FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE
NUMBER: 03-1-0415 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 1 11/08/00

PART DATA

	PART NAME / **VENDOR NAME**	**PART NUMBER** / **VENDOR NUMBER**
LRU	: LINE LH2 ARROWHEAD PRODUCTS	MC271-0073-0001 13531-302

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
LINE, LH2 17 INCH DIA. VACUUM JACKETED.

REFERENCE DESIGNATORS: FH7

QUANTITY OF LIKE ITEMS: 1

FUNCTION:
THE LINE EXTENDS FROM THE ORBITER/ET DISCONNECT TO THE FEED LINE MANIFOLD. PROVIDES MEANS OF LOADING/DRAINING LH2 INTO ET & LH2 FLOW FOR SSME OPERATION. THE LINE INCORPORATES PENETRATIONS FOR LH2 PRESSURE AND TEMPERATURE TRANSDUCERS, AND VACUUM JACKET FOR INSULATION. THE VACUUM JACKET INCORPORATES A RUPTURE DISK, EVACUATION VALVE, VACUUM GAGE, AND GETTER ASSEMBLY.

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SUBSYSTEM NAME: MAIN PROPULSION
LRU: LH2 17" FEEDLINE, VACUUM JACKETED **CRITICALITY OF THIS**
ITEM NAME: LH2 17" FEEDLINE, VACUUM JACKETED **FAILURE MODE:** 1/1

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:
FATIGUE, MATERIAL DEFECT

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:
HAZARDS ASSOCIATED WITH LEAKAGE OF CRYOGENIC PROPELLANTS. DURING ENGINE OPERATION, POSSIBLE PREMATURE SHUTDOWN OF ALL SSME'S DUE TO LOSS OF PROPELLANT. POSSIBLE LOSS OF CRITICAL ADJACENT COMPONENTS DUE TO CRYO EXPOSURE. POSSIBLE AFT COMPT OVERPRESS AND FIRE HAZARD. LEAKAGE IN THE AFT COMPT DETECTABLE DURING LOADING USING HAZARDOUS GAS DETECTION SYSTEM (HGDS).

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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:
NONE.

-DISPOSITION RATIONALE-

(A) DESIGN:
THE FEEDLINE ASSEMBLY IS A 17-INCH DIAMETER LIQUID HYDROGEN FEEDLINE. THE PRESSURE CARRIER IS CONSTRUCTED OF INCONEL 718. THE THREE BALL-STRUT TIE ROD ASSEMBLIES (BSTRA) GIVE THE FEEDLINE FLEXIBILITY TO PROVIDE FOR DIFFERENTIAL MOVEMENT BETWEEN THE EXTERNAL TANK DISCONNECT AND THE LH2 FUEL MANIFOLD. THE BSTRA INCORPORATE 2 PLY BELLOWS TO MINIMIZE STRESS LEVELS AND FLOW LINERS TO ELIMINATE FLOW INDUCED VIBRATION. THE LINE IS DESIGNED FOR A MAXIMUM OPERATING PRESSURE OF 45 PSIA AT 423 DEG F AND A NOMINAL FLOW RATE OF 444 POUNDS PER SECOND. MAXIMUM STATIC PRESSURE IS 55 PSIG. THE LINE CAN WITHSTAND A PRESSURE SURGE 40 TO 50 PSIG IN 200 MILLISECONDS AND A THERMAL CHANGE FROM 200 DEG F TO MINUS 423 DEG F. THE PROOF PRESSURE FACTOR IS 1.2 AND THE BURST PRESSURE FACTOR IS 1.5. THE USEFUL DYNAMIC LIFE IS 14.2 HOURS (EQUIVALENT TO 100 ORBITER MISSIONS). 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 VACUUM JACKET WILL WITHSTAND AN IMPLOSION PRESSURE OF 22 PSI.

(B) TEST:
ATP

EXAMINATION OF PRODUCT.

VACUUM JACKET PRESSURE RISE.

PRESSURE CARRIER AND VACUUM JACKET LEAKAGE (AMBIENT).

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

PROOF PRESSURE TEST.

OPERATIONAL TEST (CRYO).

ELEVATED AMBIENT TEMPERATURE TEST.

CERTIFICATION

THE TYPE I LINE WAS SUBJECTED TO THE FOLLOWING QUALIFICATION TESTS:

ENDURANCE - 2200 STRUCTURAL DEFLECTION CYCLES WHILE FILLED WITH LN2 AND PRESSURIZED AT 45 PSIG.

PRESSURE TEST SURGE - 50 CYCLES COMPRESSED AND 50 CYCLES EXTENDED POSITION, FILLED WITH LN2 AND CYCLED FROM ZERO TO 55 TO ZERO PSIG.

THERMAL CYCLE -100 TEMPERATURE SHOCK CYCLE, AMBIENT TO MINUS 423 DEG F TO AMBIENT.

VIBRATION - IN ALL THREE AXES:

SINUSOIDAL SWEEP OVER THE FREQUENCY RANGE OF 5 TO 2000 HZ.

RANDOM VIBRATION WAS MAINTAINED AT THE INLET AND OUTLET ENDS FOR 3.9 HOURS, VIBRATION AT THE OUTLET END WAS CONTINUED FOR 9.4 HOURS AT A PRESSURE OF 35 PSIG. LINE FILLED WITH LH2, PRESSURIZED TO 30 PSIG (RANDOM VIBRATION).

PRESSURE CARRIER - EXTERNALLY PRESSURIZED IMPLOSION TEST TO 30 PSID ACROSS THE PRESSURE CARRIER.

PRESSURE CYCLE - 1140 CYCLES, PRESSURE CYCLE VARYING IN RANGE FROM 0 TO 55 PSIG AT 83% AND 90 % COMPRESSED POSITION.

BURST PRESSURE - NO LEAKAGE OR DAMAGE AFTER 5 MINUTES AT 85 PSIG.

ET/ORB UMBILICAL SEP TEST

THE 17" LINE WAS ATTACHED TO THE UMBILICAL ASSEMBLY DURING THE SEPARATION TEST PROGRAM. THE UMBILICAL/LINE ASSEMBLY WAS SUBJECTED TO RANDOM VIBRATION TESTS (4.4 HOURS PER AXIS) WHILE FILLED WITH LH2. THE LINE WAS ALSO SUBJECTED TO UMBILICAL RETRACT TESTS AT BOTH NOMINAL CONDITIONS AND SIMULATED HYDRAULIC RETRACT ACTUATOR FAILURES.

OMRSD

ANY TURNAROUND CHECKOUT IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.

(C) INSPECTION:

RECEIVING/INSPECTION

RAW MATERIALS, INCLUDING CHEMICAL AND MECHANICAL REQUIREMENTS, ARE VERIFIED BY INSPECTION FOR MATERIAL AND PROCESS CERTIFICATION.

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ASSEMBLY/INSTALLATION
SPECIAL CONSIDERATIONS GIVEN TO HIGH STRENGTH STRUCTURAL STEELS (INCONEL 718), DURING FABRICATION, IS VERIFIED. ALL COMPONENTS ARE VISUALLY, DIMENSIONALLY, AND INCREMENTALLY INSPECTED DURING FABRICATION. SEALING SURFACES PROTECTION IS VERIFIED. MACHINING OPERATION OF FLANGE DETAIL PARTS ARE PER DRAWING AND APPLICABLE SPECIFICATION AND IS VERIFIED BY INSPECTION.

NON DESTRUCTIVE EVALUATION
WELDS ARE FLUORESCENT PENETRANT AND RADIOGRAPHICALLY INSPECTED. MACHINED PARTS ARE FLUORESCENT PENETRANT INSPECTED.

TESTING
ATP VERIFIED BY INSPECTION.

CRITICAL PROCESSES
HEAT TREATMENT VERIFIED BY INSPECTION.

CONTAMINATION CONTROL
PARTS PROTECTION FROM DAMAGE AND CONTAMINATION ARE VERIFIED. CLEANLINESS TO LEVEL 400 VERIFIED BY INSPECTION.

HANDLING/PACKAGING
PACKAGING FOR SHIPMENT VERIFIED BY INSPECTION.

(D) FAILURE HISTORY:
THE OV104 LH2 TYPE II (12 INCH) LINE HAD EXCESSIVE VACUUM PRESSURE RISE AFTER ATP ELEVATED TEMPERATURE TEST. CRACKS IN THE SEALING WELD (NON-STRUCTURAL) OF THE BALL STRUT TIE ROD ASSEMBLY BELLOWS ADAPTER WERE FOUND. SEALING WELD WAS REVISED TO REDUCE THE NUGGET SIZE AND MINIMIZE THERMAL EFFECTS. EFFECTIVITY IS FOR ALL OV104 AND SUBS LINES (REFERENCE CAR AC5228). THIS IS A ONE TIME OCCURRENCE. ALL PRIOR AND SUBSEQUENT LINES HAVE PASSED ATP. THIS FAILURE IS ATP SCREENABLE.

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 -

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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