Literature Review – Wood Dust Explosions

Recent sawmill fires in BC have focused local industry and governments on wood dust and its potential for causing explosions. Dust explosions and fires have been recognized as a major problem in Canada, the US and Europe for many years—particularly among those responsible for worker health and safety. In the United States, the Occupational Health and Safety Administration (OHSA), is working on a set of regulations concerning combustible dust. Currently OSHA has a short-term measure in place to facilitate inspection of all workplaces where combustible dust is generated. The grain handling industry has a history of grain dust fires and explosions, and they have had great success in reducing these by following specifically written OSHA regulations for their industry. It is anticipated that similar success can be achieved for other industries that produce combustible dust.

The most critical parameters of combustible wood dust that can cause explosions are particle size, particle size distribution, moisture content and concentration of wood dust in the air. Wood dust below 420 microns in size and with moisture content below 33% (dry basis) is considered to be explosive. Also, wood dust found either in an air mixture at only 25% of the minimum explosible concentration or deposited in a layer greater than 1/8-inch on a surface is considered to be a deflagration hazard. This literature review focuses on regulatory information pertaining to these key factors. There has been extensive research in these areas but the research results are not included in this review since they have not been scrutinized by the health and safety regulatory agencies.

Directly Relevant to Wood Dust Regulation

Two key sources of information about wood dust explosions and fires are:

- National Fire Prevention Association NFPA 664: *Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities*[1]
- Fire Protection Handbook 20th Edition Volume 1[2].

Key Points: *NFPA 664—Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities*

This Standard establishes minimum requirements for fire and explosion prevention and protection for lumber mills. It outlines general requirements and definitions of terms—some of the more important terms are listed below.

- *Deflagrable Wood Dust* is a wood particulate with a mass median particle size of 500 microns or smaller, having a moisture content less than 25% (wet basis) or 33.3% (dry basis – the usual method employed to express moisture content in the wood industry).
- *Deflagration Hazard* exists if any of the following conditions are present: deflagrable wood dust is considered to be present if there is a layer of dust deeper than 1/8-inch on a horizontal surface over 5% of the area concerned or deflagrable wood dust is suspended in air at a concentration in excess of 25% of the minimum explosible concentration (MEC) as measured in mass per unit volume or grams of dust per cubic metre of air.

- Evaluation of a hazard should be determined by means of actual test data. Tests for the following can be made: MEC, particle size distribution and moisture content.
- Moisture content has a profound effect on the propagation of dust fires, because dust with low moisture content has a lower minimum ignition temperature and energy requirement and a lower MEC; the cut-off for the effects of moisture content is approximately 30 to 33% (dry basis) since moisture contents above this range can reduce the effects of an explosion by absorbing the heat generated.
- Removal of dust using compressed air is to be limited to a pressure of 15 psi, otherwise a potentially explosive dust cloud could result.

Key Points: *Fire Protection Handbook 20th Edition Volume 1 Chapter 8 Section 6: Dust*

- The finer the particulate, the more easily it is ignited—with the threshold being particles of 420 microns of equivalent diameter.
- Particle size is usually determined using standard sieves which work well for spherical or cubic particle shapes. Wood particulates are usually elongated rather than being spherical or cubic, hence an equivalent particle diameter has to be determined.
- Equivalent particle diameter is the diameter of a round particle that has the same surface area to volume ratio as an elongated wood particle.
- Highly elongated and fibrous particles behave as if they were much smaller because of the higher average surface area to average volume ratio—therefore simple sieve analysis can lead to dangerous underestimation of the hazard.
- Tests to determine the minimum explosible concentration of wood dust take into account particle size distribution, chemistry, moisture content and particle shape.
- Mitigation practices for dust explosions can be found in NFPA 654 *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing and Handling of Combustible Particulate Solids*[3]. Key practices are: minimize the escape of dust from process equipment using dust collection equipment; utilize surfaces that minimize dust accumulation and facilitate cleaning; inspect for dust accumulation in hidden areas; use cleaning methods that do not generate dust clouds; and develop and implement a hazardous dust inspection, testing and housekeeping program.

Sampling and Testing

The following publications provide some information regarding dust sampling recommendations, although there are no specific protocols for collecting wood dust.

How Well Do You Know Your Dust?[4]

This paper is intended to provide information on the process of specifying a dust collection system by first knowing the properties of the dust via sampling techniques. When collecting dust samples the recommendation provided by the author is to not include dust swept from the floor nor from a hopper as this dust may contain impurities and larger dust particles that would generally have enough mass to fall to the floor.

ASTM E 1515 Standard Test Methods for Minimum Explosible Concentration of Combustible Dust[5]

This Standard is used in North America to determine the minimum concentration of a dust-air mixture that will propagate a deflagration in a closed container.

- Recommendation is to follow a dust sampling procedure as described in the ASTM *Manual on Test Sieving Methods*[6].
- Dust particle size recommended for testing should have 95% of the particles less than or equal to 75 microns.
- Dust particles are all dried to a moisture content of 5% or below to conduct this test.

Other Information Relevant to Wood Dust

The US Department of Labor's Occupational Safety & Health Administration (OSHA) is working on the creation of a combustible dust regulatory standard for general industry. In the meantime, it has re-issued *Combustible Dust National Emphasis Program (NEP) CPL 03-00-008*[7] which provides policies and procedures for inspecting workplaces where combustible dust is present. The OSHA admits that existing standards are fragmented and incomplete and do not regulate important elements of combustible dust hazards. The National Fire Protection Association's (NFPA) detailed guidelines for preventing and mitigating dust fires and explosions are widely considered to be effective though they are voluntary. It is expected the OSHA will adopt many of the practices found in the various NFPA Standards.

The OSHA has the authority to set national workplace safety standards, whereas in Canada workplace safety standards are set and enforced by provincial authorities. WorkSafeBC regulations and guidelines refer to both the OSHA Instruction—*Combustible Dust National Emphasis Program* and various NFPA standards dealing with combustible dust. WorkSafeBC has recently released the *Combustible Dust Strategy – Phase 1 (Sawmills)*[8]. Until adopted in some form by WorkSafeBC, the US-sourced standards are only guidelines for use by the Canadian industries to which they might apply.

Indirectly Relevant to Wood Dust

Other industries have had problems with dust fires and explosions, including: coal, pharmaceuticals, plastics and metal grinding, food, pet food, sugar refining and grain handling, all of which produce and process products with a combustible dust content. The grain handling industry has been very successful by adopting strategies that have greatly reduced dust explosions. In Germany, considerable research has been done in categorizing over 4000 types of dust for particle size and their explosive factors.

Coal Industry

Best practices in the U.S. coal industry (power station) to control explosions started with sharing information with all stakeholders in the industry[9], as it was a common problem. The British coal-fired power plants have written best practices[10] in which they recommend that the best places to control dust emissions are at transfer points such as chutes and open conveyor transfer points. These dust-generating areas need to have dust containment systems fitted or, if already in place, regularly checked to see if they are working. Dust extraction systems should be added to open conveyor transfer points where complete enclosure is not possible. Dust extraction should not be used as a

replacement for enclosure but used in combination. The better the enclosure, the less costly the extraction system and the more effective it will be. Transfer zones should use optimizing transfer chute geometry to minimize impact zones. As for housekeeping, cleaning is made easier if ledges are eliminated by adding angled plates to overhead beams and erecting "tents" over flat tops of equipment areas. Access points to conveyors and chutes should be closed properly via hatches to seal shut.

Grain Industry

The grain industry has their own OSHA Standard – *Grain Handling Facilities, 1910.272 App A*[11] — to address hazards found in grain handling facilities, with particular emphasis on fire and explosion hazards. Best practices resulted from industry members getting together to design new facilities that minimize the effects of an explosion[12]. These included putting more hazardous equipment outside the facility or in separate structures and having the equipment protected by explosion venting to the outside. They have added suppression or hazard monitoring systems with centralized PLC controls to receive signals of potential hazards. Equipment has had enclosures added to keep dust in and, where possible, have shrouding or covering over belt conveyors. Oil suppression systems are also used to help control dust. As for housekeeping, a written housekeeping plan should be provided that stipulates the need for periodic inspection of the facility for excessive dust levels with emphasis on priority areas that are defined as being within a prescribed distance from a known dust source. Blow downs using compressed air are permitted provided good controls are in place to ensure no ignition sources are in the area, such as hot or overheated equipment and that there are no open sparks of any kind.

Europe

Combustion and Explosion Characteristics of Dusts BIA Report 13/97[13]

- Fine dust ignites more easily and reacts more violently than coarser dust hence the emphasis should be on determining the characteristics of fine dust.
- Tests of deposited dust are generally conducted on the dust fraction <250 microns .
- Tests on whirled-up dust, as found in dust clouds, are conducted on the fraction <63 microns.
- Reduction in the explosion characteristics of dust occurs above 30% moisture content (dry basis).

Gestis-Dust-Ex[14] is a database on the combustion and explosion characteristics of over 4000 types of dust of which wood dust, and wood dust mixtures with other materials is well covered.

Glossary

Micron – a millionth of a metre

Deflagration – a flame spread rate of less than the speed of sound

Explosion – a rapid release of high pressure gas into the environment

Detonation – a flame spread rate that is above the speed of sound

Combustible Dust – a combustible particulate solid that presents a fire or deflagration hazard when suspended in some oxidizing medium (air) over a range of concentrations, regardless of particle size or shape

Minimum Explosive Concentration (MEC) – The minimum concentration of combustible dust suspended in air, measured in mass per unit volume that will support a deflagration

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