

**SSME FMEA/CIL  
REDUNDANCY SCREEN**

Component Group: Combustion Devices  
 CIL Item: A205-D9  
 Part Number: RS009122  
 Component: Baffleless Main Injector (Phase II+)  
 FMEA Item: A205  
 Failure Mode: Interpropellant plate cracks.

Prepared: A. Kay  
 Approved: T. Nguyen  
 Approval Date: 9/9/99  
 Change #: 1  
 Directive #: CCBD ME3-01-6239

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Phase	Failure / Effect Description	Criticality Hazard Reference
SMC 4.1	Ignition would occur in main injector resulting in injector/powerhead burnout, and aft compartment overpressurization and fire. Loss of vehicle.  Redundancy Screens: SINGLE POINT FAILURE: N/A	ME-FB4S, ME-FB4M, ME-FB4A,C

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**SSME / A/CIL  
DESIGN**

Component Group: Combustion Devices  
CIL Item: A205-08  
Part Number: RS009122  
Component: Baffleless Main Injector (Phase II+)  
FMEA Item: A205  
Failure Mode: Interpropellant plate cracks.

Prepared: A. Kay  
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Approval Date: 9/9/99  
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Design / Document Reference

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

THE MAIN INJECTOR BODY IS FABRICATED FROM AN INCONEL 718 ALLOY FORGING. INCONEL 718 WAS SELECTED FOR ITS STRENGTH, DUCTILITY, RESISTANCE TO CORROSION/STRESS CORROSION CRACKING, OXYGEN COMPATIBILITY AND WELDABILITY (1). THE INTERPROPELLANT PLATE INCORPORATES A HEAT SHIELD ACROSS THE FACE AS PROTECTION FROM THERMAL DAMAGE DUE TO HOT-GAS (2). HYDROGEN TRANSPIRATION COOLING OF INJECTOR FACEPLATE RESTRICTS THERMAL GROWTH WHICH GREATLY REDUCES THE POSSIBILITY OF CRACKING. THE BENDING FLEXIBILITY OF THE LIQUID OXYGEN POSTS IS SUFFICIENT TO COMPLY WITH THE RADIAL THERMAL EXPANSION AND CONTRACTION OF THE INJECTOR FACE. WELD AREAS SUBJECT TO HYDROGEN EMBRITTLEMENT ARE OVERLAYED FOR PROTECTION. THE ANALYSIS FOR HIGH CYCLE FATIGUE MEETS CEI REQUIREMENTS (3) (4). MAIN INJECTORS ARE LOW CYCLE FATIGUE LIFE LIMITED BY MAJOR WAFER (5). THE PRIMARY STRESS FACTOR OF SAFETY MEET CEI REQUIREMENTS (4). THE INTERPROPELLANT PLATE PARENT MATERIAL WAS CLEARED FOR FRACTURE MECHANICS/IDE FLAW GROWTH SINCE IT CONTAINS NO FRACTURE CRITICAL PARTS (6). THE FMA/CIL WELDS ARE CLEARED FOR FRACTURE MECHANICS/IDE FLAW GROWTH BY THE WELD ASSESSMENT (7). TABLE A205 LISTS ALL FMA/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). BY ANALYSIS, ALL CRACKS ARE SELF-LIMITING. THE BAFFLELESS MAIN INJECTOR HAS COMPLETED DVR TESTING (8).

(1) RSS-8572-10; (2) RS009122; (3) RL00532 CP320R0003B; (4) RSS-8560 CP320R0003B; (5) DAR 2551; (6) NASA TASK 117; (7) RSS-8756; (8) RSS-8879-1

**FAILURE CAUSE: B: Heat shield failure.**

THE HEAT SHIELD IS MADE FROM 304L CRES WIRE CLOTH 316L FOIL, AND 304L CRES SHEET. BOTH MATERIALS ARE RESISTANT TO DEGRADATION IN THE HOT-GAS ENVIRONMENT (1). THE HEAT SHIELD IS REINFORCED AROUND THE O.D. AND IS SECURED IN A SLOT BETWEEN THE INJECTOR AND THE POWERHEAD BY A RETAINER RING AND PROTECTOR SHIELDS (2). THE HEAT SHIELD IS RETAINED IN A SLOT IN THE POWERHEAD ASSEMBLY WHICH REDUCES SUSCEPTABILITY TO DAMAGE RESULTING FROM HIGH-VELOCITY GASES. THE LOSS OF SEVERAL OUTER ROW HEAT SHIELD RETAINERS WILL NOT ADVERSELY AFFECT HEAT SHIELD RETENTION DUE TO PLATES WHICH OVERLAY THE OUTER PERIPHERY OF THE HEAT SHIELD SCREEN. THE HEAT SHIELD LAYERS ARE FUSED BY E.B. CUTTING THE POST HOLES (3). THE HEAT SHIELD IS HELD IN PLACE BY HEAT SHIELD RETAINERS ON EACH POST.

(1) RSS-8572-10; (2) RS009122; (3) RS009142

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**SSME FMEA/CIL  
INSPECTION AND TEST**

Component Group: Combustion Devices  
 CIL Item: A205-09  
 Part Number: RS009122  
 Component: Baffleless Main Injector (Phase II+)  
 FMEA Item: A205  
 Failure Mode: Interpropellant plate cracks.

Prepared: A. Kay  
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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A	BODY MAIN INJECTOR MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION REQUIREMENTS	RS009138
		ALL TEST SAMPLES FROM EACH FORGING ARE SUBMITTED FOR MECHANICAL PROPERTIES AND GRAIN SIZE INSPECTION PER DRAWING AND SPECIFICATION REQUIREMENTS.	RB0170-153
		ROUGH MACHINED FORGING ARE ULTRASONICALLY INSPECTED FOR DEFECTS PER DRAWING REQUIREMENTS.	RSC09136 RS009138
		FINISH MACHINED INJECTOR BODY IS PENETRANT INSPECTED PER SPECIFICATION REQUIREMENTS.	RA0115-116
	WELD INTEGRITY	THE INJECTOR POST OUTER ROW IS PENETRANT INSPECTED ON O.D. AFTER INJECTOR ELEMENT INERTIA WELDING PER DRAWING REQUIREMENTS.	RS009126 RAD0115-116
		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 RA1607-071 RA0115-116 RA0115-006 RA0115-127 RA1115-001 RFG0011-20
		HEAT TREAT IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RA0611-320
		INTERPROPELLANT PLATE AND INJECTOR POSTS ARE PROOF PRESSURE TESTED	RS009125
	ASSEMBLY INTEGRITY	HOT FIRE TESTING AND 2ND E & M INSPECTIONS VERIFY PLATE INTEGRITY	RL00050-04 RL00055-06 RL00056-07
	B	HEAT SHIELD HEAT SHIELD PROTECTOR HEAT SHIELD RETAINERS	
MATERIAL INTEGRITY		MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION AND DRAWING REQUIREMENTS.	RE0170-196 RE0160-054 OO-S-763
PROPER HEAT SHIELD INSTALLATION		THE HEAT SHIELD AND RETAINER INSTALLATION AROUND LOX POST ARE VERIFIED PER SPECIFICATION AND DRAWING REQUIREMENTS.  THE HEAT SHIELD IS INSPECTED AT THE FLOW SHIELD AREA FOR EVIDENCE OF DAMAGE PRIOR TO LAUNCH (LAST TEST).	RSC09122 RL00191  OMRSD V41BUJ000

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Component : Combustion Devices  
CIL Item: A205-09  
Part Number: RS009122  
Component: Baffleless Main Injector (Phase II-)  
FMEA Item: A205  
Failure Mode: Interpropellant plate cracks.

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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 SA21/88/308 and Rockaldyne letter 68RC09751.		
Operational Use:	No: Applicable.		

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**SSME I A/CIL  
WELD JOINTS**

Component Group: Combustion Devices  
 CIL Item: A205  
 Component: RS009122  
 Part Number: Baffleless Main Injector (Phase II+)  
 A205

Prepared: A. Kay  
 Approved: T. Nguyen  
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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	
MAIN INJECTOR ASI LINE	RS009061	3	GTAW	I		X	X	
MAIN INJECTOR ASI LINE	RS009061	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	9	EBW	I				
MAIN INJECTOR	RS009126	3	CBW	I	X			
MAIN INJECTOR	RS009126	10	EBW	II	X	X	X	
MAIN INJECTOR	RS009126	12-13	GTAW	I	X			
MAIN INJECTOR BODY	RS009126	14-15	GTAW	I	X	X	X	
MAIN INJECTOR BODY	RS009126	16	GTAW	I	X	X	X	
MAIN INJECTOR BODY	RS009126	17	GTAW	I	X	X	X	
MAIN INJECTOR	RS009126	20	GTAW	I	X			
MAIN INJECTOR	RS009126	21	GTAW	I	X			
MAIN INJECTOR	RS009126	22	GTAW	I	X			
MAIN INJECTOR	RS009126	23-29,54	GTAW	I	X			
MAIN INJECTOR	RS009126	44-45	EBW	I	X	X	X	
MAIN INJECTOR	RS009126	50-51	CBW	Ia	X	X	X	
MAIN INJECTOR	RS009126	59	EBW	I,II	X			
MAIN INJECTOR	RS009126	60-61	GTAW	II	X			
MAIN INJECTOR BODY	RS009237	600 FLCS	FRW	I		X	X	
MAIN INJECTOR LOX SUPPLY LINE	RC018C15	1	GTAW	I	X	X		

SSWIE FIVEA/CIL

**FIELD CONFIGURATION VARIANCES FROM CIL RATIONALE**

Component Group: Combustion Devices  
 Item Name: Baffleless Main Injector (Phase II+)  
 Item Number: A205  
 Part Number: RS009122

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Base Line Rationale	Variance	Change Rationale	Variant Case Number
1. NO RATIONALE EFFECTED	REWORKED BAFFLE POSTS EXIST ON 2 DASH NUMBERS.	INLINE REWORK OF COMPLETED BAFFLE MAIN INJECTOR IS AN ALLOWABLE ALTERNATE TO THE BAFFLELESS MAIN INJECTOR	RS009122-1571, RS009122-1581
2. NO RATIONALE EFFECTED.	BLOCK I Isp IMPROVEMENTS DO NOT EXIST ON 2 POWERHEADS	BLOCK I FLIGHT ENGINES MEET CEI REQUIREMENTS FOR Isp. HOWEVER, CERTAIN FLIGHT MANIFESTS REQUIRE AN INCREASE IN Isp FROM THE BLOCK I FLIGHT ENGINES. THE MAIN INJECTOR PRIMARY AND SECONDARY FACEPLATES WERE MODIFIED TO ENHANCE THE COMBUSTION PROCESS.	RS009122-1671
3. A205-12 AND A205-13, BLOCK III Isp IMPROVEMENTS.	THE BLOCK I FLIGHT ENGINES DO NOT HAVE THE MODIFIED MAIN INJECTOR PRIMARY AND SECONDARY FACEPLATES, ROW 13, FUEL SLEEVES AND NEW V-SEAL	BLOCK I FLIGHT ENGINES MEET CEI REQUIREMENTS FOR Isp	RS009122-1681

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