FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE
NUMBER: 03-1-0429 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 1 11/08/00

PART DATA

	PART NAME / **VENDOR NAME**	**PART NUMBER** / **VENDOR NUMBER**
LRU	: LH2 HIGH POINT BLEED LINE	MC271-0075-0010
	SENIOR FLEXONICS (KETEMA DIVISION)	8-031291-1

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
LINE, LH2 HIGH POINT BLEED, 0.75 DIAMETER VACUUM JACKETED.

REFERENCE DESIGNATORS: FH19

QUANTITY OF LIKE ITEMS: 1

FUNCTION:
THE LINE EXTENDS FROM A PORT ON THE LH2 FEED DISCONNECT (PD2) TO THE HI POINT BLEED VALVE (PV22), PROVIDING A PATH FOR GH2 TO BLEED FROM THE HIGH POINT OF THE ENGINE FEED SYSTEM. BLEED OPERATION IS INITIATED AT THE START OF FAST FILL AND TERMINATES AT HI POINT BLEED VALVE CLOSURE (APPROXIMATELY T-20 SECONDS). THE LINE HAS A VACUUM JACKET THAT INCORPORATES A RUPTURE DISC, EVACUATION VALVE, INTEGRAL SUPPORT BRACKET, THERMOCOUPLE GAGE, AND GETTER ASSEMBLY.

FAILURE MODES EFFECTS ANALYSIS FMEA -- CIL FAILURE MODE

NUMBER: 03-1-0429-01

REVISION#: 1 11/08/00

SUBSYSTEM NAME: MAIN PROPULSION
LRU: LH2 HIGH POINT BLEED LINE, FH19 **CRITICALITY OF THIS**
ITEM NAME: LH2 HIGH POINT BLEED LINE, FH19 **FAILURE MODE:** 1R2

FAILURE MODE:
LOSS OF VACUUM DURING PROPELLANT LOADING

MISSION PHASE:
PL PRE-LAUNCH
LO LIFT-OFF

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

CAUSE:
FATIGUE FAILURE, MATERIAL DEFECTS

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

REDUNDANCY SCREEN
A) PASS
B) PASS
C) PASS

PASS/FAIL RATIONALE:
A)

B)

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:
RESULTS IN EXCESSIVE HEAT LEAK INTO LH2 SYSTEM INABILITY TO MAINTAIN PROPELLANT QUALITY DURING LOADING. RESULTS IN LCC TEMPERATURE VIOLATION AND LAUNCH SCRUB.

(B) INTERFACING SUBSYSTEM(S):

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE NUMBER: 03-1-0429-01

SAME AS A.

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

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

(E) FUNCTIONAL CRITICALITY EFFECTS:
1R/2 2 SUCCESS PATHS. TIME FRAME - PRELAUNCH

1) LOSS OF LINE VACUUM JACKET, RESULTING IN LH2 MANIFOLD TEMPERATURE OUT OF LCC LIMITS (HIGH).
2) LH2 MANIFOLD TEMPERATURE TRANSDUCER (V41T1428A) -ERRONEOUS INDICATION WITHIN LCC LIMITS.

POSSIBLE GAS FORMATION IN LH2 MANIFOLD RESULTING IN GAS INGESTION INTO SSMES AT ENGINE START. RESULTS IN POSSIBLE UNCONTAINED ENGINE DAMAGE DUE TO PUMP CAVITATION. HAZARDS ASSOCIATED WITH FIRE/EXPLOSION. POSSIBLE LOSS OF CREW/VEHICLE.

-DISPOSITION RATIONALE-

(A) DESIGN:
THE LH2 HI POINT BLEED LINE PRESSURE CARRIER, INCLUDING GIMBAL ASSEMBLIES, IS CONSTRUCTED OF INCONEL 718. THE THREE GIMBAL ASSEMBLIES PROVIDE FOR DIFFERENTIAL MOVEMENT BETWEEN THE LH2 FEEDLINE DISCONNECT (PD2) AND THE HI POINT BLEED VALVE (PV22). 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 GIMBAL JOINT WAS DESIGNED TO PRECLUDE GENERATION OF PARTICLES IN EXCESS OF 400A PER MA0110-301.

THE MAX OPERATING PRESSURE IS 45 PSIG. THE MAX STATIC PRESSURE IS 55 PSIG. THE PROOF PRESSURE FACTOR IS 2.0 (110 PSIG) AND THE BURST PRESSURE FACTOR IS 4.0 (220 PSIG). STRUCTURAL ANALYSIS INDICATES POSITIVE (GREATER THAN 1.4) MARGINS OF SAFETY FOR ALL CONDITIONS OF LINE OPERATION. THE MAX PRESSURE DROP IS 0.50 PSI AT 3.5 PSIG AND A FLOW RATE OF 0.037 LBS/SEC (GH2).

THE OPERATING LIFE, FOR THE LINE ASSEMBLY, IS 225 HOURS OF FLOW WHICH IS EQUIVALENT TO THE TOTAL FLOW PERIOD FOR 100 ORBITER MISSIONS. THE PRESSURE CARRIER WILL WITHSTAND AN IMPLOSION PRESSURE OF 40 PSID. THE VACUUM JACKET WILL WITHSTAND AN IMPLOSION PRESSURE OF 22 PSID. THE LINE ASSEMBLY CAN

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0429-01

WITHSTAND A PRESSURE SURGE OF 40 TO 50 PSIG IN 200 MILLISECONDS AND A THERMAL CHANGE 70 DEG F TO 200 DEG F AND 70 DEG F TO -423 DEG F.

THE LINE ASSEMBLY IS ENCAPSULATED BY A SINGLE-PLY INCONEL 718 VACUUM JACKET, WITH THE EXCEPTION OF END FLANGES AND BOSSES. THE VACUUM JACKET CONSISTS OF STRAIGHT, CORRUGATED, AND BELLOWS SECTIONS INTERCONNECTED INTO A SINGLE ANNULUS. THE VACUUM JACKET IS SEPARATED FROM THE PRESSURE CARRIER BY APPROXIMATELY 0.5 INCH. IT IS DESIGNED TO ABSORB THE THERMAL CHANGES OF THE PRESSURE CARRIER. THE VACUUM JACKET IS SERVICED BY A SINGLE EVACUATION VALVE, THERMOCOUPLE GAGE, AND BURST DISC. THE BURST DISC RUPTURE PRESSURE IS 25 PSIG MAXIMUM. THE VACUUM JACKET WILL WITHSTAND A NEGATIVE DIFFERENTIAL PRESSURE OF 22 PSID. WHEN EVACUATED TO LESS THAN 1000 MICRONS, THE VACUUM JACKET MEETS THE LINE ASSEMBLY INSULATION REQUIREMENT OF 30.0 BTU PER HOUR PER SQUARE FOOT MAXIMUM.

THE USEFUL DYNAMIC LIFE IS 14.2 HOURS (EQUIVALENT TO 100 ORBITER MISSIONS). THE PRESSURE CARRIER MEETS THE FRACTURE ANALYSIS REQUIREMENT FOR 400 MISSIONS.

(B) TEST:
ATP

EXAMINATION OF PRODUCT

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

PROOF PRESSURE - 110 PSIG.

OPERATIONAL TEST
LINE ASSEMBLIES ARE SUBJECTED TO A 5 MOTION ENVELOPE CYCLES 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; 14.5 PSID.

CERTIFICATION

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 48 MINUTES AT THE INLET END AND 13.3 HOURS AT THE OUTLET END.

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0429-01

FLOW TEST -
MAXIMUM DELTA P OF 0.0213 PSI (0.50 ALLOWED) AT A FLOW RATE OF 0.037 LBS/SEC OF GH2 AT 3.5 PSIG.

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 - 3 CYCLES.

CHAMBER TEMPERATURE REDUCED TO -150 DEG F FOR 4 HOURS.

LINE FILLED WITH LN2.

LINE ALLOWED TO VENT WHILE CHAMBER TEMPERATURE WAS INCREASED TO 275 DEG F.

5 OPERATION CYCLES IN THE EXTREME MOTION WHILE FILLED WITH LN2 AND PRESSURIZED TO 45 PSIG.

HEAT TRANSFER TEST -
FILLED WITH LH2; CHAMBER TEMPERATURE -50 DEG F; VACUUM JACKET TEMPERATURE WAS -65 DEG F (VACUUM JACKET TEMPERATURE WARMER THAN -290 DEG F).

IMPLOSION TEST -
22 PSID ACROSS VACUUM JACKET FOR 3 MINUTES; VACUUM ANNULUS PRESSURIZED TO 52 PSIG AND HELD FOR 3 MINUTES. PRESSURE CARRIER AND VACUUM JACKET HAD NO DEFORMATION.

PRESSURE CARRIER LEAKAGE - 14.5 PSIG.

VACUUM JACKET RISE -
500 MICRON RISE DURING QUALIFICATION TESTS AND 3 MICRONS/DAY AVERAGE RISE.

BURST TEST - NO LEAKAGE OR DAMAGE AFTER 5 MINUTES AT 220 PSIG.

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

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0429-01

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:
NO CREW ACTION CAN BE TAKEN.

- 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	: 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