SSME F A/CIL
REDUNDAN / SCREEN

Component Group:	Combustion Devices	Prepared:	A. Kay
CIL Item:	A050-01	Approved:	T. Nguyen
Part Number:	RS007010	Approval Date:	9/9/93
Component:	Powerhead	Change #:	1
FMEA Item:	A050	Directive #:	CCBO MS3-01 5208
Failure Mode:	Preburner liner failure.	Page:	1 of 1

Phase	Failure / Effect Description	Critical ity Hazard Reference
SMC 4.1	Preburner liner failure results in loss of coolant, injector baffle, and faceplate erosion. Injector debris punctures nozzle tubes. Tearing of liner restricts turbine discharge flow. Nozzle damage and turbine discharge restrictions result in increased turbine temperatures. Liner failure may result in heat exchanger coil failure or LOX post fracture. Loss of vehicle Redundancy Screen: SINGLE POINT FAILURE: N/A	1 ME-B2M, ME-B6S, ME-B6S,A,C, ME-B6M ME-C1S, M, ME-D1S,M, ME-B1S,A,M,C, ME-B2S, ME-B2A,C

SSME FMEA/CIL
DESIGN

Component Group:	Combustion Devices
CIL Item:	A050-01
Part Number:	RS007010
Component:	Powerhead
FMEA Item:	A050
Failure Mode:	Preburner liner failure.

Prepared:	A. Kay
Approved:	T. Nguyen
Approval Date:	9/8/93
Change #:	1
Directive #:	CCBD ME3-01-5238
Page:	1 of 1

Design / Document Reference

FAILURE CAUSE: A: Preburner liner/extension or weld/parent material failure.

THE PREBURNER LINER ASSEMBLIES (1) IS A WELDMENT OF HAYNES 188 FORGING (2) AND HAYNES 188 SHEET METAL COMPONENTS (3). HAYNES 188 WAS SELECTED ON THE BASIS OF ITS STRENGTH AT HIGH TEMPERATURES, RESISTANCE TO CREEP AND ITS RESISTANCE TO HYDROGEN ENVIRONMENT EMBRITTLEMENT (4). THE CYLINDRICAL LINER FORMS AN ANNULUS WHEN INSTALLED IN THE PREBURNER BODY (5). THE LINER IS WELDED TO A HAYNES 188 METERING RING (6). THE METERING RING DESIGN INCORPORATES A SERIES OF MACHINED RECESSES IN A LIP WHICH INTERFACES WITH A SIMILAR LAND ON THE PREBURNER BODY. THE SERIES OF RECESSES CONTROL HYDROGEN COOLANT FLOW WHICH ORIGINATES FROM THE ORIFICED PREBURNER BODY (7). THE HYDROGEN COOLANT IS DISCHARGED AT THE LOWER END OF THE LINER/PREBURNER BODY INTERFACE TO THE HOT-GAS SUPPLY FOR THE TURBINES. THE INNER DIAMETER OF THE LINER FORMS A DUCT WHICH DIRECTS HOT-GAS TO THE TURBINE ENTRANCES HYDROGEN BOUNDARY LAYER COOLANT IS PROVIDED TO THE HOT-GAS SIDE OF THE LINER BY A PARALLEL SERIES OF ORIFICES MACHINED IN THE INJECTOR FACEPLATE (8). THE DIVERGENT SECTION OF THE LINER IS FURTHER HEAT PROTECTED BY A THERMAL COATING SYSTEM (9). THE THERMAL COATING, IN CONJUNCTION WITH THE HYDROGEN BOUNDARY LAYER COOLANT, PROVIDE ADEQUATE PROTECTION AGAINST THE HOT-GAS ENVIRONMENT.

(1) R001504 R0011582 (2) AMS 5772; (3) AMS 5508; (4) RSS-9561-9; (5) RS009023; (6) R001548 R0014654; (7) RS009302; (8) RS009028 RS029011; (9) RA0109-018 RA0109-019, RA0109-020

FAILURE CAUSE: B: Preburner liner retention system failure due to multiple failure of liner retention straps.

THE PREBURNER LINER ASSEMBLY IS RETAINED IN THE PREBURNER BODIES BY A SYSTEM OF EQUALLY SPACED RECTANGULAR HAYNES 188 STRIPS (1). HAYNES 188 WAS SELECTED ON THE BASIS OF ITS STRENGTH, RESISTANCE TO CREEP, AND HIGH CYCLE FATIGUE PROPERTIES (2). THE STRIPS ARE TIG WELDED AT ONE END TO THE INNER DIAMETER OF THE PREBURNER BODY. THE OPPOSITE END IS TIG WELDED TO THE OUTER DIAMETER OF THE LINER. BOTH ENDS OF THE LINER STRIPS INCORPORATE MACHINED RADII TO ATTENUATE HIGH CYCLE FATIGUE EFFECTS.

A-12

(1) RS009015 (2) RSS-8591-9

FAILURE CAUSE: ALL CAUSES

HIGH AND LOW CYCLE FATIGUE LIFE OF THE LINERS AND LINER RETENTION SYSTEM MEET CEI REQUIREMENTS (1). THE MINIMUM FACTORS OF SAFETY FOR THE LINERS AND LINER RETENTION SYSTEM MEET CEI REQUIREMENTS (2). THE LINER PARENT MATERIAL WAS CLEARED FOR FRACTURE MECHANICS/NDE FLAW GROWTH SINCE IT CONTAINS NO FRACTURE CRITICAL PARTS (3). THE FMEA/CIL WELDS ARE CLEARED FOR FRACTURE MECHANICS/NDE FLAW GROWTH BY THE WELD ASSESSMENT (4). TABLE A050 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 (4). SECTIONING OF THE LINERS IN ENGINE 2010 SHOWED THAT LACK OF PENETRATION IN THE LINER WELDS DID NOT ADVERSELY AFFECT THE WELD INTEGRITY (5). THE POWERHEAD ASSEMBLY HAS COMPLETED DVS TESTING (6). CONTINUED USE WITH ALLOWABLE DISCREPANCIES RESULTING FROM OPERATION IS EVALUATED AND CONTROLLED PER THE REQUIREMENTS OF THE MAINTENANCE CONTROL DOCUMENT (7).

(1) RLD0532,BD CP320R0003B. (2) RSS-8548, CP320R0003B; (3) NASA TASK 117; (4) RSS-8756. (5) LL85-0018; (6) DVS-101; (7) RSS-8793

SSME FMEA/CIL
INSPECTION AND TEST

Component Group:	Combustion Devices	Prepared:	A. Kay
CIL Item:	A050-01	Approved:	T. Nguyen
Part Number:	RS007010	Approval Date:	9/9/99
Component:	Powerhead	Change #:	1
FMEA Item:	A050	Directive #:	CCBD ME3-01-5238
Failure Mode:	Preburner liner failure.	Page:	1 of 1

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A	LINER ASSEMBLY LINER EXTENSION LINER ASSEMBLY METERING RING		R0011054 R0011048 R0011562 R0011554
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.	AMS 5772 AMS 5608
		PREBURNER LINER FORGINGS ARE ULTRASONIC AND PENETRANT INSPECTED PER SPECIFICATION REQUIREMENTS	RA0115-012 RA0115-115
	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.	RL10011 RA0607-094 RA0115-115 RA0115-005 RA0115-127 RA1115-001
	SURFACE FINISH	PREBURNER LINER THERMAL COATING IS APPLIED PER SPECIFICATION REQUIREMENTS.	RAC109-018 RAC109-019 RAC109-020
B	LINER STRIP LINER STRIP		RSC09015 RSC09031
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.	AMS 5608
	ASSEMBLY INTEGRITY	WELDING GEOMETRY OF STRIPS IS CONTROLLED PER DRAWING REQUIREMENTS.	RSC07010 RSC07051
		THE HOT FIRE TESTING AND 2ND E & M INSPECTIONS VERIFY LINER INTEGRITY.	RL00050-04 RL00050-05 RL00050-07
ALL CAUSES		THE LINER ASSEMBLIES ARE VISUALLY INSPECTED FOR DAMAGE AFTER EVERY FLIGHT AND EACH TIME THE PUMP IS REMOVED (LAST TEST).	OMRSD V41BU0.040 OMRSD V41BU0.091 OMRSD V41BU0.092

Failure History: Comprehensive failure history data is maintained in the Problem Reporting database (PRAMS/PRACA)
Reference NASA letter SA21/89/308 and Rocketdyne letter 88RC09761.

Operational Use: Not Applicable.

SSME PA/CIL
WELD JOINTS

Component Group: Combustion Devices
CIL Item: A050
Component: RS007010
Part Number: Powerhead
A050

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
OPB INLET ELBOW	R0010749	*	GTAW	I		X		(A700)
OPB INLET ELBOW	R0010749	4	GTAW	I		X		(A700)
OPB INLET ELBOW	R0010749	5	GTAW	I		X	X	(A700)
OPB INLET ELBOW	R0010749	6	GTAW	I	X	X	X	(A700)
OPB INLET ELBOW	R0010749	7(OPT)	GTAW	I		X		(A700)
OPB INLET ELBOW	R0010749	8(OPT)	GTAW	I		X		(A700)
OPB INLET ELBOW	R0010749	9	GTAW	I		X	X	(A700)
OPB INLET ELBOW	R0010749	10	GTAW	I	X	X	X	(A700)
OPB INLET ELBOW	R0010749	11(OPT)	GTAW	I		X	X	(A700)
OPB INLET ELBOW	R0010749	12(OPT)	GTAW	I		X		(A700)
FUEL PREBURNER LINER	R0011054	1(OPT)	FBW	I		X	X	(A600)
FUEL PREBURNER LINER	R0011054	1(OPT)	GTAW	I		X	X	(A600)
FUEL PREBURNER LINER	R0011054	2(OPT)	GTAW	I		X	X	(A600)
FUEL PREBURNER LINER	R0011054	2(OPT)	EBW	I				(A600)
OXIDIZER PREBURNER LINER	R0011582	1(OPT)	GTAW	I		X		(A700)
OXIDIZER PREBURNER LINER	R0011582	1(OPT)	EBW	I		X		(A700)
OXIDIZER PREBURNER LINER	R0011582	2(OPT)	EBW	I		X		(A700)
OXIDIZER PREBURNER LINER	R0011582	2(OPT)	GTAW	I		X		(A700)
OXIDIZER PREBURNER LINER	R0011582	2-17	GTAW	II				(A700)
POWERHEAD	RS007010	1	GTAW	I	X	X		
POWERHEAD	RS007010	2A(OPT)	GTAW	II	X			
POWERHEAD	RS007010	2B(OPT)	GTAW	II	X			
POWERHEAD	RS007010	3	GTAW	I				
POWERHEAD	RS007010	4	GTAW	I	X			
POWERHEAD	RS007010	5	GTAW	I	X			
POWERHEAD	RS007010	6	GTAW	I	X			
POWERHEAD	RS007010	7	GTAW	I	X			
POWERHEAD	RS007010	12	GTAW	I	X	X		
POWERHEAD	RS007010	13	GTAW	I		X	X	
POWERHEAD	RS007010	14	GTAW	I	X			
POWERHEAD	RS007010	15	GTAW	I	X			

Component	Basic Part Number	Weld Number	Weld Type	Class	Root Side Not Access	Critical Initial Flaw Size Not Detectable HCF	LCF	Comments
POWERHEAD	RS007010	16	GTAW	I		X	X	
POWERHEAD	RS007010	17	GTAW	I		X	X	
POWERHEAD	RS007010	18	GTAW	I	X	X	X	
POWERHEAD	RS007010	21	EBW	I	X			
POWERHEAD	RS007010	22	GTAW	I	X			
POWERHEAD	RS007010	23	GTAW	II	X			
POWERHEAD	RS007010	32	GTAW	II	X	X	X	(A700)
CPB FUEL SUPPLY DUCT	RS007012	2	GTAW	I				
CPB FUEL SUPPLY DUCT	RS007012	3	GTAW	I		X	X	
CPB FUEL SUPPLY DUCT	RS007012	6	GTAW	I		X		
CPB FUEL SUPPLY DUCT	RS007012	7	GTAW	I	X	X		
CPB FUEL SUPPLY DUCT	RS007012	8	GTAW	I		X		
CPB FUEL SUPPLY DUCT	RS007012	9	GTAW	I		X	X	(A150)
PREBURNER FUEL SUPPLY DUCT	RS007030	1,2	GTAW	I				(A150)
OXID TANK PRESSURANT DUCT	RS007049	1	GTAW	I				(A150)
OXID TANK PRESSURANT DUCT	RS007049	2	GTAW	I			X	(A150)
OXID TANK PRESSURANT DUCT	RS007049	3	GTAW	I				
HOT GAS MANIFOLD	RS007051	13,14	EBW	II	X	X	X	
HOT GAS MANIFOLD	RS007051	15,16	EBW	II	X	X	X	(A600)
HOT GAS MANIFOLD	RS007051	17-24	GTAW	II	X		X	
HOT GAS MANIFOLD	RS007051	29-40	GTAW	II	X			
HOT GAS MANIFOLD	RS007051	41	EBW	II	X			
HOT GAS MANIFOLD	RS007051	42	EBW	II	X	X		
HOT GAS MANIFOLD	RS007051	43,44	EBW	III	X	X	X	
HOT GAS MANIFOLD	RS007051	48,51	GTAW	II	X			
HOT GAS MANIFOLD	RS007051	52,70	GTAW	I	X	X	X	(A700) (A600)
HOT GAS MANIFOLD	RS007051	64	GTAW	I	X	X	X	(A700)
HOT GAS MANIFOLD	RS007051	73	GTAW	I	X	X	X	(A600)
HOT GAS MANIFOLD	RS007051	80,81,147	EBW	II	X	X	X	
HOT GAS MANIFOLD	RS007051	83,84	GTAW	II	X			
HOT GAS MANIFOLD	RS007051	96,97	GTAW	II	X			
HOT GAS MANIFOLD	RS007051	101	EBW	II	X	X		
HOT GAS MANIFOLD	RS007051	113-124	GTAW	II	X			
HOT GAS MANIFOLD	RS007051	133	GTAW	II	X	X		

Component	Basic Part Number	Weld Number	Weld Type	Class	Root Side Not Access	Critical Initial Flaw Size Not Detectable HCF	LCF	Comments
HOT GAS MANIFOLD	RS007051	134	GTAW	II	X			
HOT GAS MANIFOLD	RS007051	135,136,156	GTAW	I/I	X			
HOT GAS MANIFOLD	RS007051	139-141	GTAW	I		X	X	(A700)
HOT GAS MANIFOLD	RS007051	142-144	GTAW	I		X	X	(A500) (A700)
HOT GAS MANIFOLD	RS007051	145-146	EBW	I				
HOT GAS MANIFOLD	RS007051	148	EBW	I	X	X		
HOT GAS MANIFOLD	RS007051	149	GTAW	I	X	X	X	
FUEL LINER	RS007064	3(OPT)	EBW	I				
FUEL LINER	RS007064	3(OPT)	GTAW	I				
FUEL LINER	RS007065	3(OPT)	EBW	I				
FUEL LINER	RS007065	3(OPT)	GTAW	I				
FUEL LINER	RS007065	4(OPT)	GTAW	II				
FUEL LINER	RS007065	4(OPT)	EBW	II				
FUEL LINER	RS007065	8	GTAW	II	X			
FUEL LINER	RS007065	9	GTAW	II	X			
FUEL LINER	RS007065	10	GTAW	II	X			
FUEL LINER	RS007065	18(OPT)	GTAW	II	X			
FUEL LINER	RS007065	19	GTAW	II	X			
FUEL LINER	RS007065	20	GTAW	II	X			
FUEL LINER	RS007065	21	GTAW	II	X			
FUEL LINER	RS007065	22	GTAW	II	X			
FUEL LINER	RS007065	23	GTAW	II				
FUEL LINER	RS007065	24	GTAW	II				
OXIDIZER LINER	RS007066	2(OPT)	GTAW	II	X			
OXIDIZER LINER	RS007066	2(OPT)	EBW	II	X			
OXIDIZER HGM STRUC SHELL	RS007070	3(OPT)	EBW	I				
OXIDIZER HGM STRUC SHELL	RS007070	4	GTAW	I	X			
OXIDIZER HGM STRUC SHELL	RS007070	5(OPT)	EBW	I		X	X	
OXIDIZER HGM STRUC SHELL	RS007070	29(OPT)	GTAW	II	X			
OXIDIZER HGM STRUC SHELL	RS007070	31,32(OPT)	GTAW	I	X			
OXIDIZER HGM STRUC SHELL	RS007070	33(OPT)	GTAW	II	X			
FUEL HGM STRUC SHELL	RS007071	1	EBW	I		X		
FUEL HGM STRUC SHELL	RS007071	3,45	GTAW	II	X	X	X	
FUEL HGM STRUC SHELL	RS007071	7	GTAW	I				