

The design and surface characteristics of the coil include fin material, type, thickness, height, and spacing, as well as the area ratio of the external heat transfer surface to that of the internal tube surface. Also, provisions for increasing air turbulence by means of specially-shaped fins may be advantageous.

The coil air velocity is determined by dividing the air volume (based on standard air) by the actual net face area of the coil finned surface. (Standard air is substantially equivalent to dry air at 70 F and 29.92 in. Hg barometric pressure.)

At the same mass air velocity, varying performance can be obtained, depending upon the turbulence of the air flow across the coil surface and the uniformity of distribution of the air over the coil face. The latter is important in obtaining reliable test ratings, and in realizing rated performance in actual installations. High air flow resistance through the coil assists in distributing the air uniformly over the coil for optimum performance. Incorrect inlet duct connections (at sharp angle to coil face) cause reverse air currents through portions of the coil, reducing capacity. Good duct approach and use of baffles or vanes improves coil performance.

Heat transfer capacity information given in manufacturers' catalogs is usually based on actual laboratory tests. To simplify coil selection, data are presented in the form of tables or charts.

HEATING COIL PERFORMANCE

Heating coil performance depends upon:

1. Overall heat transfer coefficient from the fluid flowing inside the tubes of the coil to the air flowing over the coil surface.
2. The logarithmic mean temperature difference between the fluid flowing inside the tubes of the coil and the air flowing over the coil surface.
3. The heat transfer surface area or physical dimensions of the coil.
4. Fluid flow arrangement.

The sensible heat transfer capacity of a coil can be expressed by the following basic equation:

$$q = U_o \times (\Delta t_m) \times A \times N \quad (1)$$

where

- q = total amount of heat transferred by the coil, Btu per (hour) (square foot of coil face area).
- U_o = overall heat transfer coefficient of the coil, Btu per (hour) (square foot of external coil surface) (Fahrenheit degree temperature difference between the fluid within the coil and the air flowing over the coil).
- Δt_m = the logarithmic mean temperature difference between the fluid flowing inside the coil tubes and the air passing over the coil, Fahrenheit degrees.
- A = external surface area of the coil, square feet per (square foot of coil face area) (row of coil depth).
- N = number of coil tube rows in direction of air flow.

Overall Heat Transfer Coefficients

The rate of heat flow is usually expressed by heat transfer coefficients. The overall heat transfer coefficient for a specific

coil design results from the combined effects of three heat transfer coefficients:

1. The film coefficient of heat transfer between the air and the external surface of the coil, usually given in Btu per (hour) (square foot external surface) (Fahrenheit degree mean temperature difference).
2. The film coefficient of heat transfer between the internal surface of the coil and the fluid flowing inside the coil tubes, usually given in Btu per (hour) (square foot internal surface) (Fahrenheit degree mean temperature difference).
3. The conductivity of the coil surface, consisting of tube walls and fins, usually given in Btu per (hour) (square foot of surface) (Fahrenheit degree per inch).

These three coefficients acting in series result in an overall heat transfer coefficient in accordance with the basic laws given in Chapters 4 and 24. The overall heat transfer coefficient for a finned-tube coil for the sensible transfer of heat (heating or cooling) can be expressed by the following simplified basic equation:

$$\frac{1}{U_o} = \frac{1}{h_o} + \frac{L}{k} + \frac{1}{h_i} \quad (2)$$

where

- U_o = overall heat transfer coefficient, Btu per (hour) (square foot external surface) (Fahrenheit degree mean temperature difference between air and fluid within the coil tubes).
- h_o = film coefficient of heat transfer between the internal surface of the coil and the fluid flowing within the coil tubes, Btu per (hour) (square foot internal surface) (Fahrenheit degree mean temperature difference between the surface and the average fluid temperature).
- B = ratio between external and internal heat transfer surface areas. This ratio is introduced into the equation in order to place the internal heat transfer fluid coefficients on the basis of external surface.
- h_i = heat transfer film coefficient between the air and the external surface of the coil, Btu per (hour) (square foot external surface) (Fahrenheit degree mean temperature difference between the air and the external surface).
- k = conductivity of coil tube material, Btu per (hour) (square foot) (Fahrenheit degree per inch of tube wall thickness).
- L = thickness of tube wall, inches.
- η = fin efficiency or effectiveness, to correct for the resistance to the flow of heat through the fins, percent.

When the tube walls of the coil are relatively thin and made of materials having high conductivity, as is the case for all lightweight finned-tube heat transfer surfaces, the term L/k in Equation 2 becomes negligible and is usually disregarded.

For typical finned-tube coil designs, the ratio B expressing the ratio of the total external surface to the internal surface, varies from approximately 10 to 35.

Although the sensible transfer of heat for finned-tube coils can be expressed by Equations 1 and 2, the performance of coils where dehumidification takes place, cannot be predicted on the basis of overall coefficients. The performance of dehumidifying air cooling coils is discussed in Chapter 34.

AIR CLEANERS

Supply Air Cleaners: Rating, Test Methods, Types, Performance, Selection and Maintenance, Installation

THIS chapter deals with the cleaning of supply air or recirculated air for conditioning of building interiors where dust content seldom exceeds 4 grains per 1000 cu ft of air.

With certain exceptions, air cleaners discussed in this chapter are not applicable to the cleaning of exhaust gas streams, principally because of these extreme differences in dust concentrations; supply air filters are used once, after which they must be laboriously cleaned or discarded.

SUPPLY AIR CLEANERS

Atmospheric dust is a complex mixture of matter made up of smokes, dusts, mists, and fumes which are generally referred to as aerosols. A sample of atmospheric dust gathered at any given point will generally contain minute particles of materials that are common to that locality together with other components which may have had their origin at quite some distance but which have been dispersed by wind or air currents. The components will generally vary with factors such as the geography of the locality in question, the season of the year, the direction of the wind, and proximity of manufacturing plants. A sample of atmospheric dust will usually contain minute quantities of soot and smoke; silica; clay; decayed animal and vegetable matter; organic materials in the form of lint and plant fibers; metallic fragments. It may also contain mold spores, bacteria, plant pollen and similar allergens which may motivate attacks on persons of allergic sensitivity.

The particles in the atmosphere can range in size from less than 0.01 micron up to things which are caught by an ordinary fly screen, such as lint, leaves, and insects. Almost all conceivable shapes and sizes are represented. This wide variety makes it impossible to design one type of cleaner that will be best for all applications. Mechanical filters of the low-pressure-drop type can remove large particles effectively.

Other mechanical filters can remove extremely fine particles, but may have higher pressure drop and cost. Electronic air cleaners also remove the fine particles of atmospheric dust, but have a relatively high first cost.

Different fields of application require different degrees of effectiveness. In industrial ventilation, it may only be necessary to remove the coarser dust particles from the air stream insofar as the cleanliness of the structure and the protection of the mechanical equipment is concerned. In other instances, the application may involve the protection of an area where discoloration is to be prevented. Unfortunately, the smaller components of atmospheric dust are the worst offenders from the point of view of smudging and discoloring the interior of filtered spaces. Electronic air cleaners or high-efficiency dry filters are required for their removal. When ultimate efficiency is required for removing as possible radioactive or other dangerous particles as possible, extremely high efficiency mechanical filters should be employed.

The characteristics of aerosols which affect the performance of an air filter include particle size, particle shape, specific gravity, concentration, etc. One of the most important of these is particle size. Fig. 1 of Chapter 11 shows the sizes and

The general responsibility for this chapter is assigned to TC 9.4, Air Cleaning and Purification Equipment.

characteristics of airborne particulate matter and the wide range of particle size which may be encountered. Cleaning efficiency also is affected to some extent by the velocity of the air stream. Since the purpose of a filter is to remove as much of the contamination as practical, it is obvious that the degree of air cleanliness required is a major factor in influencing choice of filter design. Removal of these particle size fractions becomes progressively difficult as the particle sizes decrease.

The function of air cleaners is to remove the particulate matter from outdoor air for supply to building interiors, and from the recirculated air stream within the building interior. Removal of particulate matter is required in order to minimize the soiling of surfaces and equipment in contact with the air stream. Surface soiling includes a variety of effects, some caused mainly by the coarser particles and some by the finer ones. Some effects are, for example, gravity sedimentation of the larger particles; accumulations on heat exchanger surfaces; localized smudging of walls or ceilings; generalized darkening of walls, ceilings and draperies; contamination in various industrial processes, such as electric equipment rooms, paint drying and clean rooms.

Considerations of cost, both initial investment and maintenance, space requirements, and resistance in conjunction with wide-ranging individual criteria as to required degree of air cleanliness, have resulted in a wide variety of commercial air cleaners. Comparisons between them can be made only from data obtained by standardized test methods; intelligent use of the test data depends on an understanding of test procedures employed. The following discussion of current methods of rating and testing will aid in better understanding of the later description of air cleaners.

RATING OF AIR CLEANERS

The two operating characteristics that distinguish the various types of air cleaners are efficiency and dust-holding capacity. Efficiency in common air cleaning terminology is synonymous with the term *arrestance* and measures the ability of the air cleaner to remove particulate matter from an air stream. Dust-holding capacity defines the amount of a particular type of dust that an air cleaner can hold and determines the operating life of the air cleaner which is fixed mainly by some value of maximum tolerable resistance in particular circumstances. Complete rating of air cleaners then requires data on both efficiency and dust-holding capacity; the only exception is the ionizer-plate type electronic air cleaner wherein performance ratings are based on efficiency only, since resistance does not increase significantly with dust load. With the ionizer-plate electronic air cleaner, some other criterion must be used to establish cleaning or maintenance schedule. Usually the maintenance cycle for cleaners is set at sufficiently frequent intervals to prevent blowoff of accumulated dust from collector plates.

Test Methods

A number of procedures for evaluating air cleaner efficiency have been proposed. Except for electronic air cleaners and those filtering devices of similar high efficiency, most of these