

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE****NUMBER: 03-1-0433 -X****SUBSYSTEM NAME:** MAIN PROPULSION**REVISION:** 1 02/22/01

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**PART DATA**

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	<b>PART NAME</b>	<b>PART NUMBER</b>
	<b>VENDOR NAME</b>	<b>VENDOR NUMBER</b>
LRU	: LINE ASSEMBLY (LO2)	V070-415143
LRU	: LINE ASSEMBLY (LH2)	V070-415519

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**EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:**

LINE ASSY, DELTA PRESSURE LO2 & LH2. .25 DIA. CONSISTS OF TUBING SEGMENTS, DYNATUBE FITTINGS, AND BRAZE JOINTS.

**REFERENCE DESIGNATORS:****QUANTITY OF LIKE ITEMS:** 2

ONE LINE ASSY, LO2

ONE LINE ASSY, LH2

**FUNCTION:**

A TEE CONNECTS TO THE LO2 DELTA "P" TRANSDUCER. ONE LEG CONNECTS TO A FLEX LINE WHICH CONNECTS TO THE SENSE PORT OF THE REPRESS REGULATOR. THE OTHER LEG CONNECTS TO THE LO2 ORB/ET DISCONNECT (PD1). THIS FMEA/CIL DISCUSSES THIS ASSEMBLY UP TO THE FLEX LINE. REFERENCE FMEA/CIL 03-1-0607 FOR THE FLEX LINE. SIMILAR DESIGN FOR THE LH2 SYSTEM.

**FAILURE MODES EFFECTS ANALYSIS FMEA -- CIL FAILURE MODE**

**NUMBER: 03-1-0433-01**

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**SUBSYSTEM NAME: MAIN PROPULSION**

**LRU: LH2/LO2 DELTA-P TRANSDUCER LINE ASSEMBLY**

**CRITICALITY OF THIS**

**ITEM NAME: LH2/LO2 DELTA-P TRANSDUCER LINE ASSEMBLY**

**FAILURE MODE: 1/1**

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**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:**

METAL FATIGUE, MATERIAL DEFECT, IMPROPER BRAZE

**CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO**

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**REDUNDANCY SCREEN**

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

**PASS/FAIL RATIONALE:**

A)

B)

C)

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**- FAILURE EFFECTS -**

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**(A) SUBSYSTEM:**

PROPELLANT LEAK INTO AFT COMPARTMENT. POSSIBLE LOSS OF CRITICAL ADJACENT COMPONENTS DUE TO CRYOGENIC EXPOSURE. POSSIBLE AFT COMPT OVERPRESS AND FIRE/EXPLOSION HAZARD. LEAKAGE ON GROUND DETECTABLE USING HAZARDOUS GAS DETECTION SYSTEM (HGDS).

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE  
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**(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:**

1R/2 2 SUCCESS PATHS. TIME FRAME - MANIFOLD REPRESS.

- 1) SENSE LINE RUPTURE/LEAKAGE.
- 2) MANIFOLD RELIEF SYSTEM FAILS TO RELIEVE

FIRST FAILURE RESULTS IN HIGH FLOW FROM REPRESS REGULATOR. SECOND FAILURE RESULTS IN INABILITY TO RELIEVE, RUPTURE OF THE MANIFOLD AND POSSIBLE AFT COMPARTMENT OVERPRESS. LOSS OF GHE SUPPLY RESULTING IN LOSS OF ENTRY PURGE. POSSIBLE LOSS OF CREW/VEHICLE.

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**-DISPOSITION RATIONALE-**

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**(A) DESIGN:**

DESIGNED TO A MINIMUM FACTOR OF SAFETY OF 2.0 PROOF AND 4.0 BURST. THE DYNATUBE FITTINGS 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.

**(B) TEST:**

ATP

THE LO2 LINE ASSEMBLY IS PROOF PRESSURE TESTED TO 286 PSIG AND LEAK CHECKED AT 100 PSIG AFTER INITIAL INSTALLATION IN THE VEHICLE.

THE LH2 LINE ASSEMBLY IS PROOF PRESSURE TESTED TO 66 PSIG AND LEAK CHECKED AT 30 PSIG AFTER INITIAL INSTALLATION IN THE VEHICLE.

CERTIFICATION

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE  
NUMBER: 03-1-0433-01**

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 IS, THEREFORE, CONSIDERED QUALIFIED BY SIMILARITY FOR ORBITER USAGE EXCEPT FOR FLEXURAL FATIGUE AND RANDOM VIBRATION FOR THE LONG-LIFE ORBITER REQUIREMENTS.

DYNATUBE FITTINGS AND SEALS WITH 304L CRES 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  $1 \times 10^{-6}$  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 10,000,000 CYCLES OF FLEXURE.

VIBRATION - 7 TEST SPECIMENS WERE SUBJECTED TO 45 MINUTES OF TEST 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.

DATA FROM THE MISSION DUTY CYCLES CONDUCTED ON MPTA WERE ALSO USED TO CERTIFY TUBING INSTALLATIONS.

**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

CLEANLINESS LEVEL TO IS VERIFIED (400 FOR LH2 AND 800A FOR LO2). CORROSION PROTECTION IS VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION

PARTS PROTECTION FROM DAMAGE AND CONTAMINATION ARE VERIFIED. COMPONENTS ARE INSPECTED VISUALLY, DIMENSIONALLY, AND INCREMENTALLY DURING FABRICATION. TUBE AND AXIAL ALIGNMENT OF DYNATUBE FITTINGS ARE VERIFIED. TORQUES ARE

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VERIFIED. SEALING SURFACE VERIFIED BY INSPECTION. MANDATORY INSPECTION POINTS ARE INCLUDED IN THE ASSEMBLY PROCEDURES.

**CRITICAL PROCESS**

LUBRICANT TO ALL THREADED FLUID FITTING COUPLING ARE VERIFIED. ELECTRICAL BONDING IS VERIFIED. HEAT TREATMENT AND PART PASSIVATION ARE ALSO VERIFIED. EACH TUBE JOINT IS VERIFIED VISUALLY.

**NON DESTRUCTIVE EVALUATION**

RADIOGRAPHIC INSPECTION OF INDUCTION BRAZE JOINTS 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:**

FLIGHT: NO CREW ACTION CAN BE TAKEN.

GROUND: GROUND OPERATIONS SAFING PROCEDURES CONTAIN SAFING SEQUENCE OF EVENTS FOR MAJOR LEAKS IN THE PROPELLANT SYSTEMS.

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**- APPROVALS -**

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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