

CRITICAL ITEMS LIST (CIL)

SYSTEM:	Propulsion/Mechanical	FUNCTIONAL CRIT:	1R
SUBSYSTEM:	Ground Umbilical Carrier Assembly	PHASE(S):	b
REV & DATE:	J, 12-19-97	HAZARD REF:	P.05, S.11
DCN & DATE:	005, 6-30-00		
ANALYSTS:	J. Attar/H. Claybrook		

FAILURE MODE: Fails to Separate

FAILURE EFFECT: b) Loss of mission and vehicle/crew due to structural damage to ET.

TIME TO EFFECT: Seconds

FAILURE CAUSE(S):
 A: Pyro Separator Bolt Fails to Fracture from Pyro Charge
 B: Defective Pressure Cartridge Component
 C: Structural Failure of Cartridge Adapter

REDUNDANCY SCREENS:
 Screen A: N/A - Pyro Device
 PASS - Electrical Circuit
 Screen B: N/A
 Screen C: PASS

FUNCTIONAL DESCRIPTION: Interface hardware to attach ground facilities to ET to provide hazardous gas detection and separation at lift-off.

FMEA ITEM CODE(S)	PART NO.	PART NAME	QTY	EFFECTIVITY
2.14.1.1	82629021000-059 -060	Ground Umbilical Carrier Assy	1 1	LWT-54 thru 114 LWT-115 & Up

REMARKS:

CRITICAL ITEMS LIST (CIL)
CONTINUATION SHEET

SYSTEM: Propulsion/Mechanical
SUBSYSTEM: Ground Umbilical Carrier Assembly
FMEA ITEM CODE(S): 2.14.1.1

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

DESIGN:

The Ground Umbilical Carrier Assembly (GUCA) is a retractable carrier plate consisting of a 7" hydrogen vent disconnect, six pressurization disconnects, two electrical instrumentation connections, mounting provisions for the pyro separator bolt, cavity purge orifice and attaching support hardware. The GUCA is held in a mated position by a pyro separator bolt which attaches to a key lock insert in the External Tank carrier assembly (ETCA). The GUCA pivots away from the Intertank on pivot supports, and retracts away from the ET at T-0.

A cartridge actuated pyro separator device is used to attach and release the GUCA. The assembly consists of a separator bolt, an internal piston, an adapter, and two pyrotechnic cartridges. Each cartridge incorporates a NASA Standard Initiator (NSI) that is threaded and welded into the cartridge body. Electrical signals from the ground facility are hardwired to each NSI to initiate the pyrotechnic charge. The pressure from each cartridge goes into the parallel type adapter and exits from a single port against the piston causing bolt fracture. The pressure output from one cartridge is sufficient for bolt separation.

- A-C: The GUCA is designed for repeated use and is capable of operating in the primary mode of release, after and during exposure to specified environments for 74 cycles of engagement and disengagement at cryogenic temperatures. In its service usage, the assembly and its component subassemblies are refurbished as required prior to its next use (O & M Manual MMC-ET-CR00023). The service life and primary mode of release were verified by test and analysis.
- A: The pyro separator bolt is designed to fail at the separation notch in the bolt at an axial tensile load of 8000 ± 500 lbs. The separator bolt is fabricated from Inconel 718 per AMS 5662, has been designed to meet the required minimum ultimate (1.30) safety factor (ET Stress Report 826-2188) and meets other operating and nonoperating requirements specified by PD5000020. Material selected in accordance with MMC-ET-SE16 and controlled per MMMA Approved Vendor Product Assurance Plan assures conformance of composition, material compatibility and properties.
- B, C: Pressure Cartridge components and the cartridge adapter components are fabricated from Inconel 718 per AMS 5662 and are capable of withstanding a proof pressure of 1.2 times the maximum anticipated operating pressure without deformation. Material selected in accordance with MMC-ET-SE16 and controlled per MMMA Approved Vendor Product Assurance Plan assures conformance of composition, material compatibility and properties.
- B: Moisture intrusion is precluded by thin closure disks that are welded across the explosive and propellant chambers. Selection of explosive mix and propellant per MIL-R-398 and Hi-Shear drawing 939321 respectively, assures repetitive conformance of composition and properties. Weights are controlled per 9391435 (Hi-Shear). Dimensional control of the bulkhead and explosive/propellant chambers, along with weight, mix and packing requirements of the explosive/propellant during the build cycle assures nominal operating characteristics.

Redundancy Description

The facility lanyard provides standby redundancy to separate the GUCA from the ETCA. The pyro separator contains additional redundancy for failure cause B through the incorporation of the two pyrotechnic cartridges which upon ignition provides pressure to fracture the bolt attaching the GUCA to the ET. The pressure cartridges are redundant to each other and individual ignition sources are simultaneously ignited. The pressure output from either cartridge is sufficient for bolt fracture.

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DESIGN: (cont)

Effects of First Failure

Failure Causes A & C

If GUCA/ETCA separation fails to occur due to cause A or C, the facility lanyard will separate the GUCA.

Failure Cause B

If one of the two pressure cartridges fails, pressure output from the other cartridge will fracture the pyro bolt and GUCA/ETCA separation will occur.

Effects of First Redundancy Loss

Failure Causes A & C

If facility lanyard fails to separate the GUCA, the effects described in "Failure Effect" above will occur.

Failure Cause B

If both pressure cartridges fail, the facility lanyard will then cause GUCA/ETCA separation.

Effects of Second Redundancy Loss:

Failure Cause B only:

If facility lanyard fails to separate the GUCA, the effects described in "Failure Effect" above will occur.

TEST:

The Ground Umbilical Carrier Assembly is qualified. Reference COO MMC-ET-TM06-038.

The Pyro Separator Assembly is qualified. Reference COO MMC-ET-TM06-067.

Development: Prior to firing, the adapter and cartridge body were subjected to proof and burst pressure of 33,000 and 42,500 psi respectively. No leakage, yielding or failure occurred. Two expended cartridge bodies were subjected to proof pressure of 32,500 psi. No leakage, yielding, or failure occurred (936116 - 1094 Hi-Shear).

Qualification: Testing of one GUCA and ETCA included 15 life cycle separations at cryogenic temperature using pyro separator bolt. In addition, the carrier assemblies were separated two times at cryogenic temperatures using lanyard separation mode. There was no evidence of structural damage (MMC-ET-RA09-48).

Qualification (Component): The pyro separator assembly is qualified by engineering test, and by similarity to the -039 assembly.

Twenty separator assemblies (PD5000020-039) were test fired at ambient and -200°F and included units that were subjected to vibration, drop test, over torque and 85% pyro charge. The specimens successfully performed the separation function (MMC-ET-RA09-64).

Four separator assemblies (PD5000020-059) were performance tested with single cartridge pyro loaded to 85%. Firings were conducted two each at ambient and -200°F without and with a preload of 4000 lbs on the bolt. The specimen successfully performed the separation function. One separator assembly was internally pressurized to 43,000 psi while in the lock shut condition. The pressure was contained without any indication of deformation or damage prior to 41,535 psi. At 43,000 psi, the 3/8 inch stud buckled and broke but there was no leakage (MMC-ET-RA09-64).

Two additional tests were conducted with dual cartridges and 100% pyro load. Both resulted in bolt fracture.

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TEST: (cont)

Ultimate strength tests were performed on three bolts (from the lot of test bolts) to verify that the bolts met the 8000 + 500 lb (tension) requirement. All three bolts had acceptable ultimate strengths (Hi-Shear ETR 9363116-2576).

Verification: Five separator assemblies (PD5000020-059) with single cartridge pyro loaded at 60% (4) and 70% (1) were fired with no preload and at -200°F. All specimens successfully performed the separation function (ETR 9363116-2576 Hi-Shear).

System Qualification: The ET umbilical and intertank access arm system qualification testing was conducted at the Launch Equipment Test Facility (LETF) at KSC. The objectives were to verify the KSC ground system hardware design and to perform integrated testing with the ETCA. Testing was conducted in a series of 13 tracking tests and 17 disconnect tests simulating various vehicle configurations with motions for anticipated environmental, test, and launch conditions from predicted worst-case vehicle stacking and on-pad positioning offsets, including 2.75 seconds of simulated engine firing. Test results and data analysis verified that the KSC design/hardware is satisfactory, and when integrated with the MSFC flight umbilical, the system meets all of the specified requirements and is qualified for Space Shuttle operations at launch sites (KSC-DD-119-TR).

Life and Age Control: Useful life of the pyro device is a minimum of ten years from the date of destructive lot acceptance test (NSTS 08060). Age life tests up to the ten year point are accomplished to demonstrate that performance characteristics continue to meet lot acceptance. Extension of the age life beyond ten years requires annual testing per the criteria of NSTS 08060.

Lot Acceptance:

Vendor - (Subassembly): (Hi-Shear 9363067-2347)

- A: Perform tension proof load and ultimate strength tests.
- C: Perform proof pressure test on pressure cartridge body.

Vendor - (Pressure Cartridge): (Hi-Shear 9391479-2340)

- B: Perform x-ray inspection, and n-ray inspection on all production units.
- B, C: Perform a closed bomb firing and pressure time test on ten percent of lot size or ten units (minimum) selected from the production lot.

Vendor - (Total Assembly): (Hi-Shear 9363116-1669)

- A-C: Perform lot acceptance test on ten percent of lot size or ten units (minimum) selected from production lot.

NOTE: Lot size equals sample size plus usable units.

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INSPECTION:

Vendor Inspection - Lockheed Martin Surveillance:

- A-C: Verify materials selection and verification controls (MMC-ET-SE16 and drawings 9363068, 9391479, 9391480, 939039, 9392039, 9391023, 9392038, and 9363116, Hi-Shear).
- A: Penetrant inspect (MIL-I-6866, Type I, Method B).
- A: Witness assembly and torque (drawing 9363067 and 9363116, Hi-Shear).
- B: Witness material mix (Procedure 700527, Hi-Shear).
- B: Witness packaging (document 700916, Hi-Shear).
- B: Inspect welding (Inert gas weld per HSC 9391479-1133 or EB weld per HSTC 700968, Hi-Shear).
- C: Witness assembly and torque (drawing 9391479, Hi-Shear).

Lockheed Martin Procurement Quality Representative:

- A: Witness tension proof load and ultimate strength tests (Document 9363067-2347, Hi-Shear).
- A: Verify bore and groove dimensions (drawing 9363068, Hi-Shear).
- C: Witness pressure cartridge body proof pressure test (Document 9363067-2347, Hi-Shear).
- B, C: Verify X-ray, N-ray examinations of product and closed bomb firing (document 9391479-2340, Hi-Shear).
- A-C: Witness lot acceptance test (ATP 9363116-1669, Hi-Shear).

Launch Site:

- A-C: Witness installation and torque (drawings 82629021000 and 82629021109, and OMI T1147).

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.