

---

**FAILURE MODE EFFECTS ANALYSIS/CRITICAL ITEMS LIST**

---

|                           |  |                      |
|---------------------------|--|----------------------|
| FMEA NUMBER: HMLA-7       | ORIGINATOR: JSC                          | PROJECT: GFE Orbiter |
| PART NAME: Li-BCX Battery | LRU PART NUMBER: SED39126030-301         | QUANTITY: 4 per LRU  |
| PART NUMBER: 3B1910-XA    | LRU PART NAME: EMU Helmet Light Assembly | SYSTEM: DTO 671      |
| DRAWING: SED39126046      | SUBSYSTEM: N/A                           | EFFECTIVITY: STS-69  |

---

**CRITICALITY:**CRITICAL ITEM? YES X NO \_\_\_\_\_CRITICALITY CATEGORY: 1/1**REDUNDANCY SCREENS:**A - PASS  
B - PASS  
C - PASS

---

**FUNCTION:** Power source for light bulbs on each side of helmet

---

**FAILURE MODE:** Internal short resulting in rapid temperature rise, venting/explosion**CAUSE:** Excessive vibration or shock; Defective separator membrane (manufacturing defect)**FAILURE DETECTION:** Loss of lighting, audible noise**REMAINING PATHS:** Other side of Helmet Mounted Light Assembly; other crewmember's Helmet Mounted Light Assembly; payload bay lighting**EFFECT/MISSION PHASE:** EVA**CORRECTIVE ACTION:** None

---

**-FAILURE EFFECTS-**

---

**END ITEM:** Light becomes inoperable on that side of helmet.**INTERFACE:** Possible contamination or damage to EMU. (See LiBCX Battery Hazard Report for contamination cleanup procedures.)**MISSION:** Possible loss of mission.**CREW/VEHICLE:** Possible injury to or loss of crewmember if venting/explosion occurs.

---

---

## FAILURE MODE EFFECTS ANALYSIS/CRITICAL ITEMS LIST

---

|                           |  |                      |
|---------------------------|--|----------------------|
| FMEA NUMBER: HMLA-7       | ORIGINATOR: JSC                          | PROJECT: GFE Orbiter |
| PART NAME: Li-BCX Battery | LRU PART NUMBER: SED39126030-301         | QUANTITY: 4 per LRU  |
| PART NUMBER: 3B1910-XA    | LRU PART NAME: EMU Helmet Light Assembly | SYSTEM: DTO 671      |
| DRAWING: SED39126046      | SUBSYSTEM: N/A                           | EFFECTIVITY: STS-69  |

---

### HAZARD INFORMATION:

HAZARD: YES   X   NO       

HAZARD ORGANIZATION CODE: N/A

HAZARD NUMBER: N/A

---

TIME TO EFFECT: Immediate

TIME TO DEFECT: Immediate

TIME TO CORRECT: None

---

### REMARKS:

#### RATIONALE FOR ACCEPTABILITY

##### (A) DESIGN:

Design features to minimize failure mode:

- a. The Li-BCX cell uses lithium as the anode and thionyl chloride (SOCl<sub>2</sub>) with 16% bromine chloride (BrCl) as the catholyte reacting on an inert carbon cathode to produce an open circuit voltage of 3.9 volts. The normal operating temperature range for the Li-BCX cell is -40°F to +160°F.
- b. A fiberglass separator material between the positive and negative electrodes is designed to provide ion conduction while insulating against internal shorts.
- c. The cell contents are contained in an approximately 0.8 mm thick 304 stainless steel case with a welded metal lid.
- d. As of February 1987, the "D" cell design has been modified to resist leaking and venting at temperatures up to 149°C (300°F) (Report NAS 9-17701 and JSC 22940, "LIBCX D Cell Delta Qual").
- e. In 1994, a change in the pin diameter (larger pin for ease of manufacture) decreased the absolute pressure capability of the D cell such that the fresh cell and totally discharged cell temperature limit is now 125°C (257°F); however, a partially discharged cell (such as one self-heating under internally shorting conditions) still retains tolerance to 149°C (300°F).

---

PREPARED BY: J. Holt

REVISION:

DATE: June 23, 1995

---

---

**FAILURE MODE EFFECTS ANALYSIS/CRITICAL ITEMS LIST**

---

|                           |  |                      |
|---------------------------|--|----------------------|
| FMEA NUMBER: HMLA-7       | ORIGINATOR: JSC                          | PROJECT: GPE Orbiter |
| PART NAME: LI-BCX Battery | LRU PART NUMBER: SED39126030-301         | QUANTITY: 4 per LRU  |
| PART NUMBER: 3B1910-XA    | LRU PART NAME: EMU Helmet Light Assembly | SYSTEM: DTO 671      |
| DRAWING: SED39126046      | SUBSYSTEM: N/A                           | EFFECTIVITY: STS-69  |

---

**HAZARD INFORMATION:**HAZARD: YES  NO 

HAZARD ORGANIZATION CODE: N/A

HAZARD NUMBER: N/A

---

TIME TO EFFECT: Immediate

TIME TO DEFECT: Immediate

TIME TO CORRECT: None

---

**REMARKS:****RATIONALE FOR ACCEPTABILITY****(B) TEST:**

Test or analysis to detect failure mode:

- a. Vendor cell acceptance and lot certification tests (JSC-EP5-83-025). A certified lot is defined as a set of cells which has been consecutively made within four consecutive calendar days using a single batch of electrolyte mix. Additionally, the cells are made from one batch of anode, cathode, and separator material. To certify a lot, a sample (approximately 20%) of a lot is subjected to the following tests performed by the vendor:
  1. Capacity Discharge - one sample (9%) of cells are discharged through a 20 ohm load at 70°F until reaching a cutoff voltage of 2 volts. Pass/fail criterion average capacity must be greater than 13 ampere-hours. Fuse Check - 3 ampere fuse must blow within 15 seconds at 6 amperes. Overdischarge Tolerance - 3 weeks after the discharge test 2/3 of the capacity cells are overdischarged at 1 ampere for 16 hours at 160°F. Pass/fail criterion - no venting or rupture of cell material with by-pass diodes attached. An additional overdischarge test is run at 70°F at 3 amperes with diodes for 2 hours in reversal, with the same pass/fail criteria.
  2. High Temperature Exposure - a second sample (3%), fresh and an equal number discharged, is placed in an oven at 200°F for 2 hours. Pass/fail criterion - no venting or leakage.
  3. Short Circuit Tolerance - a third sample (4%) is electrically shorted through a load equal to or less than 50 milliohms. Pass/fail criterion - no venting or leakage.

PREPARED BY: J. Holt

REVISION:

DATE: June 23, 1995

---

## FAILURE MODE EFFECTS ANALYSIS/CRITICAL ITEMS LIST

|                           |  |                      |
|---------------------------|--|----------------------|
| FMEA NUMBER: HMLA-7       | ORIGINATOR: JSC                          | PROJECT: GFE Orbiter |
| PART NAME: Li-BCX Battery | LRU PART NUMBER: SED39126030-301         | QUANTITY: 4 per LRU  |
| PART NUMBER: 3B1910-XA    | LRU PART NAME: EMU Helmet Light Assembly | SYSTEM: DTO 671      |
| DRAWING: SED39126046      | SUBSYSTEM: N/A                           | EFFECTIVITY: STS-69  |

### HAZARD INFORMATION:

HAZARD: YES X NO \_\_\_\_\_

HAZARD ORGANIZATION CODE: N/A

HAZARD NUMBER: N/A

TIME TO EFFECT: Immediate

TIME TO DEFECT: Immediate

TIME TO CORRECT: None

### REMARKS:

#### RATIONALE FOR ACCEPTABILITY

##### (B) TEST (cont):

4. A sample of two D cells per lot is also tested to 257°F for 15 minutes, one fresh cell and one totally discharged cell is used. It must not leak or vent during this period.
5. Visual, open circuit voltage (OCV), and load voltage tests are performed on 100% of the cells.
6. A sample from each lot (2 fresh and 2 discharged) of the cells are tested to the following spectrum by the vendor who subjects them to acceptance vibration test for 15 minutes in each of three mutually perpendicular axes, according to the following spectrum, before being discharged for capacity information:

|                      |                        |
|----------------------|------------------------|
| Frequency Level (Hz) |                        |
| 20 to 80             | + 3 db/octave          |
| 80 to 350            | 0.1 g <sup>o</sup> /Hz |
| 350 to 2000          | - 3 db/octave          |

The OCV is monitored during testing and a load test is performed after vibration testing is complete.

##### b. Boeing FEPC Acceptance Test (P528/ATP-08002)

A visual inspection and OCV acceptance is performed on all delivered cells prior to being placed in the freezer storage (bonded storage) for later issue for incorporation into flight applications. Load voltage testing is performed on cells prior to assembly into batteries for flight applications.

PREPARED BY: J. Holt

REVISION:

DATE: June 23, 1995

---

**FAILURE MODE EFFECTS ANALYSIS/CRITICAL ITEMS LIST**

---

|                           |  |                      |
|---------------------------|--|----------------------|
| FMEA NUMBER: HMLA-7       | ORIGINATOR: JSC                          | PROJECT: GFE Orbiter |
| PART NAME: Li-BCX Battery | LRU PART NUMBER: SED39126030-301         | QUANTITY: 4 per LRU  |
| PART NUMBER: 3B1910-XA    | LRU PART NAME: EMU Helmet Light Assembly | SYSTEM: DTO 671      |
| DRAWING: SED39126046      | SUBSYSTEM: N/A                           | EFFECTIVITY: STS-69  |

---

**HAZARD INFORMATION:**HAZARD: YES X NO \_\_\_\_\_

HAZARD ORGANIZATION CODE: N/A

HAZARD NUMBER: N/A

TIME TO EFFECT: Immediate

TIME TO DEFECT: Immediate

TIME TO CORRECT: None

---

**REMARKS:****RATIONALE FOR ACCEPTABILITY****(C) INSPECTION:**

MANUFACTURING: During vendor cell manufacturing/acceptance test (JSC-EP5-83-025), 100% of the cells are manufactured under on-site defense contract administration services (DCMC) delegation.

- a. Electrode plates and separator material are checked for burrs and misalignment.
- b. Ohmic resistance across the dry cell terminal is checked.
- c. Each cell is identified by a serial number.
- d. After filling the cell with electrolyte, each cell is x-rayed in two directions to examine the assembled internal configuration.
- e. The cells are put in an oven at 160°F for 2 hours followed by:
  1. OCV test - must be greater than 3.85 volts
  2. Load test - must be greater than 3.5 volts
  3. Size and weight check to verify no swelling or venting occurred

---

PREPARED BY: J. Hoit

REVISION:

DATE: June 23, 1995

---

---

---

## FAILURE MODE EFFECTS ANALYSIS/CRITICAL ITEMS LIST

---

---

|                           |  |                      |
|---------------------------|--|----------------------|
| FMEA NUMBER: HMLA-7       | ORIGINATOR: JSC                          | PROJECT: GFE Orbiter |
| PART NAME: Li-BCX Battery | LRU PART NUMBER: SED39126030-301         | QUANTITY: 4 per LRU  |
| PART NUMBER: 3B1910-XA    | LRU PART NAME: EMU Helmet Light Assembly | SYSTEM: DTO 671      |
| DRAWING: SED39126046      | SUBSYSTEM: N/A                           | EFFECTIVITY: STS-69  |

---

### HAZARD INFORMATION:

HAZARD: YES  NO

HAZARD ORGANIZATION CODE: N/A

HAZARD NUMBER: N/A

---

TIME TO EFFECT: Immediate

TIME TO DEFECT: Immediate

TIME TO CORRECT: None

---

### REMARKS:

#### RATIONALE FOR ACCEPTABILITY

(D) FAILURE HISTORY:

To date, no internal shorting or hazardous event failures have been reported, upon delivery of approximately 1 million D cells in field use (out of a total of approximately 2.5 million of all sizes of spirally wound cells in the field). As of December 1992, approximately 1000 Li-BCX cells have flown in the Shuttle without a hazardous event occurring.

(E) OPERATIONAL USE:

- a. Operational Effect of Failure: Possible loss of crewmember
- b. Crew Action: None identified
- c. Crew Training: The crew will be trained to perform a pre-use visual and subjective temperature checkout of the battery cells when possible.
- d. Mission Constraints: None identified
- e. In-Flight Checkout: A pre-use visual and subjective temperature checkout of the battery cells will be performed when possible.

---

PREPARED BY: J. Holt

REVISION:

DATE: June 23, 1995

---