Aon Safety Information Bulletin — April 26th, 2012

Combustible Wood Dust in Sawmills: Preventing and Mitigating the Effects of Fire and Explosions

Two separate, recent catastrophic events affecting sawmills in BC have served as a critical reminder of how large a role strong risk management practices play in this industry segment. Aon is committed more than ever to our clients in the management of risk with a strong focus on safety and property conservation.

The most recent provincial developments in BC included the Labour Minister, Margaret MacDiarmid, instructing WorkSafeBC to take the "extraordinary step" of sending orders to sawmill employers in BC to conduct "full hazard identification, risk assessment and safety reviews, with particular focus on sawdust accumulation and potential ignition sources."

On April 25th, 2012, WorkSafeBC informed to the media that inspection officers will be conducting on-site follow-ups at each sawmill within two weeks to ensure compliance.

On the same date, the union representing sawmill workers in B.C. has reported to be in talks with the Ministry of Labour to create regulations that will require employers to deal with sawdust accumulation in their mills.

Purpose

This Safety Information Bulletin highlights:

- Hazards associated with wood combustible wood dusts;
- Work practices and guidelines that reduce the potential for a wood combustible dust explosion, or that reduce the danger to employees if such an explosion occurs; and,
- Training to protect employees from these hazards.

Background

Dust Fire and Explosion

Combustible dusts are fine particles that present an explosion hazard when suspended in air in certain conditions. A dust explosion can be catastrophic and cause employee deaths, injuries, and destruction of entire buildings.

Regrettably, in many combustible dust accidents, employers and employees were unaware that a hazard even existed.

According to a report issued by the Occupational Safety and Health Administration of the US in October 2009, there have been nearly 280 dust fires and explosions at industrial sites across North America over the prior 25 years. Those accidents have caused 130 fatalities and about 780 injuries. Like most fires, a dust fire occurs when fuel (the combustible dust) is exposed to a source of ignition in the presence of oxygen. Removing any one of these elements of the fire "triangle" eliminates the possibility of a fire.

For dust explosions, two additional conditions are required: dispersion and confinement. Suspended dust burns more rapidly and confinement allows for pressure build-up. Incidents of dust explosions can sometimes reveal a pattern of multiple subsequent explosions. The initial explosion can disturb dust that has settled over a period of time causing it to become airborne resulting in a secondary explosion that propagates throughout the plant often with catastrophic results. On occasions, there have been more than one subsequent explosions.

In addition to sawmills and wood working operations, various other industries are at risk of dust explosions including but not limited to: wood product manufacturing; combustible metal processing; chemical manufacturing; food and pharmaceutical production; grain storage, sugar mills, fabrication of rubber and plastic products; and coal-fired power plants.

Combustible materials which have been implicated in some dust explosions include: wood dust; coal; chemicals; rubber; grain dust; sugar; flour; and a number of metals such as aluminum.

Causal factors usually listed in incident forensic investigation reports include inadequacies in the following areas:

- Housekeeping to control dust accumulations;
- Ventilation system design;
- Maintenance of ovens, driers and furnaces;
- Equipment safety devices.
- Hazard assessment, and
- Hazard communication.

Elements Needed for a Fire (the "Fire Triangle")

1. Combustible dust (fuel);
2. Ignition source (heat); and,
3. Oxygen in air (oxidizer).

Additional Elements Needed for a Combustible Dust Explosion

4. Dispersion of dust particles in sufficient quantity and concentration; and,
5. Confinement of the dust cloud.

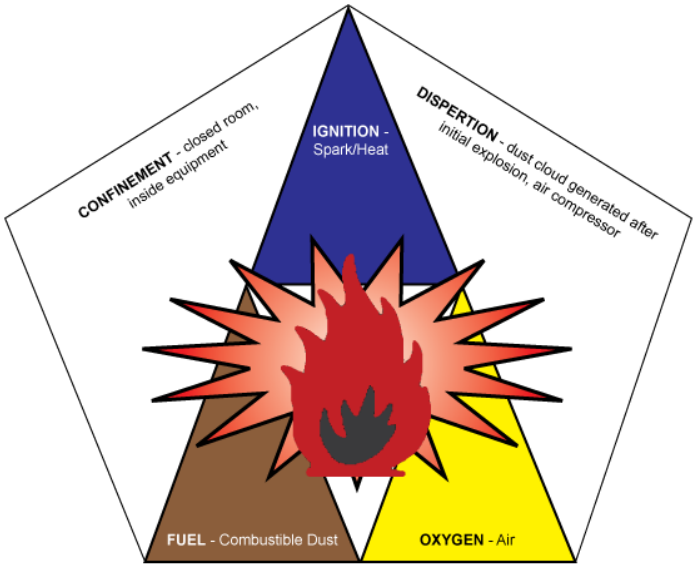

Figure 1. Explosion Pentagon

The addition of the latter two elements to the fire triangle creates what is known as the "explosion pentagon" (see Figure 1). If a dust cloud (diffused fuel) is ignited within a confined or semi-confined vessel, area, or building, it burns very rapidly and may explode. The safety of employees is threatened by the ensuing fires, additional explosions, flying debris, and collapsing building components.

An initial (primary) explosion in processing equipment or in an area where fugitive dust has accumulated may shake loose more accumulated dust, or damage a containment system (such as a duct, vessel, or collector). As a result, if ignited, the additional dust dispersed into the air may cause one or more secondary explosions (see Figure 2). These can be far more destructive than a primary explosion due to the increased quantity and concentration of dispersed combustible dust.

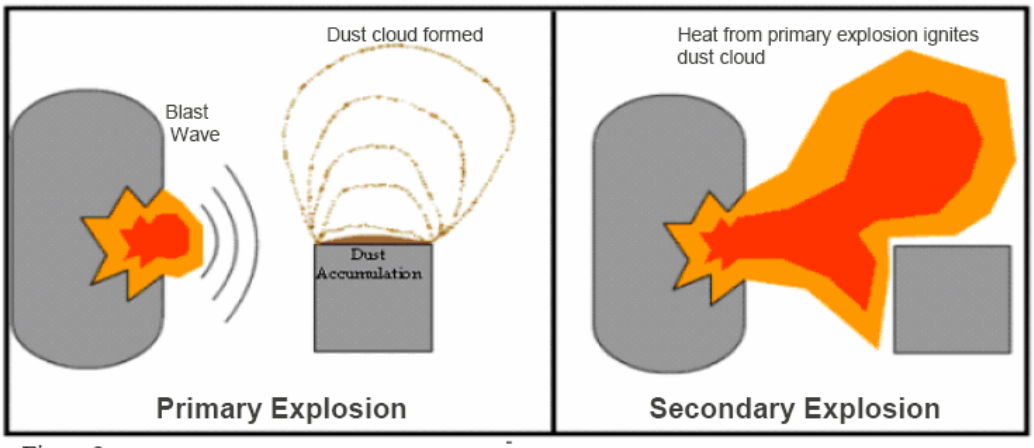

Figure 2

If one of the elements of the explosion pentagon is missing, a catastrophic explosion cannot occur. Two of the elements in the explosion pentagon are difficult to eliminate: oxygen (within air), and confinement of the dust cloud (within processes or buildings). However, the other three elements of the pentagon can be controlled to a significant extent, as it is discussed further in this document.

Facility Dust Hazard Assessment

A combustible wood dust explosion hazard may exist in your plant. Aon has devised a Facility Sawdust Hazard Assessment specifically tailored to address concerns in sawmills and wood working plants. It produces effective risk control recommendations that will help you manage your exposure while keeping your total cost of risk at a bay. Contact your Aon representative for more information. See list of contacts at the end of this bulletin.

Facility Analysis Components

Facilities should carefully identify the following in order to assess their potential for dust explosions:

- Materials that can be combustible when finely divided;
- Processes which use, consume, or produce combustible dusts;
- Areas where combustible dusts may build up;
- Hidden areas where combustible dusts may accumulate;
- Means by which dust may be dispersed in the air; and
- Potential ignition sources.

Dust Combustibility

The primary factor in an assessment of these hazards is whether the dust is in fact combustible. Any "material that will burn in air" in a solid form can be explosive when presented in finely divided particulates.

Combustible Dust is defined by NFPA 654 - *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids* - as: “A finely divided combustible particulate solid that presents a flash fire hazard or explosion hazard when suspended in air or the process-specific oxidizing medium over a range of concentrations“.

The same standard defines Combustible Particulate Solid as: “Any solid material composed of distinct particles or pieces, regardless of size, shape, or chemical composition that presents a fire hazard”.

Dust Explosibility

Different dusts of the same combustible material may have different ignitability and explosibility characteristics, depending upon many variables such as particle size, shape, and moisture content. Additionally, these variables can change while the material is passing through process equipment. For this reason, published tables of combustible dust explosibility data may be of limited practical value.

Also, industrial settings may contain high-energy ignition sources such as welding torches or open flame devices that can provide the ignition energy necessary to ignite larger particulate sizes.

The pine beetle epidemic in BC has had an impact on raw timber supply for many sawmills. Some mills that process these logs may have experienced a noticeable increase in combustible dust generation which, in turn, significantly increases the overall hazard associated with dust management and the

need for adequate housekeeping practices that are commensurate with the exposure.

Deflagrable Wood Dust is defined by NFPA 664 - *Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities* - as: “Wood particulate that will propagate a flame front, thus presenting a fire or explosion hazard, when suspended in air, or the process-specific oxidizing medium over a range of concentrations, regardless of particle size or shape; wood particulate with a mass median particle size of 500 microns or smaller (i.e., material that will pass through a U.S. No. 35 Standard Sieve), having a moisture content of less than 25 percent (wet basis).”

The same standard defines Dry Nondeflagrable Wood Dust as “Wood particulate with a mass median particle size greater than 500 microns (i.e., material that will not pass through a U.S. No. 35 Standard Sieve), having a moisture content of less than 25 percent (wet basis).”

Electrical Classification

The facility analysis must identify areas requiring special electrical equipment classification due to the presence (or potential presence) of combustible dust. Detailed requirements for equipment and for electrical installations in hazardous areas are in NFPA 70, the *National Electrical Code.*

Further guidance on area classification is contained in NFPA 654 - *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids* as well as in *NFPA 664 - Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities*.

The overall dust hazard designation for electrical requirements is Class II. This is further broken down into Divisions which represent the probability of dust being present at any given time. Additionally, each dust is assigned a group (E, F, or G), representing the dust types (metal, carbonaceous, organic and other, respectively) with different properties. For instance, group G dusts includes atmosphere that may present combustible dusts of wood, flour, grain, plastic, and some chemicals.

For Class II locations, Groups E, F, and G, the classification involves the tightness of the joints of electrical assembly and shaft openings to prevent the entrance of dust in the dust-ignition proof electrical enclosure, the blanketing effect of layers of dust on the equipment that may cause overheating, and the ignition temperature of the dust. It is necessary, therefore, that equipment be identified not only for the class but also for the specific group of dust that will be present.

Sections 500.7(A) through (L) of the NFPA 70 provides acceptable protection techniques for electrical and electronic equipment in hazardous (classified) locations.

Other Hazard Analysis Considerations

The amount of dust accumulation necessary to cause an explosive concentration can vary greatly. This is because there are so many variables – the particle size of the dust, the method of dispersion, ventilation system modes, air currents, physical barriers, and the volume of the area in which the dust cloud exists or may exist. As a result, simple rules of thumb regarding accumulation (such as writing in the dust or visibility in a dust cloud) can be subjective and misleading. The hazard analysis should be tailored to the specific circumstances in each facility and the full range of variables affecting the hazard.

Many locations need to be considered in an assessment. One obvious place for a dust explosion to initiate is where dust is concentrated. In equipment such as dust collectors, a combustible mixture could be present whenever the equipment is operating. Other locations to consider are those where dust can settle, both in occupied areas and in hidden concealed spaces. Fugitive dust can occur where conveying systems change direction or at transfer points. For sawmill operations, areas that must specifically be considered include (but are not limited to) the following:

- Debarking operations;
- Primary breakdown operations (saws);
- Chipper enclosures;
- Chip screening operations; and,
- Conveying and transfer points.

A thorough analysis will consider all possible scenarios in which dust can be dispersed, both in the normal process and potential failure modes.

After hazards have been assessed and hazardous locations are identified, one or more of the following prevention, protection and/or mitigation methods may be applied.

Dust Control

NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids* and NFPA 664 - *Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities* contain comprehensive guidance on the control of dusts to prevent explosions. The following are some of its recommendations:

- Minimize the escape of dust from process equipment or ventilation systems;
- Use dust collection systems and filters;
- Utilize surfaces that minimize dust accumulation and facilitate cleaning;
- Provide access to all hidden areas to permit inspection;
- Inspect for dust residues in open and hidden areas, at regular intervals;
- Clean dust residues at regular intervals;
- Use cleaning methods that do not generate dust clouds, if ignition sources are present;
- Only use vacuum cleaners approved for dust collection;
- Locate relief valves away from dust hazard areas; and
- Develop and implement a hazardous dust inspection, testing, housekeeping, and control program (with established frequency and methods).

Ignition Control

NFPA 654 -*Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids* and NFPA 664 - *Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities* also contains comprehensive guidance on the control of ignition sources to prevent explosions. The following are some of its recommendations:

- Use appropriate electrical equipment and wiring methods;
- Control static electricity, including bonding of equipment to ground;
- Control smoking, open flames, and sparks;
- Control mechanical sparks and friction;
- Use separator devices to remove foreign materials capable of igniting combustibles from process materials;
- Separate heated surfaces from dusts;
- Separate heating systems from dusts;
- Proper use and type of industrial trucks;
- Proper use of cartridge activated tools; and

- Adequately maintain all the above equipment.

The use of proper electrical equipment in hazardous locations is crucial to eliminating a common ignition source. The classification of areas requiring special electrical equipment is discussed in the Facility Dust Hazard Assessment section above. Once these areas have been identified, special Class II wiring methods and equipment (such as "dust ignition-proof" and "dust-tight") must be used as required by NFPA 70 Article 500. It is important not to confuse Class II equipment with Class I explosion-proof equipment, as Class II addresses dust hazards, while Class I addresses gas, vapor and liquid hazards.

Damage Control

NFPA 654 - *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*, contains comprehensive guidance to minimize the danger and damage from an explosion. The following are some suggested protection methods:

- Separation of the hazard (isolate with distance);
- Segregation of the hazard (isolate with a barrier);
- Deflagration venting of a building, room, or area;
- Pressure relief venting for equipment;
- Provision of spark/ember detection and extinguishing systems;
- Explosion protection systems (also refer to NFPA 69, Standard on Explosion Prevention Systems);
- Sprinkler systems; and
- The use of other specialized suppression systems.

Training

Employees

Workers are the first line of defense in preventing and mitigating fires and explosions. If the people closest to the source of the hazard are trained to recognize and prevent hazards associated with combustible dust in the plant, they can be instrumental in recognizing unsafe conditions, taking preventative action, and/or alerting management. All employees should be trained in safe work practices applicable to their job tasks, as well as on the overall plant programs for dust control and ignition source control. They should be trained before they start work, periodically to refresh their knowledge, when reassigned, and when hazards or processes change.

Management

A qualified team of managers should be responsible for conducting a facility analysis (or for having one done by qualified outside consultants*) prior to the introduction of a hazard and for developing a prevention and protection scheme tailored to their operation. Supervisors and managers should be aware of and support the plant dust and ignition control programs. Their training should include identifying how they can encourage the reporting of unsafe practices and facilitate abatement actions.

* Aon has developed an effective sawmill dust hazard assessment survey that has been proven to

help sawmills and woodworking facilities control these exposures while keeping the total cost of risk management under check. Contact your Aon representative for more information.

Aon has designated team of experts that will be readily available to look after your needs for sawdust risk control including full hazard identification, risk assessment and safety reviews, with particular focus on sawdust accumulation and potential ignition sources.

Aon Contacts

Insurance	Risk Control
Joe Hawk, CRM, A.I.I.C. Tel: 604.443.3308 | Cell: 604.376.0848 | Fax: 604.443.5247 joe.hawk@aon.ca	**Luis Marin, CIP** t 604.443.2458 | c 604.657.4127 | f 604.443.2501 luis.marin1@aon.ca
	Corey Gardiner t 250.413.2219 | c 250.217.2943 | f 250.388.5164 corey.gardiner@aon.ca

References

1. Occupational Safety and Health Administration (OSHA), the Massachusetts Office of the State Fire Marshall, and the Springfield Arson and Bomb Squad. "Joint Foundry Explosion Investigation Team Report." OSHA, Springfield, MA, (No date).

2. Chemical Safety and Hazard Investigation Board (CSB). "Investigation Report: West Pharmaceutical Services, Inc. Dust Explosion." CSB, Washington, DC, September 2004.

3. Chemical Safety and Hazard Investigation Board (CSB). "Investigation Report: CTAAcoustics, Inc. Combustible Dust Fire and Explosions." CSB, Washington, DC, September 2004.

4. Chemical Safety and Hazard Investigation Board (CSB). "CSB Investigators Find Likely Source of Dust Explosion at Indiana Automotive Plant." CSB News Release, Washington, DC, November 5, 2003.

5. National Fire Protection Association (NFPA). "Industrial Fire Hazards Handbook," 3rd Edition. NFPA, Inc., Quincy, MA, 1990.

General Information

Eckhoff, Rolf K. "Dust Explosions in the Process Industries," 3rd Edition, Gulf Professional Publishing, 2003.

Bartknecht, W. "Dust Explosions: Course, Prevention, and Protection," Springer- Verlag, 1989. Hatwig, M., and Steen, H. (eds.), "Handbook of Explosion Prevention and Protection," Wiley-VCH, 2004.

Frank, Walter. "Dust Explosion Prevention and the Critical Importance of Housekeeping," Process Safety Progress, vol. 23, no. 3, September 2004, pp. 175-184.

Limiting Conditions