
FAILURE MODE EFFECTS ANALYSIS/CRITICAL ITEMS LIST

FMEA NUMBER: ECC-01	ORIGINATOR: JSC	PROJECT: GFE Orbiter
PART NAME: Li-BCK Battery	LRU PART NUMBER: SED39124778-303	QUANTITY: 4 per LRU
PART NUMBER: 528-20067	LRU PART NAME: Electronic Cuff Checklist Assembly	SYSTEM: EMU
DRAWING: Boeing 528-20067-1	SUBSYSTEM: ECC	EFFECTIVITY: All Orbiters

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

FUNCTION: Provides power to the Electronic Cuff Checklist (ECC)

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 power, turned-off display screen**REMAINING PATHS:** None**EFFECT/MISSION PHASE:** EVA**CORRECTIVE ACTION:** None

-FAILURE EFFECTS-**END ITEM:** Touch Screen becomes inoperable**INTERFACE:** None**MISSION:** Possible loss of mission**CREW/VEHICLE:** Possible injury to or loss of crewmember if venting/explosion occurs

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FMEA NUMBER: ECC-01	ORIGINATOR: JSC	PROJECT: GFE Orbiter
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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 (SOCl₂) 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 0.5 mm thick 304 stainless steel case with a welded metal lid.
- d. As of December 1991, the "C" cell has been designed to resist leaking and venting at temperatures up to 149°C (300°F) (Report NAS 9-118395 and EP5-91-034, "PRC-112, Survival Radio and EP5 Certification Report.").

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REVISION:

716195
DATE: July 1, 1995

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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 75 ohm load at 70°F until reaching a cutoff voltage of 2 volts. Pass/fail criterion average capacity must be greater than 6.5 ampere-hours. Fuse Check - 4 ampere fuse must blow within 15 seconds at 8 amperes. Overdischarge Tolerance - 3 weeks after the discharge test 2/3 of the cells capacity are overdischarged at 0.5 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 500 milliohms. Pass/fail criterion - no venting or leakage.

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RATIONALE FOR ACCEPTABILITY

(B) TEST (cont):

4. A sample of two C cells per lot is also tested to 300°F for 15 minutes, one fresh cell and one totally discharged cell is used. The samples cells must not leak or vent during this period.
5. A sample of four cells per lot (2 fresh and 2 discharged) are subjected to random vibration for 15 minutes per axis prior to being discharged for capacity information. The random vibration testing is identical to that for NASA acceptance in item 7 below.
6. Visual open circuit voltage (OCV) and load voltage tests are performed on 100% of the cells.
7. A sample from each lot 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 g²/Hz
350 to 2000 - 3 db/octave

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

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RATIONALE FOR ACCEPTABILITY

(B) TEST (cont):

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

1. A visual inspection and OCV are 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 application.

(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.

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

- 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

(D) FAILURE HISTORY:

To date, no internal shorting or hazardous event failures have been reported, upon delivery 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.

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REMARKS:

RATIONALE FOR ACCEPTABILITY

(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.

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