

**SSME FMEA/CIL  
REDUNDANCY SCREEN**

Component Group: Combustion Devices  
CIL Item: A200-08  
Part Number: RS009122  
Component: Main Injector  
FMEA Item: A200  
Failure Mode: External rupture.

Prepared: A. Kay  
Approved: T. Nguyen  
Approval Date: 9/0/99  
Change #: 2  
Directive #: CCBD ME3-0\*-5208

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Phase	Failure / Effect Description	Criticality Hazard Reference
SMC 4.1	Fuel and hot-gas leakage into the aft compartment will cause overpressurization and fire. Loss of vehicle.  Redundancy Screens: SINGLE POINT FAILURE: N/A	1 ME-B4S ME B4A,C ME-B4M

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DESIGN

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Failure Mode: External rupture.

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Approval Date: 9/9/99  
Change #: 2  
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Design / Document Reference

**FAILURE CAUSE: A: Weld or parent material failure.**

THE ASI LINE IS SUPPORTED AT THE FLANGE TO REDUCE LINE LOADING AND DAMPEN VIBRATION (1). THE ASI ASSEMBLY IS MADE OF INCONEL 625. INCONEL WAS CHOSEN FOR ITS BRAZABILITY AND WELDABILITY. THE COMPONENT DESIGN OPERATES AT WELL BELOW THE CRITICAL TEMPERATURES FOR HYDROGEN EMBRITTLEMENT (2). A FATIGUE ANALYSIS WAS PERFORMED ON THE MAIN INJECTOR. THE ANALYSIS RESULTED IN CEI REQUIREMENTS BEING MET FOR HIGH CYCLE FATIGUE AND LOW CYCLE FATIGUE (3). THE PRIMARY STRESS FACTOR OF SAFETY MEET CEI REQUIREMENTS (4). THE ASI FUEL LINE PARENT MATERIALS WERE CLEARED FOR FRACTURE MECHANICS/INDE FLAW GROWTH SINCE IT CONTAINS NO FRACTURE CRITICAL PARTS (5). THE FMEA/CIL WELDS ARE CLEARED FOR FRACTURE MECHANICS/INDE FLAW GROWTH BY THE WELD ASSESSMENT (6). TABLE A200 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 (6). A GAP BETWEEN THE WALL AND THE ASI LINE REDUCES THE CHANCE OF CRACK INITIATION FROM IMPACTING OR RUBBING ON THE DOME D ASSEMBLY RESULTS OF ENGINE 2010 SHOWED THAT NO ANOMALOUS CONDITIONS EXISTED (7). THE MAIN INJECTOR HAS COMPLETED DVS TESTING (8).

(1) RS007004; (2) RSS-8572-9; (3) RL00532, CP320R0003B; (4) RSS-8546 CP320R0003B; (5) NASA TASK 117; (6) RSS-8756; (7) IL CD 36-1042; (8) DVS-101

**FAILURE CAUSE: B: Liquid metal embrittlement at braze areas.**

THE BRAZE JOINTS ARE DONE IN A TEMPERATURE CONTROLLED FURNACE (1). THIS REDUCES THE POTENTIAL FOR LIQUID METAL EMBRITTLEMENT OR BRAZE DEFECTS. PREVIOUS PROBLEM AREAS AT THE THRUST CONE WITH LIQUID METAL EMBRITTLEMENT HAVE BEEN RE-DESIGNED TO ELIMINATE THE BRAZING AND SLEEVE (2). THE OTHER BRAZE JOINTS ARE NOW BEING WELDED WITH THE EXCEPTION OF THE FUEL INLET TO BODY, WHICH REMAINS A BRAZE JOINT (3). THIS JOINT IS BRAZED TOGETHER WITH NO INDUCED LOADS.

(1) RA1007-009; (2) RS009126; (3) RSC0906\*

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**SSME FMEA/CIL  
INSPECTION AND TEST**

Component Group: Combustion Devices  
 CIL Item: A200-08  
 Part Number: RS009122  
 Component: Main Injector  
 FMEA Item: A200  
 Failure Mode: External rupture.

Prepared: A. Kay  
 Approved: T. Nguyen  
 Approval Date: 9/9/99  
 Change #: 2  
 Directive #: CCBD #E3-01-5239

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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A	INJECTOR BODY ASI TUBE ASI ASSEMBLY		RS009126 RSC09126 RS009061
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION AND DRAWING REQUIREMENTS	RB0170-213 RS009126 RS009051
		TUBING WALL THICKNESS IS INSPECTED WHEN RAW STOCK IS RECEIVED.	RB0170-213
		ASI LINE IS ULTRASONICALLY AND PENETRANT INSPECTED PER SPECIFICATION REQUIREMENTS	RA0115-012 RA0115-116
	TUBE CLEARANCE WELD INTEGRITY	TUBE-TO-THRUST CONE CLEARANCE IS VERIFIED AFTER WELDING PER DRAWING REQUIREMENT.  ALL WELDS ARE INSPECTED TO DRAWING AND SPECIFICATION REQUIREMENTS PER WELD CLASS. INSPECTIONS INCLUDE VISUAL DIMENSIONAL, PENETRANT RADIOGRAPHIC, ULTRASONIC, AND FILLER MATERIAL, AS APPLICABLE.	RS009125  RL10011 RAC007-094 RA0115-116 RA0115-006 RA0115-127 RA1115-001
B	BRAZE WELD INTEGRITY	ALL BRAZE WELDS ARE INSPECTED FOR DEFECTS AND PROPER BRAZE FLOW  ASI WELDS ARE PENETRANT INSPECTED AFTER PROOF TEST PER SPECIFICATION REQUIREMENTS.	RA1627-009 RL02127
ALL CAUSES	ASSEMBLY INTEGRITY	ASI ASSEMBLY IS PROOFED AND LEAK TESTED PER DRAWING AND SPECIFICATION REQUIREMENTS.  THE HOT FIRE TESTING AND 2ND E & M INSPECTIONS VERIFY ASSEMBLY INTEGRITY.  TUBE-TO-THRUST CONE CLEARANCE IS INSPECTED PRIOR TO EVERY FLIGHT EXTERIOR OF ASI LINES ARE VISUALLY INSPECTED PRIOR TO LAUNCH. THE SIGNATURE LEAK TEST VERIFIES NO EXTERNAL LEAKAGE PRIOR TO EACH LAUNCH. (LAST TEST)	RS009126 RI 00127  RL00056-04 RL00056-05 RI 00056-07  OMRSD W41BU0.020 OMRSD W41BU0.029 OMRSD S00000 950

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Component: Combustion Devices  
CIL Item: A200-08  
Part Number: RS009122  
Component: Main Injector  
FMEA Item: A200  
Failure Mode: External rupture.

Prepared: T. Nguye  
Approved: T. Nguye  
Approval Date: 9/9/99  
Change #: 2  
Derivative #: 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/PRACA) Reference: NASA letter SA21/98/308 and Rocketdyne letter 88RC0976		
Operational Use:	Not Applicable		

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SSME / A/CIL  
WELD JOINTS

Component Group: Combustion Devices  
 CIL Item: A200  
 Component: RS009122  
 Part Number: Main Injector  
 A200

Prepared: A. Kay  
 Approved: T. Nguyen  
 Approval Date: 9/9/99  
 Change #: 1  
 Directive #: CCBD ME3-01-523A  
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Component	Basic Part Number	Weld Number	Weld Type	Class	Root Side Not Access	Critical Initial		Comments
						Flaw Size Not	Detectable	
						HCF	LCF	
MAIN INJECTOR ASI	RSC09061	3	GTAW	I		X	X	
MAIN INJECTOR ASI	RSC09061	5	GTAW	I		X	X	
MAIN INJECTOR	RS009126	1	EBW	I				
MAIN INJECTOR	RS009126	6,7,52,53	GTAW	I	X	X	X	
MAIN INJECTOR	RS009126	8	EBW	I		X		
MAIN INJECTOR	RS009126	9	EBW	I	X			
MAIN INJECTOR	RS009126	10	EBW	II	X	X	X	
MAIN INJECTOR	RS009126	12,13	GTAW	I	X			
MAIN INJECTOR	RS009126	14,15	GTAW	I	X	X	X	
MAIN INJECTOR	RS009126	16,17	GTAW	I		X	X	
MAIN INJECTOR	RS009126	20	GTAW	I	X			
MAIN INJECTOR	RS009126	21	GTAW	II	X			
MAIN INJECTOR	RS009126	22	GTAW	I	X			
MAIN INJECTOR	RS009126	23-25,54	GTAW	I	X			
MAIN INJECTOR	RS009126	44,45	GTAW	I		X	X	
MAIN INJECTOR	RS009126	50,51	EBW	Ia	X	X	X	
MAIN INJECTOR	RS009126	59	EBW	I,b	X			
MAIN INJECTOR	RS009126	60,61	GTAW	II	X	X		
INLET SHELL	RSD05235	1 LFT	EBW	I				
INLET SHELL	RSC09235	1 RHT	EBW	I		X	X	
INLET SHELL	RSC05237	600 FLCS	FRW	I	X			

**SSME FMEA/CIL  
FIELD CONFIGURATION VARIANCES FROM CIL RATIONALE**

Component Group: Combustion Devices  
Item Name: Main Injector  
Item Number: A200  
Part Number: R5009122

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

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Base Line Rationale	Variance	Change Rationale	Variant Dash Number
1. A200-07 LOX ASI SLEEVE BRAZE IS X-RAYED AND BORESCOPEO (ECP 697)	NO BORESCOPE INSPECTION.	VISUAL VERIFICATION GAVE ADDITIONAL CONFIDENCE THAT BRAZING HAS NOT CREATED LIQUID METAL EMBRITTLEMENT. USE AS IS RATIONALE: 1. ALL SLEEVES ARE X-RAYED, WHICH SPECIFICALLY INSPECTS FOR LIQUID METAL EMBRITTLEMENT CRACKING; 2. JOINT SUSCEPTIBILITY IS LOW (NO STRAIN ON TUBE DURING WELDING, BRAZE MUST FLOW ONLY TO WITNESS HOLE).	-741, -751, -771, -761, -791, -801.
2. A200-06 WALL THICKNESS OF SECONDARY FACEPLATE RETAINERS INCREASED ON OUTER THREE ROWS. (ECP 634)	PREVIOUS CONFIGURATION HAD A THINNER WALL.	THICKER WALLS GAVE ADDITIONAL LOX POST SUPPORT IN THE HIGH FLOW AREAS. USE AS IS RATIONALE: 1. HIGH FLOW AREA POSTS WERE PLUGGED AND RODDED FOR ADDITIONAL SUPPORT; 2. LIFE LIMIT ON THE MAIN INJECTOR LOX POSTS PREVENTS DAMAGE LEVELS FROM EXCEEDING ALLOWABLE LIMITS. (DAR 1373)	-771
3. A200-06 EDDY CURRENT INSPECTION ON ALL LOX POST INERTIA WELDS. (ECP 342)	NO EDDY CURRENT INSPECTION OF INERTIA WELDS.	EDDY CURRENT INSPECTION PROVIDE ADDITIONAL CONFIDENCE IN INTERNAL WELD INTEGRITY. USE AS IS RATIONALE: 1. INERTIA WELDS ARE CONTROLLED BY SPECIFICATION; 2. NO FAILURE HISTORY WITH HAYNES 188 POSTS; 3. SURFACE FINISH IS CONTROLLED TO REDUCE STRESS CONCENTRATIONS; 4. ROW 13 POSTS ARE DYE PENETRANT INSPECTED ON O.D	-791, -751, -771, -781, -791, -801, -811, -851.
4. A200-07 ELIMINATION OF BRAZE JOINTS OF ASI INLET TUBE TO BIFED TIRES	BRAZED PREVIOUS CONFIGURATION	ELIMINATION OF BRAZE JOINT ELIMINATES THE POSSIBILITY OF LIQUID METAL EMBRITTLEMENT. USE AS IS RATIONALE: 1. BRAZE JOINTS ARE DONE WITHOUT INDUCED LOADS 2. NO RESIDUAL STRESSES IN TUBES. 3. SECTIONED HARDWARE SHOWS NO PROBLEMS	-741, -771, -781.
5. A200-07 SPLITTER VANE GEOMETRY IS VERIFIED PER CURRENT DRAWING REQUIREMENTS. (ECP 989R1)	SPLITTER VANE GEOMETRY DOES NOT MEET CURRENT DRAWING REQUIREMENTS.	RE-DESIGN OF THE SPLITTER VANE ALTERED THE STRUCTURAL RESPONSE OF THE VANES TO FLOW, ELIMINATING FLOW INDUCED CRACKING. USE AS IS RATIONALE: 1. ENGINES NOT MEETING CURRENT SPLITTER VANE DRAWING REQUIREMENTS ARE SCREENED AT GREEN RUN TO IDENTIFY THOSE EXHIBITING THE 4 KHz RESPONSE. THESE ENGINES ARE REWORKED TO CURRENT DRAWING REQUIREMENTS. RE-PRESSURE TESTED AND RE-IDENTIFIED.	-1021, -1141, -1161, -1171, -1201, -1301, -1311, -1321, -1361, -1441

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