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# Reference Guide to Odor Thresholds for Hazardous Air Pollutants Listed in the Clean Air Act Amendments of 1990

Air RISC

AIR RISK INFORMATION SUPPORT CENTER

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# REFERENCE GUIDE TO ODOR THRESHOLDS FOR HAZARDOUS AIR POLLUTANTS LISTED IN THE CLEAN AIR ACT AMENDMENTS OF 1990

Prepared for

Air Risk Information Support Center (Air RISC)
U.S. Environmental Protection Agency

Sponsored by:

Environmental Criteria and Assessment Office
Office of Health and Environmental Assessment
Office of Research and Development
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Office of Air Quality Planning and Standards
Office of Air and Radiation
Research Triangle Park, NC 27712

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## AUTHORS, CONTRIBUTORS, AND REVIEWERS

This document was prepared by TRC Environmental Consultants, Inc., under Contract No. 68D90173 with the Environmental Protection Agency, Research Trianlge Park, NC, Daniel J. Guth, Ph.D., Technical Monitor.

The following TRC Envionmental Consultants, Inc., personnel were involved in the preparation of this document: Samuel S. Cha (Project Manager), Jocelyn R. Mellberg, Gary L. Ginsberg, Ph.D., Karen E. Brown, Kara Raabe, and Joseph C. Coco.

The following scientists reviewed an earlier draft of this document and submitted comments:


William S. Cain, M.D.
John B. Pierce Laboratory
Yale University
New Haven, CT

Dennis Demchak
Connecticut Bureau of Air Management
Hartford, CT

Carol A. Dupraz
Consultant
White Plains, NY

Sherry Selevan, Ph.D.
U.S. Environmental Protection Agency
Human Health Assessment Group
Washington, DC

Chon R. Shoaf, Ph.D.
U.S. Environmental Protection Agency
Environmental Criteria and Assessment Office
Research Triangle Park, NC

Amos Turk, Ph.D.
Consulting Chemist
Danbury, CT

Susan F. Velasquez
U.S. Environmental Protection Agency
Environmental Criteria and Assessment Office
Cincinnati, OH

Winona Victery, Ph.D.
U.S. Environmental Protection Agency
Region 9
San Francisco, CA

## PREFACE

Many State and local agencies are developing or implementing programs to control emissions of toxic air pollutants. To successfully carry out these programs, in many cases, agency personnel must be familiar with a wide range of issues related to health, exposure, and risk assessment for toxic air pollutants. However, locating appropriate sources of information on these topics is not always an easy task. This reference guide to odor thresholds has been prepared by the U.S. Environmental Protection Agency's (EPA's) Air Risk Information Support Center (Air RISC) as a resource tool for State and local air pollution control agencies and EPA Regional Offices to identify information regarding odor thresholds for hazardous air pollutants.

Air RISC is operated by EPA's Office of Air Quality Planning and Standards (OAQPS) and Office of Health and Environmental Assessment (OHEA). The key goal of Air RISC is to provide technical assistance to State and local air pollution control agencies and EPA Regional Offices, in obtaining, reviewing, and interpreting health, exposure, and risk assessment information for air pollutants. Through Air RISC, State, local, and EPA Regional Office personnel can request expert guidance and information on health, exposure, and risk assessment issues and methodologies related to air pollutants.

In response to a large number of requests concerning the identification and interpretation of odor thresholds for a variety of chemicals, Air RISC initiated the project that resulted in this document. This document consists of three sections. Section 1 is an introductory discussion of basic concepts related to olfactory function and the measurement of odor thresholds. Section 1 also describes the criteria that are used to evaluate and determine the acceptability of published odor threshold values. Section 2 contains the tabulated results of a literature search and critical review of published odor threshold values for the chemicals listed as hazardous air pollutants in the Clean Air Act Amendments of 1990 at the time of passage. Each odor threshold value is evaluated according to the criteria discussed in Section 1 and a geometric mean of the acceptable values is provided as the best estimate of the odor threshold. Section 3 lists the references used in preparation of this report.

# 1. INTRODUCTION

The growing public concern about chemicals in the environment has resulted in legislation such as the 1986 Superfund Amendments and Reauthorization Act, Title III, and 1990 Clean Air Act Amendment, Title III, air toxic provisions. Historically, local environmental protection agencies report that odor complaints make up a large number of the citizen complaints received. In general, the public does not understand the relationship between odor and risk and believes "If it smells, it must be bad." Local agency staff answering these complaints sometimes have to assess the potential health risk from exposure to chemicals by relying on odor threshold values reported in the literature; unfortunately, these reported odor threshold values vary considerably from one literature source to another. It is not uncommon for reported odor threshold values of some chemical compounds to range over three or four orders of magnitude. Major sources of variability include the type of data source; differences in experimental methodology; and the characteristics of human olfactory response, which demonstrate a great deal of interindividual variability.

A recent report from the American Industrial Hygiene Association reviewed and critiqued odor threshold data ("Odor Thresholds for Chemicals with Established Occupational Health Standards", American Industrial Hygiene Association, 1989). The project identified and compiled experimental odor threshold references in the literature, and evaluated methodologies used in published reports against a set of objective criteria. Using these methods to eliminate questionable data, an attempt was made to estimate a better odor threshold value for certain compounds if the information was available. The geometric mean of the acceptable data was taken and is considered to be a reasonable estimate of the actual odor threshold (American Industrial Hygiene Association, 1989).

This approach is now being used to focus upon the hazardous air pollutants listed in the 1990 Clean Air Act Amendment for EPA's Air Risk Information Support Center. One of the major goals is to provide state and local agencies with data tables and an explanatory narrative so that community odor perception can be properly evaluated and interpreted in terms of chemical exposure and risk.

A related issue is how to assess health risks when odors are detected. This could be done by systematically comparing odor thresholds to guidelines or standards for ambient or occupational exposure depending upon the population of concern. The purpose would be to determine whether, or in which cases, the detection of odor is a suitable indicator of health risk. Factors that affect this analysis are variability in the odor threshold data and in the human olfaction mechanism and the choice of health-based ambient criteria and background information pertinent to the particular case in which odors are detected.

This document contains a general background discussion of odor threshold measurement, interpretation and use in risk assessment. Section 1.1 presents background material on odor perception and odor properties. In Section 1.2, a brief review of odor threshold methodology is given. Section 1.2 also describes the criteria used to evaluate the odor threshold sources. Section 1.3 will discuss the use of odor thresholds as a tool in assessing risk. Section 1.4 describes the literature search and review procedure. Summaries of available odor threshold data are presented in tabular form in Section 2. Section 3 contains the references cited in the summaries and sources used during the research for this report.

## 1.1 THE CONCEPT OF ODOR THRESHOLD

A brief review of the sensory properties of odor and some of the attributes of human olfactory response is presented to facilitate understanding of odor threshold values.

### 1.1.1 Dimensions of Odor

The sensory perception of odorants has four major dimensions: detectability, intensity, character, and hedonic tone. Odorant *detectability* (or threshold) refers to the theoretical minimum concentration of odorant stimulus necessary for detection in some specified percentage of the population. This is usually defined as the mean, 50% of the population; however, it is sometimes defined as 100%

(including the most insensitive) or 10% (the most sensitive). Threshold values are not fixed physiological facts or physical constants but are a statistical point representing the best estimate value from a group of individual responses. As such, it may be an interpolated concentration value and not necessarily one that was actually presented. Two types of thresholds are evaluated: the *detection* threshold and the *recognition* threshold. The detection threshold is the lowest concentration of odorant that will elicit an olfactory response without reference to odor quality in a specified percentage of a given population. In test procedures it is the minimum concentration of stimulus detected by a specific percentage of the panel members. Additionally, Russian literature defines detection thresholds as absolute thresholds (i.e., the lowest concentration that will produce any measurable physiological change [e.g., as an electroencephalogram response] in the most sensitive human subject).

The detection threshold is identified by an awareness of the presence of an added substance. The recognition threshold is defined as the minimum concentration that is recognized as having a characteristic odor quality by a specific percentage (usually 50%) of the population.

Odor *intensity* refers to the perceived strength of the odor sensation. Intensity increases as a function of concentration. The relationship between perceived strength (intensity) and concentration can often be expressed as a power function, as follows (Stevens' Law):

$$S = k\,I^n$$

where $S$ = perceived intensity of sensation, $k$ = y-intercept, $I$ = physical intensity of stimulus (odorant concentration), and $n$ = exponent of psychophysical function, typically less than 1.0.

In logarithmic coordinates, Stevens' Law becomes $\log S = n \log I + \log K$, which is a linear function with slope equal to $n$. An intensity function for a standard odorant, 1-butanol, is shown in logarithmic coordinates in Figure 1-1. The slope of the function varies with type of odorant typically over a range from about 0.2 to 0.7. The slope of the function for butanol shown in Figure 1-1 equals

0.66. This is an important consideration in the control of odors. A discussion of odor intensity and how such curves are derived can be found in Dravnieks (1972).

In air pollution control, we are often concerned with the "dose-response" or psychophysical function, which is reflected by the slope. The slope also describes the degree of dilution necessary to decrease the intensity. A low slope value would indicate an odor

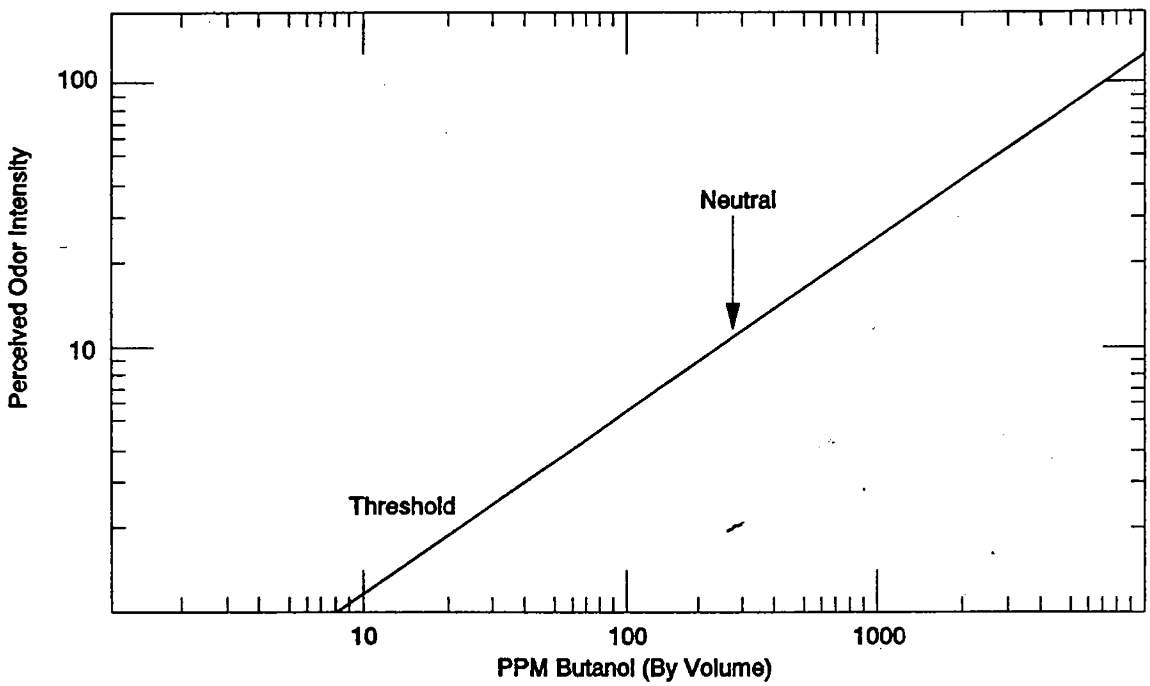


**Figure 1-1. An intensity function for 1-butanol.**

that requires greater relative dilution for the odor to dissipate; a high slope value indicates an odor that can more quickly be reduced by dilution. Examples of compounds with low slope values include hydrogen sulfide, butyl acetate, and the amines; those with high slope values are ammonia and the aldehydes. In general, substances with low thresholds yield low slopes and those with high thresholds show high slopes. The relative slopes of hydrogen sulfide and ammonia are depicted schematically in Figure 1-2. Similar curves for other compounds can be found in Dravnieks (1972). The difference in the degree to which these two chemicals affect the olfactory system is apparent from this illustration. For a 1:1 mixture of ammonia and hydrogen sulfide, ammonia is often perceived as the odor character of the mixture at higher concentration levels. However, when diluted, or if the observer walks away from the source, the hydrogen sulfide odor becomes the dominating odor character. This phenomenon is commonly encountered at wastewater treatment plants.

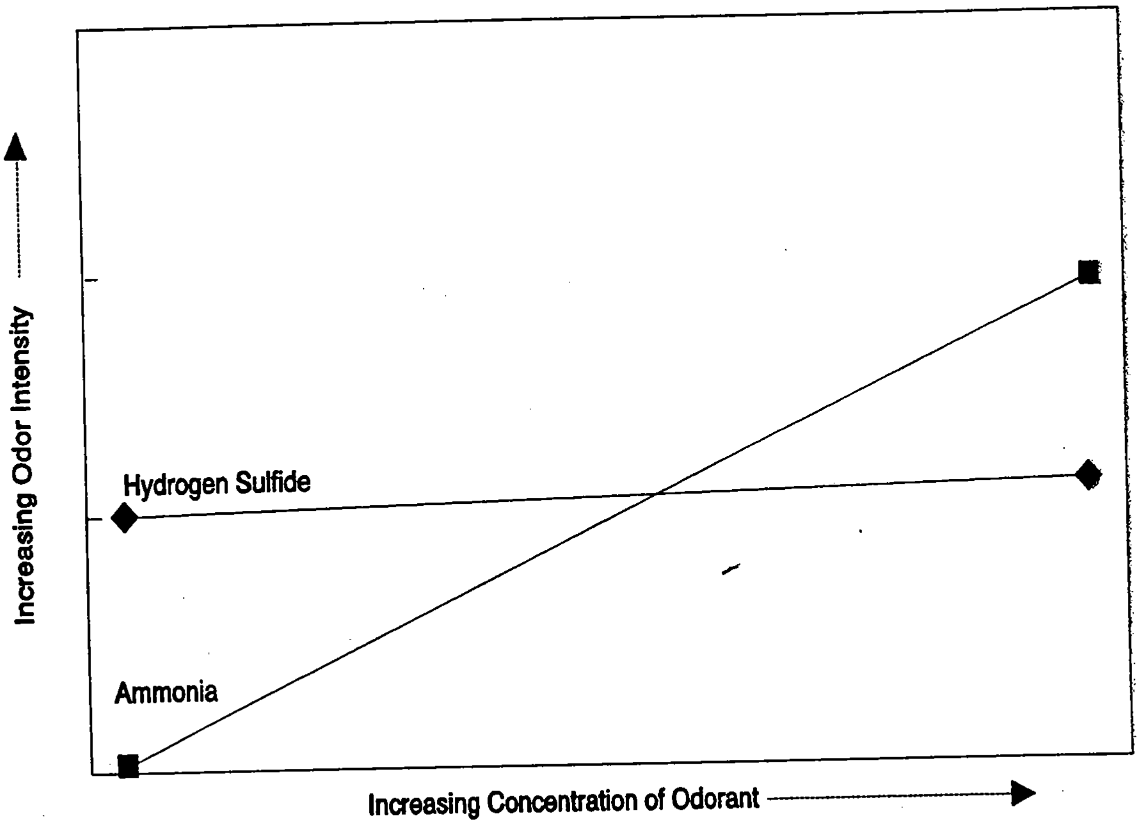


**Figure 1-2. Relative slopes of psychophysical functions for ammonia and hydrogen sulfide. The schematic diagram depicts the steep odor intensity/concentration slope for ammonia as compared to the shallow slope for hydrogen sulfide. The difference in slopes means that at high concentrations of both odorants, the predominant odor will be that of ammonia, while at lower concentrations hydrogen sulfide will be detected.**

The third dimension of odor is the *character*, in other words, what the substance smells like. An American Society for Testing and Materials (ASTM) publication (Dravnieks, 1985) presents character profiles for 180 chemicals using 146 descriptors, rated on a scale of 0 to 5. The descriptors include such terms as fishy, hay, nutty, creosote, turpentine, rancid, sewer, and ammonia.

The fourth dimension of odor is *hedonic tone*. Hedonic tone represents a judgment of the relative pleasantness or unpleasantness of the odor. Perception of hedonic tone outside the laboratory is influenced by such factors as subjective experience, frequency of occurrence, odor character, odor intensity, and duration.

### 1.1.2 Introduction to Olfactory Function

Human odor perception has a few functional aspects of particular relevance: sensitivity, specificity, and somewhat independent processing of olfactory input by the cortex and more primitive brain structures. The close coupling of molecular odorant recognition events to neural signaling enables the nose to detect a few parts per trillion of some odorants (Reed, 1990). The molecular nature of recognition permits the nose to distinguish between very similar molecules.

The initial events of odor recognition occur in a mucous layer covering the olfactory neuroepithelium, which overlays the convoluted cartilage in the back of the nasal cavity. Each of the millions of olfactory neurons in the middle layer of this epithelium extends a small ciliated dendritic knob to the surface epithelial layer and into the overlaying mucus. As in the immune system, receptors on different cells have different specificities. The binding of a single odorant molecule to a receptor on this dendritic tip may be adequate to trigger a neural signal to the brain. On each tip dozens of cilia increase the surface area available for recognition events and may stir the local mucus, aiding in the rapid detection of small concentrations of odorants. Individual receptors desensitize with use, temporarily losing their ability to transduce signals.

The peripheral olfactory neurons project to the olfactory bulb from which signals are relayed to the olfactory cortex and more primitive brain structures such as the hippocampus and amygdala. This last structure affects whole brain-body emotive states. For further information on the olfactory system physiology, see Dodd and Castellucci (1991).

Human response to odorant perception follows certain characteristic patterns common among sensory systems. For example, olfactory acuity in the population conforms to a normal distribution. Most people, assumed to be about 96% of the population, have a "normal" sense of smell as depicted in Figure 1-3. Two percent of the population are predictably hypersensitive and two percent insensitive. The insensitive range includes people who are anosmic (unable to smell) and hyposmic (partial smell loss). The sensitive range includes people who are hyperosmic (very sensitive) and people who are sensitized to a particular odor through repeated exposure. Individual threshold concentrations may be normally distributed around the mean value (e.g., Figure 1-3) or log-normally distributed. In some instances, the threshold distribution is bimodel, with a small antinode that represents

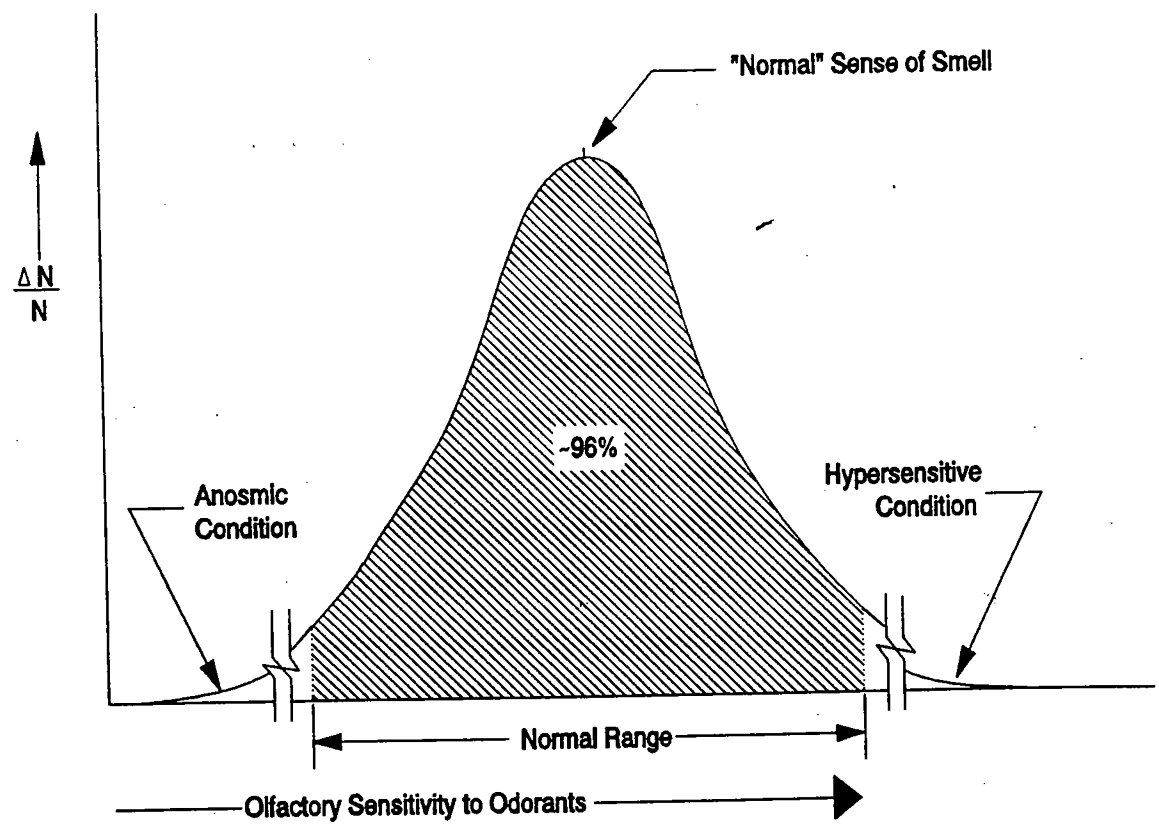


**Figure 1-3. Illustration of the normal range concept showing a potential population distribution of olfactory sensitivities to odorants.**

people with a specific insensitivity, commonly called specific anosmia. For example, the odor threshold for hydrogen cyanide is bimodally distributed since there are at least two distinct groupings with markedly different abilities to detect hydrogen cyanide (Agency for Toxic Substances and Disease Registry, 1988).

Another property of olfactory functioning includes adaptation to an odor, also known as olfactory fatigue. These terms describe a temporary desensitization after smelling an odor. After smelling a strong odor, a weaker near-threshold odor may not be detectable. For this reason, odor threshold measurement studies must be carefully designed.

As mentioned in the previous section, mixtures of compounds such as ammonia and hydrogen sulfide may have varying odor character depending on their relative concentrations. All odorants have the ability to mask the odor of other compounds, in mixtures of appropriate proportions. Some mixtures of odorants may be perceived as qualitatively different from the individual components (Foster, 1963; Mitchell and McBride, 1971). The perceived intensity of a mixture of two odors can be represented using a vector model. Two odors can be thought of as the vectors A and B. The length of the vectors can represent the relative intensities of the odors. The angle between the two vectors typically has a value of about 110 degrees. The vector model illustrates the nature of mixtures of odors. The intensities are not simply additive. Two odors in concentrations that give similar intensities, when added together can result in an odor with intensity that is approximately the same, but with a slightly different character or quality than the two odors as perceived individually (Berglund, 1974).

A sensory property of odor that can cause confusion in organoleptic (i.e., sensory as opposed to analytical) odor identification is that odor character may change with concentration. For example, butyl acetate has a sweet odor at low concentrations, but takes on its characteristic banana oil odor at higher intensities. Carbonyl sulfide has a "fireworks" or "burnt" character at concentrations below 1 part per million (ppm) and "rotten egg" character at higher levels. This, along with individual variability, accounts for discrepancies in odor character reports. The odor character descriptors in this paper are based on a combination of reports in the literature and experience in odor investigation.

The ability to discriminate between different odor intensities is very sensitive. It has generally been found that concentrations higher or lower by 25 to 33% are perceived as different. In a carefully controlled study by Cain (1977), the average perceptible difference between concentrations was 11%, ranging from 5 to 16% for different compounds.

As noted above, there are two basic types of odor thresholds: the detection threshold and the recognition threshold. Detection is defined as the concentration at which the average panel member notices an odor, but cannot necessarily identify it. The recognition threshold is the lowest concentration at which the average panelist can identify a definite character of the odor. The difference in concentration between detection and recognition thresholds can vary from approximately twofold to tenfold. For example, Hellman and Small (1974) found the detection and recognition thresholds of acetophenone to be 0.3 ppm and 0.6 ppm, which is a twofold concentration difference. While for acrylic acid, the thresholds were found to be 0.092 ppm and 1 ppm, an 11-fold concentration difference.

The order of presentation of odorants in experimental determination of odor threshold is very important so as not to induce olfactory fatigue. The olfactometer commonly used in recent odor threshold experiments is a device that dilutes samples of odorant with odor-free air and presents the diluted samples to panelists in ascending order of concentration in two- or threefold concentration steps. Panelists choose which of the three nozzles in a cup differs from the other two. In this forced-choice procedure, panelists must pick a port whether they detect a difference or not (i.e., panelists are asked to guess even if they discern no difference). Odorous exhaust air from the olfactometer is removed through an exhaust line outside the building to avoid odor build-up within the room. A thorough discussion of olfactometers and odor threshold measurement is given in Dravnieks (1980).

## 1.2 EVALUATION OF ODOR THRESHOLD INFORMATION

Odor threshold determination has interested researchers for a century. Over this period, hundreds of threshold measurements along with nearly as many measurement techniques have been reported in the literature. Odor thresholds are often determined in a laboratory setting using various methods to dilute odorants that are presented to a panel of subjects. In order to consistently evaluate experiments of odor thresholds, which vary widely in design and reporting detail, a set of standard criteria was established.

### 1.2.1 Criteria Used To Evaluate Odor Threshold Information

The method of presentation of the odorant is dependent upon what chemical odor threshold is to be measured. In this report, only gas-air mixtures have been considered. A delivery system that reduces the intake of unmeasured ambient air is most desirable.

A known concentration of odorant is delivered to the panel and responses are measured. Usually a verbal response is taken by a monitor. Responses can include whether or not an odor is detected, the strength of the odor, and odor quality (e.g., pleasant vs. unpleasant, fishy, aromatic, etc.).

Once the responses of the panel are recorded, statistical methods can be used to determine the odor threshold for either detection or recognition. Some of the important variables of odor threshold measurement are discussed below.

A set of criteria considered essential to any modern threshold determination procedure was developed (see below). The sources with published odor thresholds (listed in Section 2) were evaluated in terms of their conformity to these criteria. The criteria are summarized below.

Sources that did not account for these criteria in their experimental design were not accepted. For example, a random presentation series was accepted when concentration levels were evaluated by different subjects (Gundlach and Kenway, 1939) but not when presented to the same subjects. An exception would be when a random presentation to the same subjects was used, but the interval between trials was long enough to permit reversal of olfactory adaptation.

### 1.2.1.1 Panel Size of at Least Six per Group

In order to approximate the distribution of olfactory sensitivity in the population, it is preferable to use a large number of subjects or, since this is often impossible, a smaller group selected to represent the general population. Accordingly, to replicate the distribution curve shown in Figure 1-3, it is preferable to use a larger panel with fewer trials rather than a small panel (e.g., 2 or 4 subjects) with many trials. Additionally, panels of fewer than six subjects reduce precision for a reliable mean value. Repeatability for individuals' threshold results are poor (±18%); therefore, results should not be based on the repeated observations of less than six panelists. However, there is a point beyond which more panelists become superfluous. One study found that a pooled group of ten with one trial produced the same thresholds as a group of thirty-six with five trial presentations (Punter, 1983). Odor threshold determinations using fewer than six panelists or with the number of panelists not reported were not accepted.

### 1.2.1.2 Panelist Selection Based on Odor Sensitivity

Prospective panelists should be evaluated for olfactory sensitivity to the chemical compounds in question. This will insure that the panel will not include judges with general or specific anosmia. An early version of an ASTM threshold procedure (ASTM 1391-57 Syringe Dilution Method) recommended testing with only two all-purpose odorants, vanillin and methyl salicylate. Subsequent studies showed that these compounds did not rate panelists properly. Panelists should be evaluated with a compound selected to represent the particular chemicals under investigation, rather than with two standard compounds.

Physiological and personal factors to be considered when selecting a panel include smoking, drug dependency, pregnancy, sex, and age. Smokers should be excluded from the panel even though the effect of smoking on olfactory acuity is unclear. Studies have reported results ranging from definite to no effect from smoking (see Cometto-Muniz and Cain, 1982, for discussion).

Drug dependency and pregnancy are known to reduce and elevate odor perception, respectively (Amerine et al., 1965). Anosmia due to drug dependency would be discovered during screening. Similarly, prospective panelists being treated with high levels of medication would be screened and omitted from the panel. Pregnant women should be excluded as a precautionary measure.

As with smoking, results of investigations of changes in olfactory acuity due to age and sex are in disagreement. The common conception has been that women are more sensitive than men and that sensory acuity decreases with age. However, this may be too simplistic an explanation. Recently, the approach has been to separate odor sensitivity from odor identification ability (e.g., see Doty et al., 1984, for changes with age; Cain, 1982, for differences between sexes).

Odor threshold determinations were not accepted if there was no screening of panelists reported.

#### 1.2.1.3 Panel Calibration

Panel odor sensitivity should be measured over time to monitor gross individual discrepancies and maintain panel consistency. Individual variability is ±18% while person-to-person variability can differ by four orders of magnitude. A daily rating of an n-butanol wheel olfactometer would provide a quick and accurate measure of individual and group variability.

#### 1.2.1.4 Consideration of Vapor Modality (Air or Water)

Vapor modality (i.e., whether the odor measured is in the form of a gas-air mixture or vapor over an aqueous or other solution) is determined by the test purpose and in turn determines the presentation method. The majority of reported thresholds are gas-air measurements. Therefore, some criteria for the apparatus will pertain directly to gas-air instead of vapor over an aqueous solution. Only gas-air mixtures were accepted in this report.

#### 1.2.1.5 Diluent in Accord with Compound

The diluent, whether liquid or gaseous, should be consistent with the chemical compounds tested and not influence odor perception. For example, diluent air may be filtered through activated carbon or be unfiltered room air. Liquid diluents include water, diethyl phthalate, benzyl benzoate, and mineral oil. The selected diluent is determined by the test purpose and practical considerations of the compound. Additionally, the relative humidity of diluent air (or other inert gas) should be controlled at approximately 50%.

#### 1.2.1.6 Presentation Mode That Minimizes Additional Dilution (Ambient) Air Intake

Vapors are inhaled from openings of varying size. Some of these allow ambient air to be inspired along with the sample, thereby increasing the dilution factor by an unknown amount. Common delivery systems are (1) nose ports held under the nostrils, (2) vents into which the whole head is inserted, (3) flasks into which the nose is inserted, (4) syringes that impinge vapor into the nose, and (5) whole rooms into which the odorant is injected. In general, an opening that allows insertion of the nose or the whole head is desirable as it reduces the intake of ambient air. Delivery systems that did not control the mixing of the odorant with ambient air were not accepted.

#### 1.2.1.7 Analytic Measurement of Odorant Concentration

The concentration of odorant as it reaches the panelist should be measured accurately. The capability to measure concentration of some odorants has occurred only recently. Therefore, a major problem with early threshold studies and a drawback of some modern studies is the absence of such analytic devices.

#### 1.2.1.8 Calibration of Flow Rate and Face Velocity (for Olfactometers)

Important system calibrations include flow rate and face velocity. Flow rates on individual olfactometers vary from 0.5 L/min to more than 9 L/min. This disparity in the flow rate has been found to cause a fourfold difference in threshold values. Odorant flow rate should be at approximately 3 L/min, although researchers differ in their opinion of a "best" flow rate. Flow rate then becomes an important consideration in the critique. The face velocity refers to the rate at which the odor is flowed at the panelist and should be maintained at a flow barely perceptible by the panelist.

#### 1.2.1.9 Consideration of Threshold Type (Detection or Recognition)

Thresholds may be either of two types, detection or recognition. The detection threshold is defined as the lowest concentration at which a specified percentage of the panel (usually 50%) detects a stimulus as being different from odor-free blanks. The recognition threshold is the lowest odorant concentration at which a specified percentage of the panel (again, usually 50% or the median) can ascribe a definite character to the odor. In general, recognition thresholds are approximately two to ten times higher than detection thresholds (Hellman and Small, 1974). The type of threshold measured is dependent on the test purpose. For example, detection thresholds are of greater interest in basic research, while recognition thresholds are of greater value to the food industry. Recognition and detection thresholds are differentiated in this report.

#### 1.2.1.10 Presentation Series That Reduces Olfactory Fatigue

Concentration presentation order is an important factor in the presentation method, as olfactory adaptation occurs rapidly. After three minutes of exposure to an odorant, perceived intensity is reduced about 75% (Bartoshuk and Cain, 1977). A common method to control for this is to present concentrations in ascending order (from weaker to stronger concentrations, or greater to lesser dilution) or to allow for long periods between presentations. Descending and random presentation series do not control for adaptation unless specific steps are taken to eliminate it. Recognizing the need to control for adaptation in random or descending patterns of presentation, researchers apply various methods such as presenting one concentration per day (Dixon and Ikels, 1977) or using different subjects at each concentration step (Gundlach and Kenway, 1939). Odor threshold determinations were accepted only if the methods used controlled adequately for adaptation.

#### 1.2.1.11 Repeated Trials

Individual test-retest reliability for threshold values is generally low (Punter, 1983) but is dependent on the number of trials (Cain and Gent, 1991).

Determinations should be repeated for reliability. Additionally, computing the mean across panelists' scores will reduce individual variability.

#### 1.2.1.12 Forced-Choice Procedure

A forced-choice procedure minimizes anticipation effects for thresholds by eliminating false positive responses. Panelists choose between the stimuli and one or two blanks.

Use of forced-choice procedures was not stringently applied as a criterion. An earlier method, presenting a stimuli and blank as a paired comparison, was also included in this category. Both methods reduce anticipation effects.

#### 1.2.1.13 Concentration Step Increasing by a Factor of Two or Three

In determining odor threshold values, the odorant should be presented successively at concentration intervals no more than three times the preceding one. Interval size is determined by the range of sensitivity of the sample of panelists and by the number of concentrations that can be analyzed in a given experiment. Smaller step size may result in failure to identify the threshold for all panelists. Larger step size might result in a less precise calculation of the average threshold because of the extrapolation over a greater range. A 3-fold interval is selected as a maximum necessary to result in a useful dose-response.

### 1.2.2 Critique of Odor Threshold Measurement Techniques

Threshold compilations such as Van Gemert and Nettenbreijer (1977), Verschueren (1977), and Fazzalari (1978) contain threshold values from sources published in the early 1900s and before. In some cases, reported threshold values vary by a factor of a million or more for one compound. The reported values for n-butyl alcohol range from $1.8 \times 10^{-4}$ to $1.45 \times 10^{-7}$ g/L (Amoore and Hautala, 1983).

The fact that threshold values and the methodology involved may vary widely has often been recognized. Factors affecting threshold measurement (Punter,

1983) include stimuli flow rate, olfactometric systems, age and type of panelist, instruction and threshold procedure, and panelists' experimental experience.

Other important factors contributing to threshold value variability are the purity of the chemical compound, the type of threshold (detection or recognition) determined, and the stimulus itself (water vapor or gas vapor). These last two factors make the practice of pooling thresholds questionable at best. Considering the sources of variability, it is understandable that published threshold values differ.

References were reviewed for their overall adherence to experimental procedures that address the response characteristics of the human olfactory system. The results of the literature search and review are presented in tabular form in Section 2. The following are included in Table 2-1.

- CAS RN (Chemical Abstracts Service registry number)
- Chemical name and some of its synonyms
- Chemical formula
- Molecular weight
- First author, date
- Odor threshold
- Type of threshold
- Geometric mean of critically acceptable odor threshold value
- Type of odor threshold represented by geometric mean
- Odor character

## 1.3 ODOR THRESHOLDS IN RELATION TO RISK ASSESSMENT

The detection of chemical odors may trigger odor complaints that are associated with safety concerns due to chemical exposure. The key questions regarding odor detection, safety, and risk assessment are:

1. If a chemical odor is present, does that indicate a health risk?

2. If chemical odors are absent, does that signify an absence of health risk?

3. Does olfaction provide an adequate margin of safety by allowing detection of toxic chemicals that prompts avoidance of exposure?

Knowledge of odor threshold values, together with a variety of background information, toxicity data, and analytical data are necessary to answer these questions in specific situations.

### 1.3.1 Relationship Between Odor Threshold Values and Health-Based Ambient Criteria

The relationship between odor threshold values and health-based exposure criteria (e.g., inhalation reference concentrations [RfCs] for noncancer endpoints, inhalation risk-specific concentrations for cancer risk, acceptable ambient concentrations [AACs], occupational exposure limits [OELs]) is an essential determinant of the usefulness of odor as an indicator in a site evaluation. If the odor threshold value is lower than the ambient criteria, then absence of odor may signify that the ambient concentration is below that which could produce adverse health effects. In this case, detection of odor is not a sufficient indicator of whether a health threat is posed because the ability of the sensory apparatus to quantify odor and thus chemical exposure is very limited. Accurate methods of chemical quantification need to be used to determine whether ambient concentrations are sufficient to pose a risk.

The converse of the above, cases in which the odor threshold value is greater than health-based ambient criteria, present the opposite type of problem. In this case, odor is useful as an indicator of potential harm since the detection of odor indicates chemical concentrations in the potentially toxic range. However, a lack of odor does not necessarily indicate absence of risk, since toxic effects can occur at chemical concentrations that are below that perceptible by the nose. Here again, analytical chemistry is needed to ensure that toxic levels of ambient contaminants are not present.

Chemical mixtures can present odors that may or may not reflect the hazard potential of the chemical constituents. For example, a highly odorous but relatively nontoxic chemical may be present along with a nonodorous but highly toxic chemical. In this case, the odorous chemical serves as a warning that the toxic chemical is present. However, there may be instances in which the two chemicals become dissociated (aging of the mixture, in different manufacturing or disposal processes, etc.); and judgments about the presence or absence of the toxic component would be incorrect if they were based upon detection of the odorous component. Therefore, assumptions about the relationship between odor and risk can only be made for the specific circumstances in which chemical mixtures are found.

An exemplary study of complex mixtures and odor at an industrial site was that performed for tar-contaminated soils at manufactured gas plants (Roberson et al., 1989). For analysis of odors from complex mixtures, the odorous sample must be fractionated and fractions characterized in terms of odor and chemical identity. In this case, the sample was analyzed by gas chromatography with mass spectrometry (GC/MS) in such a way so that the GC effluent was split delivering a portion to the MS and a portion to the odor scientist. This enabled the odor associated with each component to be separately evaluated. Several different types of soil contamination were evaluated in this way to describe the prevalent odors and chemical constituents associated with different soil samples. Odor threshold values were then compared to health-based ambient criteria to determine if odor detection would be a suitable marker for elevated risks. The ambient criteria were threshold limit values (TLVs) for workers and 1/100th the TLV for a residential exposure limit. In their samples, odorous components (thiophene, hydrogen sulfide, naphthalene) were detected in conjunction with relatively nonodorous components (cycloalkanes, benzene), thus providing an applicable signal for toxicant exposure. The authors concluded from this study that health risks were unlikely where no odor is present, but analytical data are needed if odors can be detected. Their conclusion, however, did not carefully consider the relative concentrations of odorous vs. nonodorous/toxic components, in relation to differences between odor threshold values for the odorous compounds and exposure limits for the most toxic compounds. Both the relative quantities and the odor threshold-to-exposure limit ratios of all chemicals in the mixture must be assessed before firm conclusions can be drawn. However, the study reported a fairly good correlation between the perceived odor intensity and the measured levels of naphthalene, total polycyclic aromatic hydrocarbons, and total volatile organic compounds. Thus, in this case, where odors were detected they were useful indices of exposure to toxic components.

These types of relationships between odor thresholds and health-based ambient criteria are the basis for using odor as an indicator of toxicity and risk. However, as outlined below, several additional factors must be taken into account when attempting to relate odor to risk.

#### 1.3.1.1 Background Exposure

Continued exposure to odorous chemicals generally causes a decreased ability to smell these chemicals. Therefore, if the background concentration in the vicinity of a source is sufficient to cause a detectable odor, the odor threshold value for individuals in the affected environment may be higher than that reported in the literature. If reported odor threshold concentrations are lower than the ambient criteria, the desensitizing influence of background exposure may narrow or eliminate the safety margin between the odor threshold concentration and the ambient criteria. In this case, a previously unexposed person may be warned by olfactory indicators from an episode of excessive chemical release, while a chronically exposed person might not as readily detect the release and thus be at greater risk. Therefore, to evaluate whether detection of a chemical via the sense of smell is a reasonable indicator of risk, the ambient concentrations that the receptor is acclimated to must be known, together with the chemical's ability to desensitize olfaction.

#### 1.3.1.2 Variability in the Odor Threshold Data

As discussed in previous sections, the odor threshold literature for a particular chemical can provide a wide range of threshold values. Often the disparity stems, in part, from interindividual differences in olfaction, and in part, from methodological differences. A wide range of odor thresholds presents a large degree of uncertainty regarding the threshold for a particular individual. This diminishes the usefulness of the odor threshold for assessing whether a margin of safety exists between it and the ambient criteria value. Further, the variability decreases the usefulness of odor detection as an indicator of toxicant exposure.

Another related factor that governs the usefulness of the threshold data for risk assessment is the type of threshold reported. While detection thresholds may be more commonly reported, they are not as useful as recognition thresholds because simply detecting an olfaction stimulus may not be a sufficient warning of chemical exposure. Further, in situations where numerous chemicals are present, a specific and characteristic odor may be required to clearly indicate that a release above background has occurred. Therefore, the utility of and margin of safety afforded by the threshold can be overestimated if the threshold is for detection rather than recognition. However, in cases where individuals anticipate a chemical exposure, odor detection may be a suitable signal to trigger a more extensive investigation.

#### 1.3.1.3 Choice of Health-Based Ambient Criteria

The ambient criteria used for comparison with odor threshold values can greatly affect the interpretation of odor threshold value usefulness as an indicator of risk. Use of OELs such as TLVs (American Conference of Governmental Industrial Hygienists, 1986), permissible exposure limits (PELs), recommended exposure limits (RELs), or short-term exposure limits (STELs) may be appropriate for the workplace.

However, these OELs are not considered to be protective of the general population, which may receive continuous ambient exposure, and which may include more sensitive individuals (e.g., young children, pregnant woman, the elderly). This has been addressed by numerous states and localities in the form of AACs, which are potentially useful health-based ambient criteria, especially because they have been developed for a large number of chemicals.

Other types of health-based criteria are the inhalation RfC and the inhalation unit risk. The RfC is an estimate (with uncertainty spanning perhaps an order of magnitude) of the daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime (U.S. Environmental Protection Agency, 1990). The RfCs are developed by EPA, and values are verified by the RfD/RfC Work Group, which affords a degree of oversight and standardization. The RfCs are based upon available toxicity data (subchronic and chronic animal studies and epidemiological studies) and are derived by dividing the highest concentration level at which no adverse effects were seen (the NOAEL) by uncertainty factors to approximate, as necessary, interspecies extrapolations, intraspecies variability, data base deficiencies, extrapolation from subchronic to chronic effects, and extrapolation from a lowest observable adverse effect level (LOAEL) to a NOAEL. Uncertainty factors are applied to the exposure concentration after calculation of the human equivalent concentration as described in U.S. Environmental Protection Agency, (1990). The RfCs are based upon the most sensitive toxicity endpoint, as determined by available data. If several reliable studies are available, the RfC is based upon the study demonstrating effects at the lowest concentration. The RfC values are available from EPA in online format (Integrated Risk Information System [IRIS], U.S. Environmental Protection Agency, 1991).

The inhalation unit risk is the cancer risk level associated with a specific ambient concentration. The U.S. EPA has derived these values and has normalized them to an ambient concentration of 1 $\mu g/m^3$ (i.e., the risk per $\mu$g chemical/$m^3$ air) assuming exposure for a lifetime. To convert these values for use as health-based ambient criteria, the concentration associated with a specific level of risk (e.g., $1 \times 10^{-6}$) can be calculated by dividing the target risk level by the unit risk factor. For example, the unit risk factor for acrylonitrile is $6.8 \times 10^{-5}$ per $mg/m^3$ (U.S. Environmental Protection Agency, 1991) and the ambient concentration associated with a 1 × $10^{-6}$ risk is 0.015 $mg/m^3$, which conceivably could be used as the health-based ambient criteria protective against cancer risk. The inhalation unit risk factors available on IRIS have undergone a review and verification process in the Carcinogen Risk Assessment Verification Endeavor Work Group, which ensures that appropriate test data and standardized methods were used to derive the values.

The RfC values and inhalation unit risk factors are currently in preparation for the 189 listed chemicals. Many of the listed chemicals will not have verified inhalation RfC values or unit risk factors, in large part due to the general lack of chronic toxicity studies conducted by the inhalation route of exposure. Thus, the evaluation of the usefulness of odor threshold values for risk assessment suffers from the relative lack of inhalation toxicology data. However, detailed analysis of the toxicology data base development for RfC and unit risk estimates is proceeding in EPA, as is the development of methods for risk assessment of acute exposure. New inhalation studies, method development, or dose route extrapolation will make possible the derivation of new ambient criteria for use in assessing the relationship between odor and risk.

### 1.3.2 Theoretical Considerations: Is There a Link Between Odor and Toxicity?

Detection of chemical odors may raise health concerns due to the awareness of exposure to chemicals. However, while odor itself is a signal of some type of exposure, it does not necessarily indicate a potential health risk unless the detected chemical is identified, and its toxicity is understood. Without this information, odor detection is not useful in risk assessment. This is because the mechanisms that appear to be involved with odor detection have very little to do with the mechanisms involved in chemical-induced toxicity and carcinogenesis.

The mechanisms involved in toxic phenomena are likely to be quite specific and distinct from those involved in olfaction. Although the toxic mechanisms for many agents require further study, a unifying hypothesis for cytotoxicants and carcinogens is that highly reactive species result from chemical entry into a cell

(Coles, 1984; Vaca et al., 1988; Recknagel and Glende, 1973). These species may be the parent molecule, metabolites, or endogeneous molecules (e.g., superoxide, lipid peroxides), which become disproportionately numerous due to xenobiotic influences on normal cellular functioning. These reactive species are typically electrophiles or oxidants, which can then irreversibly bind to or denature tissue macromolecules (DNA, protein) such that normal structure and function is lost. While many exceptions to this mechanistic framework likely exist, key aspects of this hypothesis are relevant for a wide variety of potent toxicants and carcinogens.

The major distinctions between toxicant and odorant mechanisms are site of action (nasal olfactory epithelium for odorants; various organs for toxicants), type of receptor (odor receptor for odorants; DNA, miscellaneous protein receptors, or oxidant systems for toxicants), and the chemical requirements for efficacy. The key point is that odorants need not be strong toxicants and toxicants need not be odorous, so that there is no rationale for making assumptions about risk based solely upon odor perception. However, detection of odor in combination with information regarding chemical identity and toxic potency can be useful information, especially in those cases where the odor threshold concentration is known and can be compared to health-based ambient criteria. Since odor threshold concentration values are often imprecise and since they may not be relevant for a particular individual, it is advisable to obtain quantitative analytical data in cases where unknown or suspicious odors are detected, or where potentially harmful chemical releases are suspected, even if no odors are detected.

### 1.3.3 Conclusions

Odor thresholds can be useful as a screening level, semi-quantitative approach for hazard identification in cases where:

1. The chemical identity of the odor is known or can reasonably be presumed;

2. Acute and chronic toxicity data are available and these data have been converted to appropriate health-based ambient criteria; and

3. The odor threshold data is not highly uncertain (i.e., reliable measurements of odor threshold fall within an order of magnitude range).

In these cases, Table 1-1 applies. If the odor threshold is above the threshold for toxic effects or safety concerns and an odor is detected, then cessation of exposure is prudent until further testing can be done. Conversely, if the odor threshold is clearly below the toxicity threshold and no odors are detected, then there is no immediate cause for concern. In cases where the odor threshold is similar to or greater than the ambient criteria, the absence of odor is not informative. Further, when the odor threshold is less than or similar to the ambient criteria and odor is detected, the hazard potential cannot be evaluated without analytical data. Although the detection of odor does not necessarily indicate risk in these cases, it does indicate a chemical exposure that should be analyzed and quantified.

**TABLE 1-1. RELATIONSHIP BETWEEN ODOR THRESHOLD VALUES AND AMBIENT CRITERIA**

| | Odor Threshold Below Ambient Criteria | Odor Threshold ≈ Ambient Criteria | Odor Threshold Above Ambient Criteria |
|---|---|---|---|
| No odor | Low level of concern | Analytical data required | Analytical data required |
| Odor detected | Analytical data required | Analytical data required | High level of concern |

## 1.4 LITERATURE SEARCH AND REVIEW

### 1.4.1 Critiqued Odor Threshold Values

The literature search consisted of a review of odor threshold compilations that were prepared by Van Gemert (1982), Van Gemert and Nettenbreijer (1977), Stahl (1973), Fazzalari (1978), and the American Industrial Hygiene Association (1989). The original references were then located if possible and reviewed based on the criteria discussed in Section 1.2.1. Those references that were accepted are listed in Table 2-1 and coded with an "A" next to the author's name.

The critiqued references and the odor threshold values are presented in Table 2-1. Threshold methodologies are evaluated according to each of the thirteen criteria discussed in Section 1.2.1. The geometric mean value, based on all accepted values, or recommended best estimate for the odor threshold for each of the compounds is given in Table 2-1. This is a common practice in sensory evaluation, as it accounts for the wide range of response over several orders of magnitude. The means were rounded off to two significant digits. Where values were given as a range, the geometric mean of the two points was taken for the threshold.

In some cases, the mean value for detection is higher than the mean value for recognition. This is a result of pooling of several data sets for the geometric mean.

Odor character descriptors in Table 2-1 are based on reports in the literature and experience in odor investigation. The intensity level at which the character is determined is seldom given in the sources reviewed. Since odor character can change with intensity, it should be remembered that the character reported may differ from source to source. The purpose here is to include an observation on the odorant character to accompany the threshold value.

# 2. ODOR THRESHOLD DATA FOR INDIVIDUAL CHEMICALS AND CHEMICAL CATEGORIES

Table 2-1 summarizes all published odor thresholds for the 189 hazardous air pollutants found to have reported odor thresholds. Chemicals are listed alphabetically. There are two sets of entries for each chemical: Phase I Unreviewed Sources and Phase II Critiqued Sources. Under the former are presented odor threshold values from sources that either were rejected or were not reviewed. Under the latter are presented odor threshold values from primary experimental sources that were critiqued. The table provides the following information.

- CAS number
- Chemical name and synonyms
- Chemical formula
- Molecular weight
- Last name of the first author listed for the source
- Source code:
  - A Accepted value based on critique
  - B Rejected value based on criteria
  - B1 Rejected value—water threshold
  - B2 Rejected value—minimum perceptible value
  - B3 Rejected value—water threshold/air conversion
  - B4 Rejected value—intensity
  - B5 Rejected value—insufficient methodology
  - C1 Rejected source based on review—secondary source
  - C2 Rejected source—incidental reference
  - C3 Rejected source—passive exposure/workplace
  - C4 Rejected source—passive exposure/experiment
  - D1 Omitted source—unpublished data
  - D2 Omitted source—personal communication
  - D3 Omitted source—anonymous reference
  - D4 Omitted source—omitted in Gemert
  - D5 Omitted source—pre-1900 reference
  - E1 Source located but not reviewed
  - E2 Source not located

- Odor threshold values in milligrams per cubic meter ($mg/m^3$) and parts per million (ppm)
- Type of threshold: d = detection, r = recognition, ng = not given
- Geometric mean odor threshold
- Type of geometric mean threshold: d = detection, r = recognition
- Odor characteristic

TABLE 2-1 REPORTED ODOR THRESHOLDS FROM ALL SOURCES

# TABLE 2-1. REPORTED ODOR THRESHOLDS FROM ALL SOURCES

| CAS # | Compound Name Synonyms | Formula | M.W. | Source | Code | Odor Thresholds mg/m³ | Odor Thresholds ppm | Type of Threshold | Geometric Mean Air Odor Threshold (ppm) | Geometric Mean Air Odor Type of Threshold | Odor Characteristic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 75070 | Acetaldehyde | $C_2H_4O$ | 44.05 | Unreviewed Sources | | | | | 0.067 | d | Pungent/fruity |
| | Ethanal | | | Zwaardemaker (1914) | E2 | 0.7 | 0.39 | d | | | |
| | | | | Backman (1917) | E1 | 0.062-0.075 | 0.034-0.042 | r | | | |
| | | | | Takhirov (1974) | E1 | 0.49 | 0.27 | ng | | | |
| | | | | Anonymous (1980) | D3 | 0.0027 | 0.0015 | d | | | |
| | | | | Anonymous (1980) | D3 | 0.027 | 0.015 | r | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Pliska and Janicek (1965) | B | 1,800 | 1,000 | ng | | | |
| | | | | Katz and Talbert (1930) | A | 0.12 | 0.067 | d | | | |
| | | | | Gofmekler (1967) | B2 | 0.012 | 0.0067 | d | | | |
| | | | | Leonardos et al. (1969) | B | 0.38 | 0.21 | r | | | |
| | | | | Hartung et al. (1971) | B5 | 0.005 | 0.0028 | ng | | | |
| 60355 | Acetamide | $CH_3CONH_2$ | 59.07 | Unreviewed Sources | | | | | None | | Mousy |
| | Acetic Acid Amide | | | Backman (1917) | E1 | 140-160 | 58-66 | r | | | |
| | Ethanamide | | | Critiqued Sources | | | | | | | |
| | | | | No A or B Codes | - | - | - | - | | | |
| 75058 | Acetonitrile | $C_2H_3N$ | 41.05 | Unreviewed Sources | | | | | 1,611 | d | Etherish, aromatic |
| | Methyl Cyanide | | | No C-E Codes | - | - | - | - | | | |
| | Ethanenitrile | | | Critiqued Sources | | | | | | | |
| | | | | Pozzani et al. (1959) | A | <67 | <40 | ng | | | |
| | | | | Dravnieks (1974) | A | 1,950 | 1,161 | d | | | |

## TABLE 2-1 (cont'd). REPORTED ODOR THRESHOLDS FROM ALL SOURCES

| CAS # | Compound Name Synonyms | Formula | M.W. | Source | Code | Odor Thresholds mg/m³ | Odor Thresholds ppm | Type of Threshold | Geometric Mean Air Odor Threshold (ppm) | Geometric Mean Air Odor Type of Threshold | Odor Characteristic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 98862 | Acetophenone | $C_6H_5COCH_3$ | 120.2 | Unreviewed Sources | | | | | 0.3 | d | Sweet/almond, |
| | Acetylbenzene | | | Gavaudan and | | | | | 0.6 | r | pleasant |
| | Methyl Phenyl Ketone | | | Poussel (1966) | E1 | 0.23 | 0.047 | ng | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Imasheva (1963) | B2 | 0.01 | 0.002 | ng | | | |
| | | | | Tkach (1965) | B2 | 0.01 | 0.002 | ng | | | |
| | | | | Korneev (1965) | B2 | 0.01 | 0.002 | ng | | | |
| | | | | Hellman and Small (1974) | A | 1.5 | 0.3 | d | | | |
| | | | | Hellman and Small (1974) | A | 2.9 | 0.6 | r | | | |
| 53963 | 2-Acetylaminofluorene<br>2-Acetamidofluorene | $C_{15}H_{13}NO$ | 223.3 | No sources found | | | | | | | |
| 107028 | Acrolein | $C_3H_4O$ | 56.06 | Unreviewed Sources | | | | | 1.8 | d | Pungent, choking |
| | 2-Propenal | | | Buchberg et al. (1961) | E2 | 0.2-0.7 | 0.087-0.31 | ng | | | |
| | Acrylaldehyde | | | Knuth (1973) | D2 | 0.14 | 0.061 | ng | | | |
| | | | | Anonymous (1980) | D3 | 0.069 | 0.03 | d | | | |
| | | | | Anonymous (1980) | D3 | 0.32 | 0.14 | r | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Katz and Talbert (1930) | A | 4.1 | 1.8 | ng | | | |
| | | | | Plotnikova (1957) | B2 | 0.8 | 0.35 | ng | | | |
| | | | | Leonardos et al. (1969) | B | 0.48 | 0.21 | r | | | |
| | | | | Sinkuvene (1970) | B2 | 0.07 | 0.031 | ng | | | |
| | | | | Cormack et al. (1974) | B | 0.23 | 0.1 | ng | | | |
| 79061 | Acrylamide<br>Acrylic Amide<br>Ethylenecarboxamide | $CH_2CHCONH_2$ | 71.08 | No sources found | | | | | | | Odorless |

# TABLE 2-1 (cont'd). REPORTED ODOR THRESHOLDS FROM ALL SOURCES

| CAS # | Compound Name Synonyms | Formula | M.W. | Source | Code | Odor Thresholds mg/m³ | Odor Thresholds ppm | Type of Threshold | Geometric Mean Air Odor Threshold (ppm) | Geometric Mean Air Odor Type of Threshold | Odor Characteristic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 79107 | Acrylic Acid | $C_3H_4O_2$ | 72.06 | Unreviewed Sources | | | | | 0.092 | d | Rancid/plastic/ |
| | Glacial Acrylic Acid | | | No C-E Codes | - | - | - | - | 1.0 | r | sweet/acrid |
| | 2-Propenoic Acid | | | Critiqued Sources | | | | | | | |
| | Propenoic Acid | | | Hellman and Small | | | | | | | |
| | Vinyl Formic Acid | | | (1974) | A | 0.27 | 0.092 | d | | | |
| | Acroleaic Acid | | | Hellman and Small | | | | | | | |
| | Propenoic Acid | | | (1974) | A | 3 | 1 | r | | | |
| | Ethylene Carboxylic Acid | | | | | | | | | | |
| 107131 | Acrylonitrile | $C_3H_3N$ | 53.06 | Unreviewed Sources | | | | | 1.6 | d | Onion/garlic, mild |
| | Vinyl Cyanide | | | No C-E Codes | - | - | - | - | | | |
| | 2-Propenenitrile | | | Critiqued Sources | | | | | | | |
| | | | | Stalker (1963) | A | 3.4 | 1.6 | d | | | |
| | | | | Leonardos et al. | | | | | | | |
| | | | | (1969) | B | 47 | 22 | r | | | |
| 107051 | Allyl Chloride | $C_3H_5Cl$ | 76.53 | Unreviewed Sources | | | | | None | | Pungent, |
| | 3-Chloro-1-propene | | | Shell Chemical | | | | | | | unpleasant |
| | 3-Chloropropene | | | Corporation (1958) | C1 | 9.3-18.6 | 3.0-5.9 | ng | | | |
| | | | | Torkelson et al. | | | | ng | | | |
| | | | | (1959) | C4 | 3-9 | 1-3 | | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Leonardos et al. | | | | r | | | |
| | | | | (1969) | B | 1.5 | 0.48 | | | | |
| 92671 | 4-Aminobiphenyl | $C_{12}H_{11}N$ | 169.2 | Unreviewed Sources | | | | | None | | |
| | p-Aminobiphenyl | | | Beckman (1917) | E1 | 0.15-0.17 | 0.022-0.025 | r | | | |
| | Diphenylamine | | | Critiqued Sources | | | | | | | |
| | | | | No A or B Codes | - | - | - | - | | | |

## TABLE 2-1 (cont'd). REPORTED ODOR THRESHOLDS FROM ALL SOURCES

| CAS # | Compound Name Synonyms | Formula | M.W. | Source | Code | Odor Thresholds mg/m³ | Odor Thresholds ppm | Type of Threshold | Geometric Mean Air Odor Threshold (ppm) | Geometric Mean Air Odor Type of Threshold | Odor Characteristic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 62533 | Aniline | $C_6H_5NH_2$ | 93.12 | Unreviewed Sources | | | | | 10 | ng | Pungent/oily, characteristic |
| | | | | Tempelaar (1913) | E2 | 0.97 | 0.25 | d | | | |
| | | | | Huijer (1917) | E2 | 0.046 | 0.012 | d | | | |
| | | | | Backman (1917) | E1 | 5.0-5.8 | 1.3-1.5 | r | | | |
| | | | | Geier (1936) | E2 | 1.2-1.5 | 0.32-0.39 | d | | | |
| | | | | Geier (1936) | E2 | 2.0-2.5 | 0.53-0.66 | r | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Jacobson et al. (1958) | A | 38 | 10 | ng | | | |
| | | | | Tkachev (1963) | B2 | 0.37 | 0.097 | ng | | | |
| | | | | Leonardos et al. (1969) | B | 3.8 | 1 | r | | | |
| 90040 | o-Anisidine | $C_7H_9NO$ | 123.2 | No Sources Found | | | | | | | |
| 1332214 | Asbestos | Magnesium and/or Iron Silicate Fibers | | No Sources Found | | | | | | | Odorless |

## TABLE 2-1 (cont'd). REPORTED ODOR THRESHOLDS FROM ALL SOURCES

| CAS # | Compound Name Synonyms | Formula | M.W. | Source | Code | Odor Thresholds mg/m³ | Odor Thresholds ppm | Type of Threshold | Geometric Mean Air Odor Threshold (ppm) | Geometric Mean Air Odor Type of Threshold | Odor Characteristic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 71432 | Benzene | $C_6H_6$ | 78.11 | Unreviewed Sources | | | | | 61 | d | Aromatic/ |
| | | | | Backman (1917) | E1 | 6.6-6.9 | 2.1-2.2 | r | 97 | r | sweet/solvent |
| | | | | Backman (1918) | E2 | 5.3 | 1.7 | ng | | | |
| | | | | Grijns (1919) | E2 | 420 | 131 | ng | | | |
| | | | | Schley (1934) | E2 | 8.8 | 2.8 | d | | | |
| | | | | Schley (1934) | E2 | 12 | 3.8 | r | | | |
| | | | | Deadman and Prigg (1959) | E2 | 9 | 2.8 | d | | | |
| | | | | Koster (1971) | E2 | 37 | 12 | d | | | |
| | | | | Naus (1962) | C1 | 6 | 1.9 | d | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Jones (1954) | B | 480-510 | 150-160 | r | | | |
| | | | | Jones (1955) | B | 180 | 56 | d | | | |
| | | | | Novikov (1957) | B2 | 4.9 | 1.5 | ng | | | |
| | | | | Gusev (1965) | B2 | 2.8-4.0 | 0.88-1.3 | ng | | | |
| | | | | May (1966) | A | 180 | 56 | d | | | |
| | | | | May (1966) | A | 310 | 97 | r | | | |
| | | | | Elfimova (1966) | B5 | 2.5 | 0.78 | ng | | | |
| | | | | Leonardos et al. (1969) | B | 15 | 4.7 | r | | | |
| | | | | Alibaev (1970) | B2 | 2.9 | 0.91 | ng | | | |
| | | | | Dravnieks and O'Donnell (1971) | B5 | 38 | 12 | ng | | | |
| | | | | Laffort and Dravnieks (1973) | B | 14.5 | 4.5 | ng | | | |
| | | | | Dravnieks (1974) | A | 380 | 119 | d | | | |
| | | | | Punter (1980) | A | 108 | 34 | d | | | |
| 92875 | Benzidine<br>4,4'-Bianiline<br>p,p'-Bianiline<br>4,4'-Biphenyldiamine | $C_{12}H_{12}N_2$ | 184.2 | No Sources Found | | | | | | | |
| 98077 | Benzotrichloride<br>Benzenyl Chloride<br>Benzotrichloride<br>Benzenyl Trichloride<br>Benzylidyne Chloride | $C_6H_5CCl_3$ | 195.5 | No Sources Found | | | | | | | Penetrating |

## TABLE 2-1 (cont'd). REPORTED ODOR THRESHOLDS FROM ALL SOURCES

| CAS # | Compound Name Synonyms | Formula | M.W. | Source | Code | Odor Thresholds mg/m³ | ppm | Type of Threshold | Geometric Mean Air Odor Threshold (ppm) | Geometric Mean Air Odor Type of Threshold | Odor Characteristic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 100447 | Benzyl Chloride<br>alpha-Chlorotoluene | $C_7H_7Cl$ | 126.58 | Unreviewed Sources | | | | | 0.041 | ng | Pungent |
| | | | | No C-E Codes | - | - | - | - | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Katz and Talbert (1930) | A | 0.21 | 0.041 | | | | |
| | | | | Leonardos et al. (1969) | B | 0.24 | 0.046 | r | | | |
| 92524 | Biphenyl<br>Phenylbenzene | $C_{12}H_{10}$ | 154.21 | Unreviewed Sources | | | | | None | | Pleasant/ butter-like |
| | | | | No C-E Codes | - | - | - | - | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Solomin (1961) | B2 | 0.06 | 0.0095 | | | | |
| 117817 | Bis(2-ethylhexyl) Phthalate (DEHP)<br>Bis(2-ethylhexyl)phthalate<br>Phthalic Acid, bis(2-ethylhexyl)ester | $C_{24}H_{38}O_4$ | 390.6 | No Sources Found | | | | | | | |
| 542881 | Bis(chloromethyl)ether<br>Chloromethyl Ether<br>Dichlorodimethyl Ether | $(CH_2Cl)O(CH_2Cl)$ | 115 | No Sources Found | | | | | | | |
| 75252 | Bromoform<br>Tribromomethane | $CHBr_3$ | 252.75 | Unreviewed Sources | | | | | None | | Chloroform/ sweet/ suffocating |
| | | | | Passy (1893) | D5 | 2-5 | 0.19-0.48 | d | | | |
| | | | | Backman (1917) | E1 | 2.2-2.5 | 0.21-0.24 | r | | | |
| | | | | Grijns (1919) | E2 | 150 | 15 | ng | | | |
| | | | | Rocén (1920) | E2 | 30 | 2.9 | r | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | No A or B Codes | - | - | - | - | | | |

# TABLE 2-1 (cont'd). REPORTED ODOR THRESHOLDS FROM ALL SOURCES

| CAS # | Compound Name Synonyms | Formula | M.W. | Source | Code | Odor Thresholds mg/m$^3$ | Odor Thresholds ppm | Type of Threshold | Geometric Mean Air Odor Threshold (ppm) | Geometric Mean Air Odor Type of Threshold | Odor Characteristic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 106990 | 1,3-Butadiene | $C_4H_6$ | 54.09 | Unreviewed Sources | | | | | 0.45 | d | Aromatic/ rubber, |
| | Butadiene | | | Deadman and | | | | | 1.1 | r | mild |
| | Divinyl | | | Prigg (1959) | E2 | 2.1 | 0.95 | d | | | |
| | Biethylene | | | Jeltes (1975) | E2 | 0.22 | 0.099 | ng | | | |
| | Erythrene | | | Critiqued Sources | | | | | | | |
| | | | | Mullins (1955) | B5 | 169 | 76 | r | | | |
| | | | | Ripp (1968) | B2 | 4 | 1.8 | ng | | | |
| | | | | Laffort and | | | | | | | |
| | | | | Dravnieks (1973) | B | 5.8 | 2.6 | ng | | | |
| | | | | Hellman and Small | | | | | | | |
| | | | | (1974) | A | 1 | 0.45 | d | | | |
| | | | | Hellman and Small | | | | | | | |
| | | | | (1974) | A | 2.4 | 1.1 | r | | | |
| 156627 | Calcium Cyanamide | $CaCN_2$ | 80.1 | No Sources Found | | | | | | | |
| | Calcium Carbamide | | | | | | | | | | |
| 105602 | Caprolactam | $C_6H_{11}ON$ | 113.2 | Unreviewed Sources | | | | | None | | |
| | 6-Aminohexanoic Acid | | | No C-E Codes | - | - | - | - | | | |
| | 6-Aminohexanoic Acid Lactam | | | Critiqued Sources | | | | | | | |
| | | | | Krichevskaya (1968) | B2 | 0.3 | 0.065 | ng | | | |
| 133062 | Captan | $C_9H_8O_2SNCl_3$ | 300.6 | No Sources Found | | | | | | | Slightly pungent |
| 63252 | Carbaryl | $C_{12}H_{11}NO_2$ | 201.2 | No Sources Found | | | | | | | |
| 75150 | Carbon Disulfide | $CS_2$ | 76.13 | Unreviewed Sources | | | | | None | | Vegetable sulfide/ |
| | | | | Deadman and Prigg | | | | | | | medicinal |
| | | | | (1959) | E2 | 0.07 | 0.022 | d | | | |
| | | | | Frantikova (1962) | E2 | 1.3 | 0.42 | ng | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Hildenskiold (1959) | B2 | 0.05 | 0.016 | ng | | | |
| | | | | Baikov (1963) | B2 | 0.08-0.5 | 0.026-0.16 | ng | | | |
| | | | | Leonardos et al. | | | | | | | |
| | | | | (1969) | B | 0.65 | 0.21 | r | | | |

## TABLE 2-1 (cont'd). REPORTED ODOR THRESHOLDS FROM ALL SOURCES

| CAS # | Compound Name Synonyms | Formula | M.W. | Source | Code | Odor Thresholds mg/m$^3$ | Odor Thresholds ppm | Type of Threshold | Geometric Mean Air Odor Threshold (ppm) | Geometric Mean Air Odor Type of Threshold | Odor Characteristic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 56235 | Carbon Tetrachloride | $CCl_4$ | 153.82 | Unreviewed Sources | | | | | 255* | d | Sweet/dry/ |
| | Tetrachloromethane | | | Lehmann and | | | | | 250 | r | cleaner, |
| | Perchloromethane | | | Schmidt-Kehl (1936) | E1 | 900 | 143 | ng | | | distinctive |
| | Benzinoform | | | Davis (1934) | C1 | 500 | 79 | ng | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Allison and Katz | | | | | | | |
| | | | | (1919) | B5 | 4,533 | 720 | ng | | | |
| | | | | May (1966) | A | 1,260 | 200 | d | | | |
| | | | | May (1966) | A | 1,600 | 250 | r | | | |
| | | | | Leonardos et al. | | | | | | | |
| | | | | (1969) | B | 135-630 | 21-100 | r | | | |
| | | | | Belkov (1969) | B5 | 11.5-58 | 1.8-9.0 | ng | | | |
| | | | | Nikiforov (1970) | B5 | 10.58 | 1.68 | ng | | | |
| | | | | Dravnieks (1974) | A | 3,700 | 588 | d | | | |
| | | | | Punter (1980) | A | 884 | 141 | d | | | |
| 463581 | Carbonyl Sulfide | COS | 60.07 | Unreviewed Sources | | | | | 0.1 | ng | sulfide |
| | Carbon Oxysulfide | | | No C-E Codes | - | - | - | - | | | |
| | Carbonyl Oxysulfide | | | Critiqued Sources | | | | | | | |
| | | | | Polgar et al. (1975) | A | 0.25 | 0.1 | ng | | | |
| 120809 | Catechol | $C_6H_6O_2$ | 110.1 | No Sources Found | | | | | | | |
| | 1,2-Benzenediol | | | | | | | | | | |
| | 2-Hydroxyphenol | | | | | | | | | | |
| 133904 | Chloramben | $C_7H_5NO_2Cl_2$ | 206 | No Sources Found | | | | | | | |
| 57749 | Chlordane | $C_{10}H_6C_{18}$ | 409.8 | No Sources Found | | | | | | | Odorless |
| | 1,2,3,4,5,6,7, 8,8-octachloro-2,3,3a,4,7,7a-hexahydro-4,7-methano-1H-indene | | | | | | | | | | |

# TABLE 2-1 (cont'd). REPORTED ODOR THRESHOLDS FROM ALL SOURCES

| CAS # | Compound Name Synonyms | Formula | M.W. | Source | Code | Odor Thresholds mg/m³ | Odor Thresholds ppm | Type of Threshold | Geometric Mean Air Odor Threshold (ppm) | Geometric Mean Air Odor Type of Threshold | Odor Characteristic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 7782505 | Chlorine | $Cl$ | 35.45 | Unreviewed Sources | | | | | 0.18 | d | Suffocating/ sharp/bleach |
| | | | | Fieldner et al. (1921) | C1 | 10 | 6.9 | ng | | | |
| | | | | Smolczyk and Cobler (1930) | E2 | 1.43-14.3 | 0.99-9.9 | ng | | | |
| | | | | Styazhkin (1963) | E2 | 0.7 | 0.48 | ng | | | |
| | | | | Rupp and Henschler (1967) | C4 | 0.06-0.15 | 0.041-0.1 | d | | | |
| | | | | Rupp and Henschler (1967) | C4 | 0.3 | 0.2 | r | | | |
| | | | | Kramer (1976) | D2 | 3.2-7.8 | 0.21-5.38 | ng | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Takhiroff (1957) | B2 | 0.8 | 0.55 | ng | | | |
| | | | | Leonardos et al. (1969) | B | 0.6 | 0.41 | r | | | |
| | | | | Dixon and Ikels (1977) | A | 0.23 | 0.16 | d | | | |
| 79118 | Chloroacetic Acid | $C_2H_3ClO_2$ | 94.5 | Unreviewed Sources | | | | | None | ng | Penetrating odor similar to vinegar |
| | | | | Backman (1917) | E1 | 0.6 | 0.19 | r | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Smith and Hochstettler (1969) | B | 0.05 | 0.02 | r | | | |
| 532274 | 2-Chloroacetophenone<br>Phenyl Chlromethyl Ketone<br>Phenacyl Chloride | $C_8H_7ClO$ | 154.6 | Unreviewed Sources | | | | | 0.07 | ng | Pungent/floral |
| | | | | No C-E Codes | - | - | - | - | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Katz and Talbert (1930) | A | 0.1-0.7 | 0.02-0.11 | ng | | | |
| 108907 | Chlorobenzene<br>Monochlorobenzene | $C_6H_5Cl$ | 112.56 | Unreviewed Sources | | | | | 1.3 | d | Almond-like/ shoe polish |
| | | | | Backman (1917) | E1 | 7.5-8.1 | 1.6-1.8 | r | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Mateson (1955) | B5 | 21.6 | 4.7 | ng | | | |
| | | | | Tarkhova (1965) | B2 | 0.4 | 0.087 | ng | | | |
| | | | | Leonardos et al. (1969) | B | 0.97 | 0.21 | r | | | |
| | | | | Smith and Hochstettler (1969) | B | 3 | 0.65 | r | | | |
| | | | | Punter (1980) | A | 5.9 | 1.3 | d | | | |

# TABLE 2-1 (cont'd). REPORTED ODOR THRESHOLDS FROM ALL SOURCES

| CAS # | Compound Name Synonyms | Formula | M.W. | Source | Code | Odor Thresholds mg/m³ | Odor Thresholds ppm | Type of Threshold | Geometric Mean Air Odor Threshold (ppm) | Geometric Mean Air Odor Type of Threshold | Odor Characteristic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 510156 | Chlorobenzilate | $C_{16}H_{14}Cl_2O_3$ | 325.2 | No Sources Found | | | | | | | |
| 67663 | Chloroform | $CHCl_3$ | 119.4 | Unreviewed Sources | | | | | 192 | d | Sweet/ |
| | Trichloromethane | | | Passy (1893) | D5 | 30 | 6.1 | d | | | suffocating |
| | | | | Tempelaar (1913) | E2 | 3,000 | 614 | d | | | characteristic |
| | | | | Backman (1917) | E1 | 14.1-15.1 | 2.9-3.1 | r | | | |
| | | | | Grijns (1919) | E2 | 2,350 | 481 | ng | | | |
| | | | | Rocén (1920) | E2 | 730 | 150 | d | | | |
| | | | | Rocén (1920) | E2 | 2,500 | 512 | r | | | |
| | | | | Mitsumoto (1926) | E1 | 353.8-589 | 72.5-121 | r | | | |
| | | | | Schley (1934) | E2 | 42 | 8.6 | d | | | |
| | | | | Schley (1934) | E2 | 56 | 11 | r | | | |
| | | | | Morimura (1934) | E1 | 480-622 | 98-127 | r | | | |
| | | | | Lehmann and Schmidt-Kehl (1936) | E1 | 1,000-1,500 | 205-307 | ng | | | |
| | | | | Janicek et al. (1960) | E1 | 3,700 | 758 | ng | | | |
| | | | | Naus (1962) | C1 | 3 | 0.6 | d | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Allison and Katz (1919) | B5 | 3,300 | 676 | ng | | | |
| | | | | Scherberger et al. (1958) | B | 6,900 | 1,413 | r | | | |
| | | | | Dravnieks (1974) | A | 1,350 | 276 | d | | | |
| | | | | Punter (1980) | A | 650 | 133 | d | | | |
| 107302 | Chloromethyl Methyl Ether | | | No Sources Found | | | | | | | Irritating |
| 126998 | Chloroprene | $C_4H_5Cl$ | 88.54 | Unreviewed Sources | | | | | None | | Rubber |
| | 2-Chloro-1,3-butadiene | | | Nystrom (1948) | C1 | 500-1,000 | 138.1-276.1 | r | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Mnatsakanyan (1962) | B | 0.4-2.0 | 0.11-0.55 | ng | | | |
| 1319773 | Cresols (isomers and mixtures) | | | | | | | | | | |
| | Cresylic Acid | | | | | | | | | | |
| | See o-Cresol | | | | | | | | | | |
| | See m-Cresol | | | | | | | | | | |
| | See p-Cresol | | | | | | | | | | |

## TABLE 2-1 (cont'd). REPORTED ODOR THRESHOLDS FROM ALL SOURCES

| CAS # | Compound Name Synonyms | Formula | M.W. | Source | Code | Odor Thresholds mg/m$^3$ | Odor Thresholds ppm | Type of Threshold | Geometric Mean Air Odor Threshold (ppm) | Geometric Mean Air Odor Type of Threshold | Odor Characteristic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 95487 | o-Cresol | $C_7H_8O$ | 108.1 | Unreviewed Sources | | | | | None | | Phenolic, tarry |
| | o-Cresylic Acid | | | Backman (1917) | E1 | 0.004 | 0.0009 | r | | | |
| | 2-Methylphenol | | | Stuiver (1958) | E2 | 0.0004 | 0.00009 | d | | | |
| | | | | Kendall et al. (1968) | E2 | 0.0028 | 0.00063 | r | | | |
| | | | | Anonymous (1980) | D3 | 0.0017 | 0.00038 | d | | | |
| | | | | Anonymous (1980) | D3 | 0.027 | 0.0061 | r | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | No A or B Codes | - | - | - | - | | | |
| 108934 | m-Cresol | $C_7H_8O$ | 108.1 | Unreviewed Sources | | | | | 0.004 | d | Phenolic |
| | 3-Methylphenol | | | Backman (1917) | E1 | 0.0007-0.0009 | 0.00016-0.00020 | r | | | |
| | | | | Stuiver (1958) | E2 | 0.0004 | 0.00009 | d | | | |
| | | | | Anonymous (1980) | D3 | 0.00057 | 0.00013 | d | | | |
| | | | | Anonymous (1980) | D3 | 0.011 | 0.0025 | r | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Nader (1958) | A | 0.00022-.035 | 0.000050-0.0079 | ng | | | |
| 106445 | p-Cresol | $C_7H_8O$ | 108.1 | Unreviewed Sources | | | | | None | | Phenolic |
| | p-Hydroxytoluene | | | Backman (1917) | E1 | 0.03-0.04 | 0.0068-0.0090 | r | | | |
| | 4-Methylphenol | | | Baldus (1936) | E2 | 0.0125 | 0.0028 | d | | | |
| | | | | Baldus (1936) | E2 | 0.015 | 0.0034 | r | | | |
| | | | | Stuiver (1958) | E2 | 0.00005 | 0.000011 | d | | | |
| | | | | Punter (1975, 1979) | D1,D2 | 0.024 | 0.0054 | d | | | |
| | | | | Anonymous (1980) | D3 | 0.00018 | 0.000041 | d | | | |
| | | | | Anonymous (1980) | D3 | 0.0084 | 0.0019 | r | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Leonardos et al. (1969) | B | 0.0044 | 0.00099 | r | | | |

## TABLE 2-1 (cont'd). REPORTED ODOR THRESHOLDS FROM ALL SOURCES

| CAS # | Compound Name Synonyms | Formula | M.W. | Source | Code | Odor Thresholds mg/m$^3$ | Odor Thresholds ppm | Type of Threshold | Geometric Mean Air Odor Threshold (ppm) | Geometric Mean Air Odor Type of Threshold | Odor Characteristic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 98828 | Cumene<br>Isopropylbenzene | $C_9H_{12}$ | 120.2 | Unreviewed Sources | | | | | 0.032 | d | Sharp |
| | | | | Koster (1971) | E2 | 0.25 | 0.051 | d | 0.047 | r | |
| | | | | Anonymous (1980) | D3 | 0.074 | 0.015 | d | | | |
| | | | | Anonymous (1980) | D3 | 0.54 | 0.11 | r | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Solomin (1964) | B2 | 0.06 | 0.012 | ng | | | |
| | | | | Elfimova (1966) | B5 | 0.025 | 0.0051 | ng | | | |
| | | | | Turk (1973) | B | 4.8-6.4 | 0.98-1.3 | r | | | |
| | | | | Hellman and Small (1974) | A | 0.04 | 0.008 | d | | | |
| | | | | Hellman and Small (1974) | A | 0.23 | 0.047 | r | | | |
| | | | | Punter (1980) | A | .65 | 0.132 | d | | | |
| 94757 | 2,4-D, Salts and Esters<br>2,4-Dichlorophenoxyacetic Acid | $C_8H_6Cl_2O_3$ | 221 | No Sources Found | | | | | | | |
| 72559 | DDE<br>Dichlorodiphenyldichloroethylene | $(ClC_6H_4)_2{:}CCl_2$ | | No Sources Found | | | | | | | |
| 334883 | Diazomethane | $CH_2N_2$ | 42.04 | No Sources Found | | | | | | | |
| 132649 | Dibenzofuran<br>Diphenylene Oxide | $C_{12}H_8O$ | 168.2 | No Sources Found | | | | | | | |
| 96128 | 1,2-Dibromo-3-chloropropane | $C_3H_5Br_2Cl$ | 236.3 | Unreviewed Sources | | | | | None | | |
| | | | | Torkelson and Rowe (1981) | C1 | 0.1-0.3 | 0.01-0.03 | ng | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | No A or B Codes | - | - | - | - | | | |
| 84742 | Dibutylphthalate | $C_6H_4$<br>$(COOC_4H_9)2$ | 278.3 | No Sources Found | | | | | | | Slightly ester |
| 106467 | p-Dichlorobenzene<br>1,4-Dichlorobenzene | $C_6H_4Cl_2$ | 147 | Unreviewed Sources | | | | | 0.12 | d | Camphor/ mothballs, penetrating |
| | | | | Hollingsworth et al. (1956) | C3 | <90 | <15 | ng | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Punter (1980) | A | 0.73 | 0.121 | d | | | |

## TABLE 2-1 (cont'd). REPORTED ODOR THRESHOLDS FROM ALL SOURCES

| CAS # | Compound Name Synonyms | Formula | M.W. | Source | Code | Odor Thresholds mg/m³ | Odor Thresholds ppm | Type of Threshold | Geometric Mean Air Odor Threshold (ppm) | Geometric Mean Air Odor Type of Threshold | Odor Characteristic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 91941 | 3,3'-Dichlorobenzidine | $C_{12}H_{10}Cl_2N_2$ | 253.1 | No Sources Found | | | | | | | |
| 111444 | Dichloroethyl Ether<br>Bis(2-chloroethyl) Ether | $C_4H_8Cl_2O$ | 143 | No Sources Found | | | | | | | Sweet, like chloroform |
| 542756 | 1,3-Dichloropropene<br>1,3-Dichloropropylene<br>3-Chloroallyl Chloride<br>3-Chloropropenyl Chloride | $C_3H_4Cl_2$ | 111 | No Sources Found | | | | | | | |
| 62737 | Dichlorvos<br>2,2 Dichloroethenyl Dimethyl Phosphate<br>2,2 Dichlorovinyl Dimethyl Phosphate<br>Phosphoric Acid, 2,2-Dichloroethenyl Dimethyl Ester<br>Phosphoric Acid, 2,2-Dichlorovinyl Dimethyl Ester | $C_4H_7O_4PCl_2$ | 221 | No Sources Found | | | | | | | |
| 111422 | Diethanolamine<br>3-Azapentane-1,5-Diol<br>2,2 Dihydroxydiethylamine | $C_4H_{11}NO_2$ | 105.1 | Unreviewed Sources | | | | | None | | |
| | | | | England et al. (1976) | E2 | 1.2 | 0.28 | r | | | |
| | | | | Critiqued Sources<br>No A or B Codes | - | - | - | - | | | |
| 64675 | Diethyl Sulfate<br>Diethyl Sulphate<br>Ethyl Sulfate<br>Sulfuric Acid, Diethyl Esters | $C_4H_{10}SO_4$ | 154.2 | No Sources Found | | | | | | | Faint, ethereal, irritating after-effect |
| 121697 | Dimethylaniline<br>N,N-Dimethylaniline<br>N,N-Diethyl Aniline | $C_8H_{11}N$ | 121.2 | Unreviewed Sources | | | | | None | | Oily |
| | | | | Backman (1917) | E1 | 0.8-1.0 | 0.16-0.20 | r | | | |
| | | | | Geier (1936) | E2 | 0.005-0.1 | 0.0010-0.020 | d | | | |
| | | | | Geier (1936) | E2 | 0.05-0.25 | 0.010-0.050 | r | | | |
| | | | | Deadman and Prigg (1959) | E2 | 0.012 | 0.0024 | d | | | |
| | | | | Critiqued Sources<br>No A or B Codes | - | - | - | - | | | |

## TABLE 2-1 (cont'd). REPORTED ODOR THRESHOLDS FROM ALL SOURCES

| CAS # | Compound Name Synonyms | Formula | M.W. | Source | Code | Odor Thresholds mg/m³ | Odor Thresholds ppm | Type of Threshold | Geometric Mean Air Odor Threshold (ppm) | Geometric Mean Air Odor Type of Threshold | Odor Characteristic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 119904 | 3,3-Dimethoxybenzidine<br>Dianisidine | $C_{14}H_{16}N_2O_2$ | 244.3 | No Sources Found | | | | | | | |
| 60117 | Dimethyl aminoazobenzene<br>Benzenamine,<br>N,N-dimethyl-4-(phenylazo)<br>p-(Dimethylamino) Azobenzene<br>4-(N,N-Dimethylamino)azobenzene | $C_{14}H_{15}N_3$ | 225.3 | No Sources Found | | | | | | | |
| 119937 | 3,3'-Dimethyl Benzidine<br>Dimethyl Carbamoyl Chloride<br>Carbamic Chloride, Dimethyl<br>Dimethylcarbaminc Acid Chloride<br>Dimethylcarbamidoyl Chloride<br>Dimethylcarbamyl Chloride<br>Dimethylchloroformamide<br>Ortho-Tolidine | $C_{14}H_{16}N_2$ | 212.3 | No Sources Found | | | | | | | |
| 68122 | Dimethyl Formamide<br>N,N-Dimethyl Formamide<br>DMF | $C_3H_7ON$ | 73.09 | Unreviewed Sources | | | | | None | | Fishy |
| | | | | No C-E Codes | - | - | - | - | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Odoshashvili (1962) | B2 | 0.14 | 0.047 | ng | | | |
| | | | | Leonardos et al. (1969) | B | 300 | 100 | r | | | |
| 57147 | 1,1-Dimethylhydrazine<br>N,N-Dimethylhydrazine<br>unsym-Dimethylhydrazine | $C_2H_8N_2$ | 60.1 | Unreviewed Sources | | | | | 10 | | Fishy/ammonia |
| | | | | Rumsey and Cesta (1970) | C3 | <0.75 | <0.31 | ng | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Jacobson et al. (1955) | A | 15-35 | 6.1-14 | ng | | | |
| 131113 | Dimethyl Phthalate | $C_{10}H_{10}O_4$ | 194.2 | No Sources Found | | | | | | | |
| 77781 | Dimethyl Sulfate<br>Sulfuric Acid, Dimethyl Ester | $C_2H_6O_4$ | 102.1 | No Sources Found | | | | | | | |

# TABLE 2-1 (cont'd). REPORTED ODOR THRESHOLDS FROM ALL SOURCES

| CAS # | Compound Name Synonyms | Formula | M.W. | Source | Code | Odor Thresholds mg/m³ | Odor Thresholds ppm | Type of Threshold | Geometric Mean Air Odor Threshold (ppm) | Geometric Mean Air Odor Type of Threshold | Odor Characteristic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 534521 | 4,6-Dinitro-o-cresol, and Salts | $C_7H_6N_2O_5$ | 198.1 | Unreviewed Sources | | | | | | | |
| | 4,6-Dinitro-2-methylphenol | | | Kurtschatowa and | | | | | None | | |
| | | | | Dawidkowa (1970) | E2 | 0.004-0.021 | 0.0005-0.0026 | ng | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | No A or B Codes | | | | | | | |
| 51285 | 2,4-Dinitrophenol | $C_6H_4N_2O_5$ | 184.1 | No Sources Found | | | | | | | Sweet, musty |
| 121142 | 2,4-Dinitrotoluene | $C_7H_6N_2O_4$ | 182.1 | No Sources Found | | | | | | | |
| 123911 | Dioxane | $C_4H_8O_2$ | 88.1 | Unreviewed Sources | | | | | 22* | d | Sweet/mild, |
| | 1,4-Diethylene Dioxide | | | Koster (1971) | E2 | 45-9,400 | 12-2,609 | d | 22 | r | alcohol/ ethereal |
| | 1,4-Dioxane | | | Wirth and Klimmer | | | | | | | |
| | Diethylene Oxide | | | (1937) | C1 | 10 | 2.8 | d | | | |
| | Dioxyethylene Ether | | | Critiqued Sources | | | | | | | |
| | 1,4-Diethyleneoxide | | | May (1966) | A | 620 | 172 | d | | | |
| | | | | May (1966) | A | 1,000 | 278 | | | | |
| | | | | Hellman and Small | | | | r | | | |
| | | | | (1973, 1974) | A | 2.9 | 0.8 | | | | |
| | | | | Hellman and Small | | | | d | | | |
| | | | | (1973, 1974) | A | 6.5 | 1.8 | | | | |
| | | | | Dravnieks (1974) | A | 270 | 75 | r | | | |
| | | | | | | | | d | | | |
| 122667 | 1,2-Diphenylhydrazine | $C_{12}H_{12}N_2$ | 184.2 | No Sources Found | | | | | | | |
| 106898 | Epichlorohydrin | $C_3H_5ClO$ | 92.53 | Unreviewed Sources | | | | | None | | Chloroform, |
| | 1-Chloro-2,3-epoxypropane | | | Shell Chemical | | | | | | | pungent, garlic, |
| | Glycidyl Chloride | | | Corporation (1959) | C1 | 38-46 | 10-12 | ng | | | sweet |
| | 3-Chloropropene-1,2-oxide | | | Critiqued Sources | | | | | | | |
| | | | | Fomin (1966) | B2 | 0.3 | 0.08 | ng | | | |
| 106887 | 1,2-Epoxybutane | $C_4H_8O$ | 72.12 | No Sources Found | | | | | | | |
| | 1,2-Butylene Oxide | | | | | | | | | | |

# TABLE 2-1 (cont'd). REPORTED ODOR THRESHOLDS FROM ALL SOURCES

| CAS # | Compound Name Synonyms | Formula | M.W. | Source | Code | Odor Thresholds mg/m³ | Odor Thresholds ppm | Type of Threshold | Geometric Mean Air Odor Threshold (ppm) | Geometric Mean Air Odor Type of Threshold | Odor Characteristic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 140885 | Ethyl Acrylate<br>Ethyl 2-Propenoate | $C_5H_8O_2$ | 100.1 | Unreviewed Sources | | | | | 0.00024<br>0.00037 | d<br>r | Sweet/ester/ plastic |
| | | | | Anonymous (1980) | D3 | 0.00082 | 0.0002 | d | | | |
| | | | | Anonymous (1980) | D3 | 0.0053 | 0.0013 | r | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Leonardos et al. (1969) | B | 0.0019 | 0.00046 | r | | | |
| | | | | Hellman and Small (1973, 1974) | A | 0.001 | 0.00024 | d | | | |
| | | | | Hellman and Small (1973, 1974) | A | 0.0015 | 0.00037 | r | | | |
| 100414 | Ethyl Benzene<br>Phenylethane | $C_8H_{10}$ | 106.2 | Unreviewed Sources | | | | | None | | Oily/solvent, aromatic |
| | | | | Koster (1971) | E2 | 0.4 | 0.092 | d | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Ivanov (1964) | B2 | 2.0-2.6 | 0.46-0.60 | ng | | | |
| 51796 | Ethyl Carbamate<br>Urethane | $C_3H_7NO_2$ | 89.1 | No Sources Found | | | | | | | Odorless |
| 75003 | Ethyl Chloride<br>Chloroethane | $C_2H_5Cl$ | 64.52 | No Sources Found | | | | | | | Etherial, pungent |
| 106934 | Ethylene Dibromide<br>Dibromoethane | $BrCH_2CH_2Br$ | 187.9 | No Sources Found | | | | | | | Sweet |

# TABLE 2-1 (cont'd). REPORTED ODOR THRESHOLDS FROM ALL SOURCES

| CAS # | Compound Name Synonyms | Formula | M.W. | Source | Code | Odor Thresholds mg/m$^3$ | Odor Thresholds ppm | Type of Threshold | Geometric Mean Air Odor Threshold (ppm) | Geometric Mean Air Odor Type of Threshold | Odor Characteristic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 107062 | Ethylene Dichloride | $C_2H_4Cl_2$ | 98.96 | Unreviewed Sources | | | | | 26 | d | Chloroform |
| | 1,2-Dichloroethane | | | McCawley (1942) | E2 | 1,200-4,000 | 297-988 | ng | 87 | r | |
| | Ethylene Chloride | | | Irish (1963) | C1 | 200 | 49 | ng | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Jones (1955) | B | 1,500 | 371 | d | | | |
| | | | | Borisova (1957) | B2 | 1.75-23.2 | 4.3-5.7 | ng | | | |
| | | | | Scherberger et al. (1958) | B | 820 | 203 | r | | | |
| | | | | May (1966) | A | 450 | 111 | d | | | |
| | | | | May (1966) | A | 750 | 185 | r | | | |
| | | | | Dravnieks and O'Donnell (1971) | B5 | 190 | 47 | ng | | | |
| | | | | Hellman and Small (1974) | A | 25 | 6 | d | | | |
| | | | | Hellman and Small (1974) | A | 165 | 41 | r | | | |
| 107211 | Ethylene Glycol | $C_2H_6O_2$ | 62.07 | No Sources Found | | | | | | | Odorless |
| 151564 | Ethylenimine | $C_2H_5N$ | 43.07 | Unreviewed Sources | | | | | None | | Ammonia |
| | Dimethylenimine | | | Carpenter et al. (1948) | C4 | 3.6 | 2 | ng | | | |
| | Aziridine | | | Critiqued Sources | | | | | | | |
| | | | | Berzins (1966) | B5 | 1.25-3.5 | 0.71-2.0 | ng | | | |
| 75218 | Ethylene Oxide | $C_2H_4O$ | 44.05 | Unreviewed Sources | | | | | 257 | d | Sweet/olefinic |
| | Oxirane | | | No C-E Codes | - | - | - | - | 493 | r | |
| | 1,2-Epoxyethane | | | Critiqued Sources | | | | | | | |
| | | | | Jacobson et al. (1956) | A | 1,260 | 690 | ng | | | |
| | | | | Yuldashev (1965) | B2 | 1.5 | 0.82 | ng | | | |
| | | | | Hellman and Small (1974) | A | 470 | 257 | d | | | |
| | | | | Hellman and Small (1974) | A | 900 | 493 | r | | | |
| 96457 | Ethylene Thiourea | $C_3H_6N_2S$ | 102.1 | No Sources Found | | | | | | | Faint ammonia |
| 75343 | 1,1-Dichloroethane | $C_2H_4Cl_2$ | 98.97 | No Sources Found | | | | | | | |

# TABLE 2-1 (cont'd). REPORTED ODOR THRESHOLDS FROM ALL SOURCES

| CAS # | Compound Name Synonyms | Formula | M.W. | Source | Code | Odor Thresholds mg/m³ | ppm | Type of Threshold | Geometric Mean Air Odor Threshold (ppm) | Geometric Mean Air Odor Type of Threshold | Odor Characteristic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 50000 | Formaldehyde<br>Methanal | $CH_2O$ | 30.03 | Unreviewed Sources | | | | | None | | Pungent/strong |
| | | | | Backman (1917) | E1 | 0.033-0.036 | 0.027-0.029 | r | | | |
| | | | | Buchberg et al. (1961) | E2 | 1.1-2.2 | 0.90-1.8 | ng | | | |
| | | | | Takhirov (1974) | E1 | 0.065 | 0.053 | ng | | | |
| | | | | Makeicheva (1978) | E1 | 0.077 | 0.063 | ng | | | |
| | | | | Anonymous (1980) | D3 | 0.49 | 0.4 | d | | | |
| | | | | Anonymous (1980) | D3 | 2.3 | 1.9 | r | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Melekhina (1958) | B2 | 0.07 | 0.057 | ng | | | |
| | | | | Pliska and Janicek (1965) | B | 12,000 | 9,770 | ng | | | |
| | | | | Sgibnev (1968) | B2 | 0.3-0.4 | 0.24-0.33 | ng | | | |
| | | | | Leonardos et al. (1969) | B | 1.2 | 0.98 | r | | | |
| | | | | Fel'dman and Bonashevskaya (1971) | B2 | 0.073 | 0.059 | ng | | | |
| 76448 | Heptachlor | $C_{10}H_5Cl_7$ | 375.3 | No Sources Found | | | | | | | |
| 118741 | Hexachlorobenzene | $C_6Cl_6$ | 284.8 | No Sources Found | | | | | | | |
| 87683 | Hexachlorobutadiene | $C_4Cl_6$ | 260.8 | No Sources Found | | | | | | | Mild |
| 77474 | Hexachlorocyclopentadiene<br>Perchlorocyclopentadiene | $C_5Cl_6$ | 272.8 | Unreviewed Sources | | | | | None | | Harsh, pungent |
| | | | | Treon et al. (1955) | C2 | 1.7 | 0.15 | ng | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | No A or B Codes | | | | | | | |
| 67721 | Hexacloroethane | $C_2Cl_6$ | 236.7 | No Sources Found | | | | | | | Camphor-like |
| 822060 | Hexamethylene-1,6-diisocyanate | $C_8H_{12}N_2O_2$ | 168.2 | No Sources Found | | | | | | | |
| 680319 | Hexamethylphosphoramide<br>Hempa | $C_6H_{18}N_3PO$ | 179.2 | No Sources Found | | | | | | | Mild, ammonia |

## TABLE 2-1 (cont'd). REPORTED ODOR THRESHOLDS FROM ALL SOURCES

| CAS # | Compound Name Synonyms | Formula | M.W. | Source | Code | Odor Thresholds mg/m³ | Odor Thresholds ppm | Type of Threshold | Geometric Mean Air Odor Threshold (ppm) | Geometric Mean Air Odor Type of Threshold | Odor Characteristic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 110543 | Hexane<br>n-Hexane | $C_6H_{14}$ | 86.17 | Unreviewed Sources | | | | | None | | Faint gasoline |
| | | | | Patty and Yant (1929) | C4 | 875 | 248 | ng | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Laffort and Dravnieks (1973) | B | 230 | 65 | ng | | | |
| 302012 | Hydrazine | $N_2H_4$ | 32.05 | Unreviewed Sources | | | | | 3.7 | d | Ammonia |
| | | | | No C-E Codes | . | . | . | . | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Jacobson et al. (1955) | A | 3.9-5.2 | 3.0-4.0 | ng | | | |
| | | | | Jacobson et al. (1958) | A | 5.2 | 4 | ng | | | |
| 7647010 | Hydrogen Chloride<br>Hydrochloric Acid | HCl | 36.47 | Unreviewed Sources | | | | | None | | Sharp/ suffocating, irritating |
| | | | | Schley (1934) | E2 | 4.5 | 3.02 | ng | | | |
| | | | | Heyroth (1963) | C1 | 1.5-7.5 | 1.01-5.03 | d | | | |
| | | | | Styazhkin (1963) | E2 | 0.2 | 0.134 | ng | | | |
| | | | | Takhirov (1974) | E1 | 0.38 | 0.255 | ng | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Melekhina (1968) | B2 | 0.39 | 0.262 | d | | | |
| | | | | Leonardos et al. (1969) | B | 15 | 10.06 | r | | | |
| 7664393 | Hydrogen Fluoride<br>Hydrofluoric Acid | HF | 20.01 | Unreviewed Sources | | | | | None | | |
| | | | | No C-E Codes | . | . | . | . | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Sadilova (1968) | B2 | 0.03 | 0.04 | ng | | | |
| 123319 | Hydroquinone | $C_6H_6O_2$ | 110.1 | No Sources Found | | | | | | | |
| 78591 | Isophorone<br>3,5,5-Trimethyl-2-cyclohexenone | $C_9H_{14}O$ | 138.2 | Unreviewed Sources | | | | | 0.19 | d | Sharp |
| | | | | No C-E Codes | . | . | . | . | 0.53 | r | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Hellman and Small (1974) | A | 1.1 | 0.19 | d | | | |
| | | | | Hellman and Small (1974) | A | 3 | 0.53 | r | | | |

# TABLE 2-1 (cont'd). REPORTED ODOR THRESHOLDS FROM ALL SOURCES

| CAS # | Compound Name Synonyms | Formula | M.W. | Source | Code | Odor Thresholds mg/m³ | Odor Thresholds ppm | Type of Threshold | Geometric Mean Air Odor Threshold (ppm) | Geometric Mean Air Odor Type of Threshold | Odor Characteristic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 58899 | Lindane (all isomers) | $C_6H_6Cl_6$ | 290.8 | No Sources Found | | | | | | | |
| 108316 | Maleic Anhydride 2,5-Furandione | $C_4H_2O_3$ | 98.06 | Unreviewed Sources | | | | | None | | Acrid, faint |
| | | | | No C-E Codes | • | • | • | • | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Grigor'eva (1984) | B2 | 1.0-1.3 | 0.25-0.32 | ng | | | |
| 67561 | Methyl Alcohol Methanol | $CH_4O$ | 32.04 | Unreviewed Sources | | | | | 160 | d | Sour/sweet |
| | | | | Passy (1892) | D5 | 1,000 | 764 | d | 690 | r | |
| | | | | Zwaardemaker (1914) | E2 | 600 | 458 | d | | | |
| | | | | Backman (1917) | E1 | 900-1,000 | 687-763 | r | | | |
| | | | | Grijns (1919) | E2 | 2,150 | 1,641 | ng | | | |
| | | | | Jung (1936) | E2 | 23.4-54.6 | 17.9-41.7 | d | | | |
| | | | | Jung (1936) | E2 | 54.6-62.4 | 41.7-47.7 | r | | | |
| | | | | Gavaudan et al. (1948) | E2 | 150 | 114 | ng | | | |
| | | | | Janicek et al. (1960) | E1 | 4,000 | 3,053 | ng | | | |
| | | | | Anonymous (1980) | D3 | 74 | 56 | d | | | |
| | | | | Anonymous (1980) | D3 | 260 | 198 | r | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Mullins (1955) | B5 | 19,300 | 14,729 | r | | | |
| | | | | Scherberger et al. (1958) | B | 1,950 | 1,490 | r | | | |
| | | | | Chao-Chen-Tzi (1959) | B2 | 4.3 | 3.3 | ng | | | |
| | | | | Pliska and Janicek (1965) | B | 260,000 | 198,416 | ng | | | |
| | | | | May (1966) | A | 7,800 | 5,950 | d | | | |
| | | | | May (1966) | A | 11,700 | 8,930 | r | | | |
| | | | | Ubaidullaev (1966) | B2 | 4.5 | 3.4 | ng | | | |
| | | | | Leonardos et al. (1969) | B | 130 | 99 | r | | | |
| | | | | Hellman and Small (1974) | A | 5.5 | 1.2 | d | | | |
| | | | | Hellman and Small (1974) | A | 69 | 53 | r | | | |

# TABLE 2-1 (cont'd). REPORTED ODOR THRESHOLDS FROM ALL SOURCES

| CAS # | Compound Name Synonyms | Formula | M.W. | Source | Code | Odor Thresholds mg/m$^3$ | Odor Thresholds ppm | Type of Threshold | Geometric Mean Air Odor Threshold (ppm) | Geometric Mean Air Odor Type of Threshold | Odor Characteristic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 72435 | Methoxychlor | $C_{16}H_{15}Cl_3O_2$ | 345.7 | No Sources Found | | | | | | | Slightly fruity |
| 74839 | Methyl Bromide | $CH_3Br$ | 94.94 | No Sources Found | | | | | | | Relatively |
| | Bromomethane | | | | | | | | | | odorless, |
| | | | | | | | | | | | sweet, chloroform |
| 74873 | Methyl Chloride | $CH_3Cl$ | 50.49 | Unreviewed Sources | | | | | None | | Sweet/etherish |
| | Chloromethane | | | No C-E Codes | . | . | . | . | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Leonardos et al. | | | | | | | |
| | | | | (1969) | B | >21 | >10 | r | | | |
| 71556 | Methyl Chloroform | $C_2H_3Cl_3$ | 133.4 | Unreviewed Sources | | | | | 385 | d | Sweet/etherish |
| | 1,1,1-Trichloroethane | | | Kendall et al. (1968) | E2 | 88 | 16 | r | 715 | r | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Scherberger et al. | | | | | | | |
| | | | | (1958) | B | 1,650 | 302 | r | | | |
| | | | | May (1966) | A | 2,100 | 385 | d | | | |
| | | | | May (1966) | A | 3,900 | 715 | r | | | |
| 78933 | Methyl Ethyl Ketone | $C_4H_8O$ | 72.1 | Unreviewed Sources | | | | | 17* | d | Sweet/sharp, |
| | 2-Butanone | | | Backman (1917) | E1 | 63-70 | 21-24 | r | 17 | r | acetone |
| | MEK | | | Anonymous (1980) | D3 | 8.4 | 2.8 | d | | | |
| | | | | Anonymous (1980) | D3 | 29 | 9.8 | r | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | May (1966) | A | 80 | 27 | d | | | |
| | | | | May (1966) | A | 163 | 55 | r | | | |
| | | | | Leonardos et al. | | | | | | | |
| | | | | (1969) | B | 29 | 9.8 | r | | | |
| | | | | Mukhitov and | | | | | | | |
| | | | | Azimbekov (1972) | B5 | 0.75 | 0.25 | ng | | | |
| | | | | Dravnieks (1974) | A | 250 | 85 | d | | | |
| | | | | Hellman and Small | | | | | | | |
| | | | | (1974) | A | 5.8 | 2 | d | | | |
| | | | | Hellman and Small | | | | | | | |
| | | | | (1974) | A | 16 | 5.4 | r | | | |
| | | | | Hartung et al. (1971) | B5 | 7 | 2.4 | ng | | | |

## TABLE 2-1 (cont'd). REPORTED ODOR THRESHOLDS FROM ALL SOURCES

| CAS # | Compound Name Synonyms | Formula | M.W. | Source | Code | Odor Thresholds mg/m³ | Odor Thresholds ppm | Type of Threshold | Geometric Mean Air Odor Threshold (ppm) | Geometric Mean Air Odor Type of Threshold | Odor Characteristic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 60344 | Methyl Hydrazine | $CH_6N_2$ | 46.07 | Unreviewed Sources | | | | | 1.73 | | Like ammonia |
| | | | | No C-E Codes | - | - | - | - | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Jacobson et al. (1955) | A | 1.9-5.7 | 1.0-3.0 | ng | | | |
| 74884 | Methyl Iodide<br>Iodomethane | $CH_3I$ | 141.9 | No Sources Found | | | | | | | |
| 108101 | Methyl Isobutyl Ketone<br>Hexone<br>MIBK<br>4-Methyl-2-pentanone | $C_6H_{12}O$ | 100.2 | Unreviewed Sources | | | | | 0.88 | d | Sweet/sharp, |
| | | | | Backman (1917) | E1 | 0.6-0.8 | 0.15-2.0 | r | 2.1 | r | pleasant |
| | | | | Anonymous (1980) | D3 | 0.7 | 0.17 | d | | | |
| | | | | Anonymous (1980) | D3 | 2.8 | 0.69 | r | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | May (1966) | A | 32 | 7.8 | d | | | |
| | | | | May (1966) | A | 64 | 16 | r | | | |
| | | | | Stone et al. (1967) | B | 0.97-9.7 | 0.24-2.4 | d | | | |
| | | | | Steinmetz et al. (1969) | B | 1.21 | 0.3 | d | | | |
| | | | | Leonardos et al. (1969) | B | 1.9 | 0.46 | r | | | |
| | | | | Hellman and Small (1974) | A | 0.4 | 0.1 | d | | | |
| | | | | Hellman and Small (1974) | A | 1.1 | 0.27 | r | | | |
| 624839 | Methyl Isocyanate<br>Isocyanic Acid-Methyl Ester<br>MIC | $C_2H_3NO$ | 57.05 | Unreviewed Sources | | | | | None | | |
| | | | | Kimmerle and Eben (1964) | C4 | 5 | 2.1 | ng | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | No A or B Codes | - | - | - | - | | | |

# TABLE 2-1 (cont'd). REPORTED ODOR THRESHOLDS FROM ALL SOURCES

| CAS # | Compound Name Synonyms | Formula | M.W. | Source | Code | Odor Thresholds mg/m³ | Odor Thresholds ppm | Type of Threshold | Geometric Mean Air Odor Threshold (ppm) | Geometric Mean Air Odor Type of Threshold | Odor Characteristic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 80626 | Methyl Methacrylate | $C_5H_8O_2$ | 100.1 | Unreviewed Sources | | | | | 0.049 | d | Plastic/sharp |
| | Methyl 2-methyl-2-propenoate | | | Holland (1974) | D2 | 0.057 | 0.014 | ng | 0.34 | r | |
| | | | | Anonymous (1980) | D3 | 0.62 | 0.15 | d | | | |
| | | | | Anonymous (1980) | D3 | 1.9 | 0.46 | r | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Filatova (1962) | B2 | 0.2 | 0.049 | ng | | | |
| | | | | Leonardos et al. (1969) | B | 0.85 | 0.21 | r | | | |
| | | | | Hellman and Small (1973, 1974) | A | 0.2 | 0.049 | d | | | |
| | | | | Hellman and Small (1973, 1974) | A | 1.4 | 0.34 | r | | | |
| 1634044 | Methyl Tert Butyl Ether | $(CH_3)_3COCH_3$ | 88.15 | No Sources Found | | | | | | | |
| 101144 | 4,4-Methylene bis(2-Chloroaniline) | $C_{13}H_{14}Cl_2N_2$ | 269.2 | No Sources Found | | | | | | | |
| 75092 | Methylene Chloride | $CH_2Cl_2$ | 84.94 | Unreviewed Sources | | | | | 144 | d | Sweet/ |
| | Dichloromethane | | | Lehmann and Schmidt-Kehl (1936) | E1 | 1,100 | 317 | ng | 227 | r | ethereal, penetrating |
| | | | | Basmadshijewa et al. (1970) | E2 | 4.1-33.2 | 1.2-9.6 | d | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Scherberger et al. (1958) | B | 1,530 | 440 | r | | | |
| | | | | May (1966) | A | 500 | 144 | d | | | |
| | | | | May (1966) | A | 790 | 227 | r | | | |
| | | | | Leonardos et al. (1969) | B | 730 | 210 | r | | | |
| 101688 | Methylene Bisphenyl Isocyanate | $C_{15}H_{10}O_2N_2$ | 250 | Unreviewed Sources | | | | | None | | |
| | Diphenylmethane 4,4-Diisocyanate | | | Woolrich (1982) | C1 | 4 | 0.39 | ng | | | |
| | Methylene Diphenyl Diisocyanate | | | Critiqued Sources | | | | | | | |
| | MDI | | | No A or B Codes | - | - | - | - | | | |
| 101779 | 4,4-Methylenedianiline | $C_{13}H_{14}N_2$ | 198.3 | No Sources Found | | | | | | | |
| | para,para'-Diaminodiphenylmethane | | | | | | | | | | |

# TABLE 2-1 (cont'd). REPORTED ODOR THRESHOLDS FROM ALL SOURCES

| CAS # | Compound Name Synonyms | Formula | M.W. | Source | Code | Odor Thresholds mg/m³ | ppm | Type of Threshold | Geometric Mean Air Odor Threshold (ppm) | Geometric Mean Air Odor Type of Threshold | Odor Characteristic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 91203 | Naphthalene | $C_{10}H_8$ | 128.2 | Unreviewed Sources | | | | | 0.038 | d | Tar/cresote/ mothballs |
| | | | | Backman (1917) | E1 | 0.05-0.055 | 0.0095-0.0105 | r | | | |
| | | | | Mitsumoto (1926) | E1 | 4.0-4.4 | 0.76-0.84 | r | | | |
| | | | | Morimura (1934) | E1 | 3.37-5.34 | 0.64-1.02 | r | | | |
| | | | | Robbins (1951) | C3 | <1.6 | 0.31 | ng | | | |
| | | | | Critiqued Sources | | | 0.038 | | | | |
| | | | | Punter (1980) | A | 0.2 | | d | | | |
| 98953 | Nitrobenzene | $C_6H_5NO_2$ | 123.1 | Unreviewed Sources | | | | | 1.9 | ng | Almonds/shoe polish |
| | | | | Hermanides (1909) | E2 | 0.0412 | 0.0082 | r | | | |
| | | | | Zwaardemaker (1914) | E2 | 0.041 | 0.0082 | d | | | |
| | | | | Backman (1917) | E1 | 0.34-7.0 | 0.068-0.14 | r | | | |
| | | | | Henning (1924) | C1 | 0.0065 | 0.0013 | d | | | |
| | | | | Van Anrooji (1931) | E2 | 0.019 | 0.0038 | d | | | |
| | | | | Janicek et al. (1960) | E1 | 19 | 3.78 | ng | | | |
| | | | | Gavaudan and Poussel (1966) | E1 | 0.15 | 0.03 | ng | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Allison and Katz (1919) | B5 | 146 | 29 | ng | | | |
| | | | | Katz and Talbert (1930) | A | 9.6 | 1.9 | ng | | | |
| | | | | Andreeshcheva (1964) | B2 | 0.0182 | 0.0036 | ng | | | |
| | | | | Leonardos et al. (1969) | B | 0.024 | 0.0048 | r | | | |
| | | | | Randebrock (1971) | B5 | 0.002 | 0.0004 | ng | | | |
| 92933 | 4-Nitrobiphenyl | $C_{12}H_9NO_2$ | 199.2 | No Sources Found | | | | | | | |
| 100027 | 4-Nitrophenol | $C_6H_5NO_3$ | 139.1 | Unreviewed Sources | | | | | None | | |
| | | | | Stuiver (1958) | E2 | 2.3 | 0.4 | d | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | No A or B Codes | - | - | - | - | | | |

# TABLE 2-1 (cont'd). REPORTED ODOR THRESHOLDS FROM ALL SOURCES

| CAS # | Compound Name Synonyms | Formula | M.W. | Source | Code | Odor Thresholds mg/m³ | Odor Thresholds ppm | Type of Threshold | Geometric Mean Air Odor Threshold (ppm) | Geometric Mean Air Odor Type of Threshold | Odor Characteristic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 79469 | 2-Nitropropane | $C_3H_7NO_2$ | 89.09 | Unreviewed Sources | | | | | None | | Sweet, slight |
| | beta-Nitropropane | | | Treon and Dutra | | | | | | | |
| | Dimethylnitromethane | | | (1952) | C1 | 297-1,050 | 82-288 | ng | | | |
| | Isonitropropane | | | Hine et al. (1978) | C1 | 580 | 159 | r | | | |
| | Nitroisopropane | | | Critiqued Sources | | | | | | | |
| | | | | No A or B Codes | - | - | - | - | | | |
| 684935 | N-Nitroso-N-methylurea | $H_2NCON(NO)CH_3$ | 103.1 | No Sources Found | | | | | | | |
| 62759 | N-Nitrosodimethyl Amine | $C_2H_6N_2O$ | 74.08 | Unreviewed Sources | | | | | None | | |
| | N-Methyl-N-Nitrosomethanamine | | | No C-E Codes | - | - | - | - | | | |
| | Dimethyl Nitrosamine | | | Critiqued Sources | | | | | | | |
| | DMN | | | Prusakov et al. | | | | | | | |
| | DMNA | | | (1976) | B2 | 0.024-0.04 | 0.0079-0.013 | ng | | | |
| 59892 | N-Nitrosomorpholine | | | No Sources Found | | | | | | | |
| 56382 | Parathion | $C_{10}H_{14}O_5PSN$ | 291.3 | No Sources Found | | | | | | | Faint |
| | Ethyl Parathion | | | | | | | | | | |
| 82688 | Pentachloronitrobenzene | $C_6Cl_5NO_2$ | 295.3 | No Sources Found | | | | | | | Very weak/musty |
| | Quintobenzene | | | | | | | | | | |
| 87865 | Pentachlorophenol | $C_6HCl_5O$ | 266.3 | No Sources Found | | | | | | | |
| 127184 | Perchloroethylene | $C_2Cl_4$ | 165.8 | Unreviewed Sources | | | | | 47 | d | Etherish |
| | Tetrachloroethylene | | | Carpenter (1937) | C4 | <340 | <50 | ng | 71 | r | |
| | | | | Anonymous (1980) | D3 | 12 | 2 | d | | | |
| | | | | Anonymous (1980) | D3 | 55 | 8 | r | | | |
| | | | | Torkelson and Rowe | | | | | | | |
| | | | | (1981) | C1 | 340 | 50 | ng | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | May (1966) | A | 320 | 47 | d | | | |
| | | | | May (1966) | A | 480 | 71 | r | | | |
| | | | | Leonardos et al. | | | | | | | |
| | | | | (1969) | B | 32 | 5 | r | | | |

## TABLE 2-1 (cont'd). REPORTED ODOR THRESHOLDS FROM ALL SOURCES

| CAS # | Compound Name Synonyms | Formula | M.W. | Source | Code | Odor Thresholds mg/m³ | Odor Thresholds ppm | Type of Threshold | Geometric Mean Air Odor Threshold (ppm) | Geometric Mean Air Odor Type of Threshold | Odor Characteristic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 108952 | Phenol<br>Carbolic Acid;<br>Phenic Acid;<br>Phenylic Hydroxide;<br>Hydroxybenzene;<br>Oxybenzene | $C_6H_5OH$ | 94.11 | Unreviewed Sources | | | | | 0.060 | d | Medicinal/ acid/creosote |
| | | | | Grijns (1906) | E2 | 2.2-6.8 | 0.57-1.8 | ng | | | |
| | | | | Zwaardemaker (1914) | E2 | 4 | 1 | d | | | |
| | | | | Backman (1917) | E1 | 0.13-0.26 | 0.034-0.068 | r | | | |
| | | | | Henning (1924) | C1 | 1.2 | 0.31 | d | | | |
| | | | | Takhirov (1974) | E1 | 0.022 | 0.0057 | ng | | | |
| | | | | Punter (1975, 1979) | D1,D2 | 0.8 | 0.21 | d | | | |
| | | | | Makeicheva (1978) | E1 | 0.027 | 0.007 | ng | | | |
| | | | | Anonymous (1980) | D3 | 0.046 | 0.012 | d | | | |
| | | | | Anonymous (1980) | D3 | 0.22 | 0.057 | r | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Mukhitov (1962) | B2 | 0.022 | 0.0057 | ng | | | |
| | | | | Itskovich and Vinogradova (1962) | B5 | 3 | 0.78 | ng | | | |
| | | | | Pogosyan (1965) | B2 | 0.022 | 0.0057 | ng | | | |
| | | | | Korneev (1965) | B2 | 0.0172 | 0.0045 | ng | | | |
| | | | | Makhinya (1966) | B2 | 0.022 | 0.0057 | ng | | | |
| | | | | Basmadzhieva and Argirova (1968) | B2 | 0.021 | 0.0055 | ng | | | |
| | | | | Leonardos et al. (1969) | B | 0.18 | 0.047 | r | | | |
| | | | | Punter (1980) | A | 0.23 | 0.06 | d | | | |
| 106503 | p-Phenylenediamine | $C_6H_8N_2$ | 108.2 | No Sources Found | | | | | | | |
| 75445 | Phosgene<br>Carbonyl Chloride | $Cl_2CO$ | 98.92 | Unreviewed Sources | | | | | None | | Haylike |
| | | | | Fieldner et al. (1921) | C1 | 23 | 5.7 | ng | | | |
| | | | | Schley (1934) | E2 | 0.5 | 0.12 | d | | | |
| | | | | Schley (1934) | E2 | 0.5-1.0 | 0.12-0.25 | r | | | |
| | | | | Patty (1963a) | C1 | 2 | 0.49 | ng | | | |
| | | | | Suchier (1930) | C2 | 4 | 1 | ng | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Leonardos et al. (1969) | B | 4 | 1 | r | | | |

## TABLE 2-1 (cont'd). REPORTED ODOR THRESHOLDS FROM ALL SOURCES

| CAS # | Compound Name Synonyms | Formula | M.W. | Source | Code | Odor Thresholds mg/m$^3$ | Odor Thresholds ppm | Type of Threshold | Geometric Mean Air Odor Threshold (ppm) | Geometric Mean Air Odor Type of Threshold | Odor Characteristic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 7803512 | Phosphine | $PH_3$ | 34 | Unreviewed Sources | | | | | 1.0 | ng | Garlic |
| | | | | Valentin (1848) | D5 | 1.4 | 1 | ng | | | |
| | | | | Valentin (1850) | D5 | 0.13 | 0.094 | ng | | | |
| | | | | Singh et al. (1967) | C2 | 7 | 5 | d | | | |
| | | | | Berck (1968) | C2 | <2 | <1.4 | r | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Leonardos et al. (1969) | B | 0.03 | 0.022 | r | | | |
| | | | | Fluck (1976) | A | 0.014-2.8 | 0.010-2.014 | ng | | | |
| 7723140 | Phosphorus | P | 30.97 | No Sources Found | | | | | | | Practically odorless |
| 85449 | Phthalic Anhydride<br>1,3-Isobenzofurandione<br>PAN | $C_8H_4O_4$ | 166.1 | Unreviewed Sources | | | | | None | | Choking |
| | | | | No C-E Codes | - | - | - | - | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Slavgorodskiy (1968) | B2 | 0.32 | 0.053 | ng | | | |
| 1336363 | Polychlorinated Byphenyls<br>Aroclors | | | No Sources Found | | | | | | | |
| 1120714 | 1,3-Propane Sultone | | | No Sources Found | | | | | | | |
| 57578 | beta-Propiolactone | $C_3H_4O_2$ | 72.07 | No Sources Found | | | | | | | Pungent |

# TABLE 2-1 (cont'd). REPORTED ODOR THRESHOLDS FROM ALL SOURCES

| CAS # | Compound Name Synonyms | Formula | M.W. | Source | Code | Odor Thresholds mg/m³ | Odor Thresholds ppm | Type of Threshold | Geometric Mean Air Odor Threshold (ppm) | Geometric Mean Air Odor Type of Threshold | Odor Characteristic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 123386 | Propionaldehyde<br>2-Propynal | $C_3H_6O$ | 58.08 | Unreviewed Sources | | | | | 0.04 | d | Pungent, suffocating, unpleasant |
| | | | | Backman (1917) | E1 | 0.02 | 0.008 | r | 0.08 | r | |
| | | | | Knuth (1973) | D2 | 0.026 | 0.011 | ng | | | |
| | | | | Bedborough and Trout (1979) | E2 | 0.014 | 0.0058 | d | | | |
| | | | | Anonymous (1980) | D3 | 0.0036 | 0.0015 | d | | | |
| | | | | Anonymous (1980) | D3 | 0.036 | 0.015 | r | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Hartung et al. (1971) | B5 | 1.7 | 0.72 | ng | | | |
| | | | | Pliska and Janicek (1965) | B | 0.022 | 0.0093 | ng | | | |
| | | | | Teranishi et al. (1974) | B3 | 0.02 | 0.008 | ng | | | |
| | | | | Hellman and Small (1974) | A | 0.2 | 0.08 | r | | | |
| | | | | Hellman and Small (1974) | A | 0.1 | 0.04 | d | | | |
| 114261 | Propoxur (Baygon)<br>Orthoisopropoxyphenyl-N-methylcarbamate | $C_{11}H_{15}NO_3$ | 209.2 | No Sources Found | | | | | | | Odorless |
| 78875 | Propylene Dichloride<br>1,2-Dichloropropane | $C_3H_6Cl_2$ | 113 | Unreviewed Sources | | | | | 0.26 | d | Sweet/ chloroform |
| | | | | No C-E Codes | - | - | - | - | 0.52 | r | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Hellman and Small (1974) | A | 1.2 | 0.26 | d | | | |
| | | | | Hellman and Small (1974) | A | 2.4 | 0.52 | r | | | |
| 75569 | Propylene Oxide<br>Methyloxidrane<br>Propene Oxide<br>1,2-Epoxypropane | $C_3H_6O$ | 58.08 | Unreviewed Sources | | | | | 45* | d | Sweet/ethereal |
| | | | | No C-E Codes | - | - | - | - | 35 | r | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Jacobson et al. (1956) | A | 473 | 199 | ng | | | |
| | | | | Hellman and Small (1974) | A | 24 | 10 | d | | | |
| | | | | Hellman and Small (1974) | A | 84 | 35 | r | | | |

## TABLE 2-1 (cont'd). REPORTED ODOR THRESHOLDS FROM ALL SOURCES

| CAS # | Compound Name Synonyms | Formula | M.W. | Source | Code | Odor Thresholds mg/m³ | Odor Thresholds ppm | Type of Threshold | Geometric Mean Air Odor Threshold (ppm) | Geometric Mean Air Odor Type of Threshold | Odor Characteristic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 75558 | 1,2-Propyleinimine (2-Methyl Aziridine) | $C_3H_7N$ | 57.1 | No Sources Found | | | | | | | Strong, ammonia-like |
| 91225 | Quinoline | $C_9H_7N$ | 129.2 | Unreviewed Sources | . | | | | 5.3 | d | Unpleasant/ peculiar |
| | | | | Geier (1936) | E2 | 0.03 | 0.0057 | d | | | |
| | | | | Geier (1936) | E2 | 0.05-0.1 | 0.009-0.189 | r | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Gundlach and Kenway (1939) | A \ | 28 | 5.3 | d | | | |
| 106514 | Quinone | $C_6H_4O_2$ | 108.1 | Unreviewed Sources | | | | | None | | Irritating |
| | 1,4-Benzoquinone | | | Backman (1917) | E1 | 0.047-0.05 | 0.0106-0.0113 | r | | | |
| | | | | Oglesby et al. (1947) | C3 | 0.44 | 0.1 | ng | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | No A or B Codes | . | . | . | . | | | |
| 100425 | Styrene, Monomer | $(C_8H_8)n$ | 104.1 | Unreviewed Sources | | | | | 0.15* | d | Sharp/sweet/ |
| | Phenyl Ethylene | | | Wolf et al. (1956) | E2 | 43-258 | 10-61 | ng | 0.15 | r | aromatic, |
| | Polystyrene | | | Deadman and Prigg (1959) | E2 | 0.11 | 0.026 | d | | | unpleasant |
| | Vinyl Benzene | | | Anonymous (1980) | D3 | 0.14 | 0.033 | d | | | |
| | Cinnamene | | | Anonymous (1980) | D3 | 0.73 | 0.17 | r | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Li-Shen (1961) | B2 | 0.02 | 0.0047 | ng | | | |
| | | | | Stalker (1963) | A | 0.073 | 0.017 | d | | | |
| | | | | Muehlen (1968) | B | 4.3 | 1 | r | | | |
| | | | | Leonardos et al. (1969) | B | 0.2-0.4 | 0.047-0.094 | r | | | |
| | | | | Smith and Hochstettler (1969) | B | 0.2 | 0.047 | r | | | |
| | | | | Hellman and Small (1973, 1974) | A | 0.22-0.64 | 0.052-0.15 | d | | | |
| | | | | Hellman and Small (1973, 1974) | A | 0.64 | 0.15 | r | | | |
| | | | | Dravnieks (1974) | A | 8 | 1.9 | d | | | |

# TABLE 2-1 (cont'd). REPORTED ODOR THRESHOLDS FROM ALL SOURCES

| CAS # | Compound Name Synonyms | Formula | M.W. | Source | Code | Odor Thresholds mg/m³ | Odor Thresholds ppm | Type of Threshold | Geometric Mean Air Odor Threshold (ppm) | Geometric Mean Air Odor Type of Threshold | Odor Characteristic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 98093 | Styrene Oxide | $C_8H_8O$ | 120.2 | Unreviewed Sources | | | | | 0.081 | d | Sweet/pleasant |
| | 1-Phenyl-1,2-Epoxyethane | | | No C-E Codes | - | - | - | - | 0.4 | r | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Hellman and Small (1974) | A | 0.3 | 0.081 | d | | | |
| | | | | Hellman and Small (1974) | A | 2 | 0.4 | r | | | |
| 1746016 | 2,3,7,8-Tetrachlorodibenzo-p-dioxin<br>Dioxin | | | No Sources Found | | | | | | | |
| 79345 | 1,1,2,2-Tetrachloroethane<br>Acetylene Tetrachloride<br>sym-Tetrachlorethane | $C_2H_2Cl_4$ | 167.9 | Unreviewed Sources | | | | | 7.3 | d | Solvent |
| | | | | Lehmann and Schmidt-Kehl (1936) | E1 | 20 | 2.9 | ng | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Dravnieks (1974) | A | 50 | 7.3 | d | | | |
| 7550450 | Titanium Tetrachloride | $TiCl_4$ | 189.7 | No Sources Found | | | | | | | Acrid, choking |

# TABLE 2-1 (cont'd). REPORTED ODOR THRESHOLDS FROM ALL SOURCES

| CAS # | Compound Name Synonyms | Formula | M.W. | Source | Code | Odor Thresholds mg/m³ | Odor Thresholds ppm | Type of Threshold | Geometric Mean Air Odor Threshold (ppm) | Geometric Mean Air Odor Type of Threshold | Odor Characteristic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 108883 | Toluene | $C_7H_8$ | 92.13 | Unreviewed Sources | | | | | 2.8 | d | Sour/burnt, |
| | Toluol; | | | Backman (1917) | E1 | 3.5-3.6 | 0.93-0.96 | r | 7.6 | r | benzene-like |
| | Methylbenzene; | | | Backman (1918) | E2 | 2 | 0.53 | ng | | | |
| | Phenylmethane | | | Grijns (1919) | E2 | 170 | 45 | ng | | | |
| | | | | Schley (1934) | E2 | 6 | 1.6 | d | | | |
| | | | | Schley (1934) | E2 | 16 | 4.2 | r | | | |
| | | | | Deadman and Prigg (1959) | E2 | 5.5 | 1.5 | d | | | |
| | | | | Koster (1971) | E2 | 13.7 | 3.6 | d | | | |
| | | | | Naus (1962) | C1 | 2 | 0.53 | d | | | |
| | | | | Winneke and Kastka (1975) | E2 | 46-84 | 12-22 | ng | | | |
| | | | | Anonymous (1980) | D3 | 3.5 | 0.93 | d | | | |
| | | | | Anonymous (1980) | D3 | 18 | 4.8 | r | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Nader (1958) | A | 0.08-1.9 | 0.021-0.50 | ng | | | |
| | | | | Stalker (1963) | A | 1 | 0.27 | d | | | |
| | | | | Gusev (1965) | B2 | 1.5-3.2 | 0.40-0.85 | ng | | | |
| | | | | May (1966) | A | 140 | 37 | d | | | |
| | | | | May (1966) | A | 260 | 69 | r | | | |
| | | | | Leonardos et al. (1969) | B | 8.1-17.8 | 2.1-4.7 | r | | | |
| | | | | Dravnieks and O'Donnell (1971) | B5 | 45 | 12 | ng | | | |
| | | | | Hellman and Small (1973, 1974) | A | 0.6 | 0.16 | d | | | |
| | | | | Hellman and Small (1973, 1974) | A | 7 | 1.9 | r | | | |
| | | | | Dravnieks (1974) | A | 60 | 16 | d | | | |
| | | | | Punter (1980) | A | 25.4 | 6.7 | d | | | |
| 95807 | 2,4-Toluene Diamine | $C_7H_{10}N_2$ | 122.2 | No Sources Found | | | | | | | |

## TABLE 2-1 (cont'd). REPORTED ODOR THRESHOLDS FROM ALL SOURCES

| CAS # | Compound Name Synonyms | Formula | M.W. | Source | Code | Odor Thresholds mg/m³ | Odor Thresholds ppm | Type of Threshold | Geometric Mean Air Odor Threshold (ppm) | Geometric Mean Air Odor Type of Threshold | Odor Characteristic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 584849 | 2,4-Toluene Diisocyanate | $C_9H_6N_2O_2$ | 174.2 | Unreviewed Sources | | | | | None | | Sharp/pungent |
| | Tolylene Diisocyanate | | | Zapp (1957) | C1 | 2.8 | 0.4 | ng | | | |
| | 2,4-Diisocyanato-1-methylbenzene | | | Henschler et al. (1962) | C3 | 0.14-0.35 | 0.020-0.050 | ng | | | |
| | | | | Chizhikov (1963) | E1 | 0.2 | 0.03 | ng | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Leonardos et al. (1969) | B | 15 | 2.11 | r | | | |
| 95534 | o-Toluidine | $C_7H_9N$ | 107.2 | Unreviewed Sources | | | | | None | | |
| | 2-Methylbenzenamine; | | | Huijer (1917) | E2 | 29 | 6.6 | d | | | |
| | 1-Amino-2-methylbenzene; | | | Backman (1917) | E1 | 4.0-5.4 | 0.91-1.23 | r | | | |
| | 2-Methylaniline; | | | Stuiver (1958) | E2 | 0.11 | 0.025 | d | | | |
| | 2-Aminotoluene | | | Critiqued Sources | | | | | | | |
| | | | | No A or B Codes | - | - | - | - | | | |
| 8001352 | Toxaphene | $C_{10}H_{10}Cl_8$ | 413.8 | No Sources Found | | | | | | | Mild, chlorine, camphor |
| | Chlorinated Camphene | | | | | | | | | | |
| 120821 | 1,2,4-Trichlorobenzene | $C_6H_3Cl_3$ | 181.5 | Unreviewed Sources | | | | | None | | Aromatic |
| | | | | Rowe (1975) | D2 | 22 | 2.96 | ng | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | No A or B Codes | - | - | - | - | | | |
| 79005 | 1,1,2-Trichloroethane | $C_2H_3Cl_3$ | 133.4 | No Sources Found | | | | | | | Chloroform-like, sweet |

## TABLE 2-1 (cont'd). REPORTED ODOR THRESHOLDS FROM ALL SOURCES

| CAS # | Compound Name Synonyms | Formula | M.W. | Source | Code | Odor Thresholds mg/m³ | Odor Thresholds ppm | Type of Threshold | Geometric Mean Air Odor Threshold (ppm) | Geometric Mean Air Odor Type of Threshold | Odor Characteristic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 79016 | Trichloroethylene | $C_2HCl_3$ | 131.4 | Unreviewed Sources | | | | | 82 | d | Ether/solvent, |
| | 1,1,2-Trichloroethylene; | | | Lehmann and | | | | | 108 | r | chloroform |
| | TCE; | | | Schmidt-Kehl (1936) | E1 | 900 | 167 | ng | | | |
| | Trichloroethene | | | Weitbrecht (1957) | C1 | 110 | 20 | ng | | | |
| | | | | Frantikova (1962) | E2 | 69 | 13 | ng | | | |
| | | | | Naus (1962) | C1 | 3 | 0.56 | d | | | |
| | | | | Torkelson and Rowe (1981) | C1 | 538 | 100 | ng | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Scherberger et al. (1958) | B | 410 | 76 | r | | | |
| | | | | May (1966) | A | 440 | 82 | d | | | |
| | | | | May (1966) | A | 580 | 108 | r | | | |
| | | | | Malyarova (1967) | B5 | 2.5-21 | 0.5-4.0 | ng | | | |
| | | | | Leonardos et al. (1969) | B | 115 | 21 | r | | | |
| 95954 | 2,4,5-Trichlorophenol | $C_6H_3Cl_3O$ | 197.5 | No Sources Found | | | | | | | Strong disinfectant |
| 88062 | 2,4,6-Trichlorophenol | $C_6H_3Cl_3O$ | 197.5 | Unreviewed Sources | | | | | 0.00002 | d | Strong |
| | | | | Backman (1917) | E1 | 0.0010-0.0016 | 0.0001-0.0002 | r | | | disinfectant |
| | | | | Kendall et al. (1968) | E2 | 0.021 | 0.0026 | r | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Punter (1980) | A | 0.00016 | 0.00002 | d | | | |
| 121448 | Triethylamine | $C_6H_{15}N$ | 101.2 | Unreviewed Sources | | | | | <0.10 | d | Fishy/ammonia |
| | | | | No C-E Codes | - | - | - | - | 0.88 | r | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Tkachev (1970) | B5 | 0.33 | 0.08 | ng | | | |
| | | | | Hellman and Small (1974) | A | <0.4 | <0.10 | d | | | |
| | | | | Hellman and Small (1974) | A | 1.1 | 0.27 | r | | | |
| | | | | Laing et al. (1978) | A | 11.9 | 2.9 | r | | | |
| | | | | Homans et al. (1978) | A | 2.7 | 0.65 | ng | | | |

## TABLE 2-1 (cont'd). REPORTED ODOR THRESHOLDS FROM ALL SOURCES

| CAS # | Compound Name Synonyms | Formula | M.W. | Source | Code | Odor Thresholds mg/m³ | Odor Thresholds ppm | Type of Threshold | Geometric Mean Air Odor Threshold (ppm) | Geometric Mean Air Odor Type of Threshold | Odor Characteristic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1582098 | Trifluralin | $C_{13}H_{16}N_3O_4F_3$ | 335.3 | No Sources Found | | | | | | | |
| 540841 | 2,2,4-Trimethylpentane<br>Isooctane | $C_8H_{18}$ | 114.2 | No Sources Found | | | | | | | |
| 108054 | Vinyl Acetate | $C_4H_6O_2$ | 86.09 | Unreviewed Sources | | | | | 0.11 | d | Sour/sharp |
| | | | | | | | | | 0.4 | r | |
| | | | | Deese and Joyner (1969) | C4 | <1.4 | <0.40 | r | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Gofmekler (1960) | B2 | 1 | 0.28 | ng | | | |
| | | | | Hellman and Small (1973, 1974) | A | 0.4 | 0.11 | d | | | |
| | | | | Hellman and Small (1973, 1974) | A | 1.4 | 0.4 | r | | | |
| 593602 | Vinyl Bromide | $C_2H_3Br$ | 107 | No Sources Found | | | | | | | |
| 75014 | Vinyl Chloride<br>Chloroethylene<br>Chloroethene | $C_2H_3Cl$ | 62.5 | Unreviewed Sources | | | | | None | | Sweet/ethereal |
| | | | | No C-E Codes | - | - | - | - | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Hori et al. (1972) | B | 26-52 | 10-20 | ng | | | |
| 75354 | Vinylidene Chloride<br>1,1-Dichloroethylene | $C_2H_2Cl_2$ | 96.94 | Unreviewed Sources | | | | | None | | |
| | | | | Janicek et al. (1960) | E1 | 5,500 | 1,390 | ng | | | |
| | | | | Irish (1963) | C1 | 2,000-4,000 | 504-1,009 | ng | | | |
| | | | | Dalla Valle and Dudley (1939) | E2 | 4.3 | 1.08 | d | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | No A or B Codes | - | - | - | - | | | |
| 1330207 | Xylene (Dimethylbenzene)<br>See o-Xylene<br>See m-Xylene<br>See p-Xylene | $C_8H_{10}$ | 106.2 | | | | | | | | Sweet |

## TABLE 2-1 (cont'd). REPORTED ODOR THRESHOLDS FROM ALL SOURCES

| CAS # | Compound Name Synonyms | Formula | M.W. | Source | Code | Odor Thresholds mg/m³ | Odor Thresholds ppm | Type of Threshold | Geometric Mean Air Odor Threshold (ppm) | Geometric Mean Air Odor Type of Threshold | Odor Characteristic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 95476 | o-Xylene | $C_8H_{10}$ | 106.2 | Unreviewed Sources | | | | | 5.4 | d | |
| | 1,2-Dimethylbenzene | | | Backman (1917) | E1 | 1.0-1.2 | 0.23-0.28 | r | | | |
| | | | | Backman (1918) | E2 | 0.8 | 0.18 | ng | | | |
| | | | | Stuiver (1958) | E2 | 2.1 | 0.48 | d | | | |
| | | | | Koster (1971) | E2 | 11 | 2.5 | d | | | |
| | | | | Naus (1962) | C1 | 1 | 0.23 | d | | | |
| | | | | Anonymous (1980) | D3 | 0.77 | 0.18 | d | | | |
| | | | | Anonymous (1980) | D3 | 3.1 | 0.71 | r | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Punter (1980) | A | 23.6 | 5.4 | d | | | |
| 108383 | m-Xylene | $C_8H_{10}$ | 106.2 | Unreviewed Sources | | | | | 0.73 | d | |
| | 1,3-Dimethylbenzene | | | Backman (1917) | E1 | 1.1-1.3 | 0.25-0.30 | r | | | |
| | | | | Stuiver (1958) | E2 | 0.35 | 0.081 | d | | | |
| | | | | Koster (1971) | E2 | 0.7-86 | 0.16-20 | d | | | |
| | | | | Anonymous (1980) | D3 | 0.52 | 0.12 | d | | | |
| | | | | Anonymous (1980) | D3 | 2.4 | 0.55 | r | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Gusev (1965) | B2 | 0.6-1.9 | 0.14-0.44 | ng | | | |
| | | | | Dravnieks and O'Donnell (1971) | B5 | 1.3 | 0.3 | ng | | | |
| | | | | Punter (1980) | A | 1.5-4.9 | 0.35-1.1 | d | | | |
| 106423 | p-Xylene | $C_8H_{10}$ | 106.2 | Unreviewed Sources | | | | | 2.1 | d | |
| | 1,4-Dimethylbenzene | | | Backman (1917) | E1 | 1.4-1.5 | 0.32-0.35 | r | | | |
| | | | | Stuiver (1958) | E2 | 0.6 | 0.14 | d | | | |
| | | | | Koster (1971) | E2 | 8 | 1.8 | d | | | |
| | | | | Knuth (1973) | D2 | 0.8 | 0.18 | ng | | | |
| | | | | Anonymous (1980) | D3 | 0.52 | 0.12 | d | | | |
| | | | | Anonymous (1980) | D3 | 2.2 | 0.51 | r | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Leonardos et al. (1969) | B | 2 | 0.46 | r | | | |
| | | | | Punter (1980) | A | 9.1 | 2.1 | d | | | |
| 0 | Antimony Compounds | | | No Sources Found | | | | | | | |

## TABLE 2-1 (cont'd). REPORTED ODOR THRESHOLDS FROM ALL SOURCES

| CAS # | Compound Name Synonyms | Formula | M.W. | Source | Code | Odor Thresholds mg/m³ | Odor Thresholds ppm | Type of Threshold | Geometric Mean Air Odor Threshold (ppm) | Geometric Mean Air Odor Type of Threshold | Odor Characteristic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | Arsenic Compounds (inorganic including arsine) | | | | | | | | | | |
| | Arsine | $AsH_3$ | 77.95 | Unreviewed Sources | | | | | None | | |
| | Arsenic Hydride | | | Patty (1983b) | C1 | <3.2 | <1 | ng | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | No A or B Codes | . | . | . | . | | | |
| | Diphenylcyanarsine | | | Unreviewed Sources | | | | | None | | |
| | | | | Flury (1921) | C4 | <0.005 | | ng | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | No A or B Codes | . | . | . | . | | | |
| | Ethyldichloroarsine | $C_2H_5AsCl_2$ | 174.9 | Unreviewed Sources | | | | | None | | Fruity |
| | | | | Flury (1921) | C4 | 0.17-0.85 | 0.024-0.12 | ng | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | No A or B Codes | . | . | . | . | | | |
| 0 | Beryllium Compounds | | | No Sources Found | | | | | | | |
| 0 | Cadmium Compounds | | | No Sources Found | | | | | | | |
| 0 | Chromium Compounds | | | No Sources Found | | | | | | | |
| 0 | Cobalt Compounds | | | No Sources Found | | | | | | | |
| 0 | Coke Oven Emissions | | | No Sources Found | | | | | | | |
| | See Polycyclic Organic Matter | | | | | | | | | | |
| | See Benzene | | | | | | | | | | |
| | See Toluene | | | | | | | | | | |

## TABLE 2-1 (cont'd). REPORTED ODOR THRESHOLDS FROM ALL SOURCES

| CAS # | Compound Name Synonyms | Formula | M.W. | Source | Code | Odor Thresholds mg/m³ | Odor Thresholds ppm | Type of Threshold | Geometric Mean Air Odor Threshold (ppm) | Geometric Mean Air Odor Type of Threshold | Odor Characteristic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | Cyanide Compounds | | | | | | | | | | |
| | Methyl Isocyanide | | | Unreviewed Sources | | | | | None | | |
| | Methylcarbyamine | | | Pozlomek et al. | | | | | | | |
| | | | | (1971) | C1 | 0.0006-0.006 | | r | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Stone and Pryor | | | | | | | |
| | | | | (1967) | B | 0.0069-0.0127 | | d | | | |
| | | | | Stone and Pryor | | | | | | | |
| | | | | (1967) | B | 0.069 | | r | | | |
| | Hydrogen Cyanide | HCN | 27 | Unreviewed Sources | | | | | None | | Faint, bitter almonds |
| | | | | Fieldner et al. | | | | | | | |
| | | | | (1921) | E2 | 1 | 0.091 | d | | | |
| | See Acetonitrile | | | | | | | | | | |
| | Methyl Cyanide | | | | | | | | | | |
| | See Acrylonitrile | | | | | | | | | | |
| | Vinyl Cyanide | | | | | | | | | | |
| 0 | Glycol Ethers | | | | | | | | | | |
| 110805 | 2-Ethoxyethanol | $C_6H_{10}O_3$ | 160.2 | Unreviewed Sources | | | | | 2.7 | d | Sweet/ |
| | Ethylene Glycol Monoethyl Ether | | | No C-E Codes | - | - | - | - | 5.1 | r | musty, |
| | Monoethyl Ether of Ethylene Glycol | | | Critiqued Sources | | | | | | | rose-like |
| | Cellosolve | | | May (1966) | A | 90 | 24 | d | | | |
| | | | | May (1966) | A | 180 | 49 | r | | | |
| | | | | Hellman and Small | | | | | | | |
| | | | | (1973, 1974) | A | 1.1 | 0.3 | d | | | |
| | | | | Hellman and Small | | | | | | | |
| | | | | (1973, 1974) | A | 2 | 0.54 | r | | | |

# TABLE 2-1 (cont'd). REPORTED ODOR THRESHOLDS FROM ALL SOURCES

| CAS # | Compound Name Synonyms | Formula | M.W. | Source | Code | Odor Thresholds mg/m$^3$ | Odor Thresholds ppm | Type of Threshold | Geometric Mean Air Odor Threshold (ppm) | Geometric Mean Air Odor Type of Threshold | Odor Characteristic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | Glycol Ethers (cont'd) | | | | | | | | | | |
| | 2-Ethoxyethyl Acetate | $C_6H_{10}O_3$ | 180.2 | Rejected/Unreviewed Sources | | | | | 0.08 | d | Sweet/ester/ |
| | Ethyl Glycol Acetate | | | | | | | | 0.13 | r | fruity |
| | Ethylene Glycol Monoethyl Ether Acetate | | | No C-E Codes | - | - | - | - | | | |
| | Cellosolve Acetate | | | Critiqued Sources | | | | | | | |
| | | | | Hellman and Small (1973, 1974) | A | 0.3 | 0.08 | d | | | |
| | | | | Hellman and Small (1973, 1974) | A | 0.7 | 0.13 | r | | | |
| 0 | Lead Compounds | | | No Sources Found | | | | | | | |
| 0 | Manganese Compounds | | | No Sources Found | | | | | | | |
| 0 | Mercury Compounds | | | No Sources Found | | | | | | | |
| 0 | Fine Mineral Fibers | | | No Sources Found | | | | | | | |
| 0 | Nickel Compounds | | | | | | | | | | |
| | Nickel Carbonyl | $Ni(CO)_4$ | 170.7 | Unreviewed Sources | | | | | None | | Sooty |
| | Nickel Tetracarbonyl | | | Armit (1907) | E2 | 3.5 | 0.5 | ng | | | |
| | | | | Kincaid et al. (1956) | C1 | 7-21 | 1.0-3.0 | ng | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | No A or B Codes | - | - | - | - | | | |
| 0 | Polycyclic Organic Matter | | | | | | | | | | |
| | Acenaphthene | $C_{12}H_{10}$ | 154.2 | Unreviewed Sources | | | | | None | | |
| | Naphthyleneethylene | | | Lillard and Powers (1975) | E2 | 3.1 | 0.5 | d | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | No A or B Codes | - | - | - | - | | | |
| | 1-Aminonaphthalene | $C_{10}H_9N$ | 143.2 | Unreviewed Sources | | | | | None | | |
| | | | | Backman (1917) | E1 | 0.014-0.29 | 0.024-0.5 | r | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | No A or B Codes | - | - | - | - | | | |

# TABLE 2-1 (cont'd). REPORTED ODOR THRESHOLDS FROM ALL SOURCES

| CAS # | Compound Name Synonyms | Formula | M.W. | Source | Code | Odor Thresholds mg/m³ | Odor Thresholds ppm | Type of Threshold | Geometric Mean Air Odor Threshold (ppm) | Geometric Mean Air Odor Type of Threshold | Odor Characteristic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | Polycyclic Organic Matter (cont'd) | | | | | | | | | | |
| | 1-Hydroxynaphthalene | $C_{10}H_8O$ | 144.2 | Unreviewed Sources | | | | | None | | |
| | 1-Naphthol | | | Backman (1917) | E1 | 0.0030-0.0052 | 0.00051-0.00088 | r | | | |
| | alpha-Naphthol | | | Critiqued Sources | | | | | | | |
| | | | | No A or B Codes | - | - | - | - | | | |
| | 2-Hydroxynaphthalene | $C_{10}H_8O$ | 144.2 | Unreviewed Sources | | | | | None | | Faint, phenolic |
| | 2-Naphthol | | | Backman (1917) | E1 | 0.23-0.30 | 0.040-0.051 | r | | | |
| | beta-Naphthol | | | Critiqued Sources | | | | | | | |
| | | | | No A or B Codes | - | - | - | - | | | |
| | Indene | $C_9H_8$ | 117.2 | Unreviewed Sources | | | | | None | | |
| | Indonaphthene | | | Deadman and Prigg (1959) | E2 | 0.02 | 0.004 | d | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | No A or B Codes | - | - | - | - | | | |
| | Indole | $C_8NH_7$ | 117.2 | Unreviewed Sources | | | | | None | | Strong/ unpleasant, weak/pleasant |
| | 1-Benzo[b]pynole | | | Punter (1975, 1979) | D1,D2 | 0.0071 | 0.015 | d | | | |
| | | | | Templaar (1913) | E2 | 0.0006 | 0.00013 | d | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | No A or B Codes | - | - | - | - | | | |
| | 3-Methylindole | $C_9H_9N$ | 131.2 | Unreviewed Sources | | | | | 0.019 | | Fecal |
| | Skatole | | | Hermanides (1909) | E2 | 0.00035 | 0.000065 | r | | | |
| | | | | Zwaardemaker (1914) | E2 | 0.0004 | 0.000075 | d | | | |
| | | | | Van Anrooji (1931) | E2 | 0.00078 | 0.00015 | d | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Katz and Talbert (1930) | A | 0.1 | 0.019 | ng | | | |
| | Phenanthrene | $C_{14}H_{10}$ | 178.2 | Unreviewed Sources | | | | | None | | |
| | | | | Backman (1917) | E1 | 0.055-0.06 | 0.0075-0.0082 | r | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | No A or B Codes | - | - | - | - | | | |

## TABLE 2-1 (cont'd). REPORTED ODOR THRESHOLDS FROM ALL SOURCES

| CAS # | Compound Name Synonyms | Formula | M.W. | Source | Code | Odor Thresholds mg/m³ | Odor Thresholds ppm | Type of Threshold | Geometric Mean Air Odor Threshold (ppm) | Geometric Mean Air Odor Type of Threshold | Odor Characteristic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | Polycyclic Organic Matter (cont'd) | | | | | | | | | | |
| 110861 | Pyridine | $C_5H_5N$ | 79.1 | Unreviewed Sources | | | | | 1.85* | d | Nauseating |
| | Azabenzene | | | Tausch (1974) | E2 | 198.5 | 61.4 | d | 0.74 | r | |
| | Azine | | | Zwaardemaker (1914) | E2 | 0.04 | 0.012 | d | | | |
| | | | | Sales (1958) | E2 | 0.42 | 0.13 | ng | | | |
| | | | | Geier (1936) | E2 | 0.095 | 0.03 | r | | | |
| | | | | Geier (1936) | E2 | 0.09 | 0.028 | d | | | |
| | | | | Van Anrooji (1931) | E2 | 0.078 | 0.024 | d | | | |
| | | | | Hermanides (1909) | E2 | 0.16 | 0.049 | r | | | |
| | | | | Koelega (1974) | E2 | 25,391 | 7,849 | d | | | |
| | | | | Hangartner (1981) | E2 | 0.08-2.9 | 0.025-0.90 | ng | | | |
| | | | | Dalla Valle and Dudley (1939) | E2 | 3.7 | 1.14 | d | | | |
| | | | | Washburn (1926) | E2 | 0.00041 | 0.00013 | ng | | | |
| | | | | Washburn (1926) | E2 | 1.58 | 0.49 | ng | | | |
| | | | | Tausch (1974) | E2 | 31,482 | 9,730 | d | | | |
| | | | | Moncrieff (1951) | E2 | 0.97 | 0.3 | d | | | |
| | | | | Amerine et al. (1965) | E1 | 0.74 | 0.23 | d | | | |
| | | | | Janicek et al. (1960) | E1 | 4.6 | 1.42 | ng | | | |
| | | | | Backman (1917) | E1 | 0.02 | 0.006 | r | | | |
| | | | | Sutton (1963) | C1 | <3.2 | <1.0 | ng | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | Laffort and Dravnieks (1973) | B | 0.74 | 0.23 | ng | | | |
| | | | | Allison and Katz (1919) | B5 | 32 | 9.9 | ng | | | |
| | | | | Kristesashvili (1965) | B2 | 0.21 | 0.06 | ng | | | |
| | | | | Leonardos et al. (1969) | B | 0.067 | 0.021 | r | | | |
| | | | | Jones (1955c) | B | 40 | 12 | d | | | |
| | | | | Katz and Talbert (1930) | A | 0.074 | 0.023 | ng | | | |
| | | | | Dravnieks (1974) | A | 6 | 1.85 | d | | | |
| | | | | Laing et al. (1978) | A | 2.4 | 0.74 | r | | | |

See Quinoline
See 2-Acetylaminofluorene

# TABLE 2-1 (cont'd). REPORTED ODOR THRESHOLDS FROM ALL SOURCES

| CAS # | Compound Name Synonyms | Formula | M.W. | Source | Code | Odor Thresholds mg/m³ | Odor Thresholds ppm | Type of Threshold | Geometric Mean Air Odor Threshold (ppm) | Geometric Mean Air Odor Type of Threshold | Odor Characteristic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | Radionuclides | | | No Sources Found | | | | | | | |
| 0 | Selenium Compounds | | 80.98 | Unreviewed Sources | | | | | None | | Garlic |
| | Hydrogen Selenide | $H_2Se$ | | Dudley and Miller (1941) | C1 | <1.0 | 0.3 | ng | | | |
| | | | | Critiqued Sources | | | | | | | |
| | | | | No A or B Codes | - | - | - | - | | | |

[*]The mean detection threshold may be greater than or equal to the recognition threshold as a result of pooling several data sets.

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