

Layers of Protection: Minimizing the Impact of Combustible Dust

**Robert Whittenberger
President
Abigail Lutte
Tyndale Company, Inc.
Pipersville, PA**

Introduction

Combustible dust remains one of the most formidable, deadly, and unpredictable hazards in the workplace. As of yet, the far-reaching safety, economic, and ethical consequences of combustible dust explosions have not been easily conquered by safety professionals, industry experts, lawmakers, or employers. Currently, OSHA is reviewing the best strategy for mitigating and preventing the hazard, and the time that has thus far been spent investigating, researching, and reviewing hazard mitigation regulations is only a testament to the hazard's complexity. Recognizing the devastating impact of the hazard, the Chemical Safety Board recommended that OSHA issue a standard designed to prevent combustible dust fires and explosions in general industry in November 2006. Since then, there have been at least 25 additional combustible dust explosions resulting in 103 injuries and 18 deaths.¹ As OSHA reviews and considers multiple proposals for a regulation on the federal level, are there any steps that companies can take to help protect their employees—and themselves—from the far-reaching consequences of combustible dust?

Legislation on Combustible Dust

Education regarding and adherence to current applicable standards and the dialogue surrounding them—in addition to the use of protective clothing—may significantly reduce the potential for worker injury, employer liability, and the tarnishing of a company's reputation that results from a single combustible dust explosion. Although a standard administered by OSHA will likely provide greater clarity, accountability, and uniformity of protective requirements to industries susceptible to the hazard, the potential for worker injury in the interim should motivate employers to act on the information that is available now. “This is straightforward and hard to argue: To save workers' lives, we want all employers to find and fix their hazards.”² Several standards currently exist to address some of the implications of the combustible dust hazard and may even prevent explosions if employers follow them.

Currently, OSHA's strategy is poised to address the following requirements in an interim standard (to be issued within 12 months and to be effective until the final rule is decided). This interim standard will provide a regulatory measure to protect workers during the long decision-making process necessary to formulate a final standard. These requirements per OSHA's interim standard will also most likely apply to the final rule:

- Hazard assessment specifically for combustible dust
- Written programs with provisions for hazardous dust inspection, testing, hot work, ignition control, and housekeeping. Annual safety training may also be required.
- Engineering controls, administrative controls, and operating procedures, including the safe use and maintenance of equipment.
- Workplace inspection and housekeeping to prevent accumulation of combustible dust.
- Participation of employees and their representatives, including annual training to prevent the hazard from occurring.³

A few guiding principles from current standards may help industries across the board to minimize the potential for a combustible dust explosion—and address many, if not all, of the above OSHA requirements for its yet unwritten combustible dust regulation. “Well-trained and empowered workers are better prepared to help alert management to potential workplace hazards before tragedy strikes. Informed workers are safely inoculated against unscrupulous employers who would seek to exploit them in order to gain an unfair advantage in the marketplace.”⁴ Training, awareness, and communication are proven to be highly effective tools for reducing hazards in the workplace.

In many OSHA and NFPA standards, many, if not all, of the elements of OSHA’s regulatory focus can be addressed properly and fully in the most susceptible industries. The standards currently available serve as guides for preventing and mitigating the hazard under many circumstances, and it is worthwhile to become educated on them even if they are not all-encompassing or federally regulated. “Implementation of such means of hazard control is both technologically and economically feasible and would substantially reduce risks related to combustible dust fires and explosions to workers.”⁵ Following the safety processes outlined in these standards will significantly reduce the likelihood of an explosion, and the use of PPE further protects employees and employers from the life-threatening hazard of combustible dust.

OSHA (Occupational Safety and Health Association) is a federal organization created by the Occupational Safety and Health Act of 1970 charged to create legislation to ensure safe and healthful working conditions for working men and women by setting and enforcing standards and by providing training, outreach, education, and assistance.⁶ The OSH Act covers employers and their employees either directly through federal OSHA or through an OSHA-approved state program. State programs must meet or exceed federal OSHA standards for workplace safety and health.

NFPA (National Fire Protection Association) is an international nonprofit established in 1896 whose mission is “to reduce the worldwide burden of fire and other hazards on the quality of life by providing and advocating consensus codes and standards, research, training, and education.”⁷ NFPA is the world’s leading advocate of fire prevention and is an authoritative source on public safety. NFPA develops, publishes, and disseminates more than 300 consensus codes and standards intended to minimize the possibility and effects of fire and other risks.

ASTM International develops international standards for materials, products, systems and services used in construction, manufacturing and transportation. Currently, approximately 12,000 ASTM standards are used around the world “to improve product quality, enhance safety, facilitate market access and trade, and build consumer confidence.”⁸

Combustible Dust: The Hazard

Although the more immediate hazards of operating mechanical equipment, faulty ergonomic practices, and dangerous chemicals often claim more attention from safety professionals than what may appear to be harmless accumulations of dust particles in corners and ceilings, combustible dust is as immediate and deadly a hazard as any. Although combustible dust has been recognized as a significant hazard since the early 1900s, the dramatic increase of explosions over the past 20 years has given everyone from employers to lawmakers pause to consider a remedy.

What is combustible dust? Combustible dust can consist of practically any accumulated material if it is finely divided, although some dusts are considerably more explosive than others. (It is worth noting that sugar—a dust with a very low explosivity rating—caused a combustible dust explosion that killed 14 people and injured 38 others at Imperial Sugar). OSHA’s definition of combustible dust provides an accurate generalization of the elements needed as follows: “organic or inorganic dust particles that are finely ground and pose a deflagration or other fire hazard when suspended in air or another oxidizing medium over a range of concentrations.”⁹ Prior to an explosion, finely divided dust is disturbed from its resting position and suspended in the air or introduced to another oxidant. An ignition source such as static, a spark, an ember, a hot surface, friction heat or flame comes in contact with dispersed dust, causing an explosion. OSHA has defined a dangerous accumulation of dust to be 1/32 of an inch or thicker, about the thickness of a US dime. Dust particle size and density affect combustibility; the more finely divided dust is, the more likely it is to combust. Moreover, confined, poorly ventilated areas are more likely targets for combustible dust explosions than well-ventilated workplaces. Ignition source heat and moisture play an essential role in the severity of a dust explosion. As a rule, these five elements interact in order for an explosion to occur:



Exhibit 1. Five elements are involved in a combustible dust explosion.

In many cases, an initial explosion such as the one above propagates secondary explosions, which are often far more powerful and deadly than primary explosions—as was the case at Imperial Sugar in 2008. The interplay of the five above variables can result in powerful, unpredictable, and often fatal dust explosions. Additionally, lack of employer and employee awareness was a common factor in throughout all the major cases investigated by the Chemical Safety Board and others over the past 10-15 years (Colonna 2009). As part of its National Emphasis Program to concentrate resources on this deadly hazard, OSHA first identified 48 industries potentially affected by combustible dust to target, and later revised the number to 64.¹⁰

Many industries not listed by OSHA's National Emphasis Program may also be at risk for explosions.

The types of combustible dust are as numerous as the industries affected by them and include such materials as: metal dust, wood dust, coal or carbon dust, plastic dust, organic dusts such as sugar, flour, paper, soap, or dried blood, and certain textile materials. The CSB's Combustible Dust Investigation Report¹¹ addresses the most common of the many types of dust:

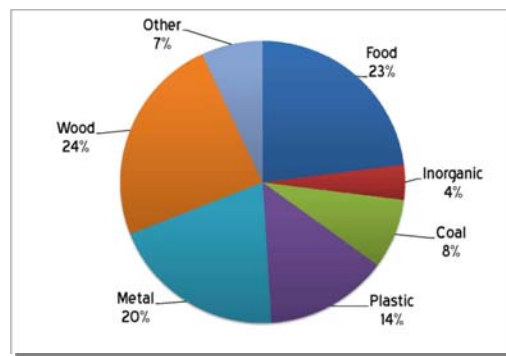


Exhibit 2. Dust accidents encompass a variety of dust materials.

The data above indicates the complexity and extensive scale of the combustible dust explosion hazard. In 71% of the explosions investigated by the CSB, fatalities occurred.¹² Due to the extensive nature of the hazard, OSHA's list of firms is a list of target industries and may exclude many industries with a known combustible dust hazard. "In particular, the food products, chemicals, metal products, and rubber/plastic products industries account for more than 70% of inspections."¹³ It is significant that the current NFPA standards cover the combustible dust hazard for the above four most-affected industries.

The Current Standards

Developing a full understanding of the standards that pertain to worker safety and combustible dust is a positive step employers can take to provide a safer work environment for their employees. As yet, the only OSHA standard pertaining to combustible dust is the Grain Handling Standard, which specifically addresses combustible dust. Numerous other OSHA standards provide guidelines for hazard assessment, protective equipment, and safety programs that do not name combustible dust specifically. In addition to these, many NFPA standards provide guidance on specific industries susceptible to combustible dust, although no one standard addresses the hazard as a whole. ASTM has also addressed worker safety in this regard; currently ASTM Sub-Committee F23 (a committee solely focused on PPE and protective clothing) is working to publish a guide on combustible dust. Though the OSHA, NFPA, and ASTM regulations, standards, and guides do not in themselves provide a comprehensive mitigation strategy applicable to all industries, understanding each of them provides effective insight into combustible dust mitigation and worker safety.

Though only one regulation pertains to combustible dust specifically—the Grain Handling Standard—other regulations provide insight into worker protection. The current standards—both the federal regulations and the voluntary consensus standards—are discussed below in three groups. The first group consists of standards which specifically address the combustible dust hazard or offer more than one mitigation strategy. The second group consists of

standards which may reference combustible dust or only address a single dust mitigation strategy. The third group refers to industry-specific standards.

Group 1: Primary Combustible Dust Standards								
Standard	Hazard Assessment	Written Programs	Engineering Controls	Workplace Inspection	Housekeeping	Employee/Employer Communication	FR Clothing	Required by Law
OSHA General Duty	X					X		Yes
OSHA 1910.22 Housekeeping				X	X			Yes
OSHA 1910.84 Ventilation			X	X	X			Yes
OSHA 1910.132 PPE	X			X		X	X	Yes
OSHA 1910.132 Enforcement Policy	X			X		X	X	Yes
NFPA 69 Explosion Prevention		X	X		X			No
NFPA 2112 FR Garments Flash Fire	X	X					X	No
NFPA 2113 FR Garments Care	X	X					X	No
NFPA 654 Preventing Dust Explosions	X	X	X	X	X	X	X	No
ASTM F1930 Flash Fire Manikin Test	X						X	No

Table 1. Primary Combustible Dust Standards.

OSHA General Duty Clause

Pending Dust Standard Requirements Addressed: Hazard Assessment, Workplace Inspection

Requires, in part, that “every employer covered under the Act furnish to his employees...a place of employment which [is] free from recognized hazards that are causing or likely to cause death or serious physical harm to his employees.”¹⁴ One of the most commonly cited violations in reference to combustible dust incidents, the General Duty Clause requires employers to be thoroughly aware of hazards and to act accordingly.

Complying with this standard may require documentation of management level activities such as facilities inspections, task hazard analyses, employee safety awareness training, and development and review of work rules and written emergency plans. Citations for failure to comply with the General Duty Clause are among the most common.

OSHA 1910.22—General Requirements Housekeeping

Pending Dust Standard Requirements Addressed: Workplace Inspection, Housekeeping

Requires that employers keep workplaces in a generally clean and orderly condition for the protection of personnel. Combustible dust can be considered a serious housekeeping hazard.

“All places of employment, passageways, storerooms, and service rooms shall be kept clean and orderly and in a sanitary condition.”¹⁵ This includes: floors, aisles and passageways, covers and guardrails, and floor loading areas.

OSHA 1910.84—Ventilation

Pending Dust Standard Requirements Addressed: Engineering Controls, Workplace Inspection, Housekeeping

OSHA 1910.84 addresses proper working conditions for employees in need of continuous ventilation due to airborne hazards such as exhaust, dust particles (such as combustible dust), and fumes. Highlights pertaining to combustible dust in the standard are as follows:

- “The concentration of respirable dust or fume in the breathing zone of the abrasive-blasting operator or any other worker shall be kept below the levels specified in 1910.1000.
- “Blast-cleaning enclosures shall be exhaust ventilated in such a way that a continuous inward flow of air will be maintained at all openings in the enclosure during the blasting operation.
- “All air inlets and access openings shall be baffled or so arranged that by the combination of inward air flow and baffling the escape of abrasive or dust particles into an adjacent work area will be minimized and visible spurts of dust will not be observed.”¹⁶

OSHA 1910.132—Personal Protective Equipment

Pending Dust Standard Requirements Addressed: Hazard Assessment, Workplace Inspection, Employer/Employee Communication

The OSHA 1910.132 Personal Protective Equipment standard addresses the measures that employers should take provide employees with protective apparel where a hazard exists. Flame resistant clothing is an often-cited means of offering protection to employees in the production-related industries, well servicing, and oil and gas drilling occupations. Wherever a hazard exists, an employer must conduct a hazard assessment:

- “The OSHA personal protective equipment standard, 29 CFR 1910.132, requires companies to complete a hazard assessment to determine the protective equipment appropriate for all of the workplace hazards. This includes protective clothing, such as FRC, when the hazards include the potential for fires.”

OSHA 1910.132 also addresses specific types of protective equipment to be provided, “Protective equipment, including personal protective equipment for eyes, face, head, and extremities, protective clothing, respiratory devices, and protective shields and barriers shall be provided, used and maintained...wherever it is necessary by reason of hazards of processes or environment, chemical hazards, radiological hazards, or mechanical irritants encountered in a manner capable of causing injury or impairment in the function of any part of the body through absorption, inhalation, or physical contact.” Where an employee is at-risk for a flash fire burn, such as those related to combustible dust, citation language from OSHA may include the following: “The employer failed to provide and ensure the use of flame- retardant treated clothing (FRC) necessary to protect employees from burns due to potential flash fires.”¹⁷

OSHA 1910.132—FR Clothing Enforcement Policy

An enforcement policy for flame resistant clothing in oil and gas drilling, well servicing, and production-related occupations, this document mandates flame resistant clothing for those specific occupations.

- “...FRC includes both flame-resistant and fire retardant treated clothing. Clarification of the need to provide and use FRC during certain drilling, servicing, and production-related operations is necessary to resolve its inconsistent use among drilling contractors, well servicing contractors, and oil and gas companies that employ thousands of workers in these operations.”
- “The use of FRC greatly improves the chance of a worker surviving and regaining quality of life after a flash fire. FRC can significantly reduce both the extent and severity of burn injuries to the body.”¹⁸

NFPA 69—Standard on Explosion Prevention Systems

Pending Dust Standard Requirements Addressed: Written Programs, Engineering Controls, Housekeeping

Especially applicable to the combustible dust hazard, NFPA 69 requires testing, third party inspection, and design documentation on engineering systems that prevent any flammable substance from accumulating. The standard covers minimum requirements for installing systems for the prevention of explosions in enclosures that contain flammable concentrations of flammable gases, vapors, mists, dusts, or hybrid mixtures.¹⁹ In addition, the following are discussed:

- Design system verification through testing
- 3rd-party inspection and approval of protection systems by an internationally recognized testing laboratory for the function intended, as specified in Chapters 7 through 14
- Management of change
- Regular testing and maintenance
- Commissioning tests
- Design documentation

NFPA 2112—Standard on Flame-Resistant Garments for Protection of Industrial Personnel against Flash Fire

Pending Dust Standard Requirements Addressed: Hazard Assessment, Workplace Inspection

NFPA 2112 specifies the minimum design, performance, certification requirements, and test methods for flame-resistant garments for use in areas at risk from flash fires. The primary performance specification in NFPA 2112 is a performance standard designed to establish a benchmark performance for FR garments exposed to flash fire.

- NFPA 2112 establishes specific criteria for testing garments using the ASTM F1930 test method.
- The fabric must not melt, drip, or have more than 2 seconds afterflame or 4.0 inches char length when tested and after 25 launderings, according to the ASTM D6413 test method.
- Tyndale’s “Flash Fire Rated” clothing is defined as having 50% or less predicted body burn in 3 seconds, according to the specifications of NFPA 2112 (ASTM 6413 test method).

NFPA 2112 requires the following:

- All garments must have a product label or labels permanently and conspicuously attached to each flame-resistant garment.
- All garments labeled as compliant with NFPA 2112 must meet or exceed all applicable requirements specified in this standard and shall be UL certified
- The UL certification organization's label, symbol, or identifying mark shall be attached to the product label, be part of the product label, or be immediately adjacent to the product label.
- NFPA 2112 outlines 17 test methods, including: flame resistance, manikin testing, thermal shrinkage resistance, heat resistance and a host of other tests.²⁰

NFPA 2113—Standard on the Selection, Care, Use, and Maintenance of Flame Resistant Garments for Protection of Industrial Personnel against Flash Fire

Pending Dust Standard Requirements Addressed: Hazard Assessment

NFPA 2113 is a companion standard to NFPA 2112 and describes the selection, care, use, storage and maintenance of clothing used to protect against flash fire. It offers recommendations on best practices to follow and is a helpful guide for users and administrators of FR clothing programs.²¹

NFPA 654: Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing and Handling of Combustible Particulate Solids

Pending Dust Standard Requirements Addressed: Hazard Assessment, Written Programs, Engineering Controls, Workplace Inspection, Housekeeping, Employer/Employee Communication

The most comprehensive standard on combustible dust, NFPA 654 is a clear guide for the prevention of dust explosions that many industries can follow to significantly reduce the chance for dust explosions. NFPA 654 offers guidance on best engineering practices associated with combustible dust. Combustible dust is any finely divided solid—such as flour, wood dust, or aluminum dust—that will explode when dispersed in air and ignited. The standard includes information on avoiding dust explosions through both facility design and housekeeping. Additionally, information on controlling ignition sources and explosion mitigation strategies is provided. Optimally, dust should be prevented through effective housekeeping measures.

- Requirements of NFPA 654 include information on facility design, process hazard analysis, basis for deflagration protection, and an analysis of the physical and chemical properties of the given combustible dust.
- This standard is on a five year revision cycle; the 2006 edition is expected to be updated in 2011. Changes expected to take effect in the revised standard include the following additions regarding Personal Protective Equipment:
 - “Operators shall wear flame-resistant garments as specified in NFPA 2112 and any other personnel protective equipment required for protection against flash fire hazards during charging operations.
 - “Operating Plans shall include the use of flame-resistant garments as specified in NFPA 2112 for all exposed personnel when the design dust mass accumulation exceeds the threshold value determined per section 6.1
 - “Operating and maintenance procedures shall address personal protective equipment (PPE) for tasks involving or handling of combustible dust according to the following: PPE shall include flame resistant garments in accordance with the workplace

hazard assessment required by NFPA 2112: Where a dust explosion hazard or flash fire hazard exists, flame resistant garments shall be required for all exposed personnel.”²²

ASTM F1930—Standard Test Method for Evaluation of Flame Resistant Clothing for Protection against Flash Fire Simulations Using an Instrumented Manikin

Pending Dust Standard Requirements Addressed: Hazard Assessment

ASTM F1930 specifies a standard process for measuring the average predicted body burn of a fabric based on a laboratory flash fire simulation.

- The fabric is sewn into a standard coverall pattern.
- The coverall is placed on an instrumented manikin.
- Sensors measure the covers quantitative measurements and subjective observations that characterize the performance of single layer garments or protective clothing ensembles in a simulated flash fire environment having controlled heat flux, flame distribution, and duration.
 - Heat transmitted to each sensor location on the surface of an instrumented manikin is converted to show the corresponding predicted degree of burn injury to human tissue.
 - The sum of these values can then be converted to a percentage to show the total area of predicted burn injury.
 - Use of the predicted burn injury to evaluate the heat transferred to the manikin does not constitute a material's performance specification.
 - The visual and physical changes to the single layer garment or protective clothing ensemble are recorded to aid in understanding how the burn injury results can be interpreted.
 - The measurements obtained and observations noted can only apply to the particular garment(s) or ensemble(s) tested using the specified heat flux, duration, and flame distribution.

This standard should be used to measure and describe the response of materials, products, or assemblies to heat and flame under controlled conditions and should not be used to describe or appraise the fire-hazard or fire-risk of materials, products, or assemblies under actual fire conditions.²³

Group 2: Secondary Combustible Dust Standards								
Standard	Hazard Assessment	Written Programs	Engineering Controls	Workplace Inspection	Housekeeping	Employee/Employer Communication	FR Clothing	Required by Law
OSHA 1910.38 Emergency Action		X	X			X		Yes
OSHA 1910.146 Confined Spaces	X		X					Yes
OSHA 1910.307 Hazardous Locations	X			X		X		Yes
OSHA 1910.1200 Hazard Communication		X				X	X	Yes
F23 ASTM Pending Dust PPE							X	No

Table 2. Secondary Combustible Dust Standards

OSHA 1910.38—Emergency Action Plans

Pending Dust Standard Requirements Addressed: Engineering Controls, Employer/Employee Communication, Written Programs

Emergency action plans are particularly applicable to the combustible dust standard because they enable employees to escape in the event of a combustible dust explosion. “An employer must have an emergency action plan whenever an OSHA standard in this part requires one....”²⁴ An emergency action plan must include at a minimum:

- Procedures for reporting an emergency
- Procedures for emergency evacuation
- Procedures to account for employees after evacuation
- The name/job title of each employee who may be contacted about the plan
- Employee alarm system
- Review of emergency action plan / training

OSHA 1910.146—Permit-Required Confined Spaces

Pending Dust Standard Requirements Addressed: Hazard Assessment, Engineering Controls,

Though this standard does not specifically apply to agriculture, construction, or shipyard employment, the confined spaces standard specifies a maximum airborne concentration of combustible dust for employees who are exposed to the hazard of permit-required confined spaces.²⁵

OSHA 1910.307—Hazardous Locations

Pending Dust Standard Requirements Addressed: Hazard Assessment, Workplace Inspection, Employer/Employee Communication

Covers the requirements for electric equipment and wiring in locations that are “classified depending on the properties of the flammable vapors, liquids or gases, or combustible dusts or fibers that may be present therein and the likelihood that a flammable or combustible concentration or quantity is present.”²⁶ Hazardous locations may include such facilities as aircraft hangars, gasoline dispensing and service stations, paint-finishing process plants, health care facilities, and agricultural facilities.

Each area, room, section or area shall be considered individually in determining its classification. Classifications range from Class I-Class III and are separated into different divisions.

OSHA 1910.1200—Hazard Communication

Pending Dust Standard Requirements Addressed: Written Programs, Employer/Employee Communication

Requires chemical manufacturers or importers to assess the hazards of chemicals which they produce or import, and all employers to provide information to employees about hazardous chemicals to which they are exposed:

- Hazard communication program
- Labels and other forms of warning
- Material safety data sheets
- Information and training

- Requires distributors to transmit the required information to employers.

The standard ensures that the hazards of all chemicals produced or imported are evaluated, and that information concerning their hazards is transmitted to employers and employees. This information should be passed to employees through “comprehensive hazard communication programs, which are to include container labeling and other forms of warning, material safety data sheets and employee training.”²⁷

Task Committee F23 Combustible Dust Guide

The ASTM Task Committee F23 on protective clothing meets to “develop standard specifications, test methods, practices, guides, terminology, and classifications for protective clothing and personal protective equipment (PPE) designed to be constructed to protect the user from potential occupational hazards...”²⁸ Recognizing the importance of creating a combustible dust guide, a subcommittee of ASTM Committee F23 is offering its insight on protective equipment in a new guide to be released in approximately 24 months. The guide will specifically address FR clothing. This guide will be available in the future for employers to use as a best practice handbook. The guide is under development

Group 3: Industry Specific Standards Referencing Combustible Dust								
Standard	Hazard Assessment	Written Programs	Engineering Controls	Workplace Inspection	Housekeeping	Employee/Employer Communication	FR Clothing	Required by Law
OSHA 1910.269 Electric T&D	X	X	X	X	X	X	X	Yes
OSHA 1910.272 Grain Handling	X	X	X	X	X	X		Yes
NFPA 61 Food Processing Dust	X	X	X	X	X			No
NFPA 484 Metal Dust	X	X	X	X	X	X		No
NFPA 655 Sulfur Fires and Dust	X		X	X	X			No
NFPA 664 Wood Fires and Dust	X	X	X	X	X	X		No

Table 3. Industry-Specific Standards on Combustible Dust

OSHA 1910.269—Electric Power Generation, Transmission and Distribution

Pending Dust Standard Requirements Addressed: Hazard Assessment, Written Programs, Engineering Controls, Workplace Inspection, Employer/Employee Communication

Written for employees in the electric power industry, 1910.269 covers the maintenance of applicable electrical equipment in a non-hazardous way. The standard covers the operation and maintenance of electric power generation, control, transformation, transmission, and distribution lines and equipment. The standard’s combustible dust provisions are as follows:

- “Where coal-handling operations may produce a combustible atmosphere from fuel sources or from flammable gases or dust, sources of ignition shall be eliminated or safely controlled to prevent ignition of the combustible atmosphere.”²⁹

OSHA 1910.272—Grain Handling Facilities

Pending Dust Standard Requirements Addressed: Hazard Assessment, Written Programs, Engineering Controls, Workplace Inspection, Housekeeping, Employer/Employee Communication

The only OSHA standard pertaining specifically to combustible dust, the Grain Handling Facilities Standard sets requirements for the control of fires and explosions, among other hazards. Highlights are as follows:

- Contains requirements for the control of grain dust fires and explosions, and certain other safety hazards associated with grain handling facilities.
- Requirements: Training, Housekeeping, Preventative Maintenance (engineering controls)³⁰

NFPA 61: Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities

Pending Dust Standard Requirements Addressed: Hazard Assessment, Written Programs, Engineering Controls, Workplace Inspection, Housekeeping

A guide written specifically for food processing and agricultural facilities, NFPA 61 offers guidance on:

- Facilities that receive, handle, process, dry, blend, use, mill, package, store, or ship dry agricultural bulk materials
- All facilities designed for manufacturing and handling starch, including drying, grinding, conveying, processing, packaging, and storing dry or modified starch, and dry products and dusts generated from those processes.
- Seed preparation and meal-handling systems

Prescribes requirements for safety to life and property from fires and minimize the potential of damage from explosions. Includes prescribed methods for construction, explosion prevention and relief, and venting.³¹

NFPA 484—Standard for Combustible Metals

Pending Dust Standard Requirements Addressed: Hazard Assessment, Written Programs, Engineering Controls, Housekeeping, Employer/Employee Communication

Requires specific methods for the production, processing, finishing, handling, recycling, storage, and use of all metals and alloys that are in any form capable of explosion or combustion.

- Applies to operations where metal or metal alloys are subjected to processing or finishing operations that produce combustible powder or dust shall include, but shall not be limited to: machining, sawing, grinding, budding, and polishing.
- Determination of the combustibility or explosivity of a metal, metal powder, or metal dust
- Metals covered under this standard include: alkali metals, aluminum, magnesium, niobium, tantalum, zirconium, among others.
- Requires employers to provide a reasonable level of protection from loss of life and property from fire and explosion.
- “A hazard assessment shall be performed to resolve any conflicts between the requirements of this hazard and any other NFPA code or standard.”³²

NFPA 655: Standard for Prevention of Sulfur Fires and Explosions

Pending Dust Standard Requirements Addressed: Hazard Assessment, Engineering Controls, Housekeeping, Workplace Inspection

Outlines handling of sulfur, training, inspection, and dust control.

- Applies to crushing, grinding, or pulverizing of sulfur and to the handling of sulfur in any form. The standard does not apply to the mining, recovery of, or transportation of sulfur.
- Provides requirements to eliminate or reduce the hazards of explosion and fire inherent in the processing and handling of sulfur.
- Provides requirements to eliminate or reduce the hazards of explosion and fire inherent in the processing and handling of sulfur.
- Includes specifications for explosion prevention in equipment
- Where there is an explosion hazard, dust collectors are required to be located outside of buildings.³³

NFPA 664: Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities

Pending Dust Standard Requirements Addressed: Engineering Controls, Hazard Assessment, Workplace Inspection, Housekeeping, Employer/Employee Communication

NFPA 664 addresses the minimum requirements for fire and explosion prevention and protection of industrial, commercial, or institutional facilities that process wood or manufacture wood products, using wood or other cellulosic fiber as a substitute for or additive to wood fiber, and that process wood, creating wood chips, particles, or dust. NFPA 664 also provides minimum requirements for the design, operation, and maintenance of woodworking and wood processing facilities for the safety to life, property protection, and mission continuity from fire and explosion.³⁴

Preventing Combustible Dust Explosions

Once the likelihood of an explosion of any severity has been determined, safety professionals should educate workers on effective methods for hazard removal. This might include housekeeping instructions, ensuring proper ventilation, removing or monitoring ignition sources, and providing safety equipment. The extent of hazard removal will depend on the company, the breadth of the hazard, and the feasibility of prevention methods. Until OSHA develops an official, federally enforceable regulation, reliance on the above NFPA, ASTM, and OSHA standards above will provide an excellent measure of protection for most—if not all—industries. In addition to becoming educated on the current standards, employers should consider purchasing flame resistant clothing for their employees.

Though flame resistant clothing is not yet required for workers exposed to flash fire hazards in many industries, its procurement may be the last and most important step a company can take to protect the lives of workers. Many companies have already taken this preventative measure to avert worker injury—including Imperial Sugar. Even companies that implement all known mitigation strategies will find that cost-effective flame resistant clothing will offer peace of mind in the event that an explosion ever does occur. Until there is a unified, enforced standard regarding this hazard, voluntary compliance with the current recommendations is necessary to ensure worker safety. Preventing the thousands of worker burn injuries that occur every year should be on the forefront of each employer's priority list—regardless of the cost.

The benefits and drawbacks of requiring flame resistant clothing for workers exposed to combustible dust has been an issue that OSHA has sought feedback on from stakeholders. At the most recent OSHA stakeholder meetings in 2010, participants addressed the pros and cons of requiring flame resistant clothing for workers exposed to combustible dust. Some arguments against providing flame resistant clothing were provided and were as follows:

- “The grain and feed industry does not support the use of flame-retardant clothing. Housekeeping measures have already reduced the number of fatalities. Requiring flame-retardant clothing would probably cause more problems and expense than it would be worth.
- “OSHA’s personal protective equipment (PPE) standard sufficiently addresses flame-retardant clothing, allowing employers to conduct hazard assessments and determine whether flame-retardant clothing is necessary.
- “Employees who are required to wear flame-retardant clothing sometimes express negative opinions on the comfort of the clothing. Extreme employee discomfort might cause a more significant safety hazard than would have been prevented by the flame-retardant clothing.”³⁵

Though the above arguments appear persuasive on the surface, their validity falls short with analysis:

- OSHA’s Grain and Feed handling standard, the only federal regulation pertaining specifically to combustible dust, is a testament to the explosive danger inherent in this specific industry. Though stakeholders may be correct in stating that the number of explosions has been reduced, even one fatality costs far more than donning FRC at the employee level. The CSB concludes: “Studies have shown that burns to over 75% of the body can occur easily from the ignition and continued burning of conventional clothing versus workers that don FRC, which do not continue to burn when exposed to a flame source.”³⁶ Dr. David Michaels, the Assistant Secretary of Labor for OSHA, addressed an audience in the wake of several oil and drilling flash fire explosions: “The catastrophes we have seen must serve as a solemn warning that management cannot afford to be lulled into complacency by DART rates and other statistics that, like the stock market, offer no guarantee of future performance against catastrophic incidents.”³⁷ The Grain and Feed industry, like any other, should not be lulled into complacency when any chance of a combustible dust explosion claiming a life still exists. The most recent statistics indicate that fatalities have decreased by 60% since the standard became law—which is still a 40% failure rate.
- OSHA’s PPE standard (1910.132) does address significant elements of wearing personal protective equipment once a hazard analysis is performed, but it is not applicable specifically enough to the combustible dust hazard to ensure employer compliance. “Protective equipment...shall be provided...wherever it is necessary of reason of hazards of processes or environment, chemical hazards, radiological hazards, or mechanical irritants encountered in a manner capable of causing injury...”³⁸ Though many employers have taken precautions, the use of flame resistant clothing for employees in a combustible dust environment is still a too-vague conclusion to draw for many businesses.
- The argument against flame resistant clothing’s comfort and cost is a poor one, especially in light of the health care, litigation expenses, and the psychological and sociological devastation of a single burn injury—not to mention a death. Dr. Michaels asserts, “Many employers in the industry have been requiring the use of flame-resistant clothing for years. FRC is widely available in all clothing types, with fabric weights, breathability and comfort comparable to non-FR clothing. The cost of providing an outer

layer of FRC is not significantly more than supplying non-FRC cotton work clothing that many contractors already supply.”³⁹ The wide plethora of FR clothing available in most any conceivable weight, weave, breathability, and price gives employers no excuse to pass over its potential benefits. “Now here's the point: One of these two workers had donned his FRC and while he was burned, he survived. The worker next to him was not wearing FRC, and he sustained severe burns and subsequently died from his injuries. His name is Abel Garcia. He was only 39 years old.”⁴⁰ Such powerful anecdotal evidence from the primary safety organization in the country for flame resistant clothing’s protective capabilities should be enough to motivate anyone.

Combustible dust explosions, if unpredictable and difficult to analyze, are preventable. In the wake of dozens of deaths and hundreds of injuries related to this hazard, lawmakers are poised to offer a federal regulation attempting to regulate and thereby eliminate the hazard. By drawing on current NFPA, OSHA, and ASTM standards available, OSHA is performing a benchmark safety analysis that, though not enforceable, should give employers pause to follow suit. Employers have the same standards at their fingertips that lawmakers do, and becoming educated on them is perhaps one of the most meaningful, ethical and economically sound decisions a company susceptible to combustible dust can make. As OSHA prepares to regulate the following factors of workplace safety: hazard assessment, written programs, engineering controls, workplace inspection and housekeeping, and employee/employer participation—employers can adapt many of the principles outlined in the above standards to preemptively protect their employees. In sum, FR clothing provides a final layer of protection that often proves to indeed be the last line of defense that prevents injury and death.

Endnotes

¹ 112th Congress 1st Session H.R. 522. 2011. *To require the Secretary of Labor to issue an interim occupational safety and health standard regarding worker exposure to combustible dust, and for other purposes* (retrieved February 26, 2011) (<http://www.gpo.gov/fdsys/pkg/BILLS-112hr522ih/pdf/BILLS-112hr522ih.pdf>).

² Occupational Safety and Health Administration (OSHA). 2010. *Oil and Gas Safety Conference* (retrieved February 21, 2011) (http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=SPEECHES&p_id=2329).

³ 112th Congress 1st Session H.R. 522. 2011. *To require the Secretary of Labor to issue an interim occupational safety and health standard regarding worker exposure to combustible dust, and for other purposes* (retrieved February 26, 2011) (<http://www.gpo.gov/fdsys/pkg/BILLS-112hr522ih/pdf/BILLS-112hr522ih.pdf>).

⁴ Occupational Safety and Health Administration (OSHA). 2010. *Oil and Gas Safety Conference* (retrieved February 21, 2011) (http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=SPEECHES&p_id=2329).

⁵ Occupational Safety and Health Administration (OSHA). *About OSHA* (retrieved February 28, 2011) (<http://www.osha.gov/about.html>).

⁶ IBID.

⁷ National Fire Protection Association (NFPA). *About NFPA* (retrieved February 28, 2011) (<http://www.nfpa.org/categoryList.asp?categoryID=143&URL=About%20NFPA>).

-
- ⁸ American Society for Testing and Materials (ASTM). *About ASTM* (retrieved February 28, 2011) (<http://www.astm.org/ABOUT/overview.html>).
- ⁹ Occupational Safety and Health Administration (OSHA). 2008. CPL 03-00-008, *Combustible Dust National Emphasis Program (Reissued)* (retrieved February 25, 2011) (http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=DIRECTIVES&p_id=3830#scope).
- ¹⁰ US Chemical Safety and Hazard Investigation Board (CSB). 2006. Report No 2006-H-1, *Investigation Report: Combustible Dust Hazard Study* (retrieved February 25, 2011) (http://www.csb.gov/assets/document/Dust_Final_Report_Website_11-17-06.pdf).
- ¹¹ IBID.
- ¹² IBID.
- ¹³ Occupational Safety and Health Administration (OSHA). *Status Report on Combustible Dust National Emphasis Program* (retrieved February 22, 2011) (http://www.osha.gov/dep/combustible_dust/combustible_dust_nep_rpt_102009.html).
- ¹⁴ Occupational Safety and Health Administration (OSHA). OSH Act Section 5(a) (1), *General Duty Clause* (retrieved February 22, 2011) (http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9714).
- ¹⁵ Occupational Safety and Health Administration (OSHA). 29 CFR 1910.22, *General Requirements: Housekeeping* (retrieved February 15, 2011) (http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9714).
- ¹⁶ Occupational Safety and Health Association (OSHA). 29 CFR 1910.94, *Ventilation* (retrieved February 25, 2011) (http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=9734&p_table=standards).
- ¹⁷ Occupational Safety and Health Administration (OSHA). 2010. *Enforcement Policy for Flame-Resistant Clothing in Oil and Gas Drilling, Well Servicing, and Production-Related Operations* (retrieved February 25, 2011) (http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=INTERPRETATIONS&p_id=27296).
- ¹⁸ IBID.
- ¹⁹ National Fire Protection Association (NFPA). NFPA 69, *Standard on Explosion Prevention Systems* (retrieved February 25, 2011) (<http://www.nfpa.org/aboutthecodes/AboutTheCodes.asp?DocNum=69>).
- ²⁰ National Fire Protection Association (NFPA). NFPA 2112, *Standard on Flame Resistant Garments for Protection of Industrial Personnel against Flash Fire* (retrieved February 24, 2011) (<http://www.nfpa.org/aboutthecodes/AboutTheCodes.asp?DocNum=2112>).
- ²¹ National Fire Protection Association (NFPA). NFPA 2113, *Standard on Selection, Care, Use, and Maintenance of Flame Resistant Garments for Protection of Industrial Personnel against Flash Fire* (retrieved February 24, 2011) (<http://www.nfpa.org/aboutthecodes/AboutTheCodes.asp?DocNum=2113>).
- ²² National Fire Protection Association (NFPA). NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids* (retrieved February 24, 2011) (<http://www.nfpa.org/aboutthecodes/AboutTheCodes.asp?DocNum=654>).
- ²³ ASTM Standard F 1930, "Standard Test Method for Evaluation of Flame Resistant Clothing for Protection against Flash Fire Simulations Using an Instrumented Manikin," ASTM International, West Conshohocken, PA, www.astm.org.

-
- ²⁴ Occupational Safety and Health Administration (OSHA). 29 CFR 1910.38, *Emergency Action Plans* (retrieved February 25, 2011) (http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=9726&p_table=STANDARDS).
- ²⁵ Occupational Safety and Health Administration (OSHA). 29 CFR 1910.146, *General Environmental Controls* (retrieved February 25, 2011) (http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=9797).
- ²⁶ Occupational Safety and Health Administration (OSHA). 29 CFR 1910.307, *Hazardous (classified) Locations* (retrieved February 24, 2011) (http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=9884&p_table=STANDARDS).
- ²⁷ Occupational Safety and Health Association (OSHA). 29 CFR 1910.1200, *Hazard Communication* (retrieved February 25, 2011) (http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10099).
- ²⁸ American Society of Testing and Materials (ASTM). *ASTM F23 Fact Sheet* (retrieved February 23, 2011) (http://www.astm.org/COMMIT/F23_Fact_sheet.pdf).
- ²⁹ Occupational Safety and Health Administration (OSHA). 29 CFR 1910.269, *Electric Power Generation, Transmission, and Distribution* (retrieved February 25, 2011) (http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=9868).
- ³⁰ Occupational Safety and Health Administration (OSHA). 29 CFR 1910.272, *Grain Handling Facilities* (retrieved February 25, 2011) (http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9874).
- ³¹ National Fire Protection Association (NFPA). NFPA 61, *Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities* (retrieved February 25, 2011) (<http://www.nfpa.org/aboutthecodes/AboutTheCodes.asp?DocNum=61>).
- ³² National Fire Protection Association (NFPA). NFPA 484, *Standard for Combustible Metals* (retrieved 24, 2011) (<http://www.nfpa.org/aboutthecodes/AboutTheCodes.asp?DocNum=484>).
- ³³ National Fire Protection Association (NFPA). NFPA 655, *Standard for Prevention of Sulfur Fires and Explosions* (retrieved February 23, 2011) (<http://www.nfpa.org/aboutthecodes/AboutTheCodes.asp?DocNum=655>).
- ³⁴ National Fire Protection Association (NFPA). NFPA 664, *Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities* (retrieved February 24, 2011) (<http://www.nfpa.org/aboutthecodes/AboutTheCodes.asp?DocNum=664>).
- ³⁵ Occupational Health and Safety Administration (OSHA). 2010. *OSHA Clarification Letter on 1910.132* (retrieved February 23, 2011) (http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=INTERPRETATIONS&p_id=25366).
- ³⁶ Industrial Fire Journal. *CSB Recommendations Deficient—Flash Fire Hazards* (retrieved February 23, 2011) (http://www.hemmingfire.com/news/fullstory.php/aid/616/CSB_Recommendations_Deficient-Flash_Fire_Hazards.html).
- ³⁷ Occupational Safety and Health Administration (OSHA). 2010. *Oil and Gas Safety Conference* (retrieved February 21, 2011) (http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=SPEECHES&p_id=2329).
- ³⁸ Occupational Safety and Health Administration (OSHA). 29 CFR 1910.132, *Personal Protective Equipment* (retrieved February 25, 2011) (http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9777).

³⁹ Occupational Safety and Health Administration (OSHA). 2010. *Oil and Gas Safety Conference* (retrieved February 21, 2011) (http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=SPEECHES&p_id=2329).

⁴⁰ IBID.

Bibliography

112th Congress 1st Session H.R. 522. 2011. *To require the Secretary of Labor to issue an interim occupational safety and health standard regarding worker exposure to combustible dust, and for other purposes* (retrieved February 26, 2011) (<http://www.gpo.gov/fdsys/pkg/BILLS-112hr522ih/pdf/BILLS-112hr522ih.pdf>).

American Society for Testing and Materials (ASTM). *About ASTM* (retrieved February 28, 2011) (<http://www.astm.org/ABOUT/overview.html>).

American Society of Testing and Materials (ASTM). *ASTM F23 Fact Sheet* (retrieved February 23, 2011) (http://www.astm.org/COMMIT/F23_Fact_sheet.pdf).

ASTM Standard F 1930, "Standard Test Method for Evaluation of Flame Resistant Clothing for Protection against Flash Fire Simulations Using an Instrumented Manikin," ASTM International, West Conshohocken, PA, www.astm.org.

Colonna, Guy R. "NFPA Combustible Dust Hazard Codes and Standards," *National Fire Protection Agency (NFPA)* (retrieved February 21, 2011) (http://www.nfpa.org/assets/files/PDF/Foundation%20proceedings/NFPA_Combustible_Dust_Hazard_Codes_and_Standards_Colonna.pdf).

Industrial Fire Journal. *CSB Recommendations Deficient—Flash Fire Hazards* (retrieved February 23, 2011) (http://www.hemmingfire.com/news/fullstory.php/aid/616/CSB_Recommendations_Deficient-Flash_Fire_Hazards.html).

National Fire Protection Association (NFPA). *About NFPA* (retrieved February 28, 2011) (<http://www.nfpa.org/categoryList.asp?categoryID=143&URL=About%20NFPA>).

National Fire Protection Association (NFPA). NFPA 61, *Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities* (retrieved February 25, 2011) (<http://www.nfpa.org/aboutthecodes/AboutTheCodes.asp?DocNum=61>).

National Fire Protection Association (NFPA). NFPA 69, *Standard on Explosion Prevention Systems* (retrieved February 25, 2011) (<http://www.nfpa.org/aboutthecodes/AboutTheCodes.asp?DocNum=69>).

National Fire Protection Association (NFPA). NFPA 484, *Standard for Combustible Metals* (retrieved 24, 2011) (<http://www.nfpa.org/aboutthecodes/AboutTheCodes.asp?DocNum=484>).

National Fire Protection Association (NFPA). NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids* (retrieved February 24, 2011) (<http://www.nfpa.org/aboutthecodes/AboutTheCodes.asp?DocNum=654>).

National Fire Protection Association (NFPA). NFPA 655, *Standard for Prevention of Sulfur Fires and Explosions* (retrieved February 23, 2011) (<http://www.nfpa.org/aboutthecodes/AboutTheCodes.asp?DocNum=655>).

National Fire Protection Association (NFPA). NFPA 664, *Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities* (retrieved February 24, 2011) (<http://www.nfpa.org/aboutthecodes/AboutTheCodes.asp?DocNum=664>).

National Fire Protection Association (NFPA). NFPA 2112, *Standard on Flame Resistant Garments for Protection of Industrial Personnel against Flash Fire* (retrieved February 24, 2011) (<http://www.nfpa.org/aboutthecodes/AboutTheCodes.asp?DocNum=2112>).

National Fire Protection Association (NFPA). NFPA 2113, *Standard on Selection, Care, Use, and Maintenance of Flame Resistant Garments for Protection of Industrial Personnel against Flash Fire* (retrieved February 24, 2011) (<http://www.nfpa.org/aboutthecodes/AboutTheCodes.asp?DocNum=2113>).

Occupational Safety and Health Administration (OSHA). 29 CFR 1910.22, *General Requirements: Housekeeping* (retrieved February 15, 2011) (http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9714).

Occupational Safety and Health Administration (OSHA). 29 CFR 1910.38, *Emergency Action Plans* (retrieved February 25, 2011) (http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=9726&p_table=STANDARDS).

Occupational Safety and Health Association (OSHA). 29 CFR 1910.94, *Ventilation* (retrieved February 25, 2011) (http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=9734&p_table=standards).

Occupational Safety and Health Administration (OSHA). 29 CFR 1910.132, *Personal Protective Equipment* (retrieved February 25, 2011) (http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9777).

Occupational Safety and Health Administration (OSHA). 29 CFR 1910.146, *General Environmental Controls* (retrieved February 25, 2011) (http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=9797).

Occupational Safety and Health Administration (OSHA). 29 CFR 1910.269, *Electric Power Generation, Transmission, and Distribution* (retrieved February 25, 2011) (http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=9868).

Occupational Safety and Health Administration (OSHA). 29 CFR 1910.272, *Grain Handling Facilities* (retrieved February 25, 2011) (http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9874).

Occupational Safety and Health Administration (OSHA). 29 CFR 1910.307, *Hazardous (classified) Locations* (retrieved February 24, 2011) (http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=9884&p_table=STANDARDS).

Occupational Safety and Health Association (OSHA). 29 CFR 1910.1200, *Hazard Communication* (retrieved February 25, 2011) (http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10099).

Occupational Safety and Health Administration (OSHA). *About OSHA* (retrieved February 28, 2011) (<http://www.osha.gov/about.html>).

Occupational Safety and Health Administration (OSHA). 2008. CPL 03-00-008, *Combustible Dust National Emphasis Program (Reissued)* (retrieved February 25, 2011) (http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=DIRECTIVES&p_id=3830#scope).

Occupational Safety and Health Administration (OSHA). 2010. *Enforcement Policy for Flame-Resistant Clothing in Oil and Gas Drilling, Well Servicing, and Production-Related Operations* (retrieved February 25, 2011) (http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=INTERPRETATIONS&p_id=27296).

Occupational Safety and Health Administration (OSHA). 2010. *Oil and Gas Safety Conference* (retrieved February 21, 2011)

(http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=SPEECHES&p_id=2329).

Occupational Health and Safety Administration (OSHA). 2010. *OSHA Clarification Letter on 1910.132* (retrieved February 23, 2011)

(http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=INTERPRETATIONS&p_id=25366).

Occupational Safety and Health Administration (OSHA). OSH Act Section 5(a) (1), *General Duty Clause* (retrieved February 22, 2011)

(http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9714).

Occupational Safety and Health Administration (OSHA). *Status Report on Combustible Dust National Emphasis Program* (retrieved February 22, 2011)

(http://www.osha.gov/dep/combustible_dust/combustible_dust_nep_rpt_102009.html).

US Chemical Safety and Hazard Investigation Board (CSB). 2006. Report No 2006-H-1.

Investigation Report: Combustible Dust Hazard Study. (retrieved February 5, 2010)

(http://www.csb.gov/assets/document/Dust_Final_Report_Website_11-17-06.pdf).