VEOLIA
ENVIRONMENTAL SERVICES

BATTERY PACKAGING GUIDELINES

Veolia ES Technical Solutions, LLC (Veolia) has developed these guidelines for packaging batteries in an effort to provide its customers with instructions on how to safely package and ship batteries for recycling or disposal. By following these proper packaging methods, any potential hazards will be minimized while the batteries are accumulated at the generator's location as well as during transportation to a recycling or disposal facility.

Recently there have been several incidents reported where a fire has occurred as a result of small batteries being improperly packed in a drum. Veolia's goal is to assure that all batteries it manages are properly packaged and therefore the risk of such an incident occurring is minimized.

All batteries pose potential hazards during transportation, therefore it is imperative that all batteries comply with the proper US Department of Transportation (US DOT) packaging requirements that are referenced in this document. These guidelines were specifically developed to address the shipment of batteries by highway, rail and cargo vessel. Additional requirements may apply to air shipments.

General Guidelines applicable to ALL batteries, regardless of type or size:

- Only chemically compatible battery types should be packed in the same package. Do not mix acidic batteries with alkaline batteries.
- To prevent short circuiting the US DOT has identified the following methods as acceptable methods of short circuit protection:
  1. Packaging each battery or each battery-powered device when practicable, in fully enclosed inner packagings made of non-conductive material;
  2. Separating or packaging batteries and battery-powered devices in a manner to prevent contact with other batteries, devices or conductive materials (e.g., metal) in the packagings; or
  3. Ensuring exposed terminals are protected with non-conductive caps, non-conductive tape, or by other appropriate means. Proper insulation includes taping the terminals of the batteries or packaging in individual plastic bags. Clear tape is preferred so that battery identification is still possible. Other forms of insulation may also be used.
- To prevent damage to terminals the US DOT has identified the following methods as acceptable methods for protecting battery terminals:
  1. Securely attaching covers of sufficient strength to protect the terminals;
  2. Packaging the battery in a rigid plastic packaging; or
  3. Constructing the battery with terminals that are recessed.
- Batteries that evolve gas and are packaged in drums, must have pressure relief bungs in the lids.
- All batteries should be stored in a cool, dry environment.
- Leaking batteries must be individually packaged and may require shipment as an EPA hazardous waste.
- Batteries secured to a pallet with shrink-wrap in accordance with 49 CFR §173.159(c)(1) are considered to be a single non-bulk package even if the completed package weighs more than 400 kg (882 pounds). Therefore, marking and labeling should be in accordance with the non-bulk packaging requirements found under §172.301 and §172.400.
- Incident reporting in accordance with §171.16 is required for ALL incidents involving shipments of batteries or battery-powered devices including fire, violent rupture, explosion, or a dangerous evolution of heat. This requirement applies to all battery shipments, including batteries that are prepared as excepted from the HMR requirements.

Health and Safety Considerations:

Many batteries contain toxic and/or corrosive materials. While intact, these batteries do not pose a health or safety hazard during use. However, if a battery becomes damaged there is a potential for exposure to these hazardous materials. If a battery becomes damaged or begins to leak consult a Material Safety Data Sheet from the manufacturer of the battery to obtain applicable health and safety data.

Battery Specific information:

The following pages contain specific packaging requirements for the most common battery types currently available. If you have a specialty battery that is not identified in the following guidelines please contact your customer service representative for specific packaging requirements (i.e. special use batteries, thermal batteries, etc.).

The battery specific packaging information contained in this document is strictly to be used as guidance when packaging batteries. Per US DOT regulation and agency guidance documents, any electrical device, even one not otherwise subject to the HMR (either by specific exception from the HMR, or because the device and its power source contains no material meeting the definition of a hazardous material), is forbidden from being offered for transportation, or transported, if the device is likely to create sparks or a dangerous evolution of heat, unless packaged in a manner that precludes such an occurrence.

This document will be amended by Veolia as additional information regarding battery packaging becomes available.

Key Definitions:

Anode - The electrode where oxidation occurs in an electrochemical cell. It is the negative electrode on a battery.

Battery - A device consisting of one or more electrically connected electrochemical cells which is designed to receive, store, and deliver electric energy.

Cathode - The electrode where reduction occurs in an electrochemical cell. It is the positive electrode on a battery.

Cell - A system consisting of an anode, cathode, and an electrolyte, plus such connections (electrical and mechanical) as may be needed to allow the cell to deliver or receive electrical energy.

Electrolyte - A chemical compound (salt, acid, or base) that dissociates into electrically charged ions when dissolved in a solvent. The resulting electrolyte (or electrolytic) solution is an ionic conductor of electricity.

Hermetically sealed - A device or unit that is sealed and for practical purposes is considered airtight.

Primary cells and batteries - Non-rechargeable cells and batteries.

Secondary cells and batteries - Rechargeable cells and batteries.

ALKALINE

TYPICAL USES: Flashlights, cameras, portable radios, audio players, and toys.

COMPOSITION: Alkaline batteries have a zinc anode and a manganese dioxide cathode. The electrolyte used in an alkaline battery is a paste of either potassium hydroxide or sodium hydroxide. Each of these components, along with conductors and separators are then assembled into or contained within a hermetically sealed unit.

US DOT DESCRIPTION:

Proper Shipping Name	Batteries, dry, sealed, n.o.s.
Hazard Class	N/A (NONE)
Identification Number	N/A
Packing Group	N/A

US DOT PACKAGING REQUIREMENTS: 49 CFR §172.102 Special Provision 130
All dry cell batteries must be prepared and packaged in a manner to prevent:

1. A dangerous evolution of heat,
2. Short circuits, **and**
3. Damage to terminals

Batteries must be packaged in strong outer packagings or, if large enough, firmly secured to pallets capable of withstanding the shocks normally incident to transportation.

US EPA REGULATIONS: Since this class of battery does not fail the TCLP nor does it contain any free liquids, it is not classified as a hazardous waste as defined by the US EPA and as such, is not subject to the universal waste requirements. Individual states may adopt more stringent regulations than the federal regulations; therefore, alkaline batteries may be classified as a universal waste in some states.

LEAD ACID, WET CELL

TYPICAL USES: Automotive, marine, industrial applications.

COMPOSITION: Lead acid batteries have a lead anode and a lead dioxide cathode. The electrolyte is an aqueous solution of sulfuric acid. The battery cell contains 60 to 75 percent lead and lead oxide, by weight, and the electrolyte contains between 28 and 51 percent sulfuric acid, by weight.

US DOT DESCRIPTION:

Proper Shipping Name	Batteries, wet, filled with acid
Hazard Class	8
Identification Number	UN2794
Packing Group	PG III

US DOT PACKAGING REQUIREMENTS: 49 CFR §173.159
All lead acid batteries must be prepared and packaged in a manner to prevent:

1. A dangerous evolution of heat,
2. Short circuits, **and**
3. Damage to terminals

Batteries must be packaged in USDOT authorized packagings which include:

1. Specification packages listed in 49 CFR §173.159(c). The most common of these containers are the 4G fiberboard box and the 1H2 poly drum. Metal drums are not authorized for shipping wet cell batteries,
2. Firmly secured to skids or pallets capable of withstanding the shocks normally incident to transportation. The pallet must not exceed a height of 1.5 times the width of the pallet and must be capable of withstanding a superimposed weight of 2 times the weight of the pallet. The battery terminals must not be relied upon to support any of the superimposed weight, or
3. In accordance with one of the other packaging alternatives not specifically listed above.

US EPA REGULATIONS: Rules specific to the recycling of lead acid batteries are contained in 40 CFR part 266 Subpart G. As an alternative to this section, generators of lead acid batteries may choose to manage their lead acid batteries in accordance with the universal waste standards. When managed as a universal waste, each battery or each package containing batteries must be marked with the words "Universal Waste Batteries," "Waste Batteries," or "Used Batteries."

When not shipped as exempt or universal waste, the RCRA Waste code D002 (corrosive) and D008 (lead) would need to be included on the manifest.

LEAD ACID, NONSPILLABLE
(Valve Regulated Lead Acid)

TYPICAL USES: Camcorders, computers, portable radios, lawn equipment, portable industrial equipment, marine applications

COMPOSITION: Like wet cell lead acid batteries, nonspillable or Valve Regulated Lead Acid (VRLA) batteries also have a lead anode, a lead dioxide cathode, and an aqueous sulfuric acid electrolyte. However, because of the way in which nonspillable batteries are manufactured, the electrolyte will not spill out of the battery. Although somewhat of a misnomer, these batteries are often referred to as sealed lead acid batteries. There are two primary categories of nonspillable batteries:

1. Absorbed glass mat (AGM) batteries, these batteries contain a liquid electrolyte that is absorbed into a glass mat sandwiched between the electrodes.
2. Gel cell batteries, these are batteries which have a chemical added to the electrolyte which causes it to form a gel which will not spill from the battery.

Nonspillable batteries authorized to be shipped under the below listed shipping name and packaging standards must be clearly marked “NONSPILLABLE” or “NONSPILLABLE BATTERY” by the manufacturer.

US DOT DESCRIPTION:

Proper Shipping Name	Batteries, wet, non-spillable
Hazard Class	8
Identification Number	UN2800
Packing Group	PG III

US DOT PACKAGING REQUIREMENTS: 49 CFR §173.159a
Nonspillable lead acid batteries must be prepared and packaged in a manner to prevent:

1. A dangerous evolution of heat,
2. Short circuits, **and**
3. Damage to terminals

The batteries must also be packaged in strong outer packagings and the battery and outer packaging must be plainly and durable marked “NONSPILLABLE” or “NONSPILLABLE BATTERY”.

US EPA REGULATIONS: Rules specific to the recycling of lead acid batteries are contained in 40 CFR part 266 Subpart G. As an alternative to this section, generators of lead acid batteries may choose to manage their lead acid batteries in accordance with the universal waste standards. When managed as a universal waste, each battery or each package containing batteries must be marked with the words “Universal Waste Batteries,” “Waste Batteries,” or “Used Batteries.”

When <u>not</u> shipped as exempt or universal waste, the RCRA Waste code D002 (corrosive) and D008 (lead) would need to be included on the manifest.

LITHIUM, LITHIUM POLYMER and LITHIUM ION



TYPICAL USES: Cameras, calculators, watches, computers, etc.

COMPOSITION: The table below lists several of the most common types of lithium batteries.

ANODE	CATHODE	ELECTROLYTE	CATEGORY OF BATTERY
Lithium	Manganese Dioxide	Lithium perchlorate in an organic solvent*	Primary/Non-rechargeable
Lithium	Iron Sulfide	Organic solvent*	Primary/Non-rechargeable
Lithium	Thionyl Chloride	Lithium tetrachloroaluminate in thionyl chloride	Primary/Non-rechargeable
Lithium	Sulfur Dioxide	Lithium bromide in sulfur dioxide and acetonitrile	Primary/Non-rechargeable
Graphite	Metal oxide/salts**	Lithium salts in an organic solvent*	Secondary/Rechargeable

*Organic solvents may include one or more of the following: propylene carbonate, dioxolane, dimethoxyethane, ethylene carbonate

** Common metal oxides include lithium cobalt oxide, lithium manganese oxide and lithium iron phosphate.

US DOT DESCRIPTION:

Proper Shipping Name	Lithium Batteries
Hazard Class	9
Identification Number	UN3090
Packing Group	PG II

US DOT PACKAGING REQUIREMENTS: 49 CFR §173.185
All lithium batteries must be prepared and packaged in a manner to prevent:

1. A dangerous evolution of heat,
2. Short circuits, **and**
3. Damage to terminals

Lithium batteries and cells shipped for disposal or recycling must be packaged in strong outer packagings.

Additional exceptions for small and medium sized lithium cells/batteries – Relief from certain DOT requirements can be found in 49 CFR §172.202 Special Provisions 188 and 189.

US EPA REGULATIONS: Lithium metal is a water reactive metal. As such lithium batteries should be managed as a universal waste in accordance with 40 CFR Part 273. All containers of universal waste batteries must be marked with the words “Universal Waste Batteries,” “Waste Batteries,” or “Used Batteries.”

MAGNESIUM

TYPICAL USES: Same as alkaline

COMPOSITION: Magnesium batteries have a magnesium anode, manganese dioxide cathode, and an electrolyte of a paste containing magnesium bromide or magnesium perchlorate with a chromate inhibitor to prevent corrosion to the magnesium anode. Each of these components, along with conductors and separators are then typically assembled into or contained within a hermetically sealed unit. If the battery is not a hermetically sealed unit, the battery should be considered a specialty battery and the following information is not applicable. For assistance in determining the proper packaging for these specialty batteries please contact customer service.

US DOT DESCRIPTION:

Proper Shipping Name	Batteries, dry, sealed, n.o.s.
Hazard Class	N/A (NONE)
Identification Number	N/A
Packing Group	N/A

US DOT PACKAGING REQUIREMENTS: 49 CFR §172.102 Special Provision 130
All dry cell batteries must be prepared and packaged in a manner to prevent:

1. A dangerous evolution of heat,
2. Short circuits, **and**
3. Damage to terminals

Batteries must be packaged in strong outer packagings or, if large enough, firmly secured to pallets capable of withstanding the shocks normally incident to transportation.

US EPA REGULATIONS: Based on the original composition and charge state of the battery, these batteries may fail the TCLP for chromium. As such magnesium batteries should be managed as a universal waste in accordance with 40 CFR Part 273. All containers of universal waste batteries must be marked with the words “Universal Waste Batteries,” “Waste Batteries,” or “Used Batteries.”

MERCURY

TYPICAL USES: Hearing aids, pacemakers, camera, calculators, watches, etc.

COMPOSITION: Mercury batteries have a zinc anode and a mercuric oxide cathode. The electrolyte used in a mercury battery is a paste of either potassium hydroxide or sodium hydroxide. Each mercury cell contains a total of 20 to 50 percent mercury by weight. Each of these components, along with conductors and separators are then assembled into or contained within a hermetically sealed unit.

US DOT DESCRIPTION:
Packages containing less than 3 pounds of mercury batteries

Proper Shipping Name	Batteries, dry, sealed, n.o.s.
Hazard Class	N/A
Identification Number	N/A
Packing Group	N/A

US DOT PACKAGING REQUIREMENTS: 49 CFR §172.102 Special Provision 130
All dry cell batteries must be prepared and packaged in a manner to prevent:

1. A dangerous evolution of heat,
2. Short circuits, **and**
3. Damage to terminals

Batteries must be packaged in strong outer packagings.

Packages which contain greater than 3 pounds of mercury batteries meet the US DOT definition of a hazardous substance and must be prepared for transport in accordance with the US DOT regulations using the proper shipping name “RQ Environmentally Hazardous Substance solid, n.o.s. (Mercury)”.

US EPA REGULATIONS: Mercury batteries typically fail the TCLP for mercury. As such, all mercury batteries should be managed as a universal waste in accordance with 40 CFR Part 273. All containers of universal waste batteries must be marked with the words “Universal Waste Batteries,” “Waste Batteries,” or “Used Batteries.”

When not shipped as universal waste, the RCRA Waste code D009 (mercury) would need to be included on the manifest.

NICKEL CADMIUM, WET CELL

TYPICAL USES: Industrial applications, back up batteries and computers

COMPOSITION: Nickel cadmium (NiCd) batteries have a cadmium anode and a nickel oxyhydroxide cathode. The electrolyte within a wet cell NiCd battery is an aqueous solution of potassium hydroxide.

US DOT DESCRIPTION:

Proper Shipping Name	Batteries, wet, filled with alkali
Hazard Class	8
Identification Number	UN2795
Packing Group	PG III

US DOT PACKAGING REQUIREMENTS: 49 CFR §173.159
All wet cell NiCd batteries must be prepared and packaged in a manner to prevent:

1. A dangerous evolution of heat,
2. Short circuits, **and**
3. Damage to terminals

Batteries must be packaged in US DOT authorized packagings which include:

1. Specification packages listed in §173.159(c). The most common of these containers are the 4G fiberboard box and the 1H2 poly drum. Metal drums are not authorized for shipping wet cell batteries,
2. Firmly secured to skids or pallets capable of withstanding the shocks normally incident to transportation. The pallet must not exceed a height of 1.5 times the width of the pallet and must be capable of withstanding a superimposed weight of 2 times the weight of the pallet. The battery terminals must not be relied upon to support any of the superimposed weight, or
3. In accordance with one of the other packaging alternatives not specifically listed above.

US EPA REGULATIONS: Wet cell NiCd batteries contain a liquid electrolyte which exhibits the characteristic of corrosivity and when tested will fail the TCLP for cadmium. As such, wet cell NiCd batteries should be managed as a universal waste in accordance with 40 CFR Part 273. All containers of universal waste batteries must be marked with the words “Universal Waste Batteries,” “Waste Batteries,” or “Used Batteries.”

When not shipped as a universal waste, the RCRA Waste code D002 (Corrosivity) and D006 (cadmium) would need to be included on the manifest.

NICKEL CADMIUM, DRY CELL

TYPICAL USES: Cameras, rechargeable appliances such as portable power tools, hand held vacuums, etc.

COMPOSITION: Dry cell nickel cadmium (NiCd) batteries have a cadmium anode and nickel oxyhydroxide cathode. The electrolyte used in a dry cell NiCd battery is a paste of potassium hydroxide. Each of these components, along with conductors and separators are then assembled into or contained within a hermetically sealed unit.

US DOT DESCRIPTION:

Proper Shipping Name	Batteries, dry, sealed, n.o.s.
Hazard Class	N/A
Identification Number	N/A
Packing Group	N/A

US DOT PACKAGING REQUIREMENTS: 49 CFR §172.102 Special Provision 130
All dry cell batteries must be prepared and packaged in a manner to prevent:

1. A dangerous evolution of heat,
2. Short circuits, **and**
3. Damage to terminals

Batteries must be packaged in strong outer packagings or, if large enough, firmly secured to pallets capable of withstanding the shocks normally incident to transportation.

US EPA REGULATIONS: Dry cell NiCd batteries typically will fail the TCLP for cadmium. As such, dry cell NiCd batteries should be managed as a universal waste in accordance with 40 CFR Part 273. All containers of universal waste batteries must be marked with the words “Universal Waste Batteries,” “Waste Batteries,” or “Used Batteries.”

When not shipped as a universal waste, the RCRA Waste code D006 (cadmium) would need to be included on the manifest.

NICKEL METAL HYDRIDE

TYPICAL USES: Cameras, rechargeable appliances such as portable power tools, hand held vacuums, etc.

COMPOSITION: Nickel metal hydride (NiMH) batteries have a hydrogen-absorbing metal alloy anode and a nickel oxyhydroxide cathode. The electrolyte in a NiMH battery is typically a potassium hydroxide paste. Each of these components, along with conductors and separators are then assembled into or contained within a hermetically sealed unit.

US DOT DESCRIPTION:

Proper Shipping Name	Batteries, dry, sealed, n.o.s.
Hazard Class	N/A
Identification Number	N/A
Packing Group	N/A

US DOT PACKAGING REQUIREMENTS: 49 CFR §172.102 Special Provision 130
All dry cell batteries must be prepared and packaged in a manner to prevent:

1. A dangerous evolution of heat,
2. Short circuits, **and**
3. Damage to terminals

Batteries must be packaged in strong outer packagings or, if large enough, firmly secured to pallets capable of withstanding the shocks normally incident to transportation.

US EPA REGULATIONS: Since this class of battery does not fail the TCLP nor does it contain any free liquids, it is not classified as a hazardous waste as defined by the US EPA and as such, is not subject to the universal waste requirements. Individual states may adopt more stringent regulations than the federal regulations; therefore, NiMH batteries may be classified as a universal waste in some states.

SILVER OXIDE

TYPICAL USES: Hearing aids, watches, cameras, calculators

COMPOSITION: Silver oxide batteries have a zinc anode and a silver oxide cathode. The electrolyte used in a silver oxide battery is a potassium hydroxide or sodium hydroxide paste. Each of these components, along with conductors and separators are then assembled into or contained within a hermetically sealed unit. In addition to the above materials, many of the older silver oxide batteries contained a significant amount of mercury. Batteries containing both silver and mercury should be managed as mercury batteries. The below listed information is for non-mercury containing silver oxide batteries.

US DOT DESCRIPTION:

Proper Shipping Name	Batteries, dry, sealed, n.o.s.
Hazard Class	N/A
Identification Number	N/A
Packing Group	N/A

US DOT PACKAGING REQUIREMENTS: 49 CFR §172.102 Special Provision 130
All dry cell batteries must be prepared and packaged in a manner to prevent:

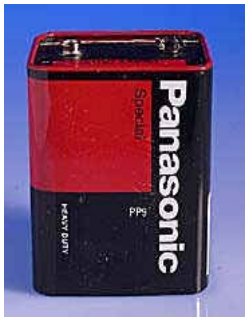
1. A dangerous evolution of heat,
2. Short circuits, **and**
3. Damage to terminals

Batteries must be packaged in strong outer packagings or, if large enough, firmly secured to pallets capable of withstanding the shocks normally incident to transportation.

US EPA REGULATIONS: Silver oxide batteries typically will fail the TCLP for silver and older silver oxide batteries will typically fail the TCLP for silver and mercury. As such, silver oxide batteries should be managed as a universal waste in accordance with 40 CFR Part 273. All containers of universal waste batteries must be marked with the words “Universal Waste Batteries,” “Waste Batteries,” or “Used Batteries.”

When <u>not</u> shipped as a universal waste, the RCRA Waste code D011 (silver) would need to be included on the manifest.

CARBON ZINC



TYPICAL USES: Flashlights, toys, etc.

COMPOSITION: Carbon zinc batteries, often referred to as Heavy Duty Batteries, have a zinc anode and a cathode that contains a mixture of manganese dioxide, carbon and electrolyte. The batteries also contain a carbon electrode that serves as a cathode current collector. The electrolyte is an aqueous solution of ammonium chloride and zinc chloride or a solution of zinc chloride. The electrolyte is mixed the other components of the battery to form a paste. Each of these components, along with conductors and separators are then assembled into or contained within a hermetically sealed unit.

US DOT DESCRIPTION:

Proper Shipping Name	Batteries, dry, sealed, n.o.s.
Hazard Class	N/A (NONE)
Identification Number	N/A
Packing Group	N/A

US DOT PACKAGING REQUIREMENTS: 49 CFR §172.102 Special Provision 130
All dry cell batteries must be prepared and packaged in a manner to prevent:

1. A dangerous evolution of heat,
2. Short circuits, **and**
3. Damage to terminals

Batteries must be packaged in strong outer packagings or, if large enough, firmly secured to pallets capable of withstanding the shocks normally incident to transportation.

US EPA REGULATIONS: Since this class of battery does not fail the TCLP nor does it contain any free liquids, it is not classified as a hazardous waste as defined by the US EPA and as such, is not subject to the universal waste requirements. Individual states may adopt more stringent regulations than the federal regulations; therefore, carbon zinc batteries may be classified as a universal waste in some states.

APPENDIX

The following contains excerpts from the US DOT regulations, 49 CFR Part 171-173, that are referenced in the guidance document. These regulations are current as of April 2009.

§172.102, SPECIAL PROVISION 130 - Dry batteries not specifically covered by another entry in the §172.101 Table must be described using this entry. Batteries described as " Batteries, dry, sealed, n.o.s" are hermetically sealed and generally utilize metals (other than lead) and/or carbon as electrodes. These batteries are typically used for portable power applications. The rechargeable (and some non-rechargeable) types have gelled alkaline electrolytes (rather than acidic) making it difficult for them to generate hydrogen or oxygen when overcharged and therefore, differentiating them from non-spillable batteries. " Batteries, dry, sealed, n.o.s." are not subject to any other requirements of this subchapter except for the following:

(1) Incident reporting requirements. For transportation by aircraft, a telephone report in accordance with §171.15(a) is required if a fire, violent rupture, explosion or dangerous evolution of heat (*i.e.*, an amount of heat sufficient to be dangerous to packaging or personal safety to include charring of packaging, melting of packaging, scorching of packaging, or other evidence) occurs as a direct result of a dry battery. For all modes of transportation, a written report submitted, retained, and updated in accordance with §171.16 is required if a fire, violent rupture, explosion or dangerous evolution of heat occurs as a direct result of a dry battery or battery-powered device;

(2) Batteries and battery-powered device(s) containing batteries must be prepared and packaged for transport in a manner to prevent:

  (i) A dangerous evolution of heat;

  (ii) Short circuits, including but not limited to the following methods:

    (a) Packaging each battery or each battery-powered device when practicable, in fully enclosed inner packagings made of non-conductive material;

    (b) Separating or packaging batteries in a manner to prevent contact with other batteries, devices or conductive materials (*e.g.* , metal) in the packagings; or

    (c) Ensuring exposed terminals or connectors are protected with non-conductive caps, non-conductive tape, or by other appropriate means; and

  (iii) Damage to terminals. If not impact resistant, the outer packaging should not be used as the sole means of protecting the battery terminals from damage or short circuiting. Batteries must be securely cushioned and packed to prevent shifting which could loosen terminal caps or reorient the terminals to produce short circuits. Batteries contained in devices must be securely installed. Terminal protection methods include but are not limited to the following:

    (a) Securely attaching covers of sufficient strength to protect the terminals;

    (b) Packaging the battery in a rigid plastic packaging; or

(c) Constructing the battery with terminals that are recessed or otherwise protected so that the terminals will not be subjected to damage if the package is dropped.

(3) When transported by aircraft, for a battery whose voltage (electrical potential) exceeds 9 volts:

(i) When contained in a device, the device must be packaged in a manner that prevents unintentional activation or must have an independent means of preventing unintentional activation (*e.g.* , packaging restricts access to activation switch, switch caps or locks, recessed switches, trigger locks, temperature sensitive circuit breakers, etc.); and

(ii) An indication of compliance with this special provision must be provided by marking each package with the words " not restricted" or by including the words " not restricted" on a transport document such as an air waybill accompanying the shipment.

§172.102, SPECIAL PROVISION 188 - *Small lithium cells and batteries.* Lithium cells or batteries, including cells or batteries packed with or contained in equipment, are not subject to any other requirements of this subchapter if they meet all of the following:

a. *Primary lithium batteries and cells.*

(1) Primary lithium batteries and cells are forbidden for transport aboard passenger-carrying aircraft. The outside of each package that contains primary (nonrechargeable) lithium batteries or cells must be marked " PRIMARY LITHIUM BATTERIES-FORBIDDEN FOR TRANSPORT ABOARD PASSENGER AIRCRAFT" or " LITHIUM METAL BATTERIES-FORBIDDEN FOR TRANSPORT ABOARD PASSENGER AIRCRAFT" on a background of contrasting color. The letters in the marking must be:

(i) At least 12 mm (0.5 inch) in height on packages having a gross weight of more than 30 kg (66 pounds); or

(ii) At least 6 mm (0.25 inch) on packages having a gross weight of 30 kg (66 pounds) or less, except that smaller font may be used as necessary to fit package dimensions; and

(2) The provisions of paragraph (a)(1) do not apply to packages that contain 5 kg (11 pounds) net weight or less of primary lithium batteries or cells that are contained in or packed with equipment and the package contains no more than the number of lithium batteries or cells necessary to power the piece of equipment;

b. For a lithium metal or lithium alloy cell, the lithium content is not more than 1.0 g. For a lithium-ion cell, the equivalent lithium content is not more than 1.5 g;

c. For a lithium metal or lithium alloy battery, the aggregate lithium content is not more than 2.0 g. For a lithium-ion battery, the aggregate equivalent lithium content is not more than 8 g;

d. Effective October 1, 2009, the cell or battery must be of a type proven to meet the requirements of each test in the UN Manual of Tests and Criteria (IBR; see §171.7 of this subchapter);

e. Cells or batteries are separated or packaged in a manner to prevent short circuits and are packed in a strong outer packaging or are contained in equipment;
f. Effective October 1, 2008, except when contained in equipment, each package containing more than 24 lithium cells or 12 lithium batteries must be:
    (1) Marked to indicate that it contains lithium batteries, and special procedures should be followed if the package is damaged;
    (2) Accompanied by a document indicating that the package contains lithium batteries and special procedures should be followed if the package is damaged;
    (3) Capable of withstanding a 1.2 meter drop test in any orientation without damage to cells or batteries contained in the package, without shifting of the contents that would allow short circuiting and without release of package contents; and
    (4) Gross weight of the package may not exceed 30 kg (66 pounds). This requirement does not apply to lithium cells or batteries packed with equipment;
g. Electrical devices must conform to §173.21;
h. For transportation by aircraft, a telephone report in accordance with §171.15(a) is required if a fire, violent rupture, explosion or dangerous evolution of heat (*i.e.,* an amount of heat sufficient to be dangerous to packaging or personal safety to include charring of packaging, melting of packaging, scorching of packaging, or other evidence) occurs as a direct result of a lithium battery. For all modes of transportation, a written report submitted, retained, and updated in accordance with §171.16 is required if a fire, violent rupture, explosion or dangerous evolution of heat occurs as a direct result of a lithium battery or battery-powered device; and
i. Lithium batteries or cells are not authorized aboard an aircraft in checked or carry-on luggage except as provided in §175.10.

§172.102, SPECIAL PROVISION 189 - *Medium lithium cells and batteries.* Effective October 1, 2008, when transported by motor vehicle or rail car, lithium cells or batteries, including cells or batteries packed with or contained in equipment, are not subject to any other requirements of this subchapter if they meet all of the following:

a. The lithium content anode of each cell, when fully charged, is not more than 5 grams.
b. The aggregate lithium content of the anode of each battery, when fully charged, is not more than 25 grams.
c. The cells or batteries are of a type proven to meet the requirements of each test in the UN Manual of Tests and Criteria (IBR; see §171.7 of this subchapter). A cell or battery and equipment containing a cell or battery that was first transported prior to January 1, 2006 and is of a type proven to meet the criteria of Class 9 by testing in accordance with the tests in the UN Manual of Tests and Criteria, Third revised edition, 1999, need not be retested.

d. Cells or batteries are separated or packaged in a manner to prevent short circuits and are packed in a strong outer packaging or are contained in equipment.

e. The outside of each package must be marked " LITHIUM BATTERIES-FORBIDDEN FOR TRANSPORT ABOARD AIRCRAFT AND VESSEL" on a background of contrasting color, in letters:

    (1) At least 12 mm (0.5 inch) in height on packages having a gross weight of more than 30 kg (66 pounds); or

    (2) At least 6 mm (0.25 inch) on packages having a gross weight of 30 kg (66 pounds) or less, except that smaller font may be used as necessary to fit package dimensions.

f. Except when contained in equipment, each package containing more than 24 lithium cells or 12 lithium batteries must be:

    (1) Marked to indicate that it contains lithium batteries, and special procedures should be followed if the package is damaged;

    (2) Accompanied by a document indicating that the package contains lithium batteries and special procedures should be followed if the package is damaged;

    (3) Capable of withstanding a 1.2 meter drop test in any orientation without damage to cells or batteries contained in the package, without shifting of the contents that would allow short circuiting and without release of package contents; and

    (4) Gross weight of the package may not exceed 30 kg (66 pounds). This requirement does not apply to lithium cells or batteries packed with equipment.

g. Electrical devices must conform to §173.21 of this subchapter; and

h. A written report submitted, retained, and updated in accordance with §171.16 is required if a fire, violent rupture, explosion or dangerous evolution of heat (*i.e.* , an amount of heat sufficient to be dangerous to packaging or personal safety to include charring of packaging, melting of packaging, scorching of packaging, or other evidence) occurs as a direct result of a lithium battery or battery-powered device.

§173.159 Batteries, wet

(a) Electric storage batteries, containing electrolyte acid or alkaline corrosive battery fluid (wet batteries), may not be packed with other materials except as provided in paragraphs (g) and (h) of this section and in §§173.220 and 173.222; and any battery or battery-powered device must be prepared and packaged for transport in a manner to prevent:

    (1) A dangerous evolution of heat (*i.e.* , an amount of heat sufficient to be dangerous to packaging or personal safety to include charring of packaging, melting of packaging, scorching of packaging, or other evidence);

    (2) Short circuits, including, but not limited to:

(i) Packaging each battery or each battery-powered device when practicable, in fully enclosed inner packagings made of non-conductive material;

(ii) Separating or packaging batteries and battery-powered devices in a manner to prevent contact with other batteries, devices or conductive materials (*e.g.* , metal) in the packagings; or

(iii) Ensuring exposed terminals are protected with non-conductive caps, non-conductive tape, or by other appropriate means; and

(3) *Damage to terminals.* If not impact resistant, the outer packaging must not be used as the sole means of protecting the battery terminals from damage or short circuiting. Batteries must be securely cushioned and packed to prevent shifting which could loosen terminal caps or reorient the terminals. Batteries contained in devices must be securely installed. Terminal protection methods include but are not limited to:

(i) Securely attaching covers of sufficient strength to protect the terminals;

(ii) Packaging the battery in a rigid plastic packaging; or

(iii) Constructing the battery with terminals that are recessed or otherwise protected so that the terminals will not be subjected to damage if the package is dropped.

(b) For transportation by aircraft:

(1) The packaging for wet batteries must incorporate an acid- or alkali-proof liner, or include a supplementary packaging with sufficient strength and adequately sealed to prevent leakage of electrolyte fluid in the event of spillage; and

(2) Any battery-powered device, equipment or vehicle must be packaged for transport in a manner to prevent unintentional activation or must have an independent means of preventing unintentional activation (*e.g.,* packaging restricts access to activation switch, switch caps or locks, recessed switches, trigger locks, temperature sensitive circuit breakers, etc.).

(c) The following specification packagings are authorized for batteries packed without other materials provided all requirements of paragraph (a) of this section, and for transportation by aircraft, paragraph (b) of this section are met:

(1) Wooden box: 4C1, 4C2, 4D, or 4F.

(2) Fiberboard box: 4G.

(3) Plywood drum: 1D.

(4) Fiber drum: 1G.

(5) Plastic drum: 1H2.

(6) Plastic jerrican: 3H2.

(7) Plastic box: 4H2.

(d) The following non-specification packagings are authorized for batteries packed without other materials provided all requirements of paragraph (a) of this section, and for transportation by aircraft, paragraph (b) of this section are met:

(1) Electric storage batteries are firmly secured to skids or pallets capable of withstanding the shocks normally incident to transportation are authorized for transportation by rail, highway, or vessel. The height of the completed unit must not exceed 11/2times the width of the skid or pallet. The unit must be capable of withstanding, without damage, a superimposed weight equal to two times the weight of the unit or, if the weight of the unit exceeds 907 kg (2,000 pounds), a superimposed weight of 1814 kg (4,000 pounds). Battery terminals must not be relied upon to support any part of the superimposed weight and must not short out if a conductive material is placed in direct contact with them.

(2) Electric storage batteries weighing 225 kg (500 pounds) or more, consisting of carriers' equipment, may be shipped by rail when mounted on suitable skids. Such shipments may not be offered in interchange service.

(3) One to three batteries not over 11.3 kg (25 pounds) each, packed in strong outer boxes. The maximum authorized gross weight is 34 kg (75 pounds).

(4) Not more than four batteries not over 7 kg (15 pounds) each, packed in strong outer fiberboard or wooden boxes. The maximum authorized gross weight is 30 kg (65 pounds).

(5) Not more than five batteries not over 4.5 kg (10 pounds) each, packed in strong outer fiberboard or wooden boxes. The maximum authorized gross weight is 30 kg (65 pounds).

(6) Single batteries not exceeding 34 kg (75 pounds) each, packed in 5-sided slip covers or in completely closed fiberboard boxes. Slip covers and boxes must be of solid or double-faced corrugated fiberboard of at least 91 kg (200 pounds) Mullen test strength. The slip cover or fiberboard box must fit snugly and provide inside top clearance of at least 1.3 cm (0.5 inch) above battery terminals and filler caps with reinforcement in place. Assembled for shipment, the bottom edges of the slipcover must come to within 2.5 cm (1 inch) of the bottom of the battery. The completed package (battery and box or slip cover) must be capable of withstanding a top-to-bottom compression test of at least 225 kg (500 pounds) without damage to battery terminal caps, cell covers or filler caps.

(7) Single batteries exceeding 34 kg (75 pounds) each may be packed in completely closed fiberboard boxes. Boxes must be of double-wall corrugated fiberboard of at least 181 kg (400 pounds) test, or solid fiberboard testing at least 181 kg (400 pounds); a box may have hand holes in its ends provided that the hand holes will not materially weaken the box. Sides and ends of the box must have cushioning between the battery and walls of the box; combined thickness of cushioning material and walls of the box must not be less than 1.3 cm (0.5 inch); and cushioning must be excelsior pads, corrugated fiberboard, or other suitable cushioning material. The bottom of the battery must be protected by a minimum of one

excelsior pad or by a double-wall corrugated fiberboard pad. The top of the battery must be protected by a wood frame, corrugated trays or scored sheets of corrugated fiberboard having minimum test of 91 kg (200 pounds), or other equally effective cushioning material. Top protection must bear evenly on connectors and/or edges of the battery cover to facilitate stacking of batteries. No more than one battery may be placed in one box. The maximum authorized gross weight is 91 kg (200 pounds).

(e) When transported by highway or rail, electric storage batteries containing electrolyte or corrosive battery fluid are not subject to any other requirements of this subchapter, if all of the following are met:

(1) No other hazardous materials may be transported in the same vehicle;

(2) The batteries must be loaded or braced so as to prevent damage and short circuits in transit;

(3) Any other material loaded in the same vehicle must be blocked, braced, or otherwise secured to prevent contact with or damage to the batteries; and

(4) The transport vehicle may not carry material shipped by any person other than the shipper of the batteries.

(f) Batteries can be considered as non-spillable provided they are capable of withstanding the following two tests, without leakage of battery fluid from the battery:

(1) *Vibration test* . The battery must be rigidly clamped to the platform of a vibration machine, and a simple harmonic motion having an amplitude of 0.8 mm (0.03 inches) with a 1.6 mm (0.063 inches) maximum total excursion must be applied. The frequency must be varied at the rate of 1 Hz/min between the limits of 10 Hz to 55 Hz. The entire range of frequencies and return must be traversed in 95 ± 5 minutes for each mounting position (direction of vibrator) of the battery. The battery must be tested in three mutually perpendicular positions (to include testing with fill openings and vents, if any, in an inverted position) for equal time periods.

(2) *Pressure differential test* . Following the vibration test, the battery must be stored for six hours at 24 °C ± 4 °C (75 °F ± 7 °F) while subjected to a pressure differential of at least 88 kPa (13 psig). The battery must be tested in three mutually perpendicular positions (to include testing with fill openings and vents, if any, in an inverted position) for at least six hours in each position.

(g) Electrolyte, acid or alkaline corrosive battery fluid, packed with batteries wet or dry, must be packed in one of the following specification packagings:

(1) In 4C1, 4C2, 4D, or 4F wooden boxes with inner receptacles of glass, not over 4.0 L (1 gallon) each with not over 8.0 L (2 gallons) total in each outside container. Inside containers must be well-cushioned and separated from batteries by a strong solid wooden partition. The completed package must conform to Packing Group III requirements.

(2) Electrolyte, acid, or alkaline corrosive battery fluid included with electric storage batteries and filling kits may be packed in strong rigid outer packagings when shipments are made by, for, or to the Departments of the Army, Navy, or Air Force of the United States. Packagings must conform to military specifications. The electrolyte, acid, or alkaline corrosive battery fluid must be packed in polyethylene bottles of not over 1.0 L (0.3 gallon) capacity each. Not more than 24 bottles, securely separated from electric storage batteries and kits, may be offered for transportation or transported in each package.

(3) In 4G fiberboard boxes with not more than 12 inside packagings of polyethylene or other material resistant to the lading, each not over 2.0 L (0.5 gallon) capacity each. Completed packages must conform to Packing Group III requirements. Inner packagings must be adequately separated from the storage battery. The maximum authorized gross weight is 29 kg (64 pounds). These packages are not authorized for transportation by aircraft.

(h) Dry batteries or battery charger devices may be packaged in 4G fiberboard boxes with inner receptacles containing battery fluid. Completed packagings must conform to Packing Group III requirements. Not more than 12 inner receptacles may be packed in one outer box. The maximum authorized gross weight is 34 kg (75 pounds).

(i) When approved by the Associate Administrator, electric storage batteries, containing electrolyte or corrosive battery fluid in a separate reservoir from which fluid is injected into the battery cells by a power device cartridge assembled with the battery, and which meet the criteria of paragraph (f) are not subject to any other requirements of this subchapter.

§173.159a Exceptions for Non-spillable batteries

(a) Exceptions for hazardous materials shipments in the following paragraphs are permitted only if this section is referenced for the specific hazardous material in the §172.101 table or in a packaging section in this part.

(b) Non-spillable batteries offered for transportation or transported in accordance with this section are subject to the incident reporting requirements. For transportation by aircraft, a telephone report in accordance with §171.15(a) is required if a fire, violent rupture, explosion or dangerous evolution of heat (*i.e.* , an amount of heat sufficient to be dangerous to packaging or personal safety to include charring of packaging, melting of packaging, scorching of packaging, or other evidence) occurs as a direct result of a nonspillable battery. For all modes of transportation, a written report in accordance with §171.16(a) is required if a fire, violent rupture, explosion or dangerous evolution of heat occurs as a direct result of a nonspillable battery.

(c) Non-spillable batteries are excepted from the packaging requirements of §173.159 under the following conditions:

(1) Non-spillable batteries must be securely packed in strong outer packagings and meet the requirements of §173.159(a). A non-spillable battery which is an integral part of and necessary for the operation of mechanical or electronic equipment must be securely fastened in the battery holder on the equipment;

(2) The battery and outer packaging must be plainly and durably marked " NONSPILLABLE" or " NONSPILLABLE BATTERY." The requirement to mark the outer package does not apply when the battery is installed in a piece of equipment that is transported unpackaged.

(d) Non-spillable batteries are excepted from all other requirements of this subchapter when offered for transportation and transported in accordance with paragraph (c) of this section and the following:

(1) At a temperature of 55 °C (131 °F), the battery must not contain any unabsorbed free-flowing liquid, and must be designed so that electrolyte will not flow from a ruptured or cracked case; and

(2) For transport by aircraft, when contained in a battery-powered device, equipment or vehicle must be prepared and packaged for transport in a manner to prevent unintentional activation in conformance with §173.159(b)(2) of this Subpart.

§173.185 Lithium cells and batteries

(a) *Cells and batteries.* A lithium cell or battery, including a lithium polymer cell or battery and a lithium-ion cell or battery, must conform to all of the following requirements:

(1) Be of a type proven to meet the requirements of each test in the UN Manual of Tests and Criteria (IBR; see §171.7 of this subchapter). A cell or battery and equipment containing a cell or battery that was first transported prior to January 1, 2006 and is of a type proven to meet the criteria of Class 9 by testing in accordance with the tests in the UN Manual of Tests and Criteria, Third Revised Edition, 1999, need not be retested.

(2) Incorporate a safety venting device or otherwise be designed in a manner that will preclude a violent rupture under conditions normally incident to transportation.

(3) Be equipped with an effective means to prevent dangerous reverse current flow (e.g., diodes, fuses, etc.) if a battery contains cells or series of cells that are connected in parallel.

(4) Be packaged in combination packagings conforming to the requirements of part 178, subparts L and M, of this subchapter at the Packing Group II performance level. The lithium battery or cell must be packed in inner packagings in such a manner as to prevent short circuits, including movement which could lead to short circuits. The inner packaging must be packed within one of the following outer packagings: metal boxes (4A or 4B); wooden boxes (4C1, 4C2, 4D, or 4F); fiberboard boxes (4G); solid plastic boxes (4H2); fiber drums (1G); metal drums (1A2 or 1B2); plywood drums (1D); plastic jerricans (3H2); or metal jerricans (3A2 or 3B2).

(5) Be equipped with an effective means of preventing external short circuits.

(6) Except as provided in paragraph (d) of this section, cells and batteries with a liquid cathode containing sulfur dioxide, sulfuryl chloride or thionyl chloride 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.

(d) *Cells and batteries, for disposal or recycling.* A lithium cell or battery offered for transportation or transported by motor vehicle to a permitted storage facility, disposal site or for purposes of recycling is excepted from the specification packaging requirements of paragraph (a)(4) of this section and the requirements of paragraphs (a)(1) and (a)(6) of this section when protected against short circuits and packed in a strong outer packaging conforming to the requirements of §§173.24 and 173.24a.

(g) Batteries employing a strong, impact-resistant outer casing and exceeding a gross weight of 12 kg (26.5 lbs.), and assemblies of such batteries, may be packed in strong outer packagings, in protective enclosures (for example, in fully enclosed wooden slatted crates) or on pallets. Batteries must be secured to prevent inadvertent movement, and the terminals may not support the weight of other superimposed elements. Batteries packaged in this manner are not permitted for transportation by passenger aircraft, and may be transported by cargo aircraft only if approved by the Associate Administrator prior to transportation.