PRB COAL USERS' GROUP (PRBCUG)

Recommended Practice

COAL BUNKER, HOPPER & SILO

FIRE PROTECTION GUIDELINES

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1.0 INTRODUCTION

Reliance on this guideline without the proper training, equipment and planning is irresponsible. No liability is assumed by the PRB Coal User's Group, its directors, officers or members or The TradeFair Group, Inc. for its use. Proper training, equipment and planning assistance are readily available in the commercial market.

The use of Powder River Basin (PRB) coal for power generation has increased significantly due to its low cost and low sulfur content compared to any other type of coal. Although low in sulfur, PRB coal's intrinsic characteristics contribute to higher levels of dusting, spillage and fires. The vast majority of plants that are burning or converting to PRB coal were not designed to burn or to accommodate the characteristics of this type of coal. The purpose of this guideline is to assist in establishing safe operating practices that efficiently and effectively controls and extinguishes fires and minimizes impact on plant assets for fires that ignite in coal bunkers, coal hoppers, or silos.

It is recognized that not all plants are prepared to deal with fire through the use of an on-site structural fire brigade. The term fire brigade, as used herein, refers to either an incipient or structural brigade. In either case, the plant must ensure that employees receive training commensurate with the hazards they are expected to confront.

2.0 SCOPE

This guideline is recommended for all fossil fuel plants burning or converting to PRB coal in blended or pure amounts. It is recognized that coal-handling facilities can vary significantly in physical layout. All bunker fires are different and must be dealt with individually. There is no one procedure that can be used to deal with the varying circumstances that can be encountered in bunker/silo fires. The information presented in this guideline is to be used to assist the efforts in fighting a bunker fire. However, no matter the bunker/silo design, the fundamental principals and equipment are the same. This guideline may be adapted to fit the needs of most plants.

The scope of the guideline provides information in three important areas:

- Fire Prevention & Detection
- Fire Fighting Equipment & Training
- Fire Fighting Techniques

3.0 FIRE PREVENTION AND DETECTION

The prevention of fire and explosion is the foremost objective while utilizing PRB coal. Prevention can be accomplished through the following:

3.1 Housekeeping

With reference to PRB coal, housekeeping means dust control and spillage mitigation. Float dust must be contained within transfer points. Spillage from belts must be minimized. The accumulation of PRB coal below a conveyor or on conveyor parts can contribute to spontaneous combustion. Float dust in the air and that which has settled on beams, pipes, conduits, equipment and fixtures can provide fuel for explosions. Manual daily wash down with hose streams is beneficial but generally is not totally effective in removing PRB coal debris

from under conveyors or from the overhead. Greater effectiveness can be obtained with good training and close, continuous follow-up attention.

Fixed wash down systems designed for 100% wash down coverage are commercially available. Fixed wash down systems greatly reduce labor costs and significantly improve housekeeping over manual wash down. Plants that have installed these systems report satisfaction with their performance.

3.2 Preplanning

For planned outages, the plant should take every precaution to ensure that all bunkers and silos that will become idle during the outage are emptied of coal. Bunkers and silos should be thoroughly cleaned by wash down of the interior walls and any interior structural members. Coal should not be allowed to remain on horizontal surfaces. It is recommended that a micelle-encapsulating agent be used in conjunction with water during the wash down.

Idle bunkers and silos that contain PRB coal should be monitored frequently for signs of spontaneous combustion. Monitoring can be accomplished with installed carbon monoxide monitors, infrared scanning or temperature scanning. Do not rely on visual or olfactory signs of combustion. By the time one sees or smells burning coal, the fire is underway.

Some plants have implemented the practice of inerting a bunker/silo of PRB coal with carbon dioxide (CO_2) when the enclosure is expected to sit idle for any reason. CO_2 acts as an oxygen displacer and helps prevent the spontaneous combustion process. In order for this to be effective, the enclosure must be made tight to prevent the escape of gas especially through the bottom cone since CO_2 is approximately 1.5 times heavier than air. The amount of gas needed to effectively inert the enclosure approximates 3.3 lbs per ft^3. (For example, a silo measuring 22' in diameter x 55' in height would require 3.2 tons of carbon dioxide). This would require a bulk supply of CO_2 and an extensive piping system for bunkers/silos that already do not have this type of system in place.

3.3 Bunker and Silo Design

It should be noted that an active bunker or silo should not experience a fire under normal operating conditions. If fires occur while the bunker is actively moving coal, the bunker may contain some design irregularities that are contributing to coal hang up. It has been known for PRB coal to harbor within cracked weld joints and spontaneously combust. Elimination of horizontal surfaces within the bunker or silo will greatly reduce the chances of stagnating coal.

It is recognized that bunkers and silos can be constructed differently from plant to plant. However, the most important aspect of fire prevention, no matter the design or the age of the equipment, is that mass flow of PRB coal be obtained. This will require the elimination of flat bottoms in bunkers and obtaining free flow through bottom cones. It is recommended that if mass flow is unattainable in existing equipment, evaluation of the cone's lining should be performed.

Access to the interior of bunkers and silos for fire fighting is one of the most important aspects of successful fire suppression and one of the most difficult to obtain. Ease of access is most often severely limited. For this reason, it is highly recommended that the plant preplan how access will be achieved. This may require the installation of access ports around the bunker/silo and at various levels. Silos that are greater than 50' in height should be provided with access ports at various points along the length to accommodate agent injection. The specific location of these ports must be determined after analysis of the silo's design. Although direct attack of a fire using a piercing rod is most effective, in all practicality using a rod for a fire in silos greater than 55' in height is extremely cumbersome. Consideration may have to be

given to installing a fixed hazard mitigation system, zoned for application of agent only at levels deemed to be involved with fire. Infrared thermography must be used to locate the fire so as to determine the zone that should be activated. Providing this access will save valuable time during emergency operations.

When raw coal is loaded into a bunker or silo, size segregation tends to occur. Large chunks of coal tend to roll out to the periphery of the bin, while the smaller chunks and fines stay in the center. This size segregation facilitates air migration up along the sides of the bunker/silo. It also presents a practical fire fighting challenge when using water applied from above, which will tend to "rat-hole" through the voids and can bypass the seat of the fire.

3.4 Fire and Gas Detection

A major consideration for minimizing the impact of fire is to install, in order of preference, gas or temperature monitoring devices in the bunkers and silos.

- CO Monitoring: Monitoring for carbon monoxide (CO) provides the very earliest warning of impending combustion activity. Carbon monoxide is a toxic gas, undetectable by humans, liberated at the very early stages of incomplete combustion, even before any smoke or odor of burning is detectable by a human. CO is flammable at 12-75% volume in air (The OSHA PEL for CO is 35 ppm, 8 hour TWA). While it may be normal to experience a rise and fall of background levels of CO in bunkers and silos during normal operation, monitoring will provide notification if the gas begins to continually trend upward from background levels. Desired alarm set points can be determined after the normal background level of CO is determined. The significance of CO monitoring is to watch for a continuing upward trend of CO, not necessarily waiting for CO to reach a specific set point.

- Thermal (Heat) Monitoring: Thermal detection, through the use of thermocouples, can also provide an indication of fire inside a bunker or silo. However, thermal detection will not provide the early warning that comes with CO monitoring. Thermal detection relies on the presence of heat to activate and thus a fire may be of considerable size before the thermal detector senses the excess heat.

- Infrared Scanning: Coal is a very good insulator so a deep-seated fire may not produce extremely high temperatures on the exterior surfaces of the silo/bunker. Periodic monitoring of the bunker or silo may be accomplished by using an infrared thermographic camera to scan the outside and/or inside of the enclosure. The scan will provide a visual picture of the thermal condition of the coal. This is especially helpful and may be the only way in pointing the exact location of a hot spot deep under the coal's surface.

- Methane Monitoring: Methane gas is a flammable gas that can be liberated from freshly processed coals and is not a product of the combustion process. Methane is most prevalent in coal mined from underground. PRB is surface mined and is less subject to methane production. The presence of methane does not indicate that combustion is present. It does indicate the possibility that an explosive atmosphere could develop due to the gas itself. Some plants that were originally designed for non-PRB coals may have methane monitors already installed and may be left in service. The maximum safe level of methane is 10% of the LEL.

4.0 FIRE PROTECTION EQUIPMENT & TRAINING

Dealing with a fire inside a bunker or silo is a dangerous undertaking that must be approached with the correct equipment and training. No matter the situation, the basics of dealing with the fire remain the same. However, the manner in which that attack is carried out will have a bearing on the length of time it will take to extinguish the fire. There are two recommended methods of fire extinguishment: using a fixed system installed inside the enclosure and/or using a special tool called a piercing rod. Experience indicates that the very best method of attack generally is by getting the extinguishing agent directly to the seat of the fire. Although time is of the essence in dealing with the fire, there is usually time to deal with it in a planned and effective manner without an extreme sense of urgency.

4.1 Fixed Hazard Mitigation System

A fixed (permanent) system installed inside a bunker or silo must be designed specifically for that enclosure. The system is actually not a fire suppression system per se. The system is a hybrid system that can be activated for dust control and housekeeping or it can be activated to deliver extinguishing agent in the event of fire until manual fire fighting action can take place. The problem with this system, in dealing with a fire, is that the entire contents of the enclosure may be subjected to the agent in an attempt to reach the hot spot. Because of their relatively narrow diameter, systems for silos greater than 55' in height should be zoned such that extinguishing agent can be directed to the section of the silo involved with fire. This may mean activating a zone discharge at the next level above the fire. In very rare circumstances should the entire silo have to be treated. Flooding the contents may or may not be acceptable to the plant. Although the system can deliver water only, it is recommended that the system deliver a micelle-encapsulating agent mixed with the water

4.2 Manual Fire Fighting Tools

Experience has shown that the best method of extinguishing a fire is to get the agent directly to the seat of the fire. To do this, one must know the location of the fire within the enclosure, have access to the enclosure and have the proper tools to deliver the agent. One such tool is a piercing rod. There are several rods on the commercial market that will work. The rods are designed to pierce the surface of the coal and to be manually maneuvered to the hot spot. The benefit of the rod technique is that it can be used to inert the bunker or silo atmosphere by spraying the sides and the surface of the coal with agent prior to entering the coal The rod's length can be varied with the use of 5 foot long extensions. However, the longer the rod, the less easy it is to maneuver inside the enclosure. The rod can be injected through the top or the sides of the enclosure (through pre-installed access ports).

The use of manual fire hose streams through the top of the bunker or silo is not recommended. The use of a straight fire hose stream to "drill" into the coal in an attempt to reach the fire absolutely should be avoided. This technique most likely will stir up the coal and dust and result in a flash explosion inside the bunker or silo. A secondary explosion can also occur outside the enclosure as the heat ignites float dust in the air.

4.3 Fire Extinguishing Agents

There are several extinguishing agents that have been used on coal fires. The table below indicates the extinguishing properties of the various agents.

Extinguishing Agent	Slow Penetration	Mechanical Blanket (air exclusion) NFPA 1151 for Class A Foams; NFPA 11/UL 162 for Class B Foams	Fast Penetrant (surface tension reduction) NFPA 18	Fuel Molecule Encapsulator No current NFPA or UL index test	Free Radical Interruptor No current NFPA or UL index test
Water	X				
Wetting Agent			X		
Foams		X	X		
Micelle Encapsulator			X	X	X

4.3.1 Water: Water forms the basis of an effective attack on PRB coal fires. However, water alone is not recommended. The surface tension of water does not allow it to penetrate deep below the coal's surface to reach the fire unless vast quantities are injected. Vast quantities of water inside a bunker or silo will ruin the coal inventory and may place additional loading on the structural.

4.3.2 Wetting Agent: Wetting agents have one function and that is to allow water to penetrate Class A material by reducing the surface tension of the water. The extinguishing effect is by cooling.

4.3.3 Foams: Foams contain a wetting agent component that acts as the carrier of the foam. The primary function of foams is to blanket the fuel's surface, thereby reducing oxygen availability. Foams are not very effective on coal fires due to the length of time it takes to suppress a coal fire by oxygen exclusion. Foams can be effective in excluding air from above the surface if the blanket is maintained. Mechanical foams also tend to breakdown and dissipate before extinguishment is accomplished. Deep seated Class A fires cannot be effectively extinguished with foams. Foams that pass the UL Fire Performance Criteria are Class B. Foams that do not pass the test are classified as Class A and do meet any usage criteria other than the manufacturers own recommendations.

4.3.4 Micelle-Encapsulating Agents: These agents, when used with water, are the extinguishing media of choice for PRB coal fires and for flammable liquids fires (Class A and B fires). These agents possess three significant suppression mechanics:

- Surface Tension Reduction: They reduce the surface tension of water from 72 dynes/cm^2 to less than 30 dynes/cm^2. This action provides up a 1000% increase in the wetted area as compared to using water alone.

- Micelle Formation: On Class B fires, these agents encapsulate both the liquid and vapor phase molecules of the fuel and immediately render them non-flammable.

- Free Radical Interruption: Interrupts the free radical chain reaction of the fire tetrahedron.

These agents are governed by NFPA 18 and are listed for both Class A and Class B usage. These agents can be used effectively on coal fires at concentrations of .5% to 1%.

4.3.5 Other Agents: The use of gaseous agents such as carbon dioxide and nitrogen has been tried but are not effective for rapid extinguishment due to poor cooling capacities and general lack of ability to hold the gas at proper concentration levels in bunkers and silos. Effective use of these agents requires an extended operation of hours to days depending on the quantity of coal and complexity of the fire. Independent testing has shown that the effectiveness of these gases is highly impacted by fuel geometry, fire stage, enclosure tightness, and application duration. These are not things one should have to be worried about during an emergency.

This document recommends the use of a micelle-encapsulating agent as the overall agent of choice for use in the power plant environment.

4.4 Fire Training

4.4.1 Plant Personnel: This guideline is NOT a substitute for formal and proper training in industrial fire fighting, including techniques, equipment and safe practices. Any person or entity that engages or intends to engage in fire fighting based on this guideline must first receive training consistent with the definition of fire brigade training specified by the Occupational Safety & Health Administration (OSHA 1910.156, Fire Brigade Standard).

Absolutely no attack on a bunker or silo fire should be attempted by plant personnel, without them first having been properly trained. Personnel who have been trained at the structural fire brigade level should have the basic knowledge needed. Personnel who have been trained at the incipient fire brigade level or less do not posses the required knowledge. Even though the plant may not have a structural fire brigade, any person can be trained solely to combat bunker or silo fires. The key is for personnel to be properly trained for the hazards which they are expected to confront. Specialized training for bunker and silo fire fighting is readily available from several sources. Bunker and silo fire suppression services are also available from several sources. Municipal utilities that may be exempt from complying with OSHA training regulations should not use the exempt status to avoid proper training.

4.4.2 Outside Fire Department: Some plants may rely upon the services of its local fire department for fire fighting. However, be cautioned that most municipal fire departments are themselves not prepared with the knowledge and training required for dealing with the hazards found within a power plant. The vast majority of professional and volunteer fire departments are well trained for commercial and residential structural fires. Many are less trained for heavy industrial fires and most have no idea of the hazards found inside a power plant. If your local fire department does not know about PRB coal, they are not prepared to fight a fire without additional knowledge and training. It is strongly recommended that the plant sponsor specialized training for the local fire departments on the specifics of PRB coal and other major hazards found within the plant (high pressure, high speed rotation and high voltage equipment and processes). These types of hazards are not found in other facilities and are rarely taught in fire department training. Local fire departments should carry out practice drills on the plant site to simulate actual response conditions. Annual “walk throughs” do NOT adequately prepare them for handling on-site emergencies. Specialized training and orientation for fire departments is readily available through outside consultants.

5.0 FIRE FIGHTING

If the plant does not maintain properly trained and equipped personnel to deal with the hazards as described herein, no attempt should be made to attack the fire. Instead, the plant should call upon the services of its local fire department.

5.1 Fire Fighting Equipment

While fire hose and hand line nozzles are the staple of most fire fighting techniques, this equipment is not adequate when it comes to safely and effectively dealing with fire inside a bunker or silo. The basic equipment preferred and referred to in this guideline include fire hose, a piercing rod, micelle-encapsulating agent, and an infrared camera. All fire suppression operations should be supported with the proper personal protective equipment.

A piercing rod is a specialized tool that enables direct application of extinguishing agent to the seat of the fire. A rod may be purchased from one of several vendors or a rod can be fabricated by the plant machine shop. Rods are generally made of stainless steel and come in several diameters (3/4", 1¼", 1½"). The length of the rod is determined by the number of 5' sections that are added in order to reach the fire. The tip of the rod is perforated and cone shaped to allow easy insertion deep into the coal. Rods may be used in vertical or horizontal positions. All extinguishing agent is delivered through the tip in a spray pattern. Because of the spray pattern, the tip of the rod can also be used to wash down the inside of the bunker or silo and to provide direct application of the agent to the surface of the coal. A rod, purchased on the market, can range from $5,000-$7,000 depending on the diameter and length desired.

5.2 Roles and Responsibilities

Plant Employees

Any employee who identifies a fire shall immediately report the situation in accordance with the plant's fire reporting procedure. All personnel that are not qualified Fire Brigade Members and not in proper protective equipment shall remain away from the fire scene

Employees who are not currently qualified Fire Brigade Members may be utilized, as directed by the Fire Brigade Leader, for support of Fire Brigade activities away from the area which may present danger to those not adequately protected or trained.

Fire Brigade Leader

The Fire Brigade or Fire Team Leader may utilize this document as a guideline to extinguishing fires that ignite in coal bunkers, coal hoppers, or silos. The Leader must make adjustments for actual site conditions before and during the fire suppression activities as necessary to protect fire brigade members, other personnel, and the facility. Only currently qualified Fire Brigade Members shall be used in suppression activities.

Fire Brigade Team Members

Take the necessary steps to extinguishing fires that ignite in coal bunkers, coal hoppers, or silos while taking into consideration the safety of fire brigade members, other personnel, and the facility.

Outside Fire Department

Local fire departments MUST be trained for this fire suppression operation before they are allowed to actively participate. An untrained fire fighter is just as much at risk as an untrained plant employee when it comes to this operation. Plant management must ensure that fire department personnel are accompanied at all times by experienced plant personnel.

5.3 Instructions

Immediate response is required when the odor of coal roasting or burning is necessary to control Coal Bunker, Hopper, and Or Silo Fires. Delay in taking action only allows the rate of burning to increase and require additional effort to control or suppress the fire later on.

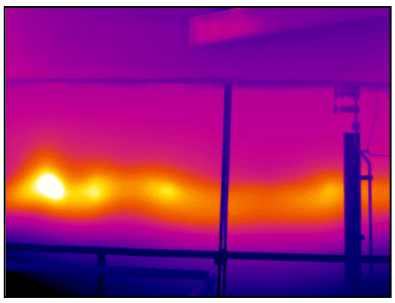
Coal fires are recommended to be extinguished using a 0.5-1.0% concentration application rate of Micelle-Encapsulator Fire Suppressant. A rate of up to 3% concentration may be used if desired. Most coal bunker fires are fought from the top of the bunker. As a general rule, it is not recommended to attack the fire from the bottom of the cone to try to extinguish a coal bunker fire that is located in the upper areas of the enclosure. This procedure could lead to a coal dust explosion. If the fire has been located in the cone and there is access to the fire via the cone, then it may make sense to attack at this level.

Usually the most readily available water supply will be from the plant or building standpipe system.

5.3.1 Step 1: Develop an Action Plan

A. When an indication of burning coal is detected, it should be investigated immediately. Unless the fire has been allowed to burn unchecked for a period of time, there is usually sufficient time to locate the fire and develop a strategy for extinguishment.

B. Perform a heat survey of the fire area with whatever heat sensing equipment is available (in order of preference: Thermal imaging camera, laser thermometer or other thermal detection device) and map to show fire location and intensity. Use of a laser pyrometer or thermal imaging camera will greatly improve the ability to quickly locate the seat of the fire. The picture at right is of an actual silo fire taken with a thermal infrared camera. The picture clearly shows the fire, indicated by the lightest colors. The fire “seam” is located along a weld joint around the circumference of the silo and is approximately 5’ in depth. This fire is approximately 12’ down from the surface of the coal.



C. Map coal bunker, hopper, or silo fire area and plot temperatures to determine location and intensity of fire. Some high-end thermal cameras are equipped with software that will produce thermographic images with temperatures correctly plotted on the image.

D. When it has been established that there is combustion in the enclosure, all coal moving activities (feeding and emptying of the effected bunker or silo) should be immediately suspended in order to analyze the temperature map and develop an action plan. Be sure all sources that could introduce fines to the bunker/silo have been deactivated. This includes baghouse returns, pneumatic conveying systems, screw conveyors, cyclone separators, airlock feeders, dribble chutes and belt scrapers.

E. Once the fire is located, determine the location of access points to the bunker or silo that will accommodate fire-fighting activities.

F. It is NOT recommended to run burning PRB coal through the feeders and mills. This procedure places the plant, equipment and employees in jeopardy due to the possibility of explosion.

G. It is NOT recommended to attempt smothering the fire with a layer of fresh coal. Attempting to run burning coal out of the silo/bunker could lead to an explosion in the feeder or in the mill if coal flow is interrupted. Deal with the fire before running or adding coal.

5.3.2 Step 2: Prepare The Area

Once an action plan has been developed, preparation for actual fire fighting activities should include the following:

A. **Neutralize Dusting**: It is recommended that the immediate area above the bunker or silo in the Tripper/Cascade Room be washed down prior to attacking the fire to prevent a possible coal dust explosion. Once attack of the fire begins, it is very possible for the burning area to collapse upon itself and create a blowback through the top of the bunker or silo. This blowback can ignite float dust that has settled on beams and other items in the tripper or cascade room. This step is optional and should be based on an informed decision by plant management as to float dust conditions.

B **Ventilation:** Begin gravity ventilation of the tripper or cascade room if possible Open overhead hatches or doors leading to the exterior of the plant. Do not open fire doors to the plant interior. Once the fire is attacked, smoke and steam will escape from the bunker or silo and will need to be ventilated to the exterior. Use of the affected bunker/silo dust collector during the fire may cause a fire or explosion in the dust collector. The dust collector can also act as a draft inducer, pulling air up through the bottom of the enclosure. Smoke can be removed by fogging the headspace with a micelle-encapsulating agent. The agent will act as a scrubber and increase visibility.

Test the atmosphere in the bunker/silo headspace if possible to determine the levels of CO. Remember that CO is explosive in the range of 12%-74% by volume in air.

C. **Stage Equipment**: Stage all equipment to the location where the fire attack will take place. Assemble the piercing rod at the bunker/silo access location.

- Stage at least five (5) 5-gallon pails of micelle-encapsulating agent at the rod's location. This amount of agent may not be needed but it is better to have too much than not enough on hand.

- Connect one 1 ½" hose to a fire hose standpipe system or service water outlet and add sections as needed, with a maximum or 150 feet of hose (less is better), to reach the area where the rod will be used.

- It is important to use less than or equal to 150 of hose between the eductor and the nozzle (less is better at that elevation). Match the flows of the eductor and nozzle. Do not connect the eductor directly to a valve or appliance. The eductor and applicator must be on the same elevation.

D. Monitor temperature every 30 minutes. Continue to monitor for the location of the hottest point of fire.

E. Set up fire brigade teams of at least two. If the fire is to be attacked from a location different than the tripper/cascade room, it is recommended to place two people in the room to monitor the effluent from the fire fighting operations. A spotter should

also be stationed at the bottom of the bunker/silo outlet. These people must have two-way communications with the fire fighting team leader at all times.

F. Wear total Personal Protective Equipment as required for fire fighting when in bunker, hopper, or silo room or near areas which contain heat, smoke, or toxic gases.

5.3.3 Step 3: Fire Extinguishment

A. Prior to injection to the seat of the fire, it may be helpful to use a fog pattern from the rod or from a fire nozzle to apply agent to the surface of the coal and to wash the sides of the enclosure as much as possible. This process will allow an immediate reduction in the explosive hazard that may be created by coal dust liberated from the enclosure when injection begins. When water is introduced into the enclosure, there could be a "blowback" reaction of flaring of volatiles. This does not always happen but be prepared for it to happen. CAUTION: Always use a fog pattern, not a straight stream, to avoid dust explosion potential. (Consider using a cellar nozzle, if available, to wash down the inside top and sides of the silo as this will provide approximately 360 degrees of coverage. The cellar nozzle can be attached to the end of a 1-inch fire hose and lowered into the silo.)

B. With the rod flowing agent, insert the piercing rod through an opening, which provides the most direct access to the hottest part of the fire area as determined by use of the heat-sensing device.

C. The piercing rod may have to be angled toward the fire depending on the location of the access hole and the hottest part of the fire. Some trial and error of rod positioning may be required.

D. Continue to work the rod into the hot spots until fire is extinguished.

E. Teamwork between the pyrometer/imager operator and the nozzleman should be used to intermittently identify the hot spots and complete the extinguishment.

F. Care should be taken to prevent the introduction of excessive amounts of water to the bunker. Large water flows will result in coal sludge accumulating in the bottom cone of the bunker, hopper, or silo and may block all coal flow or render pulverizers, ball mills, coal scales inoperable.

G. Teamwork between the nozzleman and a spotter near the bottom of the hopper outlet (located at a safe distance) should be used to intermittently identify the amount of water being discharged from the hopper.

H. During the injection of agent into the hot spot, expect a large amount of smoke to be liberated through the top of the enclosure. As the fire is extinguished, the smoke should gradually change to mostly steam. When it appears that neither smoke nor steam is being liberated, halt injection and scan for temperature.

I. Monitor the temperature of the fire area every 15 minutes for the next hour. If the temperature continues to decline, the plant should make plans to empty the bunker/silo contents as soon as possible.

J. If the temperature begins to rise, the extinguishing procedure should be repeated.

6.0 REFERENCES

1. Taamisaar, M., Baroudi, D., Latva, R,. *Extinguishing Smoldering Fires In Silos*, Brandforsk Project 745-961, Technical Research Center of Finland, 1998, 74p.

2. The PRB Coal Users' Group recognizes the assistance of the following for their technical peer review of this document: Ed Douberly, The Utility FPE Group, Inc.; Eric Dorbeck, Consumers Energy; John Ritter, PacifiCorp; Jim Beller, AEP; Norm Rockwell, TVA, Jim Coco, Marsh, Inc. C. E. Wilson, Southern Company.

3. OSHA Fire Brigade Standard, 29 CFR 1910.156.

APPENDIX

A. Coal Bunker, Hopper, Or Silo Fires Prejob Briefing Checklist

B. Coal Bunker, Hopper, Or Silo Fires Job Safety Analysis Sheet

NOTE 1: Since coal fired generating plants are built in a wide variety of configurations, more detailed preplanning than is outlined here will be required to properly prepare for a coal bunker fire at each specific facility. Plants needing additional assistance in training and planning for bunker/silo fires should contact their corporate fire protection engineer or an experienced utility fire protection consultant.

NOTE 2: For ease of reference, the following are statements from OSHA interpretation letters regarding fire brigades:

- An Incipient Fire is a "*fire which is in the initial or beginning stage and which can be controlled or extinguished by portable fire extinguishers, Class II standpipe or small hose systems without the need for protective clothing or breathing apparatus*."
- "*incipient stage fire brigade members are not to enter environments such as smoke-filled and toxic-filled environments where protective clothing or breathing apparatus are required*."
- "…*Incipient stage members would be infringing on the guidelines for an interior structural fire brigade by engaging in search and rescue activities*…"
- "*It would not be appropriate for members of an incipient fire brigade to lead fire department personnel trained in emergency operations into smoke or toxic filled areas."*
- *"an incipient stage brigade member, fully trained on the proper use of a SCBA and other confined space entry and rescue procedures, may participate in confined space rescues. The need for protective clothing must be based on specific factors associated with the rescue itself."*
- *"OSHA requires under 1910.156(b) that the employer prepare and maintain a written policy that addresses many of the issues listed above. This organizational statement or policy must address the existence of the brigade, its structure, its training requirements, and its work functions"*

Bunker and silo fire situations can be either an incipient or structural fire condition depending on the nature and extent of the fire. Any plant that does not maintain a fire brigade, incipient or structural, is advised to confer with a utility fire protection engineer before conducting fire fighting operations. In addition, National Fire Protection Association (NFPA) 1500, **Standard on Fire Department Occupational Safety and Health Program,** requires that brigade members and fire department members be "provided with training and education appropriate for the duties and responsibilities before being permitted to be engaged in emergency operations."

APPENDIX A
PREJOB BRIEFING CHECKLIST

This checklist is intended to aid supervisors in conducting and documenting effective prejob briefings.

Work To Be Performed: Coal Bunker and Silo Fire Fighting

Pre-job Briefing Considerations:

	Yes	No
• Have hazards associated with this job been identified and discussed?	☐	☐
• Have special precautions to minimize or eliminate these hazards been discussed?	☐	☐
• Have applicable safety, maintenance, or operations work procedures to be followed been discussed?	☐	☐
• Has the process for clearing equipment, machines, or circuits of hazardous energy (if applicable) been discussed?	☐	☐
• Have personal protective equipment requirements been discussed?	☐	☐

NOTE: If normally energized parts will be exposed to contact by an employee while a machine or equipment is de-energized, a test shall be performed to ensure that these parts are de-energized
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Supervisor's Signature: _____ Date: _____

APPENDIX B
JOB SAFETY ANALYSIS WORKSHEET

No.:	Job: **Coal Bunker and Hopper Fire Fighting**		Date:
Section:	Skills Required: QUALIFIED Fire Brigade Member or Leader Trained	Analysis By:	Reviewed by:

Required Personal Protective Equipment:

Bunker Coat, Bunker Boots, Helmet, Gloves, Protective Hood, Self Contained Breathing Apparatus,

Tools & Equipment Required:

1) 1 - 95 gpm in-line eductor 2) minimum of 200 feet of 1 ½" fire hose 3) 40 - 50 gallons of Micelle Encapsulator Fire Suppressant 4) 2 Fire Department style fog nozzles, 95 gpm 5) Fire fighting piercing rod (FFPR) with in-line eductor, 6) FFPR extensions 7) laser pyrometer or thermal imaging camera

Job Preparation:

1) Pre job safety briefing
2) Since coal fired generating plants are built in a wide variety of configurations, more detailed preplanning than is outlined here may be required to properly prepare for a coal bunker fire at each specific facility.
3) Heat survey of fire area with Laser thermometer or Thermal imaging camera and mapping to show fire location and intensity
4) 360 degree survey of entire fire area and enclosure to assure no unknown facts
5) Barricade off area above and below Coal bunker or hopper to protect other personnel from entering area
6) Assignment of only personnel who are currently trained as Fire Brigade Members or Leaders to perform fire-fighting tasks.

Hazardous Materials:	Special Requirements:
None`	None

Sequence of Basic Job Steps	**Potential Accidents or Hazards**	**Recommended Safe Job Procedures**
Odor of burning coal	• Coal has a unique odor as it heats. Often you can smell this odor before outright ignition takes place. This is a call to action.	• If you smell the odor of coal roasting or burning investigate immediately
Heat survey of fire area with Laser thermometer or Thermal imaging camera and mapping to show fire location and intensity	• Locating the seat of the coal bunker hopper, or silo fire can be difficult..	• Work in team of 2. Wear total Personal Protective Equipment as required for fire fighting when in bunker, hopper, or silo room or near areas which contain heat, smoke, or toxic gases
Map coal bunker, hopper, or silo or fire area and plot temperatures to determine location of fire	• The fire may be located many feet below the surface of the coal, the bunker, hopper, or silo and bunker room may be filled with smoke, or bunker may be obstructed by numerous steel cross beams	• Use of a laser pyrometer or thermal imaging camera will greatly improve the ability to quickly locate the seat of the fire.

APPENDIX B

JOB SAFETY ANALYSIS WORKSHEET

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Sequence of Basic Job Steps	Potential Accidents or Hazards	Recommended Safe Job Procedures
Temperature Trends	• Upward trends • Downward trends	• demands immediate action (see below) • require close monitoring (see below)
Analyze Temperature Map and Develop Action Plan Note: Temperatures given here are for relative reference only. It must be recognized that temperatures can and do vary significantly with different facilities and with the seasons.	• Coals with a temperature of 85 deg F or less that are trending stable or declining in temperature are generally not going to self-heat to ignition	• Routine monitoring of temperature every 1 hour
	• Potential exists for personnel injury when a fire is burning in a bunker, hopper, or silo.	• Begin to wash down bunker room or area above hopper
	• When temperatures are between 100 deg F and 120 deg F, one should rapidly react to the temperature trend.	• Monitor temperature every 30 minutes • Locate hottest point of fire • Setup to begin application of agent per procedure.
	• Coals that are 120 deg F and above need immediate attention.	• Monitor temperature every 15 minutes • Locate hottest point of fire • Setup to begin application of agent per procedure.

APPENDIX B
JOB SAFETY ANALYSIS WORKSHEET

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Sequence of Basic Job Steps	Potential Accidents or Hazards	Recommended Safe Job Procedures
Wash down the Tripper Room with 0.5-3% agent solution prior to extinguishment procedures to prevent a possible coal dust explosion	• Slipping, falling, heat, smoke, or toxic gases electrical shock **Caution: Always use a fog pattern NOT a straight stream to avoid dust explosion potential.**	• Work in teams of 2. Wear Personal Protective Equipment Wear total Personal Protective Equipment as required for fire fighting when in bunker room or near areas which contain heat, smoke, or toxic gases. • De-energize any non-water proof electrical equipment or circuits • Prepare a safety back-up fire hose line
• Working around open bunkers, coal hoppers, or silos.	• Potential hazard of falling into or partially into openings	• When working around open bunkers, coal hoppers, or silos it is essential to take precautions such as the proper use of safety belts and lanyards to prevent personnel from falling into openings.
• Fire Fighting Prepare a safety back-up line; one 1 ½" hose connected directly to the standpipe system with Fire Department style fog nozzle., 95 gpm. Prepare the agent attack line; one 1 ½" hose connected to a fire hose off of the standpipe system, with a maximum or 150' feet of hose (less is better) should be between the eductor and nozzle, -1 ½" 95 gpm in-line eductor and Fire Department style fog nozzle. 95 gpm Locate 40 - 50 gallon of agent so that the pick up tube from the eductor can be easily placed in the agent container.	• Heat, flashback, steam/ dust /methane explosion hazard to firefighting personnel • Slipping, falling, heat, smoke, or toxic gases • Back injuries handling 5 gallon containers	• Work in teams of 2. Wear total Personal Protective Equipment as required for fire fighting when in bunker room or near areas which contain heat, smoke, or toxic gases **Note:** **It is important to use less than or equal to 150' of hose between the eductor and the nozzle (less is better at that elevation) match the flows of the eductor and nozzle, don't connect the eductor directly to a valve or appliance and the eductor and applicator must be on the same elevation.** • Use proper lifting techniques and move containers with carts whenever possible

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JOB SAFETY ANALYSIS WORKSHEET

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Sequence of Basic Job Steps	Potential Accidents or Hazards	Recommended Safe Job Procedures
• Point Of agent Application	• Coal dust explosion and burns from hot water rundown	• Never attack the fire from the bottom of the bunker or hopper to try to extinguish a coal fire. This procedure could lead to a coal dust explosion • Most coal bunker, hopper, or silo fires are fought from the top of the bunker or hopper.
• Percent of agent Application	• Introduction of too much water to bunker or hopper • Not using enough to extinguish fire	• Coal fires are also recommended to be extinguished using a concentration rate of between 0.5-3%. A smaller rate will introduce more water into the enclosure than a 3% rate.
• Handling micelle encapsulating agent liquid concentrate	• .Skin and eye irritation	• These agents are non-corrosive, non-hazardous, synthetic concentrates for use by dilution with water in firefighting equipment, fixed or mobile systems. But, as with all chemicals, protective equipment is recommended such as eye protection, gloves, etc. As with all concentrates, rinse thoroughly with water if spilled

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Sequence of Basic Job Steps	Potential Accidents or Hazards	Recommended Safe Job Procedures
Apply agent to fire area	• Heat, flashback, steam/ dust /methane explosion hazard to firefighting personnel	• Once the seat of the fire has been located, it is recommended use of a fog pattern to apply agent, which will allow an immediate reduction in the explosive hazard created by coal dust.
	• Deep Seated Fire, area obstructed by numerous steel crossbeams.	• Once the fire area has been thoroughly covered using a fog pattern, the water stream should be tightened to a straight stream to facilitate penetration to the seat of the fire.
	• Hot Steel	• The 30-degree fog stream should also be used to cool the interior steel work of the bunker or hopper.
	• Bridging, ratholeing of coal due to burning coal undermining the allowing a hard top crust of coal to form blocking the agent from reaching seat of fire	• Insert a fire fighting Fire Fighting Piercing Rod through an opening in the top of the bunker or hopper directly into the hottest part of the fire area as determined by use of a Laser thermometer or Thermal imaging camera. • The rod may have to be angled toward the fire depending on the location of the access hole and the hottest part of the fire. • Continue to work the rod into the hot spots until fire is extinguished

APPENDIX B
JOB SAFETY ANALYSIS WORKSHEET

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Sequence of Basic Job Steps	Potential Accidents or Hazards	Recommended Safe Job Procedures
	• There may be hot spots fire may be located many feet below the surface of the coal, the bunker, hopper, or silo and bunker room may be filled with smoke, or the bunker, hopper, or silo may be obstructed by numerous steel cross beams. • Large water flows will result in coal sludge accumulating in the bottom of the hopper of the bunker, and may make emptying the bunker, hopper, or silo difficult or render coal scales, pulverizes, and other equipment below the hopper inoperable	• Teamwork between the pyrometer/imager operator and the nozzleman should be used to intermittently identify the hot spots and complete the extinguishment • Care should be taken to prevent the introduction of excessive amounts of water to the bunker or hopper. • Teamwork between the nozzleman and a spotter near the bottom of the hopper outlet (located at a safe distance) should be used to intermittently identify the amount of water being discharged from the hopper I