

CRITICAL ITEMS LIST (CIL)

SYSTEM:	Propulsion/Mechanical	FUNCTIONAL CRIT:	1
SUBSYSTEM:	LH2 Propellant Feed	PHASE(S):	a, b, c
REV & DATE:	J, 12-19-97	HAZARD REF:	P.06, P.07, P.09, S.06, S.11
DCN & DATE:			
ANALYSTS:	J. Kuttruff/H. Claybrook		

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.
Loss of mission due to early LH2 depletion.
- c) Loss of mission and vehicle/crew due to Orbiter/ET collision.
(Results only from Failure Cause A)
Loss of life due to ET impact outside designated footprint.

TIME TO EFFECT: Seconds

FAILURE CAUSE(S):

- A: Structural Failure of Hardline Component
- B: Structural Failure of Bellows Assembly
- C: Flange Mating Surface Defects
- D: Fracture of One Flange Bolt

REDUNDANCY SCREENS: Not Applicable

FUNCTIONAL DESCRIPTION: This 42 inch long feedline section incorporating an articulated bellows assy with cryo-pumped argon insulation jacket transports LH2 from the flanged port on the upper LH2 aft dome to the ET/Orbiter disconnect.

<u>FMEA ITEM CODE(S)</u>	<u>PART NO.</u>	<u>PART NAME</u>	<u>QTY</u>	<u>EFFECTIVITY</u>
2.5.8.1	PD4800184-029 -039	LH2 Feedline, External	1 1	LWT-54 thru 63 LWT-64 & Up

REMARKS:

CRITICAL ITEMS LIST (CIL)
CONTINUATION SHEET

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RATIONALE FOR RETENTION

DESIGN:

The line assembly is similar in size, 17 inch diameter, to the LO2 feedlines on the Saturn IC. Arrowhead Products who supplied these feedlines also supplies the LH2 External Feedline for the ET. The assembly has 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 ET7-SR-0002, Arrowhead), and other operating and nonoperating requirements specified per PD4800184. Materials selected in accordance with MMC-ET-SE16 assures repetitive conformance of composition and properties. Emphasis has been placed on joint geometry to enhance weld integrity. Fusion welding is specified and processes and quality controls are in accordance with MPS-MPQ-103 (Arrowhead) which was developed and used for the Space Shuttle Main Propulsion Engine Feedline System.

- A: Each design feature of the hardline sections have been tested and proven on similar assemblies. The line assembly is fabricated using a minimum of welded joints. Flange necks have been designed with minimum length necessary to ensure weld locations in areas of low stress. Minimum tube gage requirements have been satisfied.
- B: The pressure carrier bellows is fabricated from 3 plies of .016 inch thick aged Inconel and was selected for its excellent fatigue properties. Usage provided what is considered the optimum balance for weight, bending stress and flow induced vibration while providing adequate stability and flexibility. Assessment for flow induced vibration in accordance with MSFC Spec 20M02540 and Project Report 02 2119 (Southwest Research Institute) showed the bellows could provide adequate life at specified conditions. No flowliners are incorporated into the bellows design.
- C: Flange mating seal surface flatness, waviness and finish are specified which assures performance within the capability of the seal.
- D: 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 Line Assembly is qualified. Reference COQ MMC-ET-TM06-049.

Development - ET: An assembly was fabricated and tested to provide a confidence level to proceed with qualification testing, and to provide strain gage data for evaluation of the effects of various combinations of loading conditions on the elbow assembly. Testing included 64 flight proof load cases at ambient temperature, then 92 flight load cases, 2000 cycle loads, and 46 ultimate load cases were performed at LN2 temperature. Leakage testing performed after each of the above tests except ultimate met criteria for less than 1×10^{-8} SCCS helium at 40 psig (ET7-DTR-0005, Arrowhead).

Qualification - ET: Testing of one line assembly (in the following sequence) included: 64 proof load cases and deflection for acceptance; 500 motion cycles, 10 thermal cycles from +350°F to -300°F, 2000 load cycles, 71 psig proof pressure; sine and random vibration, 71 psig proof pressure; annulus pressure disk burst, 48 ultimate load cases, 71 psig proof pressure and 2 thermal gradient cycles -300° to 430°F. Leakage testing was performed six times during the test program and again upon test completion. All testing met criteria for leakage less than 1×10^{-8} SCCS helium at 57 psig (MMC-ET-RA09-51).

Vendor:

- A-C: Perform flight proof load test at LN2 temperature and deflection test at ambient temperature on each production assembly (ATP 14184-329, Arrowhead for LWT-54 thru 63; ATP 14184-339, Arrowhead for LWT-64 & Up).
- A-C: Perform vacuum jacket and pressure carrier leakage test on each production assembly following proof load test (ATP 14184-329, Arrowhead for LWT-54 thru 63; ATP 14184-339, Arrowhead for LWT-64 & Up).
- B: Perform spring rate test during the build cycle (ATP 14184-329, Arrowhead for LWT-54 thru 63; ATP 14184-339, Arrowhead for LWT-64 & Up).
- D: Attachment bolts are procured and tested to Standard drawing 26L2.

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INSPECTION:

Vendor Inspection - Lockheed Martin Surveillance:

- A, B: Inspect welding (MPS-MPQ-103, Arrowhead).
- A, B: Penetrant inspect welding before and after planishing (MIL-I-6866, Type I, Method A, Group IV).
- A, B: Verify X-ray results (OCI-16-057, Arrowhead).
- A, B, D: Verify materials selection and verification controls (MMC-ET-SE16, PD4800184, and Standard drawing 26L2).
- B: Inspect seam weld (drawing 14184-109, Arrowhead).
- C: Inspect flange sealing surface flatness and finish (drawing 14184-329, Arrowhead for LWT-54 thru 63; drawing 14184-339, Arrowhead for LWT-64 & Up).
- C: Inspect flange dimensions (drawings 14184-101 and 14184-329, Arrowhead for LWT-54 thru 63; drawings 14184-101 and 14184-339, Arrowhead for LWT-64 & Up).

Lockheed Martin Procurement Quality Representative:

- A-C: Witness flight proof load, vacuum jacket and pressure carrier leakage, bellows spring rate and deflection tests (ATP 14184-329, Arrowhead for LWT-54 thru 63; ATP 14184-339, Arrowhead for LWT-64 & Up).

MAF Quality Inspection:

- A, B: Inspect for freedom of damage to bellows/line assembly prior to TPS application (MPP 80971028410).
- A-C: Inspect for freedom of damage during installation and defects of sealing surfaces (drawing 80921011009 and acceptance drawing 82620000001).
- B: Inspect bellows drain holes for freedom of obstruction during post installation shakedown (MPP 80901000SCL).
- C: Verify correct alignment pins used during installation of feedline flange to seal/umbilical (drawing 80921011009).
- D: Verify installation and witness torque (drawing 80921011009).
- C, D: Witness seal flange leakage tests (MMC-ET-TMD4k).

Launch Site:

- A-D: Visually monitor for no leakage (OMRSD FILE II).
- B: Inspect bellows drain holes for freedom of obstruction (OMRSD File IV).

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.