FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE
NUMBER: 03-1-0307 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 2 11/08/00

PART DATA

	PART NAME / **VENDOR NAME**	**PART NUMBER** / **VENDOR NUMBER**
LRU	: LINE, FILL	MC271-0076-0012
	SENIOR FLEXONICS (KETEMA DIVISION)	8-031175-3

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
LINE, LO2 FILL, FOAM INSULATED (OV103 AND SUBS). 8 INCH DIAMETER.

REFERENCE DESIGNATORS: FH1

QUANTITY OF LIKE ITEMS: 1

FUNCTION:
THE 8 INCH DIAMETER LINE EXTENDS FROM THE OUTBOARD FILL VALVE (PV9) TO THE INBOARD FILL VALVE (PV10). THE LINE IS FOAM INSULATED. PROVIDES A MEANS OF LOADING & DRAINING THE ET LO2 TANK THROUGH THE PROPELLANT FEED SYSTEM. THE INBOARD VALVE IS CLOSED AFTER COMPLETION OF LOADING IN ORDER TO GRAVITY-DRAIN THE FILL LINE (PRIOR TO CLOSING THE OUTBOARD FILL & DRAIN VALVE). BOTH THE INBOARD AND OUTBOARD VALVES REMAIN CLOSED DURING ENGINE OPERATION. THE INBOARD VALVE ALSO INCORPORATES A RELIEF VALVE, RELIEVING ANY PRESSURE BUILD-UP IN THE FILL LINE. THE LINE TRANSPORTS OXYGEN OVERBOARD DURING PROPELLANT INERTING (NOMINAL MISSIONS) AND DUMP (RTLS AND TAL MISSIONS). THE LINE IS PRESSURIZED WITH HELIUM DURING ENTRY. THE LINE INCORPORATES PENETRATIONS FOR LO2 PRESSURE AND TEMPERATURE TRANSDUCERS.

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SUBSYSTEM NAME: MAIN PROPULSION
LRU: LINE, LO2 FILL/DRAIN, INSULATED **CRITICALITY OF THIS**
ITEM NAME: LINE, LO2 FILL/DRAIN, INSULATED **FAILURE MODE:** 1/1

FAILURE MODE:
RUPTURE/LEAKAGE DURING PROPELLANT LOADING, DETANKING, AND DUMP/INERT

MISSION PHASE:
PL PRE-LAUNCH
LO LIFT-OFF

VEHICLE/PAYLOAD/KIT EFFECTIVITY:

103 DISCOVERY
104 ATLANTIS
105 ENDEAVOUR

CAUSE:
MATERIAL DEFECT, FATIGUE

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:
PROPELLANT LEAK INTO AFT COMPARTMENT. POSSIBLE LOSS OF CRITICAL ADJACENT COMPONENTS DUE TO CRYOGENIC EXPOSURE. POSSIBLE AFT COMPT OVERPRESS AND FIRE/EXPLOSION HAZARD. ALSO RESULTS IN LOSS OF HELIUM SUPPLY DURING MANIFOLD REPRESS CAUSING LOSS OF AFT COMPARTMENT PURGE. LEAKAGE DETECTABLE ON GROUND 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:
1R/2 2 SUCCESS PATHS. TIME FRAME - ASCENT.
1) FILL & DRAIN LINE RUPTURE/LEAKAGE.
2) INBOARD FILL & DRAIN (PV10) FAILS TO REMAIN CLOSED.

RESULTS IN LO2 LEAKAGE INTO THE AFT COMPARTMENT. POSSIBLE AFT COMPARTMENT OVERPRESS AND FIRE/EXPLOSIVE HAZARD. POSSIBLE LOSS OF CRITICAL ADJACENT COMPONENTS DUE TO CRYO EXPOSURE. GROSS LINE LEAKAGE MAY ALSO CAUSE PROPELLANT DEPLETION RESULTING IN PREMATURE SSME CUTOFF. POSSIBLE LOSS OF CREW/VEHICLE.

-DISPOSITION RATIONALE-

(A) DESIGN:
THE PRESSURE CARRIER PORTION OF THE LINE ASSEMBLY IS CONSTRUCTED OF INCONEL 718 AND INCORPORATES THREE FLEXIBLE JOINTS AND A FLANGE AT EACH END. THE FLEXIBLE JOINTS INCORPORATE MULTI-PLY BELLOWS TO MINIMIZE STRESS LEVELS AND FLOW LINERS TO ELIMINATE FLOW INDUCED VIBRATION. THE FLEXIBLE JOINTS PROVIDE FREE MOVEMENT WITHOUT BINDING TO ACCOMMODATE THERMAL, STRUCTURAL AND VIBRATION INDUCED DEFLECTIONS.

THE MAXIMUM OPERATING PRESSURE DURING GROUND FILL OR DRAIN IS 103 PSIG (AT 10,000 GPM, MINUS 297 DEG F) AND 260 PSIG AT STATIC CONDITIONS. THE MAXIMUM OPERATING PRESSURE DURING LIFTOFF, BOOST, ORBIT, REENTRY, AND LANDING (LINE EMPTY OF FLUID) IS 275 PSIG. THE PROOF PRESSURE FACTOR IS 1.2 (330 PSIG) AND THE BURST PRESSURE FACTOR IS 1.5 (413 PSIG). THE PRESSURE CARRIER WILL WITHSTAND AN IMPLOSION PRESSURE OF AT LEAST 40 PSID AND THERMAL CHANGE OF 90 DEG F TO MINUS 320 DEG F WITHOUT PERMANENT DISTORTION OR LEAKAGE.

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 CONDITIONS OF LINE OPERATION.

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(B) TEST:
ATP

EXAMINATION OF PRODUCT AND DIMENSIONAL VERIFICATION

LINE PROOF PRESSURE - 330 PSIG (GN2)

OPERATIONAL TEST - FILLED WITH LN2, PRESSURIZED TO 280 PSIG, SUBJECTED TO NON FLOW CONDITION FLIGHT MOTION CYCLE. NO BINDING ALLOWED.

ELEVATED AMBIENT TEMPERATURE - 275 PSIG (GHE) AT 200 DEG F FOR 30 MINUTES.

LINE LEAKAGE - 14.5 PSID (AMBIENT)

CERTIFICATION

VIBRATION - IN ALL THREE AXES

SINUSOIDAL TEST FROM 5 TO 35 HZ WAS PERFORMED AT AMBIENT CONDITIONS.

RANDOM VIBRATION WAS MAINTAINED AT THE INLET AND OUTLET ENDS FOR 3.9 HOURS AND A PRESSURE RANGE OF ZERO TO 60 PSIG.

VIBRATION AT THE OUTLET END WAS CONTINUED FOR 9.4 HOURS AT A PRESSURE RANGE OF 40 TO 250 PSIG.

DURING THE RANDOM VIBRATION TESTS THE LINE ASSEMBLY WAS MAINTAINED AT LO2 TEMPERATURES WITH THE LINE DRAINED.

FLOW TEST -
LINE ASSEMBLY WAS TESTED WITH WATER IN THE COMPRESSED CONFIGURATION.

THE FLOW WAS IN THE FILL DIRECTION ONLY.

MAXIMUM FLOW PRESSURE OF 103 PSIG THE FLOW RATE WAS 11,106 GPM.

EQUIVALENT PRESSURE DROP AT 5000 GPM (LO2) WAS 5.49 PSI (9 PSI ALLOWABLE).

ENDURANCE TEST -
THE LINE WAS MAINTAINED AT -220 DEG F OR COLDER.

2000 CYCLES WERE AT AMBIENT PRESSURE AND 80% MOTION.

200 CYCLES WERE AT AMBIENT PRESSURE AND AT THE EXTREME MOTION CYCLE.

THERMAL CYCLE -
LINE ASSEMBLY WAS STABILIZED AT -150 DEG F FOR FOUR HOURS

THE PRESSURE CARRIER WAS FILLED WITH LN2, THEN DRAINED AND THEN THE TEST CHAMBER WAS RAISED TO +275 DEG F IN 2 HRS HELD FOR 30 MINUTES.

THE CHAMBER WAS RETURNED TO AMBIENT. THE LINE WAS FILLED WITH LN2 AND PRESSURIZED TO 275 PSIG.

5 OPERATION CYCLES WERE CONDUCTED.

PRESSURE CYCLE TEST -
THE TEST ASSEMBLY WAS SUBJECTED TO A TOTAL OF 1200 CYCLES DIVIDED INTO 4 GROUPS CONSISTING OF 300 CYCLES EACH.

IN EACH GROUP THE FIRST 100 CYCLES WERE CONDUCTED WITH THE ASSEMBLY COMPRESSED 50% FROM THE NON-FLOW FLIGHT CONDITION MOTION.

THE PRESSURE CYCLE WAS FROM 10 PSIG TO 120 PSIG TO 10 PSIG WHILE AT LN2 TEMPERATURE.

THE NEXT 185 CYCLES WERE FROM 10 PSIG TO 150 PSIG TO 10 PSIG WITH THE UNIT COMPRESSED TO 20% OF THE NON-FLOW FLIGHT CONDITION MOTION.

THE PRESSURE CYCLE FOR THE LAST 15 CYCLES WAS 10 PSIG TO 270 PSIG TO 10 PSIG WITH THE UNIT MAINTAINED AT 20% COMPRESSED POSITION.

BURST TEST - NO LEAKAGE OR DAMAGE AFTER 5 MINUTES AT 413 PSIG.

GROUND TURNAROUND TEST
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.

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 IS PER DRAWING AND APPLICABLE SPECIFICATION AND IS VERIFIED BY INSPECTION.

NON DESTRUCTIVE EVALUATION
WELDS ARE FLUORESCENT PENETRANT AND RADIOGRAPHICALLY INSPECTED. MACHINED PARTS ARE ETCHED PRIOR TO FLUORESCENT PENETRANT INSPECTION.

TESTING
ATP VERIFIED BY INSPECTION.

CRITICAL PROCESSES
DETAIL PARTS ARE VISUALLY INSPECTED FOR MATERIAL DEFECTS. HEAT TREATMENT VERIFIED BY INSPECTION.

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CONTAMINATION CONTROL
PARTS PROTECTION FROM DAMAGE AND CONTAMINATION ARE VERIFIED. CLEANLINESS TO LEVEL 800A 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 OXYGEN SYSTEM.

- 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