

Usual tower operating conditions conform to *Case 1*. Because of the curvature of the saturation line, operating conditions may present themselves to which neither *Case 1* nor *2* applies. Since a simple expression for the intermediate case is not available, the expression of *Case 1* may be utilized for the small number of operating conditions falling into the intermediate classification.

Make-Up Water

Since the atmospheric water cooling equipment performs its functions chiefly by evaporating a portion of the water in order to cool the remainder, there is a continual drain on the quantity of water in the system, and this loss must be replaced. Approximately 1 gal of water is lost for every 1000 gal of water cooled per degree of cooling range; so if 1000 gpm of water are cooled through a 10 F range, 10 gpm of water will be required to replace evaporated water. Replacement supply is usually regulated by a float control valve. Chemical treatment of the make-up water may be necessary to avoid excessive deposits in the condensers.

Winter Freezing

If atmospheric water cooling equipment is operated in freezing weather, the water may be cooled to freezing temperature so ice forms and collects until its weight causes damage. To obviate freezing during continued operation, the efficiency of the apparatus may be lowered. This is done on the spray pond and the spray cooling tower by reducing the quantity of water fed to the apparatus, thereby lowering the pressure at the nozzles and increasing the size of the drops produced. On the deck tower the upper system may be shut off and a secondary distribution system put in service midway down the height of the tower. The water will be kept above freezing because it will have shorter contact with the air. The mechanical draft tower can be protected by reducing the air flow through the tower, by stopping or reducing the speed of the fans, or by partially closing dampers.

If the system is operated intermittently in freezing weather, water in the basin may freeze and the expansion of the ice may do harm. Freezing during intermittent operation can be prevented only by draining the water basin when it is out of service. On small roof installations, a tank large enough to hold all the water in the system is often installed inside the building and the basin is drained into this by gravity, the pump suction being taken from this inside tank.

Air Pollution

Classification of Air Impurities, Dust Concentrations, Air Pollution and Health, Occlusion of Solar Radiation, Smoke and Air Pollution Abatement, Dust and Cinders, Nature's Dust Catcher

THE particulate impurities which contribute to atmospheric pollution include carbon from the combustion of fuels, particles of earth, sand, ash, rubber tires, leather, animal excretion, stone, wood, rust, paper, threads of cotton, wool, and silks, bits of animal and vegetable matter, and pollen. Microscopic examination of the impurities in city air shows that a large percentage of the particles are carbon.

Gaseous pollution consists of gases originating in combustion, manufacturing and biochemical processes.

CLASSIFICATION OF AIR IMPURITIES

The most conspicuous sources of atmospheric pollution may be classified in various ways, as dusts, fumes and smoke. In Fig. 1, the classification is by particle size, but recent practice favors differentiation by method of formation. Thus, *dusts* are composed of particles produced by disintegration of larger material, as by crushing or grinding, whereas *fumes* are produced by condensation, and *smoke* consists of the finer carbon particles resulting from incomplete combustion. Similarly, *mists* are formed by the breaking up of liquids and *fogs* by condensation of vapors. There is as yet, however, no general agreement on these terms.

Dusts tend to settle without agglomeration, fumes to aggregate and smoke to diffuse. Particles which approach the common bacteria in size—from 1 to 10 microns—are difficult to remove from air and are apt to remain in suspension unless they can be agglomerated by artificial means. The term fly-ash is applied to solid ashy material, usually finely divided, that is a constituent of the effluent gases from coal-fired furnaces. Cinders denote the larger solid constituents which may be entrained by furnace gases.

Particles larger than 10 microns are unlikely to remain suspended in air currents of moderate strength, but settle out by gravity at speeds dependent upon the shape, size and specific gravity of the particle and upon the wind velocity. These larger particles are of major interest to the engineer in the solution of nuisance problems; on the other hand, it is mainly the smaller particles that are of hygienic significance. A notable exception to this size limitation in the latter case is the common hay-fever producing pollen such as that from ragweed. Pollen grains may be anything from fragments 15 microns or less in diameter to whole pollens 25 microns or more in size.

The lower limit of size of particle visible to the naked eye cannot be stated definitely. It depends not only upon the individual, but also upon the shape and color of the particle and upon the intensity of light. Under ideal conditions a particle 10 microns, or even less, may be recognized, while under less favorable conditions it may be difficult or even impossible to recognize a particle of 50 microns. The lower limit of visibility should, therefore, be considered as within a range (as above) of optimum conditions stated.