FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE
NUMBER: 03-1-0404 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 1 11/60/2000

PART DATA

	PART NAME **VENDOR NAME**	**PART NUMBER** **VENDOR NUMBER**
LRU	: PUMP, RECIRCULATION SUNDSTRAND CORP.	V070-415311-003
LRU	: PUMP, RECIRCULATION SUNDSTRAND CORP.	V070-415312-001
LRU	:PUMP, RECIRCULATION SUNDSTRAND CORP.	MC281-0030-0003

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
PUMP ASSEMBLY, RECIRCULATION, THREE ELECTRICALLY DRIVEN PUMPS.

VALVE WAS ORIGINALLY DESIGNED AND MANUFACTURED BY SUNDSTRAND CORP. THE UNITED SPACE ALLIANCE-NSLD IS A CERTIFIED REPAIR DEPOT BUT HAS NOT YET BEEN CERTIFIED AS AN ALTERNATE PRODUCTION AGENCY.

REFERENCE DESIGNATORS: PP1
PP2
PP3

QUANTITY OF LIKE ITEMS: 1

FUNCTION:
RECIRCULATES LH2 DURING PRELAUNCH PHASE TO PROVIDE PROPER ENGINE INLET TEMPERATURE CONDITIONS PRIOR TO MAIN ENGINE START. THE PUMP ASSEMBLY CONSISTS OF 3 SEPARATE PUMP-MOTORS MOUNTED IN A COMMON HOUSING WHICH IS INSTALLED IN THE LH2 MANIFOLD FEEDLINE. PUMP POWER IS SUPPLIED BY THE MOBILE LAUNCH PLATFORM (MLP).

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NUMBER: 03-1-0404-02

REVISION#: 1 11/06/00

SUBSYSTEM NAME: MAIN PROPULSION
LRU: LH2 RECIRCULATION PUMP **CRITICALITY OF THIS**
ITEM NAME: LH2 RECIRCULATION PUMP **FAILURE MODE:** 1/1

FAILURE MODE:
RUPTURE/LEAKAGE DURING LOADING, ASCENT, DUMP, OR INERT.

MISSION PHASE: PL PRE-LAUNCH
LO LIFT-OFF

VEHICLE/PAYLOAD/KIT EFFECTIVITY:
102 COLUMBIA
103 DISCOVERY
104 ATLANTIS
105 ENDEAVOUR

CAUSE:
MATERIAL DEFECT, FATIGUE FAILURE, DAMAGED/DEFECTIVE SEALS.

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

REDUNDANCY SCREEN
A) N/A
B) N/A
C) N/A

PASS/FAIL RATIONALE:
A)

B)

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:
RESULTS IN LH2 LEAKAGE INTO THE AFT COMPARTMENT. PRELAUNCH GN2 PURGE OF THE AFT COMPARTMENT MAY LOWER THE GH2 CONCENTRATION BUT FIRE/EXPLOSION HAZARD STILL PRESENT. LOSS OF CRITICAL ADJACENT COMPONENTS DUE TO CRYOGENIC EXPOSURE. POSSIBLE AFT COMPARTMENT OVERPRESSURIZATION AND FIRE HAZARD. LEAKAGE IN THE AFT COMPARTMENT IS DETECTABLE DURING LOADING USING THE HAZARDOUS GAS DETECTION SYSTEM (HGDS).

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RUPTURE OF PUMP HOUSING INTERNAL TO THE MANIFOLD WILL RESULT IN PUMP PRESSURE LOSS CAUSING VIOLATION OF ENGINE INLET TEMPERATURE REQUIREMENTS FOR START.

(B) INTERFACING SUBSYSTEM(S):
SAME AS A.

(C) MISSION:
ON GROUND, VIOLATION OF HGDS LCC WILL RESULT IN LAUNCH SCRUB.

(D) CREW, VEHICLE, AND ELEMENT(S):
POSSIBLE LOSS OF CREW/VEHICLE.

(E) FUNCTIONAL CRITICALITY EFFECTS:
NONE.

-DISPOSITION RATIONALE-

(A) DESIGN:
SYSTEM PRESSURE IS 55 PSI MAXIMUM. HOUSING IS DESIGNED WITH SAFETY FACTOR OF 1.3 PROOF, 1.5 BURST. PROOF PRESSURE FOR THE RECIRCULATION PUMP HOUSING IS 78 PSIG. STRUCTURAL ANALYSIS OF THE PUMP, SUPPORTED BY MPTA STATIC FIRING STRAIN GAUGE MEASUREMENTS, SHOWS POSITIVE MARGINS OF SAFETY FOR ALL CONDITIONS OF OPERATION, AND FRACTURE ANALYSIS SHOWS THAT ALL CRITICAL PARTS ARE SATISFACTORY FOR FOUR TIMES ORBITER 100 MISSION LIFE.

THE THREE PUMP-MOTOR BOLTED COVERS ARE EXTERNALLY SEALED TO THE HOUSING FLANGE WITH A NAFLEX-TYPE SEAL (METAL STATIC FACE SEAL, WITH A TEFLON COATING). LEAK DETECTION PORTS ARE PROVIDED IN THE HOUSING FOR EACH PUMP-MOTOR COVER SEAL AND HOUSING FLANGE SEAL. INPUT POWER AND PUMP SPEED ELECTRICAL CONNECTORS ARE WELDED INTO EACH PUMP-MOTOR COVER. THE HOUSING IS CONSTRUCTED OF C355 CAST ALUMINUM ALLOY, AND THE MOTOR COVERS ARE CONSTRUCTED FROM AMS 5370, 300 SERIES, CAST STAINLESS STEEL.

(B) TEST:
ATP

PRE-CRYO TEST:
- DIMENSIONAL INSPECTION
- ELECTRICAL CHARACTERISTICS
- PROOF PRESSURE OF HOUSING FLANGE ASSY AT 78 PSIG

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LEAKAGE OF HOUSING FLANGE ASSY AT 25 PSIG, GHE
FUNCTIONAL - (3 PUMPS) 10 SEC. POWER, COASTDOWN MONITORED.

CRYOGENIC TESTS (LH2):
LEAKAGE OF HOUSING FLANGE ASSY AT 25 PSIG
FUNCTIONAL - 83 MINUTES TOTAL (17 TESTS, INCLUDING CAVITATION).

POST-CRYO TESTS:
LEAKAGE OF HOUSING FLANGE ASSY AT 25 PSIG
ELECTRICAL CHARACTERISTICS: INSULATION RESISTANCE AND DIELECTRIC STRENGTH

CERTIFICATION (ALL TESTS INCLUDE PRE- AND POST-TEST LEAKAGE)

PERFORMANCE
DRY RUNNING, AMBIENT (5 SEC POWER ON, 500 TIMES; 5-MINUTES POWER ON, 5 TIMES)
OVERSPEED (30-MINUTES AT 18K RPM, -350 DEG F, ZERO PSIG)
DRY SPINNING, AMBIENT, UNPOWERED (1.0 MIN WITH 1.0 PSID ACROSS PUMP)
125% OVERSPEED TEST (DEVELOPMENT UNIT, 20-HRS, LH2)

VIBRATION
RANDOM VIBRATION (15.2G RMS, 13.3-HRS/ 3 AXIS/ LH2)
AMBIENT SINE SWEEP 5-35 HZ

SHOCK
DESIGN SHOCK TEST PER MIL-STD-810

STRUCTURAL PRESSURE
CRYO PROOF: INTERNAL (78 PSIG, LH2, 5-MINUTES) EXTERNAL (78 PSID ACROSS HOUSING FLANGE, LH2 INTERNAL)
BURST - 2 TESTS: EACH PUMP-MOTOR (90 PSIG, 5-MINUTES), HOUSING FLANGE (90 PSIG, 5 MINUTES).

LIFE
OPERATING LIFE (LH2, 50-HRS, 205 START-STOPS)
DELTA OPERATIONAL LIFE TEST (350-HR, LH2)

THERMAL
THERMAL SHOCK (+150 DEG F TO -423, 3 CYCLES)
HIGH TEMPERATURE (+200 DEG F AT 50% RELATIVE HUMIDITY, 48 HRS)
LH2 MANIFOLD FEEDLINE TEMPERATURE CYCLE AND LOADS TEST (PUMP ASSY HOUSING INSTALLED).

FEEDLINE MANIFOLD LOADS TEST WITH LH2 RECIRCULATION PUMP HOUSING
2204 CYCLES TOTAL (LN2 AT 40 PSIG)
2000 CYCLES AT 72% MAXIMUM STRUCTURAL LOAD
200 CYCLES AT 90% MAXIMUM STRUCTURAL LOAD
4 CYCLES AT 120% MAXIMUM STRUCTURAL LOAD
VACUUM JACKET LEAKAGE VERIFICATION AT AMBIENT EVERY 400 CYCLES

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PUMP-MOTOR REMOVAL/REPLACEMENT (LRU)

POST-TEST TEARDOWN

OMRSD
ANY TURNAROUND CHECKOUT IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.

(C) INSPECTION:
RECEIVING INSPECTION
RAW MATERIALS ARE VERIFIED BY INSPECTION FOR MATERIAL AND PROCESS CERTIFICATION.

CONTAMINATION CONTROL
PARTS PROTECTION FROM DAMAGE AND CONTAMINATION REQUIRED. CLEANLINESS TO LEVEL 400 IS VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION
DRAWING TORQUE REQUIREMENTS, CRITICAL DIMENSIONS, AND SURFACE FINISHES ARE VERIFIED BY INSPECTION. LOG OF CLEAN ROOM AND TOOL CALIBRATION ARE VERIFIED. VISUAL EXAMINATION OF SEALS FOR DAMAGE AND CLEANLINESS, INSULATION OF SOLDER CONNECTION AND WINDING LEADS ARE VERIFIED BY INSPECTION. MANDATORY INSPECTION POINTS ARE INCLUDED IN THE ASSEMBLY PROCEDURE.

CRITICAL PROCESSES
PARTS PASSIVATION, HEAT TREATMENT, AND ANODIZING ARE VERIFIED. ALL SOLDERING, STRIPPING ELECTRICAL WIRES, ELECTRICAL BONDING, CHEMICAL FILM, PAINTING, CASTING, AND WELDING ARE VERIFIED BY INSPECTION.

NONDESTRUCTIVE EVALUATION
ETCHING PRIOR TO PENETRANT REQUIRED. RADIOGRAPHIC AND DYE PENETRANT INSPECTION OF WELDS ARE VERIFIED BY INSPECTION.

TESTING
ATP IS WITNESSED AND VERIFIED BY INSPECTION.

HANDLING/PACKAGING
HANDLING, PACKAGING, STORAGE, AND SHIPPING REQUIREMENTS ARE VERIFIED BY INSPECTION.

(D) FAILURE HISTORY:
AT KSC LH2 RECIRCULATION PUMP MOUNTING BOLTS INDICATED LOW TORQUE VALUES. (REFERENCE CAR AC9061). HOWEVER, NO LEAKAGE OCCURRED AND SEALING INTEGRITY WAS MAINTAINED. TORQUE RELAXATION WAS DUE TO THE USE OF UNCHAMFERED WASHERS RATHER THAN CHAMFERED WASHERS. THE SUPPLIER'S DRAWINGS WERE CHANGED, WASHERS ON ALL PUMPS REPLACED, AND BOLTS SECURED WITH SAFETY WIRE.

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CURRENT DATA ON TEST FAILURE, FLIGHT FAILURE, UNEXPLAINED ANOMALIES, AND OTHER FAILURES EXPERIENCED DURING GROUND PROCESSING ACTIVITY CAN BE FOUND IN THE PRACA DATABASE.

(E) OPERATIONAL USE:
FLIGHT: NO CREW ACTION CAN BE TAKEN.

GROUND: GROUND OPERATIONS SAFING PROCEDURES CONTAIN SAFING SEQUENCE OF EVENTS FOR MAJOR LEAKS IN THE HYDROGEN SYSTEM.

- APPROVALS -

S&R ENGINEERING	: W.P. MUSTY	: /S/ W. P. MUSTY
S&R ENGINEERING ITM	: P. A. STENGER-NGUYEN	: /S/ P. A. STENGER-NGUYEN
DESIGN ENGINEERING	: EARL HIRAKAWA	: /S/ EARL HIRAKAWA
MPS SUBSYSTEM MGR.	: TIM REITH	: /S/ TIM REITH
MOD	: BILL LANE	: /S/ BILL LANE
USA SAM	: MIKE SNYDER	: /S/ MIKE SNYDER
USA ORBITER ELEMENT	: SUZANNE LITTLE	: /S/ SUZANNE LITTLE
NASA SR&QA	: ERICH BASS	: /S/ ERICH BASS