NAME P/N QTY	CRIT	FAILURE MODE & CAUSES	FAILURE EFFECT	RATIONALE FOR ACCEPTANCE
		102FM10		
HARD TORSO SHELL, ITEM 102 --- SV772375-24 PIVOTED HTS (1) OR --- SV810003 PLANAR HTS (1)	1/1	External gas leakage beyond SOP makeup capability. Defective material; Impact. Defective O-rings; missing or loose screws or EEH nut. Crack in fiberglass shell.	END ITEM: Suit leakage to ambient. GFE INTERFACE: Premature depletion of primary O2 supply and SOP. Rapid depressurizatio n of SSA beyond SOP makeup capability. MISSION: Abort EVA. CREW/VEHICLE: Loss of crewman. TIME TO EFFECT /ACTIONS: Seconds. TIME AVAILABLE: N/A TIME REQUIRED: N/A REDUNDANCY SCREENS: A-N/A B-N/A C-N/A	A. Design - The Pivoted HTS is a 9 layered fiberglass laminated structure which provides a minimum of 0.070 inch thick fiberglass/polyester resin shell, that is designed to withstand an ultimate pressure of 13.2 psig. This is a factor of safety of 1.5 over the BTA maximum normal operating pressure of 8.8 psig. Certification for 8.8 psi was by test and analysis (ref. ILC EM 84-1108). The Planar HUT is a 9 layer laminated fiberglass/epoxy resin shell with a 0.070 inch minimum wall thickness. This structural member is designed to withstand the combined pressure loads, arm, and waist manloads with an ultimate safety factor of 2.0 and a yield safety factor of 1.5 minimum. The HUT also supports the PLSS (Item 100), DCM (Item 300), Helmet (Item 105) and EVVA (Item 108). The 4.4 psig normal operating pressure combined with the internal or external arm and waist manloads result in the minimum ultimate safety factors shown:

	Plug load (lbs)	Man load (lbs)	Ultimate Factor of Safety	Cert Test Factor of Safety
Arm	315 Axial	293 Axial	3.42 (fiberglass hoop stress)	Greater than BTA axial load arm test
Waist	808 Axial	702 Axial	2.28 (bolt tensile stress)	Greater than BTA axial load waist test
Arm	315 Axial	309 Axial 224 Tan. (UP) --- 382 Vector Sum	3.33 (fiberglass hoop stress)	3.96
Waist	808 Axial	1014 Axial	2.21 (bolt tensile stress)	Greater than BTA axial load waist test

The 5.5 maximum operating pressure combined with the internal arm and waist manloads result in the minimum ultimate safety factors shown:

	Plug load (lbs)	Man load (lbs)	Ultimate Factor of Safety	Cert Test Factor of Safety
Arm	394 Axial	117 Axial	2.97 (fiberglass	2.61

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Waist	1010 Axial	702 Axial	2.23 (bolt tensile stress)	Greater than BTA axial load waist test

The 8.8 psig maximum BTA pressure combined with the relaxed arm and waist manloads result in the ultimate safety factors shown:

	Plug load (lbs)	Man load (lbs)	Ultimate Factor of Safety	Cert Test Factor of Safety
Arm	631 Axial	90 Axial	2.78 (fiberglass hoop stress)	4.40
Waist	1616 Axial	316 Axial	2.19 (bolt tensile stress)	7.47 (fiberglass stress)

The PLSS and the DCM provides protection to the back and front of the HTS from impact. The TMG provides micrometeoroid protection.

A 63 surface finish is specified for the PLSS, DCM and EEH interface surfaces to provide a smooth sealing surface for the O-rings. The PLSS and DCM O-rings are made from Viton and the EEH O-ring is made from silicone. These O-rings seal statically which lessen leakage caused by wear. The DCM and PLSS screws are torqued to 8-10 in-lbs. The EEH connector passes through a "D" shaped hole in the HTS fiberglass shell and is sealed with an O-ring. The connector is secured by a nut which is torqued to 55 +/- 5 in-lbs and lock wired in place to prevent backing off.

B. Test -
Acceptance:
Each Pivoted HTS is proof tested at 8.0 psig and leak checked at 4.3 psig prior to delivery to ILC.

The Planar HTS is proof tested at 15.8 psig and leak checked at 4.3 psig prior to delivery to ILC.

PDA:
The following tests are conducted at the HUT assembly level in accordance with ILC Document 0111-710112:

1. Initial cavity leak test at 4.3 psig to verify leakage less than 21.0 scc/min.

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4 @ 13.2 psig
2 @ 15.8 psig

10 @ 13.2 psig
7 @ 15.8 psig

C. Inspection -
Prior to assembly of the HTS, all materials are vendor certified. Batch lot acceptance tests are run to verify integrity of materials prior to use in manufacture of the HTS. During fabrication, fiberglass test specimens are made and tensile tested to verify integrity of the material.

The following MIP's are performed during manufacture of the Hard Torso Shell to assure that the failure causes are precluded from the fabricated item:

1. The issuance of all adhesives, resins, curing agents and fiberglass are controlled by inspection.
2. Verification that the correct materials as specified by the operation sheets are used and that shelf life is within specification.
3. Recording of lot numbers.

Assembly of the HTS into the Hard Upper Torso (HUT) is monitored by inspection to Table of Operations (T.O.) requirements. This includes verification of material and cleanliness requirement.

PDA inspection includes visual and dimensional verification of hardware and softgoods to assembly drawing requirements. Packaging and cleanliness requirements are also verified.

D. Failure History -
Pivoted HUT:
B-EMU-102-A007 (3/21/89) - White lines resembling cracks noted during visual examination of Hut are results of the manufacturing process and represent no structural degradation of the fiberglass.

To date, no failure has occurred that exceeds SOP makeup capability. However, failures have occured that were within SOP make-up capability:

H-EMU-602-A002 (10/20/80) and H-EMU-602-D006 (8/31/87) - Leakage through fiberglass of neck ring. Reworked HTS per standard procedure.

H-EMU-602-D008 (2/12/91) - Leakage of HTS between PLSS pad and EEH hole. Also, leakage from above right arm opening. 2 inch x 1/2 inch delamination at first leakage site believed to be caused by mishandling. A caution was issued to all Hamilton Standard personnel involved in HTS manufacture. HTS will be reworked.

Planar HUT:
H-EMU-102--003 (12/13/00) Visual inspection revealed thin area in shell wall at fiberglass overwrap. Thin area most likely due to excessive sanding during manufacture. YTN 1256 issued to inspect all planar HUTs for similar anomaly. Operator training to be developed to better control material removal.

E. Ground Turnaround -
Tested for non-EET processing per FEMU-R-001, Pre-Flight Final SEMU Gas Structural and Leakage. None for EET processing. Every 56 hours of manned pressurized time the Pivoted HUT is separated from the DCM and PLSS and

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		102FM10		subjected to a complete visual inspection for material degradation or damage, and structural and leakage tests at HUT assembly level. Every 229 hours of manned pressurized time the Planar HUT is separated from the DCM and PLSS and subjected to a complete visual inspection for material degradation or damage, and structural and leakage tests at HUT assembly level. F. Operational Use - 1. Crew Response - Pre/post-EVA : If during airlock operations, repress airlock, otherwise consider third EMU if available, EMU no go for EVA. EVA : When CWS data confirms SOP activation, abort EVA. 2. Special Training - Standard training covers this failure mode 3. Operational Considerations - EVA checklist procedures verify hardware integrity and systems operational status prior to EVA. Flight rules define go/no go criteria related to EMU pressure. Real time data system allows ground monitoring of EMU systems.

EXTRAVEHICULAR MOBILITY UNIT

SYSTEMS SAFETY REVIEW PANEL REVIEW

FOR THE

I-102 HARD UPPER TORSO (HUT)

CRITICAL ITEM LIST (CIL)

EMU CONTRACT NO. NAS 9-97150

Prepared by: _____ 3/29/02
HS - Project Engineering

Approved by: _____
NASA - SSA/SSM

_____
HS - Reliability

_____ 5/14/02
NASA - EMU SSM

_____
HS - Engineering Manager

_____ 5/20/02
NASA - S&MA

_____ 5/23/02
NASA - MOD

_____ 6/04/02
NASA - Crew

_____ 6/14/02
NASA - Flight Ops Manager