FIGHTING FIRES WITH DRY POWDER AGENTS

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INTRODUCTION

Today's manufacturing materials and procedures are vastly different from those used in the past. We are no longer limited to materials such as steel, wood, and masonry to manufacture the items we use and take for granted on a daily basis. Materials like plastics, composites, and special metals like titanium, magnesium, sodium, and lithium have become a part of our daily lives. Instead of using manufacturing techniques like welding and drilling, we now use processes such as computer operated machining centers and automated grinding machines to create parts to much closer tolerances. These materials and manufacturing techniques present special challenges for today's fire protection experts. The purpose of this paper is to provide guidance for the protection of combustible metal hazards using available agents, hardware, and design parameters.

The fuels covered by these procedures are standard combustible metals like aluminum, magnesium, titanium, lithium, and some of their alloys. Fuels that are reactive or unstable will normally require special techniques not covered here. Combustible metals can take many shapes. Raw materials may be solid ingots, powders, chips, etc. Finished products can be anything from powders; to consumer products like automotive parts, batteries, and golf clubs; to very complex shapes like those used in the aerospace industry. Manufacturing byproducts can be fine dusts, chips, and solid scrap pieces.

Manufacturing techniques utilizing these metals may include cutting, machining, heat-treating, grinding, welding, etc. Many times these machines, including the byproduct recovery systems, are entirely enclosed and automated. This frequently results in requests by the Authority Having Jurisdiction (AHJ) to provide automatic protection for these hazards. Areas requiring protection can also include raw material storage and staging areas, byproduct storage areas, and exhaust systems which may include a dust collection system. In many cases, flammable liquids and combustible solids may also be part of the hazard. These fuels may include oil in which the combustible metal is stored, cutting oils, and packaging materials.

Burning Characteristics of Metals

The burning characteristics of most combustible metals can be compared to more common Class A materials like wood or paper. As with Class A materials, the amount of energy required to ignite the metal depends on the configuration of the fuel; large solid blocks will require much more heat to ignite than will finely divided dust or chips from a lathe. Some of these fuels will melt before they ignite, while others will remain solid while they burn. Flame progression is typically measured in minutes, not seconds, and is similar to what we would expect from Class A fuels rather than Class B materials such as gasoline. Once they are ignited, most of these materials will react violently with water; some (sodium, lithium, etc.) will also be extremely reactive with water in their un-ignited state. It is crucial that the fire protection expert understand the material being protected, its configuration, and its burning characteristics!

Because of the heat required to ignite these fuels, fires do not generally originate in the fuel itself. Typical ignition sources would be heat from a manufacturing process like grinding or machining, sparks in an exhaust system, or a fire originating in another fuel which progresses to the point where it ignites the metal.

Most metals burn at very high temperatures – much higher than normal Class A or Class B materials. The intense heat generated by these fuels will initially be limited to the area immediately surrounding the fire. Although the flame temperature is very high, the relatively slow progression of the fire may not generate enough heat to operate a heat detector. This will be a problem unless the detector is very close to the fire or until the fire has become so large that damage to the surrounding enclosure or machine is unavoidable.

Extinguishing Method of Dry Powders

Because of the reaction with moisture, use of any water-based fire protection is not permissible. Even the small amounts of moisture associated with Carbon Dioxide, halon, or other clean agents may cause an unacceptable reaction which will intensify the fire. In fact, halon agents may react with some metals, even in the absence of moisture. Standard dry chemicals will not be effective on these fuels either; the heat associated with these fires will consume the agent. Multi-purpose dry chemical may react violently if mixed in the right proportion with some of the metals.

Ansul offers a line of dry powder agents designed to suppress Class D metal fires. These agents include:

MET-L-X®

MET-L-X is composed of a salt base, a polymer for sealing, and other additives to render it free-flowing and cause heat caking, or crusting. It may be used on sodium, potassium, sodium-potassium alloy, and magnesium fires. In addition, it will control and sometimes extinguish small fires on zirconium and titanium.

NA-X®

NA-X is a low chloride (.03% by weight) sodium carbonate based agent. It contains a polymer crusting agent and other additives to make it free flowing and to cause heat caking or crusting. It may be used on sodium, potassium, and sodium-potassium alloy fires. It is a special, low chloride content agent designed to prevent corrosion of stainless steel piping in specific hazards.

LITH-X®

LITH-X is a compound of a special graphite base with additives to render it free-flowing. It does not cake or crust, but excludes air and conducts heat away from the burning mass to extinguish the fire. It was developed for use on lithium fires, and will also extinguish magnesium, sodium, and potassium fires. Lith-X will contain, and in some cases completely extinguish, fires of zirconium, titanium, and sodium-potassium alloy.

Navy 125 S Copper Powder Agent

The Navy 125 S copper powder is a patented copper-based material that was developed in conjunction with the Navy for extinguishment of lithium fires. The free flowing copper particles and the burning mass form an eutectic alloy which excludes air and conducts heat away to suppress the fire. The agent has shown the ability to cling to vertical surfaces to aid in the extinguishment of three-dimensional fires.

Dry powders use a different extinguishing method than do the standard dry chemicals. Instead of breaking the chain reaction to suppress a fire, dry powders smother a fire by forming a barrier between the fuel and the air.

LITH-X agent and the copper powder agent will also act as heat transfer agents helping to cool the fuel below its ignition temperature. Total flood protection is not an option when protecting Class D fuels; the only acceptable method of protection utilizing a fixed nozzle system is local application.

Application of agent to a fire should result in a thick blanket, usually at least 1 in. (25 mm) thick, over the entire surface of the fuel in the vicinity of the fire. To create a 1 in. (25 mm) blanket of agent, the application of agent must be approximately 10 lbs./ft.^{2} (4.5 kg/m^2) of area for most of the dry powders. The copper powder agent will require even more agent. If the hazard is three-dimensional, like a casting, some of the agents (MET-L-X, NAX, and the copper powder agent) will cling to the hot vertical surfaces, and therefore, will not require that the fuel be completely buried. This clinging ability greatly reduces the quantity of agent required. However, the crust created using this method can be broken easily and must be watched carefully with more agent being reapplied as necessary. This method of protection for fixed nozzle, local application is not recommended due to the tenuous nature of the crust.

Dry powders, other than LITH-X and the copper powder agent, tend to trap heat under the blanket of agent. For this reason, it is always important to stand-by and reapply agent as necessary. The blanket of agent may develop a crack which will allow air to pass through to the fuel below, allowing it to continue to burn under the agent blanket. Any time the agent blanket is disturbed, more agent must be applied to maintain at least a 1 in. (25 mm) blanket.

It is very important that overhaul of the hazard be delayed until the fuel has had sufficient time to cool below its ignition temperature. This may require a stand-by of 30 minutes or more to assure that the metal has cooled enough to be removed without re-ignition.

APPLICATION TECHNIQUES

Two methods can accomplish application of dry powders, manual application and fixed nozzle systems.

Manual Application

Manual application of agent can be as simple as scooping agent from a bucket and sprinkling it over the surface of the fuel. Hand portable, wheeled, and hand hose line units can also be used to apply the agent. The units allow a firefighter to maintain a greater distance from the fire and to apply the agent easily to vertical surfaces and other areas that may be difficult to reach with a scoop or shovel.

Manual application allows the firefighter to apply agent only to the area immediately surrounding the fire; agent is not wasted protecting areas not involved in the fire. This will generally require the least amount of agent to protect a given area. To determine the amount of agent required, calculate the area in square feet of the largest amount of fuel anticipated to require protection and multiply the area it will cover by 10 lbs. (4.5 kg) (agent per sq. ft. of protected area) for the standard dry powders. As an example, let's assume a storage room contains 5-gallon pails of magnesium chips. Assuming that one pail would spill, we can calculate the volume of material in the pail as approximately 0.79 ft.^{3} (0.02 m.^{2}) (12 in. (30.5 cm) dia. by 12 in. (30.5 cm) high); and assuming the pail will spill to an average depth of 3 in. (7.6 cm), the spill would cover an area of approximately 3.2 ft.^{2} (0.3 m^2). This example would require 32 lbs. (14.5 kg) of MET-L-X agent which could be supplied from a 50 lb. (22.7 kg) pail or from two 30 lb. (13.6 kg) hand portables. If using the copper powder agent, contact Ansul Distributor Technical Services Department for assistance.

Manual application of agent requires personnel to apply the agent; therefore it is limited to occupied facilities with trained firefighters and access to the hazard area. Due to the slow progression of these types of fires, another approach may be the use of a fire detection and alarm system to identify a fire and manual application to suppress it.

Fixed Nozzle Systems

Fixed nozzle systems provide the advantage of protection when people are not available to manually fight the fire. They can minimize the exposure of personnel to the hazards associated with metal fires such as heat and fumes. Fixed nozzle systems can quickly knock down and control a fire while firefighting personnel don special protective clothing and equipment, such as bunker gear and self-contained breathing apparatus.

Generally a fixed nozzle system will be the most expensive and least effective method for protection of these hazards. Except in special situations, they are limited to the application of a blanket of agent on horizontal surfaces only. Typically these systems will require more agent to protect the same hazard. In many cases, this may be an order of magnitude higher than required by portables. The reason for the large amount of agent is that the system must cover all potential fire areas with a blanket of agent as a fire may ignite anywhere within the protected space. Using our previous example, let's assume the storage room with the 5-gallon pails of magnesium is 10 ft. (3 m) long by 10 ft. (3 m) wide and doesn't include shelves; so, the only protected space is the 100 ft.^{2} (9.3 m^2) floor. The amount of agent required to protect this hazard becomes 1,000 lbs. (453.6 kg) (10 lbs. per ft.^{2}). We not only have the large amount of agent required but also require an engineered piped system to apply the agent.

It is also important to note that fixed nozzle systems can only apply agent to accessible areas. They cannot protect the insides of pails or drums that are covered or tipped over, and cannot protect inside or under pallets and shelves unless additional nozzles are installed to apply agent directly to these areas.

Protection of an exhaust system with a dry powder system is not a practical application. Ducts cannot be protected because the agent will only protect the bottom of the ducts and will not suppress fires on the sides or top. Dust collectors typically cannot be protected due to the numerous surfaces that cannot be covered by agent. However, fixed nozzle dry powder systems have been used to protect only the surface of hoppers under dust collectors.

In most cases, fixed nozzle systems must be considered as fire control systems only and should not be relied on for complete suppression of all fires. As stated previously, the blanket created by the system may crack and allow oxygen to reach the fuel. A firefighter will be needed to assure that all surfaces have been evenly coated and to reapply agent to hot spots after the system has discharged.

Although fixed nozzle systems are limited in their applicability, they may be the best solution where:

- The equipment being protected has a very high value
- Downtime to replace this equipment makes this approach acceptable
- Firefighters are not available to attack a fire
- Access to the hazard area is limited.

Combination Systems

Ansul offers a quick-connect feature for our wheeled extinguishers and large skid mounted units that allows a special nozzle to mate with a fixed piping network. This option provides the advantage of even distribution of agent over the entire area, or manual application for a specific area if the fire is small. This option will also allow discharge of multiple units through the same piping network – in essence allowing a greater supply of agent. Of course, the design parameters for a fixed nozzle system must be met for design of the piping network and nozzle layout.

Design of Fixed Nozzle Systems

Design of fixed nozzle dry powder systems is very different compared to the design of standard dry chemical systems. Agent must not only be applied to specific areas, but must also be evenly dispersed to create a uniform layer over all protected surfaces. Nozzle coverage for these systems is critical and must be understood thoroughly by the system designer. Nozzles must be located to apply the agent evenly over the entire hazard. A thorough hazard analysis is crucial to proper system design. The designer will need detailed information about the fuels, the area, and any obstructions within the area. Fixed nozzle, dry powder, system design is typically performed by the manufacturer.

If Class A or Class B materials will be present, dry chemical, carbon dioxide, or other agent systems may be required in addition to the dry powder system. If multiple systems are employed, care must be taken to determine which system should actuate first, and if one of the system discharges should be delayed. The system designer must take into account any reactions that may take place between these agents and the metals should they become involved in the fire.

Detection and Control Systems

Automatic detection systems for metal fires also create some unique problems for the system designer. Heat detectors may provide an unacceptable delay in detection time due to the limited amount of heat emitted by these fires. Smoke detectors are generally not acceptable for use with dusty materials like dry powders. Flame detectors are costly and require a clear field of vision. In many cases, manual detection of a fire may be the best approach. A brief discussion of the various types of detection along with their advantages and disadvantages follows. This discussion is not intended to cover all aspects of detection system design, only to provide some insight into the special requirements for detection of a metal fire.

Heat Detectors

This method is usually the least expensive for automatic detection of metal fires. They are available in either linear or spot, operating as fixed temperature or rate compensated. Due to the limited amount of heat initially generated by metal fires, a delay may be encountered unless the detector is adjacent to the fire. This usually means that detector spacing must be greatly reduced from that specified by NFPA 72 and the manufacturers of the devices. Ceiling mounted detectors in our example storage room may not detect a fire until the entire room is involved. It is critical to locate the detectors as close as possible to the anticipated site of all fires. Linear detectors may provide better detection because it can be run throughout the hazard, placing it closer to the fire for more rapid detection.

Flame

A flame detection system will usually provide the quickest detection of a fire. A properly designed system will allow the detectors to view all areas of the protected space without obstructions. Since most flame detectors are designed to detect hydrocarbon fires, it is very important to work with the manufacturer to select a detector that will respond to the radiant energy emitted by the anticipated metal fire.

Smoke

Smoke detectors are typically not compatible with dirty environments and dusts which may be associated with cutting and grinding operations, or generated by a dry powder discharge. The dusts from cutting or grinding operations may cause false discharges. If smoke detection is considered, the environment must be carefully evaluated and detailed maintenance procedures implemented. Consultation with the detector manufacturer is an important step in system design.

SUMMARY

Metal fire hazards are becoming more abundant. These hazards present special fire protection problems that must be thoroughly understood by the fire protection designer. The fire suppression properties of the dry powders are very different from the standard dry chemical agents; therefore, special design parameters must be followed when protecting these hazards. Manual application is typically the best method of protection. Fixed nozzle systems are available and may be required depending on the value of the hazard, availability of firefighters, and access to the hazard area. Design of these systems is different from that of standard dry chemical systems. A system designer must be familiar with the special requirements for design of these systems. Typically the manufacturer of the systems performs these designs. Automatic detection may be desired, but is limited in performance. Most systems rely on manual detection and actuation.

Metal fire hazards can be protected as long as the fire protection designer understands the special requirements and is trained to deal with them properly.

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