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Document 14.7
Safe Handling of Alkali Metals and Their Reactive Compounds

Recommended for approval by the ES&H Working Group

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New document or new requirements

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14.7

Safe Handling of Alkali Metals and Their Reactive Compounds*

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Safe Handling of Alkali Metals and Their Reactive Compounds

1.0 Introduction

1.1 Purpose and Scope

Alkali metals (lithium (Li), sodium (Na), potassium (K), rubidium (Rb), cesium (Cs), and the unstable element francium (Fr)) and their alloys are used in various LLNL operations. This document describes the hazardous properties of these materials and their reactive compounds (e.g., hydrides, oxides, and peroxides). It also provides controls for working with these alkali materials and the responsibilities of Laboratory organizations involved in the procurement, receipt, transport, use, storage and disposal of such materials.

Appendix A contains requirements for handling waste alkali metals and equipment contaminated with such materials.

1.2 Characteristics

Alkali metals and their alloys demonstrate good electrical and heat conductivity and are often used in their molten state. Thus, they are commonly referred to as "liquid metals." Cesium melts at 28°C (82.4^{0}F)—just above room temperature. The NaK alloy most commonly used consists of 78% potassium and is liquid down to –12.6°C (9.32^{0}F)—well below room temperature. All other alkali metals have relatively low melting points and high boiling points (see Table 1 for physical constants). Pure alkali metals are soft and ductile at room temperature (Cs may be liquid at 28^{0}C or 82.4^{0}F) and silver in color—except for Cs, which is golden when newly cut but will rapidly oxidize turning gray.

Table 1. Approximate physical constants of alkali metals and NaK alloy (78 % K and 22 % Na).

	Cs	Rb	K	Na	Li	NaK
Atomic weight	133	85.5	39	23	6.9	35.48
Melting Point, ^{0}C (^{0}F)	28 (82.4)	39 (102.2)	63 (145.4)	153 (307.4)	179 (354.2)	–12.6 (9.32)
Boiling Point, ^{0}C (^{0}F)	682 (1259.6)	688 (1270.4)	760 (1400)	881 (1617.8)	1338 (2440.4)	785 (1445)
Specific Gravity	1.87	1.53	0.86	0.97	0.53	0.73
Oxidation Potential, volts, M –> $M^+ + e^-$	3.026	2.98	2.931	2.71	3.041	n/a

Alkali metals form an almost unlimited variety of compounds with simple ions (e.g., chloride, nitrate), complex ions (e. g., ferrocyanide), and organic materials (e.g., oxalate). In many of these, the alkali metal ion simply serves as a counter ion and presents no hazard from a reactivity or toxicity perspective. In other compounds, such as the common laboratory and industrial chemicals NaOH and KOH, significant potential hazards may exist, but they are well understood and readily addressed by standard chemical or industrial practice.

Other, more reactive compounds, such as $LiAlH_4$, $NaBH_4$, LiH (commonly referred to as "salt"), or NaH may present special hazards depending on the specific situation. The reactivity is due to the nature of the hydride and not the alkali metal. Compounds like the simple hydrides react with active hydrogens (water, acids, alcohols, and others) according to the following

$$NaH + H^+ \rightarrow Na^+ + H_2 \quad E^\circ = -2.25 \text{ volt}$$

Which indicates that these compounds are extremely powerful reducing agents. Although the stability of the hydrides themselves vary substantially: LiH can be melted without decomposition in the absence of air or oxygen (it is also possible to disassociate LiH into lithium and hydrogen). Reaction of LiH with air is variable: massive (or "chunks") react slowly producing a $LiOH/H_2O$ surface layer which slows further reaction, finely divided LiH reacts much faster and may be pyrophoric.

$LiAlH_4$ and $NaBH_4$ are frequently encountered in synthetic chemistry where they are useful reducing agents. The reactivity of these kinds of compounds is highly variable: $NaBH_4$ is soluble in water with slight hydrolysis, $NaAlH_4$ dissolution and hydrolysis is rapid (and may be explosive).

2.0 Hazards

Alkali metals are highly reactive and therefore will never be found in nature in their pure state. Pure alkali metals are not considered "toxic" in the usual sense of the word, because it is virtually impossible to inhale or ingest the pure metal. However, reaction products, which can be produced when alkali metals come in contact with the human body or other materials, can be toxic, flammable, and corrosive. The subsections below describe the hazards and reactions of alkali metals with various substances.

2.1 Reaction of Alkali Metals with Oxygen

- Cesium, Rb, and presumably Fr react vigorously with oxygen at room temperature to form the metal oxide, which results in a self-sustaining metal fire that rapidly heats up to almost 1980°C (3596^0F).

- Liquid NaK may ignite spontaneously in the atmosphere at room temperature.
- Potassium is less reactive at room temperature and generally will not ignite spontaneously.
- Bulk Sodium and Li will not result in a fire because they are even less reactive, and oxidation occurs slowly. However, if these less reactive metals are finely divided or molten and are exposed to oxygen, spontaneous ignition may occur and a self-sustaining fire could develop.

In each case, the resulting metal oxide immediately condenses to form a dense, white fume that is highly corrosive to the lungs, eyes, and skin—where metal oxide forms metal hydroxide. These fumes can obscure vision if not contained.

Under various circumstances, alkali metals (except Li and rarely Na) if cut or scraped may react to form unstable, higher oxides (e.g., peroxides or superoxides) that may react if cut or scraped. These higher oxides can react with the base metal or organic materials in an explosive manner or can start a fire. In some cases, they may be shock sensitive.

2.2 Reaction of Alkali Metals with Water

- Alkali metals react vigorously with water to release hydrogen and form the corresponding hydroxide (e.g., sodium hydroxide), resulting in an alkaline (basic) solution. The rate of reaction increases as the atomic weight increases.
- Lithium reacts the slowest and poses the least hazard.
- The other metals react very quickly, generating great heat and splattering with the possible destruction of experimental apparatus. Hydrogen gas is also released in this reaction, and the heat can ignite the hydrogen resulting in a fire or an explosion. The broad explosive range of hydrogen (4–75%) makes this reaction very difficult to control.

2.3 Reaction of Alkali Metals with Other Materials

Molten alkali metals react with other materials as follows:

- Explosively with hydrogen forming toxic hydrides (e.g., lithium hydride).
- Vigorously with carbon tetrachloride and other halogenated hydrocarbons and plastics (e.g., Teflon and polyvinyl chloride), possibly creating an explosion and generating toxic gaseous byproducts (e.g., phosgene, perfluoroisobutylene, and acid gases).

- Vigorously with organic alcohol (the reaction rate decreases as the molecular weight increases), unsaturated organic materials, most inorganic acids, and carbon dioxide.
- Violently with organic acids and some metallic halides (e.g., mercuric chloride) upon impact.

At high temperature, lithium reacts with atmospheric nitrogen, nitrogen containing organic materials, and glass that may result in the failure of glass containers.

2.4 Reaction of Alkali Metal Compounds

The reactivity of alkali metal compounds is highly variable and is dependent on the specific compound and on many factors which include, but is not limited to, the availability of active hydrogens and water, presence of unsaturated functional groups, presence of oxygen, temperature, particle size and other factors.

3.0 Controls for Working with Alkali Metals

The three methods for mitigating hazards associated with alkali metals are engineered controls, administrative controls, and personal protective equipment. Engineered controls are the preferred means of mitigating hazards and are supplemented by the other controls as necessary. In practice, however, all of these methods are usually implemented when alkali metals are in use. The method appropriate for any experiment usually is determined by an ES&H evaluation(s) and incorporated into the hazard analysis, Integration Work Sheet (IWS) or in an operational safety plan (OSP), if applicable.

This section contains the engineered controls, administrative controls, and personal protective equipment required for work with alkali metals.

3.1 Engineered Controls

3.1.1 Design Criteria

The following criteria apply when designing equipment for use with alkali metals:

- Equipment that contains alkali metal shall be designed such that it can withstand the highest anticipated reaction temperature.
- Packless valves and seamless welded tubing should be used for liquid metal systems. Unwelded joints shall be encased in a secondary containment.

- Secondary containment shall be placed under experimental apparatus that use liquid metals (e.g. steel-drip pans with oxygen limiting perforated covers.
- Systems with liquid metals should be designed so that, in the event of a shut down, all of the metal flows by gravity to a single low point where it can be removed. A system for removing oxides that may form during the use of liquid metals should be included in the design.
- Where liquid metals other than NaK are in use, adequate heating shall be distributed to all parts of the system to prevent the metal from freezing at a cold spot. Electrical trace heating or other means may be acceptable, but steam or water heating is prohibited. Precautions shall be taken to ensure that water does not come in contact with alkali metals.
- An adequate ventilation system that is capable of capturing all evolved metal oxide or hydrogen in the worst-case accident scenario shall be provided for operations involving more than small amounts of alkali metals. The need for a dedicated system shall be evaluated. Compatibility of materials exhausted with other contaminants in the ventilation system shall be evaluated. It shall exhaust through a stack of sufficient height and distance that will prevent fumes from re-entraining into building air intakes and the levels of metal oxide on the building roof (or in other areas surrounding the building) from exceeding the ACGIH threshold limit values. A scrubber capable of removing most of the noxious metal oxide in the worse design-base accident may reduce the required stack height. Scrubbers shall be provided with emergency power.
- Systems with liquid metals shall have overpressure vents that are vented into the exhaust system.
- Where quantities of liquid metal exceeding 1 kg are in use, the ventilation system shall have emergency power.
- Inert gas blankets shall have less than
  - 35 mg/m^3 of water vapor,
  - 0.5% oxygen,
  - 1.5% hydrogen.

  Nitrogen shall not be used for operations involving liquid Li.
- Appropriate leak-detection equipment with alarms should be considered.
- Metal-handling systems should include features that allow for simplified dismantling and decontamination. See Appendix A for the requirements on handling equipment contaminated with alkali metals.

3.1.2 Transportation and Transfer of Alkali Metals

Transportation/Transfer is divided into three categories for discussion in this document. The three categories are: Incoming Transportation, On-Site Transfer, and Outgoing Transportation.

Incoming Transportation. Incoming shipments meet the requirements in 49 CFR 173.212, and alkali metals shall always be transported in their original containers. The Material Distribution Division shall deliver alkali metals (except for hazardous waste) to on-site requesters.

On-Site Transfer. Lithium, Na, and NaK, and to a lesser degree K, can be transferred in air or under oil or kerosene, as appropriate, because the rate of oxidation is fairly slow. The container shall be labeled per the storage requirements in Section 3.1.3.

All other alkali metals shall be transferred in an inert atmosphere (e.g., in a dry argon-filled or vacuum container or glove box made of materials that are compatible with the metal) to prevent exposure to air, water, or other incompatible material. The container shall be labeled per the storage requirements in Section 3.1.3.

Nitrogen may be used with alkali metals, except when handling Li because it reactively forms ruby-red Li_3N, which also is extremely reactive and may be shock sensitive.

The Responsible Individual owning the alkali metal shall verify that the individual requesting the transfer has an approved IWS or safety plan and proper facilities available before making the transfer. Trained and authorized personnel may hand carry (walk) properly packaged alkali metals from one facility to another. If any vehicle is to be used for the transfer, it shall be properly placarded. Contact either Materials Management or Materials Distribution for the correct requirements and placard materials. These organizations may, with advance notification, provide a placarded vehicle. For more information on other methods available for the safe transfer of solid and liquid metals, contact the area ES&H Team.

Outgoing Transportation. When alkali metals are to be shipped off site, the Responsible Individual who owns the material shall package the material in a suitable primary container (not glass), sealed with the appropriate noble gas atmosphere, oil or kerosene. The primary container shall be labeled per the storage requirements in Section 3.1.3, except that the date packed shall be used instead of the date received. If the detailed packing requirements for the particular alkali metal are not contained in the OSP, an IWS shall be prepared stating those requirements. This IWS shall be reviewed and approved by the ES&H Team. The primary package of the alkali metal may then be transferred to Materials Distribution Shipping Section so that the DOT-approved secondary packaging and labeling can be completed.

3.1.3 Storage

- Alkali metals shall be stored in areas where they are free of moisture, oxygen, and, in the case of Li, nitrogen. Metals should be stored in containers supplied by the manufacturer, or as stipulated in the hazard review or OSP, under mineral oil or kerosene, or in containers that are evacuated or filled with a noble gas. Even under such storage conditions, some oxide or hydroxide may be formed because of liquid or oxygen in the mineral oil or because of leakage into the inert atmosphere container.
- Only the amount of alkali metal necessary to perform the work should be removed from storage. Spare materials shall be returned to the appropriate storage container, and the container to its appropriate location.
- Storage containers shall be labeled to indicate their contents, the hazards properties, date received, weight of the metal, and type of oil or gas used to inert the metal. Furthermore, these containers should be stored individually or in a manner that allows visual inspection for container integrity.
- Storage areas shall be free of combustibles and of ignition sources.
- Building or portions of the building dedicated as storage area for alkali metals shall not be equipped with automatic sprinklers (except for the Materials Management Division Vaults). No other source of water (e.g., showers, sinks) shall be in the immediate proximity of the metal.
- Storage areas shall be prominently labeled to indicate the presence of alkali metals. Up to 5 kg of alkali may be stored in a flammable storage locker inside a building. Quantities exceeding 5 kg shall be stored in separate structures that are noncombustible (e.g., steel transportainers).

3.2 Administrative Controls

3.2.1 Safety Plans

An ES&H evaluation (IWS) is required for the following work:

- Operations involving the use of alkali metals in their molten state. An OSP or FSP will be required for other than small amounts.
- All uses of Cs, NaK, and Rb. An OSP or FSP is required for any amount of material.

- Use of other than small amounts of Li, Na, or K. Amounts exceeding 500 g during the entire experiment or for a period of one year, whichever is less, may require an OSP or FSP.
- Any changes in previously approved work that may increase the potential risk.

3.2.2 Literature Review

Prior to beginning work with reactive alkali metal compounds, a thorough literature review should be conducted to assess reactivity and incompatibilities. Useful sources include the standard texts for organic and inorganic chemistry, and the chemical research periodicals.

3.2.3 Training

All workers who handle alkali metals in quantities that require a safety plan shall complete course HS4260 (Alkali Metals) offered by the Hazards Control Department. Moreover, these workers shall be familiar with the IWS and applicable safety plans (FSP or OSP) before beginning work with alkali metals.

3.2.4 ES&H Review

The Responsible Individual shall perform a careful hazards review of the design, construction, operation, and ultimate dismantling upon completing experiments involving alkali metals. After the controls have been established, the safety plans and procedures are written and approved, and the personnel are trained, the Responsible Individual shall contact the area ES&H Team Leader, who shall arrange to have the operation reviewed by appropriate discipline personnel (usually an industrial hygienist, a fire protection engineer, and an environmental analyst).

3.2.5 Isolation

Many chemicals react with alkali metals. However, these metals are generally benign as long as they are kept away from the materials with which they react (e.g., oxygen, water, acids, halogenated hydrocarbons, and carbon dioxide). The fundamental principle is to isolate alkali metals (both in the solid and molten state) from reactive materials.

General traffic is prohibited in areas where alkali metal operations are performed. The appropriate warning signs shall be posted in these areas limiting access to authorized personnel. Further access controls, up to and including run-safe boxes, may be necessary and should be stipulated in the OSP.

3.2.6 Handling

The following requirements apply when handling alkali metals:

- Skin and eye contact with alkali metals shall be avoided. Where possible, tongs or other appropriate tools should be used to handle solid alkali metals. Syringes or other means should be used for liquid metals to prevent skin contact (see discussion in this section). Oxidized materials (white or gray surface coating) may make the metal more hazardous to handle. Materials with a yellow or orange coating may indicate the presence of peroxides or superoxides, which may be explosive if cut or abraded. These materials should not be used; they should be isolated and disposed of promptly. Contact your area ES&H Team for assistance.
- All tools used to handle alkali metals shall be dry, rust-free, clean, and composed of a material compatible with the metal. Tools can be dried by baking in an oven, desiccating in a vacuum, or rubbing with anhydrous dry soda ash.
- Containers with alkali metals shall be assumed to contain flammable hydrogen gas in the headspace, even if stored under mineral oil or inert gas. Thus, no ignition source shall be present where these containers are opened. Tools used to open the containers shall be of the sparkless variety.
- Areas where any alkali metal is handled shall be free of ignition sources. Glove boxes, hoods, or other similar apparatus shall have explosion-proof Class 1, Division 1, Group B electrical systems.
- An emergency eyewash/safety shower unit shall be available in all work areas where alkali metals are in use. This unit shall be positioned far enough away from alkali metal work so that a system failure will not pose a hazard, but near enough for quick access in the event of an emergency.

3.2.7 Procurement

The Responsible Individual (e.g., experimenters and other designated workers) shall purchase all alkali metals through the Procurement & Materiel (P&M) Department, noting the pyrophoric nature of the material on the requisition. Unicard shall not be used to purchase alkali metals in quantities greater than 500 g. The Material Distribution Division shall receive and deliver all alkali metals in their original containers to the requester.

3.3 Personal Protective Equipment

Engineering controls greatly reduce the need for personal protective equipment when handling alkali metals. Under all circumstances where alkali metals are in use, the PPE described below is required as a minimum.

- An easily removable laboratory coat (or equivalent).
- Chrome leather gloves or appropriate rubber gloves.
- Safety glasses (other protective eyewear such as chemical goggles and face shield may be required, based on the task.)

Where solid metal is handled without a barrier, a fire retardant apron and protective eyewear are required. Additional personal protective equipment shall be stipulated in the OSP in cases where large quantities of solid and liquid alkali metals are in use.

3.4 Fire and Spill Emergency Preparedness

The appropriate material shall be available to extinguish fires and contain alkali metal spills. Met-L-X, anhydrous dry soda ash, powdered graphite may be used for all alkali metals except Li. This material shall be kept in a sealed, labeled yellow container to prevent contamination and to keep it moisture-free. Only Lith-X fire extinguishers shall be used for Li fires. Workers involved in alkali metal work shall be trained to use these extinguishing materials.

Only trained personnel using personal protective equipment (as specified in the IWS, OSP or other hazard review document) shall attempt to control small, contained fires or spills. Large or uncontained fires or spills, or fires where the ventilation system does not contain all of the fumes, shall be handled only by the Fire Department. Before attempting to extinguish a metal fire or contain a spill, notify the fire dispatcher (dial 911).

3.5 Skin or Eye Contact Emergency Preparedness

If any alkali metal fragment or liquid enters the eye, it will immediately react generating considerable heat and hydroxide and likely result in severe eye damage. In such cases, the eyes shall be flushed with water from an eyewash/safety shower. Continue to flush the eye with water while someone dials 911 for emergency help.

When alkali metal comes in contact with the skin through clothing, the first response is to remove the contaminated clothing. Take extra precautions for fire and hazardous materials when handling contaminated clothing. Dial 911 for assistance.

If the alkali metal has already burned off (e.g., Rb and Cs will burn spontaneously), the victim should be drenched continually under a safety shower until emergency help arrives.

If the material is not burning (perhaps Na or Li scraps), the visible metal particulates should be removed immediately using tweezers, tongs, a scrapper or swab. The metal particulates shall be stored in either kerosene or mineral oil to avoid further reactions. The victim should be drenched continually under a safety shower until emergency help arrives.

If the material is not burning and the fragments are embedded into the skin, burn areas should be covered with mineral oil to insulate the unreacted fragments from water (References 1-3). The patient shall be transported promptly to a treatment facility, where the wound would be debrided and the remaining fragments removed. When it is certain that all metal fragments have been removed, the wound area may be irrigated with water.

4.0 Responsibilities

All workers and organizations shall refer to Document 2.1, "Laboratory and ES&H Policies, General Worker Responsibilities, and Integrated Safety Management" in the *ES&H Manual* for a list of general responsibilities. The specific responsibilities for individuals and organizations that work with alkali metals are listed under each title below.

4.1 Responsible Individual

- Ensure the following:
  - — A complete ES&H evaluation (IWS) of the proposed operation (including a review by the ES&H Team) is conducted as described in Document 2.2, "Managing ES&H for LLNL Work," in the *ES&H Manual* before starting the experiment.
  - — Personnel who work with alkali metals in quantities that require a safety plan shall complete course HS4260, "Alkali Metals." This course is offered by the Hazards Control Department.
  - — Where required, an Engineering Safety Note (ESN) is developed and referenced in the OSP for cases where liquid or solid metals are used and the safety analysis indicates a need for the document.

  - Workers comply with all requirements of the IWS, ESN and OSP. Workers shall also follow the procedures specified in this document for all purchases of alkali metals. Purchases shall be made through the Procurement & Materiel Department, and the requisition should indicate that an alkali metal is being purchased.
  - The storage, handling, and disposal of alkali metals meet the requirements of this document and other requirements in the *ES&H Manual*.
  - Notify ChemTrack when alkali metals are received, so that the proper barcodes can be applied.
  - All engineering controls (e.g., ventilation, inert gases) function properly.
  - PPE is provided to workers who handle alkali metals.
  - Only appropriate types of fire extinguishers are present in the work area where alkali metals are in use.
  - First-aid equipment (e.g., tweezers, swabs, and at least one quart of mineral oil) is available in alkali metal work areas.

- Prepare an OSP for all uses of molten alkali metals; for solid Li, Na, or K that exceeds 500 g during the entire experiment or for a period of one year, which ever is less; for any amount of Cs, Rb, or NaK; or where the ES&H evaluation so indicates.

- Contact the area ES&H Team before cleaning or dismantling any liquid metal handling system, unless procedures for such are already addressed in an OSP. See Appendix A for requirements on handling equipment contaminated with waste alkali metals.

4.2 Hazards Control Department

- Conduct hazard reviews of proposed, new or revised uses of alkali metals when requested or as required.

- Assist in the design of safety-related systems and in the preparation and review of OSPs.

- Review ESNs associated with liquid metal systems.

- Administer course HS4260, "Alkali Metals ," as required.

- Evaluate roof access classification changes that may result from the use of alkali metals.

- Review the implementation of hazard mitigation procedures and the equipment, and notify the Responsible Individual of any deficiencies.

- Respond to spills, fires, exposures, or other emergencies involving alkali metals.

- Review all requisitions for alkali metals received from the Procurement & Materiel Department (P&M) in accordance with the requirements of this document. Ensure that an IWS or safety plan (as appropriate) and other requirements have been met before the material may be ordered. Advise P&M when they can place the order.
- Ensure that the Fire Department is equipped to handle large-scale alkali metal fires onsite at all times.

4.3 Material Distribution Division

- Receive incoming shipments of alkali metals in accordance with the requirements of this document.
- Inspect incoming shipments of alkali metal containers for signs of failure (e.g., leakage). Notify the area ES&H Team if a container is damaged or corroded, or call 911 if a spill occurs.
- Deliver alkali metals to the requester in its original container.
- Prepare secondary (but not primary) packaging for outgoing shipments of alkali metals. Comply with DOT transportation requirements for alkali metals.

4.4 Environmental Protection Department

- Conduct a hazard review to evaluate environmental contamination problems, permit requirements, NEPA declarations, and other environmental issues during the experimental design phase.
- Specify requirements for packaging waste alkali metals or equipment contaminated with such materials.
- Remove and dispose of packaged waste alkali metals.
- Properly handle contaminated equipment for disposal.

4.5 Facility Point of Contact

- Maintain awareness of all operations involving alkali metals in your area of cognizance.
- Contact the ES&H Team to determine if the roof access classification of the building has changed. This is required for areas whose alkali metal system has a ventilation system.

4.6 Health Services Department

- Specify first-aid requirements for accidental exposures that involve alkali metals or their oxides or hydroxides.
- Maintain appropriate facilities for immediate support of individuals exposed to alkali metals or their alloys.

4.7 Mechanical Engineering

Mechanical Engineering shall assist Responsible Individuals with preparing ESNs pertaining to the design of alkali metal handling systems.

4.8 Procurement & Materiel Department

Refer all requests for alkali metals, in quantities greater than 500 grams, to the cognizant Hazards Control Team for review of requirements, before placing the order for the material.

5.0 Work Smart Standards

ACGIH TLVs and BEIs: Threshold Limit Values for Chemical Substances and Physical Agents, 2002 (excluding Biological Exposure Indices, TLVs for Physical Agents, and Biologically Derived Airborne Contaminants).

DOE O 440.1A, "Worker Protection Management for DOE Federal and Contractor Employees," Attachment 2, "Contractor Requirement Document," §§ 1–11, 13–18 (delete item 18.a), 19 (delete item 19.d.3) and 22,

DOE O 5480.19, Chg 1, "Conduct of Operations Requirements for DOE Facilities."

DOE-HDBK-1081-94, "Primer on Spontaneous Heating and Pyrophoricity."

49 CFR 173. 212, "Non-bulk packagings for solid hazardous materials in Packing Group II."

22 CCR §§ 66261.1–66261.126 and appendices, "Identification & Listing of Hazardous Waste."

22 CCR §§ 66262.10–66262.89, "Standards Applicable to Generators of Hazardous Waste."

6.0 References

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2. Clare, R. A and Krenzelok, E.P. "Chemical Burns Secondary to Elemental Metal Exposure: Two Cases Report," *American Journal of Emergency Medicine* **6**(4), 355–7 (July 1988).
3. Krenzelok, E. P. "Sodium and Potassium," In Hazardous Materials Toxicology – Clinical Principles of Environmental Health, Sullivans, J. B and Krieger, G. R. eds.

7.0 Resources for More Information

7.1 Contacts

See the ES&H Contact List.

7.2 Applicable Lessons Learned

Applicable lessons learned can be found at the following Internet address:

http://www-r.llnl.gov/es_and_h/lessons/lessons.shtml

7.3 Other Sources

8 CCR § 5176, "Pyrophoric Materials" (contains a few common-sense requirements that are incorporated into this document).

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Sittig M., "Safe Handling of Alkali Metals," *Industrial and Engineering Chemistry,* **48**(2), 227–229, 1956.

U.S. Division of Operational Safety. "Big K: Chemical Commotion." *Health and Safety Information*, U.S. Atomic Energy Commission, 207. Washington, DC, 1965.

Appendix A

Requirements for Handling Equipment Contaminated with Waste Alkali Metals

A.1 Disposal of Waste Alkali Metals

Waste alkali metals or equipment contaminated with such materials shall be packaged in accordance with DOT requirements. Contact your area ES&H Team or the hazardous waste technician for specific assistance.

A.2 Decontaminating, Recycling, and Disposing Contaminated Equipment

The Responsible Individual shall decontaminate equipment contaminated with alkali metals before recycling it. Decontamination is usually only a problem when the metals are used in their molten state. Some equipment may contain oxide, peroxide, or superoxide residue, which pose additional hazards during the decontamination and disassembly process. This process shall have an IWS and may need to be addressed in an OSP.

Below are general decontamination procedures. More detailed procedures can be found in Document 21.5, " Requirements for Transfer of Equipment and Property for Repair, Reuse, Maintenance, Storage, Excess, or Scrap," in Volume II of the *ES&H Manual*.

- Drain all alkali metal from the system.
- Make sure the system has no cold spots that may cause residual metal to freeze or prevent low points from draining.
- Compare the weight of the metal in the system to that removed, and account for any large loss before proceeding.
- Purge the system with inert gas (do not use nitrogen for Li) and carefully dismantle the system. Look for residual metal or white, yellow, or orange discoloration that may be indicative of dangerous oxide or superoxide deposits. In cases where purging is desired, an OSP shall be prepared. Do not use steam or alcohol to purge the system, except that a common and safe practice for NaK is to flush the system with isopropyl alcohol after draining the liquid NaK.
- Small amounts can be disposed of as hazardous waste, larger amounts should be recycled or sold as scrap.