SUBSYSTEM: RANGE SAFETY COMMAND DESTRUCT

ITEM NAME: Range Safety Distributor

PART NO.: 10406-0147

FM CODE: A11

ITEM CODE: 70-09

REVISION: Basic

CRITICALITY CATEGORY: 1R

REACTION TIME: Immediate

NO. REQUIRED: 1

DATE: March 31, 2000 CN 038

CRITICAL PHASES: Final Countdown, Boost & Separation

SUPERCEDES: March 31, 1997 CN 038

FMEA PAGE NO.: F-24A

ANALYST: S. Parvathaneni CN 038

SHEET 1 OF 8

APPROVED: S. Parvathaneni CN 038

FAILURE MODE AND CAUSES: Loss of S&A safe command and premature detonation of NSD or PETN leads. Loss of S&A command caused by:

- O Open or Short in Wiring Harness
- O Open junction block
- O Safe 1 or Safe 2 Switch Failed Open

Note: See FMEA/CIL 70-13, FM Code A07 for Unscheduled PETN Lead Ignition.

FAILURE EFFECT SUMMARY: Loss of S&A safe command will result in loss of mission, vehicle and crew if the NSD or PETN leads detonate during final countdown after S&A arming or during the final five seconds of boost. Possible loss of the vehicle, mission and crew during separation if the premature destruction occurs while the SRB is in close proximity to the orbiter. One success path remains after the first failure. Operation is not affected until both paths are lost.

REDUNDANCY SCREENS AND MEASUREMENTS:

- O PASS - Checked during bench test, ATP, ACO and final countdown. Monitored during final countdown by event measurements B55X1869X and B55X1870X.
- O FAIL - Unable to detect one switch failure after bench test.
- O PASS - No known credible causes.

RATIONALE FOR RETENTION:

A. DESIGN

O One of the functions of the RSD A is to execute the safe 1 and safe 2 input commands issued by ground support equipment (GSE) or the orbiter during separation. These commands are implemented functionally by applying power to the safe 2 circuitry upon receipt of the safe 1 command and then applying power to the S&A assembly upon receipt of the safe 2 command.

O The design of the RSD implements these functions in hardware by providing connectors, wiring harnesses, voltage regulator, board, S&A assembly controller module and associated power sources and command functions. The specific RSD design features that were implemented to mitigate all of the listed failure causes are the use of high reliability parts and the S&A command wired directly from the PWA connector to the output connector.

O The safe command is issued only in the event of a pad abort and during the separation sequence. During the separation sequence, the safe command is issued and the RSS power off command follows within micro-seconds. With this short time there is little likelihood that an electrical failure could cause an unscheduled destruct output.

.O There is a single vendor source for RSD: Bendix, Guidance Systems Division. The RSD has completed qualification to the twenty mission level (Ref. Qual Test Report EE-QTR-91-001). The mission qualification is documented in COQ A-RSS-3113-4 and COQ A-RSS-3113-5.

O All electrical and electromechanical component parts used in the RSD have traceability requirements per SE-019-33-2H. In addition, a log book is generated for each RSD assembly at the start of acceptance testing, and a complete historical record is maintained for the life of the RSD.

O SAFE 1 OR SAFE 2 SWITCH FAILED OPEN

o The safe 1 and safe 2 switches are located on the S&A assembly controller module. The controller module meets all of the requirements of the range safety distributor assembly spec for the SRB (10SPC-0148), has been flown on all shuttle missions to date, and is qualified to the twenty mission level. This module has the following design features that were incorporated to mitigate this cause of failure:

- The two-sided printed wiring board (PWB) was designed to MSFC-STD-154 and contains plated through holes that are used as mechanical reinforcement rather than as an interconnection between the two sides of the board. Electrical interconnection is by Z-wire or component. The board is conformal coated after the components have been mounted and the board has been tested. (BI-1730)

- The electrical component parts that are used in the safe 1 and safe 2 circuits are either selected from the "EEE Parts Selection and Application Guidelines," (10REQ-0036), or are screened up to the requirements of 10REQ-0036 to assure high reliability parts are used.

- The mechanical packaging design is also conservative employing component mounting for stress free solder connections, high temperature printed wiring boards and tack bonding of components where required. In addition, the design utilizes a metal frame to support, enclose and protect the PW board and components.

- Discrete components with proven reliability are used throughout the design.

- The PWB assembly is designed to operate within specification at 185^{o}F, which allows for a 30^{o}F temperature gradient from the assembly to the 155^{o}F temperature requirement for the RSD case.

- Both switches are designed to provide one hundred percent margin on output current.
- Optical isolation on the command inputs eliminates ground loop problems.
- The on/off command signals reduce the complexity of the circuits (improved reliability) as compared to sensitive analog linear circuitry.
- Adequate heat sinks are provided for all power transistors.
- The circuits have been signed to be tolerant to wide variations in power levels and voltages.

o The design features noted and the use of high reliability parts selected from or screened to 10REQ-0036, mitigate the probability of the failure causes referenced in this failure mode.

O Open or Short in Wiring Harness

o The wiring harness interconnects the connectors, junction blocks, card connectors and terminal boards. The wire and connector pins meet all of the requirements of the RSD assembly SPEC 10SPC-0148, have been flown on all shuttle missions to date and are qualified to the twenty mission level. The harness has the following design features that were incorporated to mitigate this cause of failure:

- The circuit board connectors were selected from MSFC 16A10455 and 16A10448 and torqued to MSFC 16A10310.
- Wires are terminated per NHB 5300.4 (3A-1) and JD-001, which assure reliable connections.
- The harnesses are laced per MIL-E-45782 to prevent vibration or shock damage.

o The connectors are located at each end of the RSD housing. The connector meets all of the requirements of the RSD assembly SPEC for the SRB 10SPC-0148, has been flown on all shuttle missions to date and is qualified to the twenty mission level. The connectors have the following design features that were incorporated to mitigate this cause of failure:

- These exterior flange mount connectors were selected from MSFC 40M39569 and the pin arrangement is in accordance with 16A10300.
- The selection of the pin arrangement assures that an adjacent pin short will not cause a mission failure.
- Different keying arrangements on these connectors, preclude mismating with the external harness.

o The connectors are hermetically sealed, and therefore, prevent airborne contaminants from entering the case.

O Open Junction Block

o The junction blocks are judiciously located within the RSD case. The junction blocks meet all of the requirments of the RSD assembly spec, 10SPC-0148, have been flown on all Shuttle missions to date and are qualified to the twenty-mission level. These junction blocks have the following design features that were incorporated to mitigate this cause of failure:

o The design of the junction block provides protection from contamination by use of an insulator material around the entry wire. There are no exposed electrical surfaces or points.

o The tooling and manufacturing processes that govern the assembly of he wiring harness to the junction blocks are all controlled by MSFC specs and procedures.

B. TESTING

VENDOR RELATED TESTING

- The safe and arm controller module is first tested after complete assembly at the board level and again as part of the completed RSD acceptance tests (per Acceptance Test Procedures 5135181-GTSP or 5135123-GTSP). Acceptance testing verifies no loss of S&A safe output at the time of testing. (All Failure Causes)

- All printed wire assemblies (PWA) are acceptance tested with power input and signal inputs at the minimum and maximum voltage. The test temperature is 30°F above the maximum case temperature of the RSD assembly. The elevated temperature and increased input voltage variations are used to mitigate failure of the PWAs when exposed to the RSD level temperature and voltage requirements per Acceptance Test Procedures 5136115-GTS, 5136251-GTSP and 5136994-GTSP). (All Failure Causes)

- A push/pull test is performed on all connectors and junction blocks after the wiring harness is installed in the chassis per Bendix pull test procedure 5136632 GMS.

KSC RELATED TESTING

- All RSDs, new or refurbished are bench tested per 10REQ-0021, Appendix E. (All Failure Causes)

- Safe and Arm circuitry is tested during ACO per 10REQ-0021, para. 1.2.2.14.

- Verify operation of SRSS S&A device per OMRSD File II, Vol. 1, requirement number S00000.400.

- The above referenced OMRSD testing is performed every flight.

- The S&A assembly is armed at approximately T-5 min. The S&A assembly position is monitored by event measurements B55X1869X and B55X1870Xper OMRSD File II, Vol. I, requirement number S00FM0.210.

REFURBISHMENT/RECERTIFICATION TESTING

- Previously Flown RSD's are Refurbished and Recertified for flight per 10SPC-0131 and applicable ROD's.

- All USA SRBE/TBE Recertified RSD's are Acceptance Tested per applicable RODs(All Failure Causes)

- ESD Protection Requirements are imposed per OMRS 10REQ-0021, Para. 4.11

C. INSPECTION

VENDOR RELATED INSPECTION

O Solder, flux, conformal coating, wire and copper clad board material are sample inspected upon receipt. USA SRBE PQAR verifies material certification and receiving inspection/test records per USA SRBE SIP 1091.

O Junction blocks, card connectors and environmentally sealed connectors are sample inspected upon receipt (one percent AQL). USA SRBE PQAR verifies material certification and receiving inspection/test records per USA SRBE SIP 1091.

O Transistors, optical couplers and diodes receive one hundred percent functional testing at Bendix. Capacitors and resistors are sampled at Bendix, one percent AQL. Magnetics have one hundred percent visual, dimensional and functional acceptance by Bendix Quality. USA SRBE PQAR verifies test data on electronic parts and screening test data per USA SRBE SIP 1091.

O Bendix QA inspects printed wiring boards to the requirements of MSFC-STD- 154.

O USA SRBE PQAR verifies traceability records per USA SRBE SIP 1091.
O USA SRBE PQAR verifies crimping, conformal coating and traceability records per USA SRBE SIP 1091. (No arm or fire, fire switch failed, failed power latch)

O Bendix QA inspects one hundred percent of the solder and crimp connections that go into the harness per Bendix flow chart 5116726. (Open resistor, Wiring harness) (BI-1841)

O The final loading of the modules into the distributor is witnessed by Bendix per Bendix flow chart 5116726. USA SRBE PQAR performs visual inspection of the unit after installation of plug-in boards per USA SRBE SIP 1091.

O Final acceptance is witnessed by Bendix Quality per Bendix flow chart 5116726. USA SRBE PQAR witnesses final manual acceptance testing and verifies data for all automated final acceptance testing per USA SRBE SIP 1091. (All Failure Causes)

O Critical Processes/Inspections/Operations:

- o Soldering per NHB5300.4 (3A-1) (BI-1903R1)
- o Conformal coating per MSFC-PROC-508
- o Staking per MSFC-STD-136
- o Crimping per Bendix-PROC-5136598

KSC RELATED INSPECTIONS

O USA SRBE Quality monitors and accepts distributor bench testing. (All Failure Causes)

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O USA SRBE Quality witnesses torquing of distributor to equipment panel and electrical bonding resistance between distributor and panel.

O Data from the Following OMRSD Required Test is verified to be Acceptable by a Quality Representative:

- RSD Functional Test per 10REQ-0021, paragraph 1.2.2.13 after installation. (All Failure Causes)

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- RSD Output data on all RSD's during Cross Strap Test per OMRSD File II, Vol. I, Requirements S00000.200, S00000.210, S00000. 220, S00000.230. (All Failure Causes)

- RSD Output data on all five RSS Subsystems during Final Ordnance Installation Test on the Pad Per OMRSD File II, Vol. I, Requirement S00000.380/390. (All Failure Causes)

REFURBISHMENT/RECERTIFICATION INSPECTION

O RSD's are inspected externally after each Flight per 10SPC-0131 for bent or broken connector pins and other visible damage.

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O RSDs are inspected internally after every third flight or five years, which ever come first for bent or broken connector pins, cracked solder joints, loose or broken components, arcing or burning of conformal coating, physical damage, torque or other items as applicable to product quality. The S&A, PIC, and controller modules are not disassembled for inspection. The RSD Assembly is cleaned and cosmetic damages repaired. If anomalies beyond the repairable limits outlined in 10SPC-0131 are noted, the RSD is returned to the vendor for repair and acceptance testing.

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O USB Quality Witness acceptance testing of all USA SRBE/TBE Florida Operations refurbished RSDs per design specification 10SPC-0148 (All Failure Causes)

D. FAILURE HISTORY

O Failure Histories may be obtained from the PRACA database.

E. OPERATIONAL USE

o Not applicable to this failure mode.

F. WAIVER/DAR

o BI-1730, 4-26-89, CCBD SB3-01-2322

- SPECIFIED REQUIREMENT:

  10CEI-0001 Paragraph 3.3.5.11 states that "Malfunction or inadvertent operation of vehicle electrical or electronic equipment caused by exposure to conducting or non-conducting debris or foreign material shall be prevented by design."

- DEPARTURE:

  RSDs PWAs have an exposed uninsulated air gap between each board and its card edge connector. The contacts and solder joints inside this "gap" are not conformal coated and thus subject to debris related problems.

- JUSTIFICATION:

  PWAs are inspected and cleaned to NHB 5300.4 (1C), (1D-1), (3A-1) and MSFC-STD-136 specifications. PWAs are assembled in a controlled environment and each distributor must pass vibration tests at ATP as well as a thorough electrical and functional checkout.

o BI-1841, 6-21-90, CCBD SB3-01-3470

- SPECIFIED REQUIREMENT:

  Crimping of electrical connections shall be in accordance with JD-001.

- DEPARTURE:

  RSDs do not meet crimping requirements of JD-001 paragraph 3.1.2, 3.4.2 and 3.2.1.4.

- JUSTIFICATION:

  All crimps have undergone 100 percent visual inspection by certified operators and inspectors. No-inflight failures have occurred due to improperly crimped connections.

  Although the positioner is part of the crimp tool setup, proper positioner selection is verified by certified operators and inspectors prior to use of a tool in crimping operations.

o BI-1903R1, 2-15-91, CCBD SB3-01-3982A

- SPECIFIED REQUIREMENT:

  Removal of Flux and Residue from each soldered connection shall be in accordance with NHB 5300.4(3A-1), para. 3A802.

- DEPARTURE:

  Inaccessibility of solder joint between Transistor Q2 and the series regulator PWB does not allow for proper cleaning of the solder flux and residue from each soldered connection.

- JUSTIFICATION:

All solder joints on Q2 RSD series regulators have been inspected by X-ray to verify solder connections. All RSD PWAs were built using SN63 solder with RMA Flux. The area in question is sealed to moisture by conformal coating prior to the series regulator PWB being installed in the SRB RSD. The RSD is a sealed unit with the seal integrity verified prior to each flight. Conformal coating and inert environment reduce

the possibility of organic/inorganic growth. Voltage regulation is functionally tested during ATO, ACO, SIT, Ordnance installation and final countdown. Regulated voltage LCC exists to terminate a countdown if violated.

O BI-1981, PN 10406-0147-851, SN 1000120, 01/04/96, CCBD SB3-01-5009 (BI-077 - BI-999)

- SPECIFIED REQUIREMENT:

10CEI-0001
Paragraph 3.2.7.2.1 - Ascent Vibration, Acoustic and Shock environments Paragraph 3.2.7.2.2 - ReentryVibration, Acoustic and Shock environments

- DEPARTURE:

The RSD's have always been Tested with an imposed Acceleration Spectral Density Tolerance of +3/-1.5 DB. The vendor had vibration abort limits set significantly higher during Acceptance Test for repaired RSD's.

- JUSTIFICATION:

The exceedance was within the Flight/Reentry Qualification Vibration Envelope. The Qualification Unit (IEA) has been through 20 Flight Qualification Missions. The Flight Qualification is to the maximum expected environments over the life of the RSD. This is a High Frequency narrow band spike that is separated by over 1 octave from the broad resonances.

O BI-1984, PN 10406-0147-854, SN 1000133, 1000139, 02/08/96, CCBD SB3-01-5022 (BI078-BI999)

- SPECIFIED REQUIREMENT:

10CEI-0001
Paragraph 3.2.7.2.1 - Ascent Vibration, Acoustic and Shock environments Paragraph 3.2.7.2.2 - ReentryVibration, Acoustic and Shock environments

- DEPARTURE:

The RSD's have always been Tested with an imposed Acceleration Spectral Density Tolerance of +3/-1.5 DB. The vendor had vibration abort limits set significantly higher during Acceptance.

- JUSTIFICATION:

  The exceedance was within the Flight/Reentry Qualification Vibration Envelope. The Qualification Unit (RSD) has been through 20 Flight Qualification Missions. The Flight Qualification is to the maximum expected environments over the life of the RSD. This is a High Frequency narrow band spike that is separated by over 1 octave from the broad resonances.

O BI-1987, PN 10406-0147-851, SN 1000113, 1000139, 03/18/96, CCBD SB3-01-5036

O BI-1987a, PN 10406-0147-851, SN 1000112, 1000115, PN 10406-0147-854, SN 1000135; 05/07/96, CCBD SB3-01-5065

O BI-1987b, PN 10406-0147-851, SN 1000108, 1000109, 1000125, 1000126, PN 10406-0147-854, SN 1000107, 1000116, 1000123, 1000131, 1000137, 1000138, 07/11/96, CCBD SB3-01-5081

- SPECIFIED REQUIREMENT:

  10CEI-0001
  Paragraph 3.2.7.2.1 - Ascent Vibration, Acoustic and Shock environments Paragraph 3.2.7.2.2 - ReentryVibration, Acoustic and Shock environments

- DEPARTURE:

  The RSD's have always been Tested with an imposed Acceleration Spectral Density Tolerance of +3/-1.5 DB. The vendor had vibration abort limits set significantly higher during Acceptance.

- JUSTIFICATION:

  The exceedance was within the Flight/Reentry Qualification Vibration Envelope. The Qualification Unit (RSD) has been through 20 Flight Qualification Missions. The Flight Qualification is to the maximum expected environments over the life of the RSD. This is a High Frequency narrow band spike that is separated by over 1 octave from the broad resonances.