

SINGLE POINT FAILURE
REDUNDANCY / SCREEN

Component Group: Combustion Devices
 CIL Item: A150-01
 Part Number: RSD08801
 Component: Heat Exchanger
 FMEA Item: A150
 Failure Mode: Coil fracture/leakage.

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

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Phase	Failure / Effect Description	Criticality Hazard Reference
SMC 4.1	GOX would mix with the fuel-rich hot-gas stream resulting in ignition, detonation, and burning. Burning would result in coil, HGM liner or HPOTP turbine or main injector burn-through causing loss of engine. Fuel-rich hot-gas could enter the downstream side of the coil and combine with oxygen from the bypass system, causing a fire in the discharge line that supplies the Pogo accumulator and the vehicle oxygen pressurization system. Loss of vehicle.	1 ME-93S, ME-B3A,M,C
Redundancy Screens: SINGLE POINT FAILURE: N/A		

**SSME FMEA/CIL
DESIGN**

Component Group: Combustion Devices
CIL Item: A150-01
Part Number: R5008801
Component: Heat Exchanger
FMEA Item: A150
Failure Mode: Coil fracture/leakage.

Prepared: A. Kay
Approved: T. Nguyen
Approval Date: 9/9/99
Change #: 1
Directive #: CCBDEME3-01-5238

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Design / Document Reference

FAILURE CAUSE: A: Coil weld or parent material fracture. Fracture due to fatigue.

THE HEX COIL AND BIFURCATION FITTINGS ARE MANUFACTURED USING 316L CRES MATERIAL. 316L IS DUCTILE AND PROVIDES DAMAGE RESISTANCE WITH RELIABILITY OF FABRICATION. THE HEX BIFURCATION MATERIAL IS DOUBLE VACUUM MELTED AND SUBJECT TO A STRICT INCLUSION RATING REQUIREMENT TO REDUCE SIZE AND NUMBER OF INCLUSIONS FOR IMPROVED MATERIAL INTEGRITY (4). INLET FITINGS ARE MADE FROM HAYNES 188. HAYNES 188 WAS CHOSEN FOR ITS STRENGTH. BOTH ALLOYS HAVE BEEN OXYGEN TESTED AND RATED SATISFACTORY (1). BOTH ALLOYS EXHIBIT CORROSION RESISTANCE, RESISTANCE TO STRESS CORROSION AND RESISTANCE TO HYDROGEN ENVIRONMENT EMBRITTLEMENT. TUBE WALL THICKNESS IS LIMITED AND TUBE WELDS EXPOSED TO HOT-GAS FLOW ARE MACHINED FLUSH TO LIMIT THERMAL STRAINS AND EXTEND LOW CYCLE FATIGUE LIFE. FATIGUE LIFE IS ENHANCED BY LIMITING WELD MISMATCH WITH USE OF CONSUMABLE INSERTS ON THE PRIMARY TUBE AND ALIGNMENT PINS ON THE SECONDARY TUBE. ARTIFICIAL FLAW TESTS (2) WERE PERFORMED ON THE COIL TUBING. THE TESTS INCLUDED CYCLIC LOADING OF DELIBERATELY INDUCED I.D. AND O.D. SURFACE DEFECTS. THE RESULTS SHOWED FLAWS LESS THAN 50% OF THE TUBING THICKNESS DO NOT PROPAGATE. TEST HISTORY AND COIL TUBE WEAR ANALYSIS (3) SUPPORTS THE EDDY CURRENT INSPECTION INTERVAL. COIL WELDS ARE TUNGSTEN INERT GAS WELDED USING 316L FILLER. COIL LOADING IS MINIMIZED BY THE BRACKET MOUNTING SYSTEM WHICH ACCOMODATES THERMAL EXPANSION. CLEARANCE IS PROVIDED AT THE BRACKETS ADJACENT TO THE INLET AND OUTLET TO REDUCE BENDING LOADS THERE.

(1) RSS-8581-9; (2) NASA TASK 099; (3) I.L. REL07-066; (4) RB0160-070

FAILURE CAUSE: B: Loss of channel/bracket supports.

THE BRACKETS ARE CONSTRUCTED OF HAYNES 188. HAYNES WAS SELECTED FOR HIGH STRENGTH AT ELEVATED TEMPERATURES AND RESISTANCE TO DEGRADATION IN HIGH PRESSURE HYDROGEN (1). THE BRACKETS ARE COMPOSED OF CHANNELS WELDED TOGETHER WITH REDUNDANT, LIGHTLY LOADED WELDS AND DOUBLERS WHERE REQUIRED INTO A RIGID BOX STRUCTURE.

(1) RSS-8581-9

FAILURE CAUSE: C: Damage due to impact from fragmented liner, turning vanes, or channels.

BURST TESTS WERE CONDUCTED ON TUBES WITH DELIBERATE MECHANICAL DAMAGE (1). TESTING SHOWED HIGH MARGINS MAINTAINED ON PRESSURE CAPABILITY OF TUBES, EVEN WITH EXTREME DAMAGE. THE HEX LINERS ARE MADE FROM INCONEL 903. INCONEL 903 WAS CHOSEN FOR ITS STRENGTH AND FOR ITS RESISTANCE TO DEGRADATION IN HIGH PRESSURE HYDROGEN. IT IS SEMI-CORROSION RESISTANT AND RESISTANT TO STRESS CORROSION (2). THE TURNING VANE IS MADE FROM A SINGLE INCONEL 625 CASTING WITH ELEVEN BOSSES TO ACCOMODATE MOUNTING PINS THAT ARE WELDED TO THE HEX LINER. THE TURNING VANES SLIDES ON THESE DRY-FILM LUBRICATED PINS WHICH PREVENT BINDING DURING THERMAL EXPANSION. THIS KEEPS THE STRAINS IN THE ELASTIC RANGE UNDER OPERATION, THEREBY ELIMINATING THE NEED TO PROTECT THE INCONEL 625 FROM HYDROGEN ENVIRONMENT EMBRITTLEMENT (2). THE BRACKETS ARE CONSTRUCTED OF HAYNES 188. HAYNES 188 WAS SELECTED FOR ITS STRENGTH AT ELEVATED TEMPERATURES AND FOR ITS RESISTANCE TO DEGRADATION IN HIGH PRESSURE HYDROGEN.

(1) RSS-8595-17; (2) RSS-8581-9

FAILURE CAUSE: D: Tube wall wear at support points.

CLEARANCE IS PROVIDED BETWEEN THE TUBE AND BRACKETS OR LINER AT SELECTED LOCATIONS TO PREVENT CONTACT DURING OPERATION. AT ALL OTHER LOCATIONS, THE TUBE IS HELD IN THE BRACKET DIMPLES TO MINIMIZE RELATIVE MOTION. IN ADDITION TO DVS (1), A LOOSE BRACKET VIBRATION TEST (2), TO THE DVS REQUIREMENTS WAS PERFORMED. ENGINE 2010 AND OTHER ASSEMBLIES WERE DESTRUCTIVELY ANALYZED FOR WEAR RATES TO DETERMINE INSPECTION INTERVALS. AN EDDY CURRENT INSPECTION OF THE PRIMARY TUBE IS USED TO DETERMINE COIL WEAR DUE TO ITS WALL THICKNESS AND SENSITIVITY TO DETECTION (3).

(1) RSS-513-9; (2) SSME-85-282B; (3) B5RC13430

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Component: (p) Combustion Devices
CIL Item: A150-01
Part Number: RS008801
Component: Heat Exchanger
FMEA Item: A150
Failure Mode: Coil fracture/leakage

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

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Design / Document Reference

FAILURE CAUSE: E: Tube damage during HPDTP removal and installation.

BURST TESTS WERE CONDUCTED ON TUBES WITH DELIBERATE DAMAGE. TESTING SHOWED HIGH MARGINS ON PRESSURE CAPABILITY OF TUBES, EVEN WITH EXTREME DAMAGE (1). THE TUBE IS PROTECTED FROM DIRECT PUMP CONTACT BY THE BRACKETS (2). BRACKETS ARE DESIGNED FOR CLEARANCE FROM THE PUMP AND CHAMFERS ARE PROVIDED TO PREVENT DAMAGE IF CONTACT DOES OCCUR DURING INSTALLATION OR REMOVAL.

(1) RSS-8585-17; (2) RS008808

FAILURE CAUSE: F: Coil collapse.

THE HEX COIL IS MADE FROM 316L CRES TUBING. 316L HAS EXCELLENT DUCTILITY AND PROVIDES HIGH DAMAGE RESISTANCE WITH RELIABILITY OF FABRICATION. THE ALLOY EXHIBITS GOOD CORROSION RESISTANCE, HIGH RESISTANCE TO STRESS CORROSION AND RESISTANCE TO HYDROGEN ENVIRONMENT EMBRITTLEMENT (1). COLLAPSE PRESSURE CAPABILITY OF THE COIL WAS ANALYZED AND MET CEI REQUIREMENTS (2). THIS ANALYSIS WAS BASED ON ACTUAL COLLAPSE PRESSURE TESTING OF THE TUBES.

(1) RSS-8581-9; (2) RSS-8546, CP320R0003B

FAILURE CAUSE: ALL CAUSES

THE HEAT EXCHANGER ASSEMBLY HAS SUCCESSFULLY COMPLETED DVS VIBRATION TESTING (1), DVS PRESSURE CYCLING TESTING (2), DVS ULTIMATE PRESSURE TESTING (3), DVS PROOF PRESSURE LEAK TESTING (4), AND MET ALL DVS REQUIREMENTS. ADDITIONAL VIBRATION TESTING WAS PERFORMED WITH LOOSE BRACKETS TO EVALUATE EFFECTS ON THE ASSEMBLY. NO COIL FRACTURE OCCURED (5). THE HEAT EXCHANGER ASSEMBLY PARENT MATERIALS WERE CLEARED FOR FRACTURE MECHANICS/NOF FLAW GROWTH SINCE IT CONTAINS NO FRACTURE CRITICAL PARTS (6). THE FMEA/CIL WELDS ARE CLEARED FOR FRACTURE MECHANICS/NOF FLAW GROWTH BY THE WELD ASSESSMENT (7). 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 (7). ENGINE 2010 AND OTHER ASSEMBLIES WERE DESTRUCTIVELY ANALYZED AND THERE WAS NO EVIDENCE OF IMPENDING FAILURE DUE TO COIL FATIGUE DAMAGE, LOSS OF BRACKET SUPPORT, IMPACT DAMAGE, OR COIL COLLAPSE. A FATIGUE ANALYSIS WAS PERFORMED FOR HIGH CYCLE FATIGUE AND LOW CYCLE FATIGUE WITH RESULTS SHOWING CEI LIFE REQUIREMENTS MET (8). THE MINIMUM FACTORS OF SAFETY MEET CEI REQUIREMENTS (9).

(1) RSS-513-9; (2) RSS-513-8; (3) RSS-513-10; (4) RSS-513-2; (5) SSME-85-2628; (6) NASA TASK 117; (7) RSS-8755; (8) RL00532 CP320R0003B; (9) RSS-8546, CP320R0003B

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SSME FMEA/CIL
INSPECTION AND TEST

Component Group: Combustion Devices
 CIL Item: A150-01
 Part Number: RS008601
 Component: Heat Exchanger
 FMEA Item: A150
 Failure Mode: Coil fracture/leakage.

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

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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A, F	COIL ASSEMBLY TUBE ASSEMBLY		RS008811 RS008812
	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 RA0037-094 RA0115-116 RA0115-018 RA0115-127 RA1115-001
	UNVERIFIABLE ROOT WELDS RS008812 CLASS 1-4	UNVERIFIABLE ROOT WELDS ARE INSPECTED PER DRAWING AND SPECIFICATION REQUIREMENTS AS APPLICABLE	
		WELD GEOMETRY IS INSPECTED PER DRAWING REQUIREMENTS.	RS008812 RS008811
		AN I.D. BORESCOPE PENETRANT INSPECTION IS DONE AFTER COMPLETION OF ALL TUBE WELDS, PRIOR TO WELD FLUSHING PER DRAWINGS REQUIREMENTS. RS008812 WELDS 1-3, RS008811 WELDS 1-3.	RS008812 RS008811 RA0115-116
		WELD AND ADJACENT PARENT MATERIAL WALL THICKNESSES INSPECTED FOR THINNING AND STEPS AFTER FLUSHING OPERATION. RS008812 WELDS 1-3, RS008811 WELDS 1-3.	RS008812 RS008811
		TUBE WELDS ARE X-RAYED AND PENETRANT INSPECTED AFTER MACHINING AND ETCHING ON O.D. RS008812 WELDS 1-3 PER SPECIFICATION REQUIREMENTS.	RA0115-116 RA0115-005
		ALL COIL ASSEMBLY WELDS ARE PENETRANT INSPECTED ON THE O.D. AND MICROFOCUS X-RAY INSPECTED AFTER HYDROSTATIC PRESSURE TESTING PER SPECIFICATION REQUIREMENTS. RS008811 WELDS 1-3, RS008812 WELDS 1-3, RS008812 WELD 4.	RS008811 RS008812 RA0115-006 RA0115-116
		TUBE WELDS BORESCOPED ON ID AFTER HYDROSTATIC PRESSURE TESTING. RS008811 WELDS 1-3, RS008812 WELD 4.	RS008811 RS008812
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION REQUIREMENTS (DOUBLE VACUUM MELT 316L CRES BAR PER RB0163-070).	RB0160-070

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Component: Combustion Devices
 CIL Item: A150-01
 Part Number: RS008901
 Component: Heat Exchanger
 FMEA Item: A150
 Failure Mode: Coil fracture/leakage.

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

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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A, F	MATERIAL INTEGRITY	THE STRAIGHT TUBING IS INSPECTED FOR CHEMICAL COMPOSITION, SURFACE FINISH AND DISCONTINUITIES, TENSILE AND BURST STRENGTH, EXPANSION, GRAIN SIZE AND SHAPE, SURFACE OXIDATION AND SUSCEPTABILITY TO INTERGRANULAR ATTACK PER SPECIFICATION REQUIREMENTS.	RS016C-053
		THE TUBING IS INSPECTED FULL LENGTH TO VERIFY ALL INSIDE AND OUTSIDE DIAMETERS AND WALL THICKNESS ARE PER SPECIFICATION REQUIREMENTS.	
		AFTER CYCLIC PROOF PRESSURE TESTING, STRAIGHT TUBING IS ULTRASONIC INSPECTED FOR INTERNAL DEFECTS AND THE O.D. IS PENETRANT INSPECTED PER SPECIFICATION REQUIREMENTS.	RA3115-124 RA3115-115
	COIL INTEGRITY	THE COIL IS PENETRANT INSPECTED ON THE O.D. AFTER FORMING AND PROOF TESTING PER SPECIFICATION REQUIREMENTS. SAMPLES FROM FORMED COIL ARE INSPECTED FOR WALL THICKNESS AND FORMING DEFECTS TO VERIFY ADEQUATE PROCESS CONTROL PER SPECIFICATION REQUIREMENTS.	RA3115-116 RA3132-003
		ASSEMBLED COIL IS INSPECTED FOR DENTS, SCRATCHES AND OTHER DAMAGE AFTER FABRICATION PER SPECIFICATION REQUIREMENTS	RLC0409
		BRACKETS ARE INSPECTED FOR CLEARANCE TO LINER AND HPOTP ENVELOPE AFTER ASSEMBLY.	RS005801 RI 00409
		COIL IS VISUALLY INSPECTED ON SURFACES SUSCEPTABLE TO DAMAGE WHENEVER HPOTP IS REMOVED OR EVERY 5,000 SECONDS.	RLC0409 OMRSD V41BU0 0620 OMRSD V41BU0 115
		ASSEMBLED COIL IS INSPECTED FOR SECURE BRACKETS AND TUBE SEATING IN DIMPLES WHENEVER HPOTP IS REMOVED OR EVERY 5,000 SECONDS.	
E	COIL BRACKET ASSEMBLY CHANNEL CHANNEL CHANNEL CHANNEL CHANNEL ASSEMBLY CAM		RS008806 RS008815 RS008814 RS008813 RS008809 RS008810 RS008810

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Component Group: Combustion Devices
 CIL Item: A150-01
 Part Number: RS008801
 Component: Heat Exchanger
 FMEA Item: A150
 Failure Mode: Coil fracture/leakage.

Prepared: A. May
 Approved: T. Nguyen
 Approval Date: 9/6/99
 Change #: 1
 Directive #: CCBD ME3-01-5238

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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
B	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.	RS008805 RS008813 RS008809 RS008810 RB0170-186 RB0170-179
	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 RA0115-127 RA1115-001
		BRACKETS ARE INSPECTED FOR CONTACT BY HPOTP, HPOTP ENVELOPE, COIL SECURITY WITHIN BRACKET AND BRACKET SECURITY WHENEVER HPOTP IS REMOVED, NOT TO EXCEED 5,000 SECONDS	RL00409 OMRSD V41BU0.0820
C	TURNING VANE		RS008684
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION REQUIREMENTS. VANE CASTING IS X-RAY INSPECTED PER DRAWING AND SPECIFICATION REQUIREMENTS.	RB0170-167 RF0001-001 RA0115-005
	VANE INTEGRITY	VANE ASSEMBLY IS PENETRANT INSPECTED AFTER MACHINING TO VERIFY ABSENCE OF CASTING DEFECTS PER SPECIFICATION REQUIREMENTS VANE IS INSPECTED FOR THICKNESS AND LEADING EDGE RADIUS PER DRAWING REQUIREMENTS DRY-FILM LUBE IS INSPECTED PER SPECIFICATION REQUIREMENTS THE VANE IS INSPECTED FOR CLEARANCE AND DAMAGE. VANE IS INSPECTED FOR EXCESSIVE MOVEMENT AND DAMAGE EACH TIME HPOTP IS REMOVED OR 5,000 SECONDS.	RSC08684 RAC115-116 RSC08684 REC140-017 RSC08803 RL00409 OMRSD V41BUC 0820
	HEAT EXCHANGER LINER		RS005806
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION REQUIREMENTS. MATERIAL IS MAGNETIC PARTICLE INSPECTED AFTER CHEM MILL, ANNEAL, AND HEAT TREAT PER SPECIFICATION REQUIREMENTS.	RB0170-186 RA0115-115
	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 RA0115-115
	UNVERIFIABLE ROOT WELDS RS008801 CLASS II	UNVERIFIABLE ROOT WELDS ARE INSPECTED PER DRAWING AND SPECIFICATION REQUIREMENTS AS APPLICABLE	RA0115-006 RA0115-127 RA1115-001

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Component: Combustion Devices
 CIL Item: A150-01
 Part Number: RS008501
 Component: Heat Exchanger
 FMEA Item: A150
 Failure Mode: Coil fracture/leakage.

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

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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
C	BRACKET ASSEMBLY CHANNEL CHANNEL CHANNEL CHANNEL CHANNEL ASSEMBLY CAM		RS008805 RS008815 RS008814 RS008813 RS008809 RS008810 RS008815
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.	RS008806 RS008809 RS008810 RS008813 RBC170-170 RBC170-199
		BRACKETS ARE INSPECTED FOR SECURITY AND CLEARANCES AT MANUFACTURE, EVERY TIME HPOTP IS REMOVED OR 5,000 SECONDS.	RL00405 OMRSD V41B10.082C
	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 RA2607-094 RA2115-119 RA2115-009 RA2115-127 RA1115-001
D	ASSEMBLY INTEGRITY	ASSEMBLED COIL IS INSPECTED FOR SECURE BRACKETS, TUBE SEATING AND CLEARANCES, AND COIL MOVEMENT AFTER ASSEMBLY, WHENEVER HPOTP IS REMOVED, OR PER TIME/CYCLE REQUIREMENTS	RL00409 OMRSD V41B10.082C OMRSD C005A0.015
		HEAT EXCHANGER IS EDDY CURRENT INSPECTED FOR PRIMARY TUBE WEAR AFTER THE FIRST 3,200 SECONDS OF OPERATION AND SUBSEQUENTLY AT AN INTERVAL NOT TO EXCEED 2,400 SECONDS OF OPERATION.	OMRSD V41B10.086 OMRSD C005A0.015
F	COIL INTEGRITY INSPECTION	COIL AND BRACKETS ARE INSPECTED FOR DEFORMATION AND DAMAGE. BRACKET TO PUMP CLEARANCE ENVELOPE IS INSPECTED TO ASSURE NO INTERFERENCE BETWEEN PUMP AND COIL ASSEMBLY WHENEVER HPOTP IS REMOVED.	RL00409 OMRSD V41B10.082C
ALL CALSFS	ASSEMBLY INTEGRITY	THE HOT FIRE TESTING AND ZND E & M INSPECTIONS VERIFY ASSEMBLY INTEGRITY.	RL00050-04 RL00056-06 RL00056-07
		COIL IS LEAK TESTED PRIOR TO EACH FLIGHT. (LAST TEST) HEAT EXCHANGER IS PROOF TESTED AFTER EVERY HPOTP INSTALLATION.	OMRSD V41B10.020 OMRSD V41B10.020

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Component Group: Combustion Devices
CIL Item: A150-01
Part Number: RS008E01
Component: Heat Exchanger
FMEA Item: A150
Failure Mode: Coil fracture/leakage.

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

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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/FRACA). Reference: NASA letter SA21/88/308 and Rockwell letter BRRC03751.		
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

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

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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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