NAME P/N QTY	CRIT	FAILURE MODE & CAUSES	FAILURE EFFECT	RATIONALE FOR ACCEPTANCE
		103FM15		
LOWER ARM RESTRAINT AND BLADDER, ITEM 103 (1) LEFT, (1) RIGHT ---------- 0103-810151-02 0103-810151-03 (2)	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: Loss of 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 lower arm 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. The bladder seams and flanges 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 and TMG layers. As a component of the arm assembly, 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 arm 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 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. Nominally, hoop load is absorbed by the bias direction of the fladder fabric. However, th safety factors are based on the fabric predicted hoop load of 12.6 lbs/inch, the minimum safety factor for hoop stress is 8.3 against a S/AD design minimum ultimate safety factor of 2.0 at 4.4 psid (normal operating pressure). At 5.5 psid (max failure pressure) and at 8.8 psid (max VTA operating pressure), the fabric ultimate safety factors are 6.6 and 4.2 against hoop loads of 15.7 and 25.2 lbs, respectively. The S/AD required minimum ultimate safety factor at 5.5 and 8.8 psid is 1.5. Testing has demonstrated that the breaking strength of the bladder seams mmeets 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 180 lbs/inch in the warp direction and 170 lbs/inch in the fill direction. The tearing strength is 3.5 lbs/inch minimum in both directions. Nominally, hoop load is absorbed by the bias direction of the bladder fabric. The minimum strength value, 170 lbs/inch is therefore used for determining safety factors. Based on a predicted hoop load of 12.6 lbs/inch, the minimum safety factor for hoop stress is 13.5 against a S/AD design minimum ultimate safety factor of 2.0 at 4.4 psid (normal operating pressure). At 5.5 psid (max failure pressure) and at 8.8 psid (max BTA operating pressure), the fabric ultiamte safety factors are 10.8 and 6.7 against hoop loads of 15.7 and 25.2 lbs, respectively. The S/AD required minimum ultiamte safety factor at 5.5 and 8.8 psid is 1.5. Testing has demonstrated that the breaking strength of the bladder seams meets or exceeds that of the bladder fabric. B. Test - Acceptance: As required by the Table of Operations (T/O) for the fabrication of the bladder assemblies, 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

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production.

Following fabrication, each bladder assembly is assembled into a test restraint and subjected to a leakage test at 4.3 psig to verify leakage less than 6.0 scc/min.

PDA:
The following tests are conducted at the Arm Assembly level in accordance with ILC Document 0111-710112 for the Enhanced Assembly:
1. Initial leak test at 4.3 +/- 0.1 psig to verify leakage less than 24.0 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 24.0 scc/min.
4. Final leak test at 4.3 +/- 0.1 psig to verify leakage less than 24.0 scc/min.

When delivered as a separable component of the Arm, the following tests are conducted at the Lower Arm Assembly level in accordance with Document 0111-710112 for the Enhanced Assembly:
1. Initial leakage at 4.3 + 0.1 psig to verify leakage less 6.0 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 6.0 scc/min.
4. Final leakage at 4.3 +/- 0.1 psig to verify leakage less than 6.0 scc/min.

Certification:
The bladder assemblies (solution coated urethane) were successfully tested (manned) during SSA certification to duplicate 458 hours operational life (Ref. ILC Report 0111-711330). The following usage reflecting requirement of significance to the bladder assemblies was documented during certification:

Requirement	S/AD	Actual
Shoulder Rotations	29348	60000
Elbow Flex/Ext	49660	102000
Don/Doff Cycles	98	400
Pressure Hours	458	916

The bladder assemblies were successfully subjected to an ultimate pressure of 13.2 psid during SSA certification testing (Ref. ILC Report 0111-711330). This is 1.5 times maximum BTA operating pressure based on 8.8 psid.

The bladder assembly (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
Shoulder Rotations	29348	58,800
Elbow Flex/Ext	49660	99,600
Don/Doff	98	203
Pressure Hours	458	981

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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.

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 arm assembly 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 positionning and bond acceptability.
5. Verification of seam acceptability test results.

During PDA, the following inspection points are performed at the Arm Assembly level in accordance with ILC Document 0111-710112:
1. Inspect for damage, or fabric degradation.
2. Visual inspection for damage following proof pressure test.
3. Radiographic inspection of TMG to verify absence of foreign material that could cause bladder puncture.

D. Failure History -
B-EMU-103-A044 (12/17/98). At SEMU Post ETA (STS-88), Lower Arm assembly bladder material had two bladder cloth delaminations 1/8 inch apart and located about five inches down from the Fabric Attachment Ring near the elbow gores. No corrective action is required. Delamniations are within the FEMU-R-001 and Standard Inspection Procedure (SIP) established acceptable criteria. USA and ILC concur with Hamilton Standard that no RDR should have been generated.

E. Ground Turnaround -
Tested for non-EET processing per FEMU-R-001, Pre-Flight Arm Structural and Leakage Tests. None for EET processing. Additionally, every 229 hours of manned pressurized time or 4 years chronological time the arm restraint and bladder assemblies are removed from the arm assembly and subjected to a complete visual inspection (interior and exterior surfaces) for material damage and degradation.

F. Operational Use -
1. Crew Response -
Pre EVA/post EVA: Troubleshoot problem. Consider use of third EMU. If no success, terminate EVA prep. EMU is no go for EVA.
EVA: When CWS data confirms SOP avtivation, abort EVA.
2. Training -
Standard training covers this failure mode.

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EXTRAVEHICULAR MOBILITY UNIT

SYSTEMS SAFETY REVIEW PANEL REVIEW

FOR THE

I-103 ARM ASSEMBLY

CRITICAL ITEM LIST (CIL)

EMU CONTRACT NO. NAS 9-97150

Prepared by: _____ 5/27/02
HS - Project Engineering

Approved by: _____
NASA - SSA/SSM

_____
HS - Reliability

_____ 5/14/02
NASA - EMU/SSM

_____
HS - Engineering Manager

_____ 6/17/02
NASA - S&MA

_____ 5/23/02
NASA - MOD

_____ 6/04/02
NASA - Crew

_____ 6/04/02
NASA - Program Manager