PRINT DATE: 01/24/97

FAILURE MODES EFFECTS ANALYSIS (FMEA) – CIL HARDWARE
NUMBER: 02-1B-025 -X

SUBSYSTEM NAME: LANDING/DECELERATION - BRAKE/SKID CONTROL SYS
REVISION: 0 09/19/88

PART DATA

	PART NAME **VENDOR NAME**	**PART NUMBER** **VENDOR NUMBER**
	: BRAKE/SKID CONTROL (B/SC)	
LRU	: MLG BRAKE SYSTEM HYDRO-AIRE	MC621-0055 42-40333

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
BRAKE CONTROL CIRCUIT CARD

QUANTITY OF LIKE ITEMS: 8
FOUR LEFT,
FOUR RIGHT
TWO EACH BRAKE

FUNCTION:
EACH BRAKE CONTROL CIRCUIT (BCC) CONTAINS ITS OWN LINEAR VARIABLE DIFFERENTIAL TRANSFORMER (LVDT) EXCITATION OSCILLATOR. THE BCC TRANSLATES BRAKE PEDAL POSITION (LVDT COUPLING) INTO BRAKE PRESSURE. EACH BCC CONTROLS BRAKE PRESSURE FOR ONE HALF OF ONE WHEEL.

FAILURE MODES EFFECTS ANALYSIS FMEA – CIL FAILURE MODE
NUMBER: 02-1B-025- 02

REVISION#: 1 12/20/96
SUBSYSTEM NAME: LANDING/DECELERATION - BRAKE/SKID CONTROL SYS
LRU: MLG BRAKE SYSTEM **CRITICALITY OF THIS**
ITEM NAME: BRAKE CONTROL CIRCUIT CARD **FAILURE MODE:** 1R2

FAILURE MODE:
INADVERTENT OUTPUT-RESULTING IN UNCOMMANDED BRAKE PRESSURE.

MISSION PHASE: LS LANDING/SAFING

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

CAUSE:
COMPONENT FAILURE, VIBRATION, MECHANICAL SHOCK

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

REDUNDANCY SCREEN
A) PASS
B) FAIL
C) PASS

PASS/FAIL RATIONALE:
A)

B)
CREW DOES NOT HAVE SUFFICIENT TIME TO INITIATE CORRECTIVE ACTION FOLLOWING ANTI SKID FAIL LIGHT ANNUNCIATION.

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:
UNCOMMANDED BRAKE PRESSURE ON 1/2 OF ONE BRAKE.

(B) INTERFACING SUBSYSTEM(S):

ASSESSED; E.G., STRUT LOADS OF 25, 40, 77, & 230 KLBS, BRAKING PRESSURES OF 600, 800, & 1200 PSI, MAXIMUM RUNWAY/TIRE BRAKING FRICTION OF 0.5 AND 0.3, AND INITIAL VELOCITY OF 225 & 250 KNOTS. THE TESTS PROVED THE ANTI-SKID CONTROL BOX WILL PREVENT WHEEL LOCKUP DURING BRAKING AT THESE HIGHER SPEEDS. THE TEST/SIMULATION DID NOT SHOW ANY SIGNS OF GEAR INSTABILITY. HOWEVER, AT LIGHT GEAR LOADS, DURING HIGH ANGLE OF ATTACK, IF BRAKE PRESSURE IS APPLIED TOO RAPIDLY, THERE WILL BE SIGNIFICANT ANTI-SKID ACTIVITY TO REMOVE EFFECTIVE BRAKING FOR UP TO TWO (2) SECONDS. ENOUGH SLIPPAGE OF THE TIRE COULD OCCUR TO CAUSE SOME ADDITIONAL TIRE WEAR BUT NOT AS MUCH AS SPIN UP WEAR AT TOUCHDOWN. BASED ON THE RESULT OF THESE QUAL TESTS THE ANTI-SKID CONTROL BOX IS CERTIFIED TO THE HIGHER SPEED OF 225 KNOTS, WHICH IS 45 KNOTS ABOVE THE PREVIOUS LIMIT OF 180 KNOTS.

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

(C) INSPECTION:
RECEIVING INSPECTION
MATERIAL AND PROCESS CERTIFICATION ARE VERIFIED BY INSPECTION. RECEIVING INSPECTION VERIFIES FUNCTIONAL CHARACTERISTICS. INSPECTION VERIFIES COUNT AND INSPECTS FOR IDENTITY AND DAMAGE.

CONTAMINATION CONTROL
INSPECTION VERIFIES CONTAMINATION AND CORROSION CONTROL REQUIREMENTS.

ASSEMBLY/INSTALLATION
FABRICATION IS CONTROLLED BY SEQUENCE. DESIGNATED SHUTTLE PROJECT FABRICATION AREA VERIFIED BY INSPECTION, ACCEPTABLE PRIOR TO FABRICATION.

CRITICAL PROCESSES
INSPECTION VERIFIES ORIENTATION IS CORRECT ON ORIENTATION SENSITIVE PARTS PRIOR TO SOLDERING. SOLDERING CONTROLLED PER NHB 5300.4. TECHNICIANS AND INSPECTOR CERTIFIED.

NONDESTRUCTIVE EVALUATION
INSPECTION VERIFIES BLACK-LIGHT INSPECTION FOR SOLDER RESIN RESIDUE.

TESTING
ATP IS VERIFIED BY INSPECTION, INCLUDING CIRCUIT BOARDS INSPECTED FOR CONTINUITY, RESISTANCE AND OUTPUT.

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

(D) FAILURE HISTORY:
01F026 - OV102 - RH INBOARD BRAKE OVERHEATED DURING LANDING. ANALYSIS REVEALED THAT ALL RIGHT INBOARD BRAKE ASSOCIATED PRESSURE COMMANDS MONITORED WERE HIGHER THAN TEST PROCEDURE LIMITS. FAULT WAS TRACED TO LOSS OF ZENER DIODE ON CIRCUIT BOARD. DIODE WAS REPLACED RESULTING IN

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PROPER OPERATION OF CIRCUIT. FAILURE WAS CONSIDERED AN ISOLATED MANUFACTURING DEFECT THAT ESCAPED THE 100% BOND PULL TEST.

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

(E) OPERATIONAL USE:
DURING ENTRY (EI - 13) CREW WILL CYCLE ANTI-SKID SWITCH OFF THEN ON. IF BRAKE CONTROL CIRCUIT CARD FAILURE IS DETECTED (FDA: BRAKE PRESSURE GREATER THAN 180 PSI) CREW WILL CLOSE HYDRAULIC SYSTEM ISOLATION VALVE(S) (SYSTEMS 1 & 3 OR SYSTEMS 2 & 3). THIS ACTION ISOLATES THE HYDRAULIC SYSTEM(S) FROM THE BRAKES. AFTER NOSE GEAR TOUCHDOWN, SOFTWARE COMMANDS HYDRAULIC ISOLATION VALVE #3 OPEN THEREBY RECOVERING FULL BRAKING FOR ROLLOUT.

- APPROVALS -

EDITORIALLY APPROVED	: RI	: Robert Stell Jr. 1/24/97
EDITORIALLY APPROVED	: JSC	: Tim Searcy
TECHNICAL APPROVAL	: VIA	:96-CIL-011_02-1B_Ver. 2

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ADDITIONAL FAILURE BRAKE ISOLATION VALVE (OPEN) COULD CAUSE LOCKED WHEEL AND SUBSEQUENT MLG TIRE FAILURE AT MLG TOUCHDOWN.

(C) MISSION:
AFTER TWO FAILURES, POSSIBLE LOSS OF MISSION/CREW/VEHICLE DUE TO BRAKE PRESSURE APPLIED BEFORE NLG TOUCHDOWN RESULTING IN BRAKE/WHEEL/TIRE FAILURE AND UNCONTROLLABLE YAWING FORCES.

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

(E) FUNCTIONAL CRITICALITY EFFECTS:

-DISPOSITION RATIONALE-

(A) DESIGN:
BASIC DESIGN CONCEPT HAS BEEN PROVEN BY MANY HOURS ON COMMERCIAL AND MILITARY SERVICE. ELECTRONIC PARTS WERE SELECTED FROM ORBITER PROJECT PARTS LIST (OPPL). THOSE COMPONENTS NOT ON THE OPPL WERE AUTHORIZED ON AN IRREGULAR PARTS AUTHORIZATION REQUEST. THE CONTROL BOX IS DESIGNED TO OPERATE AFTER BEING SUBJECTED TO A SAWTOOTH SHOCK PULSE OF 20G PEAK MAGNITUDE FOR A DURATION OF 10 TO 12 MILLISECONDS. ELECTRICAL DESIGN REQUIREMENTS ARE IN ACCORDANCE WITH MF004.002.

(B) TEST:
QUALIFICATION TESTS: ENVIRONMENTAL TESTING INCLUDES: HUMIDITY, SALT FOG, VIBRATION ACCELERATION & 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 BOX. THE BRAKE/SKID CONTROL SYSTEM IS SUBJECTED TO 10G UPWARD/7.5G DOWNWARD LANDING ACCELERATION IN THE VERTICAL AXIS AND 0.8 AFT/2G FORWARD IN THE LONGITUDINAL AXIS. THIS LANDING ACCELERATION IS MAINTAINED FOR A MINIMUM OF 5 MINUTES.

THE FOLLOWING IS A SUMMARY OF THE QUALIFICATION TESTING/CERTIFICATION OF THE ANTI-SKID BOX TO SPEEDS GREATER THAN 180 KNOTS:
QUAL TEST OF THE ANTI-SKID OPERATION FOR ORBITER HIGH SPEED BRAKING APPLICATIONS UP TO 250 KNOTS WAS COMPLETED ON 09/30/94 USING HYDROAIRE'S SIMULATION FACILITIES. THIS INCLUDED DUPLICATION OF THE ORBITER'S HYDRAULIC LINE LENGTHS, AND USED AN ACTUAL ORBITER PRESSURE REGULATOR, BRAKE VALVE AND STRUCTURAL CARBON BRAKES. THIRTY (30) DIFFERENT CONFIGURATIONS WERE