FIRE AND EXPLOSION HAZARD IN PHARMACEUTICAL INDUSTRY - AN OVERVIEW

Yutika Mhatre*, Simran Kaur Whala and Dr. Amjad Ali

Oriental College of Pharmacy, Department of Quality Assurance, Sanpada, Navi Mumbai 400075 University, Maharashtra, India.

ABSTRACTS

Hazard is a term associated with substances that has the potential to cause injury in a given environment or situation. Industrial hazards in manufacturing are major occupational health and safety issues. In recent years chemical safety and sound management of chemicals have seen great progress on a global scale. At the same time, the rapid increase in the production and proliferation of chemicals, both natural and synthetic, has raised concerns about their impact on the natural environment and human health. In this way industry has come to a unique position. Practically no other commercial enterprise exists such as the wide variety of potentially toxic exposures or the rapidly changing arrival of new chemical substances. In industry, this dynamic situation has been created by the increasing application of organic chemical synthesis as a technology for the production of therapeutic substances. This is what makes the job of a plant physician so instructive. Industrial safety is required to investigate all possible possibilities of accidents to prevent loss of life and permanent disability of any industrial worker, any damage to machine and material causing damage to the whole establishment.

KEYWORDS: Hazard Safety Management Industry Toxic Effects Fire and Explosion.

INTRODUCTION

Many gases, liquids and powders used in the manufacture of products are highly flammable, explosive, reactive and/or toxic. In addition, facilities have the capacity to perform many of the operations typically required - from delivery to processing in the reactor to filtration, drying, milling/micronizing, blending and packaging explosive generate environment. It is...
therefore essential for facilities to clearly understand the deflation hazards presented by the materials and equipment used in their processes.\[1\]

We partner with our customers in the industry to help them identify, assess, prevent and control fire, explosion and accidental damages in their operations. Our services include expert consultation, laboratory testing and training in the specialist areas of dust explosion and fire hazards, electrostatic hazards and processing problems, gas and vapor flammability hazards, process risk analysis, process safety management and incident investigation.

Although the bulk and fine chemical industries operate at different scales and with different equipment and processes, what they have in common is the presence of flammable materials gases, vapors, aerosols, fine dust and powdery layers most of which present an explosion. can or may cause a fire hazard if proper precautions are not taken. The complexity of modern equipment and procedures means that the only reliable approach to avoiding these hazards is through the systematic and rigorous application of hazard and risk identification techniques, coupled with good management systems and a developed skill base, to identify hazards and To ensure that the risks are properly dealt with. was quenched.\[2\]

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**Explosion and fire management**

Fire occurs in the industry more frequently than explosions and toxic release, although the consequences in terms of loss of life are generally less. So, a fire might be less hazardous. To control of fire and explosion following precautions should be followed.

1. Careful plant layout and judicious selection of constructional materials can reduce fire and explosion hazards.
2. Fire resistance brick-walls can limit the effects of an explosion.
3. The roof should be designed to lift easily under an explosive force.
4. Possible sources of fire are reduced by eliminating unnecessary ignition sources like flames, spark, smoking, welding etc.
5. The installation of sufficient temperature alarms, fire alarms, firefighting equipment etc.
6. Fire extinguishers are installed inside the hose. These are designed for extinguishing the incipient fires. The incipient fires are divided into three categories.

**Class A fires:** These types of fires are originated from ordinary combustible materials. They are controlled using water which produces quenching and cooling effects.

**Class B fires:** These types of fires are originated from oil’s, greases, flammable liquids etc. In class B fires the extinguishing agent should produce a blanketing or smoothening effect.

**Class C fires:** These types of fires are originated in electrical equipment. The extinguishing agent produces a non-conducting property.

**Health hazards in the pharmaceutical industry**

Workers generally had a better experience than their referent populations, they experienced adverse health outcomes including cancer, endocrine dysfunction, and liver disease. Industrial hygiene measurements supported the likelihood of high exposure levels to sex steroids. Suppression of endocrine function and disruption of reproductive function are evident in expose workers. The most commonly reported allergic diseases have been occupational asthma and contact dermatitis. Occupational asthma may occur among production workers, especially in the manufacture of antibiotics and enzymes. Occupational exposure to oral contraceptive pills had an adverse health effect on exposed workers resulting in an alteration in liver function and sex hormone levels. Estrogens exposure may increase the risk of Hypoestrogenism in exposed men and women.[4]

**Preventing Fire and Explosions in the Pharmaceutical Industry**

![Fig. 1: Fire and Explosion.](image-url)
The industry does a lot to advance the health and well-being of people around the world. Developing vaccines and drugs to reduce and treat disease is only part of the role of industry in raising our standard of living. But it is this same contribution that poses an occupational risk to those who work in facilities that manufacture drugs that help create and maintain well-being.

The greatest danger to workers manufacturing industrial synthetics (such as pharmaceuticals) is fire and explosion. Many materials used in the manufacture of drug solids have proven to be as combustible as dust. Take, for example, the fiery explosion at the West service plant. The January 2003 explosion and subsequent fire broke out in Kinston, North Carolina, killing six people and injuring dozens. The source of the explosion was airborne plastic powder dust that had accumulated.[5]

Disasters like this happen for a variety of reasons, often because managers and employees are unaware of the hidden indoor air quality risks, they face every day. The most important information to know is that industrial dust is highly combustible in any environment where fine particles accumulate, and heat is present. Combustion is a rapid phenomenon that occurs when particles are suspended in the air, often in an enclosed space. These explosive events can spread anywhere that dust is present in combination with uncontrolled heat and various flammable sources such as oxygen.

In a normal event, a small fire (primary explosion) occurs when a flammable material comes into contact with an ignition source. But if finer particles are present, the dust itself can ignite, causing an even bigger explosion (secondary explosion). This second flammable event may be many times the size and severity of the first, with the potential to cause even greater damage to people, products and facilities.

The most recent National Fire Prevention Association (NFPA) estimate estimates that an average of 37,000 fires occur in industrial plants and factories each year. Many, if not all, of these fires and explosions can be avoided with proper - and carefully monitored - control measures.

Although these risk factors are present, employees do not have to be victims of the hazards. Employers who protect their workplaces do so by following these guidelines, such as those below:
OSHA’s "Three C’s" for Fuel and Dust Fire Prevention

- Capture dust before it escapes into a work area by using properly designed, installed, approved, and maintained dust collection systems.
- Contain dust within the equipment, systems, or rooms that are built and operated to safely handle combustible dust.
- Clean work areas, overhead surfaces and concealed spaces frequently and thoroughly using safe housekeeping methods to remove combustible dust not captured or contained.

To underscore their prevention initiatives, OSHA included in their publication, NFPA 654, Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids.\(^6\)

The following are just some of NFPA’s dust control recommendations:

- Minimize the escape of dust from process equipment or ventilation systems;
- Use dust collection systems and filters;
- Use cleaning methods that do not generate dust clouds, if ignition sources are present;
- Develop and implement a hazardous dust inspection, testing, housekeeping, and control program (preferably in writing with established frequency and methods).

Worker safety efforts are only as good as the IAQ initiatives adopted and implemented. Proactive measures protect workers.

At AIRSInc., we help our customers in the pharmaceutical industry by identifying areas of potential risk and by supplying them with stellar air cleaning products. Call us today for a free estimate with one of our skilled and experienced clean air specialists.\(^7\)

**Major Causes of Industrial Fires and Explosions**

Industrial fires and explosions cost companies and governments billions of dollars every year, not to mention the loss of life, which can’t be described in monetary terms. According to the most recent fire statistics from the National Fire Protection Association (NFPA): An average of 37,000 fires occur at industrial and manufacturing properties every year.

**These incidents result in**

18 civilian deaths,
279 civilian injuries, and
$1 billion in direct property damage.
These disasters happen for many reasons, often because managers and employees aren’t aware of the risks that surround them at work every day.

Here are five of the most common causes of industrial fires and explosions.

1. **Combustible dust**

![Combustible dust](image)

**Fig. 2: Combustible dust.**

Often overlooked, and highly deadly, combustible dust is a major cause of fire in food manufacturing, woodworking, chemical manufacturing, metalworking, pharmaceuticals, and just about every other industry you can name. The reason is that just about everything, including food, dyes, chemicals, and metals even materials that aren’t fire risks in larger pieces — has the potential to be combustible in dust form.

And these explosions aren’t easy to contain. In the typical incident, a small fire will result from combustible material coming into contact with an ignition source. This may be a dust explosion, but it doesn’t have to be. In fact, it could be most any other type of explosion on this list.

However, this small explosion isn’t the problem. The problem is what happens next. If there’s dust in the area, the primary explosion will cause that dust to become airborne. Then, the dust cloud itself can ignite, causing a secondary explosion that can be many times the size and severity of the primary explosion. If enough dust has accumulated, these secondary
explosions have the potential to bring down entire facilities, causing immense damage and fatalities.

Just recently, OSHA fined a manufacturing company nearly $150,000 after a worker was injured while operating a dust collector. It was the company’s fourth fire in a dust collection system, and inspectors cited them for knowingly exposing workers to risk. \[9\]

**How to prevent combustible dust incidents**

The key ingredient in combustible dust fires and explosions is the presence of the dust itself. While you probably won’t be able to eliminate dust entirely, you can make sure it doesn’t accumulate to a dangerous level simply by following a regular housekeeping regimen.

Last November, one of our resident experts on the topic, participated in a podcast on avoiding combustible dust hazards and contamination.

**2. Hot work**

![Hot Work](image)

**Fig. 3: Hot Work.**

Hot work is one of the leading causes of industrial fires across all industries.

Although hot work is commonly equated with welding and torch cutting, there are many other activities — including brazing, burning, heating, and soldering — that pose a fire hazard. This is because the sparks and molten material, which reach temperatures greater than
1000°F, can easily travel more than 35 feet. Here are a few recent catastrophes that were the result of hot work: In 2014, a pier fire in California did more than $100 million in damage when it caused a partial collapse of a warehouse floor.

In 2012, three workers performing hot work died disassembling a metal crude oil tank. The sparks from the work ignited vapors inside the tank, causing a fire that then spread to nearby woods.

In 2010, one worker died and one was injured in an explosion while performing welding on a 10,000-gallon slurry tank. Similar to the previous incident, the sparks from the welding ignited vapors inside the tank. Hot work is also a major culprit in combustible dust fires, as the sparks generated from the work can ignite dust in the surrounding area.[10]

In one accident in North Carolina, three contract welders were seriously burned when sparks ignited the wood dust in the silo where they were working. The investigation found a trifecta of problems: the silo hadn’t been cleaned of dust before the work began, no hot work permit had been issued, and there was no fire protection and prevention plan in place.

**How to prevent hot work incidents**

Like combustible dust incidents, hot work disasters are preventable by following proper safety procedures. Avoid hot work if possible. This isn’t always a feasible solution, but if there’s an alternative, take it. Train personnel on the hazards associated with hot work, any site-specific hazards, the proper policies and procedures, and the use of safety equipment. Ensure that the area is clear of flammable or combustible materials including dusts, liquids, and gasses.

Use a written permit system for all hot work projects, even where permits aren’t required. Better safe than sorry!

Supervise the work. Especially if you use outside contractors, make sure a safety professional is on hand to provide supervision.

**Here are some resources where you can learn more**

NFPA 51B: Standard for Fire Prevention During Welding, Cutting, and Other Hot Work [Standard]

3. Flammable liquids and gasses
These fires, which often occur at chemical plants, can be disastrous. To see what these look like, check out this post at Industry Tap. It features videos from five chemical plant explosions that were the result of explosions of flammable materials, such as rocket fuel (which produces a flammable gas), acrylic acid, and crude oil.[11]

The 2010 power plant explosion in Middletown, CT, which killed six people and injured more than 50, can also be traced to flammable gas. In this case, the subsequent investigation revealed hundreds of safety violations, many of which OSHA deemed “willful.” As a result, the agency fined the companies involved $16.6 million, one of the largest penalties ever issued.

How to prevent flammable liquid and gas incidents

There is certainly some danger inherent in any work involving flammable liquids and gasses, but all available safety precautions should be taken to mitigate these risks.

Know the hazards. One major component of prevention is simply knowing the safety information for every liquid on your premises. This information is available on the material safety data sheet (MSDS) that comes with such products.[12]

Store flammable liquids properly. Make sure all hazardous materials are stored according to OSHA-compliant procedures. Control all ignition sources. Except for when you’re intentionally heating the flammable materials, keep ignition sources as far away from them as possible. Provide personal protective equipment. This is a must across all categories of fire hazards but especially when liquids and gasses are involved. These resources from the U.S. and Canadian federal governments provide more information about how to stay safe and compliant: OSHA, Safety and Health Regulations for Construction: Fire Protection and Prevention — Flammable Liquids [Standard] Canadian Centre for Occupational Health and Safety.[13]
4. Equipment and machinery

Faulty equipment and machinery are also major causes of industrial fires.

Heating and hot work equipment are typically the biggest problems here — in particular, furnaces that aren’t properly installed, operated, and maintained. In addition, any mechanical equipment can become a fire hazard because of friction between the moving parts. This risk can be brought down to practically zero simply by following recommended cleaning and maintenance procedures, including lubrication.[14]

What may surprise you is that even seemingly innocuous equipment can be a hazard under the right circumstances. And, in many cases, the equipment least likely to be thought of as a fire risk turns out to be the biggest problem. This is because companies may not recognize the risk and therefore won’t take the necessary precautions.

As an extreme example, consider this story from William Fries, a former director at Liberty Mutual Group: An electric eraser used by drafters at one company was stored in such a way that the nose of the eraser pressed against the side of the drawer. The contact caused the eraser to switch on and vibrate. The constant friction caused the eraser to overheat and start a fire which spread throughout the room, fueled by the stacks of papers and plans used by the drafters.

The lesson here is that when thinking about the safety of your plant, don’t forget about everyday equipment like electric erasers…and coffee makers.

How to prevent equipment and machinery incidents.
Strategies for preventing fires due to equipment and machinery issues fall into three main categories:

- Awareness
- Cleaning and housekeeping
- Maintenance

**Awareness**
You can’t prevent risks you don’t know exist. Neither can your employees. Provide safety awareness training so everyone in your facility knows what risks to watch out for and what to do if they find one.

**Cleaning and housekeeping**
Keep your equipment and machinery and the area surrounding it clean. Equipment, especially electrical equipment, that is covered with dirt or grease constitutes a huge risk. By keeping your equipment and machinery clean, you’ll up your chances that, should a fire start, it won’t have enough fuel available to burn for long.

**Maintenance**
Finally, follow the manufacturer’s recommended maintenance procedures for all of the equipment and machinery in your plant. In addition to reducing your fire risk by preventing overheating, regular maintenance will also keep your equipment working in tip-top shape.

To separate fact from fiction when it comes to fire risks, check out Control Engineering’s 10 Myths About Industrial Fire Prevention.

**5. Electrical hazards**

![Electrical Hazard](image-url)
Electrical fires are one of the top five causes of fires in manufacturing plants. Here a non-exhaustive list of specific electrical hazards:

- Wiring that is exposed or not up to code
- Overloaded outlets
- Extension cords
- Overloaded circuits
- Static discharge

The damage caused by these fires can quickly compound thanks to several of the other items on this list. Any of the above hazards can cause a spark, which can serve as an ignition source for combustible dust, as well as flammable liquids and gasses.\[^{15}\]

**How to prevent electrical fire incidents**

As with the previous risks, the key to preventing electrical fires is awareness and prevention. This involves training, maintenance, and following best practices. Here are a few to put into practice right now:

- Don’t overload electrical equipment or circuits.
- Don’t leave temporary equipment plugged in when it’s not in use.
- Avoid using extension cords, and never consider them permanent solutions.
- Use antistatic equipment where required by NFPA or OSHA.

Follow a regular housekeeping plan to remove combustible dust and other hazardous materials from areas that contain equipment and machinery. Implement a reporting system so that anyone who observes an electrical fire risk can report it without consequences. For more information on electrical safety, consult NFPA 70: National Electrical Code and OSHA’s “Electrical Safety in the Workplace.” Building fire safety into your daily operations.\[^{16}\]

This list of hazards is formidable. But don’t let it intimidate you. Fire safety is mostly a matter of establishing policies and procedures, and then ensuring they are implemented throughout your facility. Here are five ways to build fire safety into your operations from the get-go:
Conduct a hazard analysis
A Dust Hazard Analysis (DHA) is one of the requirements of NFPA 652. But don’t stop at dusts. Conduct a hazard analysis of your entire facility to discover exactly where your greatest risks lie and what you can do to address them. Reanalyze your operations regularly, for example, every time you install a new piece of equipment on your production line.

Establish fire prevention and emergency procedures.

Make sure you have policies and procedures in place that cover everything from smoking to personal protective equipment to an emergency evacuation plan. Ensure everyone has access to these documents at all times. For example, you could post them in strategic places in your facility.

Provide fire safety training
We’ve mentioned training several times already. That’s because it’s so important. Provide both general and job-specific fire safety training for everyone working in a potentially hazardous environment.

Implement a regular housekeeping routine
With equipment and machinery running, sometimes 24 hours a day, sparks and static discharge may be hard to avoid entirely. But that doesn’t mean you need to run the risk of a fire or explosion, especially one due to combustible dust. By implementing a regular housekeeping routine, you can significantly decrease the chances of a small spark turning into a huge disaster.

Inspect and maintain your equipment and systems
Keeping all of your equipment and systems in proper working order will enhance safety and make your operations more efficient. This includes maintaining the machinery on your production line as well as inspecting and testing your fire safety systems, like fire extinguishers and sprinklers. A good rule of thumb is to perform inspections every six months.¹⁷

Five major causes of artificial fires and explosions and how to help them. Explosive Dust Threat Operation in Assiduity A Practical Approach August 1, 2005 Technology, Technology-08-01-2005, Volume 2005 Supplement, Issue 5 Colorful for Safely Handling and Processing Snares Systems and measures can be used Composites in a range of
manufacturing processes. The eventuality for dust explosion during development and construction is frequently overlooked. During processing and transportation, bulk maquillages can form airborne dust shadows and induce a stationary charge. In addition, process constraint systems designed to cover workers from potent emulsion exposure can produce ideal conditions for high attention of airborne dust to collect inside processing vessels and outfit. These concerted factors can increase the threat of dust explosion during processing operations.

Under the right conditions, all accoutrements can be explosive. Analogous to hydrocarbon vapors, dust suspended in the air can enkindle and burn veritably rapidly. However, dust explosions can do, if these conditions do in a confined area similar as in processing outfit or a manufacturing suite.

In addition, dust explosions can release high pressure. Grounded on our experience, we plant that it's common for Active Accoutrements (APIs) to be suitable to release pressure in the 8-10 bar range, which is frequently relatively happens further, compared to the pressure standing of the processing outfit.[24]

Protection against dust explosions can be achieved by precluding explosions or minimizing negative impacts when an explosion occurs. This composition focuses on threat assessment approaches and perpetration strategies for engineering controls to help dust explosions in manufacturing surroundings. The compass of this composition is limited to accoutrements that may deflate. Accoutrements known to explode bear fresh control measures beyond the compass of those particulars bandied then.[25]

Although the composition is intended to be a practical companion to the operation of exposure to explosive dust, it isn't intended to be reckoned upon as a definitive threat operation program. Medicine inventors and manufacturers should produce their own threat operation programs with the help of process safety professionals to address the explosive dust pitfalls specific to their separate operations.[18]

**Hazard recognition**

The first step in evaluating explosive dust hazards is to identify the parameters that can contribute to an explosion or a deflagration.
A dust explosion is a combustion process. All components of the fire triangle oxygen, a fuel, and an ignition source must be present for a fire or an explosion to occur. If any one part is removed, the risk of explosion is eliminated. It is preferable to remove two sides of the fire triangle to provide a higher safety factor when managing dust explosion risk.\(^{[19]}\)

For a fire to occur, all components (ignition source, oxygen, and fuel) of the fire triangle must be present.

In the pharmaceutical industry, the fuel frequently is the API and, to a lesser extent, the excipients (e.g., binders, coatings). Nonetheless, APIs have a wide range of explosivity and sensitivity to an ignition source (e.g., between 1 and >1000 mJ).

Ignition source. An ignition source must provide sufficient energy to create an explosion. Ignition sources include open flames, exposure to hot surfaces, high temperatures, friction, mechanical impact (e.g., metal–metal contact), electrical sparks, and electrostatic discharge.

In the pharmaceutical industry, however, the main ignition source tends to be from an electrostatic discharge, which can be generated by processes such as sieving, milling, pouring, mixing, and pneumatic transport. The grounding and bonding of equipment and tools minimize the risk of ignition.\(^{[20]}\)

Oxygen. For an explosion to occur, an adequate amount of oxygen is required. For most organic materials such as pharmaceutical materials, oxygen concentrations that are less than 8% volume are unlikely to support combustion. By maintaining oxygen concentrations in process equipment at 5% or less, one can eliminate the risk of combustion while still allowing a 3% safety factor to account for any leaks in equipment that may allow the oxygen to escape.

Fuel. In many cases, the API is the fuel source. APIs have a wide range of explosivity or sensitivity to an ignition source. Explosive characteristics vary among materials and can depend on the properties of the material, particle size, impurities, and moisture content among other factors.
In our experience, most excipients (e.g., lactose and starch) have a low explosive potential, but there are some exceptions. For example, magnesium stearate has a low MIE (minimum ignition energy) at 1–3 mJ. When considering the fire triangle principles, the fuel or the API is always present and can rarely be eliminated.[27]

Fuel must be present in a sufficient quantity and be airborne to be explosive in a dust cloud. Explosive dust testing of the fuel is useful for determining how sensitive a compound is to an ignition source or electrostatic discharge and the explosion severity.[28]

CONCLUSION

Production and use of is expected to increase further worldwide, but also chemical hazards and fire and explosion hazards are also expected. The comprehensive review article sheds light on the effects of fire and explosion hazards, how they experienced severe adverse health outcomes, how to prevent and why industrial workers generally experienced better mortality than their referred population. The safety aspects and must be considered by the chemical industry not only in the interest of the employees or property but also for the neighboring environment. It should be clear from the foregoing that any industry, large or small, requires expert consultation especially in matters affecting the health of workers. More research is needed to clarify the relationship between workplace exposure and health outcomes. Currently, there is some consensus or regulatory standards for occupational exposure limits in the industry.

REFERENCES


2. International efforts for industrial and chemical accidents prevention, preparedness and response. Interagency.


