

SSME FMEA/CIL
REDUNDANCY SCREEN

Component Group: Block 1 Ducts and Lines
CIL Item: K610-02
Part Number: R0018043
Component: Fuel Bleed Duct (Phase II+)
FMEA Item: K610
Failure Mode: Fails to contain hydrogen.

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	Fuel leak into aft compartment. Overpressurization of aft compartment. Possible fire or detonation. Loss of vehicle. Redundancy Screens: SINGLE POINT FAILURE: N/A	1 ME-FD3P,D, ME-FD3S,A,M,C

**SSMF FMEA/CIL
DESIGN**

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Design / Document Reference

FAILURE CAUSE: A: Parent material failure or weld failure.

(-51: INCONEL 625 DUCT)

THE DUCT ASSEMBLY (1) IS MANUFACTURED UTILIZING INCONEL 718 MATERIAL FOR THE FLANGE, VALVE HOUSING AND INTERMEDIATE DUCT SUPPORT. THE REMAINDER OF THE ASSEMBLY IS INCONEL 625 TUBING, BAR AND SHEET. INCONEL 625 WAS SELECTED OVER 21-6-9 CRES BECAUSE OF ITS BETTER RESISTANCE TO STRESS CORROSION CRACKING. USE OF INCONEL 625 ALSO ELIMINATED THE NEED FOR AN ACTIVE CORROSION INHIBITOR WHICH WAS REQUIRED FOR 21-6-9 CRES DUCTS. INCONEL 625 WAS ALSO SELECTED FOR ITS STRENGTH AT CRYOGENIC TEMPERATURES AND CORROSION RESISTANCE (2). HYDROGEN ENVIRONMENT DOES NOT HAVE A SIGNIFICANT EFFECT ON INCONEL 625. 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 (2). HYDROGEN ENVIRONMENT EFFECTS ARE NOT A CONCERN DUE TO THE OPERATING ENVIRONMENT. 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 MINIMUM FACTORS OF SAFETY FOR THE DUCT MEET CEI REQUIREMENTS (3). HIGH AND LOW CYCLE FATIGUE LIFE MEET CEI REQUIREMENTS (4). THE DUCT ASSEMBLY HAS COMPLETED CERTIFICATION TESTING BY ANALYSIS, SIMILARITY AND HOT FIRE TESTING (5). THE DUCT ASSEMBLY PARENT MATERIALS WERE CLEARED FOR FRACTURE MECHANICS/NDE FLAW GROWTH, SINCE THEY ARE NOT FRACTURE CRITICAL PARTS (6). TABLE K610 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).

(-41: 21-6-9 CRES DUCT)

THE DUCT ASSEMBLY (1) IS MANUFACTURED UTILIZING INCONEL 718 MATERIAL FOR THE FLANGE, VALVE HOUSING AND INTERMEDIATE DUCT SUPPORT. THE REMAINDER OF THE ASSEMBLY IS 21-6-9 CRES TUBING, BAR AND SHEET. 21-6-9 CRES WAS SELECTED FOR ITS STRENGTH AT CRYOGENIC TEMPERATURES, CORROSION RESISTANCE, AND RESISTANCE TO STRESS CORROSION CRACKING (2). HYDROGEN ENVIRONMENT DOES NOT HAVE A SIGNIFICANT EFFECT ON 21-6-9 CRES. 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 (2). HYDROGEN ENVIRONMENT EFFECTS ARE NOT A CONCERN DUE TO THE OPERATING ENVIRONMENT. 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. AN ACTIVE CORROSION INHIBITOR IS APPLIED TO THE EXTERNAL SURFACES OF THE INSULATED DUCT FOR ADDED CORROSION RESISTANCE (8). THE MINIMUM FACTORS OF SAFETY FOR THE DUCT MEET CEI REQUIREMENTS (3). HIGH AND LOW CYCLE FATIGUE LIFE MEET CEI REQUIREMENTS (4). THE DUCT ASSEMBLY HAS COMPLETED CERTIFICATION TESTING BY ANALYSIS SIMILARITY AND HOT FIRE TESTING (5). THE DUCT ASSEMBLY PARENT MATERIALS WERE CLEARED FOR FRACTURE MECHANICS/NDE FLAW GROWTH, SINCE THEY ARE NOT FRACTURE CRITICAL PARTS (6). TABLE K610 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).

(1) R0018042; (2) RSS-8582; (3) CP320R0003B; (4) RL00532, CP320R0003B; (5) VRS-0487; (6) NASA TASK 117; (7) RSS-8756; (8) R0018043

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INSPECTION AND TEST

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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A	DUCT (-51 INCO 625) DUCT		R0018043 R0018042
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS. DETAILS ARE PENETRANT INSPECTED PER SPECIFICATION REQUIREMENTS.	R0018042 RA0115-116
	HEAT TREAT	HEAT TREAT IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RA0611-020
	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
	ASSEMBLY INTEGRITY	EXTERIOR SURFACE OF DUCT IS INSPECTED FOR SURFACE DEFECTS PER DRAWING AND SPECIFICATION REQUIREMENTS. THE ASSEMBLY IS PROOF PRESSURE TESTED PER DRAWING REQUIREMENTS. WELDS ARE PENETRANT INSPECTED AFTER PROOF PRESSURE TEST PER SPECIFICATION REQUIREMENTS.	R0018042 RA0102-003 R0018042 RA0115-116
	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
	DUCT (-41 CRES 21-6-9) DUCT		R0018043 R0018042
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS. DETAILS ARE PENETRANT INSPECTED PER SPECIFICATION REQUIREMENTS.	R0018042 RA0115-116
	HEAT TREAT	HEAT TREAT IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RA0611-020
	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
	ASSEMBLY INTEGRITY	AN ACTIVE CORROSION INHIBITOR COATING IS VERIFIED PER DRAWING REQUIREMENTS. EXTERIOR SURFACE OF DUCT IS INSPECTED FOR SURFACE DEFECTS PER DRAWING AND SPECIFICATION REQUIREMENTS. THE ASSEMBLY IS PROOF PRESSURE TESTED PER DRAWING REQUIREMENTS. WELDS ARE PENETRANT INSPECTED AFTER PROOF PRESSURE TEST PER SPECIFICATION REQUIREMENTS.	R0018043 R0018042 RA0102-003 R0018042 RA0115-116

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A	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 FMEA/CIL
WELD JOINTS

Component Group: Block 1 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	
(R0018043 - 51 INCONEL 625)								
DUCT	R0018042	1	GTAW	I	X			
DUCT	R0018042	4	GTAW	I	X			
DUCT	R0018042	8	GTAW	I	X			
DUCT	R0018042	9	GTAW	I				
DUCT	R0018042	10	GTAW	I	X			
(R0018043 - 41 CRES 21-6-9)								
DUCT	R0018042	1	GTAW	I	X	X		
DUCT	R0018042	4	GTAW	I	X			
DUCT	R0018042	8	GTAW	I	X	X		
DUCT	R0018042	9	GTAW	I		X		
DUCT	R0018042	10	GTAW	I	X	X		