PAGE: 1 PRINT DATE: 06/10/91

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.

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FAILURE MODES EFFECTS ANALYSIS FMEA – CIL FAILURE MODE
NUMBER: 02-1E-068- 02

REVISION#: 3 08/03/97

SUBSYSTEM NAME: LANDING DECELERATION - WHEEL, BRAKE & TIRE
LRU: MLG WHEEL ASSEMBLY
ITEM NAME: MLG WHEEL ASSEMBLY
CRITICALITY OF THIS FAILURE MODE: 1/1

FAILURE MODE:
LEAKAGE - RESULTING IN LANDING WITH A FLAT TIRE.

MISSION PHASE: DO DE-ORBIT

VEHICLE/PAYLOAD/KIT EFFECTIVITY:

102	COLUMBIA
103	DISCOVERY
104	ATLANTIS
105	ENDEAVOUR

CAUSE:
IMPROPER SEALING/SEATING OF - (1) TIRE TO RIM (2) WHEEL HALVES (3) THERMAL RELIEF PLUGS (4) OVER-INFLATION PLUG/TRANSDUCER TO WHEEL O-RING (5) INFLATION VALVE (6) INFLATION VALVE INTERNAL SEAT (7) LEAKING TIRE.

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

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

PASS/FAIL RATIONALE:
A)

B)

C)

- 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.

FAILURE MODES EFFECTS ANALYSIS (FMEA) – CIL FAILURE MODE
NUMBER: 02-1E-068- 02

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

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

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

(E) FUNCTIONAL CRITICALITY EFFECTS:

-DISPOSITION RATIONALE-

(A) DESIGN:
SPACE SHUTTLE WHEEL DESIGNED PER MIL-W-5013 AND THE CARBON BRAKE WHEEL INCLUDES FRACTURE CONTROL PER MC999-096. 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 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 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 2560,000 LBS. O-RING SEAL/INSTALLATION BETWEEN WHEEL HALVES PER SAE A5666A. TIRE PRESSURE TRANSDUCER/OVER-INFLATION PLUG, 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 TESTS, ULTIMATE COMBINED LOAD TEST, BURST TEST, STATIC WHEEL PRESSURE TEST, DYNAMIC TORQUE TEST, STRUCTURAL TORQUE TEST AND THERMAL RELIEF TEST.

FAILURE MODES EFFECTS ANALYSIS (FMEA) – CIL FAILURE MODE
NUMBER: 02-1E-068- 02

QUALIFICATION TESTS:
THE CONFIGURATION OF THE CARBON BRAKE ASSEMBLY WAS CERTIFIED BY QUALIFICATION TESTS ALONG WITH THE CARBON BRAKE WHEEL. A SERIES OF HIGH ENERGY STOPS WERE PERFORMED ON THE WHEEL/BRAKE ASSEMBLY DURING QUALIFICATION. TEST 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 211 LBS ORBITER WT AND 10 KNOT X-WIND AT AMBIENT TEMPERATURE.
5) ONE (1) LANDING PROFILE SIMULATING A MAXIMUM ABORT WEIGHT OF 256 K LBS 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.

THE STATIC WHEEL PERSSURE 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.

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.

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 PRESSURE
ACTING OUTBD - 145,200 LBS RADIAL LOAD AND 6800 LBS SIDE LOAD PRESSURE

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

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

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.

MLG WHEEL INSPECTION:
WHEELS ARE INSPECTED PER THE MLG WHEEL/TIRE ASSEMBLY AND INSPECTION SPECIFICATION ML0308-0142 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 ARE 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 VO70-510002 DRAWING, ML0308-0029 LANDING GEAR RIGGING SPECIFICATION AND ML0308-0142 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 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.

(E) OPERATIONAL USE:

PRINT DATE: 08/03/97

FAILURE MODES EFFECTS ANALYSIS (FMEA) – CIL FAILURE MODE
NUMBER: 02-1E-068- 02

FAILURE DETECTED ON ORBIT - AN ABORT DECISION IS REQUIRED TO ATTEMPT A LANDING BEFORE LOAD CARRYING CAPABILITY OF THE TIRE IS LOST. WHEEL FAILURE BEFORE NLG TOUCHDOWN - CREW WILL USE AERO RUDDER AND BRAKING ON THE OPPOSITE SIDE TO MAINTAIN DIRECTIONAL CONTROL.

WHEEL FAILURE AFTER NLG TOUCHDOWN - CREW WILL USE NWS, AERO RUDDER AND DIFFERENTIAL BRAKING TO MAINTAIN DIRECTIONAL CONTROL.

- APPROVALS -

EDITORIALLY APPROVED	: BNA	: J Kymura 8/3/97
EDITORIALLY APPROVED	: JSC	: D. Searcy 9-12-97
TECHNICAL APPROVAL	: VIA APPROVAL FORM	: 96-CIL-011_02-1E