NAME P/N QTY	CRIT	FAILURE MODE & CAUSES	FAILURE EFFECT	RATIONALE FOR ACCEPTANCE
		104FM34		
PRESSURE BOOT ASSEMBLY, ITEM 104 (1) LEFT (1) RIGHT ---------- 0104-210895-25/26/29/30; 0104-210895-33/34/35/36 (2)	1/1	External gas leakage beyond SOP makeup capability. Separation of seam in bladder; defective material; puncture or abrasion from broken stiffener/vacuum insert.	END ITEM: Suit gas leakage to ambient. GFE INTERFACE: Depletion of Primary O2 supply and SOP. Rapid depressurization 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 boot bladder assembly is formed from a series of patterned pieces of urethane coated nylon oxford fabric, seamed together by dielectric heat, to which a flange is also heat sealed. The bladder seams and boot flange are reinforced by heat sealed overtaping to enhance structural integrity. The solution coated bladder is protected internally, in known areas of high wear, by an additional heat sealed abrasion layer. Externally, the bladder is protected by the restraint fabric, boot sole and TMG layers. As a component of the pressure boot assembly, the bladder is entirely supported by the boot restraint. The bladder is thereby not subjected to any of the loads (man or pressure induced) experienced by the boot restraint. There are two types of bladder fabric. One is constructed of a base nylon fabric with a solution coated urethane. The other is constructed of the same bas enylon with a urethane laminate coating. The following paragraph applies to the solution coated nylon. Testing has shown that the bladder fabric minimum tensile strength is 105 lbs/inch (fill) and 140 lbs/inch (warp) and 3.5 lbs/inch in fill and 6.0 lbs/inch in warp, tearing strength. The bladder fabric is aligned with the warp parallel to the hoop load that would be sustained by the bladder in the event of a restraint fabric failure. Based on a predicted hoop load of 12.7 lbs, the minimum safety factor for hoop stress is 11.0 at 4.4 psid (normal operating pressure). At 5.5 psid (maximum failure pressure) the predicted hoop load is 15.8 lbs with a safety factor for hoop stress of 8.8. At 8.8 psid (maximum BTA operating pressure) the predicted hoop load is 25.3 lbs with a safety factor for hoop stress of 5.5. Testing has demonstrated that the tensile strength of the bladder seams meets or exceeds that of the bladder fabric. The following paragraph applies to the laminate coated nylon. Testing has shown that the bladder fabric minimum tensile strength is 170 lbs/inch (fill) and 180 lbs/inch (warp) and 3.5 lbs/inch minimum. The bladder fabric is aligned with the warp parallel to the hoop load that would be sustained by the bladder in the event of a restraint fabric failure. Based on a predicted hoop load of 12.7 lbs, the minimum safety factor for hoop stress is 14.2 at 4.4 psid (normal operating pressure). At 5.5 psid (maximum failure pressure) the predicted hoop load is 15.8 lbs with a safety factor for hoop stress of 11.3. At 8.8 psid (maximum BTA operating pressure) the predicted hoop load is 25.3 lbs with a safety factor for hoop stress is 7.1. Testing has demonstrated that the tensile strength of the bladder seams meets or exceeds that of the bladder fabric. The presence of abrasion layers in known areas of high wear, restraint and TMG, along with the physical properties of the bladder, make inadvertent puncture or abrasion unlikely. The vacuum insert is captured between the boot restraint fabric layer and the boot sole stiffener. The curvature of the insert and stiffener conforms to the foot shape. Both the insert and the stiffener are molded from pre- impregnated fiberglass. Below the stiffener, the sole is made of peroxide catalyzed silicone rubber for increased durability. The shape of the two fiberglass parts, their inherent strength and flexibility, and the cushioning effect of the layers above and below them preclude breakage that could lead to bladder puncture.

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B. Test -
Acceptance:
As required by the Table of Operations (T/O) for the fabrication of the boot bladder, heat seal samples are tensile tested to verify seam acceptability. Samples for test are taken at the start of each work shift and immediately after each machine change, tool change, machine setting change and/or each material lay-up or material lot change. Seam samples are made using production tooling and from the same portion of the roll as the material being heat sealed in production.

Following fabrication, each boot bladder is assembled into a test restraint and subjected to a leakage test at 4.3 psig to verify leakage less than 7.0 scc/min.

PDA:
The following tests are conducted at the LTA level in accordance with ILC Document 0111-70028J.
1. Initial leak test at 4.3 +/- 0.1 psig to verify leakage less than 46.5 scc/min.
2. Proof pressure test at 8.0 + 0.2 - 0.0 psig to verify no structural damage.
3. Post-proof pressure leak test at 4.3 +/- 0.1 psig to verify leakage less than 46.5 scc/min.
4. Final leak test at 4.3 +/- 0.1 psig to verify leakage less than 46.5 scc/min.

When delivered as a separable component of the LTA, the following tests are conducted at the Boot Assembly level in accordance with ILC Document 0111-70028J:
1. Initial leakage at 4.3 +/- 0.1 psig to verify leakage less than 7.0 scc/min.
2. Proof pressure test at 8.0 + 0.2 - 0.0 psig to verify no structural damage.
3. Post-proof pressure leak test at 4.3 +/- 0.1 psig to verify leakage less than 7.0 scc/min.
4. Final leakage at 4.3 +/- 0.1 psig to verify leakage less than 7.0 scc/min.

Certification:
(P/N 0104-89652):
The Enhanced Boot bladder (solution coated urethane) was successfully tested (manned) during certification to duplicate operational life (Ref ILC Doc. 0111-711330).

The following usage, reflecting requirements of significance to the boot bladder, was documented during certification:

Requirement	S/AD	Actual
Ankle Cycles	11614	24000
Walking Steps	13800	77760
Pressure Cycles	300	600
Don/Doff	98	400
Pressure Hours	458	916

The Enhanced Boot bladder was successfully subjected to a BTA ultimate pressure of 13.2 psig (1.5 times max BTA operating pressure based on 8.8 psig). (Ref. ILC

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Doc. 0111-711330).

The Enhanced Boot bladder (laminate coated urethane) was successfully tested (manned) during SSA certification to duplicate 458 hours of operational life (Ref. ILC Report 0111-712436). The following usage, reflecting requirements of significance to the bladder assembly, was documented during certification:

Requirement	S/AD	Actual
Ankle Cycles	11614	23,600
Walking Steps	4320	8,640
Pressure Cycles	300	627
Don/Doff	98	205
Pressure Hours	458	983

The Enhanced Boot Bladder was successfully subjected to an ultimate pressure of 13.2 psid during SSA certification testing (Ref. ILC Report 0111-712436). This is 1.5 times the maximum BTA operating pressure based on 8.8 psid.

C. Inspection -
Components and material manufactured to ILC requirements at an approved supplier are documented from procurement through shipping by the supplier. ILC incoming receiving inspection verifies that the materials received are as identified in the procurement documents, that no damage has occurred during shipment and that supplier certifications have been received which provide traceability information.

Where applicable, the following MIP's are performed during the boot manufacturing process to assure that the failure causes are precluded from the fabricated item:
1. Visual inspection of abrasion layer heat seal for delamination.
2. Visual inspection of bladder, before overtaping and flange installation, to classification of defects criteria.
3. Visual inspection of heat seal width.
4. Visual inspection of reinforcement tapes and flanges for positioning and bond acceptability.
5. Verification of seam acceptability test results.

During PDA, the following inspection points are performed at the LTA or boot assembly level in accordance with ILC Document 0111-70028J:
1. Visual inspection for material degradation.
2. Visual inspection for damage after proof pressure test.

D. Failure History -
(P/N 0104-89652):
J-EMU-104-A002 (10/08/93) - Enhanced LTA S/N 2002 exhibited excessive leakage through several abraded/damaged bladder areas. The damage was caused by excessive wear due to exposure to treadmill walking steps beyond the LTA S/AD 38,880 walking step requirement. In addition, a cut most likely caused by a sharp object was found in one leg restraint and bladder. No corrective action was taken, however, per ECO 941-0114, the Limited Life List requirement to track treadmill hours has been eliminated. (The preflight LTA inspection will remain

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if treadmill use has occurred).

B-EMU-104-A042 (4/10/96) - During periodic 56 hour inspection, left boot bladder had 8 delaminations; right boot bladder had 5. Bladders had 43 TMPT. Limit is 4 delaminations with under 55 TMPT. No corrective action taken.

B-EMU-104-A045 (07/18/96) - Bladder delaminations noted during visual inspection of Boots. Right Boot had 8 sites and the left Boot had 10, with 43 hr 19 minutes MPT. Limit is 4 sites with up to 55 hr MPT. Added abrasion layer contributes to delaminations; no root cause established. Inspection criteria exists for bladder delaminations. No corrective action taken.

B-EMU-104-A046 (08/13/96) - Bladder delaminations noted during visual inspection of Boots. Left Boot has 11 sites and right had 8, with 81:32 hr MPT. Limit is 8 for this MPT. Corrective action tracked by RDR # B-EMU-104-A045.

B-EMU-104-A047 (09/13/96) - Bladder delaminations noted during visual inspection of Boots. Left Boot had 7 sites, right Boot had 5, with approximately 20 hr MPT. Limit is 4 sites with up to 55 MPT. Corrective action is tracked by RDR # B-EMU-104-A045.

B-EMU-104-T004 (03/11/98) - Cracking of the urethane was discovered on the bladder cloth near the reinforcement tape that joins the bladder to the flange. The cracking occurred when excess MEK solvent, used while repairing the bladder with an adhesive patch, came in contact with an area of the bladder that was stressed (folded). The Standard Repair Procedure will be amended to advise against stressing bladder during adhesive patching operations. Also, cautions to limit the amount of adhesive and MEK and a visual inspection to verify no damage has occurred due to the patching procedure will be added.

B-EMU-104-T007 (07/30/98) - Inspection revealed bladder fabric coating was cracked. Corrective action is tracked by RDR # B-EMU-104-T004.

E. Ground Turnaround -
Tested for non-EET processing per FEMU-R-001, Pre-Flight LTA leakage test. None for EET processing. Additionally, every 4 years or 229 hours of manned pressurized time the boots are removed from the LTA and subjected to visual inspection for structural integrity and material degradation or damage.

F. Operational Use -
Crew Response -
EVA : When CWS data confirms SOP activation, abort EVA.
Special Training - Standard training covers this failure mode.
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 integrity.

EXTRAVEHICULAR MOBILITY UNIT

SYSTEMS SAFETY REVIEW PANEL REVIEW

FOR THE

I-104 LOWER TORSO ASSEMBLY (LTA)

CRITICAL ITEM LIST (CIL)

EMU CONTRACT NO. NAS 9-97150

Prepared by: _____
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_____
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Approved by: _____ 21 MAY 02
NASA – SSA/SSM

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NASA – MOD

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NASA – CTOW

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NASA – Program Manager