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## FAILURE MODE EFFECTS ANALYSIS/CRITICAL ITEMS LIST

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**FMEA NUMBER:** CSD-TCA-06

**ORIGINATOR:** JSC

**PROJECT:** Orbiter (ISSA DTO'S)

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**PART NAME:** Battery Pack

**PART NUMBER:** SED33103846-709

**LSC CONTROL NO:** N/A

**ZONE/LOCATION:** Middeck- PLB

**LRU/ORU PART NUMBER:** SED39126240-301

**LRU/ORU PART NAME:** Thermal Cube

**DRAWING/REF DESIGNATOR:** SED33103846

**EFFECTIVITY/AFFECT STAGE:** STS63 & SUBS

**QUANTITY:** 1

**SYSTEM:** EVA Equipment

**SUBSYSTEM:** Data Collection

**CRITICALITY:**

**CRITICAL ITEM?** \_\_ Yes

**CRITICALITY CATEGORY** \_\_ 1/1

**SUCCESS PATHS:** \_\_ 1 \_\_

**SUCCESS PATH REMAINING:** \_\_ 0 \_\_

**END ITEM NAME:** N/A

**END ITEM FUNCTIONAL:** N/A

**END ITEM CAPABILITY:** N/A

**END ITEM FAILURE TOLERANCE:** N/A

**REDUNDANCY SCREENS:**

1. **C/O PRELAUNCH:** N/A

2. **C/O ON ORBIT:** N/A

3. **DETECTION FLIGHT CREW:** N/A

4. **DETECTION GROUND CREW:** N/A

5. **LOSS OF REDUNDANCY FROM SINGLE CAUSE:** N/A

6. **ON-ORBIT RESTORABILITY:** N/A

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**FUNCTION:** End Item and ORU (LRU)

A hollow cube equipped with radiometers and thermocouples to obtain thermal/environmental data. A battery provides power to electronics package over a eight hour period. The assy is outfitted with an extension arm, enabling it to obtain a clear field of view away from EVA crewmember

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**FAILURE MODE CODE:** N/A

**FAILURE MODE:** Internal short of LiBCX C cell battery

**CAUSE:** shock, vibration, or defective separator membrane ( manufacturing defect )

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**REMAINING PATHS:**

N/A

**EFFECT/ MISSION PHASE:** All

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**CORRECTIVE ACTION:**

Note

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**FAILURE EFFECTS-**

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**END ITEM/LRU/ORU/ASSEMBLY:** Thermal Cube fails to operate.

**SUBSYSTEM/NEXT ASSEMBLY/INTERFACE:** N/A

**SYSTEM/END ITEM/MISSION:** Partial loss of DTO objectives

**CREW/VEHICLE:** Possible loss of crew due to toxic venting or explosion.

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## HAZARD INFORMATION:

HAZARD: YES  NO  Explosion or venting of LiBCX battery

HAZARD ORGANIZATION CODE: Controlled

HAZARD NUMBER: Li BCX-1

TIME TO EFFECT: immediate

TIME TO DETECT: seconds

TIME TO CORRECT: none

FAILURE DETECTION/FLIGHT - Visual /ground-none

## REMARKS:

This Battery is the same battery used in the Wireless Crew Communication System (WCCS). Qualification for it's use in the Thermal Cube Assy. is based on similarity to the WCCS and additional assembly level testing ( AVT, shock and Thermal Vacuum tests). The CIL was created in order to satisfy the requirements of NSTS 22206D paragraph 3.4.1.f

## -RATIONALE FOR ACCEPTABILITY-

### (A) DESIGN:

(1) The battery consists of 2 Li-BCX C-Cells which use lithium (Li) as the anode and thionyl chloride (SOCl<sub>2</sub>) with 16 percent bromide 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 LiBCX cell is -40°F to 160°F.

(2) A fiberglass separator material between the positive and negative electrodes is designed to provide ion conduction while insulating against internal shorts.

(3) The cell contents are contained in an approximately 0.019 inch thick 304L stainless steel case with a 0.093 inch TIG welded lid.

### (B) TEST:

#### Component Acceptance:

(1) Vendor cell lot certification (acceptance) test (Boeing-FEPC Spec P52/A TPR001) A certified lot is defined as a set of cells which has been consecutively made within 4 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 ( 16 to 20 percent minimum) of a lot is subjected to the following test performed by the vendor.

(2) Capacity Discharge - one sample (9 percent) of cells is 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. Over Discharge Tolerance - 3 weeks after the discharge seat, the cells are over discharged at low current for 16 hours at 160°F with bypass diodes. Pass/Fail Criterion - no venting or rupture of cell material.

(3) High Temperature Exposure - a second sample (6 percent) is placed in an oven 200°F for 2 hours. Pass/Fail Criterion - no venting or leaking.

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**TEST (cont.)**

(4) Short Circuit Tolerance - a third sample (4 percent ) is electrically shorted through a load equal to 500 milliohms Pass/Fail Criterion - no venting or leaking.

(5) A sample of four cells per lot is subjected to random vibration for 15 minutes/axis prior to being discharged for capacity information. the random vibration spectrum:

FREQUENCY Hz)	LEVEL
20 to 80	+3dB/octave
80 to 350	0.1g <sup>2</sup> /Hz
350 to 2000	-3db/octave

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

(6) A 300 degree F temperature exposure test is performed on 1 fresh cell and 1 discharged cell. Pass / Fail criteria is no venting or leakage

(7) Visual and open circuit voltage (OCV) tests is performed on 100 percent of delivered cells.

Assembly Acceptance test

The Thermal Cube Assembly is subjected to the following AVT for a duration of 1 minute per axis. The thermal cubes performance is verified prior to and following the test.

Frequency (Hz)	Level:
20	+3db/oct
80 to 350	0.40 G <sup>2</sup> /Hz
350 to 2000	-3db/oct

Component Certification:

(1) During battery certification, the LiBCX cell was evaluated over a variety of performance and off limits test conditions in order to meet the requirements for certification:

- a. Open circuit and load voltage
- b. Shock and vibration
- c. Capacity discharge.
- d. Overdischarge.
- e. High temperature exposure tolerance testing (by analysis).

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LRU/ORU PART NUMBER: SED39126240-301

QUANTITY: 1

PART NUMBER: SED31103846-709

LRU/ORU PART NAME: Thermal Cube

SYSTEM: EVA Equipment

LSC CONTROL NO: N/A

DRAWING/REF DESIGNATOR: SED31103846

SUBSYSTEM: Data Collection

ZONE/LOCATION: Middeck #1 B

EFFECTIVITY/AFFECT STAGE: ST563 & SUBS

f. Offgassing (by analysis).

## TEST (cont.)

(2) For certification testing, four batteries were subjected to random vibration according to the following spectrum for 15 minutes in each of three mutually perpendicular axis without experiencing a failure.

FREQUENCY Hz)	LEVEL
20 to 80	+3dB/octave
80 to 350	0.167g <sup>2</sup> /Hz
350 to 2000	-3 g <sup>2</sup> /Hz

(3) Shock: Testing to MIL STD - 810 for bench handling.

## Turnaround:

After battery configuration has been certified, each battery is usable for flight for the length of its shelf life from date of cell manufacture. This non-rechargeable battery may be reflown as long as it was not used during flight. Once a battery has had any use (no matter how limited) during a mission, it is removed from inventory and submitted for disposal. Unused batteries are subjected to a visual inspection, OCV, and load test and returned to flight status, provided its shelf life has not expired. The length of its shelf life is to be determined by on going test. Used batteries will be partially disassembled, the cells will be removed for disposal and the electrical components will be checked. The cases will be refurbished with new cells, and as needed, new electrical components.

## Assembly Certification

The following environmental tests are performed on the thermal cube assembly. The thermal cubes performance is verified prior to and following the test.

(1) Shock Test - 20g's, 11ms terminal sawtooth on each axis.

(2) Electromagnetic compatibility Tests - Performance to SL-E-102 verified.

(3) Thermal Vacuum Test - A thermal environment to produce an adiabatic surface temperature on an ortho fabric surface of - 128 F ( for 7hrs.) and + 255 F ( for 1 hr.) at a pressure of .0001 mm Hg.

## (C) INSPECTION:

### Manufacturing:

During vendor cell manufacturing/acceptance testing, 100 percent of the cells are manufactured under on site Defense Contract Administration Services (DCAS) delegation.

a. Electrode plates and separator material are checked for burrs and misalignment.

b. Ohmic resistance across the dry cell terminal is checked.

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c. Each cell is identified by a serial number.

d. After filling the cell with electrolyte and finishing its terminal assembly, each cell is x-rayed in two directions to examine the assembled internal configuration and its terminal assy which contains a fast blow fuse.

### **INSPECTION (cont.)**

e. After filling, all the cells are put in an oven at 160 degree 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.

Note: Visual and OCV inspections are done on 100 percent of the delivered cells. All the tests conducted in part 2 and inspections in part 3 serve to prevent the occurrence of internal shorts in light batteries containing these cells by product quality control during manufacturing and by parametric screening during cell acceptance testing.

### Assembly Inspection

Fabrication - Critical part dimensions, tolerances, application of lubricants, etc will be inspected to ensure compliance with the part's drawing. All TCA parts shall be verified to be visibly clean.

Test - Quality Assurance surveillance is required at all tests and inspection. Discrepancy reports are written on all noncompliance's

### **(D) FAILURE HISTORY:**

None reported. Over 1000 LiBCX cells have flown in the Shuttle Orbiter without a hazardous event occurring. No internal shorts have been detected in more than 4,350 cells tested at JSC. Furthermore, no such failures have been reported in any of over 2 million cells manufactured and delivered by the vendor

### **(E) OPERATIONAL USE:**

- a. Operational Effect of Failure - possible loss of crew member
- b. Crew Action - none identified.
- c. Crew Training - None. If a battery change out is needed, the crew is trained to perform a preuse visual and subject temperature checkout of the battery..
- d. Mission Constraints - None identified.
- e. In-Flight Checkout - A preuse visual and subject temperature checkout of the battery will be performed when possible.

### **(F) MAINTAINABILITY: N/A for NSTS**

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**PREPARED BY:** G. Wright

**REVISION:**

**DATE:** 10/26/94

**WAIVER NUMBER**

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**PART NAME:** Battery Pack

**LRU/ORU PART NUMBER:** SED39126240-801

**QUANTITY:** 1

**PART NUMBER:** SED33103846-700

**LRU/ORU PART NAME:** Thermal Cube

**SYSTEM:** EVA Equipment

**LSC CONTROL NO:** N/A

**DRAWING/REF DESIGNATOR:** SED33103846

**SUBSYSTEM:** Data Collection

**ZONE/LOCATION:** Middeck PLB

**EFFECTIVITY/AFFECT STAGE:** STS61 & SUBS

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