

8.2 As an additional precaution, the temperatures on the surface of the battery casings shall be monitored during the tests described in Sections 10, 13 and 17. All personnel involved in the testing of lithium batteries are to be instructed never to approach a lithium battery while the surface temperature exceeds 90°C (194°F).

8.2 revised June 24, 1999

8.3 For protection, the Test for Flaming Particles, 19.2, and the Projectile Test, 19.3 are to be conducted in a room separate from the observer.

8.3 added June 24, 1999

## 9 Temperature Measurements

9.1 Temperatures are to be measured by thermocouples consisting of wires not larger than No. 24 AWG (0.21 mm<sup>2</sup>) and not smaller than No. 30 AWG (0.05 mm<sup>2</sup>) and a potentiometer-type instrument.

9.2 The temperature measurements on the batteries are to be made with the measuring junction of the thermocouple held tightly against the metal casing of the battery.

## TESTS FOR TECHNICIAN-REPLACEABLE AND USER-REPLACEABLE BATTERIES

### ELECTRICAL TESTS

#### 10 Short-Circuit Test

10.1 Each test sample battery, in turn, is to be short-circuited by connecting the positive and negative terminals of the battery with copper wire having a maximum resistance load of 0.1 ohm. The battery is to discharge until a fire or explosion is obtained, or until it is completely discharged and the battery case temperature has returned to near ambient temperature.

10.1 revised June 24, 1999

10.2 Tests are to be conducted at room temperature and at 60 ± 2°C (140 ± 4°F). The batteries are to reach equilibrium at room temperature or 60 ± 2°C, as applicable, before the terminals are connected.

10.2 revised June 24, 1999

10.3 A battery is to be tested individually unless the manufacturer indicates that it is intended for use in series or parallel. For series or parallel use, additional tests on five sets of batteries are to be conducted using the maximum number of batteries to be covered for each configuration.

10.4 When an overcurrent or thermal protective device that has been investigated for the purpose actuates during the test, the test shall be repeated with the battery supply connected to the maximum load that does not cause the protective device to open. A protective device that has not been investigated for the purpose shall be short-circuited.

10.4 added June 24, 1999

10.5 The samples shall not explode or catch fire. The temperature of the exterior cell or battery casing shall not exceed 150°C (302°F).

10.5 added June 24, 1999

**11 Heating Test**

Section 11 relocated as Section 18A June 24, 1999

**11A Abnormal Charging Test**

11A added June 24, 1999

11A.1 Cells or batteries discharged to the manufacturer's rated capacity shall be used for this test.

11A.1 added June 24, 1999

11A.2 Each test sample battery is to be subjected to a charging current of three times the current  $I_c$ , specified by the manufacturer by connecting it in opposition to a dc-power supply. The specified charging current is to be obtained by connecting a resistor of the specified size and rating in series with the battery. The test time is to be calculated using the formula:

$$t_c = \frac{2.5 C}{3(I_c)}$$

*In which:*

$t_c$  is the charging time in hours,

$C$  is the capacity of the battery in ampere-hours, and

$I_c$  is the charging current, in amperes, specified by the manufacturer.

The minimum test time shall be 48 hours. This does not require that the initial  $I_c$  be maintained for 48 hours.

18.1 revised and relocated as 11A.2 June 24, 1999

11A.3 When a overcurrent or thermal protective device that has been investigated for the purpose actuates during the test, the test shall be repeated with the battery supply connected to the maximum load that does not cause the protective device to open. A protective device that has not been investigated for the purpose shall be short-circuited.

11A.3 added June 24, 1999

11A.4 The samples shall not explode or catch fire.

11A.4 added June 24, 1999

**11B Forced-Discharge Test**

Section 17 relocated as Section 11B June 24, 1999

11B.1 This test is intended for cells that are to be used in multicell applications, such as battery packs.

11B.1 added June 24, 1999

11B.2 A completely discharged cell is to be force-discharged by connecting it in series with fresh cells of the same kind. The number of fresh cells to be connected in series with the discharged cell is to equal the maximum number less one of the cells to be covered for series use. Five cells are to be completely discharged, at room temperature.

17.3.1 revised and relocated as 11B.2 June 24, 1999

11B.3 Once the completely discharged cell is connected in series with the specified number of fresh cells the resultant battery pack is to be short circuited.

11B.3 added June 24, 1999

11B.4 The positive and negative terminals of the sample are to be connected with a copper wire with a maximum resistance load of 0.1 ohm. The battery is to discharge until a fire or explosion is obtained, or until it is completely discharged and the battery case temperature has returned to near ambient temperature.

11B.4 added June 24, 1999

11B.5 When an overcurrent or thermal protective device that has been investigated for the purpose actuates during the test, the test shall be repeated with the battery supply connected to the maximum load that does not cause the protective device to open. A protective device that has not been investigated for the purpose shall be short-circuited.

11B.5 added June 24, 1999

11B.6 The samples shall not explode or catch fire.

11B.6 added June 24, 1999

## MECHANICAL TESTS

### 12 Crush Test

12.1 A battery is to be crushed between two flat surfaces. The force for the crushing is to be applied by a hydraulic ram with a 1.25 inch (32 mm) diameter piston. The crushing is to be continued until a pressure reading of 2500 psig (17.2 MPa) is reached on the hydraulic ram, applied force of 3000 pounds (13 kN). Once the maximum pressure has been obtained it is to be released.

12.1 revised June 24, 1999

12.2 A cylindrical or prismatic battery is to be crushed with its longitudinal axis parallel to the flat surfaces of the crushing apparatus. A prismatic battery is also to be rotated 90 degrees around its longitudinal axis so that both the wide and narrow sides will be subjected to the crushing force. Each sample battery is to be subjected to a crushing force in only one direction. Separate samples are to be used for each test.

12.3 A coin or button battery is to be crushed with the flat surface of the battery parallel with the flat surfaces of the crushing apparatus.

12.4 The samples shall not explode or catch fire.

12.4 added June 24, 1999

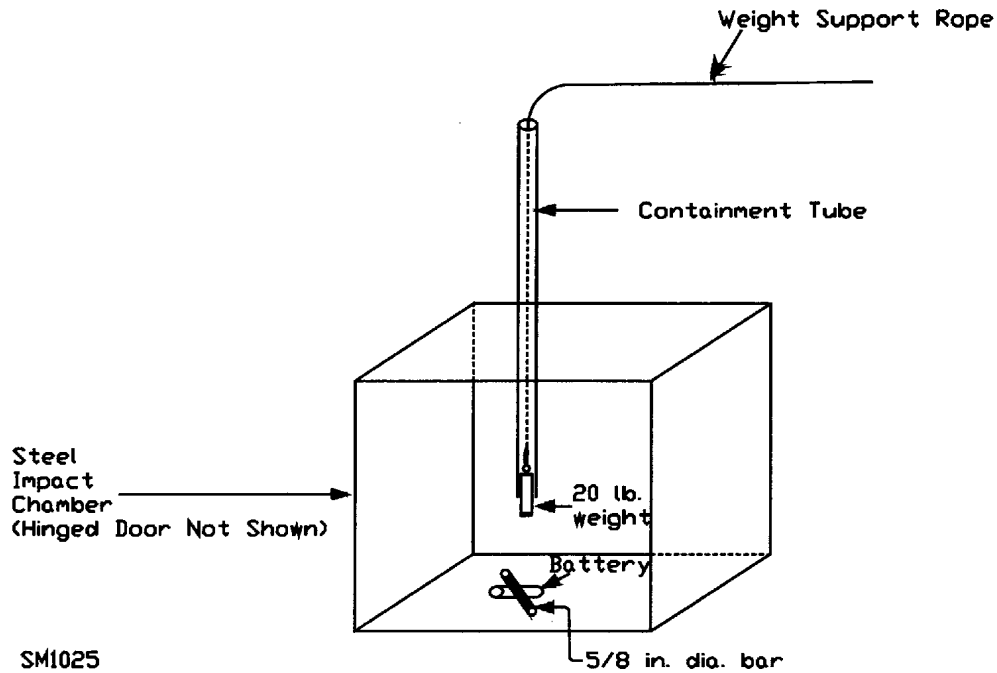
### 13 Impact Test

13.1 A test sample battery is to be placed on a flat surface. A 5/8 inch (15.8 mm) diameter bar is to be placed across the center of the sample. A 20 pound (9.1 kg) weight is to be dropped from a height of 24 ± 1 inch (610 ± 25 mm) onto the sample. (See Figure 13.1).

13.1 revised June 24, 1999

**Figure 13.1  
Impact test**

Figure 13.1 added June 24, 1999



13.2 A cylindrical or prismatic battery is to be impacted with its longitudinal axis parallel to the flat surface and perpendicular to the longitudinal axis of the 5/8 inch (15.8 mm) diameter curved surface lying across the center of the test sample. A prismatic battery is also to be rotated 90 degrees around its longitudinal axis so that both the wide and narrow sides are subjected to the impact. Each sample battery is to be subjected to only a single impact. Separate samples are to be used for each test.

13.2 revised June 24, 1999

13.3 A coin or button battery is to be impacted with the flat surface of the test sample parallel to the flat surface and the 5/8 inch (15.8 mm) diameter curved surface lying across its center.

13.3 revised June 24, 1999

13.4 The samples shall not explode or catch fire.

13.4 added June 24, 1999

**14 Humidity Test**

14 deleted June 24, 1999

14.1 Deleted June 24, 1999.

14.2 Deleted June 24, 1999.

## 14A Shock Test

Added 14A effective June 26, 2000

14A.1 The cell is to be secured to the testing machine by means of a rigid mount which supports all mounting surfaces of the cell. Each cell shall be subjected to a total of three shocks of equal magnitude. The shocks are to be applied in each of three mutually perpendicular directions unless it has only two axes of symmetry in which case only two directions shall be tested. Each shock is to be applied in a direction normal to the face of the cell. For each shock the cell is to be accelerated in such a manner that during the initial 3 milliseconds the minimum average acceleration is 75 g (where g is the local acceleration due to gravity). The peak acceleration shall be between 125 and 175 g. Cells shall be tested at a temperature of  $20 \pm 5^{\circ}\text{C}$  ( $68 \pm 9^{\circ}\text{F}$ ).

Added 14A.1 effective June 26, 2000

14A.2 The samples shall not explode or catch fire. In addition, the sample shall not vent or leak as described in 5.1.1.

Added 14A.2 effective June 26, 2000

## 15 Vibration Test

15.1 A battery is to be subjected to simple harmonic motion with an amplitude of 0.03 inch (0.8 mm) [0.06 inch (1.6 mm) total maximum excursion].

15.2 The frequency is to be varied at the rate of 1 hertz per minute between 10 and 55 hertz, and return in not less than 90 nor more than 100 minutes. The battery is to be tested in three mutually perpendicular directions. For a battery that has only two axes of symmetry, the battery is to be tested perpendicular to each axis.

15.3 The samples shall not explode or catch fire. In addition the sample shall not vent or leak as described in 5.1.1.

15.3 added June 24, 1999

## 16 Drop Test

16 deleted June 24, 1999

16.1 Deleted June 24, 1999.

## 17 Forced-Discharge Test

Section 17 relocated as Section 11B June 24, 1999

### 17.1 General

17.1 deleted June 24, 1999

17.1.1 Deleted June 24, 1999.

### 17.2 Method 1

17.2 deleted June 24, 1999

17.2.1 Deleted June 24, 1999.

**17.3 Method 2**

17.3 deleted June 24, 1999

17.3.1 Revised and relocated as 11B.2 June 24, 1999.

**18 Abnormal Charging Test**

Section 18 relocated as Section 11A June 24, 1999

18.1 Revised and relocated as 11A.2 June 24, 1999.

18.2 Deleted June 24, 1999.

**ENVIRONMENTAL TESTS****18A Heating Test**

Section 11 relocated as Section 18A June 24, 1999

18A.1 A battery is to be heated in a gravity convection or circulating air oven. The temperature of the oven is to be raised at a rate of  $5 \pm 2^\circ\text{C}$  ( $9 \pm 3.6^\circ\text{F}$ ) per minute to a temperature of  $150 \pm 2^\circ\text{C}$  ( $302 \pm 3.6^\circ\text{F}$ ) and remain for 10 minutes at that temperature before the test is discontinued.

11.1 revised and relocated as 18A.1 June 24, 1999

18A.2 The samples shall not explode or catch fire.

18A.2 added June 24, 1999

**18B Temperature Cycling Test**

7.2 revised and relocated as 18B June 24, 1999

18B.1 The batteries are to be placed in a test chamber and subjected to the following cycles:

- a) Raising the chamber-temperature to  $70 \pm 3^\circ\text{C}$  ( $158 \pm 5^\circ\text{F}$ ) within 30 minutes and maintaining this temperature for 4 hours.
- b) Reducing the chamber temperature to  $20 \pm 3^\circ\text{C}$  ( $68 \pm 5^\circ\text{F}$ ) within 30 minutes and maintaining this temperature for 2 hours.
- c) Reducing the chamber temperature to  $\text{minus } 40 \pm 3^\circ\text{C}$  ( $\text{minus } 40 \pm 5^\circ\text{F}$ ) within 30 minutes and maintaining this temperature for 4 hours.
- d) Raising the chamber temperature to  $20 \pm 3^\circ\text{C}$  ( $68 \pm 5^\circ\text{F}$ ) within 30 minutes.
- e) Repeating the sequence for a further 9 cycles.
- f) After the 10th cycle, storing the batteries for 7 days prior to examination.

Added 18B.1 effective June 26, 2000

18B.2 The samples shall not explode or catch fire. In addition, the samples shall not vent or leak as described in 5.1.1.

Added 18B.2 effective June 26, 2000

## 18C Low Pressure (Altitude Simulation) Test

Added 18C effective June 26, 2000

18C.1 Sample batteries are to be stored for 6 hours at an absolute pressure of 11.6 kPa (1.68 psi) and a temperature of  $20 \pm 3^{\circ}\text{C}$  ( $68 \pm 5^{\circ}\text{F}$ ).

Added 18C.1 effective June 26, 2000

18C.2 The samples shall not explode or catch fire as a result of the Altitude Simulation Test. In addition, the samples shall not vent or leak as described in 5.1.1.

Added 18C.2 effective June 26, 2000

## TESTS FOR USER-REPLACEABLE LITHIUM BATTERIES

### 19 General

#### 19.1 Fire-exposure test

19.1 deleted June 24, 1999

*19.1.1 Deleted June 24, 1999.*

*19.1.2 Deleted June 24, 1999.*

#### 19.2 Test for flaming particles

19.2.1 A cheesecloth panel shall not ignite when a cell or battery is subjected to the test described in 19.2.2.

19.2.1 revised June 24, 1999

19.2.2 Each test sample cell or battery is to be placed on a steel wire mesh screen having 20 openings per inch (25.4 mm) and a wire diameter of 0.017 inch (0.43 mm). The screen is to be mounted 1-1/2 inches (38.1 mm) above a burner. The fuel and air flow rates are to be set to provide a bright blue flame that causes the wire screen to glow a bright red. A panel of cheesecloth layers is to be positioned vertically 3 feet (0.91 m), from the center of the wire screen. See Figures 19.1A and 19.2A. The panel of cheesecloth is to be 1 yard square (914 mm by 914 mm) and is to consist of four layers of cheesecloth material weighing 0.4 – 0.6 ounces per square yard ( $12 - 18 \text{ g/m}^2$ ). The test sample is to be positioned so that sparks or flaming particles are ejected toward the center of the cheesecloth panel. In some cases, it shall be required to wire the test sample to the screen to hold it in place. The burner is then to be ignited and the battery is to be observed until it explodes, or until it is destroyed.

19.2.2 revised June 24, 1999

#### Figure 19.1 Test apparatus for projectile test

Figure 19.1 relocated as Figure 19.3 June 24, 1999

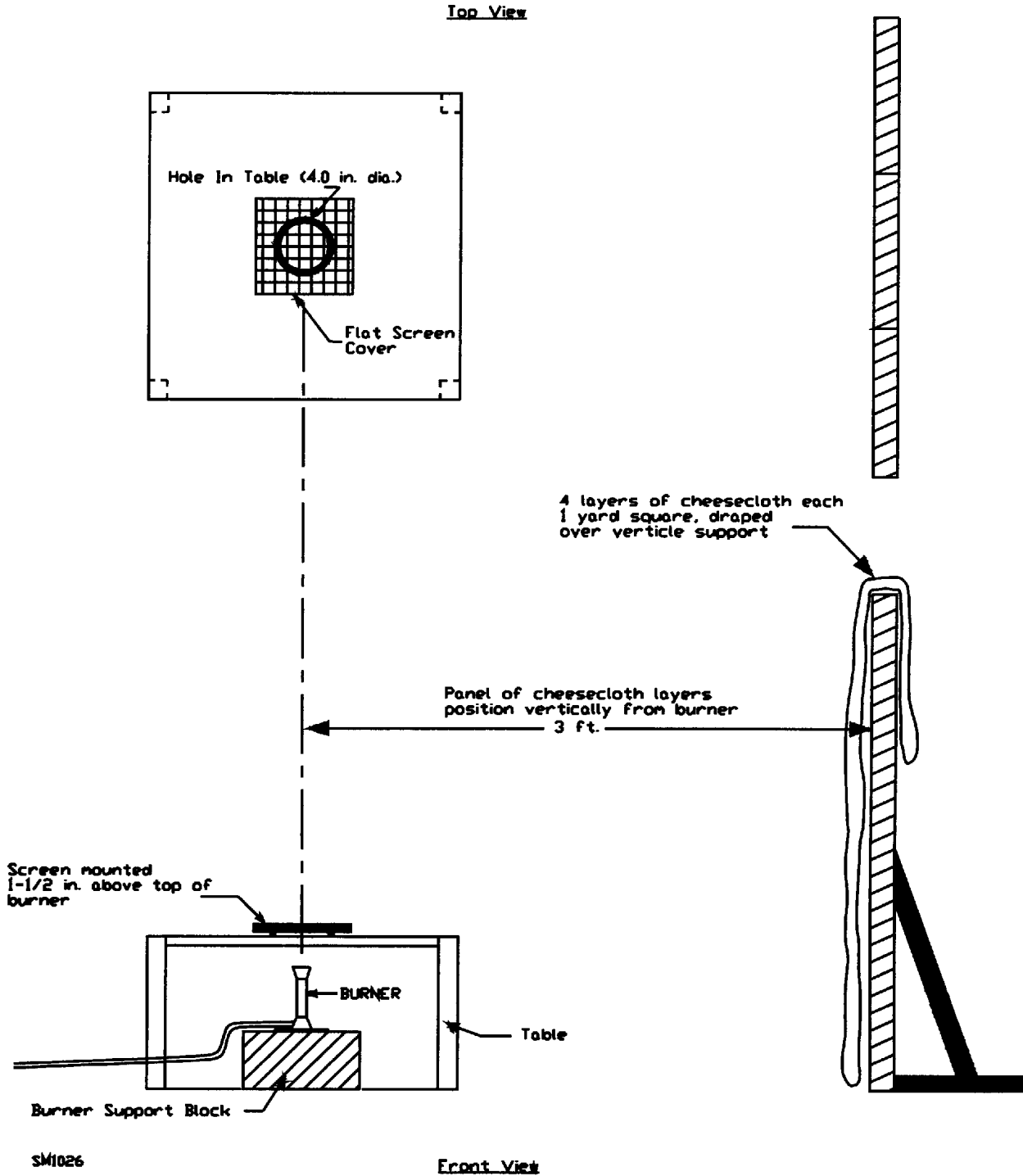
#### 19.3 Projectile test

19.3.1 When subjected to the test described in 19.3.2 no part of an exploding cell or battery shall penetrate the wire screen such that some or all of the cell or battery protrudes through the screen.

19.3.1 revised June 24, 1999

**Figure 19.1A**  
**Test apparatus for flaming particle test**

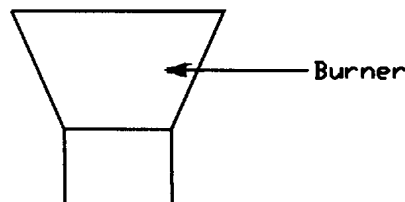
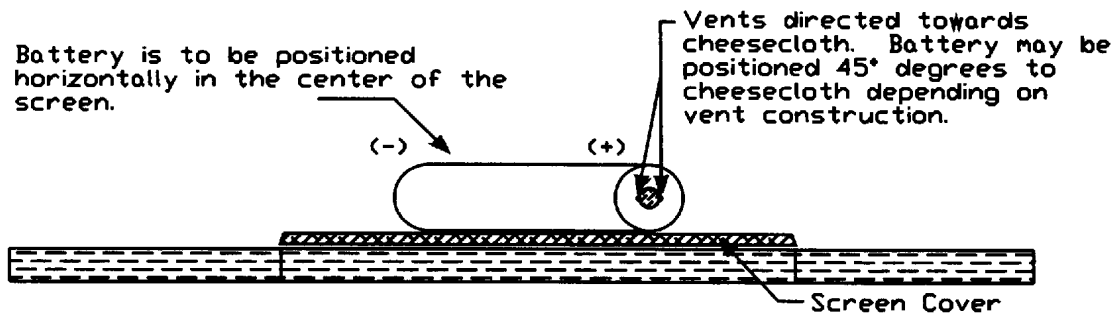
Figure 19.1A added June 24, 1999





**Figure 19.2A**  
**Battery orientation**

Figure 19.2A added June 24, 1999



SM1027

19.3.2 Each test sample cell or battery is to be placed on a platform table having a 4-inch (102-mm) diameter hole in the center covered by a screen. The screen is to be of steel wire mesh having 20 openings per inch (25.4 mm) and a wire diameter of 0.017 inch (0.43 mm). An eight-sided covered wire cage, 2 feet (610 mm) across and 1 foot (305 mm) high, made from metal screening is to be placed over the test sample. See Figure 19.3. The metal screening is to be constructed from 0.010-inch (0.25-mm) diameter metal wire with 16 – 18 wires per inch in each direction. The sample is to be placed on the screen covering the hole in the center of the table and is to be heated, until it explodes, or until it is destroyed.

19.3.2 revised June 24, 1999

**19.4 Explosion test**

19.4 deleted June 24, 1999

19.4.1 Deleted June 24, 1999.

19.4.2 Deleted June 24, 1999.

19.4.3 Deleted June 24, 1999.

**Figure 19.2**  
**Explosion test chamber**

Figure 19.2 deleted June 24, 1999

**Figure 19.3**  
**Test apparatus for projectile test**

Figure 19.1 relocated as Figure 19.3 June 24, 1999

