Odor Detection and Measurement

While odor sensing is not fully understood, what is known should be discussed insofar as it gives understanding of what constitutes an odor problem and yields some insight into certain odor control methods. Sensing involves the dissolving of odor molecules in the fluids bathing a small area high in the nasal cavity. As this occurs, some unknown interaction stimulates the generation of electrical impulses which pass along the olfactory nerve to the brain's olfactory bulb. The brain then correlates the information in terms of its past experiences. There is no reason to believe that the mechanism differs from person to person, since most people will qualify the same odors similarly. There is ample evidence, however, that the sensitivity to and reaction to an odor will vary from person to person and from time to time. For example, most people will describe acrolien as a *burnt* odor, and benzaldehyde as a *floral* or *fruity* one. In general, the women, the young, the non-drinker, and the non-smoker have more acute senses of smell than their opposites. High temperatures and high humidities reduce acuity. The former presumably dessicates the nasal mucosa, and the latter presumably floods or dilutes the concentration at the sensor. Sensitivity varies from day to day or hour to hour, depending upon the state of health, traumatic offense to the olfactory system, or recent odor exposures.

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 Yaglou[1] 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,[8] 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.[9]

In the *ADL* concept of odor intensity, a five-point scale has been developed.[10] The intensity scale is simple and constant, and is described as follows:

0—not present
)(—threshold or just recognizable
1—slight
2—moderate
3—strong

The three levels of intensity, slight, moderate, and strong, can be related to three segments of intensity on a scale of 29 levels or just noticeable differences. 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.[11]

It should be possible to establish odor standards for occupied spaces. In the past, the application of proposed standards has not been feasible, owing to the difficulty of identifying and measuring the odor-producing vapors present in a given space. However, a method using the threshold approach has recently been suggested. Once standards have been agreed upon, the number of thresholds in a given space can be measured with the aid of various air-dilution devices. It would then be possible to rate odor-control systems for their effectiveness in reducing the number of thresholds in a given time and in maintaining a reasonable odor level. That approach could be used for different types of systems using dilution with odor-free air, whether the air were brought in from outdoors, or recirculated and purified by sorption equipment.

Various chemical analytical techniques have been proposed and evaluated in an effort to standardize odor measurement methods. Detection and identification of a complex odor mixture at threshold levels is generally beyond the sensitivity of presently available analytical instruments. Concentration of the odor molecules may be achieved by adsorption on activated carbon or by absorption in a liquid. The sorbed odors may be desorbed and identified by infrared or ultraviolet spectroscopy. Alternatively, the concentrated odorants in the liquid system may be determined by standard chemical reactions.[12]

Odor Sources

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 or intensity by odor modification to create an environment of greater comfort.

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.[7] Odors may also result from wetted air-

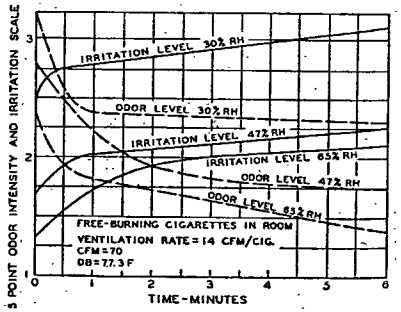


Fig. 1 .... Adaptation to Smoke Odor and Irritation Caused by Cigarette Smoke Generated in Room

conditioning coils as they become dirty. The metals and coatings used on coils materially affect the possibility of producing objectionable odors.[13] 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 temperature, has the definite effect of lowering the intensity level of cigarette smoke odor as well as that of pure vapors.[14] 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 45 to 60 percent relative humidity (see Fig. 1). 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.

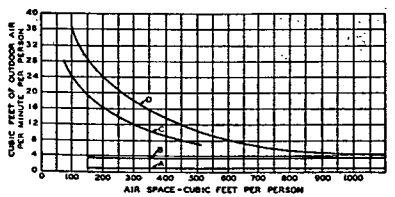
Adsorption and Release of Odors

Tests have been made on the odor adsorption and release of cotton, wool, nylon, rayon, and fir wood.[8] It was determined, by using iso-amyl acetate as the odor agent, that the odor adsorption of rayon was negligible. 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. 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.

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 odor retention of wool was comparable to that of cotton. Wood lost its odor after 300 min.

These data are meager, but indicate a trend useful for design. Application of the quantitive values should not be made without due consideration of the finish, weight, weave, and thread count of the fabrics. Further research is needed relative to these items.

While it has been shown that smoke, cooking, and body odor perception is decreased with humidity increase, where the odor source is intrinsic with the materials, as in the case of linoleum, paint, rubber, and upholstery, a reduction of relative humidity would be beneficial,[15] and would decrease the rate of odor release.



A—Air required to provide necessary oxygen content.
B—Air required to prevent CO_2 concentration from rising above 0.6 percent.
C—Air required to remove objectionable body odors from sedentary adults.
D—Data from curve C increased by 50 percent (and projected) to allow for moderate physical activity and odors.

Fig. 2 .... Minimum Ventilation Requirements to Avoid Vitiation and Obnoxious Body and Smoking Odors

ODOR REMOVAL

Odor removal may be accomplished by physical or chemical means. Ventilation with clean outdoor air, air washing or scrubbing, charcoal adsorption, chemical reaction and odor modification are physical methods available to the engineer. Chemical adsorption or destruction of odor sources, vapor neutralization, and catalytic combustion are other means. Air washing or scrubbing and combustion are of considerable value to process industries. Washing and scrubbing, like filtering, are applicable to the removal of particulates and in some cases are means of recovery of valuable product. Odors associated with the particulates are removed indirectly in such processes. Combustion of obnoxious gases is quite effective and practicable where indicated by economy. These methods are employed to alleviate the effects of harmful exhaust gases and particulates on people, vegetation, and property.

Ventilation, charcoal adsorption, and odor modification are effectively utilized in air conditioning for odor removal. The removal of odorous gases or vapors by water sprays in air-conditioning systems is most practicable for water-soluble odors such as ammonia, but not for water-insoluable odors.

Ventilation

Ventilation is an effective means of removing the contaminated air in an enclosed space by dilution. In this process, the vitiated air containing objectionable gaseous odors, irritants, particulates that obscure vision, and toxic matter are

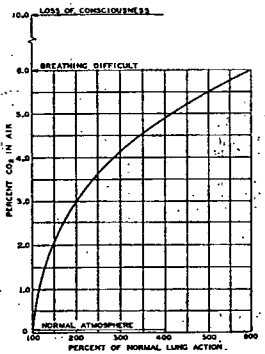


Fig. 3 .... Physiological Effect of Various Concentrations of Carbon Dioxide