

# *Lithium Iron Disulfide - Li/FeS<sub>2</sub>* Application Manual

## **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:**

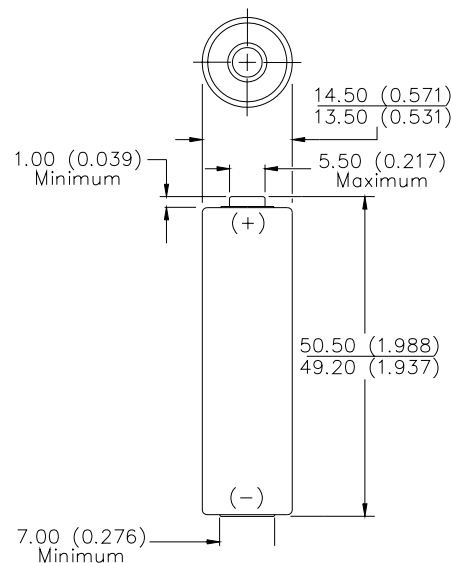
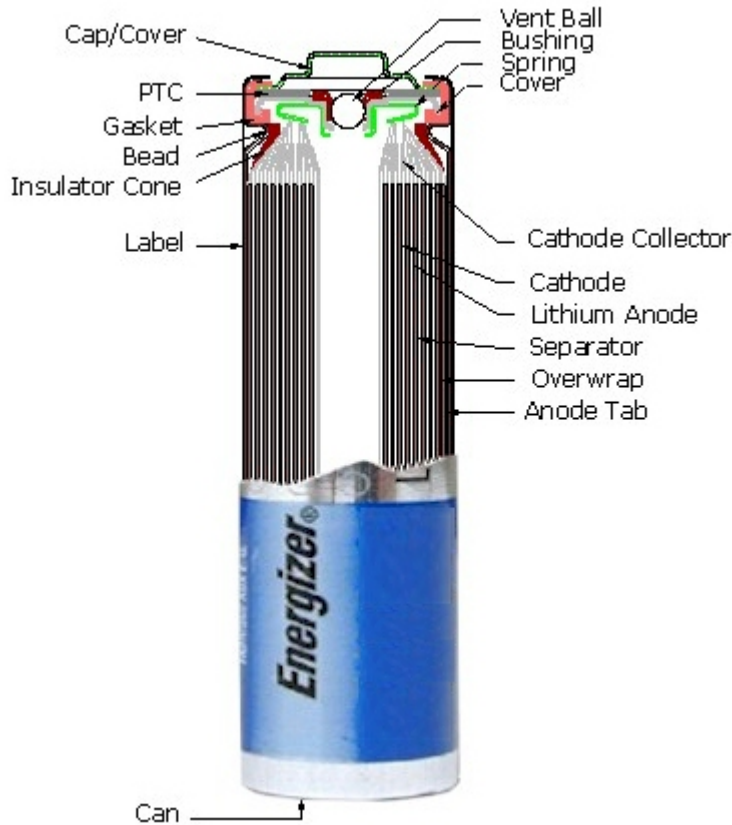
The following provides the characteristics and general guidelines for selection of Lithium/FeS<sub>2</sub> batteries.

## **Advantages:**

- Direct Compatibility - can be used in any application using primary 1.5 volt battery types.
- Longer service than other primary battery types, especially in moderate to heavy drain applications.
- Even greater service advantage over other primary battery types at low temperatures. Works at low temperature extremes where other types will not.
- Higher operating voltage and flatter discharge curve than other primary battery types.
- Superior leakage resistance compared to other primary battery types.
- Excellent performance even after 15 year storage at ambient conditions.
- Considerably lighter than other battery types.
- Good Service maintenance after high temperature storage.
- No added mercury, cadmium, or lead.

## AA Primary Cylindrical Li/FeS<sub>2</sub> (L91)

### L91 Engineering Data:



## AA Primary Cylindrical Li/FeS<sub>2</sub> (L91)

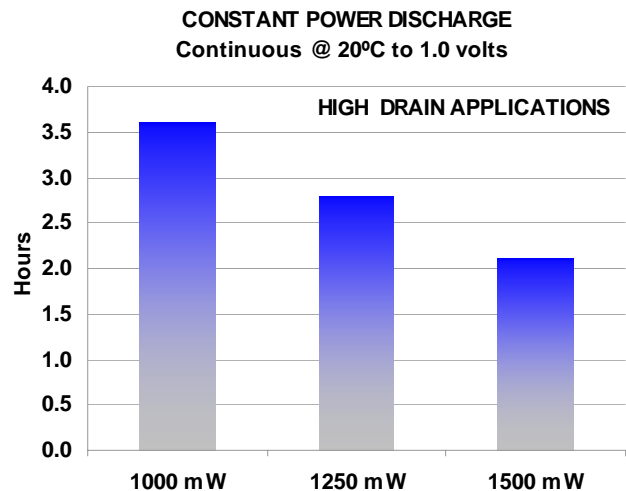
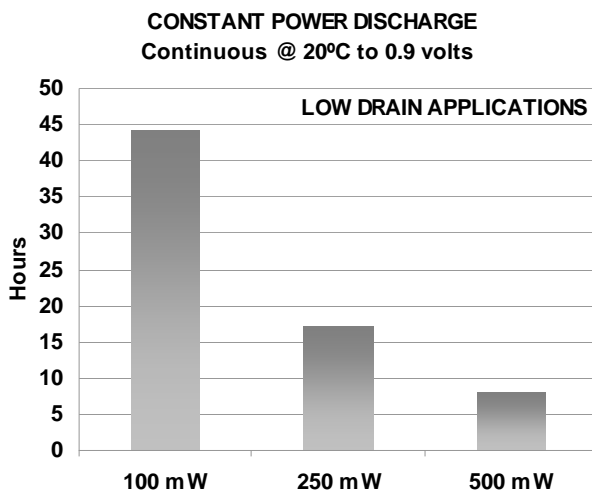
### L91 Battery Testing:

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 duration, 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.

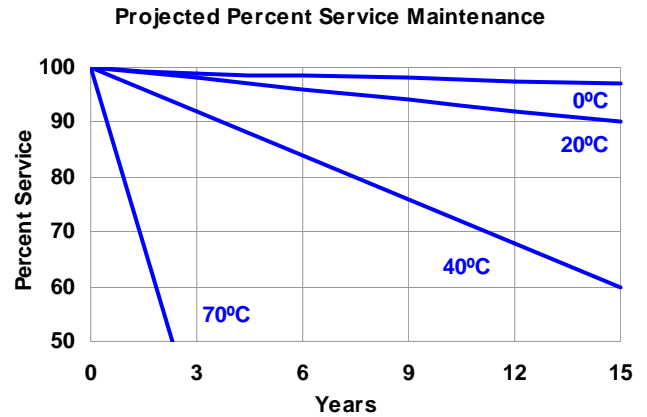
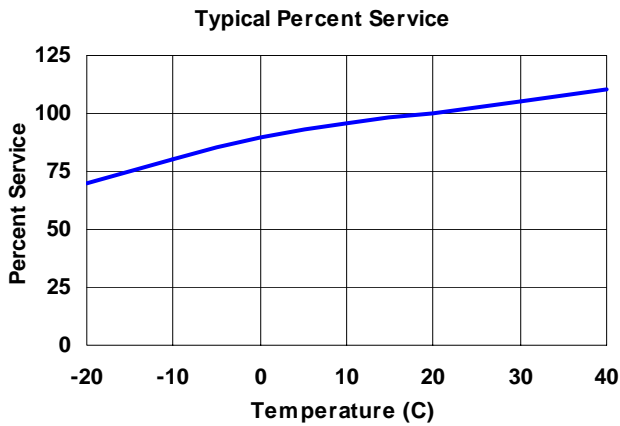
To determine the battery duration for a particular application, it is most reliable to rest the batteries in devices. When this is not practical, simulation testing can be done. If possible, determine whether the device is closest to a constant resistance, constant current or constant power load, and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

### L91 Constant Power Testing:

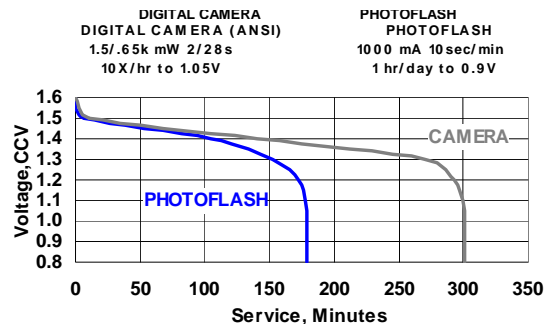
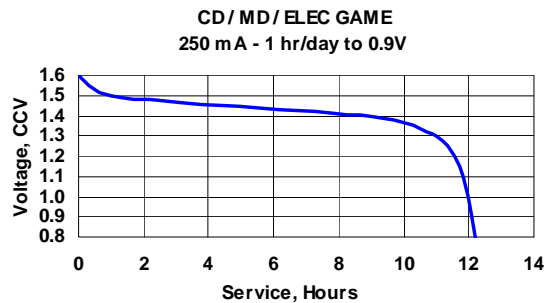
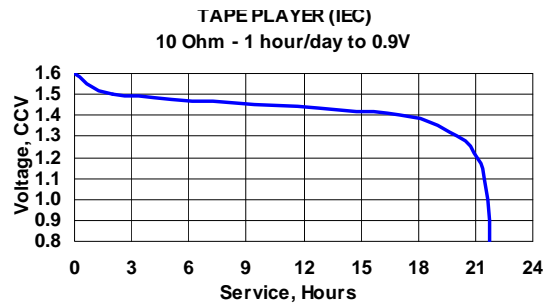
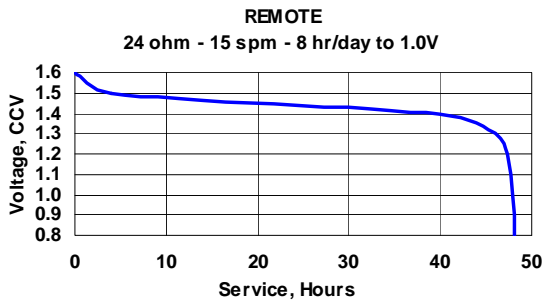
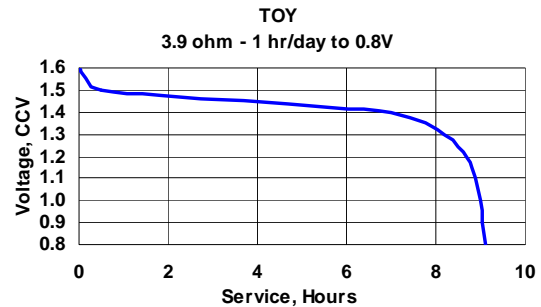
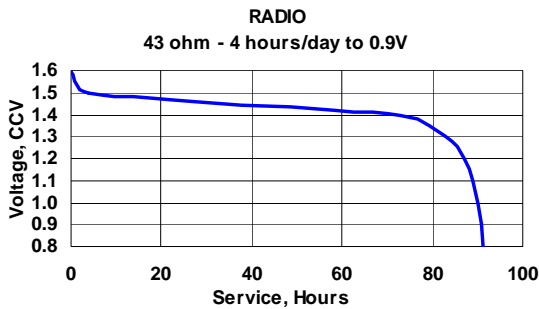


## AA Primary Cylindrical Li/FeS<sub>2</sub> (L91)

### L91 Temperature Effects:

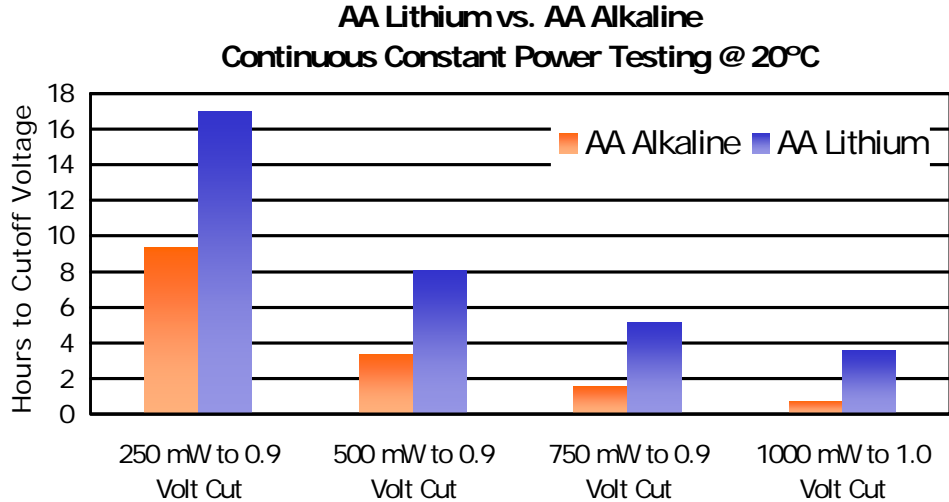


### L91 ANSI - IEC Industry Standard Tests @ 20°C:

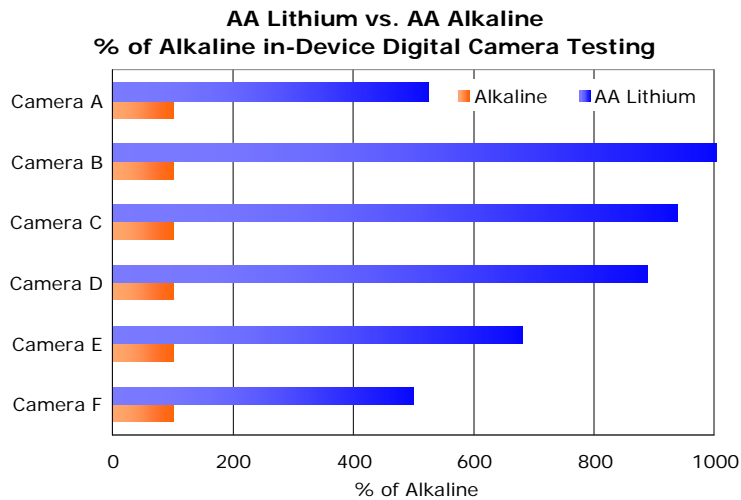


## AA Primary Cylindrical Li/FeS<sub>2</sub> (L91)

### L91 Advantage vs. Alkaline:



### Excellent choice for photo applications...



10 pictures per hour / 1 picture every 30 seconds

NOTE: Camera selection based on top selling brands in the USA at the time of testing.

## AA Primary Cylindrical Li/FeS<sub>2</sub> (L91)

### L91 technical Advantage:

#### 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 130° - 160°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 and 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

## AA Primary Cylindrical Li/FeS<sub>2</sub> (L91)

### Thermal switch characteristics and considerations

The L91 battery contains a re-settable 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 Regulations for Li/FeS<sub>2</sub> Cells and Batteries

Transportation of primary lithium cells and batteries is regulated by the following agencies.

Agency	Jurisdiction	Section
International Civil Aviation Organization (ICAO)	International air transport	Technical instructions
International Air Transport Association		Dangerous good regulations
International Maritime Dangerous Goods Code	Sea, land and rail transport	IMDG Code
US Department of Transportation (USDOT)	Air, sea, land and rail transport	49 CFR Sections 100 - 185 of the US Hazardous Materials Regulations (HMR)

The regulations are all based on the UN Recommendations on the Transport of Dangerous Goods Model Regulations and the Manual of Tests and criteria. The following regulations are in effect for shipping.

Primary Cell / Battery Max. Lithium Content	Shipping Classification / Testing	Special Packaging / Markings
1.0 gram / 2.0 grams (1)	Excepted (2)	No
5.0 grams / 25 grams	Excepted / T1-T6 (3)	No (3)
>5.0 grams / >25 grams	Class 9 / T1-T6 (4)	Yes (5)

- (1) Applies to cells and batteries with solid cathodes. The maximum lithium content for cells and batteries with liquid cathodes is 0.5 grams / 1.0 gram.
- (2) Exempt from regulations. (No testing, marking, specification packaging, or labeling required.)
- (3) Exempt from regulations only if meets requirements of UN T1-T6 Tests; otherwise may be able to be shipped Class 9 hazardous material.
- (4) Must pass UN T1-T6 Tests and be shipped as a Class 9 hazardous material.
- (5) Requires Class 9 markings, label, specification packaging, and shipping papers.

The new regulations for the transport of all lithium cells and batteries will become effective at various times in 2003 depending on the mode of transportation. The regulations will require battery makers and companies that ship equipment containing lithium cells and batteries to meet new testing, marking, packaging, labeling, and shipping manifest specifications. The regulations will be part of:

- ICAO Technical Instructions (2003-2004 Edition) and IATA Dangerous Goods Regulations (44<sup>th</sup> Edition) effective January 1, 2003.
- IMDG Code (2002 Edition) effective January 1, 2004,
- US HMR pursuant to final ruling of RSPA (expected effective date of October 1, 2003 with a one year transition to October 1, 2004.)

The following new shipping regulations will apply per the effective dates above:

Primary Cell / Battery Max. Lithium Content	Shipping Classification / Testing	Special Packaging / Markings
1.0 gram / 2.0 grams (1)	Excepted / T1-T8 (1,2)	Yes (3)
>1.0 grams / >2.0 grams	Class 9 / T1-T8 (4)	Yes (5)

- (1) Cell and battery design types manufactured prior to January 1, 2003 are exempt from T1-T8 testing through December 31, 2004.
- (2) Starting January 1, 2005 all cells and batteries must be tested. Cells and batteries that meet the requirements of the UN T1-T8 tests are exempt from regulations.
- (3) Packages containing more than 12 batteries or 24 cells must meet new packaging, marking, and shipping paper requirements.
- (4) Must meet UN T1-T8 tests and be shipped as a Class 9 hazardous material.
- (5) Requires Class 9 markings, label, specification packaging, and shipping papers.

***\*Note: The effective dates discussed above are the interpretation of the US DOT and it is assumed other regulatory bodies will adhere to these dates as well. To be absolutely sure, please contact your appropriate transportation regulatory agency.***

The UN Manual of Tests and Criteria establishes the UN T1-T8 Tests.

**Test 1: Altitude Simulation** - Simulates air transport under low-pressure conditions.

**Test 2: Thermal Test** - Assesses cell and battery seal integrity and internal electrical connections using thermal cycling to simulate rapid and extreme temperature changes.

**Test 3: Vibration** - Simulates vibration during transport.

**Test 4: Shock** - Simulates possible impacts during transport.

**Test 5: External Short Circuit** - Simulates an external short circuit.

**Test 6: Impact** - Simulates an impact.

**Test 7: Overcharge** - Evaluates the ability of a rechargeable battery to withstand overcharge.

**Test 8: Forced Discharge** - Evaluates the ability of a primary or a rechargeable cell to withstand forced discharge.

The effective dates of the new testing requirements for different modes of transportation are referenced above. These tests shall be performed, prior to shipment, once for each cell and battery of a given design. Lithium cells or batteries, which differ from a tested type by a change of more than 0.1 g or 20% by mass, whichever is greater, shall be considered a new design. The change can be to the cathode, anode, electrolyte, or any other change that would materially affect the test results. Any design considered a new design shall be subjected to specified tests. Cells and batteries of identical design need only be tested once, even if they are manufactured and shipped from multiple locations.

There are also new marking and packaging requirements for exempt cells and battery packages. Packages containing more than 24 lithium cells or 12 lithium batteries must:

- Be marked to indicate they contain lithium cells or batteries and that special procedures should be followed in the event the package is damaged.

- Be capable of withstanding a 1.2 meter drop test in any orientation. The drop shall not damage the cells or batteries contained in the package, shift the contents to allow short-circuiting, or release any of the package contents.
- Not exceed 30-kg (66.1 lbs.) gross mass.
- Contain a note with each shipment explaining that the cells or batteries are exempt from ICAO, IATA, and DOT regulations.

If Class 9 dangerous goods are packed with the contents of the package, the entire package or piece of equipment must be shipped as Class 9 hazardous material.

### Transportation Regulations for Li/FeS<sub>2</sub> Cells and Batteries (cont.)

All US employees involved in the packaging or shipment of Class 9 lithium cells and batteries must complete a "49 CFR" certified hazardous materials training course. Certifications must be renewed every three years, and it is also recommended employees attend an "IATA Training" course.

Exemptions to the regulations (or a DOT Approval) should be requested from the countries of origin and destination for a specific cells or battery types, and cleared with the carrier. Requests shall include sufficient product, cell and battery lithium content, safety test data and the application for the cells or batteries. An approval from the DOT can take up to 16 weeks to secure. DOT approvals are transferable. Cell or battery manufacturers may transfer the approval to their customers who re-ship the product.

When transported by motor vehicle for the purpose of testing, lithium cells or batteries are exempt from the UN tests or DOT approval provided the cells or batteries are individually packed in an inner packaging, surrounded by non-combustive and non-conductive cushioning material.

**Any violation of the US DOT HMR is subject to a fine up to \$27, 500. Multiple fines may be imposed for a single shipment of cells and batteries that may have a combination of testing, packaging, labeling, or other violations.**

**NOTE:** According to special provisions in the ICAO Technical Instructions and US HMR, passengers may carry-on consumer electronic devices (calculators, camcorders, cameras, cellular phones, laptop computers, PDA's, watches, etc.) using lithium batteries provided they contain less than 2 grams of lithium content or 8 grams of equivalent lithium content. Unlimited spare batteries may be carried provided the spares also meet the 2 grams lithium / 8 grams equivalent lithium rule. For spare batteries containing between 8 and 25 grams equivalent lithium content, no more than two may be carried. Passengers are prohibited from carrying any battery containing more than two grams of lithium or 25 grams equivalent lithium onto an aircraft. As in the case of shipped batteries, even spare batteries carried onto an aircraft must be protected to prevent short circuits.

*Information in this document represents performance and transportation information for lithium batteries at the time of draft. Because batteries can be modified, those considering the use of a lithium battery should contact the nearest Energizer Sales office for the latest information. The contents of this document contain general background information and do not represent an applied warranty by Eveready Battery Company, Inc for any batteries. While great effort was taken to preserve accuracy, Energizer cannot guarantee the accuracy or completeness and shall not be held liable for any errors and/or outdated information. The information does not constitute legal advice on transportation regulations, should not be considered legal advice, and should not substitute for obtaining legal advice from competent transportation regulatory authorities and experts.*

## Transportation Regulations for Li/FeS<sub>2</sub> Cells and Batteries

### Class 9 Hazardous Materials Quick Reference Guide:

#### Requirements for Shipping Class 9 Lithium Cells and batteries

1. **PACKAGING** - Must meet "Packaging Group II" performance standards as referred to in the appropriate hazardous materials transportation regulations.
  - Packages must not exceed 5 kg (gross weight) for passenger aircraft
  - Packages must not exceed 35 kg (gross weight) for cargo aircraft
2. **MARKING** - Must appear on the packaging:
  - "Lithium Batteries"
  - ID # "UN3090" ("UN3091" for lithium batteries packed with or contained in equipment)
  - Shippers name and address
  - Name and address or company or person receiving the batteries

3. **LABEL** - Must contain Class 9 Label on package.



Air Eligibility Marking Labels will also be required on air shipments effective January 1, 2004.



4. **SHIPPING DOCUMENTS** - Must contain proper shipping name, hazard class, identification number and packing group in the following order.
  - Number of packages
  - Weight
  - Page numbers and total number of pages
  - Emergency telephone number
  - Shippers certification
  - Shippers Signature - shipper shall be a trained and qualified in DOT and/or IATA/ICAO regulations
5. **SHIPPING BY AIR** - Must contain the following additional information.
  - Air tracking number
  - "Passenger and Cargo Aircraft" or "Cargo Aircraft Only" indicators
  - Airport of departure
  - Destination Airport
  - Shipment type: radioactive or non-radioactive
  - Type of packaging
  - Signing place and date of shippers certification

## Transportation Regulations for Li/FeS<sub>2</sub> Cells and Batteries

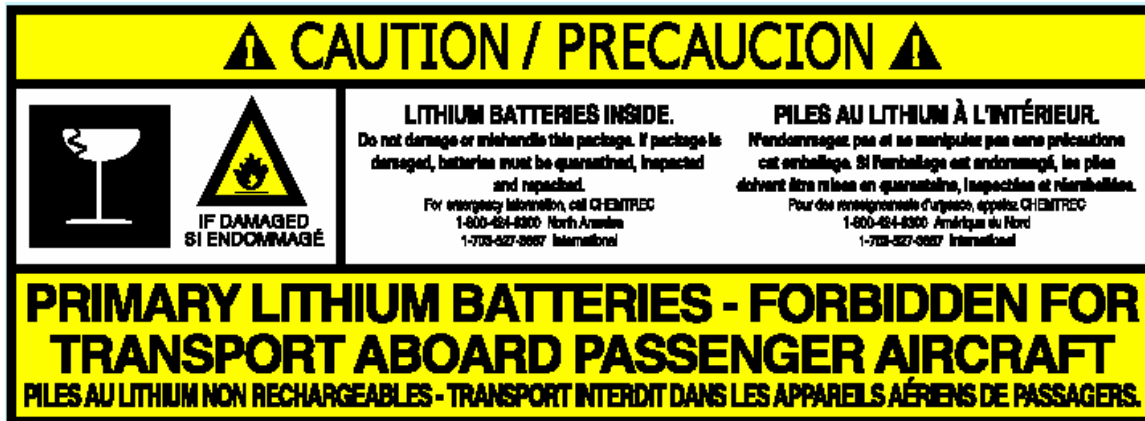
### Non-Hazardous Materials Air Shipment Quick Reference Guide:

#### Requirements for Shipping Non-hazardous Lithium Cells and batteries via Air Shipment

**MARKING** - The following must appear on the packaging:

- Shippers name and address
- Name and address or company or person receiving the batteries

**LABEL** - Caution Lithium Batteries sticker must be on package.



**SHIPPING DOCUMENTS** - The following must be included on a "NOT RESTRICTED" shipping document.

- Number of packages
- Article and description
- Net quantity per package
- Name and full address of shipper
- Name and title of authorized employee signing
- Date
- Signature of shipper - shipper shall be a trained and qualified in DOT and/or IATA/ICAO regulations