

## Hazard Awareness & Packaging Guidelines for Reactive Metals

### General

Due to recent events resulting from reactive metals handling, CEI personnel and clients are being updated regarding special packaging guidelines designed to protect the safety of our personnel, physical assets, and customer environments. CEI's Materials Management staff, in conjunction with guidelines from third party disposal outlets, has approved these alternative packaging guidelines to provide for safe storage and transportation of affected materials.

This protocol primarily impacts water reactive or potentially water reactive metals in elemental form, although there are many compounds that are also affected.

The **alkali metals** are a group in the periodic table consisting of the chemical elements lithium, sodium, potassium, rubidium, cesium and francium. This group lies in the s-block of the periodic table as all alkali metals have their outermost electron in an s-orbital. The alkali metals provide the best example of group trends in properties in the periodic table, with elements exhibiting well-characterized homologous behavior.

The **alkali metals** have very similar properties: they are all shiny, soft, highly reactive metals at standard temperature and pressure, and readily lose their outermost electron to form cations with charge +1. They can all be cut easily with a knife due to their softness, exposing a shiny surface that tarnishes rapidly in air due to oxidation. Because of their high reactivity, they must be stored under oil to prevent reaction with air, and are found naturally only in salts and never as the free element. In the modern IUPAC nomenclature, the alkali metals comprise the group 1 elements, excluding hydrogen (H), which is nominally a group 1 element but not normally considered to be an alkali metal as it rarely exhibits behavior comparable to that of the alkali metals. All the alkali metals react with water, with the heavier alkali metals reacting more vigorously than the lighter ones.

The **alkaline earth metals** are beryllium, magnesium, calcium, strontium, barium, and radium. This group lies in the s-block of the periodic table as all alkaline earth metals have their outermost electron in an s-orbital.

The **alkaline earth metals** are a group of chemical elements in the periodic table with very similar properties. They are all shiny, silvery-white, somewhat reactive metals at standard temperature and pressure and readily lose their two outermost electrons to form cations with charge 2+ and an oxidation state, or oxidation number of +2. In the modern IUPAC nomenclature, the alkaline earth metals comprise the group 2 elements.

### Hazard Awareness

#### Alkali Metals (CEI Group A)

All the alkali metals react vigorously or explosively with cold water, producing an aqueous solution of the strongly basic alkali metal hydroxide and releasing hydrogen gas. This reaction becomes more

vigorous going down the group: lithium reacts steadily with effervescence, but sodium and potassium can ignite and rubidium and cesium sink in water and generate hydrogen gas so rapidly that shock waves form in the water that may shatter glass containers. When an alkali metal is dropped into water, it produces an explosion, of which there are two separate stages. The metal reacts with the water first, breaking the hydrogen bonds in the water and producing hydrogen gas; this takes place faster for the more reactive heavier alkali metals. Second, the heat generated by the first part of the reaction often ignites the hydrogen gas, causing it to burn explosively into the surrounding air. This secondary hydrogen gas explosion produces the visible flame above the water, not the initial reaction of the metal with water (which tends to happen mostly under water).



*Alkali metal reaction with water*

Cesium	Cs		Most Reactive
Rubidium	Rb		
Potassium	K		
Sodium	Na		
Lithium	Li		Least Reactive

### **Alkaline Earth Metals Plus Zinc and Aluminum (CEI Group B)**

Alkaline earth metals are not as reactive as alkali metals. However, they are more reactive than other elements in the periodic table. They react with water to form metal hydroxide and hydrogen gas. Due to the presence of two electrons in their valence shells, they are seen to form cations with a charge of 2+. Beryllium does not react with water. However, it is a highly toxic substance as a dust.

Zinc is a member of group 12 of the periodic table. It is a moderately reactive metal and a strong reducing agent. Zinc dust is stable under normal temperatures and pressures. However, fine, condensed zinc dust or powder can heat spontaneously and ignite upon exposure to air when damp.

Aluminum is a chemical element in the boron group or group 13 of the periodic table. Aluminum powder or dust is stable under normal temperatures and pressures. However, uncoated powders may evolve hydrogen gas in contact with water.

### Impact on Waste Acceptance

Due to the reactivity and other potentially dangerous properties they will need to be packaged in accordance with specific protocols set forth in this document. If there are any deviations from these set protocols the waste may not be acceptable at or TSDFs and may be subject to rejection back to the generator.

### Requirements

At the time of profiling a completed and signed Reactive Metals Certification should be submitted.

<b>Group A Packing Protocol</b>
<b>Lithium, Sodium, Potassium, Rubidium, Cesium elements and Reactive Compounds</b>
<p><b><u>Non Lab Pack Protocol (Case by Case Approval)</u></b></p> <ul style="list-style-type: none"> <li>* All drums must be combination packaging consisting of one inner container secured in a non bulk outer packaging.</li> <li>* Inner containers should be of rigid poly construction.</li> <li>* Alkali Metals <u>must</u> be packaged as to remain <b>completely submerged</b> under virgin mineral oil, thus eliminating the potential of being exposed to air or moisture during shipment or subsequent storage.</li> <li>* Monoliths are not allowed. Material must be able to be easily repacked into smaller containers for introduction into the combustion unit.</li> </ul> <p><b><u>Lab Pack Protocol</u></b> (packaged in accordance with exception found in 49 CFR 173.12)</p> <ul style="list-style-type: none"> <li>* Maximum size of outer container must not exceed 5 gallons.</li> <li>* Maximum of ten pounds per outer container               <ul style="list-style-type: none"> <li>*Maximum of 1 pound of alkali metal per inner container</li> </ul> </li> <li>* Free liquids within inner container must not exceed 3 gallons.</li> <li>* All Alkali Metals <u>must</u> be <b>completely submerged</b> in virgin mineral oil.</li> <li>* Vacuum sealed inner containers <u>must</u> be <b>completely submerged</b> in mineral oil.</li> <li>* A minimum of 4 inches of vermiculite should be used between layers, including the bottom and top of outer container.</li> <li>* All inner containers should be separated by a minimum of 2 inches of vermiculite on the same layer.</li> <li>* Outer container <u>must</u> be a UN1A2 (Steel open head drum) tested to PGII level.</li> <li>* Outer container must be properly closed in accordance with manufacturer specifications.</li> <li>* Lithium batteries are <b>NOT</b> allowed in this protocol.</li> </ul>

**Group B Packing Protocol**

**Calcium, Magnesium, Strontium, Barium, Aluminum, Zinc elements and Reactive Compounds**

**B-1 Packing Protocol B-1 (No Weight Restrictions)**

- \* All waste streams packed under this protocol must be completely coated with virgin mineral oil in order to suppress dust formation and to prevent possible exposure to moisture.
- \* Shipping container must be UN1A2 (steel open head drum) and meet packaging requirements per US DOT for the packaged material.
- \* Container must be properly closed in accordance with manufacturer specifications.
- \* **NOTE:** Material in original packaging and unopened may be able to ship absent of the virgin mineral oil. These situations require a case by case evaluation for approval via CEI Materials Management.

**B-2 Packing Protocol B-2 (Weight Restrictions Apply; Coated or uncoated shipping allowed)**

- \* All waste streams packed under this protocol may or may not need to be coated with virgin mineral oil in order to suppress dust formation and to prevent possible exposure to moisture.
- \* Shipping Container can be UN1A2 or UN1H2 and meet packaging requirements per US DOT
- \* Restrictions by element, coating and weight allowed in table below

Element		Coated	Max. Weight
Magnesium (Mg)		YES-Under Oil	20 Pounds
Magnesium (Mg)		NO	50 Pounds
Aluminum (Al)		YES-Under Oil	20 Pounds
Aluminum (Al)		NO	150 Pounds
Zinc (Zn)		YES-Under Oil	20 Pounds
Zinc (Zn)		NO	200 Pounds

- \* **NOTE:** Always consult Clean Earth with opportunities regarding Group B Metals to discuss options for packaging and shipping.

**Impact**

If a reactive metal waste is received that does not meet the established packaging criteria or chemical composition, as profiled and certified, the shipment may be subject to a re-packaging and handling surcharge; may need to be sent to a third party for stabilization or proper packaging; or may be rejected back to the generator. This may include the cost of on-site management by CEI personnel to assure the waste is packaged in conformance with US DOT and CEI Waste Management Standards.

**Recommendations**

Work these packing protocols into generating process. Store drums packaged to these protocols to avoid potential reactions.

Contact your Clean Earth Representative for a free consultation on the safest and most cost effective management practices for your alkali metals and alkaline earth metals needs.