

1) CIL ITEM : B400-08
 2) FMEA CODE : B400
 3) COMPONENT : HPOTP
 4) PART NUMBER : B8007701
 5) SYSTEM/SUBSYSTEM : PUMPS/810XX
 6) FAILURE MODE : FLOW DISTORTION AT MAIN PUMP INLET

7) PREPARED : SSME RELIABILITY
 8) APPROVED :
 9) DATE : 06-01-95
 10) REVISION/CHANGE : -002/0
 11) EFFECTIVITY : -761
 12) HAZARD REFERENCE : SEE LISTINGS BELOW
 13) CCBD # : *ME3-01-375*

PHASE	FAILURE DESCRIPTION/EFFECT	CRITICALITY
S	<p>CAVITATION AND ENERGY LOSS IN MAIN PUMP INLET, RESULTING IN REDUCED PUMP FLOW AND DISCHARGE PRESSURE. REDUCED TURBOPUMP OUTPUT RESULTS IN REDUCED ENGINE THRUST. THIS IS SENSED BY THE CONTROLLER, WHICH INCREASES OXIDIZER PREBURNER FLOW. EXCESS TURBINE DISCHARGE TEMPERATURE WILL CAUSE REDLINE SHUTDOWN. MISSION SCRUB IF DETECTED BY REDLINE. LOSS OF VEHICLE DUE TO HPOTP TURBINE OR HEAT EXCHANGER FAILURE MAY RESULT IF NOT DETECTED.</p> <p>REUNDANCY SCREENS: TURBOPUMP SYSTEM - SENSOR SYSTEM: UNLIKE REDUNDANCY</p> <p>A: PASS. REDUNDANT HARDWARE ITEMS ARE CAPABLE OF CHECKOUT DURING NORMAL GROUND TURNAROUND. B: PASS. LOSS OF A REDUNDANT HARDWARE ITEM IS DETECTABLE DURING FLIGHT. C: PASS. LOSS OF REDUNDANT HARDWARE ITEMS COULD NOT RESULT FROM A SINGLE CREDIBLE EVENT.</p>	<p>1R HAZARD REF: ME-CIS,M.</p>
M	<p>CAVITATION AND ENERGY LOSS IN MAIN PUMP INLET, RESULTING IN REDUCED PUMP FLOW AND DISCHARGE PRESSURE. REDUCED TURBOPUMP OUTPUT RESULTS IN REDUCED ENGINE THRUST. THIS IS SENSED BY THE CONTROLLER, WHICH INCREASES OXIDIZER PREBURNER FLOW. EXCESS TURBINE DISCHARGE TEMPERATURE WILL CAUSE REDLINE SHUTDOWN. MISSION ABORT IF DETECTED BY REDLINE. LOSS OF VEHICLE DUE TO HPOTP TURBINE OR HEAT EXCHANGER FAILURE MAY RESULT IF NOT DETECTED.</p> <p>REUNDANCY SCREENS: TURBOPUMP SYSTEM - SENSOR SYSTEM: UNLIKE REDUNDANCY</p> <p>A: PASS. REDUNDANT HARDWARE ITEMS ARE CAPABLE OF CHECKOUT DURING NORMAL GROUND TURNAROUND. B: PASS. LOSS OF A REDUNDANT HARDWARE ITEM IS DETECTABLE DURING FLIGHT. C: PASS. LOSS OF REDUNDANT HARDWARE ITEMS COULD NOT RESULT FROM A SINGLE CREDIBLE EVENT.</p>	<p>1R HAZARD REF: ME-CIS,M.</p>

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CIL ITEM: 8400-08		DESIGN	DOCUMENT REF.
B - 236	<p>FAILURE CAUSE A: FRACTURE, DISTORTION OF INLET VANE</p> <p>THE MAIN PUMP INLET (1) IS AN INCONEL 718 INVESTMENT CASTING WHICH HAS A SINGLE INLET AND A FLOW DIVIDER FOR DIRECTING THE FLOW EQUALLY TO THE LEFT- AND RIGHT-HAND TURNING VANES. THE INTERNAL VANE PASSAGES ARE FINISHED BY HAND TO REMOVE "CORE METAL." THE HAND GRIND OPERATION ALSO SMOOTHS AND REMOVES ANY DISCONTINUITIES ON THE CAST SURFACE. THE INLET IS HOT ISOSTATICALLY PRESSED FOR IMPROVED MECHANICAL PROPERTIES, SOLUTION HEAT TREATED, AND AGE-HARDENED (2). INCONEL 718 IS RESISTANT TO CORROSION AND STRESS CORROSION CRACKING, AND IS LOX COMPATIBLE (3). THE LEFT- (4) AND RIGHT-HAND TURNING VANES (5) TURN THE INLET FLOW APPROXIMATELY 90 DEGREES TO THE AXIAL DIRECTION INTO THE DOUBLE ENTRY MAIN PROPELLER INDUCERS. THE TURNING PASSAGES HAVE FIVE AIRFOIL SIMPED VANES, EACH TO ASSIST IN THE CIRCUMFERENTIAL FLOW TURNING. THE TURNING VANES ALSO FUNCTION AS THE INDUCER TUNNEL WALLS, PROVIDING A CONTROLLED TIP CLEARANCE FOR THE UNSHROUDED INDUCERS. THE TURNING VANES ARE MANUFACTURED UTILIZING K-MONEL FORGINGS, WHICH ARE SOLUTION HEAT TREATED AND AGE-HARDENED (4) (5). K-MONEL WAS SELECTED FOR ITS STRENGTH AND RESISTANCE TO CORROSION, AND IS SUITED FOR APPLICATION AT POTENTIAL RUBBING INTERFACES (3). VEHICLE PROPELLANT CLEANLINESS REQUIREMENTS MINIMIZE CONTAMINATION INDUCED RUBBING OR IMPACT DAMAGE TO THE VANES (6). THE ALLOY IS DUCTILE AND TOUGH AT CRYOGENIC TEMPERATURES AND IS LOX COMPATIBLE (3). THE RIGHT AND LEFT TURNING VANES PARENT MATERIAL WAS CLEARED FOR FRACTURE MECHANICS/WDE FLAW GROWTH BY CRITICAL INITIAL FLAW SIZE DETECTABILITY AND THE MAIN HOUSING WAS CLEARED BY RISK ASSESSMENT (7). CONTINUED USE WITH ALLOWABLE DISCREPANCIES RESULTING FROM OPERATION IS EVALUATED AND CONTROLLED PER THE REQUIREMENTS OF THE MAINTENANCE CONTROL DOCUMENT (8). THESE PARTS MEET CEI REQUIREMENTS FOR HIGH CYCLE AND LOW CYCLE FATIGUE LIFE (9). THE MINIMUM FACTORS OF SAFETY FOR THESE PARTS MEET CEI REQUIREMENTS (10). THE MAIN HOUSING HAS COMPLETED DESIGN VERIFICATION TESTING FOR PROOF PRESSURE-STRESS DISTRIBUTION (11). THE CONTROLLER SOFTWARE IS CONFIGURED TO DETECT AND RESPOND TO THE FAILURES IDENTIFIED AND COMMAND A SAFE ENGINE STATE (12). REUSE OF PARTS DURING OVERHAUL ARE CONTROLLED BY THE REQUIREMENTS OF THE OVERHAUL SPECIFICATION (13).</p>		<p>(1) RS007731 (2) RS007729 (3) RSS-8578-11 (4) RS007741 (5) RS007743 (6) ICD 13H15008 (7) NASA TASK 177 (8) RSS-8793 (9) RL00532, CP320R0003H (10) RSS-8546-16, CP320R0003B (11) RSS-403-58 (12) CP406H0008 3.2.3.5:2 (13) RL00874</p>
	CIL ITEM: 8400-08		INSPECTION AND TEST
POSSIBLE CAUSES	SIGNIFICANT CHARACTERISTICS	INSPECTION(S)/TEST(S)	DOCUMENT REF.
<p>FAILURE CAUSE A:</p> <p>RS007729 - MAIN HOUSING RS007731 - HOUSING INLET RS007741 - VANE, R.H. TURNING RS007743 - VANE, L.H. TURNING</p> <p>MATERIAL INTEGRITY</p>	<p>MATERIAL INTEGRITY IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.</p>	<p>RS007729 RS007731 RS007741 RS007743</p> <p>RS007729 RB0170-051 RB0170-155</p>	

CIL ITEM: B400-08		INSPECTION AND TEST	
POSSIBLE CAUSES	SIGNIFICANT CHARACTERISTICS	INSPECTION(S)/TEST(S)	DOCUMENT REF.
	HEAT TREAT	HEAT TREAT IS VERIFIED BY SPECIFICATION REQUIREMENTS.	RA0611-020 RB0170-155
		HOUSING CASTINGS HOT ISOSTATIC PRESS IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RL00368
	ASSEMBLY INTEGRITY	HOUSING IS ULTRASONIC AND PENETRANT INSPECTED PER SPECIFICATION REQUIREMENTS.	RA0115-012 RA0115-116
		MAIN HOUSING WELDS 22 & 24 ARE MASS SPECTROMETER LEAK CHECKED PER SPECIFICATION REQUIREMENTS.	RA0115-116
		VANE FIDRINGS ARE ULTRASONIC AND PENETRANT INSPECTED PER SPECIFICATION REQUIREMENTS.	RA0115-012 RA0115-116
		A PENETRANT INSPECTION IS PERFORMED ON THE HOUSING BEFORE AND AFTER PROOF PRESSURE TESTING PER DRAWING AND SPECIFICATION REQUIREMENTS.	RS007729 RA0115-116 RL00387
		VANE DIMENSIONS ARE VERIFIED PER SPECIFICATION REQUIREMENTS.	RL00447
		TURNING VANES ARE INSPECTED FOR CAVITATION DAMAGE PER SPECIFICATION REQUIREMENTS.	RL00874
	SURFACE FINISH	CASTING SURFACE FINISHES ARE INSPECTED PER SPECIFICATION REQUIREMENTS.	RA0115-007
	CLEANLINESS OF COMPONENTS	SSME SYSTEM CLEANLINESS IS VERIFIED THROUGHOUT ASSEMBLY PER SPECIFICATION REQUIREMENTS.	RL10001
	ASSEMBLY INTEGRITY	THE PUMP SUBASSEMBLIES ARE INSPECTED DURING OVERHAUL PER SPECIFICATION REQUIREMENTS. INSPECTIONS INCLUDE: VISUAL, DIMENSIONAL, PENETRANT, AND REPLACEMENT OF USAGE ITEMS AS APPLICABLE, PER OVERHAUL CLASSIFICATION.	RL00874 RA0115-116
		OPERATION/PERFORMANCE IS VERIFIED BY ENGINE HOT FIRE TESTING AND 2ND E & M INSPECTIONS.	RL00050-04 RL00056-06 RL00056-07 RL00461

CIL ITEM: B400-08		INSPECTION AND TEST	
POSSIBLE CAUSES	SIGNIFICANT CHARACTERISTICS	INSPECTION(S)/TEST(B)	DOCUMENT REF.
		OXIDIZER SYSTEM IS PURGED PER SPECIFICATION REQUIREMENTS.	CMRSD 800F80.300 CMRSD 800F80.250 CMRSD V41C80.080 CMRSD V41C80.081
		DATA FROM PREVIOUS FLIGHT OR HOT FIRE IS REVIEWED FOR PROPER TURBOPUMP OPERATION/PERFORMANCE. (LAST TEST)	MSFC PLN 122B
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.

TABLE 8400. HIGH PRESSURE OXIDIZER TURBOPUMP
FREA/CIL WELD JOINTS

COMPONENT	BASIC PART NO.	WELD NO.	WELD TYPE	CLASS	ROOT SIDE NOT ACCESS	CRITICAL INITIAL		COMMENTS
						FLAW SIZE NOT HCF	DETECTABLE LCF	
MAIN HOUSING	RS007729	1,2	EBW	I	X	X		
MAIN HOUSING	RS007729	3	EBW	I		X		
MAIN HOUSING	RS007729	9,10	GTAW	II	X	X	X	
MAIN HOUSING	RS007729	11,12	GTAW	I		X		
MAIN HOUSING	RS007729	13	EBW	I	X	X		
MAIN HOUSING	RS007729	14-17,16	GTAW	II	X			
MAIN HOUSING	RS007729	18,19	GTAW	II	X	I	X	
MAIN HOUSING	RS007729	21,23	GTAW	II	X			
MAIN HOUSING	RS007729	22,24	GTAW	II	X			
MAIN HOUSING	RS007729	44,53-59	GTAW	I	X			
MAIN HOUSING	RS007729	45	GTAW	I	X			
MAIN HOUSING	RS007729	48	GTAW	I	X	X		X
MAIN HOUSING	RS007729	49	GTAW	I	X			
MAIN HOUSING	RS007729	50	GTAW	I				
MAIN HOUSING	RS007729	51,52	GTAW	I	X			
MAIN HOUSING	RS007729	54	GTAW	I	X			
MAIN HOUSING	RS007729	55,56	GTAW	I	X			
MAIN HOUSING	RS007729	61	GTAW	I				
MAIN HOUSING	RS007729	62	GTAW	I	X			
MAIN HOUSING	RS007729	63	GTAW	I				
MAIN HOUSING	RS007729	64	GTAW	I	X	X		
MAIN HOUSING	RS007729	65	GTAW	I	X			
MAIN HOUSING	RS007729	66-70	GTAW	II	X			
INLET HOUSING	RS007732	4	GTAW	I			I	
INLET HOUSING	RS007732	8,9	GTAW	I			I	
VOLUTE	RS007732	10,15	GTAW	I	X	I		
VOLUTE	RS007732	20,21	GTAW	I				
VOLUTE	RS007732	22,23	GTAW	I				
VOLUTE	RS007732	24,27	GTAW	I		X		X
VOLUTE	RS007732	25,26	GTAW	I				
FLANGE	RS007736	1,2	GTAW	II	X			
FLANGE	RS007736	3,26	GTAW	II	X			

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TABLE 1400. HIGH PRESSURE OXIDIZER TURBOPUMP
FREA/CIL WELD JOINTS

COMPONENT	BASIC PART NO.	WELD NO.	WELD TYPE	CLASS	ROOT	CRITICAL INITIAL		COMMENTS
					SIDE NOT ACCESS	FLAW SIZE NOT HCF	DETECTABLE LCF	
FLANGE	RS007736	6,7	GTAW	II	X			
FLANGE	RS007736	9-12,17	GTAW	II	X			
FLANGE	RS007736	13-16	GTAW	II	X			
FLANGE	RS007736	18,20	GTAW	I	X			
FLANGE	RS007736	19,21	GTAW	II	X			
FLANGE	RS007736	22	EBW	I	X			
FLANGE	RS007736	23	GTAW	II				
FLANGE	RS007736	24	GTAW	II	X			
FLANGE	RS007736	26	GTAW	II	X			
BELLOWS	RS007740	1,2,5,9	GTAW	I		X		
BELLOWS	RS007740	3,4	EBW	I				
HOUSING	RS007746	1,2	GTAW	I	X		X	
HOUSING	RS007746	3	GTAW	I	X			
HOUSING	RS007746	4	GTAW	II	X			
HOUSING	RS007746	5	GTAW	II	X		X	
HOUSING	RS007746	6-17	GTAW	II	X		X	
HOUSING	RS007746	18-29	GTAW	II	X		X	
HOUSING	RS007746	30-41	GTAW	II		X		X
BELLOWS	RS007748	1	EBW	I				
BELLOWS	RS007748	2	GTAW	I	X			
BELLOWS	RS007749	1-4	GTAW	I				
BELLOWS	RS007749	5,6	EBW	I				
BELLOWS	RS007749	11	EBW	I				
BELLOWS	RS007749	12	EBW	I				
BELLOWS	RS007751	3	EBW	I	X			
BELLOWS	RS007751	4	EBW	I	X	X		X
BELLOWS	RS007751	8	GTAW	I	X	X		
SECOND STAGE NOZZLE	RS007752	1,2	EBW	I	X			
SECOND STAGE NOZZLE	RS007752	1	GTAW	I	X	X		X
JET RING	RS007757	1	GTAW	I	X	X		X
FAIRING	RS007774	1-12	GTAW	I		X		
FAIRING	RS007774	13-24	GTAW	I		X		

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TABLE B100. HIGH PRESSURE OXIDIZER TURBOPUMP
FMEAS/CIL WELD JOINTS

COMPONENT	BASIC PART NO.	WELD NO.	WELD TYPE	CLASS	ROOT SIDE NOT ACCESS	CRITICAL INITIAL		COMMENTS
						FLAW SIZE NOT DEFECTABLE REF	NOT DEFECTABLE LCF	
FAIRING	RS007774	25-36	BTAW	I				X
FAIRING	RS007774	74	BTAW	I				
FAIRING	RS007774	75,76	BTAW	II	X			
STRUT	RS007779	23-44, 143-164	BTAW	II	X			
STRUT	RS007779	45-66, 165-186	BTAW	II	X			
STRUT	RS007779	67	BTAW	II	X			
STRUT	RS007779	69,70	EDW	II	X			
STRUT	RS007779	71	EDW	II				
STRUT	RS007779	72	EDW	II				
STRUT	RS007779	73-94	EDW	II				
STRUT	RS007779	95,96	EDW	II	X			
SHIELD	RS007781	1,11	BTAW	II				
SHIELD	RS007781	2,3,4	BTAW	II				
SEAL	RS006848	1 PLC	BTAW	I				
SEAL	RS006857	1 PLC	BTAW	I		X		X

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FIELD CONFIGURATION VARIANCES FROM CIL RATIONALE

CIL ITEMS: B400-XN	HPOIP		P/N RS007791
BASE LINE RATIONALE	VARIANCE	CHANGE RATIONALE	VARIANT DASH NUMBER
<p>1. B400-02, B400-03 SECOND STAGE NOZZLE CASTING IS NOT ISOSTATIC PRESSED PER DRAWING REQUIREMENTS. (ECP 1A-2949)</p>	<p>SECOND STAGE NOZZLE CASTINGS HAVE NOT BEEN HOT ISOSTATIC PRESSED</p>	<p>NOT ISOSTATIC PRESS INCREASES STRUCTURAL INTEGRITY BY REDUCING CASTING MICROPOROSITY.</p> <p>USE AS IS RATIONALE:</p> <ol style="list-style-type: none"> 1. LIFE LIMIT ON NON HOT ISOSTATIC PRESSED 2ND STAGE NOZZLES REDUCES PROBABILITY OF LOW CYCLE FATIGUE CRACKING RESULTING FROM EXCESSIVE MICROPOROSITY. (DAR 2147) 2. A PENETRANT INSPECTION INTERVAL HAS BEEN IMPOSED ON NON HOT ISOSTATIC PRESSED 2ND STAGE NOZZLES TO VERIFY NO CRACKING IN EXCESS OF ALLOWABLE LIMITS. (DAR 2147) 	<p>-121, -131, -141, -151, -161, -171, -181, -191, -201, -211, -221, -231, -241, -251, -261, -271, -291, -301, -311, -351, -351, -371, -401</p>
<p>2. B400-13, B400-22 PROCESSED AND INSPECTED PER SPECIFICATION REQUIREMENTS (RL00916). (ECP 909)</p>	<p>BEARINGS ARE PROCESSED AND INSPECTED PER SPECIFICATION REQUIREMENTS (RL00558).</p>	<p>LONG TERM FATIGUE LIFE OF BEARING IS EXTENDED BY REDUCING THE ALLOWABLE SIZE AND QUANTITY OF ALLOWABLE DEFECTS.</p> <p>USE AS IS RATIONALE:</p> <ol style="list-style-type: none"> 1. WEAR LIFE LIMIT ON BEARINGS PREVENTS WEAR FROM EXCEEDING ALLOWABLE LIMITS. (DAR 2054, DAR 2082) 2. CONTINUED USE WITH ALLOWABLE DISCREPANCIES IS CONTROLLED PER THE MAINTENANCE CONTROL DOCUMENT REQUIREMENTS (RSS-8793). 	<p>-121, -131, -141, -151, -161, -171, -181, -191, -201, -211, -221, -231, -241, -251, -261, -271, -291, -301, -311, -331, -351, -371, -401, -411, -421, -431, -441, -451, -461</p>

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