COMBUSTIBLE DUST HAZARD RECOGNITION

November 2013

FIPI Fire Inspection & Prevention Initiative

FITF Forest Industry Task Force

COMBUSTIBLE DUST HAZARD RECOGNITION

CBC – ANOTHER SAWMILL EXPLOSION

CBC Video Clip – Another Sawmill Explosion

Canadian Broadcasting Corporation
Broadcasting company

CBC

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What will happen to industry if another similar explosion occurs?

_____

_____

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A] COMBUSTIBLE DUST HAZARD RECOGNITION INTRODUCTORY COURSE

COMBUSTIBLE DUST HAZARD RECOGNITION

November 2013

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Hazards known for years

Many workplaces don't understand the hazards

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We would like to acknowledge that this course was developed with funding from WorkSafeBC through the Fire Inspection and Prevention Initiative (FIPI), as well as the Forest Industry Task Force (FITF).

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Workers and supervisors are the first line of defense:

- Recognizing unsafe conditions
- Taking preventative action, and/or
- Alerting management

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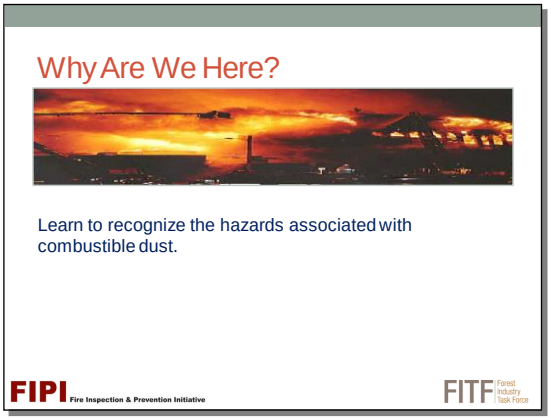

Combustible Dust explosions are very preventable
US Chemical Safety Board 3-year study
Learn from the past and from the expert

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

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

Combustible dust is a “significant industrial safety problem.”

Hazard can develop quickly or take years
Many substances are combustible when in a dry, dust form

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Determine combustibility through testing or assume it is combustible

BC wood product manufacturing operations need to understand what their combustible wood dust hazards are.

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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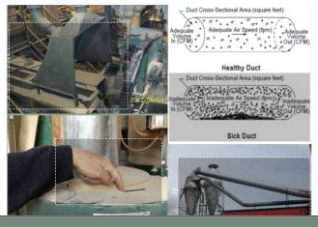
Look Out for …..



There are different places where combustible dust can accumulate.

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Look Out for …

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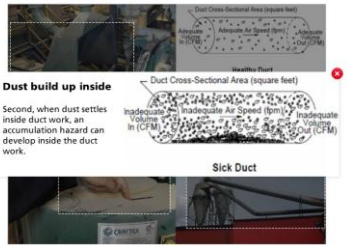
Look Out for …



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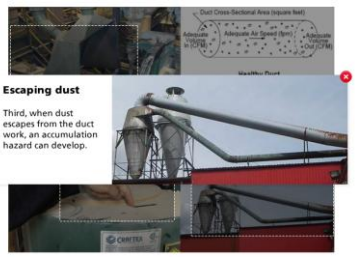
Look Out for …



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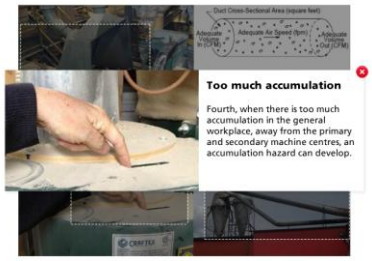
Look Out for …



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Look Out For….

Clean? … there is still a hazard to be concerned about.

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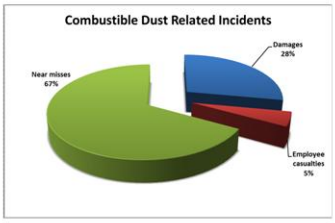
Look Out For…

Small fires. … Can't simply be put out and then forgotten.



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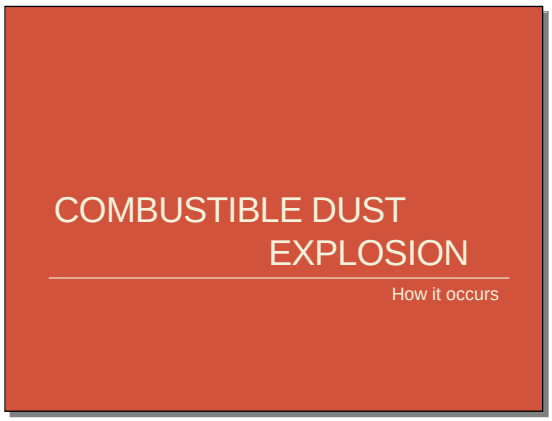
D] COMBUSTIBLE DUST EXPLOSION – HOW IT occurs



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

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.

_____

_____

_____

_____

Many workplaces don't believe it will happen to them.
At Imperial Sugar, all it took was a change in operation.
Remember the intensity and strength of the multiple secondary explosions.

_____

_____

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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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Two Categories of Dust Explosions

Primary Explosion

- Event's first Explosion
- Takes place in a confined space
- Pressure/Shock Wave
- Fire Ball

Secondary Explosion

- Primary Explosion
  - Creates & ignites new dust cloud
- Secondary Explosion occurs
- Process may repeat many times

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FM Global Video Clip – Explosive Power of Dust

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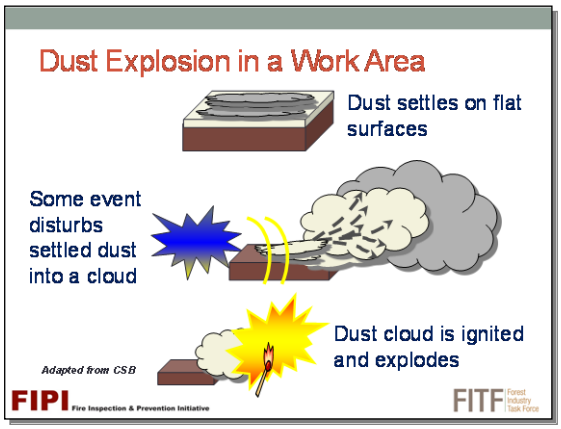
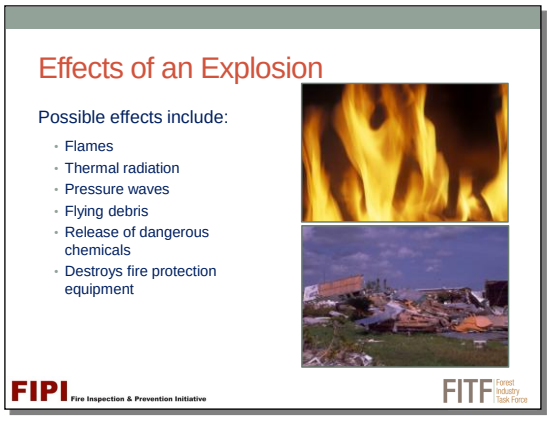
Test structure 75x stronger than a regular building

Notice the thickness of dust cloud

Notice size of fireball in real time vs slow motion

Fire ball – not much is real time and huge fireball in super slow motion.
Notice the thickness of dust cloud.
Leading pressure waves disturbs debris and dust.
Preventing dust accumulation prevents secondary explosions.





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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CSB Video Clip – How Dust Explodes

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Experts tell us that dust explosions are so preventable. Being able to prevent dust explosions begins with understanding the combustible dust explosion process.

Key video takeaways

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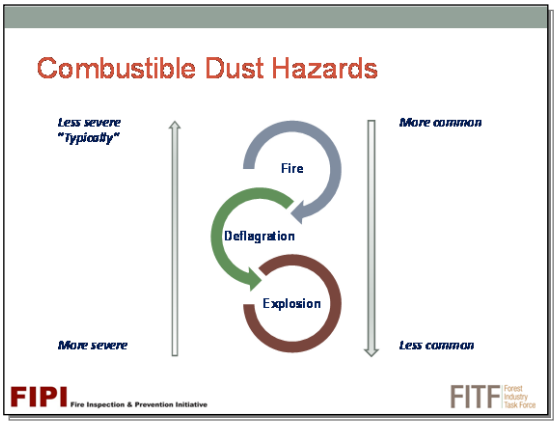
Some key takeaways from the video include:

- Many different products, when in a powdered form, are explosible.
- There are 5 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.


Combustible Dust Hazards
Less severe
"Typically"
More common
Fire
Deflagration
Explosion
More severe
Less common
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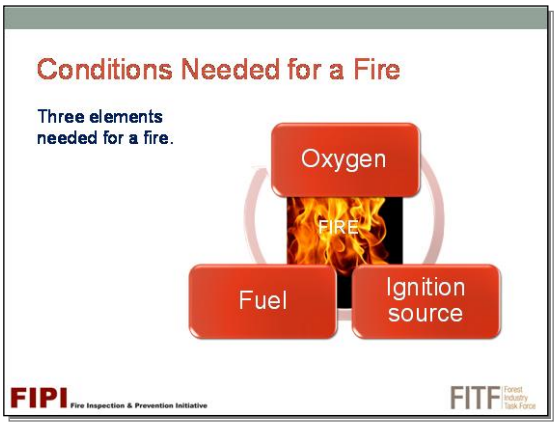
Conditions Needed for a Fire
Three elements needed for a fire.
Oxygen
FIRE
Fuel
Ignition source
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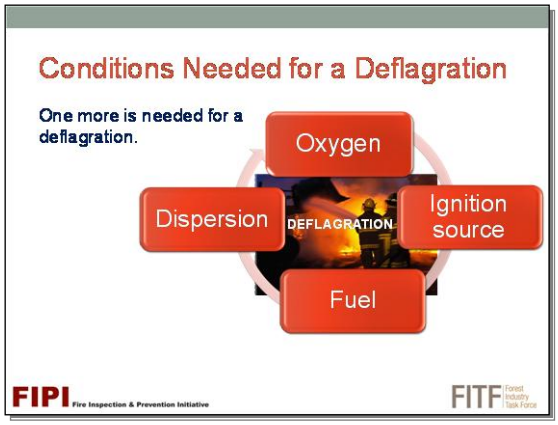
Conditions Needed for a Deflagration
One more is needed for a deflagration.
Oxygen
Dispersion
DEFLAGRATION
Ignition source
Fuel
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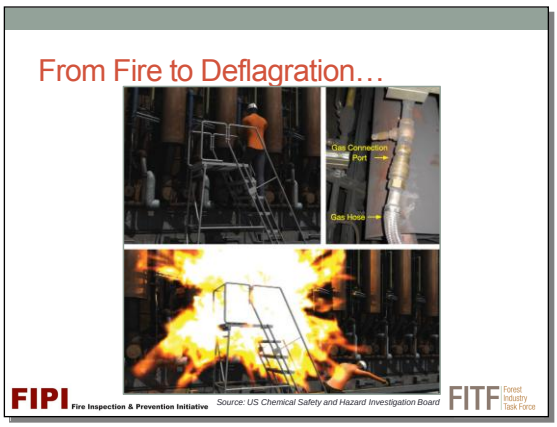
Such a deflagration fireball would severely burn a worker.

WorkSafeBC investigation - A sudden fireball caused burns to both workers.

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



First investigation - one worker died. The hot surface of the furnace was the ignition source.

_____

_____

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Second investigation – one worker died. The motor's hot surface was the ignition source.

_____

_____

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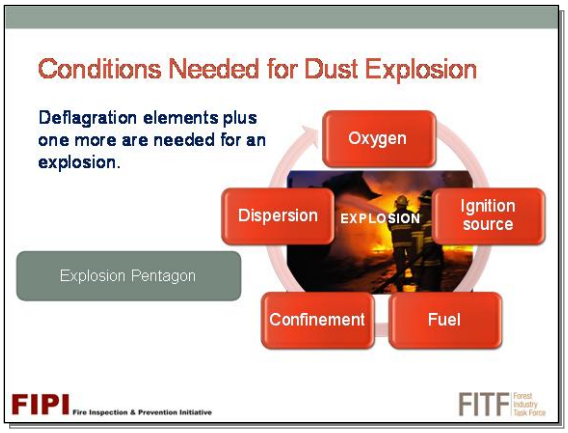
Remember the images in these last few slides!



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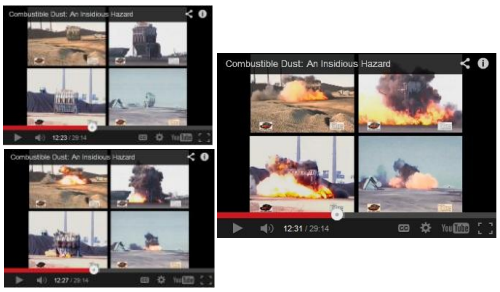
From Deflagration to Explosion…



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Prevent One Element – No Explosion!

1. Minimize fuel
2. Control for potential ignition sources
3. Control for potential mechanisms of dispersion
4. Remove the confinement
5. Remove the oxygen

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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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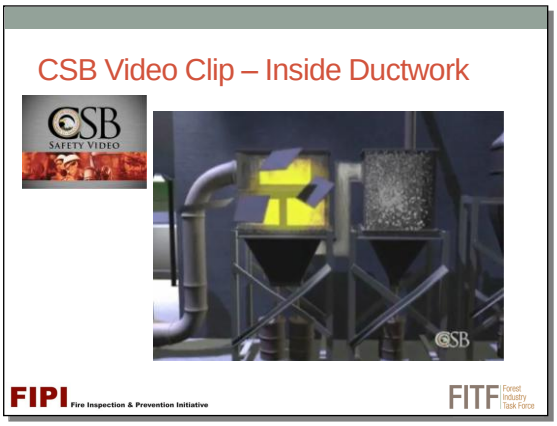

This next video clip shows exactly how a primary explosion originating in the dust collector can result in secondary explosions throughout the facility when combustible dust is allowed to accumulate in the general work area.

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- Combustible dust can accumulate in the ductwork if it is not properly designed.
- Leaks in the ductwork can contribute, over time, to the accumulation of combustible dust in the general work area.
- Explosions propagate if no explosion prevention equipment.
- Outcome: devastating secondary explosions in general work area.

_____

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

_____

_____

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?

_____

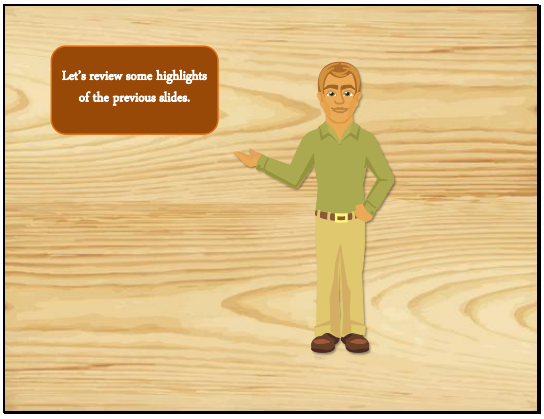
_____

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

_____

_____

E] 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. Fuel 2. Oxygen 3. Heat

2. Deflagration requires fire triangle elements plus Dispersion in air.

3. Explosion requires deflagration elements plus Containment .

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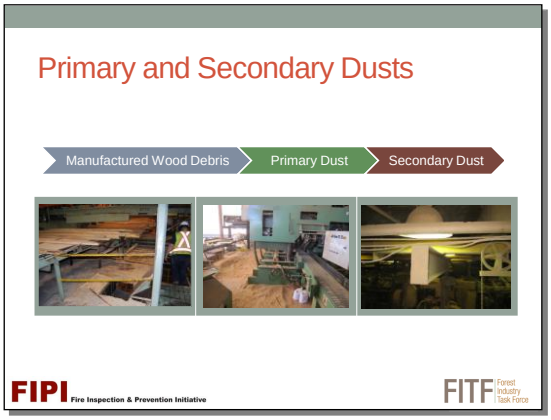
F] HAZARD: COMBUSTIBLE DUST ACCUMULATION
HOW TO RECOGNIZE THE HAZARD

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



About the Dust

- Combustible
  - Moisture content
  - Particle size
  - Particle size distribution
- Concentration of wood dust in the air
- Contained

Adding an ignition source and sufficient oxygen could result in an explosion.

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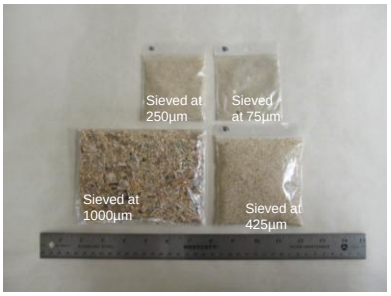
Average Size of Un-sieved Sample: 700.7µm



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Average Size of Un-sieved Sample: 700.7µm

@250µm @75µm

@1000µm @425µm

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Average Size of Un-sieved Sample: 700.7µm

@250µm @75µm

@1000µm @425µm

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How Much Dust is a Hazard?

">1/8th inch, 5% area or 1000 ft², whichever is smaller"

Cleaning Rule of Thumb: *Obscures the colour of the underlying surface.*

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Hazard Alert

WORK SAFE BC

HAZARD ALERT

Combustible dust winter alert — increased risk in winter

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

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.

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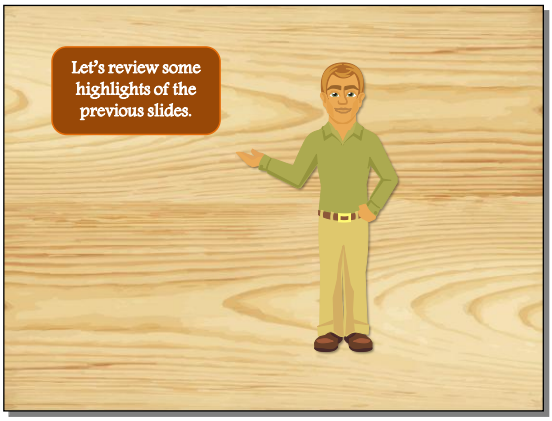
G] KNOWLEDGE CHECK #3



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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)

a. It must be combustible
b. Fine enough to be airborne
c. Dry
d. Suspended in the air in an explosive concentration
e. Contained or enclosed in confined area
f. 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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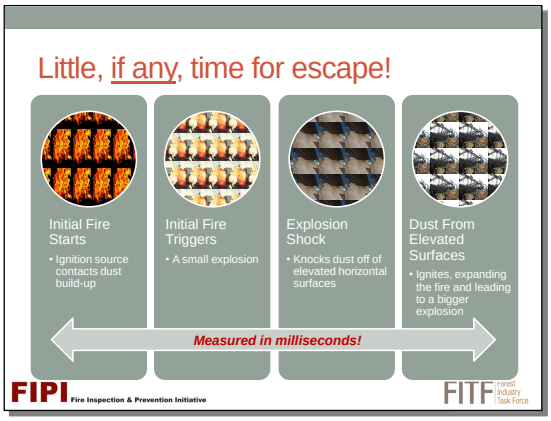
H] HAZARD: IGNITION SOURCES

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



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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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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Example of Hot Works procedures not being followed

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Example of Hot Works procedures not being followed

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Ignition Source—Static Electricity

Equipment must be rated for the job and properly grounded

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- Flowing movements of combustible wood dust
- Bond & Ground
- Plastic pipes not appropriate for ductwork

Ignition Source—Example of Static Electricity

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

Ignition Source—Electrical Equipment

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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.

Ignition Source—Example of Electrical Equipment

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Some common examples of electrical arcs and sparks include:

Ignition Source—Hot Equipment and Surfaces

Common heat sources include:

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

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Ignition Source—Smoking and Open Flames

- Site smoking policy

- Open flames

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Other Ignition Sources

- Heating Equipment
- Facility Lighting
- Tramp Metal / Foreign contaminant
- Spontaneous auto-ignition

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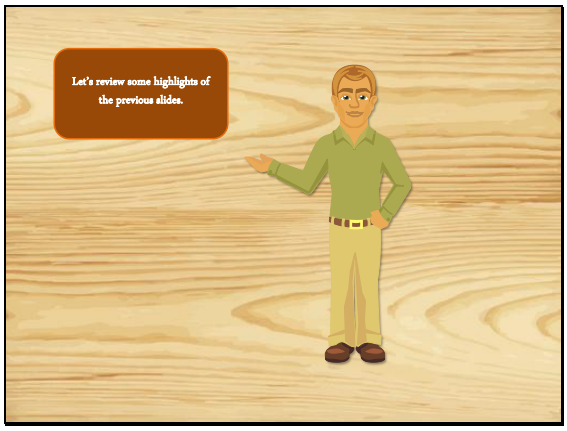
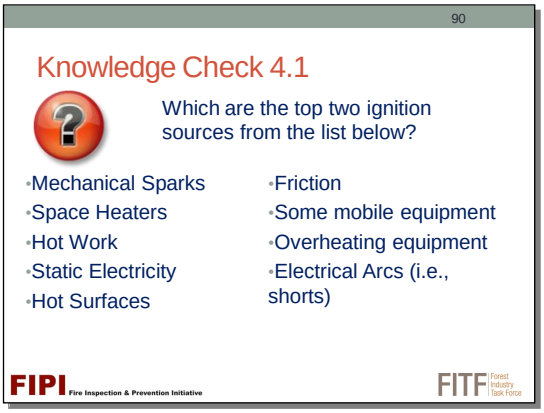
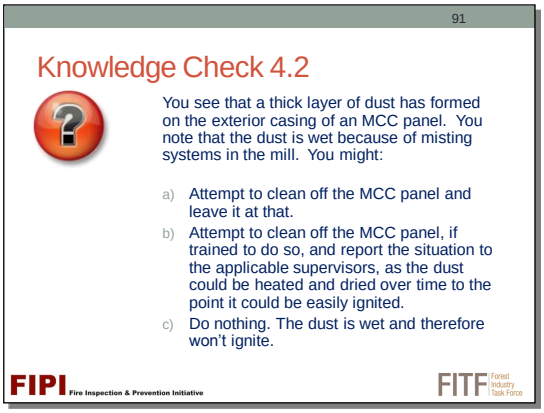
I] KNOWLEDGE CHECK #4







J] HAZARD SCENARIOS

HAZARD SCENARIOS

Scenario 1

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Misaligned blade and jammed wood product
Sparks or embers trigger primary explosion
Sparks or embers trigger primary explosion
Follow safe work procedures

Scenario 2

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Fighting a combustible dust fire can be dangerous.

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.

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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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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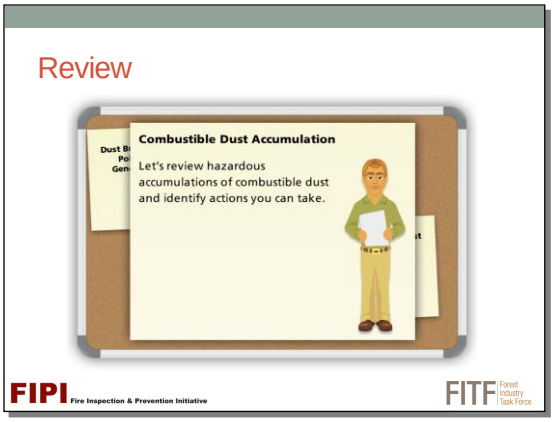
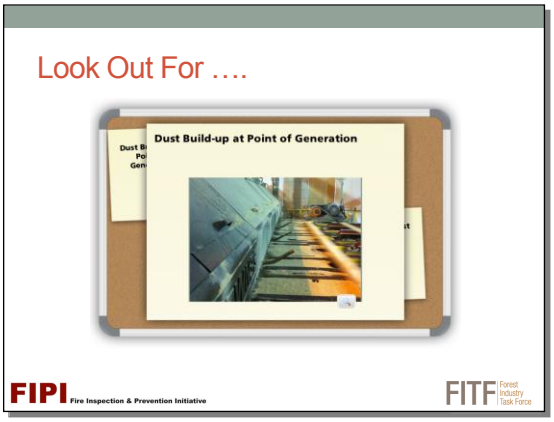
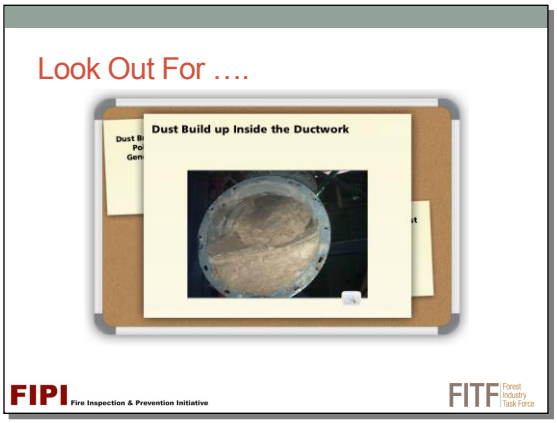
J] REVIEW

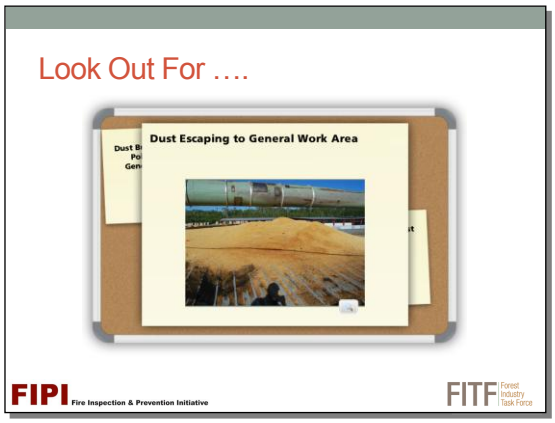




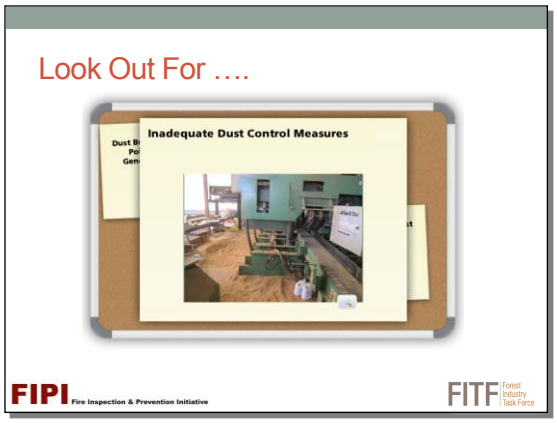
Your role is to report the accumulation to your supervisor or employer who must investigate your report and take any necessary corrective action.



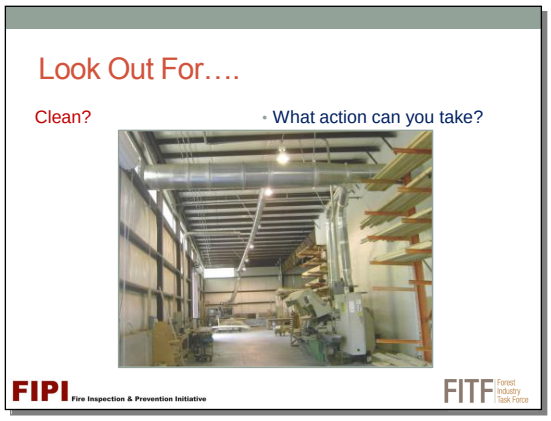
Your role is to report the accumulation to your supervisor or employer who must investigate your report and take any necessary corrective action.



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.



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.



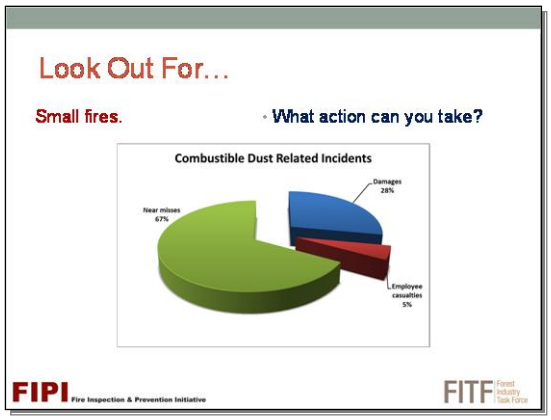
Be vigilant for the presence of tramp metals (e.g., nails, bolts) that could enter the duct work.

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.

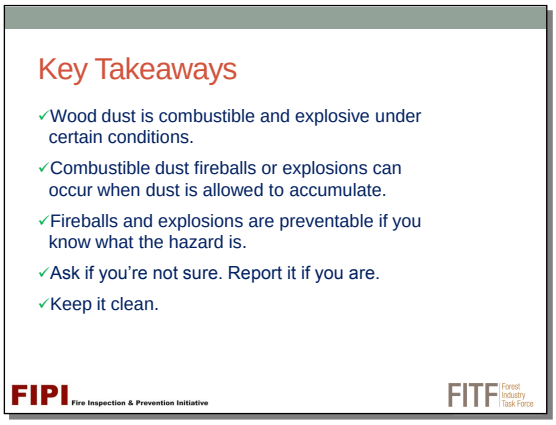
In addition, your role is to report any signs of missing, improperly functioning or disrepair of equipment to your supervisor or employer who must investigate your report and take any necessary corrective action.



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.

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



LAST WORD

Undue Hazard

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

_____

_____

_____

_____

_____

_____

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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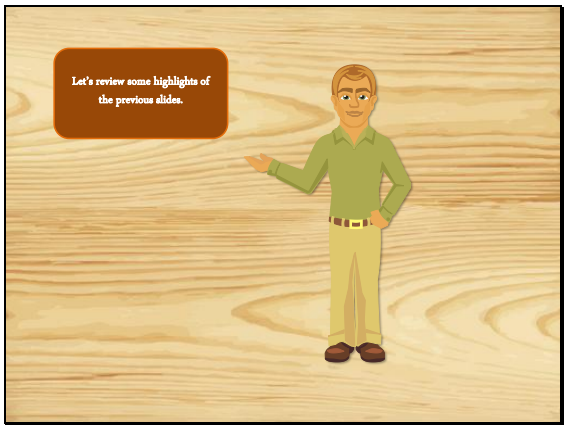
M] KNOWLEDGE CHECK #5



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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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Additional Handouts

- Combustible Dust Awareness Quick Guide

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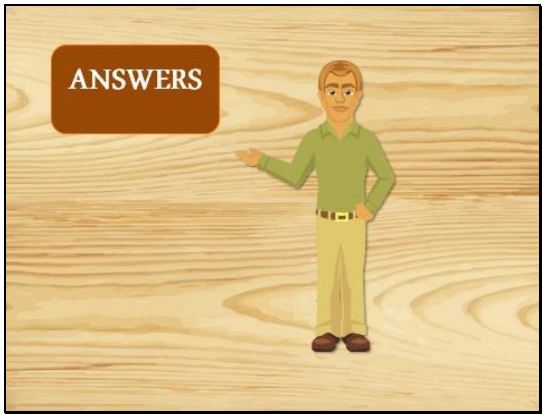
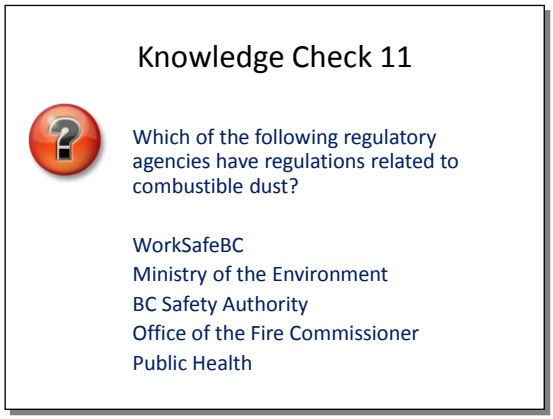
THIS ENDS THE PRESENTATION

N] KNOWLEDGE CHECK ANSWERS



N.1] KNOWLEDGE CHECK #1

N.1.1] ANSWER 1.1



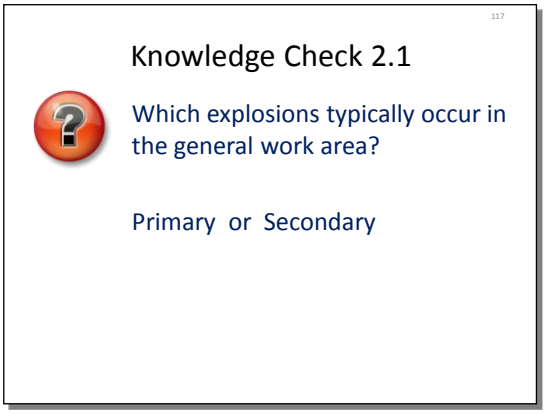
The three applicable statutes, their regulations, the responsible inspectorates and their combustible dust related focuses are:

- 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

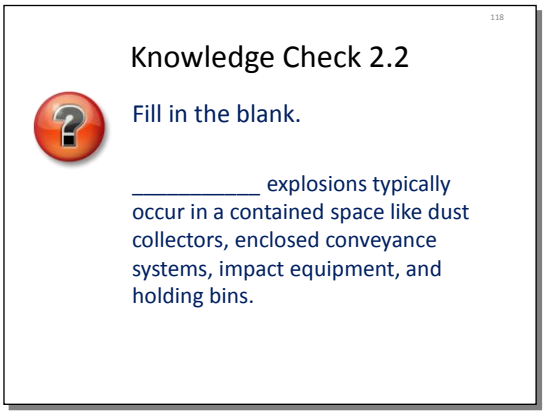


N.2.1] ANSWER 2.1

Secondary explosions typically occur in the general work area.

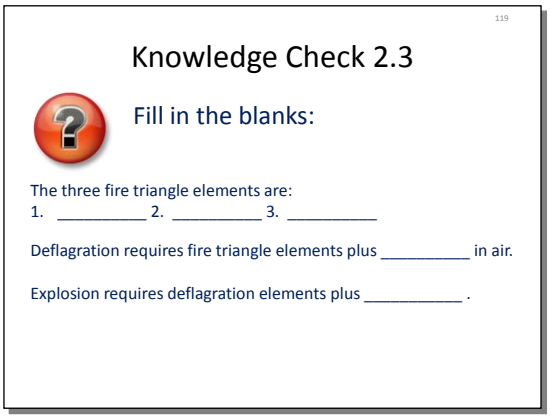
The event that will typically disturb dust that has accumulated in the general workplace is a primary explosion that originated elsewhere, often within the dust collection system. Sometimes, it is work activities around the accumulate dust that causes the disturbance of secondary dust in the general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

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



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.



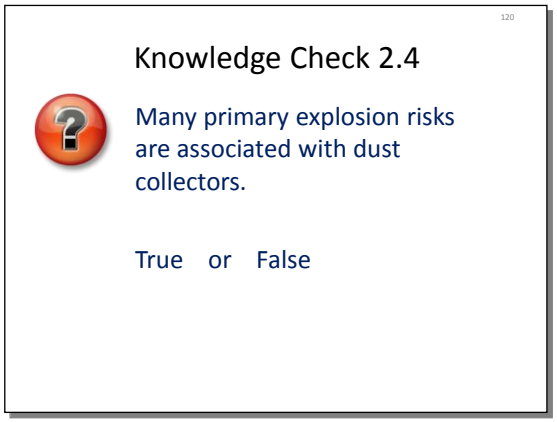
N.2.3] ANSWER 2.3

Fire Triangle:

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

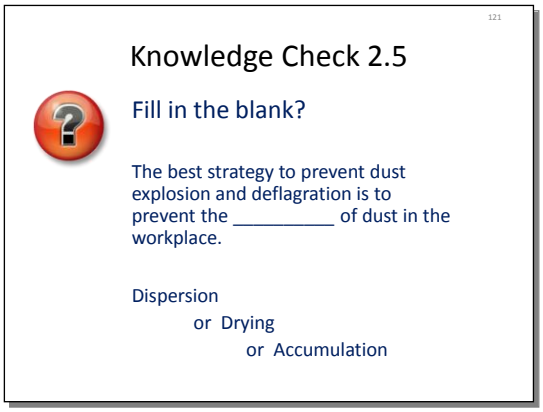
For deflagration , add '**Dispersion**'

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



N.2.4] ANSWER 2.4

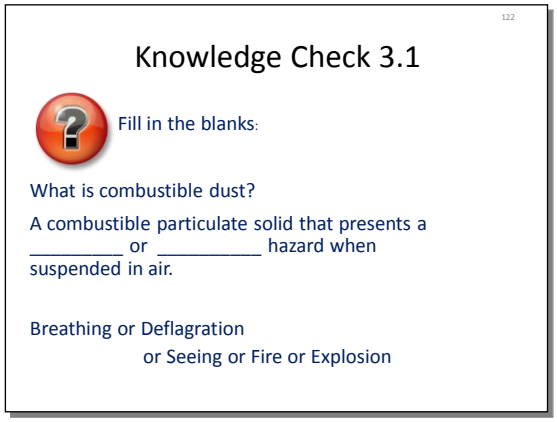
True, because dust collectors have 4 of 5 explosion pentagon elements present – fuel, oxygen, dispersion, and containment. The only element missing is an ignition source.



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



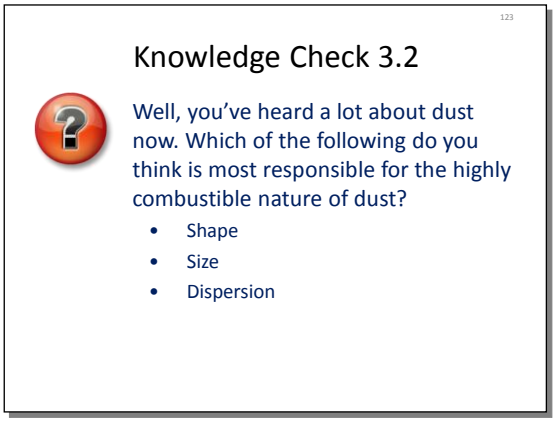
N.3.1] ANSWER 3.1

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

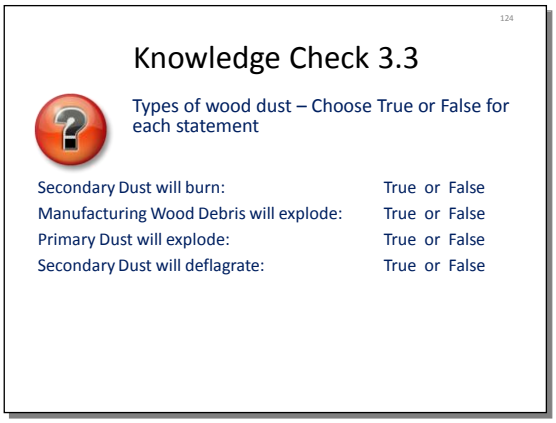


N.3.2] ANSWER 3.2

The **size** of the dust particle determines its combustibility:

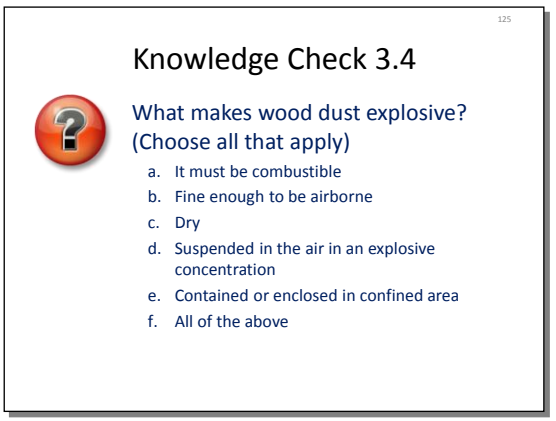
- The dust particle size must be fine enough to become airborne.
- If too many of the particles are too large, that is, over 500 micrometers (or microns), it will not explode.
- As you increase the amount of finer particles in the mixture, the risk that the dust is explosible increases. When the portion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



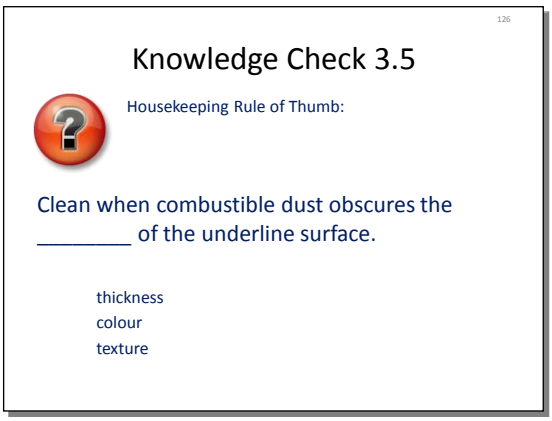
N3.3] ANSWER 3.3

- 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.)



N3.4] ANSWER 3.4

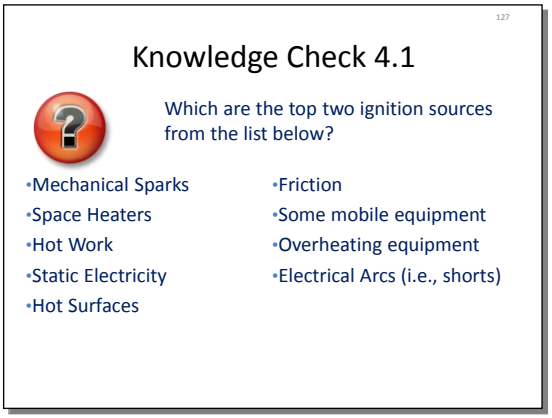
- Selection (**f**) – Refer to the "About the Dust" slide for details.



N3.5] ANSWER 3.5

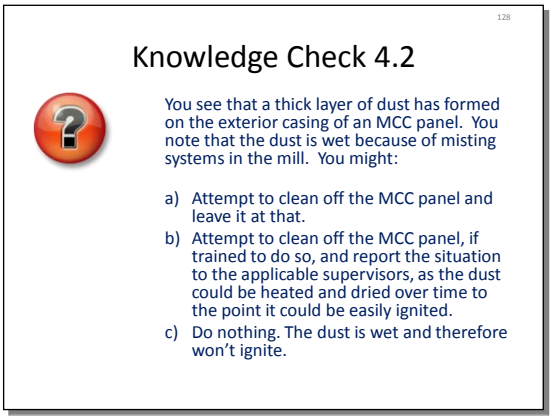
- Once the colour of the underlying surface is obscured, the thickness of the accumulated dust is approaching hazardous levels. If that accumulated dust covers a large amount of the flat surfaces in the area, an event could disperse the dust into a dust cloud, which could then be ignited by an ignition 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



N4.1] ANSWER 4.1

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



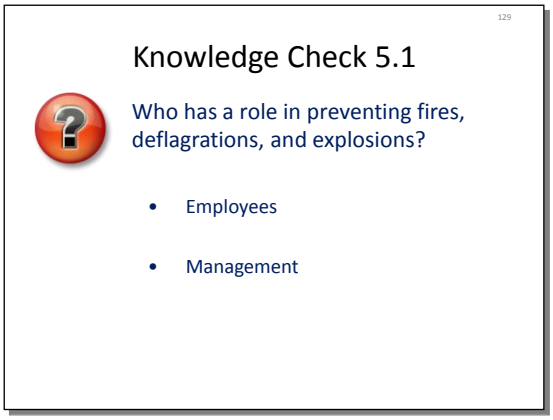
N4.2] ANSWER 4.2

Selection (**b**)

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

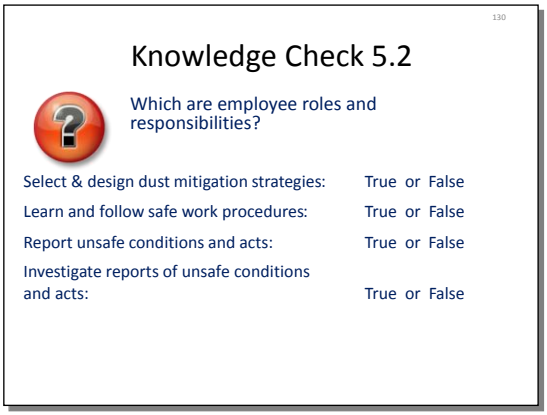
This is especially important in this situation given all the electrical equipment in the area. Remember the WorkSafeBC investigation into a deflagration incident at a main service panel? Two workers were burned.

N.5] KNOWLEDGE CHECK #5



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.



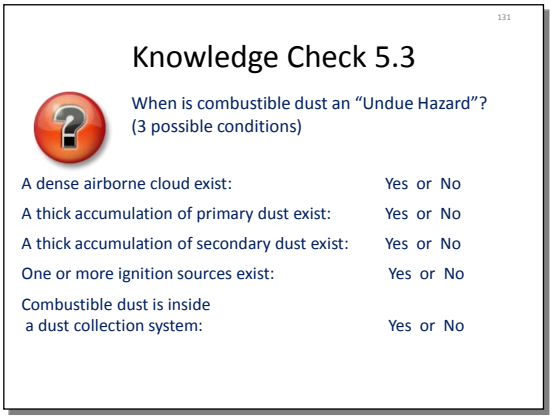
N5.2] ANSWER 5.2

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.



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.