NAME P/N QTY	CRIT	FAILURE MODE & CAUSES	FAILURE EFFECT	RATIONALE FOR ACCEPTANCE
		104FM09		
WAIST RESTRAINT AND BLADDER, ITEM 104 --- 0104-82347-131 (1) --- 0104-84811-05/10 (1) WAIST RESTRAINT AND BLADDER, ADJUSTABLE, ITEM 104 --- 0104-812355-01 (1)	1/1	External gas leakage beyond SOP makeup capability. Separation of seam or puncture in bladder. Defective material, abrasion.	END ITEM: Suit gas leakage to ambient. GFE INTERFACE: Depletion of primary O2 supply and SOP. Rapid depressurizatio n of SSA beyond SOP makeup capabilities. 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 waist bladder assembly is formed from a series of patterned pieces of urethane coated nylon oxford fabric, seamed together by dielectric heat, to which flanges are also heat sealed. All bladder seams are reinforced by heat sealed overtapes. The non-adjustable waist bladder flange is reinforced by adhesive bond overtaping. The adjustable waist bladder/flange interface is accomplished with a shear seam resulting in a seam strength equal to the material strength. The Adjustable waist bladder/flange interface is accomplished with a shear seam, resulting in a seam strength equal to the material strength. 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 and TMG layers. As a component of the LTA waist, the bladder is entirely supported by the fabric restraint. The bladder is thereby not subjected to any of the loads (man or pressure induced) experienced by the LTA waist softgoods. Seam design creates a structure at least as strong as the base bladder. Thus, seam separation is precluded. 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 base nylon 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). The tearing strength is 3.5 lbs./inch in fill and 6.0 lbs./inch in warp. 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 38.5 lbs./inch, the minimum safety factor for hoop stress is 3.6 against a S/AD design minimum ultimate safety factor of 2.0 at 4.4 psid (normal operating pressure). Testing has demonstrated that the breaking 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). The tearing strength is 3.5 lbs./inch minimum in both directions. 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 38.5 lbs./inch the minimum safety factor for hoop stress is 4.4 against a S/AD design minimum ultimate safety factor of 2.0 at 4.4 psid (normal operating pressure). Testing has demonstrated that the breaking strength of the bladder seams meets or exceeds that of the bladder fabric. The presence of abrasion layers, restraint, and TMG, along with the physical properties of the bladder make inadvertent puncture or abrasion unlikely. B. Test - Acceptance: As required by the Table of Operation (T/O) for the fabrication of the bladder assembly, heat seal samples and adhesive seam samples (flange overtop) are tensile tested and peel tested, respectively, to verify seam acceptability. Heat

NAME P/N QTY	CRIT	FAILURE MODE & CAUSES	FAILURE EFFECT	RATIONALE FOR ACCEPTANCE
		104FM09		

seal 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. Heat sealed seam samples are made using production tooling and from the same portion of the roll as the material being heat sealed in production. Peel test samples are produced and tested for each bladder assembly production lot.

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

PDA:
The following tests are conducted at the Lower Torso Assembly level in accordance with ILC Document 0111-70028J (ILC Document 0111-710112 for adjustable waist):

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 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 Waist Restraint/Bladder assembly level in accordance with ILC Document 0111-70028J(ILC document 0111-710112 for adjustable waist):

1. Initial leak test at 4.3 +/- 0.1 psig to verify leakage less than 8.0 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 8.0 scc/min.
4. Final leak test at 4.3 +/- 0.1 psig to verify leakage less than 8.0 scc/min.

Certification:
The waist bladder assembly (solution coated urethane) was successfully tested (manned) during SSA certification to duplicate operational life (Ref: Cert. Test Report for the enhanced SSA, ILC Document 0111-711330).

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

Requirement	S/AD	Actual
Waist Cycles	1234	2800
Waist Rotations	2466	6000
Pressure Cycles	300	600
Don/Doff Cycles	98	400
Pressure Hours	458	916

The waist bladder assembly was successfully subjected to an ultimate pressure of 13.2 psig during SSA certification testing (Ref. Document 0111-711330). This is 1.5 times maximum BTA operating pressure based on 8.8 psi.

NAME P/N QTY	CRIT	FAILURE MODE & CAUSES	FAILURE EFFECT	RATIONALE FOR ACCEPTANCE
		104FM09		

Further certification of a subsequent design change of significance to the waist bladder assembly was accomplished. ECO 831-0413 (Heat Sealed Bladder Tapes) was certified on the basis of ILC conducted engineering seam strength tests and by similarity with successfully certified boot bladder assemblies (Ref. ILC Engineering memorandum EM 83-1065).

The bladder assembly (laminate coated urethane, P/N 0104-84811) 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
Hip Add/Abd	458	1200
Hip Flex/Ext	1524	3200
Waist Flex/Ext	1234	2800
Waist Rotation	2466	5200
Don/Doff	98	205
Pressure Hours	458	983

The bladder assembly 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.

Adjustable Waist Assembly (P/N 0104-812355)
The adjustable waist assembly was successfully tested (manned) to duplicate operational life (Ref ILC Document 0111-712381). The following use, reflecting requirements of significance to the waist assembly, was documented during certification:

Requirements	S/AD	Actual
Flexion/Extension	1234	2600
Rotations	2466	5000
Walking Steps	4320	8640
Pressure Cycles	300	604
Don/Doff Cycles	98	204

The waist assembly was successfully subjected to a BTA ultimate pressure of 13.2 psid during certification testing (Ref. ILC Doc. 0111-712381). This is 1.5 times the maximum BTA operating pressure of 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 LTA manufacturing process to assure that the failure causes are precluded from the fabricated item:

NAME P/N QTY	CRIT	FAILURE MODE & CAUSES	FAILURE EFFECT	RATIONALE FOR ACCEPTANCE
		104FM09		1. Visual inspection of pattern pieces for compliance to pattern size shape. 2. Visual inspection of abrasion layer heat seal, where applicable, for delamination. 3. Visual inspection of pressurized bladder for defects prior to overtaping. 4. Visual inspection of bladder, before overtaping and flange installation, to classification of defects criteria. 5. Visual inspection of heat seal width. 6. Visual inspection of reinforcement tapes and flanges for positioning and bond acceptability. 7. Verification of seam acceptability test results. During PDA, the following inspection points are performed at the lower torso assembly level in accordance with ILC Document 0111-70028J (ILC Document 0111-710112 for Adjustable Waist): 1. Inspection for damage or fabric or material degradation. 2. Visual inspection for structural damage following proof pressure test. D. Failure History - Non-adjustable waist: No history of this failure mode to date. However, the following failures have occurred that were within SOP make-up capability: I-EMU-104-C003 (07/14/80). Hole in bladder due to LCVG duct abrasion. Covered vent duct with Teflon sleeve. I-EMU-104-C005 (06/22/82). Hole in bladder due to LCVG duct abrasion. Enlarged abrasion layer to cover entire bladder. J-EMU-104--011 (08/07/85). Small cut in bladder. Revised tool handling procedures. No Certification Impact. B-EMU-104-A023 (6/25/88). Leakage in left leg bladder due to abrasion from extensive treadmill use. ECO 891-0002 restricts chamber treadmill use to 10 hours and adds visual inspection of the non-reinforced areas of trouser and boot bladders for abrasion every 4 hours of chamber time at altitude where treadmill activities occur. J-EMU-104-A002 (10/08/93). Enhanced LTA S/N 2002 leaked through several abraded/damaged bladder areas. Damage caused by excessive wear due to treadmill walking steps beyond LTA S/AD 38,880 walking step requirement. In addition, a cut most likely caused by a sharp object 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 if treadmill use has occurred). J-EMU-104--024 (9/27/95). LTA S/N 1090 leaked at a rate of 812 SCCM vs. spec of 46.5 SCCM max. A 1/4 inch break, (which appeared as a gouge) in the urethane bladder coating was found near the right side seam, caused by contact with a dosimeter mockup. The mockup had sharp edges and did not meet the drawing requirements. B-EMU-104-A069 (3/19/01) - During STS-102 post-flight processing, the LTA failed leakage testing. Waist bladder abraded by LCVG torso tubing rubbing against bladder crease. No corrective action. Adjustable Waist:

NAME P/N QTY	CRIT	FAILURE MODE & CAUSES	FAILURE EFFECT	RATIONALE FOR ACCEPTANCE
		104FM09		B-EMU-104-A068 (9/29/00) - Metal shaving approximately 1/4" long X 1/64" wide found penetrating bladder flange of waist restraint on crewmember's right side near the sixth screw hole from front center. Discovered during first time build-up of Waist Restraint Band Bladder S/N 316. Shard identified as broken piece/thread of an A286 Stainless Steel fixturing screw typically used at ILC to attach waist assembles to Standard Test Equipment. Reviewed incident with assembly and inspection to increase awareness. No other C/A taken. Pre-flight screens exist to detect this type of anomaly. 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 Waist Restraint and Bladder is removed from the LTA and completely inspected for signs of degradation or damage. F. Operational Use - 1. Crew Response 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 criterias 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: _____
HS - Project Engineering

_____
HS - Reliability

_____ 4/24/02
HS - Engineering Manager

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

_____ 5/24/02
NASA – EMU SSM

_____ 5.29.02
NASA – S&MA

_____ 5-30-02
NASA – MOD

_____ 6/04/02
NASA – CTOW

_____ 6/3/02
NASA – Program Manager