FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE
NUMBER: 02-6-SYSTEM-IM -X

SUBSYSTEM NAME: HYDRAULICS

REVISION: 5 01/05/94

PART DATA

	PART NAME / **VENDOR NAME**	**PART NUMBER** / **VENDOR NUMBER**
LRU	:HYDRAULIC SUBSYSTEM	NONE

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:

QUANTITY OF LIKE ITEMS: 1
INCLUDES THREE REDUNDANT HYDRAULIC POWER SYSTEMS

FUNCTION:
THE HYDRAULIC SUBSYSTEM GENERATES, CONTROLS, CONTAINS AND TRANSMITS FLUID POWER FOR ACTUATION OF THE AERODYNAMIC FLIGHT CONTROL SURFACES, MAIN ENGINE GIMBALS, MAIN AND NOSE LANDING GEAR, MAIN LANDING GEAR BRAKES, NOSE WHEEL STEERING AND MAIN ENGINE PROPELLANT CONTROL VALVES.

FAILURE MODES EFFECTS ANALYSIS FMEA -- CIL FAILURE MODE

NUMBER: 02-6-SYSTEM-IM- 03

REVISION#: 6 07/24/98

SUBSYSTEM NAME: HYDRAULICS
LRU: HYDRAULIC SUBSYSTEM
ITEM NAME: HYDRAULIC SUBSYSTEM

CRITICALITY OF THIS FAILURE MODE: 1/1

FAILURE MODE:
RUPTURE, TUBING

MISSION PHASE:
DO DE-ORBIT
LS LANDING/SAFING

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

CAUSE:
DEFECTIVE MATERIAL, FATIGUE

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

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

PASS/FAIL RATIONALE:
A)

B)
A LEAK OF THE NWS SWITCHING VALVE CANNOT BE DETECTED UNTIL HYDRAULIC ISOLATION VALVE OPENING (VREL=800 FPS) AND EXTEND VALVE OPENING (LANDING GEAR DEPLOYMENT).

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:

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LEAK DOWNSTREAM OF THE NWS SWITCHING VALVE (1/1) - LOSS OF TWO OF THREE (SYSTEM 1 AND SYSTEM 2) HYDRAULIC SYSTEMS FOLLOWING MAIN GEAR TOUCHDOWN DURING DEROTATION, LOAD RELIEF, OR ROLLOUT

LEAK NOT DOWNSTREAM OF THE NWS SWITCHING VALVE (1R2) - LOSS OF ONE OF THREE HYDRAULIC SYSTEMS RESULTING IN LOSS OF VEHICLE'S HYDRAULIC SYSTEM REDUNDANCY.

(B) INTERFACING SUBSYSTEM(S):
LEAK DOWNSTREAM OF THE NWS SWITCHING VALVE (1/1) - LOSS OF TWO OF THREE HYDRAULIC SYSTEMS (UNCERTIFIED CONFIGURATION) TO FLIGHT CONTROL SURFACES RESULTING IN LIMITED MOVEMENT RATES FOR DEROTATION CONTROL AND LOAD RELIEF. LOSS OF ALL NOSEWHEEL STEERING CAPABILITY DURING ROLLOUT (DIFFERENTIAL BRAKE STILL AVAILABLE). LOSS OF TWO OF THREE HYDRAULIC POWER SYSTEMS TO BRAKES (100% BRAKES STILL AVAILABLE).

LEAK NOT DOWNSTREAM OF THE NWS SWITCHING VALVE (1R2) - LOSS OF HYDRAULIC POWER FOR ENGINE VALVE CONTROL RESULTING IN LOSS OF ONE SSME THRUST CONTROL, HOWEVER, ENGINE VALVES WILL LOCK INTO POSITION AND ENGINE WILL CONTINUE TO OPERATE. LOSS OF REDUNDANT HYDRAULIC POWER SYSTEM FOR TVC ACTUATOR. LOSS OF HYDRAULIC REDUNDANT DEPLOYMENT CAPABILITY IF SYSTEM ONE IS LOST. LOSS OF ONE OF THREE HYDRAULIC POWER SYSTEMS TO FLIGHT CONTROL SURFACES AND BRAKES. LOSS OF ONE OF THREE ET UMBILICAL RETRACT ACTUATORS FOR EACH UMBILICAL PLATE. HYDRAULIC FLUID ON TPS SCREED MAY CAUSE DEGRADED TPS BONDS.

(C) MISSION:
LEAK DOWNSTREAM OF THE NWS SWITCHING VALVE (1/1) - POSSIBLE LOSS OF CREW/VEHICLE WITH THIS FAILURE, IF LEAK MAGNITUDE IS SUFFICIENT TO CAUSE LOSS OF HYD SYSTEM 1 BETWEEN GEAR DEPLOY AND TOUCHDOWN, AND LOSS OF HYDRAULIC SYSTEM 2 DURING DEROTATION (BRAKE ISOLATION VALVE 2 OPENS AT WOW + 160 MS). THIS REDUCES HYD FLOW TO ACTUATORS, CAUSES SWITCHING VALVE MOVEMENT, AND INDUCES HYD PRL (PRIORITY RATE LIMITING). THIS IS AN UNCERTIFIED CONFIGURATION RESULTING IN LIMITED AEROSURFACE RATES FOR DEROTATION CONTROL AND LOAD RELIEF. LOSS OF CONTROL DURING DEROTATION MAY RESULT CAUSING EXCESSIVE NOSEGEAR STRUCTURAL LOADS AT NOSEGEAR TOUCHDOWN.

LEAK NOT DOWNSTREAM OF THE NWS SWITCHING VALVE (1R2) - ABORT DECISION OR POSSIBLE EARLY MISSION TERMINATION.

(D) CREW, VEHICLE, AND ELEMENT(S):
LEAK DOWNSTREAM OF THE NWS SWITCHING VALVE (1/1) - SAME AS ABOVE FOR (C).

LEAK NOT DOWNSTREAM OF THE NWS SWITCHING VALVE (1R2) - NONE.

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(E) FUNCTIONAL CRITICALITY EFFECTS:
LEAK DOWNSTREAM OF THE NWS SWITCHING VALVE (1/1) - SAME AS ABOVE FOR (C).

LEAK NOT DOWNSTREAM OF THE NWS SWITCHING VALVE (1R2) - POSSIBLE LOSS OF CREW/VEHICLE WITH TWO FAILURES. THIS FAILURE PLUS LOSS OF SECOND HYDRAULIC SYSTEM OR LANDING GEAR PYROTECHNIC DEPLOYMENT IF SYSTEM ONE IS LOST. CRITICALITY 1 FOR SSME INDUCED RTLS.

-DISPOSITION RATIONALE-

(A) DESIGN:
SIMILAR TUBING QUALIFIED FOR AND USED ON HIGH PERFORMANCE AIRCRAFT (B-1, C5A, F14, F15). TUBING WAS REQUALIFIED FOR NSTS (LOWER OPERATING PRESSURES AND THINNER WALL THICKNESSES). SYSTEM INCORPORATES DESIGN MARGINS OF SAFETY WHICH INCLUDES ENVIRONMENTAL STRESS FACTORS, FRACTURE MECHANICS (WHERE APPLICABLE) SYSTEM WAS QUALIFIED FOR 400 MISSIONS INCLUDING. PRESSURE IMPULSE, AND MECHANICAL FLEXURE (ROTORY AND PLANER).

(B) TEST:
QUALIFICATION
EXAMINATION OF PRODUCT - MATERIALS, WORKMANSHIP, AND DIMENSIONS.

PROOF PRESSURE - TESTED AT 6,000 PSIG FOR PRESSURE, 3,000 PSIG FOR RETURN (EXCEPT DYNATUBE FITTINGS). PASS/FAIL CRITERIA. NO EXTERNAL LEAKAGE AND NO STRUCTURAL FAILURE.

MECHANICAL FLEXURAL TEST - TESTED AT 275 DEG F AT BENDING STRESS LEVEL OF 25,000 PSI, 3,000 PSIG PRESSURE, 1,500 PSIG RETURN FOR 10 MILLION CYCLES AND 45 HZ. (1 OF 8 FITTING AND 1 OF 6 TUBING SPECIMENS.) PASS/FAIL CRITERIA: THE S/N CHARACTERISTIC CURVE NUMBER SHALL BE NO GREATER THAN 4.

MECHANICAL FLEXURAL (ROTORY) TEST - TESTED AT 275 DEG F AT BENDING STRESS OF 19,000 PSI, 3,000 PSIG PRESSURE, 1,500 PSIG RETURN FOR 2 MILLION CYCLES AND 45 HZ. (1 OF 6 FITTING AND 1 OF 6 TUBING SPECIMENS) TELEDYNE AND LINAIR ONLY.) PASS/FAIL CRITERIA: THE S/N CHARACTERISTIC CURVE NUMBER SHALL BE NO GREATER THAN 4

TORSIONAL FLEXURAL TEST - TESTED AT 275 DEG F AT BENDING STRESS OF 25,000 PSI, 3,000 PSIG PRESSURE, 1,500 PSI RETURN FOR 2 MILLION CYCLES AND 45 HZ. (PERMASWAGE AND DYNATUBE FITTINGS/TUBING ASSEMBLIES) PASS/FAIL CRITERIA: THE S/N CHARACTERISTIC CURVE NUMBER SHALL BE NO GREATER THAN 4.

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IMPULSE TEST - 200,000 PRESSURE WAVE CYCLES AT 275 DEG F, FIRST PEAK PRESSURE OF 4,500 PSIG, SECOND PEAK OF 92 PERCENT OF FIRST PEAK, DOWN TO 3,000 PSIG AT 60-70 HZ. PASS/FAIL CRITERIA: NO EXTERNAL LEAKAGE OR STRUCTURAL FAILURE.

BURST TEST - 12,000 PSIG PRESSURE, 6,000 PSIG RETURN. PASS/FAIL CRITERIA: NO LEAKAGE OR RUPTURE.

N2 LEAK TEST - 100 PSIG FOR 24 HOURS; 3,000 PSIG PRESSURE, 1,500 PSIG RETURN; 6,000 PSIG PRESSURE, 3,000 PSIG RETURN WITH 14,000 PSI STRESS LEVEL FOR 7 HOURS. (PERMASWAGE AND DYNATUBE FITTINGS/TUBING ASSEMBLIES.) PASS/FAIL CRITERIA. EXTERNAL LEAKAGE OF NO MORE THAN 10 CC/HR.

VIBRATION TEST - RANDOM VIBRATION LEVELS ACCORDING TO THE PARTICULAR LOCATION AS INSTALLED IN THE VEHICLE AT VARIOUS VIBRATION SPECTRUMS ACCORDING TO MF0004-014 (ENVIRONMENTAL REQUIREMENTS AND TEST CRITERIA FOR THE ORBITER VEHICLE).

GROUND TURNAROUND TEST
ANY TURNAROUND CHECKOUT TESTING IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.

(C) INSPECTION:
RECEIVING INSPECTION
ALL RAW MATERIAL AND COMPONENTS ARE VERIFIED BY INSPECTION. MC SPEC HARDWARE IS VERIFIED BY SOURCE INSPECTION FOR FABRICATION/ASSEMBLY AND FUNCTIONAL OPERATION, AT SUPPLIER, TO SPECIFICATION REQUIREMENTS. INSPECTION VERIFIES THAT 3A1-2.5V TITANIUM TUBING IS CERTIFIED TO THE REQUIREMENTS OF MBO170-084

CONTAMINATION CONTROL
CLEANLINESS LEVEL 190 PER MAO110-301 IS VERIFIED BY INSPECTION

CRITICAL PROCESSES
PERMASWAGE PROCESS IS VERIFIED BY INSPECTION.

NONDESTRUCTIVE EVALUATION
PENETRANT AND ULTRASONIC INSPECTION ARE VERIFIED BY INSPECTION.

ASSEMBLY/INSPECTION
ALL COMPONENTS/HARDWARE ARE VERIFIED BY INSPECTION AT DETAIL FABRICATION AND ASSEMBLY. LEAK AND PRESSURE TEST AT SUB-ASSEMBLY AND INSTALLATION LEVELS ARE VERIFIED BY INSPECTION. INSTALLATION PER MAO102-306 IS VERIFIED BY INSPECTION. INSPECTION VERIFIES THAT ALL PROCESSING MATERIALS IN CONTACT WITH TITANIUM ARE PER MFO004-018. SEALING SURFACES ARE VERIFIED BY INSPECTION.

TESTING
FUNCTIONAL TEST AND SUBSYSTEMS, AND FULL INTEGRATION, PER TMO/TCP, SYSTEM SERVICING REQUIREMENTS PER MLO/TCP. TESTING IS VERIFIED BY INSPECTION.

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HANDLING/PACKAGING
INSPECTION VERIFIES PACKAGING PRIOR TO SHIPMENT.

(D) FAILURE HISTORY:
CURRENT DATA ON TEST FAILURES, FLIGHT FAILURES, UNEXPLAINED ANOMALIES AND OTHER FAILURES EXPERIENCED DURING GROUND PROCESSING ACTIVITY CAN BE FOUND IN THE PRACA DATA BASE.

(E) OPERATIONAL USE:
LEAK DOWNSTREAM OF THE NWS SWITCHING VALVE - LEAK IS NOT DETECTABLE PRIOR TO LANDING GEAR DEPLOYMENT. SUFFICIENT TIME MAY NOT BE AVAILABLE FOR CREW ACTION FOLLOWING GEAR DEPLOYMENT. THE CREW MAY BE ABLE TO CONTROL VEHICLE DEROTATION RATE SUFFICIENTLY FOR A SAFE NOSEGEAR TOUCHDOWN AND ROLLOUT.

LEAK NOT DOWNSTREAM OF THE NWS VALVE - A RAPID LEAK WOULD DEPLETE THE HYDRAULIC SYSTEM BEFORE ACTION COULD BE TAKEN. ACTION MAY BE TAKEN BY THE CREW FOR SMALL LEAKS. THE ISOLATION VALVE MAY BE CLOSED FOR LEAK ISOLATION. THE HYDRAULIC MAIN PUMP MAY BE DEPRESSURIZED TO DECREASE THE LEAK RATE. TIMING OF THE ACTION WOULD BE DEPENDENT ON THE FLIGHT PHASE AND THE SYSTEM REQUIREMENTS.

- APPROVALS -

EDITORIALLY APPROVED	. BNA	: J. Kimura 7-30-98
TECHNICAL APPROVAL	. VIA APPROVAL FORM	: 95-CIL-009_02-6