ANSI E1.40 – 2016 (R2021)
Recommendations for the Planning of Theatrical Dust Effects

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Interest category codes:

CP = custom-market producer
DE = designer
DR = dealer rental company
G = general interest
MP = mass-market producer
U = user

Table of Contents

Basic Dust Use Guidelines

- Determine the appropriate product for the application.
- Ensure you know the precise composition of the product you are using.
- Obtain an Safety Data Sheet (previously called a Material Safety Data Sheet, or MSDS) for the product and abide by any associated exposure limits.
- Use only as much dust as necessary.
- Use dust only where it is necessary.
- Use dust only when it is necessary.
- Avoid exposing unnecessary personnel.
- Monitor and control usage and ventilation throughout.
- Inform personnel on the products being used and post appropriate warnings.
- Follow manufacturers' instructions.
- Use appropriate Personal Protective Equipment (PPE).
- Use appropriate equipment and tools.
- Read this document and follow the recommendations listed.

1 Scope

A wide variety of products are used to create dust effects in entertainment productions. Such effects are most commonly used in motion picture and television production; However, they are also used in theatrical productions and within theme parks. The use of dust in this manner raises concerns for potential hazards including combustibility and health effects from inhalation or ingestion, which, although well known in some sectors of the industry, are poorly understood in others. This document provides recommendations for how to plan the use and assess the safety of such effects.

2 Introduction

The word *dust* is non-specific and means different things to different people. Dust is used in this document as a generic term referring to any solid particles scattered or suspended in the air where the common denominator is the use to which it is put, as a set dressing or as a special effect. Dust can be used in small quantities, such as to sprinkle on books or props to age them or to enhance artificial cobwebs, all the way up to extensive use on film sets where a complete realistic environment is being created. Dust use in film sets for special effects is very common, and the users in that industry are usually more familiar with the techniques than those in theatrical venues. However, the same basic principles of safe operation apply to everyone, no matter the application.

3 Major Categories of Dust

The dust used in theatrical effects generally can be broken down into three major categories—plant and animal-based, mineral, and synthetic—depending on the source of the dust.

3.1 Plant and animal-based

Plant and animal-based dusts are those based on naturally occurring products from plants or animals. Examples of common products derived from plants or animals that have been used as a theatrical dust effect include wheat flour, rice flour, rice gluten, corn starch, coffee creamers, and crushed nutshells.

3.2 Mineral

Mineral-based dusts include fuller's earth, kaolin, aluminum magnesium silicate, pyrolite, pyrophyllite, and diatomaceous earth. Diatomaceous earth is the fossilized remains of diatoms and hard-shelled algae, so it could be classified as a plant or animal-based dust, but fossilization leaves only the mineral remains of those life-forms, particularly silica, behind in the diatomaceous earth.

3.3 Synthetic

There are many synthetic products that might be used to make dust. Colored dyes, ground plastics, and extremely high density glycols, such as polyethylene glycol 3350, might be among the things considered for dust effects.

Note: None of these classifications (plant and animal-based, mineral, or synthetic) is inherently safer than another. For example, wood dust is a plant product, but most wood dusts are confirmed carcinogens. Titanium dioxide is a white pigment that is found in minerals such as rutile and anatase. (Rutile is about 98% titanium dioxide.) The International Agency for Research on Cancer has classified it as a group 2B carcinogen based on inhalation studies.

4 Potential Hazards of Dust

4.1 Exposure

4.1.1 Topical Exposure and Allergies

In low concentrations dust can cause immediate topical irritation of the eyes, skin, nose, and throat. These irritations can be exacerbated if the exposed person is allergic or sensitive to the specific material, particularly if it is an organic dust. Irritation may be caused either by mechanical or chemical irritant characteristics of the dust. For applicable products, the SDS should list the potential mode(s) of irritation.

4.1.2 Inhalation

Dust may also be inhaled into the lungs. The lungs are protected by a series of defense mechanisms in different regions of the respiratory tract. When a person breathes in the nose and upper throat efficiently filter out most large particles, until they are removed mechanically by blowing the nose, sneezing, or coughing.

Some smaller particles will succeed in passing through the nose to reach the windpipe and the dividing air tubes that lead to the lungs. These airways are lined by cells that produce mucus that catches most of the remaining dust particles. Tiny hairs called cilia, covering the walls of the air tubes, move the mucus upward and out into the throat, where it is either coughed up and spat out, or swallowed.

If the dust particles are small enough they may avoid these defenses and reach the tiny air sacs (alveoli) in the deeper parts of the lungs. Depending on the particles degradeability and solubility in body fluids or in cells, the particles may dissolve and enter the blood stream, may be broken down and the byproducts metabolized, or they remain in the alveoli indefinitely.

Generally, dust can cause respiratory health effects in two ways: by being trapped in the lungs where it can cause local damage or irritation, or by absorption directly into the bloodstream. Ingestion of toxic dust can also cause adverse health effects by absorption through the digestive system.

4.1.2.1 Silica

Of particular concern for deep lung inhalation are inorganic dusts containing crystalline silicon dioxide, also known as silica. The term “silica” is often used commonly to refer to at least three substances that contain silicon, but only the first of these contains forms of crystalline silica.

- crystalline silica, such as sand or quartz.
- amorphous silica (non-crystalline)
- silicates, such as clay (aluminum silicates)

It is only the crystalline form (free silica) found in quartz, tridymite, cristobalite, and other nonsilicates that cause silicosis. Silicosis is a slow cumulative lung disease caused by the inhalation of free silica particulates, which may not manifest itself until many years after exposure. The mechanism is as follows: after the macrophages ingest silica particles, they die and give off toxic substances. These substances cause localized fibrous or scar tissue to form in the lungs. This tissue is the body's normal way of repairing itself, however, in the case of crystalline silica so much fibrous tissue and scarring can form that lung function may be impaired. The general name for this condition of fibrous tissue formation and scarring is fibrosis, and the particles that cause fibrosis or scarring are called fibrogenic. When fibrosis is caused by crystalline silica, the condition is called silicosis. Silica in the crystalline form also is a confirmed carcinogen.

Amorphous silica and the many various silicates do not cause silicosis. However, they have been associated with respiratory irritation and other adverse effects. There are air quality standards for some of

the silicate minerals, but there is not enough data on most of them to set standards. These dust should not be considered to be without hazards. Those silicates that can reach the alveoli are likely to remain for life. Most silicates also are found in nature contaminated with some crystalline silica.

4.1.2.2 Fuller's Earth

Historically fuller's earth was commonly used for theatrical dust. However, fuller's earth is an inadequate catch-all name with no agreed or defined composition and is often used as a generic term to describe a broad range of kaolin (clay) based products containing aluminum magnesium silicate. Fuller's earth may also be known as montmorillonite, kaolin, kaolinite, floridin, bentonite, wilkonite, and halloysite.

Fuller's earth is no longer widely used as a theatrical dust product because of the product's historically high free silica content. If you intend to use fuller's earth it is important to obtain a current Safety Data Sheet (SDS) for the specific product you are using and to check the crystalline silica content of that specific product. Although a product is not called fuller's earth, it does not mean it is free of crystalline silica.

4.1.2.3 Wood

The dust from many forms of wood are now thought to be carcinogenic by the American Conference of Governmental Industrial Hygienists (ACGIH). Currently, OSHA regulates wood dust as a nuisance dust. However, OSHA encourages employers to keep exposures to a minimum and to observe the ACGIH Threshold Limit Value (TLV) levels.

4.2 Combustion

Finely dividing a material into a dust vastly increases the surface area of the product in contact with air and can turn a material that is only slightly combustible into a severe fire or explosion hazard. This is a particular problem with plant and animal-based dusts; common materials such as flour can be highly explosive when finely dispersed in the air. OSHA 3371-08 2009 - Health Communication Guidance on Combustible Dusts contains generic advice on dealing with and mitigating such hazards and lists the following materials as examples of potential explosion hazards: metal dust, such as aluminum and magnesium; wood dust; plastic or rubber dust; biosolids; coal dust; plant and animal-based dusts, such as flour, sugar, paper, soap, and dried blood; and dusts from certain textiles.

Different dusts of the same chemical material can have different ignitability and explosibility characteristics, depending upon physical characteristics such as particle size, shape, and moisture content. These physical characteristics can change during manufacturing, use or while the material is being processed.

There are five key elements for a dust fire or explosion; if these elements are missing a fire or explosion cannot occur. The first three elements are those needed for any fire, i.e., the familiar fire triangle:

1. Combustible dust (fuel)
2. Ignition source (heat)
3. Oxygen in air (oxidizer)

An additional element must be present for a combustible dust flash-fire, technically called a deflagration:

4. Dispersion of dust particles in the air in sufficient quantity and concentration

The resulting deflagration can be exacerbated by confinement to make a combustible dust explosion:

5. Confinement of the dust cloud.

If the use of a potentially combustible dust is contemplated, mitigation of these five elements must be considered. Of these, the most important is insuring the dust is not dispersed in the air in significant amounts. Even removing all ignition sources including heat, sparks, and flame, cannot ensure that the dust will not be ignited by an unexpected static discharge. Clean up of these substances also must be done without creating airborne dust clouds.

A combustible dust cloud in a room or confined area is more dangerous than one out in the open. However, a cloud of dust can ignite and burn in the open causing harm to those in or near the cloud.

5 Risk Reduction

5.1 Product Selection

- First and foremost make sure you know the precise composition of the product you are using.
- Obtain and read a Safety Data Sheet for the product and abide by any associated exposure limits. Many products have Permissible Exposure Limits (PEL) established by Federal or State OSHA. Refer to Federal and State OSHA Regulations for further information.
- Give preference to materials for which there are recognized exposure limits and avoid using materials for which there are no recognized limits.
- If non-organic materials are used, pay particular attention to the crystalline or free silica content.
- Avoid using products containing known carcinogens.
- Consult the SDS to identify if a material or product contains a sensitizer and avoid using products containing known sensitizers.
- Use the largest particle size commensurate with achieving the desired effect. In particular, products containing a significant concentration of particles under 10 microns, which are more likely to be inhaled deeply into the respiratory system, should be avoided.
- Avoid using products that are combustible, particularly when a large amount of the product is needed or there is a risk that it will get dispersed into the air.
- For film and television production consider adding dust effects digitally.

5.2 Product Usage

- Inform all cast and crew about the products being used, potential effects, and the necessary precautions that should be taken.
- Provide audience signage to warn of the effect being used.
- If possible mix or bind the product with a liquid medium (such as water or non-toxic binders or adhesives) to reduce the chance of it becoming airborne. If it cannot be mixed or bound in this way, then dampen the product whenever possible.
- If the product contains a range of particle sizes screen or filter out smaller particles.
- Use the minimum possible product to create the effect needed.
- Monitor and control usage and ventilation throughout the application and use to ensure that exposure is maintained at or below applicable exposure limits.
- Follow manufacturer's instructions.

- Eliminate or limit exposure by removing unnecessary personnel, particularly when the material is being applied.
- For set decorating, apply the product when there are few people around.
- If the usage is indoors, periodically ventilate the area.

5.3 Use PPE and Appropriate Tools

- Provide proper Personal Protective Equipment (PPE) as necessary.
- Provide appropriate tools for application of the dust effect and later clean up.