

**SSME FMEA/CIL
REDUNDANCY SCREEN**

Component Group: Combustion Devices
 CIL Item: A200-01
 Part Number: RS009122
 Component: Main Injector
 FMEA Item: A200
 Failure Mode: ASI fails to ignite.

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

Page: 1 of 1

Phase
S
4.1

Failure Effect Description

The main chamber pressure gases do not ignite. Low main chamber pressure results in failure to satisfy ignition confirmed limits and controller initiated shutdown. Miss on scrub. Loss of vehicle due to LOX duct rupture may result if failure to establish MCC ignition is not detected.

Criticality
Hazard Reference
R
MS-84S

Redundancy Screens: MAIN INJECTOR SYSTEM - SENSOR SYSTEM- UNIQUE REDUNDANCY

A: Pass - Redundant hardware items are capable of checkout during normal ground turnaround.

B: Pass - Loss of a redundant hardware items is detectable during flight.

C: Pass - Loss of redundant hardware items could not result from a single credible event.

**SSME FMEA/CIL
DESIGN**

Component Group: Combustion Devices
C/L Item: A200-01
Part Number: RS009122
Component: Main Injector
FMEA Item: A200
Failure Mode: ASI fails to ignite.

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

Page: 1 of 1

Design / Document Reference

FAILURE CAUSE: A: Contamination which blocks fuel orifices or passages.

THE FUEL IS FILTERED TO 400 MICRONS AT THE EXTERNAL TANK (1). THE FUEL ASI DELIVERY SYSTEM IS DESIGNED TO REMOVE ANY PARTICLES THAT MAY CAUSE CUTOFF OR PARTIAL BLOCKAGE OF THE PASSAGES. A FILTER LOCATED AT THE HEAD OF THE DELIVERY SYSTEM REMOVES PARTICLES FROM THE FUEL THAT MAY BE LARGE ENOUGH TO CAUSE A REDUCTION IN FUEL FLOW (2). THE FILTER IS DESIGNED TO STOP PARTICLES IN THE FUEL AND ALLOW THEM TO SETTLE OFF THE FILTER FACE (3). THIS ALLOWS FOR PARTICLE REMOVAL WITHOUT FILTER FLOW REDUCTION. SHOULD GROSS CONTAMINATION OCCUR, THE FILTER CAN WITHSTAND PLUGGING OF OVER HALF OF ITS SURFACE AREA PRIOR TO A REDUCTION IN ASI CHAMBER FUEL DELIVERY. PRE-START HELIUM PURGE MINIMIZES POSSIBILITY OF ICE BLOCKAGE OF ASI. THE ASI FUEL FILTER IS FABRICATED FROM INCONEL 625 ALLOY, WHICH WAS SELECTED BECAUSE OF ITS BRAZEABILITY, WELDABILITY, MACHINABILITY, AND MATERIAL PROPERTIES (4). INCONEL 625 CAN BE BRAZED WITHOUT PLATING IN A CONTROLLED ATMOSPHERE. THE FUEL FILTER IS BRAZED IN EITHER HYDROGEN, ARGON AND HELIUM, HELIUM OR VACUUM (5). THE ASI FUEL FILTER HAS BEEN ANALYZED FOR FLOW INDUCED LOADS, DYNAMIC LOADS, AND PRESSURE LOADS AND MEETS THE HIGH CYCLE AND LOW CYCLE FATIGUE LIFE CIL REQUIREMENTS (6). THE MINIMUM FACTORS OF SAFETY FOR THE ASI FUEL FILTER MEET CEI REQUIREMENTS (7). THE ASI SYSTEM HAS BEEN DESIGN VERIFICATION TESTED FOR LOW PRESSURE IGNITION AND LOW MIXTURE RATIOS. THE FLEET LEADER ASI FUEL FILTER HAS BEEN REMOVED FOR MICROSCOPIC AND PENETRANT INSPECTION ON TWO OCCASIONS WITHOUT DETECTING ANY ANOMALIES (7).

(1) CD 13M15000; (2) RS007004; (3) R0018225; (4) RSS-8572-9; (5) RA0107-D10; (6) RL00532, CP32CR00038; (7) MPR-95-0659

FAILURE CAUSE: B: Contamination which blocks oxidizer orifices or passages.

THE OXIDIZER SUPPLY IS FILTERED TO 800-MICRONS AT THE EXTERNAL TANK (1). THE OXIDIZER ASI DELIVERY SYSTEM IS DESIGNED TO REMOVE ANY PARTICLES THAT MAY CAUSE CUTOFF OR PARTIAL BLOCKAGE OF THE PASSAGES. THE ASI SYSTEM HAS BEEN DESIGN VERIFICATION TESTED FOR LOW PRESSURE IGNITION AND LOW MIXTURE RATIOS.

(1) CD 13M15000

FAILURE CAUSE: ALL CAUSES

THE ASI CAN OPERATE OVER A WIDE MIXTURE RATIO RANGE AND PARTIAL BLOCKAGE CAN STILL ALLOW TIMELY IGNITION OF THE PROPELLANTS (1).

(1) RSS-305-19

A-62

**SSME FM CIL
INSPECTION AND TEST**

Component Group: Combustion Devices
 CIL Item: A200-01
 Part Number: R5009122
 Component: Main Injector
 FMEA Item: A200
 Failure Mode: ASI fails to ignite.

Prepared: A. Kay
 Approved: T. Nguyen
 Approval Date: 8/9/99
 Change #: 2
 Directive #: CCBD ME3-01-5238

Page: 1 of 1

Failure Causes	Significant Characteristics	Inspector(s) / Test(s)	Document Reference
A	FILTER		R0019226
	FUEL FILTER INTEGRITY	FILTER BRAZE JOINTS ARE INSPECTED TO VERIFY COMPLETE COVERAGE.	
	ASI SYSTEM CLEANLINESS	ASI SUBASSEMBLIES ARE CLEANED DURING MANUFACTURING AND PRIOR TO FINAL ASSEMBLY.	RL10001 RA1510-005
		AFTER BRAZING, THE PASSAGE PORTS AND ORIFICES ARE INSPECTED FOR BLOCKAGE DUE TO BRAZING MATERIAL.	RA1607-003
		DURING PROPELLANT CONDITIONING, THE FUEL SYSTEM IS PURGED TO MAINTAIN IT FREE OF MOISTURE AND ICE	OMRSD S00FB0 310 OMRSD S00FB0 320
B	ORIFICES		R5009038
	ASI SYSTEM CLEANLINESS	ASI SUBASSEMBLIES AND THE MOV ARE CLEANED DURING MANUFACTURING TO OXYGEN SERVICE REQUIREMENTS.	RL10001
		AFTER BRAZING, THE PASSAGE PORTS AND ORIFICES ARE INSPECTED FOR BLOCKAGE DUE TO BRAZING MATERIAL.	RA1607-003
		DURING THE PROPELLANT CONDITIONING, THE OXIDIZER ASI SYSTEM IS PURGED TO MAINTAIN IT FREE OF MOISTURE AND ICE.	OMRSD S00FB0 300
ALL CAUSES	PROPELLANT SYSTEM CLEANLINESS	SSME PROPELLANT SYSTEMS ARE DRIED AND VERIFIED DRY PRIOR TO EACH FLIGHT	OMRSD V41060 000 OMRSD V41060 001
	ASSEMBLY INTEGRITY	THE HOT FIRE TESTING AND 2ND B & M INSPECTIONS VERIFY CORRECT OPERATION.	RL00350-04 RL00356-06 RL00356-07
		ASI CHAMBERS ARE INSPECTED FOR DAMAGE PRIOR TO EACH LAUNCH. (LAST TEST)	OMRSD V416U0 029

A-63

Failure History: Comprehensive failure history data is maintained in the Problem Reporting database (PRAMS/PRACA)
 Reference: NASA letter SA21/93/309 and Rocketdyne letter 88R003761.
 Operational Use: Not Applicable

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
 Page: 1 of 1

A-97

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	RSD08235	1 LFT	EBW	I				
INLET SHELL	RSC08235	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: 9/8/99
 Change #: 1
 Directive #: CCDD ME3-01-5238

Page: 1 of 1

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

A-98