

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE

NUMBER: 03-1-0604 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 1 11/08/00

PART DATA

| PART NAME | PART NUMBER |
|-----------------------------|----------------------|
| VENDOR NAME | VENDOR NUMBER |
| LRU : FLEX HOSE | MC271-0077-0018 |
| COAST METAL CRAFT/FMH CORP. | 92145 |
| : | |

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:

FLEX HOSE/LINE ASSEMBLY, HELIUM, LO2 MANIFOLD REPRESSURIZATION. THE LINE ASSEMBLY CONSISTS OF A FLEX HOSE, DYNATUBE FITTINGS, AND TUBE SEGMENT.

REFERENCE DESIGNATORS:

QUANTITY OF LIKE ITEMS: 1

FUNCTION:

THE FLEX HOSE ASSEMBLY PROVIDES REPRESSURIZATION CAPABILITY OF THE LO2 MANIFOLD. THE LINE ASSEMBLY PROVIDES THE FLOW PATH FOR HELIUM FROM THE LO2 REPRESSURIZATION REGULATOR (PR5) OUTLET TO THE INLETS OF THE LO2 REPRESSURIZATION CHECK VALVE (CV12) AND TO THE GO2 PRESSURIZATION MANIFOLD REPRESSURIZATION CHECK VALVE (CV10) DURING BOTH PROPELLANT DUMP AND MANIFOLD REPRESSURIZATION. THE FLEXIBLE HOSE ACCOMODATES THE VIBRATION AND STRUCTURAL DEFLECTIONS BETWEEN THE FORWARD THRUST STRUCTURE AND THE LO2 ET/ORBITER 17-INCH DISCONNECT PNEUMATIC PANEL.

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SUBSYSTEM NAME: MAIN PROPULSION

LRU: LO2 MANIFOLD PRESSURIZATION FLEX HOSE

ITEM NAME: 3/4" FLEX HOSE ASSEMBLY

CRITICALITY OF THIS

FAILURE MODE: 1R2

FAILURE MODE:

RUPTURE/LEAKAGE

MISSION PHASE:

PL PRE-LAUNCH

LO LIFT-OFF

DO DE-ORBIT

VEHICLE/PAYLOAD/KIT EFFECTIVITY:

102 COLUMBIA

103 DISCOVERY

104 ATLANTIS

105 ENDEAVOUR

CAUSE:

MATERIAL DEFECT, FATIGUE, DAMAGED BRAZE JOINTS, DAMAGED/DEFECTIVE JOINT SEALS

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

REDUNDANCY SCREEN

A) PASS

B) N/A

C) PASS

PASS/FAIL RATIONALE:

A)

B)

FAILURE IS STANDBY REDUNDANT TO LEAKAGE PAST CV10, FAILURE IS NOT DETECTABLE.

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:

DURING THE PRESSURIZED DUMP, HELIUM WILL LEAK FROM THE REPRESS SYSTEM INTO THE AFT COMPARTMENT. FAILURE HAS NO EFFECT ON THE LO2 DUMP.

(B) INTERFACING SUBSYSTEM(S):

SAME AS A.

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(C) MISSION:

NO EFFECT FOR NOMINAL, ATO, OR AOA MISSIONS.

(D) CREW, VEHICLE, AND ELEMENT(S):

SAME AS C.

(E) FUNCTIONAL CRITICALITY EFFECTS:

CASE 1:

1R/2 2 SUCCESS PATHS. TIME FRAME - PRELAUNCH, ASCENT.

- 1) LINE ASSY RUPTURES.
- 2) CHECK VALVE (CV10) FAILS TO CHECK.

GO2/GHE FROM THE ET PRESSURIZATION SYSTEM (THROUGH CV10) WILL ENTER THE AFT COMPARTMENT. POSSIBLE VIOLATION OF ET MINIMUM STRUCTURAL REQUIREMENTS. POSSIBLE LOSS OF CRITICAL FUNCTIONS DUE TO COMPONENT EXPOSURE TO HIGH PRESSURE GAS. POSSIBLE FIRE/EXPLOSION HAZARD.

LEAKAGE OF GO2/GHE IS DETECTABLE ON GROUND PRIOR TO T-31 SECONDS/T-9 MINUTES (RESPECTIVELY) USING HAZARDOUS GAS DETECTION SYSTEM (HGDS).

POSSIBLE LAUNCH SCRUB DUE TO LCC VIOLATION.

POSSIBLE LOSS OF CREW/VEHICLE.

(CHECK VALVE (CV10) FAILING TO CHECK IS NOT AN AFT COMPARTMENT OVERPRESSURIZATION CONCERN DURING PRE PRESSURIZATION SINCE THE 0.015 INCH ORIFICE (RP1) WILL PRECLUDE SUFFICIENT FLOW RATE.)

CASE 2:

1R/2 2 SUCCESS PATHS. TIME FRAME - PRELAUNCH, ASCENT.

- 1) LINE ASSY RUPTURES.
- 2) CHECK VALVE (CV12) FAILS TO CHECK.

LO2 FROM THE FEEDLINE MANIFOLD (THROUGH CV12) WILL ENTER THE AFT COMPARTMENT. POSSIBLE LOSS OF CRITICAL FUNCTIONS DUE TO COMPONENT EXPOSURE TO CRYOGENICS. POSSIBLE FIRE/EXPLOSION HAZARD.

LEAKAGE DETECTABLE ON GROUND PRIOR TO T-31 SECONDS USING HAZARDOUS GAS DETECTION SYSTEM (HGDS).

POSSIBLE LAUNCH SCRUB DUE TO LCC VIOLATION.

POSSIBLE LOSS OF CREW/VEHICLE.

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-DISPOSITION RATIONALE-

(A) DESIGN:

THE FLEX HOSE/LINE ASSEMBLY IS DESIGNED TO A MINIMUM FACTOR OF SAFETY OF 2.0 PROOF PRESSURE AND 4.0 BURST PRESSURE. THE MECHANICAL FITTINGS (DYNATUBE) ARE MANUFACTURED FROM INCONEL 718 1/2 INCH DIAMETER BY 0.025 INCH WALL THICKNESS. THE TUBE SEGMENT IS MANUFACTURED FROM 304L CRES 1/2 INCH DIAMETER BY 0.025 INCH WALL THICKNESS. ALL INCONEL TUBE ENDS ARE NICKEL PLATED.

THE FLEXIBLE HOSE ASSEMBLY IS CONSTRUCTED USING 321 CRES TUBING (1/2 INCH OUTER DIAMETER, 0.028 INCH WALL THICKNESS), FLEX LINES (321 CRES BELLOWS COVERED WITH ONE LAYER OF 321 CRES BRAID), AND ONE MECHANICAL FITTING (DYNATUBE DUAL SEAL MADE OF 718 INCONEL). THE PARTS ARE CONNECTED TOGETHER USING INERT ARC WELDING.

THE LINE SEGMENTS AND FLEXIBLE HOSE ASSEMBLY ARE CONNECTED BY INDUCTION BRAZING USING 304L CRES UNIONS AND BRAZE ALLOY PREFORMS (81.5 AU, 16.5 CU, 2 NI). THE ROCKWELL INTERNATIONAL BRAZE ALLOY WAS SELECTED BECAUSE OF ITS LOWER BRAZING TEMPERATURE REQUIREMENT THAN THE INDUSTRY STANDARD, AIDING IN THE PREVENTION OF EXCESSIVE GRAIN GROWTH AND REDUCING EROSION OF TUBE ENDS.

(B) TEST:

FLEX HOSE ASSEMBLY

ATP

EXAMINATION OF PRODUCT

PROOF PRESSURE TEST
PRESSURE: 715 PSIG

MINIMUM INSIDE DIAMETER TEST

LEAKAGE TEST
NO GREATER THAN 1×10^{-5} SCCS
PRESSURE: 350 PSIG

LENGTH VERIFICATION
PRESSURE: 350 PSIG

CERTIFICATION

SALT FOG (BY SIMILARITY TO TYPE III)

RANDOM VIBRATION
48 MINUTES IN EACH OF 3 AXES
AMBIENT TEMPERATURE AND PRESSURE
PROOF AND LEAK TEST

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POST TEST INSPECTION
LINE LENGTH
INTERNAL DIAMETER VERIFICATION
BRAID INSPECTION

BURST HYDROSTATIC TO 1400 PSIG

LINE ASSEMBLY

ATP

THE LINE ASSEMBLY IS PROOF PRESSURE TESTED TO 520 PSIG AND LEAK CHECKED AT 200 PSIG AFTER INSTALLATION IN THE VEHICLE.

CERTIFICATION

CERTIFICATION OF THE TUBING INSTALLATION WAS ACCOMPLISHED BY ROCKWELL INTERNATIONAL PER THE "ORBITER TUBING VERIFICATION PLAN SD75-SH-205".

THE 304L CRES TUBING WAS CERTIFIED FOR THE APOLLO PROPULSION SYSTEM, THE F5E, A-9, C130A, 707, 727, AND 737 AIRCRAFT. THE TUBING WAS QUALIFIED BY SIMILARITY AND BY ANALYSIS FOR ORBITER USAGE EXCEPT FOR FLEXURE FATIGUE AND RANDOM VIBRATION FOR THE LONG-LIFE ORBITER REQUIREMENTS. DATA FROM THE MISSION DUTY CYCLES CONDUCTED ON MPTA WERE ALSO USED TO CERTIFY TUBING INSTALLATIONS.

304L TUBING WITH DYNATUBE FITTINGS AND SEALS WAS SUBJECTED TO THE FOLLOWING QUALIFICATION TESTS:

PROOF PRESSURE
TWO TIMES OPERATING PRESSURE

EXTERNAL LEAKAGE
1.5 TIMES OPERATING PRESSURE
1X10⁻⁶ SCCS MAX

IMPULSE FATIGUE (200,000 CYCLES)

FLEXURE FATIGUE (10 MILLION FLEXURE CYCLES)

VIBRATION (7 UNITS)
45 MINUTES AT 0.4 G²/HZ
30 MINUTES AT 0.7 G²/HZ
10 MINUTES AT 0.2 G²/HZ

BURST TEST
FOUR TIMES OPERATING PRESSURE

OMRSD

ANY TURNAROUND CHECKOUT IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.

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(C) INSPECTION:

RECEIVING INSPECTION

INCOMING MATERIALS ARE VERIFIED FOR MATERIAL AND PROCESS CERTIFICATION. RECEIVING RECORDS AND CERTIFICATES ARE MAINTAINED FOR VERIFICATION.

CONTAMINATION CONTROL

INSPECTION VERIFIES CLEANLINESS OF INTERNAL WETTED SURFACES OF HOSES AND LINES TO LEVEL 100A. ENDS OF CLEANED TUBES ARE SEALED TO EXCLUDE CONTAMINATION. RESISTANCE TO CORROSION IS CHECKED PER REQUIREMENTS.

ASSEMBLY/INSTALLATION

ASSEMBLY SURFACE ROUGHNESS FINISHED TO 125 RMS IS VERIFIED BY INSPECTION. PARTS ARE EXAMINED TO ENSURE CLEARANCE OF BURRS AND SHARP CORNERS PRIOR TO ASSEMBLY. MANDATORY INSPECTION POINTS ARE INCLUDED IN THE MANUFACTURING PROCESS. TORQUE APPLIED TO INSTALL FLUID LINE AND FITTING IS VERIFIED IN ACCORDANCE WITH REQUIREMENT.

CRITICAL PROCESS

BRAZING AND ELECTRICAL BONDING TEST FOR TUBING ARE CHECKED AND VERIFIED BY INSPECTION. DRY FILM LUBRICANT APPLIED TO ALL MALE THREADED FLUID FITTING COUPLINGS, EXCEPT BOSS END, IS VERIFIED. ELECTROPOLISHING OF PART EXTERNAL SURFACES AND TUBE ENDS ARE VERIFIED BEFORE WELDING. ALL INERT ARC FUSION WELDED JOINTS ARE INSPECTED PER REQUIREMENT. PART PASSIVATION AND HEAT TREATMENT ARE VERIFIED TO THE SPECIFICATION.

NONDESTRUCTIVE EVALUATION

CLASS I WELDS ARE VERIFIED BY RADIOGRAPHIC INSPECTION. OTHER WELDS ARE VERIFIED BY DYE PENETRANT. HELIUM LEAK TEST IS MONITORED TO DETECT LEAKAGE FROM ASSEMBLY.

TESTING

ATP, INCLUDING PROOF PRESSURE TEST, IS WITNESSED AND VERIFIED BY INSPECTION.

HANDLING/PACKAGING

PRE-PACKAGING IS VERIFIED TO ENSURE ITEMS ARE HANDLED TO THE SPECIFIED CLEANLINESS LEVEL. HUMIDITY INDICATORS INSTALLED IN THE CONTAINER WALL OF PACKAGES MONITOR IN-TRANSIT ENVIRONMENT. ALL PACKAGING OF SHIPMENT IS VERIFIED BY INSPECTION.

(D) FAILURE HISTORY:

ONE FAILURE OCCURRED DURING QUALIFICATION FLEXURE TESTING OF THE -0003 LINE ASSEMBLY WHICH IS NOT USED ON THE VEHICLE (REFERENCE CARS A6721, A7512, A9422). STRUCTURAL FAILURE OF BRAIDS OCCURRED DUE TO BRAID LOCKUP. THE TEST FIXTURE CREATED ABNORMAL LOADING ON THE LINE CONTRIBUTING TO RUPTURE OF THE BRAID. CORRECTIVE ACTION WAS TO ADD DRY FILM LUBE TO THE EXTERNAL SURFACE. THIS ACTION IS NOT REQUIRED ON THE OTHER LINE CONFIGURATIONS.

DURING ATP CONDUCTED IN OCTOBER 1976, TWO FLEX HOSES FAILED TO PASS THE PROOF PRESSURE TEST CONDUCTED AT +1695/-153 PSIG (REFERENCE CAR A5194). THE

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HOSES FAILED BETWEEN 1200-1600 PSIG WHEN THE BRAID AT ONE END OF THE ASSEMBLY PARTED FROM THE BRAID RING AND WELD ADAPTER. INVESTIGATION REVEALED A STRENGTH DEFICIENCY AND LOW WELD EFFICIENCY IN THE BRAID MATERIAL. THE BRAID DEFICIENCY WAS CAUSED BY THE REDESIGN OF BOTH INTERCORES TO MEET FLOW INDUCED VIBRATION REQUIREMENTS. THE UNITS WERE REWORKED TO CORRECT THE BRAID DEFICIENCY. THE AFFECTED DRAWINGS AND DOCUMENTATION WERE CHANGED TO REFLECT THE REWORK. ALL VEHICLES CONTAIN THE PROPER BRAID REDESIGN.

CURRENT DATA ON TEST FAILURE, FLIGHT FAILURE, UNEXPLAINED ANOMALIES, AND OTHER FAILURES EXPERIENCED DURING GROUND PROCESSING ACTIVITY CAN BE FOUND IN THE PRACA DATABASE.

(E) OPERATIONAL USE:

NO CREW ACTION CAN BE TAKEN.

- APPROVALS -

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|---------------------|------------------------|----------------------------|
| S&R ENGINEERING | : W.P. MUSTY | : /S/ W. P. MUSTY |
| S&R ENGINEERING ITM | : P. A. STENGER-NGUYEN | : /S/ P. A. STENGER-NGUYEN |
| DESIGN ENGINEERING | : EARL HIRAKAWA | : /S/ EARL HIRAKAWA |
| MPS SUBSYSTEM MGR. | : TIM REITH | : /S/ TIM REITH |
| MOD | : BILL LANE | : /S/ BILL LANE |
| USA SAM | : MIKE SNYDER | : /S/ MIKE SNYDER |
| USA ORBITER ELEMENT | : SUZANNE LITTLE | : /S/ SUZANNE LITTLE |
| NASA SR&QA | : ERICH BASS | : /S/ ERICH BASS |