

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE**

NUMBER: 03-1-0421 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 1

11/08/00

**PART DATA**

	<b>PART NAME</b>	<b>PART NUMBER</b>
	<b>VENDOR NAME</b>	<b>VENDOR NUMBER</b>
LRU	: LINE, LH2 RECIRC BYPASS SENIOR FLEXONICS (KETEMA DIVISION)	MC271-0075-0011 8-031163-3
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**EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:**

LINE, LH2 RECIRC BYPASS, 2 INCH DIAMETER VACUUM JACKETED.

**REFERENCE DESIGNATORS:** FH11  
FH13  
FH15

**QUANTITY OF LIKE ITEMS:** 3  
ONE OF EACH PART NUMBER PER VEHICLE

**FUNCTION:**

EACH LINE EXTENDS FROM THE RECIRC PUMP ASSEMBLY TO THE INDIVIDUAL RECIRCULATION VALVES (PV14, 15, 16), PROVIDING A BYPASS AROUND THE CLOSED PREVALVE DURING SSME PRECONDITIONING. THE LINE HAS A VACUUM JACKET THAT INCORPORATES A RUPTURE DISK, EVACUATION VALVE, INTEGRAL SUPPORT BRACKET, THERMOCOUPLE GAGE, AND GETTER ASSEMBLY.

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**NUMBER: 03-1-0421-02**

**REVISION#: 1 11/08/00**

**SUBSYSTEM NAME: MAIN PROPULSION**

**LRU: LINE, LH2 RECIRC BYPASS**

**ITEM NAME: LINE,LH2 RECIRC BYPASS**

**CRITICALITY OF THIS**

**FAILURE MODE: 1/1**

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**FAILURE MODE:**

RUPTURE/LEAKAGE DURING, LOADING, ASCENT, AND DUMP.

**MISSION PHASE:**

PL PRE-LAUNCH

LO LIFT-OFF

**VEHICLE/PAYLOAD/KIT EFFECTIVITY:**

- 102 COLUMBIA
- 103 DISCOVERY
- 104 ATLANTIS
- 105 ENDEAVOUR

**CAUSE:**

FATIGUE FAILURE, MATERIAL DEFECT

**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:**

HAZARDS ASSOCIATED WITH LEAKAGE OF LH2 IN AFT COMPARTMENT. POSSIBLE LOSS OF CRITICAL ADJACENT COMPONENTS DUE TO CRYO EXPOSURE. POSSIBLE AFT COMPARTMENT OVERPRESSURIZATION AND FIRE/EXPLOSION HAZARD. LEAKAGE DURING LOADING DETECTABLE USING HAZARDOUS GAS DETECTION SYSTEM (HGDS). FOR ASCENT, DEPLETION OF FUEL RESULTING IN POSSIBLE PREMATURE SSME SHUTDOWN.

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**(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.

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**-DISPOSITION RATIONALE-**

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**(A) DESIGN:**

THE LH2 ENGINE RETURN LINES PRESSURE CARRIER IS CONSTRUCTED OF INCONEL 718. THE THREE GIMBAL ASSEMBLIES PROVIDE FOR DIFFERENTIAL MOVEMENT BETWEEN THE RECIRC PUMP AND THE RECIRC SHUTOFF VALVE. THE GIMBAL ASSEMBLY CONSISTS OF TWO OPPOSITE FORMED FORKS LOCATED 90-DEGREES TO EACH OTHER AND LINKED TOGETHER WITH ENTRAPPED PINS THROUGH A GIMBAL RING. THE GIMBAL JOINT INCORPORATES MULTI-PLY BELLOWS TO MINIMIZE STRESS LEVELS AND FLOW LINERS TO ELIMINATE FLOW INDUCED VIBRATION.

THE OPERATING LIFE, FOR THE MANIFOLD AND LINE ASSEMBLIES, IS 225 HOURS OF FLOW WHICH IS EQUIVALENT TO THE TOTAL FLOW PERIOD FOR 100 ORBITAL MISSIONS. THEY ARE DESIGNED FOR A MAXIMUM OPERATING PRESSURE OF 45 PSIG AT -423 DEG F AND A FLOW RATE OF 1.5 POUNDS PER SECOND. MAXIMUM STATIC PRESSURE IS 55 PSIG.

THE PROOF PRESSURE FACTOR IS 1.5 AND THE BURST PRESSURE FACTOR IS 2.0. THE PRESSURE CARRIER MEETS THE FRACTURE ANALYSIS REQUIREMENT FOR 400 MISSIONS. STRUCTURAL ANALYSIS INDICATES POSITIVE (GREATER THAN 1.4) MARGINS OF SAFETY FOR ALL CONDITIONS OF LINE OPERATION.

THE PRESSURE CARRIER WILL WITHSTAND AN IMPLOSION PRESSURE OF 40 PSID, A PRESSURE SURGE 40 TO 50 PSIG IN 200 MILLISECONDS, AND A THERMAL CHANGE FROM 70 DEG °F TO 200 DEG °F AND 70 DEG °F TO -423 DEG °F. THE VACUUM JACKET WILL WITHSTAND AN IMPLOSION PRESSURE OF 22 PSID.

**(B) TEST:**  
ATP

EXAMINATION OF PRODUCT

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VACUUM JACKET PRESSURE RISE - 3 MICRONS/DAY; 60 MICRONS MAXIMUM.

PROOF PRESSURE - 83 PSIG.

OPERATIONAL TEST

LINE ASSEMBLIES ARE SUBJECTED TO A MINIMUM OF ONE COMPLETE MOTION ENVELOPE CYCLE WHILE FILLED WITH LN2 AND PRESSURIZED TO 45 PSIG.

TEMPERATURE TEST - PRESSURIZE TO 45 PSIG; EXTERNAL TEMPERATURE STABILIZED AT 200 DEG F FOR 30 MINUTES, MEASURE VACUUM JACKET RISE RATE (3 MICRONS/DAY; 60 MICRONS MAXIMUM).

PRESSURE CARRIER AND VACUUM JACKET LEAKAGE (CRYO/AMBIENT - DOES NOT INCLUDE THE END FLANGES WHICH ARE EXTERNAL TO VACUUM JACKET).

PRESSURE CARRIER LEAKAGE - AMBIENT; 15 PSID.

CERTIFICATION

THE ENGINE NUMBER 1 AND ENGINE NUMBER 3 LINE ASSEMBLIES WERE QUALIFIED BY SIMILARITY TO THE ENGINE NUMBER 2 LINE ASSEMBLY, WHICH WAS SUBJECTED TO THE FOLLOWING QUALIFICATION TESTS:

VIBRATION - IN ALL THREE AXES, FILLED WITH LH2, AND PRESSURIZED TO 45 PSIG.

SINUSOIDAL SWEEP OVER THE FREQUENCY RANGE OF 5 TO 35 HZ.

RANDOM VIBRATION WAS MAINTAINED FOR 13.3 HRS.

ENDURANCE TEST - 2000 CYCLES WERE AT 80% ANGULATION; 200 CYCLES WERE AT EXTREME MOTION WHILE FILLED WITH LN2 AND PRESSURIZED TO 45 PSIG.

TEMPERATURE CYCLING TEST - (AMBIENT TO -150 DEG F FOR 4 HOURS; TO 275 DEG F FOR 30 MIN; TO AMBIENT).

3 CYCLES WITH LINE FILLED WITH LN2 AND PRESSURIZED TO 45 PSIG. DURING EACH CYCLE, AT LEAST ONE ANGULATION OPERATION CYCLE WAS PERFORMED.

IMPLOSION TEST - 22 PSID ACROSS VACUUM JACKET FOR 3 MINUTES; VACUUM ANNULUS PRESSURIZED TO 50 PSIG AND HELD FOR 3 MINUTES.

PRESSURE CARRIER LEAKAGE - 14.5 PSID.

VACUUM JACKET LEAKAGE - 500 MICRON MAXIMUM INCREASE DURING QUALIFICATION TESTS.

BURST TEST - NO LEAKAGE OR DAMAGE AFTER 5 MINUTES AT 110 PSIG.

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OMRSD

ANY TURNAROUND CHECKOUT IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.

**(C) INSPECTION:**

RECEIVING INSPECTION

RAW MATERIALS ARE VERIFIED BY INSPECTION FOR MATERIALS AND PROCESSES CERTIFICATION.

CONTAMINATION CONTROL

CLEANLINESS TO LEVEL 400 IS VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION

COMPONENTS ARE INSPECTED VISUALLY, DIMENSIONALLY, AND INCREMENTALLY DURING FABRICATION. MACHINING OPERATION OF FLANGE DETAIL PARTS IS VERIFIED PER DRAWING AND APPLICABLE SPECIFICATION. DRAWING TORQUE REQUIREMENTS, TOLERANCES, AND SURFACE FINISHES ARE VERIFIED BY INSPECTION. INSPECTION FOR ALIGNMENT AND VACUUM JACKET PRESSURE IS MONITORED AND VERIFIED. ELECTROETCH MARKING IDENTIFICATION OF LINES IS VERIFIED BY INSPECTION. MANDATORY INSPECTION POINTS ARE INCLUDED IN THE ASSEMBLY PROCEDURE.

CRITICAL PROCESSES

WELDING, PARTS PASSIVATION, HEAT TREATMENT, AND ELECTROPOLISH OF TUBING ARE ALL VERIFIED BY INSPECTION. LUBRICATION OF GIMBAL PINS IS VERIFIED.

NONDESTRUCTIVE EVALUATION

ETCHING AND DYE PENETRANT INSPECTION VERIFIED ON ALL MACHINED PARTS. X-RAY AND DYE PENETRANT INSPECTION OF WELDS ARE VERIFIED BY INSPECTION.

TESTING

ATP IS OBSERVED AND VERIFIED BY INSPECTION.

HANDLING/PACKAGING

PACKAGING FOR SHIPMENT IS 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.

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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	: EARL HIRAKAWA	: /S/ EARL HIRAKAWA
MPS SUBSYSTEM MGR.	: TIM REITH	: /S/ TIM REITH
MOD	: BILL LANE	: /S/ BILL LANE
USA SAM	: MIKE SNYDER	: /S/ MIKE SNYDER
USA ORBITER ELEMENT	: SUZANNE LITTLE	: /S/ SUZANNE LITTLE
NASA SR&QA	: ERICH BASS	: /S/ ERICH BASS