

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE**

NUMBER: 03-1-0191 -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 DOWNSTREAM OF HELIUM PNEUMATIC CHECK VALVE CV9, NORMALLY UNPRESSURIZED DURING ASCENT (REFER TO FMEA/CIL 0192 FOR LO2 PREVALVE CLOSING ACTUATION LINES). EACH LINE CONNECTS A THREE-WAY SOLENOID VALVE TO A VALVE ACTUATOR PORT AND ANTI-SLAM PORT (LH2 PREVALVES ONLY).

LINES ARE BETWEEN THE FOLLOWING SOLENOID VALVES AND PNEUMATIC ACTUATORS:

LV47 TO PD1,	LV21 TO PV5
LV66 TO PD1 LATCH,	LV23 TO PV6
LV49 TO PD2,	LV72 TO PV17
LV68 TO PD2 LATCH,	LV73 TO PV18
LV51 TO PD3,	LV79 TO PV22
LV19 TO PV4,	

**REFERENCE DESIGNATORS:**

QUANTITY OF LIKE ITEMS: 11

**FUNCTION:**

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

LO2 ORB/ET FEED DISC & LATCH (PD1) AND CLOSING/UNLOCK SOLENOIDS (LV47,66); LH2 ORB/ET FEED DISC & LATCH (PD2) AND CLOSING/UNLOCK SOLENOIDS (LV49,68); LH2 ORB/ET RECIRCULATION DISCONNECT (PD3) AND CLOSING SOLENOID (LV51); LH2 PREVALVES (PV4,5,6) AND CLOSING SOLENOIDS (LV19,21,23); LH2 RTLS DUMP VALVES (PV17,18) AND OPENING SOLENOIDS (LV72,73); LH2 HIGH POINT BLEED VALVE (PV22) AND OPENING SOLENOID (LV79).

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**LRU: GHE ACCUM LEG LINE ASSY - UNPRESSURIZED**

**CRITICALITY OF THIS**

**ITEM NAME: GHE ACCUM LEG LINE ASSY - UNPRESSURIZED**

**FAILURE MODE: 1R3**

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**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? YES**

RTLS RETURN TO LAUNCH SITE  
TAL TRANS-ATLANTIC LANDING  
PAD PAD ABORT  
ATO ABORT TO ORBIT  
AOA ABORT ONCE AROUND

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**REDUNDANCY SCREEN**

A) PASS  
B) N/A  
C) PASS

**PASS/FAIL RATIONALE:**

A)

B)

RUPTURE OF LINE TO LH2 HIGH POINT BLEED LINE IS STANDBY REDUNDANT TO SOLENOID FAILS ON. FAILURE IS NOT DETECTABLE.

RUPTURE OF LINES TO OTHER VALVES IS DETECTABLE WHEN VALVES ARE OPERATED DURING POST MECO AND DUMP OPERATIONS.

C)

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**- FAILURE EFFECTS -**

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**(A) SUBSYSTEM:**

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MAY PREVENT THE:

APPLICATION OF CLOSING PRESSURE TO THE LH2 PREVALVES (REFERENCE FMEA/CIL 03-1-0228),

THE LH2 ORB/ET FEED DISC (REFERENCE FMEA/CIL 03-1-0218),

THE LO2 ORB/ET FEED DISC (REFERENCE FMEA/CIL 03-1-0220),

THE LH2 ORB/ET RECIRCULATION DISC (REFERENCE FMEA/CIL 03-1-0216);

APPLICATION OF PRESSURE TO UNLOCK THE LH2 AND/OR LO2 ORB/ET FEED DISCONNECT LATCH (REFERENCE FMEA/CIL 03-1-0264);

APPLICATION OF OPENING PRESSURE TO THE LH2 RTLS DUMP VALVES (REFERENCE FMEA/CIL 03-1-0245),

THE LH2 HIGH POINT BLEED VALVE (REFERENCE FMEA/CIL 03-1-0250).

**(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.

FOR THE LINES CONNECTING THE LH2 PREVALVE CLOSING SOLENOID TO THE PREVALVE ACTUATOR (PREVALVES ARE MAINTAINED CLOSED PRIOR TO ENGINE START) AND THE LH2 HIGH POINT BLEED OPENING SOLENOID TO THE VALVE ACTUATOR, LEAKAGE WILL BE DETECTABLE ON GROUND USING HAZARDOUS GAS DETECTION SYSTEM (HGDS).

FOR ABORTS, LH2 PREVALVE FAILS TO CLOSE TO ISOLATE A SHUTDOWN ENGINE WITH UNCONTAINED DAMAGE (ASSUMES ENGINE IS DAMAGED ONLY TO THE EXTENT THAT ISOLATION OF THE DAMAGE WILL SAFE THE SYSTEM) CAUSING POSSIBLE AFT COMPARTMENT OVERPRESSURIZATION AND FIRE/EXPLOSION HAZARD AND POSSIBLE LOSS OF CRITICAL ADJACENT COMPONENTS DUE TO CRYO EXPOSURE. FOR PAD ABORTS MAIN FUEL VALVE LEAKAGE RESULTS IN HAZARDOUS OVERBOARD LEAKAGE OF LH2.

**(C) MISSION:**

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

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

POSSIBLE LOSS OF CREW/VEHICLE FOR RTLS AND TAL ABORTS. OTHERWISE, NO EFFECT.

**(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) MPS PNEUMATIC ISOLATION VALVE (LV7 OR LV8) FAIL TO CLOSE WHEN COMMANDED BY CREW TO ISOLATE LEAK OR MPS PNEUMATIC SYSTEM FAILS TO RE-ACTIVATE WHEN COMMANDED BY CREW AT MECO-30 SECONDS.

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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 OVERPRESS, 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-**

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**(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 FITTINGS 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 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 MISSION 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 - PRESSURIZE 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  $1 \times 10^{-6}$  SCCS.

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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.

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 DURING FABRICATION. TUBE AND AXIAL ALIGNMENT OF DYNATUBE FITTINGS ARE 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 IS 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.

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**(E) OPERATIONAL USE:**

PNEUMATIC TANK, REGULATOR, AND ACCUMULATOR PRESSURE ARE ON S/M ALERT FDA SYSTEM AND THE BFS SYSTEM SUMMARY DISPLAY. THIS ALLOWS THE FLIGHT CREW TO RESPOND TO A PNEUMATIC HELIUM SYSTEM LEAK INDEPENDENT OF GROUND CONTROL.

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**- 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	: 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