

**SSME EA/CIL  
REDUNDANCY SCREEN**

Component Group: Electrical Harnesses  
 CIL Item: H101-01, H102-01  
 Part Number: RS008101, RS008102  
 Component: Armored - 115V AC Power 1W1, 1W2  
 FMEA Item: H101, H102  
 Failure Mode: Open or short circuit in harness. Loss of connector.

Prepared: P. Ho  
 Approved: T. Nguyen  
 Approval Date: 5/3/00  
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Phase	Failure / Effect Description	Criticality Hazard Reference
M 4.2	<p>Failure of both harnesses causing a loss of AC power results in disqualification of both controller channels and a MCF indication. Mission abort.</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>	<p>1R            ME-G4M,            ME-G9P,S,A,M,C,D</p>

**SSME FMEA/CIL**  
**DESIGN**

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**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, 40M39569; (5) RL00041

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**FAILURE CAUSE: ALL CAUSES**

THE POWER HARNESSES IN EACH ENGINE CONTROLLER ARE REDUNDANT (1). A FAILURE OF BOTH POWER SUPPLY HARNESSSES (MULTIPLE FAILURE) WOULD RESULT IN A CONTROLLER INITIATED PNEUMATIC SHUTDOWN (2). THE ORBITER 400 Hz POWER SYSTEM IS COMPRISED OF THREE BUSSES (3). THE A CHANNEL OF EACH CONTROLLER CONNECTS TO A DIFFERENT ORBITER BUS (3). THE B CHANNEL OF EACH CONTROLLER CONNECTS TO THE SAME BUS AS THE A CHANNEL ON THE NEXT ENGINE, (I.E., BUS 1 - ME1 DCU A & ME3 DCU B; BUS 2 - ME2 DCU A & ME1 DCU B; BUS 3 - ME3 DCU A & ME2 DCU B). THE POWER DISTRIBUTION IS SET UP IN THIS WAY TO PRECLUDE A SINGLE BUS FAILURE FROM REMOVING ALL POWER FROM ONE ENGINE CONTROLLER. HOWEVER, SHOULD A CONTROLLER POWER SUPPLY FAIL AND SHORT THE BUS, THE CONTROLLER CHANNEL (ON ANOTHER ENGINE) THAT SHARES THE SAME BUS MIGHT DETECT THE POWER FAILURE AND HALT DUE TO A POWER FAILURE INTERRUPT. THE CONTROLLER CHANNELS (ALL ENGINES) THAT ARE ON DIFFERENT BUSSES WOULD BE UNAFFECTED. THE CONTROLLER SOFTWARE IS CONFIGURED TO DETECT AND RESPOND PROPERLY TO THE FAILURES IDENTIFIED, IMPLEMENT THE NECESSARY REDUNDANT CONTROLLER CHANNEL SWITCHING, AND COMMAND A SAFE ENGINE STATE WHEN REDUNDANCY IS LOST (2). THE HARNESS DESIGN IS TESTED PER HARNESS DESIGN VERIFICATION TESTING (4), INCLUDING VIBRATION TESTING (5), SAFETY FACTOR CRITERIA TESTING (6), AND DURING ENGINE DVS TESTING (7).

(1) DS25401; (2) CP406R0008, 3.2.1:9; (3) ICD 13M15000; (4) DVS-SSME-202; (5) RSS-202-6; (6) RSS-202-20; (7) DVS-SSME-101

## SSME FMEA/CIL INSPECTION AND TEST

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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A	1W1 HARNESS 1W2 HARNESS		RS008101 RS008102
	ASSEMBLY INTEGRITY	<p>THE FOLLOWING TESTS ARE PERFORMED DURING MANUFACTURING AND ASSEMBLY ACCEPTANCE:</p> <ul style="list-style-type: none"> <li>- ALL WIRES ARE SUBJECTED TO SPARK AND DIELECTRIC TESTING.</li> <li>- ALL CONTACTS IN THE CONNECTORS ARE SUBJECTED TO A RETENTION TEST.</li> <li>- A RESISTANCE TEST BETWEEN THE BRAID AND MATING CONNECTOR FLANGE IS PERFORMED ON THE LIGHTNING BRAID/CONNECTOR AND VERIFIED TO BE WITHIN SPECIFICATION.</li> <li>- EACH WIRE RUN IS VERIFIED FOR END-TO-END CONTINUITY.</li> <li>- INSULATION RESISTANCE BETWEEN EACH CONDUCTOR AND EVERY OTHER CONDUCTOR IS VERIFIED TO BE WITHIN SPECIFICATION.</li> <li>- A DIELECTRIC WITHSTANDING VOLTAGE TEST BETWEEN EACH CONDUCTOR AND EVERY OTHER CONDUCTOR, SHELL OR SHIELD VERIFIES THE LEAKAGE CURRENT TO BE WITHIN SPECIFICATION.</li> </ul>	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"> <li>- INSPECTION OF HARNESSES PRE- AND POST-INSTALLATION.</li> <li>- ROUTING REQUIREMENTS WHICH INCLUDE:               <ul style="list-style-type: none"> <li>INSTALLATION PATH, CLAMP LOCATIONS, AND SIZES.</li> <li>SEPARATION DISTANCE REQUIREMENTS FROM OBJECTS WHICH COULD CAUSE CABLE OR CONNECTOR DAMAGE.</li> <li>MINIMUM BEND RADII.</li> </ul> </li> <li>- INSPECTION OF CONNECTORS PRIOR TO MATING. THIS INCLUDES BACKSHELL, PINS, AND GROMMET INSPECTIONS.</li> </ul>	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"> <li>- CRIMPING OF ELECTRICAL CONNECTOR CONTACTS.</li> <li>- USE OF FLEXIBLE INSULATION SLEEVING.</li> <li>- INSTALLATION OF HEAT SHRINKABLE, SILICON RUBBER, STRAIGHT TUBING, AND MOLDED PARTS.</li> <li>- SELECTION AND USAGE OF PROTECTIVE CLOSURES.</li> </ul> <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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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	1W1 HARNESS 1W2 HARNESS ASSEMBLY INTEGRITY	<p>ALL CONTROLLER DATA FROM THE PREVIOUS FLIGHT IS REVIEWED. ANY ANOMALOUS CONDITION NOTED REQUIRES FURTHER TESTING OR HARDWARE REPLACEMENT PRIOR TO THE NEXT FLIGHT.</p> <p>RE-TEST REQUIREMENTS AFTER HARNESS REPLACEMENT OR CONNECTOR DEMATE VERIFY THAT THE PROPER CONTROLLER ELECTRICAL CHECKOUTS ARE PERFORMED TO RE-VALIDATE THE HARNESS ASSEMBLY.</p> <p>HARNESSES ARE INSPECTED FOR DAMAGE AND PROPER ROUTING DURING POST FLIGHT EXTERNAL INSPECTION.</p> <p>HARNESS OPERATION IS VERIFIED EVERY MISSION FLOW AND AFTER ANY REPAIR OR REPLACEMENT BY THE FOLLOWING CONTROLLER ELECTRICAL CHECKOUTS: (LAST TEST)</p> <ul style="list-style-type: none"> <li>- CONTROLLER POWER APPLICATION AND COMMAND ACCEPTANCE.</li> <li>- SENSOR AND IGNITER CHECKOUT.</li> <li>- FLIGHT READINESS TEST.</li> <li>- ACTUATOR CHECKOUT.</li> <li>- PNEUMATIC CHECKOUT.</li> </ul>	<p>RS008101 RS008102 MSFC PLN 1228</p> <p>OMRSD V41ZA0.010</p> <p>OMRSD V41BU0.030</p> <p>OMRSD V41AN0.010 OMRSD V41AQ0.010 OMRSD V41AS0.030 OMRSD V41AS0.010 OMRSD V41AS0.020</p>

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: Not Applicable.

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