

Is This Combustible “Dust”?

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Dust explosions and fires are serious hazards in the process industries that have led to loss of life, injury to plant personnel and millions of dollars in damages. There have been several U.S. Chemical Safety Board reports on the subject of dust explosions and the Occupational Safety and Health Administration (OSHA) has issued a National Emphasis Program (NEP) instructing auditors about how to assess a dust explosion hazard. Currently, except for an old grain handling standard, there is no national regulation governing the mitigation of combustible dust explosion hazards. There are however, a set of consensus standards from the National Fire Protection Agency (NFPA) with regard to combustible dust fire and explosion risk mitigation. These are considered RAGAGEP (Recognized And Generally Accepted Good Engineering Practice) and are incorporated in many local building and fire codes. The OSHA NEP on combustible dust and the relevant NFPA standards are attempting to address issues such as dust explosion venting, dust explosion suppression, fugitive dust clean up, combustible dust hazard classification zones, etc. In all cases they are addressing “dust” hazards, but what is a "dust"? The NFPA 654 defines it as finely divided particles that can be dispersed in air.

Other NFPA standards define 'dust' as *particulates with particle size limitations*. For example, section 3.3.27.1 of NFPA 664-2012, 'Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities,' states that a Deflagrable Wood Dust is wood particulate matter capable of propagating a flame that has a mass mean diameter of 500 microns or smaller. Then section 3.3.27.2 of the same standard states that dry, nondeflagrable wood dust is wood particulate material that has a mass median particle size greater than 500 microns. NFPA 664 is not alone in this type of narrow interpretation. Section 3.3.1 of NFPA 61-2008, 'Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities,' states that Agricultural Dust is any finely divided solid agricultural material 420 microns or smaller in diameter that presents a fire or explosion hazard when dispersed and ignited in air. Even OSHA defines combustible dust as flammable particulate material less than 420 micron. The rationale being that particles greater than 420-500 microns do not pose a threat of an explosion. From firsthand experience in operating a testing laboratory, we know that this is not true.

For illustrative purposes let us consider wood 'dust.' The 'dusts' selected for this study was purchased from American Wood Fibers. Two grades were selected to provide distinct particle size distributions. The first was a fine material which will be referred to as Wood Flour and the second was a coarse material which will be referred to as Wood Dust. The Wood Dust material was sieved to remove the fraction of particles that were between 500 μm and 850 μm for testing (removing fines). The Wood Flour is very fine with a mean particle diameter of approximately 60 μm . The sieved Wood Dust is very coarse having a mean diameter of approximately 840 μm ; this material can even be considered as 'nondeflagrable wood dust' per the NFPA 664 standard.

It is important to note that even though the Wood Dust was sieved material there might still be particles which have elongated morphologies so the short axis may be less than 850 μm , allowing the particle to pass through the sieve, but the long axis may be much greater than the screen opening. Figure 1 is a micrograph of the type of particle which would have passed through the sieve.

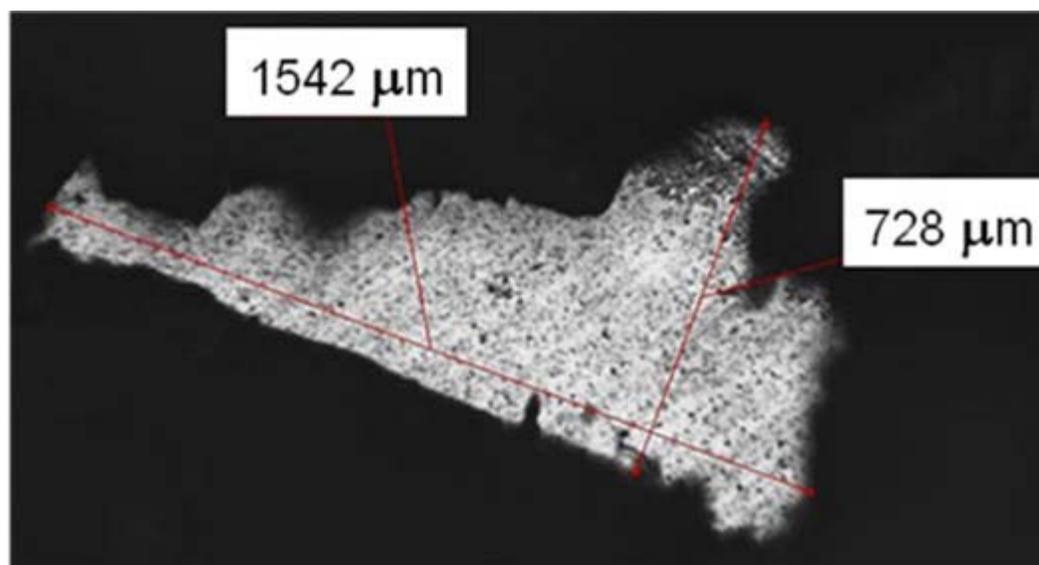


Figure 1 Micrograph of a Wood Dust particle.

These two materials were used as the source samples for various mixtures used for explosion severity tests that were performed. The Wood Flour mixtures with 0%, 50%, 80%, 90%, and 95% Wood Dust mixtures were tested in addition to 100% Wood Dust.

In order to establish the explosibility of the wood mixtures, test method ASTM E1226-10, '*Standard Test Method for Explosibility of Dust Clouds*', was selected to be performed in both chambers to ascertain explosion severity. In this method a pre-weighed dust mixture is dispersed into the combustion chamber with compressed air creating a confined cloud of 'dust.' Then after a preset delay, two 5-kJ igniters are discharged and the resulting pressure rise from the combustion of the cloud is recorded as a function of time. This process is repeated with increasing quantities of dust until a maximum value has been found for the explosion overpressure and the maximum rate at which the explosion progresses. According to ASTM E1226, dusts deflagrations producing P_{max} greater than 1 barg are explosible. An example of a typical pressure-time trace is presented in Figure 2 below.

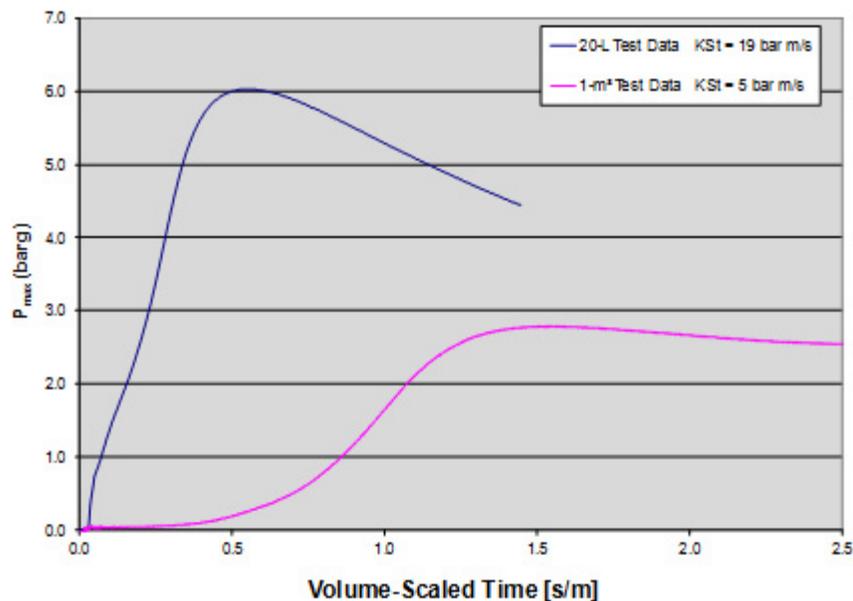


Figure 2 Pressure-time traces of 100% Wood Dust deflagration tests.

In Figure 2, the test data is plotted for 100% coarse Wood Dust in both the 20-L chamber and 1-m³ chamber. The explosion overpressure, expressed in barg, is plotted on the ordinate with the volume-scaled time, in s/m, on the abscissa. The results from the 20-L chamber (blue line) indicate that the deflagration resulted in a 6 bar overpressure with a 19 bar m/s rate of pressure rise. Additionally, the 1-m³ data (pink line) indicates that the deflagration in that chamber produced an overpressure of 2.8 bar and a rate of pressure rise of 5 bar m/s. It is important to note that the dispersion mechanism on the 1-m³ chamber was designed primarily to disperse very fine dust having a particle size less than 65µm. As a result, slow burning of dust clouds at high dust loadings with coarse material may be expected. The important factor to note is that material; which according to some NFPA standards, should not be capable of supporting flame propagation, appears to do so very well.

As the coarse Wood Dust is 'contaminated' with fine material (adding Wood flour to Wood Dust) the explosion severity measurements in the two chambers become similar. A comparison of the peak overpressures are made in Figure 3 where the data is plotted as a function of percent coarse Wood Dust in the mixture. As in the previous figure, the Wood Flour ' Wood Dust mixtures are explosible for all samples tested.

(This information is discussed in greater detail in a presentation authored by Erdem Ural (Loss Prevention Science & Technologies, Inc.) , Stuart Johnson (Fike Corporation) and Ashok Ghose Dastidar titled 'Effect of Particle Shape and Size Distribution on Dust Explosion Risks' and delivered at the 8th Global Congress on Process Safety, from April 1-5, 2012 in Houston, TX.)

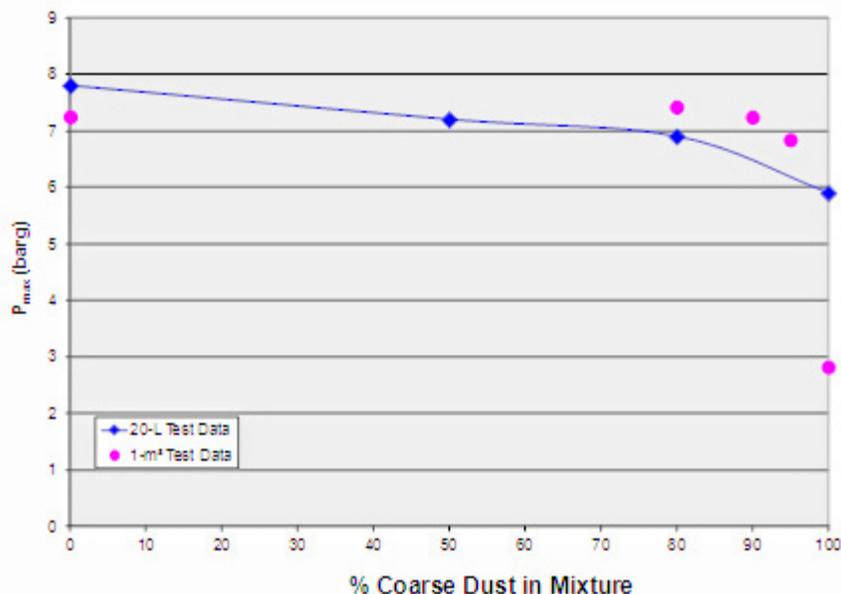


Figure 3 Explosion overpressure in the 20-L chamber and the 1-m³ chamber as a function of percent coarse Wood Dust in the mixture.

The test data clearly demonstrates that 'nondeflagrable' wood dust as defined in NFPA 664 is actually an explosion hazard and that even a small amount of contamination with wood fines (Wood Flour in this case) is capable of making weak explosions energetic. Similar deflagration results were observed in the 1-m³ and 20-L scale for various dusts mixtures tested. Thereby putting to rest the very dangerous myth that coarse wood particles having a mean particle size greater than 500 micron do not pose a dust explosion risk.

References

- NFPA 664: Standard For The Prevention Of Fires And Explosions In Wood Processing And Woodworking Facilities,
- NFPA 61: Standard For The Prevention Of Fires And Dust Explosions In Agricultural And Food Processing Facilities,
- ASTM E1226 (2010) Standard Test Method for Explosibility of Dust Clouds, Erdem Ural, Stuart Johnson and Ashok Ghose Dastidar, 'Effect of Particle Shape and Size Distribution on Dust Explosion Risks' 8th Global Congress on Process Safety, from April 1-5, 2012 in Houston, TX.

About the author

Dr. Ashok Ghose Dastidar is the Vice President, Dust & Flammability Testing and Consulting Services at Fauske & Associates. Dr. Dastidar specializes in Chemical Process Hazards Analysis, Flammable Dusts, Liquids & Vapors Explosion and Combustion Hazards Analysis and Testing and Electrostatic Hazards Analysis. He has extensive technical experience performing tests and analyzing data to determine the following:

- Electrostatic Hazards ' Field measurements, discharge potential, charge transfer and ignitability,
- Dust Explosibility Hazards ' ease of ignitability and explosion severity,
- Flammability Hazards ' ease of ignitability and explosion severity of liquid and vapor explosions,
- Thermal Stability and Reactivity Hazards ' by Differential Scanning Calorimetry and Dewar Tests,
- Hazard Analysis and Risk Mitigation ' using HAZOP, FMEA/FMECA, and FTA.

Dr. Dastidar is a member of the Editorial Advisory Board for Powder Bulk Solids and has published 12 articles including: A. G. Dastidar, B. N. Reyes, and C. J. Dahn, 'Evaluation of dust and hybrid explosion potential in process plants', *Process Safety Progress*, vol 24, no. 4, pp 294-298, 2005.

He has also presented at more than 23 conferences including: A. G. Dastidar, C. J. Dahn, B. Cole and K. H. Lo, 'Incendiary Nature and Electrostatic Discharge Characteristics of FRP Pipes', Fourth International

Conference on Composite Materials for Offshore Operations. Houston, TX, October 4 ' October 6, 2005.