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REDUNDANCY

Volume:	Combustion Devices	Prepared:	M. Oliver
Item Name:	Large Throat Main Combustion Chamber	Approved:	M. La Croix
Item Number-Mode:	A335-02	Approval Date:	10/30/00
Part Number:	R046300	Change #:	5
Failure Mode:	Fuel leaks into the closed cavity between the liner and structural jacket.	Directive #:	CCBD ME3-01 -5212

Phase Scenario	Failure / Effect Description	Criticality Hazard Reference
SMC 4.1	Leakage into the closed jacket cavity causes burst diaphragm rupture, venting the cavity into the engine fuel drain system. Excessive leakage causes deformation of the liner in the divergent section. Significant changes in the exhaust gases flow produces a strong shock at the downstream nozzle wall. Tube failures cause loss of fuel to the preburners and high turbine temperatures. Cavity overpressurization causes ripping of welds, sudden loss of fuel, engine failure, and aft compartment overpressurization and fire. Loss of vehicle. Redundancy Screen: SINGLE POINT FAIURE: N/A	1 ME-B5S; ME-B5M; ME-B5A,C.

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DESIGN

Volume:	Combustion Devices	Prepared:	M. Oliver
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Failure Mode:	Fuel leaks into the closed cavity between the liner and structural jacket.	Directive #:	CCBD ME3-01-5212

Design	Document Reference
<p>Failure Cause(s): A: Failure in EDNi liner closeout structure caused by long liner inner wall crack(s). THE PRE-START PURGE MINIMIZES THE POSSIBILITY OF ICE FORMATION IN COOLANT PASSAGE. THE COOLANT PASSAGES ARE DESIGNED SUCH THAT MINOR REDUCTION IN COOLANT FLOWRATE CAN BE SUSTAINED WITHOUT FAILURE OF THE HOT-GAS WALL. CRACKS IN THE HOT GAS WALL GROW SLOWLY DUE TO INCREASED COOLANT BEING LOCALLY DUMPED THROUGH THE CRACK. USAGE LIMITS FOR MCC HOT WALL CRACKS HAVE BEEN ESTABLISHED. USAGE LIMITS ARE DEFINED BY SPECIFICATION (1). NARLOY - Z IS USED AS THE COMBUSTION CHAMBER HOT GAS WALL MATERIAL BECAUSE OF ITS ABILITY TO RESIST THERMAL STRAINS GENERATED DURING TEST. IT EXHIBITS EXCELLENT THERMAL CONDUCTIVITY, THERMAL FATIGUE, AND STRENGTH AT ELEVATED TEMPERATURES (2). CHANNEL PASSAGES ARE DESIGNED TO ALLOW PASSAGE OF PARTICLES UP TO 0.035. THE CRITICAL REGIONS OF THE HOT-GAS WALL ARE POLISHED TO MAINTAIN LAMINAR FLOW AND REDUCE ROUGHENING OF THE SURFACE (3). ELECTRODEPOSITED NICKEL WAS SELECTED AS THE STRUCTURAL CLOSEOUT MATERIAL BECAUSE OF ITS GOOD STRENGTH AND SUITABILITY IN PROVIDING A TRANSITION METAL FOR WELDING THE JACKET TO THE LINER (4). IT HAS A BARRIER OF ELECTRODEPOSITED COPPER WHICH PROVIDES HYDROGEN EMBRITTLEMENT PROTECTION FOR THE ELECTRODEPOSITED NICKEL (5). A PRIMARY STRESS FACTOR OF SAFETY MEETS CEI REQUIREMENTS (6). HIGH CYCLE AND LOW CYCLE FATIGUE LIFE OF THE LINER MEETS CEI REQUIREMENTS (7). THE LINER PARENT MATERIALS WERE CLEARED FOR FRACTURE MECHANICS/NDE FLAW GROWTH SINCE IT CONTAINS NO FRACTURE CRITICAL PARTS (8).</p>	<p>(1) RL00050-04, RF0001-053; (2) 572K; (3) R0017707; (4) MPTR-71-175-302; (5) SSME-72-1326; (6) SSE-44L-03, CP320R0003B; (7) RL00532, CP320R0003B; (8) NASA TASK 117</p>
<p>Failure Cause(s): B: Jacket EB closeout weld overpenetration into EDNi liner. ELECTRON BEAM BACK-UPS PROVIDE A MINIMUM OF 50% BACKUP MATERIAL FOR PROTECTION AGAINST OVERPENETRATION OF EB CLOSEOUT WELDS INTO THE ELECTRODEPOSITED NICKEL LINER (1). THE EB WELD PROCESS GIVES EXCELLENT UNIFORM WELDING WITH CONTROLLED PENETRATION. THE WELDING PROCESS ENTAILS SAMPLE SPECIMENS AND CONTROLLED PARAMETERS PER SPECIFICATION REQUIREMENTS (2).</p>	<p>(1) R046297; (2) RA1607-071</p>
<p>Failure Cause(s): C: Fracture of manifold to liner welds. THE TWO WELD JOINTS THAT MAY CAUSE INTERNAL LEAKAGE ARE WELD JOINT 10 (LINER TO INLET MANIFOLD) AND WELD 15 (LINER TO FORWARD END OF JACKET). HASTELOY "W" WAS SELECTED FOR WELD 10 DUE TO ITS WELDABILITY AND COMPATIBILITY WITH EACH BASE METAL (1). THE WELD PREPARATION OF JOINT 10 IS SPECIFIED PER DRAWING REQUIREMENTS (2)(3). WELD JOINT 10 IS NOT SUSCEPTABLE TO HYDROGEN EMBRITTLEMENT DUE TO</p>	<p>(1) 572K; (2) R0017706; (3) R046290; (4) 572K;</p>

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CRYOGENIC TEMPERATURES (4). WELD JOINT 15 USES NICKEL 61 FOR THE WELD MATERIAL BECAUSE OF ITS COMPATABILITY WITH INCONEL 718, THE NICKEL BASE, AND INCOLOY 903. JOINT 15 IS PRE-HEATED PRIOR TO WELDING AND IS MADE IN SEVERAL SEGMENTS TO PRECLUDE POST WELD SHRINKAGE RESULTING IN RESIDUAL STRESSES. THE WELD PREPARATION IS SPECIFIED ON THE DRAWINGS (2) (5). JOINT 15 IS PROTECTED FROM HYDROGEN EMBRITTLEMENT BY COPPER PLATING (6). THE PLATING IS CONTROLLED FOR COVERAGE AND THICKNESS BY SPECIFICATION (6). THE PRIMARY STRESS FACTORS OF SAFETY MEET CEI REQUIREMENTS (7). THE JACKET SIDE OF WELD 15 IS PROTECTED FROM HYDROGEN EMBRITTLEMENT BY AN INCOLOY 903 OVERLAY (8). RELIEF GROOVES ON BOTH SIDES OF WELD 15 REDUCE THE STRESS LEVELS IN THE WELD MATERIAL AND PREVENT DELAMINATION OF THE ELECTRODEPOSITED NICKEL (2)(8). HIGH CYCLE AND LOW CYCLE FATIGUE LIFE OF THE WELDS MEET CEI REQUIREMENTS (9). THE FMEA/CIL WELDS ARE CLEARED FOR FRACTURE MECHANICS/NDE FLAW GROWTH BY THE WELD ASSESSMENT (10). TABLE A335 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 (10).

(5) R046300;
(6) RA1109-002;
(7) RSS-8756, CP320R0003B;
(8) R046297;
(9) RL000532, CP320R0003B;
(10) RSS-8756

Failure Cause(s): All Causes

THE MCC INCORPORATES A VENT PORT TO ALLOW PASSAGE OF GASES FROM THE CLOSED LINER/JACKET AREA THROUGH THE DRAIN LINES AND OUT THE REAR OF THE VEHICLE. THE MCC BURST DIAPHRAGM VENT SYSTEM MAINTAINS A GREATER THAN 1.4 FACTOR OF SAFETY FOR START AND MAINSTAGE AND A 1.14 FACTOR OF SAFETY IS MAINTAINED FOR CUTOFF.

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INSPECTION & TEST

Volume:	Combustion Devices	Prepared:	d. Early
Item Name:	Large Throat Main Combustion Chamber	Approved:	T. Nguyen
Item Number-Mode:	A335-02	Approval Date:	10/30/00
Part Number:	R046300	Change #:	3
Failure Mode:	Fuel leaks into the closed cavity between the liner and structural jacket.	Directive #:	CCBD ME3-01-5212

Significant Characteristics	Inspection(s) / Test(s)	Document Reference
Failure Cause(s): LINER, SLOTTED	A: Failure in EDNi liner closeout structure caused by long liner inner wall crack(s).	R0017706
E.D. COPPER CLOSEOUT AND BOND	HOT WATER IMMERSION TEST CHECKS FOR PLATING DEFECTS AND ADHESION.	RA1609-018
	THE ELECTRODEPOSITED COPPER AND ELECTRODEPOSITED NICKEL SPECIMENS ARE EXAMINED FOR CONFORMANCE PER SPECIFICATION REQUIREMENTS.	RA1609-018
	A PROOF PRESSURE TEST IS PERFORMED AFTER ELECTRODEPOSITED NICKEL PLATING.	RL00787
	A MASS SPEC LEAK TEST IS PERFORMED AFTER MAIN COMBUSTION CHAMBER ASSEMBLY PROOF TEST.	RL00874
Failure Cause(s): ELECTRON BEAM WELD COVER PENETRATION; R046300 WELDS 5,6,7,16,39 40	B: Jacket EB closeout weld overpenetration into EDNi liner.	RA1607-071 RA1115-001 RL00778 RA0115-116 RL00781 RL00784
WELD INTEGRITY	EB WELD SAMPLES MADE PRIOR TO ACTUAL WELD, VERIFY CORRECT WELD PENETRATION AND SETUP. AN ULTRASONIC INSPECTION CHECKS THE WELD PENETRATION. THE PROCEDURE AND PENETRATION IS CHECKED PER WELD SPECIFICATION.	RL10011 RA1607-071 RA0115-116 RA0115-006 RA1115-001 RL00778 RL01129 RL00781 RL00782
	A MASS SPEC LEAK CHECK IS PERFORMED FOLLOWING PROOF PRESSURE TEST.	
	ALL WELDS ARE INSPECTED TO DRAWING AND SPECIFICATION REQUIREMENTS PER WELD CLASS. INSPECTIONS INCLUDE: VISUAL, DIMENSIONAL, PENETRANT, RADIOGRAPHIC, ULTRASONIC, AND FILLER MATERIAL, AS APPLICABLE.	
	SPECIAL INSPECTIONS PER SPECIFICATIONS OF MCC CHAMBER ASSEMBLY EB WELDS ARE PERFORMED (INCLUDING BORING, ETCH, PENETRANT, AND WELD FILL).	

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Failure Cause(s): WELD INTEGRITY	C: Fracture of manifold to liner welds. 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 RA1115-001
UNVERIFIABLE ROOT WELDS R046300 WELDS CLASS II - 10,15	UNVERIFIABLE ROOT WELDS ARE INSPECTED PER DRAWING AND SPECIFICATION REQUIREMENTS AS APPLICABLE. WELD 15 IS CLEANED AND VISUALLY INSPECTED USING 3X MAGNIFICATION OR GREATER AFTER EACH WELD PASS. EACH WELD PASS IS PEENED FOR STRESS RELIEF. WELD 10 ROOT PASS IS PENETRANT INSPECTED PER SPECIFICATION REQUIREMENTS. COMPLETED WELD JOINTS ARE LEAK TESTED PER SPECIFICATION REQUIREMENTS. MCC ASSEMBLY IS PROOF PRESSURE TESTED PER SPECIFICATION REQUIREMENTS. A MASS SPEC LEAK TEST IS PERFORMED POST PROOF TEST.	R046300 RA0115-116 RL00776 RL00784 RL00784
COPPER PLATE OVERLAY ON WELD 15	PLATING IS INSPECTED FOR COVERAGE AND THICKNESS PER SPECIFICATION REQUIREMENTS.	RA1109-002

Failure Cause(s): ASSEMBLY INTEGRITY	All Causes THE HOT FIRE TESTING AND 2ND E & M INSPECTIONS VERIFY LINER AND WELD INTEGRITY. MCC HOT-GAS WALL IS INSPECTED AFTER EACH LAUNCH FOR CRACKS. A BURST DIAPHRAGM INSPECTION IS PERFORMED AFTER HOT-FIRE FOR POSSIBLE PRESSURIZATION DUE TO LEAKAGE (LAST TEST).	RL00050-04 RL00056-06 RL00056-07 OMRSD V41BU0.029 RL00050-04 RL00056-06 RL00056-07
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Failure History:	Comprehensive failure history data is maintained in the Problem Reporting database (PRAMS/PRACA) Reference: NASA letter SA21/88/308 and Rocketdyne letter 88RC09761.	
Operational Use:	Not Applicable.	

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WELD JOINTS

Volume: Combustion Devices
Item Name: Large Throat Main Combustion Chamber
Item Number: A335
Part/Alternate Number: R046300

Prepared: M. Oliver
Approved: T. Nguyen
Approval Date: 9/9/99
Change #: 3
Directive #: CCBDE ME3-01 -5238

Component	Basic Part Number	Weld Number	Weld Type	Class	Root Side Not Access	Critical Initial		Comments
						Flaw Size	Not Detectable	
						HCF	LCF	
MAIN COMBUSTION CHAMBER	R046300	5	EBW	Ia	X	X	X	
MAIN COMBUSTION CHAMBER	R046300	6,7	EBW	Ib	X	X	X	
MAIN COMBUSTION CHAMBER	R046300	58,59	GTAW	II	X	X	X	
MAIN COMBUSTION CHAMBER	R046300	10	GTAW	II	X	X	X	
MAIN COMBUSTION CHAMBER	R046300	11,12	GTAW	II	X	X	X	
MAIN COMBUSTION CHAMBER	R046300	13,14	GTAW	II	X	X	X	
MAIN COMBUSTION CHAMBER	R046300	15	GTAW	II	X	X	X	
MAIN COMBUSTION CHAMBER	R046300	16	EBW	II	X	X	X	
MAIN COMBUSTION CHAMBER	R046300	18	EBW	I	X			
MAIN COMBUSTION CHAMBER	R046300	22,23	EBW	I, Ia	X			
MAIN COMBUSTION CHAMBER	R046300	39,40	EBW	I	X			
MAIN COMBUSTION CHAMBER	R046300	68	GTAW	II	X	X	X	
MAIN COMBUSTION CHAMBER	R046300	69,70	GTAW	II	X	X	X	

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FIELD CONFIGURATION VARIANCES FROM CIL RATIONALE

Volume: Combustion Devices
Item Name: Large Throat Main Combustion Chamber
Item Number: A335
Part/Alternate Number: R046300

Prepared: M. Oliver
Approved: T. Nguyen
Approval Date: 10/30/00
Change #: 1
Directive #: CCBD ME3-01 -5212

Base Line Rationale	Variance	Change Rationale	Variant Dash Number
A335-02 MONITOR MCC LINER CAVITY PRESSURE MEASUREMENTS FOR EVIDENCE OF LEAKAGE (ECP 1343).	BURST DIAPHRAGM LEAK CHECK.	A BURST DIAPHRAGM INSPECTION IS PERFORMED AFTER HOT- FIRE FOR POSSIBLE LEAKAGE INTO MCC LINER CAVITY PER SPECIFICATIONS (RL00050-04, RL00056-06, & RL00056-07). A BURST DIAPHRAGM LEAK CHECK IS PERFORMED PRIOR TO EACH FLIGHT PER OMRSD V41BQ0.240.	NONE
