

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE

NUMBER: 03-1-0416 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 2 11/08/00

PART DATA

	PART NAME	PART NUMBER
	VENDOR NAME	VENDOR NUMBER
LRU	: LH2 MANIFOLD ARROWHEAD PRODUCTS	MC271-0073-0005 13535-302

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:

LH2 MANIFOLD 17 INCH DIA. VACUUM JACKETED.

REFERENCE DESIGNATORS: MA2

QUANTITY OF LIKE ITEMS: 1

FUNCTION:

THE 17 IN. DIA. MANIFOLD EXTENDS FROM THE 17 IN. MAIN DUCT TO THE FLANGE ATTACHMENTS FOR THE 3 INDIVIDUAL PREVALVES. PROVIDES MEANS OF LOADING/DRAINING LH2 INTO THE ET AND LH2 FLOW FOR SSME OPERATION. THE MANIFOLD ASSY CONTAINS A FLANGE FOR ATTACHMENT OF THE INBOARD FILL VALVE, AND A FLANGE TO MOUNT THE RECIRCULATION PUMP. THE MANIFOLD INCORPORATES A VACUUM JACKET FOR INSULATION. THE VACUUM JACKET INCORPORATES A RUPTURE DISK, EVACUATION VALVE, VACUUM GAGE, AND GETTER ASSEMBLY.

FAILURE MODES EFFECTS ANALYSIS FMEA -- CIL FAILURE MODE

NUMBER: 03-1-0416-02

REVISION#: 1 08/17/01

SUBSYSTEM NAME: MAIN PROPULSION

LRU: LH2 17" MANIFOLD

ITEM NAME: LH2 17" MANIFOLD

CRITICALITY OF THIS

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 PRESSURE CARRIER SUB-ASSEMBLY OF THE MANIFOLD IS CONSTRUCTED OF INCONEL 718. THE MANIFOLD HAS LUGS FOR ATTACHMENT TO THE AFT FUSELAGE STRUCTURE AND SIX FLANGES TO PERMIT ATTACHMENT OF THREE ENGINE FEEDLINE PREVALVES, LH2 INLET LINE, LH2 RECIRC PUMP, AND FILL/DRAIN LINE. THE LH2 INLET FLANGE INCORPORATES LEAK DETECTION PORTS. THE MANIFOLD IS DESIGNED FOR A MAXIMUM OPERATING PRESSURE OF 45 PSIA AT -423 DEG F AND AN INLET FLOW RATE OF 444 POUNDS PER SECOND, NOMINAL. MAXIMUM STATIC PRESSURE IS 55 PSIG. THE LINE CAN WITHSTAND A PRESSURE SURGE FROM 40 PSIG TO 50 PSIG IN 200 MILLISECONDS AND A THERMAL CHANGE FROM 200 F TO MINUS 423 °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 MANIFOLD OPERATION.

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 AN IMPLOSION PRESSURE OF 22 PSI. 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.

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(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.

ELEVATED AMBIENT TEMPERATURE TEST.

FLANGE LEAKAGE TEST AT AMBIENT AND CRYO CONDITIONS.

CERTIFICATION TEST

THE TYPE 5 LH2 MANIFOLD LINE ASSEMBLY WAS SUBJECTED TO THE FOLLOWING QUALIFICATION TESTS:

THERMAL CYCLE - 110 CYCLES FROM ROOM AMBIENT TO 423 F TO ROOM AMBIENT.

PRESSURE CYCLING - 100 CYCLES FROM 0 PSIG TO 55 PSIG AND BACK TO ZERO PSIG WHILE FILLED WITH LN2.

EXTERNAL LOADS TEST - MANIFOLD FILLED WITH LN2 AND PRESSURIZED TO 40 PSIG DURING 5 FLANGE LOAD CASES. EACH LOAD CASE CONSISTED OF:

- A. 400 CYCLES AT 72% OF LIMIT LOAD.
- B. 40 CYCLES AT 90% OF LIMIT LOAD
- C. 1 CYCLE AT 120% OF LIMIT LOAD.

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

VIBRATION - ALL THREE AXES.

SINUSOIDAL RESONANCE SURVEY FROM 5 TO 2000 HZ WAS CONDUCTED WITH THE LINE PRESSURIZED TO 20 PSIG WITH HELIUM.

RANDOM VIBRATION TEST WERE CONDUCTED 13.3 HOURS IN EACH AXIS. THE TESTS WERE PERFORMED WITH THE LINE FILLED WITH LIQUID HYDROGEN AND PRESSURIZED TO 35 PSIG.

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

OMRSD

ANY TURNAROUND CHECKOUT IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.

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(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 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.

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- 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