from damage prior to assembly	ADR149
H	t.	Forward exit cone sealing surfaces are free from damage prior to assembly	ADR165
H	u.	Throat support housing O-ring groove is free of pitting prior to O-ring installation	ADR166
H	v.	Housing-Throat Support, Nozzle aft end O-ring groove is free from corrosion and contamination prior to assembly	ADR180
H	w.	Forward exit cone glass O-ring grooves are free of cracks, ridges and blemishes including scratches and gouges prior to O-ring installation	ADR202
H	x.	Throat support housing sealing surfaces are free from damage prior to assembly	ADR205
J	y.	Housing, Exit Cone, Nozzle forward end mating surface is free from corrosion and contamination prior to assembly	ADR077
J	z.	Application of filtered grease to Housing-Throat Support, Nozzle aft end sealing surface prior to assembly	ADR103
J	aa.	Throat inlet-to-forward exit cone socket head cap screws are identified per drawing requirements	ADR163
K	ab.	Bolts are free of cracks prior to lubricant application	ADR035
K	ac.	Bolts are free of burrs and nicks prior to lubricant application	ADR036
K	ad.	Bolts are free of thread damage prior to lubricant application	ADR037
9. For Shipping Kit-Segment verify:			
H	a.	EDR unit, proper calibration prior to shipment	AIC003
H	b.	EDR unit proper activation prior to shipment	AIC005
H	c.	Transportation EDR data is acceptable	RAA232
10. For New Forging, Forward Exit Cone, Nozzle QA verifies:			
C,E,I	(T)	a. Ultrasonic	ADG158,ADG159
11. For New Forging, Throat Housing, Nozzle QA verifies:			
E,I,K	(T)	a. Ultrasonic	AFN177,AFN184