Under special conditions the products of combustion during an explosion cannot be released immediately to the outside atmosphere but may have to be diverted into adjoining spaces of larger but finite dimensions. In such circumstances the pressure in the explosion space does not necessarily decrease with increase in vent area (see Figure 9) because part of the dust mixture is ejected into and explodes in the larger chamber.

The proper areas of vents and the suitability of a vent closure depend on several factors, which include: (*a*) strength of structure or enclosure; (*b*) the

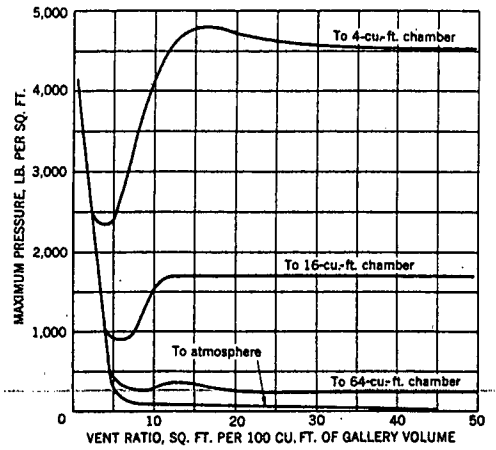

Figure 9. Venting coal dust explosions from 1 cubic foot gallery to atmosphere and to cubical chambers of various sizes. (Courtesy Bureau of Mines, U. S. Department of the Interior.)

maximum explosion pressure and the average rate of pressure rise of the explosive dust; (*c*) the position of the vents with respect to the origin of the explosion; (*d*) bursting strength of the vent closure, or the minimum pressure required to open the vent closure if movable as a whole; (*e*) the inertia of the vent closure. Recommended (unrestricted) venting areas range from 1 square foot for each 10 to 30 cubic feet of enclosure for small equipment and light construction, to 1 square foot per 80 cubic feet for large rooms and buildings with heavy, reinforced concrete construction. Additional recommendations on this subject are given in the NFPA Guide for Explosion Venting.

5. Dust collectors should preferably be located outside of buildings or in detached rooms provided with adequate explosion vents; this applies particularly to dry collectors. For certain dusts, wet collectors, preferably of liquid precipitation type, are recommended; these should have positive ventilation of the sump. Individual dust-collection units, installed close to the dust source, should be used. Ducts leading to and from collectors should be as short and straight as possible.

Blowers for drawing dust-laden air into collectors should be on the clean-air sides of collectors.

6. Grinding, conveying, and other equipment can frequently be protected by introducing a continuous flow of inert gas into the equipment, thereby reducing the normal oxygen content to a point at which the dust will not explode.[21] The inert gas for this purpose can be obtained by purifying furnace or boiler flue gases; by hydrocarbon combustion, ammonia combustion, or air fractionation; dilution of air with carbon dioxide or with nitrogen from high-pressure cylinders; or by use of argon or helium. Various methods of producing and using inert gases are described in the NFPA Standard for Fire and Explosion Prevention by Inerting.

TABLE 16

Maximum Permissible Oxygen Content to Prevent Ignition of Combustible Metal Powders

Type of dust	Limiting percentage of oxygen, spark ignition[a] Air-CO_2 mixture	Air-N_2 mixture	Air-He mixture	Air-A mixture
Aluminum, atomized	7	9	10	—
Antimony	16	—	—	—
Iron, hydrogen reduced	13	—	—	—
Iron carbonyl	10	—	—	—
Magnesium, atomized	<3	2	3	—
Magnesium, milled and stamped	[b]	—	—	—
Manganese	15	—	—	—
Silicon	13	—	—	—
Tin	16	—	—	—
Vanadium	13	—	—	—
Zinc	10	10	—	—
Dowmetal	[b]	3	3	—
Ferrotitanium, low carbon	13	—	—	—
Ferrosilicon (88% Si)	19	—	—	—
Magnesium-aluminum (50-50)	[b]	6	6	
Thorium	[b]	2.5	5	2
Thorium hydride (ThH_2)	6	5	5	4
Titanium	[b]	6	7	4
Titanium hydride (TiH_2)	13.5	10	8.5	8
Uranium	[b]	1.5	2.5	2
Uranium hydride (UH_3)	0.5	2.5	4	2
Zirconium	[b]	4	5	4
Zirconium hydride (ZrH_2)	11	8	8.5	6

[a] In the furnace test, dust clouds of Zr, Th, U, and UH_3 also ignited in CO_2. During heating for several minutes undispersed layers of samples of the following metal powders ignited (glowed) in CO_2: stamped Al, Mg, Zn, Mg-Al, Dowmetal, Ti, TiH_2, Zr, ZrH_2, Th, ThH_2, U, and UH_3. Visible burning of dust layers was also observed in N_2 with powders of Mg, Sn, Mg-Al, Dowmetal, Ti, TiH_2, Zr, Th, ThH_2, U, and UH_3.

[b] Dust clouds of these powders ignited by electric spark in an atmosphere of commercial CO_2.

[21] H. R. Brown, *U. S. Dept. Agr. Tech. Bull.* No. 74, 1928.