

SSME FMEA/CIL
REDUNDANCY SCREEN

Component Group: **Electrical Harnesses**
 CIL Item: **H110-01, H111-01**
 Part Number: **RS008110, RS008111**
 Component: **Conventional - Hydraulic Actuator Fail-safe Servoswitches 1W10, 1W11**
 FMEA Item: **H110, H111**
 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 4.2	<p>Failure of both harnesses causing loss of current in both servoswitch coils on one actuator causes servoswitch to de-energize open; this actuator goes into hydraulic lockup; when detected by controller self-test or SEII, controller initiates hydraulic lockup and MCF indication. Mission abort may result when hydraulic lockup occurs during Max Q throttling.</p> <p>Redundancy Screens: HARNESS SYSTEM: LIKE REDUNDANCY</p> <p>A: Pass - Redundant hardware items are capable of checkout during normal ground turnaround. B: Fail - Loss of a redundant hardware items is not detectable during flight. C: Pass - Loss of redundant hardware items could not result from a single credible event.</p>	<p>1R ME-B2M, ME-G4M</p>

**SSME EA/CIL
DESIGN**

Component Group: Electrical Harnesses
CIL Item: H110-01, H111-01
Part Number: RS008110, RS008111
Component: Conventional - Hydraulic Actuator Fail-safe Servoswitches 1W10, 1W11
FMEA Item: H110, H111
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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). CABLE ROUTING IS CONTROLLED BY THE ASSEMBLY DRAWINGS (4) THAT ESTABLISH THE RETAINING CLAMPS AND RESTRAINING TIES. THE SECURING CLAMPS (5) INCORPORATE RUBBER GROMMETS THAT PREVENT PINCHING OR CUTTING OF THE INSTALLED HARNESS.

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

**FAILURE CAUSE: B: Loose, worn, or damaged pin or pins.
C: Damaged contact or crimp.
E: Connector shell failure.
F: Torque lock damage (non-extended life).**

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 ANTI-FLOOD VALVE HARNESSES (4) ARE HIGH CYCLE FATIGUE LIMITED BY MAJOR WAIVER (5). THE CONNECTORS ARE SELECTED IN ACCORDANCE WITH MSFC STANDARDS FOR USE ON ROCKET PROPELLED VEHICLES (6). BENT OR WORN PINS ARE REMOVABLE AND REPLACEABLE. BAYONET LOCKING RINGS ARE PROVIDED TO PREVENT CONNECTORS FROM BACKING OFF (2).

(1) RL10014; (2) RES1229, RES1235; (3) RL00532, RSS-8546, CP320R0003B; (4) RS008112, RS008114; (5) DAR 1726; (6) 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. GOLD IS RESISTANT TO WATER CORROSION AND HUMIDITY (2). 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) RC1229, RC1235; (5) RL00113

FAILURE CAUSE: ALL CAUSES

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 (1). THE HARNESS DESIGN IS TESTED PER HARNESS DESIGN VERIFICATION TESTING (2), INCLUDING VIBRATION TESTING (3), SAFETY FACTOR CRITERIA TESTING (4), AND DURING ENGINE DVS TESTING (5).

(1) CP406R0008; (2) DVS-SSME-202; (3) RSS-202-6; (4) RSS-202-20; (5) DVS-SSME-101

SSME FMEA/CIL INSPECTION AND TEST

Component Group: Electrical Harnesses
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 Part Number: RS008110, RS008111
 Component: Conventional - Hydraulic Actuator Fail-safe Servoswitches 1W10, 1W11
 FMEA Item: H110, H111
 Failure Mode: Open or short circuit in harness. Loss of connector.

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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A	1W10 HARNESS 1W11 HARNESS		RS008110 RS008111
	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. - 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 RL00113 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: <ul style="list-style-type: none"> 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 RL00039 RL00039
B, C, E, F	CONNECTOR CONNECTOR		RES1229 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. 	RA1613-005 RB0150-009 RA0605-018, RL00113 RA0116-054
		<p>COMPLETED ASSEMBLY IS INSPECTED FOR CONTACT PIN RETENTION, MISSING PARTS, AND DAMAGE OR DEFECTS TO SHELL OR PINS PER SPECIFICATION REQUIREMENTS.</p> <p>FOLLOWING INSTALLATION, THE CONNECTOR TORQUE STRIPE IS VERIFIED PER SPECIFICATION REQUIREMENTS.</p>	RL00113 RS007007 RA1606-018
D	CONNECTOR CONNECTOR		RES1229 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>	RL00113 RL00113

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Component: Conventional - Hydraulic Actuator Fail-safe Servoswitches 1W10, 1W11
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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
D	SURFACE FINISH	THE PLATING ON THE CONNECTOR PINS IS INSPECTED PER SPECIFICATION REQUIREMENTS.	RC1229 RC1235
	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	1W10 HARNESS 1W11 HARNESS		RS008110 RS008111
	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, PROPER ROUTING, AND PROPER TORQUE LOCK APPLICATION 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: (LAST TEST) - SENSOR CHECKOUT. - FLIGHT READINESS TEST. - PNEUMATIC CHECKOUT.	OMRSD V41AQ0.010 OMRSD V41AS0.030 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.

SSME FMEA/CIL
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Phase	Failure / Effect Description	Criticality Hazard Reference
M 4.2	<p>Following a harness channel A failure, detection of a harness channel B failure results in disqualification of actuator channels and hydraulic lockup response. Mission abort may result if lockup occurs during Max Q throttling.</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-B6M, ME-C1S,M, ME-G4M</p>

**SSME EA/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). CABLE ROUTING IS CONTROLLED BY THE ASSEMBLY DRAWINGS (4) THAT ESTABLISH THE RETAINING CLAMPS AND RESTRAINING TIES. THE SECURING CLAMPS (5) INCORPORATE RUBBER GROMMETS THAT PREVENT PINCHING OR CUTTING OF THE INSTALLED HARNESS.

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

**FAILURE CAUSE: B: Loose, worn, or damaged pin or pins.
C: Damaged contact or crimp.
E: Connector shell failure.
F: Torque lock damage (non-extended life).**

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 ANTI-FLOOD VALVE HARNESSES (4) ARE HIGH CYCLE FATIGUE LIMITED BY MAJOR WAIVER (5). THE CONNECTORS ARE SELECTED IN ACCORDANCE WITH MSFC STANDARDS FOR USE ON ROCKET PROPELLED VEHICLES (6). BENT OR WORN PINS ARE REMOVABLE AND REPLACEABLE. BAYONET LOCKING RINGS ARE PROVIDED TO PREVENT CONNECTORS FROM BACKING OFF (2).

(1) RL10014; (2) RES1229, RES1235; (3) RL00532, RSS-8546, CP320R0003B; (4) RS008112, RS008114; (5) DAR 1726; (6) 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. GOLD IS RESISTANT TO WATER CORROSION AND HUMIDITY (2). 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) RC1229, RC1235; (5) RL00113

FAILURE CAUSE: ALL CAUSES

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 (1). THE HARNESS DESIGN IS TESTED PER HARNESS DESIGN VERIFICATION TESTING (2), INCLUDING VIBRATION TESTING (3), SAFETY FACTOR CRITERIA TESTING (4), AND DURING ENGINE DVS TESTING (5).

(1) CP406R0008; (2) DVS-SSME-202; (3) RSS-202-6; (4) RSS-202-20; (5) DVS-SSME-101

SSME FMEA/CIL
INSPECTION AND TEST

Component Group: **Electrical Harnesses**
 CIL Item: **H110-01, H111-01**
 Part Number: **RS008110, RS008111**
 Component: **Conventional - Hydraulic Actuator RVDT's 1W10, 1W11**
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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A	1W10 HARNESS 1W11 HARNESS		RS008110 RS008111
	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. - 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 RL00113 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: <ul style="list-style-type: none"> 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 RL00039 RL00039
B, C, E, F	CONNECTOR CONNECTOR		RES1229 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 CONTACT PIN RETENTION, MISSING PARTS, AND DAMAGE OR DEFECTS TO SHELL OR PINS PER SPECIFICATION REQUIREMENTS.</p> <p>FOLLOWING INSTALLATION, THE CONNECTOR TORQUE STRIPE IS VERIFIED PER SPECIFICATION REQUIREMENTS.</p>	RA1613-005 RB0150-009 RA0605-018, RL00113 RA0116-054 RL00113 RS007007 RA1606-018
D	CONNECTOR CONNECTOR		RES1229 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>	RL00113 RL00113

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Component: Electrical Harnesses
CIL Item: H110-01, H111-01
Part Number: RS008110, RS008111
Component: Conventional - Hydraulic Actuator RVDT's 1W10, 1W11
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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
D	SURFACE FINISH	THE PLATING ON THE CONNECTOR PINS IS INSPECTED PER SPECIFICATION REQUIREMENTS.	RC1229 RC1235
	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	1W10 HARNESS 1W11 HARNESS		RS008110 RS008111
	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, PROPER ROUTING, AND PROPER TORQUE LOCK APPLICATION 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: (LAST TEST) - SENSOR CHECKOUT. - FLIGHT READINESS TEST. - PNEUMATIC CHECKOUT.	OMRSD V41AQ0.010 OMRSD V41AS0.030 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.

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Phase	Failure / Effect Description	Criticality Hazard Reference
S 4.2	<p>Single harness failure causing OPOVA or FPOVA excursion within RVDT limits may result in controller initiated shutdown due to a SLE indication. Mission scrub. Loss of vehicle due to turbopump failure may result if turbine overtemperature condition occurs and is not detected.</p> <p>Redundancy Screens: HARNESS SYSTEM - ENGINE SYSTEM: UNLIKE REDUDANCY</p> <p>A: Pass - Redundant hardware items are capable of checkout during normal ground turnaround. B: Fail - Loss of a redundant hardware items is not detectable during flight. C: Pass - Loss of redundant hardware items could not result from a single credible event.</p>	<p>1R ME-B4S, ME-B2S, ME-B6S, ME-C3S</p>
M 4.2	<p>Single harness failure causing channel A failure: Actuator fails to respond to controller commands; controller switches to channel B all actuators. Second harness failure causes controller to initiate hydraulic lockup. Mission abort may result when hydraulic lockup occurs during Max Q throttling.</p> <p>Redundancy Screens: HARNESS SYSTEM: LIKE REDUNDANCY</p> <p>A: Pass - Redundant hardware items are capable of checkout during normal ground turnaround. B: Fail - Loss of a redundant hardware items is not detectable during flight. C: Pass - Loss of redundant hardware items could not result from a single credible event.</p>	<p>1R ME-G4M</p>
M 4.3	<p>Single harness failure causing OPOVA or FPOVA excursion within RVDT limits may result in controller initiated shutdown due to a SLE indication. Mission abort. Loss of vehicle due to turbopump failure may result if turbine overtemperature condition occurs and is not detected.</p> <p>Redundancy Screens: HARNESS SYSTEM - ENGINE SYSTEM: UNLIKE REDUNDANCY</p> <p>A: Pass - Redundant hardware items are capable of checkout during normal ground turnaround. B: Fail - Loss of a redundant hardware items is not detectable during flight. C: Pass - Loss of redundant hardware items could not result from a single credible event.</p>	<p>1R ME-B2M, ME-B6M, ME-G4M</p>

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**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). CABLE ROUTING IS CONTROLLED BY THE ASSEMBLY DRAWINGS (4) THAT ESTABLISH THE RETAINING CLAMPS AND RESTRAINING TIES. THE SECURING CLAMPS (5) INCORPORATE RUBBER GROMMETS THAT PREVENT PINCHING OR CUTTING OF THE INSTALLED HARNESS.

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

FAILURE CAUSE: B: Loose, worn, or damaged pin or pins.

C: Damaged contact or crimp.

E: Connector shell failure.

F: Torque lock damage (non-extended life).

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 ANTI-FLOOD VALVE HARNESSES (4) ARE HIGH CYCLE FATIGUE LIMITED BY MAJOR WAIVER (5). THE CONNECTORS ARE SELECTED IN ACCORDANCE WITH MSFC STANDARDS FOR USE ON ROCKET PROPELLED VEHICLES (6). BENT OR WORN PINS ARE REMOVABLE AND REPLACEABLE. BAYONET LOCKING RINGS ARE PROVIDED TO PREVENT CONNECTORS FROM BACKING OFF (2).

(1) RL10014; (2) RES1229, RES1235; (3) RL00532, RSS-8546, CP320R0003B; (4) RS008112, RS008114; (5) DAR 1726; (6) 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. GOLD IS RESISTANT TO WATER CORROSION AND HUMIDITY (2). 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) RC1229, RC1235; (5) RL00113

FAILURE CAUSE: ALL CAUSES

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 (1). THE HARNESS DESIGN IS TESTED PER HARNESS DESIGN VERIFICATION TESTING (2), INCLUDING VIBRATION TESTING (3), SAFETY FACTOR CRITERIA TESTING (4), AND DURING ENGINE DVS TESTING (5).

(1) CP406R0008; (2) DVS-SSME-202; (3) RSS-202-6; (4) RSS-202-20; (5) DVS-SSME-101

SSME FMEA/CIL INSPECTION AND TEST

Component Group: Electrical Harnesses
 CIL Item: H110-01, H111-01
 Part Number: RS008110, RS008111
 Component: Conventional - Hydraulic Actuator Servovalves 1W10, 1W11
 FMEA Item: H110, H111
 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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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A	1W10 HARNESS 1W11 HARNESS		RS008110 RS008111
	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. - 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 RL00113 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 RL00039 RL00039
B, C, E, F	CONNECTOR CONNECTOR		RES1229 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 CONTACT PIN RETENTION, MISSING PARTS, AND DAMAGE OR DEFECTS TO SHELL OR PINS PER SPECIFICATION REQUIREMENTS.</p> <p>FOLLOWING INSTALLATION, THE CONNECTOR TORQUE STRIPE IS VERIFIED PER SPECIFICATION REQUIREMENTS.</p>	RA1613-005 RB0150-009 RA0605-018, RL00113 RA0116-054 RL00113 RS007007 RA1606-018
D	CONNECTOR CONNECTOR		RES1229 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>	RL00113 RL00113

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Component Group: **Electrical Harnesses**
 CIL Item: **H110-01, H111-01**
 Part Number: **RS008110, RS008111**
 Component: **Conventional - Hydraulic Actuator Servovalves 1W10, 1W11**
 FMEA Item: **H110, H111**
 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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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
D	SURFACE FINISH	THE PLATING ON THE CONNECTOR PINS IS INSPECTED PER SPECIFICATION REQUIREMENTS.	RC1229 RC1235
	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	1W10 HARNESS 1W11 HARNESS		RS008110 RS008111
	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, PROPER ROUTING, AND PROPER TORQUE LOCK APPLICATION 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: (LAST TEST) - SENSOR CHECKOUT. - FLIGHT READINESS TEST. - PNEUMATIC CHECKOUT.	OMRSD V41AQ0.010 OMRSD V41AS0.030 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.