

**SSME FMEA/CIL**  
**REDUNDANCY SCREEN**

Component Group: Ducts and Lines  
CIL Item: K203-01  
Part Number: RES1221  
Component: Oxidizer Bleed Flex Line  
FMEA Item: K203  
Failure Mode: Fails to contain oxidizer.

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
PSMCD 4.1	Oxidizer leakage into aft compartment. Overpressurization of aft compartment. Loss of vehicle.  Redundancy Screens: SINGLE POINT FAILURE: N/A	1 ME-C3P,D, ME-C3S, ME-C3M, ME-C3A,C

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**SSME FMEA/CIL  
DESIGN**

Component Group: Ducts and Lines  
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Component: Oxidizer Bleed Flex Line  
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Failure Mode: Falls to contain oxidizer.

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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). ALL MATERIALS USED IN THE LINE FABRICATION ARE LOX COMPATIBLE (2). INSTALLATION IS CONTROLLED FOR ANGULARITY AND OFFSET PER SPECIFICATION REQUIREMENTS (3). 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 DUCT 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. 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, AND VIBRATION DVS TESTING (6). ANALYSIS/TESTING SHOWED NO POTENTIAL BELLOW EXCITATION OF RESONANCE DUE TO FLOW INDUCED VIBRATION (6) (7). THE LINE ASSEMBLY PARENT MATERIALS WERE CLEARED FOR FRACTURE MECHANICS/NDE FLAW GROWTH, SINCE THEY ARE NOT FRACTURE CRITICAL PARTS (8). TABLE K203 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 (9).

(1) RES1221; (2) RSS-8575, RSS-8582; (3) RA1102-006; (4) RSS-8546, CP320R0003B; (5) RL00532, CP320R0003B; (6) RSS-511-09, RSS-511-31, RSS-511-45, RSS-511-47, RSS-511-48; (7) NASA TASK 086; (8) NASA TASK 117; (9) RSS-8756

**SSME FMEA/CIL**  
**INSPECTION AND TEST**

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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A, B	FLEX LINE, OXIDIZER BLEED		RES1221
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	RES1221
	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. - FLEXUAL ENDURANCE. - VACUUM LEAK. - SECTIONING.	RC1315 RC1315 RC1315 RC1315 RC1315
	ACCEPTANCE TESTING	A BALL CHECK IS PERFORMED ON EACH LINE PER SPECIFICATION REQUIREMENTS. LINE IS PROOF PRESSURE TESTED PER SPECIFICATION REQUIREMENTS.	RC1315 RC1315
		LINE IS MASS SPECTROMETER LEAK TESTED PER SPECIFICATION REQUIREMENTS.	RC1315
	FLIGHT FLOW TESTING	THE EXTERNAL SURFACE IS VISUALLY INSPECTED PRIOR TO EACH LAUNCH. A HELIUM SIGNATURE LEAK TEST IS PERFORMED PRIOR TO EACH LAUNCH. (LAST TEST)	OMRSD V41BU0.030 OMRSD S00000.950

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.

**SSME EA/CIL  
WELD JOINTS**

Component Group: Ducts and Lines  
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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	RES1221	1	GTAW	I	X			
LINE	RES1221	3	GTAW	I	X			
LINE	RES1221	4	GTAW	I	X			
LINE	RES1221	10,11	GTAW	I	X			
LINE	RES1221	6,9	GTAW	II	X			
LINE	RES1221	7,8	GTAW	II	X			
LINE	RES1221	12,15	GTAW	II	X			
LINE	RES1221	13	GTAW	II	X			
LINE	RES1221	14	GTAW	II	X			
LINE	RES1221	16	GTAW	I	X			
LINE	RES1221	17	GTAW	I	X			
LINE	RES1221	18	GTAW	II	X			
LINE	RES1221	19	GTAW	II	X			
LINE	RES1221	20	GTAW	II	X			
LINE	RES1221	21	GTAW	II	X			
LINE	RES1221	22	GTAW	I	X			
LINE	RES1221	23	GTAW	I	X			
LINE	RES1221	24	GTAW	I	X			
LINE	RES1221	25	GTAW	I	X			