

SSME FMEA/CIL
REDUNDANCY SCREEN

Component Group: Ducts and Lines
CIL Item: K202-02
Part Number: RS007035
Component: LPOTP Turbine Drive Duct
FMEA Item: K202
Failure Mode: Internal structural failure.

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
SMC 4.1	Fire from LOX impact or rubbing. Loss of vehicle. Redundancy Screens: SINGLE POINT FAILURE: N/A	1 ME-C3S, ME-C3M, ME-C3A,C

**SSME F A/CIL
DESIGN**

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Design / Document Reference

FAILURE CAUSE: A: Structural failure of: Stabilizer, Inlet sleeve, Outlet sleeve, Filters.

THE STABILIZER AND SLEEVES (1) ARE MANUFACTURED UTILIZING INCONEL 718. INCONEL 718 WAS SELECTED FOR ITS STRENGTH, RESISTANCE TO STRESS CORROSION, CORROSION RESISTANCE, HIGH/LOW CYCLE FATIGUE CHARACTERISTICS, AND WELDABILITY (3). THE FILTER ASSEMBLY (2) IS MANUFACTURED UTILIZING 316L CRES AND WAS SELECTED BECAUSE OF ITS STRENGTH FOR THE APPLICATION. MATERIALS ARE HEAT TREATED TO DEVELOP FULL MATERIAL STRENGTH AND HARDNESS (3). ALL MATERIALS USED IN THE DUCT FABRICATION ARE LOX COMPATIBLE (3). INSTALLATION IS CONTROLLED FOR ANGULARITY AND OFFSET (4). MATING ROTATIONAL SURFACES HAVE TIGHT TOLERANCE CONTROLS TO INCREASE SURFACE CONTACT AREA WHICH REDUCES GALLING, STRESS RISERS, AND OFFSET LOADING. TOLERANCE CONTROLS ALSO DECREASE LUBRICANT WEAR, INCREASING LIFE. DRY-FILM LUBRICANT IS USED TO REDUCE FRICTION, GALLING, AND PARTICLE GENERATION. INTERNAL STABILIZERS REDUCE TURBULENCE OVER THE BELLOWS ASSEMBLY AND PROVIDES LAMINAR FLOW WHICH INHIBITS FLOW INDUCED VIBRATION. VENT HOLES ARE MANUFACTURED IN THE STABILIZERS TO EQUALIZE PRESSURE ACROSS THE SURFACE. SCREENS KEEP CONTAMINATION FROM COLLECTING IN THE CONVOLUTION AREA IN ADDITION TO EQUALIZING PRESSURE. MINIMUM FACTORS OF SAFETY FOR THE DUCT MEET CEI REQUIREMENTS (5). HIGH AND LOW CYCLE FATIGUE LIFE FOR THE DUCT MEET CEI REQUIREMENTS (6), EXCEPT THE FLEX JOINTS ARE HIGH CYCLE FATIGUE LIFE LIMITED BY MAJOR WAIVER (12). THE FLEX JOINT HAS COMPLETED BENDING MOMENT, FLEXURAL ENDURANCE, ULTIMATE PRESSURE, PROOF PRESSURE, VIBRATION, AND SECTIONING DVS TESTING (7). THE DUCT ASSEMBLY PARENT MATERIALS WERE CLEARED FOR FRACTURE MECHANICS/NDE FLAW GROWTH, SINCE THEY ARE NOT FRACTURE CRITICAL PARTS (8). TABLE K202 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). THE VISUAL BELLOWS INSPECTION, HE MASS LEAK AND ACCESSIBLE BELLOWS WELDS DYE PENETRANT INSPECTION TEST HAVE BEEN COMPLETED ON ENGINE 2010 (10) AND 2014 (11) FLEX JOINTS, NO ANOMALIES WERE FOUND ON 2010. ON 2014, THE HELIUM LEAK TEST OF THE FIRST DOWNSTREAM FLEX JOINT SLIGHTLY EXCEEDED THE MAXIMUM ALLOWABLE LEAKAGE RATE. LEAKAGE DID NOT EFFECT ENGINE PERFORMANCE OR DUCT FUNCTION. THE 2010 DUCT HAD ACCUMULATED 65 STARTS AND 19,903 SECONDS. THE 2014 DUCT HAD ACCUMULATED 53 STARTS AND 15,346 SECONDS.

(1) RS008641, RS008661; (2) RS008751; (3) RSS-8582, RSS-8575; (4) I.L. 0126-8066; (5) RSS-8546, CP320R0003B; (6) RL00532, CP320R0003B; (7) RSS-511-43; (8) NASA TASK 117; (9) RSS-8756; (10) CD#2-0152; (11) CD#2-87-0031; (12) DAR 2120

SSME FMEA/CIL
INSPECTION AND TEST

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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A	STABILIZER		RS008641
	STABILIZER		RS008661
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	RS008641 RS008661
	HEAT TREAT	HEAT TREAT IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RA0611-020
	SURFACE FINISH	THE STABILIZER DRY-FILM LUBRICATION IS VERIFIED PER DRAWING REQUIREMENTS.	RS008641 RS008661
	ASSEMBLY INTEGRITY	INNER RADII ARE INSPECTED PER DRAWING REQUIREMENTS.	RS008641 RS008661
	INLET/OUTLET SLEEVE		RS008641
	INLET/OUTLET SLEEVE		RS008661
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RB0170-153
	HEAT TREAT	HEAT TREAT IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RA0611-020
	SURFACE FINISH	THE SLEEVE DRY-FILM LUBRICATION IS VERIFIED PER DRAWING REQUIREMENTS.	RS008641 RS008661
	ASSEMBLY INTEGRITY	INNER RADII ARE INSPECTED PER DRAWING REQUIREMENTS.	RS008641 RS008661
	FILTER		RS008751
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	RS008751
	FLEX JOINT		RS008641
	FLEX JOINT		RS008661
	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	THE FLEX JOINT IS GIMBAL TESTED PER DRAWING REQUIREMENTS.	RS008641 RS008661
		THE FLEX JOINT IS ACCEPTANCE TESTED PER SPECIFICATION REQUIREMENTS.	RL00210 RL00211
	DUCT		RS007035
COMPONENT CLEANLINESS	ASSEMBLY IS VERIFIED CLEAN PER SPECIFICATION REQUIREMENTS.	RA1610-002 RA1610-004	
FLIGHT FLOW TESTING	THE EXTERNAL SURFACE IS VISUALLY INSPECTED PRIOR TO EACH LAUNCH. (LAST TEST)	OMRSD V41BU0.030	

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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

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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	RS007035	1	GTAW	I		X		
DUCT	RS007035	2	GTAW	I				
DUCT	RS007035	3,4	GTAW	I	X			
DUCT	RS007035	5	GTAW	I				
DUCT	RS007035	7-13	GTAW	I				
DUCT	RS007035	14	GTAW	I	X	X		
DUCT	RS007035	15	GTAW	I				
DUCT	RS007035	16	GTAW	I	X			
DUCT	RS007035	17	GTAW	I				
DUCT	RS007035	18,20,21	GTAW	I				
DUCT	RS007035	19	GTAW	I	X	X		
DUCT	RS007035	22	GTAW	I	X			
FLEX JOINT	RS008641	1-4	EBW	I	X			
FLEX JOINT	RS008641	5,6	GTAW	I	X			
FLEX JOINT	RS008641	16 PLCS	GTAW	III	X			
FLEX JOINT	RS008661	1-4	EBW	I	X			
FLEX JOINT	RS008661	4 PLCS	EBW	I	X			
FLEX JOINT	RS008661	5,6	GTAW	I	X			
FLEX JOINT	RS008661	16 PLCS	GTAW	III	X			
BELLOWS	RS008895	1-4	GTAW	I				
BELLOWS	RS008895	5,6	EBW	I				
BELLOWS	RS008896	1-4	GTAW	I				
BELLOWS	RS008896	5,6	EBW	I				