

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE

NUMBER: 03-1-0457 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 2 02/22/01

PART DATA

| | PART NAME | PART NUMBER |
|-----|---------------------------|----------------------|
| | VENDOR NAME | VENDOR NUMBER |
| LRU | : LINE ASSEMBLY BOEING | V070-415519 |

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:

LINE ASSEMBLY, LH2 RECIRCULATION RELIEF AND MANIFOLD REPRESSURIZATION. 3/8 AND 3/4 INCH DIAMETER. CONSISTS OF TUBE SEGMENTS, TEES, MECHANICAL FITTINGS, AND BRAZE JOINTS. FOAM INSULATED.

REFERENCE DESIGNATORS:

QUANTITY OF LIKE ITEMS: 1

FUNCTION:

THE LINE ASSEMBLY EXTENDS FROM THE OUTLET OF THE RECIRCULATION MANIFOLD RELIEF VALVE (RV7) AND FROM THE OUTLET OF THE MANIFOLD REPRESSURIZATION CHECK VALVE (CV15) TO A PORT IN THE 17 INCH DISCONNECT (PD2) AND INLET TO THE LH2 HIGH POINT BLEED VALVE (PV22). IT PROVIDES A FLOW PATH FOR LH2/GH2 FROM THE RECIRCULATION SYSTEM TO THE FEED SYSTEM WHEN THE RECIRC RELIEF VALVE (RV7) RELIEVES/OPENS. THE LINE PROVIDES A HELIUM FLOW PATH FOR MANIFOLD REPRESSURIZATION (POST VACUUM INERT AND ENTRY).

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NUMBER: 03-1-0457-01

REVISION#: 1 02/21/01

SUBSYSTEM NAME: MAIN PROPULSION

LRU: LH2 REPRESSURIZATION LINE ASSEMBLY

ITEM NAME: LH2 REPRESSURIZATION LINE ASSEMBLY

CRITICALITY OF THIS

FAILURE MODE: 1/1

FAILURE MODE:

RUPTURE/LEAKAGE DURING LOADING, ASCENT, DUMP/INERT AND ENTRY

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

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:

LH2 LEAKAGE INTO THE AFT COMPARTMENT. GN2 PURGE OF THE AFT COMPARTMENT MAY LOWER THE GH2 CONCENTRATION, BUT THE FIRE/EXPLOSION HAZARD IS STILL PRESENT. LEAKAGE DETECTABLE ON GROUND USING HAZARDOUS GAS DETECTION SYSTEM (HGDS). POSSIBLE OVERPRESSURIZATION OF THE AFT COMPARTMENT AND FIRE/EXPLOSION HAZARD. POSSIBLE LOSS OF ADJACENT CRITICAL FUNCTIONS DUE TO CRYO EXPOSURE.

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RESULTS IN POSSIBLE LOSS OF HELIUM SUPPLY DURING MANIFOLD REPRESSURIZATION (POST VACUUM INERT AND ENTRY) 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:
NONE.

-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 LINE SEGMENTS ARE MADE OF 304 L CRES TUBING ONE IS 0.75 INCH DIAMETER, 0.028 INCH WALL THICKNESS AND THE OTHER LINE SEGMENT IS 0.38 INCH DIAMETER, 0.20 WALL THICKNESS. THE TEES ARE MANUFACTURED FROM 21-6-9 CRES AND THE DYNATUBE FITTINGS ARE INCONEL 718.

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 66 PSIG AND LEAK CHECKED AT 30 PSIG AFTER INSTALLATION IN THE VEHICLE.

CERTIFICATION

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

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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.

- 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

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REQUIRED, IS VERIFIED. MANDATORY INSPECTION POINTS ARE INCLUDED IN THE ASSEMBLY PROCEDURE.

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.

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 |