FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE
NUMBER: 02-1B-028 -X

SUBSYSTEM NAME: LANDING/DECELERATION - BRAKE/SKID CONTROL SYS
REVISION: 4 12/20/96

PART DATA

	PART NAME **VENDOR NAME**	**PART NUMBER** **VENDOR NUMBER**
LRU	: MLG BRAKE SYSTEM	MC621-0055
SRU	: BRAKE/SKID SERVO VALVE	MC621-0055-0012

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
CARBON BRAKE/SKID CONTROL SERVO VALVE

QUANTITY OF LIKE ITEMS: 8
LEFT HAND-FOUR RIGHT HAND-FOUR

FUNCTION:
METERS HYDRAULIC PRESSURE TO BRAKE CHAMBER (THROUGH MODULE BRAKE PORT) IN PROPORTION TO ELECTRICAL COMMAND RECEIVED FROM THE BRAKE/SKID CONTROL BOX.

PAGE: 2 PRINT DATE: 10/11/90

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE
NUMBER: 02-1B-028-01

REVISION# 2 10/11/90 R
SUBSYSTEM: LANDING/DECELERATION - BRAKE/SKID CONTROL SYS
LRU :MLG BRAKE SYSTEM CRITICALITY OF THIS
ITEM NAME: MLG BRAKE SYSTEM FAILURE MODE:1R3

FAILURE MODE:
JAMMED CLOSED

MISSION PHASE:
DO DE-ORBIT

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

■ CAUSE:
CONTAMINATION, FLAPPER ASSEMBLY BROKEN, SECOND SLIDE STAGE JAMMED.

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

REDUNDANCY SCREEN A) PASS
B) FAIL
C) PASS

■ B)
SCREEN "B" FAILS BECAUSE THERE IS NO INDICATION OF THIS FAILURE AFTER GROUND CHECKOUT AND BEFORE BRAKE SYSTEM IS USED.

- FAILURE EFFECTS -

■ (A) SUBSYSTEM:
LOSS OF 12.5% OF BRAKING CAPABILITY.

■ (B) INTERFACING SUBSYSTEM(S):
EXTENDED ROLLOUT, POSSIBLE LOSS OF MISSION/CREW/VEHICLE WITH FAILURE OF THE REMAINING THREE SERVO VALVES ON THE AFFECTED SIDE.

■ (C) MISSION:
SAME AS (B)

■ (D) CREW, VEHICLE, AND ELEMENT(S):
SAME AS (B)

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE NUMBER: 02-1B-028-01

- DISPOSITION RATIONALE -

(A) DESIGN:
THE SERVO VALVE IS DESIGNED TO OPERATE AFTER BEING SUBJECTED TO A SAWTOOTH SHOCK PULSE OF 50-G PEAK MAGNITUDE FOR A DURATION OF 10 TO 12 MILLISECONDS. HYDRAULIC SYSTEM FILTER MODULE IS 5 MICRON ABSOLUTE. THE BRAKE/SKID CONTROL HYD. MODULE INLET AND OUTLET FILTERS ARE 5 MICRON NOMINAL, 15 MICRON ABSOLUTE AND THE SERVO VALVE FILTER IS 15 MICRON NOMINAL, 40 MICRON ABSOLUTE.

(B) TEST:
QUALIFICATION TEST: QUAL TESTING INCLUDES IMPULSE PRESSURE TESTING PEAK PRESSURE 4,500 POUNDS PER SQUARE INCH (PSI), TOTAL CYCLES - 60,000, TEMPERATURE 200 DEG F FLUID -275 DEG F AMBIENT. BURST PRESSURE TEST - 7500 PSIG - FLUID AND AMBIENT TEMPERATURE -275 DEG F.
ENVIRONMENT TESTING INCLUDE; HUMIDITY, SALT FOG, VIBRATION ACCELERATION AND SHOCK - TEST SPECIMEN ARE SUBJECTED TO FUNCTIONAL TESTS BEFORE AND AFTER EACH ENVIRONMENT TEST. EQUIPMENT NORMALLY OPERATING DURING EXPOSURE TO THESE ENVIRONMENTS ARE ALSO FUNCTIONALLY MONITORED DURING QUALIFICATION TESTING. ACCEPTANCE VIBRATION TEST IN ACCORDANCE WITH NASA SPECIFICATION SP-T-0023B ARE PERFORMED ON THE BRAKE/SKID CONTROL SYSTEM IS SUBJECTED TO 10-G UPWARD/7.5-G DOWNWARD LANDING ACCELERATION IN THE VERTICAL AXIS AND 0.8 AFT/2-G FORWARD IN THE LONGITUDINAL AXIS. WHEEL SPEED SENSORS ARE SUBJECTED TO 20-G UP AND DOWN IN THE VERTICAL AXIS AND 20-G AFT AND FORWARD IN THE LONGITUDINAL AXIS. THIS LANDING ACCELERATION IS MAINTAINED FOR A MINIMUM OF 5 MINUTES.

HIGH TEMPERATURE TESTING IS PERFORMED ON ALL EQUIPMENT EXCEPT THE CONTROL BOX AND COMMAND TRANSDUCER PER METHOD 501, PROCEDURE I, OF MIL-STD-810, TEST TEMP IS 275 DEG F.

LOW TEMP TESTING IS CONDUCTED AT MINUS 80 DEG F AND MINUS 65 DEG F.

ACCEPTANCE TEST: ACCEPTANCE TESTS ARE PERFORMED ON ALL UNITS DELIVERED FOR FUNCTIONAL USE - THE TESTS INCLUDE; COMPONENT FUNCTIONAL TESTS AND PROOF PRESSURE TESTING. ALL HYDRAULIC COMPONENTS ARE CAPABLE OF WITHSTANDING 60,000 PRESSURE IMPULSE CYCLES WHILE AT FLUID TEMPERATURE OF 200 DEG F.

OMRSD: BRAKE PEDAL/HYDRAULIC DYNAMIC INSTABILITY;
TEST CONDITIONS - (1) RMG/LMG WOW SIGNALS ACTIVATED (INDICATORS OFF)
(2) HYDRAULIC SYSTEM 1,2 & 3 SUPPLY PRESSURE: 3000 PLUS OR MINUS 200 PSI.
(3) SKID CONTROL ACTIVATED (FAIL INDICATOR OFF) DURING THIS TEST EACH

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE
NUMBER: 02-1B-028-01

BRAKE PEDAL IS PUMPED TO 1/4, 1/2, 3/4 AND FULL WHILE IT'S ADJACENT PEDAL IS HELD IN THE FULLY DEPRESSED POSITION - CORRESPONDING BRAKE PRESSURES ARE VERIFIED.

HYDRAULIC SWITCHING/CONTROL VALVE:
THIS TEST VERIFIES OPERATION OF THE BRAKE MODULE AS DIRECTED BY ANTI-SKID CONTROL BOXES "A" AND "B".

FREQUENCY - ALL VEHICLES AT GROUND TURNAROUND.

(C) INSPECTION:
RECEIVING INSPECTION
MATERIAL AND PROCESS CERTIFICATIONS ARE VERIFIED BY INSPECTION.
RECEIVING INSPECTION VERIFIES FUNCTIONAL CHARACTERISTICS.

CONTAMINATION CONTROL
INSPECTION VERIFIES CLEANLINESS AND CORROSION CONTROL REQUIREMENTS.

ASSEMBLY/INSTALLATION
VALVE VISUALLY AND DIMENSIONALLY VERIFIED DURING FABRICATION.
DESIGNATED SHUTTLE PROJECT FABRICATION AREA VERIFIED BY INSPECTION ACCEPTABLE PRIOR TO FABRICATION.

CRITICAL PROCESSES
INSPECTION VERIFIES EDM AND GRINDING. INSPECTION VERIFIES MAGNETIC PARTICLE INSPECTION AFTER GRINDING TO CATCH ANY POTENTIAL CRACKS FROM THE GRINDING OPERATION.

NONDESTRUCTIVE EVALUATION
INSPECTION VERIFIES X-RAY, PENETRANT AND MAGNETIC PARTICLE INSPECTION OF VARIOUS PARTS.

TESTING
ACCEPTANCE TESTING INCLUDING PROOF PRESSURE FOR EXTERNAL LEAKS IS VERIFIED BY INSPECTION.

PACKAGING/HANDLING
HANDLING AND PACKAGING REQUIREMENTS ARE VERIFIED BY INSPECTION.

(D) FAILURE HISTORY:
CAR NO. A3882 - DURING ATP, PRIOR TO QUAL, UNIT EXPERIENCED EXCESSIVE HYSTERISIS ON J2 CONTROL VALVE THAT IS INDICATIVE OF CONTAMINATION OR PLUGGED ELEMENT. IT WAS DETERMINED THAT OPERATION AT MINUS 65 DEGREES F. CAUSED THE BRAKE PORT FILTERS TO RUPTURE INTRODUCING CONTAMINATION INTO THE UNIT.
CORRECTIVE ACTION: REQUIREMENT OF MINUS 65 DEGREES F. OPERATING CHANGED TO MINUS 65 DEGREES F. NON-OPERATING, CAPABLE OF OPERATING AT MINUS 10

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE
NUMBER: 02-1B-028-01

DEGREES F. AND OPERATING TO FULL PERFORMANCE AT PLUS 30 DEGREES F. THUS MEETING THE SHUTTLE HYDRAULIC SYSTEM OPERATING REQUIREMENTS.
CAR K80014 - DURING VEHICLE CHECKOUT OF THE ORBITER BRAKE SYSTEMS ONE CHANNEL ON THE HYDRAULIC BRAKE MODULE (S/N 116) EXHIBITED A LAGGING RESPONSE TO PEDAL COMMANDS AND HELD PRESSURES OF 340 TO 990 PSIA AFTER PEDAL RELEASE. THE CAUSE WAS ATTRIBUTED TO SILTING WHICH IS COMMON TO HYDRAULIC UNITS AFTER LONG PERIODS OF INOPERATION.
CORRECTIVE ACTION: PROCEDURES ARE INCORPORATED IN BOTH THE GROUND AND CREW OPERATIONS TO PREVENT AND CLEAR FAILURES. IF UNCOMMANDED PRESSURES ARE DETECTED DURING A MISSION THE CREW WILL PERFORM THE FOLLOWING:

A. SHUT OFF THE ISOLATION VALVE IF THE PRESSURE DOES NOT CLEAR THEN,
B. SHUT OFF APU TO THE AFFECTED BRAKE

(E) OPERATIONAL USE:
CREW CAN COMPENSATE EITHER BY CHANGING BRAKING PROCEDURE AND/OR USE OF NWS TO MAINTAIN DIRECTIONAL CONTROL.

- APPROVALS -

RELIABILITY ENGINEERING	G. T. TATE	10/22/90
DESIGN ENGINEERING	M. T. PORTER	10/24/90
QUALITY ENGINEERING	D. DESAI	10/23/90
NASA RELIABILITY		
NASA SUBSYSTEM MANAGER		12/3/90
NASA QUALITY ASSURANCE		11-5-90