

**SSME EA/CIL
REDUNDANCY SCREEN**

Component Group: Block 1 Ducts and Lines
 CIL Item: K602-02
 Part Number: R0018041
 Component: LPFTP Turbine Drive Duct (Phase II+)
 FMEA Item: K602
 Failure Mode: Piece part structural failure.

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

Page: 1 of 1

Phase	Failure / Effect Description	Criticality Hazard Reference
S 4.1	<p>Internal failure cause particle generation; piece flows downstream blocking LPFTP nozzle vane causing a loss of turbine power resulting in reduced output to the HPFTP. In the event of HPFTP cavitation, excessive turbine discharge temperatures results in a premature engine shutdown. Mission scrub. Loss of vehicle due to HPFTP turbine failure may result if overtemperature condition is not detected.</p> <p>Redundancy Screens: DUCT 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>	1R ME-FD1S
M 4.1	<p>Internal failure cause particle generation; piece flows downstream blocking LPFTP nozzle vane causing a loss of turbine power resulting in reduced output to the HPFTP. In the event of HPFTP cavitation, excessive turbine discharge temperatures results in a premature engine shutdown. Mission abort. Loss of vehicle due to HPFTP turbine failure may result if overtemperature condition is not detected.</p> <p>Redundancy Screens: DUCT 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>	1R ME-FD1M

SSME FMEA/CIL
DESIGN

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Design / Document Reference

FAILURE CAUSE: A: Internal structural failure of: Stabilizer, Inlet/outlet sleeves/tubes, Welds.

THE FLEX JOINTS ARE DOUBLE BELLOWS SEGMENTED WITH EXTERNAL GIMBAL LINKAGE. STABILIZER (1), AND INLET AND OUTLET SLEEVES AND END FLANGES (1) ARE MANUFACTURED UTILIZING INCOLOY 903. INCOLOY 903 WAS SELECTED FOR ITS STRENGTH AND ITS RESISTANCE TO HYDROGEN ENVIRONMENT EFFECTS. IT IS WELDABLE AND IS RESISTANT TO STRESS CORROSION CRACKING (2). MOVING PARTS INCORPORATE RADIUS ON ENDS TO PREVENT NARROW CONTACT POINTS AND LOADING. DURING OPERATION, PRESSURE SEPARATING LOADS APPLIED TO THE BELLOWS MAINTAIN A CONSTANT LOADING FORCE ON THE MOVING PARTS. DRY-FILM LUBRICANT IS USED TO REDUCE FRICTION AND GALLING. 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. 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. 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 FOR THE DUCT MEETS CEI REQUIREMENTS (5). THE DUCT ASSEMBLY PARENT MATERIAL WAS CLEARED FOR FRACTURE MECHANICS/NDE FLAW GROWTH BY RISK ASSESSMENT (6). TABLE K602 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 VISUAL BELLOWS INSPECTION, HE MASS LEAK, AND ACCESSIBLE BELLOWS WELDS DYE PENETRANT INSPECTION TEST HAS BEEN COMPLETED ON ENGINES 2010 (8) AND 2014 (9) FLEX JOINTS. NO ANOMALIES WERE FOUND. THE 2010 DUCT HAD ACCUMULATED 65 STARTS AND 19,903 SECONDS. THE 2014 DUCT HAD ACCUMULATED 53 STARTS AND 15,346 SECONDS.

(1) RS008901, RS008921; (2) RSS-8582; (3) RSS-511-13; (4) CP320R0003B; (5) RL00532, CP320R0003B; (6) NASA TASK 117; (7) RSS-8756; (8) CD#2-0152; (9) CD#2-87-0031

**SSME FT /CIL
INSPECTION AND TEST**

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Page: 1 of 2

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A	STABILIZER		RS008901
	STABILIZER		RS008921
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	RS008901 RS008921
		THE INCOLOY BAR IS PENETRANT INSPECTED PER SPECIFICATION REQUIREMENTS.	RA0115-116
	HEAT TREAT	HEAT TREAT IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RA0611-020
	SURFACE FINISH	THE STABILIZER DRY-FILM LUBRICATION IS VERIFIED PER DRAWING REQUIREMENTS.	RS008901 RS008921
	ASSEMBLY INTEGRITY	INNER RADII ARE INSPECTED PER DRAWING REQUIREMENTS.	RS008901 RS008921
	SLEEVE/TUBES		RS008901
	SLEEVE/TUBES		RS008921
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	RS008901 RS008921
		THE SLEEVE AND TUBES BAR MATERIAL IS PENETRANT INSPECTED PER SPECIFICATION REQUIREMENTS.	RA0115-116
	HEAT TREAT	HEAT TREAT IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RA0611-020 RA1611-002
	SURFACE FINISH	THE SLEEVE DRY-FILM LUBRICATION IS VERIFIED PER DRAWING REQUIREMENTS.	RS008901 RS008921
	ASSEMBLY INTEGRITY	THE SLEEVE INNER RADII ARE INSPECTED PER DRAWING REQUIREMENTS.	RS008901 RS008921
	WELDS		RS008901
	WELDS		RS008921
	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
	FLEX JOINT		RS008901
	FLEX JOINT		RS008921
	ASSEMBLY INTEGRITY	THE FLEX JOINT IS GIMBAL TESTED PER DRAWING REQUIREMENTS.	RS008901 RS008921
	THE FLEX JOINT IS ACCEPTANCE TESTED PER SPECIFICATION REQUIREMENTS.	RL00376 RL00377	

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Page: 2 of 2

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A	DUCT		
	COMPONENT CLEANLINESS	COMPONENT CLEANLINESS IS VERIFIED PER SPECIFICATION REQUIREMENTS.	R0018041
	FLIGHT FLOW TESTING	THE EXTERNAL SURFACE IS VISUALLY INSPECTED PRIOR TO EACH LAUNCH. (LAST TEST)	R0018041
			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.

**SSM FMEA/CIL
WELD JOINTS**

Component Group: Block 1 Ducts and Lines
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 Page: 1 of 1

Component	Basic Part Number	Weld Number	Weld Type	Class	Root Side Not Access	Critical Initial Flaw Size Not Detectable		Comments
						HCF	LCF	
BELLOWS	RS008888	1-4	GTAW	I				
BELLOWS	RS008888	5,6	EBW	I				
BELLOWS	RS008889	1-4	GTAW	I				
BELLOWS	RS008889	5,6	EBW	I				
FLEX JOINT	RS008901	1-4	EBW	I				
FLEX JOINT	RS008901	5-8	EBW	I	X			
FLEX JOINT	RS008921	1,2	EBW	I			X	
FLEX JOINT	RS008921	3-6	EBW	I	X			
DUCT	R0018041	1	GTAW	I	X			
DUCT	R0018041	2	GTAW	I				
DUCT	R0018041	3	GTAW	I				
DUCT	R0018041	4	GTAW	I	X		X	
DUCT	R0018041	5	GTAW	I				
DUCT	R0018041	6	GTAW	I	X		X	
DUCT	R0018041	7	GTAW	I	X		X	
DUCT	R0018041	8	GTAW	I				
DUCT	R0018041	9	GTAW	I	X			
DUCT	R0018041	10	GTAW	I	X			
DUCT	R0018041	11	GTAW	I	X		X	