Coal Fire Risk

Introduction

Bulk storage of any combustible materials leads to fire risk in many large storage areas such as waste bunkers, wood or paper stockpiles and coal storage yards.

Self-ignition usually starts within the bottom layers of a stockpile as a result of temperature increases in the material. Continuous monitoring of the surface layers enables a fast location of hot spots rapid response to coal fires at initial stage.

It is obvious and well proven that coal fire fighting at the initial stage increases the probability to control and extinguish the fire it with low effort.

The fires usually start as 'hot spots' in the coal accumulation. These are places where the generated heat cannot be dissipated efficiently while there is still enough oxygen to promote the oxidation reaction of the coal. The heat created by the

Why and When Self-Ignition May Occur?

First the coal's temperature begins to climb above ambient. At about 65°C-150°C measurable quantities of gas-aerosols, hydrogen and CO gases announce the danger of possible combustion.

As the temperature increases further, at about 315°C-370°C relatively large, visible particulates are emitted. Soon, as the hot spot heating rate increases in intensity, reaching about 400°C-425°C, incipient combustion, and ultimately self-ignition and flame, will occur.

The risk from fire exists anywhere significant amounts of coal are in use or storage. After all, coal is flammable and susceptible to a variety of ignition scenarios. One of the most frequent and serious causes of coal fires is spontaneous combustion.

In fact, spontaneous combustion is one of the most prevalent and serious causes of coal fires. It has been a well-known, and long-feared, danger at coal storage sites all over the world.

Coal reacts with atmospheric oxygen even at ambient temperatures and this reaction is exothermic. If the heat liberated during the process is allowed to accumulate, the rate of the above reaction increases exponentially and there is a further rise in temperature.

When this temperature reaches the ignition temperature of coal, the coal starts to burn and the phenomena is described as spontaneous combustion.

Preventing spontaneous combustion coal fires involves attention to many different factors.

Among the most critical are the type, age, and composition of coal, how it is stored, and how it is used.

Given the right kind of coal, oxygen, and a certain temperature and moisture content, coal will burn by itself.

Spontaneous combustion has long been recognized as a fire hazard in stored coal. Spontaneous combustion fires usually begin as "hot spots" deep within the reserve of coal.

The hot spots appear when coal absorbs oxygen from the air. Heat generated by the oxidation then initiated the fire.

Such fires can be very stubborn to extinguish because of the amount of coal involved and the difficulty of getting to the seat of the problem. Moreover, coal in either the smoldering of flaming stage may produce copious amounts of CH_4 and CO gases.

In addition to their toxicity, these gases are highly explosive in certain concentrations, and can further complicate efforts to fight this type of coal fire.

Even the most universal firefighting substance, water, cannot be used indiscriminately. Because of the remote possibility of a steam explosion, it is advisable that water be applied carefully and from a safe distance.

What May Cause Spontaneous Coal Combustion?

The following general factors contribute to spontaneous coal fires:

- Long coal handling procedures which allow long-time retention of coal, which increases the possibility of overheating.
- New coal added on top of old coal created segregation of particle sizes, which is a major cause of overheating.
- Insufficient, temperature probes installed in the coal bunker resulted in an excessive period of time before the fire is detected.
- Failure of equipment needed to fight the fire.
- Ineffective capability and use of CO_2 suppression system.
- Delay in the application of water.
- Inadequate policies, procedures, and training of personnel prevented proper decision making, including the required knowledge to immediately attack the fire.

Recommendations:

- Know the coal that is going to be used. E.g. anthracite has high carbon content and is much less combustible than low oxygen content bituminous coal. Freshly mined coal absorbs oxygen more quickly than coal mined at an earlier time, and is more likely to overheat spontaneously.
- Air circulating within a coal pile should be restricted as it contributes to heating; compacting helps seal air out.
- Moisture in coal contributes to spontaneous heating because it assists the oxidation process and should be limited to 3%.

- Coal having high moisture content should be segregated and used as quickly as possible. Efforts should be made to keep stored coal from being exposed to moisture.
- Dry coal shall be kept dry and shall be not exposed to any rain during storage period. This concerns what is known as the heat-of-wetting; ⇨ Drying coal is an endothermic process [heat is absorbed] and lowers the temperature of the coal. Wetting (or gaining moisture) is an exothermic process and the liberated heat can accelerate the spontaneous heating of the coal.
- Following the "first in, first out" rule of using stock reduces the chance for hot spots by helping preclude heat buildup for portions of stock which remain undisturbed for a long term. The design of coal storage bins is important in this regard.
- A high ambient temperature aids the spontaneous heating process.
- Use coal as quickly as practicable. The longer large coal piles are allowed to sit, the more time the spontaneous process has to work.
- The shape and composition of open stockpiles can help prevent fires. Dumping coal into a big pile with a trestle or grab bucket can lead to problems. Rather, coal should be packed in horizontal layers, which are then leveled by scraping and compacted by rolling. This method helps distribute the coal evenly and thus avoids breakage and segregation of fine coal. Segregation of coal particles by size should be strenuously avoided, as it may allow more air to enter the pile and subsequent heating of finer sizes.
- The height of the coal pile is also important. Limit unlayered, uncompacted high grade coal to a height of 5m; maximum height is 8m for layered and packed coal.

- Properly inspect, test and maintain installed fire protection equipment.
- Maintain an update pre-fire plan and encourage regular visits to coal facilities by the site or local emergency response force.

Summary

Coal presents hazards between the time it is mined and its eventual consumption in boilers and furnaces.

Below are listed some of the characteristics of spontaneous fires in coal.

These characteristics, together with above recommendations can be used to evaluate the potential for coal fires and as guidelines for minimizing the probability of a fire.

(1) The higher the inherent (equilibrium) moisture, the higher the heating tendency.

(2) The lower the ash free calorific value (Btu), the higher the heating tendency.

(3) The higher the oxygen content in the coal, the higher the heating tendency.

(4) Sulfur, once considered a major factor, is now thought to be a minor factor in the spontaneous heating of coal. There are many very low-sulfur western sub-bituminous and lignite coals that have very high oxidizing characteristics and there are high sulfur coals that exhibit relatively low oxidizing characteristics.

(5) The oxidation of coal is a solid/gas reaction, which happens initially when air (a gas) passes over a coal surface (a solid). Oxygen from the air combines with the coal, raising the temperature of the coal. As the reaction proceeds, the moisture in the coal is liberated as a vapor and then some of the volatile matter that normally has a distinct

odor is released. The amount of surface area of the coal that is exposed is a direct factor in its heating tendency. The finer the size of the coal, the more surface is exposed per unit of weight (specific area) and the greater the oxidizing potential, all other factors being equal.

(6) Many times, segregation of the coal particle sizes is the major cause of heating. The coarse sizes allow the air to enter the pile at one location and react with the high surface area fines at another location. Coals with a large top size [e.g., 100 mm], will segregate more in handling than those of smaller size [50 mm].

(7) It is generally believed that the rate of reaction doubles for every 8 to 11ºC increase in temperature.

(8) Freshly mined coal has the greatest oxidizing characteristic, but a hot spot in a pile may not appear before one or two months. As the initial oxidization takes place, the temperature gradually increases and the rate of oxidization accelerates.

(9) There is a critical amount of airflow through a portion of a coal pile that maximizes the oxidation or heating tendencies of coal. If there is no airflow through a pile, there is no oxygen from the air to stimulate oxidation. If there is a plentiful supply of air, any heat generated from oxidation will be carried off and the pile temperature will reach equilibrium with the air temperature; this is considered a ventilated pile.

(10) When there is just sufficient airflow for the coal to absorb most of the oxygen from the air and an insufficient airflow to dissipate the heat generated, the reaction rate increases and the temperatures may eventually exceed desirable limits.