FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE
NUMBER:03-1-0461 -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, 1 INCH DIAMETER. CONSISTS OF TUBING SEGMENTS, FLANGE FITTING, AND BRAZE JOINTS.

REFERENCE DESIGNATORS:

QUANTITY OF LIKE ITEMS: 1

FUNCTION:
THE LINE EXTENDS FROM THE LH2 FEEDLINE RELIEF VALVE (RV6) OUTLET TO THE FLAME ARRESTOR (FL1), PROVIDING A PATH FOR OVERBOARD FLOW.

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SUBSYSTEM NAME: MAIN PROPULSION
LRU: LH2 RELIEF VALVE OUTLET LINE ASSEMBLY **CRITICALITY OF THIS**
ITEM NAME: LH2 RELIEF VALVE OUTLET LINE ASSEMBLY **FAILURE MODE:** 1R2

FAILURE MODE:
RUPTURE/LEAKAGE DURING POST MECO RELIEF OPERATIONS.

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)** PASS
B) N/A
C) PASS

PASS/FAIL RATIONALE:
A)

B)
LINE RUPTURE IS STAND-BY REDUNDANT TO MANIFOLD SYSTEM RELIEF.

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:
NO EFFECT FIRST FAILURE.

LH2 SYSTEM DOES NOT NOMINALLY REACH RELIEF PRESSURE.

(B) INTERFACING SUBSYSTEM(S):

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SAME AS A.

(C) MISSION:
POSSIBLE LOSS OF CREW/VEHICLE.

(D) CREW, VEHICLE, AND ELEMENT(S):
SAME AS C.

(E) FUNCTIONAL CRITICALITY EFFECTS:
CASE 1.
1R/2 2 SUCCESS PATHS. TIME FRAME - POST MECO.
1) RUPTURE/LEAKAGE OF RELIEF LINE.
2) RELIEF VALVE (RV6) FAILS TO REMAIN CLOSED.

LH2 LEAKAGE INTO 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.

CASE 2.
1R/3 3 SUCCESS PATHS. TIME FRAME - PRELAUNCH AND ASCENT.
1) RUPTURE/LEAKAGE OF RELIEF LINE.
2) RELIEF SHUTOFF VALVE (PV8) FAILS TO REMAIN CLOSED.
3) RELIEF VALVE (RV6) FAILS TO REMAIN CLOSED.

LH2 LEAKAGE INTO 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, 1.0 INCH O.D AND 0.020 INCH WALL THICKNESS. THE FLANGE IS MANUFACTURED FROM 21-6-9 CRES MATERIAL.

THE TUBE SEGMENTS AND FLANGE 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

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TEMPERATURE REQUIREMENT THAN THE INDUSTRY STANDARD, AIDING IN THE PREVENTION OF EXCESSIVE GRAIN GROWTH AND REDUCING EROSION OF TUBE ENDS.

(B) TEST:
ATP

THE FLANGE IS PROOF PRESSURE TESTED TO 600 PSIG AND LEAK CHECKED AT 300 PSIG WITH GHE. AFTER INSTALLATION THE LINE ASSEMBLY IS PROOF PRESSURE TESTED TO 300 PSIG AND LEAK CHECKED AT 40 PSIG.

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 TIME MAX OPERATING AND HELD FOR 5 MINUTES.

IMPULSE FATIGUE
200,000 CYCLES, BENDING STRESS 20,000 PSI. 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

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

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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. 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, AND PARTS PASSIVATION ARE ALSO VERIFIED.

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