SUBSYSTEM: RANGE SAFETY COMMAND DESTRUCT

ITEM NAME: Range Safety Distributor

PART NO.: 10406-0147 FM CODE: A03

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 SUPERCEDES: March 31,1997 CN 038

FMEA PAGE NO.: F-19 ANALYST: S. Parvathaneni CN 038

SHEET 1 OF 7 APPROVED: S. Parvathaneni CN 038

FAILURE MODE AND CAUSES: Unscheduled destruct output to NSD A or B caused by:

O Two failed "ON" transistor switches in RS controller module. The switches are in series and must fail in sequence.

FAILURE EFFECT SUMMARY: Unscheduled detonation of LSC leading to loss of mission, vehicle and crew. One success path remains after the first failure. Operation is not affected until both paths are lost.

REDUNDANCY SCREENS AND MEASUREMENT:

1. Pass- The switches are tested during ATP, bench test, ACO, SIT and at ordnance installation. The switches are monitored from lift-off through separation by Event Measurements B55X1865X, B55X1866X, B55X1867X and B55X1868X, and voltage measurements B55V1623C and B55V1624C.

2. Fail - Unable to detect shorted fire switch unless arm switch is on or shorted.

3. Pass- No known credible causes

RATIONALE FOR RETENTION:

A. DESIGN

O The RSD is designed with an arm switch in series with the fire switch such that the fire switch can not latch or output until the arm switch is on. The PIC circuit is designed so that the capacitor bank will not charge if a fire command is received before the arm command. This failure mode would require the arm latch switch to short at least 150 milliseconds before the fire latch switch shorted.

O There is a single vendor source for the RSD, Bendix Guidance and System Division. Bendix has been certified as a supplier by completing qualification testing. The RSD has completed delta qualification to the twenty mission level (Ref. Qual Test Report EE-QTR-91-001). The mission qualification is documented in COQ R-ASS-3113-4 and COQ A-RSS-3113-5.

O Two Failed "On" Transistor Switches in RS Controller Module

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 incorporated to mitigate this cause of failure.

O The multi-layered PWB is designed and inspected to the requirements of 50M60420. 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.

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 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)

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

O 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.

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

- O The use of latching concepts improves the probability of responding 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.

- O Adequate heat sinks are provided for all power transistors.

- O 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 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.

B. TESTING

VENDOR RELATED TESTING

- O The switch circuits are first tested at the board assembly level and again during the acceptance test of the RSD. This circuit is functionally tested, including no shorted arm or fire switch, by Range Safety System Tests performed on the forward skirt prior to stacking. A similar test is performed after the SRB is clustered with the Orbiter and ET. (Switches).

- O All newly assembled boards are subjected to Fairchild card testing before power is applied per 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°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. (Switches)

- O The switch has its electrical characteristics tested after complete assembly on its plug-in board, and is tested again as part of the completed distributor assembly acceptance testing per Acceptance Test Procedures 5135181-GTSP and 5135123-GTSP. (Switches)

KSC RELATED TESTING

- O Each RSD received at KSC (new or refurbished) is bench tested prior to installation per requirements of 10REQ-0021, Appendix E. (Switches)

- 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 The destruct output cannot be tested after live ordnance is connected. (Switches)

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 RODs.
- O All USA SRBE/TBE Recertified RSD's are Acceptance Tested per design specification 10SPC-0148 (All Failure Causes)
- O ESD Protection Requirements are imposed per OMRS 10REQ-0021, Para. 4.11

C. INSPECTION:

VENDOR RELATED INSPECTION

- 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 data per USA SRBE SIP 1091. (Switches)
- O Bendix QA inspects printed wiring boards to the requirements of 50M60420.
- O The assembly is checked to appropriate drawings. 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 one hundred percent of the solder and crimp connections that go into the harness per Bendix Flow Chart 5116726. USA SRBE PQAR performs visual inspection of harness and visual inspection of assembly of harness in chassis per USA SRBE SIP 1091. (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 manual acceptance testing and verifies data for all automated final acceptance testing per USA SRBE SIP 1091. (Switches)
- O Critical Processes/Inspections/Operations:
  - o Soldering per NHB5300.4(3A-1)
  - o Conformal Coating per MSFC-PROC-508
  - o Staking per MSFC-STD-136

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 applicable RODS(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-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 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.