Journal of the Air Pollution Control Association

ISSN: 0002-2470 (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/uawm16

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To cite this article: William F. Kerka & Elmer R. Kaiser (1958) An Evaluation of Environmental Odors, Journal of the Air Pollution Control Association, 7:4, 297-301, DOI: 10.1080/00966665.1958.10467818

To link to this article: https://doi.org/10.1080/00966665.1958.10467818

Published online: 19 Mar 2012.

An Evaluation of Environmental Odors*

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While man has greatly expanded his manufacturing capacities and has concentrated industry within limited boundaries, he has in many cases created contaminated environments. The degree to which this contamination has become a public nuisance depends among other things, upon the concentration and character of the source, the area over which contamination takes place, the residential population of the area, and the atmospheric conditions prevailing in the region. It would indeed be a great day for the Air Pollution Control Association if all potential contamination could be readily controlled and eliminated at the source. While progress has been made in this direction, there are still many industrial processes where control may prove ineffective or too costly, or where public disapproval has not been voiced strongly enough to justify these preventative measures. We must not blame industry alone for this plight, however, since the rapid growth of population in our crowded communities has in itself augmented atmospheric pollution.

From the standpoint of the air-conditioning engineer, it is not his primary concern to evaluate the methods used to control industrial contamination at the source, except possibly where the source and the air-conditioned space are in the same building. He is concerned, however, with the problem of removing from our air-conditioned buildings the outdoor pollution that has entered either through infiltration or through the use of outdoor make-up air in the air-conditioning system. Before the engineer can hope to cope with this problem, a knowledge of the offending contaminant must be realized.

* Presented at the 50th Annual Meeting of the Air Pollution Control Association held at St. Louis, Mo., June 2-6, 1957.

List of Contaminants from City Bureaus

For the past several years, the Air Pollution Control Association has been furnishing the American Society of Heating and Air Conditioning Engineers' Research Laboratory with lists of odorants and contaminants most frequently reported by city bureaus. A tabulation of these data has been prepared and is shown in Table I. The odorants have been divided into the various categories as shown, and only the 3 most frequently reported odorants in each category are tabulated, except in the General Industrial Odors where the 6 most frequently reported odorants are listed.

Under Animal Odors, the meat-packing and rendering-plant odors were the most frequently reported. Fish oil odors, including those from the smoking process, ranked second; and poultry-processes and poultry-ranch odors were ranked in third place.

In the second category (Odors from Combustion Processes), gasoline and diesel-engine exhaust odors were reported most frequently. Coke-oven and coal-gas odors, probably from steel mill operation, ranked second; and fuel-oil odors from maladjusted heating systems ranked third.

In the other categories, coffee-roasting odors, paint, lacquer and varnish odors, hydrogen sulfide, odors of burning rubber from smelting and debonding, foundry core-oven odors, odors from home incinerators and backyard trash fires, mercaptans from refineries, odors of putrefication and oxidation from organic wastes, and odors from city sewers carrying industrial waste were reported the most frequently in their respective groups.

Of all the odors listed, the meat-packing and rendering-plant odors were the most frequently reported. Automotive exhaust odors ranked second, and coffee-roasting odors, paint, lacquer, and varnish odors, and coke-oven and coal-gas odors tied for third place. The odors themselves probably consist of complex compounds of hydrocarbons, nitrides, acroleins, aldehydes, and alcohols.

Some of the odor classes in Table I could possibly be combined. For example, the decomposition and putrefication of organic wastes are probably associated with the meat-processing or fertilizer plants and could therefore be tabulated under these categories.

Although a tabulation of these odors shows which are encountered most frequently, more data (as enumerated at the beginning of the paper) are certainly needed to indicate the degree to which each is responsible for contamination and air pollution in our urban areas.

Methods of Odor Control

Earlier, it was pointed out that the air-conditioning engineer is concerned with outdoor odors that enter buildings through infiltration and through the use of outdoor make-up air. As time passes, however, buildings will be built, so to speak, tighter and tighter; and as indoor odors will ultimately be controlled and removed from the air-conditioning system, the use of outdoor make-up air will be reduced. During many periods of the year, the recirculation of indoor air is, of course, a necessity for the most economy in operation. The goal, where negligible infiltration occurs, is far from being reached however so that outdoor contamination is the concern of the air-conditioning engineer.

Just how do we go about controlling and removing these unwanted odors? In any air-conditioning system, it would be economical to use one unit for the removal of both indoor air-conditioning odors and the odors in outdoor make-up air. Under some conditions, this may not be possible, however. One of the most common methods of removing odorous vapors is by passing the air stream through a bed of activated carbon. The carbon of course has a great affinity for gas and vapors and can adsorb up to ⅓ to ½ of its weight. Several commercial activated-carbon units are now available on the market. The operating life of any unit would depend on the character and concentration of the odorant vapor being adsorbed, and time of exposure. When the carbon is no longer able to adsorb additional malodor, it must either be replaced or reactivated. For best results, the carbon filters should be used in conjunction with mechanical filters and/or electrostatic precipitators. The latter will remove fine particulate matter on which odorous vapors may be adsorbed, but will not in itself remove vapors or gases.

Air washers are commonly used in air-conditioning systems and many water-soluble odors are removed in the process. Likewise, in the dehumidification process of cooling-coils, water-soluble odors are removed along with the condensate. As one theater manager put it, *one can always tell how exciting the motion picture of the previous night was by smelling the body odor laden condensate on the cooling coils the next morning.*

Where outdoor make-up air contains considerable dust, electrostatic precipitators, dry air filters and viscous filters have been employed for the removal of contaminants.

Ozone has been employed as a deodorizing agent and is being used in the control of odors produced by industrial processes. To some extent, ozone has been used in air-conditioned spaces, but as yet, its claim of destroying odors by oxidation needs further investigation, since the action of ozone is not fully understood. Secondary effects such as the fatigue of the olfactory senses and the presence of nitrogen and hydrogen compounds formed in ozone production add to the problem.

Odor masking has been used in reducing the obnoxiousness of odors generated in industrial or chemical processes. Masking agents have not been employed to any great extent in central air-conditioning systems, although some have been used as odor counteractants in individual rooms. The effect caused by the masking agent is that of overshadowing the unwanted odor, or decreasing the sensitivity of the olfactory receptors, or of canceling the obnoxious odor.

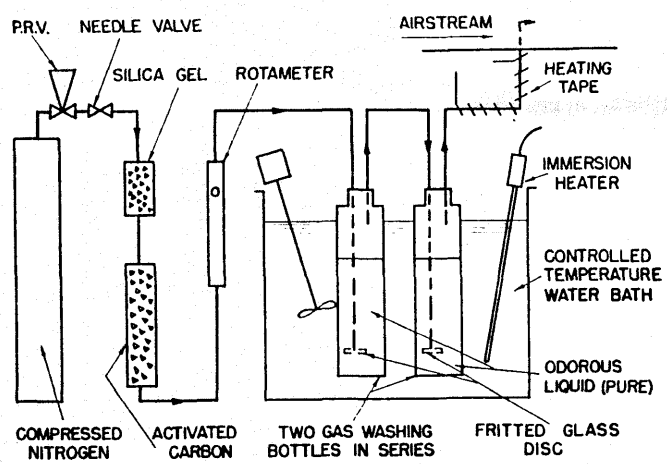
The elimination of odors by catalytic combustion is perhaps the only method that actually destroys an odor. While the method has been employed in the control of industrial pollution at the generating source, it does not have any practical application to comfort air-conditioning systems.

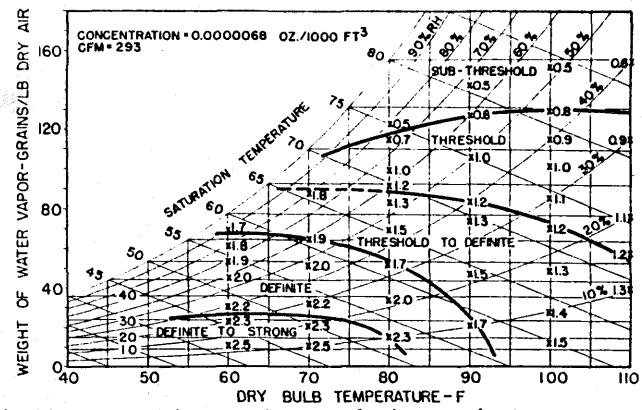
With this brief description of the possible methods used for odor control, it should be pointed out that there is still a great need for further information regarding the performance, applicability, and limitations of these methods. It is only through further research that basic and fundamental answers to odor-control problems can be obtained.

TABLE I

List of Odors Most Frequently Reported by City Bureaus

Source of odor	No. of times reported
I — Animal Odors	
1. Meat packing and rendering plants	12
2. Fish-oil odors from manufacturing plants	5
3. Poultry ranches and processing	4
II — Odors from Combustion Processesffl	
1. Gasoline and diesel engine exhaust	10
2. Coke-oven and coal-gas odors (steel mills)	8
3. Maladjusted heating systems	3
III — Odors from Food Processes	
1. Coffee roasting	8
2. Restaurant odors	4
3. Bakeries	3
IV — Paint and Related Industries	
1. Mfr. of paint, lacquer, and varnish	8
2. Paint spraying	4
3. Commercial solvents	3
V — General Chemical Odors	
1. Hydrogen Sulfide	7
2. Sulphur Dioxide	4
3. Ammonia	3
VI — General Industrial Odors	
1. Burning rubber from smelting & debonding	5
2. Odors from dry-cleaning shops	5
3. Fertilizer plants	4
4. Asphalt odors — roofing and street paving	4
5. Asphalt odors — manufacturing	3
6. Plastic manufacturing	3
VII — Foundry Odors	
1. Core-oven odors	4
2. Heat treating, oil quenching, and pickling	3
3. Smelting	2
VIII — Odors from Combustible Waste	
1. Home incinerators and backyard trash fires	4
2. City incinerators burning garbage	3
3. Open-dump fires	2
IX — Refinery Odors	
1. Mercaptans	3
2. Crude oil and gasoline odors	3
3. Sulphur	1
X — Odors from Decomposition of Waste	
1. Putrefication and oxidation — organic acids	3
2. Organic nitrogen compounds — decomposition of protein Above odors are probably related to meat processing plants	2
3. Decomposition of lignite (plant cells)	1
XI — Sewage Odors	
1. City sewers carrying industrial waste	3
2. Sewage treatment plants	2





(Left) Fig. 1. Schematic drawing of odor introduction apparatus (Pure Vapors). (Above) Fig. 2. Odor perception trends for Iso-valeric acid.

The Findings of the Odor-Research Programs

What has the American Society of Heating and Air-Conditioning Engineers been doing to stimulate basic odor research? Besides the program being conducted at the Society Laboratory, papers and reports on the odor problems related to air conditioning are encouraged.

Effect of Temperature and Humidity on Odor Perception

The first phase of the program at the Laboratory has established the effect of temperature and humidity on odor perception[1]. Experiments were conducted in two rooms which were equipped with complete and separate air-conditioning systems for adjusting the temperature and humidity over a wide range. Pure-vapor odorants were introduced into the room supply ducts, and the physical concentration of the odorant within the test rooms was maintained at a constant value for each temperature and humidity condition studied.

Odor Introduction Apparatus

The apparatus used for the introduction of pure odorous vapors consisted of 2 gas-washing bottles in series through which nitrogen was bubbled (Fig. 1). Nitrogen was used in place of air since it was less likely to react chemically with the odorant. The nitrogen was passed through beds of silica gel and activated carbon to remove inherent moisture and odor before it was metered by a rotameter into the bubblers.

The nitrogen leaving the second bottle was saturated with vapor and entered the air-supply duct via a tube, heated with a resistance tape to prevent condensation. The apparatus was constructed of glass, and ground joints were used (after the bed of activated carbon) to prevent contamination. The gas-washing bottles were surrounded by a controlled temperature water bath. The concentration of odorant was calculated from its vapor-pressure properties, the amount of nitrogen bubbled through the washers, and the quantity of air supplied to the test room. The concentration was checked by adsorbing the odorant on activated carbon and measuring the increase in weight.

The odor-perception level in the test rooms for each condition was judged by a panel of 6 persons who entered the rooms and evaluated the perception level by using the intensity scale shown in Table II. The use of these scales is convenient since the word description of the odor level is identified by a numerical value which can be treated statistically. In this scale, a score of 1 was used when the panel member could just identify the quality of the odor. An intensity level between threshold and definite was scored 1½, and so on.

Perception Trends

The results of the evaluations by the panel members for one of the three pure vapors studied is shown in Fig. 2, which is a plot of the mean scores on the psychrometric chart. In this case, the odorant was iso-valeric acid maintained at a constant physical concentration of 0.0000068 oz./1000 ft.³ Each area bounded by the heavy lines represents a constant perception level. Examination of Fig. 2 indicates that an increase in humidity at constant dry-bulb temperature tends to lower the perception level of the odor having a constant physical concentration. In the case of iso-valeric acid, this effect appears more pronounced at higher temperatures. Likewise, an increase in temperature at constant specific humidity lowered the perception level slightly, except at higher humidities where a slight reversal appears.

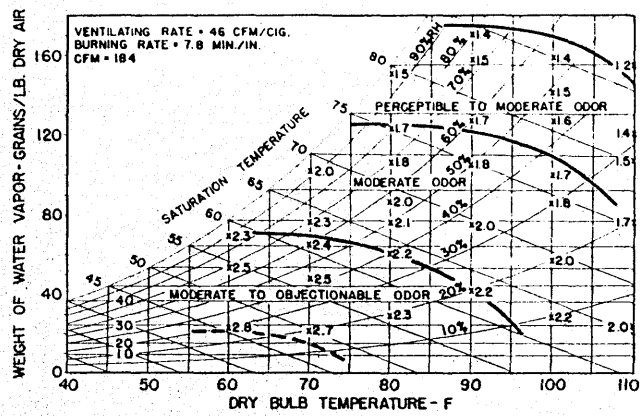
TABLE II

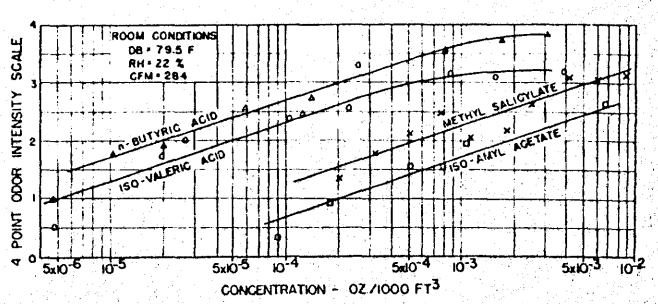
Sensory Scale for Evaluating Intensity Levels

Degree of odor intensity	Description
0	Odorless
1	Threshold
2	Definite
3	Strong
4	Overpowering

Similar evaluations were made on cigarette smoke, and the results are shown in Fig. 3. In this case a slightly different word description was used which seemed more applicable to tobacco smoke. The concentration of cigarette smoke was maintained constant by using 46 cfm. of supply air/cigarette with a fixed burning rate of 7.8 min./in. Here again evaluations of odor intensity made over a wide range of conditions indicate that an increase in humidity at constant dry-bulb temperature tends to lower the perception level of cigarette smoke. Also, an increase in temperature at constant specific humidity tends to lower the perception level slightly.

What do these areas of perception level signify? Referring to Fig. 4, it was found that under a fixed condition of temperature and humidity it was necessary to increase the physical concentration of the pure-vapor odorant tenfold in order to raise the perception level 1 point, and a one-hundred fold increase was necessary in order to raise the intensity level 2 points. Therefore, in Fig. 2, any in-





(Left) Fig. 3. Odor perception trends for cigarette smoke.

(Above) Fig. 4. Odor intensity vs. concentration.

crease in humidity that lowers the perception level 1 point has the same effect as lowering the concentration by 90%.

It certainly would be ideal from the standpoint of lowering the odor-perception levels if all we had to do were to increase the humidity of our environments. However, the problem is not so simple. For one thing, one has to consider the comfort of the persons in the environment. The problem is further complicated by some of the findings of Dr. R. L. Kuehner. Although Dr. Kuehner[2] has verified our conclusion that the perception level decreases with an increase in humidity, he has shown that under humid conditions some substances (linoleum, for example) will actually liberate more odorant. All of us have experienced the effect of getting on a crowded bus on a warm rainy day. The odor from the damp clothing is quite noticeable, resulting from an actual increased rate of odorant production. It would appear then that nature has been wise in giving our olfactory senses a built-in safety factor by lowering our perception acuteness under humid conditions when the rate of odorant production is increased.

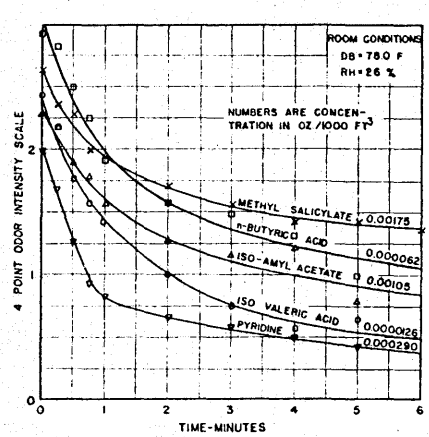


Fig. 5. Adaptation to pure-vapor odors.

Odor Adaptation

Exposure to odors over a period of time can cause a decrease in perception level. What actually happens is that the odor receptors in the nasal passages become fatigued. We can probably recall the experience of entering an occupied room that was noticeably stuffy with body odor, and then after a period of time, realizing that the perception level had decreased. For this reason, an individual is not aware of his own breath or body odor simply because he has become adapted to it.

To illustrate the effect of odor adaptation, the panel members were exposed to a constant physical concentration of odorant for a given period of time. The member entered the test room and sniffed immediately for an initial impression. Breathing normally through the nose, judgments were made every 15 sec. for the first minute and every minute thereafter for a maximum of 6 min.

Fig. 5 gives the results for a number of pure vapors. Each point represents the mean score of 6 to 8 judges. The concentration was adjusted to give initial readings between 2 (definite) and 3 (strong). In all of the tests, adaptation was greatest during the first stages of exposure. The curves for iso-valeric acid and n-butyric acid are nearly the same shape (although displaced), indicating an identical adaptation rate. In all of the tests, the conditions were maintained at 78°F. dry-bulb and 26% RH.

Tobacco smoke is one of the major odorants that one encounters in air-conditioned spaces. While one can become adapted to the odor of tobacco smoke, the irritation to the eyes, nose, or throat generally increases with time of exposure. The results of evaluations made by panel members exposed to cigarette smoke over a given period time are shown in Fig. 6. Here we find that the initial impression is to rate the odor level high and the irritation level low. With time of exposure, however, the odor-perception level decreases while the irritation level rises. Again we find that at higher humidities (above 50%) the levels are lower than at lower humidities (below 35%).

Besides the problem of removing common odors in occupied spaces, another serious problem arises. Surfaces have a tendency to adsorb odors (especially when cool) and reliberate them when warm. For complex odors such as cooking, body, and tobacco odors, the most obnoxious components appear to be the ones most readily adsorbed. The adsorption on the surfaces of the cooling coils and the duct work of the air-conditioning system is in itself an odor source when *unloading* occurs. Mr. A. B. Hubbard and his co-workers have investigated a number of materials and coated surfaces used in coil construction.[3] The materials were subjected to controlled-generated odors and were then evaluated by panel members for their pickup and

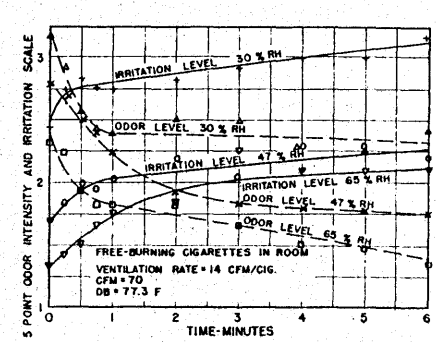


Fig. 6. Adaptation to cigarette-smoke odor, and irritation caused by cigarette smoke generated in room.

purging-rate characteristics. The best materials were those which exhibited little pickup and then purged or reliberated the adsorbed odors rapidly. Aluminum was found to be one of the best materials, while bare copper exhibited the poorest qualities.

At the present time, the odor-research program is continuing at the ASHAE Laboratory where the odor adsorption and desorption qualities of fabrics and building-material surfaces are being evaluated. In this study, a bottle technique is being used for odor evaluation. Samples are loaded with odorant and placed in bottles after specified periods of airing. Human subjects then evaluate the odor levels in a set of bottles (one set for each airing time) containing varying sample sizes until a threshold level is reached. This level is fixed by the ratio of bottle volume to sample area. This gives a definite tangible number that can serve as an index to predict the degree of odor level in rooms and occupied spaces where the wall surfaces, draperies, or rugs are exposed to odorants. A plot of this $\frac{V}{A}$ ratio versus the airing time for various materials will show the ones that *unload* the most rapidly and the ones that adsorb the most odorant (zero airing time).

A representative range of fabric surfaces including cotton, wool, and synthetics will be studied. While pure vapors will first be used, the ultimate aim of the program is to investigate the effect of common air-conditioning odors such as tobacco smoke. After fabric surfaces are investigated, attention will be turned to painted and other types of building-material surfaces. In the present study, a fixed condition of temperature (75°F. dry bulb) and humidity (50% RH) is being used for loading, airing, and evaluation of the sample. A future phase of the program (probably in 1958) will be to determine the effect of temperature and humidity upon adsorption and desorption characteristics.

One can see that the odor-control problem in air-conditioned spaces has many facets, as does the control of outdoor air pollution. It is only through the cooperation of research and industry and perhaps the longing to breathe the pure air which nature has given us, that progress can be made toward clean and odor-free environments.

References

1 W. F. Kerka and C. M. Humphreys. Temperature and Humidity Effect on Odor Perception. *ASHAE Transactions.* **62**, p. 531, (1956).

2 R. Kuehner. Humidity Effects on the Odor Problem. *ASHAE Transactions.* **62**, p. 249, (1956).

3 A. B. Hubbard, N. Deininger and F. Sullivan. Air Conditioning Coil Odors. *ASHAE Transactions.* **61**, p. 431.