

SSME / FA/CIL  
REDUNDANCY / SCREEN

Component Group: Combustion Devices  
CIL Item: A150-02  
Part Number: RSD08901  
Component: Heat Exchanger  
FMEA Item: A150  
Failure Mode: Inlet bypass fno, outlet rupture

Prepared: A. Kay  
Approved: T. Nguyen  
Approval Date: 9/9/99  
Change #: 1  
Directive #: CCRD ME3 01 5238

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Phase	Failure / Effect Description	Criticality
SMC 4.1	The oxidizer would leak out of the fracture external to the Hex coil. Potential coil collapse and failure resulting in hot-gas entering the pressurant system. Overpressurization of alt compartment. Loss of vehicle	Hazard Reference 1 MF B3S, ME-B3A,M,C
	Redundancy Screens: SINGLE POINT FAILURE. N/A	

**SSME FMEA/CIL  
DESIGN**

Component Group: Combustion Devices  
CIL Item: A150.02  
Part Number: RS008801  
Component: Heat Exchanger  
FMEA Item: A150  
Failure Mode: Inlet, bypass line, outlet rupture.

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Design / Document Reference

**FAILURE CAUSE:** A: We'd or parent material fracture.

THE INLET, OUTLET, AND BYPASS LINE ASSEMBLIES ARE MADE FROM HAYNES 188. HAYNES WAS CHOSEN FOR ITS WELDABILITY, AND STRENGTH AT CRYOGENIC AND ELEVATED TEMPERATURES. THE ALLOY HAS BEEN TESTED IN OXYGEN AND FOUND TO BE SATISFACTORY (1). THE HEAT EXCHANGER OUTLET DUCT MATERIAL IS AN INCONEL 718 NICKEL BASED ALLOY. INCONEL 718 WAS SELECTED FOR STRENGTH, DUCTILITY, OXYGEN COMPATIBILITY, AND WELDABILITY (2). PRIMARY STRESS FACTORS OF SAFETY MET CEI REQUIREMENTS (3). HIGH CYCLE AND LOW CYCLE FATIGUE ANALYSIS SHOWS THAT CEI LIFE REQUIREMENTS ARE MET (4). THE BYPASS LINE WAS DVS TESTED AS A PART OF THE HEAT EXCHANGER ASSEMBLY. THE HEAT EXCHANGER ASSEMBLY HAS SUCCESSFULLY COMPLETED DVS VIBRATION TESTING (5), DVS PRESSURE CYCLING TESTING (6), DVS ULTIMATE PRESSURE TESTING (7), DVS PROOF PRESSURE LEAK TESTING (8), AND MET ALL DVS REQUIREMENTS. THE INLET, OUTLET, AND BYPASS LINE ASSEMBLIES PARENT MATERIAL WAS CLEARED FOR FRACTURE MECHANICS/INDE FLAW GROWTH SINCE THEY CONTAIN NO FRACTURE CRITICAL PARTS (9). THE FMEA/CIL WELDS ARE CLEARED FOR FRACTURE MECHANICS/INDE FLAW GROWTH BY THE WELD ASSESSMENT (10). TABLE A150 LISTS ALL 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. THOSE WELDS IN WHICH THE CRITICAL INITIAL FLAW SIZE IS NOT DETECTABLE ARE ACCEPTABLE FOR FLIGHT BY RISK ASSESSMENT (10). ENGINE 2010 AND OTHER ASSEMBLIES WERE DESTRUCTIVELY ANALYZED AND THERE WAS NO EVIDENCE OF FATIGUE.

(1) RSS-8581-3 (2) RSS-8582-6; (3) RSS-8546 CP32CR00033; (4) RL03532 CP32OR0003B (5) RSS-513-9; (6) RSS-513-8 (7) RSS-513-10; (8) RSS-513-2; (9) NASA TASK 117; (10) RSS-8756

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SSME FIRE IL  
INSPECTION AND TEST

Component Group: Combustion Devices  
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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A	BYPASS LINE HEX INLET OUTLET ASSEMBLY OUTLET DUCT	MATERIAL INTEGRITY	RS008801 RS008885 RB0170-153 RB0170-211
			RS008801 RS008885 RB0170-153 RB0170-211
			RA0115-116
			RBC170-214
	HEAT TREAT	OUTLET DUCT IS ANNEALED AND HEAT TREATED PER SPECIFICATION REQUIREMENTS.	RA0511-020
	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	PL10011 RA0507-094 RA0115-116 RA0115-006 RA0115-127 RA0115-001
		BYPASS LINE TUBE WELDS ARE BORESCOPE INSPECTED AFTER FABRICATION PER DRAWING REQUIREMENTS.	RS008801
		WELD FLUSHING IS INSPECTED PER DRAWING REQUIREMENTS.	RS008885
		ORIFICE FLANGES (INLET AND OUTLET), BYPASS LINE, AND HEX INLET AND OUTLET ASSEMBLIES, ARE HYDROSTATIC TESTED AFTER FABRICATION. (PROOF TEST)	RS008801 RS007049
		A HELIUM LEAK TEST IS PERFORMED ON THE FLANGES, COIL ASSEMBLY, AND THE BYPASS LINE AFTER FABRICATION.	RA0115-105
ASSEMBLY INTEGRITY	THE HOT FIRE TESTING AND 2ND E & M INSPECTIONS VERIFY ASSEMBLY INTEGRITY.	RI 00050-04 RL00056-06 RL00056-07	
	AN EXTERNAL LEAK CHECK OF GOX HEAT EXCHANGER JOINTS IS PERFORMED PRIOR TO EVERY FLIGHT	OMRSD V418P0.020	
	BYPASS LINE TUBING AND ORIFICE SUPPORT WIRE MESH CUSHION ARE INSPECTED FOR DAMAGE EVERY TIME HPOTP IS REMOVED, OR 5,000 SECONDS	RI 00409 OMRSD V418U0.125	
	HEAT EXCHANGER ASSEMBLY IS LEAK TESTED PRIOR TO EACH FLIGHT. (LAST TEST)	OMRSD SC0000.850	

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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
Failure History:	Comprehensive failure history data is maintained in the Problem Reporting database (PRAMS/PRACA) Reference: NASA letter SA21/85/308 and Rocketdyne letter B5RC09761.		
Operational Use:	Not Applicable.		

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**SSWIC      SAGIL**  
**WELD JOINTS**

Component Group: Combustion Devices  
 CIL Item: A150  
 Component: RS006801  
 Part Number: Heat Exchanger  
 A150

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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	
HEX BYPASS LINE	RS006895	1,2	GTAW	I		X		
HEX OUTLET MANIFOLD	RS006895	1,2	GTAW	I		X		
HEX OUTLET MANIFOLD	RS006895	3,4	GTAW	I				
HEX OXIDIZER TANK	RS006801	1	GTAW	II	X			
HEX OXIDIZER TANK	RS006801	2	GTAW	II				
HEX OXIDIZER TANK	RS006801	2	GTAW	I	X	X	X	(A350)
HEX OXIDIZER TANK	RS006801	4	GTAW	I	X	X		
HEX OXIDIZER TANK	RS006801	5	GTAW	I	X	X		
HEX OXIDIZER TANK	RS006801	6,7	GTAW	I	X			
HEX OXIDIZER TANK	RS006801	9(OPT)	GTAW	I				
HEX OXIDIZER TANK	RS006801	8(OPT)	ESW	I				
HEX OUTER SHELL	RS006802	6(OPT)	ESW	I				(A350)
HEX OUTER SHELL	RS006802	6(OPT)	GTAW	I				(A350)
HEX OXIDIZER TANK LINER	RS006806	1-9	GTAW	II	X			
HEX OXIDIZER TANK LINER	RS006806	20-23,25- 66,72-87	GTAW	II	X			
HEX OXIDIZER TANK LINER	RS006806	24,70	GTAW	I	X			
HEX OXIDIZER TANK LINER	RS006806	68,71	GTAW	I				
HEX OXIDIZER TANK LINER	RS006806	88-95	GTAW	II	X			
HEX OXIDIZER TANK LINER	RS006806	98-106	GTAW	II	X	X		
BRACKET	RS006810	1,2	GTAW	II	X			
BRACKET	RS006810	3,4	ERW	II				
BRACKET	RS006810	9,10	GTAW	II				
HEX INNER SHELL	RS006811	1	GTAW	I				
HEX INNER SHELL	RS006811	2,3	GTAW	I				
HEX COIL	RS006812	1,2	GTAW	I				
HEX COIL	RS006812	3	GTAW	I				
HEX COIL	RS006812	4	GTAW	I				

SSME - A/CIL  
**FIELD CONFIGURATION VARIANCES FROM CIL RATIONALE**

Component Group: Combustion Devices  
 Item Name: Heat Exchanger  
 Item Number: A150  
 Part Number: RS008801

Prepared: A. Key  
 Approved: T. Nguyen  
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Base Line Rationale	Variance	Change Rationale	Variant Dash Number
1. A150-01 TUBE WELDS MEASURED TO VERIFY WFLD WIDTH AND CENTERED ON JOINT (QE-86-229)	NO WELD POSITION MEASUREMENT.	MEASUREMENT ASSURED THAT WELDER COMPLETELY FUSED JOINT, WHICH PROVIDES HIGH CONFIDENCE THAT NO SIGNIFICANT WELD DEFECTS EXIST. USE AS IS RATIONALE: 1. WELD WIDTHS READ FROM ORIGINAL X-RAYS ADD CONFIDENCE THAT JOINT WAS COMPLETELY FUSED. 2. THIN WALL ALLOWS HIGH RESOLUTION X-RAYS, AND X-RAY ENHANCEMENT AND INTERPRETATION BY LEVEL 3 NDE GIVES ADDED ASSURANCE OF NO SIGNIFICANT DEFECTS. 3. ETCH AND TYPE IVC PENETRANT AFTER PROOF AND HOT FIRE OF RS008811 WELD 1 ASSURES NO SIGNIFICANT I.D. DEFECTS. 4. HIGH RESOLUTION I.D. BORESCOPE INSPECTION AFTER PROOF AND HOT FIRE OF RS008811 WELD 1 AND RS008812 WELD 3 PROVIDES ADDITIONAL CONFIDENCE THAT NO SIGNIFICANT I.D. DEFECTS EXISTS. 5. X-RAY AFTER PROOF AND HOT FIRE OF RS008812 WELDS 1, 2, AND 3 ADDS CONFIDENCE THAT NO SIGNIFICANT DEFECTS EXIST.	401, -441
2. A150-01 TUBE WELDS ARE PENETRANT INSPECTED BEFORE REAMING (QE-86-229)	NO PENETRANT BEFORE REAM OF PRIMARY TUBE WELD I.D.s.	PROVIDED ADDITIONAL CONFIDENCE THAT I.D. SURFACE DEFECTS DO NOT EXIST. USE AS IS RATIONALE: 1. THIN WALL ALLOWS HIGH RESOLUTION X-RAYS, AND X-RAY ENHANCEMENT AND INTERPRETATION BY LEVEL 3 NDE GIVES ADDED ASSURANCE OF NO SIGNIFICANT DEFECTS 2. ETCH AND TYPE IVC PENETRANT AFTER PROOF AND HOT FIRE OF RS008811 WELD 1 ASSURES NO SIGNIFICANT I.D. EFFECTS 3. HIGH RESOLUTION I.D. BORESCOPE INSPECTION AFTER PROOF AND HOT FIRE OF RS008811 WELD 1 AND RS008812 WELD 3 PROVIDES ADDITIONAL CONFIDENCE THAT NO SIGNIFICANT I.D. DEFECTS EXIST. 4. X-RAY AFTER PROOF AND HOT FIRE OF RS008812 WELD 3 ADDS CONFIDENCE THAT NO SIGNIFICANT DEFECTS EXIST. 5. LEAK TEST PRIOR TO EACH FLIGHT WILL DETECT THROUGH CRACKS. 6. RS008811 WELD 3 I.D. IS PENETRANT INSPECTED AFTER REAMING, BUT WITHOUT ETCHING	-401 -441

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Component Group: Locomotion Devices  
 Item Name: Heat Exchanger  
 Item Number: A150  
 Part Number: RS008801

Approved: T. Nguyen  
 Approval Date: 9/9/99  
 Change #: 1  
 Directive #: CCB0 ME3-01-5238

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Base Line Rationale	Variance	Change Rationale	Variant Dash Number
3. A150-01 COIL WELDS ARE X-RAYED (4 VIEWS) AFTER PROOF PRESSURE TEST. (ECP 1A0283)	ONLY 3 X-RAY VIEWS OF EACH WELD. NO X-RAY AFTER PROOF FOR RS008811 WELDS.	GAVE ADDITIONAL ASSURANCE THAT SIGNIFICANT DEFECTS ARE NOT MISSED AND THAT PREVIOUSLY UNDETECTED DEFECTS WHICH MAY GROW TO DETECTABILITY IN PROOF TEST ARE FOUND USE AS IS RATIONALE: 1. PENETRANT AFTER PROOF WOULD DETECT DEFECTS WHICH GROW TO O.D. 2. THIN WALL ALLOWS HIGH RESOLUTION X-RAYS AND X-RAY ENHANCEMENT AND INTERPRETATION BY LEVEL 3 NDE GIVES ADDED ASSURANCE OF NO SIGNIFICANT DEFECTS. 3. FITCH AND TYPE IVC PENETRANT AFTER PROOF AND HOT FIRE OF RS008811 WELDS 1 ASSURES NO SIGNIFICANT I.D. DEFECTS. 4. LEAK TEST PRIOR TO EACH FLIGHT WILL DETECT THROUGH CRACKS.	-401, -441
4. A150-01 MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION REQUIREMENTS (DOUBLE VACUUM MELT 316L GRES BAR PER R91163-070).	BIFURCATION FITTING MATERIAL IS COMMERCIAL GRADE AIR MELT 316L GRES.	DOUBLE VACUUM MELTING SPECIFICATION HAS A STRICT INCLUSION RATING REQUIREMENTS AND REDUCES THE INCIDENCE OF NON-METALLIC INCLUSION/STRINGERS WHICH COULD RESULT IN LEAKS. USE AS IS RATIONALE: 1. HEAT EXCHANGERS ARE SUBJECT TO A POST ACCEPTANCE TEST MASS SPECTROMETER LEAK DETECTOR (MSLD) CHECK PER RL00050-04 TO VERIFY LOX COIL LEAKAGE WITHIN ACCEPTANCE LIMITS. 2. FIVE HEAT EXCHANGER FABRICATION UNITS UTILIZING AIR-MELT MATERIAL WERE CRYO-CYCLED AND MASS SPECTROMETER LEAK CHECK TESTED TO VERIFY BIFURCATION JOINT INTEGRITY PER EOR 352926 3. ENGINEERING PROBABILITY ANALYSIS SHOWS "... ESSENTIALLY NO CHANCE OF HAVING A CRITICALLY SIZED LEAK OCCUR DURING A FLIGHT " THIS ANALYSIS WAS BASED ON EXTENSIVE TESTING OF ACTUAL MATERIAL SAMPLES INCLUDING: INCLUSION CROSS-SECTIONAL ANALYSIS, CRYO-CYCLING AND MASS SPECTROMETER LEAK DETECTION (MSLD) TESTING. REFERENCE UCR A010078. 4. ENGINEERING HAS DETERMINED THAT LEAKAGE RESULTING FROM BIFURCATION JOINT INCLUSION STRINGERS IS 'NOT HAZARDOUS TO ENGINE HARDWARE' AS EVIDENCED BY ENGINE 0209 WHICH SUSTAINED THREE MAINSTAGE TESTS WITH KNOWN BIFURCATION JOINT LEAKAGE WITHOUT ANY DELETERIOUS EFFECT ON ENGINE HARDWARE OR PERFORMANCE. REFERENCE UCR A022612.	-311, -341, -351, -361, -371, -381, -391, -401, -421, -431, -441, -451, -461, -471, -481, -491, -501, -521

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