FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL HARDWARE
NUMBER: M7-3-M7-X



SUBSYSTEM NAME: TUNNEL ADAPTER

REVISION : 1 05/17/91

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| | PART NAME<br>VENDOR NAME | PART NUMBER<br>VENDOR NUMBER |
|---|---|---|
| ■ LRU : | HATCH "C" AND "D" SEALS | V070-332504 |

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PART DATA

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■ EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
PRESSURE SEALS, HATCHES "C" & "D"

■ QUANTITY OF LIKE ITEMS: 4
TWO SEALS PER HATCH "C"
TWO SEALS PER HATCH "D"

■ FUNCTION:
THE PERIMETERS OF BOTH HATCH "C" AND HATCH "D" ARE EACH SEALED WITH TWO (DUAL/REDUNDANT) CONCENTRIC ANNULAR O-RING SEALS IN DOVETAIL GROOVES. AN INNER SEAL IS ON EACH HATCH AND AN OUTER SEAL IS ON EACH FLANGE OF THE TUNNEL ADAPTER.

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE
NUMBER: M7-3-M7-01



REVISION# 1 05/17/91 R

SUBSYSTEM: TUNNEL ADAPTER
LRU :HATCH "C" AND "D" SEALS
ITEM NAME: HATCH "C" AND "D" SEALS

CRITICALITY OF THIS FAILURE MODE:1R2

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■ FAILURE MODE:
LEAKAGE (O-RING SEALS)

MISSION PHASE:
OO ON-ORBIT

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

■ CAUSE:
CRACKS, LOW TEMPERATURE, MATERIAL DEGRADATION, WEAR, SEAL DAMAGED OR DISPLACED

■ CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

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■ REDUNDANCY SCREEN A) PASS
■ B) FAIL
■ C) PASS

PASS/FAIL RATIONALE:
■ A)
PASSES REDUNDANCY SCREEN "A" SINCE THE HATCH (DUAL/REDUNDANT) SEAL INTEGRITY IS VERIFIED DURING GROUND TURNAROUND.

■ B)
FAILS REDUNDANCY SCREEN "B" SINCE THE FLIGHT CREW CANNOT VERIFY THE (DUAL/REDUNDANT) SEAL INTEGRITY WHILE IN FLIGHT. PNEUMATIC PORTABLE TEST KIT C70-0749 IS NOT FLIGHT EQUIPMENT.

■ C)
PASSES REDUNDANCY SCREEN "C" SINCE THE FAILURE OF ANY ONE SEAL CANNOT CAUSE THE FAILURE OF THE OTHER REDUNDANT SEAL.

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- FAILURE EFFECTS -

■ (A) SUBSYSTEM:
NO EFFECT IF ONLY A SINGLE O-RING SEAL FAILS. FAILURE OF BOTH SEALS WOULD RESULT IN LOSS OF CABIN ATMOSPHERE TO THE OUTSIDE AND INCREASED USE OF CREW MODULE CONSUMABLES O2/N2.

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

■ (C) MISSION:
NO EFFECT IF A SINGLE SEAL FAILS. POSSIBLE EARLY TERMINATION OF MISSION IF BOTH SEALS FAIL, LOSS OF EMERGENCY EVA IF BOTH SEALS FAIL.

■ (D) CREW, VEHICLE, AND ELEMENT(S):
NO EFFECT IF A SINGLE SEAL FAILS. POSSIBLE LOSS OF CREW/VEHICLE IF LEAK RATE FROM DUAL SEAL FAILURE AND AN ADDITIONAL SEAL FAILURE WITHIN THE CREW MODULE EXCEEDS THE ARPCS MAKEUP CAPABILITY; LOSS OF EMERGENCY EVA IF BOTH SEALS FAIL.

■ (E) FUNCTIONAL CRITICALITY EFFECTS:

- DISPOSITION RATIONALE -

■ (A) DESIGN:
WHEN THE TUNNEL ADAPTER HATCHES ARE CLOSED, REDUNDANT CONCENTRIC O-RING FACE SEALS ARE COMPRESSED BY SIX LATCHES (HATCH "C") OR 17 LATCHES (HATCH "D") DRIVEN BY A MANUALLY OPERATED ACTUATOR. THE SEALS ARE BONDED INTO DOVETAIL GROOVES, ONE IN HATCH AND ONE IN TUNNEL ADAPTER FLANGE. THE HATCH IS A RIGID STRUCTURE. THE SEAL MATERIAL IS SILICONE RUBBER.

■ (B) TEST:
ACCEPTANCE TESTS: STRUCTURAL LEAK TEST OF TUNNEL ADAPTER TO 14.7 PSID IS PERFORMED.

QUALIFICATION TESTS: QUALIFICATION TESTS OF HATCH STRUCTURE PER TR S104018 INCLUDED PROOF PRESSURE TEST TO 17.7 PSID. QUALIFICATION TESTS OF SIDE HATCH INCLUDED HATCH STRUCTURAL TEST PER TR S104018 AND 2,000 OPERATING CYCLES OPEN AND CLOSE.

OMRSD: EACH SEAL CAN BE VERIFIED BY PRESSURIZING TO 15 PSID BETWEEN SEALS USING TEST PORT AND PORTABLE TEST KIT.

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REF. OMRSD V60AB0.035.

■ (C) INSPECTION:
RECEIVING INSPECTION
RECEIVING INSPECTORS INSPECT FOR DAMAGE AND WORKMANSHIP AND VERIFY THAT SEAL IS OF SINGLE PIECE MOLDED CONSTRUCTION. RECEIVING INSPECTORS CHECK IDENTIFICATION AND WALL CROSS-SECTIONAL DIAMETER ON A S-3 SAMPLING BASIS. IT IS ALSO VERIFIED THAT THE SUPPLIER SUBMITTED THE REQUIRED REPORTS.

CONTAMINATION CONTROL
RECEIVING INSPECTORS VISUALLY INSPECT SEAL FOR CLEANLINESS. INSPECTORS VERIFY, BEFORE INSTALLATION, THAT THE SEAL AND SEALING SURFACE ARE CLEAN, PER MA0106-328.

ASSEMBLY/INSTALLATION
THE SEALS ARE INSTALLED PER MA0106-328. PRIOR TO INSTALLATION AN INSPECTION IS PERFORMED TO VERIFY THAT THE SEALING SURFACE IS NOT DAMAGED.

CRITICAL PROCESSES
BONDING OF SEALS PER MA0106-328 IS VERIFIED BY INSPECTION.

TESTING
THE TUNNEL ADAPTER HIGH PRESSURE TEST TO 14.7 PSID, AND LOW PRESSURE TESTS TO 3.2 PSID ARE VERIFIED BY INSPECTION.

HANDLING/PACKAGING
THE RECEIVING INSPECTORS VERIFY THAT THE SEAL IS INDIVIDUALLY PACKAGED WITH PART NUMBER, MANUFACTURER NAME, COMPOUND NUMBER AND CURE DATE. RECEIVING INSPECTORS ALSO VERIFY THAT THE SEAL IS PACKAGED IN A WAY THAT WILL PROTECT IT DURING STORAGE.

■ (D) FAILURE HISTORY:
CAR NO. AC7947: DURING INGRESS/EGRESS HATCH SEAL CHECK, PRESSURE COULD NOT BE MAINTAINED WITHIN TOLERANCE (LOST 1.5 LB IN ONE MINUTE, SHOULD HAVE MAINTAINED WITHIN 1 LB IN ONE MINUTE); FAILURE ANALYSIS OF THE ORIGINAL SEALS INDICATED A CONFUSION AS TO PART NUMBER SINCE PART NUMBER WAS NOT IDENTIFIED TO THE PART BY DASH NUMBER WHICH COULD CAUSE LARGER OR SMALLER SEALS TO BE INSTALLED; ENGINEERING ACTIONS (E.O. A-09, V070-332504) APPROVED TO MARK SEALS AND PROMOTE CLOSER ATTENTION TO SEAL HANDLING.

CAR NO. 06F015: DURING OV-099 ON ORBIT OPERATION OF AIRLOCK HATCH "A" IN STS-6 MISSION, THE SEAL IN AIRLOCK FLANGE (OUTER SEAL) PARTIALLY CAME OUT OF ITS RETAINING GROOVE; FAILURE CAUSED BY A COMBINATION OF AN UNDERSIZE SEAL, AN OVERSIZE GROOVE, AND SEAL STICKING TO THE MATING

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SURFACE; ALUMINUM TAPE WAS ADDED TO THE SIDE WALLS OF THE SEAL GROOVE IN THE AIRLOCK FLANGE OF HATCH "A" WHERE OVERSIZE, AND BOTH SEALS (IN HATCH AND AIRLOCK FLANGE) WERE REPLACED TO RESTORE RETAINING GROOVE AND SEAL DIMENSIONS.

CAR NO. AB6601: OV-102 AIRLOCK HATCH "B" SEALS HAD A LEAK RATE OF 2.9 PSI IN ONE MINUTE (SHOULD BE 1.0 PSI MAXIMUM IN ONE MINUTE); AIRLOCK HATCH SEAL LEAKAGE WAS CAUSED BY INSUFFICIENT COMPRESSION OF SEALS DUE TO ADVERSE TOLERANCE BUILDUP BETWEEN SEALS AND GROOVES OR PERMANENT SET OF SEALS; INNER AND OUTER SEALS WERE REMOVED AND REPLACED WITH NO CORRECTIVE ACTION REQUIRED AS TOLERANCES ON SEAL DIAMETER, GROOVE DIMENSIONS AND LATCH ROLLERS WERE SATISFACTORY WITH SEAL LEAKAGE REQUIREMENTS.

CAR NO. AC7792: DURING OV-099 AIRLOCK HATCH "B" OPERATIONS, THE SEAL BONDED IN AIRLOCK FLANGE CAME OUT OF GROOVE WHEN HATCH WAS OPENED; FAILURE CAUSED BY BOND FAILURE AND SEAL STICKING TO THE MATING SURFACE AS A RESULT OF AN IMPROPERLY POST CURED SEAL; SEALS RE-BONDED (FUTURE OCCURRENCES IN FLIGHT WOULD REQUIRE A SUITED CREWMEMBER TO REPLACE THE SEAL OR IF SEAL DAMAGE OCCURS DURING HATCH CLOSING, THE REDUNDANT SEAL WOULD BE CAPABLE OF MEETING MAXIMUM ALLOWABLE LEAKAGE REQUIREMENTS).

■ **(E) OPERATIONAL USE:**
IF BOTH SEALS FAIL ON TUNNEL ADAPTER HATCH "C", INCREASED USE OF CREW MODULE CONSUMABLES CAN BE MONITORED AND ASSESSED FOR FEASIBILITY OF CONTINUING THE MISSION PER CABIN LEAK PROCEDURES AND FLIGHT RULES.
IF BOTH SEALS FAIL ON TUNNEL ADAPTER HATCH "D", EMERGENCY EVA MAY REQUIRE DEPRESSURIZATION OF SPACELAB.

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**- APPROVALS -**

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| RELIABILITY ENGINEERING | D. M. MAYNE | D.M. Mayne |
| DESIGN ENGINEERING | E. L. SALLEE | E. L. Sallee |
| QUALITY ENGINEERING | M. SAVALA | M. Savala 6/12/91 |
| NASA RELIABILITY | | 7/17/91 |
| NASA SUBSYSTEM MANAGER | | 7/17/91 |
| NASA QUALITY ASSURANCE | | 7/17/91 |