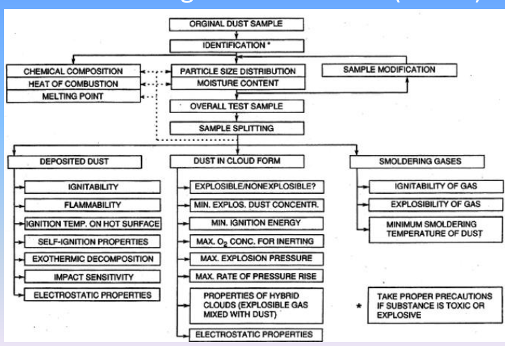
Process Hazard Analysis

2011 North Carolina Industrial Ventilation Conference

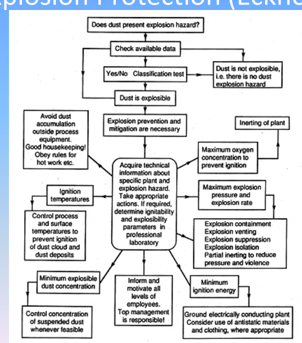
What is Included in a Process Hazard Analysis?

- The design of the processes and facilities shall consider the physical and chemical properties that establish the hazardous characteristics of the materials.
- The design of the fire and explosion safety provisions shall be based on a process hazard analysis of the facility, the process, and the associated fire or explosion hazards.
- The results of the process hazard analysis shall be documented and maintained for the life of the process.
- The process hazard analysis shall be reviewed and updated at least every 5 years.

Characterizing a Dust's Hazard (Eckoff)



A General Approach to Practical Dust Explosion Protection (Eckhoff)



How to do a Process Hazard Analysis

- Hazards analysis can get pretty sophisticated and go into much detail. Where the potential hazards are significant and the possibility for trouble is quite real, such detail may well be essential. However, for many processes and operations — both real and proposed — a solid look at the operation or plans by a variety of affected people may be sufficient. The some different methods include:
- WHAT - IF Checklist.
- Hazard and Operability Study (HAZOP).
- Failure Mode and Effect Analysis (FMEA).
- Fault Tree Analysis

Process Hazard Analysis Methods

- WHAT - IF Checklist is a broadly-based hazard assessment technique that combines the creative thinking of a selected team of specialists with the methodical focus of a prepared checklist. The result is a comprehensive process hazards analysis that is extremely useful in training operating personnel on the hazards of the particular operation.
- Hazard and Operability Study (HAZOP) is a formally structured method of systematically investigating each element of a system for all of the ways in which important parameters can deviate from the intended design conditions to create hazards and operability problems. The hazard and operability problems are typically determined by a study of the system and instrument diagrams (or plant model) by a team of personnel who critically analyze the effects of potential problems arising in each system and each vessel of the operation.

Process Hazard Analysis Methods

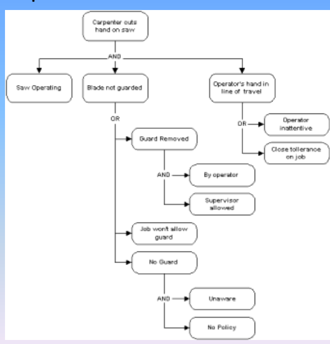
- Failure Mode and Effect Analysis (FMEA) is a methodical study of component failures. This review starts with a diagram of the process that includes all components which could fail and conceivably affect the safety of the process.
- Fault Tree Analysis is a quantitative assessment of all of the undesirable outcomes, such as a toxic gas release or explosion, which could result from a specific initiating event. It begins with a graphic representation (using logic symbols) of all possible sequences of events that could result in an incident. The resulting diagram looks like a tree with many branches — each branch listing the sequential events (failures) for different independent paths to the top event.

PHA Team Members

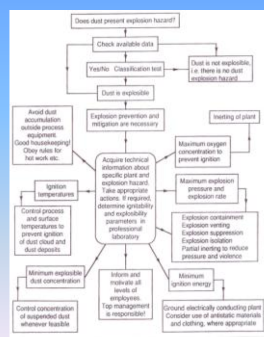
The PHA Team should consist of a representative from each of the following areas:

- Maintenance/Facilities
- Process Engineering
- Production
- Quality Assurance
- Environmental, Health and Safety
- Engineering
- Consultant (if needed)
- Equipment Manufacturer or Representative (if needed)
- Corporate Engineering, Safety or QA (if needed)

Example of Fault Tree Hazard Analysis



Combustible Dust Hazard Analysis



Evaluate the Potential for or Severity of Fire or Explosion by

- Introducing or increasing flow or quantity of flammable substances?
- Introducing or increasing the exposure of a flammable substance to air?
- Introducing a new ignition source (sparking , static, friction, flame, lightning, elevated surface temperature, etc.)?
- Creating a flammable mixture that did not previously exist?
- Causing the operating temperature of a substance to rise above its ignition temperature?

Evaluate the Potential for or Severity of Fire or Explosion by (cont.)

- Introducing combustible dusts into the process and/or cause combustible dust to become airborne?
- Changing the electrical classification of an area?
- Introducing equipment not approved for a classified area?
- Introducing the storage or use of materials incompatible with each other?
- Impairing the effectiveness of current fire protection system (sprinklers, alarms, fire walls, explosion venting, separation distances)

Evaluate the Potential of Equipment Failure, Explosion, or Implosion by:

- Introducing or increasing flammable mixtures?
- Creating the potential for a runaway reaction?
- Generating excess pressure in the system/process?
- Creating a vacuum?
- Introducing or using materials incompatible with the intended equipment?

Evaluate the Potential for Adverse Health effects by:

- Introducing or increasing personal exposure to harmful levels of hazardous chemicals?
- Introducing or increasing respiratory hazards?
- Introducing or increasing personal exposure to harmful levels of noise, radiation (UV or gamma sources), vibration, heat/cold, lasers?
- Creating the potential for an oxygen deficient environment?

Evaluate the Risk or Severity of an Environmental Release by :

- Creating a need for or impairing the effectiveness of containment systems?
- Creating a need for or impairing the effectiveness of drain or sump systems?
- Creating a need for or impairing the effectiveness of leak detection or level detection systems?
- Creating or increasing the generation of hazardous waste?
- Creating or increasing waste water discharge?
- Creating or increasing sources of air emissions?

Evaluate the Life Safety Requirements:

- Deflagration prevention and control for occupied enclosures shall prevent the structural failure of the enclosure and minimize injury to personnel in adjacent areas outside of the enclosure.
- Deflagration prevention and control for unoccupied enclosures shall prevent the rupture of the enclosure.
- Deflagration prevention and control shall be arranged to avoid injury to personnel.

Evaluate the Property Protection Requirements:

- Deflagration prevention and control systems shall be designed to limit damage of the protected enclosure.
- Deflagration prevention and control systems shall be arranged to avoid ignition of adjacent property.
- Deflagration prevention and control systems shall be designed to avoid damage to adjacent property.
- Deflagration prevention and control shall be designed to avoid projectile damage to adjacent property.

Evaluate Methods Based on the Prevention or Limitation of Damage

The following shall be considered methods based on preventing or limiting damage:

(1) Predeflagration detection and ignition control systems
(2) Deflagration suppression
(3) Isolation methods
(4) Deflagration pressure containment

The limitations specific to each method shall be considered and are specified in the corresponding chapter for each method.

Evaluate Methods Based on the Prevention or Limitation of Damage, Factors to Be Considered

The following factors shall be considered in the selection of one of the methods and the design of the system:
- (1) Effectiveness of each method
- (2) Reliability of the system
- (3) Personnel hazards inherent in each method

The reliability of the system chosen shall be assessed using the following factors:
- (1) System design basis
- (2) Possibility of electrical and mechanical malfunction
- (3) Dependence on sophisticated activating systems
- (4) Need for special installation, training, operating, testing, and maintenance procedures
- (5) Further limitations as presented in each chapter.

Evaluate Design Considerations of Oxidant Concentration Reduction

The following factors shall be considered in the design of a system intended to reduce the oxidant concentration:
- (1) Required reduction in oxidant concentration
- (2) Variations in the process, process temperature and pressure, and materials being processed
- (3) Source purge gas supply and equipment installation
- (4) Compatibility of the purge gas with the process
- (5) Operating controls
- (6) Maintenance, inspection, and testing
- (7) Personnel exposure due to leakage of purge gas to surrounding areas
- (8) Need for breathing apparatus by personnel
- (9)*Reduced effectiveness of purge gas due to equipment leakage and loss through vents.

Evaluate Design Considerations of Combustible Concentration Reduction

All of the following factors shall be considered in the design of a system intended to reduce the combustible concentration below the LFL:
- (1) Required reduction in combustible concentration
- (2) Variations in the process, process temperature and pressure, and materials being processed
- (3) Operating controls
- (4) Maintenance, inspection, and testing

The LFLs of the combustible components shall be determined at all operating conditions, including startup and shutdown.

Evaluate Design Considerations of Deflagration Control by Suppression

Enclosures that can be protected by a deflagration suppression system shall include, but shall not be limited to, the following equipment:
- (1) Processing equipment, such as reactor vessels, mixers, blenders, pulverizers, mills, dryers, ovens, filters, screens, and dust collectors
- (2) Storage equipment, such as atmospheric or low-pressure tanks, pressure tanks, and mobile facilities
- (3) Material-handling equipment, such as pneumatic and screw conveyors and bucket elevators
- (4) Laboratory and pilot plant equipment, including hoods, glove boxes, test cells, and other equipment
- (5) Aerosol filling rooms

The suppression system shall be of a design that has been tested under deflagration conditions to verify performance.

Evaluate Design Considerations of Deflagration Control by Active Isolation

The detection conditions, and the positioning of the detection points and the minimum and maximum barrier locations shall be based on a quantitative analysis that includes factors such as, but not limited to, the following parameters:
- (1) The entire range of flammable concentrations
- (2) Time required for detection for the least-sensitive and the most-sensitive mixtures
- (3) Possible ignition locations in the primary enclosure
- (4) Time required for barrier formation
- (5) Flame speeds and pressures expected in the pipe
- (6) Time of flame front propagation to the barrier position
- (7) Flow velocity

Piping, ducts, and enclosures protected by an isolation system shall be designed to withstand estimated pressures as provided by the isolation system manufacturer..

Evaluate Design Considerations of Deflagration Control by Passive Isolation

The technique of deflagration isolation by passive means shall be permitted for interruption or mitigation of flame, deflagration pressures, pressure piling, and flame-jet ignition between enclosures that are interconnected by pipes for ducts.

Piping, ducts, and enclosures protected by an isolation system shall be designed to withstand estimated pressures as provided by the isolation system manufacturer.

Passive Isolation Techniques. Passive isolation system design shall be permitted to be based on various techniques that include, but are not limited to, the use of the following equipment:
- (1) Flame front diverters
- (2) Passive float valve
- (3) Material chokes (rotary valves)
- (4) Static dry flame arresters
- (5) Hydraulic (liquid seal)–type flame arresters
- (6) Liquid product flame arresters

Evaluate Design Considerations of Deflagration Control by Vents

Deflagration vents shall limit the reduced pressure (*Pred) within an enclosure and any attached vent ducts*

Combustible materials outside the enclosure shall not attain their ignition temperature from flame or hot gases discharged from a deflagration vent.

Blast load from deflagration vent discharge shall limit the risk of damage to exposed structures.

Access to spaces into which deflagration vents discharge shall be restricted so as to minimize, to a level acceptable to the authority having jurisdiction, the risk of injury from flame, hot gases, hot particles, or projectiles.

The vents may impact the structural steel supports of enclosures due to overturning moments

Process Hazard Analysis- Fire Scenarios

Include all of the fire scenarios in the PHA including:

- Each fuel object in the compartment.
- The fuel object that produces the most rapidly developing fire during startup, normal operating conditions, or shutdown.
- The fuel object that produces the most rapidly developing fire under conditions of a production upset or single equipment failure.
- The fuel object that produces the greatest total heat release during startup, normal operating conditions, or shutdown.
- The fuel object that produces the greatest total heat release under conditions of a production upset or single equipment failure.
- The fuel object that can produce a deep-seated fire during startup, normal operating conditions, or shutdown.
- The fuel object that can produce a deep-seated fire under conditions of a production upset or single equipment failure

Process Hazard Analysis- Explosion Scenarios

Include all of the explosion scenarios in the PHA including:

- Each duct, enclosed conveyor, silo, bunker, cyclone, dust collector, or other vessel containing a combustible dust in sufficient quantity or conditions to support the propagation of a flame front during startup, normal operating conditions, or shutdown.
- Each duct, enclosed conveyor, silo, bunker, cyclone, dust collector, or other vessel containing a combustible dust in sufficient quantity or conditions to support the propagation of a flame front under conditions of a production upset or single equipment failure.
- Each building component containing a combustible dust in sufficient quantity or conditions to support the propagation of a flame front during startup, normal operating conditions, or shutdown.
- Each building component containing a combustible dust in sufficient quantity or conditions to support the propagation of a flame front under conditions of a production upset or single equipment failure.

Process Hazard Analysis- Sources of Ignition

Ignition sources that are part of the process:

- Open flames
- Hot surfaces on process and electrical equipment
- Smoldering or burning conveyed process materials
- Mechanical impact creating heat or sparks
- Electric sparks from equipment
- Electric sparks from electrostatic discharges
- Exothermic reactions

Process Hazard Analysis- Sources of Ignition

Ignition sources that can be effective by way of proper work practice controls:

- Smoking
- Open flames
- Open light (bulbs)
- Welding
- Abrasive cutting
- Grinding
- Anti-static clothing

Process Hazard Analysis- Sources of Fuel

Fuel sources that are part of the process:

- Material handling equipment
- Conveyors
- Silos
- Natural Gas, Oil, Propane, etc. utility services
- Combustible vapors as part of the process air stream.
- Air-material separators (filter/receivers and dust filters)
- Material not captured by filtration system hoods

Process Hazard Analysis- Sources of Fuel

Fuel sources that can be effective by way of proper work practice controls:

- Maintenance of the above process fuel source equipment.
- Housekeeping
- Waste removal
- Raw material storage and handling.

Process Hazard Analysis – Sources of Ignition

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Thank You

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