

SSME FMEA/CIL
REDUNDANCY SCREEN

Component Group: Electrical Harnesses
 CIL Item: H103-01, H104-01, H105-01
 Part Number: RS008103, RS008104, RS008105
 Component: Armored - Vehicle Command 1W3, 1W4, 1W5
 FMEA item: H103, H104, H105
 Failure Mode: Open or short circuit in harness. Loss of connector.

Prepared: P. Ho
 Approved: T. Nguyen
 Approval Date: 5/3/00
 Change #: 1
 Directive #: CCBD ME3-01-5287

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Phase	Failure / Effect Description	Criticality Hazard Reference
M 4.1	<p>Harness failures causing 2 or 3 channels failing the vote (all 3 for shutdown enable and shutdown) results in command not being accepted and a MCF indication. Last accepted command remains in effect. Engine shutdown may be delayed by prevalve closure. Loss of vehicle.</p> <p>Redundancy Screens: HARNESS SYSTEM: LIKE REDUNDANCY</p> <p>A: Pass - Redundant hardware items are capable of checkout during normal ground turnaround. B: Pass - Loss of a redundant hardware items is detectable during flight. C: Pass - Loss of redundant hardware items could not result from a single credible event.</p>	1R ME-C1A,C

SSME IEA/CIL
DESIGN

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Design / Document Reference

FAILURE CAUSE: A: Conductor or insulation damage caused by vibration, flexure, routing, or clamping.

MATERIAL SELECTION OF THE WIRES, INSULATORS, CONNECTORS, AND ASSEMBLY TECHNIQUES ARE CONTROLLED BY SPECIFICATION (1) TO GUARD AGAINST THE FAILURE OF THE HARNESS IN THE ENVIRONMENTS IT IS EXPOSED TO. THESE CONTROLS ARE ESTABLISHED BY GOVERNMENT SPECIFICATIONS FOR CONNECTORS (2) AND WIRE SELECTION (3), AND ARE KEYED TO THE FUNCTION AND USAGE OF THE HARDWARE. TO PRECLUDE SINGLE POINT ELECTRICAL FAILURES, REDUNDANT FUNCTIONS ARE IMPLEMENTED IN SEPARATE HARNESSES, ROUTED THROUGH DIFFERENT PATHWAYS. TO PREVENT DETERIORATION OF THE CONDUCTOR OR INSULATOR, WIRES ARE OF SUCH CROSS SECTION AS TO PROVIDE AMPLE AND SAFE CURRENT CARRYING CAPACITY. THE MAXIMUM DESIGN CURRENT IN ANY WIRE IS LIMITED SO THAT "WIRE TOTAL TEMPERATURE" WILL NEVER EXCEED THE RATED WIRE TEMPERATURE (1). HARNESS ASSEMBLIES INCORPORATE A FLEXIBLE GLASS FILLER CORD TO ENHANCE CABLE ROUNDING (1). THE CORD HELPS IN ELIMINATING EXCESSIVE BEND RADII THAT MAY CAUSE WIRE DAMAGE. TEFLON FILM WRAP AND TEFLON TAPE COVER THE WIRE BUNDLES TO PROTECT THE INSULATION FROM ABRASIVE DAMAGE. THE ABLATIVE SILICONE TUBING AND WIRE MESH SHEATH PROTECTS THE ENTIRE WRAP FROM SHARP IMPACTS OR HANDLING DAMAGE (4). CABLE ROUTING IS CONTROLLED BY THE ASSEMBLY DRAWINGS (5) THAT ESTABLISH THE RETAINING CLAMPS AND RESTRAINING TIES. THE SECURING CLAMPS (6) INCORPORATE RUBBER GROMMETS THAT PREVENT PINCHING OR CUTTING OF THE INSTALLED HARNESS.

(1) RL10014; (2) 40M39569; (3) 40M50577, 40M50578; (4) RL00041; (5) RS007007; (6) RE127-2018

**FAILURE CAUSE: B: Loose, worn, or damaged pin or pins.
 C: Damaged contact or crimp.
 E: Connector shell failure.**

CONNECTOR SELECTION OF THE ASSEMBLIES IS CONTROLLED BY SPECIFICATION REQUIREMENTS (1). THE REQUIREMENTS INCORPORATE CONTROLS (2) THAT ARE KEYED TO GUARD AGAINST THE ENVIRONMENTS THEY ARE EXPOSED TO. THE CONNECTORS MEET CEI REQUIREMENTS FOR HIGH CYCLE FATIGUE, LOW CYCLE FATIGUE, AND MINIMUM FACTORS OF SAFETY (3). THE CONNECTORS ARE SELECTED IN ACCORDANCE WITH MSFC STANDARDS FOR USE ON ROCKET PROPELLED VEHICLES (4). BENT OR WORN PINS ARE REMOVABLE AND REPLACEABLE. BAYONET LOCKING RINGS ARE PROVIDED TO PREVENT CONNECTORS FROM BACKING OFF (2).

(1) RL10014; (2) RES1235; (3) RL00532, RSS-8546, CP320R0003B; (4) 40M39569

FAILURE CAUSE: D: Corrosion or moisture.

THE ELECTRICAL COMPONENTS OF THE WIRE HARNESS ARE PROTECTED FROM CORROSION BY INHERENT MATERIAL DESIGN AND PROTECTIVE EXTERNAL COVERING OF THE CABLE. THE WIRE INSULATION IS COMPOSED OF TEFLON (1). TEFLON HAS RESISTANCE TO FLUIDS AND ATMOSPHERIC VAPORS. THE CONNECTOR CONTACTS ARE PLATED WITH GOLD OVER NICKEL UNDERPLATE (2). GOLD IS RESISTANT TO WATER CORROSION AND HUMIDITY. EXCEPT FOR POTTED CONNECTORS, THE CONNECTOR BACKSHELL IS PROTECTED BY SILICON RUBBER (3) TO PROTECT THE CONNECTOR FROM THE MAXIMUM SPECIFIED OPERATIONAL ENVIRONMENTS. PIN INSERT INTERFACIAL SEALS (4) ARE PROVIDED TO REDUCE CORROSION. CONNECTORS ARE MAINTAINED IN THEIR SEALED BAGS UNTIL READY FOR ASSEMBLY. CONNECTORS ARE PROTECTED TO PREVENT DAMAGE OR CONTAMINATION RESULTING FROM CONTACT WITH EACH OTHER OR ADJACENT OBJECTS (5).

(1) 40M50577; (2) MSFC-SPEC-250; (3) RL10014; (4) RC1235; (5) RL00041

FAILURE CAUSE: ALL CAUSES

COMMAND AND DATA CHANNELS INCORPORATE REDUNDANT HARNESSES. THE HARNESS DESIGN IS TESTED PER HARNESS DESIGN VERIFICATION TESTING (1), INCLUDING VIBRATION TESTING (2), SAFETY FACTOR CRITERIA TESTING (3), AND DURING ENGINE DVS TESTING. (4)

(1) DVS-SSME-202; (2) RSS-202-6; (3) RSS-202-20; (4) DVS-SSME-101

SSME FMEA/CIL INSPECTION AND TEST

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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A	1W3 HARNESS 1W4 HARNESS 1W5 HARNESS		RS008103 RS008104 RS008105
	ASSEMBLY INTEGRITY	<p>THE FOLLOWING TESTS ARE PERFORMED DURING MANUFACTURING AND ASSEMBLY ACCEPTANCE:</p> <ul style="list-style-type: none"> - ALL WIRES ARE SUBJECTED TO SPARK AND DIELECTRIC TESTING. - ALL CONTACTS IN THE CONNECTORS ARE SUBJECTED TO A RETENTION TEST. - A RESISTANCE TEST BETWEEN THE BRAID AND MATING CONNECTOR FLANGE IS PERFORMED ON THE LIGHTNING BRAID/CONNECTOR AND VERIFIED TO BE WITHIN SPECIFICATION. - EACH WIRE RUN IS VERIFIED FOR END-TO-END CONTINUITY. - INSULATION RESISTANCE BETWEEN EACH CONDUCTOR AND EVERY OTHER CONDUCTOR IS VERIFIED TO BE WITHIN SPECIFICATION. - A DIELECTRIC WITHSTANDING VOLTAGE TEST BETWEEN EACH CONDUCTOR AND EVERY OTHER CONDUCTOR, SHELL OR SHIELD VERIFIES THE LEAKAGE CURRENT TO BE WITHIN SPECIFICATION. 	RB0150-044, 40M50577 RL00041, RL00249 RL00041, RL00249 RL00128 RL00128 RL00128
	INSTALLATION INTEGRITY	<p>INSTALLATION OF THE HARNESSES IS VERIFIED PER SPECIFICATIONS DEFINING THE:</p> <ul style="list-style-type: none"> - INSPECTION OF HARNESSES PRE- AND POST-INSTALLATION. - ROUTING REQUIREMENTS WHICH INCLUDE: INSTALLATION PATH, CLAMP LOCATIONS, AND SIZES. SEPARATION DISTANCE REQUIREMENTS FROM OBJECTS WHICH COULD CAUSE CABLE OR CONNECTOR DAMAGE. MINIMUM BEND RADII . - INSPECTION OF CONNECTORS PRIOR TO MATING. THIS INCLUDES BACKSHELL, PINS, AND GROMMET INSPECTIONS. 	RL00039, RS007007 RS007007 RS007007 RL00039 RL00039
B, C, E	CONNECTOR		RES1235
	ASSEMBLY INTEGRITY	<p>HARNESS/CONNECTOR ASSEMBLY PROCESSES ARE VERIFIED PER SPECIFICATIONS WHICH INCLUDE:</p> <ul style="list-style-type: none"> - CRIMPING OF ELECTRICAL CONNECTOR CONTACTS. - USE OF FLEXIBLE INSULATION SLEEVING. - INSTALLATION OF HEAT SHRINKABLE, SILICON RUBBER, STRAIGHT TUBING, AND MOLDED PARTS. - SELECTION AND USAGE OF PROTECTIVE CLOSURES. <p>COMPLETED ASSEMBLY IS INSPECTED FOR PROTECTIVE BRAID FRAYING AT THE CONNECTOR JUNCTION, CONTACT PIN RETENTION, MISSING PARTS, AND DAMAGE OR DEFECTS TO SHELL OR PINS, PER SPECIFICATION REQUIREMENTS.</p>	RA1613-005 RB0150-009 RA0605-018 RA0116-054 RL00041 RL00249
D	CONNECTOR		RES1235
	CLEANLINESS OF COMPONENTS	<p>CLEANLINESS REQUIREMENTS ARE VERIFIED PER SPECIFICATION DURING MANUFACTURING OF THE HARNESS ASSEMBLY.</p> <p>METAL TYPE DUST AND MOISTURE PROOF CAPS ARE VERIFIED INSTALLED ON THE CONNECTOR WHEN NOT IN USE.</p>	RL00041 RL00249 RL00041 RL00249
	SURFACE FINISH	THE PLATING ON THE CONNECTOR PINS IS INSPECTED PER SPECIFICATION REQUIREMENTS.	

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Composer up: **Electrical Harnesses**
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D	ASSEMBLY INTEGRITY	PRIOR TO CONNECTOR MATING, THE CONNECTOR IS INSPECTED FOR ANY CORROSION OR DAMAGE WHICH WOULD ALLOW MOISTURE TO ENTER THE CONNECTOR.	RL00039
ALL CAUSES	1W3 HARNESS 1W4 HARNESS 1W5 HARNESS		RS008103 RS008104 RS008105
	ASSEMBLY INTEGRITY	ALL CONTROLLER DATA FROM THE PREVIOUS FLIGHT IS REVIEWED. ANY ANOMALOUS CONDITION NOTED REQUIRES FURTHER TESTING OR HARDWARE REPLACEMENT PRIOR TO THE NEXT FLIGHT.	MSFC PLN 1228
		RE-TEST REQUIREMENTS AFTER HARNESS REPLACEMENT OR CONNECTOR DEMATE VERIFY THAT THE PROPER CONTROLLER ELECTRICAL CHECKOUTS ARE PERFORMED TO RE-VALIDATE THE HARNESS ASSEMBLY.	OMRSD V41ZA0.010
		HARNESSES ARE INSPECTED FOR DAMAGE AND PROPER ROUTING DURING POST FLIGHT EXTERNAL INSPECTION.	OMRSD V41BU0.030
		HARNESS OPERATION IS VERIFIED EVERY MISSION FLOW AND AFTER ANY REPAIR OR REPLACEMENT BY THE FOLLOWING CONTROLLER ELECTRICAL CHECKOUTS. SUCCESSFUL COMPLETION OF THESE CHECKOUTS VERIFY THAT THE HARNESSES HAVE NO OPEN/SHORT FAILURES: (LAST TEST)	
		- CONTROLLER POWER APPLICATION AND COMMAND ACCEPTANCE.	OMRSD V41AN0.010
		- SENSOR AND IGNITER CHECKOUT.	OMRSD V41AQ0.010
		- FLIGHT READINESS TEST.	OMRSD V41AS0.030
		- ACTUATOR CHECKOUT.	OMRSD V41AS0.010
		- PNEUMATIC CHECKOUT.	OMRSD V41AS0.020

Failure History: Comprehensive failure history data is maintained in the Problem Reporting database (PRAMS/PRACA)
 Reference: NASA letter SA21/88/308 and Rocketdyne letter 88RC09761.

Operational Use: FAILURE MODE CAN BE DETECTED IN REALTIME BY THE FLIGHT CONTROL TEAM WHO WILL EVALUATE EFFECTS UPON VEHICLE PERFORMANCE AND ABORT CAPABILITY. BASED ON THIS EVALUATION THE APPROPRIATE ABORT MODE OR SYSTEM CONFIGURATION WILL BE SELECTED. FAILURE DETECTION CUES AND ASSOCIATED SSME PERFORMANCE DATA HAVE BEEN COORDINATED BETWEEN THE ENGINEERING AND FLIGHT OPERATIONS ORGANIZATIONS WITH THE RESPONSES DOCUMENTED IN MISSION FLIGHT RULES.

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