

CRITICAL ITEMS LIST (CIL)

SYSTEM:	Propulsion/Mechanical	FUNCTIONAL CRIT:	1
SUBSYSTEM:	GH2 Pressurization	PHASE(S):	a, b, c
REV & DATE:	J, 12-19-97	HAZARD REF:	P.03, P.06,
DCN & DATE:			P.07, S.04,
ANALYSTS:	E. Flauss, H. Claybrook		S.05, S.06,
			S.11

FAILURE MODE: Leakage

FAILURE EFFECT: a) Loss of mission and vehicle/crew due to fire/explosion.
 b) Loss of mission and vehicle/crew due to fire/explosion or LH2 tank structural failure.
 Loss of mission due to premature engine shutdown caused by loss of NPSP.
 c) Loss of life due to ET impact outside designated footprint.

TIME TO EFFECT: Seconds

FAILURE CAUSE(S): A: Structural Failure of Hardline Component
 B: Flange Mating Surface Defects
 C: Structural Failure of Flex Joint
 D: Seizure of Flex Joint
 E: Structural Failure of Pivotal Support Component
 F: Structural Failure of Tank Mounting Bracket
 G: Seizure of Pivotal Support Bearing
 H: Structural Failure of Guide Rail
 I: Fracture of One Attachment Bolt

REDUNDANCY SCREENS: Not Applicable

FUNCTIONAL DESCRIPTION: Transports GHe/GH2 during prelaunch and GH2 during ascent to maintain LH2 tank ullage pressure requirements.

<u>FMEA ITEM CODE(S)</u>	<u>PART NO.</u>	<u>PART NAME</u>	<u>QTY</u>	<u>EFFECTIVITY</u>
2.7.1.1	PD4800205-009	Forward Flex Line	1	LWT-54 thru 88
	-509		1	LWT-89 & Up

REMARKS:

CRITICAL ITEMS LIST (CIL)
CONTINUATION SHEET

SYSTEM: Propulsion/Mechanical
SUBSYSTEM: GH2 Pressurization
FMEA ITEM CODE(S): 2.7.1.1

REV & DATE: J, 12-19-97
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RATIONALE FOR RETENTION

DESIGN:

The Forward Flex Line assembly consists of fixed flanges, straight tubing and tube bend sections, and 5 bellows type flexible joints. Each flexible joint contains a pressure carrier bellows and a ball strut assembly. Two supports for the line assembly are located within the intertank and provide limited line movement through a pivoting action. Attachment points are included on the line assembly and the LH2 tank forward dome. Lateral restraint is provided at the intertank penetration by guide rails. The Forward Flex Line assembly was modified for the -509 configuration by adding a third bracket to the doublers. A double fillet weld is used on the center bracket and the two outer brackets receive a single fillet weld that wraps around the bracket for added strength.

- A,C,D,
E-1: The line and support assemblies have been designed to meet the required ultimate safety factors (1.4 for loads and 1.5 for pressure) and the required yield safety factors (1.1 for loads and 1.25 for pressure) (ET Stress Report 826-2188 and ET10-SR-0002, Arrowhead). Materials selected in accordance with MMC-ET-SE16 and controlled per MMMA Approved Vendor Product Assurance Plan assures repetitive conformance of composition, material compatibility and properties.
- A, C,
D: The line assembly, except the ball within the flexible joint, is fabricated from ARMCO 21-6-9 CRES and is an all welded configuration. Emphasis has been placed on joint geometry to enhance weld integrity. The line assembly also meets the operational and nonoperational requirements defined per PD4800205. Fusion and seam welding specifications, processes, and quality controls are in accordance with MPS-MPQ-103 (Arrowhead).
- B: Flange mating seal surface flatness, waviness, and finish are specified on Engineering drawings to assure performance within the capability of the seal.
- C, D: The flexible joint assemblies provide for installation misalignments and recurring motions during loading and boost. The pressure carrier bellows is fabricated from 3 plies of .008 inch thick material and the joint design provides isolation from flow induced vibration. The ball located within the ball strut assembly is fabricated from Inconel 718. Vitrolube is applied to prevent seizure of the ball and strut.
- F: The mounting brackets are machined from 2219-T87 aluminum alloy plate and are welded to the LH2 forward dome.
- G: Bearings are selected to accommodate installation motion and load requirements. Vitrolube is applied to prevent seizure of the ball and race.
- H: The guide rail assembly is fabricated from 2024 aluminum alloy extruded angles. Dry film lubricant is applied per STP4002 to prevent galling.
- I: Attachment fasteners were selected from the Approved Standard Parts List (ASPL 826-3500), installed per STP2014 and torqued using values specified on engineering drawings.

TEST:

The Forward Flex Line Assembly is qualified. Reference COQ MMC-ET-TM06-083.

BSTRA Development Test: Five ball-strut tie rod assembly flexible joints were subjected to development tests to determine the torsional loading capability. In each test, loading was applied incrementally until failure occurred. Should binding occur, test results have shown that the BSTRA can resist up to 6,800 in-lb which is more than three times the maximum flight load (ET-DTR-10950-73, Arrowhead).

Qualification: Testing of one line assembly included load deflection, proof loads/operating pressure cycle, deflection and leakage for acceptance, 500 motion/operating pressure cycles, leakage, sine and random vibration, electrical bonding (for impedance), and ultimate load test at 2,650 psig for the line assembly, and tensile load test to 22,000 lb. on the tube bend subassembly for welds. There was no evidence of rupture or collapse as a result of the ultimate loads test. Leakage criteria was no bubbles (helium) at 300 psig. Two pivotal support assemblies were used to simulate flight configuration during the above sine and random vibration test. There was no evidence of support damage (MMC-ET-RA09-97).

Qualification - Support Strut End Bearings: Testing included radial static limit load (3000 lbs) and radial ultimate load (4500 lbs). Axial static limit load (300 lbs) and axial static ultimate load (450 lbs) tests were also performed. The bearing met all structural requirements (MMC-ET-RA09-107).

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RATIONALE FOR RETENTION

TEST (cont)

Acceptance:

Vendor - (Line Subassembly):

- A: Perform flight proof load test on the tube bend during the build cycle (ATP 14205, Arrowhead).
C, D: Perform load vs deflection test on each BSTR joint (ATP 14205, Arrowhead; ATP 205-309 or ATP 14205-309, Arrowhead as applicable for LWT-54 thru 88; ATP14205-509 for LWT-89 & Up).

Vendor - (Line Assembly):

- A, C, D: Perform proof loads/operating pressure test (ATP 14205, Arrowhead; ATP 205-309 or ATP 14205-309, Arrowhead as applicable for LWT-54 thru 88; ATP14205-509 for LWT-89 & Up).
C, D: Perform 4 deflection tests (2 with line unpressurized and 2 with line pressurized) (ATP 14205-309, Arrowhead for LWT-54 thru 88; ATP14205-509 for LWT-89 & Up).
A, C, D: Perform leakage rate test after proof loads/operating pressure test and deflection tests (ATP 14205-309, Arrowhead for LWT-54 thru 88; ATP14205-509 for LWT-89 & Up).
I: Attachment hardware is procured and tested to Standard drawing 26L4.

MAF - (Line Assembly):

- A, B: Perform dual seal leakage rate test on flange joints after installation (MMC-ET-TM04k).

Launch Site:

- B: Perform leakage test (OMRSD File IV for LWT-54 thru 84, 89 thru 93).
B: Perform seal leakage test on joint at station XT1082 after final assembly to flight configuration (OMRSD File IV and OMI T1402).

INSPECTION:

Vendor Inspection - Lockheed Martin Surveillance:

- A,C,E,
F,H,I: Verify materials selection and verification controls (MMC-ET-SE14 drawings 80911001316, 80921021032, 80914100996, Arrowhead drawings 14205-61, 14205-62, 14205-3, 14205-5, 14205-7, 14205-9, 14205-11, 14205-13, 10950-53-13-3, 10950-73-39-11 for all effectivities; Arrowhead drawings 14179-17-9, 14179-71, 10950-53-13, 10950-53-11 for LWT-54 thru 88; Arrowhead drawings 10950-73-39-13 14205-123 14205-125 for LWT-89 & up and Standard drawings 26L2, 26L4 and 36L11).
A, C: Inspect welding (MPS-MPQ-103, Arrowhead).
A, C: Penetrant inspect welding (MIL-I-6866, Type I, Method A).
A, C: Verify X-Ray results (QCI-16-057, Arrowhead).
B, D: Inspect dimensions (drawing 10950-73-25, Arrowhead).
B: Inspect mating surface flatness, finish and dimensions (drawing 14205-61 and 14205-63, Arrowhead).
D: Witness cleaning (MPS-MPQ-105, Arrowhead).
D, G: Verify vitrolube application (MPS-MPQ-121 Arrowhead, and Standard drawing 36L11).
H: Witness lubricant application (80911001316, STP4002, Type 2 Class 1, Solartec).

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INSPECTION (cont)

Lockheed Martin Procurement Quality Representative:

- A, C: Verify post proof x-ray results (drawing 14205-309, Arrowhead for LWT-54 thru 88; drawing 14205-509 for LWT-89 & up).
- A-D: Witness loads vs deflection, proof loads/operating pressure, deflection and leakage tests (ATP 205-309 or ATP 14205-309, Arrowhead as applicable for LWT-54 thru 88; ATP14205-509 for LWT-89 & up).
- A: Witness proof loads tests on tube bend (ATP 14205, Arrowhead).

MAE Quality Inspection:

- E, G: Verify installation and inspect bearing freedom of movement (drawing 80921021009).
- B: Inspect sealing surfaces for freedom of nicks, radial scratches or other imperfections (acceptance drawing 82620000001).
- B, Verify installation (drawing 80921021009).
- I: Verify fastener installation, inspect cotter pin installation, and witness torque (drawing 80921021009).
- B: Witness leakage tests (MMC-ET-TM04k).

Launch Site:

- A,C,E,
F,H,I: Inspect (visually) GH2 pressline in intertank for no damage (OMRSD, File IV).
- B: Witness leakage test (OMRSD File IV for LWT-54 thru 84, 89 thru 93).
- B: Witness seal leakage test on joint at station XT1082 (OMRSD File IV and OMI T1402).

FAILURE HISTORY:

Current data on test failures, unexplained anomalies and other failures experienced during ground processing activity can be found in the PRACA data base.