

# **Energizer Lithium L91**

## **Application Manual**

### **L91 Introduction**

This manual contains general information and data that reflects a specific battery in production at the time of preparation. Since the characteristics of individual batteries are sometimes modified, persons and businesses that are considering the use of a particular battery should contact the nearest Energizer Sales office for current information. None of the information in this manual constitutes a representation or warranty by Eveready Battery Company, Inc. concerning the specific performance or characteristics of the battery.

### **Battery Selection**

The following provides the characteristics and general guidelines for selection of the L91 Lithium/FeS<sub>2</sub> battery:

### **Advantages**

Can be used in any application that uses other AA size 1.5 volt battery types

Higher operating voltage and flatter discharge curve than other AA size 1.5 volt battery types

- ✦ Longer service than other AA size 1.5 volt battery types, especially in moderate to heavy drain applications
  
- ✦ Even greater service advantage over other 1.5 volt types at low temperatures: will work at temperatures at which other types will not
  
- ✦ Much better leakage resistance than other 1.5 volt types
  
- ✦ Performs well after up to 10 years storage
  
- ✦ Much lighter weight - 1/3 less than AA alkaline

- ☀ Good service maintenance after high temperature storage
- ☀ No added mercury, cadmium, or lead

**Limitations**

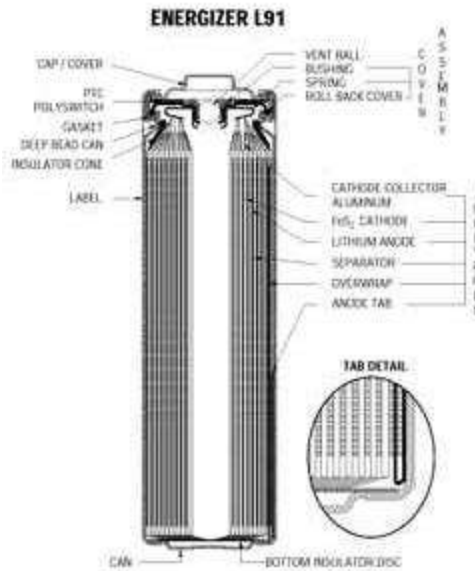
- ☀ Maximum storage and operating temperatures are limited by jacket shrinkage: no problems at 60 °C, can tolerate 71 °C for at least 1 week without exposing the bare cell
- ☀ Maximum discharge current is limited by the resettable safety switch; see section on safety switch for details

**AA Primary Cylindrical Cells**

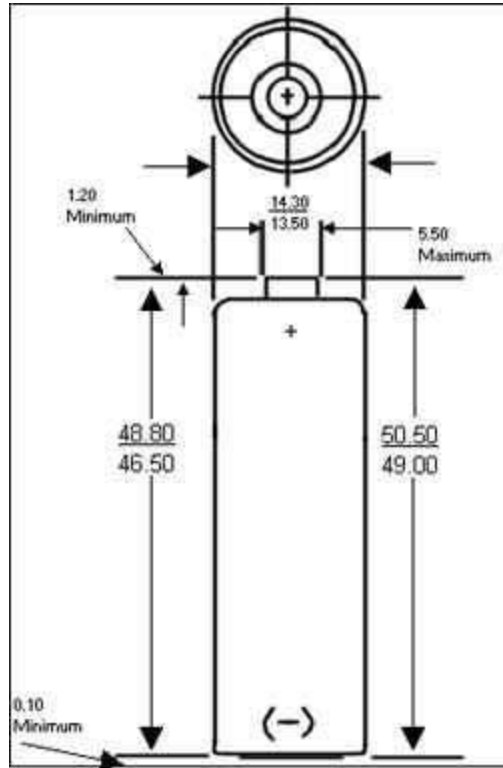
System		E91 Alkaline Zn/MnO <sub>2</sub>	L91 Lithium Li/FeS <sub>2</sub>
Battery Weight (Grams)	Nominal	23.0	14.5
Voltage		1.5	1.5
	Open Circuit	1.6	1.8
Operating Time	1400mA	0.2	1.3
(Hours to 0.90 Volt)	1000mA	0.04	2.1
	400mA	2.7	5.7
	20mA	117.0	122.0

1kHz Impedance (Ohms)		0.17	0.18
Shelf Life (Years)		7.0	10.0

### L91 Engineering Data



## DIMENSIONS (mm)



Millimeters	Inches
0.10	0.004
1.20	0.047
5.50	0.217
13.50	0.531
14.30	0.563
46.50	1.831
48.80	1.921
49.00	1.929
50.50	1.988

**Voltage Taps:** -, + 1.5

**Terminals:** Flat Contacts

**Average Weight:** 14.5 grams (0.51 oz.)

**Volume:** 8.0 cubic centimeters (0.49 cubic inch)

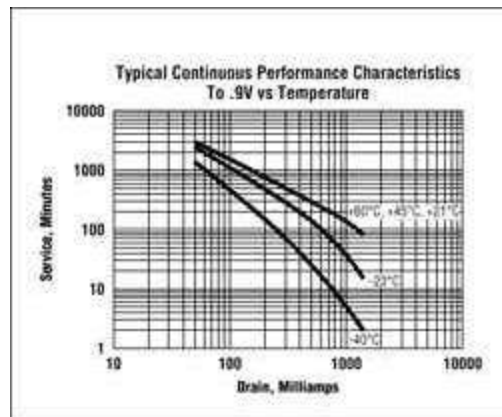
**Storage Temperature Range:** -40 C to + 60 C (-40 F to 140 F)

**Operating Temperature Range:** -40 C to + 60 C (-40 F to 140 F)

**Maximum Continuous Discharge Load:** 1.4 amps

**Lithium Quantity:** Less than 1.0 grams (0.04 oz) per cell

**Transportation:** Meets requirements of 49 CFR 173.185(b) and IATA Special Provision A45



### Battery Testing

#### Constant Resistance

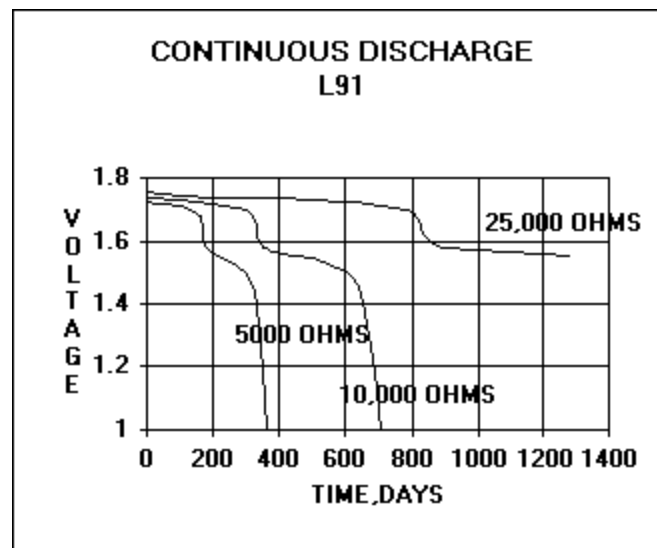
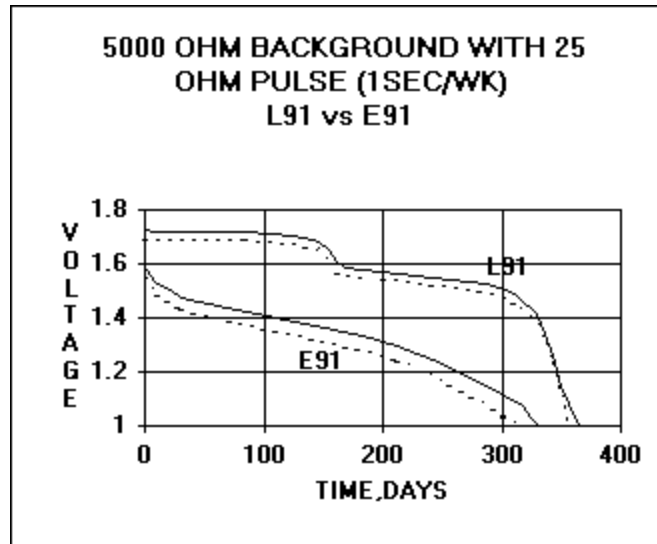
#### Constant Current

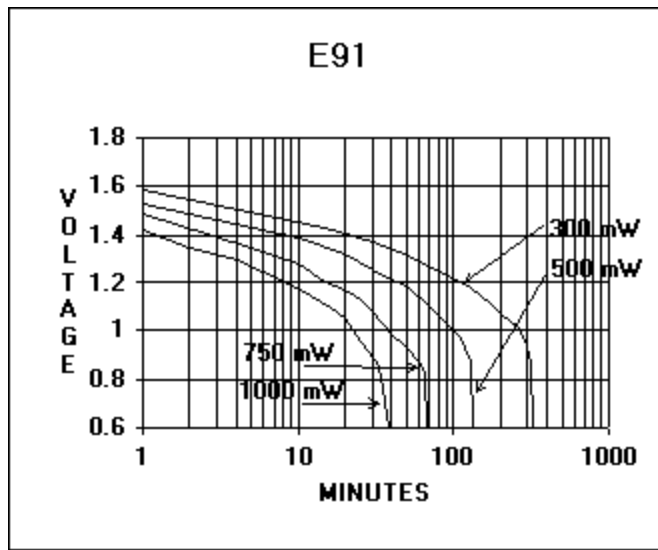
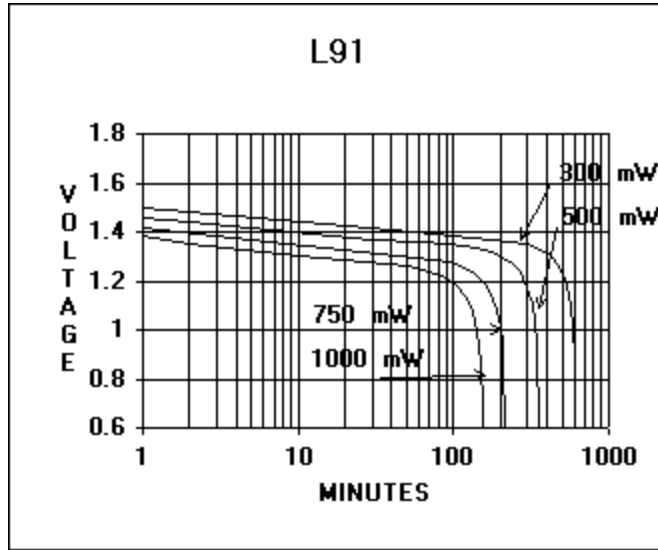
#### Constant Power

The discharge characteristics of batteries can vary, depending upon whether they are discharged at a constant resistance, constant current or constant power. Very few devices discharge batteries at a constant resistance. More often, they discharge batteries at closer to a constant current or constant power. However, because the test equipment for constant current and constant power testing is more complicated and expensive, constant resistance testing is frequently used where it will give a reasonably accurate estimate of duration.

Because of the significant differences in discharge characteristics for L91 batteries compared to AA alkaline batteries on constant resistance loads, constant resistance testing cannot be universally used to approximate relative L91 and AA alkaline battery durations, especially on heavier drains. On constant resistance discharge, L91 generally maintains a higher operating voltage during discharge. This removes capacity (amp-hours or watt-hours) at a faster rate for L91 than for alkaline batteries. This can result in understating the L91 duration for constant current and constant power applications.

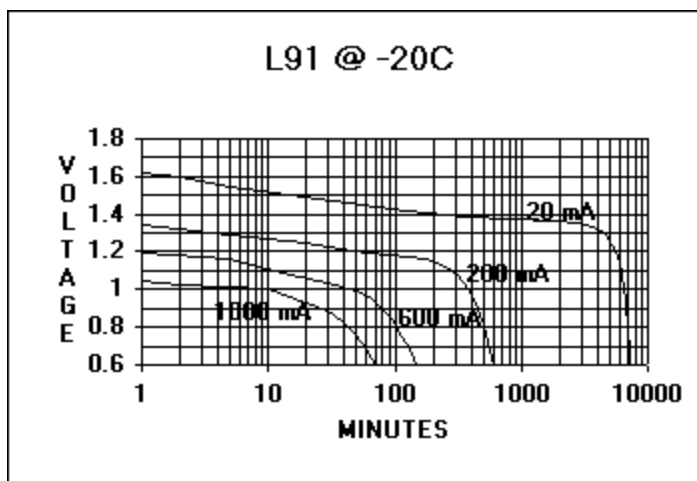
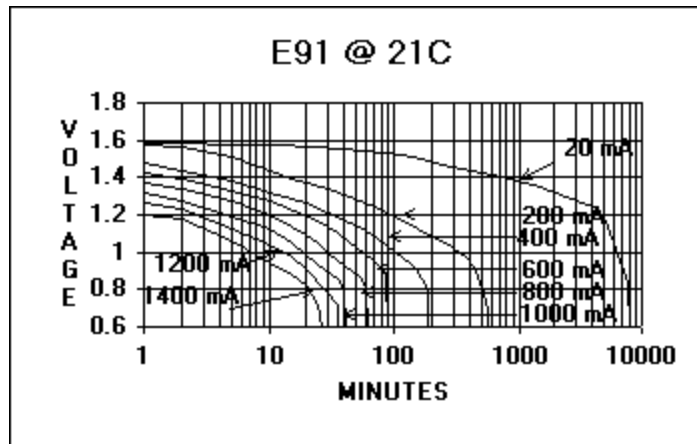
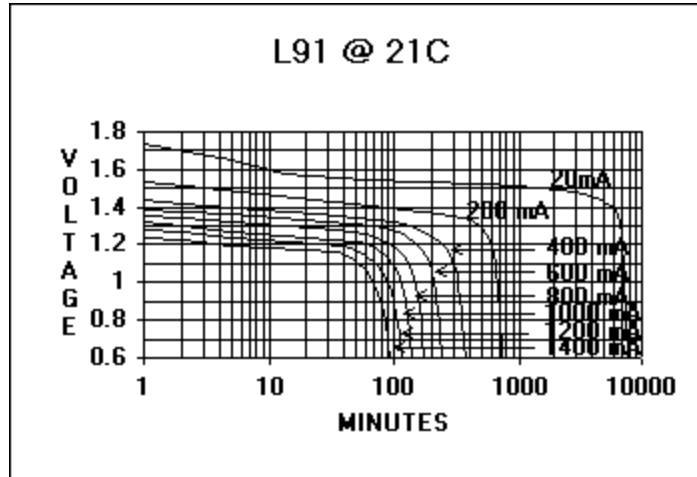
To determine the battery duration for a particular application, it is most reliable to rest the batteries in devices. When this is not practical, simulation testing can be done. If possible, determine whether the device is closest to a constant resistance, constant current or constant power load, and use the type of testing that best approximates the device.

**Constant Resistance Discharge @ 21 °C****Constant Power Continuous Discharge @ 21 °C**

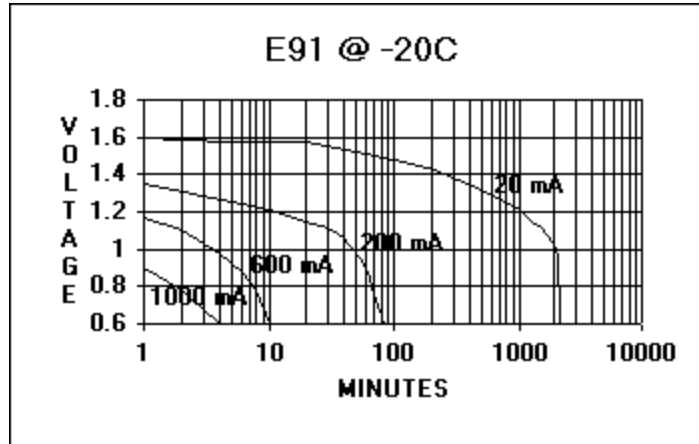


**Constant Current Continuous Discharge**

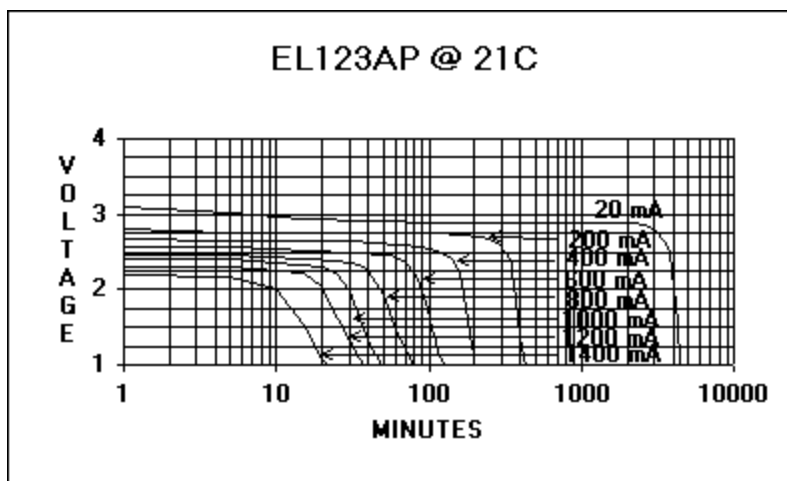
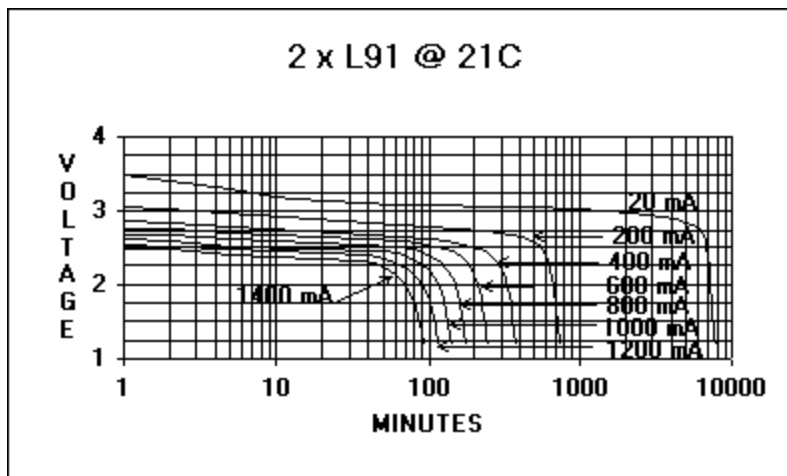
## L91 vs. E91 - Temperature Effects

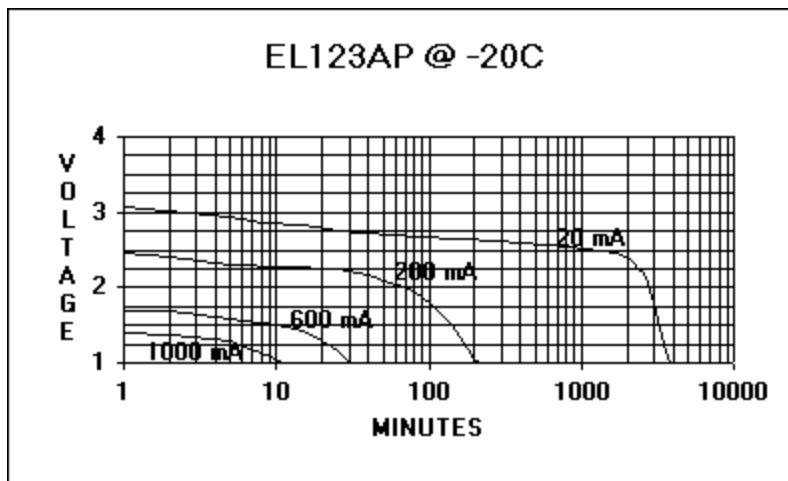
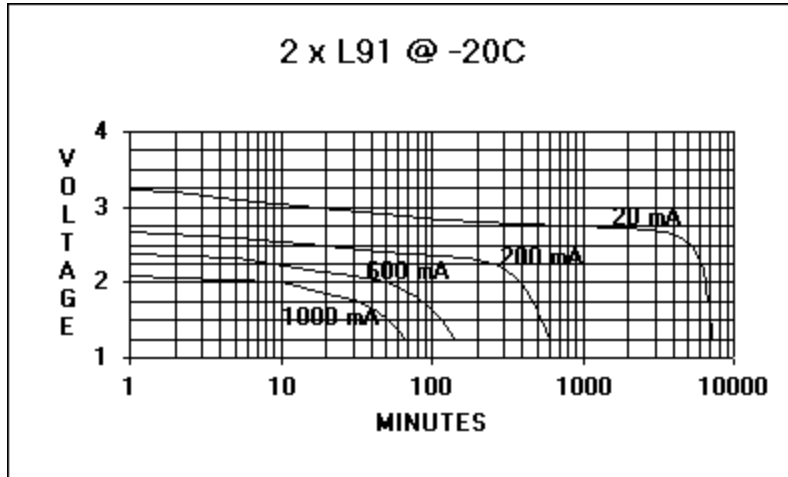




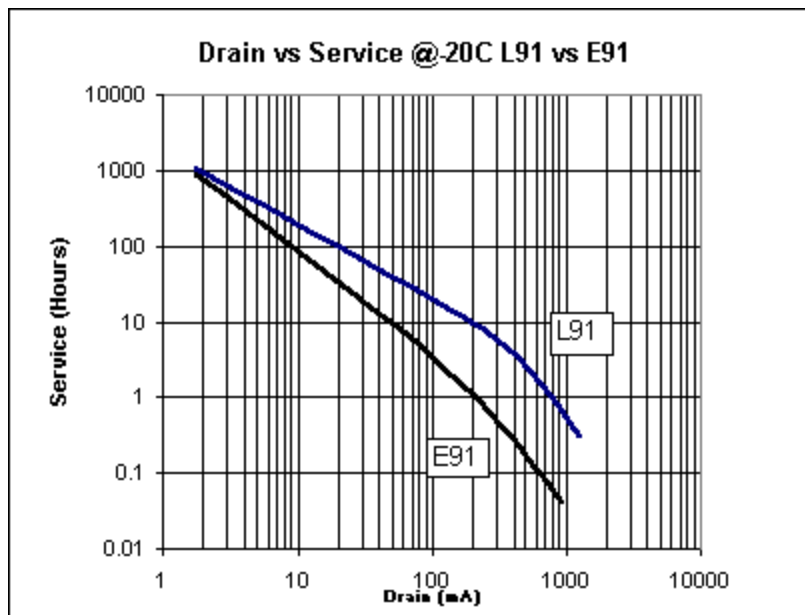
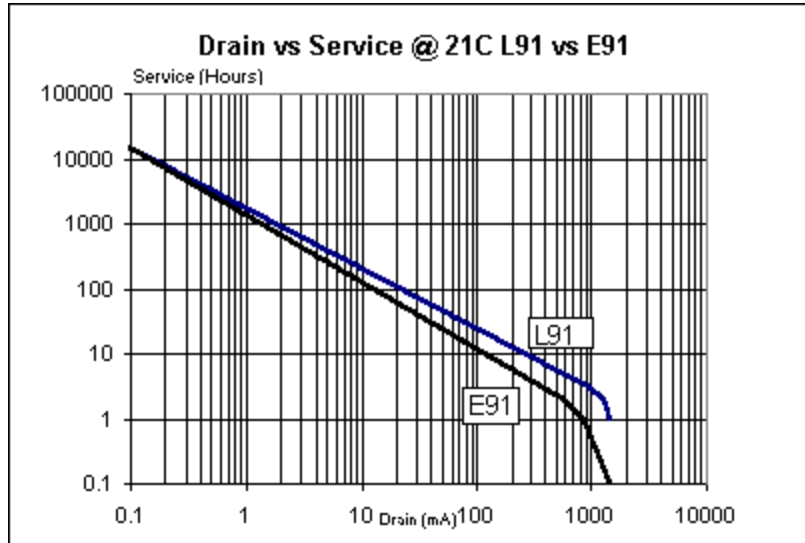


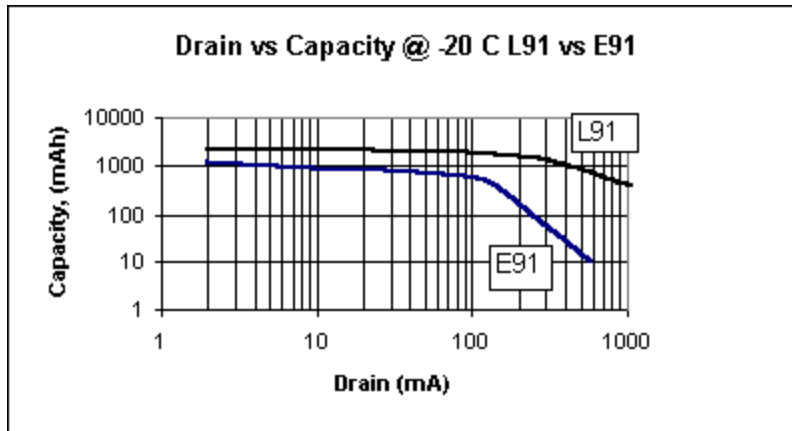
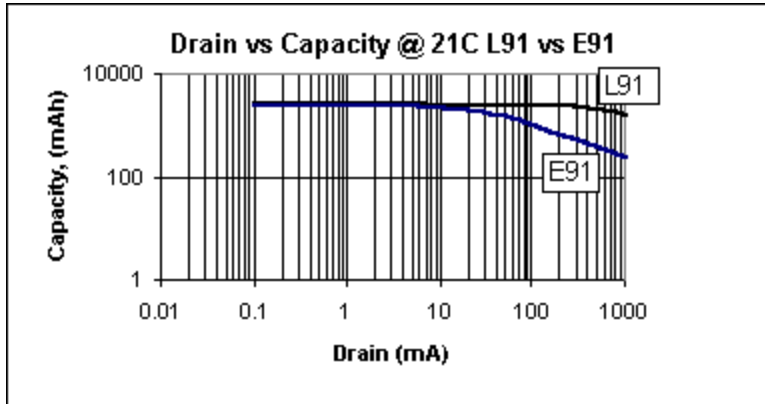
2 x L91 vs. 3 Volt Lithium Photo Battery (EL123AP)





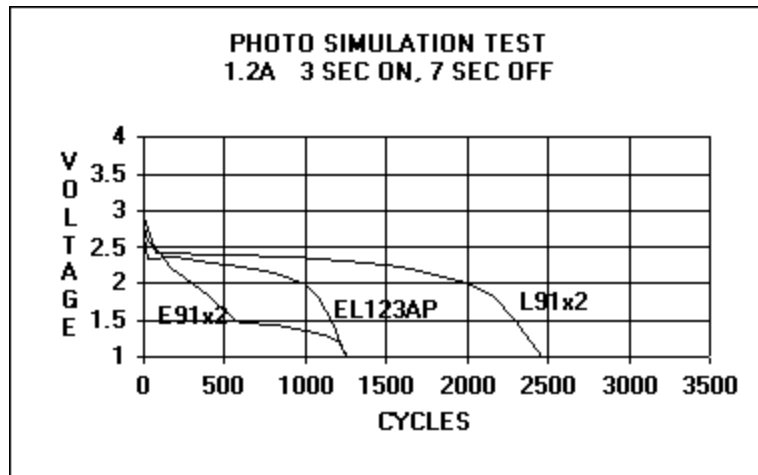
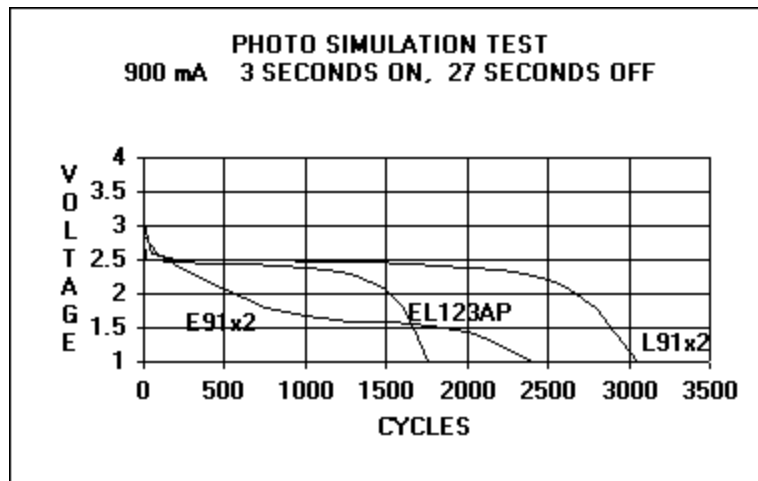
Rate Sensitivity to 0.9 Volts



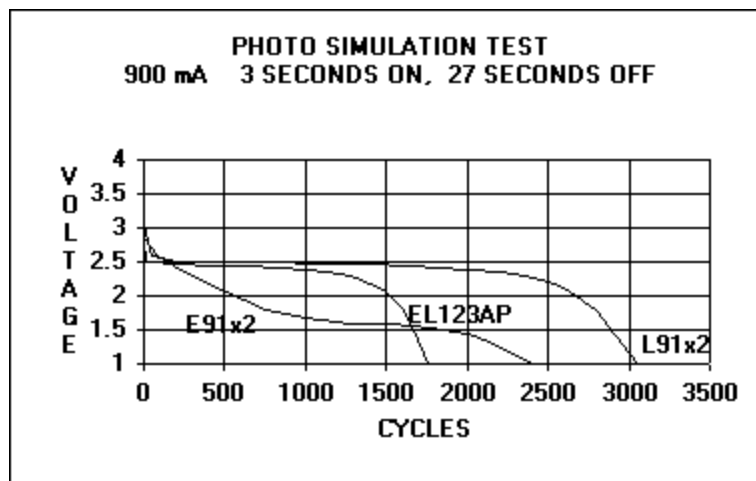
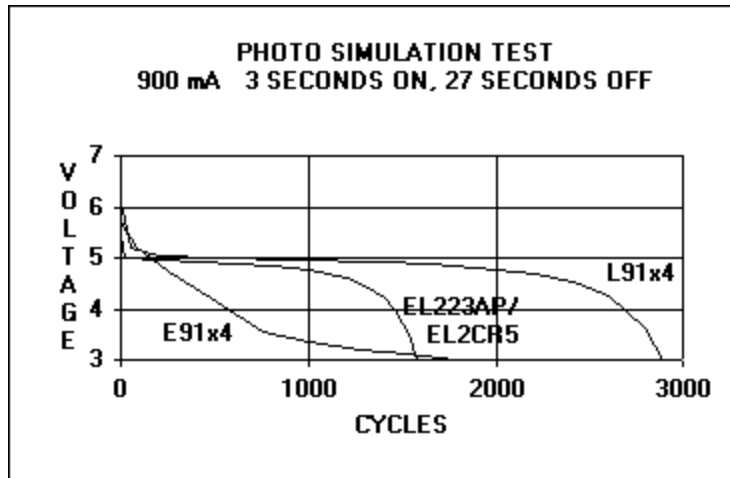


**L91 Device Testing**

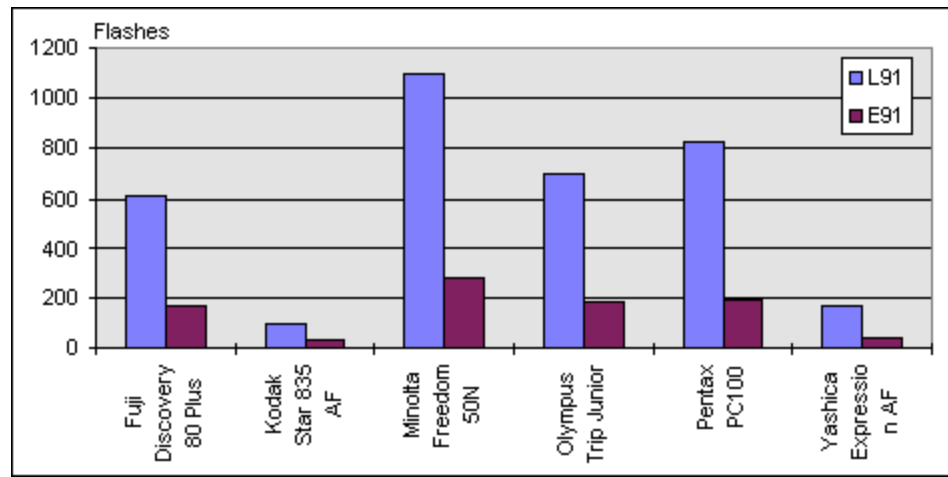
**Photo Simulation Test  
2 x AA vs. 3 Volt Lithium Photo Battery (EL123AP)**



**Photo Simulation Test  
4 x AA vs. 3 Volt Lithium Photo Battery (EL123AP)**

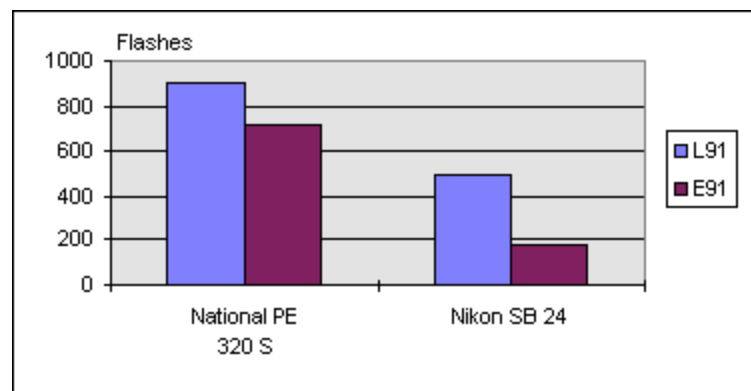


**Lens Shutter Cameras**



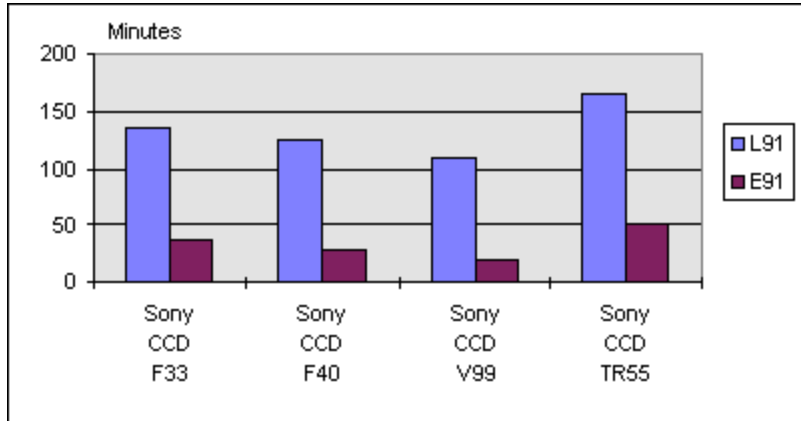
Test Description: One flash every 30 seconds to an 8 second recycle time.

**Flash Attachments**



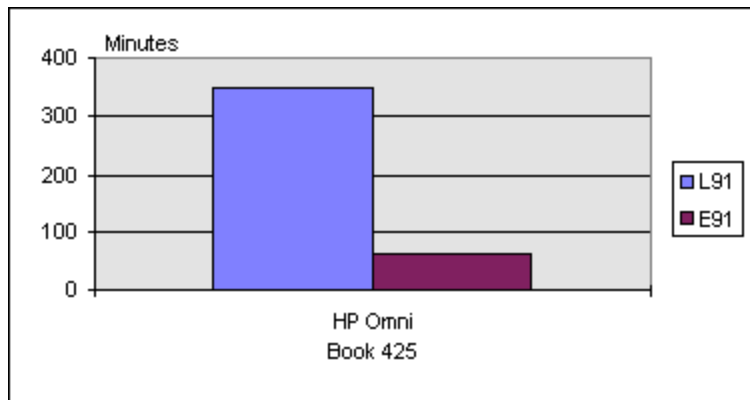
Test Description: One flash every 30 seconds to an 8 second recycle time.

**Camcorder**



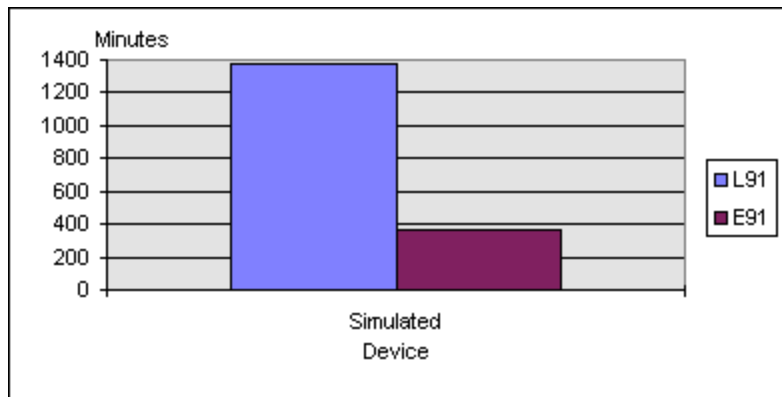
Test Description: Continuous Record

**Portable Computer**



Test Description: Continuous Operation

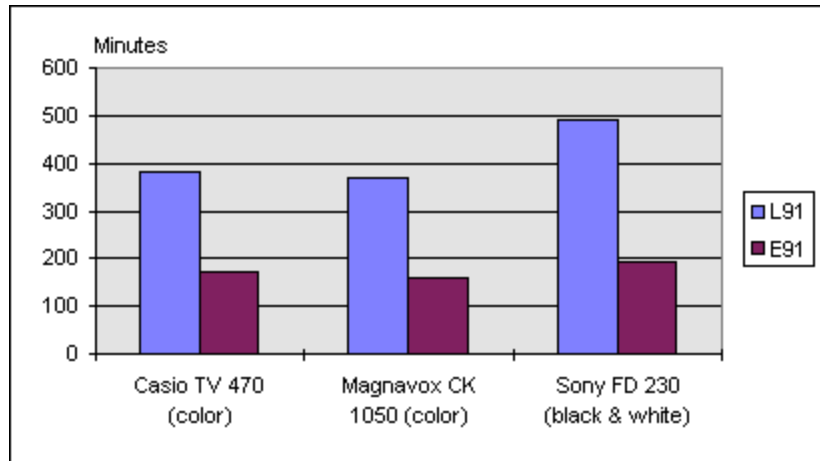
**Cellular Telephone**



Test Description: 600 mA for 5 min., 43 mA for 55 min.  
Repeat to 1.04 volts / cell

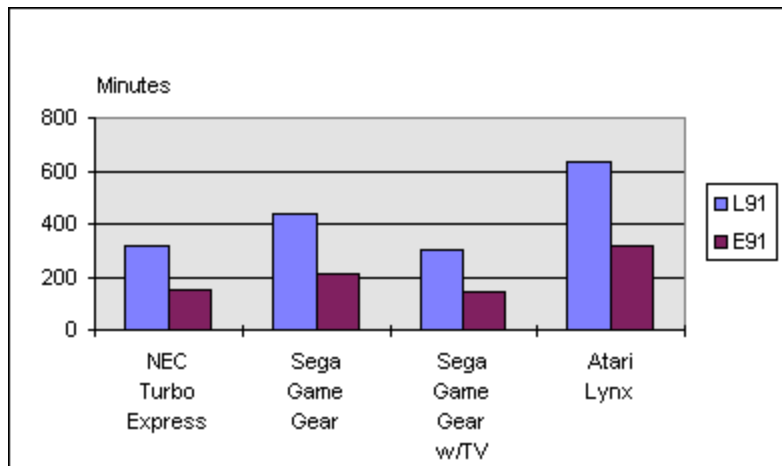


## Televisions



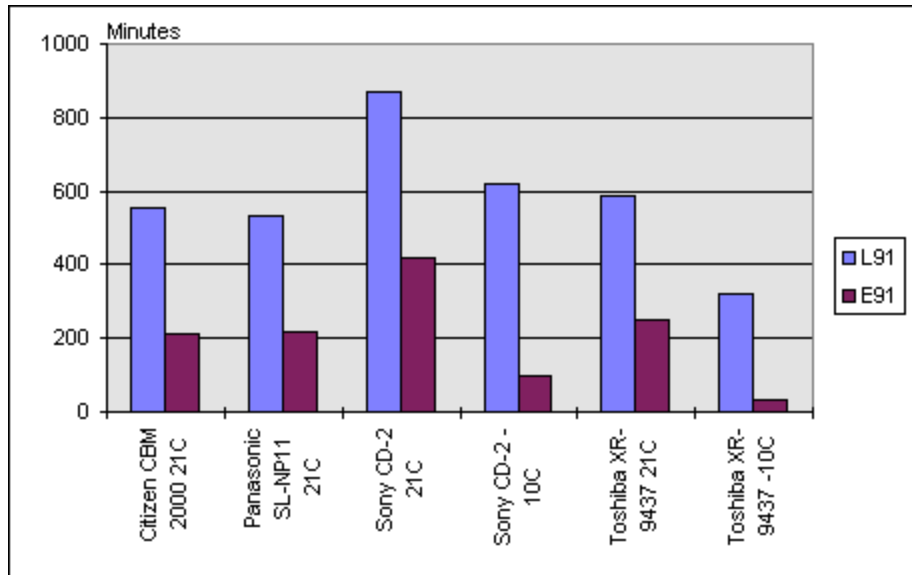
Test Description: Continuous Operation

## Portable Video Games



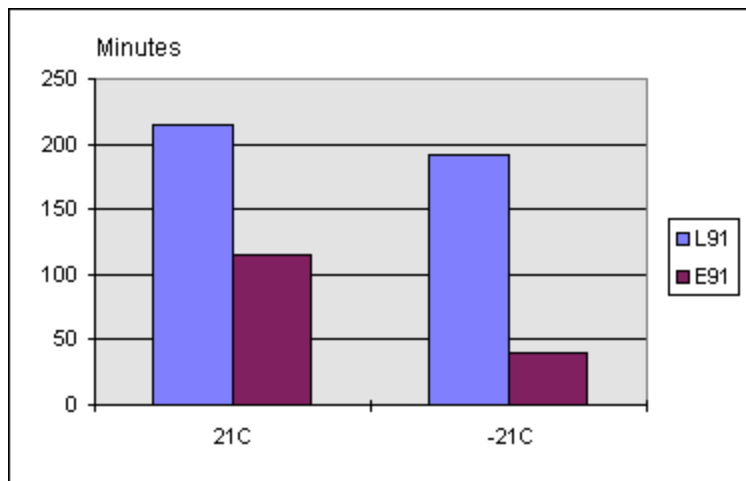
Test Description: Continuous operation. Color display.

### Compact Disc Players



Test Description: Continuous operation.

### Lights



Test Description: Continuous operation

### L91 Technical Information

#### Safety Devices

Each L91 battery contains two safety devices, which are progressive as temperature increases.

Thermal Switch (PTC) - Limits the current when the temperature reaches 85 - 95 C. On very high rates

of discharge in devices where internal cell heat is not allowed to dissipate, the PTC will temporarily increase in resistance to reduce the flow of current. After cooling, it will automatically revert back to normal condition.

Pressure Relief Vent - Operates at 120 - 130 °C.

### **Storage**

L91 batteries can be stored satisfactorily at room temperature and are stable at high temperatures. The maximum storage and operating temperatures are limited by jacket shrinkage. There are no problems at 60 °C (140 °F), and the batteries can tolerate 71 °C (160 °F) for at least 1 week.

### **Containment**

Avoid potting or encapsulation as this obstructs the pressure relief vent. This vent is required to prevent excessive pressure buildup if the battery is exposed to very high temperatures.

### **Charging**

The L91 battery is a primary battery and NOT designed to be recharged.

### **Connections**

Use the same battery pressure contacts you would use for alkaline cells. Solder connections are not recommended, and if welded connections are needed, they should be made to the nickel-plated positive cap and the nickel-plated cell bottom using a capacitor discharge welder (normal alkaline cell welding procedures).

### **Safety Warning**

Fire, explosion, burn hazard. Do not open battery, dispose of in fire, heat above 100 °C (212 °F), expose contents to water, recharge, put in backwards, mix with used or other battery types - may explode or leak and cause personal injury.

### **Disposal**

For small quantities, use the same procedures used for other Eveready and Energizer consumer products

### **Thermal switch characteristics and considerations**

The L91 battery contains a resettable thermal switch called a Positive Temperature Coefficient (PTC) device. This switch protects the battery from overheating if externally short circuited, charged or forced into deep discharge. This device is not a true switch since it does not have a completely off condition. Rather, it is a current limiter. When the PTC reaches the activation temperature, its resistance increases very rapidly. This reduces the flow of current, allowing the battery to cool. When the PTC cools to below the activation temperature, its resistance drops to a normal level. The PTC will continue to cycle from a low resistance state to a high resistance state for many cycles if the abusive condition continues or the battery is later exposed to other such conditions. Eventually the PTC may stop changing in resistance as its temperature changes, but if this does happen it will remain in a high resistance, safe condition.

There are two factors, which determine if or when the PTC will activate. One is the ambient temperature and the other is the internal heating that occurs as the result of discharge. The higher the rate of

discharge (the heavier the drain or load on the battery), the more heat is generated. On light loads the heat dissipates and is not noticeable, but on heavy drains the battery may become noticeably warm to the touch (this is also true of alkaline batteries). If the load is too heavy, the PTC will heat up to the activation temperature. The higher the ambient temperature, the lower the load that the PTC will tolerate without activating.

All of the following can affect the ambient temperature or the internal heating during discharge:

- ☀ Surrounding air temperature
- ☀ Thermal insulating properties of the battery container
- ☀ Heat generated by equipment components
- ☀ Cumulative heating effects of many batteries
- ☀ Discharge rate(s) and duration(s)
- ☀ Frequency and length of rest periods

Because of the number of other variables involved, it is difficult to predict in advance whether the L91 battery can operate under certain load conditions. The maximum continuous current drain is established at 2.0 amps; however, higher pulses can be achieved. The most reliable method to determine this is to test the batteries in the device of interest under normal worst case conditions.

While the PTC does impose some limitations on applications for which the L91 battery is suitable, it is a critical element in ensuring that the battery is safe, protecting the battery, the equipment and the user.

### ***Transportation***

#### **General Informtaion**

- I. Energizer L91 lithium batteries meet the following requirements of the US transportation regulations {49 CFR 173.185(b) - December 29, 1994}, the corresponding requirements of Special Provision A45 of the international air transportation regulations (IATA Dangerous Goods Regulations) and the corresponding requirements of Page 9033 of the international maritime regulations (International Maritime Organization IMDG Code):
  - A. Each cell has a solid cathode and contains no more than 1 gram of lithium. {49 CFR 173.185(b)(1)}
  - B. Each battery consists of one cell and contains no more than 2 grams of lithium. {49 CFR 173.185(b)(2)}
  - C. Each cell is hermetically sealed. {49 CFR 173.185(b)(3)}
  - D. The battery jacket provides effective insulation to prevent external short circuits during

normal transportation. {49 CFR 173.185(e)(3)}

E. Each battery contains no more than 1 gram of lithium. {49 CFR 173.185(b)(5)}

L91 batteries, including those installed in electronic devices, are therefore exempt from all other requirements to be transported as hazardous material if they are packed in strong packaging (except when installed in electronic devices).

- II. If a battery contains more than two L91 cells permanently connected together (e.g., welded), it constitutes a new type of battery with respect to transportation regulations. Batteries containing no more than two L91 cells are also exempt from all other requirements to be transported as hazardous material as described above. Batteries containing more than two L91 cells must pass certain testing requirements, as referenced in the regulations, before they may be transported. It is strongly recommended that persons interested in transporting batteries containing more than two L91 cells consult the applicable regulations.
- I. It may also be necessary to consult regulations of the countries of origin and destination and any countries traversed in transportation.
- IV. When transported for disposal to a permitted storage facility or disposal site, L91 cells are considered non-dangerous in transportation within the US if they meet the conditions set forth in I above.
- V. Advice is available from your Energizer representative, but

WHEN YOU OFFER REGULATED MATERIALS FOR TRANSPORTATION, COMPLIANCE WITH APPLICABLE TRANSPORTATION REQUIREMENTS IS YOUR RESPONSIBILITY.

**49 CFR 173.185**

October 1, 2000 Revision

66 Section 173.185 is revised to read as follows:

*173.185 Lithium cells and batteries*

- a. Except as otherwise provided in this subpart, a lithium cell or battery is authorized for transportation only if it conforms to the provisions of this section.
- b. *Exceptions.* Cells and batteries are not subject to the requirements of this subchapter if they meet the following requirements:
  - 1. Each cell with a liquid cathode may contain no more than 0.5 g (0.02 ounce) of lithium or lithium alloy, and each cell with a solid cathode may contain no more than 1.0 g (0.04 ounce) lithium or lithium alloy.
  - 2. Each battery with a liquid cathode may contain an aggregate quantity of no more than 1.0g (0.04 ounce) lithium or lithium alloy, and each battery with a solid cathode may contain an aggregate quantity of no more than 2.0 g (0.07 ounce) of lithium or lithium alloy.
  - 3. Each cell must be hermetically sealed.
  - 4. Cells and batteries must be separated so as to prevent short circuits and must be packed in

strong packaging, except when installed in equipment; and

5. If a liquid cathode battery contains more than 0.5 g (0.02 ounce) of lithium or lithium alloy or a solid cathode battery contains more than 1.0 g (0.04 ounce) lithium or lithium alloy, it may not contain a liquid or gas, if free, would be completely absorbed or neutralized by other materials in the battery.

(c) Cells and batteries also are not subject to this subchapter if they meet the following requirements:

1. Each cell contains not more than 5 g (0.18 ounces) of lithium or lithium alloy.
2. Each battery contains not more than 25 g (0.88 ounces) of lithium or lithium alloy.
3. Each cell or battery is of the type proven to be non-dangerous by testing in accordance with tests in part IV of the UN Recommendations on the Transport of Dangerous Goods, Tests and Criteria, such testing must be carried out on each type prior to the initial transport of that type; and
4. Cells and batteries and equipment containing cells and batteries which were first transported prior to January 1, 1995, and were assigned to Class 9 on the basis of the requirements of this subchapter in effect on October 1, 1993, may continue to be transported in accordance with the applicable requirements in effect on October 1, 1993.
- d. Cells and batteries and equipment containing cells and batteries which were first transported prior to January 1, 1995, and were assigned to Class 9 on the basis of the requirements of this subchapter in effect on October 1, 1993, may continue to be transported in accordance with the applicable requirements in effect on October 1, 1993.
  - a. Cells and batteries may be transported as items of Class 9 if they meet the requirements in paragraphs (e)(1) through (e)(9) of this section:
    1. Cells must not contain more than 12 g (0.42 ounces) of lithium or lithium alloy. When transported by passenger aircraft cells must not contain more than 3 g (0.11 ounces) of lithium or lithium alloy.
    2. Batteries must not contain more than 500 g (17.6 ounces) of lithium or lithium alloy. When transported by passenger aircraft, batteries must not contain more than 125 g (4.4 ounces) of lithium or lithium alloy.
    3. Each cell and battery must be equipped with an effective means of preventing external short circuits.
    4. Each cell and battery must incorporate a safety-venting device or be designed in a manner that will preclude a violent rupture under conditions normally incident to transportation.
    5. Batteries containing cells or series of cells connected in parallel must be equipped with diodes to prevent reverse current flow.
    6. Cells and batteries must be packed in strong inner packagings not more than 500 g (17.6 ounces) of lithium or lithium alloy. When transported by passenger aircraft, inner packaging must not contain more than 125 g (4.4 ounces) of lithium or lithium alloy.
    7. Cells and batteries must be packed in inner packaging in such a manner as to effectively prevent

short circuits and to prevent movement which could lead to short circuits.

8. Cells and batteries must be packaged in packaging conforming to the requirements of part 178 of this subchapter at the Packing Group II performance level:
  - i. Inner packaging must be packed within a wooden box (4C1, 4C2, 4D, or 4F), fiberboard box (4G), fiber drum (1G), or metal drum (1A2 or 1B2).
  - ii. Cells and batteries intended for air transportation must be packaged in metal drums (1A2 or 1B2) fitted with gas-tight gaskets; and
  - iii. When the outer packaging is metal, the inner packaging must be separated from each other and from the outer packaging by at least 25 mm (1 inch) of non-combustible cushioning material.
9. One of the following criteria must be met:
  - i. Each cell or battery is of the type proven to meet the criteria of Class 9 by testing in accordance with tests in part IV of the UN Recommendations on the transport of Dangerous Goods, tests and Criteria;
  - ii. Ten cells and one battery of each type taken from production each week should be subjected to extreme temperature exposure and the short circuit test procedures I part IV of the UN Recommendations on the transport of Dangerous Goods, Tests and Criteria, or equivalent tests approved by the Associate Administrator for hazardous Materials Safety. There should be no evidence of distortion, leakage or internal heating in conducting the extreme temperature exposure test procedure. In conducting the short circuit test procedure, if venting occurs, an open flame applied to venting fumes should not produce an explosive condition; or
  - iii. Cells and batteries that are hermetically sealed are exempt from paragraphs (e)(8)(ii) and (e)(8)(iii) of this section if the cells and batteries are subjected to the altitude simulation, extreme temperature exposure, vibration, and shock test described in the UN recommendations in the Transport of Dangerous Goods. Tests and Criteria, or equivalent tests approved by the Associate Administrator for hazardous Materials Safety, and show no visible evidence of out-gassing, leakage, loss of mass or distortion.
10. Except as provided in paragraph (l) of this section, cells or batteries may not be offered for transportation or transported if any cell has been discharged to the extent that the open circuit voltage is less than two volts or is less than 2/3 of the voltage of the fully charged cell, whichever is less.
  - f. Equipment containing or packed with cells and batteries meeting the requirements of paragraph (b) or (c) of this section is exempt from all other requirements of this subchapter.
  - a. Equipment containing or packed with cells and batteries may be transported as items of Class 9 if the batteries and cells meet all the requirements of paragraph (e)(9) of this section and are packed as follows:
    1. Equipment containing cells and batteries must be packed in a strong out packaging that is waterproof or is made waterproof through the use of a liner. The equipment must be secured within the outer packaging and be packed as to effectively prevent movement, short circuits, and

accidental operation during transport; and

2. Cells and batteries packed with equipment must be packed in inner packaging conforming to paragraph (e)(8) of this section in such a manner as to effectively prevent movement and short circuits. Not more than 5 kg of cells and batteries may be packed with each item of equipment.
- h. Cells and batteries, for disposal, may be offered for transportation or transported to a permitted storage facility and disposal site by motor vehicle when they meet the following requirements:
  1. Cells must not contain more than 12 g (0.42 ounce) and batteries must not contain more than 500 g (17.6 ounces) of lithium or lithium alloy;
  2. Be equipped with an effective means of preventing external short circuits; and
  3. Be packed in a strong outer packaging conforming to the requirements of 173.24 and 173.24a. The packaging need not conform to performance requirements of part 178 of this subchapter.
- i. Cells and batteries and equipment containing or packed with cells and batteries which do not comply with the provisions of this section may be transported only if they are approved by the Associate Administrator for Hazardous Materials Safety.
- ii. For testing purposes, cells containing not more than 12 g (0.42 ounce) of lithium or lithium alloy and batteries containing not more than 500 g (17.6 ounces) of lithium or lithium alloy may be offered for transportation or transported by highway only as items of Class 9. Packaging must conform to paragraphs (e)(8)(i) and (iii) of this section with not more than 100 cells per package.