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# DUST EXPLOSIONS DURING FIRE FIGHTING

By David J. Price, *principal engineer in charge, Chemical Engineering Division, Bureau of Chemistry and Soils* [1]

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## EXTENT OF DUST-EXPLOSION HAZARDS

The dust-explosion hazard exists in the United States in more than 28,000 manufacturing plants handling products principally of agri-

FIGURE 1.—After an explosion in a terminal grain elevator. Four men were killed in this explosion.

cultural origin. These establishments normally employ more than 1,325,000 persons and manufacture products having an annual value of more than $10,000,000,000. In addition to these industrial plants, more than 20,000 country (rural) grain-handling elevators, having a capacity of more than 500,000,000 bushels, are subject to grain-dust fires and explosions. These country elevators represent a capital investment of more than $450,000,000.

Dust explosions have occurred in practically all kinds of grain-handling plants, such as grain elevators (fig. 1), flour and feed mills (fig. 2), and starch factories, and in many industries associated with

[1] Drawings were made by Robert M. Baker and Irl Bauserman, draftsmen, Chemical Engineering Division.

the processing of agricultural products, such as sugar refining, the preparation of cocoa, chocolate, malt (fig. 3), powdered milk, and other food products, insecticides, fertilizers, wood pulp, wood products, soap powder, paper products, and many others.

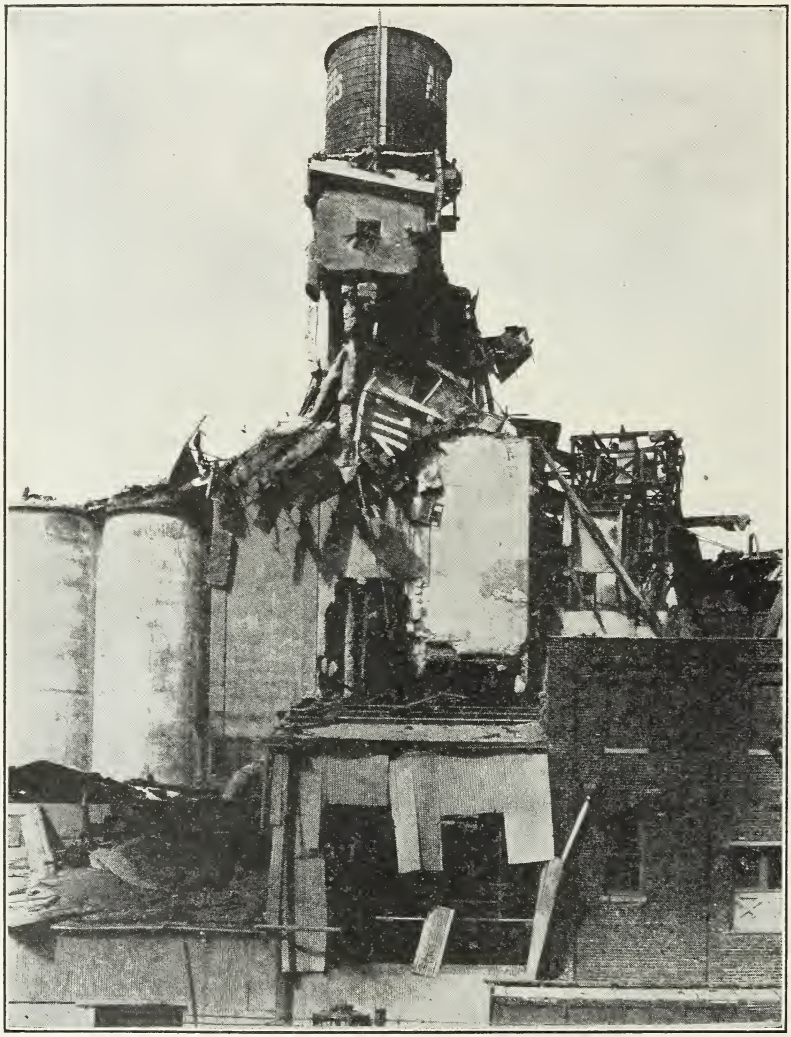

FIGURE 2.—Results of an explosion in a feed mill.

## VALUE OF SCHOOLS OF INSTRUCTION FOR FIREMEN

Although dust explosions usually occur during the operation of industrial plants, a number of disastrous explosions, resulting in the death of firemen, have occurred during fire-fighting operations. The establishment of schools of instruction for firemen, therefore, is one of the most gratifying undertakings in fire-prevention work in recent years. These schools afford a splendid opportunity to acquaint the firemen with the latest developments in fire and explosion prevention, as well as fire extinguishment.

Firemen have shown great interest in the dust-explosion and fire-prevention research work of the Bureau of Chemistry and Soils. This interest has extended beyond the methods for the actual extinguishment of fire, and has induced firemen to acquire fundamental knowledge regarding the control and prevention of explosions and fires. This circular has been prepared to assist firemen in preventing dust explosions during fire fighting, and thereby enable them to fight fires with greater safety and protection.

## CAUSES OF DUST EXPLOSIONS DURING FIRE FIGHTING

Dust explosions that occur during fire fighting may be classified as follows:

(1) Explosions caused by the full stream of water (high pressure) striking settled or static dust in various parts of the buildings. The water forces the dust cloud on the flames, and an explosion results.

(2) Explosions that occur when firemen attempt to remove dust or powdered products from bins or other inclosures. When in the

FIGURE 3.—Searching for the body of the fire department captain, who was killed in this explosion of malt dust.

form of a cloud, these materials readily ignite upon coming in contact with flames.

(3) Explosions caused by the falling of floors or the dropping of the bottom of storage bins, forcing the dust cloud on the fire and resulting in an explosion.

(4) Explosions that result from the chemical reaction between water and dust. A violent reaction takes place, for example, when water ($H_2O$) is applied to hot aluminum powder. Hydrogen is liberated and may form explosive mixtures with the air. When these explosive mixtures come in contact with the fire, explosions can readily follow. The oxygen from the water unites with the aluminum, resulting in rapid combustion.

## TYPICAL FIRES INVOLVING DUST-EXPLOSION HAZARDS

The four following typical fires involve definite dust-explosion hazards.

### FIRE IN GRAIN ELEVATOR

An alarm comes in from a grain elevator. When the firemen reach the elevator they observe smoke on the bin floor at the top of the elevator and proceed to that point with their hose lines. The officer in charge notices that smoke is coming out of one of the elevator legs

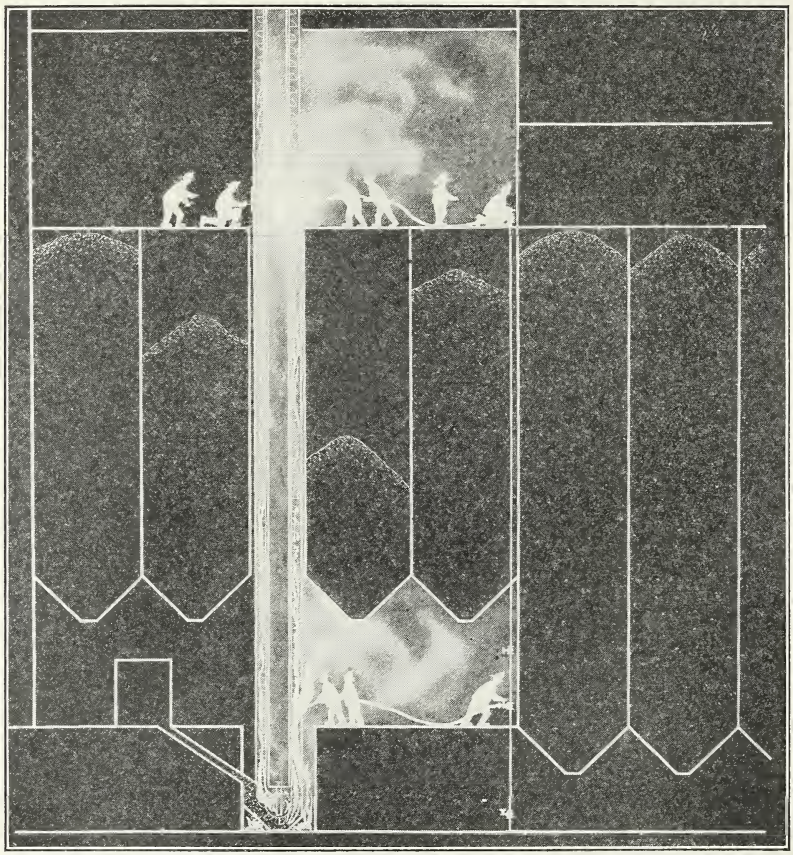

FIGURE 4.—Fire in grain elevator.

that carries the grain from the bottom of the elevator to the storage bins on the upper floor. He stations a number of men on the bin floor at the top of the elevator and then finds that no water is available at the standpipe connection.

The officer leaves most of the men on the top floor, runs down to the first floor with a detail of men, and there discovers that the supply valve is closed. About the time this valve is opened he finds the fire burning at the bottom of the leg and immediately orders the full stream turned on the fire from this point on the first floor (fig. 4). Is anything wrong with this procedure? What hazards are involved?

PROCEDURE RECOMMENDED

The turning of the full stream of water (high pressure from hose lines) on burning dust introduces a serious dust-explosion hazard. In this case, although directed at the fire at the bottom of the elevator leg, the full stream of water is liable to strike the settled dust on the interior of the leg, or to strike the exterior of the leg and dislodge the dust inside, forcing the dust cloud on the fire and thereby causing an explosion. This dust explosion will travel rapidly up the leg and endanger the firemen still on the upper floors.

The better procedure would be to remove the firemen from the floor above, and then use a spray on the fire instead of the full stream of

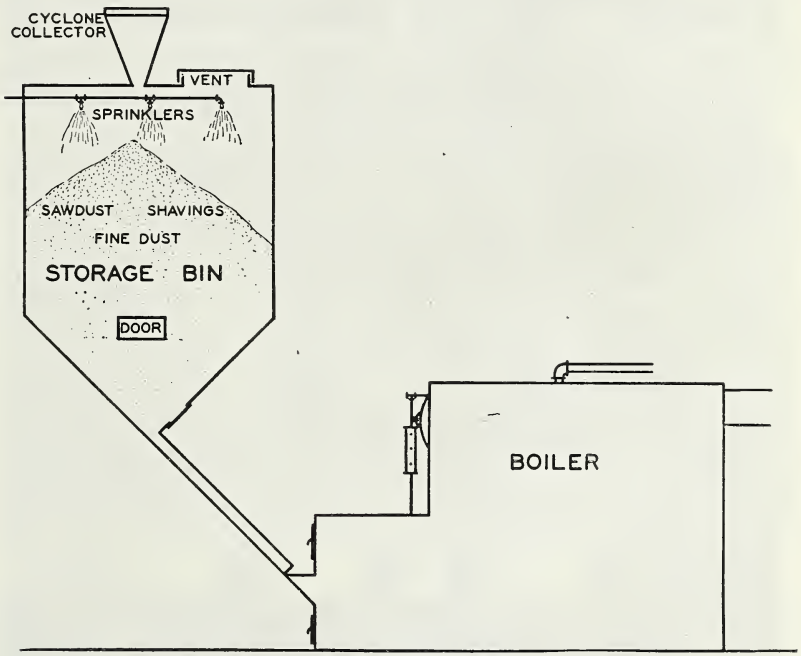


FIGURE 5.—Fire in wood-dust storage bin.

water. In fighting fires in plants where combustible dusts are present, care should be exercised so that the full stream at high pressure does not force the settled dust on the burning fire.

FIRE IN WOOD-DUST STORAGE BIN

An alarm comes in from a woodworking plant. Presumably the fire is in a storage bin located about 15 feet above the boiler-room floor (fig. 5). This bin, which is about 15 feet square and 30 feet deep, with a door at the bottom, contains sawdust, shavings, and finely divided wood particles. This material is used for fuel for a boiler about 15 feet from the bottom of the bin.

When the firemen reach the plant they find that three sprinkler heads in the bin have opened, but although they turn off the water, there is some doubt as to whether the fire has been completely extinguished. What procedure should be followed in handling this type of fire?

### PROCEDURE RECOMMENDED

In handling a fire in a wood-dust storage bin, considerable danger is incurred if an effort is made to remove the contents of the bin through the door at the bottom. The sawdust will naturally form an arch when removed in this manner, and if any smoldering fire is still in the bin, the dust will burst into flames when it reaches the air and ignite the dust cloud in suspension outside. This may cause a disas-

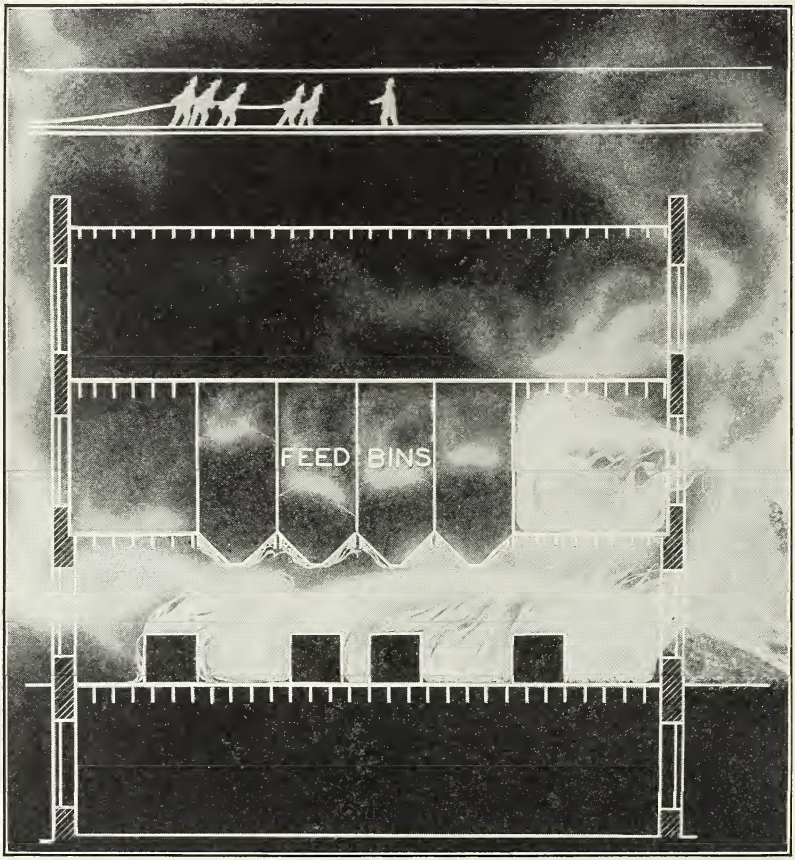


FIGURE 6.—Fire in feed mill.

trous dust explosion. There is also the possibility that the dust cloud will be ignited by the fire in the boiler.

In this case the best procedure is to flood the bin by turning on the sprinklers and running the hose lines into the top of the bin. No attempt should be made to remove the sawdust until the bin has been completely flooded and the water comes out from the bottom. This removes the possibility of a dust explosion while the bin is being emptied.

### FIRE IN FEED MILL

An alarm is received from a plant manufacturing cattle feed. When the firemen arrive they find the fire burning near the feed-

storage bins (fig. 6). The officer in charge stations the men on the bridge directly above the bins and orders them to fight the fire from that point. Is there any possible danger in this procedure?

### PROCEDURE RECOMMENDED

When combustible materials are stored in bins there is always the possibility that a dust explosion may occur when the bottoms of the bins drop or the floors fall, forcing the dust cloud on the fire. Therefore it is more desirable to fight the fire from the side rather than expose the firemen to danger by stationing them directly overhead.

The periodical inspection of industrial plants by firemen is recommended. Such inspection affords the firemen an opportunity to become acquainted with sections of the plant where combustible dusts are present. Systematic inspection of this kind makes it possible for firemen to become thoroughly familiar with structural conditions in the buildings and also the hazardous manufacturing pro-

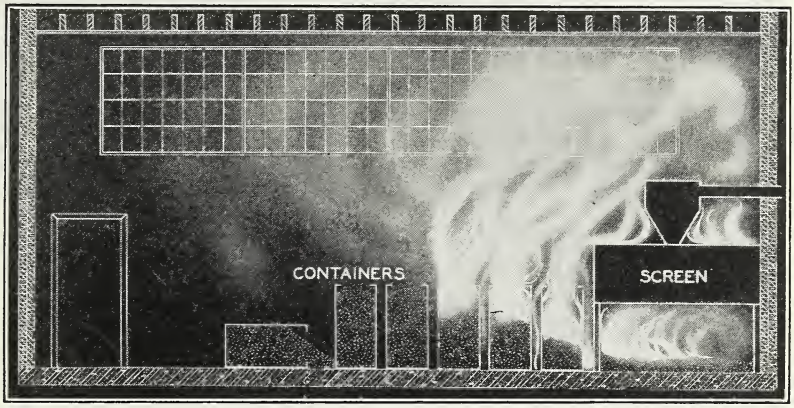


FIGURE 7.—Fire in an aluminum powder plant.

cesses which are carried on in them and to acquire a thorough knowledge of the contents of the buildings and of any combustible products handled and manufactured. Such knowledge is helpful in working out a plan of fire fighting with more adequate protection for firemen.

### FIRE IN ALUMINUM POWDER PLANT

A dust explosion occurs in an industrial plant manufacturing aluminum powder, and the fire department is called to fight the fire which follows the explosion. This fire is in the section of the plant where the aluminum powder is stored in containers (fig. 7). What procedure should be followed in handling a fire of this type?

### PROCEDURE RECOMMENDED

When water comes in contact with burning aluminum powder free hydrogen gas is liberated, and explosions may follow. When dusts of this kind are encountered, great caution should be exercised in the use of water. Water should be kept off the burning area, but if there is exposed property nearby, these buildings should be protected.

Small aluminum fires can be controlled by building a wall of dry sand around the fire and permitting the fire to burn itself out. A fire

in aluminum powder burns at a relatively slow rate so that there is usually ample time to build the wall of sand around the fire. Care

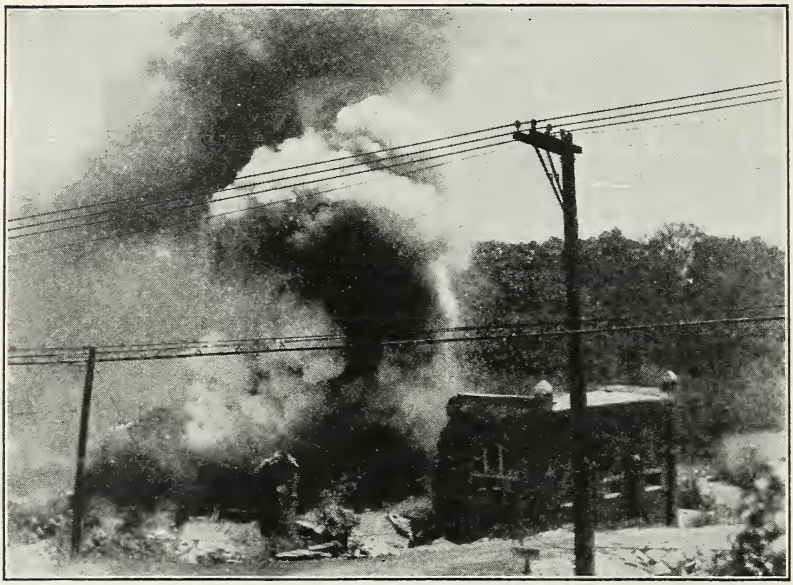

FIGURE 8.—Fire following explosion of aluminum dust.

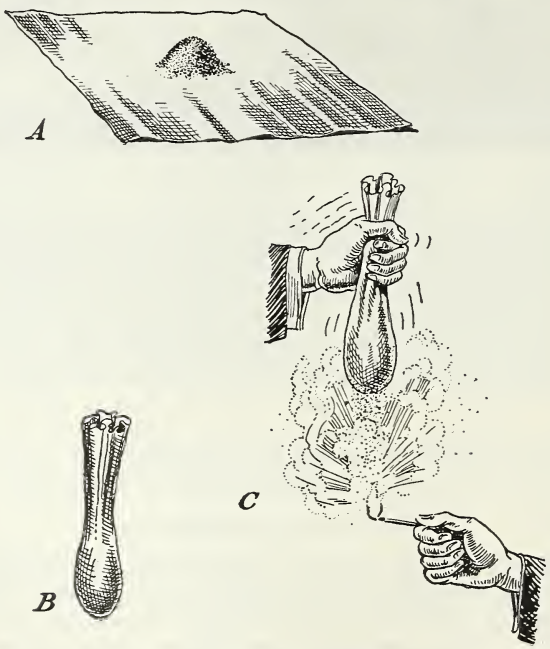


FIGURE 9.—Determining explosibility of dust: *A*, Dust placed on cheesecloth; *B*, dust bag; *C*, shaking dust on open flame.

must be exercised to prevent disturbing the aluminum dust. Sand or any other material should never be thrown on a pile of burning

aluminum dust. The fire shown in figure 8 followed an explosion caused by throwing sand on burning aluminum powder.

Factories manufacturing inflammable metallic powders and establishments that use large quantities of these materials should have generous quantities of dry sand in suitable containers for fire-fighting purposes.

FIGURE 10.—Demonstration of explosibility of dust at Virginia Firemen's Training School, Richmond, Va.

## EASY HAND METHOD OF DEMONSTRATING DUST EXPLOSIONS

It is frequently necessary to determine whether a particular dust is explosive. A method that is easy and fairly reliable but not infallible is to pour the dust to be tested on to a piece of cheesecloth about a yard square, and after forming a bag shake the dust through the cloth on to a burning match, burning waste, open flame, or similar source of ignition (figs. 9 and 10). If the dust ignites, it is definite proof that it will explode when mixed with air in proper proportions. Care must be taken to prevent burning the persons making the test. This method should not be used to test aluminum or magnesium powder.

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