

**SSME ME/CIL**  
**REDUNDANCY SCREEN**

Component Group: Ducts and Lines  
 CIL Item: K104-01  
 Part Number: RS007043  
 Component: Fuel Bleed Duct  
 FMEA Item: K104  
 Failure Mode: Loss of insulating capability.

Prepared: D. Early  
 Approved: T. Nguyen  
 Approval Date: 7/25/00  
 Change #: 1  
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Phase	Failure / Effect Description	Criticality Hazard Reference
PSMCD 4.1	Outer bellows leakage causes cryopumping, liquid nitrogen freezes between inner and outer bellows. Flex joint fails during engine gimbaling. Fuel leak into aft compartment. Aft compartment overpressurization. Possible fire or detonation. Loss of vehicle.	1 ME-D3P,D, ME-D3S,A,M,C
Redundancy Screens: SINGLE POINT FAILURE: N/A		

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

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Design / Document Reference

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**FAILURE CAUSE:** C: Damaged/defective outer bellows.

THE TUBING (1) IS FABRICATED USING INCONEL 718 SHEET. INCONEL 718 WAS SELECTED FOR ITS STRENGTH, RESISTANCE TO STRESS CORROSION CRACKING, CORROSION RESISTANCE, WELDABILITY, AND HIGH/LOW CYCLE FATIGUE CHARACTERISTICS (2). BELLOWS ARE MANUFACTURED OF MULTIPLE PLIES EVENLY SPACED, AND ANNULAR TO IMPROVE FATIGUE LIFE, REDUCE STRESS/STRAIN CONCENTRATIONS, AND MAINTAIN CONSTANT SPRING RATE. BELLOWS ARE WELDED AT THE PLY ENDS PRIOR TO HYDROFORMING TO PREVENT OIL CONTAMINATION BETWEEN BELLOWS PLIES. WELDED PLIES ENDS ARE SUBSEQUENTLY MACHINED TO A UNIFORM SURFACE BEFORE FINAL WELDING TO THE SUPPORT. THIS IMPROVES THE CONNECTING WELD QUALITY, AND REDUCES PLY DISTORTION. BACKFILL OF THE CAVITY BETWEEN THE TWO BELLOWS DURING MANUFACTURE OF THE ASSEMBLY PROVIDES A LOW-PRESSURE AREA DURING CRYOGENIC OPERATION WHICH IMPROVES INSULATING CHARACTERISTICS. THE FLEX JOINT HAS COMPLETED BENDING MOMENT, FLEXURAL ENDURANCE, ULTIMATE PRESSURE, PROOF PRESSURE, VIBRATION, AND SECTIONING DVS TESTING (3). MINIMUM FACTORS OF SAFETY FOR THE DUCT MEET CEI REQUIREMENTS (4). HIGH AND LOW CYCLE FATIGUE LIFE MEET CEI REQUIREMENTS (5). THE OUTER BELLOWS PARENT MATERIAL WAS CLEARED FOR FRACTURE MECHANICS/NDE FLAW GROWTH, SINCE THEY ARE NOT FRACTURE CRITICAL PARTS (6). TABLE K104 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 (7). THE DUCT ASSEMBLY HAS SUCCESSFULLY COMPLETED PRESSURE CYCLING AND ULTIMATE PRESSURE DVS TESTING (8). THE VISUAL BELLOWS INSPECTION, HE MASS LEAK, AND ACCESSIBLE BELLOWS WELDS DYE PENETRANT INSPECTION TESTS HAVE BEEN SUCCESSFULLY COMPLETED ON ENGINE 2010 (9) AND 2014 (10) FLEX JOINTS. NO ANOMALIES WERE FOUND. THE 2010 DUCT HAD ACCUMULATED 65 STARTS AND 19,903 SECONDS. THE 2014 DUCT HAD ACCUMULATED 55 STARTS AND 15,447 SECONDS.

(1) RS008949; (2) RSS-8582; (3) RSS-511-13; (4) RSS-8546, CP320R0003B; (5) RL00532, CP320R0003B; (6) NASA TASK 117; (7) RSS-8756, MCR 0964; (8) RSS-511-43; (9) CD#2-0152; (10) CD#2-87-0031

**SSME FW CIL  
INSPECTION AND TEST**

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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference	
C	BELLOWS		RS008949	
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	RS008949	
		THE BELLOWS GRAIN DIRECTION IS VERIFIED PER DRAWING REQUIREMENTS.	RS008949	
		THE BELLOWS SEAM WELD DIRECTION AND LOCATION ARE VERIFIED PER DRAWING REQUIREMENTS.	RS008949	
	CLEANLINESS OF COMPONENTS	THE BELLOWS PLIES ARE VERIFIED CLEAN PER SPECIFICATION REQUIREMENTS PRIOR TO ASSEMBLY AND CONVOLUTING.	RA1610-044	
		HEAT TREAT	HEAT TREAT IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RA1611-002
	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/RA1607-079 RA0115-116 RA0115-006 RA1115-001 RA0115-127	
		THE WELDS ARE PENETRANT INSPECTED AFTER PLANISHING PER SPECIFICATION REQUIREMENTS.	RA0115-116	
		ASSEMBLY INTEGRITY	THE BELLOWS ECCENTRICITY, CONVOLUTE HEIGHTS, CROWN AND ROOT RADIUS, PLY THICKNESS, AND SURFACE IRREGULARITY ARE VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.	RS008949 RL00078
			THE FLEX JOINT IS GIMBAL TESTED PER DRAWING REQUIREMENTS.	RS008942
			THE FLEX JOINT IS ACCEPTANCE TESTED PER SPECIFICATION REQUIREMENTS.	RL00220
	FLIGHT FLOW TESTING	THE EXTERNAL SURFACE IS VISUALLY INSPECTED PRIOR TO EACH LAUNCH. (LAST TEST)	OMRSD V41BU0.030	

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**

**FIELD CONFIGURATION VARIANCES FROM CIL RATIONALE**

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Base Line Rationale	Variance	Change Rationale	Variant Dash Number
1. K104-02 APPLICATION OF CORROSION INHIBITOR.	ACTIVE CORROSION INHIBITOR IS NOT APPLIED.	USE AS IS RATIONALE: (1) DUCTS ARE LOW-SHELF TIME CONFIGURATION REDUCING THE POSSIBILITIES OF CORROSION. (2) DUCTS ARE LIFE LIMITED BY MAJOR WAIVER, DAR 2080.	RS007043-121

**SSME FMEA/CIL**  
**WELD JOINTS**

Component Group: Ducts and Lines  
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 FMEA Item: K104

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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	
DUCT	RS007044	1	GTAW	I	X			
DUCT	RS007044	3	GTAW	I	X	X		
DUCT	RS007044	4	GTAW	I	X			
DUCT	RS007044	5	GTAW	I	X	X		
DUCT	RS007044	6	GTAW	I	X			
DUCT	RS007044	7-10	GTAW	I	X			
DUCT	RS007044	11	GTAW	I	X	X		
BELLOWS	RS008892	1,2	GTAW	I		X	X	
BELLOWS	RS008892	3,4	EBW	I				
BELLOWS	RS008892	5,6	GTAW	I				
FLEX JOINT	RS008942	1	EBW	I,II	X			
FLEX JOINT	RS008942	2,3	EBW	II	X			
FLEX JOINT	RS008942	4	GTAW	I	X			
FLEX JOINT	RS008942	5	GTAW	I	X			
FLEX JOINT	RS008942	6,7	GTAW	I		X		