Table 5 .... Dust Concentration Ranges

Location	Grains per 1000 Cu Ft*	Milligrams per Cubic Meter
Rural and suburban districts	0.02–0.2	0.05–0.5
Metropolitan districts	0.04–0.4	0.1–1.0
Industrial districts	0.1–2.0	0.2–5.0
Ordinary factories or workrooms	0.2–4.0	0.5–10
Excessively dusty factories or mines	4–400	10–1000
Minimum explosive concentrations	4000–200,000	10,000–500,000

* 1 grain per 1000 cu ft = 2.3 milligrams per cubic meter.
1 oz per cubic foot = 1 gram per liter = 1000 grams per cubic meter.

visor to operate his equipment in accordance with good practices and various air pollution ordinances. In the case of industrial contaminants the engineer has the responsibility of designing local exhaust systems which minimize the pickup of useful materials, and of providing proper collection equipment to reduce the amount of material discharged to the atmosphere, in accordance with good practice and existing codes.

RADIOACTIVE AIR CONTAMINANTS[9]

Radioactive contaminants may be particulate or gaseous, and are physically similar to ordinary industrial contaminants. Many radioactive materials would be *chemically toxic* if present in high concentrations, but, in practically all cases, the factor which imposes the necessity for limiting their concentration in air is their radioactivity itself. Except for most of the inert gases, the hazard from radioactive air contaminants is due to their effects on being taken inside the body. This is known as the *internal radiation hazard*. The inert gases, such as argon-41, krypton-85, and xenon-135, are hazardous because of the radiation contacting the whole body through the gas in the air which surrounds it. They are, therefore, *external radiation hazards*. Particulate contaminants may settle to the ground, where they contaminate plants and eventually enter the food chain thereby getting into the human body. Deposited material on the ground does increase the external radiation exposure, but, except in the case of fallout from nuclear weapons, or a serious reactor accident, such exposure is insignificant.

Radioactive air contaminants may emit alpha, beta, or gamma rays. The alpha rays have very low penetrating power and present no hazard, except when the material is deposited inside the body. Beta rays are somewhat more penetrating, but are still largely an internal hazard. The penetrating ability of gamma rays depends on their energy, which varies widely from one type of radioactive element or isotope to another. A clear distinction should be made between the properties of the *radioactive material* and the *radiation* given off by this material. Radioactive particulates and gases can be removed from air by devices such as filters and absorption traps, but the gamma radiation from such material is capable of penetrating solid walls. This distinction is frequently overlooked. It should be noted that the amount of radioactive material in air is measured in *curies per cubic meter*, while the dose of radiation from deposited material is measured in roentgens.

Radioactive materials present problems which make them distinctive. The concentrations at which most such materials are hazardous are much lower than hazardous concentrations of ordinary materials, and, as a result, special electronic instruments must be used to detect these hazardous levels.

The ventilation engineer faces some difficult problems in dealing with radioactive air contamination, although these differ only in degree from ordinary air pollution problems, because of the extremely low permissible concentrations for radioactive materials. For certain sensitive industrial plants, such as those in the photographic industry, the problem is one of keeping the contaminants from getting inside the plant. If radioactive materials are handled inside the plants, the problems are those of collecting the contaminated air as close to the source as possible, and then removing the contaminant from the air, with a high degree of efficiency, before releasing it to the outdoors. High efficiency filters are usually used for particulate materials, but Venturi scrubbers, wet washers, and other devices have been used to meet special needs.

The basic standards for permissible air concentrations are those of the National Committee on Radiation Protection, published by the National Bureau of Standards as Handbook No. 69. Industries operating under licenses from the Atomic Energy Commissions must meet the requirements of the Code of Federal Regulations, Title 10, Part 20, published in the Federal Register, September 7, 1960. Some states have additional requirements which must be met.

FALLOUT

As a result of the explosion of a nuclear weapon, large quantities of highly radioactive elements known as fission products are formed. These rise rapidly with the heated air and then descend to earth, while moving horizontally with air currents that prevail at various altitudes. Their velocity of descent is largely a function of their size. Particle sizes are extremely small when the fission products are formed, and remain so, in the absence of significant quantities of dust. However, if the bomb is detonated on or near the ground, large quantities of dirt are sucked up into the fireball. The fission products then attach themselves to these comparatively large dirt particles and descend rapidly to earth. Thus, the extent of spread of fallout depends on the height of detonation and on the wind speeds and directions at the various altitudes through which the material descends.

Since the rate of emission of radiation from such particles decreases rapidly with time, fallout material which reaches the earth rapidly will be much more radioactive than that which remains aloft longer. However, certain fission product elements which decay slowly are more dangerous *per unit of radioactivity* than those which decay rapidly. Of particular importance is Strontium 90, which requires about 28 years to decrease in radioactivity by half, and which concentrates in human bones. When this material is formed in bomb explosions more than 2000 ft above ground, it is carried to high elevations and, in the case of large bombs, even into the the stratosphere. From there it requires from six months to several years for it to descend to earth, depending on the height of rise and the geographic latitude of the detonation. A small portion of the Strontium 90 which reaches the earth eventually enters the human body via contaminated foods and the milk from cows grazing on contaminated grass. The extent to which this is a hazard to health is extremely difficult to evaluate, since the total amount of radiation received from this source is very small, compared to that received from natural radioactive materials which are always present. However, if some fraction of the incidence of leukemia, for example, is directly proportional to the amount of radioactive material entering the body, a slight increase in this amount may produce a slight but nonmeasurable increase in the probability of leukemia. The probability of leukemia is, itself, extremely small, but the application of a very slight and uncertain increase in the probability of leukemia to the entire population of the world may lead to a calculated increase in the leukemia rate of several hundred cases per year. The same reasoning is applied to other radiation effects of fallout, such as life shortening and production of mutations. It is the application of the minute percentage increases of radioactivity for extremely large population groups which causes divergences of opinion among well-informed people.

The preceding discussion chiefly applies to conditions resulting from testing of nuclear weapons, where a small number of devices are detonated at considerable distances from major population centers. In the case of nuclear war or a major incident involving nuclear material, the most serious immediate problem would be the external radiation from fallout material which reached the ground within a few hours after detonation.

ATMOSPHERIC POLLEN[10,11]

Pollen grains which are discharged by weeds, grasses, and trees, and are responsible for hay fever, have properties of special interest to designers of air cleaning equipment (see Allergic Disorders in Chapter 10 and Air Cleaners, Chapter 36). Whole grains and fragments transported by the air generally range between 10 and 50 microns in size, but some have been measured as small as 5 microns, and others over 100 microns in diameter. Ragweed pollen grains are fairly uniform in size, within the range of 15 to 25 microns. Pollen grains can be removed from the air more readily than the particles of dust prevalent in outdoor air or those produced by dusty processes, since the latter predominate in the size range of 0.1 to 10 microns.

Most grains are quite hygroscopic and therefore vary in weight with the humidity. Illustrations and data on individual pollen grains are available in the botanical literature. Geographical distribution of plants known to produce hay fever is also recorded.

The quantity of pollen grains in the air is generally estimated by exposing an adhesive-coated glass plate outdoors for 24 hr, and then counting calibrated areas under the microscope. Methods are available for determining the number of grains in a measured volume of air, but even their greater accuracy has not caused them to replace the more simple *gravity slide method* used for most pollen counts. Counting techniques vary somewhat, but the daily pollen counts reported in local newspapers during the hay fever season usually represent the number of grains found on 1.8 sq cm of a 24-hr *gravity slide*.

Hay fever sufferers may notice the first symptoms when the pollen count is 10 to 25, and, in some localities, the maximum figures for the seasonal peak may approach 1000 for a 24-hr period, depending upon the sampling and reporting methods used by the laboratory. Translation of gravity counts by special formulas to a volumetric basis, the number of grains per cubic yard or per cubic foot of air, is unreliable, because of the complexity of the modifying factors. When such information is important, it is best obtained directly by a volumetric instrument. The number of pollen grains per cubic yard of air evidently varies from 2 to 20 times the number found on 1 sq cm of a 24-hr gravity slide, depending on grain diameter, shape, specific gravity, wind velocity, humidity, and physical placement of the collecting plate.

AIRBORNE BACTERIA

Studies of the occurrence and significance of microorganisms in the atmospheres of the indoor world are occupying a substantial number of physicians, bacteriologists, aerobiologists, physicists, public health workers, engineers, and hospital personnel. Some data are available on the types and quantities of bacteria found in a variety of spaces, but it is not possible at present to use this information as a conclusive index of the potential health hazard of a given environment. The reported number of airborne organisms may vary from 1 to 1000 per cubic foot of air, depending somewhat on the method of testing. Many are attached to the dust particles present in the air.[12]

Where it seems advisable or desirable to control the bacterial content of rooms, public conveyances, or buildings, highly effective methods are available (see Chapter 10), and their extended use may do much to assist the workers in this field in accumulating the necessary mass of evidence that will decide the practical value of air sterilization for the control of communicable disease. It is now well established that ultraviolet radiation is feasible for the protection or preservation of pharmaceuticals, cosmetics, and food products.

REFERENCES

1 *Hygienic Guide Series* (American Industrial Hygiene Association, 14125 Prevost, Detroit 27, Mich.).

2 *Fire Hazard Properties of Flammable Liquids, Gases and Volatile Solids* (*NFPA Standard* No. 325, National Fire Protection Association, Boston, 1960).

3 *Flash Points-Trade Name Liquids 1962* (*NFPA Standard* No. 325A, National Fire Protection Association, Boston, 1962).

4 G. W. Jones: Fire and Explosion Hazards of Combustible Gases and Vapors (Chapter XVI, Section 1, Vol. 1, *Industrial Hygiene and Toxicology*, ed. F. A. Patty, Interscience Publishers, Inc., New York, 1958).

5 Irving Hartmann: Explosion and Fire Hazards of Combustible Dusts (Chapter XVI, Section 2, Vol. 1, *Industrial Hygiene and Toxicology*, ed. F. A. Patty, Interscience Publishers, Inc., New York, 1958).

6 *National Fire Codes—1963–64, Vol. 3, Combustible Solids, Dusts and Explosives* (National Fire Protection Association, Boston, 1963).

7 A. C. Stern (ed.): *Air Pollution* (Academic Press, New York, Vols. 1 and 2, 1962).

8 *Air Pollution Manual—Part I Evaluation* (American Industrial Hygiene Association, 14125 Prevost, Detroit 27, Mich., 1960).

9 L. F. Curtiss: Radiant Energy (Chapter XIX, Vol. 1, *Industrial Hygiene and Toxicology*, ed. F. A. Patty, Interscience Publishers, Inc., New York, 1958).

10 A. R. Jacobson: Natural Sources of Air Pollution (Chapter 25, Vol. II, *Air Pollution*, A. C. Stern, ed., Academic Press, New York, 1958).

11 A. H. Fletcher and C. J. Velz: Pollens—*Sampling and Control* (lecture presented at Inservice Training Course in Air Pollution, proceedings published by University of Michigan, School of Public Health, Ann Arbor, Michigan, 1950).

12 H. G. DuBuy and H. Hollaender: Sampling devices (*American Journal of Medical Science*, Vol. 209, February 1945, p. 172).

BIBLIOGRAPHY

J. M. DallaValle: *Micromeritics, The Technology of Fine Particles*, Chapter 5 (Pitman Publishing Corporation, New York, 1948).

M. B. Jacobs: *The Chemical Analysis of Air Pollutants* (Interscience Publishers, Inc., New York, 1960).

M. B. Jacobs: *The Analytical Chemistry of Industrial Poisons, Hazards, and Solvents* (Interscience Publishers, Inc., New York, 1949, 2nd ed.).