

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE

NUMBER: 03-1-0190 -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 PRESSURIZED DURING ASCENT WITH 750 PSI HELIUM. EACH LINE CONNECTS A THREE WAY SOLENOID VALVE TO A VALVE ACTUATOR PORT AND ANTI-SLAM PORT (PREVALVES ONLY).

LINES ARE BETWEEN THE FOLLOWING SOLENOID VALVES AND PNEUMATIC ACTUATORS:

LV46 TO PD1	LV16 AND LV85 TO PV3
LV65 TO PD1 LATCH	LV18 TO PV4
LV48 TO PD2	LV20 TO PV5
LV67 TO PD2 LATCH	LV22 TO PV6
LV50 TO PD3	LV24 TO PV7
LV12 AND LV83 TO PV1	LV25 TO PV8
LV14 AND LV84 TO PV2	LV76 TO PV19

REFERENCE DESIGNATORS:

QUANTITY OF LIKE ITEMS: 17

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 OPENING/LOCK SOLENOIDS (LV46,65)
 LH2 ORB/ET FEED DISC & LATCH (PD2) AND OPENING/LOCK SOLENOIDS (LV48,67)
 LH2 ORB/ET RECIRCULATION DISCONNECT (PD3) AND OPENING SOLENOID (LV50);
 LO2 PREVALVES (PV1,2,3) AND OPENING SOLENOIDS (LV12,14,16,83,84,85);
 LH2 PREVALVES (PV4,5,6) AND OPENING SOLENOIDS (LV18,20,22);
 LO2 RELIEF ISOLATION SHUTOFF VALVE (PV7) AND CLOSING SOLENOID (LV24);

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LH2 RELIEF ISOLATION SHUTOFF VALVE (PV8) AND CLOSING SOLENOID (LV25);
LO2 OVERBOARD BLEED SHUTOFF VALVE (PV19) AND CLOSING SOLENOID (LV76)

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LRU: GHE ACCUM LEG LINE ASSY-NORM PRESS

CRITICALITY OF THIS

ITEM NAME: GHE ACCUM LEG LINE ASSY-NORM. PRESS

FAILURE MODE: 1R2

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) PASS

C) PASS

PASS/FAIL RATIONALE:

A)

B)

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:

MAY PREVENT OR LOSE THE:

APPLICATION OF OPENING PRESSURE TO THE ACTUATORS ON THE:

LO2 PREVALVES (REFERENCE FMEA/CIL 03-1-0225),

LH2 PREVALVES (REFERENCE FMEA/CIL 03-1-0227),

LH2 ORB/ET FEED DISC (REFERENCE FMEA/CIL 03-1-0217),

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LO2 ORB/ET FEED DISC (REFERENCE FMEA/CIL 03-1-0219),
AND LH2 ORB/ET RECIRCULATION DISC (REFERENCE FMEA/CIL 03-1-0215);

APPLICATION OF LOCKING PRESSURE TO THE LH2 AND/OR LO2 ORB/ET FEED DISCONNECT
LATCH (REFERENCE FMEA/CIL 03-1-0263);

APPLICATION OF CLOSING PRESSURE TO:
THE LO2 RELIEF ISOLATION SHUTOFF VALVE (REFERENCE FMEA/CIL 03-1-0231),
LH2 RELIEF ISOLATION SHUTOFF VALVE (REFERENCE FMEA/CIL 03-1-0232),
AND THE LO2 OVERBOARD BLEED SHUTOFF VALVE (REFERENCE FMEA/CIL 03-1-0244).

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

(C) MISSION:
ON GROUND, POSSIBLE VIOLATION OF HGDS LCC WILL RESULT IN LAUNCH SCRUB.

(D) CREW, VEHICLE, AND ELEMENT(S):
FOR 17" DISCONNECT AND LATCH RESULTS IN LOSS OF PNEUMATIC OPENING AND LATCH
LOCKING PRESSURE AND LOSS OF REDUNDANCY FOR INADVENTENT DISCONNECT
CLOSURE.

FOR LH2 4" DISCONNECT LOSS OF OPENING PNEUMATICS, LOSS OF REDUNDANCY TO
ALLOW RELIEF OF LH2 TRAPPED IN LH2 RECIRCULATION SYSTEM.

FOR LH2 PREVALVES LOSS OF PNEUMATIC OPENING PRESSURE AND LOSS OF
REDUNDANCY PREVENTING INADVERTANT VALVE CLOSURE.

FOR LH2/LO2 MANIFOLD RELIEF SHUTOFF VALVE LOSS OF PNEUMATIC CLOSING
PRESSURE RESULTING IN LOSS OF REDUNDANCY PREVENTING OVERBOARD LEAKAGE.

FOR LO2 OVERBOARD BLEED VALVE, LOSS OF REDUNDANCY AGAINST OVERBOARD
LEAKAGE.

(E) FUNCTIONAL CRITICALITY EFFECTS:

CASE 1:

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

- 1) RUPTURE OF LINE RESULTS IN HELIUM LEAKAGE FROM MPS ACCUMULATOR
SYSTEM.
- 2) MPS ISOLATION VALVE (LV7 OR LV8) FAILS TO CLOSE WHEN COMMANDED BY
CREW TO ISOLATE LEAK, OR HELIUM SYSTEM FAILS TO REACTIVATE WHEN
COMMANDED BY CREW AT MECO-30 SECONDS.

POSSIBLE DEPLETION OF VALVE ACTUATION PRESSURE CAUSING FAILURE TO CLOSE LO2
PREVALVES AT MECO. RESULTS IN THE INABILITY TO MAINTAIN INJECTED HELIUM AND LO2
PRESSURE AT THE SSME PUMP, RESULTING IN POSSIBLE PUMP OVERSPEED AND
EXPLOSION. POSSIBLE AFT COMPARTMENT OVERPRESS AND FIRE/EXPLOSION HAZARD.

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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. LEAKAGE MAY BE DETECTABLE ON GROUND USING HAZARDOUS GAS DETECTION SYSTEM (HGDS). ALSO RESULTS IN LOSS OF GHE SUPPLY POST-MECO CAUSING POSSIBLE LOSS OF AFT COMPARTMENT PURGE.

CASE 2:

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

- 1) RUPTURE OF LINE RESULTS IN LOSS OF LO2/LH2 PREVALVE OPENING PRESSURE.
- 2) INADVERTENT ACTUATION OF LH2/LO2 PREVALVE CLOSING SOLENOID.

STOPS FUEL FLOW TO ONE SSME RESULTING IN PREMATURE ENGINE SHUTDOWN, PUMP CAVITATION & OVERSPEED. RESULTS IN UNCONTAINED ENGINE DAMAGE. POSSIBLE LINE RUPTURE DUE TO WATER HAMMER EFFECT (LINE PRESSURE EXCEEDS 150 PSI). POSSIBLE AFT COMPARTMENT OVERPRESS AND FIRE/EXPLOSIVE HAZARD. POSSIBLE VALVE VISOR FRACTURE AND INGESTION INTO ENGINE (ENGINE INLET SCREENS MAY NOT CONTAIN PARTS OF THIS SIZE). POSSIBLE LOSS OF CREW/VEHICLE

CASE 3:

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

- 1) RUPTURE OF LINE RESULTS IN LOSS OF LH2/LO2 17" DISCONNECT OPENING PRESSURE.
- 2) INADVERTENT ACTUATION OF 17" DISCONNECT CLOSING SOLENOID (DISCONNECT LATCH IS NOT CERTIFIED TO HOLD VALVE FLAPPER OPEN AGAINST ACTUATION PRESSURE).

DURING ENGINE OPERATION LH2/LO2 FLOW WILL BE TERMINATED. SURGE PRESSURE FROM VALVE CLOSURE MAY CAUSE DAMAGE OR RUPTURE TO THE MPS AND/OR ET SYSTEM, DEPENDING ON THE RATE OF CLOSURE. SHUTDOWN OF ALL THREE ENGINES WITH UNCONTAINED DAMAGE DUE TO STARVATION CUTOFF.

DURING LOADING LH2/LO2 FLOW WILL BE TERMINATED. SURGE PRESSURE FROM VALVE CLOSURE MAY CAUSE DAMAGE OR RUPTURE TO THE MPS AND/OR ET SYSTEM, DEPENDING ON THE RATE OF CLOSURE. UNABLE TO PERFORM NORMAL ET DRAIN. REQUIRES DRAIN THROUGH 4" DISCONNECT. RUPTURE OF MPS LINES WILL LEAK LH2 INTO THE AFT. POSSIBLE AFT COMPARTMENT OVERPRESS AND FIRE/EXPLOSIVE HAZARD. POSSIBLE LOSS OF ADJACENT CRITICAL FUNCTIONS DUE TO CRYO EXPOSURE. LEAKAGE DETECTABLE USING HAZARDOUS GAS DETECTION SYSTEM (HGDS). RUPTURE OF ET FEEDLINE WILL LEAK LH2 OUTSIDE OF THE VEHICLE. FIRE/EXPLOSIVE HAZARD AND POSSIBLE DAMAGE TO VEHICLE EXTERIOR.

CASE 4:

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

- 1) RUPTURE OF LINE RESULTS IN LOSS OF LH2 4" RECIRCULATION DISCONNECT OPENING PRESSURE.
- 2) INADVERTENT ACTUATION OF LH2 4" RECIRCULATION DISCONNECT CLOSING SOLENOID.
- 3) LH2 RECIRCULATION MANIFOLD RELIEF VALVE FAILS TO RELIEVE.

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RESULTS IN RUPTURE OF THE RECIRCULATION RETURN SYSTEM. LOSS OF CRITICAL FUNCTIONS DUE TO ADJACENT COMPONENT EXPOSURE TO CRYOGENICS. POSSIBLE AFT COMPARTMENT OVERPRESSURIZATION AND FIRE HAZARD. ALSO RESULTS IN LOSS OF HELIUM SUPPLY DURING MANIFOLD REPRESSURIZATION CAUSING LOSS OF AFT COMPARTMENT PURGE. POSSIBLE LOSS OF CREW/VEHICLE.

CASE 5:

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

- 1) RUPTURE OF LINE RESULTS IN LOSS OF LH2/LO2 MANIFOLD RELIEF SHUTOFF VALVE CLOSING PRESSURE.
- 2) LH2/LO2 MANIFOLD RELIEF VALVE FAILS TO REMAIN CLOSED/INTERNAL LEAKAGE.

LH2/LO2 WILL DUMP OVERBOARD RESULTING IN PROPELLANT LEAKAGE ON TO THE PAD SURFACE. FIRE/EXPLOSION HAZARD EXTERIOR TO THE VEHICLE AND ON THE PAD. FIRE AND/OR LEAKAGE MAY BE DETECTABLE USING TV CAMERAS AND FIRE DETECTOR SENSORS. POSSIBLE LOSS OF CREW/VEHICLE.

LH2/LO2 WILL DUMP OVERBOARD (640 POUNDS LH2/6200 POUNDS LO2 MAXIMUM) RESULTING IN LOSS OF PROPELLANT AND PREMATURE ENGINE SHUTDOWN. FIRE/EXPLOSION HAZARD EXTERIOR TO THE VEHICLE. POSSIBLE VIOLATION OF ET MINIMUM STRUCTURAL REQUIREMENTS DUE TO REDUCED ULLAGE PRESSURE. POSSIBLE LOSS OF CREW/VEHICLE.

CASE 6

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

- 1) RUPTURE OF LINE RESULTS IN LOSS OF LO2 OVERBOARD BLEED VALVE CLOSING PRESSURE.
- 2) LO2 OVERBOARD BLEED DISCONNECT FAILS TO REMAIN CLOSED/INTERNAL LEAKAGE.

LO2 WILL DUMP OVERBOARD (APPROXIMATELY 3000 POUNDS LO2 MAXIMUM) RESULTING IN LOSS OF PROPELLANT AND PREMATURE ENGINE SHUTDOWN. FIRE/EXPLOSION HAZARD EXTERIOR TO THE VEHICLE. POSSIBLE VIOLATION OF ET MINIMUM STRUCTURAL REQUIREMENTS DUE TO REDUCED ULLAGE PRESSURE. POSSIBLE LOSS OF CREW/VEHICLE.

-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 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.

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(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 1×10^{-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.

VIBRATION - 7 TEST SPECIMENS WERE SUBJECTED TO 45 MINUTES OF RANDOM LOCK 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

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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.

(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.

- 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