ATK ALLIANT TECHSYSTEMS
THIOKOL PROPULSION

CRITICAL ITEMS LIST (CIL)

No. 10-03-04-06/02

SYSTEM:	Space Shuttle RSRM 10	CRITICALITY CATEGORY:	1
SUBSYSTEM:	Ignition Subsystem 10-03	PART NAME:	Igniter Propellant
ASSEMBLY:	Igniter Assembly 10-03-04	PART NO.:	(See Table A-3)
FMEA ITEM NO.:	10-03-04-06 Rev N	PHASE(S):	Boost (BT)
CIL REV NO.:	N	QUANTITY:	(See Table A-3)
DATE:	27 Jul 2001	EFFECTIVITY:	(See Table 101-6)
SUPERSEDES PAGE:	435-1ff.	HAZARD REF.:	BI-03
DATED:	31 Jul 2000		
CIL ANALYST:	F. Duersch		
APPROVED BY:		DATE:	

RELIABILITY ENGINEERING: K. G. Sanofsky 27 July 2001

ENGINEERING: G. A. Ricks 27 July 2001

1.0 FAILURE CONDITION: Failure to operate (B)

2.0 FAILURE MODE: 1.0 Failure to ignite

3.0 FAILURE EFFECTS: No ignition on one RSRM could result in thrust imbalance causing loss of RSRM, SRB, crew, and vehicle

4.0 FAILURE CAUSES (FC):

FC NO.	DESCRIPTION	FAILURE CAUSE KEY
1.1	Low ignitability of propellant	
1.1.1	Propellant contamination	A
1.1.2	Propellant grain surface contamination	B
1.1.3	Ammonium Perchlorate (AP) leaching	C
1.1.4	Improper mixing techniques of propellant materials	D
1.1.5	Nonconforming raw materials	E
1.1.6	Improper propellant formulation	F
1.2	Moisture/high humidity	
1.2.1	Igniter environmental seal improperly installed or moisture intrusion after installation onto the Igniter Adapter	G
1.2.2	Moisture/high humidity during processing	H

5.0 REDUNDANCY SCREENS:

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

6.0 ITEM DESCRIPTION:

1. Igniter propellant is designated TP-H1178 and is composed of bimodal Ammonium Perchlorate (AP) oxidizer, spherical aluminum, Ferric Oxide, polybutadiene acrylic acid acrylonitrile HB polymer binder, and Epoxy Curing Agent (ECA).

2. The igniter casting process is designed to ensure the propellant grain configuration is free of foreign materials and objects. The igniter propellant grain configuration is a 40-point star web grain design. Star peaks and valleys are rounded to reduce the likelihood of stress discontinuities (Figure 1). After casting is completed and core removed, the igniter is inspected for cracks or voids.

3. The igniter is up to 90 percent of peak output by 0.045 seconds from time zero. The flame from the igniter exhausts onto the forward star of the forward segment and thus ignites this surface initially. Ignition of the rest of the propellant surface occurs very rapidly. RSRM internal pressure increases rapidly and achieves lift-off thrust in less than 0.3 seconds.

4. Igniter propellant is protected from atmospheric exposure after propellant cure by installation of an igniter environmental seal. The igniter environmental seal is a 0.1-inch thick disc of cured asbestos and silicon dioxide-filled acrylonitrile butadiene rubber (NBR). The disc is bonded over the igniter nozzle opening with an asbestos and thixotropic agent-filled epoxy sealant. The seal protects the loaded igniter propellant from degradation due to moisture or humidity. The igniter is further protected from moisture and humidity by the inner gasket, packing with retainer, initiator nozzle port environmental seals, and Barrier-Booster seals. An igniter protective cover is required to seal the Safety and Arming (S&A) device attachment flange on the Igniter Adapter. The protective cover is temporary until the S&A device is installed at KSC. The cover is made of aluminum and has an O-ring seal. Materials are listed in Table 1.

TABLE 1. MATERIALS

Drawing No.	Name	Material	Specification	Quantity
	Propellant	TP-H1178	STW5-2833	A/R
		Terpolymer (PBAN)	STW4-2600	A/R
		Liquid Epoxy Resin	STW4-2601	A/R
		Ammonium Perchlorate with Conditioner	STW4-2602	A/R
		Ferric Oxide	STW4-2604	A/R
		Aluminum, Spherical	STW4-2832	A/R
The above materials make up TP-H1178 propellant that is used in the following parts:				
1U77858	Igniter Initiator Chamber, Loaded		Various	1/motor
1U77372	Igniter Chamber, Loaded		Various	1/motor
1U76674	Forward Segment, Loaded		Various	1/motor
	Sealant	Liquid Epoxy Resin, Asbestos Float-Filled	STW5-2678	A/R

6.1 CHARACTERISTICS:

1. Igniter propellant is composed of bimodal ammonium perchlorate oxidizer, spherical aluminum, ferric oxide, polybutadiene acrylic acid- acrylonitrile (HB) polymer binder, and Epoxy Curing Agent (ECA). The propellant grain configuration in the igniter is a 40-point star and web grain design. Star peaks and

valleys are rounded to reduce the likelihood of stress discontinuities (Figure 1). The igniter is up to 90 percent of peak thrust output by 0.045 seconds from time zero. The flame from the igniter exhausts onto the forward star of the forward segment and thus ignites this surface initially. Ignition of the remaining propellant surface occurs very rapidly. RSRM internal pressure increases rapidly and achieves lift-off thrust in less than 0.3 seconds.

7.0 FAILURE HISTORY/RELATED EXPERIENCE:

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

8.0 OPERATIONAL USE: N/A

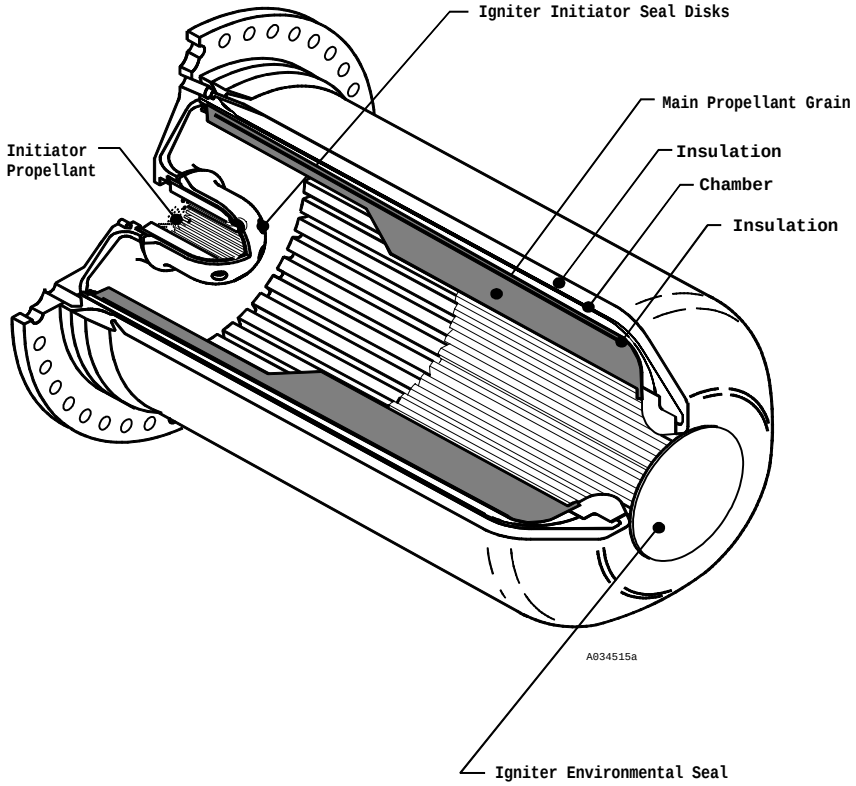

Figure 1. Igniter and Initiator Propellant Grain Configuration

9.0 RATIONALE FOR RETENTION:

9.1 DESIGN:

DCN	FAILURE CAUSES	
A,B	1.	Propellant raw materials have storage life from date of manufacture when stored at warehouse ambient conditions in unopened containers or containers which were resealed after each use. The storage life expiration date of an individual lot of material may be extended provided the material satisfactorily passes retest requirements. Contamination control requirements and procedures are described in TWR-16564. During propellant processing, temperature, moisture, humidity, and contamination are controlled per engineering drawings and shop planning for the following materials: a. Terpolymer (HB) b. Epoxy Resin c. Ammonium Perchlorate d. Aluminum, Spherical e. Ferric Oxide, Type I
A,B	2.	The igniter nozzle environmental seal provides protection against contamination after the igniter is assembled.
A,B	3.	Manufacturing processes for igniter propellant are per engineering and shop planning.
A,B	4.	Initiator and igniter shipping configuration includes an end cover to provide protection against contamination during shipping and storage.
A,B,D,E,F	5.	Design Engineering reviews, analyzes, and publishes results of 5-inch CP and Lot Acceptance Tests (LAT) per engineering.
C,G,H	6.	Delta qualification temperature and humidity testing of loaded igniter assemblies with environmental seals in place showed no propellant performance degradation per TWR-12310 and TWR-12323.
C,G,H	7.	The igniter environmental seal is a disc of cured asbestos and silicon dioxide-filled NBR. The disc is bonded over the igniter nozzle opening with an adhesive. The seal protects the loaded initiator and igniter from propellant degradation due to exposure to moisture and humidity. The igniter is further protected from moisture and humidity by the igniter inner gasket, packing with retainer, initiator nozzle port environmental seals, and Barrier-Booster seals per engineering drawings.
C,G,H	8.	An igniter protective cover is required to seal the S&A attachment flange on the Igniter Adapter. The cover is made of aluminum and has an O-ring seal per engineering drawings.
C,G,H	9.	Moisture, high humidity, and temperature conditions are maintained within limits during AP storage and during propellant mixing operations per engineering drawings and shop planning.
C,G,H	10.	Sealant raw material specifications are defined per engineering for the following materials: a. Asbestos float b. Liquid epoxy resin c. Polyamide curing agent

d. Microfine silicon dioxide

C,G,H 11. Mechanical properties data from an aging test of TP-H1178 propellant indicate allowable stresses, strains, and elastic modulus are not affected by aging per TWR-19292.

D,F 12. Qualification of the igniter verifying compliance with contractual operational requirements is reported in TWR-12310 and additional qualification of the igniter used on the RSRM is reported in TWR-18764-03.

D,F 13. Propellant mix proportions and mechanical properties of TP-H1178 are per engineering. Fine adjustment for percent of ground AP and ECA proportions are determined by standardization per engineering to meet burn rate requirements and propellant mechanical properties. Average burn rate of 5-inch CP motors is used to adjust percent ground oxidizer content that adjusts the burn rate. Liquid Strand Burn Rate (LSBR) of standardization batches is used to determine the target burn rate of production propellant batches. Tests on loaf samples are processed to determine propellant mechanical properties. Propellant standardization is the process of determining the percentages of raw materials that will produce desired propellant physical and ballistic properties of production batches per engineering.

D,F 14. Raw material weighing is per engineering drawings and specifications.

D,F 15. Propellant processing, mixing, and cure requirements are per engineering and shop planning.

E 16. Raw material conformance specifications, material property requirements, and means of verification for TP-H1178 propellant are per engineering for the following materials:

a. Terpolymer (HB)
b. Epoxy resin
c. Ammonium Perchlorate
d. Aluminum, spherical
e. Ferric Oxide, Type I

A,B 17. Propellant surfaces after trimming are per engineering drawings.

9.2 TEST AND INSPECTION:

DCN	FAILURE CAUSES and TESTS	(T)			CIL CODE
			1.	For New HB Polymer, verify:	
E		(T)	a.	Acid number	ALC000,ALC001,ALC004
E		(T)	b.	Acrylonitrile content	ALC005,ALC006,ALC009
E		(T)	c.	Agerite stalite content	ALC010,ALC011,ALC014
E		(T)	d.	Cetyldimethyl benzyl ammonium chloride content	ALC015,ALC016,ALC019
E		(T)	e.	Chloride	ALC020,ALC021,ALC024
E		(T)	f.	Unbound/total acid ratio	ALC025,ALC026,ALC029
E		(T)	g.	Infrared spectrum	ALC030,ALC031,ALC034
E		(T)	h.	Iron content	ALC035,ALC036,ALC039
E		(T)	i.	Moisture content	ALC040,ALC041,ALC045
E			j.	No shipping or handling damage	ALC046
E		(T)	k.	Viscosity	ALC060,ALC061,ALC064
A,B,E			l.	Workmanship shall be such that the HB polymer is a viscous liquid, light to dark amber/brown in color, that may contain small visible particulates	ALC065A,ALC065B
			2.	For New Liquid Epoxy Resin verify:	
C,E,G,H		(T)	a.	Hydrolyzable chlorine percent	ALD006,ALD009,ALD015
C,E,G,H		(T)	b.	Infrared spectrum	ALD030
C,E,G,H		(T)	c.	Moisture percent	ALD035,ALD038,ALD042
E			d.	No shipping or handling damage	ALD052
C,E,G,H		(T)	e.	Specific gravity	ALD061,ALD063,ALD068
A,B			f.	Workmanship is uniform in appearance and free from visible contamination	ALD075
C,E,G,H		(T)	g.	Viscosity	ALD082,ALD085,ALD091
C,E,G,H		(T)	h.	Weight per epoxy	ALD098,ALD101,ALD107
			3.	For New Ammonium Perchlorate, verify:	
E		(T)	a.	Acid insolubles	ALE001,ALE002,ALE006
E		(T)	b.	Bromate	ALE007,ALE008,ALE011
E		(T)	c.	Bulk density	ALE012,ALE013,ALE016
E		(T)	d.	Chlorate	ALE017,ALE018,ALE020
E		(T)	e.	Chloride	ALE022,ALE023,ALE026
E		(T)	f.	External moisture content	ALE028,ALE029,ALE032
E		(T)	g.	Internal moisture content	ALE033,ALE034,ALE037
E		(T)	h.	Iron	ALE038,ALE039,ALE042
E			i.	No shipping or handling damage	ALE044
E		(T)	j.	Particle size distribution	ALE045,ALE046,ALE050
E		(T)	k.	Assay, as ammonium perchlorate	ALE052,ALE055,ALE056
E		(T)	l.	pH	ALE058,ALE059,ALE062
E		(T)	m.	Phosphate	ALE063,ALE064,ALE067
E		(T)	n.	Photomicrographic analysis	ALE068,ALE069,ALE072
E		(T)	o.	Sulfated ash	ALE091,ALE092,ALE095
E		(T)	p.	Total moisture content	ALE097,ALE100,ALE101
A,B,E			q.	Workmanship is uniform in appearance and free from unacceptable contamination	ALE105
			4.	For New Ferric Oxide, verify:	
E		(T)	a.	Calcination loss	ALG000,ALG001

E	(T)	b.	Iron content	ALG010,ALG012
E		c.	No shipping or handling damage	ALG019
E	(T)	d.	Specific surface area	ALG031,ALG032
A,B,E		e.	Workmanship is uniform in appearance and free from visible contamination	ALG040
E	(T)	f.	Volatile loss	ALG049,ALG050

5. For New Aluminum, Spherical, verify:

E	(T)	a.	Active aluminum	ALU000,ALU001,ALU004
E	(T)	b.	Iron content	ALU010,ALU011,ALU014
E		c.	No shipping or handling damage	ALF011
E	(T)	d.	Magnesium content	ALU015,ALU016,ALU019
E	(T)	e.	Particle size distribution	ALU020,ALU021,ALU024
A,B		f.	workmanship uniform in appearance and free from visible contamination	ALU034
E	(T)	g.	Volatile matter	ALU036,ALU037,ALU040

6. For New Propellant, SRM, Igniter verify:

A,B,D,F		a.	Acceptability of AP during oxidizer preparation	AOW008
A,B,D,F		b.	Cleanliness and acceptability of facility during oxidizer preparation prior to grinding	AOW009
A,B,D,F		c.	Cleanliness and acceptability of tote bins during oxidizer preparation prior to grinding	AOW016
A,B,D,F		d.	Actual temperature of heated water during propellant processing	AOW024
A,B,D,F		e.	All containers are free from moisture, contamination, and foreign objects during premix preparation	AOW028
A,B,D,F		f.	All equipment is free from moisture, contamination, and foreign objects during premix preparation	AOW030
D,E,F		g.	Aluminum plus Ferric Oxide production batches, uncured propellant	AOW052
D,F		h.	Aluminum powder properly conditioned during premix preparation	AOW065
A,B,D,F		i.	AP conditioning during oxidizer preparation	AOW067
A,B,D,F		j.	AP conditioning requirement met during propellant processing	AOW068
A,B,D,F		k.	AP spillage weight is within allowable limits during propellant mixing operations	AOW077
A,B,D,F		l.	AP stock and lot numbers comply with batch card during propellant processing	AOW080
A,B,D,F		m.	Cleanliness of mixing facility prior to mixing	AOW092
D,F		n.	ECA properly conditioned during premix preparation	AOW128
A,B,D,F		o.	End of mix temperature requirement met during propellant processing	AOW130
D,E,F		p.	Ground oxidizer particle size distribution production batches	AOW134
D,F		q.	Ground oxidizer particle size distribution sampling requirements met during oxidizer preparation	AOW140
D,F		r.	HB polymer properly conditioned during premix preparation	AOW145
A,B,D,E,F	(T)	s.	LSBR production batches, uncured propellant	AOW154
D,F		t.	Mill load setting acceptable during oxidizer preparation	AOW167
A,B,D,F		u.	No lumps in propellant during propellant processing, after mixing	AOW169
D,E,F		v.	Oxidizer content production batches, uncured propellant	AOW172
D,E,F		w.	Percent HB polymer production batches, uncured propellant	AOW182
A,B,D,F		x.	Premix constituent weights comply with batch card during propellant processing	AOW190
D,F		y.	Premix constituents lot numbers comply with shop planning during premix preparation	AOW191
A,B,D,F		z.	Premix constituents stock and lot numbers comply with batch card	AOW193
A,B,D,F		aa.	Propellant samples taken after propellant mixing from different locations in the mix bowl	AOW207
D,F		ab.	Sieve analysis test during oxidizer preparation	AOW210

A,B,D,F		ac.	Stock and lot number of AP during oxidizer preparation	AOW216
D,E,F	(T)	ad.	Strain at maximum stress production batches	AOW218
D,E,F	(T)	ae.	Maximum stress production batches	AOW228
A,B,D,F		af.	Total oxidizer mixing time requirement during propellant processing	AOW238
D,E,F		ag.	Total solids production batches, uncured propellant	AOW243
D,F		ah.	Weight of spherical aluminum in bowl meets requirements during premix preparation	AOW258
D,F		ai.	Weight of AP spillage does not exceed maximum allowable limits during oxidizer preparation	AOW262
D,F		aj.	Weight of ECA meets weight requirements during premix preparation	AOW263
D,F		ak.	Weight of ground AP during oxidizer preparation	AOW265
A,B,D,F		al.	Weight of ground AP complies with batch card during propellant processing	AOW267
D,F		am.	Weight of HB polymer in bowl during premix preparation	AOW268
D,F		an.	Weight of iron oxide in mix bowl meets weight requirements during propellant premix preparation	AOW274
D,F		ao.	Weight of unground AP during oxidizer preparation	AOW275
A,B,D,F		ap.	Weight of unground AP complies with batch card during propellant processing	AOW277
D,F		aq.	Total AP weight (ground plus un-ground) meets allowable limits during oxidizer preparation	AOW279

7. For New Chamber Assembly Igniter, Loaded verify:

A,B,D,F		a.	Cleanliness of tooling and equipment prior to propellant casting	AED007
A,B		b.	Cleanliness of liner immediately prior to casting igniter	AEE007
A,B		c.	Cleanliness of tooling prior to tooling dry-fit	AEE021
A,B		d.	Propellant surfaces after trimming are per the engineering drawing	MKL044
A,B,D,F		e.	Igniter properly packaged following propellant loading	AEF132

8. For New Igniter Assembly verify:

C,G,H		a.	Adhesive radius for environmental seal bonding	MAA000
C,G,H		b.	Sealant within pot life at time of application	AMU001A
C,G,H		c.	Area where seal disc will be bonded is cleaned	MAA002
C,G,H		d.	Protective cover installed over S&A port prior to shipping of Igniter Assembly	AHJ003
C,G,H	(T)	e.	Igniter LAT for proper propellant burn time and pressure per the igniter specification	AKU003A
C,G,H		f.	Component temperatures and exposure to ambient environments during in-plant transportation or storage are per the temperature exposure limit specification	BAA015
C,G,H		g.	No evidence of AP leaching on igniter propellant	AEF018
C,G,H		h.	Proper installation of igniter environmental seal	AEE020
A,B,D,E,F	(T)	i.	Initiator LAT for proper propellant burn time and pressure per the igniter specification	AKU021
C,G,H		j.	Area where seal disc will be bonded is allowed to dry	AEF041
C,G,H		k.	Each loaded Igniter Chamber Assembly for workmanship prior to final assembly	AEF193
C,G,H		l.	Proper adhesive squeeze out after visually aligning igniter environmental seal	AEF195
C,G,H		m.	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
C,G,H	(T)	n.	Shore A hardness on cure-cup sample on each batch of sealant prior to installation of igniter into adapter per the process specification	AEF249

		9.	For New 5-inch CP, Igniter Propellant, verify:	
A,B,C,D, E,F,G,H	(T)	a.	Test data for propellant standardization and burn rate per engineering	AOW000
		10.	For New Floats, Asbestos verify:	
C,G,H	(T)	a.	Calcination loss	ALI002
C,G,H	(T)	b.	Fiber size distribution	ALI011
C,G,H	(T)	c.	pH (aqueous extract)	ALI023
C,G,H	(T)	d.	Volatile matter	ALI051
C,G,H	(T)	e.	Wet volume	ALI053
		11.	For Retest Floats, Asbestos verify:	
C,G,H		a.	Volatile matter for storage life extension	ALI051A
		12.	For New Curing Agent, Polyamide Liquid Resin, verify:	
C,G,H	(T)	a.	Amine value	ALQ001,AMQ006
C,G,H	(T)	b.	Ash content	AMQ015
C,G,H	(T)	c.	Color	ALQ026,AMQ028
C,G,H	(T)	d.	Specific gravity	AMQ033
C,G,H	(T)	e.	Viscosity	ALQ049,AMQ050
		13.	For New Silicon Dioxide, verify:	
C,G,H	(T)	a.	Bulk density	ALP002,ALP008
C,G,H	(T)	b.	Moisture	ALP058,ALP064
C,G,H	(T)	c.	pH	ALP097,ALP101
C,G,H	(T)	d.	Loss on ignition	ALP040
		14.	For New NBR, verify:	
C,G,H	(T)	a.	Elongation	ALH010
C,G,H	(T)	b.	Elongation (calendered only)	ALH062,ALH065
C,G,H	(T)	c.	Mooney viscosity	ALH041
C,G,H	(T)	d.	Mooney viscosity (extrusions only)	ALH046,ALH170
C,G,H	(T)	e.	Scorch characteristics	ALH081
C,G,H	(T)	f.	Scorch characteristics (extrusions only)	ALH086,ALH171
C,G,H	(T)	g.	Shore A hardness	ALH102
C,G,H	(T)	h.	Shore A hardness (calendered only)	ALH098,ALH109
C,G,H	(T)	i.	Specific gravity	ALH118
C,G,H	(T)	j.	Specific gravity (calendered only)	ALH121,ALH126
C,G,H	(T)	k.	Tensile strength	ALH147
C,G,H	(T)	l.	Tensile strength (calendered only)	ALH149,ALH154
C,G,H		m.	Material workmanship including uniform appearance and free from contamination	ALH168
		15.	For Retest NBR, verify:	
C,G,H	(T)	a.	Mooney viscosity	ALH049
C,G,H	(T)	b.	Scorch characteristics	ALH087
		16.	For New Chamber Assembly-Igniter, Insulation verify:	
C,G,H		a.	Insulation cure time, temperature, and pressure is acceptable	AED008

	C,G,H			b. Component temperature and exposure to ambient environments during in-plant transportation or storage are per engineering	BAA013
			17.	For New Disc, Seal Igniter verify:	
	C,G,H			a. Dimensions of igniter seal after fabrication	ACN000
			18.	For New Barrier-Booster Assembly, Loaded, verify:	
	C,G,H	(T)		a. Barrier-Booster rotor shaft and SII seals leak tested at low pressure with rotor in "SAFE" position per engineering	ADA024
			19.	For New Segment, Rocket Motor, Forward, verify:	
	C,G,H	(T)		a. Installed transducer bolt assemblies were leak tested at low and high pressures	AEG196,AEG195
	C,G,H			b. Component environments during in-plant transportation or storage	BAA021
			20.	KSC verifies:	
595	C,G,H	(T)		a. Integrity of the S&A device and S&A gasket installation by high- and low-pressure leak test per OMRSD File V, Vol I, B47SA0.110	OMD072
	C,G,H			b. Igniter seal disk is free from punctures, de-bonds, or cracks, and that the disk is still sealed and intact and has no visible penetrations, de-bonds, or cracks per OMRSD, File V, Vol I, B47SG0.020	OMD075