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

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

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

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

Absorption of Solar Radiation

Absorption of solar ultra-violet light by smoke and soot is recognized as a health problem in many industrial cities. Measurements of solar radiation in Baltimore[6] by actinic methods demonstrated that ultra-violet light intensity in the country was 50 percent greater than in the city. In New York City[7] a loss as great as 50 percent in visible light was found by photoelectric measurements.

ODOR NUISANCE

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

Control of outdoor odor nuisance is especially troublesome because of the extremely minute quantities of contaminant that are capable of offending through a wide area. New industrial chemicals with strange or unfamiliar odors tend to receive more attention from the neighborhood than the customary odors generated by well-known processes and raw materials. Methods of odor control currently in use include charcoal adsorption, scrubbing towers and air washers, chlorination, condensation, masking, passage of the odorous air through combustion chambers, dispersion through a tall stack, and best of all, substitution of less offensive materials whenever possible.[8, 9, 10, 11]

Control of air quality within buildings ventilated for human occupancy is discussed in Chapter 6. Tobacco smoke odors, cooking odors, and body odors are air contaminants of the nuisance type which now command a decisive position in the standards of air quality for indoor comfort. However, the engineer will find, at times, that odors originating *outside* buildings in industrial or business districts may determine the kind and capacity of equipment he must provide for a high quality air-supply installation.

INDUSTRIAL AIR CONTAMINANTS

Many industrial processes are sources of contaminants. Their control is an important function of the ventilating or air-conditioning engineer, because the atmosphere within buildings is the medium whereby such finely divided matter is dispersed and transported from the source to remote locations where it may cause property damage, nuisance, fire, explosion, disease, and even death.

Tables 3, 4, and 5 give maximum allowable concentration values for many industrial air contaminants. Some of these values have been proposed by ASA Sectional Committee Z37 on Allowable Concentrations of Toxic Dusts and Gases, and others by the Committee on Threshold Limits of the American Conference of Governmental Industrial Hygienists. The values have been adopted by the American Conference of Governmental Industrial Hygienists and by many of the official industrial hygiene agencies.

It must be emphasized that these limits in the great majority of instances are only *suggested maximum working levels* since they are estimates, based in many cases upon incomplete environmental and medical studies. Where there is agreement between the *ASA Standard* Z37 and ACGIH values, reliability of the ASA Standard is increased. The values are not fixed, but are subject to revision, upward or downward, with the development of new information. There is by no means complete agreement regarding these values among responsible industrial hygienists.

In applying these guide limits, the following factors must be considered:

1. The duration of exposure is 8 hr a day for 5 or 6 days a week.

2. The measurements are indicative of the concentration in the breathing zone of the exposed person.

3. The MAC is usually accepted as the average exposure value when the upper limits do not greatly exceed the MAC value. For example, it cannot be assumed that if 100 ppm is considered *safe* for 8-hour exposure, that 800 ppm for one hour will be permissible.

4. Two substances with similar MAC values may be quite different as to physiological effects at other concentrations. In one instance the selection of a limit may be predicated upon a discomfort factor, with a wide margin of safety before systemic effects would be encountered, while in another case the value represents an appreciable fraction of the concentra-

Table 3 . . . . Maximum Allowable Concentration of Gases and Vapors

Substance	ASA Standards MAC ppm[b] by volume	Threshold Limit Values ACGIH[a] 1958	
		ppm[b]	g/cu m or oz/1000 cu ft
Acetaldehyde		200	0.360
Acetic acid		10	0.025
Acetic anhydride		5	0.020
Acetone		1000	2.400
Acrolein		0.5	0.0012
Acrylonitrile		20	0.045
Allyl alcohol		5	0.012
(x) Allyl chloride		5	0.015
Allyl propyl disulfide		2	0.012
Ammonia		100	0.070
Amyl acetate		200	1.050
Amyl alcohol (iso)		100	0.360
Aniline		5	0.019
Arsine		0.05	0.0002
Benzene (benzol)	100	25	0.080
Benzyl chloride		1	0.005
Bromine		1	0.007
Butadiene (1,3-butadiene)		1000	2.200
Butanone (methyl ethyl ketone)		250	0.740
Butyl acetate (*n*-butyl acetate)		200	0.950
Butyl alcohol (*n*-butanol)		100	0.300
Butylamine		5	0.015
* Butyl cellosolve (2-butoxyethanol)		50	0.240
Carbon dioxide		5000	9.000
Carbon disulfide	20	20	0.060
Carbon monoxide	100	100	0.110
Carbon tetrachloride		25	0.160
Cellosolve (2-ethoxyethanol)		200	0.740
Cellosolve acetate (2-ethoxyethyl acetate)		100	0.540
Chlorine		1	0.003
Chlorine trifluoride		0.1	0.0004
Chlorobenzene (monochlorobenzene)		75	0.350
Chloroform (trichloromethane)		100	0.490
1-Chloro-1-nitropropane		20	0.100
(x) Chloropicrin		1	0.007
Chloroprene (2-chloro-1,3-butadiene)		25	0.090
Cresol (all isomers)		5	0.022
Cyclohexane		400	1.400
Cyclohexanol		100	0.410
Cyclohexanone		100	0.400
Cyclohexene		400	1.350
Cyclopropane		400	0.690
(x) Decaborane		0.05	0.0003
Diacetone alcohol (4-hydroxy-4-methyl-2-pentanone)		50	0.240
Diborane		0.1	0.0001
o-Dichlorobenzene		50	0.300
Dichlorodifluoromethane		1000	4.95
1,1-Dichloroethane		100	0.400
1,2-Dichloroethane (ethylene dichloride)		100	0.400
1,2-Dichloroethylene		200	0.790
Dichloroethyl ether		15	0.090
Dichloromonofluoromethane		1000	4.200
1,1-Dichloro-1-nitroethane		10	0.060
Dichlorotetrafluoroethane		1000	7.00
* Diethylamine		25	0.075
Difluorodibromomethane		100	0.860
Diisobutyl ketone		50	0.290
Dimethylaniline (N-dimethylaniline)		5	0.025
Dimethylsulfate		1	0.005
Dioxane (diethylene dioxide)		100	0.360
Ethyl acetate		400	1.400
(x) Ethyl acrylate		25	0.100
Ethyl alcohol (ethanol)		1000	1.900
Ethylamine		25	0.045
Ethyl benzene		200	0.870
Ethyl bromide		200	0.890
Ethyl chloride		1000	2.600
Ethyl ether		400	1.200
Ethyl formate		100	0.300
Ethyl silicate		100	0.850
Ethylene chlorhydrin		5	0.016
Ethylenediamine		10	0.030
Ethylenedibromide (1,2-dibromoethane)		25	0.190
Ethylene imine		5	0.009
Ethylene oxide		50	0.090
Fluorine		0.1	0.0002
Fluorotrichloromethane		1000	5.600
Formaldehyde	10	5	0.006
(x) Furfural		5	0.020
Gasoline		500	2.000
Heptane (*n*-heptane)		500	2.000
Hexane (*n*-hexane)		500	1.80
Hexanone (methyl butyl ketone)		100	0.410
Hexone (methyl isobutyl ketone)		100	0.410
Hydrazine		1	0.0013
Hydrogen bromide		5	0.017
Hydrogen chloride		5	0.007
Hydrogen cyanide		10	0.011
Hydrogen fluoride		3	0.002
Hydrogen peroxide, 90%		1	0.0014
Hydrogen selenide		0.05	0.0002
Hydrogen sulfide	20	20	0.030
* Iodine		0.1	0.001
Isophorone		25	0.140
Isopropylamine		5	0.012
* Mesityl oxide		25	0.100
Methyl acetate		200	0.610
Methyl acetylene		1000	1.650
(x) Methyl acrylate		10	0.035
Methyl alcohol (methanol)	200	200	0.260
Methyl bromide		20	0.080
Methyl cellosolve (2-methoxyethanol)		25	0.080
Methyl cellosolve acetate (ethylene glycol monomethyl ether acetate)		25	0.120
Methyl chloride	100	100	0.210
Methylal (dimethoxymethane)		1000	3.100

[a] ACGIH = American Conference of Governmental Industrial Hygienists. Reprinted by permission from *AMA Archives of Industrial Health*, September 1957, Vol. 16, pp. 261-265.

[b] Parts of vapor or gas per million parts of air by volume.

(x) These values appeared in ACGIH tentative list for 1956.

* These items include changes made by ACGIH Committee on Threshold Limits in 1958.