SAN DIEGO
HAZARDOUS INCIDENT RESPONSE TEAM

STANDARD OPERATING GUIDELINES

METAL FIRES

	ITEM	DESCRIPTION
☐	**BACKGROUND INFORMATION**	**MANY METALS HAVE THE ABILITY TO BURN AND UNDER THE RIGHT CONDITIONS CAN CREATE AN EXPLOSION.** Metals burn at relatively high temperatures and metals such as lithium, magnesium, sodium, and aluminum are water reactive. When water is applied to a metal fire, the heated water particles can separate into hydrogen gas. **ADDING WATER TO A METAL FIRE INCREASES THE BURNING INTENSITY AND CHANCES FOR AN EXPLOSION**. The hydrogen gas release can increase the chance of an explosion, especially with finer metal powders. Type D fire extinguishers are used to put out fires with combustible metals; DRY sand can also be used to control fires. **SDFD FIRE STATIONS 1 AND 10 HAVE CHEM UNITS FOR ADDITIONAL FIRE SUPPRESSION RESOURCES.**
☐	**INITIAL SIZE UP**	▪ Establish control of utilities to the affected area (water, gas, electrical, etc.) ▪ Determine metals involved and physical characteristic (i.e. shavings, powders, solids) ▪ Evaluate whether small fires can be isolated safely and allowed to burn out. ▪ Large fires may take an extended period to extinguish. Consider extended operational period. ▪ Evaluate the potential for explosions ▪ Determine whether uninvolved containers can be relocated to avoid exposure to fire ▪ **Evaluate the control and shutdown of fire protection water systems to prevent unintended contact of water** ▪ Use extinguishing agents that are compatible with the hazards present (see Mitigation & Containment below) ▪ **Determine temperatures of the metals involved in the fire with a Thermal Imaging Camera** Fires can flare up again if the product is disturbed prior to complete oxidation of the products or self-extinguishment ▪ **Prevent contact of water with burning metal** ▪ Consider safe direction of approach for any additional resources
☐	**PROTECTIVE MEASURES**	▪ **ERG Number 135, 138 and/or 170 (See Common Metals below)** ▪ Immediately isolate area up to 150 feet in all directions ▪ For fires, consider isolation and evacuation up to ½ mile in all directions ▪ Approach from upwind and upstream
☐	**TACTICAL ACTIONS**	▪ Establish Site Safety / Incident Action Plan ▪ DO NOT USE WATER OR FOAM DIRECTLY ON PRODUCT ▪ Suppress fires with Class D Extinguisher, dry chemical, DRY sand, or Met-L-X ▪ Determine if defensive action should be taken or let fire burn (consider indirect cooling) ▪ Eliminate ignition sources in the area ▪ Estimate plume projections ▪ Determine Control Zones ▪ If safe to do so, separate containers that are not impacted by fire.
☐	**MITIGATION AND CONTAINMENT**	▪ Fire involving metals or powders (aluminum, lithium, magnesium, etc.): use dry chemical, DRY sand, sodium chloride powder, graphite powder or Met-L-X powder. ▪ Lithium, use Lith-X powder. ▪ Class D Fire Extinguisher ▪ Met-L-X powder ▪ DRY Sand: sand used for covering fires must not have moisture content

☐ **FIRE SUPRESSION AGENT**

Table 1. Class D Fire Suppression Agent Effectiveness Matrix
(based on references 3 & 5)

	Sodium Chloride	Graphite	Copper Powder	Sodium Carbonate	Dry Sand
Aluminum	Yes [3,5]	No [5]	Yes [3], No[5]	Yes [5]	Yes [5]
Lithium	No [5]	Yes [3,5]	Yes [3]	Yes [5]	Yes [5]
Magnesium	Yes [3,5]	Yes [3], No [5]	Yes [3], No [5]	Yes [5]	Yes [5]
Potassium	Yes [3,5]	Yes [5]	Yes [5]	Yes [3,5]	Yes [5]
Sodium	Yes [3,5]	Yes [3,5]	Yes [5]	Yes [3,5]	Yes [5]
Tantalum	Yes [5]	No [5]	No [5]	No [5]	Yes [5]
Titanium	Yes [3, 5]	No [5]	No [5]	Yes [5]	Yes [5]

3. Nelson, R., "Extinguishing Agents and Application Techniques for Combustible Metal Fires," NFPA Handbook, Chapter 11-7, National Fire Protection Association, 2003
5. NFPA 484, "Standard for Combustible Metals," National Fire Protection Association, 2006.

☐ **COMMON METALS**

ALUMINUM: (ERG 138)
Used both as a commercially pure metal and as an alloy. In finely divided powder or dust form, aluminum and its alloys are combustible in air and present an explosion hazard. Aluminum will react violently with many chemicals. Aluminum particles and smaller turnings will react with water (Slowly/days) to form hydrogen gas which is highly flammable and explosive in favorable concentrations. When aluminum powder burns, aluminum oxide is produced.

LITHIUM: (ERG 170)
Highly flammable on contact with moisture. Readily ignited by and reacts with most extinguishing agents such as water and carbon dioxide. Reacts with water to form caustic lithium hydroxide and hydrogen gas. Lithium is spontaneously flammable in air if heated to 356°F.

MAGNESIUM: (ERG 138)
Magnesium ribbon and fine magnesium shavings can be ignited at temperatures of about 950°F and very finely divided powder has been ignited at air temperatures below 900°F (ignition temperature is 883 degrees F). Magnesium slowly oxidizes in moist air. As a dust cloud or in ribbon form, magnesium can be ignited almost instantly. Loose shavings ignite readily. Magnesium fines wet with oils may ignite spontaneously. Powders form explosive mixtures with air that may be ignited by a spark. Forms dense white smoke during fires, flame is very bright. When magnesium metal burns it reacts with oxygen found in the air to form magnesium oxide fumes.

SODIUM: (ERG 138)
Reacts violently with water to produce hydrogen gas and sodium hydroxide (corrosive, high pH). The exothermic heat of this reaction can lead to auto-ignition of the hydrogen gas and/or the metal itself and a fire/explosion hazard. Residual liquid present following the reaction may contain sodium hydroxide, a caustic, corrosive material. The ignition temperature of sodium in air depends on the area of surface exposed: vapor ignites at room temperature; droplets at about 250°F.

TITANIUM: (ERG 135)
Highly flammable. Pyrophoric in dust form. Titanium is water-reactive at 1292 °F, releasing hydrogen gas. May ignite on contact with moist air or moisture and burn rapidly with flare-burning effect. Some react vigorously or explosively on contact with water. Some may decompose explosively when heated or involved in a fire. May re-ignite after fire is extinguished. Fire will produce irritating, corrosive and/or toxic gases (titanium oxides).

☐ **OTHER REACTIVE CHEMICALS**

NITRIDES, HYDRIDES, PHOSPHIDES, AND CARBIDES
- These can react readily with water and/or air and can be flammable and/or pyrophoric
- Can generate flammable or noxious gases in contact with water
- Many nitrides react with water to generate ammonia gas
- Phosphides react with water or acids to generate phosphine gas
- Inorganic carbides react with water to generate flammable gases. Transition metal nitrides react violently with water forming the metal hydroxides and ammonia.

		▪ Hydrides may react violently or explosively on contact with water. May be ignited by friction, heat, sparks or flames. Dusts or fumes may form explosive mixtures in air. Containers may explode when heated and may re-ignite after fire is extinguished **Examples:** aluminum carbide, calcium carbide, lithium nitride, calcium nitride, aluminum phosphide, calcium phosphide, magnesium aluminum phosphide, magnesium phosphide, potassium phosphide, aluminum borohydride, aluminum hydride, calcium hydride, lithium aluminum hydride, lithium hydride, magnesium hydride, sodium borohydride, sodium hydride
☐	**TECHNICAL REFERENCES**	▪ ERG 135, 138 and/or 170 ▪ NIOSH ▪ WISER ▪ CAMEO ▪ Chemical Protective Clothing Guide ▪ NFPA No. 484 Standard for Combustible Metals
☐	**ADDITIONAL RESOURCES**	▪ Additional staffing needed? ▪ Bomb squad and use of drones, robot, water cannon, etc. ▪ SDFD Fire Stations 1 and 10 have chem unit resources ▪ Law Enforcement for site control ▪ EMS
☐	**NOTIFICATIONS**	▪ CAL OES ▪ CUPA permitted facility? ▪ Stormwater ▪ Fish and Game
☐	**USEFUL CONTACTS**	▪ Public Works / Streets Division for DRY Sand, street sweeper
☐	**PERSONAL PROTECTIVE EQUIPMENT (PPE)**	▪ Turnouts with SCBA
☐	**MONITORING & DETECTION**	▪ Thermal Imaging Camera (TIC) ▪ Combustible Gas Indicator (CGI) for flammable atmospheres including hydrogen gas ▪ Multi Rae Pro for toxic gases ▪ pH paper for runoff ▪ Safe Sites ▪ Plume Modeling
☐	**DECONTAMINATION**	▪ Remove contaminated clothing ▪ Water and detergent
☐	**CLEAN UP & DISPOSAL**	▪ Responsible Party ▪ Licensed hazardous waste contractor ▪ Waste manifests ▪ Photographs / sampling ▪ Monitor for possible corrosive run-off
☐	**INCIDENT TERMINATION**	▪ Safe to reoccupy, recheck temperatures ▪ Enforcement by CUPA