

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE
NUMBER: 02-1E-066 -X**

**SUBSYSTEM NAME: LANDING DECELERATION - WHEEL, BRAKE & TIRE
REVISION: 0 03/07/88**

PART DATA

	PART NAME	PART NUMBER
	VENDOR NAME	VENDOR NUMBER
	: CHASSIS ASSEMBLY - MLG	MC621-0051
LRU	: MLG WHEEL BRAKE ASSY B. F. GOODRICH	MC621-0075 2-1357-11

**EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
MLG WHEEL BRAKE ASSEMBLY**

REFERENCE DESIGNATORS:

**QUANTITY OF LIKE ITEMS: 4
FOUR**

**FUNCTION:
PROVIDE VEHICLE BRAKING CAPABILITY**

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REVISION#: 1 08/03/97

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LRU: MLG WHEEL BRAKE ASSY

CRITICALITY OF THIS FAILURE MODE: 1R2

ITEM NAME: MLG WHEEL BRAKE ASSY

FAILURE MODE:

STRUCTURAL FAILURE OF STATOR/ROTOR COMPONENT(S).

MISSION PHASE: DO DE-ORBIT

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

CAUSE:

HIGH TEMPERATURE STATOR DAMAGE CAUSED BY HIGH SPEED FULL APPLICATION OF BRAKES RESULTING IN BURN OUT OF DISC, SUBSTANDARD MATERIAL. HIGH ENERGY LANDING, VIBRATION, OVERLOAD.

CRITICALITY 1/1 DURING INTACT ABORT ONLY? YES
TAL TRANS-ATLANTIC LANDING

REDUNDANCY SCREEN	A) PASS
	B) FAIL
	C) PASS

PASS/FAIL RATIONALE:

A)

B)

FAILS SCREEN "B" SINCE THERE IS NO INDICATION OF THIS FAILURE BEFORE BRAKES ARE APPLIED.

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:

LOSS OF 25 PERCENT BRAKING, EXTENDED ROLLOUT. POSSIBLE BRAKE/WHEEL LOCKUP AT LOW SPEEDS RESULTING FROM COMPONENT FAILURE.

**FAILURE MODES EFFECTS ANALYSIS (FMEA) – CIL FAILURE MODE
NUMBER: 02-1E-066- 02**

BRAKE LOCKUP AT HIGH SPEEDS IS NOT A CREDIBLE FAILURE MODE. ROTORS/STATORS DO NOT HAVE THE STRENGTH/CAPABILITY TO LOCKUP A BRAKE AT HIGH SPEEDS. THE TEMPERATURES PRODUCED DURING HARD BRAKING AT HIGH SPEEDS (ENERGY IN EXCESS OF 40 MILLION FT-LBS) PRECLUDES THE POSSIBILITY OF A ROTOR/STATOR FAILURE THAT WILL LOCK UP THE BRAKES.

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

(C) MISSION:
NO EFFECT WITH FIRST FAILURE - SUFFICIENT BRAKING CAPABILITY (75%) REMAINS, WILL RESULT IN A LONGER ROLLOUT . PROBABLE LOSS OF MISSION/CREW/VEHICLE WITH A SECOND FAILURE (BRAKES, TIRES, WHEELS OR NWS) AS THAT WOULD CAUSE A FURTHER REDUCTION IN BRAKING CAPABILITY AND/OR LOSS OF DIRECTIONAL CONTROL - VEHICLE WILL DEPART RUNWAY.

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

(E) FUNCTIONAL CRITICALITY EFFECTS:
CRIT 1/1 FOR TAL ABORT SITES WITHOUT BARRIERS - FOR THE BERYLLIUM BRAKE, THE THREE BRAKE HEAT SINKS REMAINING WILL FAIL DURING ROLLOUT, DUE TO EXCEEDING THEIR MAXIMUM ENERGY CAPABILITY, AND CAUSE THE VEHICLE TO GO OFF THE END OF THE RUNWAY. *

-DISPOSITION RATIONALE-

(A) DESIGN:

THE BASELINE WHEEL BRAKE ASSEMBLY WAS DESIGNED TO FUNCTION AFTER BEING SUBJECTED TO A RADIAL LOAD OF 103,000 POUNDS. DESIGN ULTIMATE RADIAL LOAD IS 154,500 POUNDS.

LANDING SHOCK - THE BRAKE WAS DESIGNED TO OPERATE AFTER BEING SUBJECTED TO A SAWTOOTH SHOCK PULSE OF 50G PEAK AMPLITUDE FOR A PULSE DURATION OF 10 TO 12 MILLISECONDS.

DESIGN VIBRATION LEVELS SATISFY THE ENVELOPE/DURATION VALUES TO WHICH THE BRAKES WERE EXPECTED TO BE EXPOSED.

**FAILURE MODES EFFECTS ANALYSIS (FMEA) – CIL FAILURE MODE
NUMBER: 02-1E-066- 02**

THE PRESENT CONFIGURATION OF THE WHEEL BRAKE ASSEMBLY IS DESIGNED WITH ORIFICES IN THE PISTON HOUSING AND ADDED THICKNESS TO THE #2 AND #3 STATORS. THE ADDED THICKNESS TO THE STATORS GIVE THE BRAKES GREATER ENERGY ABSORBING CAPABILITY. THE BASIC BRAKE DESIGN MINIMUM FACTOR SAFETY IS 1.4.

**(B) TEST:
QUALIFICATION TESTS:**

THE PRESENT "THICK STATOR" CONFIGURATION OF THE BRAKES WAS CERTIFIED BY SIMILARITY TO THE BASELINE BRAKES AND BY COMPLETING ADDITIONAL ENERGY STOPS.

THE FOLLOWING ENERGY STOPS WERE PERFORMED ON THE THICK STATOR WHEEL/BRAKE ASSEMBLY:

2 STOPS IN THE 25 MILLION FT-LBS ENERGY LEVEL RANGE
1 STOP IN THE 36.5 MILLION FT-LBS ENERGY LEVEL RANGE AND
2 STOPS IN THE 65.5 MILLION FT-LBS ENERGY LEVEL RANGE.

THESE STOPS WERE CONDUCTED UNDER VARIOUS CONDITIONS OF BRAKE ON SPEED, MASS INERTIA, AND PRESSURE - THE WHEEL/BRAKE ASSEMBLY MET ALL THE STOPPING REQUIREMENTS. THERE WERE NO HIGH SPEED BRAKE LOCKUP INCIDENTS DURING THESE ENERGY STOPS.

BRAKE WEAR-IN HIGH ENERGY STOPS ARE PERFORMED AT 14 MILLION FT-LBS (WAS 1 MILLION FT-LBS FOR BASELINE BRAKE CONFIGURATION).

THE ENVIRONMENTAL TESTING REQUIREMENTS FOR THE THICK STATOR BRAKE WERE MET BY ANALYSIS AND SIMILARITY TO THE BASIC BRAKE CONFIGURATION REQUIREMENTS FOR HUMIDITY, SALT FOG AND BENCH HANDLING SHOCK. FLIGHT ENVIRONMENTS: LINEAR ACCELERATION - 20G UP AND DOWN (VERTICAL AXIS), 20G AFT AND FORWARD (LONGITUDINAL AXIS). THE BASELINE BRAKE WAS SUBJECTED TO A THERMALSAWTOOTH SHOCK PULSE OF 50G PEAK AMPLITUDE FOR PULSE DURATION OF 10 TO 12 MILLISECONDS. THE BRAKE WAS ALSO SUBMITTED TO AND PASSED TWO LEVELS OF RANDOM VIBRATION TESTING.

ENDURANCE TESTS (BASELINE BRAKES): BRAKES WERE SUBJECTED TO 100,000 CYCLES OF APPLICATION AND RELEASE OF 800 PSI OF HYDRAULIC PRESSURE AND 5,000 CYCLES OF APPLICATION AND RELEASE OF 3,000 PSI HYDRAULIC PRESSURE. THERE WAS NO STRUCTURAL FAILURE OF COMPONENTS AS A RESULT OF THIS TEST.

STRUCTURAL TORQUE TEST (BASELINE BRAKES):
THE WHEEL/BRAKE ASSEMBLY WITHSTOOD A STRUCTURAL TORQUE OF 107,000 FT-LBS WITHOUT COMPONENT FAILURE (EACH ROTOR AND STATOR HAD BEEN SUBJECTED TO 26,750 FT-LBS OF TORQUE).

GROUND TURNAROUND TEST
ANY TURNAROUND CHECKOUT TESTING IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD. THE OMRSD DATA PROVIDED BELOW IS NO LONGER BEING KEPT UP-TO-DATE. IF THERE IS ANY DISCREPANCY BETWEEN THE GROUND TESTING DATA PROVIDED BELOW AND THE OMRSD, THE OMRSD IS THE MORE ACCURATE SOURCE OF THE DATA.

MAIN WHEEL BRAKE WEAR AND MANUAL ROTATION:

**FAILURE MODES EFFECTS ANALYSIS (FMEA) – CIL FAILURE MODE
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DURING THIS TEST ONE HYDRAULIC SYSTEM IS APPLIED AND THE DISTANCE BETWEEN THE BRAKE PRESSURE PLATE AND THE NON-ACTUATED PISTONS IS VERIFIED. THE TEST ALSO VERIFIES THAT ALL EIGHT PISTONS (ON EACH BRAKE) MOVE THE PRESSURE PLATE, AND EACH WHEEL IS MANUALLY ROTATED AFTER BRAKE PRESSURE IS RELIEVED TO VERIFY THAT THE BRAKE ROTOR AND STATOR PLATES ARE NOT DRAGGING.

FREQUENCY - ALL VEHICLES AT GROUND TURNAROUND.

(C) INSPECTION:

RECEIVING INSPECTION

RECEIVING INSPECTION VERIFIES MATERIALS AND PROCESSES CERTIFICATION.

CONTAMINATION CONTROL

CLEANLINESS AND CORROSION CONTROL REQUIREMENTS ARE VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION

ASSEMBLED BRAKE ASSEMBLIES INSPECTED FOR PROPER ASSEMBLY. DETAIL PARTS INSPECTED FOR DAMAGE. CRITICAL DIMENSIONS AND CRITICAL SURFACE FINISHES ARE VERIFIED. FABRICATION AND ASSEMBLY PROCESSES VERIFIED BY INSPECTION.

CRITICAL PROCESSES

BERYLLIUM MACHINING IS VERIFIED BY INSPECTION.

NONDESTRUCTIVE EVALUATION

BOLTS ARE FLUORESCENT PENETRANT INSPECTED, VERIFIED BY INSPECTION. BERYLLIUM PORTION OF STATORS, ROTORS, BACPLATE AND PRESSURE PLATE ARE FLUORESCENT PENETRANT INSPECTED AND VERIFIED BY INSPECTION. CARBON PARTS ARE RADIOGRAPHICALLY INSPECTED AND VERIFIED BY INSPECTION. WHEEL DRIVE INSERTS ARE MAGNETIC PARTICLE INSPECTED AND VERIFIED BY INSPECTION. THE BRAKE PAD RETAINING WASHERS ARE EDDY CURRENT INSPECTED, AND VERIFIED BY INSPECTION.

TESTING

ATP IS VERIFIED BY INSPECTION.

PACKAGING/HANDLING

HANDLING AND PACKAGING REQUIREMENTS ARE VERIFIED BY INSPECTION.

(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. THE FAILURE HISTORY DATA PROVIDED BELOW IS NO LONGER BEING KEPT UP-TO-DATE.

FROM 1975 TO 1987, NUMEROUS DESIGN CHANGES WERE MADE AS A RESULT OF TEST/FIELD FAILURES IN AN ATTEMPT TO UPGRADE BRAKE/WHEEL PERFORMANCE CULMINATING IN THE "THICK STATOR" CONFIGURATION WHICH WILL BE INSTALL PRIOR

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TO STS-26. THESE CHANGES ARE FULLY DOCUMENTED BY MCR PROCESS.
ADDITIONALLY, A NEW BRAKE/WHEEL DESIGN (STRUCTURAL CARBON, 5 ROTOR
CONFIGURATION) IS PRESENTLY UNDER DEVELOPMENT.

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

- APPROVALS -

EDITORIALLY APPROVED	: BNA	: <u>J. Kumura 8/3/97</u>
EDITORIALLY APPROVED	: JSC	: <u>D. Leroy 9-12-97</u>
TECHNICAL APPROVAL	: VIA APPROVAL FORM	: 96-CIL-011_02-1E