

SRB CRITICAL ITEMS LIST

SUBSYSTEM: RANGE SAFETY COMMAND DESTRUCT

ITEM NAME: Directional Coupler

PART NO.: 10406-0117-105, -106, -107, -108, -109
10406-0149-854

FM CODE: A02

DCN032

ITEM CODE: 70-03

REVISION: Basic

CRITICALITY CATEGORY: IR

REACTION TIME: Seconds

NO. REQUIRED: 1

DATE: March 31, 1997

CRITICAL PHASES: Boost

SUPERCEDES: March 1, 1996

FMEA PAGE NO.: F-7

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SHEET 1 OF 5

APPROVED: P. Kalia

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FAILURE MODE AND CAUSES: Loss of RF signal output from directional coupler and loss of RF signal output from Antenna A caused by:

- Pin open or shorted on J1 or J2
- Faulty microstrip
- Pin open or shorted on J4 (GSE use only)

FAILURE MODE EFFECTS SUMMARY: Loss of capability to destruct one SRB should it 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, ordnance installation and during countdown. Checked in final countdown by receiver signal strength measurements B55E1100C and B55E1101C.
2. Fail - Unable to check redundant RF paths during flight.
3. Pass- No known credible causes.

RATIONALE FOR RETENTION:

A. DESIGN:

- The Directional Coupler is an integral part of the RF signal path from Antenna B to the integrated receiver/decoders (IRDs) and from the ground support equipment (GSE) to the IRDs. The loss of this coupler has the same effect as the loss of Antenna B. 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 two antennas on the ET, plus cross-strapping, have been implemented to satisfy this requirement. A single SRB with two operational antennas which breaks away from the cluster will also meet the requirement for ninety-five percent spherical coverage for the shuttle.
- The loss of one antenna degrades the spherical coverage to less than ninety-five percent at the specified margin of 12 db above the 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 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 directional coupler design is a more robust version of the Saturn I and V models. It has been redesigned to survive the high vibration, shock, and thermal levels encountered during the boost and descent phases of flight. The directional coupler meets all of the requirements of Spec (10SPC-0044), has been flown on all Shuttle missions to date, and is qualified to the twenty-mission level.
- The directional 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 COQs A-RSS-3107-1 and A-RSS-3107-2. The vendor's directional couplers are qualified to the twenty-mission level.
- Pin Open or Short on J2 or J1.

J1 and J2 are attached to the board with screws and washers and the screws are then epoxy-bonded to preclude opening of 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

The microstrip boards (P/N 10406-0119 and -0120) 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 Directional Coupler is subjected to acceptance testing to USBI approved procedure (LaBarge 97A1184-5) prior to delivery. Acceptance testing establishes the absence of open or short of J1 or J2 or a faulty microstrip at the time of testing. (All Failure Causes)

KSC RELATED TESTING

- O Each Directional Coupler received by USBI from SPC is bench tested as required by 10REQ-0021, Appendix E. Absence of open or shorted J1 or J2 or faulty microstrip is established at bench test.
- O After each flight, the directional coupler has the coupler dummy load replaced and receives a bench test. Directional Couplers not Certified/Recertified at KSC will be Bench Tested within 180 Days of installation or transfer as a LRU. (All Failure Causes)
- O The directional 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 Verify operation of SRSS with flight code (closed loop) per OMRSD File II, Vol. 1, requirement number S00000.390.
- O Only the input at J4, output at J1 and the associated microstrips are tested during open loop test. At approximately T-50 minutes the last closed loop test is performed. At that time the Range Safety transmitter is brought up and maintains capture of the IRD until the separation sequence is started. From T-50 until separation, the signal strength measurements B55E1100C and B55E1101C provide an indication that at least one RF signal path is operational; however, if both RF paths fail the receiver signal strength measurements will indicate the multiple failure from IRD capture (T-50) until separation.

REFURBISHMENT/RECERTIFICATION TESTING

- O Previously Flown Directional 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 Supplier Quality and USBI QAR perform in-process inspections to preclude errors in workmanship and materials during assembly of the directional coupler. Parts, material and assemblies per the list below are verified by USBI QAR:

- 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 Final acceptance test is witnessed by USBI QAR per SIP 1072. (All Failure Causes)
 - O Critical Processes/Inspections/Operations:
 - o None

KSC RELATED INSPECTION

- O USBI QA witnesses directional coupler bench testing as required by 10REQ-0021, Appendix E. (All Failure Causes)
- O USBI QA witnesses and accepts torquing of coupler mounting bolts during installation on SRB forward skirt equipment panel.
- O Connectors are inspected for damage and contamination during cable hookup per 10REQ-0021, para. 1.2.1.1.9.
- O Directional coupler functional testing is performed per 10REQ-0021, para. 1.2.1.1.6. (All Failure Causes)

REFURBISHMENT/RECERTIFICATION INSPECTION

- O After each use the Directional Coupler is inspected for damage, bent or broken connector, corrosion and salt water Contamination IAW USBI 10SPC-0131.
- D. FAILURE HISTORY:
- o Criticality Category IR:
 - No SRB failure history for this failure mode.
- E. OPERATIONAL USE
- o Not applicable to this failure mode.