FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE
NUMBER: 03-1-0462 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 1 02/21/01

PART DATA

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

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
LINE ASSEMBLY, LH2 RELIEF VALVE SENSE, 0.38 INCH DIAMETER. CONSISTS OF TUBING SEGMENTS, MECHANICAL FITTINGS, AND BRAZE JOINTS. PARTIALLY FOAM INSULATED.

REFERENCE DESIGNATORS:

QUANTITY OF LIKE ITEMS: 1

FUNCTION:
THE LINE EXTENDS FROM THE PILOT SENSE PORT OF THE LH2 RELIEF VALVE (RV6) TO THE MOUNTING FLANGE FOR THE LH2 RECIRC PUMPS (PP1, 2, 3), PROVIDING A PATH FOR THE RELIEF VALVE TO SENSE LH2 MANIFOLD PRESSURE.

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SUBSYSTEM NAME: MAIN PROPULSION
LRU: LH2 RELIEF VALVE SENSE LINE ASSEMBLY **CRITICALITY OF THIS**
ITEM NAME: LH2 RELIEF VALVE SENSE LINE ASSEMBLY **FAILURE MODE:** 1/1

FAILURE MODE:
RUPTURE/LEAKAGE DURING LOADING, ASCENT, AND DUMP/INERT.

MISSION PHASE: PL PRE-LAUNCH
LO LIFT-OFF

VEHICLE/PAYLOAD/KIT EFFECTIVITY:
102 COLUMBIA
103 DISCOVERY
104 ATLANTIS
105 ENDEAVOUR

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

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

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

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

(D) CREW, VEHICLE, AND ELEMENT(S):
POSSIBLE LOSS OF CREW/VEHICLE.

(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 MECHANICAL FITTINGS ARE MANUFACTURED FROM INCONEL 718. THE TUBE SEGMENTS ARE MANUFACTURED FROM 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 PRESSURE TESTED 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, C13OA, 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.

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL **FAILURE MODE NUMBER: 03-1-0462-01**

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 1X10-6 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.

CRITICAL PROCESSES

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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:
FAILURE TO RECONNECT THE SENSE LINE AFTER LH2 RECIRC PUMP REPLACEMENT RESULTED IN LH2 RELIEF VALVE SEAT LEAKAGE AT MPTA (REFERENCE CAR AB8858). CORRECTIVE ACTION WAS TO RECONNECT LINE AND CAUTION PERSONNEL.

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 IS REQUIRED (FIRST FAILURE).

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