SYSTEM:	Propulsion/Mechanical	FUNCTIONAL CRIT:	1
SUBSYSTEM:	LH2 Propellant Feed	PHASE(S):	a, b
REV & DATE:	J, 12-19-97	HAZARD REF:	P.09, T.03
DCN & DATE:			
ANALYSTS:	J. Kuttruff/H. Claybrook		

FAILURE MODE: Loss of Vacuum

FAILURE EFFECT: a) Loss of mission and vehicle/crew due to fire/explosion.
b) Loss of mission and vehicle/crew due to fire/explosion.

TIME TO EFFECT: Seconds

FAILURE CAUSE(S): Structural Failure of Vacuum Jacket

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.

FMEA ITEM CODE(S)	PART NO.	PART NAME	QTY	EFFECTIVITY
2.5.8.2	P04800184-029	LH2 Feedline, External	1	LWT-54 thru 63
	-039		1	LWT-64 & Up

REMARKS:

SYSTEM:	Propulsion/Mechanical	REV & DATE:	J, 12-19-97
SUBSYSTEM:	LH2 Propellant Feed	DCN & DATE:	
FMEA ITEM CODE(S):	2.5.8.2		

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. A jacket extends over the two pressure carrier bellows and connecting hardline. The annulus is evacuated and backfilled with argon gas at 1 to 2 psig. When the pressure carrier is exposed to LH2, the cryo pumped argon within the annulus provides a vacuum thermal barrier. A burst disk to atmosphere is provided in the event of LH2 leakage into the annulus that could cause a potential overpressure condition (implosion of the pressure carrier). A minimum relief pressure of 20 psig is specified.

The vacuum jacket composed of bellows, burst disk assembly and hardline components 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.

The jacket bellows is fabricated from 3 plies .008 inch thick ARMCO 21-6-9 and was selected for its excellent fatigue properties. Shields are provided which protect the bellows from damage. In the ET vertical position, the orbiter side bellows shield is in an up position. Moisture collection between the shield and bellows is prevented by drain holes placed in the shield at the low position.

TEST:

The Line Assembly is qualified. Reference COQ MMC-ET-TM06-049.

Development - Burst Disk Assembly: Twelve burst disk assemblies were tested to evaluate and verify rupture characteristics at temperatures associated with potential overpressurization. Testing was conducted on 3 each assemblies at ambient, +300°F, -150° and -300°. Acceptance criteria was met for minimum burst pressure of 20 psig and mass spectrometer leakage detection less than 1 x 10^{-6} SCCS helium (ET7-DTR-0001, Arrowhead).

Qualification. Testing of one line assembly, (in the following sequence) included: 64 proofload 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°F to 430°F. Vacuum jacket leakage testing was performed six times during the test program and again upon test completion. All testing met criteria for leakage less than $1x10^{-6}$ SCCS helium with the feedline internally pressurized to 42 psig and the vacuum annulus evacuated to 25mm Hg maximum (MMC-ET-RA09-51).

MPTA Firing/Tanking. The MPTA assembly, which is similar to the flight configuration and includes the burst disk, has accumulated 62.5 minutes of firing time, 26 cryogenic cycles and 42 pressurization cycles. Vacuum jacket integrity has been verified by visual observation, i.e., loss of vacuum would result in surface runoff of liquid air or excessive ice/frost buildup. No such occurrence has been noted by the Red team.

Acceptance - Vendor:

Perform spring rate test during the build cycle (ATP 14184-329, Arrowhead).

Perform flight proof load test at LN2 temperature, and deflection test at ambient temperature on each production assembly (ATP 14184-329, Arrowhead).

Perform vacuum jacket and pressure carrier leakage test on each production assembly following proof load tests (ATP 14184-329, Arrowhead).

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SUBSYSTEM:	LH2 Propellant Feed	DCN & DATE:	
FMEA ITEM CODE(S):	2.5.8.2		

RATIONALE FOR RETENTION

INSPECTION:

Vendor Inspection - Lockheed Martin Surveillance:

Verify materials selection and verification controls (MMC-ET-SE16 and PD4800184).

Inspect fusion buttwelds (drawing 14184-107-3 and MPS-MPQ-103, Arrowhead).

Penetrant inspect welding before and after planishing (MIL-I-6866, Type I, Method A, Group VI).

Verify x-ray results (QCI-16-057, Arrowhead).

Lockheed Martin Procurement Quality Representative:

Witness bellows vacuum annulus and pressure carrier leakage, bellows spring rate and proof tests (ATP 14184-329, Arrowhead for LWT-54 thru 63; ATP 14184-339, Arrowhead for LWT-64 & Up).

MAF Quality Inspection:

Inspect for freedom of damage to bellows assembly prior to applying TPS (MPP 80971028410).

Inspect for freedom of damage during installation (drawing 80921011009).

Inspect bellows drain holes for freedom of obstruction during post installation shakedown (MPP 80901000SCL).

Launch Site:

Visually monitor for no leakage (OMRSD File II).

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.