closures are very rare in practical situations and quite difficult to produce experimentally. Studies of large-scale coal-dust explosions in mine entries have shown that as an explosion develops, partly as a result of precompression and preheating, the explosion pressure and flame speeds often increase with increasing distance from the point of initiation. It is also known that more violent explosions are developed in a turbulent dust cloud, as in a grinding mill, than in a still cloud of the same concentration.

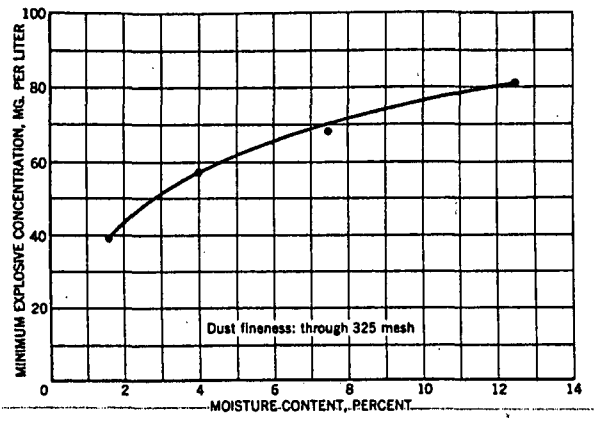

Figure 5. Effect of moisture on the minimum explosive concentration of cornstarch. (Courtesy Bureau of Mines, U. S. Department of the Interior.)

II. Laboratory Data on Dust Explosibility

Studies of the explosibility of dusts have been made by numerous investigators here and abroad, and data have been obtained on ignition temperatures, minimum explosive concentrations, maximum pressures, and other related factors. In some instances the results published by different authors vary widely, owing in part to the great difficulty in producing and maintaining uniform dust clouds in test equipment, differences in experimental procedure, and variations in dust samples, especially in regard to purity and fineness. For these reasons it does not seem appropriate to report here more than a few detailed results. For further information the reader is referred to publications that he can consult.

In this country most of the experimental work on dust explosions has been conducted by the Bureau of Mines of the United States Department of the Interior at its Pittsburgh, Pennsylvania, laboratory; by the Bureau of Agricultural Chemistry and Engineering of the United States Department of Agriculture, Washington, D. C.; by the engineering department of the Factory Insurance Association, Hartford, Connecticut; by the laboratory of the Associated Factory Mutual

Insurance Companies, Boston, Massachusetts; and by the Underwriters' Laboratories, Inc., Chicago, Illinois. A good account of early experimental work, together with descriptions of many industrial dust explosions, is supplied by Price and Brown.[10] A brief discussion of the problem, with extracts of early experimental data from various sources, is given by Gibbs.[11] Many studies are described in reports and pamphlets issued by the organizations named above and in references cited in this chapter. A list of references to work of many investigators on ignition temperature measurements is included in a bibliography of a dissertation by Brown.[12]

A. DATA ON IGNITION TEMPERATURES

The ignition temperature of a solid can be defined in many ways, and various tests have been devised to determine the temperature according to the definition used. A common definition that may be accepted for the present purpose is "that temperature at which the substance takes fire spontaneously in air."

Edwards and Harrison[13] determined the ignition temperatures of quiescent layers of various dusts during prolonged heating in an electric furnace through which air was passed at a definite rate. The reported values are given in Table 1.

TABLE 1

Dust	Ignition temperature of dust layer (° C.)	Dust	Ignition temperature of dust layer (° C.)
Cellulose	354	Paper	327
Cocoa	237	Pyrethrum flowers	252
Corn-elevator	267	Tobacco	253
Cornstarch	324	Wheat-elevator	265
Ground cloves	253	Wheat smut	255
Ground oat hulls	272	Wood flour	277
Hard-wheat flour	327	Wood-pulp	272
Leather-fertilizer	324		

In studies on the explosibilities of dusts at the Bureau of Mines laboratory, the ignition temperatures of dust clouds in air were determined by projecting them downward through a cylindrical, electrically heated laboratory furnace, and the ignition temperatures of quiescent dust layers were measured by heating them in the furnace for several minutes. In the latter tests the thickness of the dust layers was generally about $^1/_8$ inch and the air flow ranged from $^8/_4$ to a few liters per

[10] D. J. Price and H. H. Brown, *Dust Explosions, Theory and Nature of, Phenomena, Causes and Prevention.* Natl. Fire Protect. Assoc., Boston, 1922.
[11] W. E. Gibbs, *The Dust Hazard in Industry.* Ernest Benn, Ltd., London, 1925.
[12] C. R. Brown, *The Determination of the Ignition Temperatures of Solid Materials.* Catholic Univ. of America, Washington, 1934.
[13] P. W. Edwards and R. W. Harrison, *Ind. Eng. Chem., Anal. Ed.*, 2, 344 (1930).