

**SSME FMEA/CIL  
REDUNDANCY SCREEN**

Component Group: Ducts and Lines  
 CIL Item: K403-01  
 Part Number: RES1002  
 Component: Hydraulic Return Hose  
 FMEA Item: K403  
 Failure Mode: Fails to contain hydraulic fluid.

Prepared: D. Early  
 Approved: T. Nguyen  
 Approval Date: 7/25/00  
 Change #: 1  
 Directive #: CCBD ME3-01-5638

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Phase	Failure / Effect Description	Criticality Hazard Reference
M 4.1	<p>Hydraulic fluid in aft compartment. Loss of return flow to reservoir. External leakage will eventually result in low reservoir level, loss of hydraulic pressure, and engine hydraulic lockup. Loss of mission may result when hydraulic lockup occurs during Max Q throttling.</p> <p>Redundancy Screens: LINE SYSTEM - SENSOR SYSTEM: UNLIKE 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 align="center">1R ME-E1P,S,A,M,C,D</p>

**SSME EA/CIL  
DESIGN**

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Design / Document Reference

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**FAILURE CAUSE:** A: Parent material failure or weld failure.  
B: Damaged/defective bellows assembly.

THE LINE ASSEMBLY (1) AND BELLOWS ARE MANUFACTURED UTILIZING INCONEL 718. INCONEL 600 WAS USED FOR THE WIRE BRAID ON THE FLEXIBLE HOSE MEMBERS. INCONEL 718 WAS SELECTED FOR ITS STRENGTH, RESISTANCE TO STRESS CORROSION, CORROSION RESISTANCE, HIGH/LOW CYCLE FATIGUE CHARACTERISTICS, AND WELDABILITY (2). MATERIALS ARE HEAT TREATED TO DEVELOP FULL MATERIAL STRENGTH AND HARDNESS. THE BRAID MATERIAL WAS SELECTED FOR ITS STRENGTH AND CORROSION RESISTANCE (2). FLANGE SECTIONS INCORPORATE RADIUS JOINTS TO REDUCE STRESS CONCENTRATIONS. OFFSET LIMIT REQUIREMENTS ARE ESTABLISHED TO REDUCE STRESS CONCENTRATIONS AND IMPROVE WELD GEOMETRY. TUBING STOCK IS DRAWN TO MAINTAIN SURFACE REGULARITY. THE MAXIMUM BEND MOMENT DURING PRESSURIZATION IS SPECIFIED FOR PROPER LINE LOADING. BRAID IS MULTI-LAYERED INTERWOVEN WIRE FOR TENSILE REINFORCEMENT TO THE PRESSURE CARRYING BELLOWS. EXTERNAL RINGS ARE USED TO IMPROVE WELD QUALITY AND SUPPORT THE WIRE BRAID AT THE SPOOL-TO-BRAID INTERFACE. INSTALLATION IS CONTROLLED FOR ANGULARITY AND OFFSET PER SPECIFICATION REQUIREMENTS (3). MINIMUM FACTORS OF SAFETY MEET CEI REQUIREMENTS (4). HIGH AND LOW CYCLE FATIGUE LIFE MEET CEI REQUIREMENTS (5). THE FLEXIBLE LINE HAS SUCCESSFULLY COMPLETED THE BENDING MOMENT, FLEXURAL ENDURANCE, ULTIMATE PRESSURE, SECTIONING, PROOF PRESSURE, FLOW RESONANCE, AND VIBRATION DVS TESTING (6). ANALYSIS SHOWED NO POTENTIAL BELLOW EXCITATION OF RESONANCE DUE TO FLOW INDUCED VIBRATION (6). THE LINE ASSEMBLY PARENT MATERIAL WAS CLEARED FOR FRACTURE MECHANICS/NDE FLAW GROWTH, SINCE THEY ARE NOT FRACTURE CRITICAL PARTS (7). TABLE K403 LISTS ALL THE FMEA/CIL WELDS AND IDENTIFIES THOSE WELDS IN WHICH THE CRITICAL INITIAL FLAW SIZE IS NOT DETECTABLE, AND THOSE WELDS IN WHICH THE ROOT SIDE IS NOT ACCESSIBLE FOR INSPECTION. THESE WELDS HAVE BEEN ASSESSED AS ACCEPTABLE FOR FLIGHT BY RISK ASSESSMENT (8).

(1) RES1002; (2) RSS-8575, RSS-8582; (3) RA1102-006; (4) RSS-8546, CP320R0003B; (5) RL00532, CP320R0003B; (6) RSS-511-9, RSS-511-31, RSS-511-45, RSS-511-47, RSS-511-48; (7) NASA TASK 117; (8) RSS-8756

## SSME FMEA/CIL INSPECTION AND TEST

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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A, B	FLUID INTERFACE HYDRAULIC RETURN LINE		RES1002
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RC1311
	WELD INTEGRITY	ALL WELDS ARE INSPECTED TO DRAWING AND SPECIFICATION REQUIREMENTS PER WELD CLASS. INSPECTIONS INCLUDE: VISUAL, DIMENSIONAL, PENETRANT, RADIOGRAPHIC, ULTRASONIC, AND FILLER MATERIAL, AS APPLICABLE.	RL10011 RA0607-094 RA0115-116 RA0115-006 RA1115-001 RA0115-127
	HEAT TREAT	LINE HEAT TREAT IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RA1611-002
	ASSEMBLY INTEGRITY	THE LOT COMPARISON TEST IS PERFORMED PER SPECIFICATION REQUIREMENTS INCLUDING: - PROOF PRESSURE. - BENDING MOMENT. - FLEXURAL ENDURANCE. - VACUUM LEAK. - SECTIONING.	RC1311 RC1311 RC1311 RC1311 RC1311
	ACCEPTANCE TESTING	A BALL CHECK IS PERFORMED ON EACH LINE PER SPECIFICATION REQUIREMENTS. LINE IS PROOF PRESSURE TESTED PER SPECIFICATION REQUIREMENTS. LINE IS MASS SPECTROMETER LEAK TESTED PER SPECIFICATION REQUIREMENTS. QUICK DISCONNECT IS PROOF PRESSURE TESTED PER DRAWING REQUIREMENTS.	RC1311 RC1311 RC1311 RE2201
	FLIGHT FLOW TESTING	FOLLOWING REPAIR OR REPLACEMENT, AN EXTERNAL LEAK CHECK IS PERFORMED TO REVALIDATE THE SUBSYSTEM. DURING EXTERNAL INSPECTIONS, THE HYDRAULIC SYSTEM IS VISUALLY INSPECTED FOR LEAKAGE. DURING AFT CLOSEOUT INSPECTION, ANY EVIDENCE OF PREVIOUS HYDRAULIC LEAKAGE REQUIRES FURTHER DISPOSITION. (LAST TEST)	OMRSD V41GEN.575 OMRSD V41BU0.030 OMRSD V41BU0.070

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**  
**WELD JOINTS**

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Component	Basic Part Number	Weld Number	Weld Type	Class	Root Side Not Access	Critical Initial Flaw Size Not Detectable		Comments
						HCF	LCF	
LINE	RES1002	1-5	GTAW	I	X			
LINE	RES1002	10,11,18,20	GTAW	I	X			
LINE	RES1002	6,9,12,15	GTAW	II	X			
LINE	RES1002	7,8,13,14	GTAW	II	X			
LINE	RES1002	16,17	GTAW	I	X	X		
LINE	RES1002	19	GTAW	I	X			