“How to Protect the Biomass Drying Process from Fires, Explosions and Downtime”

Best Practices in Biomass Drying Safety Technology

"Protecting Production, and Optimizing Performance"

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Bio

Jeffrey C. Nichols, Managing Partner

Industrial Fire Prevention, LLC., is a specialist in process special hazards protection, and has been helping to protect production and personnel in the process industries in North America since 1979.

Jeffrey C. Nichols Extended Bio

- Managing Partner, Industrial Fire Prevention, *Manufacturer's Representatives.*
- President, South East Fire Prevention, *Consulting and Engineering.*
- Expertise protecting all types of drying, grinding, pelletizing, shredding, pulverizing, sanding, pressing, extruding, storage, conveying and dust collection systems from fires and explosions in various industries since 1979.
- Started in the dust collection business, and naturally progressed into protecting those systems when spark detection & extinguishing systems were first introduced into the United States in the late 1970's. Worked on, helped test and refine the first imported spark detection systems for the North American market, as well as Abort Gate and Back-blast damper designs, all used in the protection of dust collection, and related process equipment.

Industrial Fire Prevention, LLC.

Specialists in protecting drying, conveying and dust collection systems, utilizing state of the art:

- Spark Detection & Extinguishment Systems
- High Speed Abort Gates, Blast gates
- Cyclone Plug-up detection
- Explosion Prevention, Isolation, Venting
- Explosion Suppression, Diverters, Dampers
- Emissions Monitoring

Overview of Fire & Explosion Prevention in Biomass Drying Systems

This program will raise awareness and help attendees understand fire and deflagration hazards in biomass drying.

- Overview of Fire and Dust Explosion fundamentals
- Overview of the OSHA, FM Global, and NFPA requirements, and resources
- Overview of general Process Fire & Explosion Prevention principles
- Overview of Biomass Drying System Protection principles

Why?

Dryer Duct Fire

Biofuels Safety Trends

Risk and Safety Blog

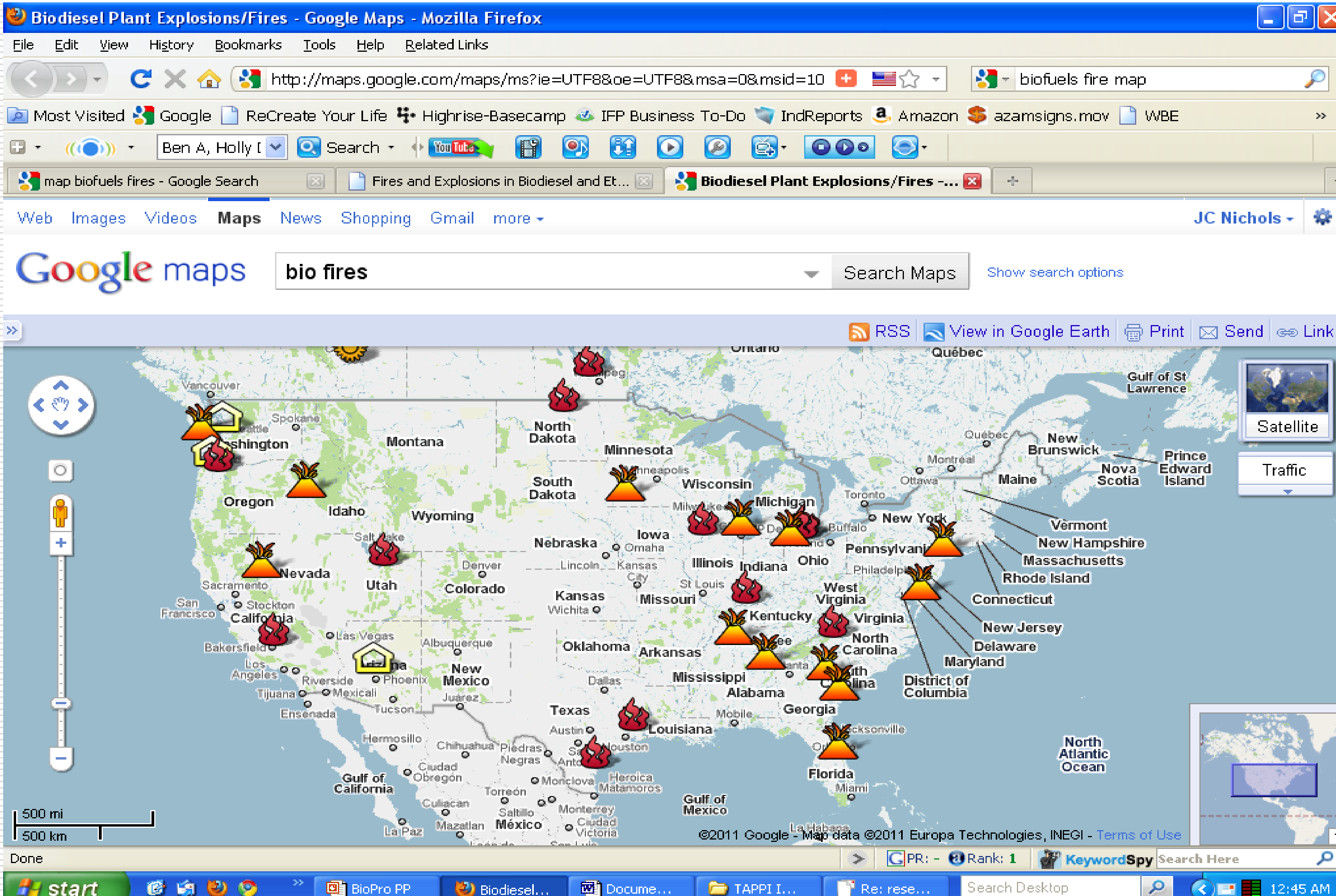
- **Fire at a Biodiesel Facility**
- Sunday, January 16th, 2011
- **Another Biodiesel Fire…hopefully the last one for 2010!**
- Wednesday, December 15th, 2010
- **Biodiesel Accident Trend Continues in 2010**
- Tuesday, August 10th, 2010
- **Biodiesel Incidents Trend**
- Tuesday, January 26th, 2010

- **"Based on the statistics, the biodiesel industry in the US is experiencing and accident every two-and-a-half months, i.e. approx. 10 weeks"**

Thanks to Dr. Sanjeev Saraf, Exponent - Risk & Safety Blog

Biofuels Fire Map

Thanks to John Astad - Combustible Dust Policy Institute



Biomass Fire Media Reports

- **January 23, 2009 German Pellet Mill Explosion**
- **August 29, 2008 Wood Pellet Dust Fire Non-Issue?**
- A New England wood pellet manufacturer experiences a second dust related fire in two weeks.
- Last month a similar combustible dust related fire at a wood pellet plant occurred at (Pellet Plant) in Kelowna, British Columbia
- From viewing the above picture, it wasn't much of a non-issue, when last year in Monticello, WI, *(Pellet plant)* exploded.
- Over the last six weeks in Marion, PA., *(Pellet Plant)*, has experienced hopper explosions twice

-John Astad - Combustible Dust Policy Institute

Biomass Fire Media Reports, cont.

- **Recent Wood Pellet Mfg. Explosions and Fires**

  8/22/08 _________ Pellets- dust explosion/hopper
  8/15/08 __________Wood Pellets- fire/sawdust dryer
  8/10/08 __________Wood Pellets- fire/pellet mill
  7/15/08 __________Pellets- dust explosion/hopper
  5/20/08 __________Wood Pellets- fire/exterior burner

- **Friday, August 22, 2008**
  Wood Pellet Plant Dust Explosion Again

- **Monday, August 18, 2008**
  Multiple Repeat Wood Pellet Plant Fires

-John Astad Combustible Dust Policy Institute

Media Reports

http://dustexplosions.blogspot.com

Friday, January 23, 2009

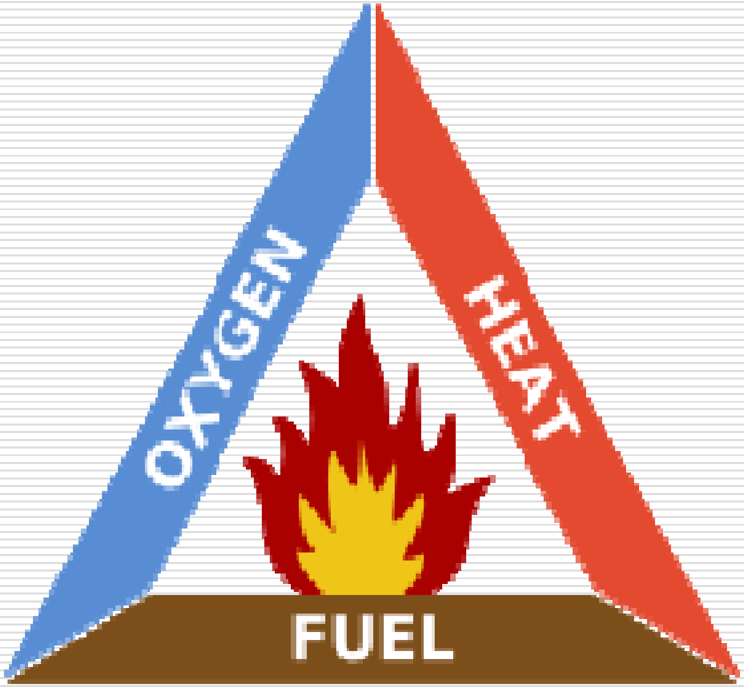
- **"Last year in the United States, nearly a half a dozen combustible dust related fires and explosions occurred in wood pellet plants within a short time span of three months."**

-John Astad, Combustible Dust Policy Institute

Fire & Deflagration Ingredients

- Combustible gases
- Combustible dust (or Hybrids Mixtures)
- Dispersion in air – dust cloud
- Accumulation on surfaces (1/32" over 5%)
- Dust Layers
- Oxygen
- Potential ignition sources

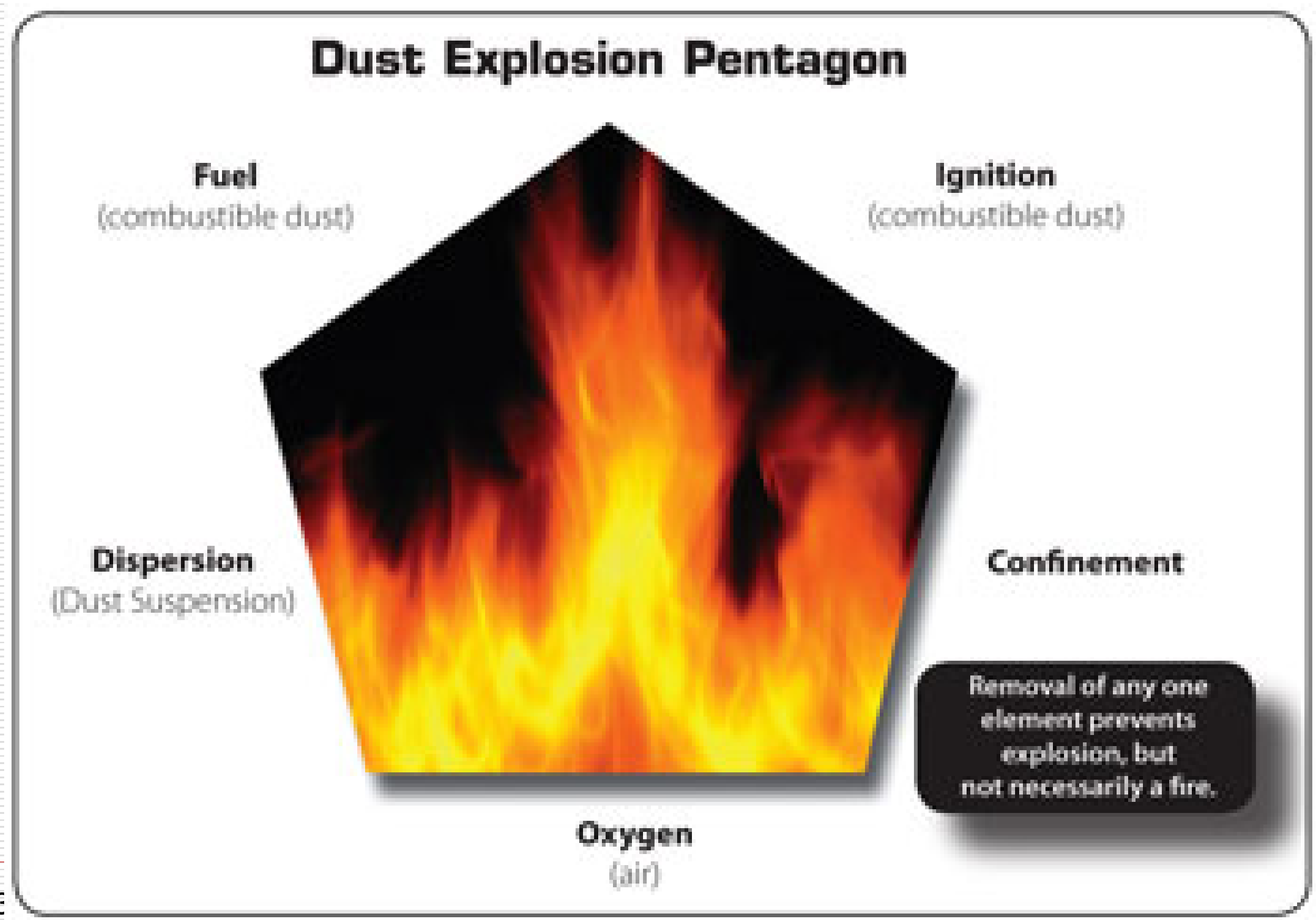
Elements: “Fire Triangle”



FIRE:

- **FUEL**
  - (Biomass Material)
- **OXIDIZER**
  - (Oxygen)
- **ENERGY** (Heat)
  - (Spark)

The "Deflagration Pentagon":



Elements for Deflagration
The "Deflagration Pentagon":

- FUEL – Material, Fines, Dust
- OXIDIZER – Oxygen (21%)
- ENERGY – Ignition, spark, heat, friction
- DISPERSION in air (dust cloud) = *FLASH FIRE*
- Within a CONFINED AREA = *DEFLAGRATION*

Factors affecting Combustibility:

- Particle size & Surface area
- Particle size distribution
- Dust concentration
- Oxygen concentration
- Moisture content
- Ignition energy, ignition temperature
- Explosibility

Factors affecting Deflagration

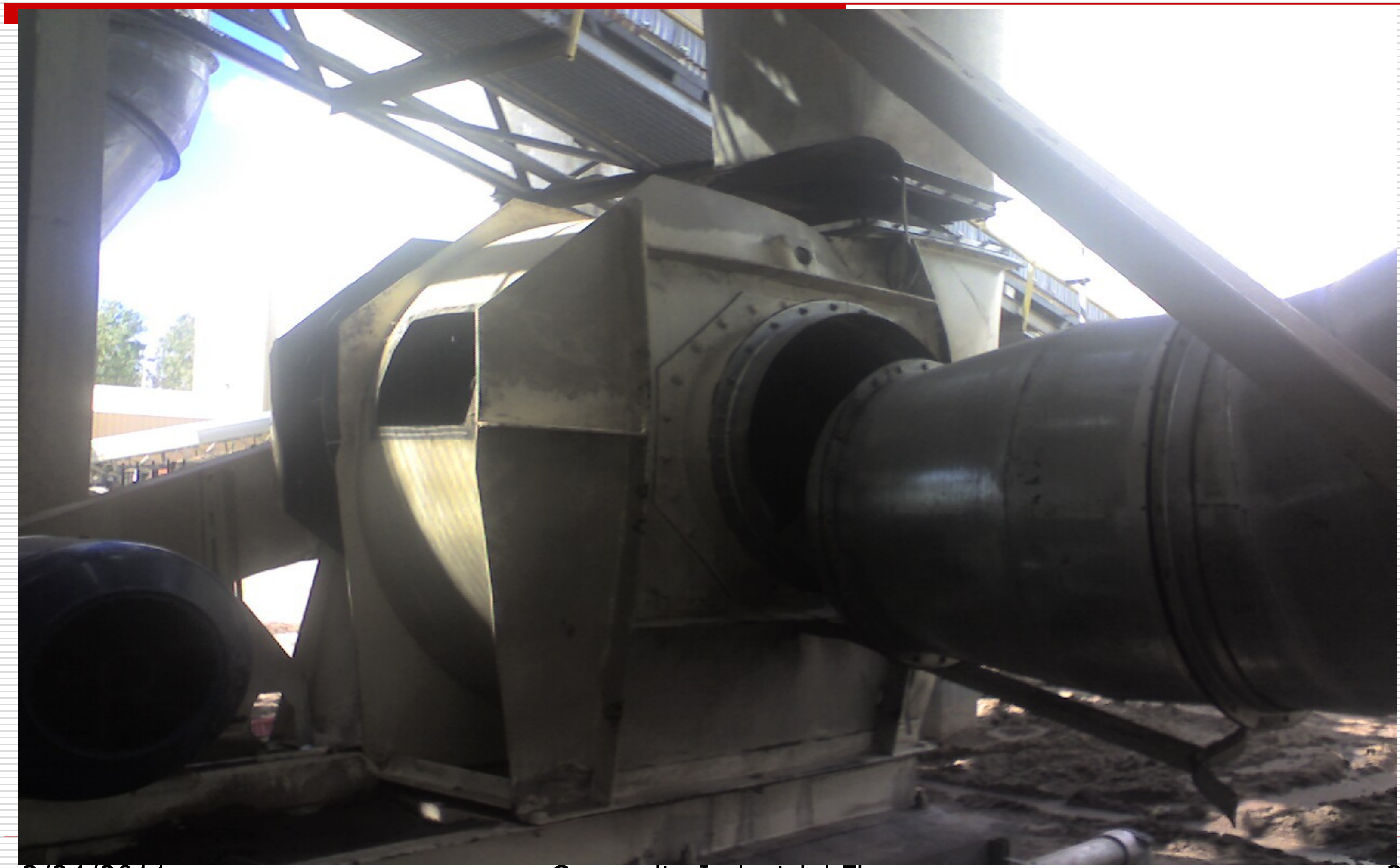
- **Fuel Properties**: must be combustible, have particle size and distribution capable of propagating a flame, in sufficient concentration & moisture content.
- **Dispersion**: dust concentration dispersion, within explosive limits, air-fuel ratio.
- **Ignition**: sufficient ignition energy.
- **Oxygen**: sufficient to sustain combustion.
- **Confinement**: sufficient over pressurization

Primary & Secondary Explosions

- A **primary** deflagration will often propagate to secondary processes, filtering, storage and even back to the production area, where more dust has dispersed, and is ignited.
- The **secondary** explosion can be <u>more violent</u> than the primary, and may cause injury, destruction and death.

Biomass explosion - cyclones

Biomass explosion - fan



KEY: *Recognize process dust as a potentially catastrophic hazard!*

- Combustible dust 500 microns or less
- Have dust tested
- Know which Safety Standards apply
- Fire & Explosion Prevention Systems
- Fire & Explosion Isolation, Protection
- Have preventative maintenance and housekeeping procedures in place

Generic* Biomass values:

95% < 75µm
less than 5% moisture
Pmax = 6.5-7.0 bar
KSt = 100 - 140 bar m/s
MEC = ~30 g/m^3
MIE = 10 < MIE < 30
MIT = ~250°C

**Data not to be used for design purposes!*

Thanks to Dr. Ashok Dastidar Fauske & Associates, LLC

General
Minimum Ignition Temperatures

MINIMUM IGNITION TEMPERATURES*

	CLOUD		LAYER	
	°C	°F	°C	°F
WOOD	480	896	260	500
PAPER	580	1076	360	680
CELLULOSE	500	932	380	716
PEAT	470	878	320	608
COCOA	580	1076	460	860
CHARCOAL	520	968	270	518
COTTON	560	1040	350	662
TOBACCO	470	878	280	536

* *Rolf K. Eckhoff, »Dust explosions in the process industries« (2nd edition)*

Common Risk Factors

- Combustible dust hazards not recognized
- Dangerous dust accumulations
- Engineering controls inadequate
- Change management inadequate
- Inadequate dust collection system design and maintenance
- Inadequate fire and explosion prevention

OSHA **Combustible Dust National Emphasis Program**

This instruction contains policies and procedures for inspecting workplaces that create or handle combustible dusts. In some circumstances these dusts may cause a deflagration, other fires, or an explosion. These dusts include, but are not limited to:

- Metal dust such as aluminum and magnesium.
- **Wood dust**
- Coal and other carbon dusts.
- Plastic dust and additives
- **Biosolids**
- Other organic dust such as sugar, flour, paper, soap, and dried blood.
- Certain textile materials

NFPA 664 Standard for the Prevention of Fires and Explosions in Woodworking Facilities

- **8.2.2.2.2* Ducts with a Fire Hazard.** Ducts conveying dry material released by equipment having a high frequency of generated sparks shall be designed and constructed in accordance with one of the following:
- (1) Equipped with a listed spark detection and extinguishing system installed downstream from the last material entry point and upstream of any collection equipment.
- (2)* Equipped with be a listed spark detection system actuating a high-speed abort gate, provided the abort gate can operate fast enough to intercept and divert burning embers to atmosphere before they can enter any collection or storage equipment.
- (3) Ducts conveying material to locations representing minimal exposure to personnel and the public at large shall be permitted without spark detection and extinguishing systems subject to a risk analysis acceptable to the Authority Having Jurisdiction.

Biomass Process

Best Practices in Biomass Drying Safety Technology

Layered Safety Systems:

- **Prevention:** Spark Detection & Extinguishment Systems, Flame Detection, Temperature Detection, Rate of Rise, Smoke, Combustion Gas detection
- **Fire Protection:** Automatic Sprinkler and Deluge systems with manual bypass
- **Explosion Protection:** Venting, Isolation and Suppression Systems
- **Interlocks:** Diverters, Fire Dumps, Sequential Shutdown, Alarms

Fire & Explosion Safety Systems

Four distinct disciplines include:

- Phase 1 - FIRE PREVENTION
- Phase 2 - FIRE PROTECTION
- Phase 3 - EXPLOSION PREVENTION
- Phase 4 - EXPLOSION PROTECTION

1 - Fire Prevention

Preventative Fire Systems are pro-active and include:

- CO / Combustible Gas detection
- Emissions Monitoring
- Heat & Smoke Detection -
- Flame Detection -
- **Spark Detection**
- **Spark Extinguishment**, suppression, inerting, spark arrestor, diverter

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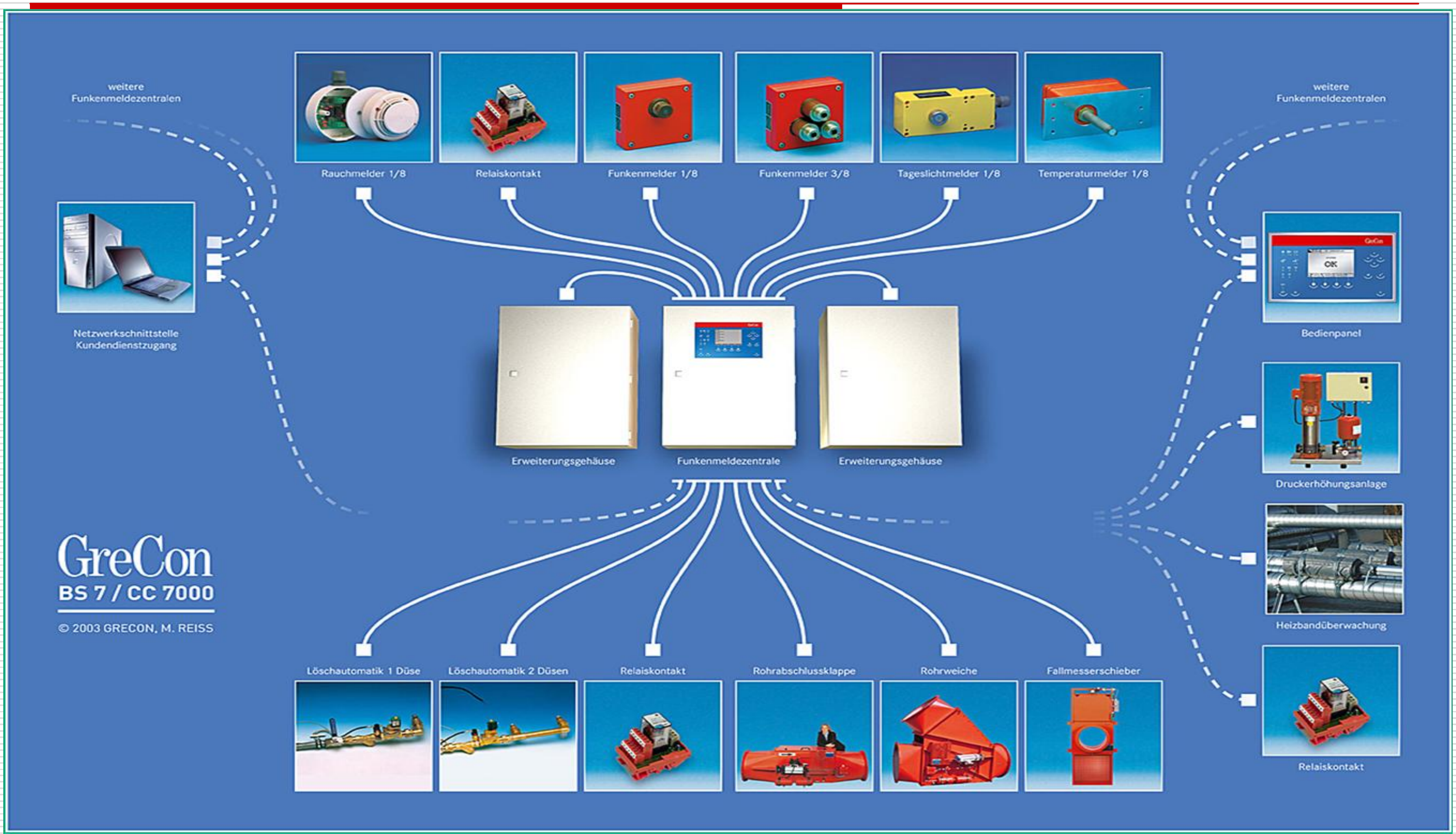
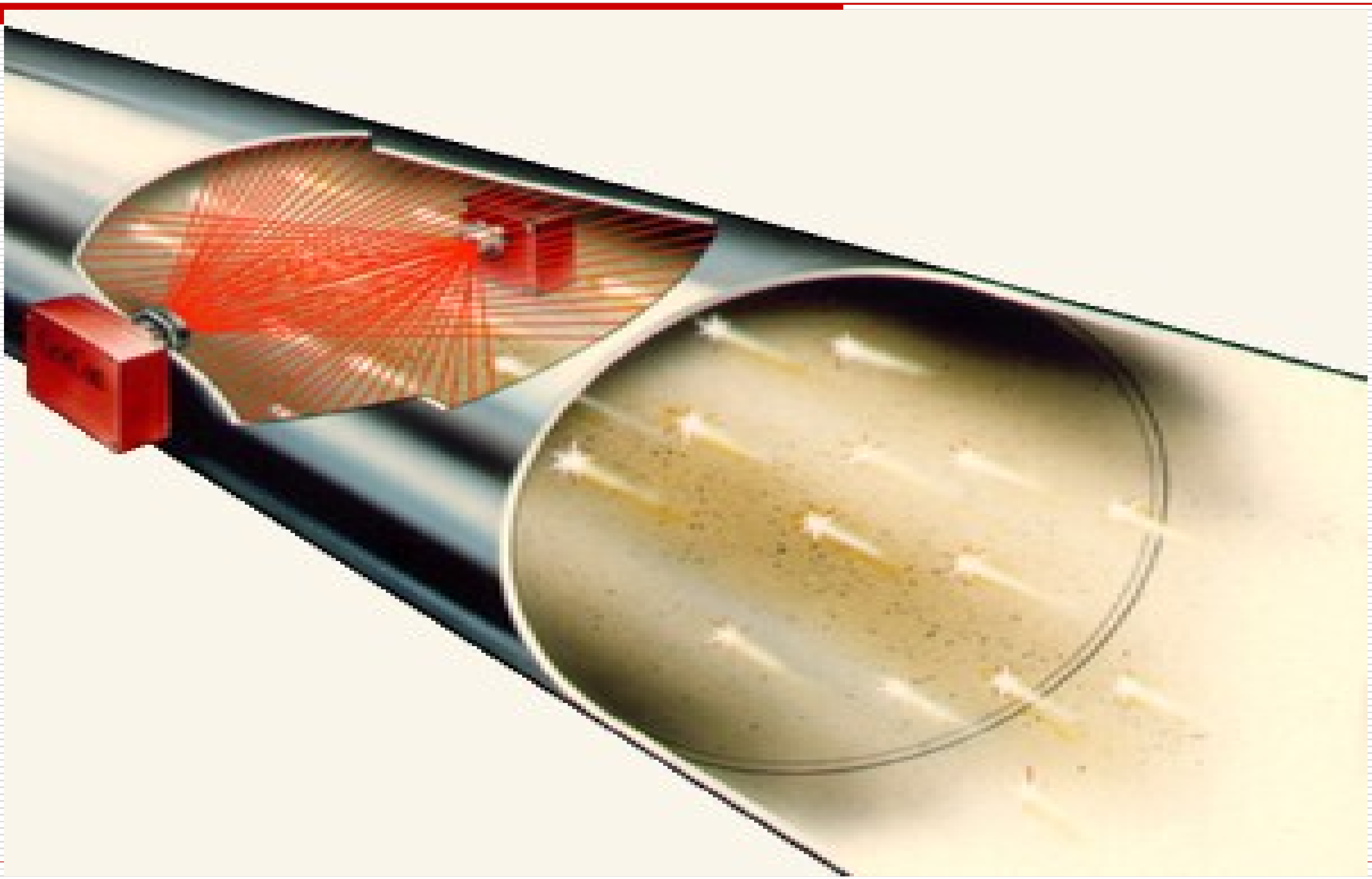
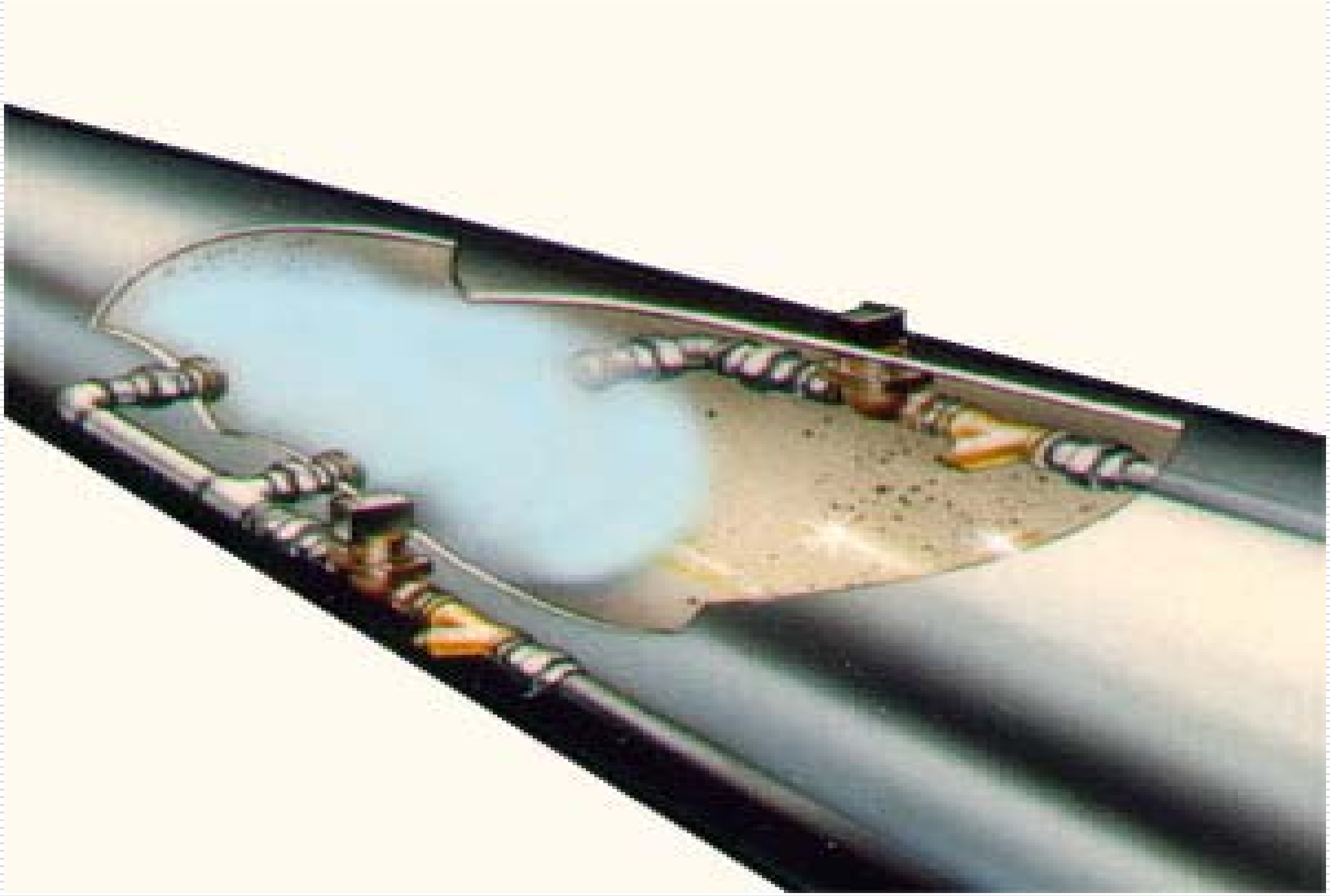
Spark Detection and Extinguishment Systems



Spark Detection Principle:
Multiple Sensors at detect point



Spark Detection Principle: Automatic Extinguishment



Fire Prevention – Best Practice

***Dust Collection Fire Prevention Method*:**

Listed Spark Detection Extinguishment System:

- **Protect Main Ducts**
- **Last Possible Spark Source**
- **Isolate Dangerous Equipment**
- **Protect Conveyors, Dust Collectors, Storage Bins, Return Air Systems**
- **Interlock Alarms and Shutdowns**

2 - Fire Protection

Fire Protection Systems are reactive, defensive systems include:

- Thermal, Rate of Rise, Temp. Detection
- UV/IR Flame Detection
- Deluge Systems
- Sprinkler Systems
- Water Mist Systems
- Fire Suppression Systems

3 - Explosion Prevention

Includes all Fire Prevention and Fire Protection methods previously mentioned, plus:

- Chemical Isolation Systems
- Mechanical Isolation Systems:
  - Diverters
  - Gates
  - Valves

4 - Explosion Protection

Defensive Mitigation Systems include:

- Explosion Doors
- Explosion Vents & Panels
- Indoor Explosion Venting
- Explosion Detection
- Explosion Suppression

Keys to Hazard Assessment & Management

- Dust Combustibility
- Process Hazard Analysis
- Electrical Hazards/Classification
- Dust Control
- Ignition Control
- Damage Control
- Training

Keys to Process Safety Management

- Develop Corp. wide Safety Mindset & Culture – top down
- Training and awareness
- Understand potential dust hazards
- Prudent and sequential start-up, operating, interlocks, shutdown, maintenance, housekeeping, safety, and change management procedures.

Process Safety Design Principles

- **Segregate** – interposing of fire and explosion resistant barriers and diverters *between combustible processes*.
- **Separate** – create distance between combustible processes.
- **Detach** – Isolate - locate combustible processes in specially constructed areas, separate building, or outside.

Dryer Protection Principles

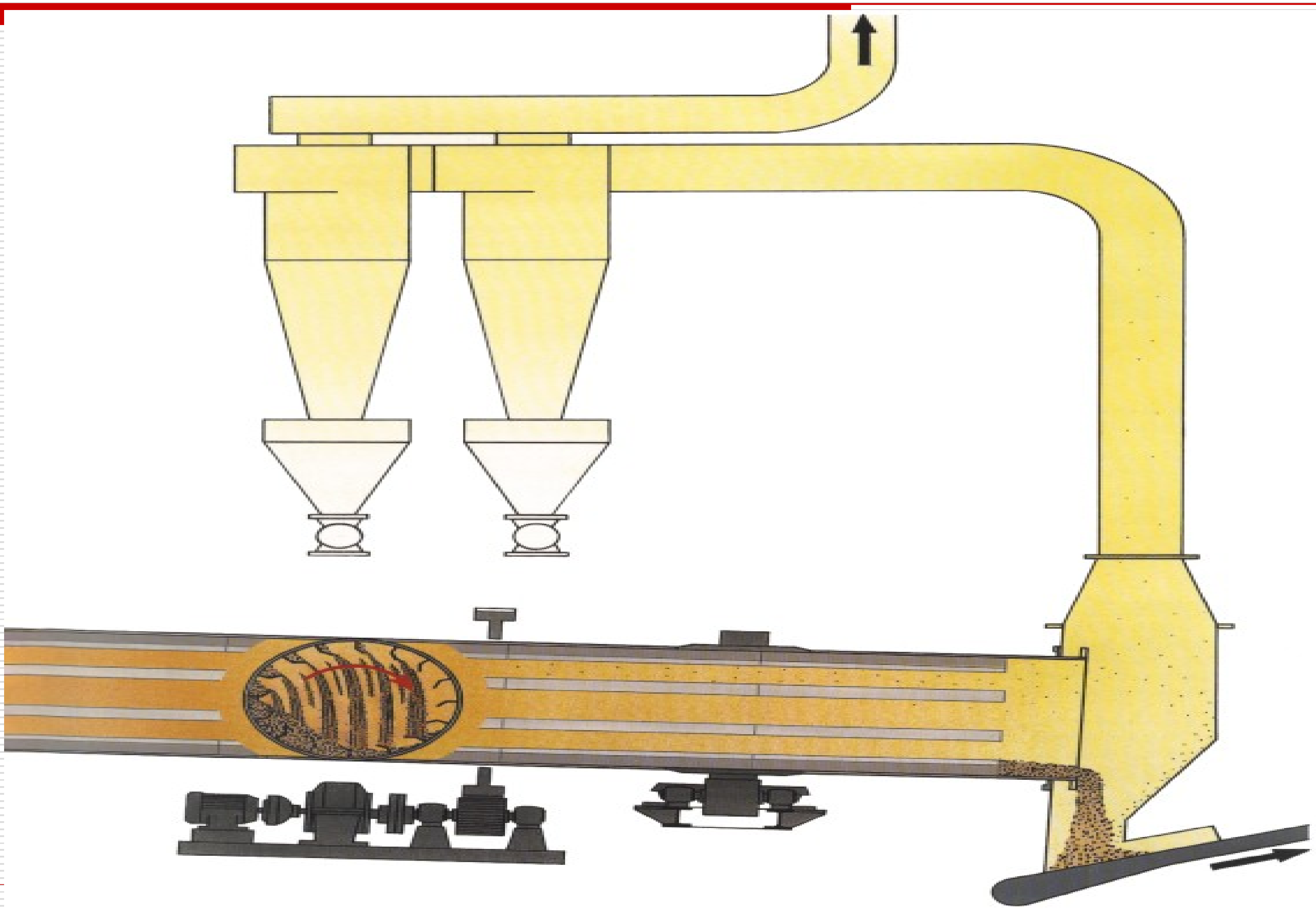
- Rotary Drum: Single or Multiple Pass, Direct or Indirect fired, drop box and mechanical conveyor, or pneumatic convey
- Flash tube, Fluidized Bed, Fixed bed/Belt, Steam, Paddle/Screw, Cascade, Pneumatic, Spray dryers

Dryer Protection Principles TSI Rotary Drum

Rotary Dryer Protection Principles

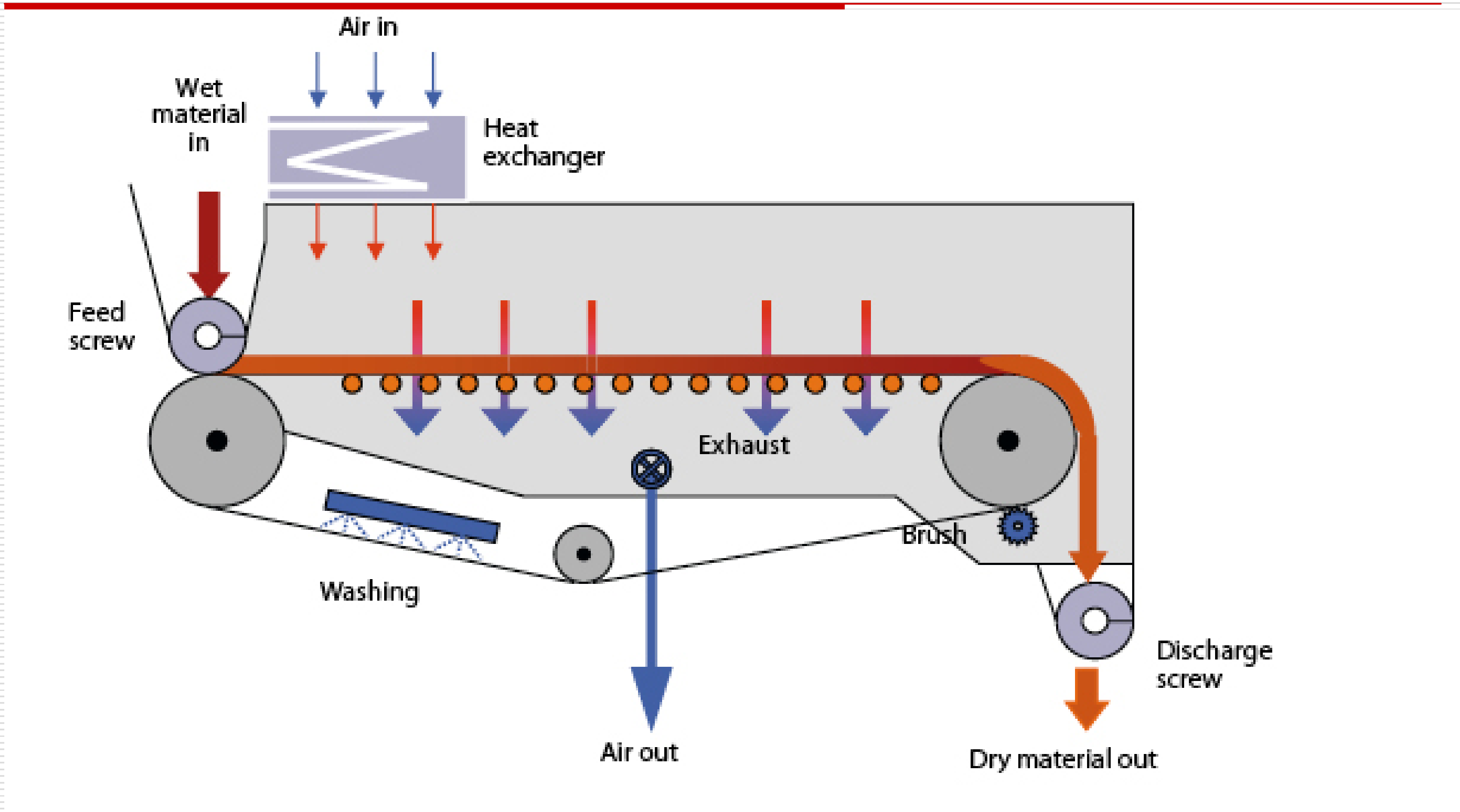
- Dryer Primary Detect & Extinguish
- Dryer Secondary Detect (& Extinguish)
- Cyclone - Detect after cyclone, interlock deluge, divert, fire dump
- Protect material flow, dust collection

Dryer Protection Principles
Barr-Rosen Dryer with Drop box

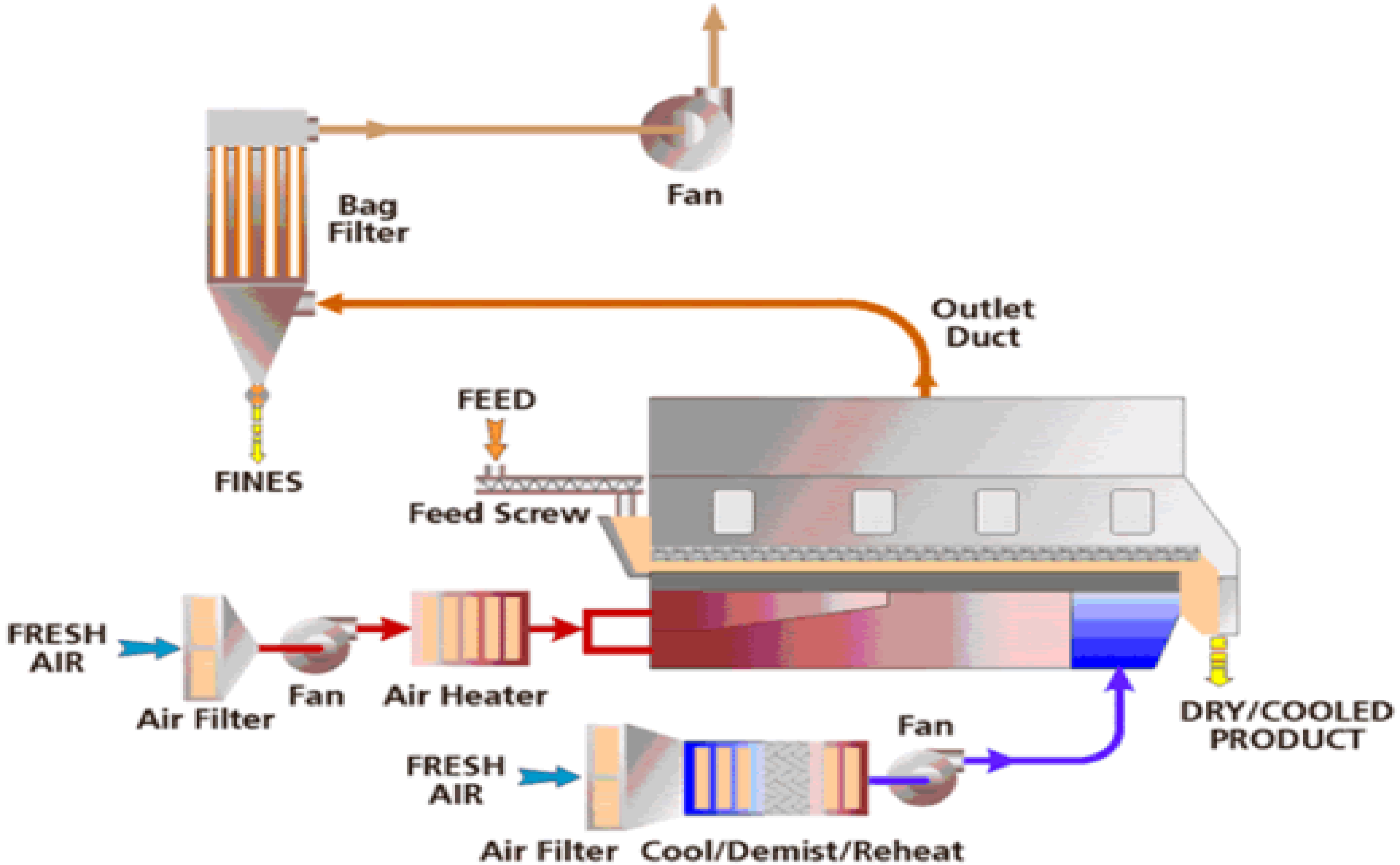


Dryer Protection Principles
Small Dryer – drop box

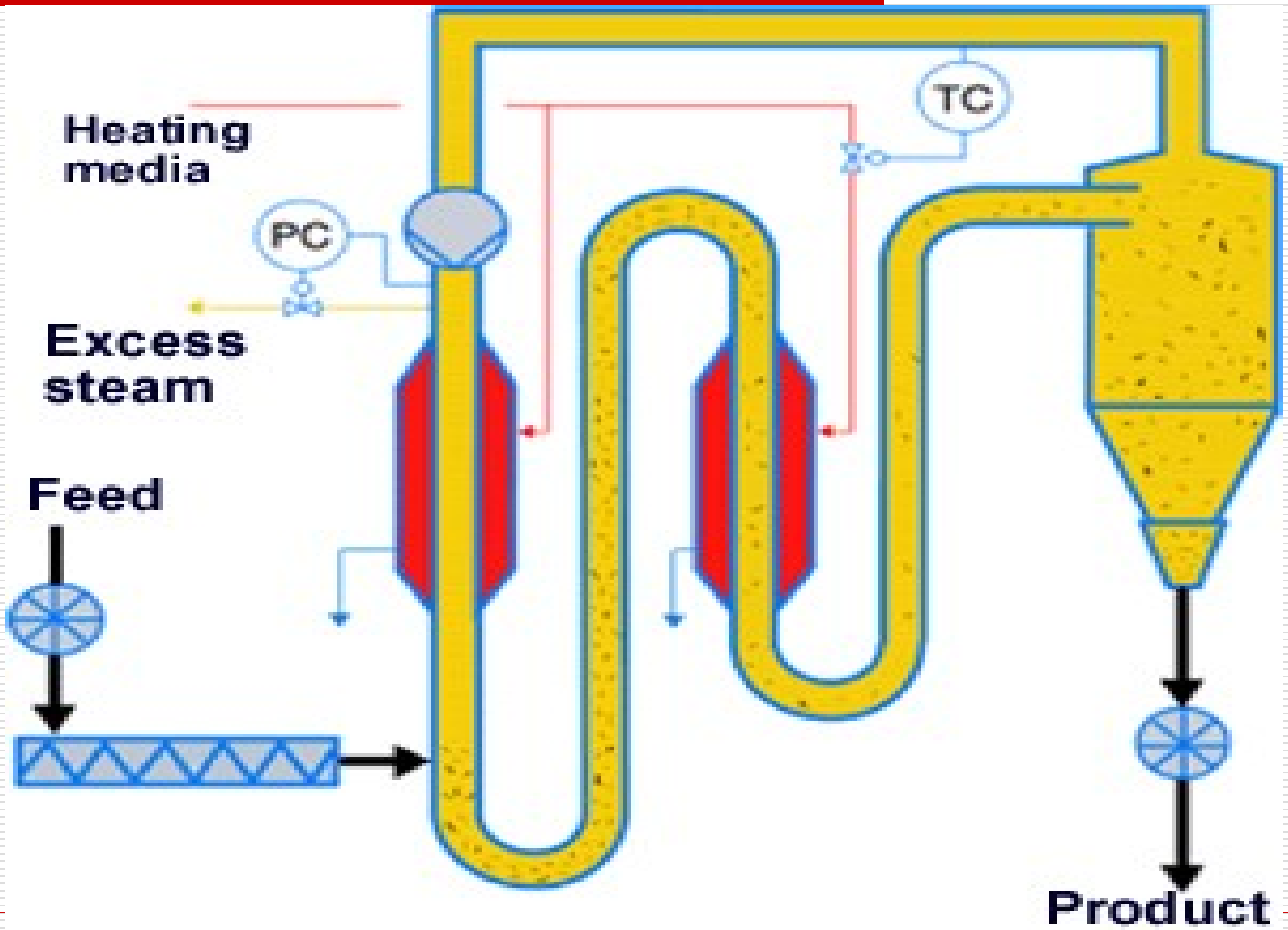
Dryer Protection Principles
Metso Biomass Belt Dryer



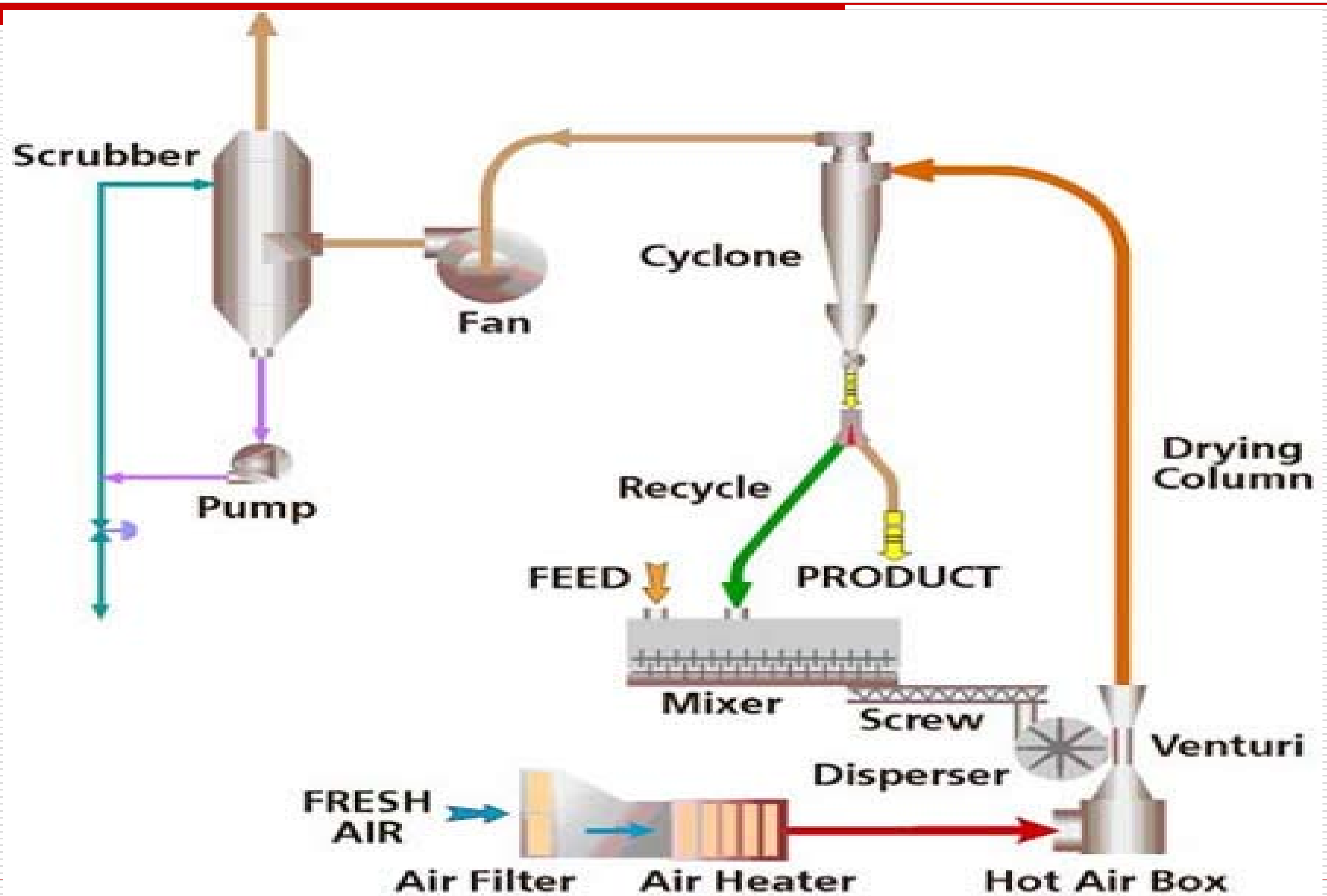
Dryer Protection Principles
Barr-Rosen Fluid Bed Dryer



Dryer Protection Principles
Barr-Rosin Steam Dryer



Dryer Protection Principles
Barr-Rosin Flash Dryer



Program Summary

- Awareness is key to prevention
- Understand process dust hazards
- Get process dust, fines tested
- Implement Safety Programs
- Control dust and ignition sources
- Prevention Programs and Systems
- Protection Systems, Mitigation

OSHA.gov Resources

OSHA.gov

- **Directives CPL 03-00-008 - Combustible Dust National Emphasis Program (Reissued)**

http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=DIRECTIVES&p_id=3830

Safety and Health Information Bulletin SHIB 07-31-2005

- **Combustible Dust in Industry: Preventing and Mitigating the Effects of Fire and Explosions**

http://www.osha.gov/dts/shib/shib073105.html

NFPA Standards

NFPA.org

http://www.nfpa.org/aboutthecodes/list_of_codes_and_standards.asp

NFPA 68, Standard on Explosion Protection by Deflagration Venting

- NFPA 69, Standard on Explosion Prevention Systems
- NFPA 70, National Electrical Code
- NFPA 91, Standard for Exhaust Systems
- NFPA 654, Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids
- NFPA 664: Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities

FM Global Resources

- FM Global Loss Prevention Data Sheets

http://www.fmglobal.com/FMGlobalRegistration/Downloads.aspx

- FM Global Data Sheets 7-76 PREVENTION AND MITIGATION OF COMBUSTIBLE DUST EXPLOSION AND FIRE

- FM Global Data Sheets 7-73 DUST COLLECTORS AND COLLECTION SYSTEMS

Deflagration Key Words

- **Kst** - Deflagration Index
- **MIE** - Minimum Ignition Energy
- **MEC** - Minimum Explosible Concentration
- **MIT** - Minimum Ignition Temp – dust cloud, Minimum ignition temp - dust layer
- **LOC** - Limiting Oxygen Concentration
- **LFL** - Lower Flammability limit
- **Pmax** - Maximum Explosion Pressure
- **(dp/dt)max** - Max Rate of Pressure Rise

Explosion Definitions

Deflagration – a flame spread rate of less than the speed of sound. (subsonic)

Explosion – a rapid release of high pressure gas into the environment.

Detonation – a flame spread rate that is above the speed of sound. (supersonic)

Combustible Dust - A combustible particulate solid that presents a fire or deflagration hazard when suspended in air or some other oxidizing medium over a range of concentrations, regardless of particle size or shape.

Explosion Definitions, cont.

Explosive material/substance – those capable of causing an explosion influenced by confinement.

Hybrid Mixture - A mixture of a flammable gas with either a combustible dust or a combustible mist.

Minimum Explosive Concentration (**MEC**) - The minimum concentration of combustible dust suspended in air, measured in mass per unit volume that will support a deflagration

Explosion Definitions, cont.

Minimum Ignition Energy **(MIE) -** The minimum ignition energy (MIE) of the sample is determined by suspending the sample in a Hartmann Lucite explosion chamber. To determine the MIE, the energy of the electrical spark used to ignite the dust is varied until the MIE is determined.

Minimum Ignition Temperature **(MIT) -** Minimum ignition temperature (MIT) is determined by using the Godbert-Greenwald furnace. Dust is discharged through this furnace at various temperatures. The lowest temperature that ignites the dust is considered to be the MIT.

Explosion Definitions, cont.

Minimum Explosible Concentration **(MEC) -** Minimum explosible concentration (MEC) of the sample is determined by suspending the sample in a 20-liter explosibility testing chamber and ignited with a 2500-joule chemical igniter. MEC is the lower concentration limit of explosibility for the dust. This limit is determined using test material that has been sieved through a 40-mesh sieve (425 µm particle size), dried, suspended in a 20-liter explosibility testing chamber. Approximately 200 grams of material with a particle size of 425 µm or less are needed for the MEC tests.

Dust Deflagration Index **(K_{st}) -** test results provide an indication of the severity of a dust explosion.