

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE**NUMBER: 03-1-0423 -X****SUBSYSTEM NAME:** MAIN PROPULSION**REVISION:** 1 02/21/01

PART DATA

	PART NAME	PART NUMBER
	VENDOR NAME	VENDOR NUMBER
LRU	: LINE ASSEMBLY, LH2 RELIEF BOEING	V070-415407

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:

LINE ASSEMBLY, LH2 RELIEF, 1 INCH DIAMETER. CONSISTS OF TUBING SEGMENT, FLANGE FITTINGS, TUBE FITTINGS, AND BRAZE JOINTS.

REFERENCE DESIGNATORS:**QUANTITY OF LIKE ITEMS:** 1**FUNCTION:**

THE LINE EXTENDS FROM THE LH2 FEEDLINE RELIEF SHUTOFF VALVE (PV8) OUTLET TO THE RELIEF VALVE (RV6) INLET, PROVIDING A PATH FOR OVERBOARD FLOW DURING RELIEF OPERATION. IT ALSO CONNECTS TO THE OUTLET OF THE RTLS REPRESS CHECK VALVE (CV30) FOR RTLS MANIFOLD REPRESSURIZATION. THE LINE ALSO CONTAINS A TEST PORT (TP25).

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SUBSYSTEM NAME: MAIN PROPULSION

LRU: LH2 RELIEF VALVE INLET LINE ASSEMBLY

ITEM NAME: LH2 RELIEF VALVE INLET LINE ASSEMBLY

CRITICALITY OF THIS

FAILURE MODE: 1/1

FAILURE MODE:

RUPTURE/LEAKAGE POST MECO.

MISSION PHASE:

PL PRE-LAUNCH
LO LIFT-OFF

VEHICLE/PAYLOAD/KIT EFFECTIVITY:

102 COLUMBIA
103 DISCOVERY
104 ATLANTIS
105 ENDEAVOUR

CAUSE:

MATERIAL DEFECT, FATIGUE FAILURE, IMPROPER BRAZE, DAMAGED/DEFECTIVE JOINT SEALS

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

REDUNDANCY SCREEN

A) N/A
B) N/A
C) N/A

PASS/FAIL RATIONALE:

A)

B)

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:

POST MECO, LH2 LEAKAGE INTO THE AFT COMPARTMENT (LINE IS NOT EXPOSED TO LH2 UNTIL RELIEF SHUTOFF VALVE (PV8) IS OPENED AT MECO). POSSIBLE LOSS OF ADJACENT CRITICAL FUNCTIONS DUE TO CRYO EXPOSURE. POSSIBLE AFT COMPARTMENT OVERPRESSURIZATION AND FIRE HAZARD.

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ALSO RESULTS IN POSSIBLE LOSS OF HELIUM SUPPLY DURING MANIFOLD REPRESSURIZATION CAUSING LOSS OF AFT COMPARTMENT PURGE.

(B) INTERFACING SUBSYSTEM(S):

SAME AS A.

(C) MISSION:

POSSIBLE LOSS OF CREW/VEHICLE.

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

SAME AS C.

(E) FUNCTIONAL CRITICALITY EFFECTS:

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

- 1) RUPTURE/LEAKAGE OF RELIEF LINE.
- 2) RELIEF SHUTOFF VALVE (PV8) FAILS TO REMAIN CLOSED.

LH2 LEAKAGE INTO THE AFT COMPARTMENT. POSSIBLE LOSS OF ADJACENT CRITICAL FUNCTIONS DUE TO CRYO EXPOSURE. POSSIBLE AFT COMPARTMENT OVERPRESSURIZATION AND FIRE HAZARD. LEAKAGE INTO AFT COMPARTMENT DETECTABLE DURING PROPELLANT LOADING USING HAZARDOUS GAS DETECTION SYSTEM (HGDS). POSSIBLE LOSS OF CREW/VEHICLE.

-DISPOSITION RATIONALE-

(A) DESIGN:

DESIGNED TO A MINIMUM FACTOR OF SAFETY OF 2.0 PROOF AND 4.0 BURST. STRUCTURAL ANALYSIS INDICATES POSITIVE MARGINS OF SAFETY FOR ALL CONDITIONS OF LINE OPERATIONS. THE TUBE MATERIAL IS 21-6-9 CRES WITH A 1.0 INCH O.D AND 0.020 INCH WALL THICKNESS. THE DYNATUBE FITTING IS MANUFACTURED FROM INCONEL 718 AND THE CROSS FITTING IS MANUFACTURED FROM 21-6-9 CRES. THE FLANGE IS MANUFACTURED FROM 21-6-9 CRES MATERIAL AND INCORPORATES A LEAK DETECTION PORT FOR MEASURING FLANGE JOINT LEAKAGE.

THE TUBE SEGMENTS, FLANGE, DYNATUBE, AND CROSS FITTING ARE CONNECTED TOGETHER BY INDUCTION BRAZING USING A 21-6-9 CRES UNION AND BRAZE ALLOY PREFORM (81.5 AU, 16.5 CU, 2 NI). THE ROCKWELL INTERNATIONAL BRAZING 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:

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ATP

THE CROSS IS PROOF PRESSURED TO 300 PSIG AND LEAK CHECKED AT 150 PSIG. THE FLANGE IS PROOF PRESSURED AT 600 PSIG AND LEAK CHECKED AT 300 PSIG.

THE LINE ASSEMBLY IS PROOF PRESSURED TO 66 PSIG AND LEAK CHECKED AT 30 PSIG AFTER INSTALLATION IN THE VEHICLE.

CERTIFICATION

CERTIFICATION OF THE TUBING INSTALLATION WAS ACCOMPLISHED BY ROCKWELL INTERNATIONAL PER THE "ORBITER TUBING VERIFICATION PLAN SD-75-SH-205". THE 21-6-9 CRES TUBING WAS PREVIOUSLY QUALIFIED FOR THE DC-10, L1011, AND 747 AIRCRAFT.

THE APOLLO INDUCTION BRAZING TECHNIQUE USING 304L AND 21-6-9 CRES TUBING WITH ROCKWELL INTERNATIONAL BRAZE UNION AND BRAZE ALLOY WAS CERTIFIED BY SUBJECTING A REPRESENTATIVE SAMPLE OF TUBE SEGMENTS TO PROOF PRESSURE, IMPULSE FATIGUE, FLEXURE FATIGUE, RANDOM VIBRATION AND BURST TEST.

TUBE SEGMENTS WERE SUBJECTED TO THE FOLLOWING:

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

IMPULSE FATIGUE
200,000 CYCLES, BENDING STRESS 20,000 PRESSURE 1000 PSIG (2 UNITS),
1500 PSIG (1 UNIT), 2000 PSIG (1 UNIT) AND 3000 PSIG (2 UNITS)

FLEXURE FATIGUE
PRESSURIZE TO OPERATING PRESSURE, 10,000,000 CYCLES

RANDOM VIBRATION
(7 UNITS) WERE SUBJECTED TO VIBRATION AT AMBIENT PRESSURE AND
TEMPERATURE CONDITIONS

BURST TESTS
2 TIMES MAX OPERATING PRESSURE

DYNATUBE FITTING TO 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 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.

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

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

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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 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

RAW MATERIALS ARE VERIFIED BY INSPECTION FOR MATERIAL AND PROCESS CERTIFICATION.

CONTAMINATION CONTROL

CLEANLINESS TO LEVEL 400 IS VERIFIED BY INSPECTION. 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. AXIAL ALIGNMENT OF DYNATUBE FITTINGS AND TUBING IS VERIFIED. TORQUES AND SEALING SURFACES ARE VERIFIED. LUBRICATION OF THREADED FLUID FITTING COUPLINGS, WHEN REQUIRED, IS VERIFIED. MANDATORY INSPECTION POINTS ARE INCLUDED IN THE ASSEMBLY PROCEDURE. INSTALLATION PER SPECIFICATION REQUIREMENTS IS VERIFIED.

CRITICAL PROCESSES

INDUCTION BRAZING IS VERIFIED BY INSPECTION. ELECTRICAL BONDING, ELECTROPOLISHING, HEAT TREATMENT, AND PARTS PASSIVATION ARE ALSO VERIFIED. NICKEL PLATING IS VERIFIED BY INSPECTION.

NONDESTRUCTIVE EVALUATION

RADIOGRAPHIC INSPECTION OF INDUCTION BRAZED JOINTS IS VERIFIED BY INSPECTION. PENETRANT INSPECTION OF DETAIL PARTS IS VERIFIED.

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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:
FLIGHT: NO CREW ACTION CAN BE TAKEN.

GROUND: GROUND OPERATIONS SAFING PROCEDURES CONTAIN SAFING SEQUENCE OF EVENTS FOR MAJOR LEAKS IN THE HYDROGEN SYSTEM.

- 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	: ERICH BASS	: /S/ ERICH BASS