SAFE HANDLING OF LITHIUM METAL

Introduction:

Lithium is a reactive caustic metal. It is routinely processed with minor deterioration of quality by oxidation, and with safety - if common sense precautions are taken.

Water as vapor or liquid is the most common enemy of solid lithium. Water vapor catalyzes the reaction of lithium with atmospheric gases to form nitrides, oxides, carbonates, and secondary products. The reaction with liquid water is strongly exothermic and forms lithium hydroxide and hydrogen. The rate of the reaction increases with the surface area. Thus, lithium foil reacts more rapidly than ingot. The heat of this reaction can cause lithium to melt, which can lead to burning. This can, in turn, ignite hydrogen-air mixtures with explosive force. The dense, white, chocking cloud of lithium oxide or hydroxide attacks skin and mucosa.

Metal quality and safe handling require that water vapor be minimized and liquid water be totally avoided. The usual ways to achieve this are with dry inert gaseous atmospheres, dehumidfied air, or an inert, saturated hydrocarbonated coating.

Handling of Lithium:

Glove Box:

Small quantities of lithium are often manipulated in glove boxes with a recirculating, inert gaseous atmosphere. Note that nitrogen is not an inert gas to lithium, although it may be inert in many organic or other reactions. Therefore, argon or helium are typically the gases recirculated. Commercially available glove boxes are equipped to continuously remove atmospheric gases which leak into the system. Reasonable maintenance insures that nitrogen, oxygen, and water vapor contamination are held to fewer than 5 ppm each. These conditions permit lithium metal quality to be maintained for many days. Metal may be melted with safety in glove boxes. Dry lithium powder can be treacherous, even in glove boxes, because of its large surface area and corresponding increased reactivity. A lithium metal dispersion in a saturated hydrocarbon is somewhat safer to use than the dry powder. A material to extinguish lithium fires, such as dry graphite with a surface active agent, should be kept in the glove box. Lith-X, manufactured by Ansul Corp., is commercially available and is recommended.

Dry Room:

Many years of experience in forming lithium foil and other shapes have shown that handling lithium in dry air allows quality and safety requirements to be met. There is no magic number for the relative humidity limit that should be sought. It is believed that a maximum of 2% relative humidity at 21 ^{o}Celcius represents a good trade-off between maintaining metal quality for a reasonable period of time and an achievable engineering design. The dehumidifying agents commonly used include lithium chloride, molecular sieves, alumina, and silica gel. After absorbing water, these agents can be regenerated by a stream of hot, dry air.

Good vapor barriers in walls, floor, and ceiling are necessary to maintain a low relative humidity. Caulked panels of an aluminum sandwich material, or welded steel plates, provide such a barrier. An extra precaution is the covering of all seams with duct tape, including exterior duct work. Vinyl tile flooring over a concrete base gives vapor tight flooring. Conductive flooring offers an extra insurance if flammable solvents are used in the dry room as significant static electric charges are generated in this condition of low humidity. In addition, an exhaust system with explosion-proof motor is necessary for removal of solvent vapors.

Equipment in the dry room should be grounded. There must be no sprinkler system or other source of water in the dry room. Buckets of Lith-X and Lith-X fire extinguishers must be readily available in the dry room. Windows should be included in dry rooms for safety reasons, and because a feeling of claustrophobia can otherwise develop. The very arid condition of a dry room rarely causes personnel discomfort. One case of eye irritation has been observed, and this was corrected by the use of a commercially available eye-drop preparation.

Molten Lithium:

The reactivity of molten lithium is much greater than solid lithium. Blanketing with argon or dry air is recommended to protect the metal and to minimize the possibility of fires. Molten lithium reacts explosively with concrete flooring, and any area wherein a liquid lithium spill may occur must have welded steel flooring. Steel curbing to confine a spill to a small area and to prevent contact with other materials is recommended. An ample supply of Lith-X is important so that small fires can be smothered early before they get out of control.

Packaging:

Lithium is conventionally packaged in hermetically sealed containers that are backfilled with argon or mineral oil. Despite the best packaging precautions, lithium should be used as soon after receipt as possible.

Storage:

Lithium should be stored in an isolated area free from sources of water, including sprinkler systems. Storage areas should not be subject to elevated temperatures, sources of open flame, or spark-generating equipment. The area should be free of other combustible materials. Quantities of Lith-X and Lith-X fire extinguishers should be available in the storage area.

Labeling:

Lithium metal is in the hazard class "Flammable Solid". As such, packages must carry the hazardous materials labels "Flammable Solid", and "Dangerous When Wet". Air cargo packages must also carry the "Cargo Aircraft Only" label.

Disposal:

Lithium disposal by conversion of the metal to one of its compounds is usually employed. Submerssion in water or lithium hydroxide solution, steam hydrolysis, or burning are the conventional methods. Only small quantities of lithium should be disposed of at one time. Metal which has been allowed to nitride extensively is more sensitive to an explosion reaction during water disposal than is superficially nitrided metal. Heavily nitrided metal may be disposed of by ambient air oxidation in an open area protected from rain. The formation of hazardous products during disposal, including hydrogen gas and lithium oxide/hydroxide, must be coped with. Only trained personnel should attempt to dispose of lithium.

Safety Considerations:

It has been emphasized above that liquid water is to be totally avoided in processing lithium metal, and that water vapor is to be minimized for both safety and quality reasons. More stringent precautions must be taken in processing molten lithium than solid lithium in a dry room environment. Suggested operational precautions follow:

Dry Room Precautions:

- Totally avoid water, (including sprinklers, steam lines, coffee, soda etc.)
- Maintain relative humidity of 2% or less. A temperature of 70 ^{o}F is suggested.
- Wear safety glasses with side shields.
- Wear Kynol or Nomex laboratory coats without cuffs.
- Wear trousers without cuffs.
- Wear conductive safety shoes.
- Wear surgical nose and mouth mask.
- Wear surgical gloves for handling dry lithium.
- Wear vinyl gloves (Sol-Vex) for handling lithium in the presence of hydrocarbon solvents.
- Maintain a supply of Lith-X in covered pails with long-handled scoops.
- Keep Lith-X fire extinguishers in dry room.
- Keep CO_2 fire extinguisher (for electrical fires only) in the dry room. Do Not ever use CO_2 on burning lithium metal.
- Do not smoke or permit open flames.
- Ground all equipment.
- Control quantity of lithium.
- Do not let lithium scrap accumulate.
- Have access to self-contained breathing apparatus and asbestos suit (outside of dry room).
- Put all lithium in sealed containers at the end of the work day and over weekends.
- Install solvent vapor alarm system.
- Remove flammable solvents from dry room at end of work day and over weekends.
- Install temperatures rise alarm system. This will signal malfunction of dehumidification system. If the alarm sounds:
  - -Report malfunction to Maintenance Department.
  - -Remove all flammable solvents from dry room.
  - -Store exposed in-process lithium in sealed containers.

- Install solvent vapor monitoring system.
- Install oxygen concentrating monitoring equipment.
- Maintain good housekeeping conditions:
  - -Place lithium scrap and chips in designated containers.
  - -Immediately wipe up spilled oil used to coat lithium or from machinery leaks.
- Carefully inspect dry room at end of day to assure that it is properly secured.
- Use explosion-proof monitors on all equipment.

Molten Lithium Precautions:

- Totally avoid water.
- Assure proper blanketing of lithium with inert gas or dry air.
- Wear full face shields.
- Wear Kynol coveralls without cuffs.
- Wear hard hats.
- Keep adequate supplies of Lith-X, including buckets and long-handled scoops, and fire extinguishers in casting area.
- Have CO_2 fire extinguishers available for electrical fires.
- Do not smoke or permit open fires.
- Install temperature rise alarm system.
- Ground all equipment.
- Blanket cast ingots in argon or oil as soon as cool.
- Store ingots in sealed drums with ring and gasket closure.
- Clean up and store any scrap lithium under oil in closed drum.
- Maintain a self-contained breathing apparatus and asbestos suit removed from the immediate casting area.

Lithium Disposal Precautions:

- Wear Kynol coveralls without cuffs.
- Wear safety glasses with side shields or full face shield.
- Wear hard hat.
- Never dispose of lithium when alone.
- Only trained personnel should dispose of lithium.

Fire Fighting:

Lithium fires are very hot and difficult to extinguish unless they are caught early. Lith-X is recommended for lithium fires. It acts by smothering the lithium. Because much heat is retained under the Lith-X, re-ignition can easily occur if the Lith-X blanket is disturbed before ambient temperatures are again reached. Dense white clouds of caustic and choking lithium oxide are formed when lithium burns. A self-contained breathing apparatus must, therefore, be worn when fighting lithium fires. If a lithium fire reaches large proportions, nothing can be done but to let it burn. In a sealed room such as a dry room, remember that the supply of oxygen is quickly consumed in feeding a lithium fire.

First Aid:

It is important to provide immediate medical attention for lithium metal burns. Particles of lithium must be removed from the person as rapidly as possible. Then wash the affected area with large volumes of water for at least 10 to 15 minutes and provide immediate medical aid.

Lithium oxide formed during a lithium fire causes coughing and choking when inhaled. Quick removal of personnel from the contaminated area and immediate medical attention is necessary. Drinking large quantities of water is helpful.

In the case of lithium in the eye, put the eye under gently running lukewarm water. Hold the eyelid open with fingers so that water runs into the eye. Run water from inside to the outside of the eye, with the burned eye nearer to the floor so that the chemical is not washed into the other eye. Continue for 15 minutes. Cover the eye with a dry sterile dressing, and get immediate medical care.

Disclaimer:

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