

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL HARDWARE

NUMBER: M7-3-M2-X

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SUBSYSTEM NAME: TUNNEL ADAPTER

REVISION : 1 05/17/91

	PART NAME VENDOR NAME	PART NUMBER VENDOR NUMBER
■ LRU :	LATCH MECHANISM, HATCH "D"	V519-593302

PART DATA

■ EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
LATCH MECHANISM, HATCH "D"

■ QUANTITY OF LIKE ITEMS: 1
ONE

■ FUNCTION:

THIS MECHANISM IS MOUNTED ON THE SPACELAB SIDE OF HATCH "D" TO SECURE IT IN THE CLOSED AND SEALED POSITION. THIS ASSEMBLY CONSISTS OF SEVENTEEN (17) APOLLO CM PROVEN HATCH-TYPE LATCHES WHICH ARE JOINED BY RODS AND LINKS. THE RODS AND LINKS MOVE CIRCUMFERENTIALLY, CAUSING THE LATCHES TO MOVE AXIALLY TO SECURE THE HATCH IN A CLOSED AND SEALED POSITION. TWO "KICKER" LATCHES INCORPORATE PROVISION FOR "BREAKING FREE" THE HATCH SEALS AGAINST ANY SMALL RESIDUAL DELTA PRESSURE, WHEN OPENING THE HATCH. THE LATCHES ARE DRIVEN BY A MANUALLY OPERATED REDUCTION GEARBOX (ACTUATOR).

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 ITEM NAME: LATCH MECHANISM, HATCH "D"

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CRITICALITY OF THIS
 FAILURE MODE: 1R2

■ FAILURE MODE:
 FAILS TO ENGAGE

MISSION PHASE:
 00 ON-ORBIT

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

■ CAUSE:
 ADVERSE TOLERANCES/WEAR, CONTAMINATION/FOREIGN OBJECT/DEBRIS, FAILURE/
 DEFLECTION OF INTERNAL PART, PHYSICAL BINDING/JAMMING

■ CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

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

PASS/FAIL RATIONALE:

- A)
 PASSES REDUNDANCY SCREEN "A" SINCE OPERATION OF THE HATCH LATCH
 MECHANISM IS VERIFIED DURING GROUND TURNAROUND.
- B)
 N/A (MECHANICAL LINKAGE)
- C)
 PASSES REDUNDANCY SCREEN "C" SINCE A FAILURE OF THE HATCH LATCH
 MECHANISM CANNOT CAUSE AN ASSOCIATED FAILURE OF ANOTHER ASSEMBLY.

- FAILURE EFFECTS -

- (A) SUBSYSTEM:
 LATCHES THAT FAIL TO ENGAGE WILL CAUSE THE LOSS OF THE ABILITY TO

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(MECHANICALLY) KEEP HATCH "D" CLOSED AND SEALED.

- (B) INTERFACING SUBSYSTEM(S):
DEGRADED CAPABILITY TO USE HATCH "C" IF HATCH "D" CANNOT BE CLOSED AND (MECHANICALLY) LATCHED AS THERE ARE NOT ENOUGH CONSUMABLES AVAILABLE TO REPRESSURIZE THE AIRLOCK/TUNNEL ADAPTER, TUNNEL AND SPACELAB (ONLY THE AIRLOCK/TUNNEL ADAPTER CAN BE REPRESSURIZED AFTER HATCH "C" IS USED FOR AN EVA). AN EVA CREWMEMBER WOULD HAVE TO FIRST PUSH ON HATCH "D" TO MAKE THE INITIAL SEAL DURING THE PRESSURE BUILDUP AFTER AN EMERGENCY EVA PRIOR TO RE-ENTERING THE CREW CABIN.
- (C) MISSION:
LOSS OF MISSION OBJECTIVES IF THE SPACELAB CANNOT BE USED AFTER AN EMERGENCY EVA.
- (D) CREW, VEHICLE, AND ELEMENT(S):
MINOR DAMAGE MIGHT OCCUR TO THE INSIDE OF THE TUNNEL ADAPTER IF HATCH "D" CANNOT BE CLOSED/LATCHED AND IS LEFT OPEN DURING THE DESCENT/LANDING PHASE. POSSIBLE INJURY TO OR LOSS OF THE EVA CREWMEMBERS IF HATCH "D" CANNOT BE KEPT CLOSED AND SEALED TO ALLOW THEIR SAFE RETURN INTO THE CREW CABIN, THROUGH HATCH "A" POST-EVA.
- (E) FUNCTIONAL CRITICALITY EFFECTS:

- DISPOSITION RATIONALE -

- (A) DESIGN:
LATCH MECHANISM BASED ON PROVEN APOLLO DESIGN. LINKAGE ATTACHMENTS HAVE DUAL ROTATING SURFACES, PROTECTIVE COVER MINIMIZES CONTAMINATION. MAXIMUM LATCHING FORCE IS 30 LB AT THE ACTUATOR HANDLE. ACTUATOR AND LINKAGE DESIGNED FOR 150 LB LIMIT LOAD AT THE HANDLE, POSITIVE MARGINS ON ALL COMPONENTS. LATCH AND LINKAGE MATERIALS (INCONEL, A286 CRES, BERYLLIUM COPPER) CHOSEN FOR HIGH STRENGTH AND LOW WEAR. DRY FILM LUBE ON BEARING SURFACES. HATCH WITHSTANDS DIFFERENTIAL PRESSURE IN BOTH DIRECTIONS. DESIGN STRESS ANALYSIS REPORT SD77-SH-0178, VOL. 6.
- (B) TEST:
QUALIFICATION TESTS: LATCHES AND ACTUATOR SYSTEM QUALIFIED BY SIMILARITY (PER CR-28-593201-001C) TO THE MECHANISMS ON THE INGRESS/EGRESS HATCH. REFERENCE FMEA/CIL O2-4A-593201-01. ACTUATOR ALSO COMPONENT QUALIFIED BY SIMILARITY TO ACTUATOR ON INGRESS/EGRESS HATCH (PER CR-28-287-0036-0006C); REFERENCE FMEA/CIL O2-4A-593202-01. CERTIFICATION BY SIMILARITY INCLUDED: FUNGUS, SALT/FOG, OZONE, SAND/DUST, TEMPERATURE CYCLE, CRASH/SHOCK, ACCELERATION, CABIN ATMOSPHERE, LIFE CYCLE (2,000 CYCLES), VIBRATION AND STRUCTURAL LOAD REQUIREMENTS.

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CERTIFICATION TESTS INCLUDED: ZERO-"G" AND ONE-"G" OPERATION (USING APPROPRIATE GSE EQUIPMENT) AND HATCH SEALING/LEAK TEST (WITH 15.0 PSID ACROSS HIGH-PRESSURE SIDE OF HATCH, WITH MAXIMUM ALLOWABLE LEAK RATE OF 1.03 SCIM), PROOF PRESSURE 17.7 PSID FOR 2.0 +/- 1.0 MINUTE (PER MLO206-0089). LATCH MECHANISM INSTALLED AND RIGGED PER TECH ORDER INSTALLATION M072-593301.

OMRSD: MECHANISM IS FUNCTIONALLY OPERATED FOR EVIDENCE OF BINDING, SURFACE CONTAMINATION AND POSSIBLE DAMAGE. VISUALLY INSPECT TUNNEL ADAPTER HATCH "D" MECHANISM LATCHES AND HINGES. FUNCTIONAL CHECK OF HATCH "D" IS PERFORMED BY OPENING AND CLOSING HATCH FROM INSIDE TUNNEL ADAPTER AND REPEATING FROM SPACELAB SIDE. ACTUATOR HANDLE AND LOCK LEVER FORCES ARE CHECKED. TESTS ARE PERFORMED WHEN THE TUNNEL ADAPTER IS INSTALLED ON THE VEHICLE.

REFERENCE OMRSD V33AEO.OXX

- (C) INSPECTION:
RECEIVING INSPECTION
MATERIAL AND PROCESS CERTIFICATIONS VERIFIED BY INSPECTION.

CONTAMINATION CONTROL
CORROSION PROTECTION PROCESSES ARE VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION
ALL DETAIL HARDWARE IS VERIFIED BY INSPECTION AT THE DETAIL LEVEL. INSPECTION VERIFICATION IS REVERIFIED PRIOR TO ASSEMBLY. ALL LATCHES ARE INSTALLED AND SYSTEMATICALLY TORQUED AND VERIFIED BY INSPECTION. ALL FASTENER TORQUES ARE VERIFIED BY INSPECTION. PEAK TORQUE (35 INCH-LB) AT EACH LATCH BELLCRANK IS MEASURED DURING INSTALLATION AND VERIFIED BY INSPECTION. ALL INSTALLATIONS, ADJUSTMENTS, AND RIGGING OF MECHANICAL UNITS (PER MLO308-0003) ARE VERIFIED BY INSPECTION.

NONDESTRUCTIVE EVALUATION
PENETRANT INSPECTION OF DETAIL HARDWARE IS VERIFIED BY INSPECTION.

CRITICAL PROCESSES
DRY FILM LUBRICATION VERIFIED BY INSPECTION.

TESTING
FUNCTIONAL TESTING VERIFIED BY INSPECTION.

- (D) FAILURE HISTORY:
CAR NO. AB3854: DURING VISUAL INSPECTION OF SIDE HATCH ASSEMBLY AFTER COMPLETION OF LIFE CYCLE TESTS AND QUALIFICATION VIBRATION TEST, TWO SHIMS WERE FOUND TORN AND WRINKLED IN LATCHES NO. 6 AND NO. 7; SHIM

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DAMAGE RESULTED FROM RADIAL (INWARD) LOADING ON LATCH BELLCRANKS DURING MORE THAN 2,000 CYCLES OF OPENING AND CLOSING THE HATCH; ALL SHIMS ON THE QUALIFICATION TEST HATCH WERE RE-INSPECTED AND REPLACED, BUT NO CORRECTIVE ACTION WAS REQUIRED AS HATCH LATCHING MECHANISM PERFORMANCE WAS NOT AFFECTED.

CAR NO. AB7348: THERE WERE UNSUCCESSFUL ATTEMPTS TO MOVE HATCH "A" TO THE CLOSED POSITION; INABILITY TO CLOSE HATCH WAS A RESULT OF MISALIGNMENT BETWEEN HINGE STOP ASSEMBLY AND LOWER HINGE ARM DUE TO YIELDING (WHICH WAS ATTRIBUTED TO IMPROPER OPERATION OF THE HATCH HINGE MECHANISM AND APPLICATION OF EXCESSIVE FORCE TO THE GSE COUNTERBALANCE); YIELDED PARTS FROM AIRLOCK HATCH "A" WERE REPLACED AND THE AIRLOCK MECHANISM TECH ORDER INSTALLATION WAS CHANGED TO CLARIFY OPERATION OF HATCHES "A" AND "B" DURING GROUND CHECKOUT.

CAR NO. AB7674: IN GROUND CHECKOUT OF AIRLOCK HATCH "B" ON OV102, CLOSING OPERATION WAS UNSUCCESSFUL IN FOUR ATTEMPTS; THE KICKER DOG ON THE CENTER LATCH WAS ON THE WRONG SIDE OF THE HATCH SILL WHICH PREVENTED ACTUATION OF LATCHES TO THE LATCHED POSITION (LATCH MECHANISM KINEMATICS ALLOWED THE CENTER LATCH KICKER DOG TO INTERFERE WITH HATCH CLOSING BECAUSE OF HATCH ORIENTATION WITH GSE SUPPORT IN ONE-G ENVIRONMENT); A DECAL WAS ATTACHED TO EACH SIDE OF AIRLOCK HATCHES "A" AND "B" TO INDICATE THE REQUIRED POSITION OF THE LATCH ACTUATOR HANDLE FOR CLOSING THE HATCH.

CAR NO. 26F009: AIRLOCK HATCH "A" DIFFICULT TO LATCH FOR ENTRY; YIELDING OF HINGE MECHANISM PARTS DUE TO OPENING HATCH AFTER SPACELAB FLIGHTS WITHOUT GSE SUPPORT; YIELDED PARTS REPLACED AND HATCH OPERATION REVERIFIED TO INCORPORATE RE-INSPECTION OF HATCH MECHANISMS AFTER EMERGENCY OPERATION WITHOUT GSE.

■ (E) OPERATIONAL USE:

IF EMERGENCY EVA IS REQUIRED AND HATCH "D" CANNOT BE CLOSED, SPACELAB WOULD HAVE TO BE DEPRESSURIZED BEFORE HATCH "C" COULD BE OPENED. ALSO, HATCH "D" WOULD HAVE TO BE HELD IN PLACE TO ALLOW REPRESSURIZING TUNNEL ADAPTER FOR CREW RE-ENTRY INTO CREW MODULE THROUGH AIRLOCK HATCH "A".

- APPROVALS -

RELIABILITY ENGINEERING: D. M. MAYNE
DESIGN ENGINEERING : R. A. SMITH
QUALITY ENGINEERING : M. SAVALA
NASA RELIABILITY :
NASA SUBSYSTEM MANAGER :
NASA QUALITY ASSURANCE :

D.M. Mayne
: *ACR* *Pop 9/8m 5/13/91*
: *M.D. Burtner* *6/10/91*
: *D.M.C.* *5/24/91*
: *Charles C. Campbell* *7/20/91*
: *OUR* *7/9/91* *Schubert*