ATK ALLIANT TECHSYSTEMS
THIOKOL PROPULSION

CRITICAL ITEMS LIST (CIL)

No. 10-03-04-26R/01

SYSTEM:	Space Shuttle RSRM 10	CRITICALITY CATEGORY:	1R
SUBSYSTEM:	Ignition Subsystem 10-03	PART NAME:	Redesigned Igniter Adapter-To-Igniter Chamber Joint, Thermal Protection System, (J-Joint and Metal Interface) (2)
ASSEMBLY:	Igniter Assembly 10-03-04		
FMEA ITEM NO.:	10-03-04-26R Rev N	PART NO.:	(See Table A-3)
CIL REV NO.:	N	PHASE(S):	Boost (BT)
DATE:	27 Jul 2001	QUANTITY:	(See Table A-3)
SUPERSEDES PAGE:	447-1ff.	EFFECTIVITY:	(See Table 101-6)
DATED:	31 Jul 2000	HAZARD REF:	BI-05
CIL ANALYST:	S. E. Rodgers		
APPROVED BY:		DATE:	

RELIABILITY ENGINEERING: K. G. Sanofsky 27 Jul 2001

ENGINEERING: B. W. Thompson 27 Jul 2001

1.0 FAILURE CONDITIONS: Failure during operation (D)

2.0 FAILURE MODE: 1.0 Thermal Failure

3.0 FAILURE EFFECT: Failure of the thermal protection system could result in failure of the igniter seal and packing with retainer which would result in hot gas flow through the joint to the atmosphere causing burn through, thrust imbalance and loss of RSRM, SRB, crew, and vehicle.

4.0 FAILURE CAUSES (FC):

FC NO.	DESCRIPTION	FAILURE CAUSE KEY
1.1	Failure of the J-Joint to obtain an interference fit	
1.1.1	Nonconforming dimensions	A
1.1.2	Improper assembly	B
1.1.3	Contamination/corrosion	C
1.1.4	Surface defects	D
1.2	Failure of adhesive	
1.2.1	Nonconforming raw materials	E
1.2.2	Improper application of adhesive	F
1.2.3	Contamination of adhesive	G
1.3	Failure of the Igniter Adapter-to-Igniter Chamber metal interface	
1.3.1	Nonconforming dimensions	H
1.3.2	Improper assembly	I
1.3.3	Corrosion	J
1.3.4	Surface defects	K

1.3.5	Improper preload	L

5.0 REDUNDANCY SCREENS:

SCREEN A: Fail--The hardware is not capable of checkout during normal ground turnaround.
SCREEN B: Fail--Loss of the thermal protection system is not detectable during flight.
SCREEN C: Pass--Loss of all redundant items in the thermal protection system cannot be the result of a credible single failure cause.

6.0 ITEM DESCRIPTION:

1. Igniter Adapter-to-Igniter Chamber J-joint Thermal Protection System. This CIL only analyzes the J-joint and metal interface. CIL 10-03-04-04/01 and /02 analyzes the rest of the insulation used in the ignition system. For all Failure Causes referring to curing, nonconforming insulation, improper insulation thickness, storage degradation, ply separations, voids, or inclusions, refer to the insulation CILs of the Igniter Chamber and Adapter. Materials are listed in Table 1.

TABLE 1. MATERIALS

Drawing No.	Name	Material	Specification	Quantity
1U77499	Igniter Assembly	Composite of Various Components		1/motor
1U77371	Chamber Assembly, Igniter, Insulated	Composite of Various Components		1/motor
1U77538	Chamber, Igniter	D6AC Steel	STW4-2706	1/motor
1U77451	Adapter Assembly, Igniter-Insulated	Composite of Various Components		1/motor
1U77450	Adapter, Igniter	D6AC Steel	STW4-2706	1/motor
1U51916	Cartridge Assembly	Lubricating Oil and Sealant/Adhesive Gelling Agent	STW5-2942	A/R
1U77462	Gasket - Inner	Seal-Fluorocarbon Rubber	MIL-R-83248, Type I, Class 1	1/motor
	Adhesive	Pressure-Sensitive, (Unmixed-Rubber Based)	STW4-3431	A/R
	Adhesive	Pressure-Sensitive, Solvent Dispersed	STW5-3479	A/R
	Corrosion-Preventive	Corrosion-Preventive and O-Ring Lubricant	STW5-2942	A/R
	Primer	Epoxy-Polyamide Primer	STW5-3226	A/R
	Paint (top coat)	Epoxy-Polyamide Paint	STW5-3225	A/R

6.1 CHARACTERISTICS:

1. The igniter seal (Figure 1) is an integral part of the inner gasket. The retainer and seals of the inner gasket function per applicable crown-to-void area. The inner gasket is located between the Igniter Chamber and the Igniter Adapter and is held in place by 36 bolts.

2. Packing with retainer (Figure 1) is installed on the inner bolt and the Special Bolt below the Special Washer (Figure 1) and is located on the Igniter Adapter flange.

3. The thermal protection system is the insulation J-joint and metal interface (Figures 1 and 2). The J-joint and metal interface provides joint thermal protection to the metal and elastomer seal downstream of the hot gas. The J-joint consists of a J-leg on the Adapter mating with the insulation on the Chamber to cause an interference fit. J-joint mating surfaces are covered with pressure-sensitive adhesive (solvent-dispersed) to assure proper mating of the joint. The metal interface is controlled by bolt preload and provides a heat sink to reduce temperature of hot gases if they pass the j-joint.

4. A failure of the J-joint and metal interface thermal protection system implies excessive heat exposure and possible failure of the igniter seal of the inner gasket. This exposes the packing with retainers or the final level of seal redundancy to the pressure of the motor. The packing with retainers are designed to prevent gasses from leaking into the atmosphere if there is failure of either or both of the thermal protection system and igniter seal.

5. Aged J-Joint samples were tested to meet resiliency requirements. Results of this testing predict that J-Joints will meet the minimum return requirements for up to five years after manufacture per TWR-17190.

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:

1. N/A

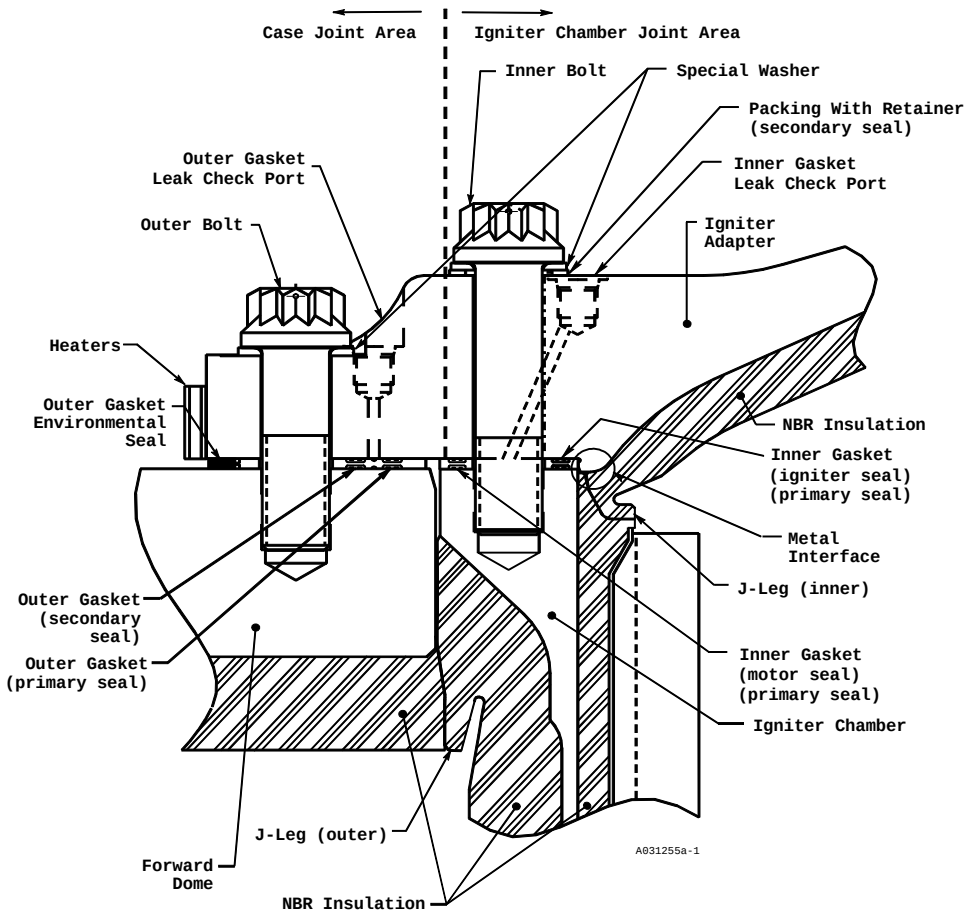

Figure 1. Igniter Adapter-to-Chamber Joint
and Igniter Adapter-to-Case Joint

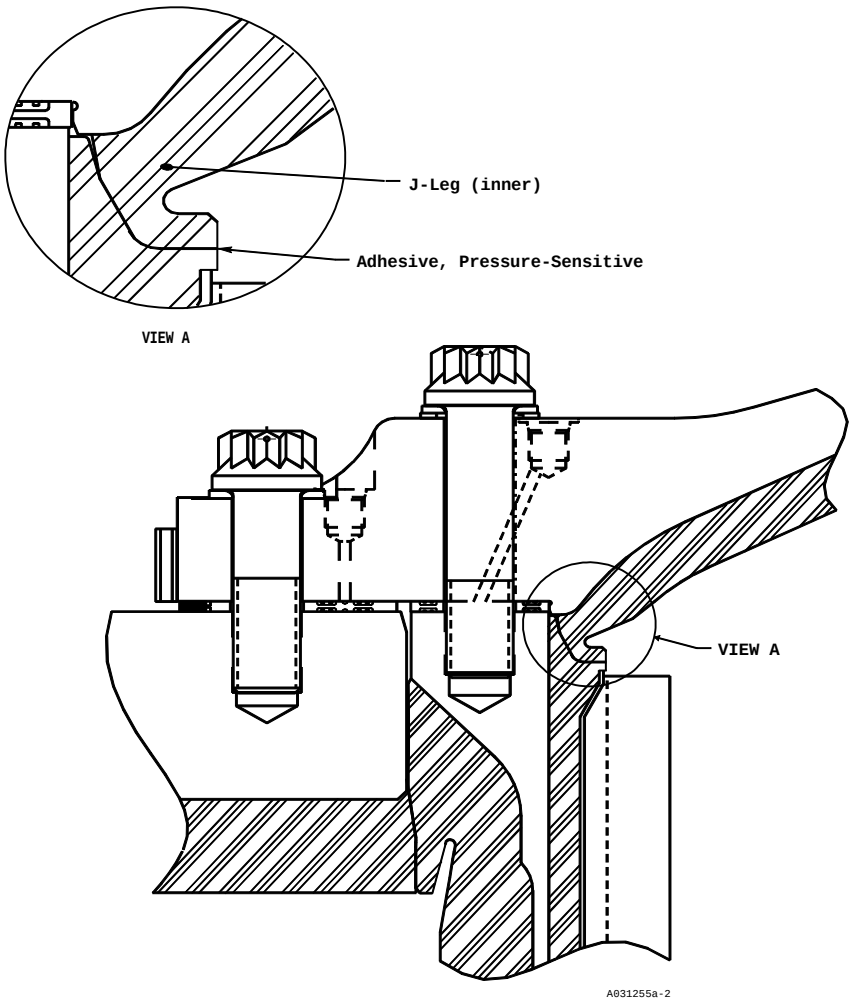

Figure 2. Igniter Adapter-to-Chamber J-Joint
Thermal Barrier System

9.0 RATIONALE FOR RETENTION:

9.1 DESIGN:

DCN		FAILURE CAUSES
A	1.	Dimensions of the J-joint are controlled per engineering drawings.
A,D,F	2.	A structural analysis of the Igniter Redesign Baseline Inner Joint is reported in TWR-61224. The J-leg provides an insulation protection (thermal protection) for the seals and bare metal of the Igniter Chamber and Adapter during motor operation.
A,D	3.	A thermal analysis was conducted on the inner J-leg to predict the thickness needed to meet CEI margin of safety requirements. Results of the analysis indicate that enough NBR insulation remains unaffected by high Chamber temperature to protect the igniter seals during flight and maintain a positive margin of safety per TWR-61613.
A,B,C,D,E,F,G	4.	Redesign Baseline Igniter J-joints and adhesive were qualified for flight in TEM-9 per TWR-17669 and FSM-3 per TWR-63347.
A,B,E,F,G	5.	Finite Element Analysis was used to evaluate insulation structural integrity. Stresses and strains in the joint insulation caused by curing, assembly, storage, and motor operation were analyzed. All safety factors in the Igniter Redesign Baseline Design of the inner joint insulation exceed the minimum safety factor of 2.0 per TWR-61224.
A	6.	A thermal analysis was conducted to predict flight temperatures of the Igniter Assembly. All temperatures predicted during flight are very low and well within their functioning limits per TWR-61559.
B	7.	Assembly repeatability was demonstrated on IJAD-I, TEM-9, and FSM-3 and reported in TWR-61015, TWR-17669, and TWR-63347
C	8.	Surfaces that affect the function of the J-joint are cleaned and verified prior to assembly per engineering drawings.
C	9.	Cleanliness of sealing surfaces to prevent contamination is controlled per shop planning, engineering, and TWR-16564.
C	10.	The Igniter Chamber and Adapter are made of high-strength D6AC steel. Because they are made of this material, they are defined as susceptible to corrosion per MSFC Specifications, and are included in the Material Use Agreement. Surfaces are provided with corrosion protection during storage or delays in manufacturing per engineering.
C	11.	New and refurbished igniter chambers and igniter adapters are cleaned by spray-in-air per engineering and corrosion is removed by glass beading or hand wipe prior to further processing. Sufficient margin of safety per TWR-17265 and TWR-61222 exists to permit subsequent refurbish cycles without excessive loss of material. A minimum acceptable wall thickness is verified in key areas after each refurbishment per engineering. The outer surface of the igniter insulated adapter is finished with primer paint and top coat paint for corrosion protection per engineering. The assembled igniter is stored in an airtight container or exposed metal surfaces remaining are coated with filtered grease.
D	12.	Surface defects in the J-leg are controlled per engineering.

E,F,G	13.	Pressure-sensitive adhesive (solvent-dispersed) used on the Igniter Redesign was certified and qualified per TWR-61040 and TWR-61041.
F	14.	Adhesive is applied to J-joint surfaces per engineering drawings and specifications.
H,I,J,K,L	15.	Igniter leak test requirements and procedures were developed per ETP-0182 and ETP-0266 and reported in TWR-17922 and TWR-19510. The leak test is performed per engineering. Seal leakage may indicate improper assembly of joint components. Leak testing may provide a secondary means of detecting surface corrosion, surface cracks or other defects on a metal sealing surface. Leak testing may also serve to detect faulty joint preload.
H	16.	Dimensions of the metal parts in the Igniter Chamber-to-Adapter joint are defined by engineering.
H	17.	Threads, thread length, and other dimensions are specified per engineering drawings.
H	18.	The Igniter Chamber is made with close tolerances on bolt holes and internal screw threads to mate with the close-fitting holes of the Adapter flange and provide high bolt preload.
H	19.	Tolerances for the redesigned Igniter baseline design are established in TWR-63258.
I	20.	Bolt installation requirements are per engineering as follows: a. Installation preparation requires cleaning of the through holes of the adapter and the threaded holes in the igniter chamber flange before assembly. b. Application of lubricant spray to bolt threads and air drying is not allowed on the shank in the packing-with-retainer contact area or under bolt heads. c. Application of filtered grease to the underside of bolt heads is required before special washers are installed. d. Installation of the special washer with chamfer side toward bolt head. e. Safety wiring of bolts per the double-twist method.
I	21.	Bolt loading procedures are per engineering. A specially designed deep socket and split collar are used for loading Special Bolt assemblies to avoid contact with adjacent bolts which could lead to incorrect reading of Special Bolt torque. A Special Bolt assembly is placed in its hole and threaded by hand. Care is taken to not damage the torque paint on the assembly. A split collar is placed around the Special Bolt and then the special socket is placed over the split collar and the bolt is torqued to the required snug torque and appropriate angle per engineering.
J,K	22.	All sealing surfaces of Igniter assembly components must conform to engineering drawings and specifications.
J	23.	The Igniter Chamber and Adapter are made of high-strength D6AC steel. Because they are made of this material they are defined as susceptible to corrosion per MSFC Specifications, and are included in the Material Use Agreement. Surfaces are provided with corrosion protection during storage or delays in manufacturing per engineering.
J	24.	The inner bolt, special bolt, (MP159) and safety wire (302 or 304 stainless) are inherently resistant to corrosion by virtue of the composition of the parent material.
J	25.	Filtered grease is applied to the underside of bolt heads before they are installed.

After the bolts are torqued, additional grease is applied at the interface of the bolts and igniter special washers with the igniter adapter flange, and along the outer edge of the inner gasket. Filtered grease must pass a qualification test for corrosion protection.

K 26. The Igniter Chamber and Adapter are refurbishable parts subject to engineering requirements and are included in TWR-16874. A fracture mechanics analysis of the modified Igniter presented in TWR-16874 shows that the Igniter Chamber and Adapter comply with the requirement of ensuring a minimum of four missions after proof test.

K 27. Inner Bolt and Special Bolt material is MP159. Limits on grain size are specified and forgings must have substantially uniform macrostructure and grain flow per engineering.

K 28. Each Inner bolt and Special Bolt is dye penetrant inspected after forming the head and prior to threading per engineering.

L 29. Materials were selected for suitability in the intended application. Developed yield strengths, as previously cited, provide sufficient margin from working loads to preclude plastic deformation of components per TWR-61222 and TWR-17265.

574 L 30. Inner bolt and Special Bolt torque values were selected on the basis of testing and historical data as documented in TWR-75936.

574 L 31. Inner bolt and Special Bolt preload is obtained by using a snug torque and angle-of-twist bolt loading method per engineering. The bolt loading method was qualified per TWR-66132 and TWR-66738. The certified angle-of-twist preload method used a hand wrench and was improved with the implementation of the motorized wrench that reduced variation and produced preloads within the certified range as documented in TWR-75936.

574 L 32. Cleaning, greasing, and installing the igniter adapter and igniter chamber joint metal components are per engineering. Inner bolt and special bolt threads are coated with lubricant spray, and the underside of each bolt head is coated with filtered grease. They are installed, torqued, and lock/safety wired per engineering. Torque values were selected on the basis of testing and historical data documented per TWR-75936.

H,I,L 33. The metal interface between the igniter adapter-to-igniter chamber, inner j-joint was added to the CIL as a contributor to the thermal protection of the joints per TWR-66503. Metal in the joint, (igniter adapter, igniter chamber) provides a heat sink that reduces the temperature of the hot gases if the gases pass the J-joint per TWR-63416. Analyses cover the pressurization and heating within the joint due to the entrance of chamber gases by way of a leak path through the joint's adhesive. Maximum steel surface temperature is below the melting point, but slightly above the design/reuse temperature. Seal temperatures were well below the ablation temperature, resulting in no seal erosion. The metal gap in this joint is controlled by flatness requirements, joint preload, and joint design (joints close under pressure).

9.2 TEST AND INSPECTION:

DCN	TESTS	(T)	FAILURE CAUSES and	CIL CODE
			1. For New Chamber Assembly-Igniter, Insulated verify:	
A,B,D			a. Proper insulation mold tooling was used during insulation application for inner joint j-leg contact surface	CAA022
A,D			b. Insulation unbonds and edge separations per engineering	AED010
D			c. Tap test inspection of Chamber insulation	AED036
D			d. General workmanship and condition of part	AED003
			2. For New Adapter Assembly, Igniter Insulated verify:	
A,D			a. Insulation lay up process is complete and acceptable	AAL011
A,D			b. General workmanship and condition of part	AAL003
A,B,D			c. Proper insulation mold tooling was used during insulation application	CAA023
D			d. Insulation cure is complete and acceptable	AAL014
D			e. Tap test of Adapter insulation for unbonds	AAL030
D			f. Insulation edge separations and other anomalies conform to finalization specification	AAL010
			3. For New Igniter Assembly verify:	
B,C,F			a. All grease and contamination were removed from Igniter Adapter and Chamber J-joint insulation areas per the process specification	CAA005
B,D			b. J-joint surface for anomalies per the igniter process finalization specification	CAA006
B,C,E,F,G			c. Adhesive was applied in the required time after surface preparation per the process specification	CAA007
B,C,E,F,G			d. Adhesive is applied properly to J-joint bonding area per the process specification	CAA008
B,C,E,F,G			e. No visible contaminants are in adhesive per the process specification	CAA009
B,C,E,F,G			f. No visible lumps or large bubbles in adhesive per the process specification	CAA010
B,E,F,G			g. Pot life was not exceeded per the process specification	CAA011
B,C,D,F			h. Periodic inspection of joint surfaces for contamination per the process specification	CAA012
			4. For New Grease verify:	
C		(T)	a. Penetration	LAA037
C		(T)	b. Dropping point	ANO042
C		(T)	c. Zinc concentration	LAA038
			5. For New Filtered grease verify:	
C			a. Contamination	ANO064
			6. For New Pressure-Sensitive Adhesive, verify:	
E,G		(T)	a. Solids content	AMJ001
E,G		(T)	b. T-peel adhesion strength	AMJ003
E,G		(T)	c. Tensile adhesion strength	AMJ005
E,G		(T)	d. Viscosity	AMJ007

7. For New Pressure-Sensitive Adhesive (Solvent-Dispersed), verify:

E,G	a.	Mixed adhesive is free from visible contamination prior to kitting	AOH001
E,G	b.	Proper mixing of adhesive and methyl chloroform	CAA001
E,G	c.	Premixed adhesive is uniform in appearance and free of visible contamination	CAA004
E,G	d.	Methyl chloroform is free of visible contamination prior to mixing	RAA141

8. For New Segment, Rocket Motor, Forward, verify:

I,J,L	a.	Filtered grease is applied to the underside of the special bolt head before installation	AEG018
I,J,K,L	b.	Special bolts are clean and free of visible contamination prior to installation	AEG166
I,J,K,L	c.	Special bolt hole threads and sealing surface in the igniter chamber are clean and free of contamination and defects prior to special bolt installation	AEG092
I,J	d.	Igniter special washer is installed correctly with chamfer towards special bolt head	AEG192
I,L	e.	Molykote lubricant spray is applied to the threads of the special bolts and air dried before installation	AEG051A
I,J,L	f.	Special bolts are installed, turned in until finger tight	AEG105
I,J,L	g.	Special bolts are tightened with a snug torque and angle-of-twist in the proper sequence	AEG428
I,J,L	h.	Special bolts are safety wired correctly using double-twist method	AEG106
I	i.	Filtered grease is applied to the packing with retainer	AEG244
J	j.	Filtered grease is applied to all exposed bare metal surfaces of the igniter after installation	AEG028
L	k.	Filtered grease is applied to the igniter adapter sealing surfaces and bolt through holes	AEG112
L	l.	Igniter special washers are clean prior to installation	AEG339
L	m.	Packing with retainer is clean and free of visible contamination prior to installation	AEG382
L	n.	Igniter adapter sealing and mating surfaces are clean and free of contamination and surface defects prior to installation	AEG168

9. For New Igniter Assembly verify:

I,J,K,L	a.	Inner bolts are clean and free of visible contamination prior to installation per the installation specification	AEF048
I,J	b.	Inner gasket is free of contamination, corrosion and excess grease prior to installation per the installation preparation specification	AEF071
I,J	c.	Special Washers are clean prior to installation per the installation specification	CCC006
I,J,L	d.	Igniter Chamber sealing and mating surfaces and threaded holes are clean and free of contamination and surface defects prior to installation per the igniter process finalization and installation preparation specifications	AEF224
I,J,L	e.	Igniter Adapter sealing and mating surfaces and threaded holes are clean and free of contamination and surface defects prior to installation per the igniter process finalization and installation preparation specifications process specifications	AEF218
I,J,L	f.	Filtered grease is applied to the underside of the inner bolt head before installation per the installation specification	AEF026
I,J	g.	Filtered grease is applied to the Chamber sealing surface per the installation preparation specification	CCC016
I,J	h.	Filtered grease is applied to the Adapter sealing surfaces and	

			bolt through holes per the installation preparation specification	CCC017
I,J,L		i.	Inner bolts are installed correctly per the installation specification	CCC033
I,J		j.	Special Washer is installed correctly with chamfer towards inner bolt head	AEF138
I,L		k.	Inner bolts are safety wired correctly using double-twist method per the applicable specification	AEF063
I,L		l.	Spray lubricant is applied to the threads of the inner bolts and air dried before installation per the installation specification	AEF022
I		m.	Proper alignment of holes, correct holes left open for special bolt assemblies	AEF196
I,L		n.	Inner bolts are tightened with a snug torque and angle-of-twist in the proper sequence	AEF281

10. For New Igniter Chamber, verify:

H		a.	Bolt hole through diameter	AEC004
H,L		b.	Tap drill depth of threaded holes	AEC049,AEC049A
H		c.	Flatness and parallelism of sealing surface	AEC087
H		d.	Outside diameter of sealing surface	AEC191
H,L		e.	Threaded holes for inner bolts	AEC261
H,L		f.	Threaded holes for Special Bolts	AEC262
H		g.	True position threaded holes	AEC264
H		h.	Inside diameter in flange area	RAA117

11. For Refurbished Igniter Chamber, verify:

H		a.	Correct thread of bolt holes after grit blasting and hydroproof	AEC035
H		b.	Flatness and parallelism of mating surfaces	AEC086

12. For New Igniter Adapter, verify:

H,L		a.	Flange thickness at inner bolt circle	AAS006,RAA105
H		b.	Diameter of inner bolt thru holes	AAS076,AAS077
H		c.	True position of inner bolt thru holes	RAA096,RAA101
H		d.	Flatness and parallelism of bottom surface (Datum -C-)	RAA109,AAS138
H		e.	Outside diameter of alignment lip	RAA115
H		f.	Height of alignment lip	RAA116
L		g.	Flange thickness at outer bolt circle	AAS005,AAS420

13. For Refurbished Igniter Adapter, verify:

H		a.	Flatness and parallelism of sealing and mating surfaces	AAS136
H,K		b.	Threaded holes conform to gauging requirements after grit blast and hydroproof testing	AAS491
H		c.	Diameter of inner bolt thru holes	AAS505
H		d.	Flange thickness	AAS061A
K		e.	Sealing and mating surfaces for surface defects and surface finish	AAS107

14. For New Igniter Inner Gasket, verify:

H		a.	Total variation in retainer thickness	ACS206
H,L		b.	Metal retainer thickness	ACS109
J	(T)	c.	Magnetic particle testing	ACS118,ACS110
J,K		d.	Voids, circumferential scratches and radial scratches in metal retainer do not exceed acceptable conditions	CCC096,ACS074
J,K		e.	Absence of corrosion on the metal retainer	CCC099,CCC049
J,K		f.	No shipping/handling damage	RAA120

		15.	For Refurbished Igniter Inner Gasket, verify:	
J,K		a.	Voids, circumferential scratches and radial scratches in metal retainer do not exceed acceptable conditions	CCC096A,ACS074A
J,K		b.	Absence of corrosion on the metal retainer	CCC099A,CCC049A
J,K		c.	No shipping/handling damage	RAA120A
		16.	For New Bolt, Igniter, Inner verify:	
H,K		a.	Threads per engineering	AHD061
H,L		b.	Bolt length	AHD035
H,L		c.	Grip length	AHD029
H,L		d.	Grip diameter	AHD025
H,L		e.	Fillet radius	AHD022
H,L		f.	Perpendicularity of bolt axis-to-bolt shoulder	AHD051
H		g.	Dimension "F"	RAA078
J,K	(T)	h.	Material--tensile ultimate strength, tensile yield strength, and alloy	RAA074
K		i.	No surface discontinuities detected by dye penetrant inspection	AHD019
K		j.	No shipping or handling damage	RAA094
L		k.	Head diameter	RAA077
		17.	For Refurbished Bolt, Igniter, Inner verify:	
H,J,L		a.	Threads are acceptable	LHA001
		18.	For New Bolt, Special, verify:	
H,K,L		a.	External threads are per engineering	ACC130
H,L		b.	Bolt length	ACC004
H,L		c.	Length, shoulder-to-thread end	ACC062
H,L		d.	Grip length	ACC000
H,L		e.	Shank fillet radius	ACC104
H,L		f.	Perpendicularity of bolt axis-to-bolt shoulder	ACC093
J,K		g.	Material--tensile ultimate strength, tensile yield strength, and alloy	RAA086
K		h.	No shipping or handling damage	ACC076
L		i.	Shank diameter	ACC102
L		j.	Head length	ACC002
		19.	For New Washer, Special, Countersunk, verify:	
J,K		a.	Cadmium plate	RAA133