

**FAILURE MODES EFFECTS ANALYSIS (FMEA) — CRITICAL HARDWARE
NUMBER: 02-1E-068-X**

**SUBSYSTEM NAME: LANDING DECELERATION - WHEEL, BRAKE & TIRE
REVISION : 2 06/10/91**

	PART NAME VENDOR NAME	PART NUMBER VENDOR NUMBER
LRU :	MLG WHEEL ASSEMBLY	MC621-0051

■ **EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:**
BERYLLIUM/CARBON BRAKE MAIN LANDING GEAR WHEEL

■ **QUANTITY OF LIKE ITEMS: 4**
FOUR

FUNCTION:
THE CIRCULAR FRAME, SPLIT WHEEL TYPE, ON WHICH THE AIRCRAFT IS MOUNTED.

PAGE: 2

PRINT DATE: 06/10/91

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE
NUMBER: 02-1E-068-01

SUBSYSTEM: LANDING DECELERATION - WHEEL, BRAKE & TIRE
LRU :MLG WHEEL ASSEMBLY
ITEM NAME: MLG WHEEL ASSEMBLY
REVISION# 2 06/10/91 R
CRITICALITY OF THIS FAILURE MODE:1/1

FAILURE MODE:
STRUCTURAL FAILURE.

MISSION PHASE:
DO DE-ORBIT

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

CAUSE:
EXCESSIVE LOAD, DEFECTIVE PART/MATERIAL, BEARING FAILURE.

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

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

- FAILURE EFFECTS -

(A) SUBSYSTEM:
LOSS OF ROLLING AND LOAD CARRYING CAPABILITY ON AFFECTED TIRE/WHEEL ASSEMBLY. LOSS OF ADJACENT TIRE/WHEEL ASSEMBLY AND LOSS OF ALL BRAKING CAPABILITY ON AFFECTED STRUT. PROBABLE FAILURE OF AFFECTED MLG STRUT OR IT'S ATTACHMENTS.

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

(C) MISSION:
PROBABLE LOSS OF MISSION/CREW/VEHICLE DUE TO EXCESSIVE YAWING FORCES OR LOSS OF 50 PERCENT OF BRAKING CAPABILITY CAUSING VEHICLE TO DEPART RUNWAY.

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

FAILURE MODES EFFECTS ANALYSIS (FMEA) — CRITICAL FAILURE MODE
NUMBER: 02-1E-068-01

- DISPOSITION RATIONALE -

■ (A) DESIGN:

SPACE SHUTTLE WHEEL DESIGNED PER MIL-W-5013 AND THE CARBON BRAKE WHEEL INCLUDES FRACTURE CONTROL PER MC999-0096. WHEEL DESIGN INCORPORATES PRESSURE/THERMAL RELIEF DEVICES TO PROTECT AGAINST EXPLOSIVE WHEEL FAILURE. DESIGNED TO WITHSTAND A SAWTOOTH SHOCK PULSE OF 50G PEAK AMPLITUDE FOR A PULSE DURATION OF 10 TO 12 MILLISECONDS WITHOUT DAMAGE. THE WHEEL IS ALSO DESIGNED TO PERFORM AFTER EXPOSURE TO A 20G VERTICAL AND LONGITUDINAL ACCELERATION.

THE BERYLLIUM BRAKE WHEEL IS CERTIFIED FOR A MAXIMUM ORBITER LANDING WT. OF 240,000 LBS. THE CARBON BRAKE WHEEL IS CERTIFIED FOR A MAXIMUM ORBITER LANDING WT. OF 256,000 LBS. O-RING SEAL/INSTALLATION BETWEEN WHEEL HALVES PER SAE A5666A. OVER-INFLATION PLUG/TIRE PRESSURE TRANSDUCER, THERMAL RELIEF PLUG AND INFLATION VALVE INSTALLATION PORTS ARE SEALED PER MS33649. INFLATION VALVE ASSEMBLY IS STANDARD MS27436. VALVE CAP DESIGN INCLUDES A REDUNDANT SEAL.

■ (B) TEST:

QUALIFICATION - WHEEL ASSEMBLY SUBJECTED TO COMBINED LIMIT LOAD TESTS, COMBINED YIELD LOAD TEST, ULTIMATE COMBINED LOAD TEST, BURST TEST, STATIC WHEEL PRESSURE TEST, DYNAMIC TORQUE TEST, STRUCTURAL TORQUE TEST AND THERMAL RELIEF TEST.

QUALIFICATION TESTS:

THE CONFIGURATION OF THE CARBON BRAKE ASSEMBLY WAS CERTIFIED BY QUALIFICATION TESTS ALONG WITH THE BASELINE WHEEL. A SERIES OF HIGH ENERGY STOPS WERE PERFORMED ON THE WHEEL/BRAKE ASSEMBLY DURING QUALIFICATION. THESE RESULTS SHOWED NO HIGH SPEED BRAKE LOCK-UP OR MATERIAL FAILURES TO THE BRAKE/WHEEL ASSEMBLY DURING THESE TESTS.

ONE (1) CARBON BRAKE WHEEL SUCCESSFULLY COMPLETED THE FOLLOWING DYNAMIC TESTS:

- 1) SLOW ROLL DYNAMOMETER TESTING FOR A TOTAL OF 990 MILES
- 2) ONE (1) LANDING PROFILE SIMULATING 211K LBS ORBITER WT AT AN INITIAL SOAKED TEMPERATURE OF 131 DEGREES F
- 3) ONE (1) LANDING PROFILE SIMULATING 211K LBS ORBITER WT AT AN INITIAL SOAKED TEMPERATURE OF -35 DEGREES F
- 4) THREE (3) LANDING PROFILES SIMULATING 211K LBS ORBITER WT AND 10 KNOT X-WIND AT AMBIENT TEMPERATURE
- 5) ONE (1) LANDING PROFILE SIMULATING AN ABORT 240K LBS ORBITER WT AND 20 KNOT X-WIND AT AMBIENT TEMPERATURE

PAGE: 4

PRINT DATE: 06/10/91

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE
NUMBER: 02-1E-068-01

- 6) ONE (1) LANDING PROFILE SIMULATING A MAXIMUM ABORT WEIGHT OF 256 K LB ORBITER AND 20 KNOT X-WIND AT AMBIENT TEMPERATURE.

THE WHEEL WAS INSPECTED AT THE CONCLUSION OF TESTING AS FRACTURE CRITICAL HARDWARE AND WAS SUBJECTED TO SPECIAL NDE EDDY CURRENT INSPECTION AT THE FRACTURE CRITICAL AREA OF THE WHEEL (WHEEL BEAD SEAT AND THE TIE BOLT HOLES) WITH NO CRACKS OR EVIDENCE OF MATERIAL FAILURE FOUND.

ACCEPTANCE TESTS INCLUDE WHEEL BALANCE AND RADIAL/LATERAL RUNOUT CHECKS. ACCEPTANCE TESTS ALSO INCLUDE DIMENSIONAL CHECKS, FINISH, CLEANLINESS AND THAT CERTIFIED MATERIALS AND PROCESSES HAVE BEEN USED.

STATIC WHEEL PRESSURE TEST - WHEEL IS INFLATED TO 1.5 TIMES RATED INFLATION PRESSURE (473 - 485 PSIG) - NO LEAKAGE WAS FOUND WHEN CHECKED.

DIFFUSION TEST - SUCCESSFULLY COMPLETED WITH NO LEAKAGE FOUND.

DYNAMIC PRESSURE TEST:

WHEEL AND TIRE ASSEMBLY WAS PRESSURIZED TO 320 PSI AND ROLLED FOR 25 MILES WITHOUT PRESSURE LOSS (5 PSI PRESSURE LOSS ALLOWED). WHEEL SUCCESSFULLY COMPLETED SLOW ROLL TEST (4 CYCLES) WHILE BEING SUBJECTED TO RADIAL LOADS FROM 53,944 LBS TO 60,000 LBS AND SIDE LOADS OF 12,000 LBS. TIE BOLTS WERE TORQUED TO 179-189 FT-LBS AND DID NOT FALL BELOW THAT RANGE (AFTER 4TH CYCLE RANGE WAS FROM 190-210 FT-LBS).

BURST TEST - PRESSURE WAS APPLIED TO THE WHEEL/TIRE ASSEMBLY UP TO 945 PSI AND HELD FOR 10 SECONDS. PRESSURE WAS THEN INCREASED TO 1103 PSI AND HELD FOR 10 SECONDS - WITH NO FAILURES. THE WHEEL/TIRE ASSEMBLY SUCCESSFULLY SATISFIED THE REQUIREMENTS WITH NO CRACKS OR EVIDENCE OF FAILURE FOUND IN THE WHEEL HALVES OR TIE BOLTS AFTER THE TIRE FAILED AT A PRESSURE OF 1137 PSI.

COMBINED LOADS TEST - THE YIELD AND ULTIMATE COMBINED LOADS WERE SUCCESSFULLY PERFORMED. WHEEL/TIRE ASSEMBLY WAS SUBJECTED TO THE FOLLOWING YIELD COMBINED LOADS:

CARBON BRAKE WHEEL:

CONDITION 1 - 126,000 LBS RADIAL LOAD AND 5,800 LBS SIDE LOAD
CONDITION 2 - 64,100 LBS RADIAL LOAD AND 21,300 LBS SIDE LOAD

BERYLLIUM BRAKE WHEEL:

ACTING INBD - 144,900 LBS RADIAL LOAD AND 6800 LBS SIDE LOAD
ACTING OUTBD - 145,200 LBS RADIAL LOAD AND 6800 LBS SIDE LOAD

ULTIMATE COMBINED LOADS: WAS 1.4 TIMES THE LIMIT LOAD
ALL DESIGN REQUIREMENTS WERE MET (LEAKAGE, INTERFERENCE ETC.).

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE
NUMBER: 02-1E-068-01**

OMRSD:

MLG WHEEL INSPECTION:

WHEELS ARE INSPECTED PER THE MLG WHEEL/TIRE ASSEMBLY AND INSPECTION SPECIFICATION MLO308-0142 WHICH STATES; "... VISUALLY INSPECT ALL COMPONENTS OF THE MAIN WHEEL ASSEMBLY FOR CRACKS, NICKS, CORROSION AND OTHER DAMAGE." THE WHEEL FLANGE SURFACES THAT CONTACT THE TIRE BEAD SEAT IS ALSO INSPECTED FOR CORROSION, NICKS, SCRATCHES AND OTHER DAMAGE. REPAIRS ARE PERFORMED PER THE MANUFACTURER'S RECOMMENDATIONS.

MLG WHEEL/TIRE CERT:

VERIFIES MLG WHEEL/TIRE ASSEMBLY HAS BEEN BUILT UP AND TESTED PER THE V070-510002 DRAWING, MLO308-0029 LANDING GEAR RIGGING SPECIFICATION AND MLO308-0142 MLG WHEEL/TIRE INSTALLATION AND INSPECTION SPECIFICATION. THIS INCLUDES TORQUING THE INFLATION VALVE CAP TO A VALUE OF 8 TO 10 IN-LBS.

FREQUENCY - ALL VEHICLES AT GROUND TURNAROUND.

■ **(C) INSPECTION:**

RECEIVING INSPECTION

RECEIVING INSPECTION VERIFIES MATERIALS AND PROCESSES CERTIFICATION.

NONDESTRUCTIVE EVALUATION

BOLTS ARE FLUORESCENT PENETRANT INSPECTED, VERIFIED BY INSPECTION. CARBON BRAKE WHEEL IS TREATED AS FRACTURE CRITICAL WITH COMPLETE FRACTURE CONTROL REQUIREMENTS IMPOSED. STANDARD NDE PER MTO501-508 IS REQUIRED FOR THE INNER WHEEL HALF, WHEEL SLEEVE, AND OUTER WHEEL HALF. SPECIAL NDE WILL BE REQUIRED FOR THE BEAD SEAT AND TIE BOLT HOLE AREAS OF THE WHEEL HALVES.

TESTING

ATP IS VERIFIED BY INSPECTION

PACKAGING/HANDLING

HANDLING AND PACKAGING REQUIREMENTS ARE VERIFIED BY INSPECTION.

■ **(D) FAILURE HISTORY:**

NONE - RELATIVE TO THIS FAILURE MODE.

■ **(E) OPERATIONAL USE:**

CREW CAN COMPENSATE EITHER BY CHANGING BRAKING PROCEDURE AND/OR USING THE NWS TO MAINTAIN DIRECTIONAL CONTROL.

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE

NUMBER: 02-1E-068-01

- APPROVALS -

RELIABILITY ENGINEERING: G. TATE
DESIGN ENGINEERING : M. T. PORTER
QUALITY ENGINEERING : D. DESAI
NASA RELIABILITY :
NASA SUBSYSTEM MANAGER :
NASA QUALITY ASSURANCE :

: *YAN*
: *[Signature]*
: *[Signature] M.T. Porter*
: *[Signature] 6/10/91*
: *[Signature] 7/26/91*
: *[Signature] 7/24/91*
: *[Signature] 6-27-91*