CRITICAL ITEMS LIST (CIL)

No. 10-03-02-01/01

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		
FMEA ITEM NO.:	10-03-02-01 Rev M	PART NO.:	(See Table A-3)
CIL REV NO.:	M	PHASE(S):	Pre-launch (PL)
DATE:	31 Jul 2000	QUANTITY:	(See Table A-3)
SUPERSEDES PAGE:	412-1ff.	EFFECTIVITY:	(See Table 101-6)
DATED:	30 Jul 1999	HAZARD REF.:	FI-01
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: Premature operation (A)

2.0 FAILURE MODE: 1.0 Premature operation

3.0 FAILURE EFFECTS: Premature ignition of one RSRM will cause thrust imbalance and loss of the RSRM, SRB, crew, and vehicle

4.0 FAILURE CAUSES (FC):

FC NO.	DESCRIPTION	FAILURE CAUSE KEY
1.1	Lightning strike	A
1.2	Electrostatic discharge	B
1.3	Increased sensitivity due to contamination	C
1.4	High temperature	D
1.5	Shock and vibration	E

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 (Figure 1) transmits the ignition process from the SRM Ignition Initiator (SIIs) to the igniter initiator. Pyrotechnic materials used are Boron-Potassium Nitrate (B-KNO_3) granules and pellets (called "Boron pellets" in drawings and specifications). The primary components of the Pyrotechnic-Basket Assembly include (Figure 3) a "Booster-Basket" housing, a perforated Booster-Tube Assembly, and two tube fittings with plugs (together called the cross-over tube) containing B-KNO_3 granules, B-KNO_3 pellets, an open-cell foam cushion placed against the pellets, frangible seals over the SII ports, and a perforated retainer plate or "Booster Cover". The Pyrotechnic-Basket Assembly is mounted on the inner surface of the Barrier-Booster Assembly, and faces toward the igniter initiator grain (Figure 2). The Pyrotechnic-Basket Assembly is surrounded by several metallic structures that protect it from outside electrical disturbances. All components of the Pyrotechnic-Basket Assembly are one-time-use items. Materials are listed in Table 1.

TABLE 1. MATERIALS

Drawing No.	Name	Material	Specification	Quantity
1U50691	Cover	301 CRES Half Hard	MIL-S-5059	1/Motor
1U50694	Cushion	Polyurethane Foam	STW4-3240	1/Motor
1U50795	Tube Assembly	304 CRES	MIL-T-8506	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-A-582	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
	Ignition Granules		STW5-2702	A/R
	Potassium Nitrate		STW4-3812	A/R
	Boron Powder		STW4-2887	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
	Polyamide Plastic Binder		STW4-2886	A/R
	Graphite Lubricant		MIL-G-155	A/R
	Lubricant	Heavy-Duty Calcium Grease	STW5-2942	A/R
1U50228	Small O-Ring	Fluorocarbon Elastomer	MIL-R-83248A	A/R
	Torque Seal	Special Purpose Lacquer	STW5-2984	A/R
	Coating, Clear	Lacquer	TT-L-50G, Type II	A/R
	Tape	Pressure-Sensitive Polyester	MIL-T-26317 or L-T-100,Type I	A/R
	Adhesive	Epoxy Resin, Metal-to-Metal Structural Bonding	MMM-A134, Type I, Class 3	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 functions as two steps in the chain of events that take place in the igniter. The Pyrotechnic-Basket is ignited by dual SIIs. The SIIs burst the frangible seals over the ports to the Pyrotechnic-Basket Assembly and ignite the B-$KN0_3$ ignition granules. The ignition granules ignite the B-$KN0_3$ pellets. Firing of the booster charge ignites the igniter initiator grain that in turn ignites the main

igniter and finally the RSRM propellant grain.

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

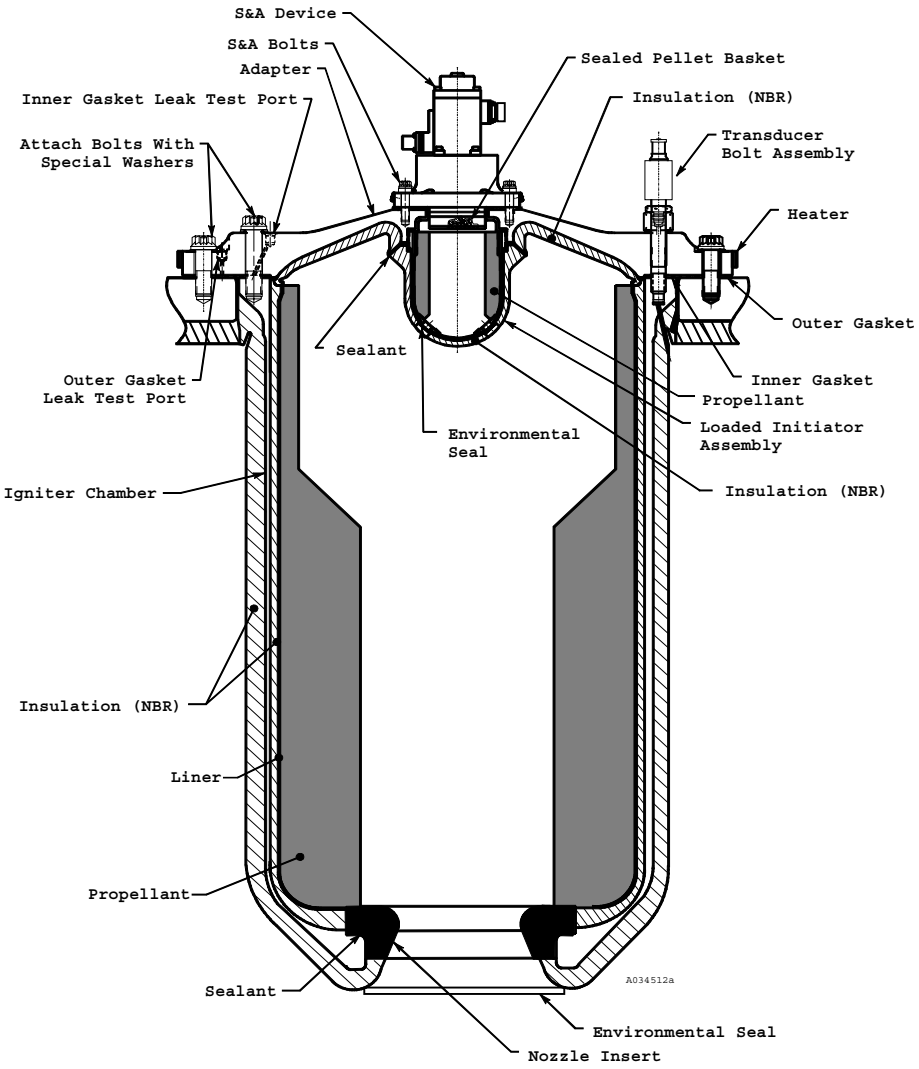

Figure 1. RSRM Ignition System

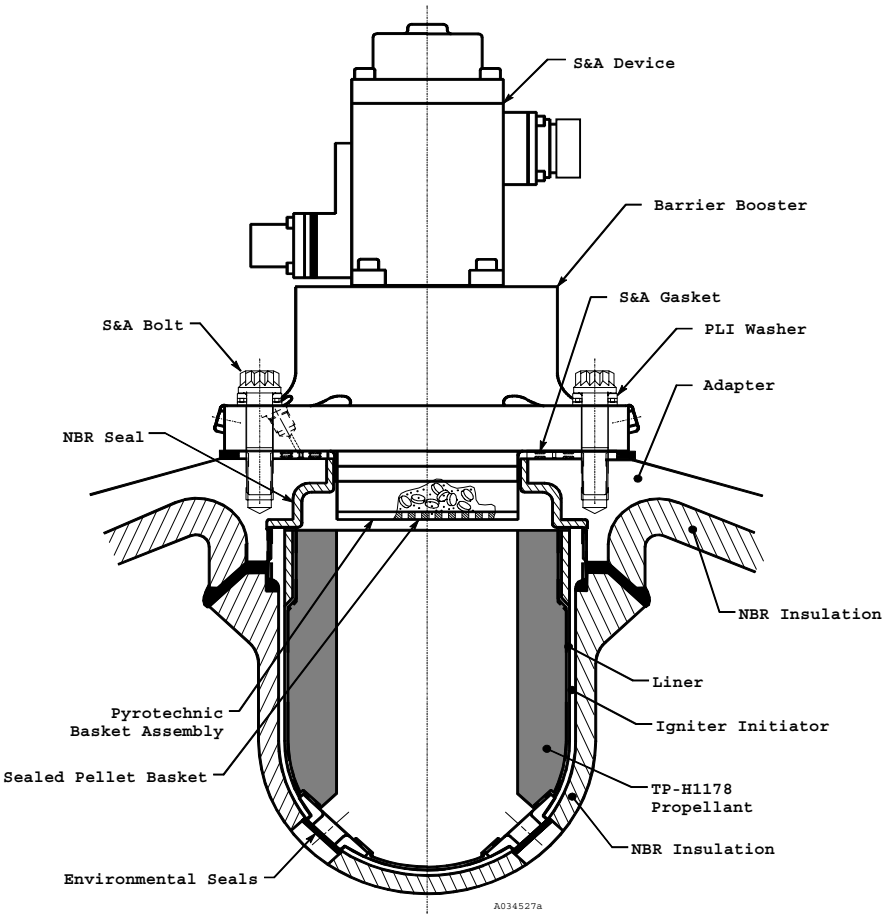

Figure 2. Loaded Igniter Initiator

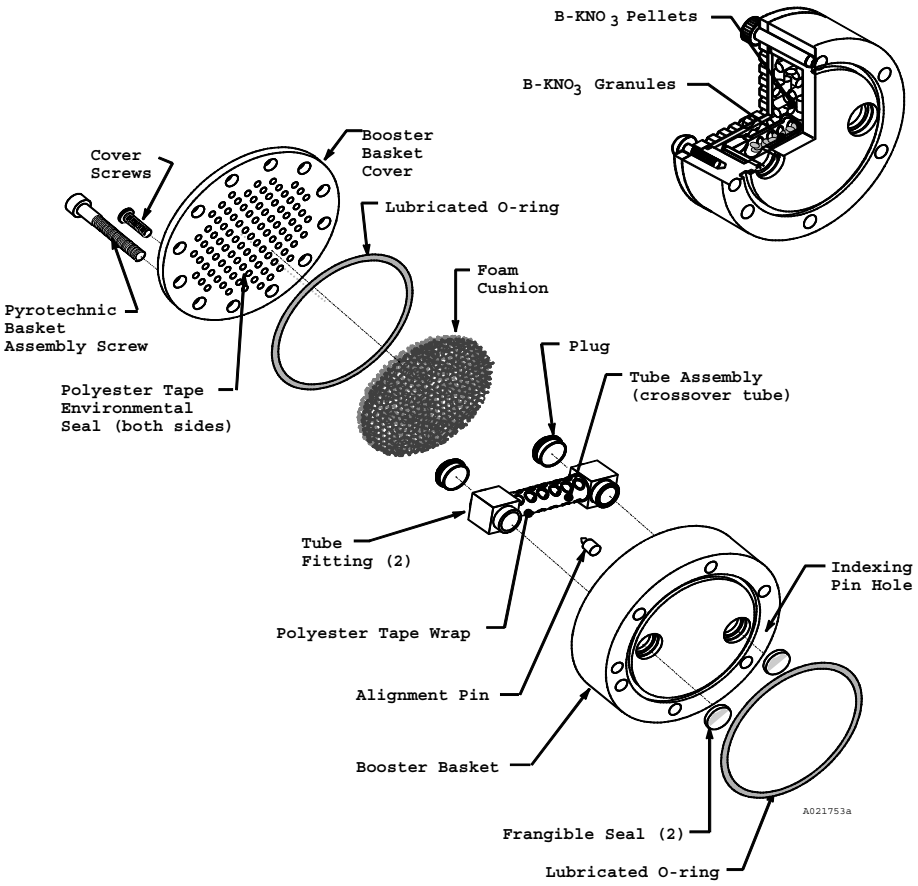

Figure 3. Pyrotechnic-Basket Assembly Section and Exploded Views

9.0 RATIONALE FOR RETENTION:

9.1 DESIGN:

DCN FAILURE CAUSES

A 1. The Pyrotechnic-Basket is enclosed in two metal structures of considerable strength: the first enclosure comprises the Barrier-Booster inner face and the igniter initiator chamber; the second enclosure is made up of the igniter adapter and the igniter chamber. Also, the Pyrotechnic-Basket itself is a sturdy, metal structure. All of these structures are electrically complete enclosures grounded to the forward dome and further enclosed within the SRB forward assembly.

A 2. The lightning path for the RSRM is provided by an electrical bonding and grounding system per MSFC Drawing 16A00100.

A,B 3. A continuous metallic path is provided by electrical bonding from the RSRM to the facility grounding system to ensure electrical resistance across the mating surfaces is within limits per NSTS-07636.

A 4. The launch vehicle is protected before launch by a catenary umbrella of grounded conductors.

A,B 5. Following are the component interfaces related to this system and the means by which electrical bonding of each interface is effected:

Interface	Electrical Bond
S&A-to-igniter adapter	Bolts and bare metal-to-metal contact
Igniter adapter-to-forward dome	Bolts and bare metal-to-metal contact
SRB forward assembly-to-forward segment	Bolts and bare metal-to-metal contact

B 6. Boron pellets and ignition granules will withstand an electrostatic discharge as required by NSTS-08060.

B 7. Tests of pellets were conducted at the U.S. Bureau of Mines, Department of the Interior facilities, and at the Hercules Powder Company Allegheny Ballistic Laboratory, where they successfully passed standard sensitivity tests such as Pendulum Friction, Static Spark, Impact, and Electrostatic Discharge (Boron-Potassium Nitrate Sensitivity Report, Atlantic Research Corporation).

C,D 8. 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.

C 9. 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.

C 10. 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 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. Booster Assembly Cover holes are sealed on both sides with polyester tape.

C,D 11. Performance and manufacturing requirements for B-KNO_3 pellets and ignition granules are per engineering.

C 12. The S&A device is shipped and stored in a sealed metal container.

C 13. Packaging, contamination controls, and 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.

C 14. 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.

C 15. 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.

C 16. After the Pyrotechnic-Basket is loaded, the following steps are performed in order:

a. The Pyrotechnic-Basket is wrapped with a minimum of 3 layers of Rymplecloth.
b. A pack of desiccant is placed next to the outside layer of Rymplecloth and the assembly is wrapped in plastic.
c. The assembly is inserted in a can with a humidity indicator.
d. Desiccant is inserted into the can and the can is sealed with waterproof tape per shop planning.

C 17. A lot acceptance test is performed at Thiokol. Data is analyzed by Design Engineering and reported in a final report for each lot.

D 18. Predicted temperature range of the Pyrotechnic-Basket is from 20°F to 120°F when installed as a part of the S&A device at KSC per TWR-11103.

D 19. Tests to determine the effects of high temperature and varying humidity on B-KNO_3 pellets and ignition granules were conducted per TWR-11331 and TWR-11522. Closed bomb tests indicated that exposure for 3 and 6 weeks at less than 60 percent relative humidity and 120°F showed no significant change in performance.

D 20. A "Hot" test was performed in which an S&A device with a loaded Pyrotechnic-Basket was heated to the maximum expected pre-launch temperature, and then subjected to the additional heating produced when "SAFE" and "ARM" power signals were sent to the S&A device, until the motor windings failed. None of the areas containing pyrotechnics increased in temperature sufficiently to cause auto ignition (maximum temperature achieved was 135°F) per TWR-12494.

E 21. Vibration environments for the Pyrotechnic-Basket Assembly are the same as

those for the S&A device.

E 22. During qualification testing, S&A assemblies (that included loaded pyrotechnic-baskets) were subjected to pre-launch vibration per TWR-12198. Vibration was applied for 10 seconds per axis along each of three principal axes.

E 23. The Pyrotechnic-Basket is nearly filled with Boron pellets and the remaining space is then filled by compressing a foam cushion over the pellets and installing the Booster Basket Cover. The purpose of the foam cushion is to restrict movement of the Boron pellets due to vibration. The cushion material is polyurethane foam, which does not exhibit degraded resiliency with age.

E 24. Processing steps are monitored for leakage paths or incomplete filling with pyrotechnics: in particular, reduced quantity of pellets or absence of the foam cushion would result in greater movement of the pellets due to shock or vibration.

9.2 TEST AND INSPECTION:

DCN	FAILURE CAUSES and TESTS	(T)			CIL CODE
			1.	For New Potassium Nitrate, verify:	
C		(T)	a.	Calcium and Magnesium	AJE009
C		(T)	b.	Chlorides	AJE017
C		(T)	c.	Granulation	AJE023
C		(T)	d.	Insoluble Material	AJE033
C		(T)	e.	Percent Iron	AJE037
C		(T)	f.	Moisture	AJE045
C		(T)	g.	pH	AJE053
C		(T)	h.	Sodium	AJE057
			2.	For New Plastic Polyamide Resin Binder, verify:	
C		(T)	a.	Workmanship (includes visible contamination)	ALX002
C		(T)	b.	Melting point	ALX003,ALX005
C		(T)	c.	Solution-cloud time	ALX008,ALX010
C			d.	Marking	ALX015B
C			e.	No shipping or handling damage	ALX015A
			3.	For New Dry Graphite, verify:	
C		(T)	a.	Acidity	AIZ000,AIZ002
C		(T)	b.	Ash	AIZ004,AIZ006
C		(T)	c.	Free Sulfur	AIZ008,AIZ011
C		(T)	d.	Particle size	AIZ013,JAA000
C		(T)	e.	Grit	AIZ017,AIZ019
C		(T)	f.	Moisture	AIZ021,AIZ023
C		(T)	g.	Silica	AIZ025,AIZ027
C		(T)	h.	Total Sulfur	AIZ031,AIZ033
			4.	For New Ignition Granules, verify:	
C,D		(T)	a.	Auto-ignition temperature	AMW005
C		(T)	b.	Boron content	AMW007
C			c.	Workmanship	AMW016
C		(T)	d.	Heat of reaction	AMW018
C		(T)	e.	Particle size	AMW026
C		(T)	f.	Potassium Nitrate content	AMW028
			5.	For New Boron Pellets, verify:	
C,D		(T)	a.	Auto-ignition temperature	ANI006
C		(T)	b.	Average crush strength	ANI008
C		(T)	c.	Boron content	ANI011
C			d.	Workmanship	ANI024
C		(T)	e.	Heat of reaction	ANI026
C		(T)	f.	Ignition pressure	ANI029
C		(T)	g.	Ignition time	ANI033
C		(T)	h.	Potassium Nitrate content	ANI044
			6.	For New Boron Powder, verify:	

C	(T)	a.	Magnesium	ALY004,ALY005
C	(T)	b.	Nitrogen	ALY008
C	(T)	c.	Particle size	ALY012,ALY013
C	(T)	d.	Sodium	ALY016
C	(T)	e.	Total Boron	ALY021,ALY020
C	(T)	f.	Water-soluble Boron	ALY024,ALY025

7. For New Polyurethane Foam, verify:

E	(T)	a.	Compression deflection	AME000
E	(T)	b.	Compression set	AME008

8. For New Booster Basket Assembly, verify,

C		a.	Polyester tape properly applied to tube	ABO012

9. For New Pyrotechnic Basket Assembly, verify:

C,E		a.	Installation of foam cushion	ACJ015
C		b.	Metal basket assembly cleaned and free from contamination	ACJ018
C,E		c.	Proper weight of B-KNO_3 granules in cross-over tube	ACJ032
C,E		d.	Proper weight of B-KNO_3 pellets loaded into Pyrotechnic Basket	ACJ034
C		e.	Pyrotechnic Basket Assembly packaged for storage in a sealed container with desiccant	ACJ036
C,E		f.	Proper torque of Booster Basket Cover screws	ACY098
C	(T)	g.	LAT of loaded Pyrotechnic Basket Assembly	AKS000
C		h.	Single lot of pellets used in each lot of Pyrotechnic-Basket Assemblies	ANI052
C		i.	B-KNO_3 granules and pellets free from visible contamination prior to loading Pyrotechnic Basket Assembly	AMW015
C		j.	Single lot of granules used in each lot of Pyrotechnic-Basket Assemblies	AMW035

10. KSC verifies:

A,B		a.	S&A device to igniter adapter electrical bonding tests per OMRSD File V, Vol I, B47SA0.100	OMD071
C		b.	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
C		c.	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