

CRITICAL ITEMS LIST (CIL)

SYSTEM: Propulsion/Mechanical
 SUBSYSTEM: LH2 Recirculation
 REV & DATE: J, 12-19-97
 DCN & DATE:
 ANALYSTS: J. Kuttruff/H. Claybrook

FUNCTIONAL CRIT: 1
 PHASE(S): a, b, c
 HAZARD REF: P.06, 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.
 Loss of mission due to early LH2 depletion.
 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: Structural Failure of Bellows Assembly
 C: Flange Mating Surface Defects
 D: Fracture of One Flange Bolt

REDUNDANCY SCREENS: Not Applicable

FUNCTIONAL DESCRIPTION: Recirculates LH2 between the ET and the Orbiter to chilldown the lines in the SSMEs such that they are free of GH2 bubbles and are at the proper temperature for engine start.

<u>FMEA ITEM CODE(S)</u>	<u>PART NO.</u>	<u>PART NAME</u>	<u>QTY</u>	<u>EFFECTIVITY</u>
2.6.1.1	PD4800178-020	LH2 Recirculation Line	1	LVT-54 & Up

REMARKS:

CRITICAL ITEMS LIST (CIL)
CONTINUATION SHEET

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RATIONALE FOR RETENTION

DESIGN:

The 4 inch diameter line assembly includes fixed end flanges, straight tube sections, tube bend sections, and two jacketed flexible joints. Lateral restraint is provided by a retaining ring located between the inner and outer bellows shield. 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-0003, Arrowhead) and other operating and nonoperating requirements of PD4800178. The assembly is fabricated from ARMCO 21-6-9 Cres and is an all welded configuration. Materials selected in accordance with MMC-ET-SE16 assures 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 line assembly was tested and proven on similar assemblies. Fabrication of the line assembly is accomplished through a minimum number of welded joints. Flange necks have been designed with minimum length necessary to insure weld location in areas of low stress. Minimum tube gage requirements have been satisfied.
- B: The pressure carrier bellows is fabricated from 3 plies of .008 inch thick material. Each tube is rolled and welded with longitudinal butt welds. The tubes are telescoped one within the other and the convolutes are roll formed. Assessment for flow induced vibration in accordance with MSFC Spec 20M02540 and Report 02-2119 (Southwest Research Institute) showed that the bellows provided adequate life for a single defined flow condition, however the analysis could not adequately verify bellows endurance for mixed phase flow conditions. Flowliners were incorporated into the bellows design.
- C: Flange mating seal surface flatness, waviness and finish are specified that 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-TM06-041.

Development - ET Joint Assembly: Aerodynamic loading was increased for flight and caused redesign of the bellows for lateral restraint. A retainer ring was incorporated between the bellows protective shields. Testing included deflection and shear load application from 150 to 1750 lbs in 100 lbs increments. Mass spectrometer leakage testing was performed by evacuating the annulus through a pinch tube then flooding the interior and exterior surfaces with GHg. Testing before and after 1250 and 1750 lb load applications met criteria for leakage less than 1×10^{-2} SCCS (ET7-DTR-14178-55, Arrowhead).

Qualification - ET: Testing of one line assembly included: proof load and one deflection motion cycle for acceptance; 500 operating motion cycles, 10 thermal cycles from -320 to +350°F, 66 psig proof pressure; vibration, 66 psig proof pressure; 100 minutes vibration at MPTA levels, burst disk pressure relief, 66 psig proof pressure; ultimate load and 66 psig proof pressure. Leakage testing was performed 4 times during the test program and upon test completion. Testing met criteria for leakage less than 1×10^{-6} SCCS helium at 41 psig (MMC ET-RA09-53).

MPTA Firing/Tanking: The flight configuration line assembly was installed prior to SF-9 and has accumulated 32.3 minutes of firing time, 9 cryogenic cycles and 19 pressurization cycles. Pressure carrier integrity has been verified by visual observation, i.e., LH2 leakage into the jacket would result in surface runoff of liquid air or excessive ice/frost buildup. No such occurrence has been noted by the Red team.

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TEST: (cont)

Vendor:

- A-C: Perform proof load test and deflection test at ambient temperature on each production assembly (ATP 14178-320, Arrowhead).
- A, B: Perform vacuum jacket and pressure carrier leakage tests on each production assembly following proof load tests (ATP 14178-320, Arrowhead).
- B: Perform spring rate test during the build cycle (ATP 14178-320, Arrowhead).
- D: Attachment bolts are procured and tested to Standard drawing 26L2.

INSPECTION:

Vendor Inspection - Lockheed Martin Surveillance:

- A, B: Inspect welding (MPS-MPQ-103 Arrowhead).
- A, B: Penetrant inspect welding (MIL-I-6866, Type I, Method A and C, Group VI).
- A, B, D: Verify materials selection and verification controls (MMC-ET-SE16, PD4800178 and Standard drawing 26L2).
- C: Inspect surface flatness, finish and dimensions (drawings 14178-59 and 14178-67, Arrowhead).

Lockheed Martin Procurement Quality Representative:

- A, B: Verify X-ray results (drawings 14178-63, 14178-65, 14178-55-3, 14178-55-7, 14178-55-8 and OCI-16-057, Arrowhead).
- A, B: Witness proof load, pressure carrier and vacuum annulus leakage, bellows spring rate and deflection tests (ATP 14178-320, Arrowhead).

MAF Quality Inspection:

- A, B: Inspect for freedom of damage to line/bellows assembly prior to TPS application (MPP 80971028411).
- C: Inspect sealing surfaces for freedom of nicks and radial scratches (Acceptance drawing 82620000001).
- C, D: Witness seal flange leakage tests (MMC-ET-TM04k).
- D: Verify installation and witness torque (drawing 80921011009).

Launch Site:

- A-D: Visually monitor for no leakage (OMRSD file II).

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.