

FILE NAME: AO Smith (AOS)

DATE: 1951

DOC#: AOS005

DOCUMENT DESCRIPTION: HVAC Guide

HEATING
VENTILATING
AIR-CONDITIONING
GUIDE
1954



ITY 628.8
LAT AMERICAN



29

Tornetta
EXHIBIT II
9-14-12 AR
BROWN & JONES

SC-ASHVE-027

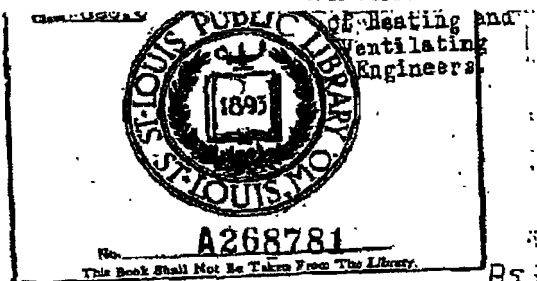
PLAINTIFF'S
EXHIBIT
Tornetta 29
9

PLAINTIFF'S
EXHIBIT
Tornetta 58

American Society of Heating and St
Ventilating Engineers
Heating ventilating air
conditioning guide.
VOL 29 19

528.8
AMERICAN

21718 78304



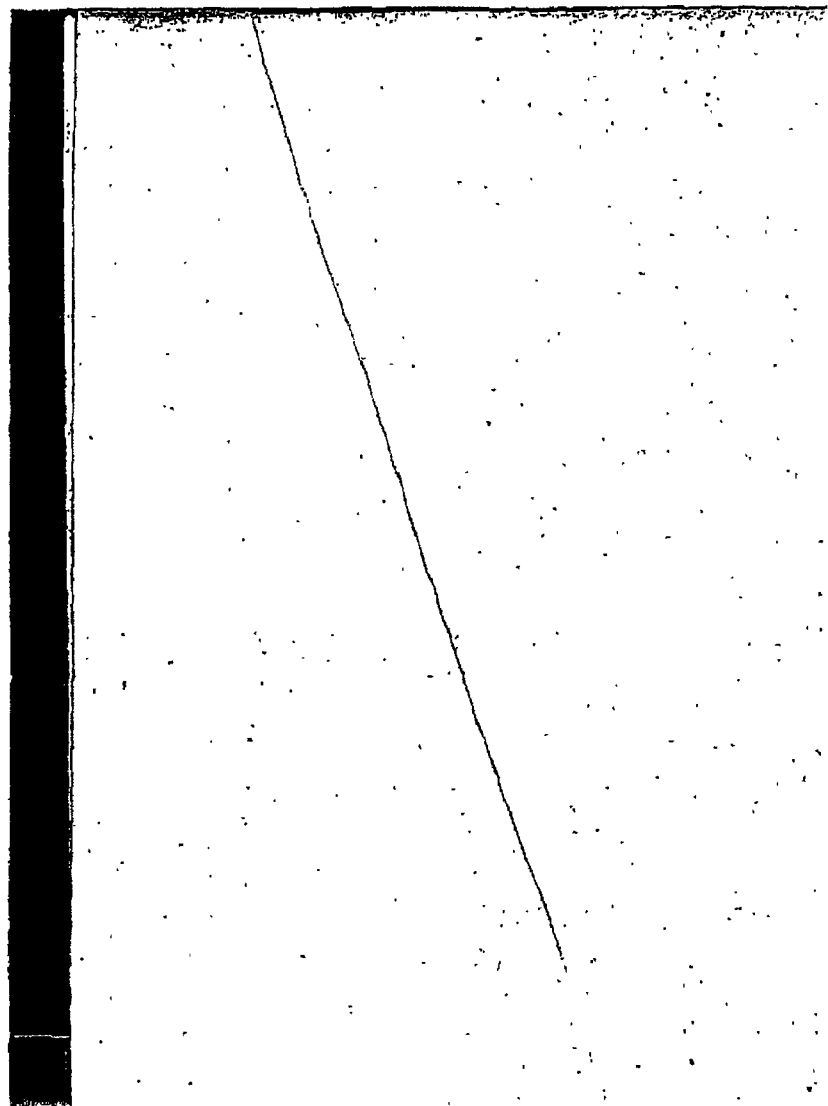
Rs

Ref 628.8

ST. LOUIS
PUBLIC
LIBRARY



**HEATING VENTILATING
AIR CONDITIONING
GUIDE 1951**



HEATING VENTILATING AIR CONDITIONING GUIDE 1951



*An Instrument of Service
Prepared for the Profession
containing*

A TECHNICAL DATA SECTION OF REFERENCE MATERIAL ON THE
DESIGN AND SPECIFICATION OF HEATING, VENTILATING AND AIR CONDI-
TIONING SYSTEMS BASED ON THE TRANSACTIONS, THE INVESTIGATIONS
OF THE RESEARCH LABORATORY AND COOPERATING INSTITUTIONS—
AND THE PRACTICE OF THE MEMBERS AND FRIENDS OF THE SOCIETY;
A MANUFACTURERS' CATALOG DATA SECTION CONTAINING
ESSENTIAL AND RELEVANT INFORMATION CONCERNING MODERN EQUIP-
MENT; COMPLETE INDEXES TO TECHNICAL AND CATALOG DATA
SECTIONS.

Vol. 29

\$1.50 per Copy

A268781

PUBLISHED ANNUALLY BY
AMERICAN SOCIETY OF HEATING
AND VENTILATING ENGINEERS
81 MADISON AVENUE
NEW YORK 10, N. Y.

Fever Therapy Locally Induced by Conditioned Air, by M. B. Fardarber, F. C. Houghton and Carl Gutberlet (A.S.H.V.E. Transactions, Vol. 45, 1949, p. 307).

"Refrigeration for Anesthesia and Therapy, by L. W. Grossman and S. E. Safford (The Modern Hospital, 64:35, 1945).

"The Effect of Low Relative Humidity and Constant Temperature on Pollen Asthma, by E. K. Sappaport, T. Nelson, and W. H. Walker (Journal of Allergy, 6:111, 1945).

"Hospital Air Conditioning, by C. F. Yaglou (The Environment and Its Effect Upon Man, Harvard School of Public Health, p. 244, 1939).

"Principles and Practices of Inhalational Therapy, by A. L. Barach (J. B. Lippincott Co., Philadelphia, London, Montreal, 1944).

"The Management of Pneumonia, by J. G. M. Bullock (Oxford University Press, p. 250, 1937).

"What Are the Right Conditions for Comfort-Cooling, by Cyril Tasker (Heating, Piping, and Air Conditioning, Aug., 1948, p. 54).

"Odor Physiology and Control, by O. P. McCord and Wm. E. Witheridge (McGraw-Hill Book Co., New York, 1948).

CHAPTER 5

AIR CONTAMINANTS

Classification of Air Contaminants; Sizes of Airborne Particles; Air Pollution by Smoke, Ash and Cinders; Smoke Abatement and Air Pollution Control; Odor Nuisances; Maximum Allowable Concentrations of Industrial Air Contaminants; Flammable Gases and Vapors; Combustible Dusts; Atmospheric Pollutants; Airborne Bacteria

THE normal constituents of the earth's atmosphere are oxygen, nitrogen, carbon dioxide, water vapor, argon, small or negligible amounts of other inert gases, hydrogen, variable traces of ozone, and small quantities of microscopic and submicroscopic solid matter, sometimes called permanent atmospheric impurities. From the viewpoint of the air conditioning engineer, all other airborne substances may be termed contaminants. This term is applied preferably, however, to undesirable or chance impurities, since the occasion may arise for adding to the air controlled amounts of solid or gaseous diluents for the prevention of explosions; germicidal vapors or mists (aerosols) for bacteria control; masking substances for odor control; or a substitute for one of the normal gases, as, for example, when helium is used to replace nitrogen in atmospheres for compressed air workers or divers.

Control of the chemical quality of air is one of the functions of complete air conditioning, and some knowledge of the composition, concentration and properties of air contaminants under various circumstances is therefore essential.

Air contaminants arise from the normal processes of wear, erosion, windstorm, sea-spray evaporation, thermal disintegration, earthquake, volcanic eruptions, combustion, manufacturing, transportation, agriculture, and the biochemical or biological processes of life. They are classified at various times as organic and inorganic, visible or invisible, microscopic or macroscopic, particulate or gaseous, toxic or harmless, beneficial or destructive. The following classification is based chiefly upon the origin or method of formation of air contaminants.

CLASSIFICATION OF AIR CONTAMINANTS

Dusts, Fumes, and Smokes are solid particulate air contaminants.

Dusts are solid particles projected into the air by natural forces, such as wind, volcanic eruption or earthquake, and by mechanical processes, such as crushing, grinding, milling, drilling, demolition, sawing, conveying, screening, bagging and sweeping. Some of these forces produce dust from larger masses, while others simply disperse materials that are already pulverized. Usually, particles are not called dust unless they are smaller than about 100 microns. Dusts may be of mineral type, such as rock, ore, metal, sand; vegetable, such as grain, flour, wood, cotton, pollen; or animal, such as wool, hair, silk, feathers, leather.

Fumes are solid particles commonly formed by the condensation of vapors from normally solid materials such as molten metals. Metallic fumes generally occur as the oxides in air because of the highly reactive nature of finely divided matter. Fumes may also be formed by sublimation, distillation, salinization, or chemical reaction, whenever such processes create airborne particles predominately below the 1 micron size. Fumes permitted to age tend to flocculate into clumps or aggregates of larger size, thereby facilitating removal from air.

Smokes are the extremely small solid particles produced by incomplete combustion

of organic substances such as tobacco, wood, coal, oil, tar and other carbonaceous materials. The term smoke is commonly applied to the mixture of solid, liquid and gaseous products of combustion, although the technical literature prefers to distinguish between such components as soot or carbon particles, fly-ash, clinders, tarry matter, unburned gases, and gaseous combustion products. The finest particulate constituents are much less than 1 micron in size, often in the range of 0.1 to 0.3 micron.

Mists and Fogs are liquid particulate air contaminants.

Mists are very small airborne droplets of materials that are ordinarily liquid at normal temperatures and pressures. They may be formed by atomizing, spraying, splashing, mixing, violent chemical reactions, electrolytic evolution of gas from a liquid, or escape of a dissolved gas upon release of pressure. Very small droplets expelled or atomized into the air by sneezing constitute mists containing microorganisms that become air contaminants.

Fogs are limited by some classifications to airborne droplets formed by condensation from the vapor state. This arbitrary distinction between mist and fog is of minor importance, as both terms are used to indicate the particulate state of airborne liquids (occasionally termed aerosols). Fog-mists are so named because of their ability to produce extra fine droplets as compared to the mist from ordinary spray devices. The highly volatile nature of some liquids quickly reduces their airborne droplets from the mist to the fog range, and eventually to the vapor phase until the air becomes saturated with that liquid. Many droplets in fogs or clouds are microscopic and submicroscopic in size, and may be conceived as the transition state between the larger mists and the vapors.

Vapors and Gases are non-particulate air contaminants.

Vapors are the gaseous phase of substances that are either liquid or solid in their commonly known state, examples being gasoline, kerosene, benzene, carbon tetrachloride, mercury, iodine, camphor. Vapors may be changed to the solid or liquid form by increasing the pressure, decreasing the temperature or applying both processes simultaneously. They are removed from the air by condensation with less difficulty than are the gases.

Gases are usually formless fluids which tend to occupy a space or envelope completely and uniformly at ordinary temperatures and pressures. The following substances qualify as gases: hydrogen, nitrogen, carbon dioxide, carbon monoxide, hydrogen, ammonia, sulfur dioxide. Gases, likewise, may be solidified or liquefied by the proper control of temperature and pressure.

The preceding classification is not suitable for the airborne living organisms, which range in size from the submicroscopic viruses to the largest pollen grains, not considering the smallest insect life. Bacteria range from about 0.2 to 5 microns in size, fungus spores from 1 to 10 microns, and pollen from 5 to 160 microns.

SIZES OF AIRBORNE PARTICLES

Fig. 1 is a graphic tabulation of the properties of airborne solids and liquids arranged according to size on the micron scale. There are 25,400 microns in 1 inch.

Particles larger than 10 microns are unlikely to remain suspended in air currents of moderate strength, but settle out by gravity at speeds dependent upon the shape, size and specific gravity of the particle, wind velocity, orientation of the collecting surface, and topography. These larger particles are of major interest to the engineer in the solution of nuisance problems, but it is usually the smaller particles, or those below 10 microns, that remain in the air long enough to be of hygienic as well as economic significance.

Industrial dust particles are predominantly of the order of 1 micron in size. Tremendous numbers are also present in the submicroscopic range below 0.5 micron, but those below 0.1 micron are not believed at

SCALE OF ATMOSPHERIC IMPURITIES

LAWS OF SETTLING IN RELATION TO PARTICLE SIZE

PARTICLES FALL WITH INCREASING VELOCITY

PARTICLES BEHAVE WITH INCREASING VELOCITY

STOKES LAW

NEWTON LAW

CUNNINGHAM CORRECTION FACTOR

MOORE LITE MOLECULES

EXPERIMENTAL EQUIPMENT

LAWS OF SETTLING IN RELATION TO PARTICLE SIZE

PARTICLES FALL WITH INCREASING VELOCITY

PARTICLES BEHAVE WITH INCREASING VELOCITY

STOKES LAW

NEWTON LAW

CUNNINGHAM CORRECTION FACTOR

MOORE LITE MOLECULES

EXPERIMENTAL EQUIPMENT

FIG. 1. SIZES AND CHARACTERISTICS OF AIRBORNE PARTICULATE MATTER

The survey¹ of atmospheric pollution in 14 American cities conducted from 1931 to 1933 indicated the average size of outdoor dust particles to be 0.5 micron, as collected by the Owens jet dust counter and measured under the microscope. Inability of the light field microscope to reveal

particles in the 0.1 micron vicinity may have influenced the determination of average particle size.

The lower limit of particle size visible to the naked eye cannot be stated definitely. It depends not only upon the individual eye, but also upon the shape and color of the particle, intensity and quality of the light, and nature of the background or opportunity for contrast. Under ideal conditions a particle of 10-micron size might be recognized, while under less favorable conditions it may be impossible to distinguish a particle smaller than 50 microns. The lower limit of visibility probably ranges from 10 to 50 microns.

Dusts, powders and granular materials are frequently classified by reference to the size of screens used for separation. Particles above 40 microns are said to be the screen sizes and those below, the sub-screen or microscopic sizes. Approximate or theoretical sizes of particles corresponding to the mesh scale of the U. S. Standard Sieve Series are given in Table 1.

Microscopic examination of screened dust indicates that the average diameter of a sample of irregular particles may be substantially larger.

TABLE 1. RELATION OF SCREEN MESH TO PARTICLE SIZE

U. S. Standard Sieve Mesh...	400	325	200	150	100	60	35	18
Nominal Sieve Opening in Microns.....	37	44	74	105	149	250	500	1000

than the openings of the screen through which it has passed, if the particle shapes deviate considerably from the spherical form.³ The smallest dimension of many such particles will correspond with the maximum permissible distance between the wires of commercial screens made to ASTM Standard Specifications. Screening does not give sharp separation into size groups, and accordingly, such a classification is statistical rather than absolute.

AIR POLLUTION BY SMOKE, ASH AND CINDERS

Total airborne solids settling in urban areas are usually reported as *soot fall* in tons per (square mile) (month). Such data published for the cities in this country range from 20 to 200 tons per (square mile) (month). To the air conditioning engineer this information may indicate the effectiveness of smoke abatement or fuel combustion control methods in his locality, but it does not provide a suitable index of the suspended dust that air cleaners in a ventilating system are expected to capture.^{4,5} Gravimetric or weight data of the type given in Table 2 are preferable. In some cases airborne particle counts may be necessary, as for pollen, bacteria, spores, and insoluble dusts causing illness or lung disease.

Dust concentrations by weight cannot be converted readily to concentrations by particle count because of the variability of particle size, shape and specific gravity, and the inherent characteristics of dust counting and weighing procedures. One milligram of dust per cubic meter of air may represent dust counts from 1 million to 100 million particles per cubic foot of air (lightfield microscope technique) according to the size distribution of

the airborne dust sample. Information of this type for a specified application is best obtained by simultaneous sampling for both counting and weighing and noting carefully at the time all factors that might affect the reproducibility of the count-weight ratio.

Smoke Abatement and Air Pollution Control

Successful abatement of atmospheric pollution caused by smoke requires the combined efforts of the combustion engineer, industrial executive, public health officer, city planning commission and the community at large. Electrification of industry and railroads, increase 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 13, 14 and 15 for further discussion on fuel burning technolo.)

TABLE 2. DUST CONCENTRATION RANGES

Location	GRAINS PER 1000 CU FT*	MILLIGRAMS PER CUBIC METRE
Rural and suburban districts.....	0.02-0.2	0.05-0.5
Metropolitan district.....	0.04-0.4	0.1-1.0
Industrial districts.....	0.1-2.0	0.2-5.0
Ordinary factories or workrooms.....	0.2-4.0	0.5-10
Excessively dusty factories or mines.....	4-400	10-1000
Minimum explosive concentrations.....	4000-900,000	10,000-900,000

* 1 grain per 1000 cu ft = 32 milligrams per cubic metre.

1 cu per cubic foot = 1 grain per liter = 100 grains per cubic metre.

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 49) 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 sulphur 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 M.A.C. (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 M.A.C. values are based, and because the exposed population contains individuals with greater variation in age and health status.

In foggy weather, or with 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, principal

pally 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 ultraviolet light by smoke and soot is recognized as a health problem in many industrial cities. Measurements of solar radiation in Baltimore⁴ by actinic methods demonstrated that ultraviolet light intensity in the country was 50 percent greater than in the city. In New York City 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.^{4, 5, 6, 7}

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 4, 4 and 5 give the maximum allowable concentration values for many industrial air contaminants as adopted by the Sectional Committee E37 on Allowable Concentrations of Toxic Dusts and Gases of the American Standards Association, and as reported by the Committee on Threshold

Limits and accepted by the American Conference of Governmental Industrial Hygienists at its 1949 meeting.

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 A.C.G.I.H. 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 M.A.C. is usually accepted as the average exposure value when the upper limits do not greatly exceed the M.A.C. 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 M.A.C. 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 concentration which may be associated with severe and irreversible injury.
5. These values are upper limits; it is desirable to operate well below the levels if the engineering and economic factors permit. The prudent engineer will incorporate a reasonable margin of safety in his estimates of ventilating capacity.

In Table 8, Column 1 lists the ASA Sectional Committee Z37 M.A.C. values; Column 2, those of the A.C.G.I.H. Committee on Threshold Limits. Column 3 gives the value in grams per cubic meter or ounces per 1000 cu ft for the corresponding A.C.G.I.H. limits; Column 4 shows the fluid ounces of chemical, if it is a liquid at 20 C (68 F), which, if equally dispersed in 1000 cu ft, would give the corresponding M.A.C.

In Table 4, Columns 1 and 2 are respectively the M.A.C. values from the ASA and A.C.G.I.H. Committees.

In Table 5, the M.A.C. values for a number of industrial dusts as given were obtained from data of the A.C.G.I.H. Committee on Threshold Limits.

Information on the properties and effects, with respect to health, of specific industrial air contaminants is available in publications listed at the end of this chapter.

FLAMMABLE GASES AND VAPORS

Adequate ventilation is a primary requirement for minimizing the hazard of fire or explosion due to gases and vapors. The need for good ventilation is not removed by the use of other precautions, such as the elimination of known ignition sources, segregation of hazardous operations, adoption of safe building construction, and installation of automatic alarms. Some safety engineers regard over-ventilation of an operation employing flammable liquids as a legitimate operating charge for the privilege or necessity of using a dangerous process. However, it is not possible to

TABLE 3. Relative Frequency of Condensation of Clays and Zeolites

[illegible]

! A.C.I.E. - American Conference of Governmental Industrial Hygienists

supply a reasonable safety factor to the ventilation estimate without considering the concentration of gases or vapors that approach the danger point. Safety engineers prefer to limit the concentration to a point lower explosive limit, and this fact should be given full weight in determining the capacity and design of ventilating equipment. Rarely should

TABLE 3. MAXIMUM ALLOWABLE CONCENTRATION OF GASES AND VAPORS

[illegible]

ppm (parts of contaminant per million parts of air, by volume, or in other words, cubic feet of contaminant per million cubic feet of air). It will be noted in Table 6 that nearly all of the substances listed have lower explosive limits above 1.0 percent, while the maximum allowable concentrations for gases and vapors in Table 3 are below 1000 ppm or 0.1 percent in most cases. Therefore, control of toxic or injurious vapors to levels below their maximum allowable concentrations for health usually requires much more effective ventilation than for the prevention of a fire hazard.

COMBUSTIBLE DUSTS

A dust explosion is essentially a sudden pressure rise caused by the very rapid burning of airborne dust. The primary explosion often originates from a small amount of dust in suspension exposed to a source of ignition, and the pressure and vibration it creates may be sufficient to dislodge large accumulations of dust on horizontal ledges or surfaces of the building and equipment, thereby creating a secondary explosion of great force.

TABLE 5. LIMITS FOR MINERAL DUSTS

SUBSTANCE	PERMISSIBLE LIMIT VALUES A.C.S.I.E. 1947 mg/m ³
Aluminum	25
Asbestos	5
Cerium dust	20
Dust (exposure to iron silico)	20
Mica (below 5% iron silico)	20
Powdered cement	25
Silica—high (above 5% free SiO ₂)	5
Silica—medium (5 to 25% free SiO ₂)	25
Silica—low (below 5% free SiO ₂)	25
Slate (below 5% free SiO ₂)	25
Soot (below 5% free SiO ₂)	25
Talc	25
Total dust (below 5% free SiO ₂)	25

* mg/m³—million particles per cubic foot of air, standard 100 ft. field count.

Thus the air conditioning engineer is involved for two reasons: (1) to obtain a movement of dust-laden air into exhaust hoods or openings, and through ventilating or pneumatic conveying ducts, in a manner that will prevent accumulation of highly flammable dust at points where it could ignite inside the equipment; and (2) to so design process ventilation as to prevent the escape of dust which might settle on horizontal surfaces and become a potential source of disaster at some distance from the dusty operation. (See Chapter 45).

Intensity of a dust explosion depends upon: chemical and thermal properties of the dust; particle size and shape; concentration in air; proportion of inert dust in the air; moisture content and composition of the air; size and temperature of the ignition source; and degree of dispersion of the dust cloud. Investigations on the explosibility of dusts require determination of the maximum pressure developed during explosion of a known air concentration, as well as determination of the rate of pressure rise. Investigators frequently experience difficulty in obtaining dust suspensions of uniform dispersion, and this should be kept in mind when comparing results from several sources.¹⁴

Minimum explosive concentrations of airborne dusts already tested range from 0.01 to 0.5 oz per cubic foot, or 10 to 500 grams per cubic meter.

TABLE 6. APPROXIMATE LIMITS OF FLAMMABILITY OF SINGLE GASES AND VAPORS IN AIR AT ORDINARY TEMPERATURES AND PRESSURES*

[illegible]

TABLE 6. APPROXIMATE LIMITS OF FLAMMABILITY OF SINGLE GASES AND VAPORS IN AIR AT ORDINARY TEMPERATURES AND PRESSURES* (Concluded)

GAS OR VAPOR	LOWER LIMIT PERCENT BY VOLUME	UPPER LIMIT PERCENT BY VOLUME	Flash Point °F Dist ^b
Propane	2.1	10.1	11
Propyl acetate	2.1	9.5	11
Propyl alcohol	2.0	10.0	11
Propylamine	2.0	11.1	11
Propylene sulfide	2.1	11.5	11
Propylene oxide	2.0	12.0	11
Styrene	1.5	13.4	11
Toluene (liquid)	1.3	7.5	40
Turpentine	1.7	17.0	20
Vinyl chloride	4.0	21.7	11
Water (steam)	1.0	10.0	11
Xylene (liquid)	1.0	6.0	11

* Adapted from: *The and Extensive Hazards of Combustible Gases and Vapors*, by G. W. Jones, Chapter 11, *Industrial Hygiene and Toxicology*, edited by J. A. Patty (Interscience Publishers, 1940); *Properties of Flammable Liquids, Gases and Solids* (American Petroleum Institute, 1940); *Properties of Flammable Liquids, Gases and Solids* (American Petroleum Institute, 1940); *Properties of Flammable Liquids, Gases and Solids* (American Petroleum Institute, 1940).

^b Closed cup refers to the equipment used in flash point determination.

of air. Maximum pressures generated have been reported as high as 500 psi, although they are more likely to be of the order of 50 psi. Investigations on the flammable characteristics of dusts are currently made at 0.1 and 0.5 oz per cubic foot.¹⁸⁻²¹

ATMOSPHERIC POLLEN

Properties of pollen grains discharged by weeds, grasses and trees and responsible for hay fever, are of special interest to designers of air cleaning equipment (see Allergic Disorders in Chapter 7, and Air Cleaning, Chapter 33). Whole grains and fragments transported by the air range chiefly between 10 and 50 microns in size, but some have been measured as small as 5 microns, and others over 100 microns in diameter. Ragweed pollen grains are fairly uniform in size within the range of 15 to 25 microns. Pollen grains can be removed from the air more readily than the particles of dust prevalent in outdoor air or produced by dusty processes, since the latter predominate in the range of 0.1 to 10 microns in size.

Most grains are quite hygroscopic and therefore vary in weight with the humidity. Illustrations and data on individual pollen grains are available in the botanical literature.^{22, 23, 24} Geographical distribution of plants known to produce hay fever is also recorded.^{25, 26}

The quantity of pollen grains in the air is generally estimated by exposing an adhesive-coated glass plate outdoors for 24 hr, and then counting calibrated areas under the microscope. Methods are available for determining the number of grains in a measured volume of air,^{21, 22, 23} but their greater accuracy has not caused them to replace the more simple *gravity slide method* used for most pollen counts. Counting techniques vary somewhat, but the daily pollen counts reported in local newspapers during the hay fever season usually represent the number of grains found on 1.8 sq. cm of a 24-hr gravity slide.

Hay fever sufferers may notice the first symptoms when the pollen count is 10 to 25, and in some localities the maximum figures for the seasonal peak may approach 1000 for a 24-hr period, depending upon the sampling.

and reporting methods of the laboratory. Translation of gravity counts by special formulas to a volumetric basis, or the number of grains per cubic yard or per cubic foot of air, is unreliable because of the complexity of the modifying factors. When such information is important, it is best obtained directly by a volumetric instrument. The number of pollen grains per cubic yard of air evidently varies from 2 to 20 times the number found on 1 sq cm of a 24-hr gravity slide, depending on grain diameter, shape, specific gravity, wind velocity, humidity and physical placement of the collecting plate.^{11, 12}

AIRBORNE BACTERIA

Study of the occurrence and significance of micro-organisms in the atmospheres of the indoor world is absorbing the energies of a substantial number of physicians, bacteriologists, aerobiologists, physicists, public health workers, engineers and hospital personnel. Some data are available on the types and quantities of bacteria found in a variety of spaces, but it is not possible at present to use this information as a conclusive index of the potential health hazard of a given environment. The reported number of airborne organisms may vary from 1 to 1000 per cubic foot of air, influenced somewhat by the method of testing.¹³ Many are attached to the dust particles present in the air.

Where it seems advisable or desirable to control the bacterial content of rooms, public conveyances or buildings, highly effective methods are available (see Chapter 7), and their extended use may do much to assist the workers in this field in accumulating the necessary mass of evidence that will decide the practical value of air sterilization for the control of communicable diseases. It is now well established that ultraviolet radiation is feasible for the protection or preservation of pharmaceuticals, cosmetics, and food products.

REFERENCES

- ¹ Atmospheric Pollution of American Cities for the Years 1931 to 1933, J. E. Ives, et al (*U. S. Public Health Service Bulletin No. 224*, March 1935).
- ² Micromeritics, The Technology of Fine Particles, by J. M. DallaValle (Fitzma Publishing Corporation, 1943).
- ³ Atmospheric Pollution Due to Smoke, by A. C. Stern (*Heating and Ventilating*, May, 1945).
- ⁴ Atmospheric Pollution Due to Dust and Clouds, by A. C. Stern (*Heating and Ventilating*, July, 1945).
- ⁵ Soilfall Studies for New York City, by J. Haged and B. Felner (*A.S.H.V.E. Journal Section, Heating, Piping and Air Conditioning*, September, 1945, p. 493).
- ⁶ The Use of Fuel Consumption and Equipment Data in the Abatement of Atmospheric Pollution, by A. C. Stern (*A.S.H.V.E. Journal Section, Heating, Piping and Air Conditioning*, August, 1945, p. 447-454).
- ⁷ Effects of Atmospheric Pollution Upon Incidence of Solar Ultra-Violet Light, by J. E. Shrader, M. H. Coibents and F. A. Roth (*American Journal of Public Health*, Vol. 19, 1929, p. 7).
- ⁸ Studies in Illumination—III: A Study of the Loss of Light Due to Smoke on Manhattan Island, by J. E. Ives (*U. S. Public Health Service Bulletin No. 107*, June, 1930).
- ⁹ Study and Control of Industrial Atmospheric Pollution Nuisances, by F. M. Reed (*American Journal of Public Health*, Vol. 35, May, 1945, p. 491-493).
- ¹⁰ Evaluation of Odor Nuisance in the Manufacture of Kraft Paper, by J. M. DallaValle and H. C. Dudley (*U. S. Public Health Service Reprint No. 2022*, Public Health Reports, Vol. 54, January 13, 1933, p. 25-43).
- ¹¹ Disposal of Refinery Wastes, Section II: Waste Gases, Vapors, Sludges and Dusts (*American Petroleum Institute*, New York City, 1933).

- 11 *Offensive Trades*, by David Ronald (William Hodge and Co., London, 1935).
- 12 *Limits of Inflammability of Gases and Vapors*, by H. F. Coward and G. W. Jones (*U. S. Bureau of Mines Bulletin No. 378*, 1933).
- 13 *Inflammation Limits and Their Practical Application in Hazardous Industrial Operations*, by G. W. Jones (*Chemical Reviews*, Vol. 32, February, 1933).
- 14 *Private Communication*, by Hyton R. Brown (*Bureau of Mines, College Park, Maryland*).
- 15 *Explosibility of Agricultural and other Dusts as Indicated by Maximum Pressure and Rates of Pressure Rise*, by F. W. Edwards and L. R. Leimbach (*U. S. Department of Agriculture Technical Bulletin No. 480*, October, 1933).
- 16 *Dust Explosion Hazards in Plants Producing or Handling Aluminum, Magnesium, or Zinc Powder*, by H. R. Brown (*U. S. Bureau of Mines Information Circular No. 7148*, March, 1941).
- 17 *Inflammability and Explosibility of Metal Powders*, by J. Hartman, J. Nagy, and H. R. Brown (*U. S. Bureau of Mines Report of Investigation No. 3722*, October, 1943).
- 18 *Inflammability and Explosibility of Powders Used in the Plastics Industry*, by J. Hartman and J. Nagy (*U. S. Bureau of Mines Report of Investigation No. 3731*, May, 1944).
- 19 *Industrial Dust Explosions*, by H. R. Brown (*U. S. Bureau of Mines, Information Circular No. 7309*, January, 1945).
- 20 *Proposed Code for the Prevention of Dust Explosions in the Plastics Industry* (*National Fire Protection Association, Boston, May, 1945*).
- 21 *National Fire Codes for the Prevention of Dust Explosions* (*National Fire Protection Association, Boston, 1945*). Contains codes for aluminum, magnesium, coal, pulverized fuel, flour, spices, starch, sugar, cocoa, sulfur and wood.
- 22 *An Introduction to Pollen Analysis*, by G. Erdtman (*Chronica Botanica Co., Waltham, Mass., 1944*).
- 23 *Pollen Grains*, by R. P. Wodehouse (McGraw-Hill Book Co., New York, 1935).
- 24 *Atmospheric Pollen*, by R. P. Wodehouse (*Aerobiology*, p. 8-31, Publication No. 17, *American Association for the Advancement of Science*, Washington, D. C., 1942).
- 25 *Hayfever Plants*, by R. P. Wodehouse (*Chronica Botanica Co., Waltham, Mass., 1945*).
- 26 *Hay Fever: A Geographical and Botanical Survey*, by E. R. Squibb and Sons, New York, 1937.
- 27 *Techniques for Appraising Air-Borne Populations of Microorganisms, Pollen and Insects* (*Phytopathology*, Vol. 31, March, 1941, p. 201-205).
- 28 *Apparatus for Determining the Pollen Concentration of the Atmosphere*, by B. J. Cody, W. F. Kinney and N. A. Karsels (*Research Department, the Detroit Edison Company, Detroit*).
- 29 *The Volumetric Incidence of Atmospheric Allergens*, by O. C. Durham (*Journal of Allergy*, Vol. 14, September, 1943, p. 445-461).
- 30 *The Volumetric Incidence of Atmospheric Allergens, II: Simultaneous Measurements by Volumetric and Gravity Slide Methods*, by O. C. Durham (*Journal of Allergy*, Vol. 15, May, 1944, p. 223-235).
- 31 *Air-Borne Fungus Spores as Allergens*, O. C. Durham (*Aerobiology*, p. 32-47, Publication No. 17, *American Association for the Advancement of Science*, Washington, D. C., 1943).
- 32 *Sampling Devices*, by H. G. DuBuy and A. Hollander (*American Journal of Medical Sciences*, Vol. 205, February, 1943, p. 173-177).

BIBLIOGRAPHY

- Abstracts and Bulletins (monthly, annual and special) Industrial Hygiene Foundation, Inc., Pittsburgh, Pa.
- Aerobiology, Publication No. 17 (*American Association for the Advancement of Science*, Washington, D. C., 1942).
- Air Sanitation and Industrial Ventilation, by W. N. Witheridge (Detroit, Mich., 1943).
- American Industrial Hygiene Association Quarterly (4400 Fifth Ave., Pittsburgh, Pa.).

Cleaver-Brooks Company

348 E. Keefe Ave., Milwaukee 12, Wisconsin

Complete
15 to 500-hp
Oil Fired

Cleaver-Brooks Steam Boilers

Self-Contained

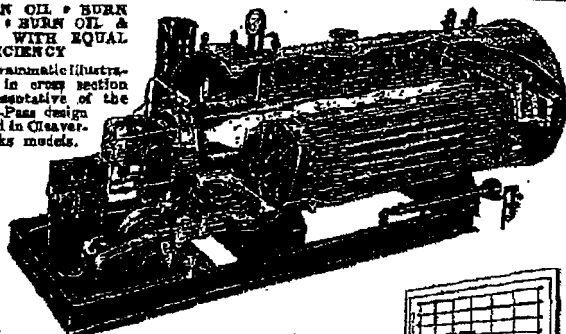
Gas Fired

Factory Tested
15 to 500 lbs. per
sq. in. Oil & Gas Fired

STANDARD SIZES												
HP	11	15	20	25	30	35	40	45	50	60	75	100
Approx. rated capacity for 150 lbs. steam per hour at 150° F.	215	1030	1125	2785	3435	4350	5350	6350	7350	8350	10350	17000

**BURN OIL • BURN
GAS • BURN OIL &
GAS WITH EQUAL
EFFICIENCY**

Diagrammatic illustration
in cross section
representative of the
Four-Pass design
found in Cleaver-
Brooks models.



The outstanding feature of the Cleaver-Brooks steam boiler is its proven high efficiency. Economy of operation is assured by establishing an efficient flame and then absorbing the maximum amount of heat in the four passes.

**CLEAVER-BROOKS HELPS YOU SELECT THE
EXACT STEAM BOILER YOU WANT TO MEET
YOUR SPECIFIC NEEDS**

JOB RATED—Each Cleaver-Brooks steam boiler is job rated to meet the steam requirements of your plant. A competent sales engineer helps analyze your load demands and takes into account these conditions:

- Maximum steam requirements in pounds per hour or boiler horse-power.
- Whether your steam load is constant or fluctuating, and the degree of fluctuation.
- The heating load requirements.
- Standby requirements.
- Steam pressure required at point of use.
- Future growth or expansion of plant facilities.
- Pop valve settings.
- Per cent of total feed water returned as condensate.
- Temperature of condensate.
- Pressure of make-up water.
- Type of fuel available.
- Electric current characteristics.
- Space and machinery arrangements. Bag-gerated boiler room layouts.
- Plant altitude above sea level.

Look for the name "CLEAVER-BROOKS" under the Boiler Section of your classified Telephone Directory.

1326

Cyclotherm Corporation

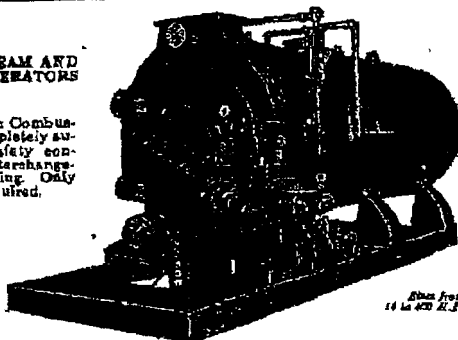
Sales and Executive Offices

Oswego, New York

Factory Distributors throughout the United States

CYCLOTHERM STEAM AND HOT WATER GENERATORS

Operate on Cyclonic Combustion principle. Completely automatic with full safety controls. Oil, gas or interchangeable gas and oil firing. Only four connections required.



Shown from
14 to 400 H.P.

The Cyclonic Combustion operating principle causes the fuel to be burned while spiraling at high velocity around the inside wall of the combustion chamber, forming virtually a tube of flame. This provides uniform and highly efficient heat transfer over the entire furnace wall without hot spots. Complete utilization of heat transfer areas provides quick heat as well as greater than 80 per cent efficiency with the reduced maintenance of a two-pass design.

15 to 80 hp models are equipped with "on-off" controls; 80 to 400 hp models have modulated control. Automatic combustion safeguard, low water and other safety controls are included.

Pressure Range

Available in standard low pressure units or high pressures up to 200 psi. Hot water generators are also available in all sizes.

Standard Burner Arrangements

Fuel	Cyclotherm Model No.
Light Oil, 1 to 3	C-500 thru C-13800
Heavy Oil, 5, 6 and Banker C	C-2800 thru C-13800
Gas, mfd., mixed and natural	C-500 thru C-13800
Comb. lt. oil and gas	C-500 thru C-13800
Comb. hvy. oil and gas	C-2800 thru C-13800

STANDARD RATINGS AND DIMENSIONS

Model No.	Max. H.P. Rating	Output B.T.U. Per Hr.	Steam Units		Hot Water Units		Overall Dimensions (Feet)		
			Steam Per Hr. (Pounds)	Equivalent Evap. (Gals. 212° F.)	Gallons Per Hr. (100° F.)	Equivalent Heat Transfer (Btu. Per Sq. Ft.)	Length	Height	Width
C-500	15	500,000	150	2,000	600	5,330	58	44 1/2	27 1/2
C-700	25	775,000	250	3,700	825	4,400	77	44 1/2	27 1/2
C-1000	35	1,050,000	350	5,100	1,145	3,700	95	44 1/2	27 1/2
C-1300	45	1,325,000	450	6,800	1,355	3,050	117 1/2	45	28 1/2
C-1800	60	1,800,000	600	9,000	1,820	2,400	135 1/2	45 1/2	28 1/2
C-2500	80	2,500,000	800	12,500	2,500	1,800	165 1/2	45 1/2	28 1/2
C-3500	110	3,500,000	1,100	17,500	3,500	1,350	205 1/2	45 1/2	28 1/2
C-4500	135	4,500,000	1,350	22,500	4,500	1,100	245 1/2	45 1/2	28 1/2
C-6000	180	6,000,000	1,800	30,000	6,000	850	305 1/2	45 1/2	28 1/2
C-8000	250	8,000,000	2,500	40,000	8,000	650	385 1/2	45 1/2	28 1/2
C-11000	350	11,000,000	3,500	55,000	11,000	500	485 1/2	45 1/2	28 1/2
C-15000	450	15,000,000	4,500	75,000	15,000	375	605 1/2	45 1/2	28 1/2
C-20000	600	20,000,000	6,000	100,000	20,000	280	745 1/2	45 1/2	28 1/2