

SRB CRITICAL ITEMS LIST

SUBSYSTEM: RANGE SAFETY COMMAND DESTRUCT

ITEM NAME: Hybrid Coupler

PART NO.: 10406-0108-108, -110, -111, -112, -113
10406-0150-852, -853

FM CODE: A02

DCN032

ITEM CODE: 70-04

REVISION: Basic

CRITICALITY CATEGORY: IR

REACTION TIME: Seconds

NO. REQUIRED: 1

DATE: March 31, 1997

DCN032

CRITICAL PHASES: Boost

SUPERCEDES: March 1, 1996

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FMEA PAGE NO.: F-9

ANALYST: D. Owens/S. Roney

DCN032

SHEET 1 OF 5

APPROVED: P. Kalia

FAILURE MODE AND CAUSES: Loss of RF output of both channels caused by:

- Pin open or shorted on input connectors (J1 and J3)
- Faulty microstrip
- Pin open or shorted on output connectors (J2 and J4)

FAILURE EFFECT SUMMARY: Loss of destruct capability of one SRB if it should break away from the cluster, leading to loss of life or injury to the public. One success path remains after the first failure. Operation is not affected until both paths are lost.

REDUNDANCY SCREENS AND MEASUREMENTS:

1. Pass- Checked at ACO, SIT, ordinance installation and during countdown. Checked in final countdown by receiver signal strength measurements B55E1100C and B55E1101C.
2. Fail - All redundant paths can not be checked in flight.
3. Pass- No known credible causes.

RATIONALE FOR RETENTION:

A. DESIGN:

- The hybrid coupler is an integral part of the RF signal path from Antenna A to the integrated receiver decoders (IRD) via J1 and from Antenna B to the IRDs via J3. The loss of the RF signal at J1 or J3 has the same effect as the loss of one antenna.
- An additional effect of the loss of the signal at J3 is the loss of the closed-loop test signals during countdown.
- The following is a rationale for retention of the command antenna system followed by the retention rationale for the directional coupler.

- AFETRM/SAMTEC-127-1 requires that the Shuttle RSS antenna system will provide ninety-five percent spherical coverage about the Shuttle and that the overall Range Safety System sensitivity will be at least 12 db below the RF signal level supplied by the Air Force ground transmission system at any point in the flight trajectory. Two independent antennas on each SRB and on the ET, plus cross-strapping, have been implemented to satisfy this requirement. The ninety-five percent coverage requirement is also met by a single SRB if it breaks away from the cluster with two good antennas.
- The loss of antenna degrades the spherical coverage to less than ninety-five percent at the specified margin of 12 db above system threshold. Each antenna is located on opposite sides of an SRB and predominantly covers one hemisphere with significant overlap into the other hemisphere.
- The intent of the AFETRM/SAMTEC-127-1 requirement is to provide destruct capability regardless of vehicle attitude (within practical limits) at any given time. The ability to destruct a vehicle with one antenna is highly dependent on the attitude of the vehicle, the position of the good antenna on the vehicle and the received signal level margin at the vehicle.
- The SRB receives an RF signal level that is typically 25 db above the measured threshold of any IRD at the maximum slant range. This excess margin of power compensates for reduced antenna coverage resulting from one failed antenna. Coverage is estimated to be eighty to eighty-five percent at a signal level that is 3 db above measured threshold.
- The worst-case condition for required operation of the RSS with one antenna failure is an SRB that has broken away from the cluster and has its antenna null pointed at the transmitter. This SRB can be expected to act erratically and not maintain attitude control in roll, pitch, and yaw. Under these conditions the null pointing position will follow changes in attitude of the free flying SRB and will eventually move away from the transmitter's direction. If the Arm and Fire commands are repeatedly sent by the transmitter, they will eventually be received and executed.
- In conclusion, the antennas are not redundant in the classical sense but are considered redundant in the operational systems mode.
- The hybrid coupler design is a more robust version of the Saturn I and V model. It has been redesigned to survive the high vibration, shock and thermal levels encountered during the boost and descent phases of flight. The hybrid coupler meets all of the requirements of Spec 10SPC-0043, has been flown on all Shuttle missions to date, and is qualified to the twenty-mission level.
- The hybrid coupler has one vendor source: LaBarge. The vendor has been certified as a supplier by completing qualification testing. LaBarge qualification is reported in Qualification Test Reports 97A1184-7F, 97A1184-9 and 45963-1 and certified by USBI COQ's A-RSS-3109-1 and A-RSS-3109-2.
- Pin Open or Short on J1 or J2, J3 or J4.
 - Connectors are attached to the board with screws and washers and the screws are then epoxy-bonded to preclude an open of the RF connector shell or center conductor. Shorts are precluded by board layout and fabrication techniques.
 - An open connector center conductor is precluded by a highly reliable captivated spring contact fuzz button.

O Faulty Microstrip

- o The microstrips (P/N 10406-0110 and -0111) are gold-plated mirror image circuit boards that are butted together to provide isolation for shorts and conductor redundancy at all positions along the microstrip, except the electrical connection points, to preclude open conductor failures. The microstrip boards are procured and processed to the requirements of MSFC-SPEC-50M60233.

B. TESTING:

VENDOR RELATED TESTING

- O Each Hybrid Coupler is subjected to an USBI approved acceptance test procedure (LaBarge 97A1184-5) prior to delivery. Acceptance testing establishes the absence of pin open or shorted on input connectors faulty microstrip, and pin open or shorted on output connectors and J4 at the time of testing. (All Failure Causes)

KSC RELATED TESTING

- O Each Hybrid Coupler received by USBI from SPC is bench tested as required by 10REQ-0021, Appendix E. Absence of pin open or shorted on J1 and J3 or J2 and J4, or faulty microstrip is established at bench test.
- O Hybrid couplers not Certified/Recertified at KSC will be Bench tested per 10SPC-0131 within 180 days of installation or transfer as a LRU. (All Failure Causes)
- O The antenna subsystem is tested to the requirements of 10REQ-0021, para. 1.2.1.1.3. (All Failure Causes)
- O Isolation testing is performed after the hybrid coupler is installed on the forward skirt equipment panel.
- O The hybrid coupler has voltage standing wave ratio (VSWR) and insertion loss testing after installation into the forward skirt per 10REQ-0021, paras. 1.2.1.1.3 and 1.2.1.1.4.
- O Open loop test performed per OMRSD File II, Volume 1, S00000.380.
- O Verify operation of SRSS with flight code (closed loop) per OMRSD File II, Vol. 1, requirement number S00000.390.
- O At approximately T-50 minutes the last closed loop test is performed. Only the input at J3, outputs at J2 and J4 and the associated microstrips are tested during the closed loop test. At that time the range transmitter is brought up and maintains capture of the IRDs until the SRB separation sequence is started. The closed loop and transmitted signals are routed through the hybrid coupler. Signal strength measurements B55E1100C and B55E1101C provide an indication that the hybrid coupler is operational.

REFURBISHMENT/RECERTIFICATION TESTING

- O Previously flown Hybrid Couplers are Inspected, repaired if necessary and Functionally Tested at USBI Florida Operations IAW 10SPC-0131.

C. INSPECTION:

VENDOR RELATED INSPECTIONS

- o USBI QAR monitors the vendor's receiving inspection and traceability records per SIP 1072.
- o Final acceptance test is witnessed by USBI QAR per SIP 1072. (All Failure Causes)
- o Supplier QA and USBI QAR perform in-process inspections to preclude errors in workmanship and materials during assembly of the hybrid coupler. Parts, material and assembly workmanship are verified by USBI QAR per the list below:
 - o Connectors per SIP 1072
 - o Base Plate per SIP 1072
 - o Mounting Sleeve per SIP 1072
 - o Spring Fuzz Button per SIP 1072
 - o Insert Base Plate per SIP 1072
 - o Printed Wiring Boards per SIP 1072
 - o Coaxial Termination per SIP 1072
- O Critical Processes/Inspections/Operations:
 - o None

KSC RELATED INSPECTION

- O USBI QA witnesses hybrid coupler bench testing. (All Failure Causes)
- O USBI QA witnesses and accepts torquing of coupler mounting bolts during installation on SRB forward skirt equipment.
- O USBI QA witnesses antenna subsystem testing. (All Failure Causes)
- O Connectors are inspected for damage and contamination during cable hookup per IOREQ-0021, para. 1.2.1.1.9.

REFURBISHMENT/RECERTIFICATION INSPECTION

- O After each use, the Hybrid Coupler is inspected for damage, bent or broken connectors, corrosion and salt water contamination IAW 10SPC-0131.

D. FAILURE HISTORY:

- o Criticality Category 1R:

No SRB failure history for this failure mode.

E. OPERATIONAL USE

- o Not applicable to this failure mode.