

commission, and the community at large. Electrification of industry and railroads, increases in the use of domestic oil and gas furnaces, and segregation of industrial districts are gradually providing effective aid in the solution of this problem. In the large cities where nuisance from smoke, fly-ash, and cinders is more serious, limited areas obtain some relief by the use of district heating. (See Chapters 33, 34, and 35 for further discussion on fuel-burning technique.)

Many present ordinances limit the number of minutes in any one hour that smoke of a specified density (determined by comparison with a Ringelmann Chart which is described in Chapter 44) may be discharged.

There is now considerable interest and activity in the control of air pollution factors in addition to smoke. Difficulty in the establishment of acceptable criteria for certain corrosive and irritant gases, such as fluorides and the oxides of sulfur and nitrogen discharged with the gases of combustion, and the frequently complicated technical and economic problems encountered in control, have delayed the drafting and enforcement of legislative measures. Recent reports of an increased incidence of diseases, such as pneumonia and lung cancer, in areas high in certain air contaminants, require further critical investigation before acceptance. The values finally adopted will undoubtedly be lower than the MAC (Maximum Allowable Concentration) limits for use in industry, because the exposure is continuous compared with the 8-hour day, 5- or 6-day week upon which MAC values are based, and because the exposed population contains individuals with greater variation in age and health status.

In foggy weather, or during an inversion of atmospheric conditions, accumulation of gaseous contaminants may cause irritation of eyes, nose, and respiratory passages, and possibly cause even more serious physiological effects. The Meuse Valley fog disaster (Belgium 1930) and the Donora smog (Pennsylvania 1948) are classic examples in the history of gaseous air pollution. In both instances it is believed that irritant gases, principally from industrial plants, accumulating during periods of exceptionally prolonged meteorological inversion and fog, contributed to the illness of many persons, and to the death of some who were especially susceptible.

Absorption of Solar Radiation

Absorption of solar ultra-violet light by smoke and soot is recognized as a health problem in many industrial cities. Measurements of solar radiation in Baltimore⁸ by actinic methods demonstrated that ultra-violet light intensity in the country was 50 percent greater than in the city. In New York City⁹ a loss as great as 50 percent in visible light was found by photoelectric measurements.

ODOR NUISANCE

A problem companionate with smoke abatement is the control of odor nuisance in the neighborhood of industrial plants discharging noxious or offensive air contaminants. Community planning and zoning will avoid much of the difficulty in the future, but meanwhile many industrial cities must resort to corrective measures by requiring installation of air cleaning devices, alteration of manufacturing processes, or termination of the offensive operation in residential or commercial districts.

Control of outdoor odor nuisance is especially troublesome because of the extremely minute quantities of contaminant that are capable of offending through a wide area. New industrial chemicals with strange or unfamiliar odors tend to re-

ceive more attention from the neighborhood than the customary odors generated by well-known processes and raw materials. Methods of odor control currently in use include charcoal adsorption, scrubbing towers and air washers, chlorination, condensation, masking, passage of the odorous air through combustion chambers, dispersion through a tall stack, and best of all, substitution of less offensive materials whenever possible.^{10, 11, 12}

ODORS AND ODOR CONTROL

Odor is defined as that property of a substance which excites the sense of smell. To be odorous, a substance is usually in a gaseous or vapor state, or possesses a vapor pressure. Some odors are pleasant, others unpleasant, depending on their psychological and sociological associations.

Odors in themselves are not the cause of organic disease. Therefore, odors constitute no direct field of activity, either for clinical medicine or for public health. The discomfort and disagreeableness that may be brought about by obnoxious odors, however, may cause some temporary ill effects. The effects that fringe upon ill health include lowered appetite, lowered water consumption, impaired respiration, nausea, vomiting, and insomnia.¹³

Odors associated with some dangerous gases and vapors serve as immediate valuable warning agents against poisoning or explosion. However, some toxic substances have no associated odors. Warning against such gases can be obtained by adding tracer or warning agents to the otherwise odorless gases, as is sometimes done with gas fuels. While odors give immediate warning to persons entering dangerous atmospheres, irritants are more satisfactory for warning against gradually increasing concentrations of a low order. Odors serve as an index to personal discomfort in enclosed spaces, but are not necessarily an index to harmful vitiation in respect to insufficient oxygen or an excess of carbon dioxide.

Odor Detection and Measurement

Odor detection and measurement must rely ultimately upon olfactory observations and human appraisal. A trained organoleptic panel is presently the best means of evaluating odor intensities because the nose is still the best instrument for odor perception.

An arbitrary preference scale of increasing odor values is usually selected. For instance, the sensory scale utilized by Yaglou¹⁴ for cigarette smoke classifies odor as: 0—imperceptible, 1—not objectionable, 2—acceptable, 3—objectionable, 4—endurable, and 5—intolerable. This scale has been found convenient for use in air-conditioning odor investigations. As discrimination develops with experience, the objective sensory scale can be divided into more classifications.

Another method, employed by Hopper,¹⁵ bases odor intensities on multiples of threshold concentrations. In this method a source of odorless air and a method of mixing it, in easily variable proportions, with the odor sample is used. The mixture is adjusted until the odor is barely discernible. The result, expressed as the ratio of mixture volume to sample volume, is called the number of thresholds. At threshold, or barely discernible intensity, the nose is operating at its most sensitive point. The number of thresholds has a useful meaning. For instance, 10 thresholds has the implication that 1 cu ft of odorous gas can taint 10 cu ft of air to a recognizable level.¹⁶

In odor intensity investigations relative to flavor and taste of foods and beverages, the following scale has been accepted: 0—odor not present, 1—odor at threshold or just recogniz-

Air Contaminants

able; 1—slight odor; 2—moderate odor; and 3—strong odor.¹⁷ Regardless of the scale used, the Weber-Fechner law for detectable low intensities of odors is generally applicable. This law states that the perceived intensity is proportional to the logarithm of the external concentration, or that the ratio, in concentrations, which produces a detectable difference, is a constant.¹⁸

Odor Sources

Odor is defined as that property of a substance which excites the sense of smell. To be odorous, a substance must be either already in a gaseous or vapor state, or possess a vapor pressure.¹⁹ When the concentration of odorous vapors in the air is insufficient to permit odor perception, the air is commonly said to be odor-free. Therefore, to eliminate or abate an odor condition, it is necessary either to remove the offending gases or vapors or adequately reduce their concentration.

The sources of odors that cause discomfort to individuals in occupancy areas are many. They may be introduced from the outdoor atmosphere and contain a high percentage of hydrogen sulfide, industrial effluents, or smog. In industrial spaces they may contain odors from chemical products such as printing ink, dyes, synthetics, and odors from manufactured rubber products. In offices, arenas, and other enclosed spaces, obnoxious odors may consist of body odors and tobacco smoke odors. Cigarette smoking may produce objectionable pyridine, ammonia odors, and irritants, and also impair visibility.²⁰ Odors may also result from wetted air-conditioning coils as they become dirty. The metals and coatings used on coils materially affect the possibility of producing objectionable odors.²¹ Odors may be contributed by linoleum, paint, upholstery, rugs, drapes, or other household furnishings. Food, cooking, and putrefaction of animal and vegetable matter are also frequent contributors.

Humidity and Temperature Effects

Research conducted at the ASHRAE RESEARCH LABORATORY and elsewhere has indicated that odor perception of cigarette smoke (suspension of tobacco tar droplets plus vapor), and pure vapors is affected by temperature and humidity. An increase in humidity, at constant dry-bulb tem-

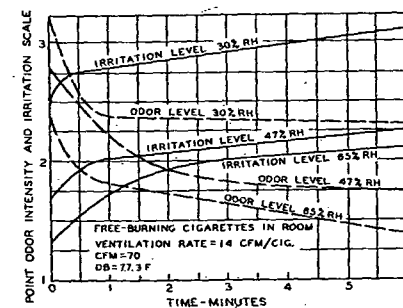
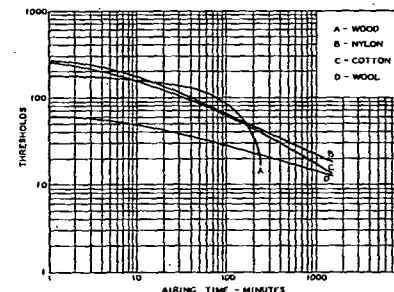


Fig. 2.... Adaptation to Smoke Odor and Irritation Caused by Cigarette Smoke Generated in Room



(Tests conducted at 75 F DB and 50% relative humidity.)

Fig. 3.... Odor Retention for Cotton, Nylon, Wool, and Wood, Using Iso-Amyl Acetate as Odorant

perature, has the definite effect of lowering the intensity level of cigarette smoke odor as well as that of pure vapors.²² This effect is more pronounced for some odorants than for others. An increase of temperature at constant specific humidity lowers the odor level of cigarette smoke slightly. Adaptation to odors takes place more rapidly during the initial stages of exposure. While the perceptible odor level of cigarette smoke decreases with time of exposure, irritation to the eyes and nose generally increases. The irritation is greatest at low relative humidities.

In order to keep odor perception and irritation at a minimum, the air-conditioned space should be operated at about 50 to 55 percent relative humidity (see Fig. 2). Since temperature has only a slight effect on odor level at constant specific humidity, it generally can be ignored and the temperature maintained at conditions desired for comfort or economy.

Adsorption and Release of Odors

Tests have been made on the odor adsorption and release of cotton, wool, nylon, rayon, and fir wood.²³ It was determined, by using iso-amyl acetate as the odor agent, that the odor adsorption of rayon was negligible. It did not adsorb enough odorant to be measured by the test methods employed. The odor adsorption at the end of a 24-hour charging period was about the same for nylon and cotton at the same temperature and humidity (Fig. 3). The odor adsorption of wool under the same test conditions was less. Adsorption of the wood samples was less than nylon and cotton, but more than wool. At 50 percent relative humidity, the maximum odor adsorption, during the 24-hour loading period, occurs at about 75 F for nylon, and is considerably less at 60 F and 90 F (Fig. 4). At 75 F, odor adsorption during the same period was found to be greater at 50 percent relative humidity than at 85 percent.

Odor retention or release as a function of airing time is affected by temperature and humidity. For the fabrics tested and at 75 F, 50 percent relative humidity conditions, odor retention after 1000 min. was reduced to 6.8 percent for cotton, 12.3 percent for nylon, and 25.8 percent for wool. In the latter case the initial wool retention was only about 25 percent of that of cotton or nylon. After 1000 min. the