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DUST EXPLOSION PREVENTION
IN
WOODWORKING INDUSTRIES

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RESEARCH WORK ON DUST EXPLOSION PREVENTION

Extensive research studies to determine the causes of dust explosions and to develop methods for their prevention have been conducted by the Federal Government and other interested agencies.

The Bureau of Mines, U. S. Department of the Interior, has established the fact that explosions can occur in bituminous coal mines without the presence of explosive mine gases, and that the ignition of coal dust itself has been responsible for many disastrous mine explosions. As a direct result of effective research work by that Bureau methods have been developed for the use of inert dusts such as shale, limestone and gypsum, for the control and prevention of coal dust explosions. Reports issued by the Safety Section of the Bureau of Mines indicate that these methods have proved very satisfactory.

The investigations of the Bureau of Agricultural Chemistry and Engineering, U. S. Department of Agriculture, have shown that under favorable conditions a dust explosion can occur in any industrial plant or manufacturing establishment where combustible dust is created during manufacturing operations. When these studies were undertaken it was generally supposed that it would be necessary to grind or crush grain and produce the powdery, starchy materials from the inside of the grain before an explosive dust would be encountered. This was largely due to the fact that an explosion of flour dust produced in the manufacture of wheat flour in a Minneapolis mill in 1878 caused the loss of 18 lives and extensive property damage. A large number of explosions in grain elevators, where no grinding or manufacturing operations were engaged in, has shown definitely that the dust produced in handling, elevating, conveying and storing of grain also is explosive.

The dust explosion hazard is now recognized in a wide range of industries such as flour and feed mills, grain elevators (both terminal and rural), starch factories, sugar refineries, woodworking plants, powdered milk plants, soap powder factories, sulphur crushing and pulverizing, hard rubber recovery plants, cork pulverizing plants, chocolate and cocoa plants, paper mills, insecticide plants, celluloid and textile plants, aluminum, zinc and magnesium plants, fertilizer plants and rosin-handling plants.

NEW MANUFACTURING PROCESSES

Many of the dust explosions in industrial plants in recent years have been directly associated with the introduction of new manufacturing processes which have opened up additional sources of ignition and have resulted in conditions favorable to explosions. It is therefore highly desirable that new manufacturing operations be carefully examined to detect possible dust explosion hazards, and that attention be given to the adoption of preventive measures.

Changes made in the industrial field, both in the manufacturing processes and in the utilization of by-products, have served to create a dust explosion hazard in many plants not previously considered susceptible.

For example, in the woodworking industry larger-scale operations creating greater quantities of dust from saws, planers, and sanders have increased the possible hazard, and the demand for wood flour has induced some operators to reduce their scrap to powdered form. Even where the scrap is used for fuel, hogs reduce the material to small size so that it can be transported mechanically, and in so doing frequently create sufficient fine dust to form an explosive mixture.

More than 60 explosions in woodworking plants have been investigated, including explosions of wood dust, wood flour, wood pulp and sawdust. In these explosions 24 persons were killed, 90 injured, and the property damage was approximately $1,125,000. The investigations showed these explosions were caused principally by fires, overheated bearings, sparks in grinders, and defective electrical equipment. A great many of the wood dust explosions occurred in shavings vaults, especially those in which the fine dust was blown into the vault with the shavings. A vault of some kind is generally provided for the collection of the refuse from the various machines in a woodworking plant, and this is the most likely spot for an explosion in the average plant.

LABORATORY TESTS ON THE IGNITION TEMPERATURES AND EXPLOSIBILITY OF WOOD DUSTS

In the laboratory, tests have shown that the ignition temperatures of wood dusts are in the same range as those of most of the cereal dusts.

The following tabulation gives the ignition temperatures of 17 woods and barks in the form of dust. It will be noted that the ignition temperatures of the coniferous woods are higher than those of the broad-leaf woods. The only exception is cedar.

Conifers	°C.	°F.	Broad-leaf Woods	°C.	°F.
Cedar	291	556	Oak	277	531
Spruce	311	592	Chestnut oak bark	251	484
Fir	322	612	Blackoak bark	267	513
Long leaf yellow pine	333	631	Cork	265	509
White pine	334	633	Maple	311	592
California white pine	329	624	Chestnut	301	574
Redwood	327	621	Balsa	293	550
Redwood bark	290	554	Fustic	290	554
			Logwood	273	523

The ignition temperature of the bark dusts is lower than that of the woods.

It is necessary to remember that these figures apply to dusts. Owing to the different cellular structures and hence different apparent densities of wood in large pieces, the ignition temperatures of woods and barks in large pieces (as distinguished from small particles) may be quite different from the order shown in the above tabulation.

The following tabulation gives the explosibility of the wood and bark dusts as determined by laboratory tests. The dusts were tested at the two concentrations of 100 and 500 milligrams per liter of air, which are equivalent to 100 and 500 ounces per 1000 cubic feet. The values for explosibility are given in pounds per square inch which represents the maximum pressure developed during the tests. To make these tests comparable, all of the dust samples were passed through a 200-mesh sieve and were dried for four hours at 70°C. (158°F.)

The Explosibility of Wood and Bark Dusts in Concentrations of 100 and 500 Milligrams per Liter of Air.

	Pressure from 100 mgms. Lbs. per sq. inch	Pressure from 500 mgms. Lbs. per sq. inch
Chestnut	27.	40.
Chestnut oak bark . . .	23.	39.
Redwood bark	22.	38.
Fustic wood	23.	39.
Long leaf yellow pine .	22.	43.
California white pine .	21.	43.
White pine	23.	44.
Fir	18.	37.
Spruce	21.	39.
Logwood	22.	36.
Blackoak bark	23.	38.
Oak	22.	40.
Redwood	25.	40.
Maple	23.	37.
Cork	25.	40.
Cedar	22.	40.
Balsa	24.	- -

The very remarkable feature of these explosibility tests is the uniform results obtained with all of the wood and bark dusts.

At the lower concentration of 100 milligrams per liter, chestnut dust produced the highest pressure of 27 pounds per square inch, while fir produced the lowest, or 18 pounds per square inch. All of the remaining wood and bark dusts were within the very narrow limits of 21 to 25 pounds per square inch.

At the higher concentration of 500 milligrams per liter, white pine produced the highest pressure of 44 pounds per square inch, while logwood produced the lowest, or 36 pounds per square inch.

It may be said that the wood dusts as a class are just as hazardous as the cereal dusts, and that one wood dust is just about as hazardous as any other. U. S. Department of Agriculture Technical Bulletin No. 490, entitled "Explosibility of Agricultural and Other Dusts as Indicated by Maximum Pressure and Rates of Pressure Rise," by Paul W. Edwards and L. R. Leinbach, contains detailed information on explosibility tests of 133 representative industrial dusts including a number of samples of dusts from woodworking industries.

SOME TYPICAL WOOD DUST EXPLOSIONS

Before considering some of the preventive measures recommended, it may be well to review briefly some of the explosions investigated in which certain outstanding facts indicate quite definitely the methods to be followed in reducing or eliminating the hazard in woodworking plants.

In one explosion in a woodworking plant in which there was less than $5,000 property damage, 18 employees were seriously burned, five of whom died later. The first ignition was believed to have occurred in the hogs where defective material, short ends, and chips from the cabinet shop were broken or cut into pieces small enough to be blown by air into the boiler house to be used for fuel. The explosion was believed to have occurred in the large cyclone dust collectors into which the hog discharged the material. Sixteen of the injured employees were in the offices, into which the fire flashed from a pipe line. The other two employees were burned while fighting the fire in the sawdust at the boiler house to which the flames spread through the dust pipes.

A serious dust explosion occurred in a woodworking plant where the shavings and dust from the finishing machines were deposited in a brick vault extending from the boiler room through the various floors to the roof of the plant. This vault, 22 ft. by 37 ft. and 35 feet high with 8-inch walls, extended 6 feet above the building and was covered with a flat wooden roof. Two metal cyclone dust collectors were supported by a steel framework directly over the vault and discharged the material they received from the machines through the wooden roof into the vault. Material was removed from the vault through three doors at the bottom located 8 feet from the furnace doors. Fire is believed to have entered the vault through one of these doors, although sparks or a smouldering fire may have been carried with the material blown into the vault from the plant. When the fire was discovered two men went to the roof of the plant and attempted to open a 2 ft. by 3 ft. door in one end of the vault. An explosion occurred instantly, and the men were buried under bricks and debris. Flames shot out of the vault openings in the boiler room and enveloped three employees there. The force of the explosion was sufficient to lift the vault roof and the heavy steel framework which supported the two cyclone collectors, and the entire mass dropped into the vault.

Other explosions are believed to have been caused by backdrafts from the firebox of boilers, and there is also a case on record where a spark from an emery wheel near a wood-finishing machine ignited the dust and the fire was drawn into the dust-collecting systems. In another case in which an employee was killed and six otherswere injured, a bolt dropped into the cutters of a grinding machine and produced a shower of sparks which ignited the finely divided dust in the air.

One of the explosions reported occurred under peculiar circumstances. Oil and sawdust on a bearing caught fire and ignited sawdust on the floor below. In an effort to extinguish the blaze, the assistant engineer dashed a pail of water on the floor with such force that some of the light dust was thrown into suspension and ignited.

Explosions in industrial plants have brought forcibly to the attention of those interested in dust explosion prevention work the need of training or instructing fire-fighting organizations in the proper methods of fighting fires where dust explosion hazards exist. This is particularly true in fighting fires in storage bins or vaults in woodworking plants. In one instance when the fire in the dust bin was apparently extinguished, the firemen opened the bottom of the bin and allowed the dust to run out on the floor, approximately fifteen feet below. As it fell to the floor a dust cloud was formed and when it was ignited by fire which apparently had been smouldering in the bin, or by the fire from a nearby furnace, the firemen were caught in the flames from the explosion and received injuries from which six of them died.

METHODS FOR PREVENTION OF WOOD DUST EXPLOSIONS

The investigation of a large number of explosions and the inspection of woodworking plants indicates very clearly some of the methods of prevention which must be adopted for the prevention of wood dust explosions.

(1) It is of course impossible to have a dust explosion without a sufficient quantity of dust in suspension in the air and a spark or flame to ignite the dust. As in all other dusty industries, therefore, cleanliness is of the utmost importance. If the plant is kept clean, there will be no dust to form a cloud through which an explosion can spread or propagate, even if a minor dust ignition should occur in or around one of the machines.

(2) Careful attention to the elimination of all possible sources of ignition, such as open flames, electrical apparatus likely to produce sparks or arcs, cutting or welding torches, and exposed-element electrical heating devices, will also serve to reduce the dust explosion hazard. It has been found possible to produce a dust explosion by breaking in a dust cloud a lighted incandescent electric lamp. Evidently the filament remains heated after the glass is broken for a sufficiently long interval to ignite the dust particles with which it comes in contact. It is essential therefore to provide double globes and guards for all lamps of this kind used in a dusty atmosphere.

(3) Steps should be taken to prevent the accumulation of static electricity on machines or equipment, because some dusts can be ignited by static sparks.

(4) Metallic sparks also are likely to cause trouble and magnetic separators should be installed wherever necessary to prevent pieces of iron or steel from entering grinders or other machines.

(5) Special care should be taken to prevent hot bearings or friction of belts and moving machinery which may cause a fire or dust ignition.

(6) Fire-resistive construction should be used wherever possible, and automatic or self-venting windows often prove valuable in releasing, before serious damage can be done, the pressure produced in a dust explosion.

SAFETY CODES FOR DUST EXPLOSION PREVENTION

The precautionary measures recommended are those more generally applicable to the average plant. The following complete safety codes developed by the dust Explosion Hazards Committee have been adopted by the National Fire Protection Association and the National Board of Fire Underwriters and approved as "American Standard" by the American Standards Association:

1. Flour and feed mills
2. Sugar and cocoa pulverizing
3. Pulverized fuel installations
4. Terminal grain elevators
5. Starch factories
6. Coal pneumatic cleaning plants
7. Wood flour manufacturing establishments
8. Spice-grinding plants
9. Wood-working plants
10. Use of inert gas for fire and explosion prevention
11. Aluminum bronze powder plants

It is suggested that owners and operators of woodworking plants obtain copies of the safety code for the industry and consider carefully the safety requirements. The Chemical Engineering Research Division in the U. S. Department of Agriculture will furnish on request any information on dust explosion prevention which is available for distribution.