Dust Collection In Metal Fabrication Industry

Hastings Air Energy

By: Allen Mejan

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Our Discussion Today

- Brief History of Combustible Dust
- What is Combustible Dust
- Housekeeping
- Design of dust collection systems
- Combustible Metal Dust (Previously NFPA 484)
- Application Focus

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History of Industrial Explosions

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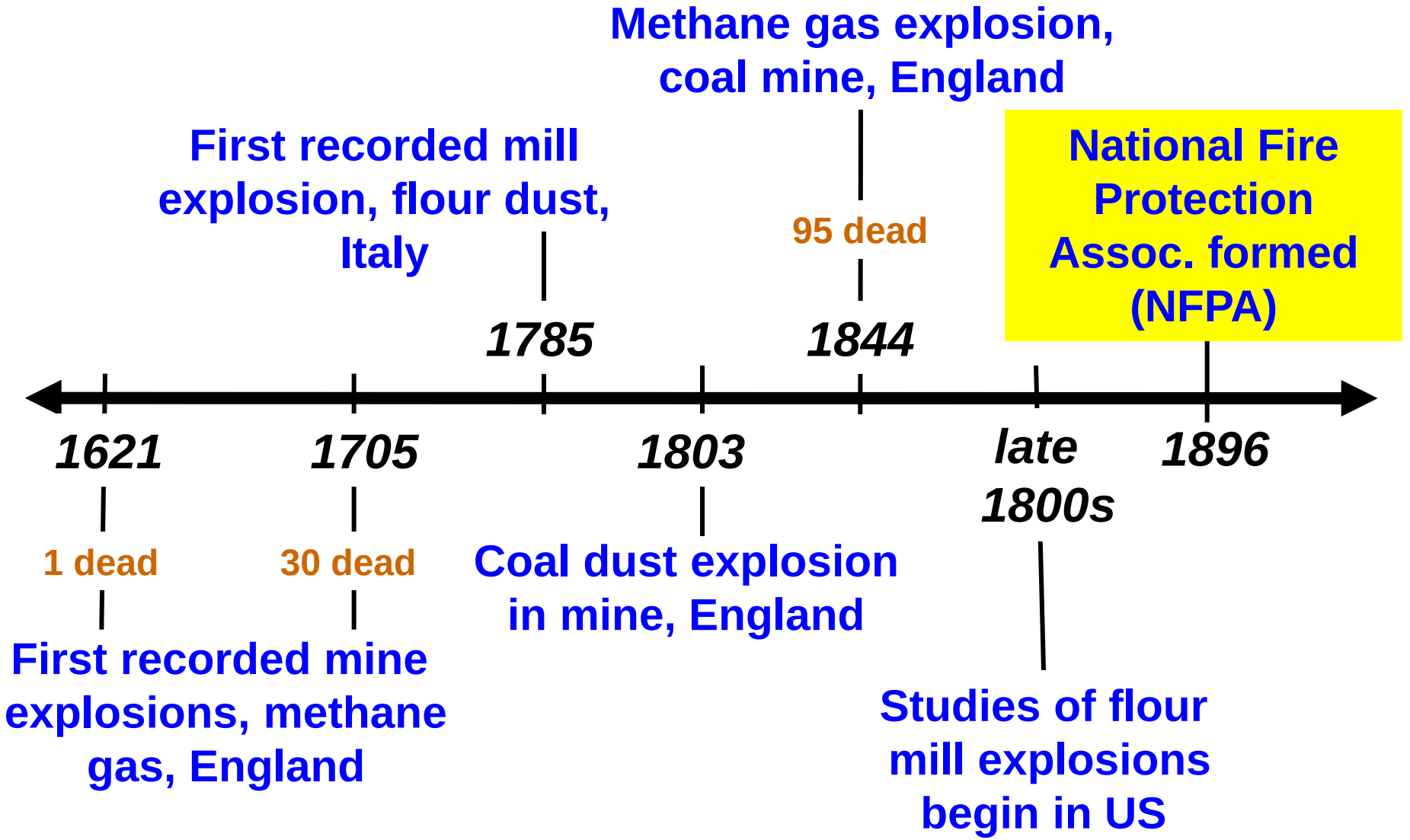
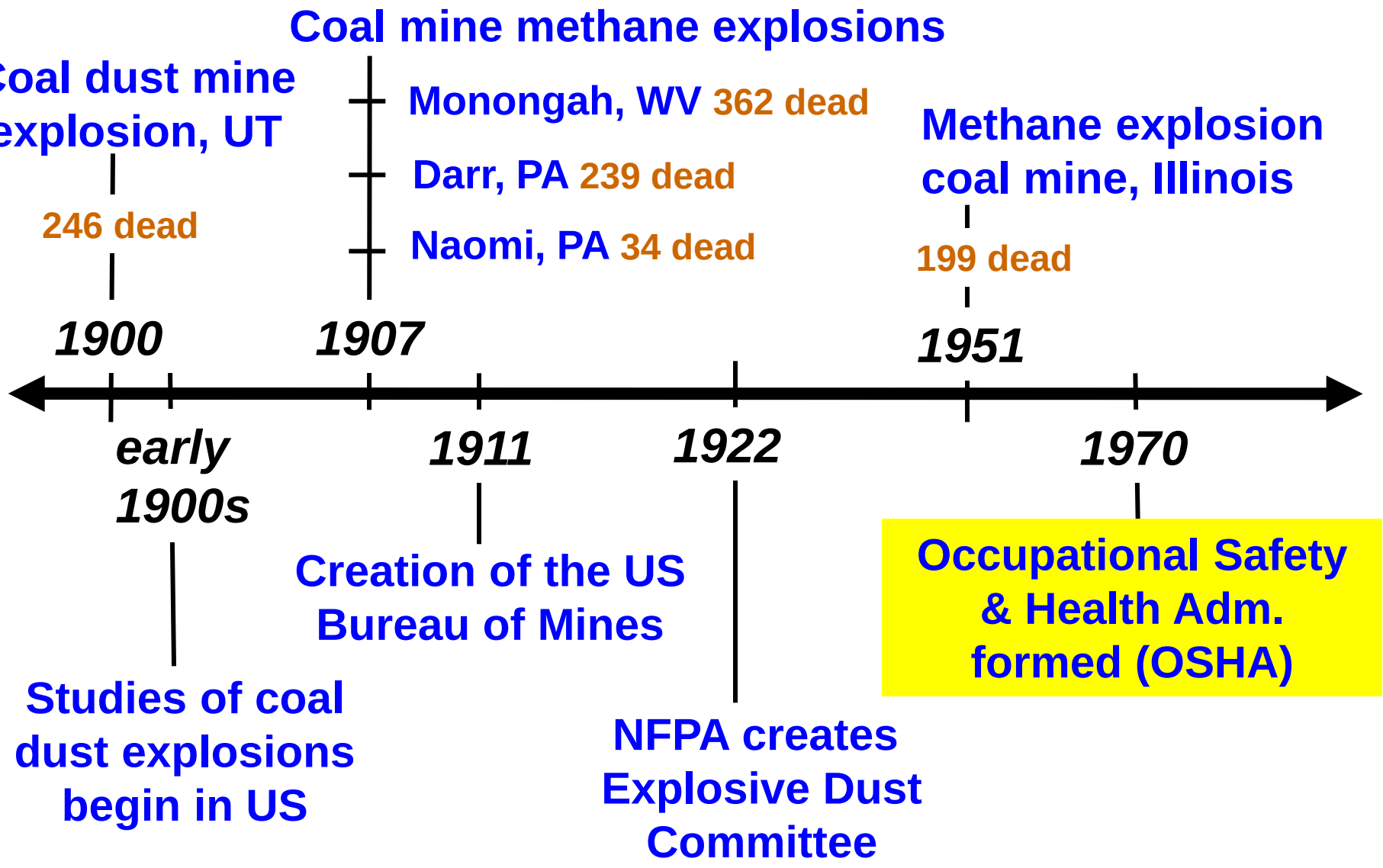
Early Timeline of Events



Early Timeline of Events



OSHA investigations

Hayes Lemmertz
Indiana 2003

1 dead
several Injured

<u>Cause:</u>
Aluminum Dust in casting facility
Incorrect Isolation

OSHA investigations

February 20, 2003
CTA Acoustics
Corbin, KY

7 dead

Cause:
Phenolic resin dust accumulated in production area exploded

OSHA investigations

February 7, 2008
Imperial Sugar
Savannah, GA

14 dead
100's injured
$8 million in OSHA fines

Cause:
Sugar dust accumulated in production areas exploded

The explosion at the Imperial Sugar plant was a worldwide news event which led to the creation of new standards and policies that would forever change the public's awareness to the dangers of combustible dust.

OSHA investigations

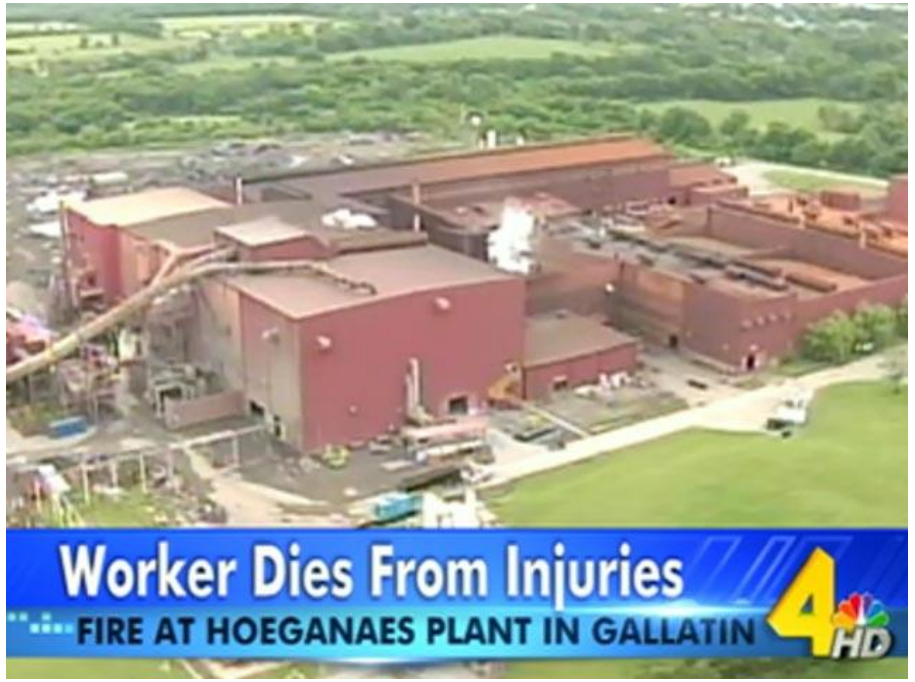
THREE Incidents

Hoeganaes
Gallatin, TN

January 31, 2011
(2 deaths)

March 29, 2011
(1 seriously injured)

May 27, 2011
(3 deaths, 2 injured)



As a result of these incidents, the CSB issued a report urging OSHA to publish a combustible standard in one year.

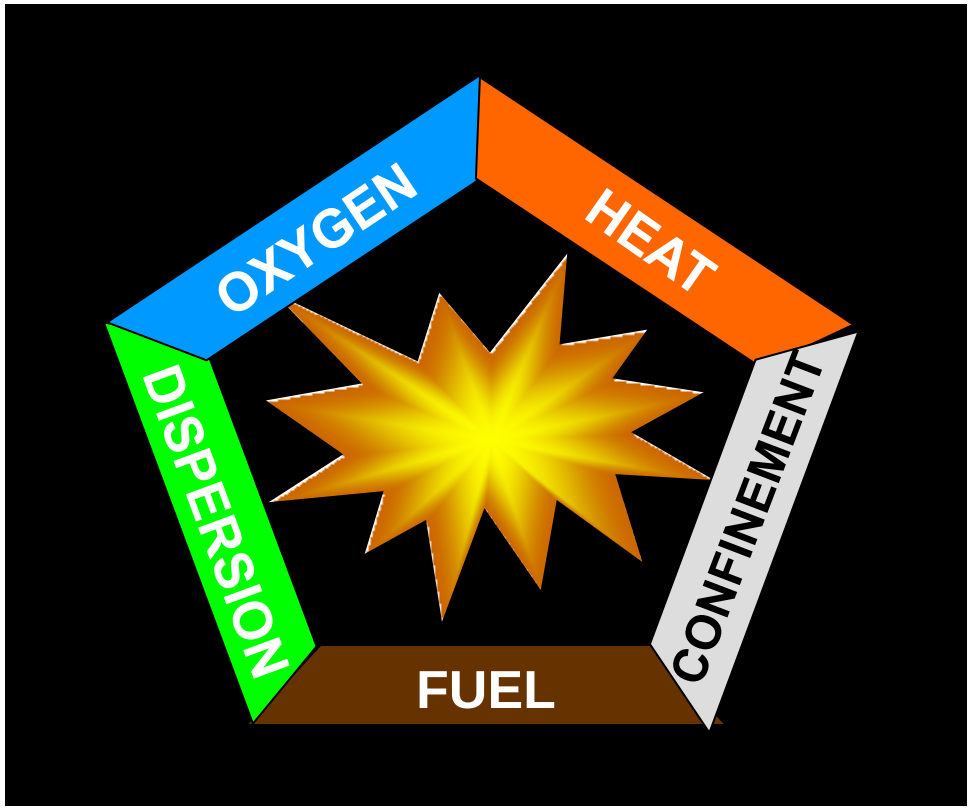
Cause:

Accumulations of fine iron powder with lack of engineering controls and basic housekeeping

Dust Explosion Pentagon

5 basic elements needed for an explosion:

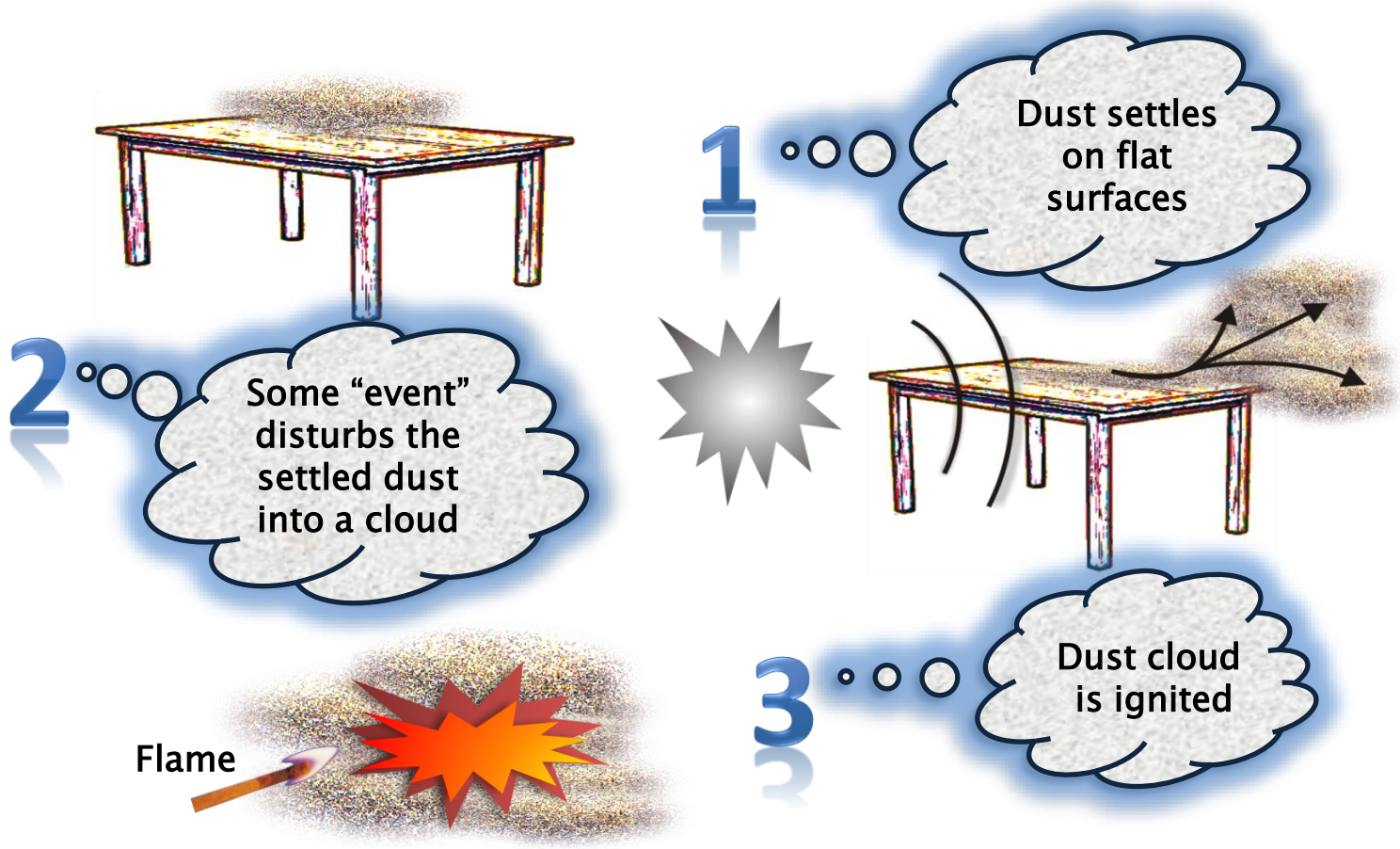
1. A fuel is needed to burn (combustible dust)
2. Oxygen is needed to sustain the fire (air)
3. Heat from an ignition source is needed (spark)
4. A high concentration of dust is dispersed into the air (deflagration)
5. The dust must be confined within an enclosure or structure (explosion)



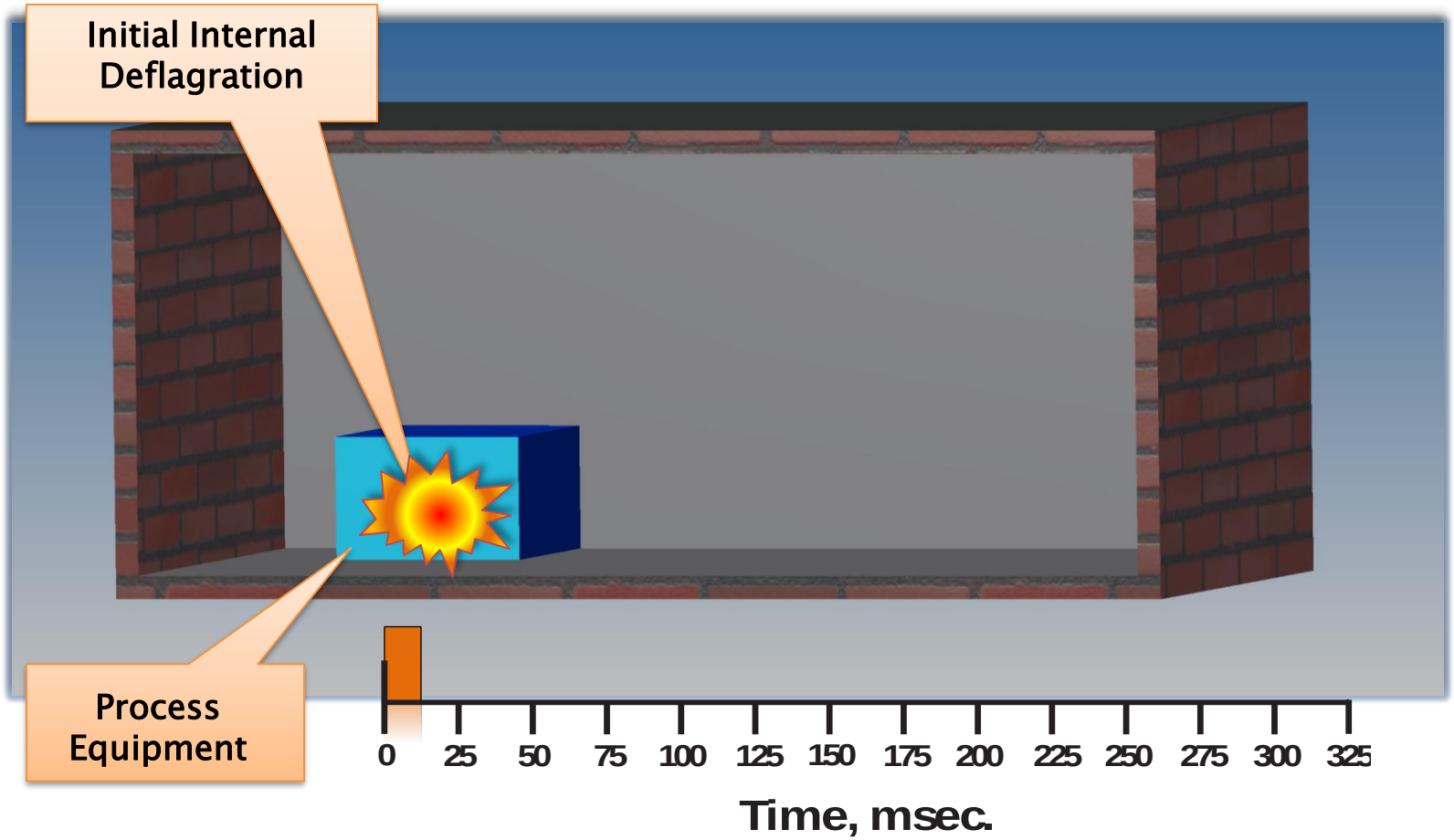
Explosion Types

- **Primary Explosion** – usually in process equipment
- A **Primary Dust Explosion** - occurs when a dust suspension within a container, room or piece of equipment is ignited and explodes
- A **secondary explosion** occurs when dust accumulated on floors or other surfaces is lifted into the air and ignited by the primary explosion

Secondary Explosion



The "Typical" Explosion Event



The "Typical" Explosion Event
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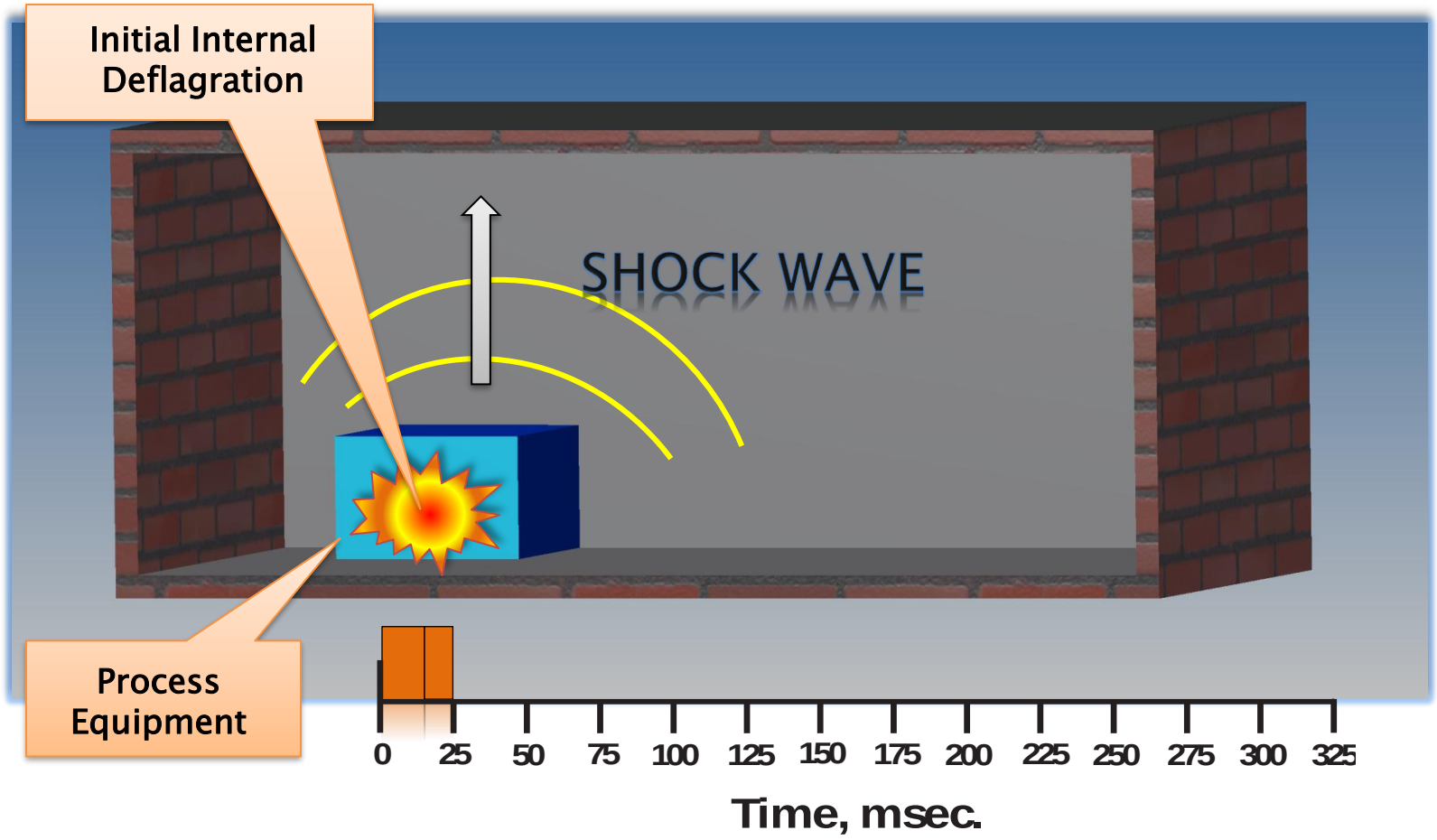

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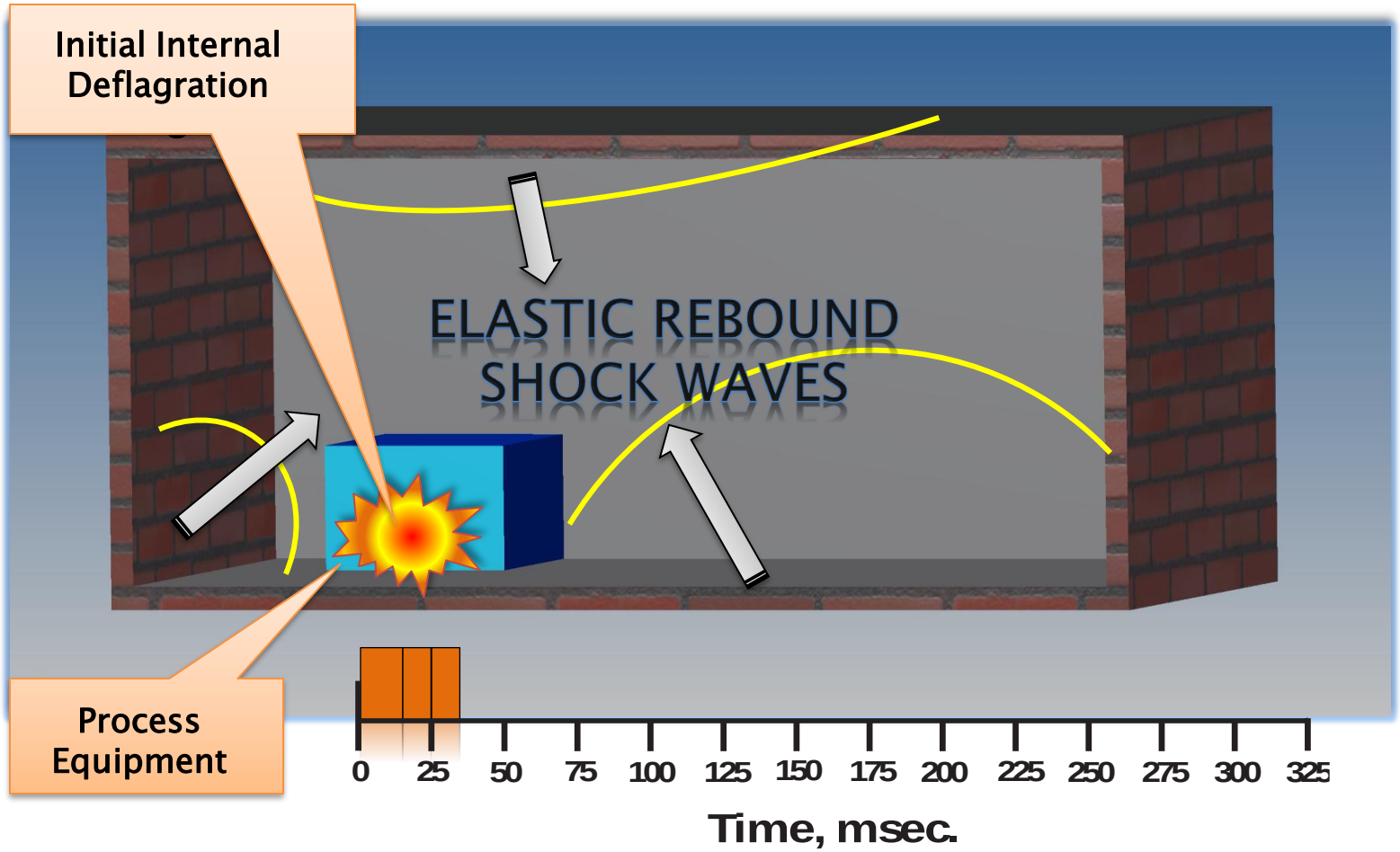

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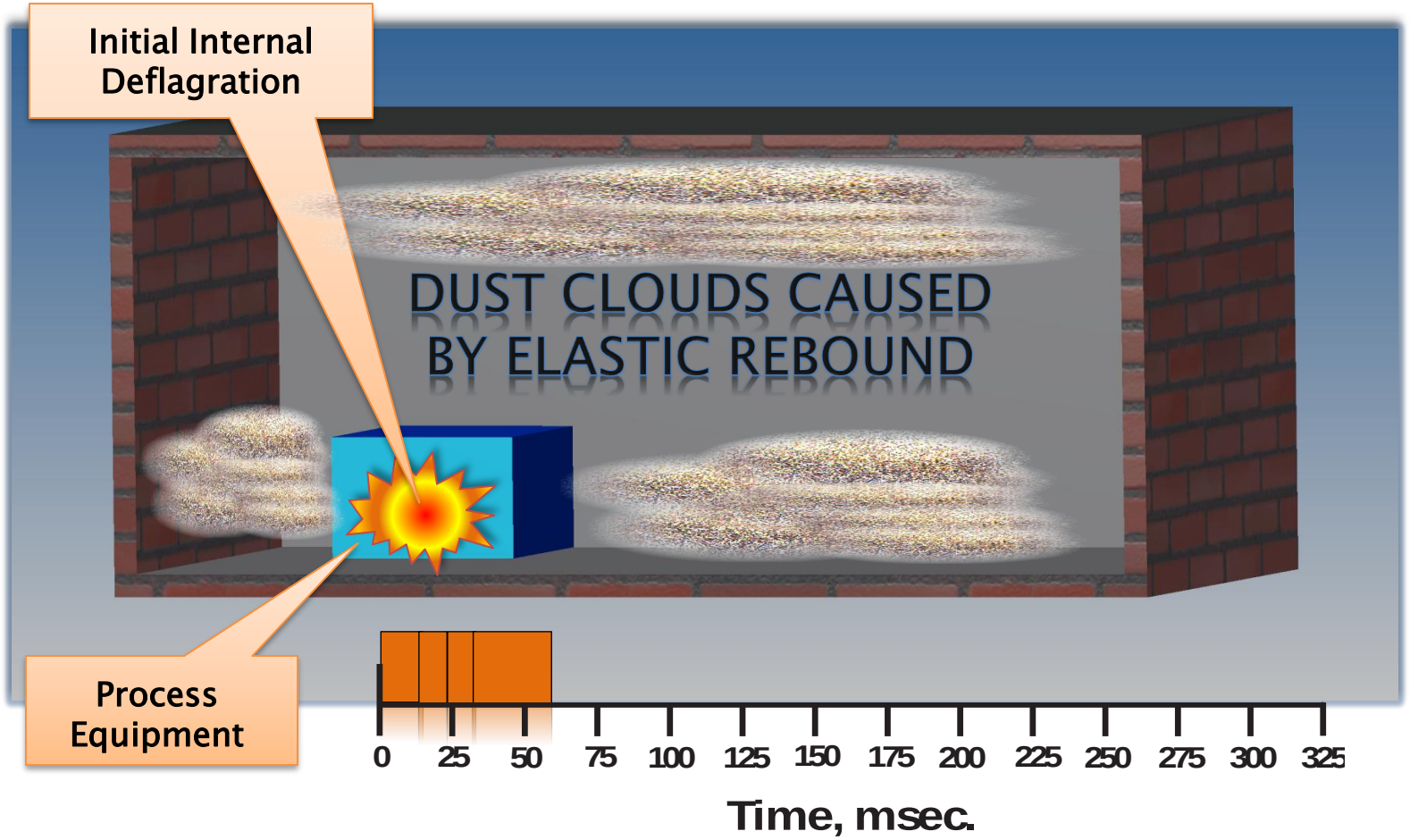

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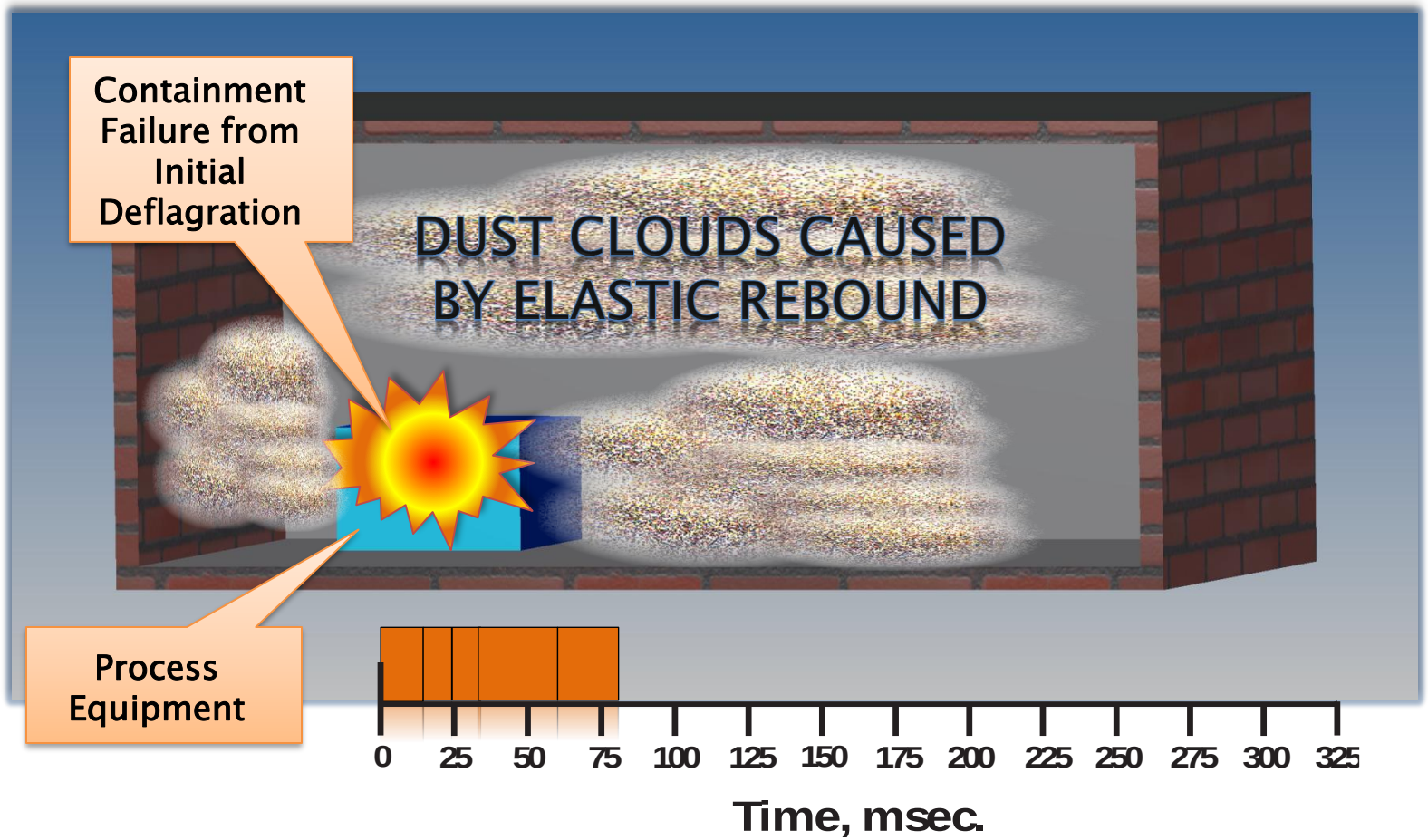

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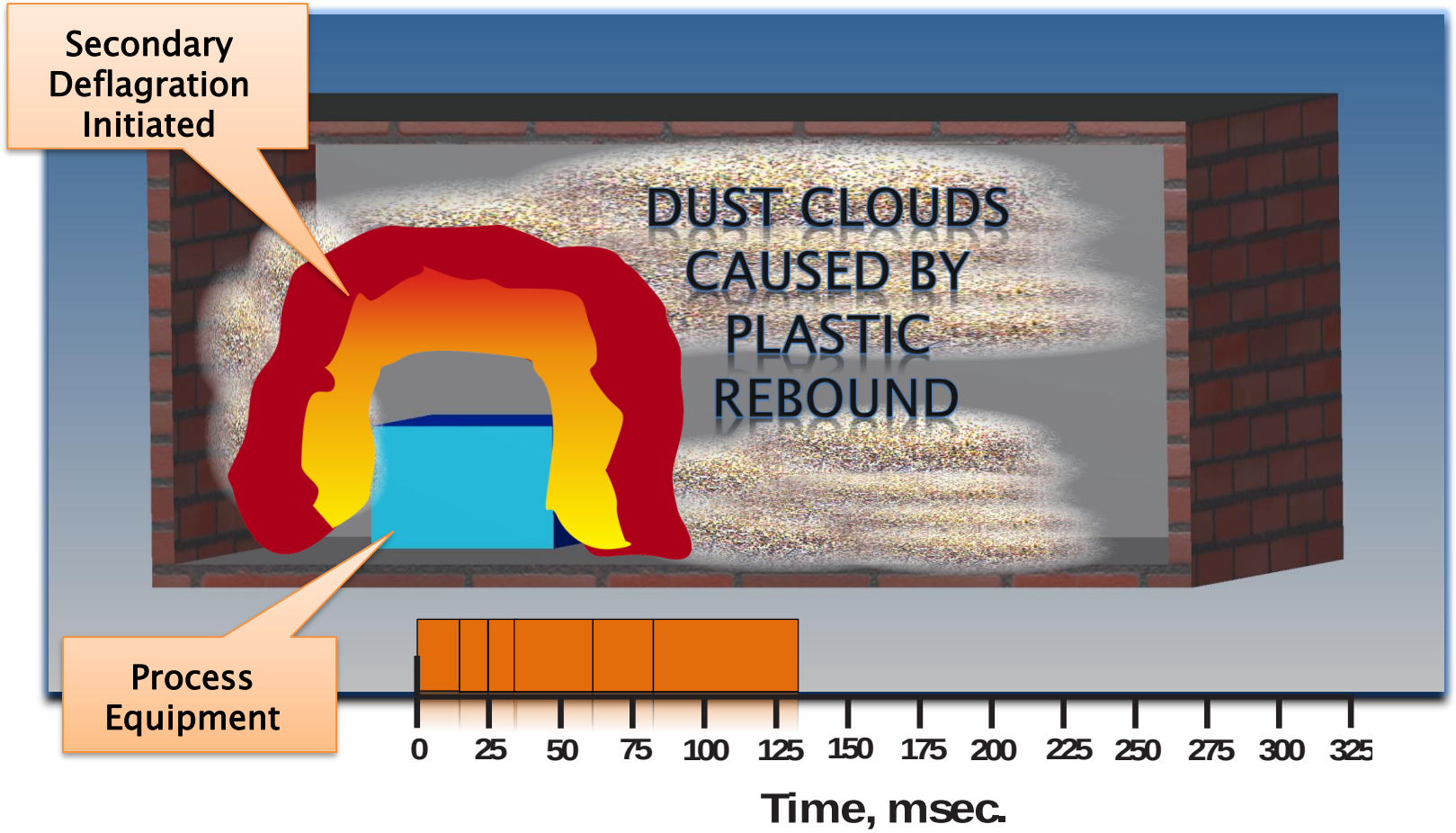

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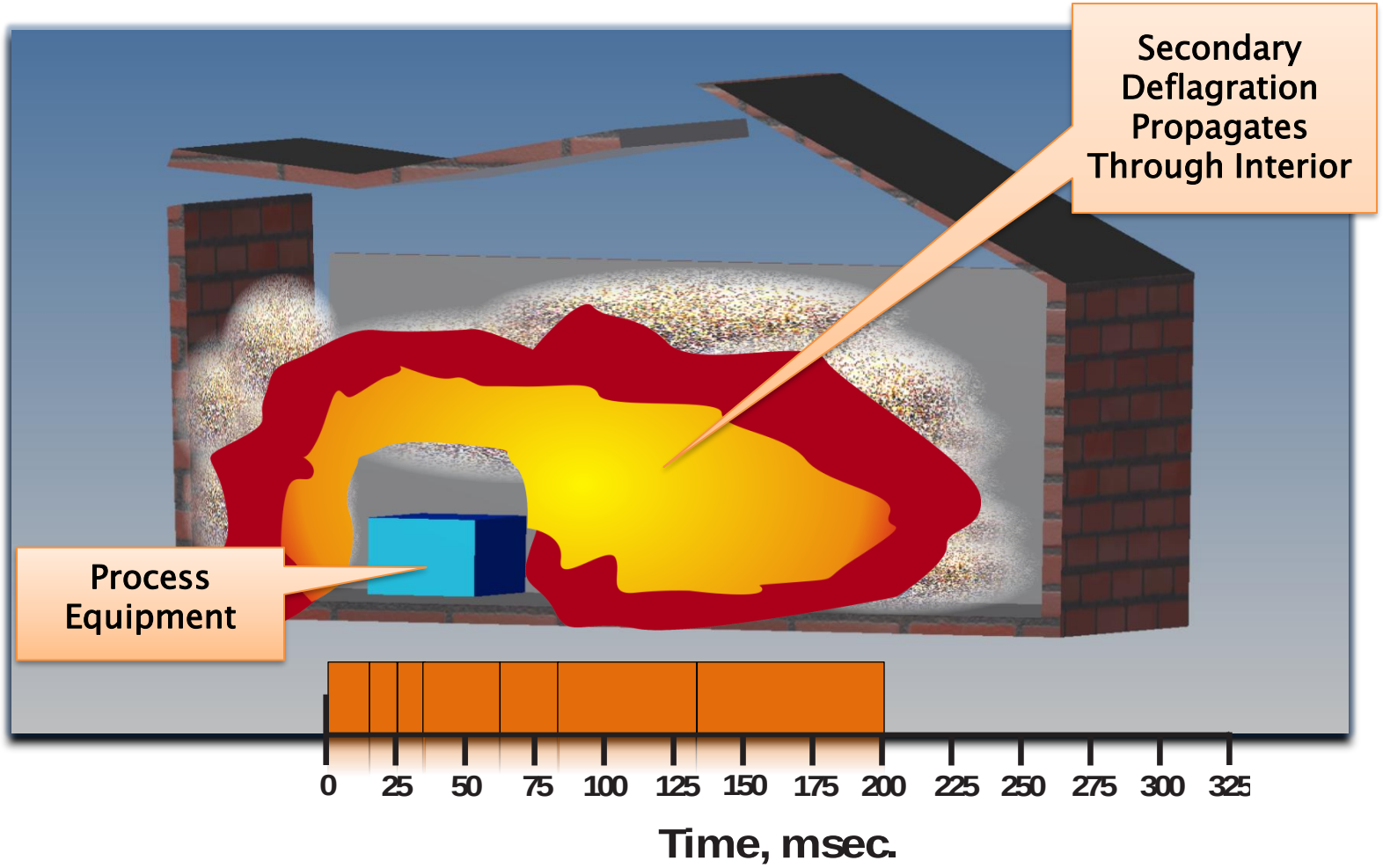

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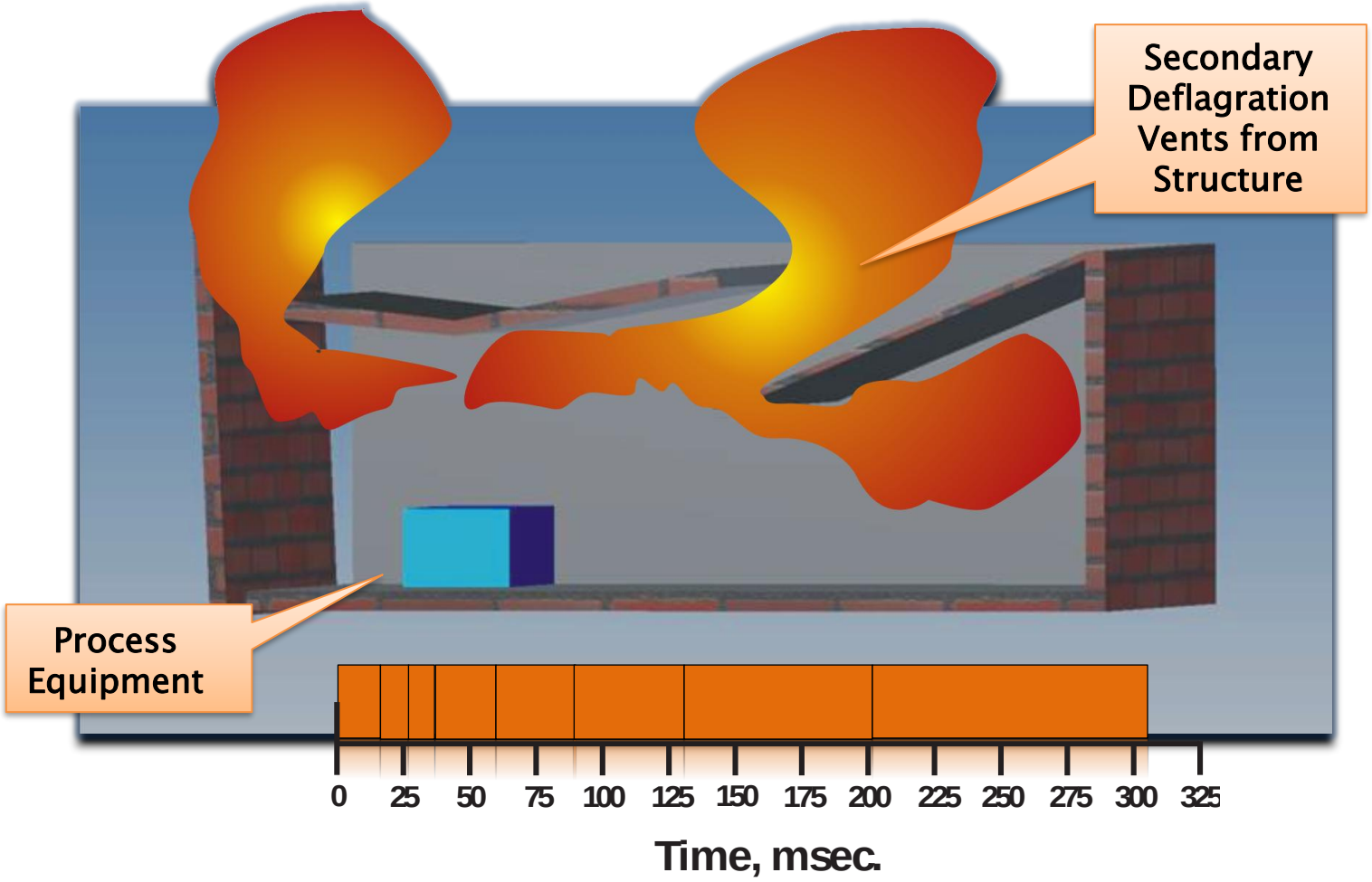

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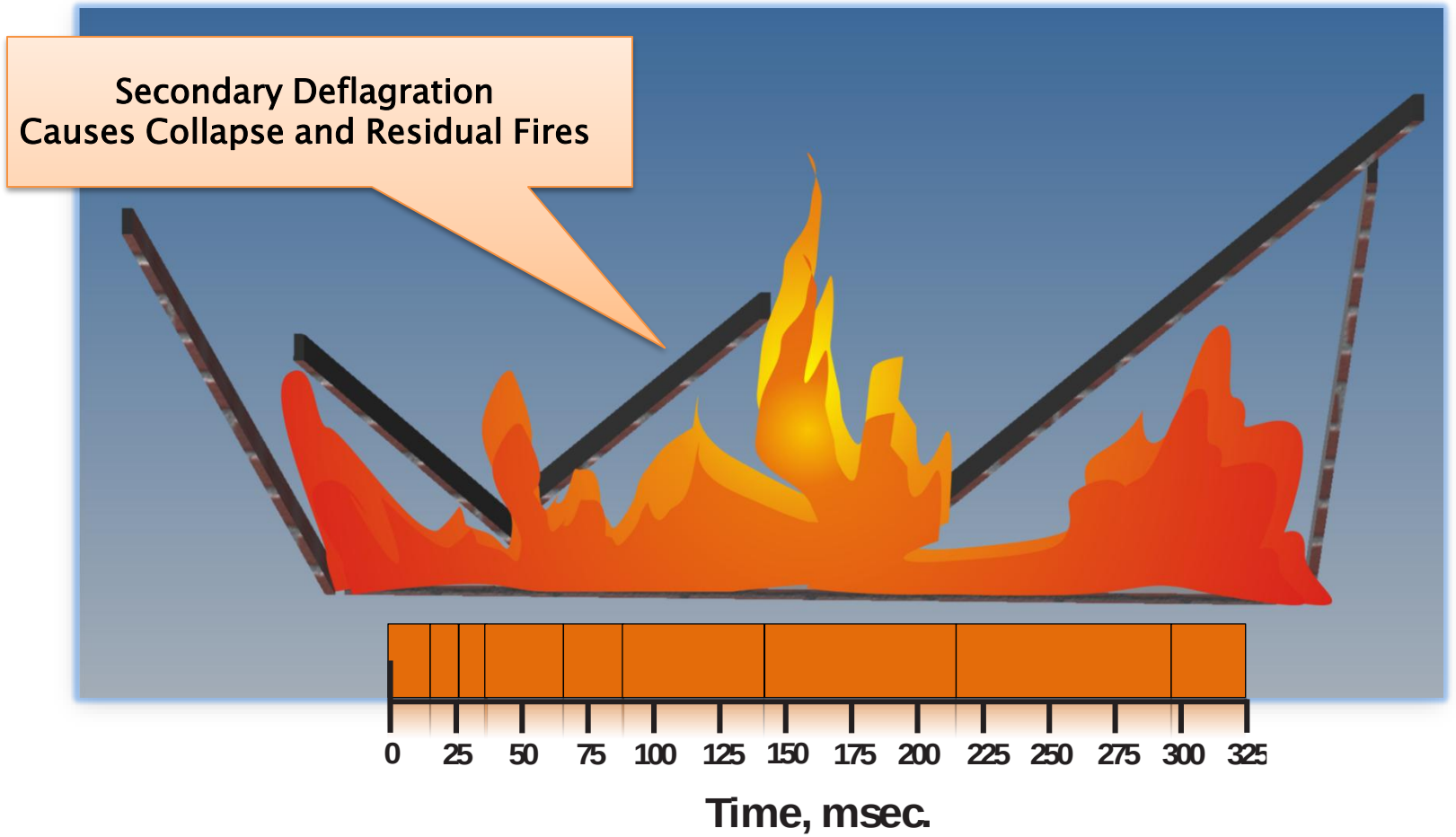
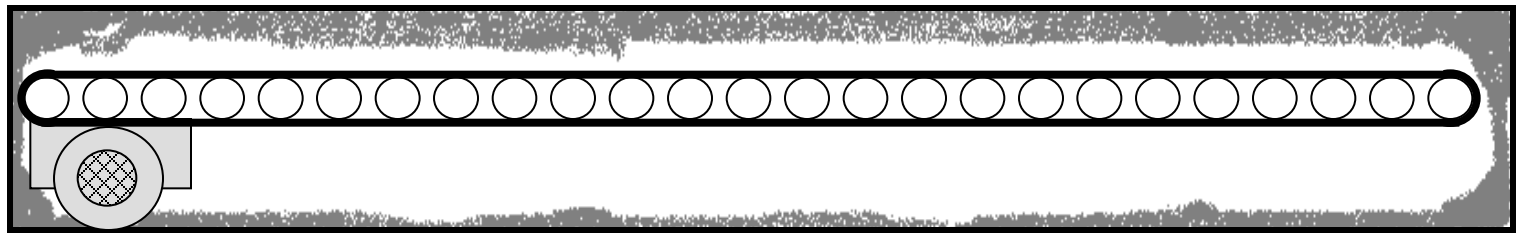
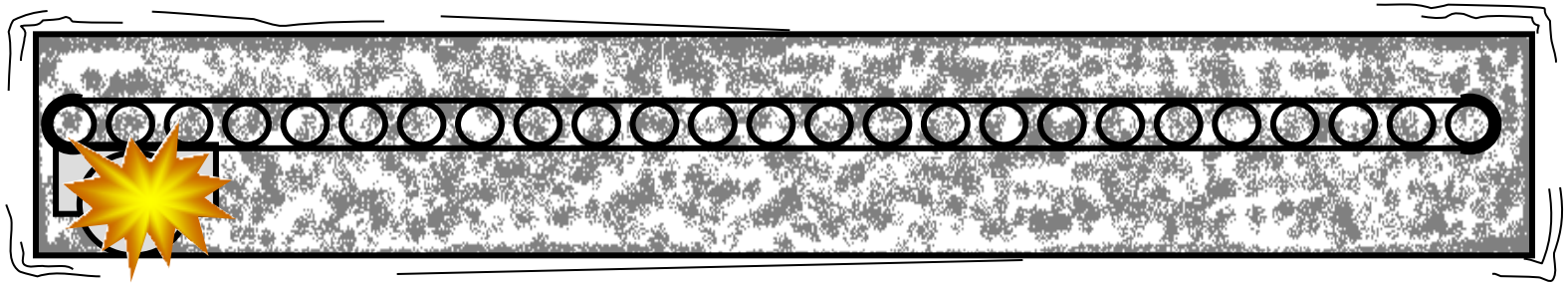


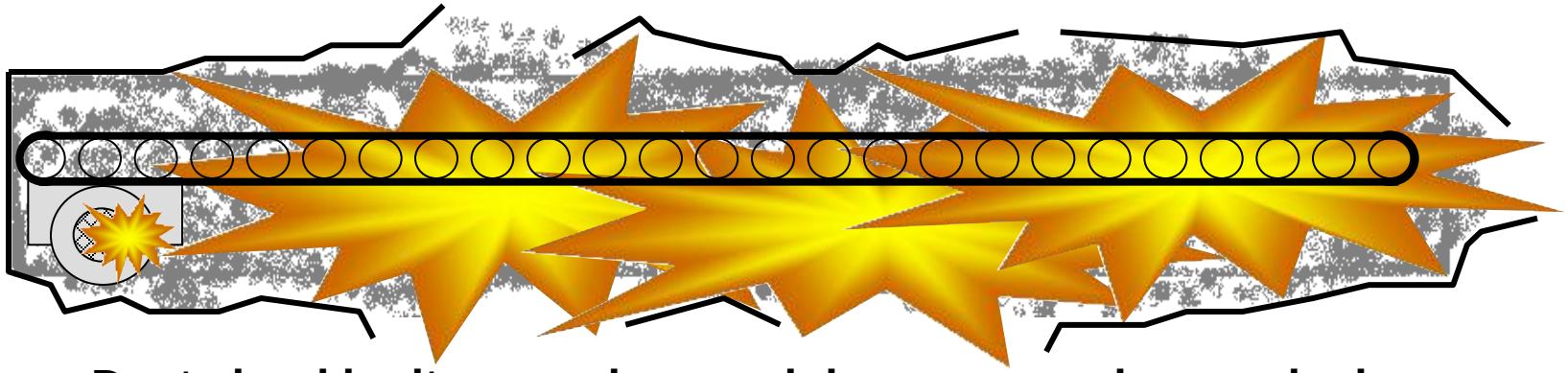
Secondary Explosions



Enclosed conveyor belt with dust build up on inside



Primary explosion from motor sparking creates a dust cloud inside enclosure



Dust cloud ignites causing much larger secondary explosion

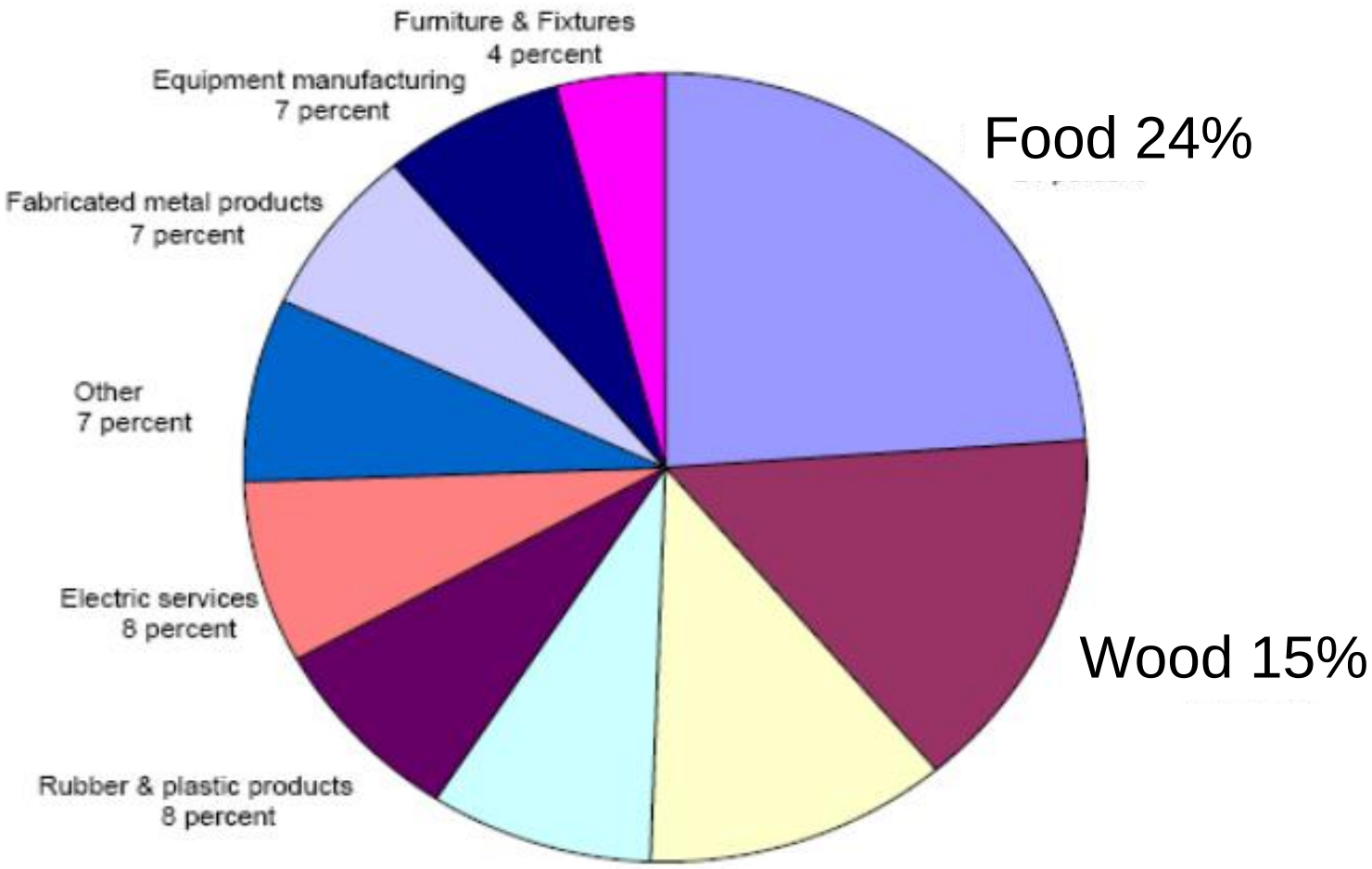
Is My Dust Combustible?

- It is up to YOU, the manufacturer, to know the composition of the material(s) you process and all applicable laws
- MSDS sheets are a starting point, but most do not address explosivity
- NFPA standards 660 – Previously 652, 664, 654, 484 and 61

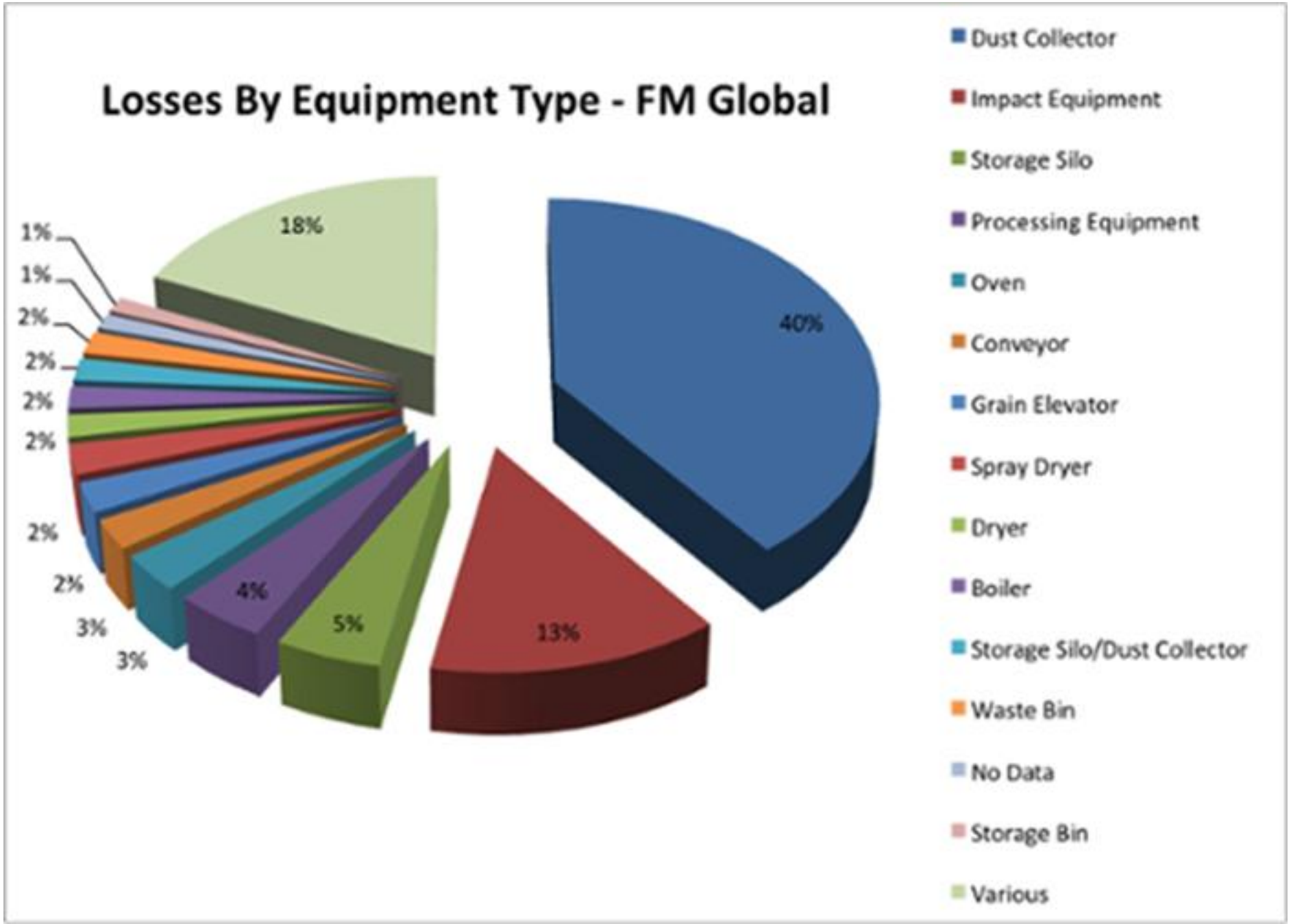
  are helpful resources
- Ideally, have your dust TESTED

Who's at Risk?

Industries having high incidence of combustible dust issues



source OSHA NEP, 2008


Losses By Equipment Type - FM Global
18%
40%
13%
5%
4%
3%
3%
2%
2%
2%
2%
2%
1%
1%
Dust Collector
Impact Equipment
Storage Silo
Processing Equipment
Oven
Conveyor
Grain Elevator
Spray Dryer
Dryer
Boiler
Storage Silo/Dust Collector
Waste Bin
No Data
Storage Bin
Various

Commonly Measured Properties of Combustible Dusts

Property	Definition	ASTM Test Method	Application
K_{St}	Dust deflagration index	ASTM E 1226	Measures the relative explosion severity compared to other dusts
P_{max}	Maximum explosion overpressure generated in the test chamber	ASTM E 1226	Used to design enclosures and predict the severity of the consequence
$(dP/dt)_{max}$	Maximum rate of pressure rise	ASTM E 1226	Predicts the violence of an explosion. Used to calculate K_{st}
MIE	Minimum ignition energy	ASTM E 2019	Predicts the ease and likelihood of ignition of a dispersed dust cloud
MEC	Minimum explosible concentration	ASTM E 1515	Measures the minimum amount of dust, dispersed in air, required to spread an explosion Analogous to the lower flammability limit (LFL) for gas/air mixtures
LOC	Limiting oxygen concentration	ASTM standard under development	Determines the least amount of oxygen required for explosion propagation through the dust cloud
ECT	Electrostatic charging tendency	No ASTM standard	Predicts the likelihood of the material to develop and discharge sufficient static electricity to ignite a dispersed dust cloud

Relevant Standards

- OSHA Combustible Dust NEP CL-03-00-008 (Reissued)
- NFPA occupancy standards – New NFPA 660 in 2025 – Previously NFPA 652 in 2015

NFPA #	Title
654	Prevention of Fire & Dust Explosions from Manufacturing, Processing, and Handling of Combustible Particulate Solids
664	Prevention of Fires & Explosions in Wood Processing and Woodworking Facilities
484	Standard for Combustible Metals, Metal Powders and Metal Dusts
61	Prevention of Fires and Dust Explosions in Agricultural and Food Products Facilities
655	Standard for Prevention of Sulfur Fires and Explosions

NFPA Design Standards

NFPA #	Title
68	Venting of Deflagrations
69	Explosion Protection Systems
70	National Electric Code
77	Recommended Practice on Static Electricity
499	Recommended Practice for the Classification of Combustible Dusts and Of Hazardous (Classified) Location for Electrical Installations in Chemical Process Areas
91	Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids

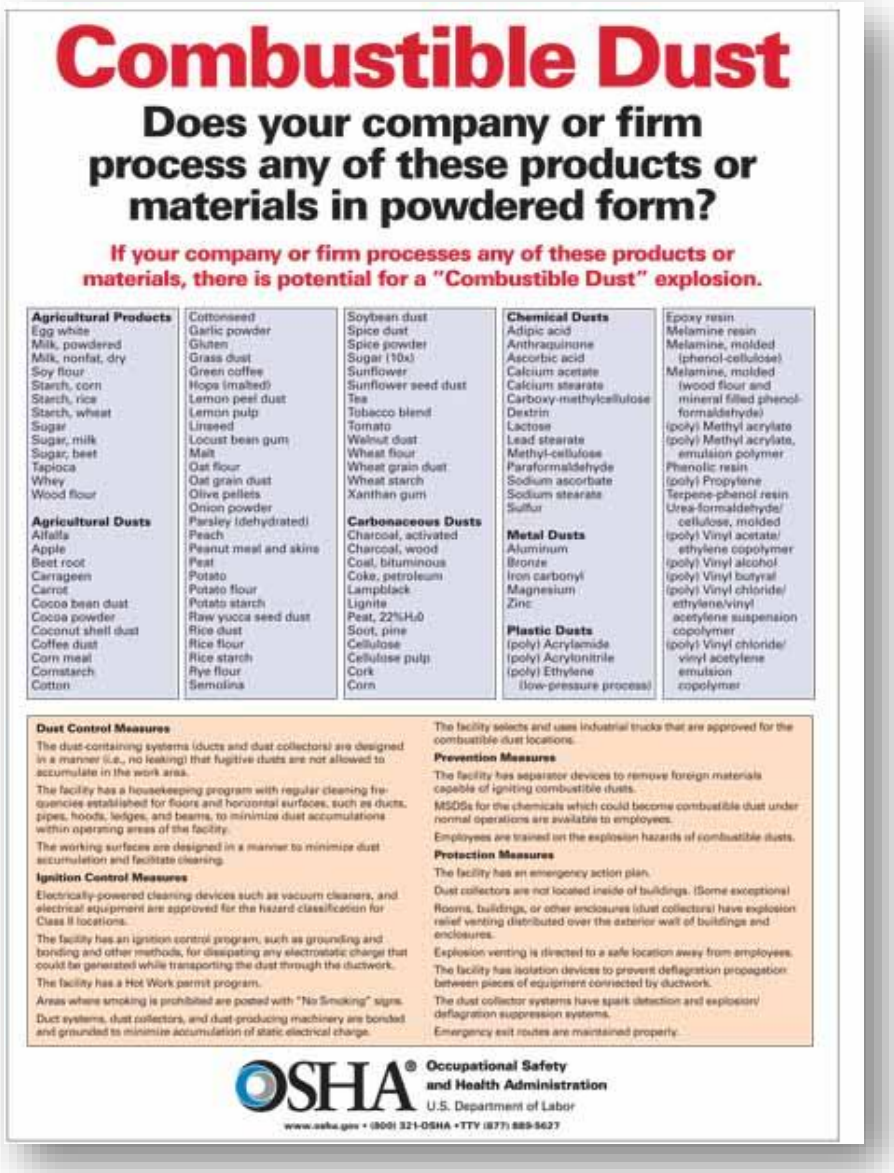
Hazard Classes of Dust Deflagration – Based on K_{St}

Hazard Class	K_{St} (bar-m/sec)	Example
St-1	< 200	Bronze 31 Bituminous Coal 129 Sugar 138
St-2	200-300	Cork 202 Cellulose 229 Phenolic Resin 269
St-3	>300	Aluminum Dust 415 Magnesium 508

Combustible Rates of Some Dusts

Material	Kst	Pmax	Stage
Grain	89	9.3	1
Coal Dust	85	6.4	1
Sugar	138	8.5	1
Aluminum (580 um)	0	0	0
Aluminum (10 um)	515	11.2	3
Magnesium (240 um)	12	7	1
Magnesium (28 um)	508	17.5	3

OSHA Poster



Combustible Dust

Does your company or firm process any of these products or materials in powdered form?

If your company or firm processes any of these products or materials, there is potential for a "Combustible Dust" explosion.

Agricultural Products
Egg white
Milk, powdered
Milk, nonfat, dry
Soy flour
Starch, corn
Starch, rice
Starch, wheat
Sugar
Sugar, milk
Sugar, beet
Tapioca
Whey
Wood flour

Agricultural Dusts
Alfalfa
Apple
Beet root
Carrageen
Carrot
Cocoa bean dust
Cocoa powder
Coconut shell dust
Coffee dust
Corn meal
Cornstarch
Cotton
Cottonseed
Garlic powder
Gluten
Grass dust
Green coffee
Hops (malted)
Lemon peel dust
Lemon pulp
Linseed
Locust bean gum
Malt
Oat flour
Oat grain dust
Olive pellets
Onion powder
Parsley (dehydrated)
Peach
Peanut meal and skins
Peat
Potato
Potato flour
Potato starch
Raw yucca seed dust
Rice dust
Rice flour
Rice starch
Rye flour
Semolina
Soybean dust
Spice dust
Spice powder
Sugar (10x)
Sunflower
Sunflower seed dust
Tea
Tobacco blend
Tomato
Walnut dust
Wheat flour
Wheat grain dust
Wheat starch
Xanthan gum

Carbonaceous Dusts
Charcoal, activated
Charcoal, wood
Coal, bituminous
Coke, petroleum
Lampblack
Lignite
Peat, 22%H₂0
Soot, pine
Cellulose
Cellulose pulp
Cork
Corn

Chemical Dusts
Adipic acid
Anthraquinone
Ascorbic acid
Calcium acetate
Calcium stearate
Carboxy-methylcellulose
Dextrin
Lactose
Lead stearate
Methyl-cellulose
Paraformaldehyde
Sodium ascorbate
Sodium stearate
Sulfur

Metal Dusts
Aluminum
Bronze
Iron carbonyl
Magnesium
Zinc

Plastic Dusts
(poly) Acrylamide
(poly) Acrylonitrile
(poly) Ethylene (low-pressure process)
Epoxy resin
Melamine resin
Melamine, molded (phenol-cellulose)
Melamine, molded (wood flour and mineral filled phenol-formaldehyde)
(poly) Methyl acrylate
(poly) Methyl acrylate, emulsion polymer
Phenolic resin
(poly) Propylene
Terpene-phenol resin
Urea-formaldehyde/cellulose, molded
(poly) Vinyl acetate/ethylene copolymer
(poly) Vinyl alcohol
(poly) Vinyl butyral
(poly) Vinyl chloride/ethylene/vinyl acetylene suspension copolymer
(poly) Vinyl chloride/vinyl acetylene emulsion copolymer

Dust Control Measures

The dust-containing systems (ducts and dust collectors) are designed in a manner (i.e., no leaking) that fugitive dusts are not allowed to accumulate in the work area.

The facility has a housekeeping program with regular cleaning frequencies established for floors and horizontal surfaces, such as ducts, pipes, hoods, ledges, and beams, to minimize dust accumulations within operating areas of the facility.

The working surfaces are designed in a manner to minimize dust accumulation and facilitate cleaning.

Ignition Control Measures

Electrically-powered cleaning devices such as vacuum cleaners, and electrical equipment are approved for the hazard classification for Class II locations.

The facility has an ignition control program, such as grounding and bonding and other methods, for dissipating any electrostatic charge that could be generated while transporting the dust through the ductwork.

The facility has a Hot Work permit program.

Areas where smoking is prohibited are posted with "No Smoking" signs.

Duct systems, dust collectors, and dust-producing machinery are bonded and grounded to minimize accumulation of static electrical charge.

The facility selects and uses industrial trucks that are approved for the combustible dust locations.

Prevention Measures

The facility has separator devices to remove foreign materials capable of igniting combustible dusts.

MSDSs for the chemicals which could become combustible dust under normal operations are available to employees.

Employees are trained on the explosion hazards of combustible dusts.

Protection Measures

The facility has an emergency action plan.

Dust collectors are not located inside of buildings. (Some exceptions)

Rooms, buildings, or other enclosures (dust collectors) have explosion relief venting distributed over the exterior wall of buildings and enclosures.

Explosion venting is directed to a safe location away from employees.

The facility has isolation devices to prevent deflagration propagation between pieces of equipment connected by ductwork.

The dust collector systems have spark detection and explosion/deflagration suppression systems.

Emergency exit routes are maintained properly.

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U.S. Department of Labor

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Metal Dusts Specifically Highlighted:

- Aluminum
- Bronze
- Iron Carbonyl
- Magnesium
- Zinc

Maintenance and Housekeeping

- Develop and maintain a housekeeping program (this is something OSHA inspectors are checking for).
- Replace mops, brooms and blow guns with more effective cleaning tools/practices. These products push dust around without removing it and can create dangerous dust clouds.
- Limit/reduce the amount of overhead horizontal surfaces (racks, piping, ductwork, drop ceilings). These areas are hard to clean and trap dust.
- Make sure equipment is grounded to avoid electrical and static sparking.

Maintenance and Housekeeping

NFPA 654 (2013 version) will include a Safe Housekeeping Hierarchy

1. Vacuum dust with a certified vacuum that is bonded and grounded, so it doesn't become an ignition source.

2. Where the vacuum cannot reach, conduct a water wash down or ***carefully*** sweep with a broom in a manner that does not stir up dust.

3. Finally, if the previous two measures are not effective, cleaning with compressed air is permissible ***only*** in small areas with operating equipment shut down.

Source: Feed & Grain, 2012

Maintenance and Housekeeping

- Utilize vacuums for source capture and as portable suction devices to prevent fugitive dust from accumulating.
- Make housekeeping as easy and ergonomic as possible by using lightweight, adjustable tools, flexible hoses and overhead cleaning accessories.
- Keep dust below 1/32” on horizontal surfaces as directed in OSHA’s NEP.
- Inspect all equipment (especially older) for possible ignition sources and for needed deflagration venting upgrades.

Choosing the Right Industrial Vacuum

- OSHA NEP raises the issue of using “properly-equipped” industrial vacuums as defined by NFPA 654.
- Classed materials may require an “explosion-proof/dust ignition proof” vacuum, as determined by Authorities Having Jurisdiction (AHJ)
- Shop-style vacuums can add to the risk!

Electric Explosion Proof/Dust Ignition Proof Vacuums

Electric vacuums certified as Explosion Proof/Dust-Ignition Proof by a Nationally Recognized Testing Lab

- CSA, UL, ETL
- EXP rated TEFC motors
- EXP rated sealed switches/connections
- Internally/externally grounded (filters, body, tank, wheels, etc.)
- Conductive hose and accessories

Beware of posers!

- Some companies offer “dressed up” models with antistatic accessories

Remember, investing in the proper equipment is only one part of the equation. Inspect your facility to ensure you have proper safety measures in place, including Explosion Prevention (NFPA 69) and Deflagration Venting devices (NFPA 68).

Pneumatic Hazardous Location Vacuums

- Powered by compressed air (Venturi principle)
- No electrical components
- No moving parts
- Used when electricity is prohibited or unavailable

Air-operated ≠ Explosion Proof

- Meet the requirements for use in Class II areas
- Made of non-sparking materials
- Outfitted with conductive hose/accessories
- Grounded (bonded)

Metal Fabricating Dust Collection Design Considerations

- Size and material of part
- Source Capture, Down/Backdraft, Booth, Ambient
- Central, packaged or semi-central
- Type of Filter
- Jibs/Overhead Cranes
- Horsepower
- Initial Capital & Total Cost of Ownership
- NFPA, OSHA & EPA
- Operator Exposure
- Operator Ergonomics
- Operator Productivity
- Manual or Robotic
- Amount of Dust/Smoke

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Thermal Producing Applications

- Smoke & Fume produced (generally 0.5-1 micron)
- Particulate is oxidized – not combustible in cases of Aluminum and Titanium
- Spark arrestors prior to collector & fire retardant filters for source capture
- Typical collectors are cartridge style with compressed air self cleaning.
- Hex-Chrome (Stainless Steel) and Manganese (Flux Core)

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Source Capture – Welding

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Portable Source Capture – Welding

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Central System

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Backdraft with Regain

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Ambient – Bag Filters

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Ambient – Self Cleaning

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Laser/Plasma

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Mechanical Dust Producing Applications

- Is dust combustible? (Aluminum, Titanium, Magnesium)
- Particulate is typically 5+ micron.
- Spark Arrestors prior to dust collector
- Fire retardant filters
- Wet or Dry collection

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NFPA 484

- All dust collection now in one chapter. No longer one section for each metal.
- No longer required to have 4500 FPM in ductwork – Although recommended in the Annex for 3500-4500 FPM.
- Dry Filters can now be used downstream of a wet collector – more on this later…
- Downdraft tables are prohibited for combustible metal dust.

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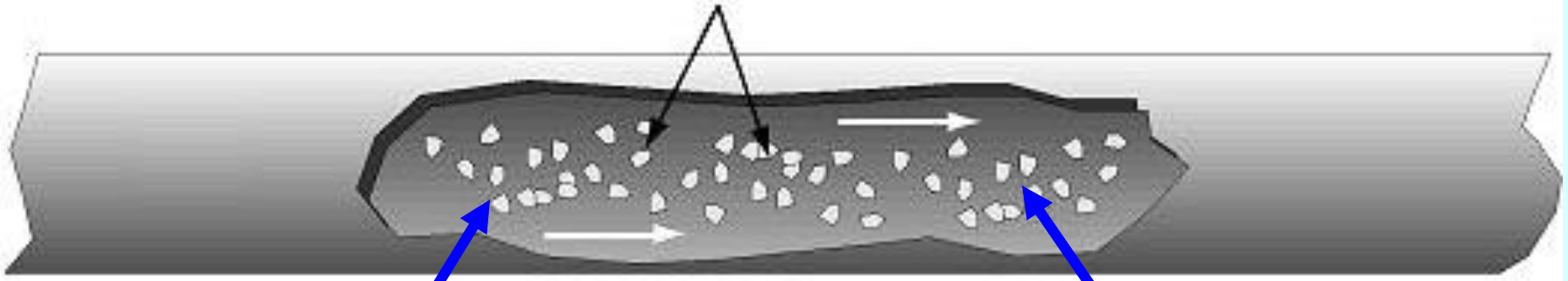
Combustible Dust – Duct Design

- Ductwork should be as short and straight as possible
- Ductwork must be made of conductive material and have a smooth interior
- Duct velocities should be between 3500-4500 – fine and course particles must be transported.
- There cannot be any unused capped outlets, pockets, or dead end spaces
- Additional branch ducts cannot be added unless a redesign of the system is performed
- Duct system along with machinery, hoods and collector must be bonded and grounded

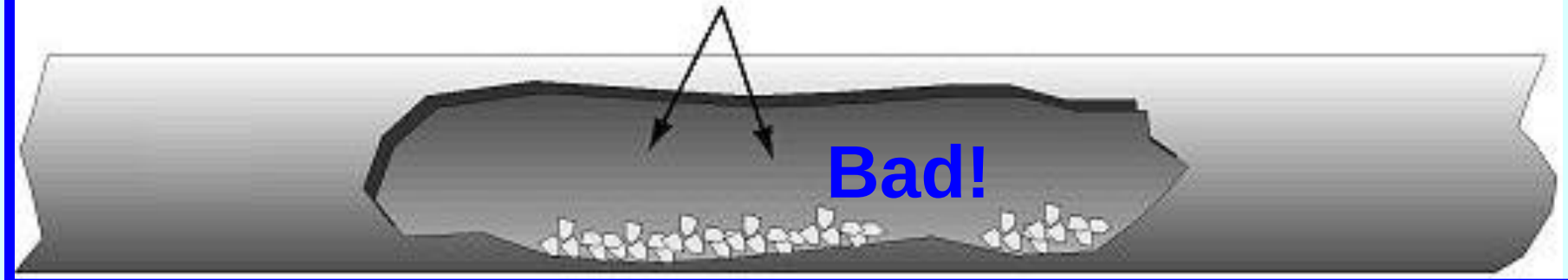
Particles are suspended



Air velocity at least 4500 ft/min

Entrainment! is what you need!

Air velocity less than 3500 ft/min



Build-up of dust particles

Ductwork

- Ducts short and straight to maximize free airflow
- No dead ends or unused caps in ducts that could trap accumulations of dust
- Ducts grounded & bonded to dissipate static electricity

Combustible Metal Dust – Dry Collectors

- Cannot recirculate back into building
- Must be located outside (except for a small portable collector)
- Must have barriers to prevent explosion back into building
- Cannot be mixed with other metals
- Must have deflagration vents or suppression & isolation
- Dust must be removed daily.
- Filters must be grounded to dissipate static electricity
- Portable collectors connected to a machine can be used with only 5 lb of dust.
- Efficient at 99% on .5 micron (cartridge style)
- Must be below 150 Kst

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Combustible Dust – Wet Collectors

- Can recirculate if tests conducted determine that the efficiency is great enough
- Level (high and low) must interlock with blower
- Sump must be vented at all times
- Sludge should be removed daily
- 99% efficient on 10 micron and 95% efficient at 5 micron
- Adds humidity back into room if recirculated – Approximately 1 GPH per 1000 CFM.
- Can have a filter downstream (not in wet collector) if:
  - Differential Filter Alarm & High Temperature Alarm
  - A means to limit hydrogen accumulation to 10 percent of the LFL
  - Static dissipative filter media

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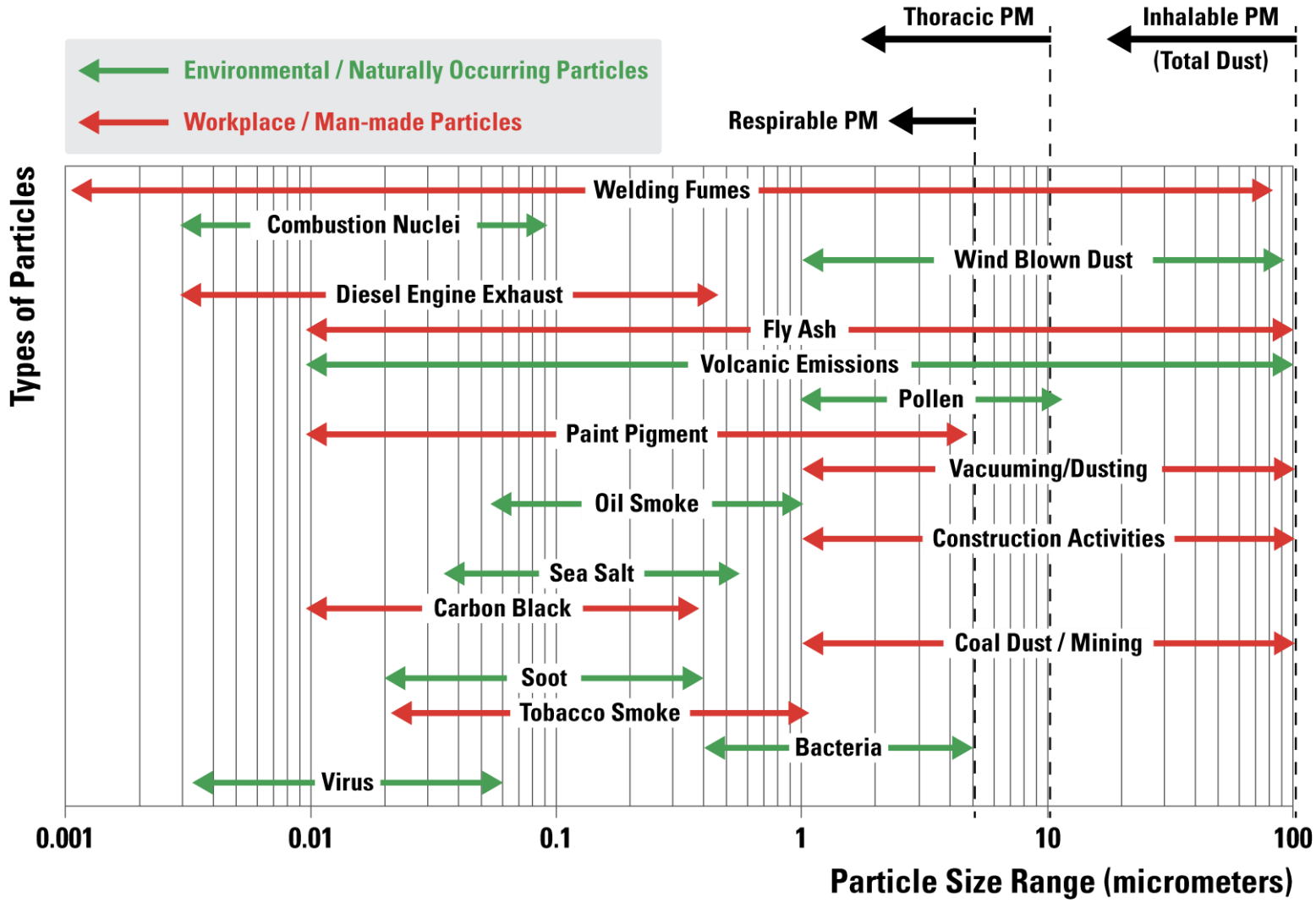
Combustible Dust – Wet or Dry Collection?

- What is the size of the particulate?
- How far away is the nearest outdoor location?
- Wet downdraft or booth – (non-ducted systems)
- Cost of each system
- Dry systems require extra barriers and explosion vents
- With Dry system, be careful to limit condensation into ductwork and collector when ducted outside. Cold seasons.
- NFPA 484 in Annex A recommends against media type collectors favoring cyclones or wet collectors.

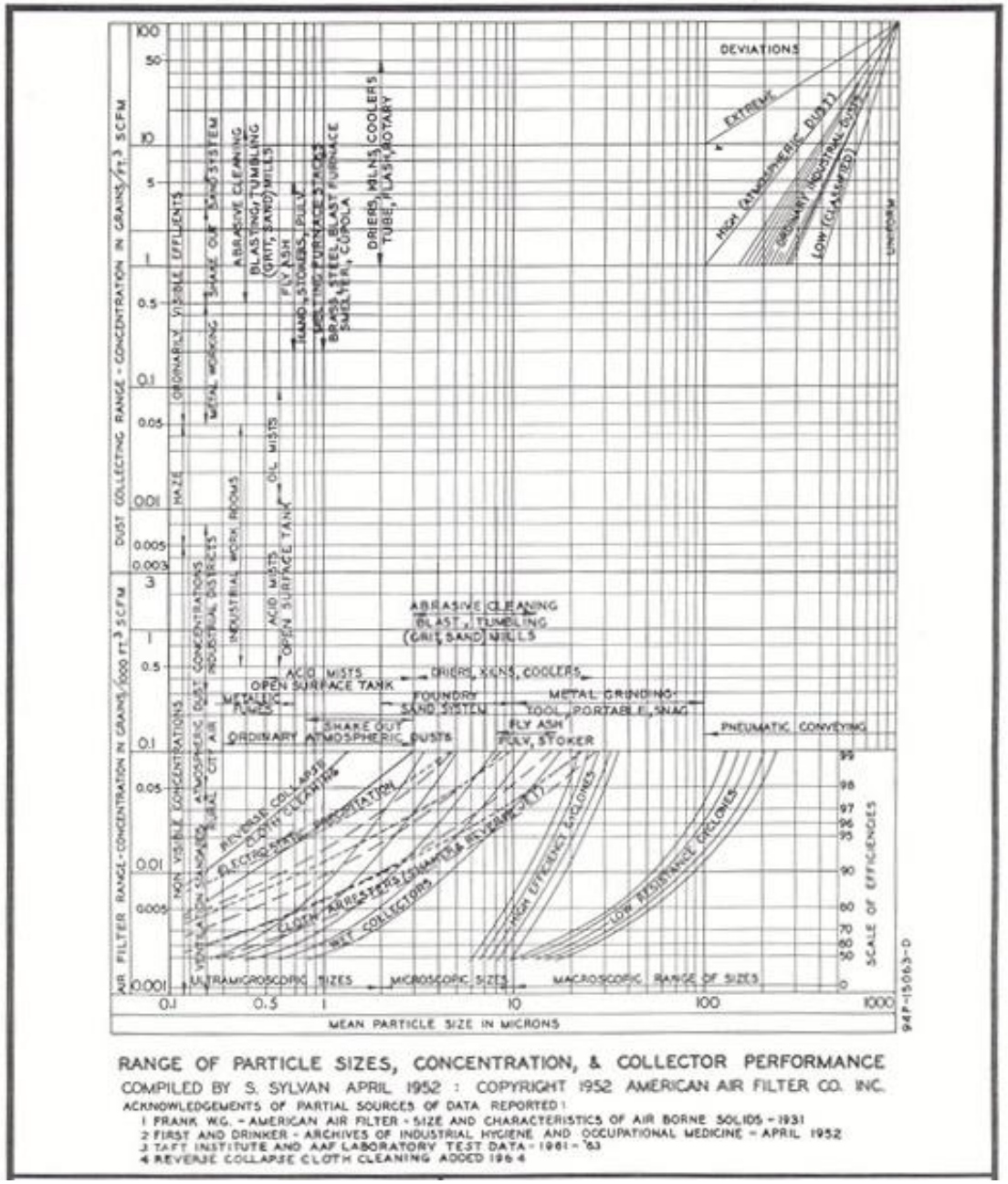
Particle Sizes in the Workplace



Efficiency Chart

American Conference of Governmental Industrial Hygienists (ACGIH)

Range of Particle Size



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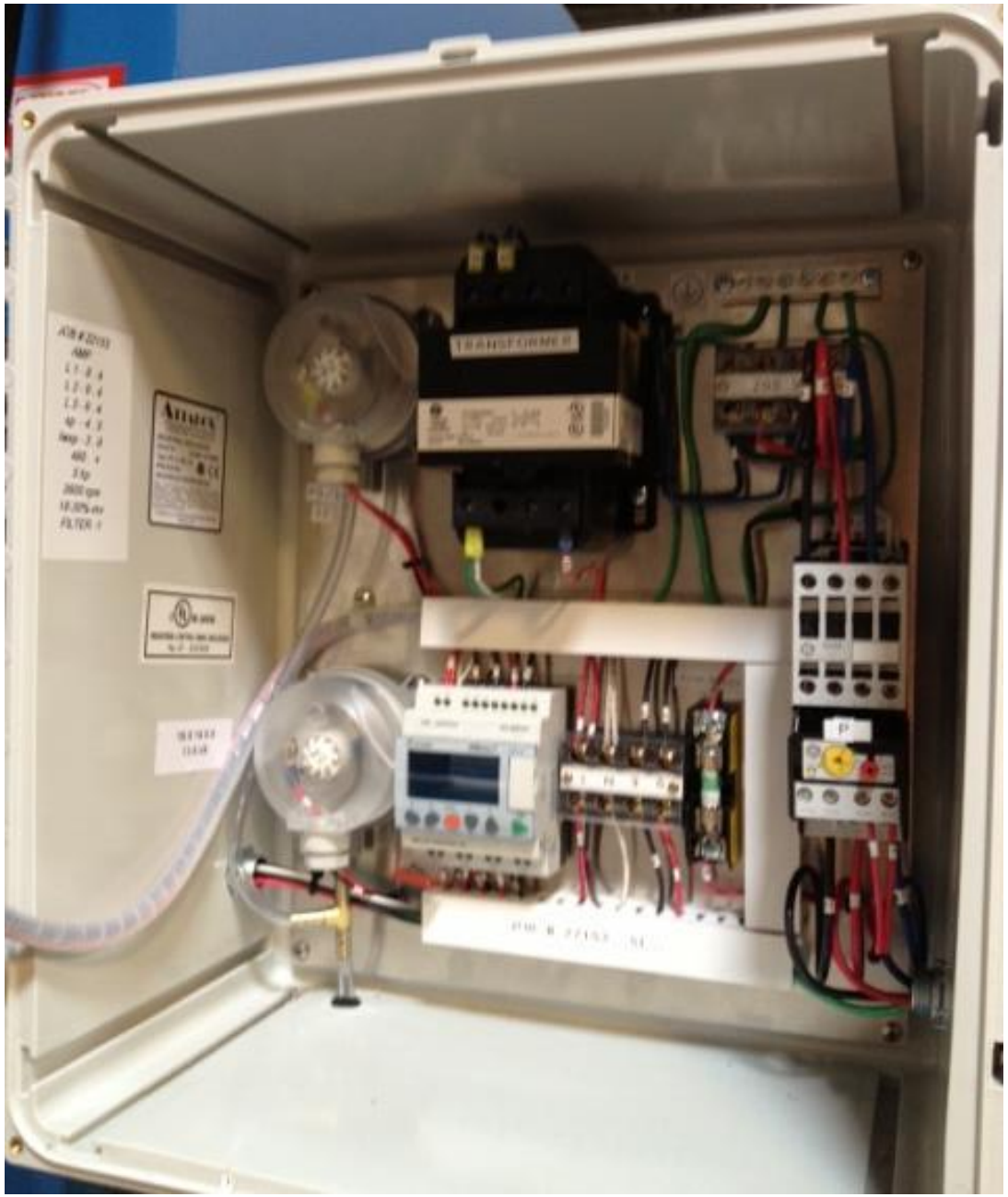
Wet Collector Features: Filter-1

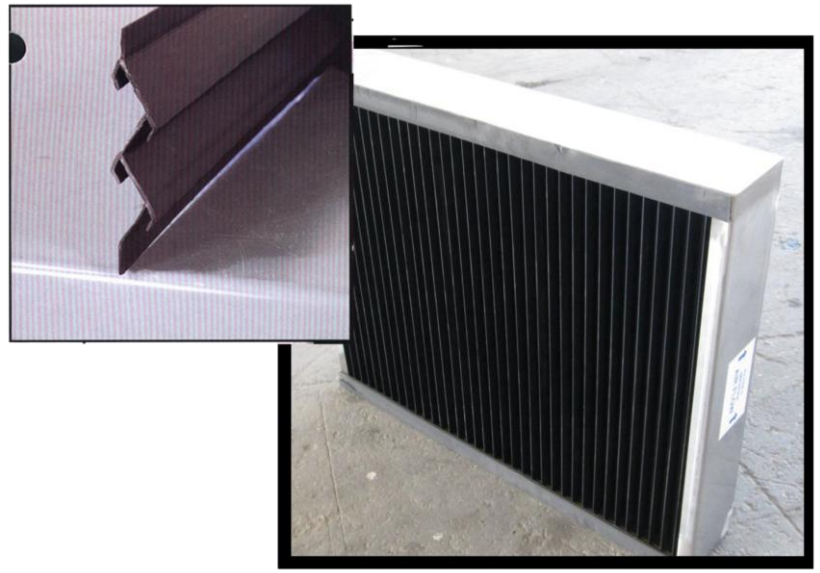
Demister Access Upper Door

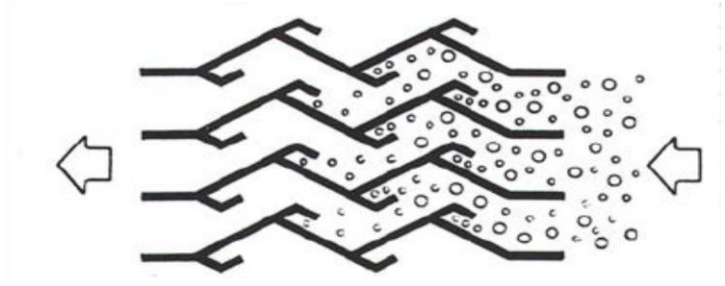
Hydrotron model MARK II HPB-12-90-1X15
Impingers to separate water from air

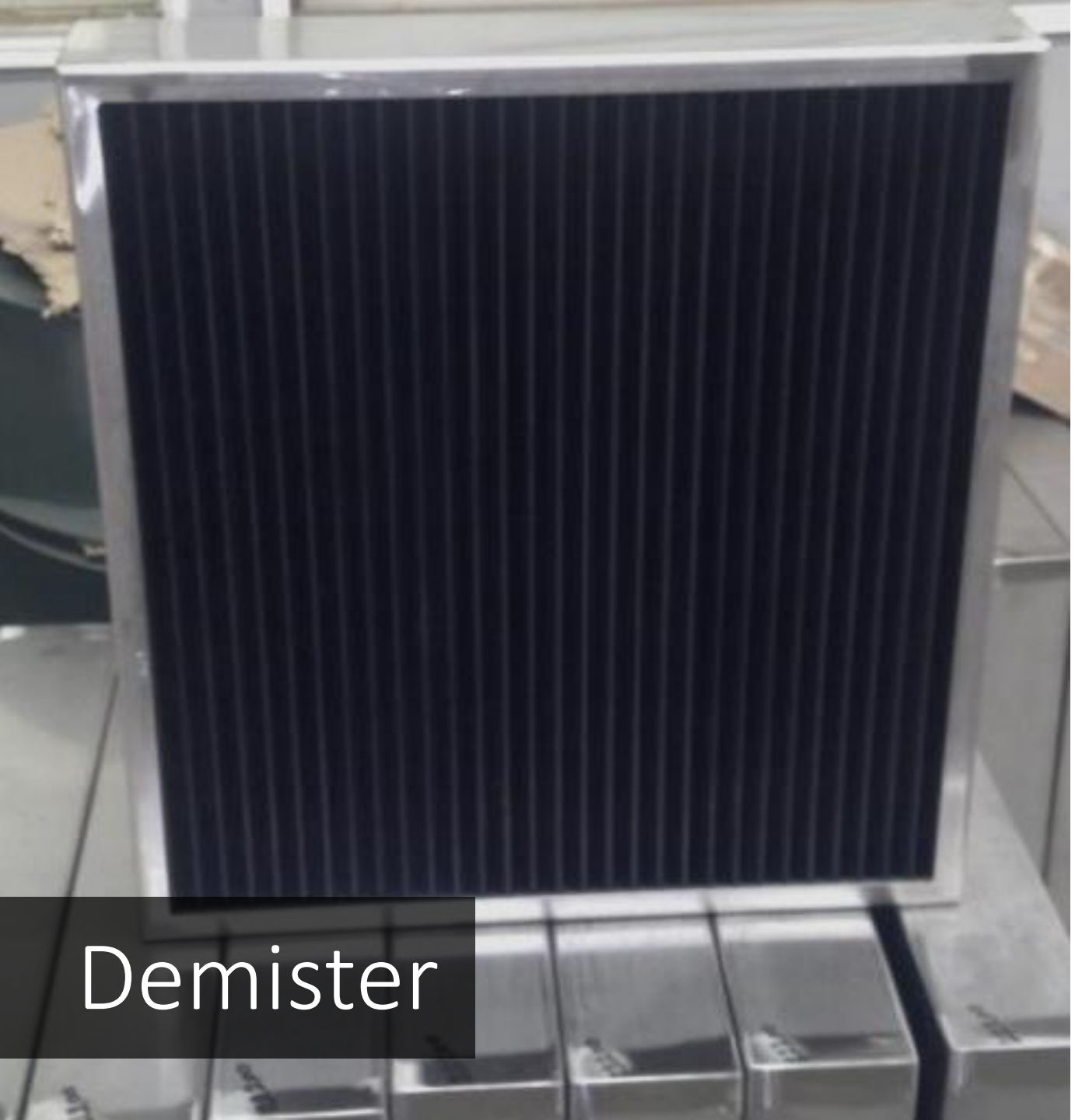


Filter-1 Impinger: Principles of Operation

- As water particles enter the impinger, the airflow is subject to multiple changes in direction. As the water follows the path of the impinger, this causes a vortex to form in front of each pocket. This vortex causes the water and any dust particles to impinge in the pocket where it is then drained by gravity back into the collector. This setup is very effective and NFPA compliant for wet collectors processing explosive dust material.
- Internal parts of the Filter-1 impinger are made of black poly vinyl chloride encased in a stainless-steel enclosure.







Demister

Optional Conveyor for HWF

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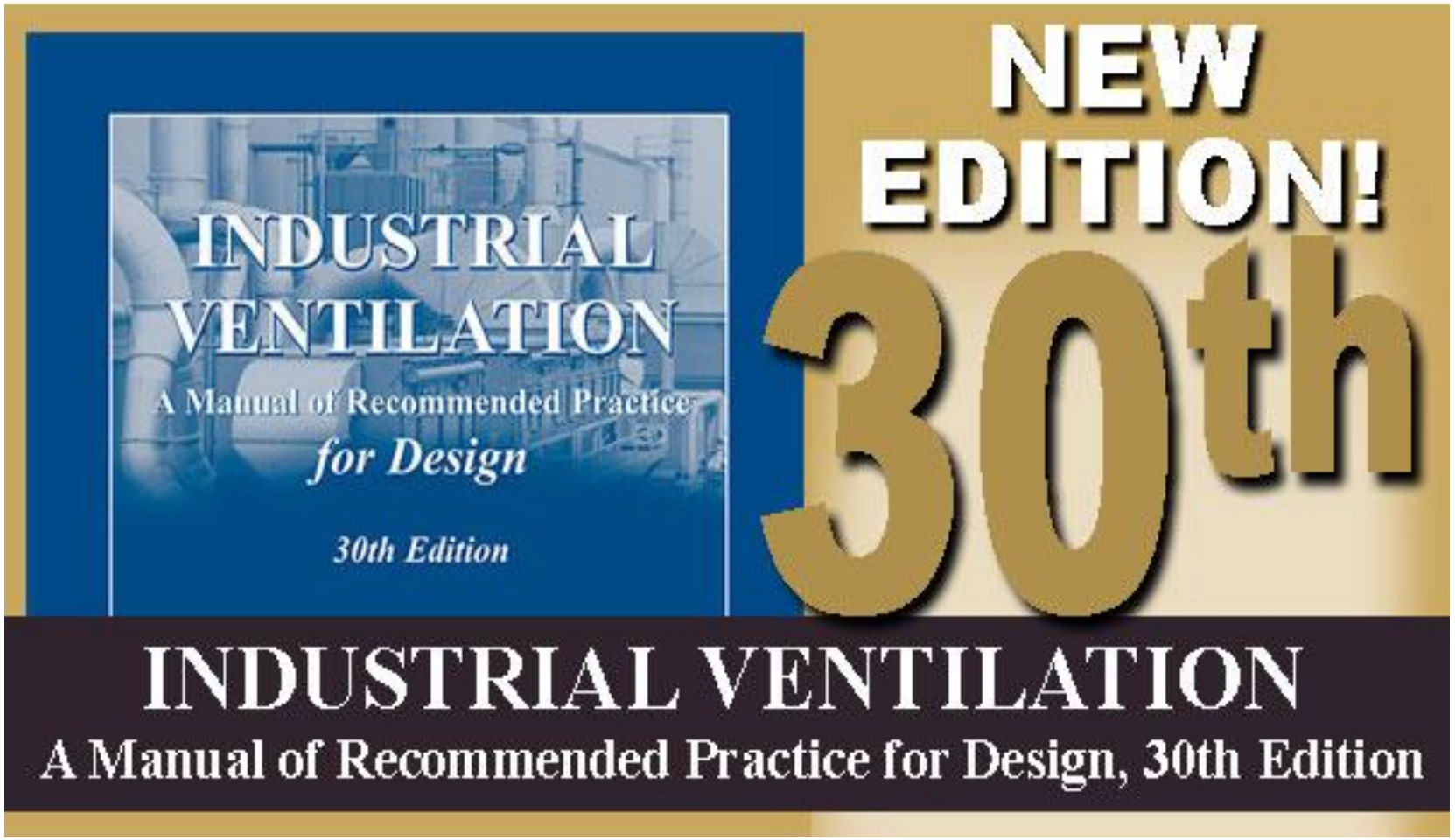
Application Photos

NOW AVAILABLE!



HWF-7

HWF-6 Source Capture

HWF-6 Source Capture

Multiple HWF-5 Ducted

Wet Ducted Collector

Multiple HWF-3 Ducted After-Filter


300-LINE CONTROL
START
STOP
DANGER
BALDOR


FILTER 1
HYDROTRON
1-800-289-0189
WWW.FILTER-1.COM
FILTER 1


FILTER 1
HYDROTRON

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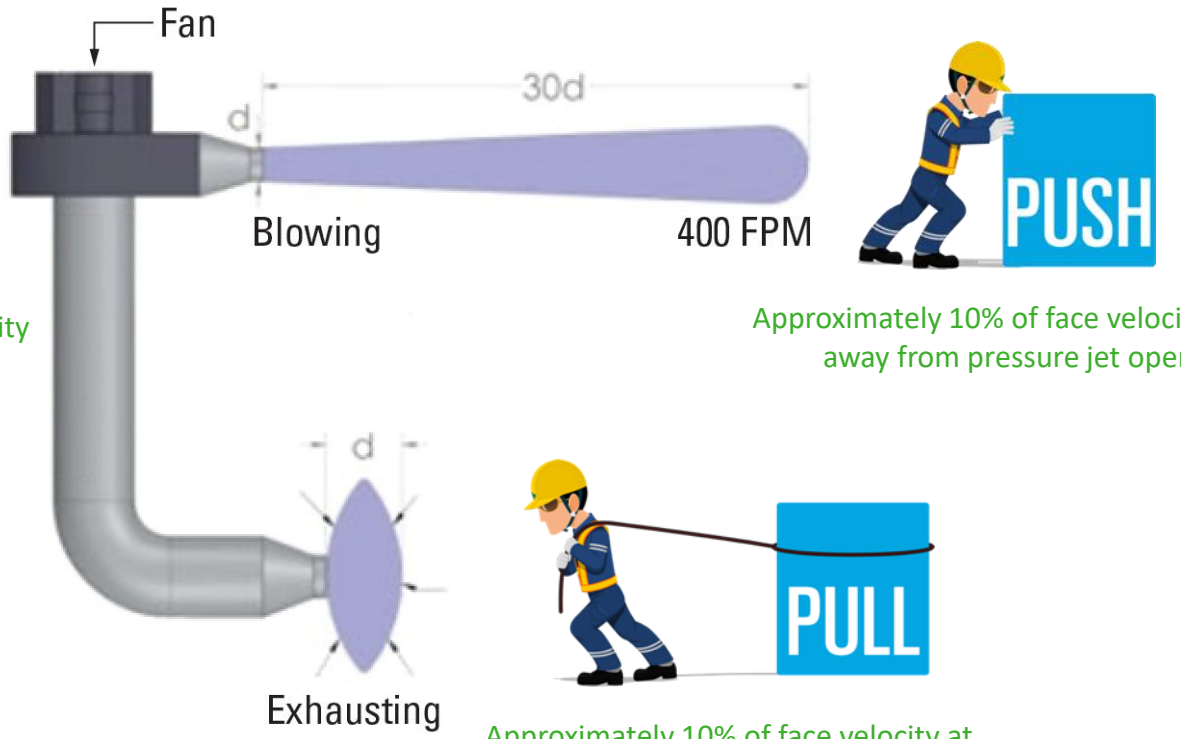
Wet Booths & Benches

Push / Pull



Airflow characteristics of blowing and exhausting (push/pull) (ref. ACGIH section 1-10)
Air can be blown 30 times farther with pushing vs. pulling
The Hastings solution directs the fugitive air toward a specific location (collector)

Flanged Velocity Contours

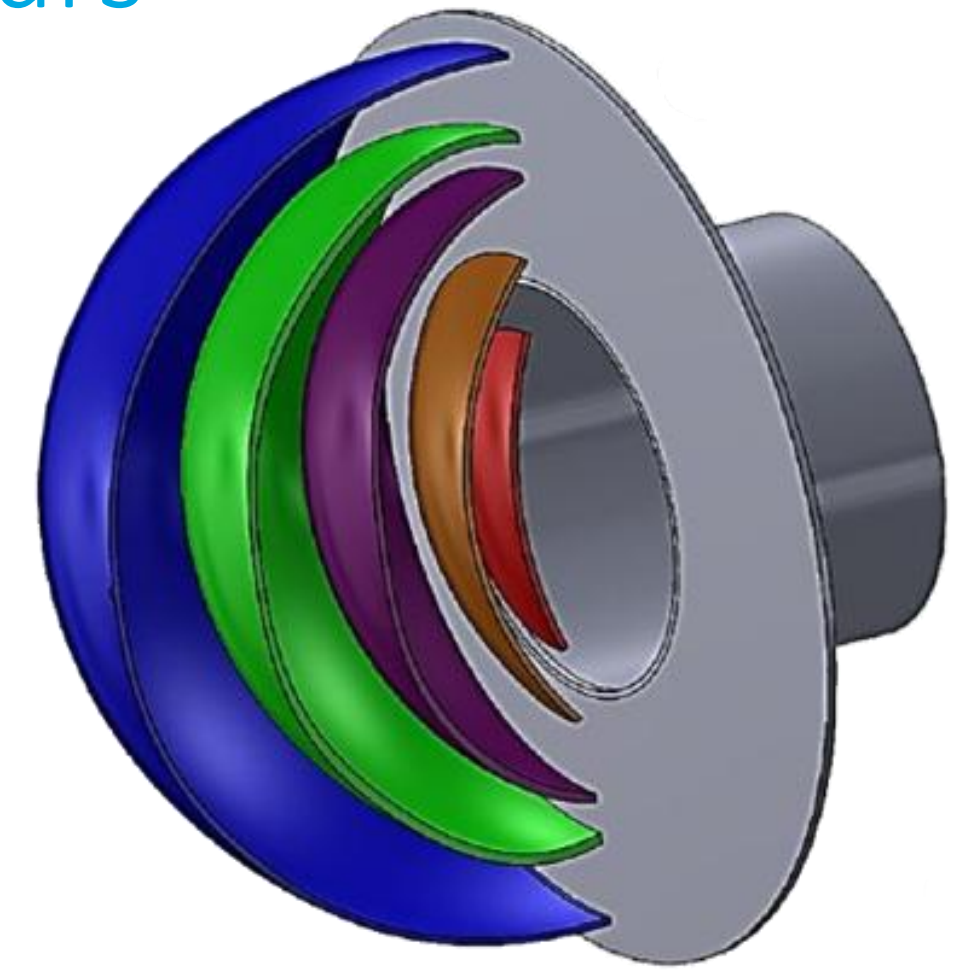
100% Velocity – 9% of Diameter

60% Velocity – 20% of Diameter

30% Velocity – 46% of Diameter

15% Velocity – 76% of Diameter

7.5% Velocity – 113% of Diameter



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Design – Push/Pull

REGAIN AIR

Re-circulated clean air replenishes the booth's environment and pushes the dust, smoke, and fumes toward the filtering area as shown in fig.4, a portion of the clean filtered air is returned through a plenum across the top of the station to form a Clean Air Curtain, pushing the contaminants away from the worker's breathing zone.

Fig.4

Wet Downdraft

- Single or Double work area
- Regain for “push/pull” to get up to 400 FPM


FILTER 1
HYDROTRON

HYDROTRON MODEL DHYD-1-95-15-10-42RCS
WET DOWNDRAFT TABLE 10’ WIDE
15 HP - 9,500 CFM, 42” DEEP WITH CRANE SLOT
AND REGAIN


FILTER
HYDROTRON
FILTER
HYDROTRON
FILTER
HYDROTRON


PELIGRO
PUEDE TITANIO
EN ESTA CABINA

Other Applications for Wet Collection

- Rubber
  - Smoldering rubber dust from grinding caused many fires in dry collectors before going to a Filter-1 wet collector
- Leather
  - Estwing Manufacturing, where leather handle is sanded, and sparks can be generated from steel
- Food Industry
  - Wet collector to collect dust from batching, blending, weighing, dumping

**Also used for heavy steel sparking applications to eliminate dust collector fires

Dust Collection – Shot/Sand Blast

- Get your dust tested. Find out Kst & Pmax
- Dust is typically too small for wet collection if explosive
- If explosive, follow NFPA 484 and add barrier (mechanical or chemical & explosion vents)
- If not explosive cartridge style or bag style collector

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Questions?

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