CRITICAL ITEMS LIST (CIL)

No. 10-03-02-01/02

SYSTEM:	Space Shuttle RSRM 10	CRITICALITY CATEGORY:	1
SUBSYSTEM:	Ignition Subsystem 10-03	PART NAME:	Pyrotechnic-Basket Assembly (1)
ASSEMBLY:	Safety and Arming Device 10-03-02	PART NO.:	(See Table A-3)
FMEA ITEM NO.:	10-03-02-01 Rev M	PHASE(S):	Boost (BT)
CIL REV NO.:	M	QUANTITY:	(See Table A-3)
DATE:	31 Jul 2000	EFFECTIVITY:	(See Table 101-6)
SUPERSEDES PAGE:	413-1ff.	HAZARD REF.:	BI-03
DATED:	30 Jul 1999		
CIL ANALYST:	S. E. Rodgers		
APPROVED BY:		DATE:	

RELIABILITY ENGINEERING: K. G. Sanofsky 31 Jul 2000

ENGINEERING: C. R. Whitworth 31 Jul 2000

1.0 FAILURE CONDITION: Failure to operate (B)

2.0 FAILURE MODE: 1.0 Failure to operate or provide required performance

3.0 FAILURE EFFECTS: Delay or no ignition on one RSRM, will cause thrust imbalance and loss of RSRM causing loss of SRB, crew, and vehicle

4.0 FAILURE CAUSES (FC):

FC NO.	DESCRIPTION	FAILURE CAUSE KEY
1.1	Low ignitability of booster granules or pellets	
1.1.1	Contamination	A
1.1.2	Improper mixing techniques	B
1.1.3	Improper B-KNO_3 pellet density	C
1.1.4	Improper formulation	D
1.1.5	Nonconforming dimensions	E
1.2	Moisture/high humidity	F
1.3	Nonconforming materials	G
1.4	Chemical decomposition due to aging	H
1.5	Inadequate booster energy released	
1.5.1	Insufficient amount of granules or pellets	I
1.5.2	Nonconforming polyester film or foam cushion	J
1.5.3	Nonconforming holes in Pyrotechnic Basket Cover	K
1.5.4	Inert B-KNO_3 granules or pellets	L

1.6	Misalignment of the Pyrotechnic Basket Assembly to the Barrier-Booster Assembly	M
1.7	Frangible seal membrane too thick	N
1.8	Nonconforming Pyrotechnic Booster Tube Assembly	
1.8.1	Nonconforming dimensions	O
1.8.2	Holes contaminated (restricted)	P
1.9	Improperly-installed bolts	Q

5.0 REDUNDANCY SCREENS:

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

6.0 ITEM DESCRIPTION:

1. The Pyrotechnic Basket Assembly is part of the Safety and Arming (S&A) device that initiates the ignition train for the RSRM. The Pyrotechnic Basket is loaded with Boron-Potassium-Nitrate (B-KNO_3) granules and pellets that are ignited by output from the RSRM Ignition Initiators (SII). The output from the Pyrotechnic Basket Assembly ignites the igniter initiator propellant grain that in turn ignites the igniter propellant grain. Primary components of the Pyrotechnic Basket Assembly include (Figure 1) a Booster-Basket Housing, perforated Booster-Tube Assembly, two tube assembly fittings with plugs, frangible seals (together called the cross-over tube) containing B-KNO_3 granules and B-KNO_3 pellets, an open cell foam cushion placed against the pellets, and a perforated retainer plate or booster cover. The booster cover is fastened to the basket housing using six pan head cap screws. The Pyrotechnic Basket Assembly is mounted on the inner surface of the Barrier-Booster Assembly using six socket head cap screws and faces toward the igniter initiator grain (Figures 1 and 2). All the components of Pyrotechnic Basket Assembly are one-time-use items. Materials are listed in Table 1.

TABLE 1. MATERIALS

Drawing No.	Name	Material	Specification	Quantity
1U50228	Packing, Preformed	Fluorocarbon Rubber	STW4-3339	2/Motor
1U50691	Cover	301 CRES Half Hard	MIL-S-5059	1/Motor
1U50694	Cushion	Polyurethane Foam	STW4-3240	1/Motor
1U50796	Tube Assembly Fitting	304 CRES	QQ-S-763	2/Motor
1U50797	Alignment Pin	Nylon	L-P-410	1/Motor
1U50798	Plug, Tube Assembly	303 CRES	ASTM A582	2/Motor
1U51701	Basket, Booster	304 CRES	QQ-S-763 Cond A	1/Motor
1U51702	Basket Assembly, Booster			1/Motor
1U51703	Basket Assembly, Pyrotechnic			1/Motor
1U77383	Housing, Barrier-Booster	A286 CRES	AMS 5737	1/Motor
1U77385	Barrier-Booster Assembly S/A Device			1/Motor
1U77386	Barrier-Booster Assembly, S&A Device, Loaded			1/Motor
1U77387	S&A Device, Rocket Motor			1/Motor
1U77461	Index Pin	A286 CRES	AMS 5737	1/Motor
NAS1190E06P8L	Screw, Self-Locking	A-286 CRES	AMS 5737	6/Motor
NAS1352C08LL20	Screw, Self-Locking	CRES Passivated	FF-S-86	6/Motor
	Ignition Granules		STW5-2702	A/R
	Polyamide Plastic Binder		STW4-2886	A/R
	B-KNO_3 Pellets		STW5-2885	A/R
	Potassium Nitrate		STW4-3812	A/R
	Boron Powder		STW4-2887	A/R
	Graphite Lubricant		MIL-G-155	A/R
	Lubricant	Heavy-Duty Calcium Grease	STW5-2942	A/R
	Torque Seal	Special Purpose Lacquer	STW5-2984	A/R
	Coating, Clear	Lacquer	TT-L-50G, Type II	A/R
	Polyester Tape	Pressure-Sensitive	MIL-T-26317 or L-T-100, Type I	A/R
	Adhesive, Epoxy	Epoxy Resin, Metal-to-Metal Structural Bonding	MMM-A-134, Type I	A/R

6.1 CHARACTERISTICS:

1. The RSRM Safety and Arming (S&A) device meets established requirements for performance, design, development, test, manufacture, and acceptance for a two-part electromechanical Safety and Arming device.

2. The Pyrotechnic Basket Assembly contains an explosive mixture of Boron-Potassium-Nitrate (B-KNO_3) granules (confined in the Booster-Tube Assembly) and B-KNO_3 pellets cushioned by an open-cell foam disk placed against the pellets. The B-KNO_3 pellets and granules function as two steps in the ignition train of the RSRM. First, the SIIs burst the frangible seals in the Pyrotechnic Basket Assembly and ignite the B-KNO_3 ignition granules that ignite the B-KNO_3 pellets. Then, the output from the Pyrotechnic Basket Assembly ignites the igniter initiator that in turn ignites the main igniter. The main igniter output ignites the SRM propellant grain (main motor). The Pyrotechnic Basket Assembly is not refurbished.

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

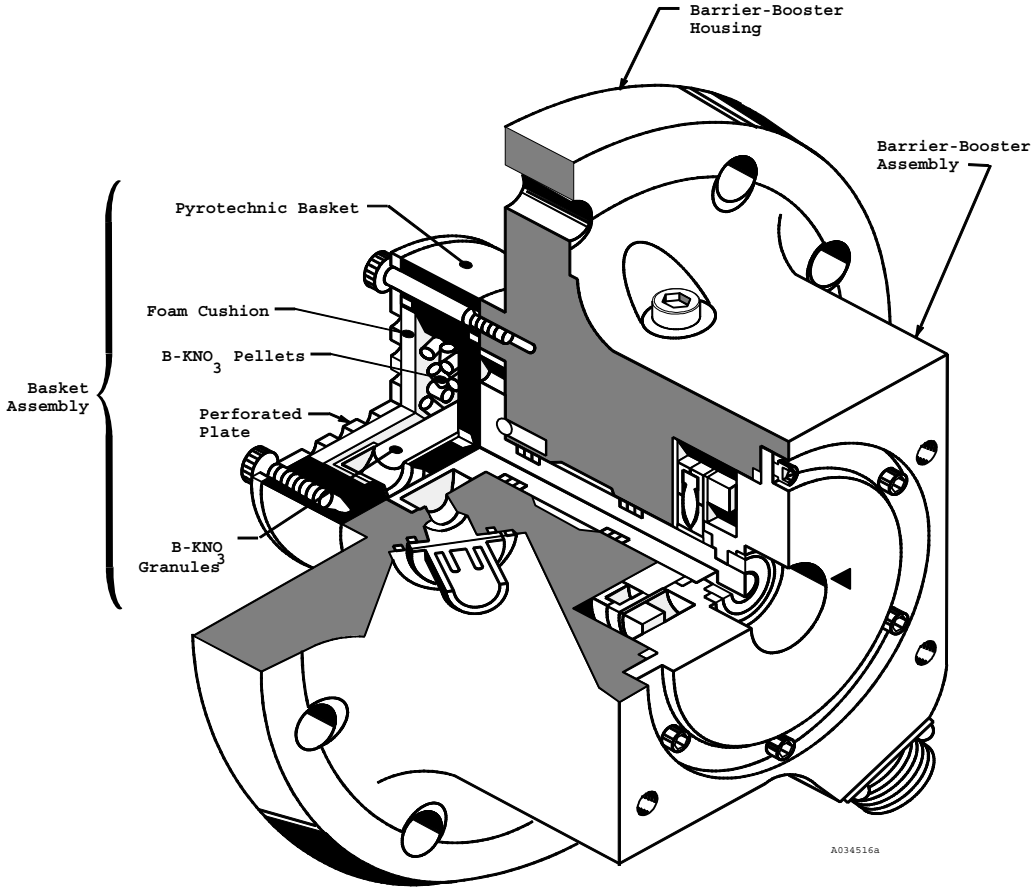

Figure 1. Pyrotechnic-Basket Assembly Mounted to Barrier-Booster Assembly Housing

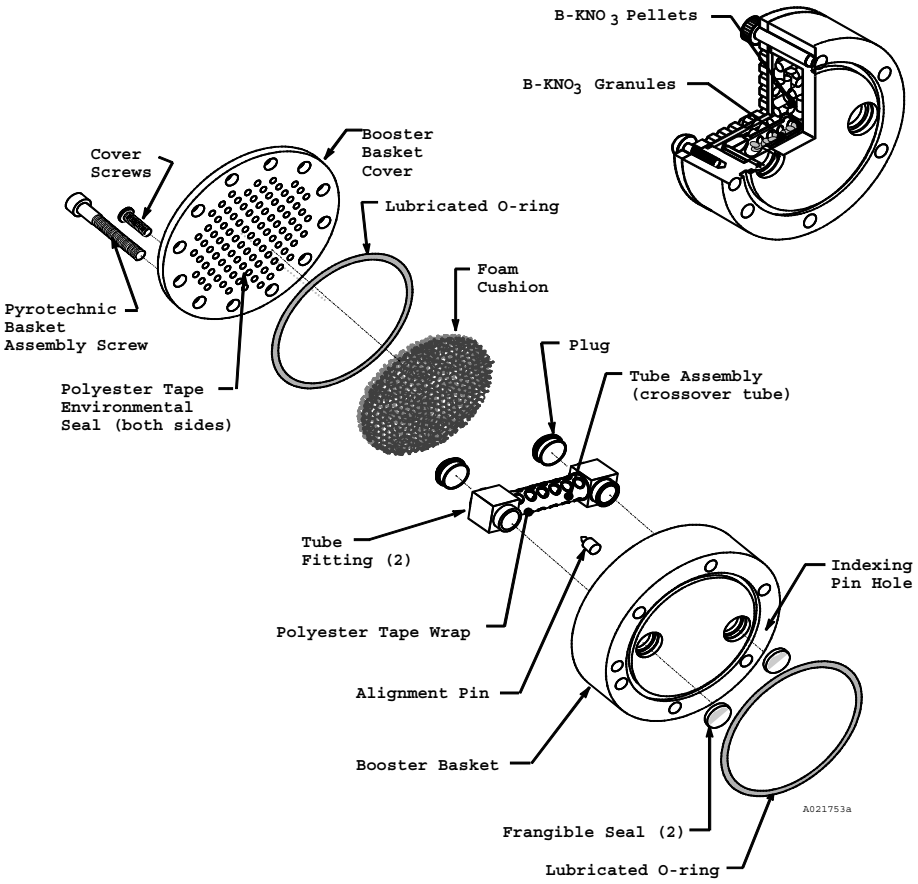

Figure 2. Pyrotechnic-Basket Assembly Section and Exploded Views

9.0 RATIONALE FOR RETENTION:

9.1 DESIGN:

DCN	FAILURE CAUSES	
A,B,C,D,E,F,G, H,I,J,K,L,M,N	1.	Each lot of Pyrotechnic-Basket Assemblies is loaded using a single lot B-KNO_3 pellets and B-KNO_3 granules, manufactured in one unchanging and continuous process per NSTS-08060. The following are used in each assembly: B-KNO_3 pellets, B-KNO_3 granules, polyester tape, foam cushion, and frangible seals.
A,F	2.	B-KNO_3 pellets and ignition granules are stored and shipped in a sealed, metal container with desiccant to prevent contamination prior to placing into the Booster Basket Assembly. After assembly, the Pyrotechnic Basket Assembly is placed in a sealed container with desiccant for storage.
A,F	3.	B-KNO_3 granules are protected from contamination by polyester tape wrapped around the Booster-Tube Assembly and by frangible seals and a Tube Assembly Plug in the Pyrotechnic Basket Assembly. The frangible seals and Tube Assembly Plug are pressed and swaged into the Tube-Fitting Assembly located in the Pyrotechnic Basket Assembly and sealed with an epoxy adhesive. The pellets are protected from contamination by the installation of a Booster Assembly Cover fastened with screws to the end of the Booster-Basket and sealed with an O-ring covered with grease. The Booster Assembly Cover holes are sealed on both sides with polyester tape.
A,B,C,D,E,F,G	4.	Formulation, manufacture, and performance requirements of B-KNO_3 pellets and B-KNO_3 granules are controlled per engineering.
A	5.	The S&A device is shipped and stored in a sealed metal container.
F	6.	The Pyrotechnic Basket Assembly, after loading with B-KNO_3 pellets and B-KNO_3 granules, is protected by a sealed metal container with desiccant. The S&A device is shipped and stored in a metal container with desiccant. A humidity indicator card is packed with the S&A device.
A,F,H	7.	Packaging, storage requirements, and procedures are per the MH&SI for the following B-KNO_3 raw materials: a. B-KNO_3 granules and pellets b. Boron powder c. Potassium nitrate d. Plastic binder
A	8.	Contamination controls for B-KNO_3 pellets and B-KNO_3 granules for formulation and storage are per the MH & SI, engineering, and shop planning.
A	9.	Contamination controls for B-KNO_3 pellets and B-KNO_3 granules for loading into the Pyrotechnic-Basket Assembly are per shop planning to ensure clean gloves are worn and the interior of the basket is cleaned.
A	10.	Thiokol cleans the interior of the basket assembly metal parts with Rymplecloth or a cotton-tipped applicator dampened with solvent prior to loading with B-KNO_3 granules per shop planning.

A	11.	The loaded Pyrotechnic Basket Assembly is protected after loading by including a pack of desiccant and being wrapped with a minimum of three layers of Rymplecloth, wrapped with plastic, and sealed with waterproof tape. The basket assembly is then inserted in a can with desiccant on top with a humidity indicator sealed with waterproof tape per shop planning.
F	12.	S&A Delta Qualification and Lot Acceptance Test of live firings are performed on Pyrotechnic Basket Assemblies and/or loaded Barrier-Booster Assemblies after acceptance testing using randomly selected assemblies to test for lot-acceptance and temperature conditioning to induce worst case conditions per TWR-13219.
A,B,C,D,E,F,G,H, I,J,K,L,M,N,Q	13.	A Lot Acceptance Test is performed at Thiokol. Data is analyzed by Design Engineering and reported in a final report for each lot.
B,C,D,E,F,G,H, I,J,K,L,M,N,Q	14.	After four years and seven years from original lot sample acceptance testing, Thiokol can re-certify the certified lot of loaded Pyrotechnic Basket Assembly for extended shelf storage life per NASA specification NSTS 08060 as specified in ATP-0001.
G	15.	Boron powder conforms to engineering.
G	16.	Potassium Nitrate conforms to engineering.
G	17.	Plastic polyamide resin binder conforms to engineering.
G	18.	Dry graphite conforms to engineering.
N	19.	Frangible seal membrane thickness is per engineering drawings.
N	20.	Proper membrane seal thickness is determined by development testing per vendor report 75060 DTR1.
G,N	21.	Frangible seal material is 6061-T6 aluminum per engineering drawings.
G,J,K	22.	The pellet retaining cushion foam pad conforms to engineering drawings.
G,J,K	23.	Polyester film tape conforms to specifications per engineering drawings.
H	24.	Shelf storage life of a loaded S&A device and loaded Pyrotechnic Basket Assembly is 4 years per TWR-14676 and TWR-17741.
H	25.	Storage life of Boron pellets, for an individual lot of material, is 1 year from date of manufacture when stored at ambient temperatures in sealed containers. Storage life of additional 1-year periods may be extended provided, upon retest, the pellets conform to ignition pressure and ignition time requirements.
H	26.	Storage life of B-KNO_3 granules is per engineering as individual lots of material. Storage life may be extended provided, upon retest, the granules conform to the heat of reaction requirement.
I,L	27.	B-KNO_3 pellet and granule load weight is per engineering drawings. Load weights of B-KNO_3 pellets and granules were established to meet RSRM performance criteria per vendor report 75060 DTR1.

I,L	28.	After loading B-KNO_3 granules in the cross over tube in the Pyrotechnic Basket, a photograph is taken for records to show the tube is full of granules with the serial number visible per shop planning.
I,L	29.	Qualification tests to establish B-KNO_3 pellet and granule weight to provide sufficient energy for reliable igniter initiator ignition were performed per vendor report 75060 DTR1.
I,L	30.	The Pyrotechnic Basket Assembly, after loading with live pellets and granules, is installed in a sealed container controlled and identified with an acceptance tag applied to the exterior of the sealed container.
J,K	31.	The number and size of holes in the Booster Basket Cover are per engineering drawings.
M	32.	The Booster Basket Assembly is aligned with an index pin located in the Barrier-Booster Housing of the Barrier-Booster Assembly per engineering drawings.
M	33.	The Booster-Tube Assembly is aligned with an alignment pin located in the Booster-Basket per engineering drawings.
M	34.	Assembly of the Pyrotechnic Basket Assembly to the Barrier-Booster Assembly is per engineering drawings and shop planning.
O,P	35.	Booster-Tube dimensions are per engineering drawings.
O,P	36.	Burrs and sharp edges are removed per engineering drawings.
O,P	37.	The Booster-Tube is cleaned prior to wrapping with pressure-sensitive polyester tape.
O,P	38.	The Booster-Tube Assembly is a CRES perforated metal tube wrapped with polyester film and filled with B-KNO_3 granules in a sealed environment.
Q	39.	Booster cover screws are self-locking.
Q	40.	Booster cover screws are torqued per engineering drawings.
Q	41.	All torque values conform to MSFC specifications.
Q	42.	Torque seal is applied to the screw heads and cover plate after the screws are torqued.
Q	43.	The Booster-Basket Assembly is aligned with an index pin located in the Barrier-Booster Assembly Housing and fastened with self-locking screws, that are torqued per engineering drawings.
B,C,D,E	44.	The S&A Device is included in life verification.

9.2 TEST AND INSPECTION:

DCN	FAILURE CAUSES and TESTS (T)			CIL CODES
		1.	For New Ignition Granules, verify:	
A,B,C,D,E G,H,I,L	(T)	a.	Auto ignition temperature	AMW005
A,B,C,D,E, G,H,I,L	(T)	b.	Boron content	AMW007
A,B,C,D,E,G,H		c.	Workmanship	AMW016
A,B,C,D,E, G,H,I,L	(T)	d.	Heat of reaction	AMW018
A,B,C,D,E, G,H,I,L	(T)	e.	Particle size	AMW026
A,B,C,D,E, G,H,I,L	(T)	f.	Potassium-Nitrate content	AMW028
H		g.	No shipping or handling damage	AMW029
F,H		h.	Humidity protection requirements by examination of indicator card	AMW030
		2.	For Retest Ignition Granules, verify:	
H	(T)	a.	Heat of reaction	AMW034
		3.	For New Boron Pellets, verify:	
A,B,C,D,E, G,H,I,L	(T)	a.	Auto ignition temperature	ANI006
A,B,C,D,E, G,H,I,L	(T)	b.	Average crush strength	ANI008
A,B,C,D,E, G,H,I,L	(T)	c.	Boron content	ANI011
B,C,D,E,G,H,I,L		d.	Diameter	ANI021
A,B,C,D,E,G,H		e.	Workmanship	ANI024
A,B,C,D,E, G,H,I,L	(T)	f.	Heat of reaction	ANI026
A,B,C,D,E, G,H,I,L	(T)	g.	Ignition pressure	ANI029
A,B,C,D,E, G,H,I,L	(T)	h.	Ignition time	ANI033
B,C,D,E,G,H,I,L		i.	Length	ANI035
F,H		j.	Humidity protection requirements by examination of indicator card	ANI036
B,C,D,E,G,H,I,L		k.	Weight	ANI042
A,B,C,D,E, G,H,I,L	(T)	l.	Potassium-Nitrate content	ANI044
		4.	For Retest Boron Pellets, verify:	
H		a.	Ignition pressure	ANI050A
H		b.	Ignition time	ANI050B
H		c.	Workmanship	ANI050C
		5.	For New Boron Powder, verify:	
A,G	(T)	a.	Magnesium	ALY004,ALY005

A,G	(T)	b.	Nitrogen	ALY008
A,G	(T)	c.	Particle size	ALY012,ALY013
A,G	(T)	d.	Sodium	ALY016
A,G	(T)	e.	Total Boron	ALY020,ALY021
A,G	(T)	f.	Water-soluble Boron	ALY024,ALY025

6. For New Potassium Nitrate, verify:

A,G		a.	Calcium and Magnesium	AJE009
A,G		b.	Chlorides	AJE017
A,G		c.	Granulation	AJE023
A,G		d.	Insoluble Material	AJE033
A,G		e.	Percent Iron	AJE037
A,G		f.	Moisture	AJE045
A,G		g.	pH	AJE053
A,G		h.	Sodium	AJE057

7. For New Plastic Polyamide Resin Binder, verify:

A,G		a.	Workmanship (includes visible contamination)	ALX002
A,G		b.	Marking	ALX015B
A,G		c.	No shipping or handling damage	ALX015A
A,G	(T)	d.	Melting point	ALX003,ALX005
A,G	(T)	e.	Solution-cloud time	ALX008,ALX010

8. For New Dry Graphite, verify:

A,G	(T)	a.	Acidity	AIZ000,AIZ002
A,G	(T)	b.	Ash	AIZ004,AIZ006
A,G	(T)	c.	Free Sulfur	AIZ008,AIZ011
A,G	(T)	d.	Particle size	AIZ013,JAA000
A,G	(T)	e.	Grit	AIZ017,AIZ019
A,G	(T)	f.	Moisture	AIZ021,AIZ023
A,G	(T)	g.	Silica	AIZ025,AIZ027
A,G	(T)	h.	Total Sulfur	AIZ031,AIZ033

9. For New Polyurethane Foam, verify:

J,K	(T)	a.	Compression deflection	AME000
J,K	(T)	b.	Compression set	AME007,AME008
J,K	(T)	c.	Density	AME012,AME013
J,K	(T)	d.	Porosity	AME016,AME017

10. For New Booster Basket Cover, verify:

J,K	a.	Polyester tape used on Pyrotechnic Basket Cover meets specification per drawing	ABH009
J,K	b.	Vendor records for number of holes in Pyrotechnic Basket Cover within specified drawing dimensions	ANG007

11. For New Booster Basket Cushion, verify:

J,K	a.	Foam cushion thickness is acceptable	ABI000

12. For New Booster Basket Frangible Seal, verify:

N	a.	Frangible seal membrane thickness conforms to drawing	ABN002
	13.	For New Barrier Booster Assembly, Loaded, verify:	
Q	a.	Cleanliness of screw holes prior to installing Pyrotechnic Basket Assembly	ACY021
F	b.	Humidity protection requirements by inspection of indicator card	ADA045
H	c.	Proper packaging and storage of Pyrotechnic Basket Assemblies	ADA133
Q	d.	Proper torque applied to Pyrotechnic Basket Assembly screw	ADA181
	14.	For New Pyrotechnic Basket Assembly, verify:	
I,L	a.	Identified by loading date	ACJ012
I,L	b.	Identified by lot number	ACJ013
I,L	c.	Identified by serial number	ACJ014
A	d.	Metal basket assembly cleaned and free from contamination	ACJ018
I,L	e.	Photograph taken showing loaded cross-over tube and serial number	ACJ023
Q	f.	Proper screws used to assemble booster cover	ACJ025
B,C,D,E,I,L	g.	Proper weight in cross-over tube of B-KNO_3 granules	ACJ032
B,C,D,E,I,L	h.	Proper weight of B-KNO_3 pellets loaded into Pyrotechnic Basket	ACJ034
A,F,H,I,J,L,K	i.	Pyrotechnic Basket Assembly packaged for storage in a sealed container with desiccant	ACJ036
G,H,J,K	j.	Recertification of Pyrotechnic Basket Assembly to extend shelf life four years after original Lot Acceptance Test	ACJ039
G,H,J,K	k.	Recertification of Pyrotechnic Basket Assembly to extend shelf life seven years after original Lot Acceptance Test	ACJ040
Q	l.	Torque seal applied between screw heads and cover plate	ACJ043
Q	m.	Proper torque of booster cover screws	ACY098
A,B,C,D,E,F,G,H, I,J,K,L,N (T)	n.	Lot Acceptance Test of loaded Pyrotechnic Basket Assembly	AKS000
F,I,L	o.	Pellets conform to specification prior to loading	AMW000
A,B,C,D,E	p.	B-KNO_3 granules and pellets free from visible contamination prior to loading Pyrotechnic Basket Assembly	AMW015
A,B,C,D,E,F,G, H,I,J,K,L,N	q.	Single lot of granules in each lot of Pyrotechnic Basket Assemblies	AMW035
H	r.	Storage life of B-KNO_3 granules has not expired prior to loading cross-over tube	AMW039
F,I,L	s.	Granules conform to specification prior to loading	ANI000
F	t.	Humidity level acceptable during loading	ANI027
A,B,C,D,E,F,G, H,I,J,K,L,N	u.	Single lot of pellets in each lot of Pyrotechnic Basket Assemblies	ANI052
H	v.	Storage life of B-KNO_3 pellets has not expired prior to loading baskets	ANI056
I,L,O,P	w.	Epoxy seal around cross-over tube for absence of cracks, unbonds or separations	DAA049
	15.	For New Booster Basket Tube Assembly, verify:	
O,P	a.	Alignment hole diameter	ABO000
O,P	b.	Booster-tube holes diameter	ABO003
O,P	c.	Tube outside diameter	ABO018
O,P	d.	Wall thickness	ABO019
J,K	e.	Polyester tape per specification	DAA031
	16.	For New Booster Basket Assembly, verify:	
O,P	a.	Booster-Tube cleaned before polyester tape is installed	ABO009

A,J,K,O,P		b. Polyester tape properly applied to tube	ABO012
	17.	For New Barrier-Booster Assembly, Loaded, verify:	
M		a. Index pin installed in Barrier-Booster housing is mated with index hole in Pyrotechnic Basket Assembly	ADA046
	18.	For New Barrier-Booster Housing, verify:	
M		a. Alignment pin hole location	ACY001
	19.	For New Booster Basket Tube Assembly, verify:	
M		a. True position of the alignment pin hole in the booster tube meets location requirements.	ABO015
	20.	For New Booster Basket, verify:	
M		a. True position of the alignment pin hole location	ACH000
M		b. True position of the indexing pin hole location	ACH023A
	21.	For New S&A Device, verify:	
H		a. Proper packaging and storage	ADB015
	22.	KSC verifies:	
A,F,G		a. S&A device for the following per OMRSD File V, Vol I, B000FL.006 1. Proper packaging and storage of loaded Pyrotechnic Basket Assemblies and S&A devices 2. Free from humidity or visible moisture 3. Expended desiccant 4. Bench test for "SAFE"-"ARM"-"SAFE" cycle 5. Bench tests for arming cycle time, motor resistance, insulation resistance	OMD022
A,F,G		b. Upon removal of the S&A device from storage and shipping container the following per OMRSD, File V, Vol I, B47SA0.020: 1. No humidity indication in excess of 50 percent by examining humidity indicator card 2. No visible moisture	OMD061
H		c. Life requirements for the expected launch schedule are met per OMRSD File II, Vol III, C00CA0.030	OMD019