

COMBUSTIBLE DUST HAZARD RECOGNITION

February 2014



FIPI Fire Inspection & Prevention Initiative

FITF Forest Industry Task Force

GUIDE FOR WORKERS AND FRONT LINE SUPERVISORS

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COMBUSTIBLE DUST HAZARD RECOGNITION

CBC – ANOTHER SAWMILL EXPLOSION



The CBC reports on the Lakeland Mill explosion in Prince George.

In the wake of the Babine Mill Explosion a few months earlier, questions are being asked. For example, how could this happen again?

This incident is terrible for the family of the worker who died and the families of those severely injured in the explosion.

In addition, the stakes are now enormous for BC's entire forestry sector:

- More scrutiny by regulators
- Less social license to conduct business (i.e., loss of public trust)

What will happen to industry if another similar explosion occurs?

A] COMBUSTIBLE DUST HAZARD RECOGNITION INTRODUCTORY COURSE



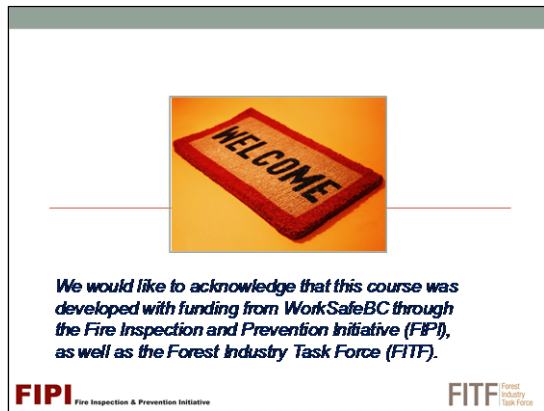
In early 2012, as the CBC news clip "Another Sawmill Explosion" reported, BC suffered two devastating mill explosions. The cause of each event's initial explosion had not yet been released at the time this presentation was prepared. Many of the secondary explosions experienced in both events were likely combustible dust explosions. These secondary explosions made both events much worse.

The fire and explosion hazards of combustible dust having been known for years by experts and many others. However these recent explosions here in British Columbia and in the United States have illustrated that many workplaces don't

understand the hazards associated with combustible dust.

Unless that changes, more catastrophic explosions will occur in the future.

A.1] WELCOME



Welcome to this education session designed to increase the combustible dust fire and explosion hazard knowledge of workers, supervisors, managers, and company owners of wood processing operations, as well as for any others who have a role in combustible dust fire and explosion hazard recognition and mitigation.

This session is a collaboration between the Fire Inspection and Prevention Initiative, funded by WorkSafeBC, and the Forest Industry Task Force.

Workers and front line supervisors 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.

Then, if managers and company owners understand the hazards associated with combustible dust, they are more likely to respond to reports from workers and supervisors about related unsafe conditions.

A.1.1] ADDITIONAL NOTES

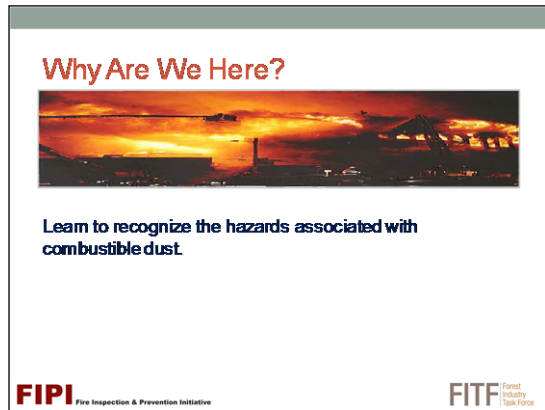
The Fire Inspection and Prevention Initiative (FIPI) was created to both:

- Improve worker safety, and
- Protect property

The focus will be fire and explosion hazards from combustible wood dust, particularly high-risk complex industrial facilities with the potential for combustible wood dust accumulation.

A key priority of the FIPI is to update training and educational material about the combustible dust hazard that can be delivered to sawmill building owners/employers and to their workforces.

A.2] WHY ARE WE HERE?



Combustible Dust is called an insidious hazard and a significant industrial safety problem.

In this introductory module, you will learn why that is true and how this course can help you address fire and explosion hazards associated with combustible dust.

At the beginning of this presentation, you learned that combustible dust is a well-known fire and explosion hazard.

Equally true is that combustible dust explosions are very preventable.

For example, the National Fire Protection Association (NFPA) has issued comprehensive standards to prevent and mitigate combustible dust explosions. These standards are widely recognized by experts as effective and authoritative. Unfortunately, their adoption by industry and regulators has been inconsistent.

To minimize the risk of combustible dust hazards, the first step is to learn to recognize the hazard and know how to eliminate or control it in your workplace.

During this presentation, reference will be made to information and video clips from the U.S. Chemical Safety Board.

Briefly, the U.S. Chemical Safety Board is an independent U.S. federal agency that conducts investigations into significant industrial fires and explosions. It undertook a 3 year nationwide study into industrial explosions involving combustible powders. Their final report contained many recommendations for implementation by industry and regulators.

Your participant's handbook contains more information on this respected organization. See the Additional Information section.

So why are we here? Simply put, to learn from the past and from the experts.

A.2.1] ADDITIONAL NOTES

We need to learn from the US Chemical Safety Board study (details below). BC workplaces should have a comprehensive combustible dust strategy that addresses hazard assessment, engineering controls, housekeeping, and worker training.

US Chemical Safety Board – Investigation Report: Combustible Dust Hazard Study

http://www.csb.gov/assets/1/19/Dust_Final_Report_Website_11-17-06.pdf

In 2003, the Chemical Safety Board (CSB) launched investigations of three major industrial explosions involving combustible powders. The CSB responded to those investigations by launching a nationwide study to determine the scope of the problem and recommend new safety measures for facilities that handle combustible powders. The CSB issued its final report at a public meeting in Washington, DC, on November 9, 2006.

The CSB identified 281 combustible dust incidents between 1980 and 2005 that killed 119 workers and injured 718, and extensively damaged industrial facilities. The incidents occurred in 44 states, in many different industries, and involved a variety of different materials.

The CSB found that the National Fire Protection Association (NFPA) has issued comprehensive standards to prevent and mitigate combustible dust explosions; the standards are widely recognized by experts as effective and authoritative. Notwithstanding, the CSB found that their adoption and enforcement is inconsistent and largely ineffective.

Most important, the CSB also found that local fire code enforcement officials rarely inspect industrial facilities, and when they do, officials focus primarily on life-safety issues such as sprinklers, extinguishers, and fire escapes, rather than on industrial hazards such as combustible dust. Furthermore, local fire code officials—as well as other health and safety professionals—are often unfamiliar with combustible dust hazards.

A.2.2] CSB STUDY – KEY FINDINGS

1. Secondary dust explosions, due to inadequate housekeeping and excessive dust accumulations, caused much of the damage and casualties in recent catastrophic incidents.
2. Consensus standards developed by the National Fire Protection Association (NFPA) that provide detailed guidance for preventing and mitigating dust fires and explosions are widely considered to be effective; however,
 - These standards are voluntary unless adopted as part of a fire code by a state or local jurisdiction, and have not been adopted in many states and local jurisdictions, or have been modified.
 - Among jurisdictions that have adopted the fire codes, enforcement in industrial facilities is inconsistent, and, in the states the CSB surveyed, fire code officials rarely inspect industrial facilities.
3. Training programs for OSHA compliance officers and fire code inspectors generally do not address recognizing combustible dust hazards.

Note: All these findings are equally applicable to British Columbia. We need to learn from this study. BC workplaces should have a comprehensive combustible dust strategy that addresses hazard assessment, engineering controls, housekeeping, and worker training.

CSB Video Resource: Combustible Dust: An Insidious Hazard
(<http://www.csb.gov/videos/combustible-dust-an-insidious-hazard/>)

A.3] CSB VIDEO CLIP – AN INSIDIOUS HAZARD



The U.S. Chemical Safety Board has produced many short videos related to Combustible Dust. This presentation has taken short clips from these videos to assist you gain the knowledge you need to protect yourself and others.

This first video clip introduces combustible dust as an insidious hazard.

A.3.1] KEY VIDEO TAKEAWAYS

There are some key takeaways to remember:

The U.S. Chemical Safety Board calls combustible dust a “significant industrial safety problem.” Why?

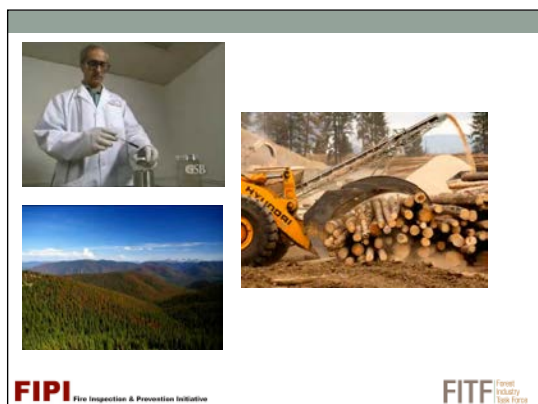
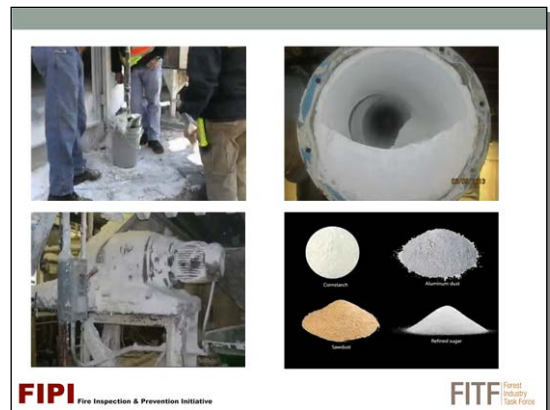
First, the hazard can take years to develop, allowing workplaces to become complacent about it and fail to take the necessary precautions. Instead they believe “We’ve operated 20, 30, or even 40 years and it’s never happened to us.” That is a very dangerous mindset and it exists because the workplace does not understand the hazards associated with combustible dust.

Second, as will be shown later in the presentation, there are many substances that are not normally combustible, that are combustible when in a dry, dust form. As a result, the video identifies a very necessary action: “If you have dust accumulations in your workplace, you need to determine if it is

combustible through

testing.” This also means that, in the absence of testing, you need to assume that your dust is combustible.

This leads to one conclusion being that “BC wood product manufacturing operations need to understand what their combustible wood dust hazards are.”



BJ KNOWLEDGE CHECK #1



Knowledge Check 1.1



Which of the following regulatory agencies have regulations related to combustible dust?

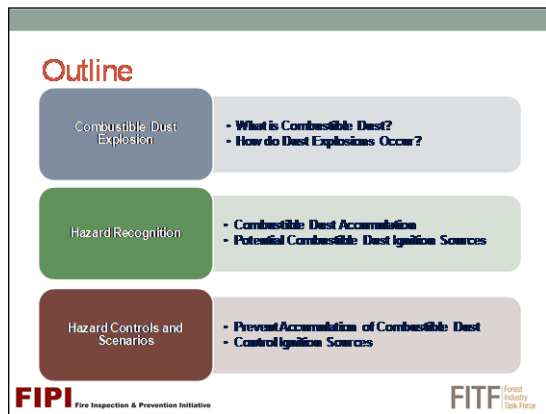
WorkSafeBC
Ministry of the Environment
BC Safety Authority
Office of the Fire Commissioner
Public Health

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Knowledge Check 1.1 – For answer, go to page 57

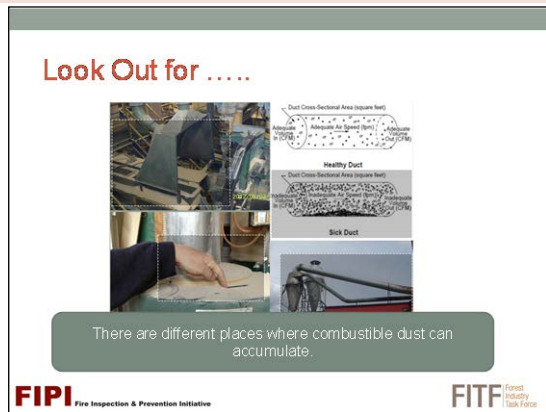
C] OUTLINE



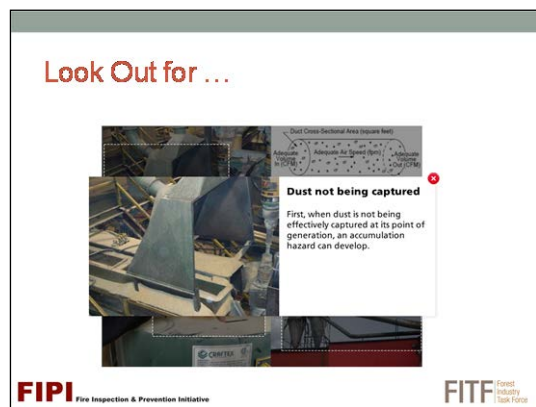
Combustible dust is a common workplace hazard that can cause fires and explosions if not properly managed.

You will learn to identify combustible dust, when it is a hazard, and especially when it is an explosion hazard. You will also learn about the common dust control mechanisms that are used.

C.1] LOOK OUT FOR



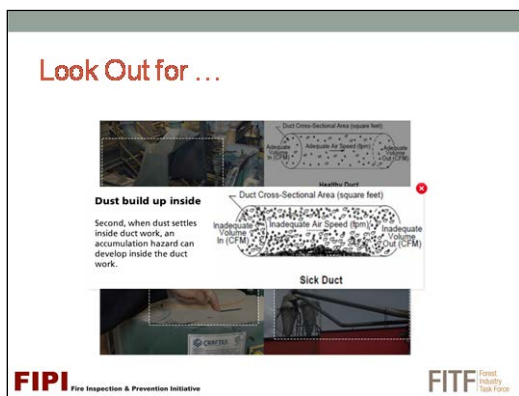
There are different places where combustible dust can accumulate and present a workplace hazard.



Look out for ...

C.1.1] DUST NOT BEING CAPTURED

First, when dust is not being effectively captured at its point of generation, an accumulation hazard can develop.



Look out for ...

C.1.2] DUST BUILD-UP INSIDE DUCT

Second, when dust settles inside duct work, an accumulation hazard can develop inside the duct work.



Look out for

C.1.3] ESCAPING DUST

Third, when dust escapes from the duct work, an accumulation hazard can develop.

Look out for ...

C.1.4] TOO MUCH ACCUMULATION

Fourth, when there is too much accumulation in the general workplace, away from the primary and secondary machine centres, an accumulation hazard can develop.

Later in the presentation, you will gain the knowledge to explain how the accumulation likely developed and its associated hazard.

C.1.4.1] ADDITIONAL COMMENT

To conclude, the inability to properly capture, transport and collect combustible dust allows dust to migrate and accumulate on flat surfaces in the general work area, in plain site or in hidden areas and often at significant distances away from their source of generation. These dust accumulations are a significant hazard as you will learn later in the presentation.

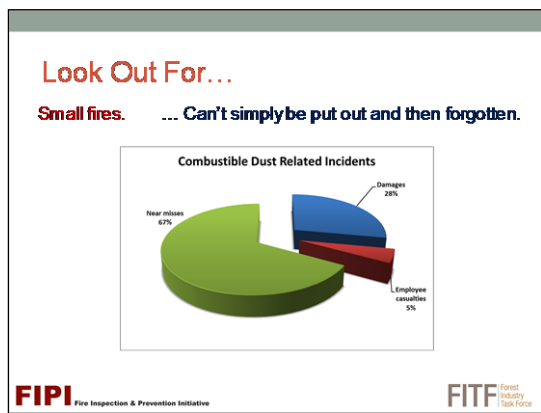




Look out for

C.1.5] CLEAN

Even when your workplace is clean and free of combustible dust, a potential hazard still exists. This is another situation that, later in the presentation, you will gain the knowledge to explain the hazard that can still develop and how to prevent it.



Look out for ...

C.1.6] SMALL FIRES

Finally, many workplaces have small fires that are easily extinguished. Unfortunately these fires are not appropriately investigated.

You will learn why these fire incidents cannot be ignored and why.

C.1.6.1] ADDITIONAL NOTES

If you have fires, they are warnings that you are not properly controlling combustible dust accumulation and/or ignition sources. You cannot ignore these fire incidents.

For example, following the incident investigation, the CSB determines that the Fatal 2003 Incident at Hayes Lemmerz Plant in Indiana was most likely caused by an explosion in the Dust Collection System. The company did not identify or control hazards of aluminum dust.

CSB Chairman Carolyn Merritt said, "This accident followed a classic syndrome we call 'normalization of deviation,' in which organizations come to accept as 'normal' fires, leaks or so-called small explosions. The company failed to investigate the smaller fires as abnormal situations needing correction or as warnings of potentially larger more destructive events. **"The CSB almost always finds that this behavior precedes a tragedy."**

<http://www.csb.gov/csb-determines-fatal-2003-incident-at-hayes-lemmerz-plant-in-indiana-most-likely-caused-by-explosion-in-dust-collection-system-company-did-not-identify-or-control-hazards-of-aluminum-dust/>

Data Source: Webinar, Combustible Dust: From Sparks to Fires to Explosions Identifying Precursors to Catastrophic Events (Combustible Dust Policy Institute. Date 2011)

<http://ohsonline.com/webcasts/2013/04/combustible-dust-from-sparks-to-fires-to-explosions.aspx>

D] COMBUSTIBLE DUST EXPLOSION – HOW IT OCCURS



The first step in learning to recognize and address combustible dust hazards is to learn how a combustible dust explosion occurs.

D.1] CSB VIDEO CLIP – SUGAR DUST EXPLOSION



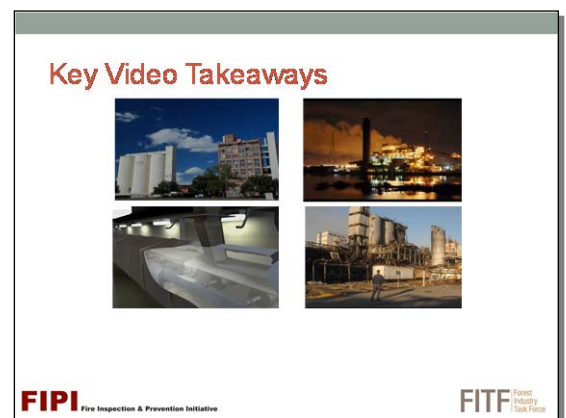
This next video will demonstrate, using the knowledge gained from a combustible dust explosion investigation, all the conditions that needed to “align themselves” for a catastrophic accident.

D.1.1] KEY VIDEO TAKEAWAYS

Earlier you learned from the US Chemical Safety Board that many workplaces simply don’t believe an explosion can occur in their workplace because it’s never happened in the past.

Imperial Sugar Refinery is an example of the consequence of that mindset. It was not adequately addressing their combustible dust accumulation. All it took was a change in operation, in this case, enclosing a conveyance system, which allowed a combustible dust cloud to form at the right airborne concentration of sugar dust to explode in the presence of an ignition source.

It did not matter that they had operated for years without an explosion. All the wrong conditions finally came together in a perfect storm scenario and the explosion occurred.




The video also illustrated the intensity and strength of the multiple secondary explosions that followed, killing several workers and destroying the refinery.

D.2] SO WHAT IS A DUST EXPLOSION?

What is a Dust Explosion?

- Ignition of a very thick dust cloud
- Very rapid burning and pressure rise



The resulting explosive force can damage plant, property, and people.

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A dust explosion is the ignition and very rapid burning of a very thick dust cloud in an enclosure or container causing a pressure rise that ruptures the enclosure or container.

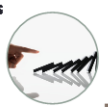
The “enclosure” can be the interior of a building if enough combustible dust is present to form an explosive dust cloud.

Tragically, we are all aware here in BC that such explosions can result in multiple deaths, very serious injuries, and significant property destruction.

D.3] TWO CATEGORIES OF DUST EXPLOSIONS

Two Categories of Dust Explosions

Primary Explosion	Secondary Explosion
<ul style="list-style-type: none">• Event's first Explosion• Takes place in a confined space• Pressure/Shock Wave• Fire Ball	<ul style="list-style-type: none">• Primary Explosion<ul style="list-style-type: none">• Creates & ignites new dust cloud• Secondary Explosion occurs• Process may repeat many times



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In the two video clips you have watched so far, there have been multiple explosions. The first explosion that started it all is known as the primary explosion.

Some event caused that first explosion to occur, typically inside an enclosed or contained space. The primary explosion then becomes the event that starts a chain reaction of secondary explosions, which can occur in other enclosed spaces and/or the general work area.

Each explosion, starting with the primary explosion, will dislodge accumulated dust with its advancing pressure wave. Then the

primary explosion fire ball will ignite the newly dislodged dust into another explosion. This process will continue until there is no more dust dislodged.

Video clips in this presentation will demonstrate how primary and secondary explosions occur and why secondary explosions cause the most damage.

D.4] FM GLOBAL VIDEO CLIP – EXPLOSIVE POWER OF DUST



We are about to watch a video produced by FM Global, a global commercial and industrial insurance provider, that will show the explosive power of combustible dust. The building used for the test is 75 times stronger than a regular building.

As you watch the video, notice how thick the dust cloud needs to be in order for it to be able to explode. A dust cloud this thick is not a regular occurrence in a workplace. If it is, then a very extreme and immediate danger exists. An often quoted analogy is that the cloud is so thick you can't see a lit 25-watt light 3

metres away from you. Such a cloud would be much thicker than the dust cloud you see behind a dump truck driving down a dry, dirt road.

The video will first show the explosion recorded in real time then replayed in super slow motion. Compare the size of the fireball you saw in real time and the size of the fireball that you saw in super slow motion. What is different?



D.4.1] FM GLOBAL VIDEO TAKEAWAYS

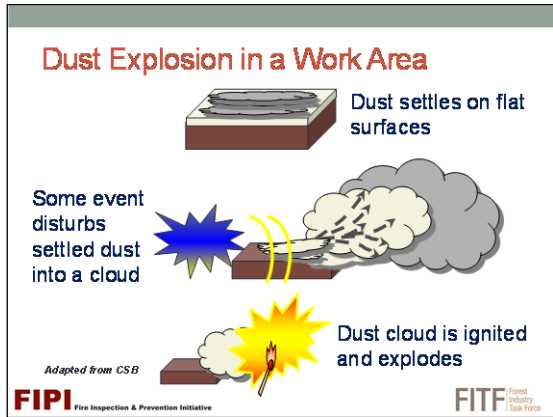
Did you notice how you did not see much of a fire ball in real time but saw a huge fire ball in super slow motion. That demonstrates how fast combustible dust will burn. And, did you notice the thickness of the dust cloud required for ignition to occur?

The video narrator also brought to your attention the disturbed debris (leaves, twigs and dirt) on the ground becoming airborne as result of the leading pressure wave.

You now know why a primary explosion will trigger one or more secondary explosions if there is accumulated dust in the general workplace.

Later, you will learn that primary explosions are still possible in a clean workplace. This fact means your workplace's combustible dust mitigation strategy must prevent wood dust accumulation in the general workplace so that if a primary explosion occurs, it could not trigger a secondary explosion.

D.5] DUST EXPLOSION IN A WORK AREA

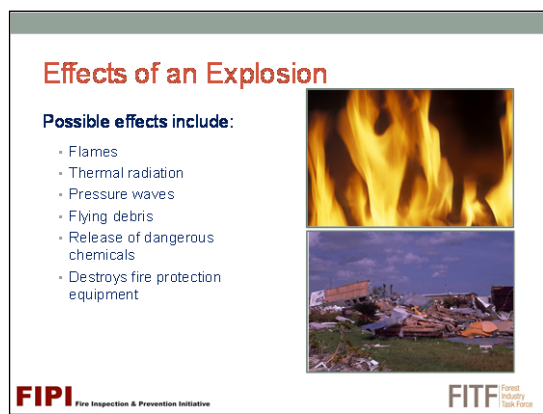


Here is an illustration to summarize what you have just learned about combustible dust explosions in the general work area.

In this illustration, dust has settled on joists, beams, ledges, equipment and other flat surfaces. Some event, typically a primary explosion, will disturb the settled dust into a cloud. Sometimes, it is work activities around the accumulated dust that causes the disturbance.

That newly formed cloud is ignited by a primary explosion fireball or another ignition source in the area.

D.6] EFFECTS OF AN EXPLOSION



Explosions are very destructive:

- The fireball, as we have seen, spreads too quickly to outrun and is strong enough to cause damage to equipment and structures.
- The thermal radiation is capable of causing severe burns and eye injuries to workers and others.
- Pressure waves will blast through containers and building walls, floors, ceilings and roofs, thereby collapsing structural members and creating flying debris.
- Flying debris can inflict additional harm on individuals and property, as well as releasing hazardous chemicals, as is or once on fire.
- All these effects can also destroy, or at least damage, fire protection equipment, making it much harder to fight the residual fires.


D.6.1] ADDITIONAL NOTES

- Release of Dangerous Chemicals – there are many issues associated with fire and/or explosion contacting dangerous chemicals:
 - i) Fuel the fire
 - ii) Explode upon heating
 - iii) Produce smoke and toxic gases
 - iv) Release into the environment

D.7] WHERE DO PRIMARY DUST EXPLOSIONS OCCUR?

Where Do Primary Dust Explosions Occur?

- Dust collectors
- Transfer points in enclosed conveyors or bucket elevators
- Elevator legs
- Electrostatic collectors
- Holding bins
- Electrical equipment (arc flash explosions)



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your workplace?

You may be surprised to learn the most common source of primary dust explosions are dust collectors. Later on in the presentation you will learn why.

As you saw in an earlier video, enclosed conveyance systems are another common source of primary explosions.

You will learn about combustible dust deflagration events. Electrical switches are common sources of severe injuries and death to workers from deflagrations.

Ask yourself – Where does or could a thick dust cloud form in

D.8] CSB VIDEO CLIP – HOW DUST EXPLODES

CSB Video Clip – How Dust Explodes



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Experts tell us that dust explosions are so preventable. A point that the U.S. Chemical Safety Board repeats in its videos. Being able to prevent dust explosions begins with understanding the combustible dust explosion process. Let's start by watching another short video clip.

Key video takeaways



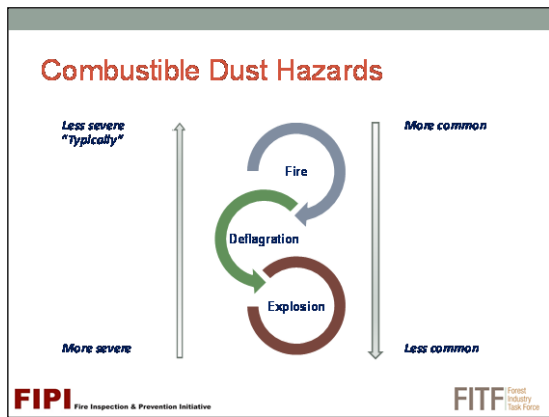
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D.8.1] KEY VIDEO TAKEAWAYS:

Some key takeaways from the video include:

- Many different products, when in a powdered form, are explosible.
- There are five elements needed for a dust explosion, which form the explosion pentagon.
- Combustible dust accumulates over time to dangerous levels in the general workplace.
- An initial event, like a primary explosion inside an enclosure, dislodges the accumulated dust and ignites one or more secondary explosions.
- Most fatalities, devastating injuries and property damage are caused by secondary explosions.

D.9] COMBUSTIBLE DUST HAZARDS



There are three hazards associated with combustible dust – fire, deflagration and explosion.

Each will be explained in the next few slides.

Fires are more common and typically less severe than explosions which are less frequent but can be much more severe.

It is important to understand all three hazards and take measures to eliminate, if possible, or control them.

D.9.1] CONDITIONS NEEDED FOR A FIRE

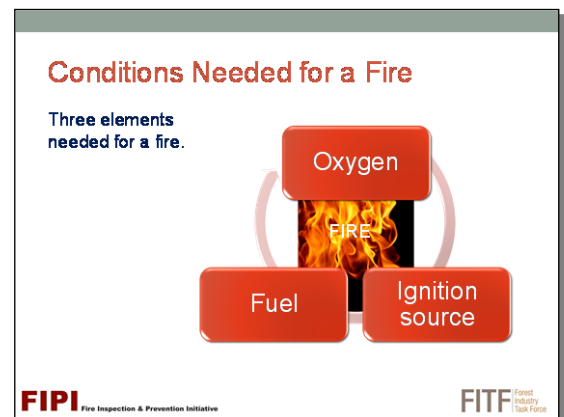
Let's start with reviewing the three elements, known as the fire triangle, that are needed for a fire:

- The "Fuel" element can be a gas, like natural gas, propane, hydrogen or acetylene; or a liquid, like gasoline, alcohol, varnish lacquer, olive oil; or a solid, like coal, wood, cloth, wax, grease, plastic.
- The "Ignition Source" element can be an open flame, a hot surface, a spark, or friction heat.
- The "Oxygen" element is typically the surrounding air.

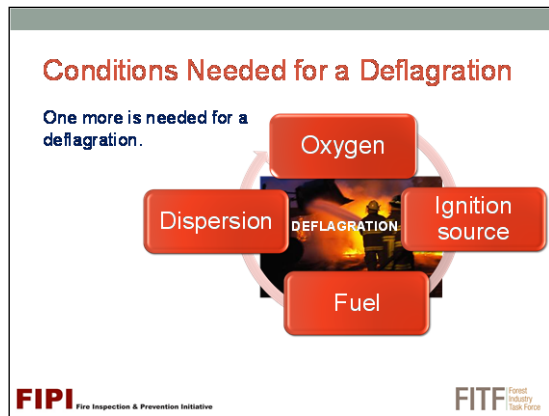
All parts of a tree, in whole or in parts, are fuel for a fire. If you have ever tried to start a fire, you know that you need to begin by lighting "kindling", that is, long, thin pieces of wood, and add bigger and bigger pieces of wood as the fire grows. Particle size matters when an ignition source contacts a fuel source.

Combustible dust, to be defined later, is a hydrophobic material, meaning it repels water. A dust fire will be difficult to extinguish if it is large enough. Also, the dust accumulation can easily become dispersed in the air if the fire is not properly fought, which could lead to a deflagration or explosion, depending on the circumstances.

Firefighting fires where there are combustible dust accumulations is not covered in this workshop.



D.9.2] CONDITIONS NEEDED FOR A DEFLAGRATION



Next we have the deflagration hazard which is very fast propagation, or spreading, of a fire. Although fast, the expanding pressure rise is not as strong as that of an explosion.

Think “woosh.” For example, you might have experienced the “woosh” sound if you had turned on the gas in your barbecue and were a little slow at lighting the gas. That was a deflagration.

A deflagration fireball hazard exists when you have four elements present: fuel, oxygen, ignition source and dispersion. Dispersion in the air occurs when the fuel, such as combustible wood dust, is in the right airborne concentration and at particle sizes small enough to become and remain airborne.

In your car’s engine, if the fuel/air mixture is too lean, your car’s engine will not start. If the fuel/air mixture is too rich, again, your car’s engine will not start. That same fuel/air is important to support a dust deflagration.

The deflagration will become more severe as the dust particle sizes get smaller. For deflagration, as with fires, particle size matters when an ignition source contacts a fuel dispersed in air.

D.9.2.1] FROM FIRE TO DEFLAGRATION



In the last video clip, we witness a deflagration when the analyst blew a small pile of dust over an open flame and creating large deflagration fireball.

It is important to recognize that, when the amount of accumulated dust is not enough to create an explosion hazard, there may be enough dust to create a large, dangerous deflagration fireball.

Photos: Courtesy of FM Global

D.9.2.2] WHY ARE DEFLAGRATION FIREBALLS DANGEROUS?



Notice how the deflagration fireball created by such a small amount of dust is enough to totally engulf the face and torso of a worker.

Such a deflagration fireball would severely burn a worker.

Remember the image in this slide!

D.9.2.3] WORKSAFEBC CASE STUDY

WorkSafeBC has investigated incidents involving combustible dust deflagration fireballs.

For example, at a wood products manufacturing plant, a three-phase motor was single-phasing. To find out why, an electrician was testing the incoming voltage to the electrical components inside a 600-volt 600-amp main service panel. A planer was assisting by holding the multi-meter, which was rated at 600 volts and was not CSA-certified. There was a flashover across the circuit board inside the multi-meter. The arc ignited sawdust in the service panel. A sudden deflagration fireball caused burns to both workers.



D.9.2.4] CSB CASE STUDY #1

The U.S. Chemical Safety Board has also investigated incidents involving combustible dust deflagration fireballs. Here are two examples.

First, as part of an ongoing furnace improvement project, a company engineer and an outside contractor were replacing igniters on a band furnace. The pair experienced difficulty in reconnecting a particular natural gas line after replacing an igniter. While using a hammer to force the gas port to reconnect, the company engineer inadvertently lofted large amounts of

combustible iron dust from flat surfaces on the side of the band furnace, spanning 20 feet above him. As soon as the dust dispersed, the engineer recalled being engulfed in flames. One worker died. The hot surface of the furnace was the ignition source.

Graphic: US Chemical Safety and Hazard Investigation Board, Hoeganaes Corporation: Gallatin, TN



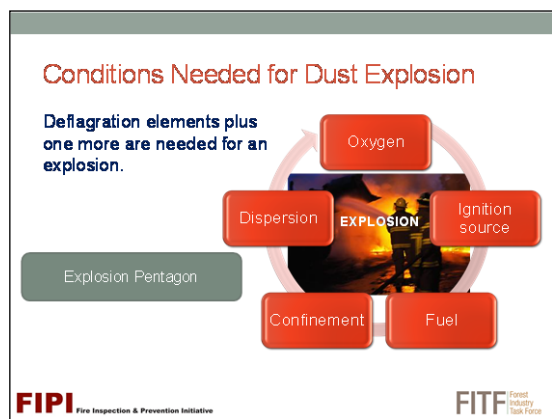
D.9.2.5] CSB CASE STUDY#2

In the second U.S. Chemical Safety Board example, plant operators suspected a bucket elevator of being off-track and a maintenance mechanic and an electrician were called to inspect the equipment. Based on their observations, they did not believe that the belt was off-track and requested, via radio, that the operator in the control room restart the motor. When the elevator was restarted, vibrations from the equipment dispersed fine iron dust into the air. One of the workers recalled being engulfed in flames, almost immediately after the motor was restarted. One worker died. The motor's hot surface was the ignition source.

A very important takeaway is that even a small amount of combustible dust can cause serious injury, even death, when dispersed in a cloud and ignited.

Remember the images in these last few slides!

D.9.3] CONDITIONS NEEDED FOR DUST EXPLOSION



A deflagration becomes an explosion when you add a fifth element – confinement, that is, the thick dust cloud is formed inside an enclosure, room or building.

The confinement allows the deflagration pressure to build-up until a point arises—within the tiniest fraction of a second typically—when it ruptures, suddenly and violently!

The five elements are known as the explosion pentagon.

Dust explosions don't happen very often because you need a "perfect storm" scenario to bring together all the five

elements of the explosion pentagon.

D.9.3.1] ADDITIONAL NOTES

Exactly how thick the dust cloud needs to be will be discussed shortly. In the earlier FM Global video clip we witness that the cloud needs to be very thick. In fact, it's so thick that you can't see a 25-watt light 3 metres away from you.

The elements are identified in the Office of the Fire Commissioner Information Bulletin, "What is Combustible Dust?" which can be viewed at the following URL:

<http://embc.gov.bc.ca/ofc/services/bulletins/index.htm>



D.9.3.2] FROM DEFLAGRATION TO EXPLOSION:

The combustible coal dust's sudden and violent explosion is seen in these still shots from the video.

They demonstrate that if dust clouds are ignited within confined areas such as buildings or equipment, dangerous pressures will be generated, exceeding the building or equipment's design strength.

Just like the deflagration, an explosion will become more severe as the dust particle sizes get smaller. For explosions, as with deflagration and fires, particle size matters when an ignition source contacts a fuel dispersed in air in a contained area.

D.9.4] PREVENT ONE ELEMENT – NO EXPLOSION

Now that you know how a deflagration or an explosion can occur you also know how to prevent them.

Simply eliminate one of the explosion pentagon elements and you prevent an explosion. Depending on which of the five elements you eliminate, you can also prevent a deflagration and/or a fire.

If we start from the bottom of the slide, removing the oxygen will prevent fires, deflagrations and explosions. Unfortunately, that is not a very practical solution in a sawmill or other wood processing operation. It is however a viable strategy in the right circumstance in other industries.



Next, we can consider removing the confinement. Some wood processing operations have removed the enclosure around outdoor passage ways which also house conveyors or ductwork. Many operations in the Lower Mainland don't have walls preventing building-wide secondary explosions. These operations may still be at risk of fire, deflagrations and small primary explosions in other enclosures.

If for some reason, combustible dust has accumulated, preventing the dispersion of that dust into a cloud can prevent a deflagration or an explosion. Unfortunately, recognizing how that accumulated dust might be dispersed is not always easy so focusing on preventing dispersion is not a practical solution in most cases.

It is always important to consider potential ignition sources and eliminate them. If you can eliminate the ignition sources, you prevent fires, deflagrations and explosions. Unfortunately, there are many different ignition sources and, even though it is necessary to find and eliminate them, it can be difficult to be 100% successful.

The most effective strategy is to address the fuel element. If there is no accumulation of dust to hazardous levels then it would not be possible to produce a thick dust cloud. Without a thick dust cloud, you can't have a deflagration or an explosion, and fires are less likely as well.

This presentation will focus on strategies to prevent the accumulation of wood dust and the control of ignition sources.

D.9.5] MAJOR EXPLOSION RISKS

Major Explosion Risks



General work area

- Combustible dust levels above 1/8"

Dust collection system

- Dust collectors located inside
- Non-existent inlet backflow prevention
- Dust collectors without vents or with undersized vents
- Inadequate safe blast zone
- Non-existent or non-functioning abort gate (recycled air)
- Inadequate dust collector hopper discharge isolation

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So what are the major explosion risks in an industrial operation?

First, in the general work area, the risk is primarily from secondary explosions. The 2012 edition of NFPA 664, Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities, states:

“A hazard exists where the layer of accumulated fugitive wood dust on upward-facing surfaces exceeds 3.2 mm (1/8”) over 5% of the area or 93 m² (1000 ft²), whichever is smaller.”

The event that will typically disturb dust that has accumulated in the general workplace is a primary explosion that originated elsewhere, often within the dust collection system.

Dust collection systems effectively prevent combustible dust from accumulating in the workplace and, at the same time, are significant sites for primary explosions.

An improperly designed and operated dust collector system can be the site of primary explosions. These design flaws include:

- Dust collector located inside buildings except as allowed by the BC Fire Code
- Inadequate explosion prevention on dust collection system including:
 - Non-existent inlet backflow prevention
 - Lack of explosion vents or undersized vents
 - Inadequate safe blast zone
 - Non-existent or non-functioning abort gates
 - Inadequate dust collector hopper discharge isolation

You likely don't know what all these explosion prevention equipment are or what they do. Ensuring the dust collection system is properly designed is the responsibility of management and its continued safe operation the responsibility of the maintenance department or crew.

If you want to learn how your dust collection system is designed to protect you from a primary explosion, make inquiries to your employer.

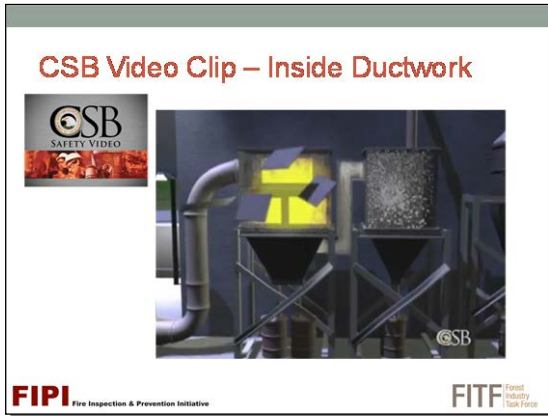
D.9.5.1] ADDITIONAL NOTES

For secondary dust accumulations check:

- Floors and below ground areas
- On and around equipment
- Leaks around dust collectors and ductwork
- Elevated areas (e.g., structural members, conduit and pipe racks, cable trays, light fixtures)

- Other elevated relatively flat surfaces
- Hidden areas in walls, ceilings and crawlspaces

D.9.6] CSB VIDEO CLIP – INSIDE DUCTWORK



This next video clip shows exactly how a primary explosion originating in the dust collector can result in secondary explosions throughout the facility when combustible dust is allowed to accumulate in the general work area.

D.9.6.1] KEY VIDEO TAKEAWAYS

- The video illustrates how combustible dust can accumulate in the ductwork if it is not properly designed.
- And leaks in the ductwork can contribute, over time, to the accumulation of combustible dust in the general work area.
- At this particular facility the dust collection system did not appear to have sufficient functioning explosion prevention equipment incorporated into the dust collection system. That allowed the primary explosion to propagate through the duct work, which contained accumulated combustible dust, and finally igniting combustible dust in the general work area.



Key video takeaways



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Consider this: How bad would the total event have been if there was no accumulation of combustible dust in the general work area?

The damage would have likely been limited to the dust collection system with few, if any, worker injuries.

Now consider what how bad the total event would have been if the dust collection system had been operating as designed, that is, no leaks and no accumulation of combustible dust in the ductwork?

Damage would likely have been limited to the dust collector

and, very few, if any, injuries to workers.

Finally, how bad would the total event have been to the dust collector if it had functioning explosion prevention equipment?

There would likely have been no damage or very little damage to the dust collector and no worker injuries.

So the key takeaways are:


- Focus on preventing the accumulation of combustible dust in the general work area by designing and operating as designed a combustible dust collection system.
- Support the dust collection system with an effective preventive maintenance program and good housekeeping.
- Ensure the dust collection system has the required explosion venting and/or explosion prevention system incorporated into its design and operation.

EJ KNOWLEDGE CHECK #2



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Knowledge Check 2.1


 Which explosions typically occur in the general work area?

Primary or Secondary

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Knowledge Check 2.2


 Fill in the blank.

_____ explosions typically occur in a contained space like dust collectors, enclosed conveyance systems, impact equipment, and holding bins.

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Knowledge Check 2.3

 Fill in the blanks:


The three fire triangle elements are:

1. _____ 2. _____ 3. _____
2. Deflagration requires fire triangle elements plus _____ in air.
3. Explosion requires deflagration elements plus _____.

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Knowledge Check 2.4


 Many primary explosion risks are associated with dust collectors.

True or False

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Knowledge Check 2.5

 Fill in the blank?

The best strategy to prevent dust explosion and deflagration is to prevent the _____ of dust in the workplace.

Dispersion
or Drying
or Accumulation

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Knowledge Check #2 – For answers, go to page 58

F] HAZARD: COMBUSTIBLE DUST ACCUMULATION HOW TO RECOGNIZE THE HAZARD

HAZARD: COMBUSTIBLE DUST ACCUMULATION

How to recognize the hazard

The next segment will show how to recognize the hazard associated with the accumulation of combustible dust in the workplace.

F.1] PRIMARY AND SECONDARY DUSTS:

To help understand what combustible dust is, it is helpful to understand how to describe different types of wood waste in a manufacturing operation.

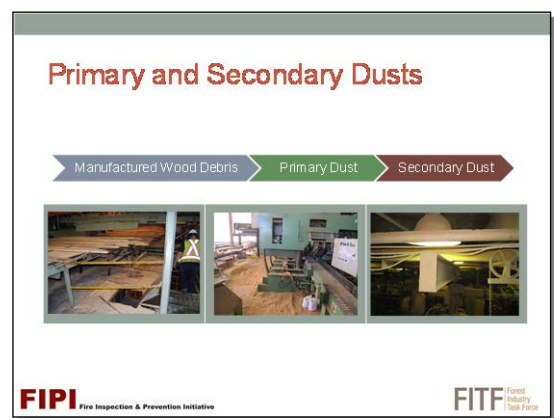
Here the wood waste is shown on a continuum.

On the left is '**manufactured wood debris**,' which is defined as a waste by-product of wood product manufacturing consisting of bark, wood chunks, some chips, and possibly some sawdust. If allowed to accumulate, debris becomes a fire hazard and, over time can release the finer, drier secondary dust, which can become a deflagration and explosion hazard.

Next is '**primary dust**,' which is created by primary machine centres and other work processes. They are those dusts found on floors and surfaces near or below the dust producing (e.g., primary breakdown) or waste handling equipment. They are the source for secondary dust, which is often the fuel source for serious deflagrations and explosions. While primary dusts may consist primarily of greener, moister and coarser particulate, unmanaged primary dusts will over time, when disturbed, release the finer, drier secondary dusts.

Finally, on the right, is secondary dust, which is the finer, drier dust that is broadly dispersed and that settle away from the production area [usually rafters, ceilings, and beam, ductwork, walls, joints, top of machinery].

When "secondary" dusts are present at 1/8" thickness over 5% of the work area or 1000 ft², whichever is smaller, they present a significant fire, deflagration and explosion hazard.



F.2] COMBUSTIBLE DUST – WHAT IS IT?



So what exactly is combustible dust?

At a base level, combustible dust is any fine material that has the ability to catch fire and exploded when mixed with air.

In an earlier video we learn that many different materials can be combustible, including some that are not “normally” combustible but can burn or explode if the particles are the right size and in the right concentration in the air.

Combustible dust types include:

- Organic material such as plastic, sawdust, flour, grains
- Un-oxidized metals such as aluminum, silicon, magnesium
- Other oxidize-able material such as sulfur, iron sulfides

If processes and activities in your workplace create dust, it should be investigated to determine if it is explosible.

Combustible wood dust is defined as a wood particulate with an average diameter of 500 micrometers or smaller (e.g., the size of granulated sugar or smaller) and moisture content typically less than 25%.

Combustible wood dust therefore makes up a very large portion of secondary dust; its portion in primary dust will vary depending on the equipment producing the dust; and make-up only a very small fraction of manufactured wood debris.

F.2.1] ADDITIONAL INFORMATION

Participant’s handbook contains a related OFC Information Bulletin.

F.2.2] DEFINITIONS

Combustible Dust: A finely divided combustible particulate solid that presents a flash fire hazard or explosion hazard when suspended in air or the process-specific oxidising medium over a range of concentrations.

Source: NFPA® 654 Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids 2013 Edition

Combustible Wood Dust: Combustible wood dust is defined as a wood particulate with an average diameter of 500 microns (µm) or smaller and a moisture content of less than 25 percent. (NFPA 664, 3.3.27.1)

F.3] ABOUT THE DUST



For a dust explosion to occur, several key conditions must be present:

- The dust must be combustible as explained in the previous slide meaning:
 - The dust must be reasonably dry, usually less than 25% moisture content.
 - The dust particle size must be fine enough to become airborne.
 - If too many of the particles are too large, that is, over 500 micrometers (or microns), it will not explode.
 - As you increase the amount of finer particles in the

mixture, the risk that the dust is explosible increases. When the portion of finer particles increases to a certain level, the mixture becomes explosible.

- The finer the dust, the faster it burns, and the greater the severity of the explosion.
- The dust concentration in air must be at the right concentration to be explosible. For combustible wood dust, that means a dust cloud so thick you can't see a lit 25-watt light 3 metres away.

F.3.1] SIEVED WOOD DUST SAMPLE

FP Innovations collected wood dust samples from 18 sawmills across BC under contract to the Manufacturers' Advisory Group. This photo shows a wood dust sample that has been sieved into different particle size. It was collected from a BC mill operating floor and is typical of waste produced by standard milling and processing operations.

The original dust sample contained a mixture of particle sizes and shapes and had an average particle size of 700 microns, with some particles substantially larger, for example, over 1000 microns in size.



The lower left photo shows the dust sample particles that were larger than 1000 microns.

The lower right photo contains the particles that ranged in size from less than 1000 microns to greater than 425 microns.

The upper left photo contains the dust sample particles that ranged between less than 425 microns to greater than 250 microns.

The upper right photo contains the particles that ranged between less than 250 microns to greater than 75 microns.

There were very few particles that were less than 75 microns.



This second photo shows a close-up of the sieved dust so that you can get a sense of the size of each particle range.

The lower right sample is similar in particle size to granulated sugar and the upper left sample would be similar or slightly larger than table salt.

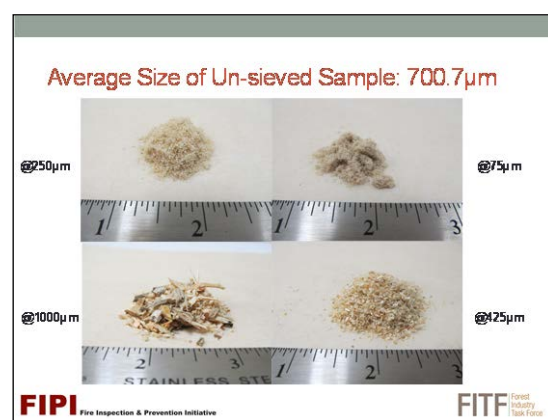
This third photo is another close-up view.

Earlier, you learned that particle size is an important combustible determinant. And, that particles sizes, less than 500 microns, were combustible.

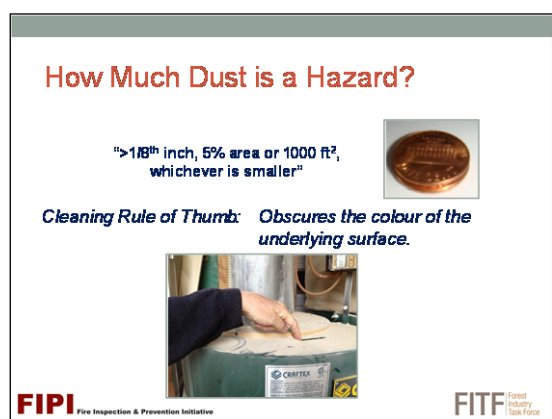
The important point is that wood dust that may appear to have large particle size will also contain many particle sizes that are smaller.

These smaller particles can become airborne when the wood dust accumulation is somehow disturbed. Once airborne, these finer particles can migrate and settle on other flat, elevated surfaces and become dangerous accumulations of secondary dust.

Have you seen secondary dust accumulations in your workplace?



F.4] HOW MUCH DUST IS A HAZARD?



Earlier, you learned that accumulated secondary dust above 1/8" over 5% of the area or 1000 ft², whichever is smaller, constitute a hazard. That's because, if that much dust becomes airborne, you can create the thick cloud needed to support a deflagration or an explosion.

A visual housekeeping rule of thumb is to clean up accumulated combustible dust when the dust accumulation obscures the colour of the underlying surface.

F.4.1] ADDITIONAL INFORMATION

A deflagration hazard may exist when either of the two following conditions exists:

- Layer of accumulated fugitive dust exceeds 1/8th inch over 5% of the area or 1,000 ft², whichever is smaller.
- Deflagrable wood dust in the air at a concentration in excess of 25% of MEC (Minimum Explosive Concentration) under normal operating conditions

Source: NFPA 664, Section 4.2.1

Also remember our discussion about fireballs. Accumulated dust, if insufficient to cause an explosion, can still produce a dangerous fireball.

NFPA 654 and FM Global Data Sheet 7-76 are referenced.

F.5] WORKSAFEBC HAZARD ALERT

WorkSafeBC issued a Hazard Alert informing everyone that the risk of a dust explosion increases during winter months.

So, what happens in the winter months?

The risk of a dust explosion increases when low humidity levels, like those seen in winter months, make dust easy to dry, disperse and ignite.

In fact, industrial accident investigations by the U.S. Chemical Safety Board found that seven out of eight fatal combustible dust explosions from 1995 to 2009 occurred during cold winter months when these weather conditions were most prominent.



One of the two tragic sawmill incidents in British Columbia occurred in the middle of winter, the second occurred in early spring.

A number of changes can commonly occur in wood processing facilities as the weather becomes colder.

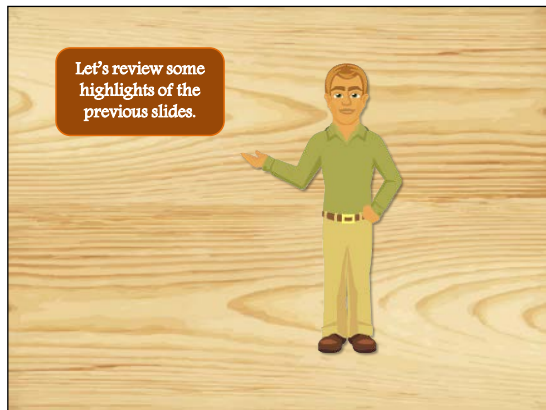
- Control measures and clean up practices that rely on the use of water may not be suitable or effective.
- Openings such as bay doors and wall dampers may be closed up increasing the degree of enclosure and reducing natural ventilation or make up air.
- Ventilation may be reduced or shut down to conserve heat.
- Re-circulation of air from exhaust systems may also increase.
- Portable heating units potentially introduce additional ignition sources into workspaces.

When going into the winter months it is important to maintain attention on controlling the risks associated with combustible dusts. Employers need to assess for any additional risks associated with the impact of the environment on dust accumulations and the methods used to control dust in the winter.

F.5.1] ADDITIONAL INFORMATION

Participant's handbook contains a copy of the Hazard Alert.

G] KNOWLEDGE CHECK #3



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Knowledge Check 3.1

Fill in the blanks:

What is combustible dust?

A combustible particulate solid that presents a _____ or _____ hazard when suspended in air.

Breathing or Deflagration
or Seeing or Fire or Explosion

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Knowledge Check 3.2

Well, you've heard a lot about dust now. Which of the following do you think is most responsible for the highly combustible nature of dust?

- Shape
- Size
- Dispersion

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Knowledge Check 3.3

Types of wood dust – Choose True or False for each statement

Secondary Dust will burn:	True or False
Manufacturing Wood Debris will explode:	True or False
Primary Dust will explode:	True or False
Secondary Dust will deflagrate:	True or False

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Knowledge Check 3.4

What makes wood dust explosive? (Choose all that apply)

- It must be combustible
- Fine enough to be airborne
- Dry
- Suspended in the air in an explosive concentration
- Contained or enclosed in confined area
- All of the above

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Knowledge Check 3.5

Housekeeping Rule of Thumb:

Clean when combustible dust obscures the _____ of the underline surface.

thickness
colour
texture

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Knowledge Check #3 – For answers, go to page 59

H] HAZARD: IGNITION SOURCES

HAZARD: IGNITION SOURCES

How to recognize the hazard

The next segment will show how to recognize the hazard associated with potential ignition sources in the workplace.

H.1] LITTLE, IF ANY, TIME FOR ESCAPE:



You saw earlier in the FM Global video that a dust deflagration fireball created by a dust explosion is barely visible unless seen in super slow motion.

The sequence has an ignition source contacting a combustible dust cloud starting a rapidly burning fire triggering a small explosion.

A shock wave from the explosion knocks dust off of elevated surfaces, which are ignited by the deflagration fireball that follows the shock wave causing a secondary explosion.

All this occurs in much less than a second!

Since there is no time to escape when an ignition source contacts a dust cloud, it is important to identify, eliminate or control ignition sources in areas where wood dust is generated or can accumulate.

Where ignition sources cannot be eliminated, for example, electrical equipment, the goal is to prevent combustible dust from contacting the ignition source.

Remember, there is little, if any time, for escape!



H.2] IGNITION SOURCES

The two images on this slide show secondary dust accumulations around ignition sources.

Can you identify the ignition sources?

They include a hot light fixture, hot electrical motor surface, potential electrical arcs from the electrical cable and the junction box if either is in a poor state of repair.

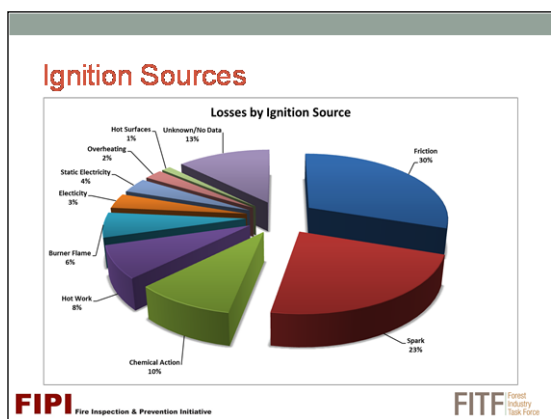
In a typical industrial operation, there are many different ignition sources that can exist.

H.2.1] ADDITIONAL INFORMATION

Common ignition sources include:

- Hot Work
- Electrical equipment (examples: fixed and portable equipment, plugs, switches)
- Electrical rooms, stray electric currents
- Static electricity
- Hot equipment (e.g., Compressors, motors, propellant-actuated tools (Hilti guns), mobile equipment, etc.)
- Hot surfaces (example: friction, fixed and portable heaters, hot bearings)
- Friction (e.g., moving parts – especially when in disrepair)
- Mechanical sparks (e.g., misalignment moving parts, tools)
- Smoking or open flames
- Lighting (fixed or portable)
- Auto ignition
- Sabotage

In a typical industrial operation, there are many different ignition sources that can exist.



H.2.2] FM GLOBAL IGNITION SOURCES STATISTICS

The FM Global chart shows the number of fires and explosions initiated by different types of ignition sources. Each major category will be discussed next.

For now, note that friction and sparks account for over 50% of the ignition sources.

Chart Source: FM Global Data Sheet 7-76

H.3] MECHANICAL SPARKS AND FRICTION:

Ignition Source—Mechanical Sparks and Friction



Sparks

- Grinding metal with an abrasive disk
- Power tools

Friction

- Overheated bearing
- Faulty equipment
- Wood debris on conveyor parts

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Statistics demonstrate that mechanical sparks and friction are the ignition source 53% of the time.

Mechanical sparks occur when there is excessive friction between metals or extremely hard substances. As the two substances rub against each other, small and very hot particles are torn off the surfaces. This tearing and heating is due to the large amount of friction.

Examples of mechanical sparking include dropping metal tools or chains, grinding metal with an abrasive disk, and damaged moving parts.


Friction, when not excessive, can cause overheating. Examples of overheating from friction include moving parts such as belts, conveyor spools, nip points, gears, drive shafts and bearings. Pieces of wood jammed against a moving part can overheat and release hot embers.

The most effective way to control most mechanical sparks and friction is to have a strong preventive maintenance program. This would include:

- Routine inspection, cleaning, maintenance and, when necessary, replacement of equipment.
- Without delay, repair equipment and parts that are producing unusual sounds, heating or vibration.
- Conduct more detailed inspections of critical components on a regular basis to ensure that critical tolerances are maintained, components are not wearing, points needing lubrication are being lubricated, and that bolts and other fasteners are tight.
- Safely clear jammed combustible material before embers can be produced.

H.4] HOT WORK

Ignition Source—Hot Work



Hot work is any operation that can produce enough heat from flame, spark or other source of ignition, with enough energy to ignite flammable vapours, gases, or dust.

This includes:

- Welding
- Cutting
- Grinding
- Brazing
- Riveting
- Drilling
- Soldering

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Statistics demonstrate that hot work is the ignition source 8% of the time.

Hot work usually involves activities like welding, cutting, grinding, brazing, flaming, chipping, air gouging, riveting, drilling, and soldering.

To prevent hot work activities from igniting a combustible dust cloud, implement a hot work policy and procedures and follow them. These procedures should include identifying and removing or shielding the combustible dust before beginning the hot work activities.

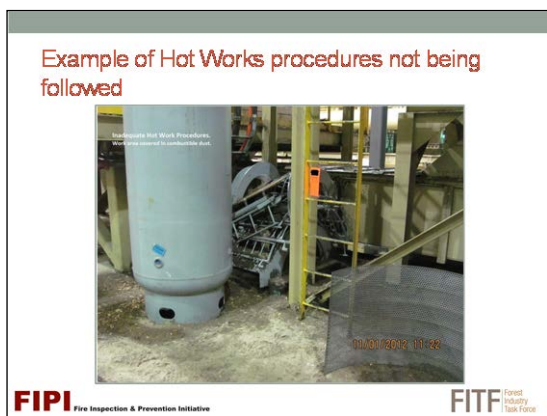
H.4.1] ADDITIONAL INFORMATION

Hot work is any operation that can produce enough heat from flame, spark or other source of ignition, with sufficient energy to ignite flammable vapours, gases, or dust.

Note: The use of certain portable open-flame type heaters (i.e. Salamander Heaters) should be discouraged. Should they be employed, the surrounding area should be treated as a hot work area.

H.4.2] HOT WORK—WHAT SHOULD BE DONE?

To prevent hot work activities from igniting a combustible dust cloud, implement a hot work policy and procedure and follow them. These procedures should include identifying and removing or shielding the combustible dust before beginning the hot work activities.



followed.

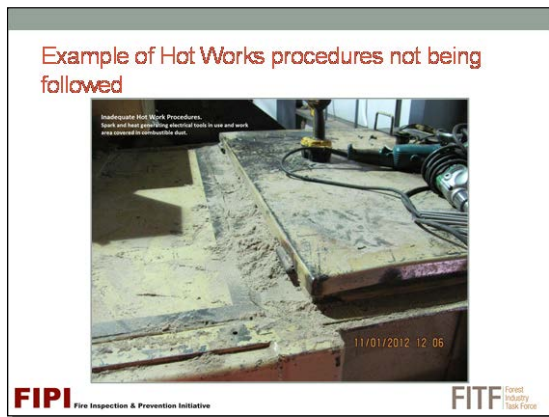
As explained earlier, removing accumulated combustible wood dust is the best strategy to prevent fires, deflagrations and explosions. Before this hot work activity was started, the combustible dust accumulation should have been removed.

H.4.3] CASE SCENARIO

This slide shows hot work activities were occurring in an area covered in combustible dust. There is even a hot work permit, completed and checked off as “OK and Ready to Start”, hanging from the ladder.

Sparks could start a fire or, if for some reason, the combustible dust becomes airborne, the sparks could ignite a deflagration fireball.

Hot work policies and procedures are useless if they are not

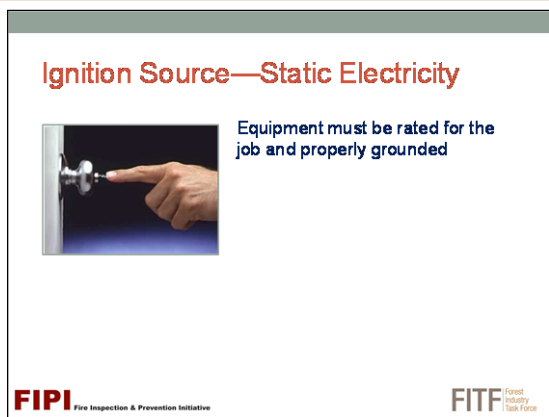


H.4.4] CASE SCENARIO

This slide shows another situation of inadequate hot work procedures.

Again the combustible dust was not removed before the hot work procedures were commenced.

H.5] STATIC ELECTRICITY



Statistics demonstrate that static electricity is the ignition source 4% of the time.

Static electricity can be generated in many different ways but the process is always the same – two surfaces contact and separate, and at least one of the surfaces has a high resistance to electrical current (and is therefore an electrical insulator).

In wood product manufacturing, the flowing movement of combustible wood dust in ductwork or through mechanical agitation can build up static electricity. When there is a static

discharge in a dust cloud, an explosion can occur.

The best way to prevent static electricity build-up is to properly bond and ground equipment. If you have wood shaping equipment and dust collection equipment, are they properly bonded and grounded?

Note: Plastic pipes have been inappropriately used in some workplaces as ductwork to transport wood dust to the dust collector. All dust collector system components should be conductive, e.g., metal.

H.5.1] CASE STUDY

Here is an example of a small deflagration that was ignited by static electricity. Workers had to manually fill a mixer with plastic powder.

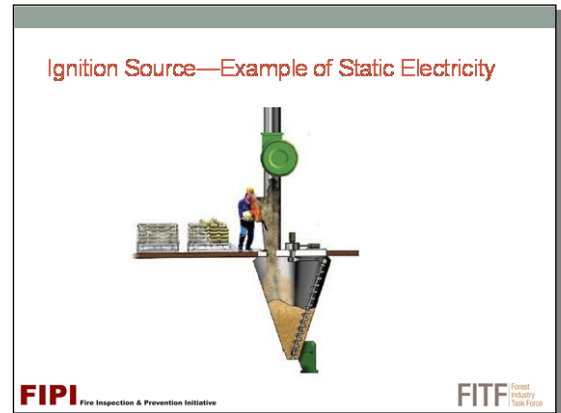
The process had a worker manually add plastic powder from bags into the top of a mixing tank. The tank was equipped with an extraction fan to prevent plastic dust from escaping the tank and entering the general work area.

A known risk of static electricity build-up in the worker was prevented by having the worker wear conductive footwear to bond the worker to the floor, which was grounded.

There was a change in process – a seemingly harmless change in product delivery: the powdered plastic bags were now being delivered shrink wrapped on pallets.

The worker removed the shrink wrap and simply tossed it on the floor, which broke the ground between the worker's conductive footwear and the floor. This allowed static electricity to build in the worker when handling and emptying the bags into the top of a mixing tank. After several bags had been emptied into the mixer, the worker had become charged. While the next bag was being emptied, a spark discharged from the worker and ignited the dust cloud into a small deflagration.

The worker suffered severe burns to his face and upper body.



H.6] ELECTRICAL EQUIPMENT



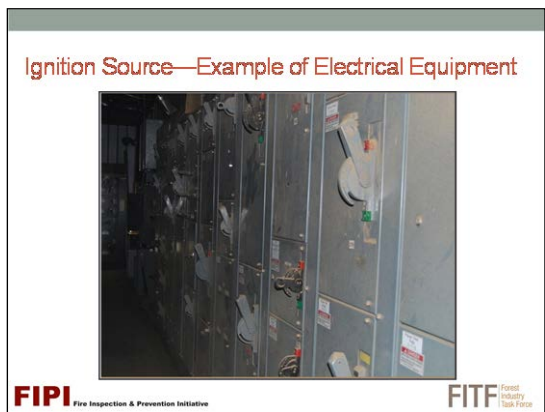
Statistics demonstrate that electrical equipment is the ignition source 3% of the time.

A word of caution: These statistics refer to a broad range of industries. The BC Safety Authority, after conducting inspections in BC sawmills and other primary wood product manufacturing, is of the opinion that electrical equipment is the ignition source more often than what these statistics demonstrates.

Regardless of the statistics, the best strategy is to prevent the accumulation of combustible dust around electrical equipment

by capturing the combustible dust at its source of generation.

If combustible dust cannot be controlled in area, ensure the electrical equipment is certified and approved for such installations. These locations, where certified equipment is required, are known as hazardous locations and are regulated by the BC Safety Authority using the Canadian Electrical and Gas Codes.



H.6.1] EXAMPLES OF ELECTRICAL EQUIPMENT

Some common examples of electrical arcs and sparks include:

- Sparking of electric motors, generators, or other electrical rotating equipment
- Arcing between contacts (i.e., switches and relays)
- Arcs due to broken, inadequate, or failed insulation
- Poor contacts between conductors, such as poorly fitted light bulbs and their sockets

H.7] HOT EQUIPMENT AND SURFACES

Statistics demonstrate that hot equipment and hot surfaces are the ignition source 3% of the time.

To prevent combustible dust fires and explosions:

- Prevent combustible dust from accumulating on and around equipment that produce heat when operating
- Shut down equipment and allow hot surfaces to cool before exposing to dust debris
- Conduct regular inspections of equipment to detect hot surfaces, and affect repairs promptly
- In addition to measuring the internal and external temperature of electrical equipment and components, the use of an infrared camera on mechanical equipment has met with success to detect hot spots.

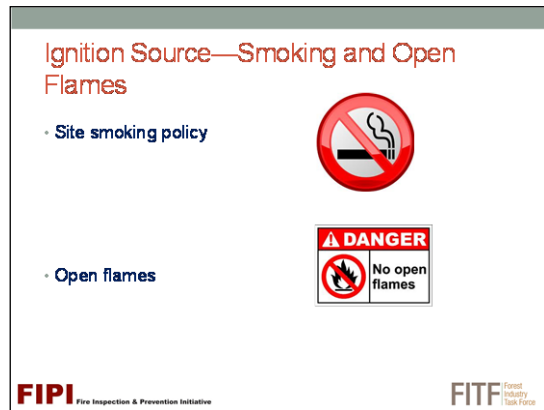


H.7.1] ADDITIONAL INFORMATION

Common heat sources include:

- Pipes, compressors, motors, portable hand tools, lighting, radiant heaters, bearings

H.8] SMOKING AND OPEN FLAMES:



In BC, smoking is not permitted inside buildings and restricted to a safe outdoor location. A safe outdoor location includes being a safe distance from combustible and flammable materials.

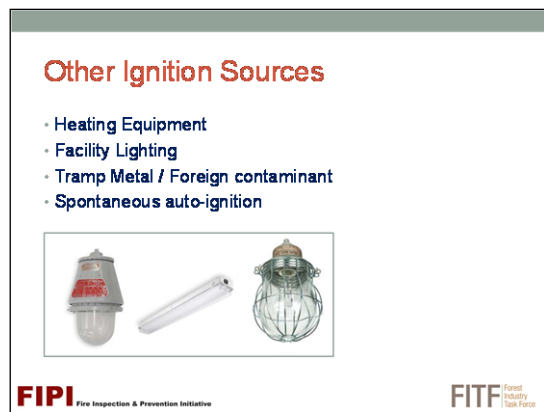
Open flame examples include ovens, dryers, and cutting torches. Don't forget to identify and control gas pilot lights, which are not typically visible and therefore easy to overlook.

H.8.1] ADDITIONAL INFORMATION

Be aware of and control all potential sources of open flames. Examples include:

- Ovens
- Dryers
- Cutting Torches
- Pilot lights

H.9] OTHER IGNITION SOURCES



There are other ignition sources that round out the list of typical ignition sources found in industrial settings. These include:

Heating equipment such as forced air heaters, especially gas-powered with a pilot light, radiant heaters and temporary heaters.

Heating equipment needs to be shielded or separated to prevent contact with combustible dust unless time to cool down is provided.

Facility lighting, bulbs and ballasts, should be adequately protected with covers to prevent dust from coming in contact with the hot surface of the light fixture or its components.

In dusty enclosures, for example, within a passive containment system, use “dust tight” light fixtures.

Tramp metal and foreign contamination are a common source of mechanical sparks within the dust collection system. Metal detectors, magnetic separation or air density separation, prior to fractioning equipment, are used to remove foreign material capable of causing sparks.


Floor level suction systems (e.g., floor sweeps) should be eliminated or else equipped with magnets to capture tramp metal.

I] KNOWLEDGE CHECK #4



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Knowledge Check 4.1


 Which are the top two ignition sources from the list below?

- Mechanical Sparks
- Space Heaters
- Hot Work
- Static Electricity
- Hot Surfaces
- Friction
- Some mobile equipment
- Overheating equipment
- Electrical Arcs (i.e., shorts)

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Knowledge Check 4.2

 You see that a thick layer of dust has formed on the exterior casing of an MCC panel. You note that the dust is wet because of misting systems in the mill. You might:

- a) Attempt to clean off the MCC panel and leave it at that.
- b) Attempt to clean off the MCC panel, if trained to do so, and report the situation to the applicable supervisors, as the dust could be heated and dried over time to the point it could be easily ignited.
- c) Do nothing. The dust is wet and therefore won't ignite.

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Knowledge Check #4 – For answers, go to page 61

J] HAZARD SCENARIOS

HAZARD SCENARIOS

J.1] SCENARIO 1



The photo shows a plywood mill's high speed sander. The combustible dust produced by the sander is captured by the dust collection system. The cleanliness of the surrounding area suggests the dust collection system is effective.

One day, a guide blade became miss-aligned dropping onto the belt and causing the wood product to jam. Shortly afterwards, an explosion occurred in the duct.

What happened?

The miss-aligned blade and the jammed wood product created mechanical sparks or hot embers that were drawn into the dust collection system.

The concentration of dust being transported in the duct was above the lower explosion limit. The sparks or embers triggered a primary explosion, which propagated into the cyclone separator causing a secondary explosion that damaged the cyclone separator and destroyed the bag house. The ensuing fire caused more damage.

Think back to the elements of the explosion pentagon. A dust collection system, by design to function properly, has four elements present when in operation. The only element missing is the ignition source. In this case the ignition source was a mechanical spark or a hot ember.

To prevent such fires and explosions, employers need to ensure there is some mechanism to quickly shut down the equipment, automatically or manually, when a jam occurs.

Operators need to be aware of the fire and explosion danger of product jams and follow the safe procedures for responding to a product jam. The dust collection system could also be equipped with explosion prevention equipment that (1) can detect and extinguish sparks and embers in the ductwork and/or (2) can detect and suppress an explosion, in its early stages, in the dust collector.

J.1.1] ADDITIONAL INFORMATION

Note cleanliness of general work area.

Photo: "Typical sander" – http://www.fe.aquacoustics.biz/Mechanical_Fires.pdf

J.2] SCENARIO 2



This photo shows an electrical motor that powers a small pulley system around a cyclone collection duct.

Friction from the output shaft bearing caused overheating and ignited the combustible dust that had accumulated on top of the motor and output shaft guard.

In this incident, there was only a fire. However, given the amount of accumulated combustible dust, the potential for a deflagration fire ball or an explosion was high and immediate if the combustible dust was somehow dispersed into a thick cloud.

For example, improperly attacking the fire, with a water stream, could cause combustible dust to become airborne and trigger a deflagration fireball or possibly a primary explosion. Assuming the rest of the facility also had excessive accumulation of combustible dust, then secondary explosions would result from the primary explosion.

The ignition source for this fire was hot equipment caused by mechanical friction. There are other potential ignition sources present including:

1. The electric motor and its cooling fins are covered in an insulating layer of combustible dust, which could eventually overheat and ignite the combustible dust.
2. There is a junction box and wires connected to the electrical motor. If either become damaged, electrical arcing from exposed wiring could ignite the combustible dust.

J.2.1] ADDITIONAL INFORMATION

Undersized circuit protection can result in explosions which destroy adjacent circuit protection and can ignite nearby combustibles. Fault current protection with fault current studies every five years or after any significant changes or inductive load additions will help prevent these losses.

Infrared thermographic surveys should be performed on all electrical equipment annually to detect hot spots. Infrared scanning is non-intrusive and is accomplished while equipment is in service.

Insulation breakdown of electrical equipment is the primary failure mode of concern in commercial and industrial buildings, and is typically caused by contamination, overheating and over-voltage.

I] YOUR ROLE

YOUR ROLE

Now that you understand the fire, deflagration and explosion hazard of combustible dust, you must fulfill your role in maintaining a safe and healthy workplace by helping to minimize the accumulation of combustible dust and managing ignition sources.

I.1] WORK IN A SAFE MANNER

Work in a Safe Manner

- Learn your employer's combustible dust mitigation and ignition control strategy
- Pre-task assessment
 - Do I see accumulations in my work area that are more than what is allowable?
 - Will my activities create a dust cloud?
 - Will I create ignition sources?
 - Am I working near existing ignition sources?
- Safe work procedures
- Emergency procedures

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ELIMINATE A HAZARD

PREVENT AN ACCIDENT

WORK SAFE BC

The first step in fulfilling your role for workplace health and safety is to learn and understand your employer's strategy for preventing the accumulation of primary and secondary dust, especially your role in that strategy.

It will likely include how to:

- Conduct housekeeping activities to keep accumulated dust levels at safe levels
- Work with the passive and active dust controls during production
- Conduct hot work activities

When you begin the day or a new task, ask yourself some questions:

- Will I disturb or create secondary combustible dust? If so, how do I manage that dust?
- Will I create ignition sources or work near existing ignition sources? If so, do I need to follow hot work procedures?

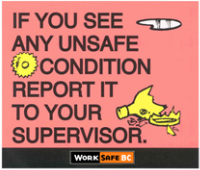
You should also know the emergency procedures in case something goes wrong.

I.2] REPORT UNSAFE CONDITIONS AND UNSAFE ACTS

Report Unsafe Conditions and Unsafe Acts

Report

- Primary and secondary dust accumulations
- Equipment in disrepair – overheating, vibrating, making noises
- Any other unintentional ignition sources
- Creating a dust cloud



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Workers are required to report unsafe acts and conditions to their supervisor or employer.

With respect to combustible dust, unsafe conditions would include:

- Accumulations of primary and secondary dusts that exceed the workplace's mitigation strategy
- Production equipment in disrepair or not functioning properly (e.g., generating too much combustible dust or becoming a source of ignition)
- Combustible dust not being captured or escaping the

dust collection system

- Monitoring equipment in disrepair or not functioning properly
- Creating a dust cloud
- Development of ignition sources

Unsafe acts would include:

- Poor housekeeping techniques (for example, creating a dust cloud)
- Not following hot work procedures (for example, ignition sources in presence of combustible dust)
- Unnecessarily generating combustible dust
- By-passing or overriding safety features

J] REVIEW



The best way to prevent the accumulation of combustible dust in the workplace, especially secondary dust, is to capture and collect it at its point of generation.

If there is accumulation, then the mitigation control is not working or does not exist.

J.1] DUST BUILD-UP AT POINT OF GENERATION



If combustible dust is escaping the capture point, it could be due to one or more of the following:

- Improper design of the capture hood
- Insufficient capacity or capture velocity
- Blockage and/or inadequate maintenance

Your role is to report the accumulation to your supervisor or employer who must investigate your report and take any necessary corrective action.

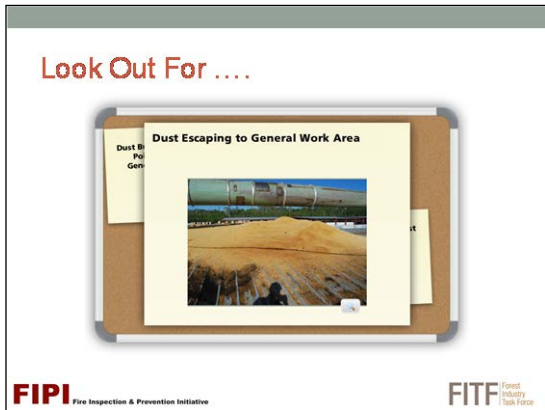
J.2] DUST BUILD-UP INSIDE THE DUCTWORK



Once the dust is inside the duct work, it needs to stay suspended in the air so that it can be transported to the dust collector and separated for disposal. If the dust settles out and builds-up inside the duct work, the effectiveness of the dust capture and transportation to the dust collector is reduced. This accumulated dust is fuel that can propagate a fire or explosion.

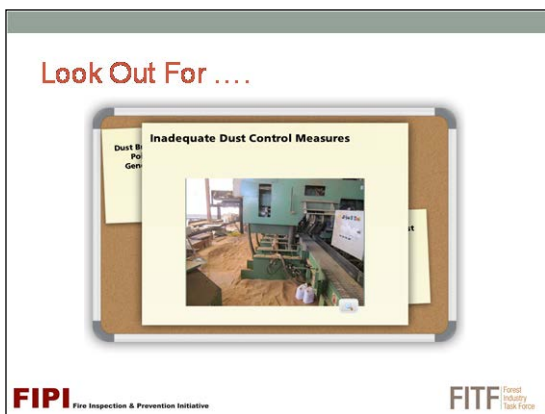
Your role is to report the accumulation to your supervisor or employer who must investigate your report and take any necessary corrective action.

J.3] DUST ESCAPING TO GENERAL WORK AREA



Whether or not dust is settling inside the ductwork, ductwork in a poor state of repair can allow combustible dust to escape into the general work area; the same goes for a dust collector in a poor state of repair.

Your role is to report the combustible dust fugitive emission to your supervisor or employer who must investigate your report and take any necessary corrective action.



Inadequate Dust Control Measures

If your workplace has an effective combustible dust mitigation strategy, combustible dust accumulation is expected to be minimal.

Too much dust accumulation suggests inadequate or non-existent dust control measures at the source of generation, or there are fugitive emissions from the dust collection system, and/or the housekeeping measures are inadequate.

Your role is to report the accumulation to your supervisor or employer who must investigate your report and take any

necessary corrective action. If authorized, you can clean-up using safe housekeeping procedures.

J.4] CLEAN WORKPLACE



Even when the general workplace is clean and the combustible dust mitigation strategy is effective, you cannot be complacent.

Your dust collection system is at risk of a primary explosion from several potential ignition sources including tramp metal and foreign contamination, static electricity and hot work.

Be vigilant for the presence of tramp metals (e.g., nails, bolts) that could enter the duct work. Control by ensuring there are adequate controls to capture tramp metals before they can enter the dust collection system.

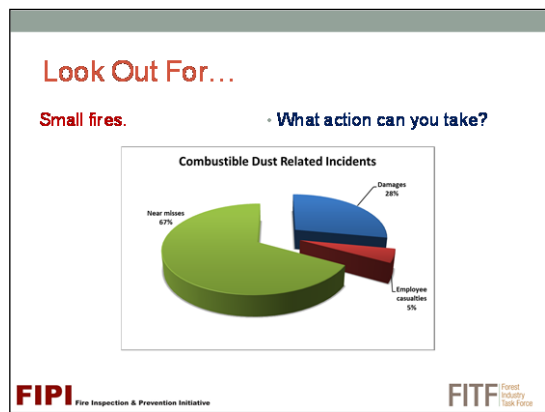
Have and follow safe work procedures to quickly shut down the equipment, remove the jammed material, and repair the equipment if necessary.

Monitor the state of repair of the bonding and grounding wires to prevent static electricity sparks.

Be sure to follow hot work procedures when conducting hot work activities on or near any component of the dust collection system.

In addition, your role is to report any signs of missing, improperly functioning or disrepair of equipment to your supervisor or employer who must investigate your report and take any necessary corrective action.

J.5] SMALL FIRES



Small fires indicate there was contact between combustible dust and an ignition source.

All fires are hazardous. Combustible dust fires have added hazards. First, if there is airborne combustible dust nearby, the fire could ignite a primary explosion. Improperly attacking the fire could also disturb the accumulated combustible dust and trigger a primary explosion or, at least cause a deflagration fireball.

Learn and follow the safe procedures for fighting a combustible dust fire.

If you spot a fire, safely put out the fire if capable; pull the fire alarm, otherwise report to your supervisor.

Fires are near misses that represent warnings that something much worse could have happened had the conditions been a little bit different!

All fires, no matter how small, must be investigated and corrective action taken.

Remember, if conditions had been a little bit different that fire could have been an explosion!

J.5.1] ADDITIONAL INFORMATION

Employers should investigate small fires and related incidents to determine why the fire controls supposedly in place did not prevent the fire, even though they were properly and safely extinguished with little injury or property damage. Were the expected controls in place and followed? If yes, are they adequate? If no, why not?

KJ KEY TAKEAWAYS

Let's summarize some key points that we have made during this combustible dust hazard recognition education.

Key Takeaways

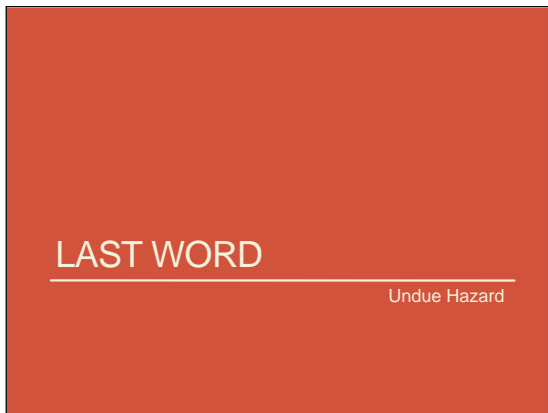
- ✓ Wood dust is combustible and explosive under certain conditions.
- ✓ Combustible dust fireballs or explosions can occur when dust is allowed to accumulate.
- ✓ Fireballs and explosions are preventable if you know what the hazard is.
- ✓ Ask if you're not sure. Report it if you are.
- ✓ Keep it clean.

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1. Wood dust is combustible and explosive under certain conditions.
2. Combustible dust deflagration fireballs or explosions can occur when dust is allowed to accumulate.
3. Deflagration fireballs and explosions are preventable if you know what the hazard is.
4. Ask if you are not sure. Report it if you are.
5. Keep it clean.

LJ] LAST WORD – UNDUE HAZARD




L.1] UNDUE HAZARD – COMBUSTIBLE DUST

Undue Hazard – Combustible Dust

Conditions might include:

1. A dense dust cloud, and/or
2. Sufficient accumulated dust on floors and/or elevated flat surfaces that could create a dense dust cloud, and
3. One or more potential ignition sources.



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Under certain conditions, combustible dust can be an undue hazard. What does that mean?

First, all workers (employees, staff, supervisors, managers, senior managers, etc.) have the right to refuse unsafe work if they believe it presents an undue hazard.

An undue hazard is a thing or condition that may expose a worker to an excessive or unwarranted risk of injury or occupational disease.

A combustible dust undue hazard would exist where a worker believes the likelihood of a combustible dust explosion is

excessive or unwarranted.

Conditions that would cause a worker to believe the risk of an explosion, within a building or an enclosed space, is excessive or unwarranted might include, but not limited to, the following:

- A dust cloud exists and/or
- There is sufficient accumulated dust on floors and/or elevated flat surfaces (for example, in excess of 1/8th inch thick and over 5% of the area) that could create a dust cloud, and
- One or more potential ignition sources exist.


In accordance with section 3.12 (1) of the Occupational Health and Safety Regulation, a worker must refuse unsafe work where an undue combustible dust hazard exist. Section 3.12 of the Regulation provides procedures to be followed to report the refusal, and to respond and resolve the refusal.

MJ KNOWLEDGE CHECK #5



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Knowledge Check 5.1


 Who has a role in preventing fires, deflagrations, and explosions?

- Employees
- Management

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Knowledge Check 5.2

 Which are employee roles and responsibilities?

Select & design dust mitigation strategies: True or False

Learn and follow safe work procedures: True or False


Report unsafe conditions and acts: True or False

Investigate reports of unsafe conditions and acts: True or False

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Knowledge Check 5.3

 When is combustible dust an "Undue Hazard"? (3 possible conditions)

A dense airborne cloud exist:	Yes or No
A thick accumulation of primary dust exist:	Yes or No
A thick accumulation of secondary dust exist:	Yes or No
One or more ignition sources exist:	Yes or No
Combustible dust is inside a dust collection system:	Yes or No

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Knowledge Check #5 – For answers, go to page 62

Additional Handouts

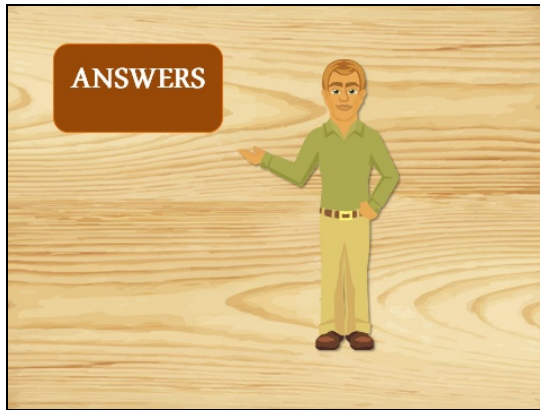
- Combustible Dust Awareness Quick Guide

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A participant's handbook contains notes from this presentation, additional handouts and references.

N] KNOWLEDGE CHECK ANSWERS



N.1] KNOWLEDGE CHECK #1

Knowledge Check 1.1



Which of the following regulatory agencies have regulations related to combustible dust?

WorkSafeBC
Ministry of the Environment
BC Safety Authority
Office of the Fire Commissioner
Public Health

N.1.1] ANSWER 1.1

The three applicable statutes, their regulations, the responsible inspectorates and their combustible dust related focuses are:

- The *Fire Services Act* and the *BC Fire Code* – When performing site inspections, Local Assistants to the Fire Commissioner, appointed by the **Office of the Fire Commissioner (OFC)**, will focus on current and effectively implemented Fire Safety Plans as required by the *BC Fire Code*, including controlling combustible dust fire/explosion hazards.
- The BC Safety Standards Act and the Safety Standards General Regulation – When performing site inspections, safety officers from the **BC Safety Authority** will focus on the installation and operation of gas and electrical equipment located in areas where combustible dust could accumulate and would therefore be considered a hazardous location, and will also focus on the licensing and certification of workers who perform work on this equipment.
- The Workers' Compensation Act and the Occupational Health and Safety Regulation – When performing site inspections, prevention officers from **WorkSafeBC** will focus on evaluating employers' management of dust dispersion and accumulation at their workplaces, including administrative and engineering controls.

N.2] KNOWLEDGE CHECK #2

Knowledge Check 2.1



Which explosions typically occur in the general work area?

Primary or Secondary

N.2.1] ANSWER 2.1

Secondary explosions typically occur in the general work area.

The event that will typically disturb dust that has accumulated in the general workplace is a primary explosion that originated elsewhere, often within the dust collection system. Sometimes, it is work activities around the accumulate dust that causes the disturbance of secondary dust in the general work area.

An earthquake is another example of an event that could disturb secondary dust accumulations in the general workplace.

Knowledge Check 2.2



Fill in the blank.

_____ explosions typically occur in a contained space like dust collectors, enclosed conveyance systems, impact equipment, and holding bins.

N.2.2] ANSWER 2.2

- **Primary** explosions typically occur in a contained space like dust collectors, enclosed conveyance systems, impact equipment, and holding bins.
- The reason is that 4 of the 5 pentagon explosion elements are present – fuel, oxygen, dispersion, and containment. The only element missing is an ignition source.

Knowledge Check 2.3



Fill in the blanks:

The three fire triangle elements are:

1. _____ 2. _____ 3. _____

Deflagration requires fire triangle elements plus _____ in air.

Explosion requires deflagration elements plus _____.

N.2.3] ANSWER 2.3

Fire Triangle:


- **Fuel**
- **Heat**
- **Oxygen**

For deflagration , add '**Dispersion**'

And, for explosion, add '**Containment**'

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Knowledge Check 2.4



Many primary explosion risks are associated with dust collectors.


True or False

N.2.4] ANSWER 2.4

True, because dust collectors have 4 of 5 explosion pentagon elements present – fuel, oxygen, dispersion, and containment. The only element missing is an ignition source.

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Knowledge Check 2.5



Fill in the blank?

The best strategy to prevent dust explosion and deflagration is to prevent the _____ of dust in the workplace.

Dispersion
or Drying
or Accumulation


N.2.5] ANSWER 2.5

The best strategy to prevent dust explosion and deflagration is to prevent the accumulation of dust in the workplace.

N.3] KNOWLEDGE CHECK #3

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Knowledge Check 3.1



Fill in the blanks:

What is combustible dust?

A combustible particulate solid that presents a _____ or _____ hazard when suspended in air.

Breathing or Deflagration
or Seeing or Fire or Explosion

N.3.1] ANSWER 3.1

A combustible particulate solid that presents a deflagration or explosion hazard when suspended in air.


Combustible Dust:

A finely divided combustible particulate solid that presents a flash fire (deflagration) hazard or explosion hazard when suspended in air or the process-specific oxidising medium over a range of concentrations.

Source of definition: NFPA® 654 Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids 2013 Edition

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Knowledge Check 3.2



Well, you've heard a lot about dust now. Which of the following do you think is most responsible for the highly combustible nature of dust?

- Shape
- Size
- Dispersion

severity of the explosion.

Also, keep in mind that explosions are possible because dust can be suspended or dispersed. Dust can be dispersed if it exists above floor level or at floor level and can be put in suspension by some activity or hazard.


N.3.2] ANSWER 3.2

The size of the dust particle determines its combustibility:

- The dust particle size must be fine enough to become airborne.
- If too many of the particles are too large, that is, over 500 micrometers (or microns), it will not explode.
- As you increase the amount of finer particles in the mixture, the risk that the dust is explosible increases. When the portion of finer particles increases to a certain level, the mixture becomes explosible.
- The finer the dust, the faster it burns, and the greater the

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Knowledge Check 3.3



Types of wood dust – Choose True or False for each statement


Secondary Dust will burn:	True or False
Manufacturing Wood Debris will explode:	True or False
Primary Dust will explode:	True or False
Secondary Dust will deflagrate:	True or False

N3.3] ANSWER 3.3

- Secondary Dust will burn – **True** (It's wood!)
- Manufacturing Wood Debris will explode – **False** (Particle sizes way too big!)
- Primary Dust will explode – **False** (Typically not enough small particles that can remain airborne in sufficient concentration to explode)
- Secondary Wood Dust will deflagrate – **True** (Small dust particles remain airborne when dispersed.)

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Knowledge Check 3.4



What makes wood dust explosive? (Choose all that apply)


- It must be combustible
- Fine enough to be airborne
- Dry
- Suspended in the air in an explosive concentration
- Contained or enclosed in confined area
- All of the above

N3.4] ANSWER 3.4

- Selection (**f**) – Refer to the “About the Dust” slide for details.

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Knowledge Check 3.5



Housekeeping Rule of Thumb:

Clean when combustible dust obscures the _____ of the underlying surface.

thickness
colour
texture


N3.5] ANSWER 3.5

- Once the colour of the underlying surface is obscured, the thickness of the accumulated dust is approaching hazardous levels. If that accumulated dust covers a large amount of the flat surfaces in the area, an event could disperse the dust into a dust cloud, which could then be ignited by an ignition source and cause an explosion.
- Even if there is insufficient amount to cause an explosion a localized deflagration (flash fire) could still occur, which could severely injure or kill a worker.

N.4] KNOWLEDGE CHECK #4

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Knowledge Check 4.1



Which are the top two ignition sources from the list below?


•Mechanical Sparks	•Friction
•Space Heaters	•Some mobile equipment
•Hot Work	•Overheating equipment
•Static Electricity	•Electrical Arcs (i.e., shorts)
•Hot Surfaces	

N4.1] ANSWER 4.1

Friction at 30% and **Mechanical Sparks** at 23% ,based on FM Global Statistics.

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Knowledge Check 4.2



You see that a thick layer of dust has formed on the exterior casing of an MCC panel. You note that the dust is wet because of misting systems in the mill. You might:

- Attempt to clean off the MCC panel and leave it at that.
- Attempt to clean off the MCC panel, if trained to do so, and report the situation to the applicable supervisors, as the dust could be heated and dried over time to the point it could be easily ignited.
- Do nothing. The dust is wet and therefore won't ignite.


N4.2] ANSWER 4.2

Selection **(b)**

“Train to do so” because there are safe work procedures to be followed when cleaning secondary combustible dust accumulations.

This is especially important in this situation given all the electrical equipment in the area. Remember the WorkSafeBC investigation into a deflagration incident at a main service panel? Two workers were burned.

N.5] KNOWLEDGE CHECK #5




Knowledge Check 5.1

Who has a role in preventing fires, deflagrations, and explosions?

- Employees
- Management

N5.1] ANSWER 5.1

Both employees and management have roles in preventing fires, deflagrations and explosions. Management will design and implement the control and mitigation program. Workers will learn and follow the program, and report unsafe acts and conditions.



Knowledge Check 5.2

Which are employee roles and responsibilities?

Select & design dust mitigation strategies:	True or False
Learn and follow safe work procedures:	True or False
Report unsafe conditions and acts:	True or False
Investigate reports of unsafe conditions and acts:	True or False


N5.2] ANSWER 5.2

False: Select and design 'dust mitigation strategies' is a management responsibility. The workers safety representatives and knowledgeable workers should be invited to participate in the design process.

True: 'Learn and follow safe work procedures' is a worker responsibility.

True: Report unsafe conditions and acts is a worker responsibility.

False: 'Investigate reports of unsafe conditions and acts' is a management responsibility. The workers safety representatives and knowledgeable workers should be invited to participate in the investigations.



Knowledge Check 5.3

When is combustible dust an "Undue Hazard"? (3 possible conditions)

A dense airborne cloud exist:	Yes or No
A thick accumulation of primary dust exist:	Yes or No
A thick accumulation of secondary dust exist:	Yes or No
One or more ignition sources exist:	Yes or No
Combustible dust is inside a dust collection system:	Yes or No

N5.3] ANSWER 5.3

To have a combustible dust undue hazard , you need to have:

A dense airborne cloud and/or

A thick accumulation of secondary dust, and

One or more ignition sources present.

Note 1: Primary dust cannot explode.

Note 2: A dust collector system is designed to capture, transport, and collect combustible dust. A properly functioning system is not an undue hazard.

ADDITIONAL INFORMATION

US CHEMICAL SAFETY BOARD'S MISSION

(Excerpt from their website's home page <http://www.csb.gov/>)

The Chemical Safety Board (CSB) is an independent federal agency charged with investigating industrial chemical accidents. Headquartered in Washington, DC, the agency's board members are appointed by the President and confirmed by the Senate.

The CSB conducts root cause investigations of chemical accidents at fixed industrial facilities. Root causes are usually deficiencies in safety management systems, but can be any factor that would have prevented the accident if that factor had not occurred. Other accident causes often involve equipment failures, human errors, unforeseen chemical reactions or other hazards. The agency does not issue fines or citations, but does make recommendations to plants, regulatory agencies such as the Occupational Safety and Health Administration (OSHA) and the Environmental Protection Agency (EPA), industry organizations, and labor groups. Congress designed the CSB to be non-regulatory and independent of other agencies so that its investigations might, where appropriate, review the effectiveness of regulations and regulatory enforcement.

In 2003, the CSB launched investigations of three major industrial explosions involving combustible powders. These explosions - in North Carolina, Kentucky, and Indiana - cost 14 lives and caused numerous injuries and substantial property losses. The Board responded by launching a nationwide study to determine the scope of the problem and recommend new safety measures for facilities that handle combustible powders. The CSB issued its final report at a public meeting in Washington, DC, on November 9, 2006, calling for a new OSHA regulatory standard designed to prevent combustible dust fires and explosions.

While some recommendations may be adopted immediately, others require extensive effort and advocacy to achieve implementation. Board members and staff work to promote safety actions based on CSB recommendations. In many cases, the lessons from CSB investigations are applicable to many organizations beyond the company investigated. Many CSB recommendations have been implemented in industry, leading to safer plants, workers, and communities.

COMBUSTIBLE DUST AWARENESS QUICK GUIDE

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Combustible Dust Awareness Quick Guide

What is a Dust Explosion?

The ignition and very rapid burning of a dust cloud in an enclosure or container causing a pressure rise (i.e., shock wave) that bursts or ruptures the enclosure or container. The event's first explosion is called the primary explosion, which can start a chain reaction of secondary explosions.

In order to explode, the dust cloud needs certain characteristics:

- The dust must be relatively dry—less of a factor at smaller particle sizes and more of a factor at large particle sizes.
- The dust particle size must be fine enough to be airborne—typically secondary dust—see definition below.
- The airborne concentration must be at its Minimum Explosive Concentration (MEC). The dust cloud is “in the range” when you can't see a 25-watt light bulb six feet away.

Combustible wood dust can be categorized as:

- **Primary dust:** Created by production or other work processes. Found on floors and surfaces near or below the dust-producing or waste-handling equipment, they are the source for secondary dusts. While primary dusts may consist primarily of greener, moister and coarser particulate, unmanaged primary dusts will over time release the finer, drier secondary dusts if they are not promptly abated and are disturbed.
- **Secondary dust:** The finer, drier dusts that are broadly dispersed and that settle away from the production area [usually rafters, ceilings, and beam, ductwork, walls, joints, top of machinery]. Secondary dusts are often the fuel source for serious fires and explosions: where “secondary” dusts are present at 1/8” over 5% of the work area they present a significant fire/explosion hazard.

How an Explosion Occurs

A dust explosion can occur when the five basic conditions of the ‘Dust Explosion Pentagon’ come together in a “perfect storm” scenario.



Figure 1: Dust Explosion Pentagon

1. **Fuel**, e.g., combustible dust
2. **Ignition source**, e.g., spark, friction, hot surfaces, open flame
3. **Oxidant**, e.g., oxygen in air
4. **Dispersion**, e.g., a dust cloud of dry wood dust at or above its Minimum Explosive Concentration (MEC)
5. **Confinement**, e.g., closed room, inside equipment or dust collector

Combustible dust is a finely divided particulate solid (e.g., typically the size of granulated sugar or smaller) that presents a flash fire hazard or explosion hazard when suspended in air.

Primary Explosion: The event's first explosion typically occurs in a dust collection system or processing equipment where dust clouds can easily form, or a small area where accumulated fugitive dust is disturbed to form a dust cloud.

Secondary Explosion: The primary explosion's shock wave will disturb accumulated (secondary) dust in the surrounding area creating another dust cloud. The shock wave is followed by burning dust thrown by the primary explosion, igniting the newly formed dust cloud and causing a secondary explosion. In similar fashion to the primary explosion, secondary explosions can trigger more secondary explosions. All large-scale dust explosions result from chain reactions of this type.

Combustible Dust Awareness Quick Guide

How to Prevent an Explosion

Prevent one explosion pentagon element from existing and an explosion is not possible.

"The most effective mitigation strategy is to minimize dust accumulation."

- → Dust collection systems that capture the dust at the source and transport the dust to a collection point for disposal are the "first best solution where practicable."
- → Passive containment systems prevent the primary dust from spreading and allow for manual removal.
- → Good housekeeping practices prevent fugitive secondary dusts from accumulating to unsafe levels in the general work area.

Good housekeeping practices means: regularly scheduled, in areas known for primary and secondary dust accumulation, using appropriate methods that prevent or minimize the generation of dust clouds.

- → Sometimes, for a variety of reasons, secondary dust may accumulate and some event will disperse that accumulation into a dust cloud.
- → Some methods of preventing the accumulation of combustible dust actually create an environment where the ignition source is the only missing element (e.g., a dust collector). For these reasons, there also needs to be a program to manage potential ignition sources, including:

• → Hot works	• → Mechanical sparks	• → Open flames/heating equip.
• → Hot equipment	• → Overheating (e.g., friction)	• → Facility lighting
• → Hot surfaces	• → Electrical equipment	• → Tramp Metal

Combustible Dust Accumulation Vigilance—What to Look For

1. → **General Housekeeping**—if there is too much dust accumulation (i.e., secondary dust levels approaching 1/8" over 5% of the area, or 1000 ft², whichever is smaller), determine why and correct.
2. → **Dust Collection Systems**
 - a. → If dust is not being captured at the source, determine why and correct.
 - b. → If dust is building up inside the duct work, determine why and correct.
 - c. → If dust is escaping the duct work or collector, determine why and correct.
 - d. → If tramp metal or other contaminants (i.e., potential ignition sources) are getting into the dust collection system, determine why and correct.
3. → If there is a history of fires in the facility, investigate their causes and correct. Why? If conditions had been a little different, it may have been an explosion instead of a fire.

Learn from these near misses!!



Major Explosion Hazard
 *Excessive secondary dust levels (See item #1 above)
 *Presence of significant dust cloud(s)



CONTRACTOR INFORMATION RE COMBUSTIBLE DUST

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CONTRACTOR INFORMATION

This workplace has a Combustible Wood Dust Mitigation and Control Program



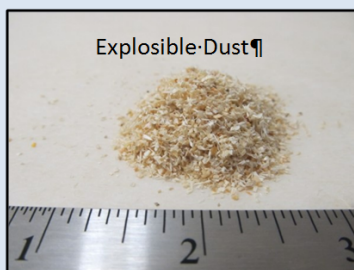
The purpose:

- To control combustible wood dust accumulation and potential ignition sources
- To prevent a combustible wood dust fire, deflagration, or explosion.

All employees and contractors are expected to work in accordance with that program.

Any contractor activity that introduces a new combustible dust hazard is an at-risk activity and must be pre-planned to mitigate the risk. The new hazard would include one or more of the following:

1. - **Added Fuel:** Activity produces wood dust, especially fine particle size dust.
2. - **Dispersion of Fuel:** Activity disperses wood dust (pre-existing accumulation or newly created) into a thick cloud.
3. - **Containment of Dispersed Fuel:** Activity disperses fuel, as a cloud, in an enclosed space or room.
4. - **Introduction of Ignition Sources:** Activity introduces one or more ignition sources (e.g., heaters, hot work, hot equipment, spark generating tools) in areas where wood dust accumulation already exist or are being created by the activity, in the general work area, in designated hazardous locations, and around or within a passive containment system, or dust collection system components such as duct work and dust collector (baghouses, cyclones, etc.).
5. - **Any activity** that might interfere with the proper functioning of the workplace's existing dust accumulation and ignition source controls.
6. - **Any activity** that might interfere with the proper functioning of the workplace's existing equipment and systems for fire suppression and explosion prevention.



Why?

When finely divided (i.e., powdered) wood dust is allowed to accumulate in the workplace, it becomes a significant fire and explosion hazard. All that is required is for some activity or event to disperse the wood dust into an airborne cloud and contact an ignition source.



For small amounts of dust, the result will be a large fireball, which is capable of severely burning workers; if the activity or event occurs in an enclosure or room with larger amounts of wood dust, a powerful explosion will result, which is capable of severely injuring or killing workers and causing significant property damage.

Refer to the *Combustible Dust Awareness Quick Guide* for more information.

Pre-Planning

Pre-planning to eliminate or minimize the risk and the proper execution of the plan are important.

For those hazard and risks that cannot be eliminated, the contractor will work with the workplace's management to develop appropriate controls and safe work procedures for the planned activities. These safe work procedures include hot work permits and housekeeping (i.e., wood dust and tramp metal/foreign contamination) before, during and after activity.

The dust explosion incident summarized below is based on an actual incident, although not wood dust. The outcome would have been the same had the combustible dust been wood dust.

Example: Working in the presence of existing combustible dust accumulation

As part of an ongoing furnace improvement project, a company engineer and an outside contractor were replacing igniters on a band furnace.

The pair experienced difficulty in reconnecting a particular natural gas line after replacing an igniter. The vibration, caused by using a hammer to force the gas port to reconnect, inadvertently lofted large amounts of combustible iron dust from flat surfaces on the side of the band furnace, spanning 20 feet above them.



Source: Chemical Safety Board
<http://www.csb.gov/hoeganaes-corporation-fatal-flash-fires/>

As soon as the dust dispersed, the engineer recalled being engulfed in flames. One worker died. The ignition source was the hot surface of the furnace.

The contractor activity disturbed an existing accumulation of combustible dust near an existing ignition source, i.e., the hot furnace surface.

Pre-job planning would have required the removal of the combustible dust accumulation. If possible, the furnace could have been shut down and allowed to cool before the work began thus removing a potential ignition source.

End of Combustible Dust Hazard Recognition Participant Handbook