SRB CRITICAL ITEMS LIST

SUBSYSTEM: RANGE SAFETY COMMAND DESTRUCT

ITEM NAME: Range Safety Distributor
Forward Integrated Electronic Assembly (IEA)*

PART NO.: 10406-0147
10400-0329-803*

FM CODE: A30

ITEM CODE: 70-09

REVISION: Basic

CRITICALITY CATEGORY: 1R

REACTION TIME: Seconds

NO. REQUIRED: 1

DATE: March 31, 2000 CN 038

CRITICAL PHASES: Boost

SUPERCEDES: March 31, 1997 CN 038

FMEA PAGE NO.: F-35

ANALYST: S. Parvathaneni CN 038

SHEET 1 OF 10

APPROVED: S. Parvathaneni CN 038

FAILURE MODE AND CAUSES: Loss of Channel A and Channel B power caused by one of the following in each channel (requires two failures):

- Open or short in wiring harness
- Open junction block
- Open shunt resistor (A side only)
- Open coil or shorted capacitor in filter (-851,-854, B side only)
- Open shunt resistor in FWD IEA (B side only)
- Open or short in wiring harness in FWD IEA (B side only)
- Failed series regulator (-851,-854, A side only;)
- Failed Power Latch Switch in RS Controller

FAILURE EFFECT SUMMARY: Loss of destruct capability of one SRB leading to loss of life or injury to the public. Inability to safe the S&A device during a launch scrub results in a hazard to the flight and ground crews until the S&A device can be accessed and mechanically safed. One success path remains after the first failure. Operation is not affected until both paths are lost.

*Forward IEA is redundant to the Range Safety Distributor for open or short in wiring harness and open shunt resistors only.

REDUNDANCY SCREENS AND MEASUREMENTS:

1. Pass - Checked during ATP, bench test, SIT and final countdown. Monitored during final countdown by voltage measurement B55V1625C and B76V1602C, current measurements B55C1051C and B76C1050C, and event measurements B55X1871X and B55X1872X.

2. Pass - Monitored from lift off to separation by voltage measurement B55V1625C and B76V1602C, current measurements B55C1051C and B76C1050C, and event measurements B55X1871X and B55X1872X.

3. Pass - No known credible causes.

RATIONALE FOR RETENTION:

A. DESIGN

O The Range Safety Distributor (RSD) is redundant in its functions. The design provides one common housing with a cast aluminum wall separating the two redundant systems (System A and System B) so that no electrical failure in one system can propagate to the other. Redundant arm and fire signals are routed to systems A and B by the wiring harness and junction blocks in each unit. The specific RSD design feature that was implemented to mitigate the failure causes is true parallel redundancy.

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-019-033-2H. 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 The design features noted and the use of high reliability parts selected from or screened to 10REQ-0036 to mitigate the probability of the failure causes referenced in the 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 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 are torqued to MSFC 16A10310.

- Wires are terminated per NHB5300.4(3A-1) and JD-001, which assure reliable connections.

- The harnesses are laced per MIL-E-45782 to prevent vibration or shock damage.

- The connectors are located at each end of the RSD housing. The connectors meet all of the requirements of the RSD assembly spec for the SRB, 10SPC-0148, have been flown on all Shuttle missions to date and are 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.

- The connectors are hermetically sealed to preclude 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 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. These junction blocks have the following design features that were incorporated to mitigate this cause of failure:
- o The junction blocks are per MSFC 16A10104. This spec governs the contact arrangement, size, materials, blocking system, mounting points and source.
- 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 the wiring harness to the junction blocks are all controlled by MSFC specs and procedures.

O Open Shunt Resistor (A side only) (B side shunt resistor located in forward IEA)

- o The shunt resistor uses silver soldered internal connections for reliability and good thermal connection characteristics.
- o The resistor is rated at 25 watts and only dissipates 0.05 watts.

O Open Coil or Shorted Capacitor in Filter (B side only)

- o Resistors, coils and capacitors are selected from or screened to the requirements of 10REQ-0036 and derated to the requirements of 10REQ-0036.

O Open Shunt Resistor (Forward IEA)

- o The Shunt Resistor and other components meet the requirement of the Forward IEA specification 5136100-CEI, Rev. E, which has flown on all Shuttle Missions to Date and is qualified for twenty missions. The Shunt resistor has the following design features incorporated to mitigate the listed Failure Cause:
  - The Resistor is selected or screened to the requirements of 85M03936 , is rated for 25 watts and only dissipates 0.05 watts in this circuit.
  - The Resistor uses silver soldered internal connections for reliability good thermal transfer characteristics.

Open or short in wiring harness in Forward IEA (B Side only)

The wiring harness interconnects the I/O connectors, junction blocks, and subassembly connectors. The wiring harness meets the requirements of Forward IEA specification 5136100-CEI, Rev. E, has flown on all shuttle missions to date and is 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 are torqued to MSFC 16A10310.
- Wires are terminated per NHB5300.4(3A-1) and JD-001, which assure reliable connections.
- The harnesses are laced per MIL-E-45782 to prevent vibration or shock damage.
- The exterior flange mount connectors were selected from MSFC 40M39569.
- The selection of the pin arrangement assures that an adjacent pin short will not cause a mission failure.
- The connectors are hermetically sealed to preclude airborne contaminants from entering the case.

O Failed Series Regulator

o The series voltage regulator has the following design features to mitigate the listed failure mode:

- The PWB is designed to MSFC-STD-154 with plated through holes per MSFC-SPEC-50M60444. The plated through holes are used as reinforcement only with electrical connection made by Z wires. The board is conformally coated after the components have been mounted and the assembly has been tested and inspected.
- Verification of the electrical design included "worst case" stress and thermal analysis which considers component tolerances and stability through end of life and predicts component temperatures. The mechanical packaging design is also conservative, employing component mounting for stress free solder connections, high temperature printed wiring boards and conformal coating.

o The electrical design of the voltage regulator is conservative. The electrical components are either selected from "EEE Parts Selection and Application Guidelines" (10REQ-0036) or are screened to the requirements of 10REQ-0036. This parts selection and screening assure the use of only high reliability parts.

- The series regulator transistor is rated at 100 watts maximum. The nominal power dissipation is 6 watts. The maximum rated current is ten amps. In the circuit, the nominal current is less than one-half amp. The worst case current is a three and one-half amp surge for 250 milliseconds during S&A assembly activation.
- The PWB is designed to operate within specification at 185^{O}F, which allows for a 30^{O}F temperature rise above the requirement for the RSD case.
- Adequate heat sinks have been provided for all power components.
- The circuits have been designed to tolerate a wide variation in power levels and voltages.

O Power Latch Switch Failure

o The unavailability of some transistors led to a complete redesign of the controller card. The new design, P/N 5107812-9 or P/N 5107812-19 (Alternate), has completed the seven mission Qual Test series (Ref.

Qual Test Report EE-QTR-001-86) and is currently undergoing the thirteen-mission Qual Test series. The new design was flown for the second time on STS-51L, and is the only approved design for SRB flights starting with BI027.

- The controller card meets all of the requirements of the range safety distributor specification P/N 10SPC-0148. This card has the following design features that were incorporated to mitigate this cause of failure.

- The multi-layered PWB is designed and inspected to the requirements of 56M60420. Electrical connection between layers is completed by plated through holes. The board is conformal coated after the electrical piece parts have been mounted and the board has been tested and inspected.

- Verification of the electrical design included "worst case" electrical stress and thermal analyses, which consider component tolerances and stability through end of life and predicts component temperatures. The mechanical packaging design is also conservative, employing component mounting for stress-free solder connections, high temperature printed wiring boards and conformal coating. (BI-1730)

- The electrical design of the control card is conservative. The electrical component parts are either selected from "EEE Parts Selection and Guidelines" (10REQ-0036) or are screened to the requirements of 10REQ-0036. This parts selection and screening assure the use of only high reliability parts.

- Arm switches are designed to provide a six hundred percent margin on current and one hundred percent on voltage at output. Fire switches are designed to provide a three hundred percent margin on output current and fifty percent on voltage.

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

- The power switch is designed to provide four hundred percent margin on output current, and one hundred twenty percent on voltage.

- Optical isolation on the cross-strapped command inputs eliminates ground loop problems.

- The use of latching concepts improves the probability to respond to commands for these functions. 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.

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

- The circuits have been designed to be tolerant to wide variations in power levels and voltages.

- One of the functions of the RSD is to execute the command to latch the power to Arm and Fire latch circuits on the Range Safety controller board and to the IRD. This command is implemented functionally by setting the power latch to the "On" position to supply power to the associated circuitry. Redundant power "on" and "off" commands are supplied to System A and System B via separate cables and connectors.

B. TESTING

VENDOR RELATED TESTING

O During manufacturing all printed wiring assemblies are tested first at the board level to more stringent requirements and again as part of the completed distributor assembly acceptance testing. Each RSD is acceptance tested. The acceptance test includes a complete functional and environmental test (per Bendix Acceptance Test Procedures 5135181-GTSP and 5135123-GTSP). Acceptance testing establishes the absence of listed failure modes at the time of testing. (All Failure Causes)

O All newly assembled boards are subjected to Fairchild card testing before power is applied per Bendix Flow Chart 5116726.

O All printed wire assemblies (PWA) are acceptance tested with the power input and signal inputs at the minimum and maximum voltage. The test temperature is 30 degrees 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)

O 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. (Open Junction Block)

KSC RELATED TESTING

O During ACO Test Operations, Electrostatic Discharge (ESD) Protection/Precautions are implemented IAW OMRSD 10REQ-0021 Paragraph 4.11

O All OMRSD RequiredTesting listed below is performed prior to each flight.

O RSS RSD circuits are verified during ACO per 10REQ-0021, Paragraph 1.2.2.13.(All Failure Causes)

O RSS RSD functions are verified during Cross Strap Test performed during Systems Integration performed per OMRSD File II Vol. I, Requirements S00000.200, S00000.210, S00000.220 and S00000.230. (All Failure Causes)

O RSS RSD functions are verified with a response Test performed during Final Ordnance Connection on the PAD per OMRSD File II Vol. I, Requirements S00000.380 and S00000.390. (All Failure Causes)

O RSS Power application is verified with a Receiver response Test performed during Final Countdown on the PAD per OMRSD File II Vol. I, Requirements S00FH0.031 or S00FH0.032.(All Failure Causes)

O RSS RSD Arm/Fire circuits are last verified during Final Ordnance Connection.

RECERTIFICATION/REFURBISHMENT TESTING

- O All Previously flown RSDs are refurbished and tested per USA SRBE 10SPC-0131.
- O All USA SRBE/TBE Florida Operations Recertified RSDs are acceptance tested per design specification 10SPC-0148. (All Failure Causes)
- O ESD Protection Requirements are imposed per OMRS 10REQ-0021, Paragraph 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 (1 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 100% visual, dimensional, and functional acceptance by Bendix Quality. USA SRBE PQAR verifies test data on electronic parts and screen test data per USA SRBE SIP 1091.
- O Bendix QA inspects printed wiring boards to the requirements of 50M60420.
- O USA SRBE PQAR verifies traceability records per USA SRBE SIP 1091.
- O Bendix QA inspects one hundred percent of the solder and crimp connections that go into the harness per Bendix Flow Chart 5116726. (Wiring Harness) (BI-1841)
- O Critical Processes/Inspections/Operations
    - o Soldering per NHB5300.4(3A-1) (BI-1903R1)
    - o Staking per MSFC-STD-136
    - o Conformal coating per MSFC-PROC-508
    - 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 Test Data from all OMRSD RequiredTesting listed below is verified acceptable by a Quality Representative:

- RSD functional verification during ACO per 10REQ-0021, Paragraph 1.2.2.13.(All Failure Causes)

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- RSD functional verification during Cross Strap Test performed during Systems Integration per OMRSD File II Vol. I, Requirements S00000.200, S00000.210, S00000.220 and S00000.230. (All Failure Causes)

- RSD Functional verification Test performed during Final Ordnance Connection on the PAD per OMRSD File II Vol. I, Requirements S00000.380 and S00000.390. (All Failure Causes)

- RSS Receiver/Decoder circuit verification performed during Final Countdown on the PAD per OMRSD File II Vol. I, Requirements S00FH0.031 or S00FH0.032.(All Failure Causes)

RECERTIFICATION/REFURBISHMENT INSPECTION

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

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O RSDs are internally inspected after every third flight or five years, which ever come first in accordance with USA SRBE 10SPC-0131 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 is cleaned and cosmetic damages repaired. If anomalies indicating damages beyond the repairable limits outlined in 10SPC-0131 are noted, the RSD is returned to the vendor fror repair and acceptance Testing. (All Failure Causes)

O USA SRBE 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-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.