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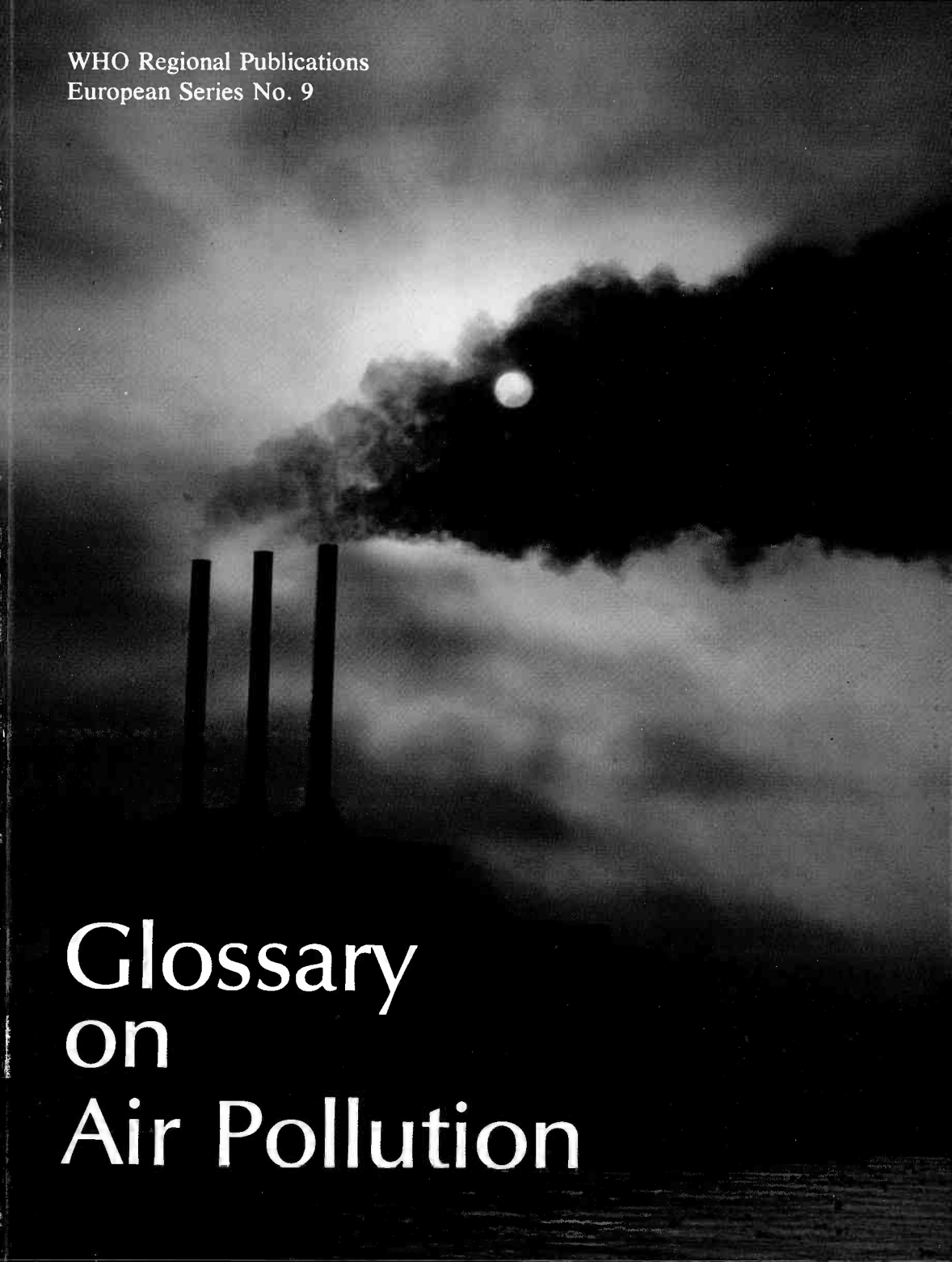

Glossary on Air Pollution

WORLD HEALTH ORGANIZATION
REGIONAL OFFICE FOR EUROPE
COPENHAGEN

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INTRODUCTION

Most of the terms used in the air pollution literature come from a wide range of disciplines – particularly chemistry (analytical, inorganic, and physical), meteorology, physics, and numerous branches of engineering and technology. Added to these are new terms that have been coined solely for use in air pollution work. All too frequently, terms that may appear to be commonly known are in fact not known with their correct meanings: such terms are consequently used incorrectly and interdisciplinary communication is hindered.

The WHO Regional Office for Europe therefore considered it useful to produce a glossary on air pollution that would, as far as possible, reflect internationally standardized terminology, as a contribution to greater understanding between air pollution workers and specialists in the different technical disciplines involved. The definitions of chemical terms are largely in accordance with those of the International Union of Pure and Applied Chemistry. A large number of definitions are quoted verbatim from standard vocabularies published by the following international organizations:

International Commission of Radiation Units and Measurements
International Electrotechnical Commission
International Organization for Standardization
Organisation internationale de Metrologie legale
World Meteorological Organization.

The WHO Regional Office for Europe extends its thanks to all these organizations for their permission to quote these definitions. The Office also thanks the Engineers' Joint Council (USA) for permission to quote the definition of "air pollution" appearing on page 76.

Numerous terms, particularly those that are used only in air pollution studies, have not yet been defined by an authoritative international body. For such terms, the definitions (and of course the terms themselves) are based on prevailing international usage. It should be emphasized that publication of these terms and definitions in this glossary does not imply that they are recommended by the World Health Organization.

Medical and statistical terms, although of course important in air pollution work, are deliberately excluded from the glossary: the former because the World Health Organization and the Council for International Organizations of

Medical Sciences are at present preparing an International Nomenclature of Diseases; the second because several vocabularies of statistical terms produced by authoritative international organizations are available.

The WHO Regional Office for Europe would like to express its indebtedness to all those who have contributed to the glossary. Particular thanks are due to Dr S.R. Craxford, who prepared the first draft as consultant to the Regional Office in this project. The Office is also grateful to the reviewers listed below, who read and commented on the draft, and to Mr D.A. Lowe, Chief, Technical Terminology Service, WHO headquarters, who gave invaluable assistance in the finalization of the volume.

The WHO Regional Office for Europe publishes this glossary on air pollution in the hope that it will prove helpful to all persons concerned professionally or otherwise with air pollution. This edition is to be regarded as provisional and suggestions from users for modifications, corrections, or additions in a future revised edition are welcomed and should be addressed to Director, Promotion of Environmental Health, WHO Regional Office for Europe, Scherfigsvej 8, 2100 Copenhagen Ø, Denmark.

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A

Abatement. The reduction or elimination of pollution, involving either legislative measures or technological procedures, or both. See also *smoke abatement.*

Absorbance. In spectrochemical analysis, a measure of the radiant (or luminous) intensity absorbed by the sample, and, hence, of the concentration of the absorbing species in the sample. It is assigned the symbol A and is defined by the equation $A = \log_{10}(I_o/I_t)$, where I_o is the radiant (or luminous) intensity incident on the sample and I_t the radiant (or luminous) intensity transmitted by the sample. It is related to *transmittance* (q.v.) by the equation $A = \log_{10}(1/\tau)$. The terms "optical density" and "extinction", which have often been applied to absorbance, are deprecated. "Absorbance" is the absorbance of the sample plus that of its container; the absorbance of the sample alone is termed "internal absorbance" or "internal transmission density". Cf. *absorption factor.*

Absorptance. See *absorption factor.*

Absorption. (1) In colloid and surface chemistry, a process whereby, when two phases are brought into contact, a given component is transferred from one phase to the other. Experimental differentiation of absorption and *adsorption* (q.v.) may be difficult, and sometimes the two processes occur simultaneously; in such cases the term "sorption" is used. (2) Of energy, a phenomenon in which radiation transfers to matter which it traverses some or all of its energy (ISO, 5).

Absorption, nondispersive infrared. See *nondispersive infrared absorption.*

Absorption coefficient, linear. *Absorbance* (q.v.) divided by path length (Cf. *absorptivity*). The "molar (linear) absorption coefficient" is the absorbance divided by the path length and by the amount of substance concentration (in moles per litre), and is assigned the symbol a; i.e., $a = A/lc$. The terms "extinction coefficient" and "molar extinction coefficient" for these quantities are deprecated.

Absorption factor. The ratio of the radiant (or luminous) flux absorbed by an optical system, an absorbing medium, etc., to the radiant (or luminous) flux incident on that system, medium, etc. It is assigned the symbol α and is defined by the equation $\alpha = \Phi_a/\Phi_o$. It may also be defined in terms of radiant intensity (i.e., radiant flux over a given solid angle) as $\alpha = I_a/I_o$. The flux (or intensity) that is absorbed clearly depends on the path length (i.e., the thickness of the medium) and on the concentration of absorbing species in the medium. The term "absorptance" should not be used. Cf. *absorbance; absorptivity.*

Absorptivity. *Absorption factor* (q.v.) per unit path length. Cf. *absorption coefficient, linear.*

Accuracy. 1: The closeness of agreement between the "true" value and the mean result which would be obtained by applying the experimental procedure a very large number of times. 2: The degree of uncertainty involved in a measured value of a given quantity. *Note* – The first definition is used in statistics, the second in fields where the "true" value concept is not accepted as valid or useful (provisional ISO, 15). Since a "true" value is an ideal value that can never be known, its validity is not accepted in many fields, particularly in many of the physical sciences.

Acicular. In the description of particles, needle shaped.

Acid. In the "aqueous system", a substance that, when dissolved in water, can form hydrogen ions, H^+ (protons). A substance can show "acidic" properties only in a proton-accepting ("basic") solvent. In water, this results in the formation of hydroxonium ions (H_3O^+); in ammonia, ammonium ions (NH_4^+). The term "acid" has been broadened in the Lewis theory to include electron-deficient substances that act as electron acceptors ("Lewis acids"). Many acids are neither corrosive nor otherwise harmful.

Acid mist. See *sulfuric acid.*

Acrolein. See *2-propenal.*

Actinometer. See *pyrheliometer.*

Active carbon. See *carbon, activated.*

Additive. In the petroleum industry, a suitable substance which, when added to a petroleum product, confers on it special properties or enhances its natural properties (ISO, 4). In general, a substance added to any material or product in order to enhance or alter its natural properties or to impart new properties to it.

Adiabatic process. A thermodynamic transformation which occurs without exchange of heat between the system considered and its environment. In adiabatic processes, "adiabatic cooling" accompanies expansion, and "adiabatic warming" accompanies compression (WMO).

Adsorption. A process whereby one or more components of an interfacial layer between two bulk phases are either enriched or depleted. If the process is one of enrichment, it is known as positive adsorption or simply adsorption;

if it is one of depletion, it is referred to as negative adsorption. The forces involved may be either chemical (valence forces), in which case the process is termed chemisorption (or chemical adsorption), or intermolecular, in which case the term physisorption (or physical adsorption) is used.

Advection. The process of transfer of air mass properties by the velocity field of the atmosphere (WMO). See also *fog, advection.*

Aerodynamic diameter. See *diameter, equivalent.*

Aerodynamic roughness. Roughness of a surface over which a fluid flows, such that the boundary layer becomes turbulent at lower flow speeds (and thus lower values of the *Reynolds number,* q.v.) than would be the case with a similar surface that was completely smooth. The drag depends on the type of surface: with a blunt object, turbulent flow leads to a decrease in total drag (despite the fact that viscous drag is increased); with a streamlined object, viscous drag constitutes the total drag, which therefore remains at a lower level if the boundary layer is maintained in the laminar state. The term "aerodynamic roughness" is relative: whether or not a given surface is "rough" depends on its degree of "roughness" relative to the thickness of the boundary layer.

Aerology. The study of the free atmosphere [i.e., that part of the atmosphere above the friction layer, in which the air motion is affected to a negligible degree by surface friction] (WMO).

Aerosol. A suspension, in a gaseous medium, of solid particles, liquid particles, or solid particles and liquid particles, having a negligible falling velocity (provisional ISO, 8). Solid particles give an "aerosol of solid particles" (*not* a "solid aerosol"), liquid particles an "aerosol of liquid particles" (*not* a "liquid aerosol"). The size of the particles in an aerosol frequently exceeds the normal colloidal limits (which are approximately 1 nm to 1 μm).

After-burner. A combustion chamber in which any smoke, carbon monoxide, or other organic substances in the exhaust gases from furnaces or certain types of engine can be completely burned. The chamber normally contains oil- or gas-fired burners to maintain the necessary high temperature, and the oxygen content of the gases is adjusted by admitting air as required. After-burners are also used to burn malodorous organic substances in gases arising from various processes. If the gases entering the after-burner are sufficiently hot, the use of a catalyst sometimes enables complete combustion to be achieved at a lower than normal temperature, and the provision of fuel to the after-burner may be necessary only when starting-up or

at low throughput. Catalytic after-burners are widely used in industry and have received a great deal of attention as a means of purifying motor vehicle exhaust gases.

Agglomerate. A collection of solid particles that adhere to each other. *Agglomeration*, the action leading to the formation of agglomerates (provisional ISO, 8).

Aggregate. In gas cleaning, a relatively stable assembly of dry particles, formed under the influence of physical forces (provisional ISO, 8). (The process of aggregate formation is known as *aggregation*.) In other contexts, the particles need not be dry. The term is used in colloid chemistry to refer specifically to the structure that results from the cohesion of colloidal particles. Aggregate formation in colloidally unstable sols is termed either *coagulation* (formation of a coagulum) or *flocculation* (formation of a floc); some authors make a distinction between the two terms, but in more general usage they are synonymous.

Air. The mixture of gases which composes the earth's *atmosphere* (q.v.) (WMO). The approximate composition of air is, by volume, nitrogen 78.0%, oxygen 20.95%, argon 0.93%, and carbon dioxide 0.03%, together with very small amounts of numerous other constitutents. The content of water vapour is highly variable and depends on atmospheric conditions. Air is said to be pure when none of the minor constitutents is present in sufficient concentration to be injurious to the health of human beings or animals, to damage vegetation, or to cause loss of amenity (e.g., through the presence of dust, dirt, or odours or by diminution of sunshine).

Air, primary. See *combustion.*

Air, secondary. See *combustion.*

Air basin (or **Airshed**). A geographic area in which, owing to meteorological factors and topographic features, the air is more or less homogeneous and across whose boundaries pollutant transport is minimal. The concept is little used because of the difficulty, at the present stage of development of meteorology and diffusion theory, in defining such areas.

Air chemistry network. An investigation of atmospheric chemistry organized in Sweden, based on measurements of the composition of rainwater and of the concentrations of sulfur dioxide in the air at a large number of sites in rural areas throughout Europe. Results are published in the journal *Tellus.*

Air monitoring. See *monitoring.*

Air pollutant. See *pollutant.*

Air pollution. See *pollution.*

Air pollution index. An arbitrary function of the concentration of one or more pollutants that is taken as a measure of the severity of pollution. For example, the following index has been used in the USA: 10 times the SO_2 concentration plus the CO concentration (both in ppm by volume) plus twice the coefficient of haze. It was considered to be a cause for alarm when the value of this index rose from its average of about 12 to 50 or more. Several such indices are used, but none has more than local use, nor has any been found fully satisfactory.

Air Quality Act. An Act passed by the US Government in 1967 requiring the states to establish regional air quality standards (and setting up a timetable for their doing so) and to control emissions in accordance with national criteria where these existed. It was amended by the Clean Air Act of 1970. See *Clean Air Act (USA).*

Air quality control region. A term used by the US Federal Government for an area either in one state, or extending into other states, in which there is a common air pollution problem.

Air quality criteria. See *criteria.*

Air quality standard. See *standard.*

Air sampling. See *sample; sampling.*

Air sampling network. See *sampling.*

Airshed. See *air basin.*

Aitken particle. A suspended particle in the atmosphere, having a diameter smaller than 10^{-1} μm and larger than about 10^{-3} μm. Owing to their small size, Aitken particles do not normally act as condensation nuclei, but they play an important role in atmospheric electric phenomena. Cf. *nucleus.*

Albedo. The ratio of the radiation (radiant energy or luminous energy) reflected by a surface to that incident upon it (WMO).

Aldehyde. An organic compound containing the group -CHO. Many aldehydes are poisonous. The nauseous smell of diesel engine exhaust is probably due to long-chain aldehydes produced by incomplete combustion of the fuel, as is the smell from poorly adjusted domestic oil burners.

Alert level. A concentration of gaseous pollutants that has been defined by a competent authority as indicating an approaching, or constituting a potential or actual, hazard to health. Several different alert levels may be defined, ranging

from a concentration at which a preliminary warning is issued to one that necessitates emergency action.

Alicyclic compound. See *hydrocarbon.*

Alkali &c Works Regulation Acts. Legislation under which emissions from major chemical works, power stations, metal works, oil refineries, etc., are controlled in the United Kingdom. The first such Act, that of 1863, dealt largely with hydrogen chloride emissions by alkali works using the salt-cake process (heating sodium chloride with sulfuric acid). The Alkali Acts were extended by the Clean Air Acts of 1956 and 1968 to cover 60 processes and the emission of 34 gases and fumes. See *Health and Safety at Work &c Act.*

Alkane. A saturated (i.e., containing no carbon-carbon double bonds) aliphatic hydrocarbon. Alkanes have the general formula C_nH_{2n+2}. The first four members of the series are methane, ethane, propane, and butane. "Alkane" is the systematic chemical name for any such compound; the term "paraffin" is also used. The basic constituents of gasoline and other petroleum products are alkanes.

Alkene. An aliphatic hydrocarbon containing at least one carbon-carbon double bond. Alkenes that contain two double bonds are termed dienes, those with three double bonds trienes, etc. "Alkene" is the systematic chemical name for any such compound; the term "olefin" is also used.

Ambient air. Usually, in the air pollution literature, the air outdoors, as opposed to that indoors (including work-places).

Amenity. Anything that contributes to comfort, convenience, or pleasantness of life. In the air pollution literature, the expression "loss of amenity" is taken to mean an adverse effect on such factors (e.g., the presence of dirt or unpleasant odours, or the diminution of sunshine). Air pollution that causes loss of amenity is not necessarily sufficient to be injurious to health or to have serious economic effects.

Ammonia. A colourless gas with a pungent choking odour; formula NH_3. In nature it is produced, *inter alia*, by the decomposition of vegetable matter, and it is a normal constituent of air in the country, levels of $5-10\,\mu g/m^3$ occurring regularly. See also *nitrogen cycle.*

Ammonia process. A term applied to a method for removing sulfur dioxide from stack gases in which the gases are scrubbed with ammonium sulfite and ammonium hydrogen sulfite solutions, to which ammonia is added at a rate equal to that of sulfur dioxide absorption. The final product is ammonium sulfate. The economic feasibility of the method depends on the price that ammonium sulfate can command as a fertilizer.

Amosite. See *asbestos.*

Amperometric method. A general term for an electroanalytic technique based on the measurement of current or current difference. Depending on the procedure involved, such methods are termed either "amperometry" or "amperometric titration", together with an appropriate modifying phrase. Amperometric methods are widely used for air pollutant measurement and are the basis of most of the instruments that are used for the continuous monitoring of sulfur dioxide concentrations in the atmosphere (such instruments are often, incorrectly, referred to as "coulometric"). Cf. *coulometric method.*

Amphibole. See *asbestos.*

Analysis, coal. The determination of the chemical and physical characteristics and of the constituents of coal. The term *general analysis* is often applied to the determination of the chemical and physical characteristics of coal other than the determination of moisture. *Ultimate analysis* is the analysis of coal expressed in terms of its carbon, hydrogen, nitrogen, sulfur, and oxygen contents. *Proximate analysis* is the analysis of coal expressed in terms of moisture, volatile matter, ash, and fixed carbon (ISO, 2). Analyses are carried out on air-dried coal and the results reported (as percentages) on a *dry* basis; they may in addition be reported on a *dry, ash-free* (daf) basis or a *dry, mineral-matter-free* (dmmf) basis. See also *ash; calorific value, gross; calorific value, net; carbon, fixed.*

Anemogram. The record made by an *anemograph.*

Anemograph (or **Recording anemometer**). An *anemometer* (q.v.) which gives a continuous record of the time variations of the wind (WMO).

Anemometer. An instrument used in the measurement of wind speed or of wind speed and direction (WMO).

Anemometer, counting (or **Run-of-wind anemometer**). An anemometer with cups or a fan whose rotation is transmitted to a mechanical counter which integrates directly the air movement (number of kilometres, for example) past the anemometer (WMO).

Anemometer, recording. See *anemograph.*

Angular. As used in the description of particles, sharp-edged or having a roughly polyhedral shape.

Anthophyllite. See *asbestos.*

Anthracite. A *hard* coal of the highest rank, with a high carbon content (usually over 90%, often about 95%) and a low content of volatile matter, which burns comparatively smokelessly.

Anticyclone (or **High**). A region of the atmosphere where the pressure is high relative to the surrounding region at the same level. It is represented on a synoptic chart by a system of isobars at a specified level or of contours at a specified pressure which enclose relatively high values of pressure or level (WMO). The winds move about the high-pressure area in a clockwise direction (as viewed from above) in the northern hemisphere and in a counterclockwise direction in the southern hemisphere. Under anticyclonic conditions the weather is frequently calm and settled, and favours the buildup of air pollution.

Anticyclonic gloom. A term applied to the reduced illumination caused by the presence of air pollutants (usually smoke) under an anticyclonic temperature inversion.

Anticyclonic inversion. See *inversion, temperature.*

Antiknock agent. A product which, added in very small quantities to fuels for spark-ignition engines, increases their resistance to knocking. In practice, organometallic compounds are used as antiknock agents, notably tetraethyllead and/or tetramethyllead used in conjunction with halogenated compounds which facilitate the evacuation of the lead after combustion (ISO, 4). For the contribution of antiknock agents to pollution, see *tetraethyllead; tetramethyllead.* Several countries have reduced, or are reducing, the permitted content of lead antiknock agents in gasoline. The use of the catalytic converter in automobile exhaust systems, has, for all practical purposes (in the USA, for example), restricted the use of gasoline containing them to automobiles manufactured before the 1974 model year.

Argon. A colourless gaseous element; atomic number 18, relative atomic mass 39.948, symbol Ar. Argon constitutes approximately 0.93% (by volume) of dry air. It is one of the *noble gases* (q.v.).

Aromatic compound. See *hydrocarbon.*

Arsenic. A semi-metallic element; atomic number 33, relative atomic mass 74.9216, symbol As. Arsenic and its compounds are poisonous at very low concentrations. Significant air pollution by arsenical dust has occurred near certain metal-smelting installations and, in India, from the burning of coal with an abnormally high arsenic content. Data reviewed by the International Agency for Research on Cancer indicate a relationship between some forms of cancer and high exposure to inorganic arsenic compounds.

Asbestos. A generic term for a class of natural fibrous silicates that are widely used for thermal and electric insulation, the manufacture of building materials and brake linings, and many other purposes. There are two main types: chrysotile (white asbestos), which is by far the most abundant form, and the amphiboles, of which the most important are crocidolite (blue asbestos), anthophyllite, and amosite. The inhalation of asbestos dust can give rise to asbestosis (a fibrous reaction of the lung) and to increased risk of lung cancer, the degree of risk depending on many factors, including intensity and duration of exposure, the type of asbestos, and the length of the fibres (the longer, thin fibres entail a greater risk). Data published by the International Agency for Research on Cancer indicate that if cancer develops, it does so a long time (30 years or more) after exposure.

Ash. The solid residue of effectively complete combustion (provisional ISO, 8).

Ash, fly. Ash entrained by combustion gases (provisional ISO, 8). In the absence of dust separators, such ash is emitted from the stack.

Ash, total. The residue of the mineral matter obtained by incinerating coal under defined conditions (ISO, 2). The definition may also be applied to other fuels. (The term "ash content" is a misnomer, since the ash is produced only as the result of the combustion process and differs in chemical composition from the original mineral matter.)

Asphalt. A mixture of *bitumen* (q.v.) and mineral matter. In North America the term asphalt is, in addition, used for bitumen alone (ISO, 4). It is a source of intense local pollution at, for example, road-building sites and works where the artificial product is manufactured.

Atmosphere. The gaseous envelope which surrounds the earth (WMO). See also *air.*

Atmospheric chemistry. The branch of meteorology concerned with the chemical composition of the atmosphere, and with the chemical and photochemical processes that occur in the atmosphere (WMO). Of particular importance to air pollution control are reactions by which pollutants (e.g., photochemical smog) are formed and those by which they are changed into inoffensive materials. See also, *inter alia, nitrogen cycle; smog; sulfur cycle.*

Atmospheric stability. See *stability; stability, static.*

Atmospheric turbulence. See *turbulence.*

Atomization. Strictly, the production of an atomic vapour, i.e., a vapour consisting of free atoms, of a given material. Atomization is important, for example, in procedures such as analytical flame spectroscopy. The term is also

widely used as a synonym for *nebulization* (q.v.), i.e., the production of a spray of droplets.

Attenuation. The reduction of a radiation quantity upon passage of radiation through matter resulting from all types of interaction with that matter. Attenuation usually does not include geometric attenuation (ISO, 5). *Attenuation of solar radiation*, the loss of energy suffered by a beam of radiant energy which traverses the earth's atmosphere. Losses are caused by scattering by air molecules, by selective absorption by certain molecules, and by scattering by aerosols (WMO).

Attenuation coefficient. Of a substance, for a parallel beam of specified radiation: the quantity in the expression $\mu\Delta x$ for the fraction removed by attenuation in passing through a thin layer of thickness Δx of that substance. It is a function of the energy of the radiation. According as Δx is expressed in terms of length, mass per unit area, moles or atoms per unit area, μ is called the linear, mass, molar, or atomic attenuation coefficient (ISO, 5).

Attrition. Wearing or grinding down by friction or abrasion; one of the basic processes that contribute to air pollution.

B

Bacharach smokemeter. See *smokemeter.*

Background pollution. The pollution that would exist at a given point if it were unaffected by pollution arising from a specified source. Thus, with respect to a given factory, the background pollution in a nearby town is the observed pollution less that part of it arising from the factory. The term is also applied to pollution as observed in the depth of the country, unaffected by any nearby sources.

Background station. A site for the observation of air pollution that is not affected by local sources of pollution. It may be in the depth of the country or at sea.

Backing (wind). A counterclockwise change of wind direction, in either hemisphere (WMO). Cf. *veering.*

Baffle chamber. A type of settling chamber, containing a system of baffles, in which coarse particulate matter (e.g., fly ash) is removed from stack gases by alteration of its direction or reduction of its velocity, or both.

Bag filter. See *filter bag.*

Bag house. See *filter bag.*

Bagasse. The fibrous part of sugar cane that remains after extraction of the juice. It is burned as a fuel and can cause serious smoke pollution.

Balloon, zero-lift. A small balloon used to track the path of a *plume* (q.v.). It is inflated with a gas that is lighter than air (usually hydrogen), the amount of gas and the weight of the balloon (including any attachments) being adjusted so that the overall buoyancy is the same as that of the plume. It is assumed that the buoyancy of such a balloon adjusts to temperature fluctuations in the surroundings and that the balloon therefore remains balanced in the plume as the latter is diluted by the air. Also called zero-weight balloon.

Banking. Partly smothering a fire with very fine coal or ash so that combustion is just maintained and relighting is not necessary when heat is wanted subsequently. In some areas it is common practice with domestic fires overnight and is apt to give rise to increased smoke pollution.

Barium sulfate method. A turbidimetric method for the determination of sulfur dioxide. Air is passed through a solution of hydrogen peroxide, with which sulfur dioxide reacts to form sulfuric acid; addition of barium chloride solution produces the insoluble sulfate, and the turbidity of the suspension is determined in a spectrophotometer.

Barogram. The record made by a *barograph* (WMO).

Barograph (or **Recording barometer**). A barometer which gives a continuous graphic representation of the atmospheric pressure variations with time (WMO).

Barometer. An instrument for measuring atmospheric pressure (WMO).

Batch process. A process in which raw materials are fed into a plant in discrete batches rather than continuously. If air pollutants are produced by such a process they are usually rather more difficult to deal with than those produced by a continuous process.

Battersea process. A method of removing sulfur dioxide from stack gases, first used at Battersea Power Station, London, England. The gas is washed with water containing a little lime under such conditions that the resulting solution of calcium sulfate is not saturated and can be discharged into the river from which the water for washing is taken.

Beaufort scale. A wind force scale, originally based on the state of the sea, expressed in numbers from 0 to 12 (WMO).

Benzene. A clear, colourless, volatile, flammable liquid; an aromatic hydrocarbon, formula C_6H_6. Benzene is widely used in the chemical industries and is a minor constituent of gasoline. It is highly toxic, and there is evidence that occupational exposure to the vapour entails an increased risk of the development of leukaemia.

Benzole and allied products. A term used in the benzole industry for a collection of aromatic hydrocarbons (benzene and its homologues) pure or commercially pure, isolated or in mixtures, and whether or not containing impurities in a substantial proportion provided that the aromatic type products predominate in the bulk of the mixture (ISO, 6). "Benzole" consists largely of benzene, together with methylbenzene (toluene), dimethylbenzenes (xylenes), and various other compounds. The term should not be applied to *benzene* (q.v.).

Benzo[*a*]pyrene. A polynuclear (5-ring) aromatic *hydrocarbon* (q.v.) that occurs, *inter alia*, in coal tar, soot, and tobacco smoke. It has been shown to be carcinogenic in laboratory animals when administered by a number of different routes. Whether or not it represents a hazard as an air pollutant is still under investigation.

Beryllium. A metallic element, atomic number 4, relative atomic mass 9.01218, symbol Be. Beryllium and its alloys and compounds are used in nuclear reactors, in the aerospace industry, and in the manufacture of electronic components (formerly also in the phosphor coating in the interior of fluorescent lamps, but owing to their toxicity their use for this purpose has been discontinued). Beryllium compounds, and the metal itself when in powder form, are highly poisonous and exposure to them may cause a chronic progressive disease known as berylliosis. Air pollution by dust containing beryllium may occur in the vicinity of factories where the metal is produced or used.

Bessemer converter. See *furnace, steel-making.*

Bifurcation. The splitting of a plume of stack gases into two as it leaves the stack.

Biometeorology. The study of the influences exerted on living organisms by the *meteorological elements* (q.v.) (WMO).

Biosphere. The spherical terrestrial layer comprising the lower part of the atmosphere, the seas, and the upper layers of the soil, within which living organisms can exist naturally (WMO).

Bitumen. A viscous liquid, semi-solid, or solid, consisting essentially of hydrocarbons and their derivatives, which is soluble in carbon disulfide. Bitumen is obtained from the distillation of suitable crude oils by treatment of the residues (or occasionally of the heaviest fraction). It is also a component of naturally occurring asphalt (ISO, 4). To improve its properties for certain uses, bitumen is oxidized by blowing air through the molten material; this process, which is carried out on a large scale, can produce intense air pollution.

Blood rain. Rain coloured red by particles of pollen, red dust, etc. (WMO).

Blow-by. See *crank-case blow-by.*

Bosch-Dunedin smokemeter. See *smokemeter.*

Boundary layer. In the flow of a fluid past a solid boundary, a thin layer of fluid close to (but not in contact with) the boundary in which there is a velocity defect, i.e., in which the flow is retarded, owing to viscous forces. Depending on the *Reynolds number* (q.v.), the boundary layer may be either laminar or turbulent. See also *flow, laminar* and *flow, turbulent. Planetary boundary layer* (or friction layer), an atmospheric layer extending from the earth's surface and of depth about 600 to 800 m, within which air motion is affected significantly by surface friction. Above this layer lies the "free atmosphere" (WMO). *Surface boundary layer* (or ground layer), a thin layer of air adjacent to the earth's surface and of a depth which has been variously given as 10 m to 100 m (WMO).

Breathing of containers. Movement of gas (oil vapour or air) in and out of the vents of storage vessels due to alternative heating and cooling (ISO, 4a). The term "breathing" is also applied to the release into the atmosphere of blow-by gases from the crank-case of an internal combustion engine through a vent known as a "breather". Both processes contribute to air pollution.

Breeching. The duct connecting a furnace to its stack.

Breeze. In the coal and coke industry, the undersize remaining after separating the smallest sizes of graded coke (ISO, 3). In meteorology, a wind whose speed ranges from approximately 3.1 – 4.1 m/s ("light breeze") to approximately 11.3 – 13.4 m/s ("strong breeze") (based on WMO). *Land breeze*, a wind of coastal regions, blowing at night from the land towards a large water surface as a result of nocturnal cooling of the land surface. *Sea breeze* (or *Lake breeze*), a wind of coastal regions, blowing by day from a large water surface (sea or lake) towards the land as a result of diurnal heating of the land surface. *Valley breeze*, an anabatic wind which blows during the day, along the slopes, from valleys towards the mountains (all WMO).

Bubbler. See *gas washbottle.*

Buoyancy. The upward force that acts on a body that is totally immersed in a fluid. It is equal to the weight of the fluid displaced by the body, so if the density of the immersed body is less than that of the fluid, there will be a net upward force on the body. As the density of a gas decreases with temperature, the upward force on a parcel of warm air will be greater than its weight and it will rise. This will continue until the parcel of air cools to the temperature of its surroundings. The behaviour of a plume of hot gas issuing from a chimney provides an example.

C

Cadmium. A metallic element, atomic number 48, relative atomic mass 112.40, symbol Cd. Some cadmium compounds are toxic. Air pollution by cadmium or its compounds is likely to occur in the vicinity of zinc smelting works (since zinc and cadmium occur together in nature) and of factories where the metal is used.

Calibration. All the operations for the purpose of determining the values of the errors of a measuring instrument (and if necessary to determine other metrological properties) (OIML). Calibration of an instrument results in a correction factor or a series of correction factors that can subsequently be applied to readings given by the instrument.

Calorific value, gross. The number of heat units measured as being liberated when unit mass of coal [or other fuel] is burned in oxygen saturated with water vapour in a bomb under standardized conditions, the residual materials being taken as gaseous oxygen, carbon dioxide, sulfur dioxide, and nitrogen, liquid water in equilibrium with its vapour and saturated with carbon dioxide, and ash (ISO, 2).

Calorific value, net. The gross calorific value less the enthalpy of evaporation of the water originally contained in the fuel and that formed during its combustion (ISO, 2).

CAMP. An acronym for Continuous Air Monitoring Program (USA).

Candle. See *lead peroxide; lead dioxide method.*

Carbon. A nonmetallic element, atomic number 6, relative atomic mass 12.011, symbol C. Carbon compounds make up all living matter and, consequently, fuels such as coal and petroleum.

Carbon, activated. A form of carbon that is characterized by its high adsorptive properties. It often takes the form of charcoal produced from wood or coconut shells, but it is also produced from bones and other sources. The carbon is activated by heating it to a temperature of 800–900 °C in the presence of steam, which gives it a porous internal structure, greatly increasing the surface area available for adsorption. Activated carbon (also termed "active carbon") is widely used as a decolourizing and deodorizing agent, as a gas adsorbent, and for many other purposes.

Carbon, fixed. That part of the carbon content of coal that remains as coke when the coal is carbonized.

Carbon black. Sustantially pure, finely divided carbon, usually produced from gaseous and liquid hydrocarbons by controlled combustion with restricted air supply so as to obtain incomplete combustion (ISO, 4). Since it is not easy to remove the last traces of the product from gases leaving the stack, the production of carbon black is often a source of intense air pollution.

Carbon cycle. In biochemistry, a series of processes in which (1) plants use atmospheric (or, in aquatic plants, dissolved) oxygen as a raw material for the production of organic matter (carbohydrates) by photosynthesis, (2) the plants either die or are eaten by animals, and (3) the decay of the plants, or the excreta of the animals, and of the animals themselves after death gives rise to carbon dioxide, which returns to the atmosphere (and water).

Carbon dioxide. A colourless, odourless gas, formula CO_2. It is approximately 50% heavier than *air* (q.v.), of which it is a normal constituent. It is formed by certain natural processes (see *carbon cycle*) and by the combustion of fuels containing carbon, and it has been estimated that the amount in the air is increasing by 0.27% annually (see also *greenhouse effect*). Only in the most exceptional circumstances do local concentrations of carbon dioxide in air rise to levels that are dangerous to health, but it plays a significant role in the decay of building stones and in corrosion.

Carbonization. An operation consisting in the treatment of coal by heat in a closed vessel usually with the object of producing coke or gas. *High temperature carbonization*, carbonization carried out generally above 900 °C. *Medium temperature carbonization*, carbonization carried out generally between 600 and 900 °C. *Low temperature carbonization*, carbonization carried out generally below 600 °C (ISO, 6). High temperature carbonization is used for the production of coal gas and (at 1300 °C) blast furnace coke. Low temperature carbonization is used to produce reactive cokes for use as "smokeless" fuels. Carbonization also gives many by-products (e.g., coal tar) of great importance to the chemical industries.

Carbonized briquette. Finely divided coal formed into a briquette, usually with pitch as a binder, and carbonized to give a relatively smokeless fuel. See also *fuel, solid smokeless.*

Carbon monoxide. A colourless, almost odourless, flammable gas, formula CO. It is produced, *inter alia*, by the incomplete combustion of organic materials (e.g., in automobile engines) and normally occurs in trace amounts in the atmosphere. At concentrations exceeding about 100 cm^3/m^3 (0.01%) it is highly toxic. Its affinity for haemoglobin (with which it combines to form carboxyhaemoglobin) is between 200 and 300 times that of oxygen, and it has the

effect of reducing the oxygen-transport capacity of haemoglobin and leading to death by asphyxiation. Concentrations of carbon monoxide in city streets (arising mainly from motor vehicle exhausts) can be sufficiently high to cause concern, as can those resulting from tocacco smoking in unventilated rooms.

Carboxyhaemoglobin. See *carbon monoxide.*

Carburettor. A device that produces a mixture of gasoline and air for admission to the cylinders of one type of spark-ignition internal combustion engine. If improperly adjusted, it can be a source of pollution by allowing gasoline vapour to escape into the air.

Carcinogen. An agent – chemical, physical, or biological – that can act on living tissue in such a way as to cause a malignancy.

Ceiling (or **Height of cloud base**). The height above the earth's surface, at a given point, of the base of the lowest cloud whose *cloud amount* (q.v.) exceeds a given value (WMO). The term "ceiling" is also applied to the maximum height in the atmosphere attained by a given air mass, including that contained within a balloon.

Ceiling projector. See *cloud searchlight.*

Cenosphere. A small hollow glassy sphere, often bearing similar excrescences. Cenospheres may be emitted from furnaces fired with pulverized fuel. They are often confused with solid glassy spheres.

Cetane number. A number on a conventional scale, indicating the ignition quality of a diesel fuel under standardized conditions. It is expressed as the percentage by volume of cetane [i.e., hexadecane] in a reference mixture having the same ignition delay as the fuel for analysis. The higher the cetane number, the shorter the ignition delay (ISO, 4).

Channelling. See *venturi effect.*

Charcoal. A form of carbon produced by the destructive distillation of wood (i.e., the heating of wood out of contact with air). See *carbon, activated.*

Chemiluminescence. The emission of absorbed energy in the form of light as a result of a chemical reaction. Measurement of the light emitted can give a measure of the concentration of one of the reactants if that of the other is known. Such methods are commonly used for the determination of atmospheric ozone and nitrogen oxide (nitric oxide), based on the reaction of these pollutants with ethylene and ozone, respectively.

Chemosphere. A term proposed for that part of the high atmosphere in which molecular dissociation and recombination take place during the day and night respectively, under the influence of ultraviolet radiation (WMO).

CHESS. An acronym for Community Health and Environmental Surveillance System (USA).

Chimney height, effective. See *stack height, effective.*

Chimney Heights Memorandum. A document issued by the United Kingdom Ministry of Housing and Local Government in 1963 (2nd ed. 1967) giving a simple method for calculating the height of stack required for a given boiler or furnace to avoid causing unacceptable pollution by sulfur dioxide in the vicinity. The document takes into account the type of district, the capacity of the plant, etc. It is not binding in law.

Chlorosis. A condition of disease in green plants marked by yellowing or whitening.

Chromatography. An analytic technique used principally for separating the components of a sample by distributing them between a stationary and a moving ("mobile") phase. The stationary phase may be a solid, a liquid, or a gel and may take the form of a column, a layer, or a film; the mobile phase may be either a liquid or a gas. In gas chromatography (GC) the mobile phase is a gas and the stationary phase is either a liquid (*gas-liquid chromatography*, GLC) or a solid (*gas-solid chromatography*, GSC). Gas chromatography, particularly with electron capture detection, can be used for the determination of hydrocarbon and certain chlorinated hydrocarbon air pollutants; with flame ionization detection it can be used for the determination of carbon monoxide. See also *flame ionization analysis.*

Chromium. A metallic element, atomic number 24, relative atomic mass 51.996, symbol Cr. It is widely used in the manufacture of alloys (e.g., stainless steel) and for electroplating. Most chromium compounds are poisonous and many cause dermatitis and skin ulceration. A possible relationship between occupational exposure to chromates and increased risk of lung cancer is under investigation. Chromium compounds are also phytotoxic and may cause damage to crops grown in the vicinity of works that produce or use them.

Chrysotile. See *asbestos.*

Classification. Of powders, separation into fractions according to particle size, shape, and density by means of a fluid. For example, advantage may be taken of the different rates of fall of the fractions through a fluid, or their different behaviour in a flowing fluid.

Clean Air Act (UK). The name given to two Acts passed by the United Kingdom Government. The 1956 Act dealt with the control of smoke from industrial and domestic sources. It was extended by the Act of 1968, particularly to control the heights of stacks of installations in which fuels containing sulfur are burned. Both Acts are now subsumed and extended under the *Control of Pollution Act (1974)* (q.v.).

Clean Air Act (USA). The name given to two Acts passed by the US Government. The Act of 1963 affirmed the authority of the Federal Government in dealing with interstate pollution situations, although it recognized air pollution to be primarily a state and local problem. The Act of 1970 empowered the Federal Government to set national air pollution standards (in place of state standards) and required the states to meet those standards (but to develop their own ways of doing so). It also set up air quality control regions immediately.

Climate. The fluctuating aggregate of atmospheric conditions characterized by the states and development of the weather of a given area. *Continental climate*, the climate characteristic of the interior of large continents. The distinctive feature is the large annual, or daily, or both annual and daily, range of temperature. *Maritime climate*, the climate of regions adjacent to the sea. It is characterized by small diurnal or annual, or both diurnal and annual, amplitudes of temperature, and by high relative humidity. *Mediterranean type of climate*, a type of climate characterized by warm, dry summers and rainy winters. *Monsoon climate*, the type of climate found in regions subject to monsoons, characterized mainly by a dry winter and wet summer. *Mountain climate*, a climate governed by the height factor. It is characterized by low pressure and by intense solar radiation rich in ultraviolet rays (all WMO).

Cloud. A visible aggregate of minute particles of liquid water or ice, or of both together, in suspension in the atmosphere. This aggregate may include larger particles of liquid water or ice, non-aqueous particles or solid particles, originating, for example, from industrial gases, smoke, or dust (WMO).

Cloud, convection. A cumuliform cloud formed in an atmospheric layer made unstable by heating of its base (WMO).

Cloud, orographic. A cloud whose presence and shape are determined by the relief of the earth's surface (WMO).

Cloud amount. The fraction of the sky covered by the clouds of a certain [type] (WMO).

Cloud base. The lowest zone of a cloud in which the degree of obscurity develops perceptibly from that which corresponds to a clear or hazy atmosphere to end in that which corresponds to the presence of water drops or ice crystals (WMO).

Cloud searchlight (or **Ceiling projector**). A projector designed to give, at night, an illuminated spot on the base of a cloud layer (WMO). The angle of inclination of this spot is measured with an instrument known as a clinometer, and the height of the cloud base may then be calculated.

Cloudy sky. Sky with a total cloud cover equal to 3, 4, or 5 oktas (an okta is cloud cover equal to one-eighth of the celestial dome) (WMO). If the cloud cover is equal to 6 or 7 oktas the sky is *very cloudy*, and if equal to 8 oktas it is *overcast.*

Coagulation. See *aggregate.*

Coal. A combustible mineral material, consisting largely of carbon together with varying amounts of hydrocarbons, other organic compounds, and inorganic materials. Classified geologically as a sedimentary rock, it is formed (by decomposition and other changes) from vegetable matter buried under sediments and subjected to pressure over geologic ages. The extent to which the changes have proceeded is a major factor in determining the type of coal: the further they have progressed, the higher the "rank" of the coal.

Coal, bituminous. Black coal with a high (as much as 40%) content of volatile matter. It burns with a smoky flame and in some countries is used for domestic heating in areas not subject to smoke control.

Coal analysis. See *analysis, coal.*

Coal equivalent. In principle, the mass of a standard coal that would on combustion produce the same quantity of heat as a given mass of a given fuel. In practice, certain arbitrary rules are applied in calculating coal equivalents, these rules varying from one country to another.

Coalescence. The action by which liquid particles in suspension unite to form particles of greater volume (provisional ISO, 8).

Coal gas. See *gas, coal.*

COH. See *haze, coefficient of.*

Coke. The solid residue of the distillation of coal at high temperature (above 800 °C) (ISO, 3). Since the sulfur content of coke is about the same as that of the coal from which it was produced, its use in place of coal has little effect on sulfur dioxide pollution; compared with coal, however, it causes very little smoke pollution. *Blast-furnace coke*, coke specially prepared in coke ovens for use in blast furnaces; usually large coke of a narrow size range (ISO, 3). This type of coke can be burned only in special stoves or furnaces in which the conditions necessary for combustion can be maintained. *Low temperature coke*,

the solid residue of the low temperature distillation of coal (500 to 800°C) (ISO, 3). Such coke is sufficiently reactive to burn on an open fire. *Metallurgical coke,* see *blast-furnace coke* above. *Petroleum coke*, a blackish solid product consisting essentially of carbon, mostly obtained by thermal cracking (ISO, 4).

Coke breeze. See *breeze.*

Coke oven. An oven for the production of blast-furnace coke by the high temperature carbonization of coal. A large number of such ovens are usually constructed in a battery. Each oven is charged with coal from the top and at the end of the carbonizing period the incandescent coke is pushed out and immediately quenched, usually with water. Charging and discharging operations give rise to intense air pollution. Pollution arising from the quenching operation can be eliminated by *dry quenching*, in which the coke is cooled by the circulation of oxygen-free gas in a closed system, the heat being recovered in a waste-heat boiler.

Cold drain. Synonym for *katabatic wind*. See *wind.*

Collection efficiency. The fraction of the total number of falling rain drops that, initially on a collision course with particles in the air, actually collides with and removes those particles. The term is also applied to the removal, in a similar manner, of fine water droplets (in which case collision is followed by coalescence) and to the removal of solid or liquid particles by collision with water droplets in a cloud.

Colorimeter. An instrument for measuring the absorption of light by a coloured solution and hence determining the concentration of a coloured constituent of the solution. Light (often of a particular wavelength, or group of wavelengths, obtained by means of a filter) is passed through a sample, the amount that is transmitted being measured either visually or (in a photoelectric colorimeter) electrically.

Combustion. A chemical reaction in which a material combines with oxygen with the evolution of heat: "burning". The combustion of fuels containing carbon and hydrogen is said to be *complete* when these two elements are all oxidized to carbon dioxide and water. Incomplete combustion may lead to (1) appreciable amounts of carbon remaining in the ash; (2) emission of some of the carbon as carbon monoxide; and (3) reaction of the fuel molecules to give a range of products of greater complexity than that of the fuel molecules themselves (if these products escape combustion they are emitted as smoke). The combustion of volatile products can be rendered more complete if air (termed "secondary air") is admitted over or beyond the fuel bed (air admitted through the fuel bed is termed "primary air"). Air in excess of the amount theoretically required for complete combustion ("excess air") is kept to the

minimum compatible with complete combustion (and absence of smoke) in order to avoid undue loss of heat in the stack gases, poor heat transfer, and oxidation of sulfur dioxide to sulfur trioxide. *Overfeed combustion*, a system in which fuel is fed in on top of the incandescent fuel bed; it tends to produce smoke. *Toroidal combustion*, a system in which vortex flow is maintained in the furnace, increasing the residence time of the fuel in the furnace and improving combustion so that little or no excess air is neccesary.

Combustion chamber. An enclosed or partially enclosed space in a boiler, furnace, engine, etc., designed for the purpose of combustion.

Compression ignition engine. See *internal combustion engine, reciprocating.*

Condensation. The change of a substance from the vapour phase to the liquid phase, usually as a result of cooling. The term is also applied to a chemical reaction in which two substances combine with the loss of water or a simple alcohol.

Condensation level. The level at which air becomes saturated on being subjected to a specified process (WMO).

Condensation nucleus. See *nucleus.*

Conductometric method. A general term for an electroanalytic procedure based on measurement of the conductance (or sometimes the admittance or susceptance) of a solution containing an electrolyte as its concentration (or volume) is varied. Conductometric methods have received wide appplication in continuous sulfur dioxide recorders. (Note: the spelling "conductimetry", "conductrimetric", etc., is deprecated.)

Contaminant. In some contexts (e.g., in relation to gas cleaning equipment), used as a synonym for "pollutant" (provisional ISO, 8). In air pollution contexts also the two terms are used synonymously, but some authors make a distinction, considering a contaminant to be an addition (e.g., carbon dioxide) to the atmosphere that causes the composition of the latter to vary from its mean global values, but which is not known to have any deleterious effect.

Control of Pollution Act (1974). An Act passed by the Government of the United Kingdom extending the provisions of the Clean Air Act (1968) and of the Alkali Acts and empowering the Government to regulate the composition of motor fuels and the sulfur content of fuel oils.

Control strategy. A combination of measures (*control techniques*) designed to reduce and control pollution. The measures may include the use of certain equipment, limits on the emission of pollutants, taxes on emissions, rules governing the location of industry, etc. The strategy may be directed against a particular pollutant or may be an overall strategy to reduce pollution in general.

Control technique. See *control strategy*.

Conurbation. An extensive urban area resulting from the expansion of a number of towns or cities to fill the original intervening rural areas.

Convection. Organized internal motions within a layer or air, leading to vertical transport of heat, momentum, etc. (WMO). In air, the convection most commonly occurs as the result of the buoyancy of a mass of air in contact with a hot surface, which leads to a vertical current of air above that surface. Convection may also occur by means of air currents and eddies that are set up mechanically, as when air passes over high ground.

Cooling tower precipitation. The drizzle that occurs around water cooling towers that are not fitted with spray eliminators. If the circulating water within the tower contains salt, sewage, or other dissolved material, such precipitation can be a source of pollution. In addition, certain wind conditions that produce a down-draft inside the tower, or high tangential velocities, may result in water droplets being blown out of the base of the tower. Cooling tower precipitation is also referred to as "drift" and "carry-over".

Coriolis force. The composite centrifugal force, due to the rotation of the earth, which acts on moving particles whose motion is considered relative to that of the earth (WMO). As a result of the Coriolis force, a particle moving on or above the surface of the earth, in a straight line relative to a frame of reference fixed in space, appears to an observer on the earth to be moving in a curved path. When viewed along the direction of motion, the particle is deflected to the right in the northern hemisphere and to the left in the southern hemisphere. The effect of the Coriolis force is negligible over distances of the order of a few kilometres, but is of great importance in determining the direction of winds and the dispersion of pollutants on a global scale.

Cost function. The relationship between the degree to which pollutant emission is reduced and the cost of such reduction.

Coulometric method. A general term for an electroanalytic procedure based on measurement of the quantity of electricity (in coulombs, hence the name) necessary to carry out a given chemical reaction. There are two general types: controlled-potential coulometry, in which a constant electrode potential is maintained by adjustment of the current, and controlled-current coulometry. Coulometric methods have been used for the measurement of pollutant concentrations in air, but most so-called coulometric techniques are in fact not coulometric at all; they are, rather, *amperometric methods* (q.v.).

Crank-case blow-by. A mixture of air, gasoline vapour, and exhaust gases that escapes from the cylinders of an internal combustion engine by blowing past the piston rings into the crank case. If this mixture is not returned to the

cylinders to be burned, it can account for some 20% of the total emission of hydrocarbons from the engine. Positive crank-case ventilation, in which the mixture is returned to the cylinders by means of suction from the intake manifold, is now obligatory in many countries.

Crank-case ventilation, positive. See *crank-case blow-by.*

Criteria (or **Exposure-effect relationship).** The quantitative relations between the exposure to a pollutant and the risk or magnitude of an undesirable effect under specified circumstances defined by environmental variables and target variables (UN proposal to the Stockholm Conference, 1972, proposed WHO/UNEP).

Crocidolite. See *asbestos.*

Cryptic damage. Damage of which there is no visible sign at the moment but that may become apparent subsequently.

Cupola. A vertical cylindrical furnace for melting metals such as cast iron or scrap iron and steel. Coke and a flux are mixed with the charge. Unless precautions are taken, cupolas can cause local air pollution by grit and dust.

Cyclone (in gas cleaning). See *dust separator.*

Cyclone (or **Depression** or **Low).** A region of the atmosphere in which the pressure is low relative to the surrounding region at the same level. It is represented on a synoptic chart by a system of isobars at a specified level or of contours at a specified pressure which enclose relatively low values of pressure or level (WMO). The inwardly spiralling winds move about the central low-pressure area in a counterclockwise direction (as viewed from above) in the northern hemisphere and in a clockwise direction in the southern hemisphere. The term "depression" is usually used in weather forecasting for cyclones other than tropical storms.

D

DAF. An acronym for "dry, ash-free". See *analysis, coal.*

Damage function. The relationship between the degree to which pollutant emission is reduced and the cost of the damage that is thereby averted.

Damper, barometric. A balanced pivoted plate set in a flue between a furnace and its stack, and actuated by the draft in the stack. If the draft becomes excessive as a result of meteorological conditions at the mouth of the stack, the damper prevents an undue rise in gas flow through the furnace.

Decay. In atmospheric chemistry, the disappearance of a pollutant as a result of absorption or chemical reaction at the earth's surface, to removal by rain, or to transformation into some other substance.

Deduster. See *dust separator.* The term is also sometimes applied to a fine sieve or elutriator for removing fine dust from powders.

Degree-day. The algebraic difference, expressed in degrees, between the mean temperature of a given day and a reference temperature. [The total degree-days for a given period are the] algebraic sum of the "degree-days" of the different days of the period (WMO). See also *degree-day, heating; temperature, accumulated.*

Degree-day, heating. A form of *degree-day* used as an indication of fuel consumption. One heating degree-day is counted for each degree that the daily mean temperature is lower than a base temperature, e.g., 19 °C (WMO). The total number of degree-days for the heating season are the algebraic sum of the degree-days for the different days of the season. See also *temperature, accumulated.*

Dendritic. In the description of particles, having a branched crystalline shape.

Deposit gauge. An instrument for measuring the amount of solid material (grit, dust, etc.) that is deposited from the air in a given time. It is very difficult indeed to make an absolute measurement of this quantity for numerous reasons, e.g., if the deposit is collected in a bowl, the aerodynamic disturbance caused by the edge of the bowl affects the flow of falling material; if the bowl is dry some of the material collected in it is re-entrained by the wind, and if it is wet it collects not only material falling into it from the air but also material picked up by the wind from the ground nearby. A number of different types of deposit

gauge have been standardized and in any comparative investigation of rate of deposit a single standard type must be used as specified. From the results obtained with one type it is impossible to predict the results that would be given by another.

DERV. An acronym for diesel engined road vehicle. The term is often applied to a special grade of *gas-oil* with an extra-low sulfur content, used as a fuel for such vehicles. See *fuel, petroleum.*

Desorption. A decrease in the amount of an adsorbed substance. The term should not be applied to the depletion of one or more components of an interfacial layer that accompanies accumulation of other components of the layer; such a depletion process is termed negative *adsorption* (q.v.).

Desulfurization. The removal of sulfur (e.g., from stack gases, coal, or oil).

Determination. In analytical chemistry, the measurement of the amount or concentration of one or more constituents of a sample.

Dew. A deposit of water drops on objects at or near the ground, produced by the condensation of water vapour from the surrounding clear air (WMO).

Dew-point. The temperature at which *dew* first appears on a solid surface whose temperature is steadily reduced below that of surrounding moist air. (The dew-point, or thermodynamic dew-point temperature, is technically defined as the temperature T_d of moist air at pressure p and with mixing ratio r at which moist air, saturated with respect to water at the given pressure, has a saturation mixing ratio r_w equal to the given mixing ratio r – WMO).

Dew-point, acid. The temperature at which a condensate of dilute sulfuric acid first appears when a sample of stack gases containing sulfur trioxide is cooled. The amount of sulfur trioxide in the gas can be calculated from this temperature if the amount of moisture in the gas is known.

Diameter, equivalent. The diameter of a spherical particle of the same density that, relative to a given phenomenon or property, would behave as the particle under investigation (provisional ISO, 8). In the study of particulate pollutants, some of the often used equivalent diameters are those related to free-falling velocity, surface area, volume, and aerodynamic properties.

Diameter, projected. The diameter of the circle whose area is equal to the projected area of a given particle.

Diameter, Stokes. The diameter of a sphere that will fall through a liquid at the same rate as a given particle under the conditions of validity of *Stokes*

law (q.v.). The Stokes diameter of a near-spherical particle of a powder is about 1.5 times its projected diameter.

Dibenzo[*b,e*][1,4]dioxin, 2,3,7,8-tetrachloro-. A compound that may be formed as a by-product in the manufacture of certain chlorinated benzene compounds, particularly trichlorophenol and its derivatives, some of which are widely used as herbicides, and that may occur as a contaminant in such products. Commonly known as TCDD or "dioxin", it is one of the most poisonous substances known, and is also teratogenic. Similar properties are shown by other chlorinated dibenzodioxins. There have been reports of illness and death resulting from occupational exposure to TCDD, and the compound has been formed and released into the atmosphere as a result of accidental overheating, etc., in factories manufacturing trichlorophenol and related products, leading to serious pollution.

Diem plate. A *deposit gauge* (q.v.) consisting of a horizontal plate coated with petrolatum, to which particles of grit and dust in the dry air adhere when they fall on it. It is widely used in the Federal Republic of Germany.

Diesel engine. See *internal combustion engine, reciprocating.*

Diesel oil. See *fuel, petroleum.*

Diffusion. The process by which fluids in contact slowly mix as a result of molecular motions, ultimately producing a homogeneous mixture. Fick's law states that the number of molecules that cross a given area per second is proportional to the area and to the concentration gradient in a direction normal to the area. Molecular diffusion should not be confused with turbulent diffusion, which brings about very much more rapid mixing. See *diffusion, turbulent.*

Diffusion, coefficient of. The coefficient of proportionality in Fick's law (see *diffusion*). It can be defined as the number of molecules that cross unit area in unit time per unit negative concentration gradient.

Diffusion, turbulent (or **Eddy diffusion**). The diffusion of matter, or of air particle properties such as heat and momentum, by eddies in a turbulent flow (WMO).

Diffusivity. See *diffusion, coefficient of.*

Diffusometer. See *pyranometer.*

Dilution index, relative. The concentration at any point of a pollutant emitted by a given source divided by its rate of emission.

Dioxin. See *dibenzo[b,e][1,4]dioxin, 2,3,7,8-tetrachloro-.*

Directional gauge. A term for any pollution measuring instrument designed to admit air for analysis, or wind-borne dust, only when the wind is in a given direction.

Dissociation. The breakdown of a substance into simpler substances owing to the addition of energy (e.g., heat) or the effect of a solvent.

Dithizone method. A method for the determination of heavy metals, particularly lead. The sample (collected by passing air through filter paper) is ashed with nitric acid and the residue dissolved in nitric acid. After adjustment of the pH ammonium cyanide is added and the solution is extracted with a chloroform solution of dithizone, followed by spectrophotometric determination.

DMMF. An acronym for "dry, mineral-matter-free". See *analysis, coal.*

Dolomite. A natural calcium magnesium carbonate. It has been proposed as a source of alkali for various methods of removing sulfur oxides from stack gases.

Donora. An industrial town in Pennsylvania, USA, where a classic air pollution episode occurred in 1948.

Dose. The quantity of a substance or the amount of energy introduced into a target in a single application or in a unit period of time (proposed definition).

Downdraft. In meteorology, a downward moving current of air of small dimensions (WMO). In pollution control the term "downdraft" is also applied to a phenomenon that occurs in connexion with stacks (chimneys). When wind blows over a building, a region of turbulence is formed above the building and a region of low pressure on the leeward side of the building. Emissions from stacks that terminate within the turbulent region are drawn down to ground level in the low-pressure region ("downdraft"), giving rise to intense pollution. A general rule for preventing this type of downdraft is that a stack should be at least 2.5 times the height, h, of any building situated within a circle of radius $2h$ around the stack. The term "downdraft" is further applied to the drawing of cold air downward into a large-diameter stack when the exit velocity of the stack gases is low.

Downwash. The drawing down of stack gases into the turbulent region in the lee of the stack, caused by the interference of the stack itself with the wind flow. The gases finally break away from the stack some way down from the top so that the net result of downwash is to reduce the effective stack height. Downwash can be avoided by having a sufficiently high efflux velocity at the mouth of the stack. A general rule is that this velocity, at full load, should be at least 1.5 times the velocity of frequently occurring high winds.

Drag. See *aerodynamic roughness.*

Driving cycle. A term applied to the manner in which a motor vehicle is driven during tests for the emission of pollutants. The vehicle is driven according to a predetermined pattern – e.g., a specified distance at a number of steady cruising speeds, a specified distance with alternating braking and acceleration (as in city driving), and so on. The tests can be performed either on the road or with the aid of a *dynamometer* (q.v.).

Drizzle. Fairly uniform precipitation composed exclusively of fine drops of water (diameter less than 0.5 mm) very close to one another (WMO).

Droplet. A particle of a liquid substance of very small mass, capable of remaining in suspension in a gas. In some suspended systems, for example clouds, their diameter can reach 200 μm (provisional ISO, 8).

"Dry". See *analysis, coal.*

"Dry, ash-free". See *analysis, coal.*

"Dry, mineral-matter-free". See *analysis, coal.*

Dry quenching. See *coke oven.*

Dust. A general term denoting solid particles of different dimensions and origins, which may generally remain in suspension in a gas for some time (provisional ISO, 8). National standards may be more specific and include particle diameters or a definition in terms of a sieve of specified aperture size. Dust occurs in the atmosphere both naturally and as a result of the activities of man.

Dust, respirable. Suspended particulate matter that can be deposited to a significant extent in the lung. There is no general agreement on the type and size of particles involved and the term may have different meanings to different authors.

Dust counter. An instrument for measuring the amount of dust contained in a given volume of air. The term *nuclei counter* refers to the type of dust counter in which the dust particles are made to serve as condensation nuclei and the drops of condensed water are counted (WMO).

Dust separator. An apparatus for separating solid particles from a gas stream in which they are suspended (provisional ISO, 8). Dust separators are widely used to remove dust and grit from stack gases and other industrial gases. They are of many different types, which may be broadly classified on the basis of whether they use or do not use a liquid to remove particles. Dust separators of the former type are known as washers (see *washer*).

Non-washer types. The *cyclone*, in gas cleaning, is a dust separator or droplet separator using essentially the centrifugal force derived from the motion of

the gas (provisional ISO, 8). A dust separator consisting of several cyclones in parallel is known as a multicyclone. In the *inertial separator* particles are removed by a combination of inertial and centrifugal forces resulting from a sudden change in direction of flow of the gas, together with impaction of the particles on a target. In the *electrostatic precipitator* the gas is passed between sets of electrodes across which a very high constant potential is maintained. The dust particles become charged and adhere lightly to one set of electrodes; they are removed by sharp tapping, causing them to fall into containers. Although expensive to install, electrostatic precipitators are relatively cheap to operate and are one of the most efficient means of removing fine dust from gases, although strict maintenance is necessary to ensure unimpaired efficiency. They are widely used in power stations burning pulverized fuel, cement works, steel works, etc. See also *impinger (*or *impactor).*

Washer types. In the *bubble washer*, the gas is bubbled through the liquid; in a *spray washer* it is passed through a chamber in which a spray of the liquid removes the dust. In the *venturi scrubber* the gas is drawn at high velocity (60–90 m/s) through a conical restriction, at the throat of which water is injected at the rate of about 1 m^3 for each 1000 m^3 of gas. The water is broken down into very fine droplets and the dust particles are thoroughly wetted; dust and water particles are subsequently removed in a cyclone. Such equipment will remove some 99% of particles smaller than 0.5 μm in diameter. Capital costs are comparatively low, but since the pressure drop across the equipment is large the power requirements are high.

Duststorm (or **Sandstorm**). An ensemble of particles of dust or sand energetically lifted to great heights by a strong and turbulent wind (WMO). Both dust and sand may be carried great distances and they greatly reduce visibility. Dust readily penetrates into buildings and results in severe soiling; sand penetrates less readily but may cause considerable erosion. The particles are usually lifted to greater heights in a duststorm than in a sandstorm.

Dust suppression. The prevention or reduction of the dispersion of dust into the air, e.g., by water sprays (ISO, 1).

Dwell time. See *residence time.*

Dynamic viscosity. See *viscosity.*

Dynamometer. As applied to the testing of motor vehicles or engines, a device that absorbs the energy produced, making it possible to conduct tests in the laboratory rather than on the road. Such dynamometers are widely used for testing the emission of pollutants under different simulated driving conditions (e.g., cruising, hill climbing). See also *driving cycle.*

E

Earthwatch Programme. An environmental assessment programme adopted by the United Nations Conference on the Human Environment, Stockholm, 1972. Ultimately at least 100 stations are to be set up for regional monitoring of long-term trends in the concentration and distribution of atmospheric contaminants.

Eddy. An element of fluid, within a turbulent mass of fluid, which has a certain identity and life history of its own (WMO). Atmospheric eddies may range from about 10 mm to several hundred kilometres in size. The dilution (by diffusion) of a plume of gas from a stack is controlled by small eddies; large-scale eddies, such as those associated with cyclones and anticyclones, play a role in the long-range transport of pollutants.

Eddy diffusion. See *diffusion.*

Eddy viscosity. See *viscosity.*

Effective chimney height. See *stack height, effective.*

Efficiency. With regard to filters, dust separators, and droplet separators, the ratio of the quantity of particles retained by a separator to the quantity entering it (it is generally expressed as a percentage) (provisional ISO, 8).

Effluent. Any fluid discharged from a given source into the external environment (provisional ISO, 8).

Efflux velocity. The linear velocity with which gas leaves a stack, which is equal to the volume of gas issuing from the stack mouth per second divided by the cross-sectional area of the mouth. If the efflux velocity is low, *downwash* (q.v.) is liable to occur. If several furnaces are connected to a single stack the efflux velocity is often undesirably low when some of the furnaces are not in operation, and it is an advantage to provide each furnace with a separate flue extending to the top of the stack, inside the outer casing.

Electron microscope. An electron-optical device which produces a greatly magnified image of an object. Detail may be revealed by virtue of selective transmission, reflection, or emission of electrons by the object (IEC, 3). A photograph taken with an electron microscope is known as an electronmicrograph. Electron microscopes are used in air pollution work for the study, at very high magnification, of individual particles (e.g., asbestos fibres) collected from the air.

Electrostatic precipitator. See *dust separator.*

Elutriation. A method of separating particles using the difference in apparent weight which may exist between the particles when they are suspended in a fluid (provisional ISO, 8). In practice, the particles are usually allowed to settle against an upward-moving flow of fluid (e.g., water or air); heavier material settles to the bottom, while fine material remains suspended and is removed with the fluid.

Emission. A measure of the extent to which a given source discharges a pollutant, commonly expressed either as a rate (amount per unit time) or as the amount of pollutant per unit volume of gas emitted.

Emission factor. The mass of a given pollutant produced by the combustion of unit mass of a given fuel.

Emission inventory. The compilation of data, either by measurement or (more usually) by estimation, from which a more or less detailed map of the distribution of emissions over a given area may be constructed, showing the positions of the more important sources and the amounts they emit, and the areas in which smaller emitters are concentrated, with the emission per unit area for each. Also called *emission survey* and *source inventory.*

Emission source. Any factory or other plant, furnace, chemical process, etc., that discharges pollutants into the air. *Point source*, a plant whose total emission of a pollutant is sufficiently large to warrant separate consideration in an *emission inventory* (q.v.), rather than inclusion with other, smaller, emission sources under "average emission per unit area". An emission of the order of 100 tonnes per year or more may lead to a plant being considered as a point source. In the USA any stack is usually considered a point source; stacks with emissions exceeding 100 tonnes per year are considered major point sources.

Emission survey. See *emission inventory.*

Enthalpy. The heat function of a system at constant pressure, defined as $H = U + pV$, where U is internal energy, p pressure, and V volume. The change in enthalpy that occurs during an isothermal phase change at constant pressure was formerly called the "latent heat" of the phase change, but this term is now deprecated. Examples of correct terminology: enthalpy of vaporization, enthalpy of condensation, enthalpy of fusion.

Entrainment. The carrying-off of a material by a flowing fluid. Thus dust is said to be entrained when it is picked up off the ground by the wind and blown away in suspension in the air.

Environment. The aggregate, at a given moment, of all external conditions and influences to which a system [or organism] is subjected (ISO, 14).

Episode. A term applied in the air pollution literature to a very restricted number of incidents when, under unusual circumstances (persistent temperature inversion and stagnant air over a city surrounded by hills, accidental escape of pollutants from industry, etc.), air pollution has risen to abnormally high levels and has remained at these levels for several days, producing marked increases in illness and death.

Equivalent standard smoke. See *smoke concentration.*

Error. A widely used term that causes great confusion owing to the fact that there are two schools of thought with respect to its meaning: one of these uses the term to mean the difference between an experimental result and the "true" value, while for the other the error is the uncertainty of an experimental result. Some workers prefer to avoid the term; if it is used, the meaning with which it is used should be made clear.

Excess air. See *combustion.*

Exhaust (or **Exhaust gases**). The gases arising from combustion in an internal combustion engine.

Extinction. A term that is, by international agreement, reserved for application to certain quantities related to the diffusion of radiation. It should not be applied to the absorption of radiation. See *absorbance; absorption coefficient, linear.*

Extinction coefficient. See *absorption coefficient, linear.*

F

Factory Acts. United Kingdom legislation that controls conditions, including air pollution, within factory buildings and over any open ground within their boundary fences.

Fallout, radioactive. (*a*) The descent to the earth's surface of the radioactive particles produced in a nuclear explosion; (*b*) the radioactive particles themselves (WMO). It is often referred to simply as "fallout", although this term is also applied to any solid particulate matter that settles out of the air on to the surface of the earth (this usage is sometimes broadened to include *wash-out*, q.v.).

Fall time. See *response time.*

Fanning. See *plume.*

Ferric oxide. See *iron(III) oxide.*

Fetch. The distance along a sea trajectory over which there blows a wind of almost uniform direction and speed (WMO).

Fibrous. In the description of particles, regularly or irregularly thread-like.

Fick's law. See *diffusion.*

Filter. In gas cleaning, an apparatus for separating solid or liquid particles from a gas stream in which they are suspended. This apparatus is generally formed of a porous or fibrous layer and/or of an assembly of porous and/or fibrous layers (provisional ISO, 8).

Filter, absolute. A term applied to a filter designed to remove particles of very small diameter (e.g., pathogenic microorganisms and radioactive dusts) from gases in which they are suspended. The efficiency of such filters is normally expressed in terms of particle diameter, and may be 99.99% or better for particles 1 μm in diameter.

Filter bag. An apparatus for removing dust from dust-laden air, employing cylinders of closely woven material which permit passage of air but retain solid particles. The term "breather bag" is deprecated (provisional ISO, 8). The bag may be up to 10 m in length and 1 m in diameter. An *efficiency* (q.v.) of 99–99.9% or better is quoted, depending on conditions. If a layer of chemically reactive dust is deposited on the fabric, gaseous pollutants in low concentration

can be removed from stack gases (e.g., fluorine compounds can be removed from the gases evolved in the electrolytic production of aluminium). An installation containing many filter bags is known as a bag house.

Fines. In the coal industry, coal having a maximum particle size usually less than 1.5 mm and rarely above 3 mm (ISO, 2). In general, that fraction of a material that has been broken down into particles too small for a given use. If not properly contained, fines can cause much air pollution by dust.

Firing. The feeding of fuel into a furnace, also termed *stoking. Spreader firing*, spreading coal evenly over the entire fuel bed, little and often. For moderate loads, little smoke need be produced.

Flaky. In the description of particles, consisting of strata, laminae, or plate-like layers.

Flame impingement. The impingement of a flame, or of a burning oil spray, against the wall of a combustion chamber. In addition to possible damage to the chamber, it may lead to the production of smoke by the immediate cooling of burning particles.

Flame ionization analysis. A method of analysis based on the formation of ions when certain substances are introduced into a hydrogen-air flame. An electric field between the jet and a collector electrode accelerates the ions to the electrode. If the hydrogen, air, and sample flowrates are maintained constant, the concentration of the substance undergoing analysis can be determined from measurement of the ion current. The technique, which was first developed as a gas chromatography detection system, is applicable to the determination of many organic air pollutants, particularly hydrocarbons.

Flare. The flame produced by the burning of surplus and residual gases at the top of a flame pipe at an oil refinery or other chemical industry factory. The gases cannot be released into the atmosphere owing to their unpleasant odour and to the explosion risk that would result. Flares can produce a great deal of smoke; this can be reduced by injecting steam or a water spray close to the point of ignition (this procedure, however, renders the flame noisy).

Fletcher's bellows. A simple portable bellows fitted with valves and charged with a suitable absorbent solution, used for withdrawing approximately 5-litre samples of stack gases for analysis. The solution reacts with one of the gas constituents, whose concentration can then be determined in the laboratory.

Flocculation. See *aggregate.*

Flow, laminar. Flow in which the air moves smoothly along streamlines which are arranged in parallel layers or sheets: opposite of turbulent flow (WMO).

Flow, turbulent. Airflow characterized by *turbulence* (q.v.) (WMO).

Flue gases. See *stack effluents.*

Fluidized bed. An apparatus in which a finely divided solid, usually sand, is supported and rendered fluid-like ("fluidized") by a column of rapidly moving gas, usually air, admitted from below. Conditions in a fluidized bed are such that fuel (e.g., oil or coal) is rapidly distributed in it, without the need for special burner systems. If suitably crushed limestone or dolomite is also introduced, much of the sulfur in the fuel is fixed as sulfate and the emission of sulfur oxides in the stack gases is correspondingly reduced. The content of nitrogen oxides is also much lower than that of stack gases from ordinary furnaces, on account of the lower combustion temperature.

Fluorescein. An intensely coloured orange-red compound that has been used to trace the dispersion of stack gases. Fine droplets of a fluorescein solution, which shows a greenish fluorescence, are introduced into the gases and their distribution in the surrounding area is determined by taking samples of air for analysis. The method is so sensitive that it can be carried out without causing nuisance in the area.

Fluoride. See *fluorine; hydrogen fluoride.*

Fluorine. A pale yellow gaseous element; atomic number 9, relative atomic mass 18.99840, symbol F. It is highly reactive, corrosive, and toxic. Some of its more soluble compounds are also very poisonous. In the air pollution literature the term "fluorine" is often used for various unspecified fluorine compounds.

Fluorite. A naturally occurring calcium fluoride. At one time it was widely used as a flux in the metallurgical industries, giving rise to pollution by fluorine compounds in the neighbourhood.

Fluorspar. See *fluorite.*

Flux. In the metallurgical industries, a substance added to minerals or metals to promote fusion in a furnace; in brazing and soldering, a substance used to promote easy flow of solder and prevent oxide formation. In physics, the rate at which particles, electricity, heat, fluid, etc., flow or are transferred, expressed in terms of quantity per unit area per unit time.

Fog. A suspension of very small water droplets in the air, generally reducing the horizontal visibility at the earth's surface to less than 1 km (WMO). *Advection fog*, fog which forms in the lower part of a moist air mass which moves over a colder surface (Cf. *sea fog*, below). *Evaporation fog*, fog in which saturation is caused within a cold and stable air mass by rapid evaporation from an

underlying warm water surface. *Frontal fog*, fog along a front, in the formation of which there occurs mixing of the two air masses present. *Ground fog*, radiation fog, of small vertical extent though often dense, through which the stars may often be seen by night and the sun by day. *High inversion fog*, fog caused by the extension downwards to the ground of a cloudy layer of stratus formed under an inversion. *Ice fog*, a suspension of numerous minute ice crystals in air, reducing the visibility at the earth's surface. *Mixing fog*, fog, thin and of short duration, produced by the mixing of two moist but non-saturated air masses of different temperature. *Radiation fog*, fog caused by the radiational cooling of the earth's surface, and therefore cooling of the surface air, to a degree sufficient to cause condensation of water vapour contained in the air. *Sea fog*, advection fog which forms over the sea. *Upslope fog*, fog formed on windward slopes of hills or mountains by forced ascent of air and associated adiabatic expansion and cooling (all WMO).

Free radical. A molecular fragment or an ion that has one or more unpaired electrons, rendering it highly reactive. Although free radicals are generally very short-lived in gaseous systems, their high reactivity enables them to take part in chemical reactions that would not otherwise occur. Thus, in the atmosphere, certain free radicals play a significant role in the production of *aldehydes* (q.v.), *ketones* (q.v.), acetylnitro peroxide (see *peroxide, acetylnitro*), and other constituents of photochemical *smog* (q.v.).

Freon®. A proprietary name for one brand of fluorinated hydrocarbons, which should be used only for that brand and not as a synonym for "fluorinated hydrocarbon". See *refrigerant.*

Front. (*a*) The surface of separation of two air masses (frontal surface); (*b*) the line of intersection of the surface of separation of two air masses with another surface or with the ground. *Cold front*, any non-occluded front which moves in such a way that colder air replaces warmer air. *Occluded front*, the front separating two cold air masses which are brought into contact as the result of the process of *occlusion* (q.v.). *Warm front*, any non-occluded front which moves in such a way that warmer air replaces colder air (all WMO).

Fuchsin-formaldehyde method. A method for the determination of sulfur dioxide. Air is passed through a solution of sodium hydroxide and glycerol; sulfur dioxide reacts to form sulfurous acid, which in turn reacts with a solution containing basic fuchsin, sulfuric acid, and formaldehyde to give a red-violet coloration, which is determined spectrophotometrically.

Fuel, authorized. A term applied in the United Kingdom to a fuel authorized, under the Clean Air Act of 1956, to be burned in smoke control areas. The combustion of such fuels is not necessarily completely smokeless. See also *fuel, solid smokeless.*

Fuel, colloidal. Fuel oil containing pulverized coal.

Fuel, fossil. A general term for any fuel (e.g., coal and petroleum) formed from the remains of plants and animals. See *coal.*

Fuel, petroleum. Any of a wide range of petroleum products used as liquid fuels for heating equipment or engines. They may be broadly classified as distillate fuels and residual oils. The more important distillates include, in order of increasing boiling range, *gasoline* (q.v.), *kerosine* (q.v.), and gas-oil (including some diesel fuels). Residual oil is the heavy oil that remains in a refinery still after removal of the different distillate fractions. *Diesel fuel*, a group of products ranging from distillates (of low sulfur content) for high-speed engines to heavy residual blends (with a sulfur content of up to 4%) for large low-speed engines. *Fuel oil*, heavy distillate, residue, or mixture of the two. It is used as fuel for the production of heat or power (ISO, 4a). *Gas-oil*, distillate (atmospheric or vacuum) having a viscosity and a distillation range intermediate between those of kerosine and spindle oils. It is treated if necessary for use as a fuel for the production of heat or power (ISO, 4a). The sulfur content of gas-oil is about 0.5 – 1%. *Heating oil*, a generic term for distillate fuel oils widely used for domestic heating.

Fuel, pulverized. Finely ground coal, usually meeting specified particle size limits.

Fuel, solid smokeless. A term commonly used in the United Kingdom for "authorized fuel". While such fuels produce much less smoke than bituminous coal, some of them are by no means smokeless. See *fuel, authorized.*

Fuel injection. The introduction under pressure of fuel into the combustion air [of an internal combustion engine] (ISO, 7). The system is now used in some spark-ignition gasoline engines, replacing the use of a carburettor; when properly adjusted it gives better control of the mixture and reduces emission of air pollutants.

Fuel oil. See *fuel, petroleum.*

Fulham-Simon-Carves process. A proposed process for removing sulfur dioxide from stack gases by scrubbing with solutions containing ammonia. The sulfur is recovered as ammonium sulfate, but with the decline in popularity of this substance as a fertilizer, the economic prospects of the process have also declined.

Fume. The whole of the combustion gases and the particles entrained by them (smoke). By extension, also the gases charged by particles resulting from a chemical process or a metallurgical operation (provisional ISO, 8). Often used in the plural ("fumes") for visible clouds of gases, vapours, or aerosols that usually have a choking or unpleasant smell.

Fumigation. In air pollution contexts, the appearance at ground level of pollutants that were previously (*a*) in a poorly dispersed smoke plume or (*b*) trapped in a temperature inversion (or between two inversion layers), as a result of turbulence (e.g., turbulence arising from early morning heating of the earth's surface by the sun).

Funnelling. See *venturi effect.*

Furfural. An *aldehyde* (q.v.); systematic name 2-furancarboxaldehyde; formula $\underline{O}CH{:}CHCH{:}\underline{C}CHO$. It is emitted, *inter alia*, by factories using the viscose process and is responsible for the "sour cabbage water" odour in their vicinity. It is highly irritant and toxic.

Furnace, blast. A furnace in which iron ores (iron oxide) are smelted with coke and lime, using a blast of air, to produce metallic iron (blast furnaces are also used for smelting ores of a number of other metals). Practically all the sulfur in the fuel remains in the slag and does not contribute to air pollution in the neighbourhood. On occasion, however, serious pollution by grit and dust occurs when the charge suddenly slips unevenly down the furnace shaft, producing a sudden rush of dust-laden gas that has to be released into the air through safety valves.

Furnace, induction. See *heating, induction.*

Furnace, open-hearth. See *furnace, steel-making.*

Furnace, sintering. A furnace in which fine iron ores, mixed with coke *breeze* (q.v.), are sintered to form agglomerates with which a blast furnace can be charged. The process gives rise to a great deal of dust, grit, and sulfur dioxide.

Furnace, steel-making. A furnace for the manufacture of steel from, for example, a mixture of crude iron (made in blast furnaces) and steel scrap by the removal of some of the carbon. Oxygen (or air in the older types of furnace) is blown into the molten iron in the presence of a suitable flux, a procedure known as "oxygen lancing". Carbon monoxide is evolved together with large quantities of iron(III) oxide fume, the individual particles of which are mostly smaller than 0.5 μm and which can cause intense pollution in the neighbourhood. If fluorite is used as a flux, fluorine compounds are also evolved. Collection of these pollutants is often difficult on account of the furnace design. This difficulty is more acute with the Bessemer converter, largely because of its tilting design, than with the open-hearth furnace. See also *cupola.*

G

Gas, coal. A mixture of gases produced from bituminous coal by destructive distillation at high temperatures. The composition varies, the major constituents being hydrogen, methane, and carbon monoxide. It was formerly used widely for domestic and industrial heating and lighting, but in many areas it has been replaced by natural gas (see *gas, natural*). See also *gas, manufactured.*

Gas, ideal. A hypothetical gas that obeys Boyle's law and Charles's law. In practice no gas is "ideal", although a few (e.g., helium and nitrogen) are very close to it at high temperature and low pressure. The gases in the atmosphere offer a reasonably close approximation to ideal behaviour if they are not saturated with water vapour.

Gas, inert. A gas that does not react with materials with which it is in contact. Nitrogen, for example, is widely used in the laboratory and in industry as an inert gas. For the "inert gases", see *noble gases.*

Gas, liquefied petroleum. A mixture of light hydrocarbons, gaseous under conditions of normal temperature and pressure and maintained in the liquid state by increase of pressure or lowering of temperature. The principal components are propane, propene, butanes, and butenes (ISO, 4).

Gas, manufactured. Any gas that is artificially produced; the term usually refers to gas supplied for domestic and industrial use. At one time, the most important manufactured gas was coal gas. In some areas this gave way to gas manufactured from petroleum distillate oils and other products. In many areas today, all manufactured gases have been, or are being, replaced by natural gas.

Gas, natural. Gaseous hydrocarbons (mainly methane) from underground deposits, the production of which may be associated with that of crude petroleum (ISO, 4). The composition varies.

Gas, perfect. See *gas, ideal.*

Gas, refinery. Gas produced in the refining of crude petroleum and consisting mainly of hydrocarbons (ISO, 4). It is used as a fuel in the refinery.

Gas, reformed. A gas of low calorific value manufactured from one of high calorific value by thermal process. See *reforming.*

Gas, sewage. Gas produced during the treatment of sewage. It consists largely of methane and can be used as a fuel in the sewage disposal works.

Gas, sour. Gas containing sulfur compounds (hydrogen sulfide and mercaptans). The term is sometimes applied to natural gas that contains more than a specified amount of hydrogen sulfide. See *sweetening.*

Gas, tail. The residual gas from a chemical process.

Gas, town. A term used in the United Kingdom for manufactured gas supplied by a gas service. See *gas, manufactured.*

Gases, inert. See *noble gases.*

Gases, stack. See *stack effluents.*

Gas-oil. See *fuel, petroleum.*

Gasoline. A refined petroleum distillate, normally boiling within the limits of 30 to 220°C, which combined with certain additives is used as fuel for spark-ignition engines. By extension, the term is also applied to other products boiling within this range, e.g., natural gasoline (casing head gasoline) (ISO, 4). For the ways in which gasoline and the combustion of gasoline can contribute to air pollution see, *inter alia, carbon monoxide; carburettor; hydrocarbon; nitrogen oxides; smog; tetraethyllead.*

Gas purifier. An apparatus for totally or partially removing one or more unwanted constituents from a gaseous medium (provisional ISO, 8).

Gas washbottle. An apparatus for passing a gas or mixture of gases through a liquid in order to remove an undesirable constituent. The gas may enter the liquid through a plain glass tube or through a section (usually in the form of a cylinder, sphere, or disc) of sintered glass to form numerous tiny bubbles and so increase contact with the liquid (the same effect is also achieved by designs in which the gas is forced to follow a long spiral passage through the liquid). The device is frequently used in the chemical analysis of pollutants in air.

Gas washing. A general term for gas cleaning or purifying processes that use a liquid as the collecting medium. See *separator; washer.* If such processes are used to remove sulfur oxides from stack gases, the latter are cooled and on emission from the stack tend to descend rapidly to ground level, causing an unacceptable nuisance, no matter how satisfactory the efficiency of removal of sulfur oxides. See also *Battersea process; Fulham-Simon-Carves process.*

GC. An acronym for gas chromatography. See *chromatography.*

GLC. An acronym for gas-liquid chromatography. See *chromatography.*

Gravimetric method. An analytical method that is based on weighing. Gravimetric methods are capable of high accuracy, but are more time-consuming and require greater skill than volumetric techniques.

Greenhouse effect. Warming of the lower layers of the atmosphere due to the fact that solar radiation, of relatively short wavelength, penetrates the atmosphere without appreciable absorption, and is, in large measure, absorbed only at the earth's surface while terrestrial radiation, of large wavelength, is absorbed by the atmosphere to a much greater extent (WMO). The phenomenon is named by analogy with a greenhouse, whose glass is much more transparent to short-wave solar radiation than to the longer-wave radiation from the interior of the greenhouse. Fears have been expressed that an increase in the concentration of carbon dioxide in the atmosphere could lead to an enhancement of the greenhouse effect with a consequent rise in temperature.

Grit. A general term for coarse particulate matter. It is sometimes defined as consisting of particles exceeding 75 μm in diameter.

Ground level concentration. The concentration of a pollutant in air to which a human being is normally exposed, i.e., between the ground and a height of some 2 m above it. It does not mean the concentration in a layer of air in direct contact with the ground, where the concentration may be low if absorption of the pollutant by the ground is occurring. The upper limit of height is flexible if concentrations do not change very much with height from 2 m upwards. When the major source of pollution is a single stack or a small group of stacks the measured ground level concentration at any point will vary very rapidly with time on account of small but rapid changes in wind speed and direction, and "ground level concentration" is meaningless without specification of the time over which the concentration is averaged.

Guides (or **Guidelines**). In environmental medicine, a collection of *criteria* (q.v.) specifically assembled to indicate threshold levels of a harmful or noxious agent consistent with the maintenance of good health (proposed definition).

Gust. A transitory, positive or negative departure, lasting a relatively short time, of the wind speed (or of a component of the wind speed in a particular direction) from its mean value (or mean value of the component) over a specified interval of time (WMO).

H

Half-life, radioactive. For a single radioactive decay process, the time required for the activity to decrease to half its value by that process. *Biological half-life* is the time required for the amount of a particular substance in a biological system to be reduced to one half of its value by biological processes when the rate of removal is approximately exponential. *Effective half-life* is the time required for the amount of a particular radionuclide in a system to be reduced to half its value as a consequence of both radioactive decay and other processes such as biological elimination and burnup when the rate of removal is approximately exponential (all ISO, 5). The half-life concept is also useful in defining the rate of removal of a pollutant from the atmosphere.

Haze. A suspension in the atmosphere of extremely small, dry particles which are invisible to the naked eye but are numerous enough to give the sky an appearance of opalescence (WMO). Since the haze particles can act as condensation nuclei, and the water vapour pressure over the droplets that may thus be formed is much lower (particularly if the haze particles are soluble) than that over larger droplets, it is difficult to draw a firm distinction between haze and *mist* (q.v.).

Haze, coefficient of (COH). A factor used, particularly in the USA, in assessing the amount of smoke or other aerosol in air. It is 100 times the *absorbance* (q.v.) of the stain produced on white filter paper when air is passed through it (absorbance being determined from measurement of the light transmitted by the stain and by clean filter paper). A COH unit is the amount of particulate matter on the paper that gives an absorbance of 0.01; i.e., if a given determination gives an absorbance of 0.01, the result is 1 COH unit. If the COH is multiplied by S/V, where S is the area of filter paper through which a volume V of air is passed, a value in terms of linear measure is obtained; in the USA it is common to report COH values per 1000 ft.

Health and Safety at Work &c Act (1974). United Kingdom legislation under which the *Alkali &c Works Regulation Acts* (q.v.) and a great deal of other legislation dealing with health and safety at work will ultimately be subsumed.

Heating, central station (or **District heating**). The heating of all buildings and dwellings within a given area from a single installation, usually by means of superheated steam. The installation may be set up specially for the purpose, or it may use the waste heat from an existing installation such as a power station or municipal incinerator. Since pollution from a single large plant can be controlled much more easily than that from a multitude of small sources, central station heating can be a valuable aid in achieving clean air.

Heating, induction. A method of heating by means of eddy currents set up within the contents of a furnace by a changing external magnetic field. Furnaces using this method of heating produce no air pollution.

Heavy metal. See *metal, heavy.*

Heliograph. See *sunshine recorder.*

Heliostat. A device that automatically orientates an instrument toward the sun or the sun's light toward the instrument.

Helium. A gaseous element, atomic number 2, relative atomic mass 4.00260, symbol He. It occurs in trace amounts in the atmosphere (about 5.2×10^{-4} per cent by volume), its concentration being maintained as a balance between its production at the earth's surface by radioactive disintegration (alpha particles are helium nuclei) and its loss from the top of the atmosphere into outer space. It is a member of the *noble gases* (q.v.).

Hexafluorosilicates. See *hydrogen fluoride.*

Humidity of the air. The water vapour content of the air (WMO). *Relative humidity of moist air with respect to water*, at a given pressure p and temperature T, the percentage ratio of the mole fraction of the water vapour N_v to the vapour mole fraction N_{vw} which the air would have if it were saturated with respect to water at the same pressure p and temperature T. It is this relative humidity which is calculated, even at temperatures below 0°C:

$$U_w = 100(N_v/N_{vw})_{p,T} = 100(pN_v/pN_{vw})_{p,T}$$
$$= 100(e'/e'_w)_{p,T}$$

[where e' is vapour pressure] . . . This definition does not apply to moist air when the pressure p is below the saturation vapour pressure of pure water at the temperature T (WMO).

Hydrocarbon. An organic compound containing only the elements carbon and hydrogen. The carbon atoms may be arranged either in open-ended chains, which may or may not be branched (see *alkane; alkene*) or in closed rings. There are two types of ring hydrocarbons: *alicyclic compounds*, consisting of three or more carbon atoms arranged in a closed ring (and whose properties are similar to those of the open-chain compounds of the same relative molecular mass), and *aromatic compounds.* The molecular structure of aromatic compounds is based on that of benzene, the simplest member of the class, which contains six carbon atoms joined by three single and three double carbon-carbon bonds. Such compounds are described as *polycyclic* if they contain two or more rings; the term "polynuclear" (as in "polynuclear aromatic hydrocarbon", frequently abbreviated PAH) is also used. The major constituents of gasoline and other petroleum fuels are hydrocarbons of the open-chain type. These compounds are not considered

to be a hazard to health even at the concentrations at which they are encountered in city air. Many aromatic hydrocarbons, on the other hand, are highly toxic. Gasoline now contains a small proportion of such compounds, but the proportion might have to be increased (in order to retain antiknock properties) if the lead content of gasoline were to be reduced, and such a change might introduce new problems. Wellknown examples of the polycyclic hydrocarbons are anthracene, naphthalene, and *benzo[a]pyrene* (q.v.).

Hydrochloric acid. An aqueous solution of *hydrogen chloride* (q.v.).

Hydrofluoric acid. An aqueous solution of *hydrogen fluoride* (q.v.).

Hydrogenation. The chemical combination of hydrogen with another substance, usually by the action of heat and pressure in the presence of a catalyst. It is widely used in the petroleum industry.

Hydrogen chloride. A colourless gas with a choking odour that fumes strongly in moist air, formula HCl. It is highly soluble in water, the solution being known as *hydrochloric acid*. Both the gas and its solution are poisonous, corrosive, and phytotoxic (although much less injurious to plants than hydrogen fluoride). In the 19th century hydrogen chloride was a common air pollutant, large amounts being emitted by factories using the salt cake process (heating sodium chloride with sulfuric acid). Today, however, it is only of relatively minor importance as an air pollutant.

Hydrogen fluoride. A colourless fuming gas or liquid (boiling point 19.5°C), formula HF. The aqueous solution is known as hydrofluoric acid. Both are highly corrosive and toxic. Many salts of hydrofluoric acid (fluorides) are also highly poisonous. The acid and fluorides are injurious to crops grown near works that emit them, particularly *superphosphate* (q.v.) works and aluminium smelting installations. Steps can be taken to prevent emissions from such works, but no solution has yet been found to the rather smaller emissions of hydrofluoric acid and compounds such as hexafluorosilicates ("silicofluorides") from brick-making works.

Hydrogen peroxide method. A method for the determination of sulfur dioxide. Air is passed through dilute hydrogen peroxide solution at pH 5, and the sulfuric acid that is formed is titrated against standard sodium hydroxide solution with mixed bromocresol green/methyl red indicator. See also *thorin method.*

Hydrogen sulfide. A colourless gas with an offensive odour (the smell of rotten eggs is due to hydrogen sulfide), formula H_2S. It is highly toxic. Hydrogen sulfide is a natural constituent of the atmosphere, although in concentrations low enough (except in the vicinity of volcanoes) to be harmless. Accidental escapes of the gas from various industrial processes have caused serious trouble (an escape from a natural gas refinery, for example, caused deaths). Hydrogen sulfide

rapidly affects the sense of smell in such a way that the odour can no longer be detected, even when the gas is present in concentrations greatly exceeding the safe limit.

Hydroperoxide. Any of a group of compounds of general formula ROOH. They occur in photochemical *smog* (q.v.) and are lachrymatory and irritant even at very low concentrations.

Hygrogram. The record made by a hygrograph (WMO).

Hygrograph. A *hygrometer* (q.v.) which includes an arrangement for the time recording of atmospheric humidity (WMO).

Hygrometer. An instrument used to measure the humidity of the air (WMO).

Hygrothermograph. See *thermohygrograph.*

Hysteresis error. The difference between the indications of a measuring instrument when the same value of the quantity measured is reached by increasing or decreasing that quantity (OIML).

I

Immission. A German term for which there is no simple English equivalent. In the Federal Republic of Germany, immissions (*Immissionen*) are legally defined as "air pollutants, noise, vibrations, light, heat, radiations, and analogous environmental factors affecting human beings, animals, plants, or other objects". They are to be distinguished from emissions (*Emissionen*), which are defined as "air pollutants, noise, vibrations, light, heat, radiations, and analogous phenomena originating from an installation" (Federal Law on Protection against Emmissions, 15 March 1974) (FRG).

Impaction. The action of forcing particles to enter into contact with a surface (provisional ISO, 8). The surface may be solid or liquid.

Impinger (or **Impactor**). A device for removing material suspended in a gas stream. The gas is accelerated through a nozzle and immediately impacts on a solid surface, on which the suspended matter is deposited. If it is convenient to collect the suspended material in a liquid, the device may be filled with one which plays no part in the separation process other than keeping the solid surface wet and removing the separated material (such devices are also used to absorb gaseous components). Impingers are commonly used in apparatus for measuring concentrations of pollutants, which they can remove with high efficiency from relatively large volumes of air. *Cascade impactor*, a device for determining the particle size distribution in an aerosol by submitting it to a series of impactions to separate and collect particles of successively smaller sizes. In one form of instrument, the aerosol is passed through a series of nozzles of decreasing aperture size, each being directed on to a microscope slide on which a fraction of the suspended material is deposited. The size-range of the material deposited on any slide depends on the diameter of the nozzle and the gas velocity.

Imprecision. See *precision.*

Incinerator. A furnace in which waste material (e.g., domestic refuse) is burned.

Inert gases. See *noble gases.*

Inertial separator. See *dust separator.*

Infrared radiation. See *radiation.*

Inhibitor. A substance, naturally occurring or added, whose presence in small amounts in a petroleum product retards or prevents the occurrence of certain

phenomena considered undesirable, e.g., gum formation in stored gasolines, colour change in lubricating oils, corrosion in turbines, etc. (ISO, 4).

Insolation. (*a*) The amount of direct solar radiation incident per unit horizontal area at a given level. (*b*) Downward-directed solar radiation (WMO). See *radiation, solar.*

Instability. See *stability, static.*

Instantaneous value. The value of a variable quantity at a given instant (IEC, 1). In the air pollution literature the term "instantaneous" is often used incorrectly to mean "over a short time".

Internal combustion engine, reciprocating. A mechanism delivering shaft power by the combustion of fuel in one or more cylinders in which working pistons reciprocate. *Spark ignition engine*, an engine in which ignition is effected by means of an electric spark. *Compression ignition engine*, an engine in which ignition is effected by the temperature of the cylinder contents, resulting solely from their compression. A compression ignition oil engine is generally known as a diesel engine (ISO, 7). For the contribution that such engines can make to air pollution see, *inter alia, crank-case blow-by; hydrocarbon; nitrogen oxides; smog; tetraethyllead; tetramethyllead.*

Inversion, temperature. A vertical temperature distribution such that temperature increases with height (WMO). The dispersion of pollutants arising near the ground is greatly hindered by the presence of a temperature inversion. *Radiation inversion*, a temperature inversion produced by cooling by radiation: from the earth's surface at night, from a surface of snow or ice, from the upper part of a layer of cloud, etc. *Subsidence temperature inversion*, an upper-level temperature inversion caused by *subsidence* (q.v.) (WMO).

Inversion layer. An atmospheric layer, horizontal or approximately so, in which the temperature increases with increasing height (WMO). Air pollutants may become trapped in the air mass beneath such a layer, since vertical transport through the layer is virtually impossible, giving rise to high levels of pollution near ground level.

Ion. An atom, molecule, or group of molecules possessing an electric charge. *Ionization*, the formation of ions by the division of molecules or by the addition or removal of electrons from atoms, molecules, or groups of the latter (IEC, 1).

Ion exchange. The exchange of ions of the same sign of electric charge between a solution and an inorganic or organic solid or liquid called an *ion exchanger*. The ion exchanger is considered to be insoluble in the solution. The use of ion exchange processes has been considered for the removal of sulfur dioxide from stack gases.

Ionization. See *ion.*

Iron(III) oxide. The red oxide of iron ("ferric oxide"), formula Fe_2O_3, which occurs naturally in the form of the mineral hematite. The iron oxide fume (consisting of particles less than 1 μm in diameter) that may be produced in steel works is not known to be directly harmful to health, although it causes a dirt and nuisance problem.

Irradiation. The process of causing radiation to interact with matter in a region (IEC, 2).

Isentropic process. A process that takes place without change of entropy. For atmospheric processes, generally equivalent to *adiabatic process* (q.v.).

Isobar. A line joining points of equal pressure on a given surface (level surface, vertical cross-section, etc.) (WMO).

Isogram. On a diagram or chart, a line of equal value of a meteorological or climatological element (WMO).

Isomer. One of two or more substances that have the same molecular formula (i.e., that contain the same number and kinds of atoms) but different structures. The phenomenon, which is known as *isomerism*, may be of several different kinds. *Isomerization* is the process of converting one isomer of a compound into one or more different isomers of the same compound. It is used, among other processes, in the refining of petroleum to give gasoline more suitable for use as an automotive fuel than would be obtained by the simple distillation of crude petroleum.

Isopleth. A line of equal value of a function of two variables. For example, a line of equal value of a meteorological element, represented as a function of the two coordinates, hours of the day and months of the year. Often the term is used loosely as a synonym of *isogram* (WMO).

Isotherm. A line which is the locus of points which have the same value of air temperature (WMO).

Isothermal layer. An atmospheric layer throughout which there is no change of temperature with height (WMO).

Isotopes. Nuclides having the same atomic number but different mass numbers (ISO, 5). (The atomic number is equivalent to the number of protons; the mass number is equivalent to the number of protons plus the number of neutrons.) All the isotopes of a given element have identical chemical properties, but differ in atomic mass; some may be radioactive and others not radioactive.

J

Jet, overfire. A jet of air or steam designed to promote turbulence above a fuel bed in a furnace and so reduce the formation of smoke.

K

Kelvin equation. See *pressure, vapour.*

Kerosine. Atmospheric (petroleum) distillate having a volatility intermediate between those of gasoline and gas-oil and distillation range generally within the limits 150 to 300°C. It is treated, if necessary, to meet the requirements for different uses of which the main ones are: lighting, heating and as fuel for gas turbines for aircraft, etc. (ISO, 4a).

Ketene. An organic compound containing the group C=C=O; general formula, RCHCO. The simplest ketene, ethenone, H_2CCO (also known as "ketene") is extremely toxic and irritating. Certain ketenes occur in photochemical smog.

Ketone. An organic compound containing the carbonyl group, C=O, attached to two carbon atoms; general formula, $R_1C(O)R_2$, where R_1 may be either the same as, or different from, R_2. Ketones are widely used as solvents. Certain ketones occur in photochemical smog.

Kiln. An oven, furnace, etc., for the heat processing of certain materials or products. *Car tunnel kiln*, a kiln for the firing of ceramic ware, heated by gas, oil, or electricity; in contrast to the older intermittent type of kiln, it is smokeless and has made a great contribution to clean air. *Claus kiln*, an installation used in the last stage of the recovery of sulfur from petroleum and natural gas. Gas rich in hydrogen sulfide is produced in the earlier stages: part is burned to give sulfur dioxide, which is mixed with the remainder over a catalyst to give elemental sulfur. In modern installations the process is conducted in two stages to increase the yield of sulfur and decrease the amount of hydrogen sulfide and sulfur dioxide that must be disposed of. *Hoffman kiln*, a commonly used brick-making kiln; it can give rise to intense pollution by smoke and by sulfur and fluorine compounds.

Konimeter. An instrument used for the approximate determination of the amount of dust in suspension in the air. A form of the instrument is based on the fact that the intensity of the coloration produced in certain substances by the condensation of water vapour increases with the dust concentration in the air (WMO).

L

Label. See *tracer.*

Labile. In meteorology, a term sometimes applied to the condition of the atmosphere when the temperature lapse rate is equal to or greater than the adiabatic lapse rate. See *lapse rate, temperature.*

Lachrymator. A substance that, in contact with the eyes, causes the production of tears.

Lapse rate, temperature. The rate of decrease of temperature with increasing height: usually an average rate over a distance, for example 100 metres, is considered (WMO). *Adiabatic lapse rate*, the theoretical temperature lapse rate of a parcel of air which moves adiabatically in the vertical (WMO). *Dry adiabatic lapse rate*, the adiabatic lapse rate of dry air, and also, very closely, of moist, unsaturated air. Its value is about 1°C/100 m (WMO). *Saturation adiabatic lapse rate*, the adiabatic lapse rate of air that is saturated with water vapour. Owing to the enthalpy of condensation, the value of the saturation adiabatic lapse rate is less than that of the dry adiabatic lapse rate (based on WMO). *Super-adiabatic lapse rate*, a temperature lapse rate of magnitude greater than the dry adiabatic lapse rate (WMO). This state of atmospheric instability is most likely to occur over a land surface strongly heated by the sun, and is usually very favourable to the dispersion of air pollutants. However, it causes looping of elevated plumes and can lead to pollutants being brought down to ground level in high concentration for short periods.

Laser. A device for the production and amplification of light. The term "laser" is an acronym for "light amplification by stimulated emission of radiation". The beam of light produced by a laser is characterized by (*a*) low divergence (the beam spreads very little and consequently there is little dissipation of energy); (*b*) coherence (the light waves have the same frequency, phase, and amplitude); and (*c*) high intensity (much greater than sunlight). It is also very nearly monochromatic; by proper design, a laser can be made to emit light of almost any wavelength. The light is produced in very short pulses (e.g., pulses of a few microseconds at intervals of a few hundred microseconds). Lasers are finding increasing use for a wide variety of purposes. For their use in the study of the dispersal of atmospheric pollutants, see *lidar.*

Latent heat. A term formerly used for the change in enthalpy that accompanies a phase change. The use of the term is deprecated. See *enthalpy.*

Lead. A metallic element; atomic number 82, relative atomic mass 207.2, symbol Pb. Lead (in the form of dust) and its compounds are highly toxic and are cumulative poisons; the compounds may be stored in the bone and subsequently released into the blood. Dusts containing lead compounds are emitted into the air from factories that use the metal and in automobile exhaust when gasoline containing lead additives is used.

Lead dioxide method. A method for estimating the rate at which sulfur dioxide in the atmosphere can react with solid surfaces. Lead dioxide of specified reactivity is spread on a linen surface in a standard way, and the linen wrapped round a vertical porcelain cylinder and exposed to the air in a *thermometer screen* (q.v.). At the end of a month the amount of lead sulfate produced is determined. The rate of reaction depends on the concentration of sulfur dioxide in the air, the wind speed, and the humidity.

Lead peroxide. A term formerly applied to lead dioxide. The term "lead peroxide candle" was formerly applied to the porcelain cylinder covered with lead-dioxide-coated linen used in the *lead dioxide method* (q.v.).

Lead susceptibility. A term applied to the degree to which the *octane number* (q.v.) of a gasoline is improved by the addition of *tetraethyllead* (q.v.).

Lead tetraethyl. See *tetraethyllead.*

Lead tetramethyl. See *tetramethyllead.*

Leeward side. In meteorology, a part of the side of a hill or mountain, or a region, which is sheltered from the wind by a relief feature (WMO). The term is also applied, as is the noun "lee", to the sheltered (downwind) side of an object such as a building.

Lidar. A system, based on the same principle as *radar* (q.v.), in which a light pulse produced by a *laser* (q.v.) is used to detect and measure the distance to an object. The name is an acronym for "light detection and ranging". Lidar has been used for several different purposes in air pollution studies, but its most important application in this area is the measurement of the density of smoke plumes.

Liege sphere. A deposit gauge consisting of an aluminium sphere, 120 mm in diameter, coated with petrolatum and exposed to the air to collect grit and dust particles that come into contact with it. The spherical shape causes less interference with air flow than other forms of deposit gauge. It is used widely in Belgium and the Netherlands.

Light. *Radiation* (q.v.) capable of stimulating the organ of vision (visible radiation) (WMO).

Limit of detection. See *sensitivity.*

Limit, lower detectable. A term sometimes applied, in air pollution measurements, to the minimum amount or concentration of a pollutant that, when applied to the detector of an instrument, results in a signal whose level s is twice that of the noise n in the instrument output. The term is misleading in that it is liable to be confused with the internationally approved term *limit of detection (*see *sensitivity).*

Linear response (of a measuring instrument). A response that is directly proportional, within specified limits, to the value of the quantity being measured (e.g., to the concentration of a pollutant in air).

Liquefied petroleum gas. See *gas, liquefied petroleum.*

Load factor. In the supply and distribution of electricity, the average load throughout the year expressed as a percentage of the highest load on the system that occurs at any time during the year. This and similar factors are important in the estimation of pollutant emission by power stations.

London smog. See *smog.*

Looping. See *plume.*

Los Angeles smog. See *smog.*

LPG. See *gas, liquefied petroleum.*

M

MAC. See *maximum permissible concentration.*

Macroclimate. The climate of a large geographical region, a continent, or even the whole globe (WMO).

Macrometeorology. The branch of meteorology which is concerned with the study of large-scale meteorological conditions. The study usually relates to a large geographical region, such as a continent or even the entire globe (WMO).

Manganese. A metallic element; atomic number 25, relative atomic mass 54.9380, symbol Mn. Manganese compounds occur in the air in small amounts near chemical plants in which they are processed; they are also used in certain fuel additives. Their possible effect on health is under investigation.

Masking. A decrease of the sensitivity or a change in the quality of the perception of one stimulus by simultaneous action of another (provisional ISO, 12). In air pollution work, the term usually applies to odour perception, and a *masking agent* may be released into the air to "mask" the presence of certain malodourous materials.

Mass spectrometry. An analytic technique that is based on the separation, according to their mass/charge quotient, and electrical measurement of ions in an instrument known as a mass spectrometer. Mass spectrometry is an extremely sensitive technique that is applicable to many air pollutants.

Maximum permissible concentration (MPC) (or maximum admissible or acceptable concentration, MAC). The concentration that, if inhaled daily (in the case of workpeople for 8 hours, in the case of the general population 24 hours), does not, in the present state of knowledge, appear capable of causing appreciable harm, however long delayed, in the target. In setting values for such concentrations and in determining the meaning of "appreciable harm" an authority will have regard, according to the nature of the pollutant, to the need for including a factor of safety, and to the degree of risk that may or may not be acceptable to individuals, population groups (e.g., workpeople), or the general population (proposed definition). See also *threshold limit value.*

Mean free path. The average distance that particles of a specified type travel before a specified type (or types) of interaction in a given medium. The mean free path may thus be specified for all interactions (i.e., total mean free path)

or for particular types of interactions such as scattering, capture, or ionization (ISO, 5). It is an important factor in reactions involving highly reactive chemical species in the atmosphere.

Mercaptan. An organic compound containing the -SH group. Mercaptans are sulfur analogues of alcohols and phenols. They have objectionable odours (the smell of the skunk is due to a mercaptan) and are sometimes added to odourless gases (e.g., natural gas) to give rapid warning of a leak. The unpleasant smell associated with oil refineries is partly due to mercaptans. They are sometime called "thiols".

Mercury. A liquid (at ordinary temperatures) metallic element, atomic number 80, relative atomic mass 200.59, symbol Hg. It is widely used in industry and some of its compounds are used as agricultural fungicides. Most mercury compounds, and the vapour of the metal itself, are intensely poisonous. While there is great concern over water pollution by mercury, and serious outbreaks of intoxication have resulted from the consumption of contaminated fish, the concentrations commonly observed in air would appear to be below the danger level.

Mesometeorology. The branch of meteorology which is concerned with the study of medium-scale meteorological conditions. The area covered is typically of the order of a few to some tens of square kilometres (WMO).

Mesopause. The top of the mesosphere at about 80 – 85 km (WMO).

Mesosphere. The region of the atmosphere, situated between the stratopause and the mesopause, in which the temperature generally decreases with height (WMO).

Metal, heavy. A metal of high relative atomic mass, e.g., lead. In the air pollution literature the term has been used loosely to include metals such as copper and zinc, and even elements such as arsenic that are not metals.

Meteor. A phenomenon other than a cloud, observed in the atmosphere or on the surface of the earth, which consists of a precipitation, a suspension or a deposit of aqueous or non-aqueous liquid or solid particles, or a phenomenon of the nature of an optical or electrical manifestation (WMO).

Meteorological element. An atmospheric variable or phenomenon which characterizes the state of the weather at a specific place at a given time (air temperature, pressure, wind, humidity, thunderstorm, fog, etc.) (WMO).

Meteorological optical range (MOR). The length of path in the atmosphere required to reduce the luminous flux in a collimated beam from an incandescent lamp at a colour temperature of 2 700 K to 0.05 of its original value, the

luminous flux being evaluated by means of the CIE (International Commission on Illumination) photopic luminosity function (WMO). This gives, in effect, an instrumental measure of visibility.

Meteorology. The science of the atmosphere (WMO). As such it is concerned with the chemistry and physics of the atmosphere, including the interaction of the atmosphere with the earth's surface and the behaviour of air pollutants after they enter the atmosphere.

Methane. A colourless, odourless gas, formula CH_4. It is flammable and forms explosive mixtures with air. Methane is the principal constituent of most natural gas and a major constituent of coal gas. It is formed in the decomposition of organic matter, e.g., in marshes, and a common term for it is "marsh gas".

Methylene blue test. A test used for determining the efficiency of air conditioning and ventilation equipment, air filters, etc., in terms of their efficiency in removing particles of methylene blue, within the size range 0.2 to 2 μm, from a fine suspension.

Microclimate. The fine climatic structure of the atmospheric layer adjacent to a particular surface (WMO). The surface is usually very small in extent – e.g., a park or a few streets.

Micrometeorology. The branch of meteorology which is concerned with the study of small-scale meteorological conditions. The study generally involves refined measurements close to the earth's surface over short periods of time (WMO).

Micro-Ringelmann chart. See *smoke chart.*

Microwave. See *radiation.*

Mie scattering. See *scattering.*

Mist. A suspension in the air of microscopic water droplets or wet hygroscopic particles, reducing the visibility at the earth's surface (WMO).

Mixing depth. See *mixing layer.*

Mixing layer. The lower part of the atmosphere within which motions are much affected by the vicinity of the surface of the earth and where, as a result, pollutants are dispersed and mixed. For convective conditions the mixing layer may extend up to several kilometres above the surface but for stable conditions its height may be only some 200 m. In the absence of temperature differences between the air and the surface, mixing is brought about solely by mechanical turbulence and the *depth of the mixing layer* (the distance between the earth's

surface and the upper boundary of the mixing layer) depends on the surface roughness and is proportional to the geostrophic wind speed.

Mixing length. The mean length of travel, characteristic of a particular motion, over which an eddy maintains its identity; analogous to the mean free path of a molecule (WMO).

Mixing ratio. For moist air, the ratio of the mass m_v of water vapour to the mass m_a of dry air with which the water vapour is associated: $r = m_v/m_a$ (WMO).

Model, mathematical. In air pollution studies, a set of formulas that take into account sources of pollution in a given area, the amounts of pollutants emitted by each, different meteorological conditions and topographical features, and other factors that affect dispersion of pollutants. Such a model can be used for the calculation of pollutant concentrations at any given point in the air.

Molybdenum. A metallic element, atomic number 42, relative atomic mass 95.94, symbol Mo. Dust containing molybdenum compounds may be emitted from certain steel works and renders herbage on which it falls harmful to cattle.

Monitoring. In environmental health, the repetitive and continued observation, measurement, and evaluation of health and/or environmental or technical data for defined purposes, according to prearranged schedules in space and time and using comparable methods for sensing and data collection (proposed definition).

Monodisperse system. A colloidal system in which all the particles are of (almost) the same size.

MOR. See *meteorological optical range.*

MPC. See *maximum permissible concentration.*

Multicyclone. See *dust separator.*

N

Naptha. A term applied to a variety of distillates obtained from either petroleum or coal tar. In the petroleum industry, a light distillate having a distillation range similar to gasoline (ISO, 4a). *Heavy naptha* and *solvent naptha*, coal tar distillates having distillation ranges of 160–220°C and 160°C, respectively.

NASN. An acronym for *National Air Sampling Network* (q.v.).

National Air Sampling Network. A network of up to 370 sampling stations in the USA, operating discontinuously on a fixed schedule. It was set up in 1953 and the measurements made at the different sites are used in a national survey of air pollution, one of several surveys currently being carried out by the Environmental Protection Agency.

National Ambient Air Quality Standards. See *standard.*

National Survey of Air Pollution. A survey set up in the United Kingdom in 1960 in which daily measurements of smoke and sulfur dioxide are made at some 1100 sites. Measurements of grit- and dustfall are also made at many sites. The survey is organized by the Warren Spring Laboratory of the Department of Industry but the measurements are made by local authorities.

Nebulization. The reduction of a solid or liquid to very fine particles (e.g., a spray of fine droplets). The device that performs the operation is termed a nebulizer. Cf. *atomization.*

Neon. A gaseous element, atomic number 10, relative atomic mass 20.179, symbol Ne. Neon is a normal constituent of the atmosphere in trace amounts. It is one of the *noble gases* (q.v.).

Nephelometer. An instrument for determining by optical methods the amount of particles suspended in a turbid medium (WMO).

Neutral stability. See *stability, static.*

Nickel. A metallic element, atomic number 28, relative atomic mass 58.71, symbol Ni. It is widely used for the manufacture of alloys, for electroplating, and for many other purposes. The possibility that nickel in some form may be carcinogenic under conditions of high exposure is under investigation.

Nitric acid. A colourless or yellowish fuming liquid, formula HNO_3. It is highly corrosive and the vapour is very hazardous. Nitric acid and nitrates (mainly ammonium nitrate) occur in the atmosphere in the form of aerosols: the acid is formed from oxides of nitrogen and then reacts with ammonia to form ammonium nitrate.

Nitric oxide. See *nitrogen oxides.*

Nitrogen. A gaseous element, atomic number 7, relative atomic mass 14.0067, symbol N. It is the principal constituent of *air* (q.v.).

Nitrogen cycle. A series of processes in which atmospheric nitrogen is converted into nitrates in soil and other nitrogenous compounds in plants, from which – directly by way of animals, or through the immediate stage of coal – ammonium compounds are formed in the soil, the latter compounds eventually breaking down to return the nitrogen to the atmosphere or to another part of the cycle.

Nitrogen dioxide. See *nitrogen oxides.*

Nitrogen oxides. A series of seven compounds, of which only three are of any significance in the atmosphere. *Dinitrogen oxide* (nitrous oxide), N_2O, a colourless gas that is believed to play an important role in the *nitrogen cycle* (q.v.). It is the most abundant atmospheric nitrogen compound but is of no significance as a pollutant. *Nitrogen oxide* (nitric oxide), NO, a colourless poisonous gas that reacts readily with oxygen (and very rapidly with ozone) to form the dioxide. It is formed by combustion processes, e.g., in furnaces and internal combustion engines (the higher the temperature, the greater the amount produced), and is an active participant in the atmospheric reactions that lead to the production of photochemical *smog* (q.v.). *Nitrogen dioxide*, NO_2, a reddish-brown poisonous gas. At ordinary temperatures the vapour is an equilibrium mixture of NO_2 and the dimer N_2O_4 (dinitrogen tetroxide); on heating, the latter dissociates and the NO_2 content increases. Above 140°C, the NO_2 dissociates into NO and oxygen. The name "nitrogen dioxide" and the formula NO_2 are used for the equilibrium mixture.

In the air pollution literature, the term "nitrogen oxides" and the formula NO_x are used for the mixture of NO and NO_2 in the air. Quantitatively the concentration of NO_x is defined as the concentration of NO_2 actually present plus the extra concentration of NO_2 that would result from the oxidation of the NO that is present. (The usual methods of measurement first determine the NO_2 present, then oxidize the NO and determine the extra NO_2 produced.)

Nitrous oxide. See *nitrogen oxides.*

Noble gases. The gaseous elements helium, neon, argon, krypton, xenon, and radon. They were formerly referred to as the "inert gases", but the use of this

term is now deprecated. All the noble gases occur in the atmosphere, although (with the exception of argon) only in trace amounts. Radon is radioactive.

Nodular. In the description of particles, having a rounded irregular shape.

Noise. (*a*) Any disagreeable or undesired sound; (*b*) sound, generally of a random nature, the spectrum of which does not exhibit clearly defined frequency components. By extension, noise may consist of electrical oscillations of an undesired or random nature (ISO, 14). Many authorities now consider noise as defined in (*a*) to be a "pollutant". Noise as defined in (*b*) is important in instrumental techniques of analysis.

Nondispersive infrared absorption. A method in common use for the estimation of carbon monoxide in air or other gases. Radiation from a source emitting a wide range of wavelengths in the infrared is passed through the gas under examination and then into a sealed cell containing pure carbon monoxide. Carbon monoxide absorbs strongly at wavelengths around 4.6 μm. The more carbon monoxide in the gas sample, the less radiation of this wavelength will reach the sealed cell to suffer absorption and so cause heating of the gas in the cell, which is measured by the resulting increase in pressure. The method is called "nondispersive" since it does not make use of monochromatic radiation (obtained by spectral dispersion) as does a spectrophotometer.

Normal temperature and pressure (NTP). A temperature of 273.15 K (0°C) and a pressure of 101 325 Pa; synonymous with "standard temperature and pressure" (STP) (however, the latter expression has sometimes been used, particularly in the engineering literature, for other, now obsolete, standard conditions).

NO_x. See *nitrogen oxides.*

NTP. See *normal temperature and pressure.*

Nucleation. The action of special particles, termed "nuclei", in the passage from the vapour phase of a substance to the liquid or solid phases, or from the liquid to the solid phase (WMO).

Nuclei counter. See *dust counter.*

Nucleus. A special minute particle on which operates the passage of atmospheric water vapour to the liquid or solid phases, or of water from the liquid to the solid phase (WMO). *Condensation nucleus*, a nucleus on which the condensation of water vapour occurs (WMO).

Nucleus, Aitken. See *Aitken particle.*

Nuisance threshold. The lowest concentration of an air pollutant that can be considered objectionable. Cf. *odour threshold.*

O

Obscuration meter. See *smokemeter.*

Occlusion. (*a*) The process of progressive decrease of area of the warm sector [i.e., that part of a depression in which the warm air mass is contained between the leading warm front and the following cold front] at the earth's surface, and its ultimate disappearance, by the junction of the cold air masses which initially precede the warm front and follow the cold front. (*b*) The front between these two cold air masses, after their junction (also temed occluded front) (WMO).

Octane number. A number on a conventional scale expressing the knock-resistance of a fuel for spark-ignition engines. It is determined in test engines by comparison with reference fuels. There are several methods of test; consequently the octane number quoted should be accompanied by reference to the method used (ISO, 4). The term arose through the use of 2,2,4-trimethylpentane ("isooctane") as a reference fuel, to which the octane number of 100 was assigned (as opposed to 0 for heptane).

Odorant. A material that has a distinctive, sometimes unpleasant, odour and that may be added to odourless materials to give warning of their presence (the term "odorizer" is also used for the latter application). In most areas the addition of an odorant to natural gas (to avoid the danger of explosions resulting from undetected leaks) is mandatory.

Odorizer. See *odorant.*

Odour fatigue. See *sensory adaptation.*

Odour threshold. In principle, the lowest concentration of an odorant that can be detected by a human being. In practice, a panel of "sniffers" is normally used and the threshold taken as the concentration at which 50% of the panel can detect the odorant (although some workers have also used 100% thresholds).

Odour intensity index. In the test method of the American Society for Testing and Materials, the number of times that an odorant must be diluted by a factor of 2 in order to reach threshold concentration.

Offensive trade. A term used in United Kingdom legislation for a process involving animal products or residues (skin, bones, fat, etc.) listed under the Public Health Acts or declared to be offensive trades by a competent authority.

Oil equivalent. In principle, the mass of a standard oil that would on combustion produce the same quantity of heat as a given mass of a given oil. In practice certain arbitrary rules are applied in calculating oil equivalents and these differ from one country to another.

Oil fuel. See *fuel, petroleum.*

Olefin. See *alkene.*

Opacity rating. A measure of the opacity of an emission; the degree of obscuration (of the vision of an observer) that is equal to the apparent obscuration produced by smoke of a given Ringelmann number. See *smoke chart.*

Optical density. See *absorbance.*

Organic compound. A compound of carbon.

Organic sulfur. See *sulfur.*

Organoleptic. Relating to an attribute perceptible by the sense organs (ISO, 12). In air pollution contexts, the attribute of a product is usually odour. *Organoleptic panel*, see *panel.*

Organometallic compound. An organic compound whose molecule contains one or more carbon–metal bonds.

Orographic. Pertaining to mountains. See *cloud, orographic.*

Orsat apparatus. An apparatus for the volumetric analysis of gases, usually flue gases. The apparatus is usually used to determine carbon monoxide, carbon dioxide, and oxygen; it may be designed to determine hydrogen, nitrogen (by difference), and other gases (such as methane and ethane) also.

Oxidant. An oxidizing substance; i.e., one that brings about the process of *oxidation* (q.v.). Atmospheric oxidants include ozone, nitrogen dioxide, and organic peroxides. They all liberate iodine from neutral solutions of potassium iodide. "Oxidant" concentrations quoted in the air pollution literature and obtained by this method are calculated on the assumption, purely as a matter of convenience in reporting the results, that all iodine is liberated by ozone.

Oxidant smog. See *smog.*

Oxidation. A loss of electrons, leading to an increase in valence number (originally the term meant combination with oxygen, but it is now given this broader meaning).

Oxygen. A gaseous element, atomic number 8, relative atomic mass 15.9994, symbol O. Molecular oxygen (O_2) constitutes about 20.95% by volume of dry air in the lower part of the atmosphere and is essential for the maintenance of almost all forms of life. Above an altitude of 20 km atomic oxygen (O) appears in significant amounts and at 100 km it is the predominant form. For the triatomic form of oxygen, see *ozone.*

Oxygen lancing. See *furnace, steel-making.*

Ozone. The triatomic allotrope of oxygen; a pale blue gas with a distinctive pungent odour; formula O_3. It is a highly reactive oxidizing agent and is very poisonous, and is considered a serious pollutant at concentrations much in excess of 125 $\mu g/m^3$. It occurs at much greater concentrations than this in the upper atmosphere, where it is formed by the action of solar ultraviolet radiation; some is mixed down into the lower atmosphere. Ozone is also formed by electric discharges (e.g., lightning) and by photochemical reactions involving hydrocarbons and oxides of nitrogen (from, for example, automobile exhaust gases).

Ozone layer (or **Ozonosphere**). An atmospheric layer lying between about 10 and 50 km [above the surface of the earth], in which the percentage of ozone is relatively high. The maximum concentration generally occurs at about 20 or 25 km (WMO).

P

PAH. An acronym for "polynuclear aromatic hydrocarbon". See *hydrocarbon.*

PAN. An acronym for "peroxyacetyl nitrate". See *peroxide, acetylnitro.*

Panel (Organoleptic panel). A group of assessors chosen to participate in a sensory test (ISO, 12).

Paraffin. See *alkane.*

Paraffin oil. See *kerosine.*

Parameter. A variable that is given a constant value for a specified application and that may denote the application (ISO, 11). The term is widely misused to mean "variable" (with which it is not synonymous) or even "factor", "influence", and similar terms.

Pararosaniline method. See *West-Gaeke method.*

Particle. A discrete element of a material regardless of its size; a small part of a solid or liquid substance (ISO, 13; provisional ISO, 8).

Particle size analysis. The science which deals with the measurement of the dimensions and the determination of the shape of particles; the whole of the operations by which a particle size distribution can be obtained (provisional ISO, 8). See also *sieving.*

Particle size distribution (or **Granulometric distribution).** A presentation, in the form of a table of numbers or a graph, of the experimental results obtained using a method or an apparatus capable of measuring the equivalent diameter of particles in a sample or capable of giving the proportion of particles for which the equivalent diameter lies between defined limits (provisional ISO, 8). See *diameter, equivalent.*

Particulate matter, suspended (or **Suspended particulates).** All solid and liquid particles in the air that are small enough not to settle out on to the earth's surface under the influence of gravity; also defined as the material that can be removed from air by passing it through a suitable filter. (If a smokemeter is calibrated against the amount of material collected in this way, it really gives information about total suspended particulate matter, of which smoke generally constitutes only a part.) See also *aerosol; dust.*

Pathogen. Etymologically, any disease-producing agent; in common usage the term is restricted to a living organism (usually a microorganism) that causes disease.

PCB. See *polychlorinated biphenyl.*

Permeation tube. A sealed polymer tube containing a liquefied sample of a given, normally gaseous, substance. At a fixed temperature this substance diffuses through the walls of the tube at a constant rate, so that by allowing a stream of air to flow past the tube at a known rate, mixtures of this gas with air at very low, but accurately known, concentrations can be prepared. This method is commonly used for calibrating instruments and analytical methods used for measuring concentrations of pollutants in air.

Peroxide, acetylnitro. An organic peroxide, formula $CH_3C(O)OONO_2$, that is a constituent of photochemical *smog* (q.v.) and that (together with related compounds) is responsible for the eye irritation caused by such smog. It is often referred to as **PAN**, an acronym for peroxyacetyl nitrate.

Peroxyacetyl nitrate. See *peroxide, acetylnitro.*

Petrol. See *gasoline.*

Phase. In physical chemistry, a homogeneous part of a system that is divided from another homogeneous part of the system by a boundary. For example, an enclosed mixture of ice, water, and water vapour exists in three phases – a solid phase, a liquid phase, and a gas phase.

Photochemical reaction. A chemical reaction brought about by the action of light. Such reactions, which can be initiated only by light that is absorbed, are essentially due to electronic excitation, and cannot be effectuated by radiation in the far infrared; they are generally brought about by visible or ultraviolet light, particularly the latter. Such reactions are responsible for the production of photochemical *smog* (q.v.).

Photochemical smog. See *smog.*

Photometry. The technique of measuring light, i.e., radiation that affects the eye. The instrument that is used is termed a *photometer.* Photometry measures luminous quantities, and the units and terminology of photometry should not be applied to radiant quantities.

Phytotoxicity. The property of being injurious to plants.

Pitot tube. A tube, one end of which is open and held perpendicular to a fluid stream in order to detect the dynamic pressure of the fluid stream. The speed

of the fluid can be determined from the difference between the impact pressure and the static pressure (WMO).

Plume. The gases issuing from a stack so long as they retain their identity as a stream of gas and do not become completely dispersed in the surrounding air. Near the stack the plume is often visible owing to water droplets, dust, or smoke that it contains, but it often persists downwind long after it has become invisible to the eye (it can, however, be detected and followed by suitable instruments). *Fanning plume*, a plume that fans out horizontally into a thin layer under stable atmospheric conditions that restrict its spread vertically. The effect is enhanced in buoyant plumes that have already spread considerably by turbulence while rising, before levelling out where the atmospheric and plume temperatures are equal. A fanning plume can cause intense pollution if it impinges on a building or hillside. *Looping plume*, a plume that appears to be following a sinuous path, usually with irregular undulations. The up and down motion starts as soon as the gas issues from the stack and is caused by atmospheric eddies, often the result of thermal convection. It is an optical illusion that any particular parcel of gas follows a sinuous path as it moves downwind; if it forms the top of a wave near the stack, it remains as the top of a wave as it moves downwind. It is the sinuosities that move with the wind, growing in size as they travel. Looping is seldom observed from stacks taller than 100 m.

Plume rise. See *stack height, effective.*

Point source. See *emission source.*

Pollen. The fine powdery substance produced by seed plants, each particle containing a male cell for the purpose of fertilization. Many pollens cause hay fever, sometimes of a very severe nature, in sensitized persons, for whom pollens constitute the worst of the air pollutants.

Pollutant. Any undesirable solid, liquid, or gaseous matter in a gaseous or liquid medium (provisional ISO, 8). For the meaning of "undesirable" in air pollution contexts, see *pollution.* Cf. *contaminant. Primary pollutant*, a pollutant emitted into the atmosphere from an identifiable source. *Secondary pollutant*, a pollutant formed by chemical reaction in the atmosphere.

Pollution. The introduction of pollutants into a liquid or gaseous medium, the presence of pollutants in a liquid or gaseous medium, or any undesirable modification of the composition of a liquid or gaseous medium (provisional ISO, 8). For purposes of air pollution control, an "undesirable modification" is one that has injurious or deleterious effects. *Air pollution* is defined by the Engineers Joint Council as "the presence in the outdoor atmosphere of one or more contaminants, such as dust, fumes, gas, mist, odor, smoke, or vapor, in quantities, of characteristics, and of duration such as to be injurious to

human, plant or animal life or to property, or which unreasonably interferes with the comfortable enjoyment of life and property" (EJC).

Pollution, exotic. Pollution that drifts into a given area from a source outside that area.

Pollution potential. A term sometimes applied to a meteorological condition that, given the existence of pollutant emissions, would be conducive to the occurrence of severe air pollution.

Pollution rose. A diagram similar to the *wind rose* (q.v.) in which the length of each radius is proportional to the average degree of pollution when the wind blows from the direction indicated. The average pollution on days of calm is written inside the circle. Wind speed percentages may also be represented by rectangles of different widths drawn along the lengths of the radii.

Polychlorinated biphenyl (PCB). Any of a series of organochlorine compounds containing two linked phenyl rings and a variable proportion of chlorine. Most commercial products contain several different isomers, and some contain polychlorinated terphenyls also. They are widely used in the electrical industry, particularly in transformers, and have also been used as lubricants, hydraulic fluids, plasticizers, flame retardants, etc. They are very stable and have become widespread in the environment, and considerable concern has been expressed over their effects on health. Polychlorinated biphenyls have become widespread in the environment, and have recently been discovered in human maternal milk.

Polycyclid hydrocarbon. See *hydrocarbon.*

Prandtl tube. A device similar to the *pitot tube* (q.v.).

Precipitation. In meteorology, a hydrometeor made up of an aggregate of aqueous particles, liquid or solid, crystallized or amorphous, which fall from a cloud or group of clouds and reach the ground (WMO). In gas cleaning, an operation in which particles are separated from a gas stream in which they are suspended, by the action of an electrical field or a thermal gradient (provisional ISO, 8).

Precipitation, amount of (or **Rainfall amount).** The thickness of the layer of water which accumulates on a horizontal surface, as the result of one or more falls of precipitation, in the absence of infiltration or evaporation, and if any part of the precipitation falling as snow or ice were melted (WMO).

Precipitation, electrostatic. Precipitation of particulate matter by an electric field between electrodes: the particles become positively charged and migrate to the negative electrodes, where they are collected. See *dust separator.*

Precipitation, thermal. A form of precipitation based on the fact that suspended particles subjected to a high thermal gradient migrate from a zone of high temperature to one of low temperature. In sampling instruments based on this principle the dust-laden gas is passed through a narrow chamber in which there is a hot wire; the particles move away from the wire and are deposited on a cold surface. Since the force on a particle is proportional to its radius, suitable arrangements of the geometry of the device enable it to be used for particle size analysis.

Precision. The closeness of agreement between the results obtained by applying the experimental procedure several times under prescribed conditions. *Note* — The smaller the random uncertainties that affect the results, the greater the precision, but precision has no numerical value. For this reason, the term *imprecision* may be preferable in some contexts (provisional ISO, 15).

Pressure, partial. Of a given constituent of a gaseous mixture, the product of the mole fraction of that constituent and the pressure of the mixture. In meteorology, the pressure exerted by one of the gaseous components of atmospheric air on the assumption that it alone exists (WMO).

Pressure, vapour. In meteorology, the product of the mole fraction of the water vapour N_v and the pressure of the moist air p: $e' = N_v p$ (WMO). Curvature has a considerable influence on vapour pressure, and the vapour pressure of a small droplet is greater than that of a bulk phase with a plane surface at the same temperature; a mathematical relationship known as the Kelvin equation shows that the difference is inversely proportional to the radius of the droplet. This effect is of great importance in determining whether, for a given partial pressure of water vapour in the atmosphere, condensation on a given nucleus is possible.

Primary air. See *combustion.*

Probe. A tube used to obtain a sample of, or to make a measurement (e.g. of pressure) in, a gas stream, particularly a gas flowing in a duct.

Projected diameter. See *diameter, projected.*

Propellant. See *refrigerant.*

2-propenal. A colourless or slightly yellow liquid with a choking odour, formula CH_2CHCHO; commonly called acrolein. It is an *aldehyde* (q.v.) and it occurs in photochemical *smog* (q.v.).

Psychrometer. An instrument used to measure the humidity of the atmosphere. It comprises two identical thermometers, the bulb of one of which is

dry, while that of the other is wet and covered by a film of pure water or ice (WMO). The humidity is determined from the readings of the two thermometers by the use of hygrometric (or psychometric) tables or charts.

Pyranometer (or **Solarimeter**). An instrument for measuring solar radiation falling from the solid angle 2π on a plane surface. It is also used, with a solar shading device, to measure diffuse solar radiation, being then termed a "diffusometer" (WMO).

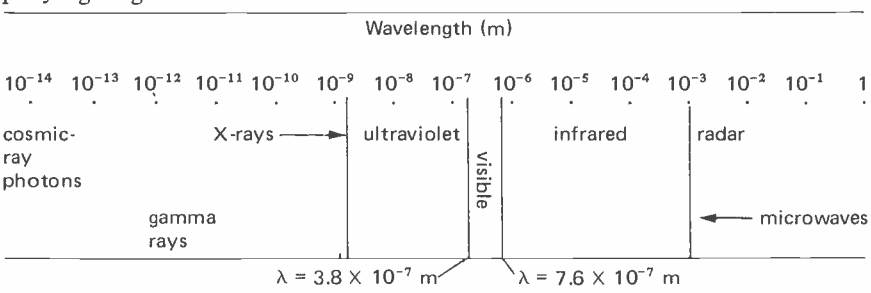
Pyrheliometer (or **Actinometer**). An instrument for measuring the total radiation falling from a small solid angle on a plane surface perpendicular to the axis of the solid angle. It is mainly used to measure direct solar radiation (WMO).

Pyritic sulfur. See *sulfur.*

Q, R

Radar. A radio method of determining at a single station the direction and distance of an object. In such a system the distance is determined by the travel time of signals from the station to the distant object and return (WMO). It can be used for tracking balloons designed to travel in plumes of polluted stack gases, etc. The term "radar" is an acronym for "radio direction and ranging".

Radiation. In general, (*a*) the emission or transfer of energy in the form of electromagnetic waves or particles; (*b*) this energy itself, also termed "radiant energy" (WMO). In radiological physics, radiation is defined more specifically as (1) electromagnetic or quantum energy (e.g., röntgen rays and gamma rays); (2) corpuscular radiation, consisting of (*a*) charged particles (e.g., alpha particles, electrons, protons, deuterons), and (*b*) uncharged particles (e.g., neutrons) (IEC, 2). The approximate locations in the electromagnetic energy spectrum of the types of radiation discussed in this glossary are indicated on the accompanying diagram.



Electromagnetic radiation spectrum

Radiation, coherent. Radiation that is in phase. See *laser.*

Radiation, diffuse solar (or **Sky radiation).** Downward scattered and reflected solar radiation, coming from the whole hemisphere with the exception of the solid angle subtended by the sun's disc (WMO).

Radiation, downward (total). Solar and terrestrial radiations directed downwards (towards the earth's surface) (WMO).

Radiation, gamma. Electromagnetic radiation emitted in the process of nuclear transition or particle annihilation (ISO, 5). It has high penetrating power. See *radiation.*

Radiation, ionizing. Any radiation consisting of directly or indirectly ionizing particles or a mixture of both. Directly ionizing particles are charged particles (electrons, protons, alpha particles, etc.) having sufficient kinetic energy to produce ionization by collision; indirectly ionizing particles are uncharged particles (neutrons, photons, etc.) which can liberate directly ionizing particles or can initiate nuclear transformations (ICRU). Ionizing radiation occurs in the atmosphere both naturally (e.g., cosmic rays and disintegration of radioactive elements in the earth) and through the activities of man (e.g., the explosion of nuclear devices and the accidental escape of material from nuclear reactors). It can cause severe cell damage and lead to cancer, and exposure to it must be strictly controlled.

Radiation, monochromatic. Radiation that consists essentially of one wavelength (or of a very narrow band of wavelengths).

Radiation, net (or **Radiation balance**). The difference between downward and upward (total and terrestrial) radiations; the net flux of all radiations (WMO). The net radiation is considered to be positive if the downward radiation exceeds the upward radiation; it is generally positive by day and negative by night.

Radiation, solar. Radiation emitted by the sun. Direct solar radiation is solar radiation coming from the solid angle of the sun's disc on a surface perpendicular to the axis of this cone, comprising mainly unscattered and unreflected solar radiation (WMO).

Radiation, terrestrial. Radiation by the earth, including its atmosphere (WMO). Its wavelength is in the range $3-100\,\mu$m, with maximum intensity at about $10\,\mu$m.

Radiation, upward (total). Solar and terrestrial radiations directed upwards (towards space) (WMO).

Radiation balance. See *radiation, net.*

Radiation night. A term sometimes applied to a night on which the absence of cloud or wind allows sufficient loss of heat from the ground by radiation for a temperature inversion to be set up. See *inversion, temperature.*

Radioactive fallout. See *fallout, radioactive.*

Radioactivity. The property of certain nuclides of spontaneously emitting particles or gamma radiation or of emitting X radiation following orbital electron capture [i.e., a transformation in which the nucleus captures an orbital electron] or of undergoing spontaneous fission [i.e., nuclear fission which occurs without the addition of particles or energy to the nucleus] (ISO, 5). The

presence of radioactive material in the air represents a serious air pollution problem. See *radiation, ionizing.*

Radiosonde. An instrument carried through the atmosphere, equipped with devices permitting one or several meteorological elements (pressure, temperature, humidity, etc.) to be determined, and provided with a radio transmitter for sending this information (WMO).

Radon. A gaseous radioactive element; atomic number 86, relative atomic mass of longest-lived isotope (radon-222) 222.0175, symbol Rn. Radon is one of the noble gases; it is the heaviest known gas. Twenty isotopes are known, their half-lives ranging from microseconds to less than 4 days. Radon-222 is formed by the decay of radium; it decays to form solid products, which are also radioactive. Minute traces of radon occur in the atmosphere, which they reach by the decay of radium in the earth's surface. The build-up of radon may present a health hazard in uranium mines.

Rain. Precipitation of liquid water particles, either in the form of drops of more than 0.5 mm diameter or of smaller widely scattered drops (WMO). See *drizzle; precipitation; shower.*

Rain day. A period of 24 hours, starting at a specified time, on which at least a specified amount of rainfall is recorded.

Rainfall amount. See *precipitation, amount of.*

Rain-out. See *wash-out.*

Range. See *meteorological optical range.*

Rayleigh scattering. See *scattering.*

Real-time measurement. A measurement that is made virtually simultaneously with the event that is measured. In air pollution studies it is to be contrasted with integrating, or time-averaging, methods in which the average concentration of a pollutant over a given period of time is determined. Real-time measurements are of particular importance when the pollutants involved are hazardous to health.

Recycling. The return of the products, or a proportion of the products, of a process for retreatment; e.g., the return of part of the exhaust gas from an internal combustion engine to the intake manifold. It is an important process for minimizing air pollution.

Re-entrainment. The return of particles, subsequent to their deposition on a collecting surface, to an air stream in which they were previously suspended.

Refinery flare. See *flare.*

Refinery gas. See *gas, refinery.*

Reflectance (or **Reflection factor).** The ratio of the radiant (or luminous) flux reflected by a surface to the radiant (or luminous) flux incident on the surface.

Reflectometer. A downward-facing *pyranometer* (q.v.) (solarimeter), used for measuring reflected solar radiation (WMO). The term is also applied to a similar instrument used to assess the darkness of the stain produced on filter paper in a *smoke filter* (q.v.).

Reforming. A thermal or catalytic process for treating light petroleum fractions to yield gasoline having a higher aromatic content and a higher octane number than the feedstock (ISO, 4).

Refrigerant. A fluid used for heat-transfer purposes in refrigerating equipment. The substances most frequently used for this purpose are fluorinated hydrocarbons, and they are also widely used as propellants in "aerosol" spray dispenser cans. They should be referred to either by their chemical names or by their international designations, which consist of a number preceded by the letter **R** (examples: **R** 12 is dichlorodifluoromethane; **R** 22 is chlorodifluoromethane). Fears have been expressed that fluorinated hydrocarbon propellants released from spray cans, drifting upward in the atmosphere, might be instrumental in reducing the amount of ozone in the ozone layer, thus permitting a greater proportion of the solar ultraviolet radiation to reach the earth's surface, with serious consequences for health.

Reinluft process. A process for removing (and recovering) oxides of nitrogen, sulfur, and phosphorus from stack gases. The gases are mixed with oxygen and converted to a higher oxidation state (a catalyst may be used to increase the efficiency of conversion) and passed upward, in countercurrent fashion, over a downward-moving bed of a special type of carbon in a multichambered adsorber. The oxides are absorbed at different temperatures. Finally they are swept out of the carbon bed at high temperature in a stream of nitrogen or carbon dioxide and reduced. The process may be carried out in the presence of water vapour, in which case the corresponding acids, rather than the gaseous oxides, are recovered.

Relative humidity. See *humidity of the air.*

Residence time. In air pollution studies, the length of time during which a given molecule of an air pollutant remains in the atmosphere (it may, at the end of that time, be replaced by another molecule, so the residence time is not the duration of air pollution). In chemical engineering, the term is applied to the length of time that a given material remains in a vessel through which it is flowing.

Residual oil. See *fuel, petroleum.*

Response time (of a measuring instrument). The time which elapses after a sudden change in the quantity being measured up to the point at which the measuring instrument gives an indication which does not differ from the correct indication corresponding to the new value of the quantity by an amount greater than a given value. In order to determine the response time it is necessary to fix for each category of instrument: (*a*) the initial value from which the change in the quantity measured must be made, (*b*) the value of this change, (*c*) the difference between the correct indication and the indication at the end of the period taken as being the response time (OIML). The response time is therefore the time required for a readout device to reach a specified fraction of its final value in response to a step-function input (e.g., a sudden increase in pollutant concentration) to the detector. If this fraction is specified as $0.63(1 - 1/e)$, the response time is equal to the *time constant*; if, as is often the case, it is specified as 0.98, the response time is approximately equal to four time constants. The response time is of critical importance when components are assembled to form an analytical system, e.g., when a recorder is added to a detector and amplifier. A short response time is important in real-time measurements, particularly those involving hazardous pollutants. (The response time is sometimes, particularly in the USA, referred to as the fall time when it follows a decrease, and the rise time when it follows an increase, in the quantity being measured.)

Reynolds number. A dimensionless parameter, one of several such numbers used in the study of fluid flow. It is the ratio of inertial forces to viscous forces and is defined as $Re = \rho v l/\eta$, where ρ is the density of a fluid, η its viscosity and v its velocity, and where l is a linear dimension that depends on the problem under study (for flow in a pipe, for example, it is the diameter of the pipe). The value of the Reynolds number determines whether flow will be laminar or turbulent.

Reynolds stress (or **Eddy shearing stress**). The tangential stress (force per unit area of surface) responsible for the transfer of momentum in a turbulent fluid. It is equal, in a given plane, to the time average of the fluid density at a point multiplied by the product of two corresponding components of the eddy velocity (WMO).

Ringelmann chart. See *smoke chart.*

Ring oven analysis. A microanalytic technique based on the use of spot tests following separation and concentration of a sample on filter paper by means of an annular heating device. The method, which is extremely sensitive, selective, simple, and inexpensive, shows great promise for the analysis of particulate air pollutants.

Rise time. See *response time.*

Risk function. The relationship between the risk of damage to a target and the concentration of air pollutants to which it is exposed.

RUDS. An acronym for "reflectance unit of dirt shade", a measure of the soiling quality of air used in the USA. The unit is defined as that stain having a reflectance of 0.01 produced on a filter paper by passing 10 000 ft (3 048 m) of air through it. The RUDS reflectance unit is analagous to the COH transmittance unit, and the linear measure of air passed through the filter paper is calculated in the same manner. See *haze, coefficient of.*

Run-of-wind. A term applied to the distance defined by nv, where n is time in seconds and v is a constant wind velocity in m/s; the figure obtained is the run-of-wind for n seconds. If the wind velocity is not constant, integration over the time period involved is necessary. See *anemometer, counting.*

S

Saltzmann method. A widely used method for the determination of nitrogen dioxide, based on the Griess-Ilosvay reaction. Air is passed through a solution of *N*-1-naphthalenyl-1,2-ethanediamine, sulfanilic acid, and acetic acid; the pink coloration is measured colorimetrically or spectrophotometrically.

Sample. A part of a population collected with the object of estimating some characteristic. It is a portion collected from a consignment, batch, or unit as being representative of it with regard to the characteristic to be investigated (ISO, 2). *Random sample*, a sample selected in such a way that all possible samples of the same size have the same chance of being chosen (ISO, 2). *Short-period sample* ("grab sample", "spot sample"), a sample of air collected over a short period of time and usually taken to a central laboratory for analysis. The WHO Expert Committee on Atmospheric Pollutants (1963) recommended that for purposes of international comparison of routine measurements a short-period sample be defined as one taken over a period of 30 minutes.

Sampler, high volume. An instrument for sampling suspended particulates by filtering air at a rapid flowrate (e.g., 1–2 m^3/min) for a period of some 24 hours. The filter is weighed before and after exposure, and the apparatus is usually designed to prevent particles exceeding about 100 μm in diameter from gaining access to the filter.

Sampler, personal. A device attached to a person that samples air in his immediate vicinity so that his exposure to pollutants may be determined.

Sampler, sequential. A term applied in the air pollution literature to a number of different sampling devices. It may apply, particularly in the USA, to an instrument with a timer, manifold, and 6 or more port valves that passes air to different sampling devices at predetermined intervals. The term is also applied to an automatic device for making hourly measurements of smoke. Air is passed through filter paper at a constant rate and smoke remains on the paper as a dark stain. The filter paper (in the form of a rolled-up strip 20–30 mm wide) passes through a filter clamp held together by springs to make an air-tight joint. At the end of each hour the clamp opens, the paper strip is moved along some 40–50 mm, and the clamp closes again. A succession of smoke stains is produced, one for each hour of the day. The term "sequential sampler" is sometimes also used for the *semi-automatic apparatus* (q.v.).

Sampling. The collection of a representative portion for analysis and testing (ISO, 2).

Sampling, isokinetic. The taking of a sample of flowing gas (particularly gas flowing through a duct) in such a way that the sample does not undergo any change in either velocity or direction at the inlet of the probe. The probe itself must also be designed so that it causes the least possible disturbance to the flow of gas in the duct. This procedure is essential in taking samples of stack gases for measurement of their dust concentration.

Sandstorm. See *duststorm.*

SAROAD. An acronym for "storage and retrieval of aerometric data".

Saturation (in meteorology). At a given temperature and pressure, the state of moist air whose mixing ratio is such that the moist air can coexist in neutral equilibrium with an associated condensed phase (liquid or solid) at the same temperature and pressure, the surface of separation being plane (WMO). See *mixing ratio.*

Scaling. The detachment of oxides and other corrosion products in the form of scales from a surface that is undergoing corrosion, exposing a fresh surface to attack.

Scattering. A process in which a change in direction or energy of an incident particle or incident radiation is caused by a collision with a particle or a system of particles (ISO, 5). *Mie scattering*, the scattering of electromagnetic radiation by spherical particles, there being no particular relationship between particle size and the wavelength of the radiation. It is of considerable importance in air pollution studies. Light is effectively scattered by particles about 0.1 –1 μm in diameter; the resulting loss of visibility is a function of the particle radius squared. *Rayleigh scattering*, scattering by particles whose radius is less than about one-tenth of the wavelength of the radiation (e.g., the scattering of light by oxygen and nitrogen molecules in the air).

Scavenging process. A process or mechanism – physical, chemical, or biological – that results in the removal of pollutants from the atmosphere (e.g., the removal of suspended particulate matter by rain).

Scrubber. See *dust separator; gas purifier; gas washing; washer.*

Secondary air. See *combustion.*

Sedimentation. The effect of gravitational forces resulting in the separation of particles from the fluid in which they are suspended (provisional ISO, 8).

Selenium. A nonmetallic element; atomic number 34, relative atomic mass 78.96, symbol Se. It is widely used in industry in the manufacture of photocells (photographic exposure meters, etc.) and semiconductor devices; it is also

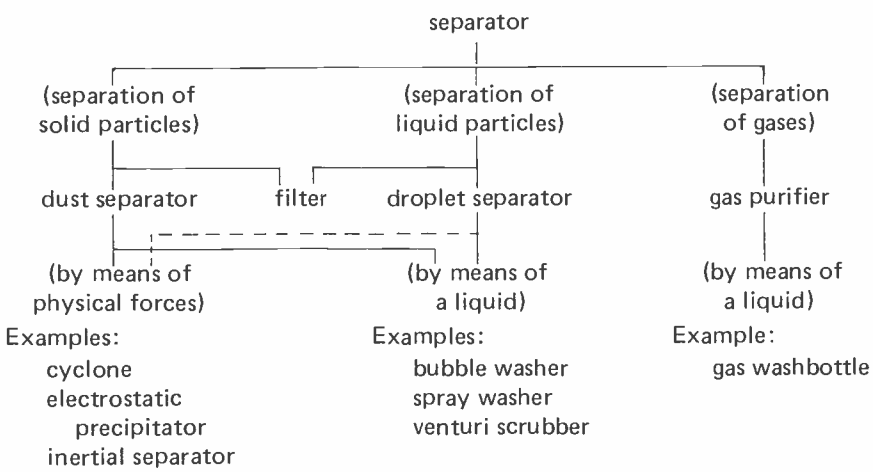
used in certain photocopying processes, in the glass-making industry, and for many other purposes. Selenium compounds are intensely poisonous.

Semi-automatic apparatus. Usually, in the air pollution literature, an air sampling apparatus containing several (usually 8–10) separate smoke filters and trains of reagent, the air stream being automatically switched from one to another at regular (usually daily) intervals. It is in common use in western Europe for daily determinations of smoke and sulfur dioxide without the need for daily visits to the site. New smoke filters and reagents are inserted when the used ones are removed for analysis at intervals of a week or 10 days.

Sensitivity. In sensory analysis, the ability to perceive, identify, and/or differentiate, qualitatively and/or quantitatively, one or more stimuli by means of the sense organs (provisional ISO, 12). In analytical chemistry, the sensitivity of a procedure is (for a simple procedure) the slope of the calibration curve, i.e., the differential of the measure with respect to concentration, dx/dc. It is *not* the smallest amount, or lowest concentration, that the procedure will detect: the correct name for the latter quantity is *limit of detection.*

Sensory adaptation. Temporary modification of the sensitivity of a sense organ due to continued and/or repeated stimulation. *Sensory fatigue*, a form of sensory adaptation in which a decrease in sensitivy occurs (ISO, 12).

Separator. An apparatus for separating any one or more of the following from a gaseous medium in which they are suspended or mixed: solid particles (filter and dust separator), liquid particles (filter and droplet separator), and gases (gas purifier) (provisional ISO, 8). The somewhat complicated terminology of separators is illustrated in the accompanying diagram. See also *dust separator; efficiency; filter; gas purifier; gas washbottle; washer.*



Settling chamber. A chamber inserted between a furnace and its stack in which coarse particulate matter settles out of the gas stream. See also *baffle chamber.*

Sewage gas. See *gas, sewage.*

Shade temperature. See *temperature, air.*

Shear. See *shear stress; wind shear.*

Shear stress. The force due to viscosity in a region of *wind shear* (q.v.) (WMO).

Shower. Precipitation, often short-lived and heavy, falling from convective clouds; the drops or solid particles in showers are usually bigger than the corresponding elements in other types of precipitation. Showers are characterized by their sudden beginning and ending, generally by large and rapid changes of intensity, and, most frequently, by the appearance of the sky; namely, rapid alternations of dark, menacing clouds (cumulonimbus) and of clearances of short duration (WMO).

Sieving. The process of separating a mixture of particles according to their size by one or more sieves. *Size analysis by sieving*, the division of a sample by sieving into size fractions, and the reporting of results (ISO, 13). The International Standard nominal aperture sizes for test sieves are 128 in number, ranging from 22 μm to 125 μm.

Silica gel. An amorphous form of silicon dioxide ("silica") that is widely used as a dehydrating agent and as a gas adsorbent in certain methods for the measurement of air pollutants. The term "silica gel" is a misnomer, since the material is not in fact a gel (although it passes through a gel stage in the course of manufacture).

Silicofluorides. See *hydrogen fluoride.*

Sink. In atmospheric chemistry, an area or part of the earth and its atmosphere in which, or a process by which, one or more pollutants is removed from the air. Moist ground, for example, forms an important sink for sulfur dioxide.

Site. In the air pollution literature, unless otherwise stated, the location of a measuring instrument.

Size analysis. The process of dividing a sample into size fractions with defined limits (ISO, 2). See also *sieving.*

Size distribution. See *particle size distribution.*

Slag. The non-gaseous waste material formed in a metallurgical furnace; it is largely nonmetallic but usually contains some metal. Slag contains as much of the undesirable constituents of the ore as possible and is withdrawn from the furnace in the molten form. Alkaline slags retain much of the sulfur in the fuel and the ore, and the gases issuing from the furnace may be virtually sulfur-free.

Slip. The proportion of the grit and dust (or other pollutant) in *stack effluents* (q.v.) that is not trapped by dust-collecting or other equipment and that therefore passes out of the stack.

Smog. A term applied to fog heavily polluted by smoke, such as used to occur in London, particularly under conditions of temperature inversion in winter. The term is also applied to the lachrymatory haze (such as occurs over Los Angeles) produced by photochemical reactions that occur under the influence of strong sunlight in air polluted by automobile exhaust gases under temperature inversion conditions. The latter type of smog is usually referred to as *photochemical smog* or *oxidant smog.*

Smog index. A mathematical relationship by which the presence or absence of photochemical smog can be determined. Such indices are based on the relationship between smog and the meteorological conditions that are conducive to its formation and take into account factors such as temperature, relative humidity, wind speed, and degree of temperature inversion.

Smoke. A suspension in the atmosphere of small particles produced by combustion (WMO). In chemistry it is defined less restrictively as an aerosol of solid (e.g., magnesium oxide smoke) or liquid (e.g., tobacco smoke) particles arising from combustion, thermal decomposition, or evaporation. The definition of the term in air pollution legislation may vary, but is generally related to emissions that can be seen issuing from a stack or chimney; the degree of darkness of such emissions may be defined in terms of the Ringelmann scale (see *smoke chart*). Cf. *fume.*

Smoke abatement. Legal measures that may be taken (on community, regional, or national level) to control smoke emissions and thus reduce pollution by smoke. In the United Kingdom, the term *smoke control* is used for such measures.

Smoke chart. A means of assessing the darkness of a plume of smoke in terms of "smoke shade". The *Ringelmann chart* consists of four squares, each ruled into a grid of small squares, but with the thickness of the black ruling different on each. When the chart is supported some 15 m from the observer, in his line of sight to the plume, the rulings cannot be distinguished, but merge to give different shades of grey; these correspond to Ringelmann shades 1 to 4. The observer notes which shade provides the closest match to the plume. (For shade 1, about 20% of the area of the square is occupied by the rulings; the corresponding

figures for shades 2, 3, and 4 are 40%, 60%, and 80%. Ringelmann shade 0 is white and shade 5 is black.) This form of the Ringelmann chart is little used now. The *micro-Ringelmann chart* is a reduced form on which are printed accurate reductions of Ringelmann shades 1–4, which merge to shades of grey when the card is held at arm's length. The card has a slot or hole through which the plume is viewed. The *miniature smoke chart* is a card on which are printed four shades of grey that match Ringelmann shades 1–4 when the card is held at arm's length (strictly, 1.5 m from the eye). It is considered to be easier to use than the micro-Ringelmann chart.

Normally the observed Ringelmann shade depends not only on the absorbance of the smoke, but also on its colour, the stack diameter, and the brightness of the background sky. By defining the Ringelmann number in relation to a standard sky and, if necessary, correcting for stack diameter, the Ringelmann number can be roughly correlated with the absorbance of the smoke as measured in the stack by an obscuration *smokemeter* (q.v.).

Smoke concentration. In principle, the concentration of smoke particles in air, expressed in terms of mass concentration (i.e., mass of smoke particles per unit volume of air). In practice it would be extremely difficult to determine such a concentration using the definition given in the entry *smoke* (q.v.). To overcome this difficulty, any of several different conventions may be used. The amount of material collected on a smoke filter under specified conditions may be weighed and the concentration of aerosol so obtained taken as the smoke concentration. Such a procedure includes aerosol particles below about 10–20 μm in size whether they originate from the incomplete combustion of fuel or not. Another convention is to use a standard calibration curve to convert the darkness of a smoke stain into the "concentration of equivalent standard smoke" (smoke concentration). Such a curve may be obtained by averaging calibration curves for several cities (the curves are obtained by running an ordinary smoke filter and a gravimetric determination of aerosol side by side). While the latter procedure is nothing more than a way of expressing the darkness of a smoke stain, or the staining capacity of the air, it has the advantage of giving the results in units that approximate more or less closely to the aerosol concentration.

Smoke control. See *smoke abatement.*

Smoke control area. In the United Kingdom, an area designated under the Clean Air Acts as one in which smoke may not be emitted from domestic chimneys or industrial stacks (or, alternatively, where only authorized fuels may be burned).

Smoke filter. An instrument for measuring the "concentration" of smoke in the air. A known volume of air is passed through a white filter paper under specified conditions and the darkness of the stain produced on the paper is assessed instrumentally. For methods of expressing the results see *haze, coefficient of; RUDS; smoke concentration; soiling index.*

Smokeless zone. In the United Kingdom, an area in a city, defined by an Act of Parliament concerned only with that city, in which the burning of fuels can be controlled with respect to the production of smoke.

Smokemeter. An instrument for measuring the concentration of smoke in stack or exhaust gases. Many smokemeters depend on the measurement of the obscuration of a beam of light by the smoke particles (obscuration meter). With others, a sample of the smoke-laden gas is filtered through a white filter paper and the darkness of the resulting smoke stain assessed. *Bacharach smokemeter*, an instrument for estimating the smoke in the stack gases of oilfired installations. A sample of gas is drawn through a filter paper by a motor-driven pump for 1 min under specified conditions and the darkness of the stain formed on the filter paper is compared with a scale of 10 shades ranging from white to black. The nearest matching shade gives the Bacharach smoke number for the gas. For a given installation this arbitrary measure may be calibrated either in terms of the concentration of stack solids in the stack effluents or of the Ringelmann shade of the plume issuing from the stack. The *Bosch-Dunedin smokemeter* and the *Hartridge smokemeter* are devices for measuring smoke in the exhaust gases from internal combustion (especially compression ignition) engines. In the former, a 300-cm^3 sample of gas is taken from the exhaust pipe and passed through a filter paper; the darkness of the stain is assessed with a reflectometer, the result giving (by means of a calibration curve) the smoke concentration. The Hartridge instrument is an obscuration meter in which light is passed through a tube of clean air on to a photoelectric cell, and the current generated compared with that produced when the tube of clean air is replaced by an identical tube containing exhaust gas.

Smoke shade. See *smoke chart.*

Smoke stain. See *smoke filter.*

Smoking, passive. A term that is applied to the exposure of a person who is not smoking to smoke from tobacco smoked by other people.

Smut. A small piece of soot that becomes detached from the wall of a stack, is swept out with the stack gases, and falls on the surrounding area. Smuts containing sulfuric acid are known as acid smuts.

Sodium chloride. Common salt, formula NaCl. Sodium chloride aerosol is produced by the breaking of waves on the sea and shore and is a common and corrosive air pollutant in maritime districts.

Soiling index. A measure of the smoke in the air, based on the darkening of a white filter paper through which a sample of air is passed. See also *haze, coefficient of; RUDS.*

Solar constant. The amount of solar radiation incident, per unit area and time, on a surface which is normal to the radiation and is situated at the outer limit of the atmosphere, the earth being at its mean distance from the sun (WMO). Its value is approximately 1 361 J/(m^2 s).

Solarimeter. See *pyranometer.*

Soot. Fine particles of carbon, or particles having a high carbon content, resulting from incomplete combustion (provisional ISO, 3).

Sootblowing. The use of jets of steam or compressed air to remove soot deposits from the heating equipment associated with boilers. The process, which may have to be carried out as often as three times a day, can give rise to intense local air pollution.

Source inventory. See *emission inventory.*

SP. An acronym for "suspended particulates". See *particulate matter.*

Spark arrester. A screen at the top of a stack or at the exit of a furnace to reduce the amount of incandescent material emitted into the air.

Specificity. Of an analytical procedure, the degree to which the procedure produces a response to only one given component of a sample, and not to any other components that may be present.

Spectrophotometry. The measurement of spectral energy distributions (i.e., of the distribution of energy as a function of wavelength) of light sources. As used in analytical chemistry it consists in the measurement of the extent to which a sample absorbs light of a characteristic wavelength or at different wavelengths in the electromagnetic radiation spectrum (*molecular absorption spectrophotometry*). (Absorbing species absorb most strongly at certain wavelengths that are characteristic of a given species and that vary from one species to another. In the spectrophotometer light of any desired wavelength, or a continuous "scan" of all the wavelengths in a given spectral region, is produced by means of a device known as a monochromator.) Spectrophotometry is one of the most powerful analytical techniques; depending on the spectral region used (infrared, visible, or ultraviolet) such absorption measurements can give a wide range of information, e.g., the purity of a sample, the concentration of a given absorbing species in a sample, or the chemical structure of a substance. It is one of the most widely used techniques for determining the concentration of pollutants in air. See also *absorbance; transmittance; spectroscopy.*

Spectroscopy. The science that deals with the study of spectra. The less general term *spectrometry* may be applied to methods involving quantitative measurements; *spectrography* refers to methods that employ photographic or

other recording. The application of spectroscopic techniques to analytical chemistry is termed *spectrochemical analysis.* All these techniques are based on the interaction of electromagnetic radiation with matter, and detection of the quanta of radiation either emitted or absorbed when the matter undergoes a transition from one energy level to another. *Emission spectroscopy* deals with the spectra produced by dispersion of the radiation emitted by an excited source; *absorption spectroscopy*, with the spectra resulting from absorption (at certain wavelengths) of energy from the radiation emitted by a continuous source. When atomic lines are observed, the two techniques are referred to as *atomic emission spectroscopy* and *atomic absorption spectroscopy*. Both these techniques are invaluable for the study of particulate matter in the atmosphere and are among the most widely used methods for the determination of metallic pollutants. (If molecular quantities are observed instead of atomic lines, the terms *molecular emission spectroscopy* and *molecular absorption spectroscopy* are used.) The general term *analytical flame spectroscopy* is applied to any of these procedures in which a flame is used for vaporization (the term "flame photometry" is deprecated); the specific terms *flame emission spectroscopy, flame atomic emission spectroscopy,* etc., are used as appropriate. As flame techniques are improved they are finding increasing application and have been used for the determination of iron and manganese, among other elements, in air. See also *spectrophotometry.*

Spoil bank. A heap of colliery waste that is allowed to build up near the pit head. In addition to stone, spoil banks may contain sufficient fine and low-grade coal to enable spontaneous combustion to occur; if it does, they become a very serious source of air pollution in the neighbourhood.

Squall. An atmospheric phenomenon characterized by a very large variation of wind speed: it begins suddenly, has a duration of the order of minutes, and decreases rather suddenly in speed. It is often accompanied by a shower or thunderstorm (WMO).

Stability. A property of the state of rest or continuous movement of a system such that any disturbance introduced into this state decreases. In meteorology, the term is often used as a synonym of static stability (WMO).

Stability, static (or **Hydrostatic stability**). The state of hydrostatic equilibrium of the atmosphere in which a particle of air moved from its initial level undergoes a hydrostatic force which tends to restore it to this level (WMO). If the particle that is moved undergoes no hydrostatic force, the condition is said to be one of "neutral stability"; if it undergoes a hydrostatic force that tends to remove it farther from its original level, the condition is one of "static (or hydrostatic) instability" (after WMO).

Stack effluents. Gases and suspended particles emitted from an industrial stack or chimney (WMO). The gases are known as stack gases (or flue gases),

and the term "stack solids" is frequently applied to their solid-particle content (dust, grit, etc.).

Stack gases. See *stack effluents.*

Stack height, effective. Stack height plus the height that the effluent plume initially rises above the stack owing to either stack draft velocity or buoyancy of the effluent, or to both (WMO). (If the axis of the approximately horizontal part of the plume is extrapolated, the height above ground of the point of intersection with the stack axis is the effective stack height.) The height above the top of the stack is the total plume rise. That part of the rise due to exit velocity is termed the kinematic plume rise; that part due to buoyancy (which is generally much greater if the temperature of the gas is higher than that of the surrounding air) is known as the thermal rise. It should be noted that the relative motion of the plume that results in the greater effective stack height also results in more rapid dilution of the plume than would occur if the material were released isokinetically from a true point source. Realistic calculations of the dilution of plume material at a given distance downwind, especially in stable atmospheric conditions when there is little ambient turbulence, should therefore take account of the additional mixing caused by the "induced turbulence" due to this relative motion.

Stack solids. See *stack effluents.*

Standard. A technical specification or other document available to the public, drawn up with the consensus or general approval of all interests affected by it based on the consolidated results of science, technology, and experience, aimed at the promotion of optimum community benefits and approved by a body recognized on the national, regional, or international level (ECE-ISO). *Primary protection standard*, in air pollution control, an accepted maximum level of a pollutant (or its indicator) in the target, or some part thereof, or an accepted maximum intake of a pollutant or nuisance into the target under specified circumstances (UN proposal, Stockholm Conference, 1972; proposed WHO/UNEP). *National Ambient Air Quality Standards*, a set of air quality standards for the USA issued by the Environmental Protection Agency. They are maximum permissible levels of sulfur and nitrogen oxides, carbon monoxide, hydrocarbons, photochemical oxidants, and suspended particulates and are designated as either primary or secondary standards. Primary standards are the maximum levels consistent, with an adequate safety margin, with the preservation of public health, and must be complied with within a specified time limit. Secondary standards are those judged to be necessary for protection against known or anticipated adverse effects other than health hazards (in practice they are concerned largely with effects on vegetation) and must be complied with "within a reasonable time".

Standard temperature and pressure (STP). See *normal temperature and pressure.*

Stevenson screen. See *thermometer screen.*

Stokes diameter. See *diameter, Stokes.*

Stokes law. A mathematical expression for the drag of a small sphere falling through an infinite fluid: $D = 6\pi\mu ru$, where μ is the viscosity of the fluid, r the radius of the sphere, and u the velocity of the sphere. It is valid only for restricted conditions (laminar flow and low Reynolds number). Stokes law is widely used in the study of the settling of particulate matter out of the atmosphere.

STP. See *normal temperature and pressure.*

Strake. A metal fin arranged helically around the upper part of a tall metal stack. Strakes affect the airflow around the stack in such a way as to reduce oscillation in high winds.

Stratmann method. A technique for determining sulfur dioxide in air. The sulfur dioxide is adsorbed on a special type of silica gel, which is then heated in a stream of hydrogen. The resulting gaseous mixture is passed over a heated platinum catalyst, the sulfur dioxide being reduced to hydrogen sulfide, which is passed into a solution of ammonium molybdate and sulfuric acid, leading to the formation of an intense blue molybdenum complex. The latter is determined photometrically and a calibration curve gives the concentration of sulfur dioxide in the original air sample. The method is widely used in the Federal Republic of Germany.

Stratopause. The top of the inversion layer in the upper stratosphere, at about 50–55 km (WMO).

Stratosphere. A region of the atmosphere, situated between the tropopause and the stratopause, in which the temperature generally increases with height (WMO).

Streamline flow. See *flow, laminar.*

Stress. See *shear stress.*

Subsidence. A slow descent of a mass of air, over a wide area, generally accompanied by horizontal divergence in the lower layers. The subsiding air is compressed and warmed and its initial stability is generally increased (WMO). An upper-level temperature inversion caused by subsidence is known as a subsidence temperature inversion (WMO).

Sulfate. A salt of sulfuric acid, H_2SO_4. Ammonium sulfate, which occurs in the atmosphere in the form of an aerosol (partly as a result of reaction between sulfur oxides and ammonia), is acidic in aqueous solution and is corrosive.

Sulfur. A nonmetallic element, atomic number 16, relative atomic mass 32.06, symbol S. Since it is a constituent of all living matter, it occurs in all fossil fuels and is emitted (in the form of sulfur oxides) when these are burned. Attention has been given to the possibility of removing the sulfur from such fuels. That part of the sulfur that occurs within the molecules of the constituents of the fuel ("organic sulfur") can be removed from coal only if the fuel is completely gasified; it can, however, be removed from petroleum, although at considerable cost. The sulfur that occurs in coal in the form of iron sulfide ("pyritic sulfur") can sometimes be removed by washing of the crushed coal.

Sulfur cycle. A series of processes in which atmospheric sulfur dioxide is oxidized to the trioxide, which combines with water and is washed out on to the earth's surface as sulfuric acid or sulfates; bacterial action converts the sulfates into hydrogen sulfide, which is then oxidized to sulfur dioxide. This mechanism maintains the global atmospheric concentration of sulfur dioxide at a roughly constant level, and it is important to ensure that the extra sulfur dioxide produced by man does not overload it, leading to a steadily increasing concentration in the air. At present there is no firm evidence either way.

Sulfur dioxide. A colourless gas or liquid (boiling point $-10°C$) with a choking odour, formula SO_2; extremely irritating and poisonous. Sulfur dioxide is a natural constituent of the atmosphere, arising from the bacterial decomposition of sulfates in the soil, from the oxidation of hydrogen sulfide produced by the decay of organic matter, from volcanoes, etc. It has been estimated that one-third of the sulfur dioxide in the atmosphere arises from the activities of man, chiefly the combustion of fossil fuels. Sulfur dioxide is one of the most widely measured air pollutants and is often used in the definition of *alert levels* (q.v.). High concentrations have been associated with many notorious air pollution episodes, but the extent to which this has contributed to the excess deaths that occurred is controversial, and there is no clear evidence of the extent to which the levels that occur in city air are harmful to man. There is, however, no doubt that such concentrations play a role in the corrosion of metals and probably in the decay of some building materials.

Sulfuric acid. A dense oily liquid, colourless when pure; formula H_2SO_4. It is highly corrosive and poisonous. Sulfuric acid is the most widely used of all industrial chemicals. As a pollutant it occurs in the atmosphere in the form of an aerosol, called *sulfuric acid mist*, produced by the oxidation of atmospheric sulfur dioxide as well as by direct emissions from stacks. These fine droplets are more difficult to remove from the air than gaseous sulfur dioxide, their life in the atmosphere is longer, and they can travel great distances with the

wind. They can reach the alveoli in the lungs without being absorbed in the wider bronchial passages, or in the nose and throat; they can, therefore, be potentially very harmful.

Sulfur trioxide. An oxide of sulfur, formula SO_3. In the solid state it exists in at least three forms, only one of which is stable, the other two being slowly converted into this form. Liquid sulfur trioxide boils at 44.5°C. All forms of sulfur trioxide are extremely reactive, corrosive, and poisonous; they react with water to form sulfuric acid and at high temperatures dissociate into sulfur dioxide and oxygen. When fuels are burned at high temperatures (e.g., in industrial furnaces) some 5% of the sulfur appears in the hot stack gases as the gaseous trioxide, but when the temperature drops this combines with water vapour to produce sulfuric acid mist. Sulfur trioxide does not exist as such in the atmosphere owing to the moisture that is always present. When data are given for atmospheric concentrations of sulfur trioxide they should be taken to mean concentrations of sulfuric acid expressed as sulfur trioxide for convenience.

Sunshine recorder (or **Heliograph**). An instrument which records the time interval during which solar radiation reaches sufficient intensity to cast distinct shadows (WMO).

Superphosphate. An important fertilizer consisting largely of calcium phosphates and calcium sulfate, together with small amounts of other compounds. It is manufactured by treating "phosphate rock" (essentially $Ca_3(PO_4)_2$) with sulfuric acid. If the rock contains fluorides they give rise to hydrogen fluoride and other gaseous fluorine compounds, which can cause serious pollution in the absence of efficient absorbing equipment.

Supersaturation with respect to water. The state of a sample of moist air in which the *mixing ratio* (q.v.) is greater than the saturation mixing ratio with respect to water, at the same temperature and pressure (WMO). *Critical supersaturation*, the degree of supersaturation required for a given condensation nucleus to grow into a cloud or fog droplet.

Surface inversion. See *inversion, temperature.*

Surveillance. See *monitoring.*

Survey. In the air pollution literature, the determination of the distribution of pollutants over a large area (e.g., a city or a country) by means of measurements made at a sufficient number of selected sites. A survey is usually continued over a number of years to ensure that all likely weather conditions are covered; if one of its aims is the detection and estimation of secular trends, a period of the order of 10 years is advisable. See *emission inventory.*

Suspended particulates. See *particulate matter, suspended.*

Sutton's diffusion formulas. Mathematical formulas for estimating the distribution of pollutant concentrations downwind of a continuous point source.

Sweetening. A process for improving the odour of a light distillate or reducing its corrosiveness; it consists in removing hydrogen sulfide and mercaptans or converting the latter to disulfides. Before treatment the distillate is termed sour; after treatment it is termed sweet (ISO, 4).

Synoptic chart (or **Weather chart**). A geographical map on which meteorological conditions or elements are represented by figures, symbols, or isopleths (WMO). The terms "synoptic map" and "weather map" are also used.

T

TCDD. See *dibenzo[b,e][1,4]dioxin, 2,3,7,8-tetrachloro-.*

TEL. See *tetraethyllead.*

TEM. See *tetramethyllead.*

Temperature, absolute. See *temperature, thermodynamic.*

Temperature, accumulated. For a given period, the sum of the departures of temperature (daily mean temperatures or others) from a reference temperature (WMO).

Temperature, air. The temperature read on a thermometer which is exposed to the air in a position sheltered from direct solar radiation (WMO).

Temperature, thermodynamic. A temperature on a scale defined in accordance with the second law of thermodynamics, which is independent of the properties of any particular substance. The terms "absolute temperature" and "Kelvin temperature" are deprecated.

Tetraethyllead. A colourless liquid, formula $Pb(C_2H_5)_4$, used as an *antiknock agent* (q.v.) in gasoline. It is poisonous by skin absorption and by inhalation of the vapour (which enters the atmosphere by vaporization at filling stations and from carburettors) and some authorities consider it to be a more dangerous pollutant than other forms of lead. Its use in gasoline leads to the emission of particulate lead compounds in exhaust gases, thus increasing atmospheric pollution; there is, however, no firm evidence that present or foreseeable concentrations are harmful.

Tetramethyllead. A colourless liquid, formula $Pb(CH_3)_4$, similar to, but more active than, tetraethyllead as an antiknock agent; consequently a smaller amount (as a gasoline additive) is required for a given performance level. This advantage is held to be outweighed by its greater volatility, leading to an increased risk of poisoning, and its use has therefore been banned in many countries.

Theodolite. An apparatus used to observe the direction of an object in space by the simultaneous determination of its azimuth and elevation (WMO). Theodolites are used to track pilot balloons for measurement of upper winds and studies of the dispersion of pollutants in the air.

Thermal. An updraft [upward moving current of air of small dimensions] produced locally above a relatively warm surface (WMO). In nature, thermals occur above ground that is heated by the sun, but they can also be formed by the waste heat from large industrial installations.

Thermal rise. See *stack height, effective.*

Thermograph. A thermometer used to give a graphical record of the time variations of temperature (WMO).

Thermohygrograph (or **Hygrothermograph**). An instrument resulting from the combination of a thermograph and a hygrograph and furnishing, on the same diagram, simultaneous time recording of atmospheric temperature and humidity (WMO).

Thermometer, dry-bulb. That of the two thermometers of a *psychrometer* (q.v.) whose bulb is bare and which indicates the air temperature (WMO).

Thermometer, wet-bulb. That of the two thermometers of a *psychrometer* (q.v.) whose bulb is wet and covered by a film of pure water or ice (WMO).

Thermometer screen (or **Thermometer shelter**). A construction for the protection of certain instruments (e.g., thermometers and psychrometers) from radiation, while at the same time ensuring sufficient ventilation (WMO). The Stevenson screen, named after the inventor, has been adopted with modification in many countries (WMO). Such screens are usually constructed with side louvers and a double bottom and roof and are used, *inter alia*, for thermometers used to measure air temperature. See *temperature, air.*

Thermosphere. A layer of the atmosphere, situated above the mesopause, in which the temperature generally increases with height (WMO).

Thiol. See *mercaptan.*

Thorin method. A method for the determination of sulfur dioxide. A sample of air is passed through dilute hydrogen peroxide solution and the sulfuric acid produced is titrated against barium perchlorate, using thorin as an indicator. Unlike the original hydrogen peroxide method in which the sulfuric acid is estimated by titration with an alkali, the thorin method is specific for sulfur dioxide.

Thoron. A term applied to the isotope of *radon* (q.v.) having a mass number of 220. It is produced by the decay of thorium.

Threshold. See *nuisance threshold; odour threshold.*

Threshold limit value. A concentration (in air) of a material to which most workers can be exposed daily without adverse effect. These values are established (and revised annually) by the American Conference of Governmental Industrial Hygienists and are time-weighted concentrations for a 7- or 8-hour workday and 40-hour workweek. For most materials the value may be exceeded, to a certain extent, provided there are compensatory periods of exposure below the value during the workday (or in some cases the week). For a few materials (mainly those that produce a rapid response) the limit is given as a ceiling concentration (i.e., a *maximum permissible concentration*, q.v.) that should never be exceeded. Threshold limit values are not intended to be lines of demarcation between safe and dangerous concentrations.

Time-averaged measurement. See *real-time measurement.*

Titrimetric method. A method for the quantitative determination of a substance in solution by means of titration – i.e., the addition, in small measured quantities, of a reagent that reacts with the substance until the reaction is complete ("end point") as indicated by a colour change, the cessation of precipitation, the colour change of an added indicator, electrical measurement, etc.

TLC. An acronym for "thin layer chromatography" and for "threshold limit concentration". See *threshold limit value.*

TLV. See *threshold limit value.*

Town gas. See *gas, maufactured.*

Trace element. An element present in very low concentrations in the air (the "trace" level is defined as having an upper limit of 100 μg/g; a lower limit is at present under study by the International Union of Pure and Applied Chemistry). Concentrations are quoted in terms of the element itself, although trace elements are almost always present in the air in the form of oxides or other compounds. Common examples of trace elements are lead, copper, zinc, arsenic, and vanadium.

Tracer. A material that can be easily identified and determined even at very low concentrations and that may be added to other substances to enable their movements to be followed or their presence detected. For example, *fluorescein* (q.v.) may be used to trace dust particles emitted from a stack; in this way confusion with dust from other sources is avoided. For the investigation of chemical changes "radio-labelled" substances are widely used; for example, the efficiency of hydrogen peroxide solution for absorbing traces of sulfur dioxide in a gas mixture can be determined by the use of sulfur dioxide containing a radioactive isotope of sulfur and measuring the loss of activity after passage through the hydrogen peroxide.

Transmission coefficient. See *transmittance.*

Transmission density. See *absorbance.*

Transmission factor. See *transmittance.*

Transmissometer. An instrument which indicates visibility by measuring the transmission . . . of a beam of light passed over a path of known length. Normally, the indications can be read at a point remote from the sending element (WMO).

Transmittance (or **Transmission factor**). The ratio of the radiant (or luminous) flux transmitted by an optical system, a medium, etc., to the radiant (or luminous) flux incident on the system, medium, etc. The term *internal transmittance* is used for the transmittance of the medium itself (i.e., disregarding the effect of the boundaries of the medium or of its container). The term "transmissivity" should *not* be used for "transmittance" or "transmission factor".

Tropopause. The upper limit of the troposphere. By convention, the "first tropopause" is defined as the lowest level at which the lapse rate decreases to 2°C/km or less, provided also that the average lapse rate between this level and all higher levels within 2 km does not exceed 2°C/km (WMO).

Troposphere. The lower part of the terrestrial atmosphere, extending from the surface up to a height varying from about 9 km at the poles to about 17 km at the equator, in which temperature decreases fairly regularly with height (WMO).

TSP. An acronym for "total suspended particulates". See *particulate matter, suspended.*

Turbidity (in meteorology). Reduced transparency of the atmosphere, caused by absorption and scattering of radiation by solid or liquid particles, other than clouds, held there in suspension (WMO).

Turbulence. Superimposed on the mean motion of the air, an agitation composed of air motions which are uncoordinated and in a state of continuous change (WMO). See also *boundary layer; flow, turbulent.*

Turbulent boundary layer. See *boundary layer.*

Turbulent diffusion. See *diffusion, turbulent.*

U

Umkehr effect. An anomaly, caused by the presence of the ozone layer at high levels, in the relative zenith intensities of certain scattered ultraviolet radiation which arrives at the earth's surface when the sun is in the zenith (WMO). The vertical distribution of ozone in the atmosphere can be calculated from the ratio of the intensities of scattering from the zenith sky at two wavelengths, at one of which ozone absorbs strongly and at the other of which it does not; on account of changing path length through the absorbing layer as the sun sinks, the ratio at first decreases and then increases (German *Umkehr*, reversal or turning back).

Unstable. See *stability, static.*

V

Vanadium. A metallic element; atomic number 23, relative atomic mass 50.9414, symbol V. Vanadium compounds may be emitted with the ash that issues from the smokestacks of installations that burn fuel oil, and since some of them are highly toxic they may have to be regarded as environmental pollutants.

Vapour pressure. See *pressure, vapour.*

Veering (wind). A clockwise change of wind direction, in either hemisphere (WMO).

Velocity, terminal. The constant, limiting velocity attained by a freely falling body (e.g., a particle or a raindrop) when the resistance of the air (drag) reaches a value that is equal to the weight of the body.

Ventilation coefficient. See *ventilation rate.*

Ventilation rate. The volume of air passing through unit width of the *mixing layer* (q.v.) per unit time.

Venturi effect. A local decrease of pressure, local increase of the wind, and the appearance of gusts in certain places when the wind blows through a narrow mountain pass or a gorge (WMO).

Venturi scrubber. See *dust separator.*

Venturi tube. A tube whose internal diameter gradually decreases to a throat and then gradually increases again to its original value. Such tubes are used in flowmeters and also in venturi scrubbers. See *dust separator.*

Viscosity. A measure of the internal resistance of a material to flow. Viscosity decreases as temperature rises (ISO, 4). In meteorology and air pollution work it is defined as the factor η in the expression $\tau = \eta(d\bar{u}/dh)$, where τ is shear stress in terms of force per unit area (the SI unit is the pascal, Pa), $\bar{u}$ is average wind speed, and h is height. It should be termed "viscosity", not "dynamic viscosity". *Kinematic viscosity*, viscosity divided by the density of the fluid. *Eddy viscosity*, in meteorology, the virtual viscosity resulting from the interaction of eddies within a turbulent flow. These eddies effect an exchange of momentum between adjacent layers in a manner similar to, but on a far larger scale than, the exchange of molecules in molecular viscosity (WMO).

Visibility. The greatest distance at which a black object of suitable dimensions can be seen and recognized against the horizon sky, or, in the case of night observations, could be seen and recognized if the general illumination were raised to the normal daylight level (WMO). Night visibility may be measured by the use of unfocused lights of specified intensity in place of a black object. Instrumentally, an estimate of visibility may be obtained from measurement of the attenuation of light over an extended path. Visibility data are usually averages of observations made all around the horizon.

Volatile matter (in coal). The loss in mass, corrected for moisture, when coal is heated out of contact with air under standardized conditions (ISO, 2). In general, the greater the volatile matter, the more smoke that is produced on combustion.

Volumetric apparatus. A term in common use in the United Kingdom for the apparatus used in the National Survey for daily measurements of smoke and sulfur dioxide.

Volumetric method. In general, a method based on the measurement of volumes; in practice, almost always a *titrimetric method* (q.v.). In the air pollution literature in the United Kingdom "the volumetric method" refers to the *hydrogen peroxide method* (q.v.) for the determination of sulfur dioxide in air.

W

Washer. A general term for a dust collector, a droplet separator, or a *gas purifier* (q.v.) operating with a liquid as the collecting medium (provisional ISO, 8). See also *dust separator.*

Wash-out (or **Rain-out**). The removal of dust, in particular radioactive dust, from the atmosphere by rain (WMO). The terms are commonly applied to the removal of all particulate matter from the atmosphere by rain. Many authorities apply the term "rain-out" to the removal of pollutants from clouds (by condensation of water vapour on the particles or by their incorporation in raindrops as the latter are being formed), and the term "wash-out" to the removal of pollutants from the air below cloud level by the rain as it falls.

Weather. The state of the atmosphere at a given time, as defined by the various *meteorological elements* (q.v.) (WMO). Cf. *climate.*

Weather map. See *synoptic chart.*

Weathershed. A term sometimes applied to the boundary between two districts having different climates. See *air basin.*

West-Gaeke method. One of the most widely used methods for the determination of sulfur dioxide in air. The air sample is passed through a solution of dipotassium tetrachloromercurate(1-), with which the sulfur dioxide reacts. The solution is then treated with bleached pararosaniline and formaldehyde, producing an intense bluish-purple coloration, which is determined spectrophotometrically.

Wet day. A period of 24 hours, starting at a given time, during which a specified minimum amount of rain is recorded. The minimum amount of rain varies; a common figure for countries in temperate regions is 1.0 mm.

Wet scrubber. See *washer.*

Wind. Air motion relative to the earth's surface. Unless it is otherwise specified, only the horizontal component is considered. *Anabatic wind*, an up-slope wind caused by lower air density along the slope than at some distance, horizontally, from it. The wind is associated with strong surface heating of the slope. *Geostrophic wind*, a theoretical wind which corresponds to equilibrium between the horizontal pressure force and the horizontal component of the deviating force due to the earth's rotation, only these forces being supposed to

act on the air. It blows parallel to straight isobars or contours. *Gradient wind*, a theoretical wind which corresponds to equilibrium between the horizontal pressure force, the horizontal component of the deviating force due to the earth's rotation, and the centrifugal force due to air motion on a curved path, only these forces being supposed to act on the air. It blows parallel to curved isobars or contours. *Katabatic wind* (or *Gravity wind*), a down-slope wind caused by greater air density along the slope than at some distance, horizontally, from it. The wind is associated with surface cooling of the slope. *Prevailing wind*, the wind whose direction, at a given place, has a clearly higher frequency than that of winds of other directions. *Surface wind*, a wind blowing near the earth's surface. It is measured, in principle, at a height of 10 metres above ground in an open situation (all WMO). *Valley wind*, synonym of valley breeze. See *breeze*.

Wind profile. A graphical representation of the variation of wind speed as a function of height or distance (WMO).

Wind rose. For a given station and period of time, a star-shaped diagram indicating the relative frequencies of different wind directions, sometimes also the frequencies of groups of wind speeds in different directions (WMO). The most common form consists of a circle from whose centre are drawn a number of radii to indicate different points of the compass, the length of each radius being proportional to the number of times during the given period that the wind blew from that direction.

Wind run. See *run-of-wind*.

Wind shear (or **Shear vector**). The space variation of the wind vector, or of a component of the wind vector, in a specified direction (WMO). The vertical wind shear is the rate of change of wind velocity with vertical distance above the ground.

Wind speed, critical. In air pollution studies, the wind speed at which the (calculated) highest ground-level concentration of a pollutant occurs.

Wind tunnel. A duct through which air can be passed at a steady rate and that is used for the investigation of airflow patterns. If a scale model of, say, a factory (with miniature stacks that emit smoke) is placed in a wind tunnel, the dispersion of the smoke (and the effects of factors such as stack geometry and efflux velocity) can be investigated.

Wind vane. A device used to indicate the direction from which the wind is blowing (WMO). It commonly consists of a pivoted rod that can turn freely about a vertical axis, having an airfoil or fin at one end and a pointer at the other. It may be connected to a recording device.

Windward side (in meteorology). The part of the side of a hill or mountain, or a region, which faces the wind relative to a relief feature (WMO). The term "windward" is applied to an area that is "upwind" from a given object or point.

X

Xenon. A gaseous element; atomic number 54, relative atomic mass 131.30, symbol Xe. It is one of the *noble gases* (q.v.). Xenon is a normal constituent of air (about 460 $\mu g/m^3$).

X-ray diffraction analysis. An instrumental technique for studying the structure of crystalline substances by means of the manner in which they diffract X-rays. It has proved valuable for the study of certain atmospheric dusts.

Y, Z

Zinc. A metallic element; atomic number 30, relative atomic mass 65.38, symbol Zn. Some zinc compounds are poisonous and under certain circumstances may be air pollutants.

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