Example Policy for Combustible Metal Fires

DATE:

SUBJECT: Combustible Metal Fires

PURPOSE: To provide operational guidelines on appropriate fire control methods when dealing with combustible metal fires involving metals such as alkali metals – lithium, sodium and potassium; alkali earth metals - magnesium, beryllium and calcium; transitional metals – hafnium, niobium, tantalum, titanium and zirconium; and other metals – aluminum. In addition, metals such as iron, etc. in a fine enough form and/or powders may also present a fire hazard to responders.

PROCEDURE:

Combustible metals involved in a fire create extreme hazards for responders if not properly handled. Burning combustible metals will produce extreme heat as compared to normal combustible materials with possible temperatures of 5000^{o}F (2760^{o}C) (magnesium) to 8500^{o}F (4700^{o}C) (zirconium).

Water and carbon dioxide when applied to burning metals will result in disassociation to their base components. Water will create a subsequent release of hydrogen and oxygen when applied to burning metal. Water in contact with molten metal will result in extreme reactions and explosions and increase burning intensity.

Combustible metals are seeing an increase use in everyday products including automobiles, and aircraft. We are also seeing more of the materials showing up in recycling facilities. It is extremely important to recognize the potential for combustible metals to be involved in a fire.

Full Structural Protective equipment ensembles and SCBA should be worn when emergency responders are dealing with Combustible Metal Fires. It should be noted however, the extreme thermal risks that are presented with Combustible Metal fires and the explosion potential when water comes in contact with a burning metal and/or molten metal.

One of the most important aspects to ensure a safe response to incidents at fixed site facilities which have metals in a combustible form, is to develop a working relationship and pre-plan with the facility prior to an incident occurring.

Employees who are to handle combustible metal fires shall be trained initially and annually on fire behavior of combustible metal fires and procedures and the risks associated with fires or explosions. Employees expected to utilize fire-extinguishing equipment on incipient fires should receive training on proper utilization of equipment. Note: that class “D” extinguishers discharge at much lower velocity than other extinguishers normally encountered.

The following general guidelines are to be taken into account when dealing with a combustible metal fire.

A. Unusual Hazards of Combustible Metal Fires

1. **Water** when applied to most burning combustible metal will result in an increase in burning intensity and explosion potential. Water applied to alkali metals not involved in fire will result in hazardous decomposition, ignition and/or explosion.

2. Application of **carbon dioxide** has similar effects as water; the carbon dioxide adds to the intensity of the burning. Most combustible metals will ignite and burn in 100-percent carbon dioxide atmospheres.

3. **Dry chemical** extinguishers used on alkali metal fires will react and intensify the fire. Extinguishers utilized on non-alkali fires are ineffective, but may be effective where flammable or combustible liquids are used on the metal is not yet involved in fire. Be aware that use of dry-chemical extinguishers, due to the discharge velocity may spread and suspend material in the air creating an explosion risk. **Extreme caution needs to be exercised prior to utilizing a dry-chemical extinguisher in any fire involving a combustible metal fire.**

4. **Halogenated** extinguishing agents used on alkali metals can result in an explosion. Halogenated extinguishing will have a detrimental effect on all other combustible metal fires, with the decomposition of products producing hazardous by-products.

5. A fire primarily involving metals displays intense orange-to-white flame and may be associated with a heavy/large production of white/gray smoke. Reactions from water in contact with a metals fire may result in popping sounds and bright flashes similar to an electrical arc; and/or violent explosions.

6. When **water** is applied to a non-alkali metal fire, it can disassociate to the basic compounds of oxygen and hydrogen. Similar results occur with **carbon dioxide**.

7. When **water** is applied to an alkali metal fire, hydroxides and hydrogen are generated immediately.

B. Conversion of Water into Hydrogen

The table below is based on the assumption that 100 percent of the hydrogen in the water is converted into the basic hydrogen element when it reacts with a combustible metal. The percent conversion will vary from metal to metal based on the specific reactions taking place. Even if there is a relatively small conversion percentage, there is the possibility of releasing large amounts of hydrogen.

Hydrogen has a heat value (BTU/lb) of about 2.8 times that of gasoline. For example, 1000 gal/min of water would convert to 2.8 x 917.4 lb/min of hydrogen = 2569 lb/min of gasoline.

Gal/Min of Water	Density of Water (lb/gal)	Lb of Water/Min.	Fraction Hydrogen	Lb/Min of Hydrogen	Lb/Min of Gasoline	Gal/Min of Gasoline 2 Density of 6 Lb/Gal
1	8.34	8.34	0.11	0.9174	2.56872	0.42812
100	8.34	834	0.11	91.74	256.872	42.812
1000	8.34	8340	0.11	917.4	2568.72	428.12

1. Fires involving combustible metals that contain **moisture** will exhibit more intense burning characteristics than dry product.

2. Dusts, fines, and powders of combustible metals present an **explosion hazard**, especially in confined spaces.

3. Dust, fines, and powders of titanium and zirconium present extreme hazards; zirconium powders having ignition temperatures as low as 68^oF (20^oC). Static electric charges can ignite some dusts and powders of titanium and zirconium.

4. Titanium and zirconium powders can exhibit pyrophoric characteristics.

5. Turnings and chips of combustible metals can ignite and burn with intensity, especially if coated with petroleum-based oil, with some spontaneous combustion having been observed.

6. With the exception of alkali metals, the larger the product, the smaller the likelihood of ignition. Bars, ingots, heavy castings, and thick plate/sheets are virtually impossible to ignite and, in most cases, will self-extinguish when the heat source is removed.

7. Sponge product of most combustible metals will burn at a slower rate, but will still produce tremendous heat.

8. Burning combustible metals can extract moisture from concrete and similar products that can intensify burning and cause spalling and explosion of the products. Burning metal will destroy asphalt and extract moisture from rock and concrete.

9. Most fires involving non-alkali combustible metals cannot be extinguished, and unless they are placed in an inert atmosphere of argon or helium; they can only be controlled.

10. Fires involving large quantities should be allowed to cool for at least 24 hours prior to being disturbed to prevent re-ignition.

11. Fires will oxidize most metals and provide a protective covering limiting open burning, be aware however that molten product may be under the protective covering.

12. Alkali metal fires can be extinguished with suitable extinguishing agent correctly applied as identified in appendix “A”

13. **Combustible** metal fines and powders that are stored and contain moisture can produce hydrogen gas.

14. **Combustible** metal fines and dusts that are reduced (not oxidized) and come in contact with other metal oxides can result in thermite reactions.

C. Proper Handling of Combustible Metal Fires

1. Perform a good size-up and identification of involved materials; the physical state of the product, e.g. chips, powder, fines, dust, etc.; and the quantity of product involved and/or potentially involved in the fire are extremely important factors for emergency responders.

2. For fires occurring at a facility it is critical to make contact with facility personnel knowledgeable of the processes and hazards and to maintain contact.

3. The **following agents shall not be used as extinguishing agents on combustible-metal fires because of adverse reactions or ineffectiveness** unless they are compatible with metal and identified as an effective extinguishing agent (see appendix “A”).

   a). Water
   b). Foams
   c). Halon
   d). Carbon dioxide
   e). Nitrogen* (IG-100)
   f). Halocarbon Clean Agents

   *Nitrogen use is prohibited as an extinguishing agent on all combustible metals with the exception of iron, steel, and alkali metals excluding lithium.

4. Ensure control of utilities (water, gas, power) and process chemicals that may traverse through affected areas.

5. Review Safety Data Sheets for the involved products and, if available, contact those familiar with the product and hazards.

6. Fires involving large quantities of product within structures can result in rapid heat build-up and smoke generation, beyond that which is normally encountered in fires involving ordinary combustibles. Fires beyond the incipient stage within structures can place personnel at risk. Extreme caution should be taken.

7. Determine if a fire can be safely isolated and allowed to burn out.

8. Uninvolved product and exposures (other than alkali metals) can be consider for exposure protection only after an adequate review is completed to ensure any runoff by hose streams does not come into contact with burning or combustible metal. **It is extremely important that care is taken to prevent runoff from hose streams coming in contact with burning material or molten product; and in the case of alkali metals any product in the area even if not involved in the fire.**

9. Ensure that uninvolved exposed **alkali metals** are **not** protected by hose streams and that water is not applied to alkali metals in a fire or non-fire situation.

10. If the fire is burning in a closed container, such as a dust collection system, argon or helium (or nitrogen for alkali metals) can be effective in controlling the fire by placing and inert blanket over the fire where an adequate delivery system is available and personnel safety is considered. Evaluation of explosion potential should also be considered, in this situation if dust should become disturbed/suspended during application.

11. **Extreme** caution needs to be taken for fires involving combustible metal powders, dusts, and fines. Explosions are possible with these products, especially if the product becomes airborne in the presence of an available ignition source.

12. Use extreme caution with fires involving combustible-metal powders, dusts, and fines because of the possibility of explosions and/or flash-fire hazards, especially if the product becomes airborne and there is an available ignition source.

13. Small and incipient fires may be contained utilizing Class D extinguishing agents, **dry** sand, or **dry** salt **(see appendix “A” for a chart on acceptable agents for a given metal)**. Note: that Met-L-X will cling to most vertical surfaces involved in a fire, i.e. castings or wheel fires, but will likely require re-application as is the case with major of the materials applied to control a combustible metal fire.

14. Most fires involving combustible metals cannot be extinguished other than by providing an inert atmosphere of argon or helium (and also nitrogen for alkali metals or iron) if the product is dry. In most cases, the fire is controlled by application of argon or helium (or nitrogen for alkali metals or iron) or the development of an oxide crust. The temperature of the material involved can remain extremely hot, and the fire can flare up again if the product is disturbed prior to the oxidation of the product and self-extinguishment.

15. Water in contact with **molten combustible metals** will result in violent steam explosions and can cause hydrogen explosions and reactions with most metals.

16. Control of domestic and fire protection water systems should be considered in fires involving a structure to prevent water contact with burning material which may have reached the melting point with resultant molten metal present.

17. Large fires are impossible to extinguish. The best approach is to isolate material as much as possible if it can be done safely. In many cases the best action can be to let the fire burn out naturally to minimize hazards to personnel and losses to exposures.

D. Vehicle Fires Involving Combustible Metal Components

1. Extreme caution should be exercised when approaching a vehicle fire. It is not uncommon for well-involved interior fires and engine compartment fires on newer vehicles to have combustible metals involved. Observe burning characteristics for signs of metal involvement. Extreme caution should be utilized on initial application of water from a safe distance with full protective equipment in place. **In all cases, if a reaction is observed cease water application.**

2. If combustible metals are suspected, **protect exposures and allow the metals to burn out prior to attempting further extinguishment.** The greatest potential for molten product is in the interior components of the vehicle; this can result in severe reactions and explosions as the smaller components are much more prone to melting and

becoming involved in the fire versus larger components of metal such as bracing support materials in engine compartments, engine blocks and wheels.

3. If a determination is made that the fire cannot be allowed to safely burn out; remote heavy streams can be considered **if appropriate safety precautions are taken, only in the case of a vehicle fire which, the quantity of metal present is usually limited.** Consideration should be given to potential impacts due to the explosion potential of the molten product, and the potential for projectiles and burning metal product from the explosion impacting personnel, bystanders and/or exposures.

Author: Kevin L. Kreitman
Date: September 2013

Appendix A

Combustible Metal Fire-Extinguishing Agents Quick Reference Chart

Extinguishing Agent	Alkali Metals		Aluminum	Magnesium	Niobium	Tantalum	Titanium	Zirconium
	Potassium, NaK, Sodium	Lithium						
Coke (Carbon Microspheroids)	YES	YES	NO	NO	NO	NO	NO	NO
Met-L-X	YES	NO	YES	YES	YES	YES	YES	YES
Lith-X	YES	YES	NO	NO	NO	NO	NO	NO
Copper Powder	YES	YES	YES*	NO	NO	NO	NO	NO
Dry Flux	YES	YES	YES	YES	NO	NO	NO	NO
Dry Sand	YES	YES	YES	YES	YES	YES	YES	YES
Dry Lithium Chloride	YES	YES	NO	NO	NO	NO	YES	YES
Dry Soda Ash	YES	YES	YES	YES	NO	NO	YES	YES
Dry Sodium Chloride	YES	YES	YES	YES	YES	YES	YES	YES
Water	NO	NO	NO	NO	NO	NO	NO	NO
Foam	NO	NO	NO**	NO	NO	NO	NO	NO
Argon	YES	YES	YES	YES	YES	YES	YES	YES
CO_2	NO	NO	NO	NO	NO	NO	NO	NO
Nitrogen	YES	NO	NO	NO	NO	NO	NO	NO
Halon	NO	NO	NO	NO	NO	NO	NO	NO
Halon Replacements	NO	NO	NO	NO	NO	NO	NO	NO

NOTES: When combustible metals are blended with other materials, the extinguishing agent should be compatible with the combustible metal.

Green text indicates the preferred extinguishing agents.

*Copper powder can be utilized on Aluminum fires but requires large quantities to be effective.

**Aqueous Film Forming Foam (AFFF) has been shown to be effective on aluminum paste fires in the incipient stage where a class B solvent is the primary fuel.

Hazards of Combustible Metals – Titanium

International Titanium Association

October 8, 2013

Kevin L. Kreitman EFO - Fire Chief, Redding CA


RAILROAD CROSSING
02
DIVISION 2


RAILROAD CROSSING
DIVISION 2
02

NIOSH Injury Report
July 13, 2010

- **Incident**
  - Seven Career Firefighters Injured at a Titanium Metal Recycling Facility Fire
- **Contributing Factors**
  - Unknown building contents
  - Unrecognized presence of combustible metals
  - Use of traditional fire suppression tactics
  - Darkness

NIOSH Injury Report
July 13, 2010

- **Key Recommendations**
  - Ensure that pre-incident plans are updated and available to responding fire crews
  - Ensure that firefighters are rigorously trained in combustible metal fire recognition and tactics
  - Ensure that policies are updated for the proper handling of fires involving combustible metals
  - Ensure that first arriving personnel and fire officers look for occupancy hazard placards on commercial structures during size-up

NIOSH Injury Report July 13, 2010

- **Key Recommendations**
  - Ensure that all firefighters communicate fireground observations to incident command
  - Ensure that firefighters wear all personal protective equipment when operating in an immediately dangerous to life and health environment
  - Ensure that an Incident Safety Officer is dispatched on the first alarm of commercial structure fires
  - Ensure that collapse/hazard zones are established on the fireground


January 29, 2009, 1941 hrs.
St. Anna, WI
Photo by NIOSH

January 29, 2009, 1953 hrs.

St. Anna, WI

NIOSH LODD Report Wisconsin, 12/29/09

- **Incident**
  - One Firefighter killed, and Eight Injured
- **Contributing Factors**
  - Wet extinguishing agent applied to a combustible metal fire.
  - Lack of hazardous materials awareness training.
  - No documented site pre-plan.
  - Insufficient scene size-up and risk assessment.
  - Inadequate disposal/storage of materials.

NFPA 484

- **Standard for Combustible Metals**
  - Includes specific chapters on alkali metals, aluminum, magnesium, niobium, tantalum, titanium, and zirconium.
  - Also includes requirements for metals not listed above, that exhibit combustible metal characteristics capable of combustion or explosion.
  - Chapter on Recycling

NFPA 484

- References to NFPA 484
  - NFPA 1
  - International Fire Code (IFC)

NFPA 484

- **Standard for Combustible Metals**
  - Current edition 2012
    - Chapter 1: Administration
    - Chapter 4: Determination of the Combustibility or Explosibility of a Metal, Metal Powder, or Metal Dust
    - Chapter 5: Determination of Dust Explosion Hazard Areas and Flash-Fire Hazard Areas
    - Chapter 6: Performance-Based Design Option

NFPA 484

- **Standard for Combustible Metals**
  - Chapter 12: Titanium
    - General Provisions
    - Facility Design Requirements
    - Primary Metal Production
    - Powder Production
    - Processing and Handling
    - Machining, Fabrication, and Finishing
    - Storage and Handling
    - Fire and Explosion Prevention

NFPA 484

- **Standard for Combustible Metals**
  - Chapter 15: Fire Prevention, Fire Protection, and Emergency Response
    - Fire Prevention
      - Inspection and Maintenance
      - **Housekeeping**
      - Control of Ignition Sources
      - Control of Combustible Materials

NFPA 484

- Standard for Combustible Metals
  - Chapter 15: Fire Prevention, Fire Protection, and Emergency Response
    - Fire Protection
      - Automatic Sprinkler Protection for Combustible Metals other than Alkali Metals
      - Sprinkler Protection of Alkali Metals
      - Extinguishing Agents and Application

NFPA 484

- **Standard for Combustible Metals**
  - Chapter 15: Fire Prevention, Fire Protection, and Emergency Response
    - Emergency Response
      - Considerations
      - Emergency Preparedness

NFPA 484

- **Standard for Combustible Metals**
  - Chapter 15: Fire Prevention, Fire Protection, and Emergency Response
    - Emergency Preparedness
      - Notification
      - Emergency Preparedness Plan

NFPA 484

- **Standard for Combustible Metals**
  - Chapter 16: Combustible Metal Recycling Facilities
    - General
    - Receiving Criteria
    - Storage of Combustible Metals for Recycling
    - Processing
    - Emergency Preparedness
    - Ignition Sources
    - Waste Disposal

NFPA 484

- **Standard for Combustible Metals**
  - Next edition 2015
    - Will include consolidated General chapter on management of change, hazard analysis, PPE, Dust explosion & flash-fire hazard areas, and segregation and separation.
    - New Chapters on Housekeeping, Control of Ignition Sources, and Dust Collection.

Combustible Metal

- Any metal composed of distinct particles or pieces, regardless of size, shape, or chemical composition that will burn.
- Chapter 4 covers determination of combustibility for metals.

Determination of Combustibility & Explosivity

- Determination of Combustibility – Screening Test
  - Unbroken strip or powder train
    - 250 mm long x 20 mm wide x 10 mm high
- Determination of Explosibility
  - ASTM E 2019, standard test method for minimum ignition energy of dust cloud in air. (Hartman Device)

Classes of Combustible Metals

- **Alkali Metals**
  - Lithium *
  - Sodium *
  - Potassium *
  - Rubidium
  - Cesium
  - Francium

* Primary metals likely to be encountered by responders.

Classes of Combustible Metals

- **Alkaline Earth Metals**
  - Magnesium *
  - Beryllium *
  - Calcium *
  - Strontium
  - Radium

* Primary metals likely to be encountered by responders.

Classes of Combustible Metals

- **Transitional Metals**
  - Hafnium *
  - Niobium *
  - Titanium *
  - Tantalum *
  - Zirconium *
  - Iron/Steel * (lower risk metal comparatively, does present a flash-fire potential for dusts and powder's)

* Primary metals likely to be encountered by responders.

Classes of Combustible Metals

- **Post-Transitional Metals**
  - Aluminum

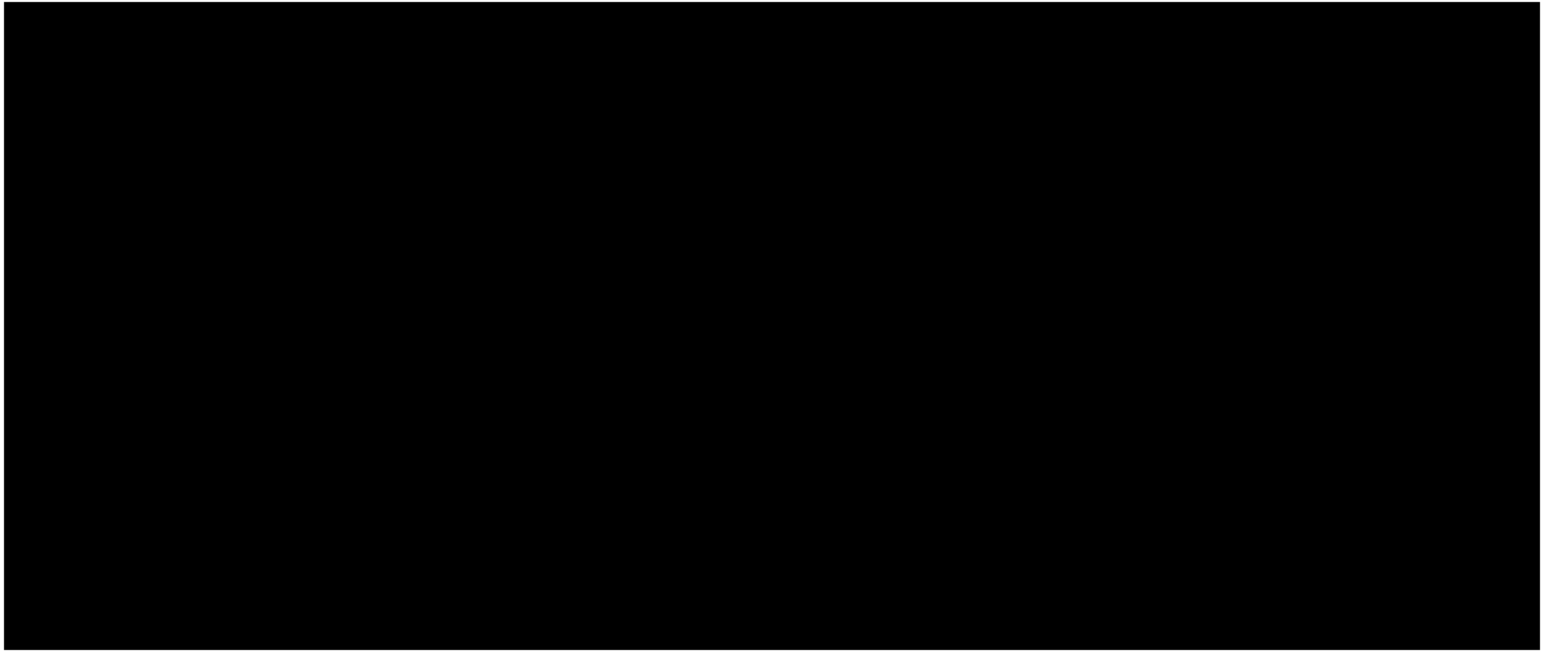
  Aluminum powder and flake present fire and explosion hazards to responders.

  Most metals can exhibit burning characteristics if in a small enough form.

Does Your Facility Have Dust and Explosion Hazards?

CSB Hoagenaes Safety Video

Cornstarch and Aluminum Dusts



The ‘Rs’ of Dust Hazards

Recognition –	GOOD
Response –	BAD
Recovery –	BAD

Good Powder or BAD DUST

- Powder is generally a product of a production operation and has value.
- Dust is the loss of powder from a production process.
- Dust that is lost from a production process is generally referred to as: FUGITIVE DUST.

FUGITIVE DUST CAN KILL!

Recognition of Fugitive Dust

- Two simple elements of Recognition:

1. Is fugitive dust present?
2. Is the fugitive dust combustible?

Fugitive Dust Explosion

- To have a fire or explosion, dust has to be present and be combustible.
- It is easy to determine if a fugitive dust is present!
- How do you determine if the dust is ‘combustible’?

TEST IT!

Definition of Combustible Metal Dusts

- **Combustible Metal Dust**
  - Any finely divided metal 420 µm (microns) or smaller in diameter (that is, material passing through a U.S. No. 40 standard sieve) that presents a fire or explosion hazard.

What particle size of dust is BAD?

U.S. STANDARD	METRIC SIZE		
MESH SIZE			
No. 40	425 (µm) micron	DUST	Kosher Salt
No. 45	355 (µm) micron	DUST	
No. 50	300 (µm) micron	DUST	
No. 60	250 (µm) micron	DUST	Sugar
No. 70	212 (µm) micron	DUST	
No. 80	180 (µm) micron	DUST	
No. 100	150 (µm) micron	DUST	Salt
No. 120	125 (µm) micron	DUST	
No. 140	106 (µm) micron	DUST	Creamora
No. 170	90 (µm) micron	DUST	
No. 200	75 (µm) micron	DUST	
No. 230	63 (µm) micron	DUST	
No. 270	53 (µm) micron	DUST	Powdered Sugar
No. 325	45 (µm) micron	DUST	
No. 400	38 (µm) micron	DUST	

Recognition

- Three Conditions Required for a Fire:

Five Conditions for a Dust Explosion

CSB Findings from Recent Dust Explosions

- Findings
  - Facilities did not fully comply with recognized guidelines and standards NFPA 484.
  - Many SDSs and product warnings do not adequately address dust explosion hazards.
  - Insurance and government inspectors did not recognize dust explosion hazards.
  - OSHA has limited regulations related to dust explosion hazards and has not adopted a comprehensive standard for the prevention and mitigation of dust explosions.

CBS Recommendations from Recent Dust Explosions

- Recommendations
  - Train inspectors to recognize dust explosion hazards.
  - Incorporate dust explosion standards into local code requirements and federal regulations.
  - Create outreach programs to educate industries about dust explosion hazards.

Control of Dust and Good Housekeeping Procedures are Key to Preventing Fires and Explosions

- Should a fire and/or explosion incident occur however, it is important to recognize the unusual hazards associated with titanium and other metals involved in fire to prevent further hazards and risks.

Unusual Hazards of Combustible Metal Fires

- **Water** when applied to burning combustible metals results in an increase in burning intensity and possible explosion, particularly if alkali metals are present.

- Application of **carbon dioxide** has similar effects as water; the carbon dioxide adds to the intensity of the burning. Most combustible metals will ignite and burn in 100-percent carbon dioxide atmospheres.

True Facts on Water Application on a Combustible Metals Fire

- Water applied to **Titanium and non-alkali metals** will disassociate to its base compounds of hydrogen and oxygen.
- Water applied to **alkali metals**, results in hydroxides and hydrogen immediately generated.
- **CO_2** will disassociate to its base compounds.
- You are potentially adding the equivalent of .43 gallons of gasoline for every gallon of **water** applied to a combustible metals fire.

Hydrogen Conversion Factor

- One gallon of water weighs 8.34 lbs
- Fraction of hydrogen = 11%
- Weight of hydrogen per gallon of water = .917 lbs
- Hydrogen has a heat value (BTU/lb) of about 2.8 times that of gasoline = 2.57 lbs/gallon.
- Gasoline has a density of 6 lbs per gallon or an equivalent of .428 gallons of gasoline applied per gallon of water.

The Hydrogen Conversion Factor

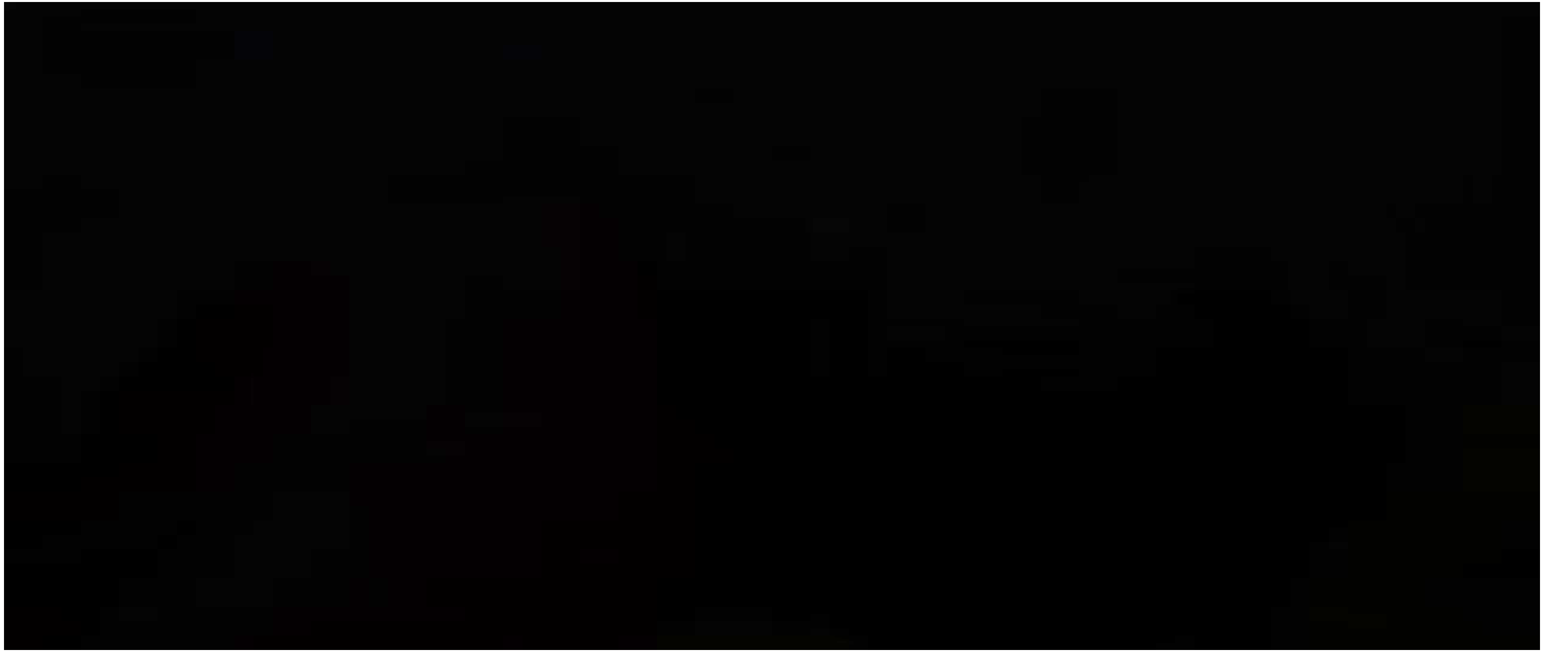
- **With the complete disassociation of water on a combustible metals fire, you are essentially providing an additional energy component equivalent of:**

  - .43 gallons of gasoline per gallon of water
  - 100 gpm = 43 gallons of gasoline
  - 1000 gpm = 430 gallons of gasoline

This does not include the addition of the oxygen you are also providing to the fire.

Would you consider ordering this hydrogen tanker to a fire scene and instructing your personnel to begin pumping hydrogen and oxygen on a fire?

Videos – Slauson Avenue Titanium Fires – You Tube



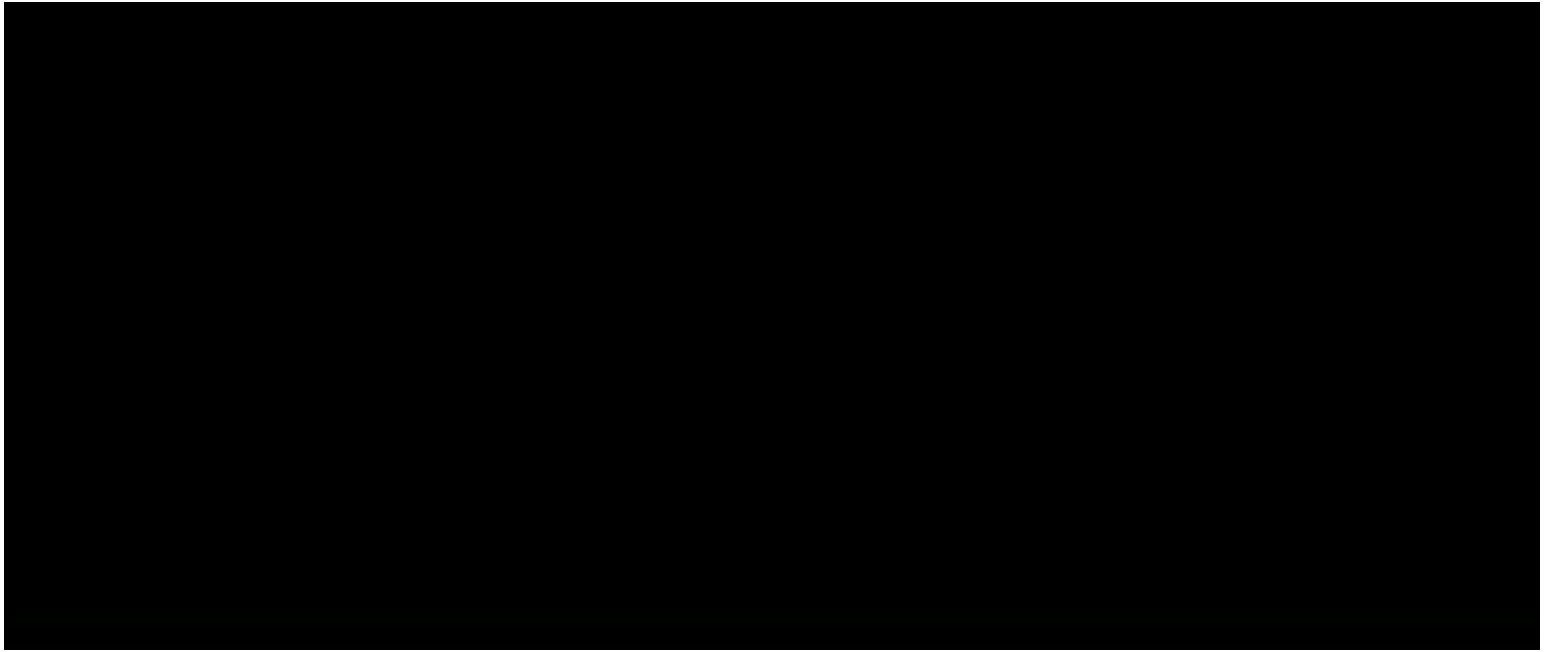
http://www.youtube.com/watch?v=NDhnwLheoU4

Videos – Slauson Avenue Titanium Fires – You Tube

http://www.youtube.com/watch?v=DRDJiCn-M80

Videos – Slauson Avenue Titanium Fires – You Tube

http://www.youtube.com/watch?v=5ykseFxoWqA




AHEAD
SAFE SCHOOL ZONE


(800) 446-4669
A-Throne

Unfortunately these incidents occur on a regular basis in the United States!

- The Fire Service and some industries have been led to believe that if enough water is put on a combustible metals fire it can be extinguished!
- When this doesn't work, a comment like, "We were trying to accelerate burning," is usually made.
- That comment is very accurate!
- Application of water on combustible metals fires makes for great news photo opportunities.

Unusual Hazards of Combustible Metal Fires

- Fires involving combustible metals that contain **moisture** will exhibit more intense burning characteristics than dry product.

Unusual Hazards of Combustible Metal Fires

- **Extreme heat** production can be produced.
- Burning titanium can potentially produce temperatures in excess of **7000**°F.
- In general, combustible metals exhibit temperatures from **4500**°F to **8500**°F.

Unusual Hazards of Combustible Metal Fires

- When dealing with a fire in a structure or confined area **extreme thermal heat** build-up will occur, creating fire gases under greater than normal pressures.

- This is an extremely dangerous situation for responders and can **rapidly** catch personnel unaware.

- Metal fires burning in ordinary combustible structures can place responders at great risk, with **flashover** potentially occurring within minutes.

Unusual Hazards of Combustible Metal Fires

- Dusts, fines, and powders of combustible metals present an **explosion hazard**, especially if suspended or disturbed in confined spaces.

- Dust, fines, and powders of titanium present **extreme hazards**; Static electric charges can ignite some dusts and powders of titanium.

Unusual Hazards of Combustible Metal Fires

- Titanium powder can exhibit **pyrophoric** characteristics.

- Turnings and chips of combustible metals can ignite and burn with intensity, especially if coated with a petroleum-based oil, with some **spontaneous combustion** having been observed.

Unusual Hazards of Combustible Metal Fires

- The larger the product, the lower the likelihood of ignition. Bars, ingots, heavy castings, and thick plate/sheets are virtually impossible to ignite and will self-extinguish in most cases when the heat source is removed.

Bars & Ingots

Unusual Hazards of Combustible Metal Fires

- **Sponge** will burn at a slower rate, but will still produce tremendous heat.

Unusual Hazards of Combustible Metal Fires

- Burning combustible metals can **extract moisture** from concrete and similar products that can intensify burning and cause spalling and explosion of the products.
- Burning metal will destroy asphalt and extract moisture from rock.

Titanium Chip Fire

Unusual Hazards of Combustible Metal Fires

- Fires involving Titanium cannot be extinguished. Unless they are placed in an inert atmosphere of argon or helium, they can only be controlled.

- Fires involving large quantities should be allowed to cool for at least 24 hours prior to being disturbed to prevent re-ignition. Fires will oxidize the metal.

Unusual Hazards of Combustible Metal Fires

- Combustible metal fines and powders that are stored and contain moisture can produce **hydrogen gas**.
- Combustible metal fines and dusts that are not oxidized and come in contact with iron oxides can result in **thermite reactions**.

Safe Handling of Fires

- A good **size-up** and identification of involved materials; physical state of the product, e.g. chips, powder, fines, dust, etc.; the quantity of product involved and/or potentially involved in the fire are extremely important factors for emergency responders.
- Obtain **Safety Data Sheets** for the involved products, and if available contact those familiar with the product and hazards.
- For fires at facilities: have someone with facility familiar with the hazards, establish and maintain direct contact with fire personnel throughout the incident.

Safe Handling of Fires

- Control Utilities and Process Hazards
  - Water Supply to the Structure
  - Power
  - Natural Gas/Propane
  - Industrial Gases, etc.

Safe Handling of Fires

- Fires beyond the **incipient** stage within structures can place responders at risk. Extreme caution should be taken prior to committing resources.
- If fires can be safely isolated, the best course of action is to allow them to burn out.

Safe Handling of Fires

- Uninvolved product and exposures in some cases can be protected by hose streams if **adequate** precautions are taken.
- It is **extremely important** that care is taken to ensure runoff from the hose streams does not come in contact with burning and/or molten material.

Proper Handling of Fires

- If a fire is burning in a **closed container**, such as a dust collection system; and an adequate delivery system is available; with consideration taken for personnel safety, utilization of argon or helium may be effective in controlling the fire by placing an inert blanket over it.

- Evaluation of explosion potential should also be considered.

Proper Handling of Fires

- **Extreme** caution needs to be taken for fires involving combustible metal powders, dusts, and fines.
- **Explosions** are possible with these products, especially if product becomes airborne with an available ignition source.
- Thin layers of dust maybe enough to produce an explosive atmosphere for products under 420 µm (microns), or a flash fire hazard.

Proper Handling of Fires

- Small and incipient fires may be contained utilizing **Class D** extinguishing agents, **dry** sand, or **dry** salt.

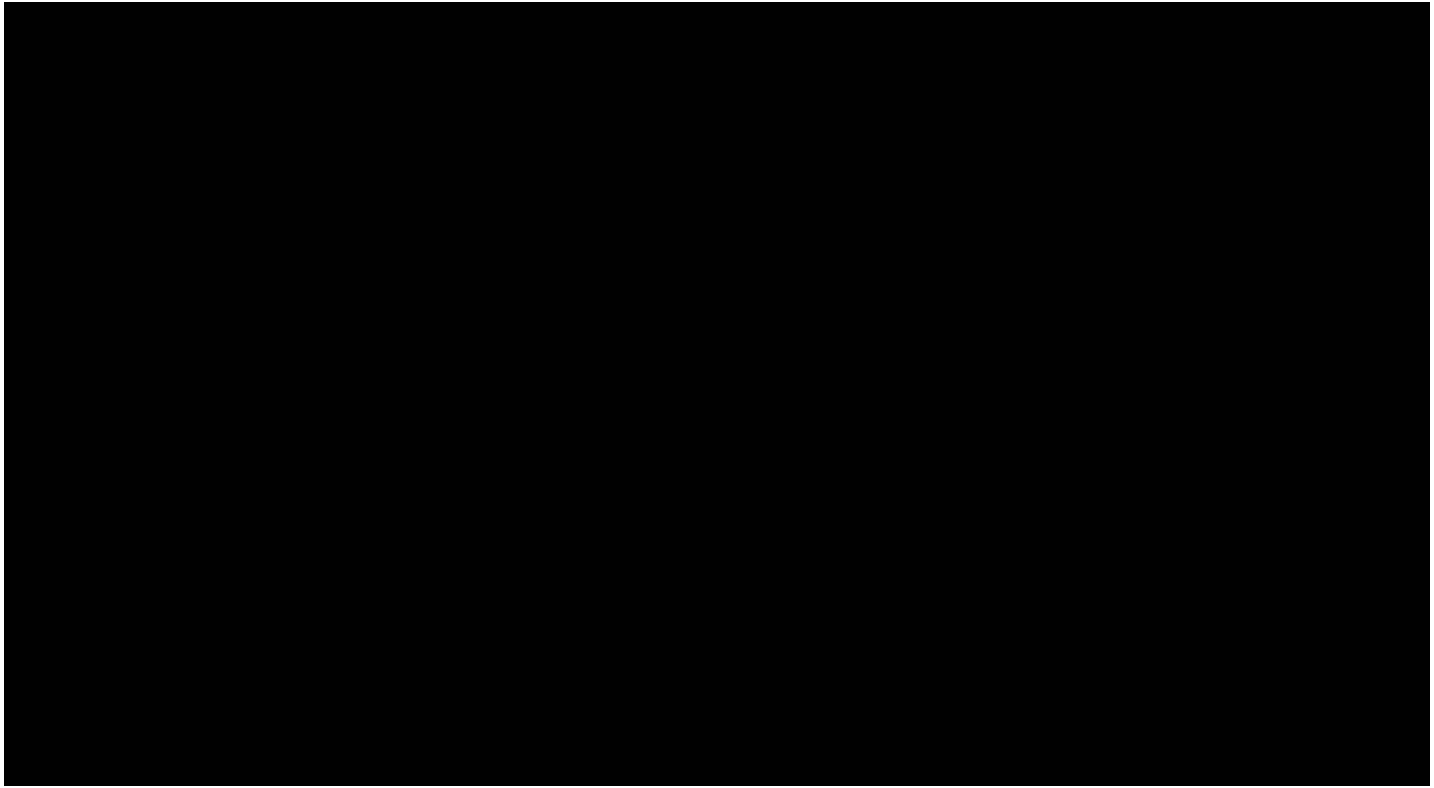
- Most fires involving combustible metals cannot be extinguished other than by providing an inert atmosphere of argon or helium if the product is dry.

- In most cases, the fire is controlled by application of one of the above products or the development of an **oxide crust**. The temperature of the material involved can remain extremely hot, and the fire can flare back up if product is disturbed prior to oxidation of product and self-extinguishment.

Fire Extinguishers

- The use of an ABC fire extinguisher in a combustible dust area is likely to cause an explosion.
- Class D fire extinguishers have restricted discharge velocity.
- Plant personnel and emergency responders need to be familiar with the use of Class D fire extinguishers.

Titanium Powder Fire



Titanium Powder After Fire

Titanium Powder After Fire

Combustible Metal Fire-Extinguishing Agents Quick Reference Chart

Extinguishing Agent	Alkali Metals		Aluminum	Iron and Steel	Magnesium	Niobium	Tantalum	Titanium	Zirconium and Hafnium
	Potassium, NaK, Sodium	Lithium							
Coke (Carbon Microspheroids)	YES	YES	NO	NO	NO	NO	NO	NO	NO
Met-L-X	YES	NO	YES	YES	YES	YES	YES	YES	YES
Lith-X	YES	YES	NO	NO	NO	NO	NO	NO	NO
Copper Powder	YES	YES	YES*	NO	NO	NO	NO	NO	NO
Dry Flux	YES	YES	YES	NO	YES	NO	NO	NO	NO
Dry Sand	YES	YES	YES	YES	YES	YES	YES	YES	YES
Dry Lithium Chloride	YES	YES	NO	NO	NO	NO	NO	YES	YES
Dry Soda Ash	YES	YES	YES	NO	YES	NO	NO	YES	YES
Dry Sodium Chloride	YES	YES	YES	NO	YES	YES	YES	YES	YES
Water	NO	NO	NO	YES	NO	NO	NO	NO	NO
Foam	NO	NO	NO**	YES	NO	NO	NO	NO	NO
Argon	YES	YES	YES	YES	YES	YES	YES	YES	YES
CO_2	NO	NO	NO	NO	NO	NO	NO	NO	NO
Nitrogen	YES	NO	NO	YES	NO	NO	NO	NO	NO
Halon	NO	NO	NO	NO	NO	NO	NO	NO	NO
Halon Clean Agent	NO	NO	NO	NO	NO	NO	NO	NO	NO

NOTES: When combustible metals are blended with other materials, the extinguishing agent should be compatible with the combustible metal. Green text indicates the preferred extinguishing agents.

***Copper powder can be utilized on Aluminum fires but requires large quantities to be effective.**

****Aqueous Film Forming Foam (AFFF) has been shown to be effective on aluminum paste fires in the incipient stage where a class B solvent is the primary fuel.**


Titanium Furnace Explosion
(Water into the crucible)

Safe Handling of Fires

- Water in contact with **molten** combustible metals will result in **violent steam** and **hydrogen** explosions and reactions.
- Large fires are impossible to extinguish. The best approach is to isolate material as much as possible, if it can be done safely.
- Protection of exposures with water streams can be considered, if adequate review is conducted and adequate drainage is present, to ensure contact of water with the burning material will not occur.
- **Let the fire burn itself out** naturally to minimize hazards to personnel and loss to exposures.

Has there been a recent major dust explosion where housekeeping was NOT cited?

NO!

Imperative Elements for the Prevention of a Dust Explosion

1. HOUSEKEEPING
2. HOUSEKEEPING
3. HOUSEKEEPING
4. HOUSEKEEPING

The Majority of Combustible Metal Incidents Can be Avoided

- Good housekeeping is a must.
- Control of Ignition sources.
- Adequate segregation of combustible metals.
- Recognition of dust hazards is a must.
- Not all dusts are problem dust.
- FUGITIVE Combustible Dust are DEADLY.
- Recovery Plans are an inadequate excuse for less than adequate implementation of Mitigation for known hazards.
- Use of **water** on fires is extremely hazardous and presents significant risks.

In Those Cases in Which a Incident was not Prevented, it is Important to Remember -

The best course of action with most metals fires is to <u>DO NO HARM</u>!

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