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Defining Dust Hazard Areas Can Help Streamline PHAs

An ioMosaic White Paper

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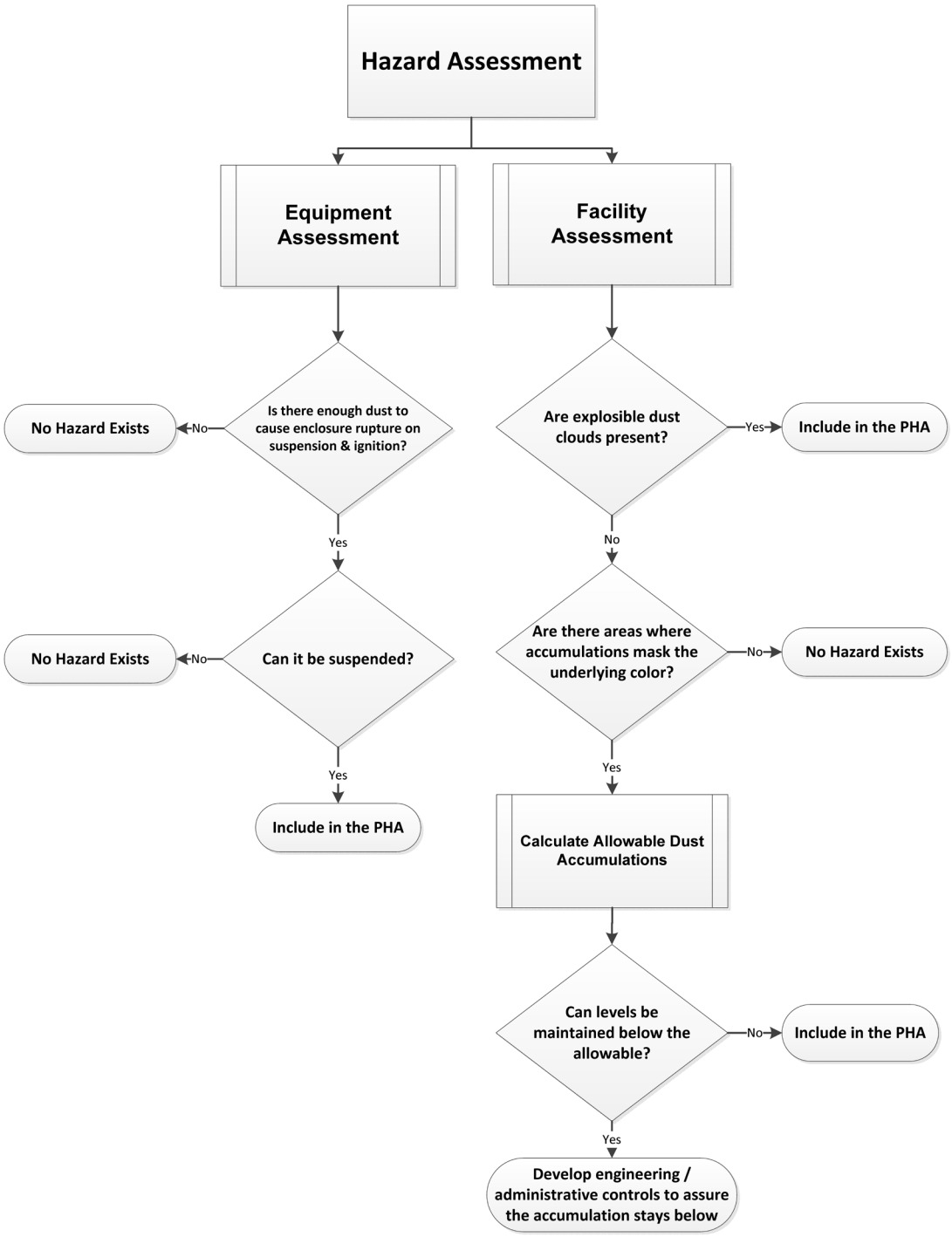
Introduction

As part of the 2013 update, NFPA 654 provides clarification on how to determine if a flash fire or explosion hazard exists. As part of the facility and systems design section, it is now required that a hazard assessment be conducted to determine if dust flash fire and dust explosion hazards exist (NFPA 654 Section 6.1). The real benefit to conducting these hazard assessments is in defining combustible dust hazard areas – both inside and external to process equipment. This paper presents a multi-step approach to conducting these hazard assessments, simplifying the process and defining the areas to evaluate during the process hazard analysis (PHA) to assure that valuable resources are spent appropriately.

The previous method for determining where hazards exist inside buildings (1/32" depth over greater than 5% of the footprint area) was open to interpretation. The new methods provide greater flexibility and clarity, taking into account the characteristics of the dust being handled, the design of the facility, as well as localized accumulations.

The flowchart in Figure 1 shows how this process can be executed. Using the left side of the chart, *each piece of equipment* can be assessed according to the criteria specified. Using the right side of the chart, *each process area* can be assessed according to the criteria specified. Working through the steps in the chart results in a list of hazardous equipment and process areas to include in the PHA.

Figure 1: Combustible Dust Hazard Assessment Flow



Implementing the chart

The first step in the assessment is to determine which pieces of process equipment present an explosion hazard. Does a sufficient amount of combustible dust exist to cause enclosure rupture if suspended and ignited? Is a means of suspending the dust present? If the answer to both is yes, the equipment presents a dust explosion hazard and should be included in the PHA.

The second step is to determine if explosible dust clouds exist external to equipment. Do dust clouds of a hazardous concentration exist? If the answer is yes, the area is a dust flash fire and explosion hazard.

The third step is to determine if external dust accumulations can reach hazardous levels. Are there areas where the dust accumulation makes the underlying colors indiscernible? If the answer is yes, determine allowable accumulations for flash fire and explosion hazards using the provided equations. This is further described in the section below.

The final step is to decide if the areas with potential hazardous accumulation levels can be maintained below the allowable threshold levels. If they can, engineering and administrative controls need to be implemented to assure that accumulation levels do not go above the allowable threshold levels. Dust collectors, housekeeping, and maintenance are some of the possible controls.

Where accumulations are allowed to reach levels above the allowable accumulation, these portions of the facility can pose flash fire and/or explosion hazards and should be included in the PHA.

During the conduct of the PHA, each piece of equipment and process area with dust explosion or flash fire hazards should be evaluated to make sure they comply with the specific requirements outlined in the applicable sections of NFPA 654. PHAs will evaluate existing controls and develop recommendations for additional protections as appropriate.

Determining Allowable Accumulations

To evaluate hazard areas external to equipment, allowable dust accumulations are determined, and comparisons made against the amount of dust accumulation which could be present in that area.

NFPA 654 presents the following four methods, which they deem to provide equivalent levels of safety:

1. Layer depth criterion
2. Mass Method A
3. Mass Method B
4. Risk evaluation method

Layer Depth Criterion

Dust Characteristics
K_{St} – Deflagration index
P_{max} – Max explosion pressure
$(dP/dt)_{max}$ – Max pressure rise rate
C_W – Worst-case dust

The layer depth criterion relies on an established accumulation depth (1/32") to determine when a hazard exists. This value can be increased for materials with bulk density less than 75 lb/ft3. Generally, a hazard is deemed to exist where the total area with accumulations exceeding the adjusted layer depth is greater than 5% of the footprint area. Additional specifics are provided in Subsection 6.1.3.2 of NFPA 654. This method evaluates the quantity of dust using the same criterion for explosion or flash fire hazards.

Mass Methods

Facility Information
A_f – lesser of floor area or 2000 m^2
H – lesser of ceiling height or 12 m
ρ – probability of flame impingement
P_{es} – Enclosure strength
DLF – Dynamic Load Factor

The mass methods rely on a determination of allowable mass accumulations. In these methods, the total accumulated dust is compared with the allowable accumulation (or threshold dust mass) calculated. Both methods include separate equations for dust explosion hazard areas and dust flash fire hazard areas. Mass Method A uses equations that have been simplified by assumptions related to the dust characteristics and the building strength. Mass Method B uses equations that take into account measured dust characteristics and building

strength. Implementation of these methods requires varying amounts of detail on the dust characteristics and the facility design. The potential dust characteristics and facility information that might be needed are provided in the boxes.

Risk Evaluation Method

The risk evaluation method requires a documented risk evaluation, acceptable to the AHJ, to determine whether or where a dust explosion hazard or dust flash fire hazard area exists. The reader is referred to NFPA 654 Section Appendix A Section A.6.1.6 for more details on this method.

All methods are “deemed to provide equivalent levels of safety”. One approach to determining which method is most applicable to the system under study is to determine if all required information is available to complete the more in-depth calculations in Mass Methods A and B. If so, then default to using the most detailed equation for which all the necessary information is available.

Once allowable accumulations are determined, the facility should compare actual dust accumulations against the allowable accumulations. Interior process areas that contain dust accumulations higher than those allowed may need additional protections from the effects of those hazards in accordance with the standard. Determination of these protections can be accomplished through the use of a PHA.

In Summary

Conduct of the hazard assessment prior to or at the beginning of the PHA can assure that analysis time is targeted on hazardous areas. The new methods provided in the 2013 edition of NFPA 654 for determining the presence of dust flash fire and explosion hazards allow the targeting of limited resources to those areas which present the greatest concern. The equations are simple and require basic information on the dusts being handled and the facility design.

References

1. NFPA 654: Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids, 2013 Edition. In *NFPA National Fire Codes Online.* Retrieved from http://codesonline.nfpa.org

Additional Resources

1. Michelle R. Murphy, 2013
2. Molly R. Myers, P.E., 2013

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