SSME FMEA/CIL
REDUNDANCY SCREEN

Component Group:	Combustion Devices	Prepared:	A. Kay
CIL Item:	A200-06	Approved:	T. Nguyen
Part Number:	RS008122	Approval Date:	9/9/99
Component:	Main Injector	Change #:	1
FMEA Item:	A200	Directive #:	CCBD ME3-01-5233
Failure Mode:	LOX post crack.	Page:	1 of 1

Phase	Failure / Effect Description	Criticality Hazard Reference
SMC 4.1	Hot-gas flows into the post, ignites with the oxidizer and begins post and injector burnout. Injector debris ruptures nozzle tubes, causing preburner fuel starvation, turbine and main injector burnout, and aft compartment overpressurization and fire. Loss of vehicle. Redundancy Screens: SINGLE POINT FAILURE: N/A	ME-B4S, ME-B4A,C, ME-B4M

SSME FMECIL
DESIGN

Component Group:	Combustion Devices
CIL Item:	A200-06
Part Number:	RS009122
Component:	Main Injector
FMEA Item:	A200
Failure Mode:	LOX post crack.

Prepared:	A. Kay
Approved:	T. Nguyen
Approval Date:	9/9/99
Change #:	1
Directive #:	CCBD ME3-94 6238
Page:	1 of 2

Design / Document Reference

FAILURE CAUSE: A: Impact damage.

HAYNES 188 ALLOY WAS SELECTED FOR THE MAIN INJECTOR LOX POSTS (1) BECAUSE OF ITS CREEP STRENGTH AT ELEVATED TEMPERATURES AND LOW CYCLE FATIGUE LIFE IN A HIGH PRESSURE HYDROGEN ENVIRONMENT (2). IT HAS THE STRENGTH REQUIRED FOR THE APPLICATION AND IS WELDABLE WITH INCONEL 718 ALLOY. THE FLOW SHIELDS, HEAT SHIELD RETAINERS, AND SECONDARY FACEPLATE RETAINERS PROTECT THE OUTER ROWS OF LOX POSTS FROM HIGH TURBULENT FLOW AT THE HOT-GAS MANIFOLD DUCT OPENINGS AND FROM FOREIGN OBJECT IMPACT (3). THE MINIMUM FACTORS OF SAFETY FOR THE MAIN INJECTOR LOX POSTS MEET CEI REQUIREMENTS (4). THE MAIN INJECTOR FROM ENGINE 2010 WAS VISUALLY INSPECTED PER SPECIFICATION (5), OVERHAUL REQUIREMENTS, AND ADDITIONAL CHECKS SUCH AS INSPECTION OF LOX POSTS, HEAT SHIELD RETAINERS, AND INTERPROPELLANT PLATE FOR DAMAGE WITH NO ANOMALOUS CONDITIONS NOTED (6).

(1) RS009130, RS009207; (2) RSS-8572-9; (3) RS009122; (4) RSS-8546, CP320R0003B; (5) RL00529; (6) I.L. CD 86-1042

FAILURE CAUSE: B: Weld or material flaws.

PARENT MATERIAL IS HAYNES 188, PROCURED TO DRAWING SPECIFICATIONS (1). HAYNES HAS GOOD STRENGTH, DURABILITY, AND WELDABILITY (2). THE WELDS ARE A FRICTION INERTIA PROCESS. THE WELDS ARE CONTROLLED BY TEST SAMPLING AND PROCESS CONTROLS (3). CONTROLS INCLUDE AXIAL UPSET, THRUST, LOAD vs TIME, TORQUE vs TIME, AND SPINDLE SPEEDS. HIGH CYCLE AND LOW CYCLE FATIGUE LIFE REQUIREMENTS OF THE MAIN INJECTOR LOX POSTS MEET CEI REQUIREMENTS (4). THE MINIMUM FACTORS OF SAFETY FOR THE MAIN INJECTOR LOX POSTS MEET CEI REQUIREMENTS (5). THE MAIN INJECTOR LOX POST PARENT MATERIAL WAS CLEARED FOR FRACTURE MECHANICS/NDE FLAW GROWTH SINCE THEY CONTAIN NO FRACTURE CRITICAL PARTS (6). THE FMEA/CIL WELDS ARE CLEARED FOR FRACTURE MECHANICS/NDE FLAW GROWTH BY THE WELD ASSESSMENT (7). 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 (7). TEN ROW 13 POSTS FROM THE HIGH FLOW AREAS OF ENGINE 2010 WERE DYE PENETRANT INSPECTED, TYPE IVC AT THE INERTIA WELD JOINT AREA AND VISUALLY INSPECTED WITH NO ANOMALOUS CONDITIONS NOTED (8).

(1) RS009130, RS009207; (2) RSS-8572-9; (3) RA1507-044; (4) RL00532, CP320R0003B; (5) RSS-8545, CP320R0003B; (6) NASA TASK 117. (7) RSS-8756. (8) I.L. CD 86-1042

FAILURE CAUSE: C: Fatigue.

THE HEAT SHIELD RETAINERS PROTECT THE BASE OF THE POSTS AND INERTIA WELD JOINT FROM THE HEAT OF THE HOT GAS STREAM. THE POST IS SUPPORTED BY THE SECONDARY FACEPLATE RETAINER AND FUEL SLEEVE (1). THE LOWER AREA OF THE POST IN THE HOT GAS STREAM HAS SPIRAL RIBBING ALONG THE POST LENGTH WHICH DESENSITIZES THE POST TO VORTEX SHEDDING PHENOMENA AND ADDS ADDITIONAL STRUCTURAL STRENGTH (2). ALL FLIGHT ENGINES HAVE HAYNES 188 POSTS FOR STRENGTH AND DURABILITY. HYDROGEN TRANSPIRATION COOLING OF THE INJECTOR FACEPLATE RESTRICTS THERMAL GROWTH WHICH GREATLY REDUCES THE POSSIBILITY OF CRACKING AN INJECTOR ELEMENT. THE BENDING FLEXIBILITY OF THE LIQUID OXYGEN POSTS IS SUFFICIENT TO COMPLY WITH THE RADIAL THERMAL EXPANSION AND CONTRACTION OF THE INJECTOR FACE. A FATIGUE ANALYSIS RESULTED IN ACCEPTANCE MARGINS OF HIGH CYCLE FATIGUE AND LOW CYCLE FATIGUE WHICH MEETS CEI REQUIREMENTS (3). LOW STRAINS ARE MAINTAINED BELOW CRACK INITIATION LEVELS FOR HYDROGEN ENVIRONMENT (4). STRAIN GAGE, STATIC PRESSURE AND DYNAMIC PRESSURE MEASUREMENTS WERE OBTAINED FROM ENGINE 0110F DURING HOT FIRE TEST. THESE MEASUREMENTS ARE USED TO ANCHOR DATA FROM A 3-D AIR FLOW MODEL WHICH PREDICTS CONDITIONS THROUGHOUT THE INJECTOR. MATERIAL PROPERTIES FOR THE LOX POST HAVE RECENTLY BEEN UPDATED BECAUSE OF A TEST PROGRAM INTENDED TO DETERMINE THE FATIGUE STRENGTH OF THE CONFIGURATION AND THE REDUCTION CAUSED BY "SCRATCHES" (5). THE DATA OBTAINED IN THESE TESTS IS USEFUL WHEN PERFORMING ANALYSIS OF THE LOX POST FATIGUE CHARACTERISTICS. DURING DISASSEMBLY OF ENGINE 2010, 10 ROW 13 POSTS WERE EVALUATED AND NO EVIDENCE OF HIGH CYCLE FATIGUE WAS FOUND (6).

(1) RS009122 (2) RS009207, RS009130. (3) RL00532 CP320R0003B (4) RSS-8572-9; (5) I.L. MFR-85-0228, (6) I.L. CD 86-1042

Component Group:	Combustion Devices	Prepared:	A. Nay
CIL Item:	A200-06	Approved:	T. Nguyen
Part Number:	RS009122	Approval Date:	9/9/99
Component:	Main Injector	Change #:	1
FMEA Item:	A200	Directive #:	CCBD MEJ-01-5238
Failure Mode:	LOX post crack.	Page:	2 of 2

Design / Document Reference

FAILURE CAUSE: D: Heat shield retainer failure.

THE HEAT SHIELD RETAINERS (1) ARE FABRICATED FROM 316 STAINLESS-STEEL. THE MATERIAL WAS CHOSEN TO ACT AS AN INSULATOR FOR THE INCONEL 718 BODY, PROTECTING IT FROM THE THERMAL STRAINS THAT WOULD BE CREATED IF HOT GAS WAS ALLOWED TO DIRECTLY CONTACT THE INCONEL 718 ALLOY (2). THE 316 STAINLESS-STEEL IS ALSO RESISTANT TO HYDROGEN ENVIRONMENT EMBRITTLEMENT. ALL MATERIAL IS PROCURED PER DRAWING REQUIREMENTS (3). THE HEAT SHIELD RETAINER IS A THIN WALLED SHELL THAT FITS OVER THE BASE OF EACH MAIN INJECTOR LOX POST (4), TO PROTECT THE INERTIA WELD AND THE BASE OF THE POST FROM DIRECT CONTACT BY THE HOT GASES. MAIN INJECTORS ARE LIFE LIMITED BY MAJOR WAIVER DUE TO POTENTIAL EXPOSURE OF THE LOX POST STUB RADIUS TO HOT GAS IMPINGEMENT (10). THE INSULATING FACTOR IS CREATED BY THE DEAD ZONE OF AIR TRAPPED BETWEEN THE POST AND RETAINER. THE HEAT SHIELD RETAINER IS HELD IN PLACE BY A CRIMP RING AND ALSO HELPS KEEP THE HEAT SHIELD AGAINST THE SURFACE OF THE INTERPROPELLANT PLATE. THE HIGH CYCLE AND LOW CYCLE FATIGUE LIFE, AND MINIMUM FACTORS OF SAFETY MEET CEI REQUIREMENTS (5). THE HEAT SHIELD RETAINER WAS CLEARED FOR FRACTURE MECHANICS/NDE FLAW GROWTH BY EITHER DETECTION OF THE CRITICAL INITIAL FLAW SIZE OR RISK ASSESSMENT (6). DISASSEMBLY RESULTS OF ENGINE 2010 SHOWED NO CRACKED POSTS EVEN THOUGH RETAINERS WERE DAMAGED FOR UP TO 15,000 SECONDS OF TESTING (7). HEAT SHIELD RETAINERS WERE RE-DESIGNED TO PRECLUDE DAMAGE FROM HIGH FLOW (8). CONTINUED USE WITH ALLOWABLE DISCREPANCIES RESULTING FROM OPERATION IS EVALUATED AND CONTROLLED PER THE REQUIREMENTS OF THE MAINTENANCE CONTROL DOCUMENT (9).

(1) RS009144, (2) RSS-8572-9 (2) RS009144; (4) RS009122; (5) RL00532, CP32CR0003B, RSS-8546; (6) NASA TASK 117; (7) I.L. CD 86-1042; (8) RS009144 (9) RSS 8793; (10) DAR 2875 DAR 2822

FAILURE CAUSE: E: Secondary faceplate retainer failure.

THE SECONDARY FACEPLATE RETAINERS (1) ARE FABRICATED FROM HAYNES 188 ALLOY. THIS MATERIAL WAS SELECTED FOR ITS CREEP STRENGTH AT ELEVATED TEMPERATURES AND ITS LOW-CYCLE FATIGUE LIFE IN HIGH PRESSURE HYDROGEN ENVIRONMENT (2). THE ALLOY IS PROCURED PER DRAWING REQUIREMENTS (3). THE SECONDARY FACEPLATE RETAINER IS DESIGNED TO PROVIDE A SUPPORT POINT FOR THE LOX POST, LOCATE AND HOLD THE SECONDARY FACEPLATE IN PLACE, AND CHANNEL FUEL RICH GASES DOWN ALONG THE OUTSIDE OF THE LOX POST (4). HIGH CYCLE AND LOW CYCLE FATIGUE LIFE, AND MINIMUM FACTORS OF SAFETY FOR THE SECONDARY FACEPLATE RETAINER MEET CEI REQUIREMENTS (5). THE SECONDARY FACEPLATE RETAINER PARENT MATERIAL WAS CLEARED FOR FRACTURE MECHANICS/NDE FLAW GROWTH SINCE IT CONTAINS NO FRACTURE CRITICAL PARTS (6). DISASSEMBLY OF ENGINE 2010 SHOWED NO CRACKED POSTS EVEN THOUGH RETAINERS WERE DAMAGED DURING TESTING (7). SECONDARY FACEPLATE RETAINERS WERE RE-DESIGNED TO IMPROVE STRUCTURAL MARGIN (8). CONTINUED USE WITH ALLOWABLE DISCREPANCIES RESULTING FROM OPERATION IS EVALUATED AND CONTROLLED PER THE REQUIREMENTS OF THE MAINTENANCE CONTROL DOCUMENT (9).

(1) RS009130, RS009134; (2) RSS-8572-9; (3) RS009133; (4) RS009122; (5) RL00532, CP32CR0003B RSS-8545; (6) NASA TASK 117; (7) I.L. CD 86-1042; (8) RS009133, RS009134; (9) RSS-8793

FAILURE CAUSE: F: Loss of function of flow shield.

INCOLOY 903 ALLOY WAS CHOSEN FOR MAIN INJECTOR FLOW SHIELDS (1) BECAUSE OF ITS THERMAL EXPANSION CHARACTERISTICS (2) WHICH SHOULD REDUCE THERMAL CRACKING. ALL 903 ALLOY IS PROCURED PER SPECIFICATION REQUIREMENTS (3). THE FLOW SHIELDS ARE DESIGNED TO DISTRIBUTE THE FLOW LOADS ON THE ROW 13 POSTS AND REDUCE THE LOAD CONCENTRATIONS (4). THE SHIELDS ALSO PROTECT THE POSTS FROM CONTAMINATION IN THE FLOW. THE HIGH CYCLE AND LOW CYCLE FATIGUE LIFE, AND MINIMUM FACTORS OF SAFETY MEET CEI REQUIREMENTS (5). THE MAIN INJECTOR FLOW SHIELDS PARENT MATERIAL WAS CLEARED FOR FRACTURE MECHANICS/NDE FLAW GROWTH SINCE THEY CONTAIN NO FRACTURE CRITICAL PARTS (6). DURING TEARDOWN OF THE MAIN INJECTOR FROM ENGINE 2010, NO ANOMALIES WITH THE FLOW SHIELDS WERE NOTED (7). CONTINUED USE WITH ALLOWABLE DISCREPANCIES RESULTING FROM OPERATION IS EVALUATED AND CONTROLLED PER THE REQUIREMENTS OF THE MAINTENANCE CONTROL DOCUMENT (8).

(1) RC019530; (2) RSS-8572-9; (3) RBC170-186; (4) RS009122 (5) RL00532, CP32CR0003B, RSS-8546; (6) NASA TASK 117; (7) I.L. CD 86-1042, (8) RSS-8793

SSME FM CIL
INSPECTION AND TEST

Component Group:	Combustion Devices	Prepared:	A. Kay
CIL Item:	A200-08	Approved:	T. Nguyen
Part Number:	RS009722	Approval Date:	9/9/99
Component:	Main Injector	Change #:	1
FMEA Item:	A200	Directive #:	CCBD ME3-01-5238
Failure Mode:	LOX post crack.	Page:	1 of 6

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference #
A	POSTS POSTS FLOW SHIELD HEAT SHIELD RETAINER BODY ASSY		RS009207 RS009130 R0019530 RS009144 RS009237
	UPSTREAM COMPONENT CLEANLINESS	ALL UPSTREAM COMPONENTS ARE CLEANED TO FUEL/LOX USAGE TO VERIFY ABSENCE OF CONTAMINATION/DAMAGING CAUSING DEBRIS.	RI 10031
	POST PROTECTION SHIELDING INTEGRITY	ALL ACCESSIBLE FLOW SHIELDS, SECONDARY FACEPLATE RETAINERS, AND HEAT SHIELD RETAINERS ON OUTER ROWS ARE VISUALLY AND BORESCOPE INSPECTED FOR SECURITY AND DAMAGE PRIOR TO EACH FLIGHT AND WHENEVER HIGH PRESSURE PUMPS ARE REMOVED. RETAINERS ARE INSPECTED ON OUTER DIAMETER FACING PORTIONS ONLY. (LAST TEST)	OMRSD V41BU0.040 OMRSD V41BU0.091 OMRSD V41BU0.092
B C	POSTS POSTS		RS009207 RS009130
	LOX POST MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION REQUIREMENTS.	
		THE POST MATERIAL IS ULTRASONICALLY INSPECTED PRIOR TO MACHINING	RA0115-012
		THE POST IS HEAT TREATED TO DRAWING AND SPECIFICATION REQUIREMENTS.	RS003027 RA0111-018
	POST SURFACE FINISH	BEFORE WELDING, POST OUTSIDE SURFACES ARE PENETRANT INSPECTED. POST I.D. IS BORESCOPED AT 4 POWER MINIMUM MAGNIFICATION FOR FLAWS.	RA0115-116 RS009130 RS009207
		THE SURFACE FINISH IS INSPECTED PER DRAWING REQUIREMENTS	RS009130 RS009207
	WELD INTEGRITY - INERTIA WELD JOINT	ALL WELD PROCESS CONTROL SAMPLES ARE DESTRUCTIVELY TESTED PRIOR TO AND AFTER WELDING. THE WELD SCHEDULE PARAMETERS ARE VERIFIED BY MACHINE READOUTS AFTER EVERY WELD. IN PROCESS WELD PARAMETER INSPECTIONS INCLUDE AXIAL UPSET MEASUREMENT, THRUST, LOAD vs TIME, TORQUE vs TIME, AND SPINDLE SPEED.	RA1507-044

Component Group:	Combustion Devices	Approved:	T. Nguyen
CIL Item:	A200-06	Approval Date:	9/9/99
Part Number:	RS009122	Change #:	1
Component:	Main Injector	Directive #:	CCBD ME3-01-5239
FMEA Item:	A200		
Failure Mode:	LOX post crack.	Page:	2 of 5

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
B, C	WELD INTEGRITY - INERTIA WELD JOINT	ALL ROW 13 POSTS ARE ETCHED AND PENETRANT INSPECTED, OD ONLY, AFTER MACHINING OF WELD FLASH.	RA0115-116
		ALL POSTS ARE EDDY CURRENT INSPECTED.	RS009237
	SMOOTH TRANSITION ACROSS THE INERTIA WELD AREA I.D. AND O.D.	THE OUTER ROW OF POSTS ARE INSPECTED FOR MISMATCH IN THE INERTIA WELDED AREA	
		THE INNER AND OUTER DIAMETERS ARE INSPECTED FOR DEFECTS PER DRAWING REQUIREMENTS.	
		AFTER WELDING AND MACHINING THE POSTS ARE INSPECTED TO VERIFY THE STUB I.D. DIAMETER IS CONTAINED WITHIN THE POST BORE DIAMETER	
		THE INERTIA WELDS ARE LEAK TESTED WITH HELIUM FOR DEFECTS. INERTIA WELDS ARE PROOF PRESSURE TESTED.	RS009237 RS009125
		THE EXTERNAL SURFACE OF INERTIA WELDS OF ROW 13 ARE VISUALLY INSPECTED AFTER PROOF PRESSURE.	RS009126
	ASSEMBLY INTEGRITY	THE HOT FIRE TESTING AND 2ND E & M INSPECTIONS VERIFY INJECTOR POST INTEGRITY.	RL00050-04 RL00050-06 RL00050-07
		AFTER EACH FLIGHT A VISUAL INSPECTION IS PERFORMED TO CHECK FOR EVIDENCE OF THERMAL DAMAGE TO THE INJECTOR. (LAST TEST)	OMRSD V41BU0.040
D	RETAINER HEAT SHIELD		RS009144
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	
		THE RETAINER IS PENETRANT INSPECTED PER SPECIFICATION REQUIREMENTS	RA0115-116
	ASSEMBLY INTEGRITY	THE RETAINER IS CLEANED AND INSPECTED PER SPECIFICATION REQUIREMENTS.	RA0170-018 RL10001

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
D	ASSEMBLY INTEGRITY	THE RETAINER IS INSTALLED AND INSPECTED PER SPECIFICATION AND DRAWING REQUIREMENTS.	RA0112-002 RL00191 RS009122
		THE RETAINERS ARE INSPECTED PER DRAWING AND SPECIFICATION REQUIREMENTS FOR FINAL ASSEMBLY ACCEPTANCE.	RL00191 RS009122
		THE HOT FIRE TESTING AND 2ND E & M INSPECTIONS VERIFY INJECTOR POST INTEGRITY.	RL00050-04 RL00056-06 RL00056-07
		AFTER EACH FLIGHT A VISUAL INSPECTION IS PERFORMED TO CHECK FOR EVIDENCE OF THERMAL DAMAGE TO THE INJECTOR.	OMRSD V41BU0.040
		ALL ACCESSIBLE FLOW SHIELDS, SECONDARY FACEPLATE RETAINERS, AND HEAT SHIELDS ON OUTER ROWS ARE VISUALLY AND BORESCOPE INSPECTED FOR SECURITY AND DAMAGE PRIOR TO EACH FLIGHT AND WHENEVER HIGH PRESSURE PUMPS ARE REMOVED. RETAINERS ARE INSPECTED ON OUTER DIAMETER FACING PORTIONS ONLY. (LAST TEST)	OMRSD V41BJ0.040 OMRSD V41BU0.081 OMRSD V41BU0.082
E	RETAINER MAIN ELEMENT - INJECTOR		RS009133
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	
		RETAINER IS PENETRANT INSPECTED PER SPECIFICATION REQUIREMENTS	RA0115-116
	ASSEMBLY INTEGRITY	RETAINER IS CLEANED AND INSPECTED PER SPECIFICATION REQUIREMENTS	RL10051
		RETAINERS ARE INSTALLED AND INSPECTED PER DRAWING REQUIREMENTS	RS009133
		RETAINER IS INSPECTED TO DRAWING REQUIREMENTS FOR DRY-FILM LUBE APPLICATION	
		RETAINER IS BRAZED AND INSPECTED PER SPECIFICATION AND DRAWING REQUIREMENTS.	RA0107-010 RB0170-160 RS009133
		RETAINERS ARE INSPECTED PER DRAWING REQUIREMENTS FOR FINAL ASSEMBLY ACCEPTANCE.	RS009133 RS009122
		THE HOT FIRE TESTING AND 2ND E & M INSPECTIONS VERIFY INJECTOR POST INTEGRITY.	RL00050-04 RL00056-06 RL00056-07
		AFTER EACH FLIGHT A VISUAL INSPECTION IS PERFORMED TO CHECK FOR EVIDENCE OF THERMAL DAMAGE TO THE INJECTOR.	OMRSD V41BU0.040
		ALL ACCESSIBLE FLOW SHIELDS, SECONDARY FACEPLATE RETAINERS, AND HEAT SHIELDS RETAINERS ON OUTER ROWS ARE VISUALLY AND BORESCOPE INSPECTED FOR SECURITY AND DAMAGE PRIOR TO EACH FLIGHT AND WHENEVER HIGH PRESSURE PUMPS ARE REMOVED. RETAINERS ARE INSPECTED ON OUTER DIAMETER FACING PORTIONS ONLY (LAST TEST)	OMRSD V41BU0.040 OMRSD V41BU0.081 OMRSD V41BU0.082

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
F	CLIP - POST STRAIGHTENING MAIN INJECTOR		R0019530
	NUT		R0011573
	T-BOLT, POST STRAIGHTENING MAIN INJECTOR		R0019531
	MATERIAL INTEGRITY - CLIP	MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RB0170-196
		CLIP IS PENETRANT INSPECTED PER SPECIFICATION REQUIREMENTS.	RA0115-116
	ASSEMBLY INTEGRITY	CLIP IS CLEANED AND INSPECTED PER SPECIFICATION REQUIREMENTS.	RL10001
		CLIP IS INSTALLED AND INSPECTED PER SPECIFICATION AND DRAWING REQUIREMENTS.	R0019530 RS009122
		HEAT TREAT IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RB0170-185 RAC611-020
	MATERIAL INTEGRITY - NUT	MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION REQUIREMENTS.	R0011573
		NUT IS PENETRANT INSPECTED PER SPECIFICATION REQUIRSMENTS.	RAC115-116
	ASSEMBLY INTEGRITY	NUT IS CLEANED AND INSPECTED PER SPECIFICATION REQUIREMENTS	RL10001
		NUT IS FLASH SILVER PLATED AND INSPECTED PER DRAWING REQUIREMENTS.	R0011573
		NUT TORQUE IS APPLIED AND INSPECTED PER DRAWING REQUIREMENTS.	RS009122
		A VISUAL INSPECTION IS PERFORMED AFTER NUT INSTALLATION HAS BEEN COMPLETED AND THE THREAD MELT HAS BEEN PERFORMED.	
		NUTS ARE INSPECTED FOR FINAL ASSEMBLY ACCEPTANCE PER DRAWING REQUIREMENTS.	R0011573 RS009122
		THE HOT FIRE TESTING AND 2ND E & M INSPECTIONS VERIFY POST INTEGRITY.	RL00050-04 RL00050-09 RL00050-07
		AFTER EACH FLIGHT A VISUAL INSPECTION IS PERFORMED TO CHECK FOR EVIDENCE OF THERMAL DAMAGE TO THE INJECTOR.	OMRSD V41BJ0.042
		ALL ACCESSIBLE FLOW SHIELDS, SECONDARY FACEPLATE RETAINERS, AND HEAT SHIELDS RETAINERS ON OUTER ROWS ARE VISUALLY AND BORESCOPE INSPECTED FOR SECURITY AND DAMAGE PRIOR TO EACH FLIGHT AND WHENEVER HIGH PRESSURE PUMPS ARE REMOVED. WHENEVER HIGH PRESSURE PUMPS ARE REMOVED FLOW SHIELDS ARE PHYSICALLY INSPECTED FOR TIGHTNESS RETAINERS ARE INSPECTED ON OUTER DIAMETER FACING PORTIONS ONLY (LAST TEST)	OMRSD V41BJ0.040 OMRSD V41BJ0.087 OMRSD V41BJ0.082
	MATERIAL INTEGRITY - T-BOLT	MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RB0170-196 R0019531
		PENETRANT INSPECTION IS PERFORMED PER SPECIFICATION REQUIREMENTS.	RAC115-116 R0019531

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
F	ASSEMBLY INTEGRITY	CLEANING IS ACCOMPLISHED PER SPECIFICATION REQUIREMENTS	RL10007 RS010531
		INSTALLATION IS VERIFIED PER SPECIFICATION AND DRAWING REQUIREMENTS.	R001953 RS009122
		A VISUAL INSPECTION IS PERFORMED AFTER NUT INSTALLATION HAS BEEN COMPLETED AND THREAD MELT HAS BEEN PERFORMED.	RS009122

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

Operational Use Not Applicable.

SSME / ATDL
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 ME3-01-5238

Component	Basic Part Number	Weld Number	Weld Type	Class	Root Side Not Access	Critical Initial Flaw Size Not Detectable HCF	Critical Initial Flaw Size Not Detectable LCF	Comments
MAIN INJECTOR ASI	RSC0906*	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	23-29,54	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	Ib	X			
MAIN INJECTOR	RS009126	60,61	GTAW	II	X	X		
INLET SHELL	RSC09235	1 LFT	EBW	I				
INLET SHELL	RSC09235	1 RHT	EBW	I		X	X	
INLET SHELL	RSC09237	600 PLCS	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: RS009122

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

Base Line Rationale	Variance	Change Rationale	Variant Dash Number
1. A200-07 LOX ASI SLEEVE BRAZE IS X-RAYED AND BORESCOPED. (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 842)	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, -81[illegible] 861.
4. A200-07 ELIMINATION OF BRAZE JOINTS OF ASI INLET TUBE TO BLEED TUBES	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 988R1)	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, -116[illegible], -1171, -120[illegible], -1301, -1311, -1321, -1361 -144[illegible]