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When a dust can explode ....
A few basics

For any dust to explode the substance it is made of must be burnable. If you can't burn it then it won't explode. You also can't have a dust explosion outdoors because most of the pressure is achieved because of both the products of combustion and the change in gas density as the temperature rises pushing against the walls of the vessel enclosing it causing the pressure to rise. If there are no walls to enclose it then it won't be an explosion – it may burn but it won't explode because there will be no pressure rise.

For the explosion to happen the following conditions must ALL apply:

- Each dust particle must be able to burn quickly
- Dust particles must be close enough together that the combustion of one particle ignites its neighbour either by heat or flame (if the dust cloud is too thin then the particles may be too far apart for this to happen)
- Dust particles must not be so close together that the burning particle can't get enough oxygen to burn properly. If there is sufficient gap around each particle for the oxygen to get to it to enable the combustion process then the rate of combustion can be high enough.

If all three conditions above meet the criteria then I only need an ignition event to trigger the dust explosion. Notice that the implication of the second criteria is that if I deliberately insert inert particles mixed into the dust cloud then the propagation of the flame front is broken each time an inert particle is encountered and the dust explosion can be dissipated and the event might simply be a fire. Note also that the implication of the third criteria is that if I surround the dust particles with an inert gas, or with a gas that reduces the available oxygen to below the level at which the particles can burn, then I also prevent the explosion from occurring.

You may also notice from the three conditions that for a dust explosion to occur there is both a lower limit to the dust concentration to enable an explosion to be viable and an upper limit at which an explosion ceases to be viable. The common statement that the concentration of dust needed for an explosion is 60 g/m^3 is just a crude rule

of thumb. Take, for example sewage sludge dust for which figures available show that an explosion can occur for concentrations anywhere in the range of 12 g/m^3 to 350 g/m^3. It is true however that if you develop a table of all the common combustible dusts and plotted a graph there would be a strong peak between 50 and 80 g/m^3 telling you that – if you're not sure most substances can explode if they are combustible at the 60g/m^3 point. It is also important to realise that the dust concentration does NOT need to be uniform across the dust cloud for the explosion to occur – So long as somewhere within the cloud the concentration conditions are right the dust explosion can occur.

Dusts are classified as class 1, 2 or 3 but it does not follow that a class 3 dust is necessarily worse than a class 1 dust. The classification uses the K_{st} number measured in the laboratory tests. A simplified way of understanding K_{st} is to think of it as the rate of pressure rise when the dust explodes. But all dusts also have a maximum limiting pressure that they can achieve in an explosion within a simple shaped vessel. This is noted as P_{max}. This means that I could have a dust with a very high rate of pressure rise in class 3 that has a much lower maximum pressure P_{max} than a dust with a low rate of pressure rise, K_{st} of 1, and a high maximum pressure, P_{max}.

Thus when you collect data on a dust you need both the K_{st} and P_{max} of the dust. This data is the cornerstone of data needed for the design of prevention measures.

Note a complex vessel shape can give you a higher P_{max} in the event of an explosion and the situation is much worse where vessels are interconnected and the explosion can propagate through the connecting pipe or duct.

Dust layers for a combustible dusts can self heat and auto-ignition then occurs and they start smouldering and/or burst into flame. When laboratories measure the capability of a dust to self-heat and self ignite they standardise on testing a 5mm layer and data is then published for that 5mm layer test. This does NOT mean that layers below 5mm won't self heat and ignite. There are charts to allow the calculation of the auto-ignition temperature for different layer thicknesses using the 5mm layer measured value as the starting point.

Finally secondary dust explosions are worse than primary ones. Often the primary event is tiny and might only be heard as a faint “pop” sound – but that little pop disturbs dust elsewhere and creates a bigger dust cloud that then goes bang – and it's that secondary dust explosions or serious of dust explosions that does the damage.

For further information and advice on dust explosibility issues and protection measures contact:

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