COMBUSTIBLE DUST HAZARD MITIGATION

February 2014

FIPI Fire Inspection & Prevention Initiative

FITF Forest Industry Task Force

GUIDE FOR FRONT LINE SUPERVISORS AND MANAGEMENT

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COMBUSTIBLE DUST HAZARD MITIGATION

A] COMBUSTIBLE DUST HAZARD MITIGATION

In Module #1, Combustible Dust Hazard Recognition, we learned that the fire and explosion hazards of combustible dust having been known for years by experts and many others.

We also learned that combustible dust explosions are very preventable. The reason being that the controls to prevent those explosions are also well known. For example, the National Fire Protection Association Standards are effective and authoritative sources of information.

Before beginning, I just want to mention that your participant's handbook will contain more information related to some slides than what will be discussed during this presentation. Be sure to read your handbook afterwards to get the full benefit from this presentation.

A.1] WHY ARE WE HERE?

Fire and explosion hazards are both a 'fire prevention and control' issue and an occupational safety issue.

It means that industrial operations like wood product manufacturing have responsibilities under at least three sets of regulations:

- The Occupational Health and Safety Regulation
- The BC Safety Standards General Regulation and related regulations
- The BC Fire Code.

Fortunately, if you eliminate or control fire hazards in and around your buildings in accordance with BC Fire Code article 2.1.1.1 by preparing and implementing an effective fire safety plan in accordance with BC Fire Code article 5.1.5.1, you will go a long way towards meeting your entire fire and explosion hazards obligations.

Today's presentation is designed to assist you understand what you need to do to with respect to combustible dust mitigation and control.

Developing a fire safety plan is not part of today's presentation. The Fire Inspection and Prevention

Initiative lead the development of a guide, Fire Safety Plan (FSP) –Development Guide for Industrial Occupancies, to assist you develop a compliant fire safety plan. Your participant's handbook contains a link to obtain a copy of this guide.

A.1.1] ADDITIONAL INFORMATION

Building Owners and Occupiers are responsible under the BC Fire Code to eliminate or control fire hazards in and around their property (Article 2.1.1.1.).

To prepare a fire safety plan for areas where processes and operations that involved a risk from explosion, high flammability or related conditions that create a hazard to life safety (Article 5.1.5.1).

BC Fire Code Article 2.1.1.1 – Application

This Part provides for the safety of the occupants in existing buildings, the elimination or control of fire hazards in and around buildings, the installation and maintenance of certain life safety systems in buildings, the installation and maintenance of posted signs and information, and the establishing of a fire safety plan in those occupancies where it is considered necessary.

BC Fire Code Article 5.1.5.1 – Fire Safety Plan

Except as provided in Sentences (2) and (3), a fire safety plan conforming to Section 2.8 shall be prepared for areas where processes and operations described in Article 5.1.1.1 take place. (Article 5.1.1.1. Application. This Part applies to processes and operations that involve a risk from explosion, high flammability or related conditions that create a hazard to life safety.)

Reference: Fire Safety Plan (FSP) – Development Guide for Industrial Operations

Your fire safety plan needs to identify how your operation is controlling fire and explosion hazards, which includes combustible dust. The combustible dust hazards are identified in the related presentation, Combustible Dust Hazard Recognition.

This presentation will introduce some of the many controls available to mitigate combustible dust accumulation and potential ignition sources.

This will allow you to return to your operation, assess its current state and, if changes are necessary, have enough understanding of what is required.

Some of those changes will likely require the assistance of subject matter experts. Your participant's handbook contains some guidance for consideration when selecting a subject matter expert.

A.2] VIDEO – "NOT ENOUGH WAS DONE"

A.2.1] BEFORE VIDEO

In the related presentation, Combustible Dust Hazard Recognition, video clips illustrating the catastrophic explosion at the Imperial Sugar Refinery were shown. This video clip highlights the US Chemical Safety Board's investigation findings into the cause of that explosion and recommendations to prevent a similar explosion.

A.2.2] AFTER VIDEO

Basically, Imperial Sugar did not do enough to mitigate the combustible dust fire and explosion risks that existed in their operations.

The US Chemical Safety Board's findings included:

- Management aware for years of sugar dust's explosive properties from dust accumulation
- The facility previously experienced an explosion and many fires fuelled by spilled sugar and accumulated dust
- Management aware of OSHA's Combustible Dust National Emphasis Program
- Despite all this knowledge, management did not do enough to manage the combustible dust hazard

The US Chemical Safety Board speculated that "Decades of operating without a catastrophic explosion may have lulled management into complacency."

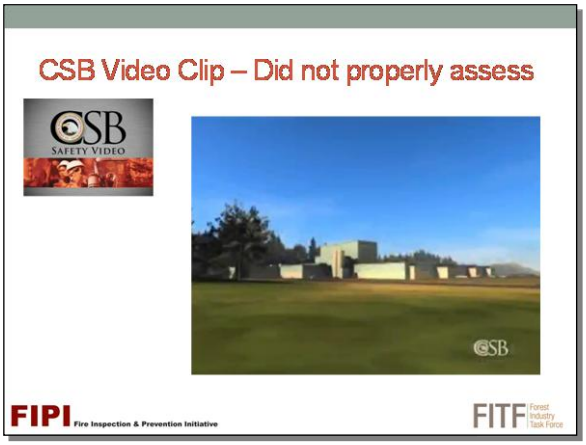
The US Chemical Safety Board made the following recommendations to Imperial Sugar:

- Apply NFPA Standards to the design and operation of the rebuilt facility
- Develop and implement comprehensive combustible dust control, housekeeping and training programs
- Improve emergency evacuation policies and procedures

It would be a worthwhile exercise to if determine those recommendations would benefit your operation.

A.3] VIDEO – "FACILITIES DO NOT PROPERLY ASSESS"

A.3.1] BEFORE VIDEO



The next video clip re-creates an explosion that occurred because the facility did not properly assess the risk of a combustible dust fire or explosion.

A.3.2] AFTER VIDEO

This video clip demonstrates that when you don't properly assess for the risk of a combustible dust fire or explosion, you will not design the buildings and equipment properly.

In this case, the facility failed to recognize that combustible dust was being released by the "waxing" process. Also, the build-up of dust above the false ceiling did not raise any concerns.

This explosion demonstrates that "not knowing if the dust in your facility is combustible can be dangerous."

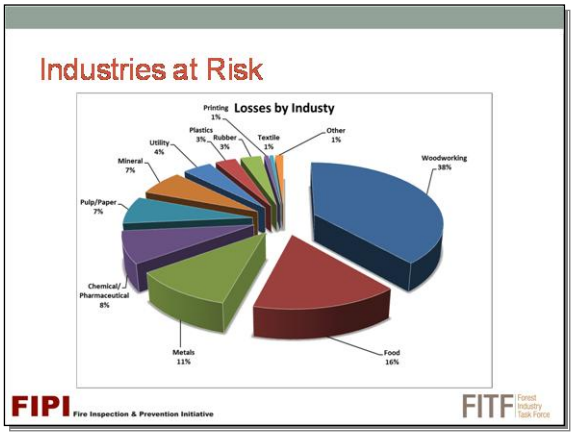
With respect to wood dust in BC, FP Innovations, under contract to the Forest Industry Task Force, undertook a study to examine fugitive wood dust accumulations from 18 sawmills across BC. The explosibility results showed that wood dust can be an explosion hazard in any BC sawmill, regardless of the type wood processed.

BC sawmills and other wood product manufacturers need to respond appropriately to the fact that all BC wood dust can be combustible under the right circumstances.

Resource: Chemical Safety Board Video – *Combustible Dust: An Insidious Hazard*

Reference: Combustible Dust Testing Sampling
http://www.worksafebc.com/news_room/features/2012/assets/pdf/CombustibleDustTestingSamplingReferencesResources.pdf

A.4] CHART—INDUSTRIES AT RISK



Source: FM Global Property Loss Prevention Data Sheets 7-76 Prevention and Mitigation of Combustible Dust Explosion and Fire.

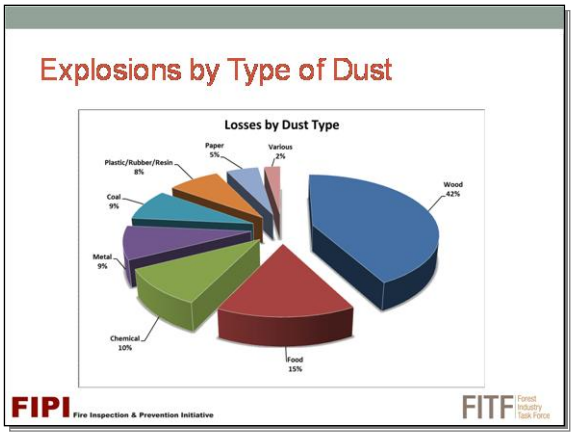
Combustible dust is not limited to wood. The FM Global chart illustrates the industries at risk of a combustible dust fire and/or explosion.

Dust explosions have occurred in many different industries, including agriculture, food products, chemicals, textiles, forest and furniture, woodworking, metal processing, paper products, pharmaceuticals and coal.

Notice that the Wood Products industry makes up 38% of explosions which is more than twice as many incidents as the next industry – food.

The Grain Industry has been very successful at reducing the number of combustible grain dust explosions by implementing robust mitigation strategies. BC's wood product manufacturing industry can do the same.

A.5] CHART—EXPLOSIONS BY TYPE OF DUST



Source: FM Global Property Loss Prevention Data Sheets 7-76 Prevention and Mitigation of Combustible Dust Explosion and Fire.

The FM Global chart illustrates the combustible dust fire/explosion incidents by dust type.

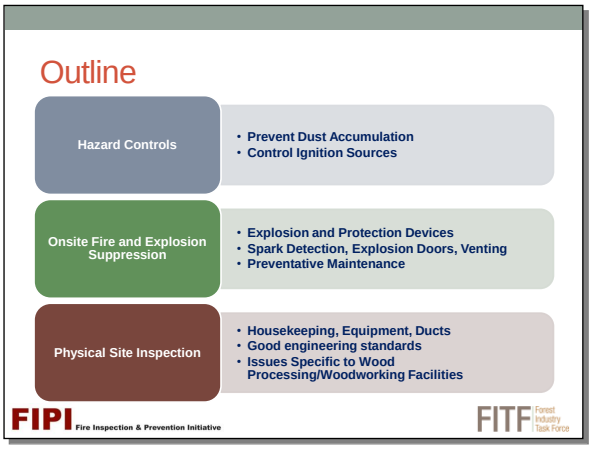
Wood Dust is the dust "at fault" 42% of the time and almost 3 times more often than the next serious dust type – food.

When you combine the FM Global data with the US Chemical Safety Board combustible dust investigation findings, and with the FP Innovations findings, a very clear warning emerges:

- Just because your operations has never experienced a catastrophic explosion does not mean you will never experience one. Remember, it takes a "perfect storm" scenario to bring all five explosion pentagon elements together to create that catastrophic explosion. Imperial Sugar operated for decades before that "perfect storm" scenario finally happened to them.
- Don't let "It's never happened here before" lull your operation into a false sense of security. You ignore the combustible wood dust explosion hazard at serious peril to your workforce and your operation.
- It's not a matter of if, but when! That 'when' can be 30 years from now, or it could be next week.

Be sure it will never happen to your operation – ensure the appropriate mitigation strategies are implemented. This workshop will help get you started.

A.6] WORKSHOP OUTLINE



We now know that combustible dust is a common workplace hazard that can cause fires and explosions if is it not properly managed.

This workshop is designed to increase your awareness about wood dust hazards and the available controls to mitigate those hazards.

By the end of the presentation, you will understand some of the available dust control mechanisms.

One common control mechanism is a dust collection system. There are some important considerations for the design of these systems at the point where dust is captured, within the dust transportation components to the dust collector, and with the dust collector itself. There is also explosion prevention equipment for dust collection systems. These will be discussed as well.

The session will end with a discussion to correlate the dust mitigation strategies with physical site inspections.

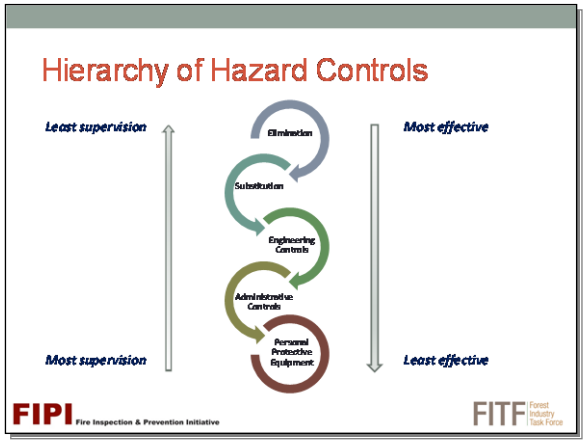
B] HAZARD CONTROLS—PREVENT ACCUMULATION OF COMBUSTIBLE DUST

HAZARD CONTROLS

Prevent accumulation of combustible dust

In this next module, we will discuss different types of controls that can be used to prevent the accumulation of combustible wood dust in the general workplace.

B.1] HIERARCHY OF HAZARD CONTROLS



Before we begin discussing those controls, we will take a few minutes to briefly explain the hierarchy of controls that should guide the selection of the control measure for a particular hazard.

B.1.1] ELIMINATION

The best way to control a hazard is to eliminate it and remove the danger. This can be done by changing a work process in a way that will get rid of a hazard. It should be your first consideration.

B.1.2] SUBSTITUTION

Substitution is the second best way to control a hazard. This means substituting something else in its place that would be non-hazardous or less hazardous to workers. For example, substitute a fan with metal blades with a fan with non-spark producing blades so that sparks, an ignition source, are not created inside the dust collection system.

B.1.3] ENGINEERING CONTROLS (SAFEGUARDING TECHNOLOGY)

If a hazard cannot be eliminated or a safer substitute cannot be found, the next best approach is to use engineering controls to keep the hazard from reaching the worker. This could include building design and construction material, combustible dust collection systems, bonding and grounding, explosion proof equipment, intrinsically safe electrical equipment.

B.1.4] ADMINISTRATIVE CONTROLS (TRAINING AND PROCEDURES)

If engineering controls cannot be implemented or are insufficient, administrative controls should be considered. Administrative controls involve changes in workplace policies and procedures such as:

- Hot Work Permit system
- Manual cleaning of combustible dust accumulation,
- Labelling containers and storage spaces for flammable/combustible materials
- Training

B.1.5] PERSONAL PROTECTIVE EQUIPMENT

The use of personal protective equipment (PPE) is the last resort w hen it is not practicable to use other controls. PPE controls the hazards by placing protective equipment directly on workers' bodies. Examples of PPE include: respirators, gloves, protective clothing, hard hats, goggles, and ear plugs.

Personal protective equipment is the *least* effective method for protecting workers from hazards because:

- The hazard is not eliminated or changed.
- If the equipment is inadequate or fails, the worker is exposed to the hazard.
- No personal protective equipment is fool-proof (for example, fire-resistant clothing).
- Personal protective equipment is often uncomfortable and can place an additional physical burden on a worker.
- Personal protective equipment can actually create hazards. For example, the use of respirators for long periods of time can put a strain on the heart and lungs.

Note: When planning for hazard controls, remember that the control selected must not eliminate one hazard while creating another. For example, it is not acceptable to place regular lighting within a passive containment enclosure if dust clouds are common. The light is an ignition source, which could complete the explosion pentagon. Hazard control measures should eliminate or reduce hazards for all who are potentially exposed to them.

B.2] IDENTIFY DUST ACCUMULATION AREAS

If you are ready to make your workplace safer from combustible dust, the first step is to identify where wood dust might accumulate.

You need to consider the processes that use, consume or produce wood dust. In a wood product manufacturing operation, you would look at the typical primary and secondary machine centres, all which cut, shape or otherwise change wood material.

Next you need to consider where wood dust accumulates away from the processes that produce the dust. This might be in the general work area, in concealed areas like attics, false ceilings, crawl spaces, electrical panels and wall spaces, and within the various components of the dust collection system.

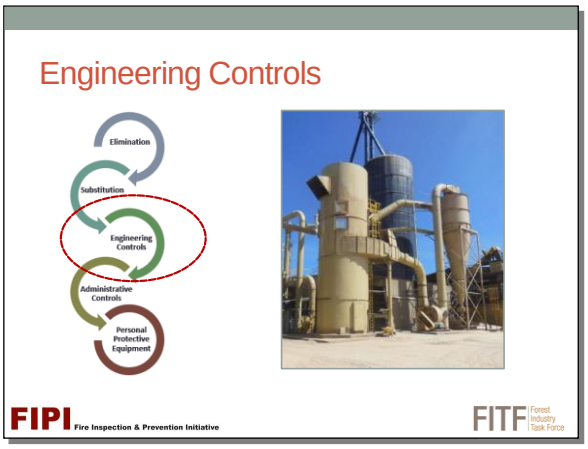
Finally, you need to consider if some of the accumulated dust is fugitive dust, meaning dust escaping from a dust collection system component, like duct work or the collector itself.

If you effectively collect the dust at it source then any dust, if any, that escapes the capture hood and accumulates in the general work area, is easily managed with a good housekeeping program.

If you effectively maintain your dust collection system, there should little, if any, fugitive dust.

Now that you have identified where the dust accumulates and why, it is time to consider the best way to address that accumulation.

B.3] ENGINEERING CONTROLS TO PREVENT ACCUMULATION



Let's start with the hierarchy of controls. Many processes that cut, shape or otherwise change wood material produces wood dust. Since the process produces the hazard (i.e., combustible dust) – elimination and substitution are not possible.

Where elimination and substitution are not possible, the next solution to consider is engineering controls.

Before we proceed, please note this **disclaimer**:

When selecting dust accumulation control strategies, it is important to understand the pros and cons, and the best location for use of each engineering control option. This presentation is insufficient to help make those decisions. It will likely require someone with the appropriate subject matter expertise.

B.3.1] CONSTRUCTION FEATURES

Construction features, such as surface slipperiness, sloping, and sealing, can reduce the accumulation and spread of wood dust.

These construction features can also simplify and complement good housekeeping practices.

Finally, they will assist to limit the spread of damage should a fire or explosion event occur.

The BC Building Code is an excellent reference. It contains fire safety and fire protection features that should have been incorporated in a building at the time of its original construction. Reviewing the code may identify features that are not currently part of your building that, if added, assist manage the accumulation of combustible dust if added.

There are several questions you can use to determine if modified construction features would be a good engineering control option in some parts of your operation. (See Additional Information below)

The top photo on this slide shows how a flat ledge was sloped to minimize dust accumulation and facilitate housekeeping.

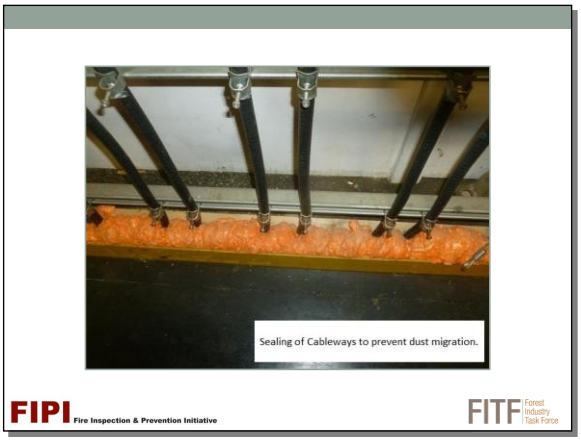
The bottom photo shows walls sheeted and painted gloss white to repel dust, thereby minimizing accumulation and facilitating housekeeping.

B.3.1.1] ADDITIONAL INFORMATION

Question to consider:

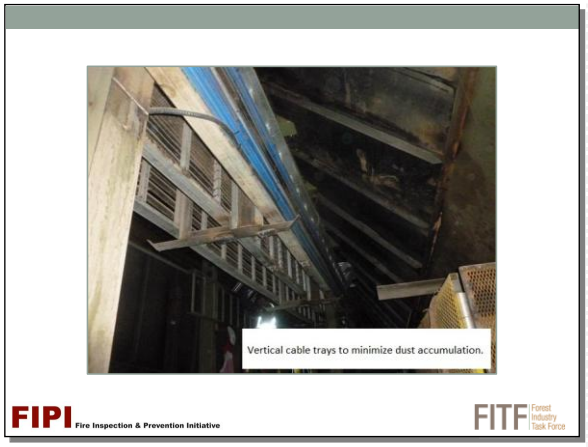
- Have building design features been utilized/incorporated to complement housekeeping and reduce dust accumulations?
- Have rooms and buildings with potential for combustible dust explosion been correctly identified? Examples could include chipper, screener, hog or sander enclosures.
- Are the interior surfaces of the building designed to facilitate cleaning? Have features such as high gloss paint or enclosing open stud walls/ceilings with plywood or sheet metal to assist with housekeeping and minimize dust accumulation?
- Are structural steel members with ledges and horizontal surfaces boxed in or enclosed?
- Are all enclosed areas fully sealed to prevent dust from entering the enclosure?
- Are windows, ledges, girders, beam and other horizontal surfaces including light fixtures provided with sharply sloped surfaces (40^0 – 60^0) to minimize dust deposits?

B.3.1.2] EXAMPLES OF GOOD CONSTRUCTION PRACTICES



Sealing cracks, for example of cableways though walls, prevents dust migration from one area another, or to prevent dust from accumulating in wall and ceiling cavities

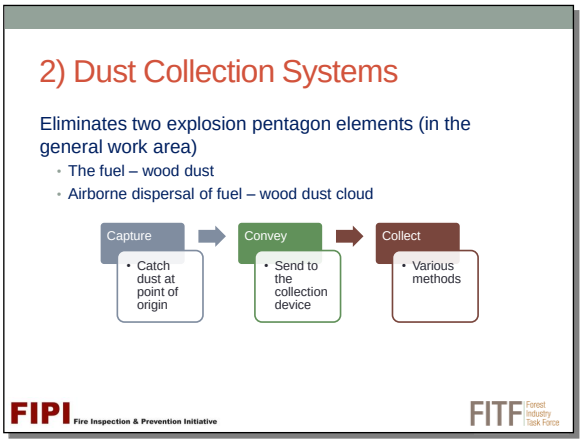
Reducing horizontal surfaces minimizes the available horizontal surfaces for dust accumulation. In this photo, cable trays where installed vertically to minimize dust accumulation.



Material conveyance systems can release wood dust into the general work area and elsewhere. This can be reduced by fully or partially enclosing the conveyance system.

A word of caution: This passive containment system is effective and safe when properly designed but can increase the risk of an explosion if improperly designed and/or operated. Recall from the Combustible Dust Hazard Recognition workshop that the primary explosion at the Imperial Sugar plant was in a fully enclosed belt conveyor system.

B.3.2] DUST COLLECTION SYSTEMS



The best mitigation strategy is to capture the dust at the point where it is produce so that it cannot spread and accumulate throughout the general workplace.

For many dust producing machines, that means connecting them to a dust collection system, which is another engineering control option. Dust collection systems also prevent dust clouds from forming.

If wood dust is not accumulating in the general work area and is not dispersed in the air, then two explosion pentagon elements are avoided, namely fuel and dispersion.

The BC Fire Code requires the use of dust collection systems, designed in conformance with good engineering practice, to prevent the accumulation of dust and keep suspended dusts at a safe concentration inside a building.

The Occupational Health and Safety Regulation has similar requirements. (See Additional Information section below)

Dust collection systems work on the basic formula of capture, convey and collect.

First, the dust must be captured. This is typically the weakest point in the system because, quite often, it is not properly designed.

Second, the dust must be conveyed pneumatically to the dust collector. If not designed correctly dust will settle and plug duct work.

Finally, the dust is collected. This is done via a variety of means, depending on the application and the dust being handled. It can be as simple as a basic pass-through filter, a cyclonic separator, or an

impingement baffle. It can also be as complex as an electrostatic precipitator, a multistage baghouse, or a chemically treated wet scrubber or stripping tower.

B.3.2.1] ADDITIONAL INFORMATION:

Dust collection systems capture combustible wood dust at the point of origin to prevent (1) accumulation of dust on floors, elevated flat surfaces, and other areas, and (2) wood dust clouds from forming, which means the prevention of two explosion pentagon elements: fuel and airborne dispersion of fuel, respectively.

Prevention of dust accumulation is the most effective explosion mitigation strategy. This is reflected in the BC Fire Code, which requires the use of dust collection systems.

The BC Fire Code section 5.3 says

- "Dust-collecting systems ***shall*** be provided to prevent the accumulation of dust and keep suspended dusts at a safe concentration inside a building."
- "A dust-collecting system required in Sentence (1) ***shall*** be designed in conformance with good engineering practice **such as that described** in NFPA 664: Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities, and NFPA standards on dust explosion hazards, and ***shall***
    - Be made of noncombustible materials, and
    - Not create sparks upon physical contact in the fan assembly.

The Occupational Health and Safety Regulation has similar requirements. Section 5.71 provides requirements for exhaust ventilation systems and dust collection where operations or work processes present a risk of fire or explosion. Refer to *G5.71(3) Location and construction of dust collectors* for guidance on locating and constructing dust collectors used to control combustible dusts so that workers will not be endangered in the event of an explosion inside the collector.

Dust Collection Systems (Engineering Controls)

A dust collection system is an air quality improvement system used in industrial, commercial, and home production shops to improve breathable air quality and safety by removing particulate matter from the air and environment. Dust collection systems work on the basic formula of capture, convey and collect.

First, the dust must be captured [typically the weakest point in the system if not properly designed]. This is accomplished with devices such as capture hoods to catch dust at its source of origin. Many times, the machine producing the dust will have a port to which a duct can be directly attached.

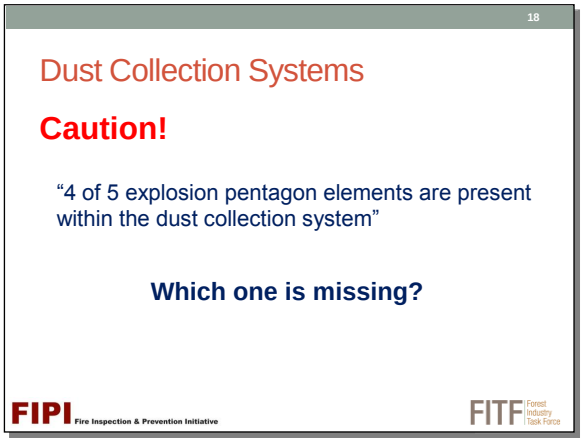
Second, the dust must be conveyed pneumatically to the dust collector. This is done via a ducting system, properly sized and manifold to maintain a consistent minimum air velocity required to keep the dust in suspension for conveyance to the collection device. A duct of the wrong size, wrong material, too many elbows and improper duct junctions can lead to material settling in the duct system and clogging it.

Finally, the dust is collected. This is done via a variety of means, depending on the application and the dust being handled. It can be as simple as a basic pass-through filter, a cyclonic separator, or an

impingement baffle. It can also be as complex as an electrostatic precipitator, a multistage baghouse, or a chemically treated wet scrubber or stripping tower.

The dust collection system includes explosion venting and spark detection and suppression equipment in the ducting and a deluge system in the bag cyclone to suppress fires and explosions. To keep these systems operating efficiently and as designed, this equipment should be on a regular preventative maintenance (PM) schedule which includes inspection, cleaning and servicing.

B.3.2.2] CAUTION



By their very nature and design, dust collection systems contain four of the five explosion pentagon elements:

- The wood dust is the fuel.
- The pneumatic conveyance and the collector provide the oxygen, the dispersion of the fuel and the containment.

The only explosion pentagon element missing is ignition source. There are many potential ignition sources that could trigger an explosion inside the dust collector system.

Shortly, we will show statistics that demonstrate dust collection systems are the most frequent site for primary explosions.

The Combustible Dust Hazard Recognition presentation included a video clip that illustrated how an explosion in a dust collector or ductwork could propagate through the ductwork, then the general work area.

The BC Fire Code identifies the minimum explosion prevention equipment that must be included on a dust collection system. Referring back to the Combustible Dust Hazard Recognition Presentation, if there is no accumulation in the general work area and there is no accumulation inside the duct work, then compliance with the minimum requirements of the BC Fire Code will likely suffice to protect workers and property.

According to NFPA, there may be good business reasons for equipping your dust collection systems with additional explosion prevention equipment. An explosion in the dust collector system could shut down production until the damage is repaired. The longer the shutdown, the more costly the impact of the explosion.

B.3.2.3] ADDITIONAL INFORMATION

Proper design requires features to prevent the generation of sparks and other ignition sources in and around all dust collection system components. Because the consequence of an ignition source within the dust collection system is so severe, spark detection and deluge systems and explosion controls can be installed to reduce or eliminate these risks.

Part of the process means assessing dust collection systems for potential combustible dust explosions. Some questions:

- Is the entire dust collection system from the capture point to the air exhaust point bonded and grounded?
- Is the dust collection system located outside the building more than 10m from the building or separated by a minimum 2 hour fire wall? A location on the roof of the building is acceptable if the roof is also fire rated for a minimum of 2 hours.
- Are explosion vents directed away from building, walkways, and other areas frequented by workers?
- Are cyclones or bag house type collectors that are connected to process equipment with a potential to produce sparks or embers:
    - Equipped with an approved spark detection system?
    - Equipped with an approved sprinkler system both above and below the collector bags?
    - Equipped with a high-speed abort gate?
    - Provided with counterweighted back draft dampers on in-feed duct work?
    - Provided with explosion-relief panels directed away from buildings where personnel congregate?

Process equipment with a potential to produce sparks or embers includes, but is not limited to:

- Fractionating equipment
- Rotary drum driers
- Pellet coolers

B.3.2.4] REFERENCE – BC FIRE CODE, DIVISION B, PART 5

Here are some of the pertinent sections:

5.3.1.4. Dust Collectors

1) Except as provided in Sentence (2), a dust collector having a capacity greater than 0.5 m^3/s shall

a) be located outside of a *building*, and

b) be equipped with explosion venting to the outdoors of not less than 0.1 m^2 of vent area for each cubic metre of dust collector enclosure volume.

2) A dust collector described in Sentence (1) is permitted to be located inside a *building* if it is

a) provided with explosion venting to the outdoors as specified in Clause (1)(b),

b) equipped with an automatic explosion prevention system, or

c) located in a room with *fire separations* having a *fire-resistance rating* of not less than 1 h and provided with explosion venting to the outdoors.

3) When air exhausted by a dust collector described in this Article is returned to a *building*, the dust-collecting system shall be designed so that

a) returned air will not create an explosion hazard inside the *building*, and

b) the exhaust fan and ancillary equipment are automatically shut down in the event of a fire or an explosion inside the dust collector.

5.3.1.5. Bonding and Grounding

1) Electrically conducting parts of conveying systems, dust collectors, dust-producing machines and any equipment capable of accumulating static electricity located in an atmosphere containing *combustible dusts* shall be electrically bonded and grounded.

2) Static electricity shall be prevented from accumulating on machines or equipment subject to static electricity buildup by appropriate bonding, grounding and static eliminating devices.

5.3.1.6. Explosion Venting

1) Except as provided in Article 5.3.1.7., an activity that creates an atmosphere containing significant concentrations of *combustible dusts* shall be located only in a *building* provided with explosion venting to the outdoors.

2) When explosion venting is required in this Section, it shall be designed to prevent critical structural and mechanical damage to the *building* in conformance with good engineering practice such as that described in NFPA 68, "Explosion Protection by Deflagration Venting." (See A-3.2.8.2.(1)(d) in Appendix A.)

5.3.1.7. Explosion Prevention Systems

1) In processes where an explosion hazard is present and conditions exist that prevent adequate explosion venting as required in this Section, an explosion prevention system shall be provided.

2) When an explosion prevention system is required in this Section, it shall be designed in conformance with good engineering practice such as that described in NFPA 69, "Explosion Prevention Systems."

5.3.1.8. Electrical Interlocks

2) Equipment required to have a dust-collecting system shall be interlocked to prevent it from operating if the dust-collecting system is not in operation.

5.3.1.9. Separators

3) Separators shall be provided to prevent the entrance of foreign materials that may cause sparks in conveying equipment, dust collectors, dust-producing machines and any equipment located in an atmosphere containing *combustible dusts*.

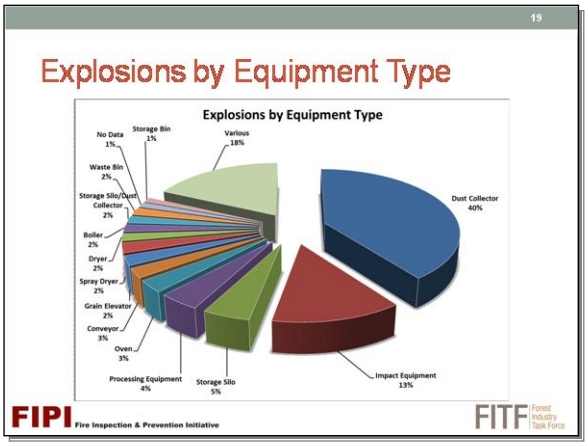
5.3.1.10. Ignition Sources

1) Unless controlled in a manner that will not create a fire or explosion hazard, a device, operation or activity that produces open flames, sparks or heat shall not be permitted. (See A-4.1.5.2.(1) in Appendix A.)

2) Portable electrical equipment used in atmospheres containing *combustible dusts* shall conform to the British Columbia Electrical Safety Regulation.

3) Smoking shall not be permitted in atmospheres containing *combustible dusts*.

B.3.3] CHART—EXPLOSIONS BY EQUIPMENT TYPE



Source: FM Global Property Loss Prevention Data Sheets 7-76 Prevention and Mitigation of Combustible Dust Explosion and Fire.

FM Global statistics demonstrate that dust collector is, by far, the location of the primary explosion. At 40% of the time, dust collectors are the location 3 times more often than the next equipment type, impact equipment.

A dust collector has dust that is suspended in air. Also, because a dust collector is designed to handle material produced elsewhere, the ignition source does not have to come from within the dust collector. A source picked up in the dust production area can ignite an explosion in the dust collector.

Explosions in impact equipment are also frequent. The data shows a significant number involving grinders, sanders, pulverizers, ball and hammer mills, chippers, shredders, etc. The mechanical energy expended in these processes can translate into the generation of heat or spark energy required to ignite a dust cloud.

B.3.4] DUST COLLECTION SYSTEM EXAMPLES

The photo on the right is an example of a cyclone where the dust is separated from the air and collected at the bottom of the cyclone and the clean air is exhausted at the top.

The photo on the left is an example of a baghouse. The filter media allows the air to pass through but not the dust.

Both are engineering control options to separate the wood dust from the air and collected for disposal or other use.

DUST COLLECTION SYSTEM EXAMPLES (CONT'D)

On this slide, we have two examples of enclosureless dust collectors.

Enclosureless dust collectors need to comply with Division B of the BC Fire Code, or, with the approval of the Authority Having Jurisdiction, comply under Division C of the BC Fire Code by meeting the enclosureless dust collector indoor criteria in NFPA Standard 664, 2012 Edition.

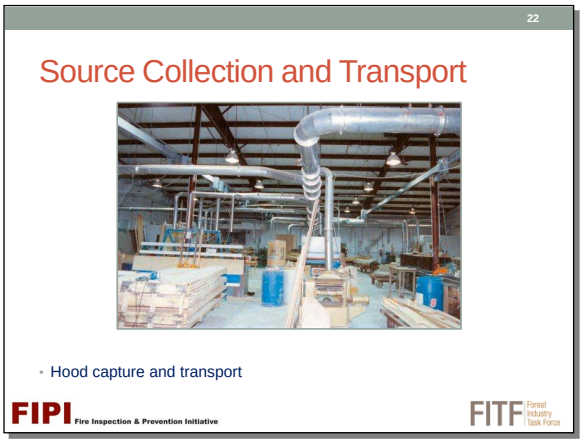
Both examples do not appear to comply with the BC Fire Code requirements under Division B or C. Before installing an enclosureless dust collector, consult with your local fire department or Authority Having Jurisdiction.

Wet scrubbers, not shown, are another type of dust collector type. Water and baffles are used to separate the dust from the air.

B.3.4.1] ADDITIONAL INFORMATION:

BC Fire Code requirements: An enclosureless dust collector with a capacity greater than 0.5 m3/s (1060 CFM) is not allowed indoors in accordance with BCFC Division B. In order to install a unit with a capacity greater than 0.5 m3/s, you need acceptance of the AHJ in accordance with BCFC Division C. AHJ acceptance would likely required adherence to NFPA-664 2012 edition. Note: AHJ means Authority Having Jurisdiction, which is the local municipal government, usually through its fire department.

B.3.5] SOURCE COLLECTION AND TRANSPORT



Earlier, we mentioned that the point of capture is the typically the weakest link, primarily because the design of dust capture hoods is not widely understood.

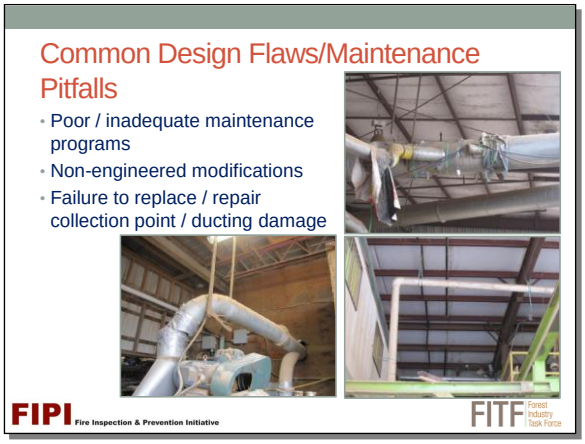
Hood design is greatly based on site application, equipment and operators, and positioned close to the dust origin point. One size does not fit all.

If your dust collection system is not capturing all the dust being generated, the hood design might not be correct.

Once captured, the dust needs to be conveyed pneumatically to the dust collector. To be effective, the ductwork needs to be properly design to work with the capture hood and maintain sufficient transport velocity to keep the dust suspended in the air.

If dust is accumulating inside the duct work, the ductwork design and/or the transport velocity are not correct.

B.3.5.1] COMMON DESIGN FLAWS AND/OR MAINTENANCE PITFALLS – DUST COLLECTION EQUIPMENT



The three photographs on this slide illustrate some common design flaws and/or maintenance pitfalls with respect to dust collection equipment.

The bottom right photograph shows plastic pipe is used to convey the dust. This design or modification does not conform to good engineering practice because plastic is not an electrical conductor. The ductwork should be made of metal.

The other two photographs show inadequate repair to damaged ductwork, including use of duct tape, makeshift ductwork hangers, and adding weight to the duct work by hanging or attaching other items to the ductwork.

B.3.5.2] ADDITIONAL INFORMATION

It is clear that unless designed properly and properly maintained, the dust collection system will not work as designed and the risk of deflagration and explosion increases. Here are more examples of poor design and maintenance.

- Poor / inadequate maintenance programs (as per recent information release from WSBC)
- Non-engineered modifications to ventilation systems following initial design and installation
- Failure to replace / repair collection point / ducting damage
- Inadequate design around ducting junction points, including the location of inspection ports.
- Inadequate design of dust collection hoods
- Insufficient transport velocity in system (under-designed system)

B.3.6] PASSIVE CONTAINMENT

Another type of engineering control is passive containment. Ensuring that passive containment is the right control option is important. Like dust collectors, passive containment creates an environment with the potential to have 4 of 5 explosion pentagon elements present with the ignition source being the only missing element.

The goal of passive containment is to enclose/contain fugitive combustible dust emissions from equipment and machinery so that it cannot accumulate in the general work area, on adjacent equipment or building structures.

Passive containment is typically used at Primary Machine Centres and on conveyance systems that respectively, produce and transport primary dust of green lumber and represent less of a risk of causing a combustible dust cloud to form.

A word of caution: Do not automatically assume this is true. Analyze your process' dust to determine its combustibility.

B.3.5.6.1] ADDITIONAL INFORMATION

When selecting dust accumulation control strategies, it is important to understand the pros and cons, and the best location for use of each method (not provided in this presentation).

Typical Primary Machine Centres and conveyance systems include:

- Debarkers
- Canters
- Edge-trimmers/gang saws
- Planer/moulder
- Chippers/hogs
- Conveyors/transfer points
- Drop outs/chutes

Common ignition sources in these environments include improper hot work on or nearby, open flames nearby, faulty or unsuitable electrics and lighting, equipment overheating, sparks (from tramp metal, mechanical friction or static electricity).

Curtains or enclosures should ideally be non-combustible. If vinyl “strip” type curtains or doors are used, it should be confirmed that the material has an acceptable flame spread rating (ASTM-E84 Class A; <25 flame spread index recommended) and that the material used is “self-extinguishing.”

Using temporary enclosures such as plastic tarps or plastic sheeting (construction polypropylene) is strongly discouraged due the high potential for rapid flame spread and smoke development.

B.3.5.7] MISTING

Misting knocks down airborne dust using water or a chemical.

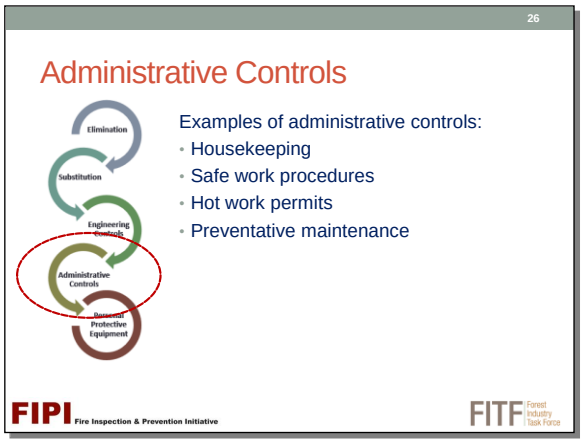
The top photograph shows a nozzle releasing misting water using water pressure only. The bottom photograph shows misting by having water injected into the air stream of a fan.

Caution: Evaluate the hazard of using misting near electrical equipment and MCC’s and near dust collection systems that could get clogged with wet dust.

Another concern with misting is its suitability for use during winter months. As with all options, it is important to understand where and when each option works best.

When selecting dust accumulation control strategies, it is important to understand the pros and cons, and the best location for use of each method (not provided in this presentation).

B.4] ADMINISTRATIVE CONTROLS TO PREVENT ACCUMULATION



If engineering controls are not possible or not enough, the hierarchy of controls moves down to administrative controls.

Administrative procedures include things like housekeeping, safe work procedures like hot work permits, and preventative maintenance. Training is also considered an administrative control.

Work scheduling is another example.

B.4.1] HOUSEKEEPING

Research has shown that facilities that are well maintained experience fewer fires, explosions and other accidents.

Such a focus creates a culture of awareness and constant vigilance. These facilities recognize that housekeeping is an on-going operation; it is not a hit-and-miss cleanup done occasionally.

Specific to combustible dust, manual clean up should be conducted on a regular frequency to prevent accumulations from reaching 1/8" thickness over a large area.

Manual clean-up of combustible dust can disperse secondary combustible dust into the air if not performed properly. If that occurs in the presence of an ignition source, a dangerous deflagration fireball can occur; if the cleanup is in an enclosed area, an explosion can occur. For that reason, safe work procedures are required to safely clean up accumulated dust, whether you are using sweeping, vacuuming or wash down methods.

The safe work procedures would identify how to perform the task without creating dust clouds and includes limitations on the use of compressed air to clean surfaces.

This will typically require the use of specific equipment to assist with the safe clean-up.

B.4.1.1] ADDITIONAL INFORMATION

NFPA 664, Chapter 11, contains some comprehensive guidance on housekeeping.

Housekeeping Defined: Housekeeping is the process of organizing, cleaning, and maintaining a facility, keeping hazards in check and goods out of aisles, removing dust, and handling storage properly. Good housekeeping is key component of any loss prevention program and involves all employees. Effective housekeeping is an ongoing operation: it is not a hit-and- miss cleanup done occasionally.

The importance of a Housekeeping Program in loss prevention is to prevent the spread of fire. It is also linked to employee safety and accident prevention. Good housekeeping sets the tone for all property loss prevention and control efforts.

Objectives of Housekeeping Management:

- decreased fire and explosion hazards
- safer work environment for all employees
- lower employee exposure to hazardous substances (e.g. dusts, vapours)
- more efficient equipment cleanup and maintenance
- better control of tools and materials, including inventory and supplies

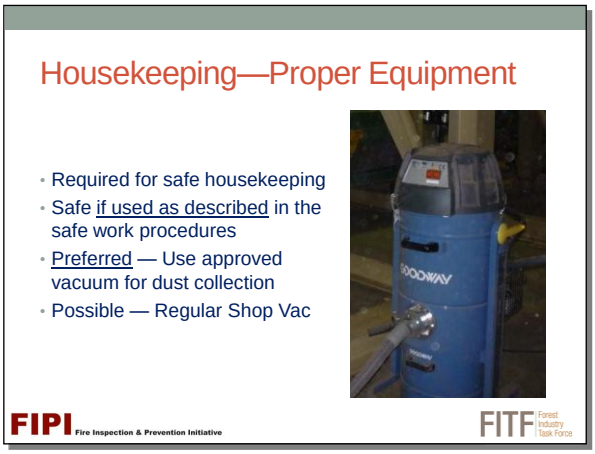
Key Components of Housekeeping Management:

A good housekeeping program identifies and assigns responsibilities for the following:

- clean up during the shift
- cleanup activities during non-production hours and during plant shutdowns
- waste disposal
- removal of unused materials
- inspection to ensure cleanup is complete and address deficiencies

Safe work procedures are required to safely clean up accumulated dust.

B4.1.2] HOUSEKEEPING—PROPER EQUIPMENT



As mentioned in the last slide, housekeeping, to be conducted safely, requires the use to the proper equipment.

Cleaning tools include items such as wet rags and soft bristle brooms, if used as described in the safe work procedures.

The preferred method, however, is vacuuming, using an approved vacuum for dust collection. That means using:

- portable industrial vacuum cleaners certified for use in Class II Division 2 areas
- a central vacuum system
- or, contractors who specialized in industrial vacuuming.

Class II, Division 2 basically means areas in which combustible dust may be found even though the combustible dust is normally in closed containers or closed systems but from which combustible dust could escape.

The BC Safety Authority may accept the use of portable vacuum cleaners not certified for hazardous locations in certain situations. It requires an assessment of the work area environment and the vacuum cleaner by a qualified person in order to make that determination. Please contact the Authority for more information.

B.4.1.2.1] ADDITIONAL INFORMATION

Environment external to the vacuum

The use of electrical equipment within a classified ‘hazardous location’ for which the equipment is not certified can be hazardous. Care must be taken to ensure that the vacuum use does not present an ignition risk within a combustible environment or present a risk of deflagration.

Environment within the vacuum

Vacuum cleaners, whether portable or fixed, are “mini dust collector systems,” which means they are at risk of internal explosion should an ignition source (e.g., hot ember, tramp metal, static electricity, internal electrical arc) is inadvertently created inside the unit. NFPA 654, section 8.2.3, Portable Vacuum Cleaners, describes the requirements portable vacuum cleaners should meet in order to collect combustible dust particulate solids. Industrial grade vacuum cleaners are acceptable for certain applications. Consider using:

- portable industrial vacuum cleaners certified (i.e., intrinsically safe, explosion proof) for use to collect combustible dust unless an assessment of the work area environment and the vacuum cleaner by a qualified person indicates a vacuum not certified for use with combustible dusts can be used safely, or
- a central vacuum system, or
- contractors who specialized in industrial vacuuming.

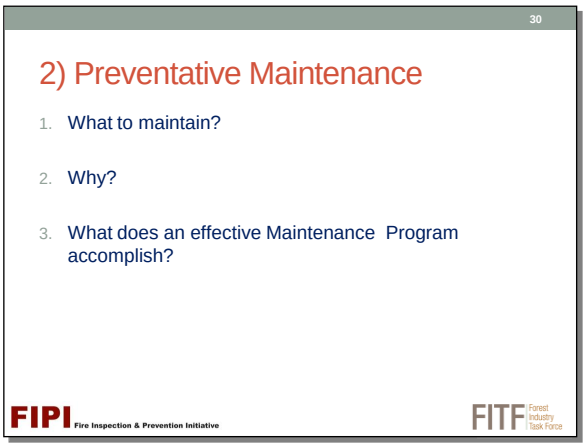
B.4.1.3] GROUP DISCUSSION – HOUSEKEEPING SCENARIO

This photo shows two days of accumulated dust. Is this reflective of good housekeeping?

Clearly the answer is 'NO'. There are many potential ignition sources. For example, electrical equipment and hot surfaces.

At the very least, a deflagration hazard exists. Think back to the WorkSafeBC and US Chemical Safety Board case studies in the Hazard Recognition Module that resulted in workers being badly burned or killed from small amounts of combustible dust.

B.5] PREVENTATIVE MAINTENANCE



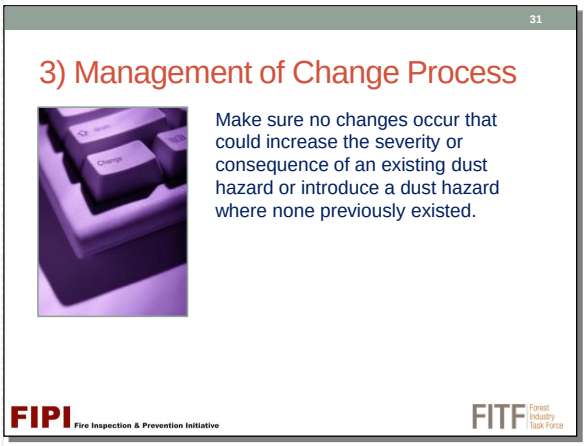
Much of the equipment use in production, dust collection, and fire protection will require preventative maintenance to continue to operate effectively over time and not contribute to a combustible dust fire, deflagration or explosion.

With respect to the combustible dust hazards, preventative maintenance will be concerned with monitoring and maintaining, in a good state of repair, things such as:

- combustible dust containment and conveyance systems to minimize fugitive dust releases
- moving or rotating equipment and belts that could become a source of friction
- motors and other hot surfaces to ensure combustible dust does not accumulate on their surfaces and cause overheating
- metal and non-metal detection and extraction equipment to ensure spark producing items do not enter dust collection systems
- fire prevention equipment like spark detection and extinguishing systems, explosion isolation devices, and relief vents

Source: FM Global Property Loss Prevention Data Sheets 7-76, section 2.1.6

B.6] MANAGEMENT OF CHANGE



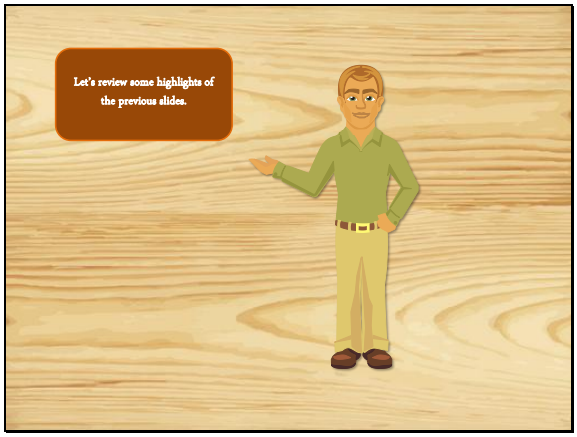
In Module #1, Combustible Dust Hazard Recognition, we learned that Imperial Sugar changed their operation by enclosing a sugar product conveyance system, which created the conditions that lead to the [primary] explosion.

In another case study, we learned that a simple change in product delivery, like the use of shrink wrap, created a situation where static electricity became an ignition source for a small explosion.

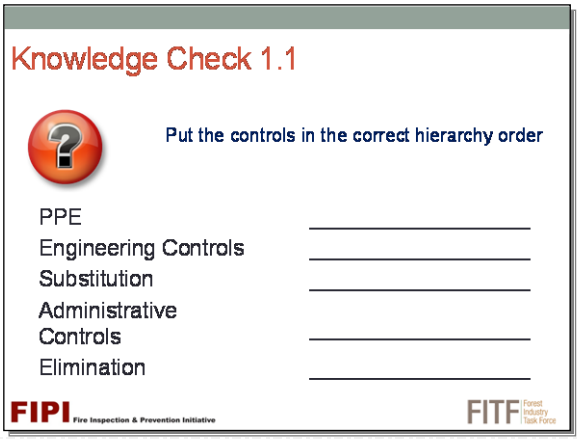
A management-of-change process should be implemented in all facilities handling combustible dusts.

The goal is to make sure no changes occur that could increase the severity or consequence of an existing dust hazard or introduce a dust hazard where none previously existed.

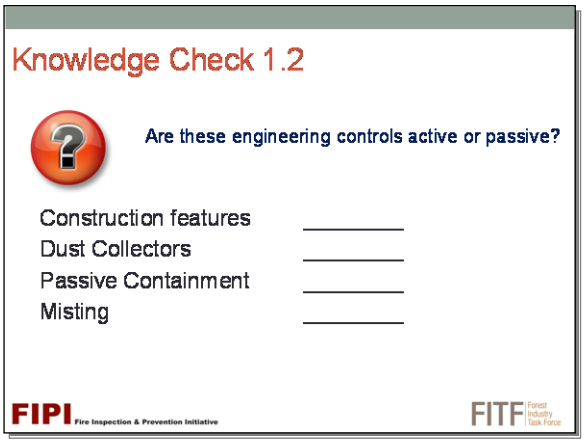
C.] KNOWLEDGE CHECK #1



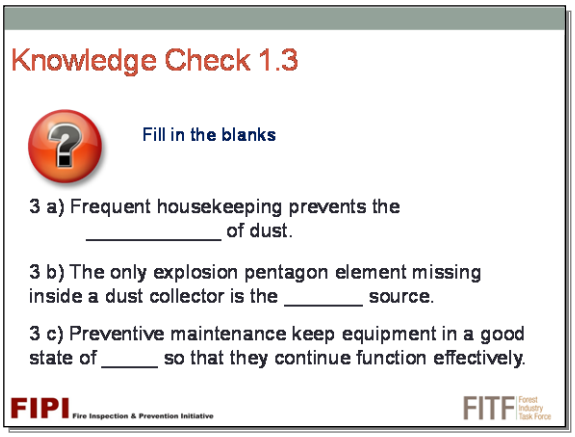
KNOWLEDGE CHECK 1.1



KNOWLEDGE CHECK 1.2



KNOWLEDGE CHECK 1.3



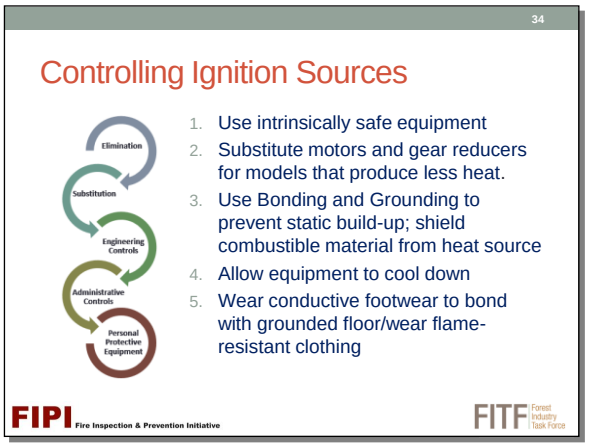
D] HAZARD CONTROLS—CONTROL OF IGNITION SOURCES

HAZARD CONTROLS

Control of Ignition Sources

In this next module, we will discuss different types of controls that can be used on potential ignition sources in the general workplace.

D.1] CONTROLLING IGNITION SOURCES

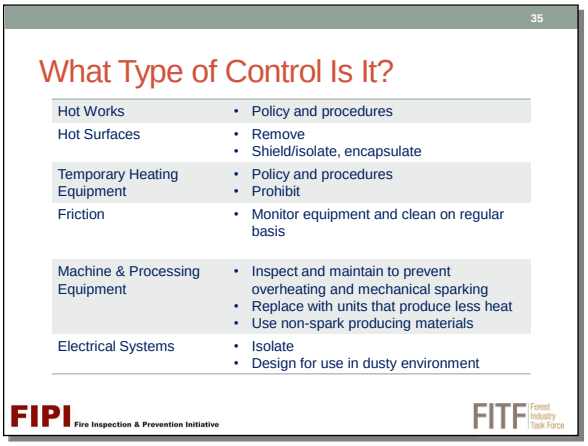


Like all hazards, the hierarchy of controls must be employed when addressing ignition sources.

For example:

- The use of intrinsically safe equipment and non-spark producing fans eliminate the hazard.
- Substitute open drip-proof motors with, for example, TEFC (totally enclosed, fan cooled) motors or gear reducers with models that produce less heat.
- The use of Bonding and Grounding to prevent static build-up, shielding combustible material from heat source, and tramp metal detection and separation are engineering controls.
- Allowing time for equipment to cool down before beginning work is an administrative control.
- Personal Protective Equipment (PPE) includes conductive footwear to bond with grounded floor and wear flame-resistant clothing.

D.1.1] WHAT TYPE OF CONTROL IS IT?



Let's look at some different controls in use against ignition sources and see how easy it easy it is to identify what type of control it is.

A firm's Hot Works Policy and Procedures are an example of administrative controls. The procedures may require some engineering controls, like shielding, to be used.

For Hot Surfaces, control options include removal, which means elimination, or shield, isolate, or encapsulate; which are all examples of engineering controls.

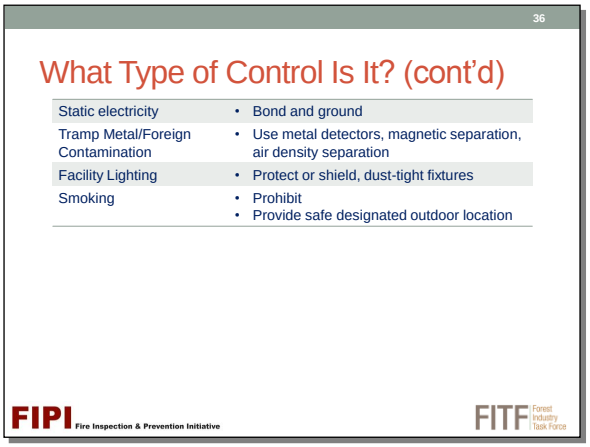
The use of temporary heating equipment can be prohibit, which means elimination, or use as per policy and procedures, which means administrative control.

To address friction, you can monitor equipment and clean on regular basis, both which are administrative controls.

For the operation of machine & processing equipment, inspection and maintenance to prevent overheating and mechanical sparking would be administrative controls while the use non-spark producing materials would be examples of substitution.

For your plant's electrical systems, options include isolation and designing for use in dusty environment, both which are engineering controls.

D.1.2] WHAT TYPE OF CONTROL IS IT? (CONT'D)



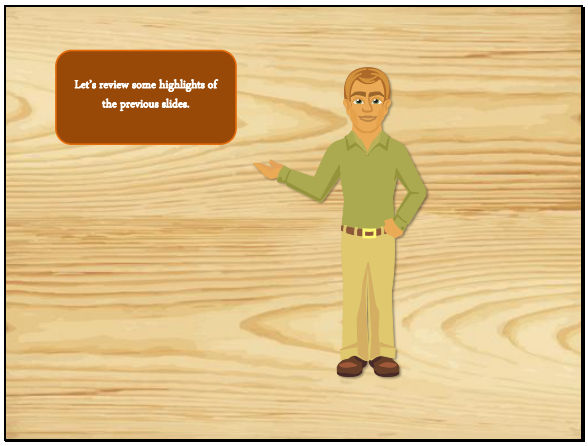
To protect against static electricity, the most common control is to "bond and ground," which is an engineering control.

To protect against tramp metal/foreign contamination, you can use metal detectors, magnetic separation, air density separation, all of which are examples of engineering controls.

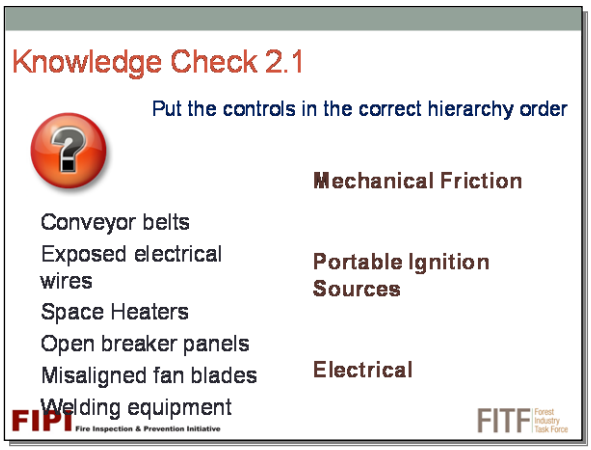
For a facility's lighting systems, options include protect or shield the fixtures or use dust-tight fixtures, all of which are engineering controls.

With smoking, by regulation indoor smoking is prohibited, which eliminates the hazard while a safe designated outdoor location would be an administrative control.

E] KNOWLEDGE CHECK #2



KNOWLEDGE CHECK 2.1



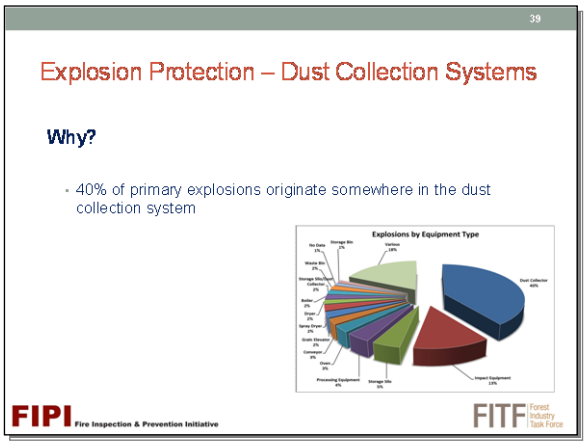
F] EXPLOSION PROTECTION—DUST COLLECTORS

EXPLOSION PROTECTION

Dust Collectors

In this next module, we will discuss different types of explosion protection equipment that is used in dust collectors.

F.1] WHY?

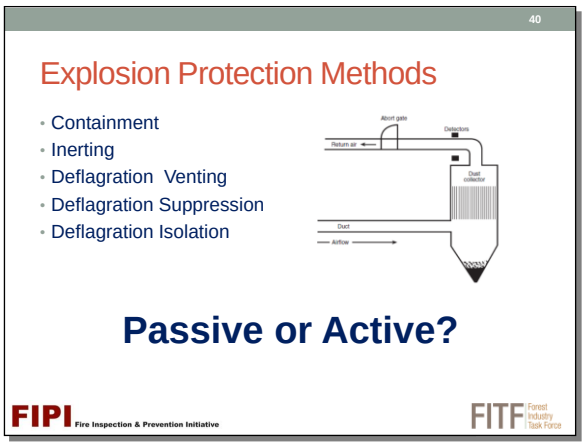


Why would we want to include explosion protection equipment in dust collectors?

Earlier we learned that 40% of primary explosions originate somewhere in the dust collection system. Some of these explosions occurred despite controls being in place to prevent ignition sources from entering the dust collection system.

Because equipment failure and mistakes happen, we need some back up in the form of explosion protection equipment.

F.2] EXPLOSION PROTECTION METHODS



NFPA 664, Annex B, Explosion Protection, identifies five common methods of explosion protection.

These methods can be categorized as passive or active.

A **passive system** reacts to the event and controls the explosion so as to keep employees safe and minimize equipment damage in the plant.

An **active system**, by contrast, detects and react prior to or during an explosion to prevent or extinguish the explosion just as it is starting.

The five common methods are:

- Containment, a passive method
- Inerting, an active method
- Deflagration Venting, a passive method
- Deflagration Suppression, an active method
- Deflagration Isolation, an active method

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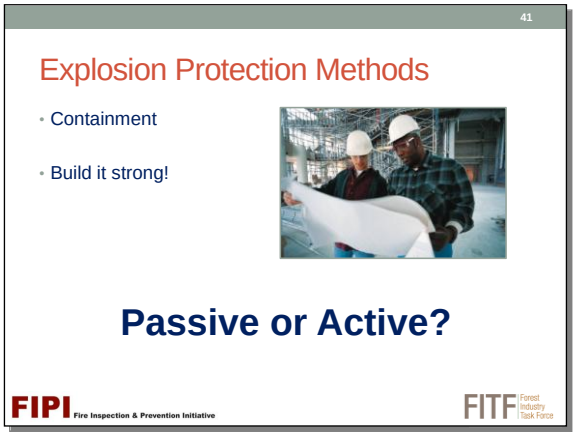
F.2.1] CONTAINMENT



The containment method of explosion protection means building the process structure strong enough to withstand an explosion.

There are two basic design types:

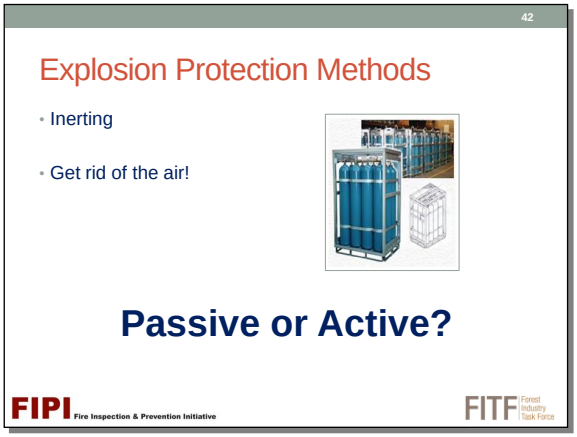
i. Explosion resistant design in which there is no deformation of structure, and
ii. Shock resistant design in which some deformation of the structure is possible.

There is little maintenance with the containment method due to its passive approach to explosion.

The initial costs are typically high and the process structure can add significant weight loading onto the plant structure.

Can you remember what kind of protection method this is … it's a passive method.

F.2.2] INERTING

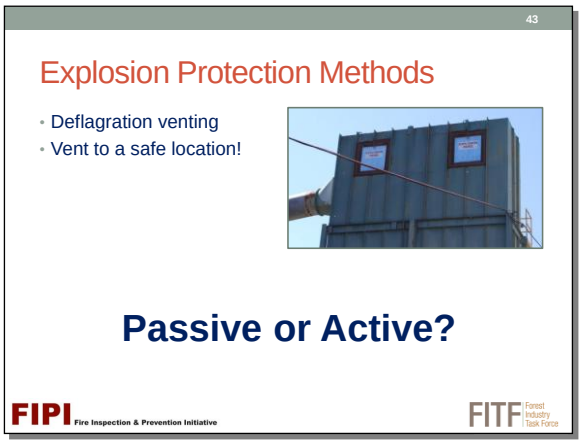


Inerting is an explosion protection method where the oxygen concentration in an enclosure is lowered by introducing an inert gas like nitrogen or carbon dioxide.

In the right application, inerting is effective but can be expensive to maintain and introduces an asphyxiation hazard to workers. It is not typically used in wood products manufacturing.

Can you remember what kind of protection method this is … it's an active method.

F.2.3] DEFLAGRATION VENTING



Deflagration Venting is an explosion protection method where a panel or door is provided to relieve the expanding hot gases of a deflagration from a process component or room.

Deflagration venting is required by the BC Fire Code unless conditions exist that prevent adequate explosion venting.

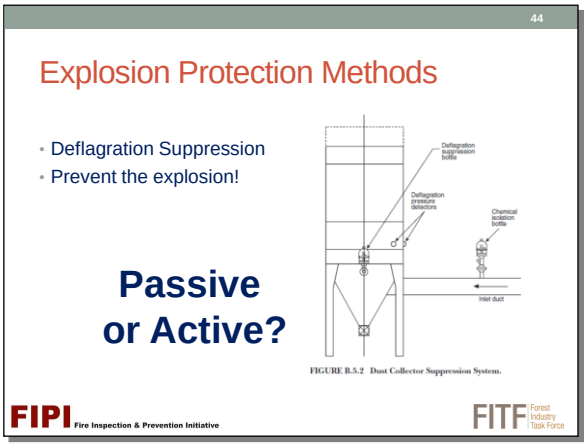
If the dust collector is located outdoors, the initial cost and maintenance cost for deflagration venting are low.

Costs are increased if the dust collector is located indoors and at significant distances from exterior walls.

If an explosion occurs, the vents open allowing the fireball to escape. A safe blast zone has to be created to address this severe fire hazard.

Can you remember what kind of protection method this is … it's a passive method.

F.2.4] DEFLAGRATION SUPPRESSION



Deflagration Suppression uses a high-speed flame-extinguishing system to detect and extinguishes a deflagration before destructive pressures are created.

This method eliminates the flame, reduces the chance of a subsequent fire and prevents equipment damage.

As can be expected, cost are generally higher than for deflagration venting because of its more complex design and the need for regular maintenance.

Can you remember what kind of protection method this is … it's an active method.

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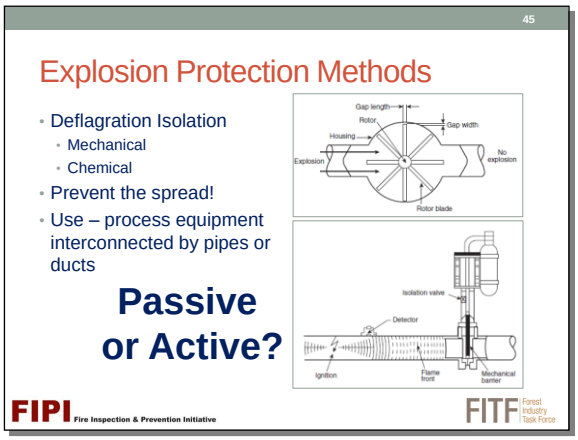
F.2.5] DEFLAGRATION ISOLATION



In Module #1, Combustible Dust Hazard Recognition, a video illustrated how, at an aluminum wheel manufacturer, an explosion that originated in the dust collector propagated through the ductwork and ignited secondary dust in the general work. The chain reaction of explosions caused several worker deaths and significant damage to the facility.

Deflagration Isolation is an explosion protection method designed to prevent such explosion propagation.

There are two types isolation methods:

1. Mechanical isolation can be provided by rotary airlock valves and high-speed knife gate valves.
2. Chemical isolation is achieved by the rapid discharge of a chemical extinguishing agent into the interconnecting pipe or duct.

Both isolation methods are activated by a deflagration detector.

A word of caution: Chemical deflagration isolation should not be confused with ignition spark suppression systems, which are intended to detect burning particles traveling down a duct and extinguish them with a downstream spray of water. They are not designed to stop deflagrations once they have started and are ineffective for preventing deflagration propagation through the interconnected equipment.

Can you remember what kind of protection method this is … it's an active method.

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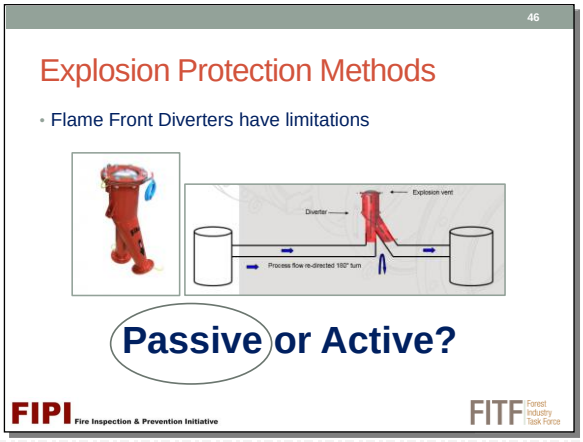
F.2.6] FLAME FRONT DIVERTERS

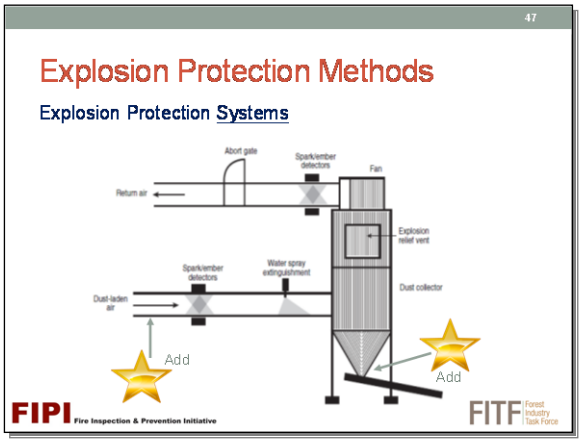


A flame front diverter prevents flames from propagating from one piece of equipment to another through the interconnecting piping.

These devices do have limitations under certain situations. Therefore, before they are used, they should be tested for the desired application.

Can you remember what kind of protection method this is … it's a passive method.

F.2.7] EXPLOSION PROTECTION SYSTEMS



You can maximize protection from flames and explosions by using active and/or passive equipment in combination.

The illustration on the slide is an example of a basic spark detection and extinguishing system for a single dust collector.

It contains detectors and extinguishers prevent sparks/embers in collector feed from entering the dust collector. This is active equipment.

It includes the deflagration or explosion relief vent to vent the deflagration fireball to a safe location. This is passive equipment.

It includes detectors in return air plenum to prevent sparks/embers and fire ball from entering the main

building or other equipment by activating a high speed abort gate to vent to safe outdoor location. This is active equipment.

There are limitations on the minimum compliance approach from a business approach.

Although people are protected, productivity is often reduced when a combustible dust fire/explosion event occurs within the dust collection system. If a spark or other ignition source is a rare event, this is not a serious problem. However, if sparks are more common, then shutdowns are more common. If so, explosion protection systems that can return facility to production quickly, although more costly to install, may be more economical over time.

In the illustration on the slide, the explosion protection system could be made more complete.

First, deflagration isolation could be added on the collector supply feed to prevent an explosion in the dust collector from propagating back through the in-feed ductwork.

Second, deflagration isolation could be added on the dust collector hopper discharge to prevent an explosion in the dust collector from propagating into the dust discharge component.

Third, to prevent a fire ball and pressure wave from being created inside the dust collector, deflagration suppression could be added inside the dust collector.

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F.3] INSPECTION AND MAINTENANCE

It is very important that inspection and maintenance of your suppression and venting systems be done on a regular basis, in accordance with the manufacturer's recommendations and, possibly, NFPA standards.

If the suppression system has been activated, all components shall be inspected, replacement parts installed if necessary, and the system tested prior to restoration to full operation condition.

Explosion vents will require visual verification that the vent closure is in place and able to function as intended. Their maintenance include preventative and remedial to ensure proper operation of the vent closure.

F.3.1] ADDITIONAL INFORMATION

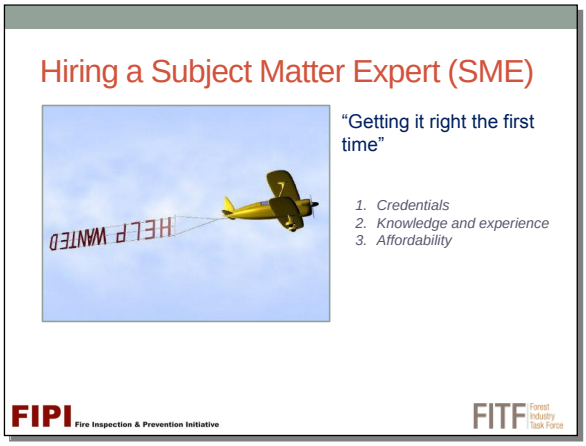
NFPA 69, *Standard on Explosion Prevention Systems*

- Suppression systems shall be thoroughly inspected and tested at 3-month intervals by personnel trained by the system's manufacturer.
- If the suppression system has been activated, all components shall be inspected, replacement parts installed if necessary, and the system tested prior to restoration to full operation condition.

NFPA 68, *Standard on Explosion Protection by Deflagration*

- Explosion vents – visual verification that the vent closure is in place and able to function as intended.
- Maintenance includes preventative and remedial actions taken to ensure proper operation of the vent closure.

F.4] Hiring a Subject Matter Expert (SME)



By now, you have likely realized that, as you assess your needs to protect your employees and operations from the risk of combustible dust fire/explosions, "getting it right the first time" is important, operationally and financially.

The current state of Fire Safety Plans and dust mitigation programs of many BC operations are not adequate. The significant contributing factor is that the individuals who developed, designed or installed did not have the appropriate subject matter expertise to accomplish the tasks they were assigned.

Employers are not expected to know everything. "Getting it right the first time" will likely require the assistance of one or more subject matter experts (SMEs).

There are a number of subject matter experts who can help to make sure you have a safe workplace.

Unfortunately not all individuals claiming subject matter expertise will be as qualified as they purport to be.

Being duly diligent in your SME selection process will increase the likelihood that the developed plan or designed system will be effective, meet regulatory requirements and your business needs, and not require re-writes (e.g., Fire Safety Plans) or expensive retrofits of newly installed systems.

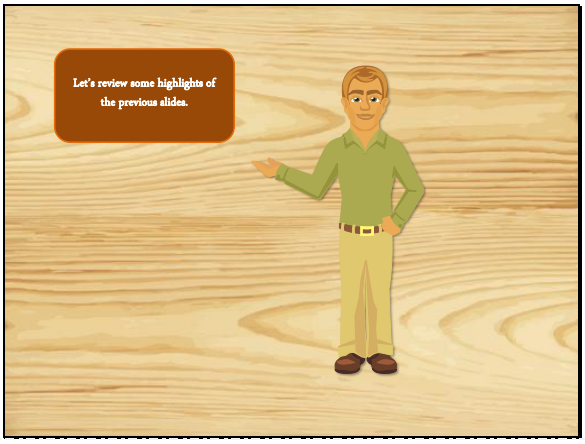
F.4.1] ADDITIONAL INFORMATION

Reference: Excerpt from FIPI June 5th, 2013 letter to solid wood product manufacturers – Attachment A– *Selecting Subject Matter Expertise (SME) – Your Due Diligence*

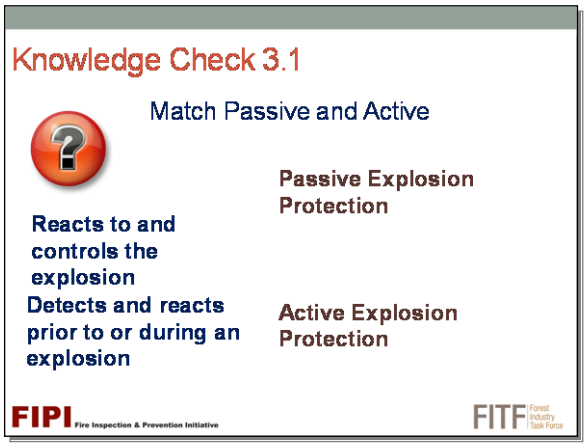
It includes how to review:

- Credentials
- Knowledge and expertise
- Affordability

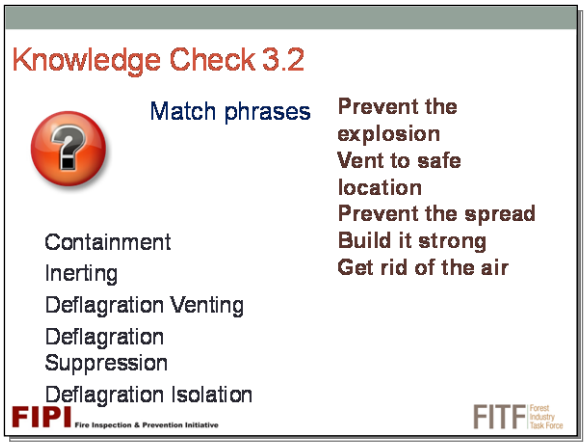
G] KNOWLEDGE CHECK #3



KNOWLEDGE CHECK 3.1



KNOWLEDGE CHECK 3.2



H] PHYSICAL SITE INSPECTION—COMBUSTIBLE DUST HAZARD

In this next module, we will discuss the visual combustible dust accumulation that might be observed in the workplace.

H.1] MAJOR EXPLOSION RISKS

Let’s re-cap a bit.

The general work area is typically at risk for secondary explosions. It is therefore imperative to keep secondary dust levels in the general area below hazardous levels, usually by capturing combustible dust at its source, using passive or active dust collection systems, and through good housekeeping practices.

The dust collection systems, passive and active, are typically at risk for primary explosions. It is therefore imperative to control ignition sources and incorporate fire protection features in the dust collection system.

H.2] WHAT TO LOOK FOR

H.2.1] DUST COLLECTING AROUND THE DUST CAPTURE POINT

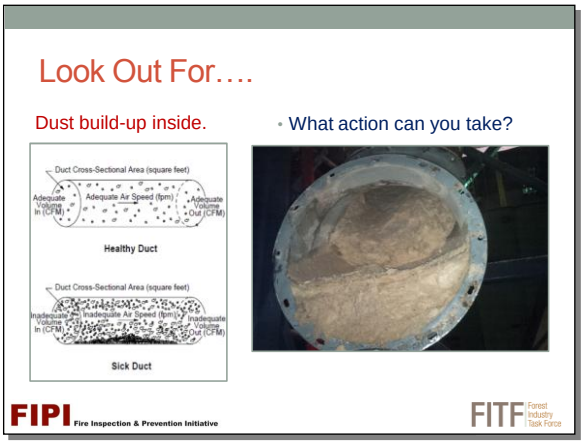
When you observe dust collecting around the dust capture point it means the hood is not effective at capturing the wood dust as it is being generated.

There are one or more issues that could be contributing to this lack of effectiveness, such as improper design, insufficient capacity or capture velocity, blockage and/or inadequate maintenance.

In the slide photo of trim saws, very fine dust is not being captured.

If workers report or you observe this issue, management needs to clean the accumulation without undue delay and take action to improve the efficacy of the capture hood.

H.2.2] DUST BUILDUP INSIDE DUST TRANSPORT DUCTWORK



When you observe dust buildup inside dust transport ductwork, it means the duct work is not designed properly or the transport velocity is too low allowing the dust to settle somewhere inside the duct work.

The photo on the right shows ductwork with a very thick layer of accumulated dust due to poor transport velocity.

If workers report or you observe this issue, management needs to clean the duct work without undue delay and take action to improve efficacy of dust transport

H.2.3] DUST ESCAPING THE DUST TRANSPORT DUCTWORK OR COLLECTION VESSEL

When you observe dust escaping the dust transport ductwork or collection vessel, it means the ductwork in state of disrepair.

Both photos on this slide show evidence of wood dust escaping the duct work. The photo on the right shows repairs made to prevent more dust from escaping, which is the appropriate action to take. At the time the photo was taken, the accumulated dust had not yet been removed. This accumulation is outdoors so there is no explosion risk. It is still a risk of fire and deflagration.

If workers report or you observe this issue, management needs to clean dust accumulation without undue delay and identify and correct reason for fugitive emissions.

H.2.4] DUST IN THE GENERAL AREA

(Escaping from production processes and/or dust collection system and accumulating in general work area)

The photo on the right shows a very heavy accumulation of primary dust. The finer dust particles in an accumulation like this, when disturbed, become airborne and settle on flat surfaces away from the machine centre, like for example, as shown in the photo on the left.

The photo on the left shows secondary dust accumulation, which means a fine powdery dust that has obscured the green colour of the underlying equipment.

A very serious explosion risk exists when duct accumulation reaches 1/8th inch and covering about 5% of the area up to 1000 ft^2. A rule of thumb is not to allow secondary dust levels to obscure the colour of the underlying surface.

If facility has implemented an effective dust mitigation strategy that included capturing the dust at its generation source, any dust that escapes can be readily managed by an effective housekeeping program.

If you observe excessive dust accumulation in the general area like in these photos, it means there are inadequate or non-existent dust control measures at sources and/or there is inadequate housekeeping.

If workers report or you observe this issue, management needs to clean accumulation without undue delay and investigate and determine reason for accumulation, and correct.

H.2.5] CLEAN WORKPLACE –COULD THERE STILL BE A PROBLEM?

The photo on this slide shows a very clean workplace with the machine centres connected to a dust collection system.

We can conclude that the capture hoods, the duct work and fan capacity were properly designed. The system is operating effectively.

This workplace is to be commended for "getting it right."

There is still one issue to be concerned about. Remember we learned that 40% of the primary explosions occur somewhere in the dust collection system.

If you remember in the aluminum wheel manufacturer's catastrophic explosion, the primary explosion in the dust collector propagated back into the general work area through the ductwork. We also discussed wood material jamming against a moving belt, heating up and releasing hot embers.

So there could still be a problem even when the workplace is clean. Is there a process for preventing tramp metal or foreign contamination, like hot wood embers, from entering the dust collection system? Is it effective?

Management needs to ensure workers know how to safely address a product jam and be watchful for tramp metal and/or have magnetic or other type of separator.

Management also needs to ensure maintenance is on top of this issue.

H.2.6] SMALL FIRES

Even in workplaces with a robust combustible dust management program, fires do occur from time to time.

Events like an ignition source being previously unknown or a piece of equipment becoming faulty and not recognized quickly enough can cause fires in workplaces.

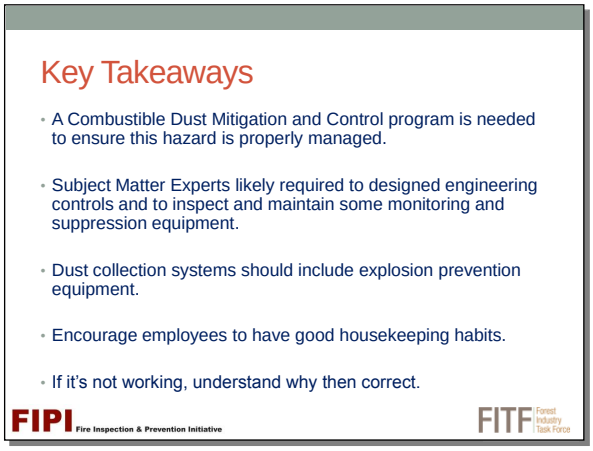
We have to be grateful that the resultant incident was a small fire and not a more catastrophic deflagration or explosion. From that perspective, a fire is a near miss meaning if the circumstances would have been slightly different a more catastrophic event might have occurred.

Imperial Sugar recorded many fires in the decades before its catastrophic explosions. The inference is that they did not sufficiently investigation and/or learned from those events.

If you have a fire, it means somehow there was contact between combustible dust and an ignition source and your mitigation program was not effective in that circumstance.

Management needs to investigate the cause of the fire and take corrective action. If several fires have occurred over time, review all and look for trends

H.3] KEY TAKEAWAYS

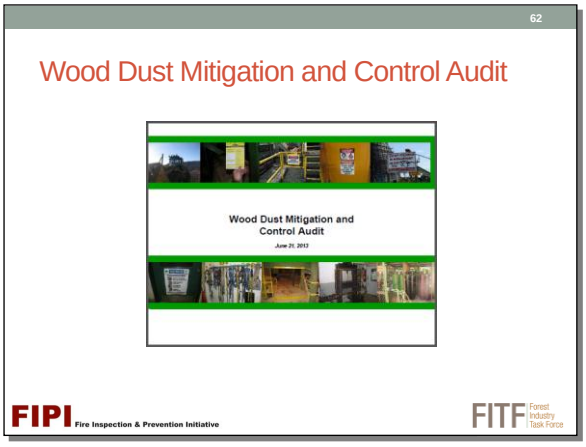


I] LAST WORD—INDUSTRY'S WOOD DUST MITIGATION AND CONTROL AUDIT

LAST WORD

Industry's Wood Dust Mitigation and Control Audit

I.1] MILL SAFETY: FOREST INDUSTRY TASK FORCE AUDIT



British Columbia's wood products manufacturers are working together to advance research and best practices in improving mill safety in response to the devastating explosions at Babine Forest Products and Lakeland Mills.

The CEOs from the major wood products manufacturing companies in British Columbia gathered to create a plan for improving safety.

One outcome of their work is the Wood Dust Mitigation and Control Audit. The audit is a set of clear and auditable standards that can be utilized to independently assess the safety of mills across the industry.

Completing the audit will give your facility a very good understanding of the state of effectiveness of your program and, if necessary, where improvements are required.

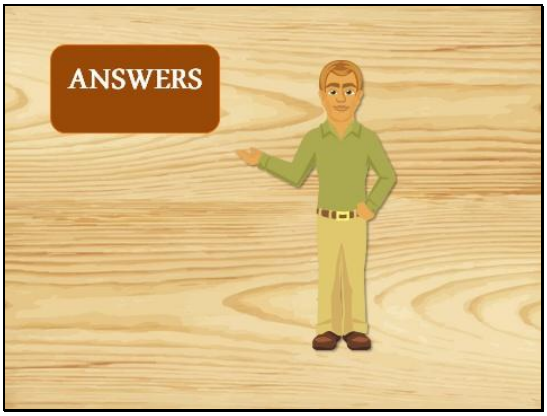
Reference: *Forest Industry Task Force, Wood Dust Mitigation and Control Audit June 21, 2013*

Reference: This page contains information that will help sawmills manage dust and keep informed about the Task Force activities and findings. http://www.cofi.org/bc-forest-industry/mill-safety-forest-industry-task-force/

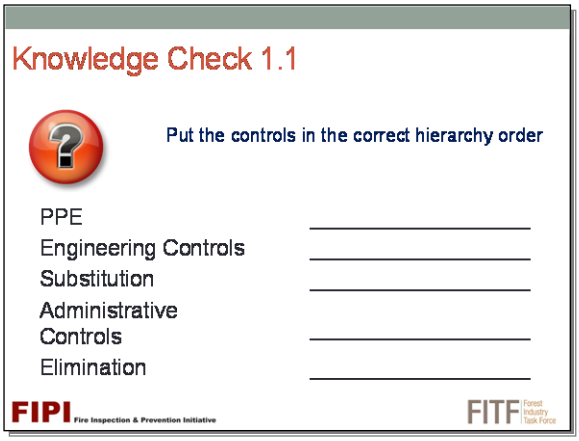
J] ADDITIONAL RESOURCES

- NFPA 664: *Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities*
- NFPA 654*: Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*
- NFPA 68: *Standard on Explosion Protection by Deflagration Venting*
- NFPA 69: *Standard on Explosion Prevention Systems*
- NFPA 91: *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids*
- NFPA 77: *Recommended Practice on Static Electricity*
- *NFPA 499 – Classification of Combustible Dusts and Hazardous Locations*
- *OSHA-Occupational Safety & Health Administration*
- *US Chemical Safety Board*
- *FM Global Insurance Company Loss Prevention Data Sheet 7-76, Prevention and Mitigation of Combustible Dust Explosions and Fires*

K] KNOWLEDGE CHECK ANSWERS

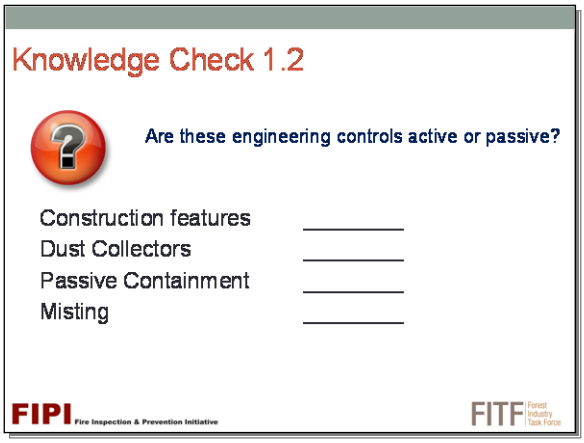


K.1] KNOWLEDGE CHECK #1



K.1.1] ANSWER 1.1

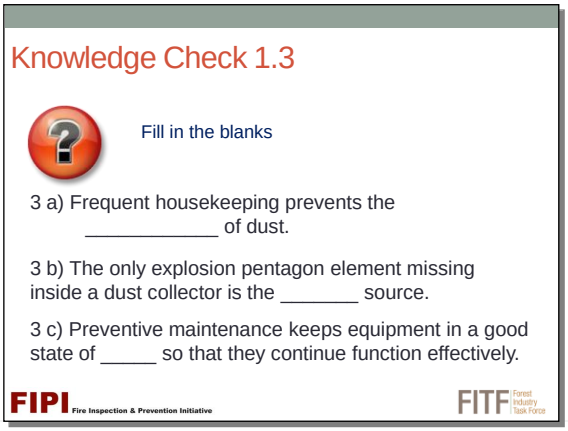
- Elimination
- Substitution
- Engineering Controls
- Administrative Controls
- Personal Protective Equipment (PPE)



K.1.2] ANSWER 1.2

- Construction Features – Passive
- Dust Collectors – Active
- Passive Containment – Passive
- Misting - Active

K.1.3] ANSWER 1.3



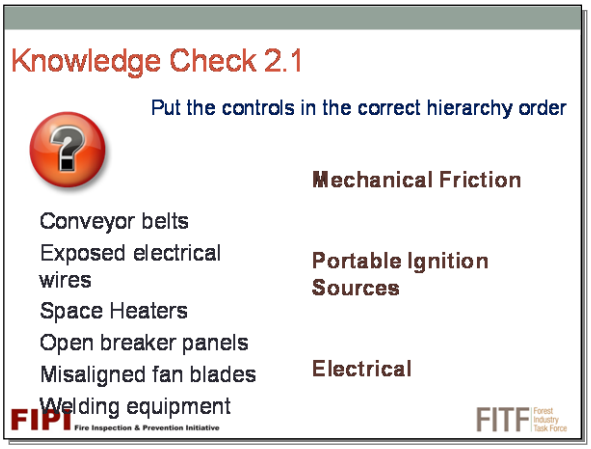
3a) Frequent housekeeping prevents the accumulation of dust.

3b) The only explosion pentagon element missing inside a dust collector is the ignition source.

3c) Preventive maintenance keeps equipment in a good state of repair so that they continue to function effectively.

K.2] KNOWLEDGE CHECK #2

K.2.1] ANSWER 2.1



Mechanical Friction:

- Conveyor Belts
- Misaligned Fan Blades

Portable Ignition Sources

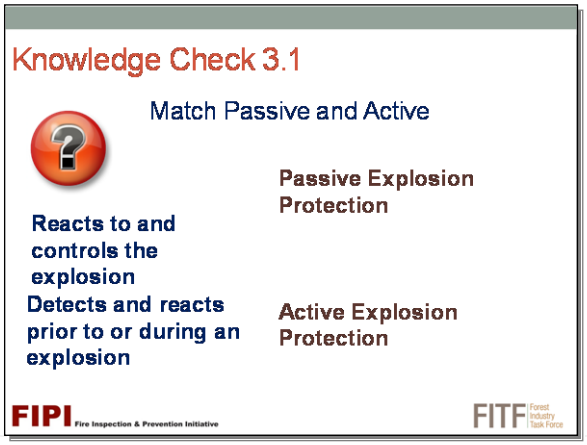
- Space Heaters
- Welding Equipment

Electrical

- Exposed Electrical Wires
- Open Breaker Panels

K.3] KNOWLEDGE CHECK #3

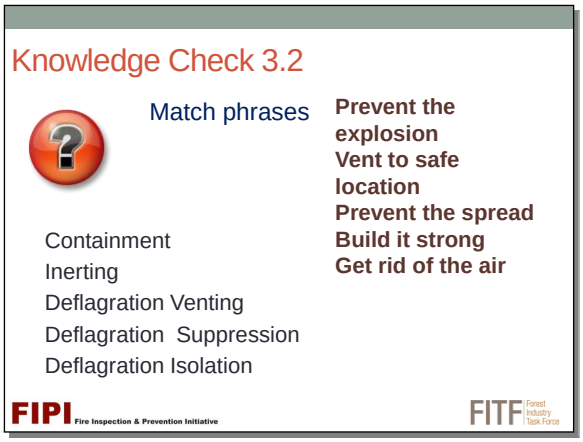
K.3.1] ANSWER 3.1



Passive Explosion Protection – reacts to and controls the explosion

Active Explosion Protection – Detects and reacts prior to or during an explosion.

K.3.2] ANSWER 3.2



Containment – Build it strong!

Inerting –Get rid of the air!

Deflagration Venting – Vent to a safe location!

Deflagration Suppression – Prevent the explosion!

Deflagration Isolation – Prevent the spread!