ATK ALLIANT TECHSYSTEMS
THIOKOL PROPULSION

CRITICAL ITEMS LIST (CIL)

No. 10-03-02-00/02

SYSTEM:	Space Shuttle RSRM 10	CRITICALITY CATEGORY:	1R
SUBSYSTEM:	Ignition Subsystem 10-03	PART NAME:	Safety and Arming Device
ASSEMBLY:	Safety and Arming Device 10-03-02	PART NO.:	(See Table A-3)
FMEA ITEM NO.:	10-03-02-00 Rev N	PHASE(S):	Prelaunch (PL)
CIL REV NO.:	N	QUANTITY:	(See Table A-3)
DATE:	27 Jul 2001	EFFECTIVITY:	(See Table 101-6)
SUPERSEDES PAGE:	409-1ff.	HAZARD REF.:	FI-01
DATED:	31 Jul 2000		
CIL ANALYST:	D. J. McGough		
APPROVED BY:		DATE:	

RELIABILITY ENGINEERING: K. G. Sanofsky 27 July 2001

ENGINEERING: B. L. Baugh 27 July 2001

1.0 FAILURE CONDITION: Failure to operate (B)

2.0 FAILURE MODE: 4.0 Safety and Arming (S&A) device "ARMED" when required to be "SAFED"

3.0 FAILURE EFFECTS: Premature ignition of one RSRM in the event of inadvertent firing of an SRM Ignition Initiator (SII), resulting in loss of the RSRM, SRB, crew, and vehicle

4.0 FAILURE CAUSES (FC):

FC NO.	DESCRIPTION	FAILURE CAUSE KEY
4.1	S&A device does not return to "SAFE" position during S&A device functional test prior to forward skirt closeout at KSC	
4.1.1	Open circuit (broken wire/contamination) or short circuit in arming-monitor connector or in wiring to motor	A
4.1.2	Motor failure	B
4.1.3	Clutch failure	C
4.1.4	Drive train failure	D
4.1.5	Binding of components	E
4.2	Position indication switches indicate "SAFE" when rotor is in "ARMED" position	
4.2.1	Electrical switch deck assembly or S&A device connector is reverse wired (i.e., indicates "SAFED" when "ARMED")	F
4.2.2	Barrier-Booster switch deck assembly improperly keyed to the Barrier-Booster rotor shaft	G
4.2.3	Improper assembly	H
4.2.4	Contamination	I

5.0 REDUNDANCY SCREENS:

SCREEN A: Pass--The proper S&A device indication is capable of verification during mission turnaround.
SCREEN B: Fail--An S&A device that indicates "SAFE" when rotor is in "ARM" position is not detectable by the crew.
SCREEN C: Pass--The elements cannot be lost due to a single credible cause or event.

6.0 ITEM DESCRIPTION:

1. Safety and Arming Device (Figures 1, 2, and 3). Materials are listed in Table 1.

TABLE 1. MATERIALS

Drawing No.	Name	Material	Specification	Quantity
1U50266	Arming-Monitor Assembly S&A Device			1/Motor
1U50600	Actuator, A-M Assembly			1/Motor
1U50623	Stop Plate, Switch Deck Assembly	6061-T6511	QQ-A-200/8	1/Motor
1U50635	Shaft, Armature	416 CRES	ASTM-A-582,A-581	1/Motor
1U50637	Holder, Brush Plate Assembly	Half Hard Brass	QQ-B-613	1/Motor
1U77755	Clutch Disk	Brake Block RF-34		1/Motor
1U50665	Gear Cluster, Spur	416 CRES Copper, 642	ASTM-A-581,A-582 QQ-C-465	3/Motor
1U50667	Spring	Music wire	ASTM A228	1/Motor
1U50688	Rotor, Output Barrier	A286 CRES	AMS 5737	1/Motor
1U50695	Connector Assembly, Barrier Booster (B-B)			1/Motor
1U77100	Bearing, Corrosion Resistant	440C CRES		2/Motor
1U77385	Barrier-Booster Assembly S/A Device			1/Motor
1U77387	S/A Device, Rocket Motor			1/Motor

6.1 CHARACTERISTICS:

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

2. The S&A device is designed to prevent inadvertent ignition of the SRB, and to facilitate desired ignition on demand. It is a two-part electromechanical assembly consisting of an arming-monitor assembly and a Barrier-Booster assembly.

3. The arming-monitor assembly contains the electric drive motor, switches, reduction gears, clutch, manual safing mechanism safing pin, and visual position indicator. The Barrier-Booster assembly contains electrical position indicator circuits, a mechanical barrier, two initiators, and a pyrotechnic-basket assembly.

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

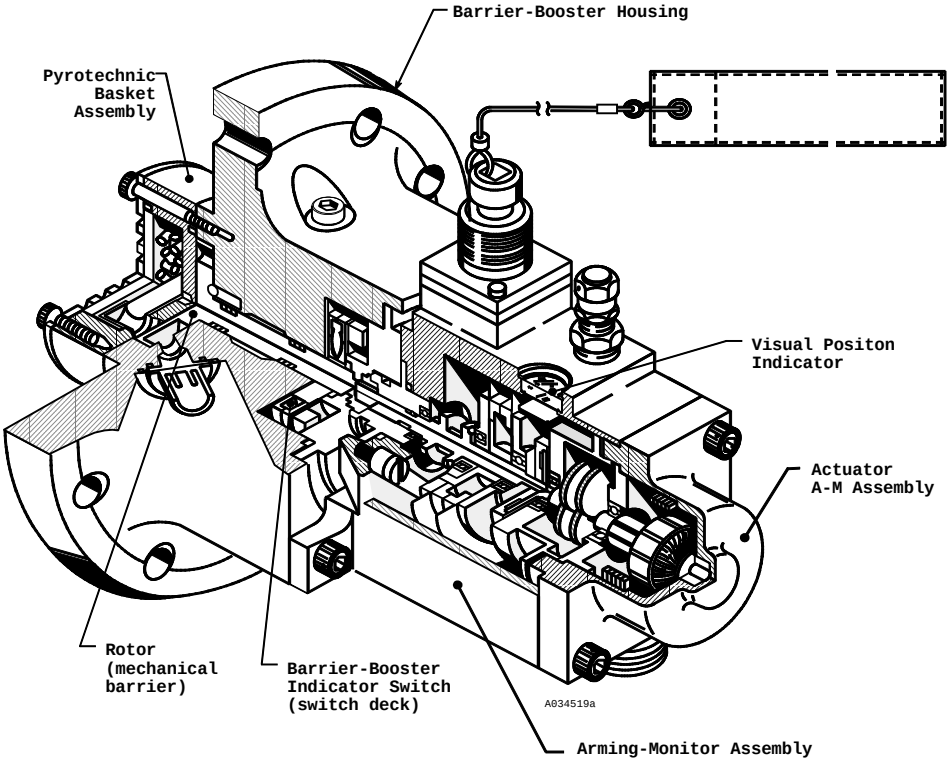

Figure 1. S&A Device

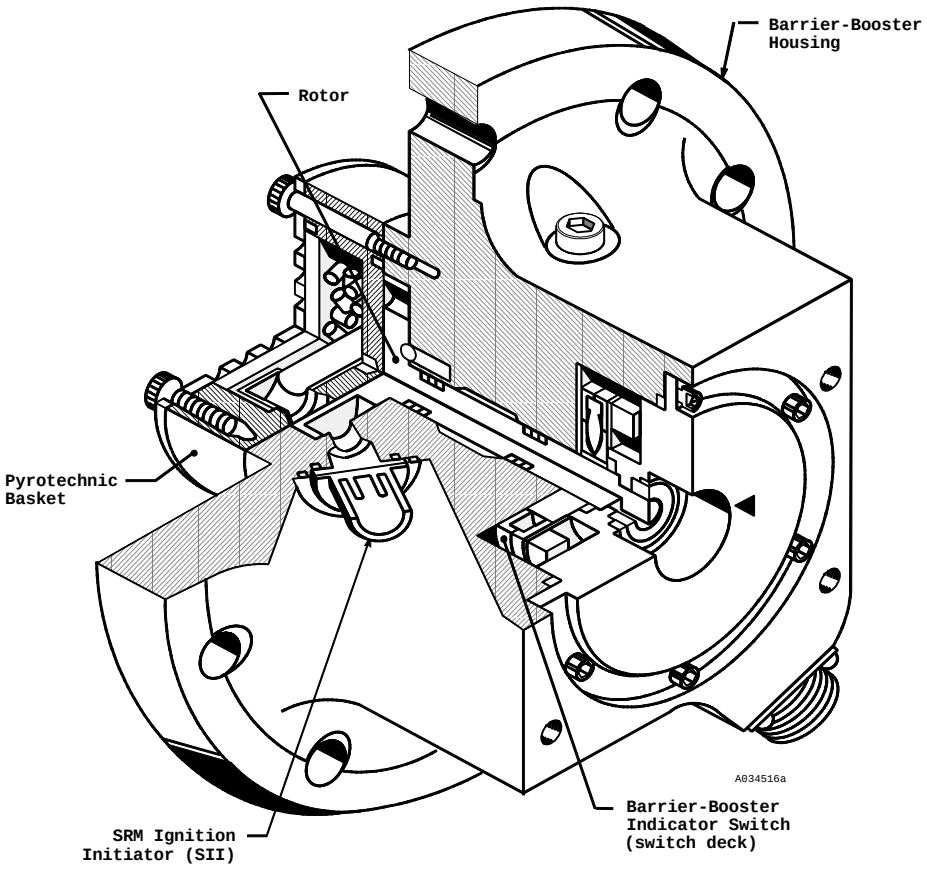

Figure 2. Barrier-Booster Assembly

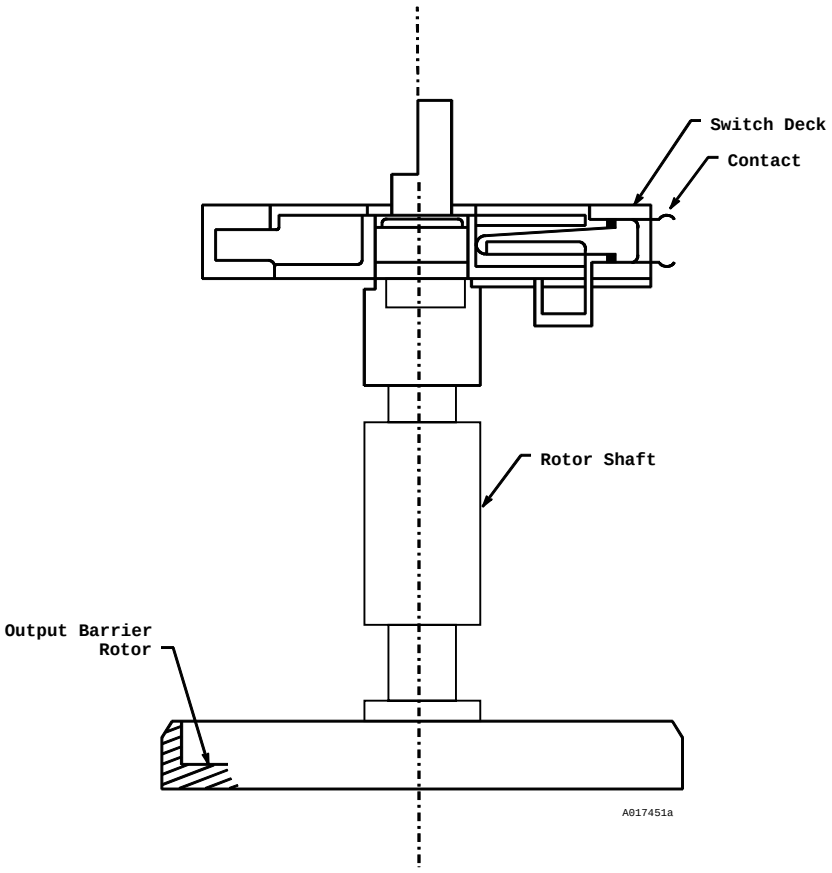

Figure 3. Switch Deck and Rotor Shaft

9.0 RATIONALE FOR RETENTION:

9.1 DESIGN:

DCN	FAILURE CAUSES	
A,B,C,D,E, F,G,H,I	1.	The design is based on similar successful designs from the Short Range Attack Missile (SRAM) and Minuteman programs.
A,B	2.	The design includes provisions for electrical safing, arming, and status monitoring.
A,B	3.	After assembly of the S&A device, Thiokol performs acceptance tests for proper cycling per engineering.
A,B	4.	S&A wire conforms to engineering drawings.
A,B	5.	Sleeving on connector solder points is used to prevent short circuits per engineering drawings.
A,B	6.	Solder connections must satisfy the requirements of engineering drawings.
A,B	7.	Assembly of the Actuator motor at the supplier is controlled by engineering drawings.
C,D,E	8.	S&A device assembly is per engineering drawings and shop planning.
A,B,C,D,E	9.	Eight S&A devices were designated as qualification test units and were subjected to environmental exposures and functional tests equivalent to 25 flights of flight vibration, a 5000-cycle test, and a stalled arming test. All eight devices were still operable but had not incurred a degree of wear or damage sufficient to preclude normal operation in an actual flight per TWR-12198.
C,D,E	10.	The motor gearbox is located in the arming monitor actuator and provides rotational motion for safing and arming. The motor operates within a specified voltage range. The reduction gearbox has four gears within an aluminum housing and 625:1 gear reduction is used to multiply torque well above the required amounts.
C,D,E	11.	The gear train is covered to prevent entry of foreign materials per engineering drawings.
C,D,E	12.	The clutch disk rests between the drive faces of the friction plate and clutch plates. It is supported radially by ball bearings mounted in the bearing plates attached to the gear housing.
C,D,E	13.	The clutch assembly transmits the drive torque of the motor gearbox to the arming motor arming shaft. It allows the motor to overrun and limits torque after the switch deck stops reach the bottom.
C,D,E	14.	The actuator drive shaft is a passivated 416 CRES turning. It has the clutch plate on the output end, a bearing surface, the square input spline, and a cylindrical shaft on which the number three gear cluster is mounted. The clutch plate is held perpendicular to the bearing surface within limits. The drive shaft turns in an unshielded single row radial ball bearing that is pressed into the gear housing. This bearing is CRES 440C steel per engineering drawings and TWR-50263. A shoulder on the drive shaft transfers the clutch axial load into the bearing and thus into the gear housing.

	C,D,E	15. The spur gear is copper aluminum alloy per Federal Specifications with dimensions controlled by engineering drawings.
	C,D,E	16. The pinion gear is heat treated CRES per engineering with dimensions controlled by engineering drawings.
	C,D,E	17. Running clearance between gear clusters is controlled per engineering drawings.
	C,D,E	18. The drive train has a positive margin of safety based upon a safety factor of 1.4 per TWR-11186.
	C,D,E,F,G,H,I	19. The Arming Monitor Actuator Ball Bearings are CRES 440C steel per engineering drawings. Corrosion resistant bearings are qualified for this application by similarity per TWR-50263.
	F,G,H,I	20. The three screw holes for installation of the switch deck are arranged so that the switch deck may be installed in only one position per engineering drawings.
	F,G,H,I	21. Wires are color-coded and length controlled to preclude improper installation per engineering drawings.
	F,G,H,I	22. The switch deck assembly is keyed to the Barrier-Booster Rotor in only one position.
	F,G,H,I	23. The "SAFE" and "ARM" indicator circuits are independent per engineering drawings and TWR-18157.
	F,G,H,I	24. The stop on the switch deck assembly prevents rotation of the rotor if the switch deck is installed incorrectly per engineering drawings.
	F,G,H,I	25. Improper positioning of electrical contacts in the switch deck assembly prevents the full range of the rotor position indications from being obtained and would be detected during S&A device electrical checkout per engineering.
	F,G,H,I	26. The switch deck assembly contacts are lubricated and the contacts are ultrasonically cleaned per engineering. Remaining detailed parts of the S&A device are cleaned per engineering.
578	B	27. Proper installation of the shim and spring tension washers in the blind hole of the arming monitor are verified by X-ray inspection.

9.2 TEST AND INSPECTION:

DCN	FAILURE CAUSES and TESTS (T)			CIL CODES
		1.	For New S&A Device, verify:	
	A,B,C,D,E, F,G,H,I (T)	a.	Individual electrical checkout per specification	ADB011
	A,B,C,D,E, F,G,H,I	b.	Certification review completed	DAA010
		2.	For New Barrier-Booster Assembly, verify:	
	F,G,H,I	a.	Certificate of Conformance	ACZ055
	F,G,H,I (T)	b.	High-pressure leak tests on unloaded Barrier-Booster assembly rotor shaft O-rings, rotor in "ARM" position	ACZ090
	F,G,H,I (T)	c.	High-pressure leak tests on unloaded Barrier-Booster assembly rotor shaft O-rings, rotor in "SAFE" position	ACZ092
	F,G,H,I (T)	d.	Vibration tests	ACZ181
	F,G,H,I (T)	e.	Electrical circuit testing	ACZ072
	F,G,H,I	f.	Correct installation of switch deck assembly	ACZ062
	F,G,H,I	g.	Proper assembly per drawings and specifications	ACZ150
		3.	For Refurbished Barrier-Booster Assembly, verify:	
	F,G,H,I	a.	Proper assembly per drawings and specifications	ACZ150A
	F,G,H,I	b.	Certificate of Conformance	ACZ054A
	F,G,H,I	c.	Correct installation of switch deck assembly	ACZ062A
	F,G,H,I (T)	d.	High-pressure leak tests on unloaded Barrier-Booster assembly rotor shaft O-rings, rotor in "ARM" position.	ACZ090A
	F,G,H,I (T)	e.	High-pressure leak tests on unloaded Barrier-Booster assembly rotor shaft O-rings, rotor in "SAFE" position.	ACZ092A
	F,G,H,I (T)	f.	Vibration tests	ACZ182
	F,G,H,I (T)	g.	Electrical circuit testing	ACZ072A
	F,G,H,I	h.	Workmanship	ACZ188A
		4.	For New Arming Monitor Assembly, verify:	
	A,B,C,D,E, F,G,H,I (T)	a.	Acceptance test vibration	AAR000
	A,B,C,D,E, F,G,H,I (T)	b.	Reduced voltage cycling	AAR018
	A,B,C,D,E, F,G,H,I (T)	c.	Manual safing and lock test	AAR010
	A,B,C,D,E, F,G,H,I (T)	d.	Torque	AAR021
	A,B,C,D,E, F,G,H,I (T)	e.	Current leakage	AAR009
	A,B,C,D,E, F,G,H,I (T)	f.	Minimum cycle voltage	AAR017
	A,B,C,D,E,F,G,H,I	g.	Supplier inspection sheets are complete and acceptable	AAX028
578	B,E	h.	X-ray inspection for proper installation of shim and spring tension washers	SER219
		5.	For Refurbished Arming Monitor Assembly, verify:	
	A,B,C,D,E,			

	F,G,H,I A,B,C,D,E,	(T)	a.	Minimum cycle voltage	DAA006
	F,G,H,I A,B,C,D,E,	(T)	b.	Manual safing and lock test	DAA007
	F,G,H,I A,B,C,D,E,	(T)	c.	Torque	DAA008
	F,G,H,I A,B,C,D,E,	(T)	d.	Current leakage	DAA009
	F,G,H,I A,B,C,D,E,	(T)	e.	Acceptance test vibration	DAA044
	F,G,H,I	(T)	f.	Reduced voltage cycling	DAA045
	A,B,C,D,E,F,G,H,I		g.	Supplier inspection sheets are complete and acceptable	AAX028A
578	B,E		h.	X-ray inspection for proper installation of shim and spring tension washers	SER220

6. For New Arming Monitor Actuator, verify:

	A,B,C,D,E	(T)	a.	Dielectric test	AAX002
	A,B,C,D,E	(T)	b.	Minimum motor starting voltage	AAX023
	C,D,E		c.	Running gear clearance between gear clusters	AAX027

7. For New Arming Monitor Armature Shaft, verify:

	A,B	(T)	a.	Material properties of armature shaft material is CRES 416, ASTM A581, Condition T	AAX009

8. For Refurbished Barrier-Booster Connector Assembly, verify:

	F,G,H,I		a.	Condition of refurbished switch deck and connector assembly	ABJ001

9. KSC verifies:

	A,B,C,D,E, F,G,H,I	(T)	a.	S&A device "SAFE"-"ARM"-"SAFE" verification test (prior to skirt closeout), KSC monitors the status of the "ARM" and "SAFE" position switches and visually verifies that the status is correct. If the wrong status is returned, KSC manually installs the safing pin and verifies that the S&A device is "SAFED" per OMRSD File V, Vol I, B47SA0.070	OMD065
	A,B,C,D,E, F,G,H,I	(T)	b.	S&A device "SAFE"-"ARM"-"SAFE" verification test (prior to skirt closeout), KSC monitors the status of the "ARM" and "SAFE" position switches and visually verifies that the status is correct. If the wrong status is returned, KSC manually installs the safing pin and verifies that the S&A devices "SAFED" per OMRSD File V, Vol I B47SA0.080	OMD066
	A,B,C,D,E, F,G,H,I	(T)	c.	Per the Launch Commit Criteria Document (NSTS 16007), S&A device is armed at approximately T-5 minutes and the status of both the "ARMED" and the “SAFED" position switches is continuously monitored from T-4:50 until RSRM ignition per OMRSD File II, Vol I, S00FM0.210	OMD018
	C,D,E	(T)	d.	Tests in accordance with the certification review (as required by JSC Specification NSTS 08060) were conducted for each S&A device per OMRSD File V, Vol I, B000FL.002	OMD060
	F,G,H,I		e.	S&A device is in "SAFE" locked position prior to use per OMRSD File V, Vol I, B47SA0.030	OMD062
	F,G,H,I		f.	S&A device for the following per OMRSD File V, Vol I,	

B000FL.006: OMD022

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