Journal of Loss Prevention in the Process Industries xxx (2015) 1–6

Contents lists available at ScienceDirect

Journal of Loss Prevention in the Process Industries

journal homepage: www.elsevier.com/locate/jlp

Drying of combustible powders – Risk & mitigation

Henry L. Febo Jr.

FM Global, Norwood, MA, USA

ARTICLE INFO

Article history:
Received 11 September 2014
Received in revised form
23 December 2014
Accepted 29 December 2014
Available online xxx

Keywords:
Combustible dust
Dryers
Loss history
Hazards
Mitigation methods

ABSTRACT

This paper provides an overview of the various processes for drying combustible powders with particular emphasis on spray, fluid bed and ring dryers. Clients of FM Global, an industrial property insurance company, have experienced numerous explosion and fire losses in dryers and the primary causes and equipment involved in recent events are reviewed. Several case examples are provided. Key operating parameters that can impact the hazard created by processing combustible dusts are highlighted. For each dryer type the key controls, alarms and interlocks are addressed as well as the protection and mitigation features that can be installed. This will emphasize FM Global loss prevention guidelines but will also point out differences with NFPA and EU codes.

1. Introduction

A number of different processes for drying combustible powders are in use depending on various characteristics of the material being processed. FM Global clients have experienced explosion and fire losses in drying operations that have caused extensive equipment damage with a serious impact on production and loss of sales. A number of large incidents have occurred in Europe and the UK.

The paper will review the loss history experienced by FM Global over the last 25 years and point out significant causes of incidents in these systems. This also includes some information on incidents provided by a major manufacturer of process dryers.

There will be an overview of the processes with emphasis on operational parameters that can impact the hazard created by processing combustible dusts. While the systems can be quite different in size, function and operating conditions, a number of common hazards are present.

The review of each dryer type will include a discussion of process hazards, key controls, alarms and interlocks and description of the protection and mitigation features that can be installed to minimize the effects of unexpected fire and explosion events. This will emphasize FM Global Loss Prevention Data Sheets but will also point out similarities and differences with NFPA and EU codes.

2. General overview of drying operations

There are a number of dryer types that can be used in industry for processing solids. Dryers can be of the continuous or batch type and heating may be direct or indirect. Heating can be provided by combustion of a fuel directly into the drying chamber or indirectly by using another media to carry heat to the drying chamber. The indirect heating may be provided by air, steam, hot water or organic heat transfer fluids.

Most dryers operate at approximately atmospheric pressures but some sensitive materials are dried under vacuum and at lower temperatures and these are most often small batch processes.

The product handled can be combustible or not which has a significant impact on the hazards that are present. For this discussion, the focus will be on dryers handling combustible particulate as these present both fire and explosion hazards.

Small quantities of materials are often dried in batch tray dryers and these present little or no explosion hazard from the solids being processed but can present vapor explosion hazards if the fluid being removed is an ignitable liquid. They can also present fire hazards if spilled materials remain in the dryer for extended periods.

(Ignitable Liquid: Any liquid or liquid mixture that will burn. A liquid will burn if it has a measurable fire point. Ignitable liquids can also be classified as flammable or combustible liquid and these classifications are primarily based on flash point.)

Operations involving large amounts of material require the use of continuous dryers and the large rates of dry product increase the

E-mail address: henry.febo@fmglobal.com.

http://dx.doi.org/10.1016/j.jlp.2014.12.019
0950-4230/

potential for both explosion and fire. The most common types of continuous dryers include:

- Belt or band dryers
- Flash dryers
- Ring dryers
- Rotating drum dryers
- Spray dryers
- Fluidized bed dryers

Drying operations present many hazards both from an operational standpoint to insure quality product is produced and from the safety aspect to insure there are no accidents that interrupt operations or harm employees. Equipment that is well controlled to produce quality product often has reduced the kinds of maloperation that result in damage to property or exposure to personnel (When conducting a risk review of an operation, layer of protection analysis (LOPA) is often used and process control & alarms are usually considered the first layer).

Some of the common hazards of drying operations include:

- Fuel explosions
- Release of flammable vapors/solvents
- Deposits
- Overheating
- Spontaneous heating – autoignition
- Sparks
  - Electrostatic
  - Friction
  - Electrical
- Dust fire or explosion
- Discharge hot product to downstream processes or storage

Fuel explosion frequency is addressed early in the project because fuel firing issues can have a major impact on product quality. Proper design of the fuel firing control system and application of standard codes of installation such as FM Global Loss Prevention Data Sheet 6–9, *Industrial Ovens and Dryers*, NFPA 86 *Standard for ovens and Furnaces* and BS 5410, part 3, *Code of practice for oil firing. Installations for furnaces, kilns, ovens and other industrial purposes* will limit the risk from this exposure.

While the hazard produced by the removal of flammable vapors and solvents from the dry product is usually recognized, the hazards presented by the use of organic heat transfer fluids (HTF) can be misunderstood by both the user and installer because most have high flash and boiling points. This misunderstanding has caused many unexpected fire and explosion losses in industry. Guidance on the hazards and methods of protecting operations handling HTF can be found in FM Global Loss Prevention Data Sheet 7–99, *Heat Transfer by Organic and Synthetic Fluids.*

To prevent the hazards of overheating, spontaneous heating, fire and explosion caused by the combustible powders being handled, proper understanding of the material properties is needed. Some of the more common properties that may be needed (a hazard assessment could point to those specifically needed) include:

- Kst, P_{max} (ASTM 1226 or EN 14034-1, 2)
- Minimum ignition energy (MIE – ASTM E2019 or EN 13821)
- Minimum explosible concentration (MEC – ASTM E1515 or EN 14034-3)
- Thermal stability
  - DSC (Differential scanning calorimetry)
  - DTA (Differential thermal analysis)
- Isothermal stability test
  - Spontaneous ignition test (UN Division 4.2)
- Layer ignition test (ASTM E2021)
- Cloud ignition test (ASTM E1491)
- Limiting oxidant concentration of dust clouds (LOC – ASTM E2931 or EN 14034-4)
- Limiting oxidant concentration for gases (LOC – ASTM E2079 or EN 14756)
- Resistivity, conductivity, chargeability
- Toxicity

Later in this paper, details of some hazards related to specific dryer types are addressed.

3. Loss history

To understand the exposures that can be presented by drying operations it is useful to review loss history. In a recent 25 year period, FM Global clients had 22 explosions, 1 implosion and 38 fires involving dusts in various types of industrial dryers. The average explosion loss was 7 times more costly than the average fire loss (cost involves both property damage and business interruption). The cause of these incidents is shown in Table 1. The data are not surprising with overheating and open flame representing over half the incidents.

With respect to the 61 losses, Table 2 shows the industry groups involved with these losses and the food and chemical industry are responsible for over half the losses. Of those food industry losses 12 are spray dryers. Recently we have seen losses in the food industry mainly in milk/infant formula processing becoming more common. All of the textile industry losses were fires, not explosions.

Finally we can look at the data by dryer type (Table 3) and spray dryers are the most common followed by band and rotary dryers. Spray dryers are equally distributed between explosion and fire incidents, band dryers are all fire but one and 6 of the rotary incidents were fires.

One of the limitations with insurance data is small incidents or those below the deductible go unreported skewing the data to larger losses and making the apparent frequency look lower than reality. It is not possible to develop a true frequency of occurrence because of the lack of information on how many dryers are present in our client's locations.

GEA – Niro, a major manufacturer of industrial spray dryers shared some of their incident information. The data is based on an estimated 4500–5000 dryers in service in a period of over 40 years. They indicate 285 recorded incidents with 229 fires and 56 explosions. Of those, they classified 174 (60%) of them as 'major' and noted that at least 28 started in the fluidized bed dryer. They identified the following as major contributing factors.

Table 1
Dryer incidents by cause.

Cause	Number of losses
Overheating	20
Unknown	11
Open flame	9
Spark (Other than static)	5
Chemical reaction	5
Component failure	4
Friction	2
Hot surface	2
Hot work	1
Static	1
Implosion	1
Grand total	61

Please cite this article in press as: Febo, Jr., H.L., Drying of combustible powders – Risk & mitigation, Journal of Loss Prevention in the Process Industries (2015), http://dx.doi.org/10.1016/j.jlp.2014.12.019