| NAME P/N QTY | CRIT | FAILURE MODE & CAUSES | FAILURE EFFECT | RATIONALE FOR ACCEPTANCE |
|---|---|---|---|---|
| | | 103FM05 | | |
| UPPER ARM RESTRAINT AND BLADDER ASSEMBLY, ITEM 103 (1) LEFT (1) RIGHT<br>----------<br>0103-88953-04<br>(2) | 1/1 | External gas leakage beyond SOP make-up capability.<br><br>Separation of seam or puncture in bladder. Defective Material, abrasion. | END ITEM:<br>Suit gas leakage to ambient.<br><br>GFE INTERFACE:<br>Depletion of primary O2 supply and SOP. Rapid depressurizatio n of SSA beyond SOP makeup capability.<br><br>MISSION:<br>Loss of EVA.<br><br>CREW/VEHICLE:<br>Loss of crewman.<br><br>TIME TO EFFECT /ACTIONS:<br>Seconds.<br><br>TIME AVAILABLE:<br>N/A<br><br>TIME REQUIRED:<br>N/A<br><br>REDUNDANCY SCREENS:<br>A-N/A<br>B-N/A<br>C-N/A | A. Design -<br>The upper 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.<br><br>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.<br><br>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 bladder fabric. However, the safety factors are based on the fabric yarns (fill yarns) which have the least strength. Based on a predicted hoop load of 18.7 lbs/inch, the minimum safety factor for hoop stress is 5.6 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 ultimate safety factors are 4.5 and 2.8 against hoop loads of 23.4 and 37.4 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 meets or exceeds that of the bladder fabric.<br><br>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 9.1 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 ultimate safety factors are 7.2 and 4.5 against hoop loads of 23.4 and 37.4 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 meets or exceeds that of the bladder fabric.<br><br>B. Test -<br>Acceptance:<br>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 production. |

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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 4.3 scc/min. for the Non-Enhanced Assembly and less than 10.0 scc/min for the Enhanced Assembly.

PDA:
The following tests are conducted at the Arm Assembly level in accordance with ILC Document 0111-70028J for Non-Enhanced Assembly and 0111-710112 for 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 Upper Arm Assembly level in accordance with Document 0111-70028J for Non-Enhanced Assembly and 0111-710112 for Enhanced Assembly:

1. Initial leakage at 4.3 +/- 0.1 psig to verify leakage less than 14.0 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 14.0 scc/min.
4. Final leakage at 4.3 +/- 0.1 psig to verify leakage less than 14.0 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 requirements of significance to the bladder assemblies, was documented during certification:

| Requirement | S/AD | Actual |
|---|---|---|
| Add/Abd | 8484 | 18000 |
| Rotation | 29348 | 60000 |
| Lateral/Medial | 4092 | 10000 |
| Flex/Extension | 7430 | 16000 |
| Don/Doff Cycles | 98 | 400 |
| Pressure Hours | 458 | 916 |

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 |
|---|---|---|
| Add/Abd | 8484 | 17,200 |
| Rotation | 29348 | 58,800 |
| Lateral/Meidal | 4092 | 8,400 |

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| | | |
|---|---|---|
| Flex/Ext | 7430 | 15,200 |
| Don/Doff | 98 | 203 |
| Pressure Hours | 458 | 981 |

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 positioning 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 for Enhanced Assembly:
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.
4. Structural and leakage tests.

D. Failure History -
None.

E. Ground Turnaround -
Ground Turnaround - Tested for non-EET processing per FEMU-R-001, Pre-Flight Final SEMU Gas Structural and Leakage. 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 -
PreEVA/PostEVA: Trouble shoot problem. If no success use third EMU if available. EMU is "no go" for EVA.
EVA: When CWS data confirms SOP activation, abort EVA.

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| | | 103FM05 | | 2. Training - Standard training covers this failure mode.<br><br>3. Operational Considerations -<br>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 and SOP operation. Real Time Data System allows ground monitoring of EMU systems. |

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