

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- NON-CIL HARDWARE**NUMBER: 03-1-0194 -X****SUBSYSTEM NAME:** MAIN PROPULSION**REVISION:** 2 02/21/01**PART DATA**

| PART NAME | PART NUMBER |
|-------------------------------|----------------------|
| VENDOR NAME | VENDOR NUMBER |
| LRU : LINE ASSEMBLY BOEING | V070-415141 |

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:

LINES UPSTREAM OF HELIUM PNEUMATIC CHECK VALVE CV9, NORMALLY UNPRESSURIZED DURING ASCENT. EACH LINE CONNECTS A THREE WAY SOLENOID VALVE TO A VALVE ACTUATOR PORT AND ANTI SLAM PORT (FILL & DRAIN VALVES ONLY).

LINES ARE BETWEEN THE FOLLOWING SOLENOID VALVES AND PNEUMATIC ACTUATORS:

| | |
|--------------|----------------------|
| LV28 TO PV9 | LV39 TO PV13 |
| LV30 TO PV10 | LV36 TO PV14, 15, 16 |
| LV32 TO PV11 | LV77 TO PV20 |
| LV34 TO PV12 | LV78 TO PV21 |

REFERENCE DESIGNATORS:**QUANTITY OF LIKE ITEMS:** 10**FUNCTION:**

EACH LINE TRANSMITS PNEUMATIC PRESSURE TO OPERATE ITS CORRESPONDING PNEUMATIC VALVE. THE VALVES CONNECTED TO THESE LINES ARE:

LO2 OUTBOARD FILL & DRAIN VALVE (PV9) AND OPENING SOLENOID (LV28),
 LO2 INBOARD FILL & DRAIN VALVE (PV10) AND OPENING SOLENOID (LV30),
 LH2 OUTBOARD FILL & DRAIN VALVE (PV11) AND OPENING SOLENOID (LV32),
 LH2 INBOARD FILL & DRAIN VALVE (PV12) AND OPENING SOLENOID (LV34),
 LH2 TOPPING VALVE (PV13) AND OPENING SOLENOID (LV39),
 LH2 RECIRCULATION VALVES (PV14,15,16) AND OPENING SOLENOID (LV36),
 LO2 POGO RECIRCULATION ISOLATION VALVES (PV20,21) AND CLOSING SOLENOID (LV77,78).

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SUBSYSTEM NAME: MAIN PROPULSION

LRU: GHE REG LEG LINE ASSY-UNPRESSURIZED

CRITICALITY OF THIS

ITEM NAME: GHE REG LEG LINE ASSY-UNPRESSURIZED

FAILURE MODE: 1R3

FAILURE MODE:

RUPTURE/LEAKAGE

MISSION PHASE:

PL PRE-LAUNCH

LO LIFT-OFF

VEHICLE/PAYLOAD/KIT EFFECTIVITY:

102 COLUMBIA

103 DISCOVERY

104 ATLANTIS

105 ENDEAVOUR

CAUSE:

FATIGUE, MATERIAL DEFECTS, IMPROPER BRAZE, DAMAGED/DEFECTIVE JOINT SEAL

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

REDUNDANCY SCREEN

A) PASS

B) N/A

C) PASS

PASS/FAIL RATIONALE:

A)

B)

FILL AND DRAIN VALVES AND TOPPING VALVE PASS B SCREEN SINCE RUPTURE/LEAKAGE IS DETECTABLE DURING MPS DUMP (PNEUMATIC VALVE FAILS TO ACTUATE).

RECIRCULATION AND POGO VALVES ARE STAND-BY REDUNDANT TO UPSTREAM SOLENOIDS FAILING ON.

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:

MAY PREVENT THE:

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APPLICATION OF OPENING PRESSURE TO THE ACTUATOR ON THE LO2 OUTBOARD FILL & DRAIN VALVE (REFERENCE FMEA/CIL 03-1-0221),
LO2 INBOARD FILL & DRAIN VALVE (REFERENCE FMEA/CIL 03-1-0223),
LH2 OUTBOARD FILL & DRAIN VALVE (REFERENCE FMEA/CIL 03-1-0270),
THE LH2 INBOARD FILL & DRAIN VALVE (REFERENCE FMEA/CIL 03-1-0272),
THE LH2 TOPPING VALVE (REFERENCE FMEA/CIL 03-1-0230),
THE LH2 RECIRCULATION VALVES (REFERENCE FMEA/CIL 03-1-0229),
THE LO2 POGO RECIRCULATION ISOLATION VALVES (REFERENCE FMEA/CIL 03-1-0243).

(B) INTERFACING SUBSYSTEM(S):

RUPTURE OF THESE LINES HAS NO EFFECT DURING ASCENT SINCE THEY ARE UNPRESSURIZED PRIOR TO MECO. RESULTS IN LOSS OF GHE SUPPLY POST MECO (WHEN THESE LINES PRESSURIZE) CAUSING INABILITY TO OPERATE RESPECTIVE VALVES AND POSSIBLE LOSS OF AFT COMPARTMENT PURGE.

WHEN THE LINES ARE PRESSURIZED FOR VALVE ACTUATION DURING PRELAUNCH OPERATIONS, LEAKAGE MAY BE DETECTABLE ON GROUND USING HAZARDOUS GAS DETECTION SYSTEM (HGDS).

(C) MISSION:

ON GROUND, POSSIBLE VIOLATION OF HGDS LCC WILL RESULT IN LAUNCH SCRUB.

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

FOR LO2 FILL AND DRAIN VALVES AND POGO VALVES, NO EFFECT.

FOR LH2 TOPPING VALVE AND RECIRCULATION VALVES, NO EFFECT.

FOR LH2 FILL AND DRAIN VALVES, CREW WILL OPEN RTLS DUMP VALVES FOR PROPELLANT DUMP AND INERTING.

(E) FUNCTIONAL CRITICALITY EFFECTS:

1R/3 3 SUCCESS PATHS. TIME FRAME - ASCENT.

- 1) RUPTURE/LEAKAGE OF AN UNPRESSURIZED GHE ACTUATOR LINE.
- 2) PREMATURE ACTUATION OF THE RUPTURED LINE'S CONTROLLING SOLENOID.
- 3) FAILURE OF CV9 TO CHECK/REMAIN CLOSED.

POSSIBLE DEPLETION OF PNEUMATIC HELIUM SUPPLY (BOTH THE ACCUMULATOR AND NON-ACCUMULATOR LEGS) CAUSING FAILURE TO CLOSE LO2 PREVALVES AT MECO. RESULTS IN THE INABILITY TO MAINTAIN INJECTED HELIUM (PROVIDED BY THE ENGINE HELIUM SUPPLY) AND LO2 PRESSURE AT THE SSME PUMP CAUSING POSSIBLE PUMP OVERSPEED AND CAVITATION AT MECO. MAY RESULT IN UNCONTAINED ENGINE DAMAGE, POSSIBLE AFT COMPARTMENT OVERPRESSURIZATION, AND FIRE/EXPLOSIVE HAZARD. AT MECO, THE ENGINE NUMBER TWO HELIUM SUPPLY IS SWITCHED INTO THE PNEUMATIC VALVE SYSTEM (VIA LV10) AS A BACKUP, BY SOFTWARE COMMAND, WHICH MAY ACTUATE THE LO2 PREVALVES CLOSED. POSSIBLE LOSS OF CREW/VEHICLE.

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-DISPOSITION RATIONALE-

(A) DESIGN:

DESIGNED TO A MINIMUM FACTOR OF SAFETY OF 2.0 PROOF AND 4.0 BURST. THE MECHANICAL FITTINGS (DYNATUBE) ARE MANUFACTURED FROM INCONEL 718. THE TUBE SEGMENTS ARE MANUFACTURED FROM 304L CRES TUBING. THE TUBE SEGMENTS AND FITTING ARE CONNECTED TOGETHER BY INDUCTION BRAZING USING A CRES UNION AND A BRAZE ALLOY PREFORM (81.5 AU, 16.5 CU, 2 NI). THE ROCKWELL INTERNATIONAL BRAZE ALLOY WAS SELECTED DUE TO ITS LOWER BRAZING TEMPERATURE REQUIREMENT THAN THE INDUSTRY STANDARD, AIDING IN THE PREVENTION OF EXCESSIVE GRAIN GROWTH AND REDUCING EROSION OF THE TUBE ENDS.

(B) TEST:

ATP

THE LINE ASSEMBLY IS PROOF PRESSURED TO 1225 PSIG AND LEAK CHECKED AT 750 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". 304L CRES TUBING WAS CERTIFIED FOR THE APOLLO PROPULSION SYSTEMS, THE F5E, A-9, C130A, 707, 727, AND 737 AIRCRAFT. THE TUBING WAS QUALIFIED BY SIMILARITY AND BY ANALYSIS FOR ORBITER USAGE EXCEPT FOR FLEXURAL FATIGUE AND RANDOM VIBRATION FOR THE LONG-LIFE ORBITER REQUIREMENTS. DATA FROM THE MISSING DUTY CYCLES CONDUCTED ON MPTA WERE ALSO USED TO CERTIFY TUBING INSTALLATIONS.

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

PROOF PRESSURE - PRESSURIZED TO TWO TIMES OPERATING PRESSURE AND HELD FOR 5 MINUTES.

EXTERNAL LEAKAGE - LEAK CHECKED AT 1-1/2 TIMES OPERATING PRESSURE. MAXIMUM ALLOWABLE LEAK RATE IS 1×10^{-6} SCCS.

BURST TEST - EXCEEDED 4 TIMES OPERATING PRESSURE.

IMPULSE FATIGUE - 200,000 CYCLES AT A CYCLIC RATE OF 70 +/- 5 CYCLES PER MINUTE FROM ZERO PSIG TO OPERATING PRESSURE TO ZERO PSIG.

FLEXURE FATIGUE - SPECIMENS WERE FILLED WITH HYDRAULIC FLUID AND PRESSURIZED TO OPERATING PRESSURE. THE SPECIMENS WERE THEN TESTED TO 10 MILLION CYCLES OF FLEXURE.

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VIBRATION - 7 TEST SPECIMENS WERE SUBJECTED TO 45 MINUTES OF RANDOM VIBRATION AT 0.4 G2/HZ, 30 MINUTES AT 0.7 G2/HZ AND 10 MINUTES AT 0.2 G2/HZ AT AMBIENT PRESSURE AND TEMPERATURE CONDITIONS.

OMRSD

ANY TURNAROUND CHECKOUT IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.

(C) INSPECTION:

RECEIVING/INSPECTION

ALL DETAIL HARDWARE IS VERIFIED, BY INSPECTION, INDIVIDUALLY AT THE DETAIL LEVEL ON MANUFACTURING ORDERS, WITH ALL PROCESSES INCORPORATED.

CONTAMINATION CONTROL

CLEANLINESS LEVEL IS VERIFIED TO 100A. CORROSION PROTECTION IS VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION

PARTS PROTECTION FROM DAMAGE AND CONTAMINATION IS VERIFIED. COMPONENTS ARE INSPECTED VISUALLY, DIMENSIONALLY, AND INCREMENTALLY FABRICATION. SEALING SURFACES PROTECTION IS VERIFIED. MACHINING VERIFIED. TORQUES ARE VERIFIED. SEALING SURFACE IS VERIFIED BY INSPECTION. MANDATORY INSPECTION POINTS ARE INCLUDED IN THE ASSEMBLY PROCEDURES.

CRITICAL PROCESS

LUBRICATION OF ALL THREADED FLUID FITTING COUPLINGS IS VERIFIED. ELECTRICAL BONDING IS VERIFIED. HEAT TREATMENT AND PART PASSIVATION ARE ALSO VERIFIED.

NON DESTRUCTIVE EVALUATION

RADIOGRAPHIC INSPECTION OF INDUCTION BRAZES IS VERIFIED BY INSPECTION.

TESTING

ATP VERIFIED BY INSPECTION.

HANDLING/PACKAGING

PACKAGING FOR SHIPMENT VERIFIED BY INSPECTION.

(D) FAILURE HISTORY:

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:

FOR LH2 FILL AND DRAIN VALVES, CREW WILL OPEN RTLS DUMP VALVES FOR PROPELLANT DUMP AND INERTING.

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- APPROVALS -

| | | |
|---------------------|------------------------|--------------------------|
| 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 | : LEE DURHAM | :/S/ LEE DURHAM |
| MPS SUBSYSTEM MGR. | : TIM REITH | :/S/ TIM REITH |
| MOD | : JEFF MUSLER | :/S/ JEFF MUSLER |
| USA SAM | : MIKE SNYDER | :/S/ MIKE SNYDER |
| USA ORBITER ELEMENT | : SUZANNE LITTLE | :/S/ SUZANNE LITTLE |
| NASA SR&QA | : BILL PRINCE | :/S/ BILL PRINCE |