NAME P/N QTY	CRIT	FAILURE MODE & CAUSES	FAILURE EFFECT	RATIONALE FOR ACCEPTANCE
		102FM11		
HARD TORSO SHELL, ITEM 102 ---------- SV772375-24 (1)	1/1	Loss of axial restraint, gimbal pivot socket. Defective material, Impact; Debonding of pivot socket (from HUT shell).	END ITEM: Loss of arm to HUT attachment. GFE INTERFACE: Loss of axial load restraining capability. Bellows separated from HTS. 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: Immediate. TIME AVAILABLE: N/A TIME REQUIRED: N/A REDUNDANCY SCREENS: A-N/A B-N/A C-N/A	A. Design - The sockets are made of AMS 5512 stainless steel for strength and corrosion resistance. The socket recess is flash chrome plated .0002 - .0004 to minimize wear and galling. The portion imbedded in fiberglass has tabs and a through hole to aid in anchoring to the fiberglass shell. The position of the gimbal pivots in relation to the DCM and PLSS significantly reduces the possibility of impact directly at the pivot area, thus minimizing failure due to impact. Additionally, the TMG provides a barrier to micrometeoroid impact, further reducing the potential for failure due to impact. The pivot sockets are imbedded in the fiberglass shell in a secondary operation. This entails cutting out the fiberglass to accept the shape of the pivot such that the tabs of the pivot are firmly anchored in the parent fiberglass material. The pivot is then bonded to the shell with EA934 epoxy adhesive. Primary structural containment is then provided by wrapping layers of fiberglass over the tabs and scarfing these layers into the parent fiberglass shell. A scarf joint is specified around the pivot to obtain a fiberglass bond joint that has shown during pivot pull out tests to provide a minimum ultimate safety factor of 2.15. To preclude debonding, the pivot and the fiberglass bond areas are sandblasted and solvent cleaned prior to bonding and an adhesive metal primer is applied to the pivot. Radial load limiters are bonded to the fiberglass retention rings on HUT's that have a gap of 0.1075 inches or more between the fiberglass retainer ring and the scye bearing retainer ring. The radial load limiter is a rectangular shim that assists in reacting pivot loads into the Hard Torso Shell to preclude gimbal pullout. The load limiter is bonded using EA934NA epoxy adhesive to the fiberglass retainer in the front pivot area only. B. Test - Acceptance: A load is applied to each of the pivots to verify the integrity of the pivot and the pivot assembly process. All pivots have been pull tested to the maximum S/AD operating load for each size HTS. Since March 1985, the acceptance test load has been increased to provide greater pivot attachment assurance and verification of a minimum safety factor of 1.35 (See table below). S/AD Load (lbs) per ARM (2 pivots) / Test Load (lbs) per ARM (2 pivots) / Factor of Safety HTS Size: Extra-Large — 724 — 980 — 1.35 HTS Size: Large — 684 — 957 — 1.4 After completion of the pull test the pivot socket is visually inspected at 10X power for signs of degradation. Certification: The HUT was successfully tested (manned) during SSA certification to duplicate operational life. (Ref. EM 83-1083, ILC Report 0111-70027 and EM 98-0008). The following usage reflecting requirements of significance to the HUT was documented during certification:

NAME P/N QTY	CRIT	FAILURE MODE & CAUSES	FAILURE EFFECT	RATIONALE FOR ACCEPTANCE
		102FM11		

Requirement	S/AD	Actual
Pressure Hours	461	1707
Pressure Cycles	432	1425
Don/Doff Cycles	144	625

The HUT was successfully subjected to an ultimate pressure fo 13.2 psid during SSA certification testing (Ref ILC Report 0111-79405). This is 1.5 times the maximum BTA operating pressure based on 8.8 psid.

Two tests of production HTS's verified a minimum pivot strength of 780 pounds. Worst-case load on an extra-large HUT at 5.5 psig suit pressure (212 lbs. plug load) plus maximum man load (150 lbs) on a pivot is 362 lbs. This represents a 2.15 ultimate strength safety factor. Ref. H.S. Documents SEMU-62-005 and SEMU-62-007.

The radial load limiters successfully passed certification testing duplicating 14 year (softgoods) operational cycle life requirements. (Ref. HS EMUM-543).

C. Inspection -
For engineering information, each HTS pivot socket fiberglass/adhesive attachment is holographed before and after the pivot pull test. These holographs are examined by Hamilton Standard engineering. The holograph process is used by H.S. engineering to locate and evaluate potential defects after assembly or testing.

HTS pivot sockets are holograph inspected, pull tested and evaluated during eight year softgood refurbishment.

The following MIP's are performed during installation of pivot sockets into the Hard Torso Shell to assure that the failure causes are precluded:

1. The issuance of all adhesives, resins, curing agents and fiberglass are controlled by inspection per SVHS-8091.
2. Verification that the correct materials specified by the operation sheets are used and that the shelf life is within specification.
3. Recording of lot numbers.
4. Dimensional inspection of the pivot socket and installation process.

D. Failure History -
B-EMU-102-A012 (3/21/89). Tracked by B-EMU-102-A006.

H-EMU-102--002 (11/21/88). Tracked by B-EMU-102-A006.

B-EMU-102-A006 (2/10/89)
Three WETF HUTs exhibited cracks in the fiberglass above the front pivots due to adhesive bond failure of the Hysol/metal pivot socket bond joint, subsequent metal pivot deflection, and HUT fiberglass crack initiation and propagation. Failure was due to poor metal pivot surface preparation (for bonding) and degradation of the adhesive bond in presence of water (WETF). Also, damage occured when hammering out the arms from the gimbal.
The following WETF HUT Testing has been added:

NAME P/N QTY	CRIT	FAILURE MODE & CAUSES	FAILURE EFFECT	RATIONALE FOR ACCEPTANCE
		102FM11		1) A visual inspection of the front pivots for bond degradation. 2) Mobil 28 grease replaced Krytox at the gimbal to scye bearing interface, 3) Shuck and deflection tests at 40 hr inspection to screen for pivot bond degradation. B-EMU-102-A025 (12/23/93). The left arm pivot separated from the HUT during WETF testing due to adhesive detachment from the metal pivot and a thin wall condition in the fiberglass shell which encapsulates the pivot. The adhesive detachment is typical of WETF and is caused by moisture permeating the bond, therefore, Class I flight HUTs are unaffected. The thin wall condition occurred because prior to 1983, there were improper methods to verify the fiberglass wall thickness. Flight HUTs produced prior to 1983, when improved inspections and a 1.4 safety factor pull test were imposed on all Class I HUTs, will undergo x-ray for thin wall condition and be refurbished if necessary. B-EMU-102-T001 (8/19/96). Class III Hut failed Shuck and Deflection test with 186 MPT due to fiberglass delamination at pivot mount caused by fiberglass bond degradation in WETF water environment. No Class I failures of this type have been experienced because they are exposed to "dry" air environment. No corrective action required. E. Ground Turnaround - Tested per FEMU-R-001, Pre-Flight Final SEMU Gas Structrual and Leakage. Every 56 hours of manned pressurized time the HUT is separated from the DCM and PLSS and subjected to complete visual inspection which includes a 10X power inspection of the pivot bond areas. Additionally, the HUT is subjected to structural and leakage tests at HUT level. Additionally, every 12 months, the pivot socket bearing surfaces are lubricated with a mixture of Krytox oil and molybdenum disulfide powder. F. Operational Use - 1. Crew Response - Pre/PostEVA: If during airlock operations, repress airlock. Consider third EMU if available. EMU no go for EVA. EVA: When CWS data confirms SOP activation, abort EVA. 2. 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: _____
HS - Project Engineering

_____
HS - Reliability

_____ 4/24/02
HS - Engineering Manager

Approved by: _____
NASA – SSA/SSM

_____
NASA – EMU SSM

_____ 6/26/02
NASA - S & MA

_____ 6/27/02
NASA - MOD

_____ 7/8/02
NASA - Crew

_____ 7-1-02
NASA Program Manager