

Fig. 2 .... Floor Plan of Restaurant Building

a. Their capacity should be reduced if greater than ventilation requires.
b. Fan connections should be relocated or rearranged to improve hood efficiency or to facilitate smoke removal.
c. Oversize fans can often be equipped with two-speed motors, or dampers can be provided to permit full-capacity short-period purging. This is of particular value in night clubs and cocktail lounges, where excessive smoking prevails.
d. Additional supply fans should be provided in kitchen areas to balance any existing exhaust fans and thereby prevent excessive removal of conditioned air from adjacent spaces. In this connection it is sometimes possible to discharge the air from a restaurant exhaust fan directly into the kitchen, thereby giving the kitchen employees the benefit of cooler air and also reducing the output required from additional kitchen supply fans.

3. Other improvements which are common to all air conditioning installations and should be considered are:
a. Insulation of sunlit roof areas.
b. Spraying of sunlit roofs with waste condenser water.
c. Insulation of floors above hot kitchens or boiler rooms and ventilation of such spaces.
d. Installation of awnings or Venetian blinds at sunlit glass.
e. Installation of vestibules or revolving doors to prevent excessive door infiltration.
f. Sealing of openings, and weatherstripping of doors and windows.

ANALYSIS AND DIVISION OF ZONES

After making the survey and before starting the heat gain or loss estimate to determine the capacities of equipment required, it is advisable to separate various areas that suggest zoning. Zoning in general may be required due to differences in sunlight exposure or because of variations in occupant load.

The necessity for zoning is illustrated by Fig. 2. Inspection of this restaurant immediately indicates three zones: A, B, and C, on the basis of sun exposure. A has a maximum sunlight gain in the afternoon, B in the morning, and C none at all. On the basis of occupants, A has peak loads occurring between 12:30 and 2 p.m. and also between 7 and 11 p.m. every day of the week; B has peak loads between 7 p.m. and 1 a.m., Monday through Saturday, and on Sundays between 1 and 3 p.m. also 7 p.m. to midnight; C has peaks between 3 p.m. and 1 a.m. During the heating season, Zone C, which does not have an outside exposure, will not require heating, and will require cooling when Zones A and B require heating.

It follows therefore that proper application of zone control for winter conditioning is just as important as for summer. Too often the air conditioning engineer will concentrate his thinking upon the cooling problem only and forget about what might happen in winter. Two winter problems which present themselves frequently in restaurant application are:

1. *Windows:* It is common practice to place the dining tables next to large windows consequently under-window heating should be provided together with weatherstripped or double sash to provide maximum comfort to the patrons.
2. *Doors:* The heavy infiltration of outdoor air through restaurant doors makes it imperative to provide radiation or unit heaters at the doors. The use of a heated vestibule is recommended.

LOAD CALCULATIONS

A detailed heat estimate is required for each zone. This will determine the dew point and quantity of air required for the peak load of each area, thereby permitting proper selection of the air handling, heating and low side equipment. To determine the capacity of the refrigerating equipment, a separate combined heat estimate is required. Peak loads which do not occur simultaneously should not be added together lest the resultant equipment selection be larger and more costly than actually required for the application.

In most cases, inspection will indicate at what time of day the peak load occurs, but if this is doubtful, additional heat gain or loss estimates should be made. In each estimate, the actual value of the load component that is occurring at the particular time should be used. This is graphically shown in Fig. 3, which is a load analysis of the hourly cooling load of a typical restaurant. The use of a simple graph when determining the combined heat gain or loss estimate of a multizone application will show at a glance the overall combined peak load to be handled by the refrigeration equipment.

Load Factors

No attempt will be made in this chapter to give the details for computation of the thermal loads due to the separate items such as: indoor and outdoor design temperatures, ventilation requirements, solar heat and transmission, internal heat and moisture loads, or infiltration of outdoor air. These items are treated in Chapter 25 and 26 of the 1961 Guide And Data Book. Some comments will, however, be

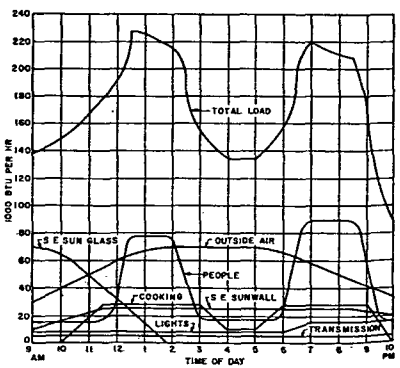

Fig. 3 .... Hourly Cooling Load Analysis of a Typical Restaurant

made to emphasize the significance of some features of these items:

1. *Outdoor design conditions.* Very often the peak loads in restaurants and night clubs occur at night when outside dry- and wet-bulb temperatures are substantially below published maximums.
2. *Indoor design conditions.* In selecting design conditions the time of patron occupancy should be considered, since those entering for a short stay after exposure to outdoor extremes are comfortable in a room of higher temperature than would satisfy those who remain long enough to become acclimated. Night clubs and deluxe restaurants should usually be operated at a lower effective temperature than cafeterias and noonday restaurants.

Very often, the ideal design condition must be rejected in favor of a poorer but still acceptable one due to cost of equipment required or equipment performance limitations. In changing from the ideal, a condition of equal comfort can be maintained by changing only the combination of dry bulb temperature and relative humidity for the same effective temperature within the comfort zone. Restaurant applications frequently fall in this category, since the high ratio of latent to sensible heat may result in uneconomical equipment selection unless a combination of lower design dry bulb and higher relative humidity (giving equal effective temperature) is selected.

3. *Ventilation requirements.* The minimum recommended ventilation is 12 cfm per person for restaurants with normal tobacco smoke and odor contamination. This should be substantially increased for cocktail bars, night clubs and similar applications.
4. *Solar heat and transmission.* The effect of lag due to the construction of walls and roofs should be carefully analyzed in determining peak loads. The effect of sunlight on a heavy masonry wall may not be felt within the air-conditioned space for several hours after exposure, whereas a lightly constructed wall would give full effect almost at once. The wall factor is usually a minor part of the total heat load for a restaurant, but the roof gain may be extremely large. The heat lag effect should therefore be carefully considered in determination of peak loads.
5. *Internal heat and moisture loads.* These are loads due to occupants, motors and lights, restaurant appliances and infiltration.

Separate calculations should be made for patrons and employees. It is necessary to proportion the sensible and latent load for people sitting and at work in accordance with design temperature selected because the ratio of latent to sensible heat is reduced as the room temperature is lowered. Adequate hoods are required to remove heat from appliances. The following features should be incorporated in the design of an adequate hood:

a. It should be directly over the appliance and as low as possible to minimize the effect of air cross currents.
b. Positive exhaust should be used since gravity hoods are seldom effective.
c. The higher the face velocity of the hood the better; good practice indicates a minimum of 50 ft per min. Very often the use of standard hoods under these conditions will require more air removal than can be economically delivered by the air conditioning equipment. Since all air exhausted from the conditioned space must be balanced by an equal amount of outdoor air through the equipment, the ventilation requirements may be exceeded and result in unsatisfactory equipment selection. Under these conditions it is possible to install specially designed hoods with high velocity peripheral slots and reduce the exhaust air quantity as much as 50 percent. (See Fig. 4.)

Infiltration. This is a considerable factor in many restaurant applications due to short occupancy which results in frequent opening of doors. Infiltration through doors is accentuated by the need for large quantities of air to replace that exhausted through hoods and for smoke removal. It is therefore advisable to provide vestibules or revolving doors wherever possible to reduce infiltration.

SELECTION OF EQUIPMENT

After determining the heat gain or loss for cooling, heating or both, the application engineer is faced with the proper selection of equipment. It is not possible to establish rules which immediately indicate whether the equipment should be central station type, self-contained, storage type, etc., because of the varying factors for each application. Regardless of the type selected, good restaurant applications should have the following features:

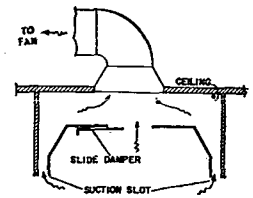

Fig. 4 .... Section of Exhaust Hood Using Suction Slots

1. Full capacity to handle the peak load with outdoor air in sufficient quantity to balance all exhaust fans and to meet good ventilation standards.
2. Proper air distribution to keep air motion well below 50 fpm to prevent drafts. A higher air motion is permissible in dance floor areas such as found in night clubs. Air distribution is frequently a difficult problem in restaurants and tap rooms with low beamed ceilings. Care should be taken to avoid air stream impingement on beams and columns, and to secure uniform coverage over the room by supplying air at a sufficiently large number of points. Poor air distribution in existing dining room and restaurant applications is so frequently found that the topic cannot be emphasized too much. One of the worst pitfalls is the propensity to over-blow, with consequent drafts down the walls, or impingement of two streams resulting in turbulence in the breathing zone. Designers should be encouraged to increase outlet area and decrease static pressure in such situations in order to deliberately under-blow. For the critical applications so often found in restaurants with low ceilings and high loadings requiring large air quantities, a suggested order of preference for the type of distribution is as follows: (a) perforated ceiling, (b) ceiling diffusers, and (c) side wall outlets.

   In some cases sidewall outlets should not be used.
3. Provision should be made for step control of refrigeration to give satisfactory and economical operation under reduced loads.
4. Air should be exhausted at the ceiling for removal of smoke and odors where these are a problem.

Some factors which influence equipment selection are as follows:

1. Building design and space limitations very often favor one type of equipment as against another. For example, in a restaurant having a vestibule with available space above it a system with the high side equipment in the basement and the low side equipment above the vestibule may be satisfactory. Such an arrangement saves valuable space, even though self-contained units located within the conditioned space may prove somewhat lower in first cost. In general, small cafeterias, bars, etc. with loads up to 10 tons can be most economically conditioned with package units, while the larger and more elaborate establishments would require built-up central plants.
2. High water costs, scarcity, or contaminated supply favor the use of cooling towers or evaporative condensers. It is well to keep in mind that evaporative condensers can be frequently made to serve a dual purpose in conserving water costs as well as removing smoke and odors. In other words, the air required by the evaporative condenser can be drawn from the conditioned space, thus eliminating the necessity for operating additional exhaust fans and also improving the overall efficiency of the plant due to the low wet-bulb temperature of air entering the condenser.
3. The usual practice for the smaller restaurant applications has been to use direct-expansion systems. Face and bypass control of the dehumidifier together with at least three steps of refrigeration capacity is one of the most satisfactory methods of controlling the conditions in restaurant applications. This control permits dehumidification to continue throughout the range from light to full load conditions. Large establishments are often handled by