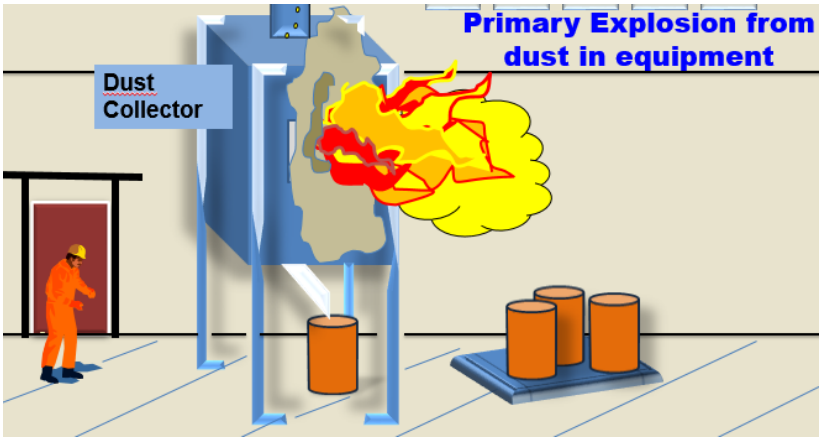
Basic Concepts of Dust Explosions

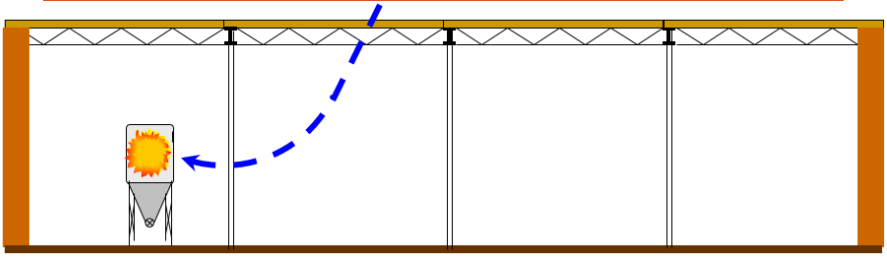
Dust explosions have devastating power and can destroy a building in less than a second.

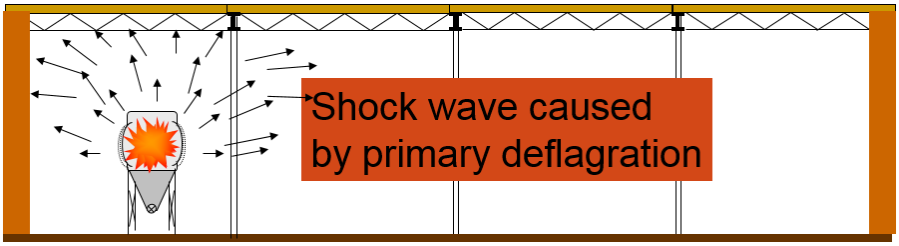
Imperial Sugar Company, Port Wentworth GA.
Explosion and Fire
Feb. 7, 2008
13 Dead and Numerous serious injuries



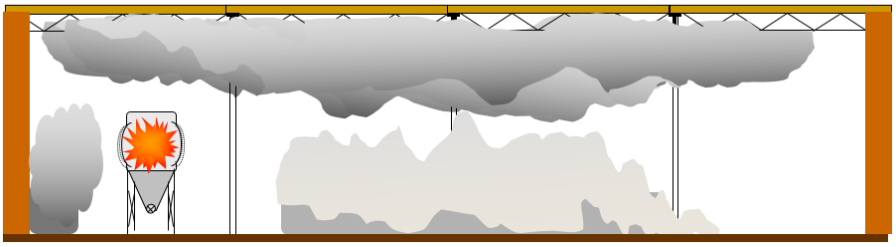
Dust explosions are really a two stage explosion. An initial (primary) explosion in processing equipment creates a shock wave that raises accumulated dust in the plant. This cloud of raised dust is then ignited in a second and much larger explosion. It is this second explosion that does the damage. The various steps of the process are described in the following series of diagrams.

Primary deflagration inside process equipment

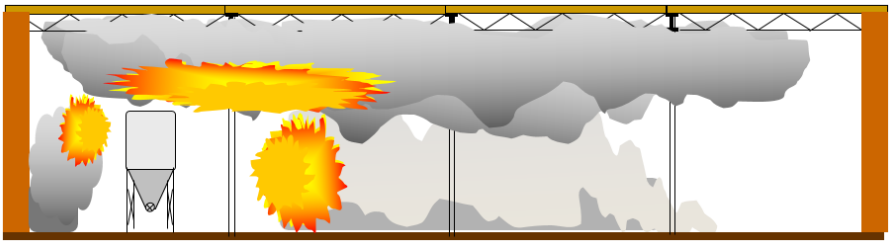




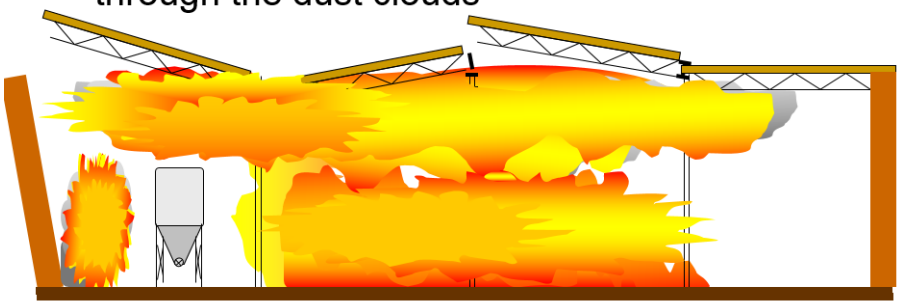
Dust clouds thrown in the air by the shock waves



Secondary deflagration ignited



Secondary Deflagration is propagated
through the dust clouds



The five ingredients required for a dust explosion are:

1. Combustible particulates sufficiently small to burn rapidly when ignited
2. A suspended cloud of these combustible particulates at a concentration above the Minimum Explosive Concentration (MEC)
3. Confinement of the dust cloud by an enclosure or partial enclosure
4. Oxygen concentration greater than the Limiting Oxygen Concentration (LOC) for the suspended dust cloud
5. *Delayed* ignition source of adequate energy or temperature to ignite the suspended cloud.

The National Fire Protection Association (NFPA) has had several definitions of combustible dusts over the years. The current definition in NFPA 654 is “a combustible particulate solid that presents a fire or deflagration hazard when suspended in air or some other oxidizing medium over a range of concentrations, regardless of particle size or shape.” Previous editions of NFPA 654 and the 2004 edition of the NFPA Glossary of Terms define a combustible dust as “any finely divided solid material that is 420 microns or smaller in diameter (material passing a U.S. No. 40 Standard Sieve) and presents a fire or explosion hazard when dispersed in air.” The reason for the revision is that many combustible fiber segments, flat platelets, and agglomerates do not readily pass through a No. 40 sieve, but they can be dispersed to form a combustible dust cloud. In practice, questions of combustibility as well as particle size often arise when evaluating the potential explosion hazard of marginally small particles or mixtures of combustible and noncombustible particulates. Many laboratories doing dust explosibility tests have developed dust explosibility screening tests, also called Go/No Go tests, to deal with these questions. Chapter 4 of the CCPS *Guidelines for Safe Handling of Powders and Bulk Solids* describes some of these tests.

Types of Dusts Associated with Combustion Explosions

Metal – aluminum, iron carbonate, zinc, bronze, magnesium

Plastics / Rubbers – molded cellulose, polyethylene, polypropylene, polyacrimide, expoxy or phenolic resin

Food – rice, sugar, coffee, cocoa powder, spices powder, potato starch, oats, wheat corn, soybean powder, barley

Chemicals – lactose, dextrin, ascorbic acid, calcium acetate, methylcellulose

Powders containing cellulose – charcoal, wood dust, coal dust, cellulose, some dry chemicals

Size Matters

The dust particles must be very small to contribute to a dust explosion. Combustible dust is typically considered to be less than 420 microns in diameter. As the dust size gets smaller, the risk of explosion increases.

You also need to have a certain (high) level of dust. This is the part that people are often confused about. The Minimum Explosive Concentration is extremely high and they know that they don't have that level of dust in their plant.

For example, the Minimum Explosive Concentration (MIC) may be 40 – 50 grams/m^3. This is perhaps 1,000 times of a worker exposure to dust. But what is the concentration inside a covered conveyor system at a transfer point when it falls from one conveyor onto the next? These concentration can be reached in bucket elevations, conveyor housings, bag houses and transfer and/or discharge points.

You also have to think peak concentration at any time. There might be a very high concentration inside a piece of equipment for a fraction of a second. If there is an ignition source during the fraction of a second, that is all it takes to start the process of a combustion explosion. That initial explosion creates a pressure wave that stirs up all of the accumulated dust from the floor, rafters, tops of equipment, etc., all at once.

Magnet used to take out any metal scraps (nails, bolts, washers, etc.) in a grain handling process to prevent sparks later in the milling process where the grain is ground up. Scrap metal hitting or caught in the grinder could produce a spark in the high density dust cloud inside the grinder.