

CRITICAL ITEMS LIST (CIL)

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

FAILURE MODE: Leakage

FAILURE EFFECT: a) Loss of mission and vehicle/crew due to clogging of Orbiter feedline screens, inadequate LH2 supply to engines during start and uncontrolled SSME shutdown.
 b) Loss of mission and vehicle/crew due to gas ingestion in LH2 feed, clogging/rupture of Orbiter feedline screens and uncontrolled SSME shutdown.

TIME TO EFFECT: Seconds

FAILURE CAUSE(S): A: Structural Failure of Hardline Component
 B: Structural Failure of Bellows Assembly
 C: Fracture of One Flange Bolt
 D: Flange Mating Defects

REDUNDANCY SCREENS: Not Applicable

FUNCTIONAL DESCRIPTION: The 35 inch long feedline bellows section transports LH2 from the siphon to the flanged port on the upper LH2 tank aft dome. The bellows accommodates manufacturing and installation tolerances and relative motion during loading, pressurization and flight.

FMEA ITEM CODE(S)	PART NO.	PART NAME	QTY	EFFECTIVITY
2.5.5.1	PD4800177-010	LH2 Internal Feedline, Bellows	1	LWT-54 & Up

REMARKS:

CRITICAL ITEMS LIST (CIL)
CONTINUATION SHEET

SYSTEM: Propulsion/Mechanical
SUBSYSTEM: LH2 Propellant Feed
FMEA ITEM CODE(S): 2.5.5.1

REV & DATE: J, 12-19-97
DCN & DATE: 005, 6-30-00

RATIONALE FOR RETENTION

DESIGN:

The 17 inch diameter LH2 internal feedline assembly consists of a bellows, tube section and fixed and fixed/floating end flanges. The assembly is of welded construction and has been designed for 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 DI 221, Metal Bellows). All components except the floating flange are fabricated from 300 series CRES. The flange is machined from 6061 T6 aluminum. Fusion and seam resistance welding are controlled by CPS 1012 and CPS 1009 Metal Bellows, MIL-W-6858 class B and SSP MPD-33 class R. MIL-W-6858 is limited to LWT-54 thru 113 and SSP MPD-33 class R is effective for LWT-114 & Up.

- A: Flanges have been designed for minimum thickness to meet deflection requirements. Mounting pads are integral with the upstream flange and the socket weld of the tube to flange provides for good stress transition. Materials were selected in accordance with MMC-ET-SE16 and assures repetitive conformance of composition and properties.
- B: The bellows is a 2 ply construction with relatively low convolution height and open pitch. Each tube .012 inch thick 321 CRES is rolled and welded with two longitudinal butt welds. The tubes are telescoped one within the other and the convolutes are roll formed. The open pitch allows larger form radius for good stress distribution and is more resistant to flow vortex shedding. Assessment for flow induced vibration in accordance with MSFC Spec 20M02540 and Project Report 02 2119 (Southwest Research Institute) showed that the bellows could provide adequate life at specified conditions. No flow liners are incorporated into the design.
- C: Attachment fasteners were selected from the Approved Standard Parts List (ASPL 826-3500), installed per STP2014 and torqued using values specified on Engineering drawings.
- D: Ring and fixed flange dimensions and mating surface flatness, waviness and finish are specified which ensures flange contact and sealing performance.

TEST:

The Line Assembly is qualified. Reference COQ MMC-ET-TM06-004.

Development - EI: One assembly was subjected to testing that included collapse pressure, leakage at operating pressure, operating life, and vibration. Leakage testing of the bellows assembly was performed at operating pressure before, midway, and after the operating life tests (1000 cycles of deflection) and after each axis of vibration.

Leakage testing of the bellows assembly was performed with a leak detector solution, with an internally applied pressure of 29.9 psig GN2 and/or GHe at ambient temperature, for a period of 3 minutes. In all cases, no evidence of leakage was detected (CR 317, Metal Bellows).

Qualification - EI: Qualification tests on one bellows assembly was performed and results are reported in Qualification Test Report MMC-ET-RA09-17. A Helium leakage test at 13 psig was performed after each of the following tests: Operating life (500 motion cycles), vibration, thermal cycle, ultimate load, and collapse. Initial leak test after 36 psig proof was performed at 32 psig. All other testing was accomplished at 13 psig and met criteria for no evidence of leakage (no bubbles).

Margin: The above qualification unit was further subjected to a series of margin tests that included deflection, operating life (500 motion cycles), leakage, and deflection. Leakage testing met acceptance criteria for no evidence of bubbles at 13 psig (H40687, MMC Denver Qualification Test Procedure).

After the above testing the unit was subjected to MPTA vibration levels for 100 minutes in each of the three axes. Leakage testing after test increments of 10, 20, 30, and 40 minutes met acceptance criteria for no evidence of bubbles at 5 psig (4290, MMC Denver Environmental Test Procedure).

MPTA Firing/Tankings: The MPTA assembly has accumulated 62.5 minutes of firing time, 26 cryogenic cycles and 42 pressurization cycles. Prior to SF-7, strain gages were attached to the bellows convolutes for the measurement of stress associated with flow induced vibration. No appreciable change in strain gage output was noted during all subsequent firings, indicating that there was no flow induced vibration for the flow regime through 104% power rating. No visual defects were noted during tank entries, the last of

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DCN & DATE: 005, 6-30-00

RATIONALE FOR RETENTION

TEST: (cont)

which was after SF-12.

Vendor:

- A, B: Perform proof pressure, leakage and deflection tests on each production assembly (ATP 77342, Metal Bellows for LWT-54 thru 113; 2077342, Stainless Steel Products for LWT-114 & Up).
- C: Attachment bolts are procured and tested to Standard drawing 26L2.

INSPECTION:

Vendor Inspection - Lockheed Martin Surveillance:

- A: Ultrasonic inspect (drawings 77344 and 77345, Metal Bellows for LWT-54 thru 113; 2077344 and 2077345, Stainless Steel Products for LWT-114 & Up).
- A-C: Verify materials selection and verification controls (MMC-ET-SE16, Standard drawing 26L2, and PD4800177).
- A, B: Inspect welding (CPS 1012, Metal Bellows and MIL-W-6858, Class A for LWT-54 thru 113; CPS 1012, SSP MPD-33 class R, Stainless Steel Products for LWT-114 & Up).
- A, B: Penetrant inspect welding (CPS 3011, Metal Bellows).
- D: Inspect flange mating surface, finish and dimensions (drawings 73822 and 77345, Metal Bellows for LWT-54 thru 113; 2073822 and 2077345 Stainless Steel Products for LWT-114 & Up).

Lockheed Martin Procurement Quality Representative:

- A, B: Verify X-ray results (CPS 3107, Metal Bellows, LWT-54 thru 113; SSP MPD-83 Supp. 1, Stainless Steel Products for LWT-114 & Up).
- A, B: Witness proof pressure, leakage, and deflection tests (ATP 77342, Metal Bellows for LWT-54 thru 113; 2077342, Stainless Steel Products for LWT-114 & Up).

MAE Quality Inspection:

- A, B: Inspect for freedom of damage during post installation shakedown inspection (MPP 80904000SCL for LWT-54 thru 68 and 80934003719 for LWT-69 & up)
- C: Inspect bolts for freedom of damage prior to installation (MPP 80924901916).
- D: Inspect sealing surfaces for freedom of nicks and radial scratches (Acceptance drawing 82620000001).
- C, D: Verify installation and witness torque (MPP 80924901916).
- D: Inspect flange sealing surface flatness, finish and dimensions (drawing 80914961960).

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.

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TIME TO EFFECT: Seconds

FAILURE CAUSE(S): A: Structural Failure of Hardline Component
 B: Flange Mating Surface Defects
 C: Fracture of One Flange Bolt (Reference CIL No. 2.5.5.1)

REDUNDANCY SCREENS: Not Applicable

FUNCTIONAL DESCRIPTION: Transports LH2 from the feedline inlet near the base of the LH2 tank aft dome to the internal LH2 feedline bellows.

FMEA ITEM CODE(S)	PART NO.	PART NAME	QTY	EFFECTIVITY
2.5.6.1	80924901909-009 -500	LH2 Internal Feedline, Welded Assy (Siphon)	1 1	LWT-54 thru 88, 600 & Up LWT-89 thru 599

REMARKS: