

SSME FMEA/CIL
REDUNDANCY SCREEN

Component Group: Ducts and Lines
CIL Item: K201-03
Part Number: RS007015
Component: LPOTP Discharge Duct
FMEA Item: K201
Failure Mode: Fretting of internal parts.

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 ignition of internal parts. 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: Relative motion of: Hub/Hub, Liner/Liner, Tie/Hub, Retainer/Hub.

THE HUBS, LINERS, TIE, AND RETAINER (1) ARE MANUFACTURED UTILIZING INCONEL 718. ALL MATERIALS USED IN THE DUCT FABRICATION ARE LOX COMPATIBLE (2). MATERIALS ARE HEAT TREATED FOR HARDNESS (1). INSTALLATION IS CONTROLLED FOR ANGULARITY AND OFFSET (3). MOVING PARTS INCORPORATE RADII ON ENDS TO PREVENT NARROW CONTACT POINTS AND LOADING THAT MAY CAUSE HEAT GENERATION. SURFACE FINISHES REDUCE FRICTION BETWEEN MOVING PARTS. 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, GALLING, AND PARTICLE GENERATION (1). CONTACTING ROTATING SURFACES HAVE CLOSE TOLERANCE REQUIREMENTS TO MAINTAIN EVEN LOADING. TIGHT TOLERANCE CONTROLS INCREASE SURFACE CONTACT AREA WHICH REDUCES GALLING, STRESS RISERS, AND OFFSET LOADING. DRY-FILM LUBRICANT IS USED TO REDUCE FRICTION, GALLING, AND PARTICLE GENERATION. TOLERANCE CONTROLS ALSO DECREASE LUBRICANT WEAR, INCREASING LIFE. INTERNAL LINERS REDUCE TURBULENCE OVER THE BELLOWS ASSEMBLY AND PROVIDES LAMINAR FLOW WHICH INHIBITS FLOW INDUCED VIBRATION. FRETTING REQUIREMENTS ARE ESTABLISHED FOR LOT ACCEPTANCE TEST (4). THE FLEX JOINT HAS COMPLETED BENDING MOMENT, FLEXURAL ENDURANCE, VIBRATION, AND SECTIONING DVS TESTING (5). THE VISUAL BELLOWS INSPECTION, HE MASS LEAK, AND ACCESSIBLE BELLOWS WELDS DYE PENETRANT INSPECTION TESTS HAVE BEEN COMPLETED ON ENGINE 2010 (6) AND 2014 (7) FLEX JOINTS. NO ANOMALIES WERE FOUND. THE 2010 DUCT HAD ACCUMULATED 58 STARTS AND 18,150 SECONDS. THE 2014 DUCT HAD ACCUMULATED 60 STARTS AND 17,099 SECONDS.

(1) RS008601; (2) RSS-8582, RSS-8575; (3) I.L. 0126-8066; (4) RL00208; (5) RSS-511-13; (6) CD#2-0152; (7) CD#2-87-0031

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INSPECTION AND TEST

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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A	HUBS		RS008601
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	RS008601
	HEAT TREAT	THE SUBASSEMBLY, WELDED HUBS, AND LEGS HEAT TREAT IS VERIFIED PER SPECIFICATION AND DRAWING REQUIREMENTS.	RA0611-020 RS008601
	SURFACE FINISH	THE HUB DRY-FILM LUBRICATION IS VERIFIED PER DRAWING REQUIREMENTS.	RS008601
	ASSEMBLY INTEGRITY	INNER RADII ARE INSPECTED PER DRAWING REQUIREMENTS.	RS008601
		THE BALL AND SOCKET JOINT LAPPING, AND ALIGNMENT ARE VERIFIED PER DRAWING REQUIREMENTS.	RS008601
	LINERS		RS008601
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	RS008601
	HEAT TREAT	HEAT TREAT IS VERIFIED PER SPECIFICATION AND DRAWING REQUIREMENTS.	RA0611-020 RS008601
	SURFACE FINISH	THE LINERS DRY-FILM LUBRICATION IS VERIFIED PER DRAWING REQUIREMENTS.	RS008601
	ASSEMBLY INTEGRITY	INNER RADII ARE INSPECTED PER DRAWING REQUIREMENTS.	RS008601
	TIE/HUB		RS008601
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	RS008601
	HEAT TREAT	HEAT TREAT IS VERIFIED PER SPECIFICATION AND DRAWING REQUIREMENTS.	RA0611-020 RS008601
	SURFACE FINISH	THE TIE AND HUB CONTACT SURFACE DRY-FILM LUBRICATION IS VERIFIED PER DRAWING REQUIREMENTS.	RS008601
	ASSEMBLY INTEGRITY	INNER RADII ARE INSPECTED PER DRAWING REQUIREMENTS.	RS008601
		THE TIE (RETAINER) LOAD TEST IS PERFORMED PRIOR TO CAP AND NOSE CLOSE-UP WELD PER DRAWING REQUIREMENTS.	RS008601
	RETAINER/HUB		RS008601
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	RS008601
	HEAT TREAT	THE RETAINER AND HUB HEAT TREAT IS VERIFIED PER SPECIFICATION AND DRAWING REQUIREMENTS.	RA0611-020 RS008601
	SURFACE FINISH	THE RETAINER AND HUB DRY-FILM LUBRICATION IS VERIFIED PER DRAWING REQUIREMENTS.	RS008601
	ASSEMBLY INTEGRITY	INNER RADII ARE INSPECTED PER DRAWING REQUIREMENTS.	RS008601
		THE RETAINER IS LOAD TESTED PRIOR TO CAP AND NOSE CLOSE-OUT WELD PER DRAWING REQUIREMENTS.	RS008601
	FLEX JOINT		RS008601

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A	ASSEMBLY INTEGRITY	THE FLEX JOINT IS GIMBAL TESTED PER DRAWING REQUIREMENTS.	RS008601
		THE FLEX JOINT IS ACCEPTANCE TESTED PER SPECIFICATION REQUIREMENTS. (LAST TEST)	RL00208
	DUCT		RS007015
	CLEANLINESS OF COMPONENTS	ASSEMBLY IS VERIFIED CLEAN PER SPECIFICATION REQUIREMENTS.	RA1610-002 RA1610-004

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

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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	RS007015	1	GTAW	I				
DUCT	RS007015	2	GTAW	I	X			
DUCT	RS007015	3	GTAW	I	X			
DUCT	RS007015	4	GTAW	I	X	X		
DUCT	RS007015	5	GTAW	I	X			
DUCT	RS007015	6	GTAW	I	X			
DUCT	RS007015	7	GTAW	I	X	X		
DUCT	RS007015	8	GTAW	I	X	X	X	
DUCT	RS007015	9	GTAW	I		X		
DUCT	RS007015	10	GTAW	I				
DUCT	RS007015	11	GTAW	I	X			
DUCT	RS007015	12	GTAW	I				
DUCT	RS007015	13	GTAW	I	X			
FLEX JOINT	RS008601	1	GTAW	III	X	X		
FLEX JOINT	RS008601	2	GTAW	II	X			
FLEX JOINT	RS008601	3	GTAW	III	X			
FLEX JOINT	RS008601	4-9	GTAW	I				
FLEX JOINT	RS008601	10-15	GTAW	I				
FLEX JOINT	RS008601	16	GTAW	I				
FLEX JOINT	RS008601	17	GTAW	II	X			
FLEX JOINT	RS008601	18	GTAW	I		X		
FLEX JOINT	RS008601	25-28	GTAW	II				
FLEX JOINT	RS008601	33	GTAW	I		X		
FLEX JOINT	RS008601	34	GTAW	I				
FLEX JOINT	RS008601	35	GTAW	I				
FLEX JOINT	RS008601	36	GTAW	I				
FLEX JOINT	RS008601	52	GTAW	II		X		
FLEX JOINT	RS008601	18 PLCS	GTAW	III	X			
BELLOWS	RS008893	1-3	GTAW	I				
BELLOWS	RS008893	4,5	EBW	I				
BELLOWS	RS008893	6,7	GTAW	I				