SSME FMEA/CIL
REDUNDANCY SCREEN

Component Group:	Combustion Devices	Prepared:	A. Kay
CIL Item:	A205-07	Approved:	T. Nguyen
Part Number:	RS009122	Approval Date:	9/9/99
Component:	Baffleless Main Injector (Phase II+)	Change #:	2
FMEA Item:	A205	Directive #:	CCBD ME3-01-5238
Failure Mode:	External rupture.	Page:	1 of 1

Phase	Failure / Effect Description	Criticality Hazard Reference
SMC 4.1	LOX leakage into aft compartment causes overpressurization and fire. Loss of vehicle.	1 ME-FB4S, ME-FB4M, ME-FB4A,C
	Redundancy Screens: SINGLE POINT FAILURE: N/A	

SSME FMEA/CIL DESIGN

Component Group:	Combustion Devices	Prepared:	A. Kay
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Component:	Baffleless Main Injector (Phase II+)	Change #:	2
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Design / Document Reference

FAILURE CAUSE: A: Weld or parent material failure.

THE OXIDIZER INLET HIGH PRESSURE CAVITIES AND INLET DUCT ARE CONSTRUCUTED FROM INCONEL 718. THE WEIGHT SAVINGS PROVIDED BY THE HIGH STRENGTH OI INCONEL 718 IS THE PRIMARY REASON FOR ITS SELECTION. INCONEL 718 IS DUCTILE AT CRYOGENIC TEMPERATURES (1) THE ENTIRE SUBASSEMBLY RECEIVES A HEAT TREAT TO GIVE IT FULL STRENGTH (2). A STRUCTURAL ANALYSIS WAS PERFORMED TO VERIFY THE STRUCTURAL INTEGRITY OF THE BAFFLELESS MAIN INJECTOR DESIGN CHANGES THE ANALYSIS SUBSTANTIATED THE STRUCTURAL CAPABILITY TO MEET THE STRUCTURAL DESIGN REQUIREMENTS THIS ANALYSIS WAS BASED ON AN ASSESSMENT OF THE MOST CRITICAL ENGINE OPERATING CONDITIONS TO ESTABLISH THE LIMIT DESIGN PRESSURE AND THE MAXIMUM EXPECTED OPERATING LOADS. THE ANALYSIS FOR THE BAFFLELESS MAIN INJECTOR MEETS CEI REQUIREMENTS FOR HIGH CYCLE AND LOW CYCLE FATIGUE (3) (4). FACTORS OF SAFETY FOR PRIMARY STRESS SHOW ACCEPTABLE MARGINS MEETING CEI REQUIREMENTS (4). INCONEL 718 IS OXYGEN COMPATIBLE UNDER THESE CONDITIONS (5). THE CONFIGURATION OF THE OXIDIZER CAVITIES WAS SELECTED TO MOVE THE LOAD CONCENTRATION AWAY FROM THE WELD JOINT AND PARENT MATERIAL THE OXIDIZER INLET PARENT MATERIAL WAS CLEARED FOR FRACTURE MECHANICS/NDE FLAW GROWTH SINCE IT CONTAINS NO FRACTURE CRITICAL PARTS (6). THE FMEA/CIL WELDS ARE CLEARED FOR FRACTURE MECHANICS/NDE FLAW GROWTH BY THE WELD ASSESSMENT (7). TABLE A205 LISTS ALL 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). THE BRAZE JOINTS ARE ACCOMPLISHED IN A TEMPERATURE CONTROLLED FURNACE (1). THIS REDUCES THE POTENTIAL FOR LIQUID METAL EMBRITTLEMENT OR BRAZE DEFECTS. STRAIN GAUGE AND ACCELEROMETER DATA HAVE BEEN OBTAINED DURING TESTING IN THE AREA OF THE OXIDIZER INLET SHELLS AND INTLET TEE TO DETERMINE THE ENVIRONMENT AND STRAINS IN THIS AREA THE FACE AND/OR ROOTSIDE GEOMETRY OF CRITICAL WELDS IS CONTROLLED PER DRAWING REQUIREMENT AS APPLICABLE.

(1) RSS-9572-10; (2) RS009126; (3) RL00532, CF320R0003B; (4) RSS-8550, CP320R0003B, (5) RSS-8571-10; (6) NASA TASK 117; (7) RSS-8756

FAILURE CAUSE: B: Splitter failure.

SPLITTER VANE CRACKING ON THE PHASE II MAIN INJECTOR WAS ASSOCIATED WITH FLOW INDUCED VIBRATION. THE BAFFLELESS MAIN INJECTOR UTILIZES A RE-DESIGNED SPLITTER VANE WHICH ELIMINATES THE FLUID STRUCTURAL COUPLING MECHANISM RESPONSIBLE FOR FLOW INDUCED CRACKING THE RE-DESIGN WAS VERIFIED BY EXTENSIVE ANALYSIS AND SUCCESSFUL HOT-FIRE TESTING (1) OF LATER PHASE II CONFIGURATION INJECTORS. ANALYSIS FOR THE SPLITTER DESIGN REFLECTS INFINITE LIFE AND ADEQUATE FACTORS OF SAFETY (2).

(1) RL00050-04. (2) ECP 959, R0017522

FAILURE CAUSE: ALL CAUSES

THE BAFFLELESS MAIN INJECTOR HAS COMPLETED DVR TESTING (1).

(1) RSS-8879-*

SSME FMEA/CIL
INSPECTION AND TEST

Component Group:	Combustion Devices	Prepared:	A. Kay
CIL Item:	A205-07	Approved:	T. Nguyen
Part Number:	RS009122	Approval Date:	9/9/99
Component:	Baffleless Main Injector (Phase II+)	Change #:	2
FMEA Item:	A205	Directive #:	CCBD ME3-01-5238
Failure Mode:	External rupture.	Page:	1 of 2

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A	INLET FLANGE		RS009148
	INLET ELBOW		R0017621
	INLET CAP		RS009423
	INLET CAP		RS009154
	ASSEMBLY BODY		RS009126
	OXIDIZER SHELLS		RS009235
	TORUS STRUCTURE		RS009145
	BASE		RS009124
	TEE		R0017622
	ASI LINE		R0016015
	IGNITER ASSEMBLY		RS009061
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RB0170-153 RB0170-174 RB0170-154 RB0170-155 RB0170-213
		ASI TUBING IS INSPECTED ULTRASONICALLY AND THE O.D. IS PENETRANT INSPECTED PER SPECIFICATION REQUIREMENTS.	RB0170-213
		INLET TEE, FLANGE, TORUS, BASE AND SHELLS ARE PENETRANT INSPECTED PER SPECIFICATION REQUIREMENTS.	RA0115-[illegible]5
	HEAT TREAT	HEAT TREAT IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RS009148 R0017621 RS009423 RS009154 RS009126 RS009235 RS009145 RS009124 R0017622 RA0611-020
	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.	RL[illegible]011 RA1607-071 RA0115-116 RA0115-035 RA0115-127 RA1115-001 RT0001-120
		THE OXIDIZER TORUS WELDS ARE INSPECTED PRIOR TO AND AFTER E.B. WELDING TO ASSURE CORRECT E. B. WELD TRACKING AND PENETRATION (INCLUDING BORING, ETCH, PENETRANT AND PLUG WELDING).	RL00261

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A	WELD INTEGRITY	THE WELD 55 AND 56 BRAZE JOINTS ARE INSPECTED VISUALLY, RADIOGRAPHICALLY, AND BORESCOPED PER DRAWING REQUIREMENTS. RADIOGRAPHIC INSPECTION PROVIDES 90% COVERAGE. LME DEFECTS ARE DETECTABLE WITH 90% COVERAGE DUE TO FLAW SIZE BEING GREATER THAN 10%.	RS009128 RA0107-005 RA0116-006
		RS009061 WELD IS VISUALLY INSPECTED FOR BRAZE FLOW AND LEAK CHECKED AFTER FURNACE BRAZING.	RA1607-009
		WELD 16 GEOMETRY (RADIUS BETWEEN WELD BEAD AND INLET TEE) IS VERIFIED PER DRAWING REQUIREMENTS.	RS009128
		OXIDIZER INLET SHELLS AND THE TORUS AREAS ARE INSPECTED FOR CORRECT CONTOUR AFTER WELDING.	
B	TEE		RC017622
		MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION REQUIRMENTS.	RB0170-153
		ALL TEST SAMPLES FROM EACH FORGING ARE SUBMITTED FOR MECHANICAL PROPERTIES AND GRAIN SIZE INSPECTION PER DRAWING AND SPECIFICATION REQUIREMENTS.	RC017622 RB0170-153
		TEE IS PENETRANT INSPECTED PER SPECIFICATION REQUIREMENTS.	RA0116-116
		TEE IS HEAT TREATED AS A DETAIL AND AT INJECTOR ASSEMBLY LEVEL.	RA0611-020
		GIMBAL ACCELEROMETERS AND STRAIN GAUGES DETECT HIGH VIBRATIONAL LOADING DURING HOT-FIRE ACCEPTANCE TESTING, AND SCREEN UNACCEPTABLE UNITS OUT.	RL00050-04 RL00491
		ENGINE GIMBAL ACCELEROMETER DATA FROM THE PRIOR FLIGHT IS REVIEWED TO DETECT HIGH VIBRATIONAL LOADS.	MSFC PLN 1228
ALL CAUSES		THE OXIDIZER MANIFOLD IS PROOF PRESSURE TESTED, LEAK CHECKED, AND PENETRANT INSPECTED PRIOR TO THRUST CONE INSTALLATION PER DRAWING AND SPECIFICATION REQUIREMENTS.	RS009128 RL00127 RA0116-116
	ASSEMBLY INTEGRITY	THE HOT FIRE TESTING AND 2ND E & M INSPECTIONS VERIFY INJECTOR INTEGRITY	RL00050-04 RL00056-05 RL00056-07
		THE INJECTOR IS VISUALLY INSPECTED EXTERNALLY PRIOR TO EACH LAUNCH.	OMRSD V41BU0.029
		THE HELIUM SIGNATURE LEAK TESTING VERIFIES NO EXTERNAL LEAKAGE INTO AFT COMPARTMENT (LAST TEST).	OMRSD S00000.950

Failure History: Comprehensive failure history data is maintained in the Problem Reporting database (PRAMS/PPAGA)
Reference: NASA letter SA21/88/308 and Rocketdyne letter 88RC09761.

Operational Use: Not Applicable.

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
Approval Date: 9/9/99
Change #: 2
Directive #: CCBD ME3-01 5238

Component	Basic Part Number	Weld Number	Weld Type	Class	Root Side Not Access	Critical Initial Flaw Size Not Detectable HCF	LCF	Comments
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	8	EBW	I				
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 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	EBW	Ia	X	X	X	
MAIN INJECTOR	RS009126	59	EBW	I,Ib	X			
MAIN INJECTOR	RS009126	60-61	GTAW	II	X			
MAIN INJECTOR BODY	RS009237	600 PLCS	FRW	I		X	X	
MAIN INJECTOR LOX SUPPLY LINE	RS018015	1	GTAW	I	X	X		

FIELD CONFIGURATION VARIANCES FROM CIL RATIONALE

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

Prepared: A. Kay
Approved: T. Nguyen
Approval Date: 9/9/99
Change #: 2
Directive #: CCBD ME3-01 5238

Base Line Rationale	Variance	Change Rationale	Variant Dash 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	RS009122-1671, RS009122-1681
2. NO RATIONALE EFFECTED.	BLOCK I Isp IMPROVEMENTS DO NOT EXIST ON 2 POWERHEADS	BLOCK I FLIGHT ENGINES MEET CEI REQUIRMENTS 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 IIA 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