

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE

NUMBER: 03-1-0421 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 1

11/08/00

PART DATA

	PART NAME	PART NUMBER
	VENDOR NAME	VENDOR NUMBER
LRU	: LINE, LH2 RECIRC BYPASS SENIOR FLEXONICS (KETEMA DIVISION)	MC271-0075-0011 8-031163-3
LRU	: LINE, LH2 RECIRC BYPASS SENIOR FLEXONICS (KETEMA DIVISION)	MC271-0075-0012 8-031164-3
LRU	: LINE, LH2 RECIRC BYPASS SENIOR FLEXONICS (KETEMA DIVISION)	MC271-0075-0013 8-031165-3

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.

FAILURE MODES EFFECTS ANALYSIS FMEA -- CIL FAILURE MODE

NUMBER: 03-1-0421-01

REVISION#: 1 08/27/01

SUBSYSTEM NAME: MAIN PROPULSION

LRU: LINE, LH2 RECIRC BYPASS

ITEM NAME: LINE,LH2 RECIRC BYPASS

CRITICALITY OF THIS

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 DEFECT

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: 03-1-0421-01**

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

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.

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0421-01**

THE PRESSURE CARRIER WILL WITHSTAND AN IMPLOSION PRESSURE OF 40 PSID. THE VACUUM JACKET WILL WITHSTAND AN IMPLOSION PRESSURE OF 22 PSID 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 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.

(B) TEST:
ATP

EXAMINATION OF PRODUCT

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.

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0421-01**

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.

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.

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0421-01**

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