SUBSYSTEM: RANGE SAFETY COMMAND DESTRUCT

ITEM NAME: Range Safety Distributor (RSD)

PART NO.: 10406-0147

FM CODE: A15

ITEM CODE: 70-09

REVISION: Basic

CRITICALITY CATEGORY: 1

REACTION TIME: Immediate

NO. REQUIRED: 1

DATE: March 31, 2000 CN 038

CRITICAL PHASES: Boost

SUPERCEDES: March 31, 1997 CN 038

FMEA PAGE NO.: F-26

ANALYST: S. Parvathaneni CN 038

SHEET 1 OF 8

APPROVED: S. Parvathaneni CN 038

FAILURE MODE AND CAUSES: Unscheduled destruct command output channels A and/or B, left or right SRB (failure must occur after arm command is issued, but prior to issuance of destruct command) caused by:

O Shorted fire switch.

FAILURE EFFECT SUMMARY: Loss of mission, vehicle and crew. This is a critical failure only for the time period (seconds) after a valid arm command is received and prior to receiving a valid fire command. This failure is the same as the intended and eminent effect after a valid arm command is issued. An arm command is issued only after a decision is made to destruct. The Range Safety Officer (RSO) does not send the arm command until vehicle destruction is required. The STS Operation Flight rules (JSC, final edition dated 12-16- 85 and amended by PCN1) states in rules 2-16 and 4-21: "The Range Safety programmed time delay between arm and fire will not provide for crew escape."

RATIONALE FOR RETENTION:

A DESIGN:

Two RSD functions are to execute the Arm and Fire commands that are issued by the IRDs. These commands are implemented functionally by setting the arm latch switch to supply power to the fire latch switch and to supply power to the PIC capacitor charge/discharge circuitry. The fire latch switch commands the capacitor discharge circuits "on". The PIC discharges the stored capacitor energy into an associated NSD device via output connectors and cables. The design of the RSD implements these functions in hardware by providing connectors, wiring harnesses, junction blocks, controller boards, PIC boards, and associated power sources and command functions.

The Range Safety Distributor (RSD) is designed with the arm switch in series with the fire switch, so that the fire switch cannot latch or output until the arm switch is on. This failure mode exists only during the period from approximately 150 milliseconds after the arm command until the issuance of a destruct command. If the fire switch shorts prior to the arm command, the PIC will dud upon issuance of an arm command. The PIC is designed so that the capacitor bank will not charge if a fire command is received before the arm command; therefore, if the short occurs prior to the arm command, the PIC capacitor bank can never charge. If the short occurred within 150 ms after the arm command is issued, the PIC capacitor bank will not have stored enough energy to fire a NSD and will probably dud (Ref. Test Report 16A00100, paragraph 7.6.1).

- 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.

- 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.

- Shorted Fire Switch

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 PWB assembly is designed to operate within spec 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.

- 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.

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

O The electrical design of the controller 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.

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

O This failure mode could be caused by the failure of any one of several electronic piece parts. The individual piece parts are listed in Bendix "FMEA and Critical Items List for the SRB RSD" (5499795). All the critical parts are selected from "EEE Parts Selection and Application Guide lines", (10REQ-0036) or have been screened to the requirements of 10REQ-0036. In addition, the circuit design provides considerably more derating than required by 10REQ-0036. The derating of each piece part is reported in Bendix "RSD Controller Electrical Component Stress Analysis, (5460556-MT, Revision A).

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. The PIC module, purchased as a complete assembly, is functionally tested before installation into the RSD and again as part of the RSD. Each RSD is acceptance tested. The acceptance test includes a complete functional and environmental test. (Ref. Bendix Acceptance Test Procedures 5135181-GTSP and 5135123-GTSP). Acceptance testing establishes the absence of the failure mode at the time of testing. (Shorted Fire Switch)

O All newly assembled boards are subjected to Fairchild card testing before power is applied. (Ref. Bendix Flow Chart 5116725). (Shorted Fire Switch)

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 $30^{O}F$ 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 (Ref. Acceptance Test Procedures 5136115-GTS, 5136251-GTSP and 5136994-GTSP). (Shorted Fire Switch)

O A push/pull test is performed on all printed wiring board connectors and junction blocks after the wiring harness is installed in the chassis (Ref. Bendix Pull Test Procedure 5136632 GMS).

KSC RELATED TESTING

O All RSDs (new or refurbished) received at KSC are bench tested prior to installation per 10REQ-0021, Appendix E. (Shorted Fire Switch)

O RSS arm and fire circuits are tested during ACO per 10REQ-0021, paragraphs 1.2.2.15.1 and 1.2.2.15.2 respectively. (Shorted Fire Switch)

O Verify open loop response by all five receiver/decoder subsystems using test code for SRSS per OMRSD File II, Vol. 1, requirement number S00000.380.

O Verify operation of SRSS with flight code (closed loop) per OMRSD File II, Vol. 1, requirement number S00000.390.

O Destruct output receives its final check during ordnance installation. (Shorted Fire Switch)

The above referenced OMRSD testing is performed every flight

REFURBISHMENT/RECERTIFICATION TESTING

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

O All USA SRBE/TBE Recertified RSD's are Acceptance Tested per applicable ROD's. (All Failure Causes)

O 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. 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 inspection and functional test 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 electrical parts and screening data per USA SRBE SIP 1091. (Shorted Fire Switch)

O Bendix QA inspects printed wiring boards to the requirements of 50M60420.

O USA SRBE PQAR verifies crimping, conformal coating and traceability records per USA SRBE SIP 1091.

O Bendix QA and USA SRBE PQAR verify that all test procedures are current and approved, and verify all board level test data per USA SRBE SIP 1091 and Bendix Flow Chart 5116726.

O Bendix QA inspects 100% of the solder and crimp connections that go into the harness per Bendix Flow Chart 5116726. (BI-1841)

O The final loading of the modules into the distributor is witnessed by Bendix QA per Bendix Flow Chart 5116726. USA SRBE PQAR performs visual inspection of 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 acceptance testing and verifies data for all automated final acceptance testing per USA SRBE SIP 1091. (Shorted Fire Switch)

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

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.

CN 038

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.

CN 038

O USB Quality Witness acceptance testing of all USA SRBE/TBE Florida Operations refurbished RSDs per applicable RODS(All Failure Causes)

KSC RELATED INSPECTIONS

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

CN 038

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)

CN 038

- 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)

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 n a controlled environment and each distributor must pass vibration tests at ATP as well as a thorough electrical and unctional 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 10406-0147-851, SN 1000133, 1000139, 02/08/96, CCBD SB3-01-5022

- 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 Acceptance

- JUSTIFICATION:

  The exceedance was within the Flight/Reentry Qualification Vibration Test 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.

O BI-1987, PN 10406-0147-851, SN 1000133, 1000139, 03/18/96, CCBD SB3-01-5036

O BI-1987A, PN 10406-0147-851, SN 1000112, 1000115, 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