

OVERVIEW

The purpose of the Symposium on Industrial Dust Explosions was to provide a forum for the discussion of dust explosion hazards. In the coal mining, electric power generation, grain handling, plastics, chemicals, wood products, and metal powders industries, dust explosions and fires have been a continuing problem. Various preventive and protective measures must be taken to ensure safety. The papers presented at the symposium provided new data from laboratory and large-scale dust explosibility testing, data from recent accident investigations in industry, and information on the practical design of preventive and protective measures for industrial equipment.

The symposium was successful in increasing the communication among the various scientists and engineers in the field of dust explosibility hazards. In addition to the papers by U.S. researchers, there were eight papers from Europe, one from China, and one from Canada. The Europeans have several standard laboratory test methods for measuring the explosibility characteristics of dusts. The Dusts Subcommittee of ASTM Committee E27 on the Hazard Potential of Chemicals has as its purpose the development and standardization of test methods, equipment, and nomenclature relating to research on the deflagration characteristics of dusts. Another symposium cosponsor, NFPA Committee on Explosion Protection Systems, is involved in the development of guides for the sizing of vents for the protection of industrial equipment from accidental dust deflagrations. The papers presented at the symposium and the resulting discussions have increased the dissemination of knowledge regarding dust explosion hazards and may also help to bring about a consensus regarding standard test methods for measuring dust deflagration characteristics.

This STP resulting from the symposium should be of interest to researchers in the dust explosibility field and to safety engineers in the various industries that produce or handle combustible dusts.

Acknowledgments

As coeditors of this STP, we would like to thank the other symposium Chairmen, Robert P. Benedetti of NFPA and Thomas F. Hoppe of Ciba-Geigy, for their assistance in the planning and execution of the symposium. We also acknowledge the valuable advice and assistance of E. Dale Weir, ASTM E27 Committee Chairman, from the symposium planning to the review of the revised papers for the STP. We would also like to thank the Program Committee, which was responsible for the review and selection of the abstracts of the papers presented at the symposium and which assisted in symposium organization and execution. In addition to the symposium Cochairmen and the E27 Chairman, the Program Committee members were: Ronald S. Conti of the Bureau of Mines; Thomas E. Frank of Factory Mutual Engineering; Joseph P. Gillis of Fenwal; Steven J. Luzik of the Mine Safety and Health Administration; J. Bruce Powers of Dow Chemical; John E. Rogerson, consultant; Michael J. Sapko of the Bureau of Mines; and Richard Siwek of Ciba-Geigy.

In addition to the papers and discussion at the symposium, there were tours of the Bureau of Mines research facilities at the Pittsburgh Research Center and at the Lake Lynn Laboratory. We would like to express our appreciation to John N. Murphy, Research Director; Richard W. Watson, Research Supervisor of the Fires and Explosions Group; and other Bureau personnel for organizing these tours and otherwise assisting with the symposium. An example of the large-scale dust explosibility research at the Bureau of Mines is the series of photographs on the front cover showing a demonstration dust explosion exiting from the portal of the Bureau's Experimental Mine. Bureau research was also described in four papers at the symposium.

Technical Summary

The papers at the symposium and in the STP can be divided into two main groups. The first deals with laboratory and large-scale explosibility testing of dusts. The second deals with accident investigations of dust explosions in industry and the design of measures to prevent dust explosions or to protect equipment and personnel from the results of accidental dust explosions. The papers presented at the symposium were revised for the STP based on audience discussion at the symposium and on a detailed peer review process.

The first paper in the STP is an Introduction to Dust Explosions by Hertzberg and Cashdollar. This invited paper describes the phenomena of dust explosions in general terms. The topics discussed include flame propagation, rapid pressure rise, turbulence, flammability limits, ignitability characteristics, chemical reactions, effects of initial temperature and pressure, particle size effects, hybrid mixtures, and inerting and extinguishment.

The next series of papers describe the results of laboratory and large-scale testing of dusts.

The paper by Wiemann entitled Influence of Temperature and Pressure on the Explosion Characteristics of Dust/Air and Dust/Air/Inert Gas Mixtures describes the results of tests in a 1-m³ chamber. He measured the maximum explosion pressures, rates of pressure rise, and limiting oxygen concentrations as a function of initial pressure and temperature for various dusts.

Conti and Hertzberg discuss the temperatures at which dust clouds autoignite in a 1.2-L furnace. They present minimum autoignition temperatures for a variety of dusts and gases and discuss the relevance of these temperatures to the evaluation of the ignition probability of dusts and gases in an industrial situation.

Abrahamsen discusses the various dust explosibility and ignitability testing procedures used in the United Kingdom and their relevance to explosion prevention and protection in industry.

Pineau and Ronchail describe large scale tests in their invited paper entitled Propagation of Coal Dust Explosions in Pipes. The test facilities included a 1-m³ chamber and pipes with diameters of 0.15, 0.25, and 0.44 m and lengths of 10, 20, 30, and 40 m. Flame propagation in the pipes was monitored with pressure transducers, flame sensors, and high-speed movies.

Srinath, Kauffman, Nicholls, and Sichel also studied flame propagation in pipes in their paper entitled Secondary Dust Explosions. A primary explosion disperses and ignites a nominal loading of dust placed on the floor and/or walls of their 0.3-m-diameter by 37-m-long tube, thus generating the secondary explosions.

Cashdollar, Sapko, Weiss, and Hertzberg report on dust explosion research at the U.S. Bureau of Mines. They compare laboratory tests in a 20-L chamber with full-scale tests in two experimental mines. This is the first of four papers dealing with underground coal mines.

Michelis, Margenburg, Müller, and Kleine report the results of coal dust explosion tests in a German underground experimental mine. In particular, they studied the buildup and development of the propagating explosions.

Ng, Sapko, Furno, and Pro describe U.S. Bureau of Mines research on the suppression of coal dust and methane gas explosions by both passive and triggered barriers. The tests were conducted in an underground experimental mine.

Zhou and Lu describe Chinese research on the suppression of coal dust explosions by water barriers. Their tests were conducted in both an aboveground gallery and an underground experimental mine in China. This paper was presented at the symposium by Lung Cheng of the U.S. Bureau of Mines at the request of the authors, who were unable to attend.

The invited paper by Bartknecht is entitled Preventive and Design Measures for Protection Against the Danger of Dust Explosions. It introduces a series of papers on the practical topic of dust explosion hazards in industry. Bartknecht's paper discusses the prevention of dust explosions by avoiding explosible dust-air mixtures, by inerting, or by elimination of ignition sources. If explosions cannot be prevented, various equipment design measures such as pressure resistant design, venting, or explosion suppression can be used.

The next paper, by Zalosh, is a Review of Coal Pulverizer Fire and Explosion Incidents. Overall statistics and individual accidents are reviewed to learn causes and prevention measures.

Carini and Hules also report on the statistics of coal pulverizer explosions. In addition to the statistical data, they report on a series of experimental tests relating to coal dust explosions in pulverizers and pipes.

Alameddin and Luzik report case histories of accidents at coal fired cement kilns. The coal firing systems are described, and the individual accidents are studied to learn causes and preventive measures.

Geysen, Belman, and Scheys investigated a dust explosion in the Belgian sugar processing industry and discuss recommended preventive measures. This paper was presented at the symposium by Reinhard Bruderer of Ciba-Geigy at the request of the authors, who were unable to attend.

The next four papers deal with the grain industry. Kauffman presents statistics and individual case histories of dust explosion incidents in the U.S. grain industry.

The invited paper by Eckhoff describes a Differentiated Approach to the Sizing of Dust Explosion Vents. In particular, he discusses the effects of turbulence and ignition source location on the venting of large, slender silos up to 236 m³ in volume.

Moore describes the Suppression of Maize Dust Explosions. These were intermediate and large scale tests in 6- to 25-m³ vessels. Various media were used in triggered suppressant systems to extinguish developing grain dust explosions.

Rajendran describes the calibration and performance of several types of dust probes that he used to measure dust concentrations in bucket elevators in the grain handling industry.

The next three papers deal with the problems of electrical and mechanical ignition sources. The paper by Napier and Roopchand on the Ignition Probability of Hybrid Mixtures could not be presented at the symposium but has been included in the STP. They discuss the effect of added small amounts of flammable gases on the electrical ignitability of dusts.

Dahn and Reyes studied the characteristics of metal grinding sparks as ignition sources for dust explosions.

Vaicauski reports on the testing of Electrical Equipment for Use in Class II Hazardous Locations. The equipment must be dust ignition proof, dust tight, or intrinsically safe to prevent electrical ignition of the dust.

The last paper, by Verakis and Nagy, is a Brief Historical Summary of Dust Explosions. They describe early accidental dust explosions in industry in the eighteenth and nineteenth centuries. They also discuss the early research on the explosibility of dusts in the nineteenth and early twentieth centuries.

The papers in this STP present the current state of knowledge on the subject of dust explosions. Areas for future research include the ignitability and explosibility characteristics of hybrid mixtures of combustible dusts and gases, the conditions for transition from deflagration to detonation, and the measurement of the turbulence levels in laboratory test chambers and industrial equipment. Scientists and engineers also need to reach a consensus on the best laboratory test methods for measuring the ignitability and explosibility characteristics of dusts and the applicability to industrial situations.

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