control the system at all times is one of the most important factors having to do with the design of the system and for this reason the proper use and application of controls should be considered at the time the heating or cooling system is being designed. Wherever possible the system should be designed to facilitate control operation. This section includes factors which should be considered in the design of a new heating or cooling system, or the modernization of an existing one, to enable the control system to produce the best possible results.

The design of the system and its controls should take into consideration the nature and type of the building in which it is to be used and the results it is desired to accomplish. Quality of the control equipment should be consistent with the accuracy of control required. Where results more precise than those for normal comfort applications are required, such as in certain manufacturing areas, constant temperature rooms, etc., both the air conditioning system and the control system should be given special consideration so that the required results can be produced. Controls can be made to produce almost any degree of accuracy required, but it is useless to provide such controls unless the air conditioning system is capable of properly responding to the demands of the controllers. For example, it is virtually impossible to maintain close control of temperature and humidity by starting and stopping a refrigeration compressor or opening and closing a refrigerant valve. It is necessary instead to employ refrigeration equipment which will permit proportional control by one of the methods discussed in Chapter 37, or to use a chilled-water system with a cooling coil or air washer that will permit proportional control. Neither is it good practice or economical to select equipment capable of producing far more precise control than the application requires, or to unnecessarily complicate the system to obtain special sequences or cycles of operation. It is well to remember that the system must be adjusted and maintained in operation for many years, and the simplest system that will produce the necessary results is usually the best.

SIZE OF CONTROLLED AREA

No individually controlled area should be excessively large because the difficulties of obtaining good distribution and of finding a representative location for the space controls become greater as the area increases. Each individually controlled area must have similar load characteristics throughout and otherwise should conform to the recommendations given in the section on Zone Control. For uniform conditions throughout the area equitable distribution must be provided by competent engineering design, careful sizing of equipment and proper balancing of the system. The control can measure conditions only at the point where it is located, and it cannot compensate for variable conditions throughout the area caused by improper distribution or inadequate design. Areas or rooms having dissimilar load characteristics, or having different conditions to be maintained, should be individually controlled. The smaller the controlled area the better will be the control obtained and the more nearly will the system approach the optimum in performance and flexibility.

Even when individual room control is employed it often is well to consider some form of overall zone control of the whole system in accordance with the major factor influencing system load. Thus the water temperature in a hot water heating system, the steam temperature or pressure in a steam heating system, or the delivered air temperature in a central fan system may be varied inversely as the outdoor temperature varies. This obtains a fair share of the necessary control on the system as a whole, relieves the individual space controls of a part of their burden and makes more accurate space control possible. Furthermore, modifying the basic rate of heating or cooling input to the system in accordance with system load reduces losses in the distribution system. The cost of the additional controls is often justified by the reduction in operating costs.

Where such overall system controls are employed, accurate zoning, while desirable, is not necessary. The system must always be able to satisfy the area or room having the greatest demand. The individual controls take care of the variations in demand within the area served by the system. The more accurately the system is zoned the larger will be the share of the control accomplished by the overall system controls, the smaller will be the system distribution losses, and the more accurately will the individual space controls be able to maintain the space conditions.

EQUIPMENT SELECTION AND LAYOUT

Heating and cooling coils should be carefully selected to avoid oversizing. A coil that is too large is not only more difficult to control but may increase air temperature stratification. When temperature measuring elements are to be placed between coils, ample space between the coils must be provided. The measuring element should be located as near as possible to the coil it is controlling. For example, an idle water coil interposed between a thermostat and the coil it is controlling introduces enough thermal inertia to make it difficult to produce stable control.

The elimination of stratification in an air handling system is essential not only in producing good control but in obtaining equitable distribution of heating or cooling. Outdoor-air and return-air dampers should be arranged in such a way as to help blend the outdoor air and return air. Face dampers should be placed far enough from coils to allow for equalization of air flow over the coil surface. The controller for face and bypass dampers must be located far enough downstream so that the air has become thoroughly mixed before reaching the controller. Other sources of stratification are coils which heat or cool unevenly and coils arranged in parallel and controlled in sequence. Whenever stratification cannot be eliminated by proper design or arrangement of equipment, special baffles, mixing chambers or other mechanical devices should be used for this purpose. If stratification still exists at a point where the measuring element of a thermostat is to be located, the use of a long averaging element, or one made up of a number of small elements, may make a suitable temperature measurement possible. This does not solve the other problems relating to stratification which can cause discomfort or, in extreme cases, freezing of equipment.

Good air distribution and properly spaced diffusers and grilles will greatly assist in maintaining even temperatures throughout an area. A space temperature controller cannot prevent drafts. This can be accomplished only by proper attention to such factors as balancing the system, by introducing air in the correct manner, and by providing a suitable low-limit control on the delivered-air temperature. A system that employs constant air volume with variable air temperature results in more uniform distribution than one which requires variations in air volume to achieve temperature control. Varying the volume of air affects both ventilation and distribution, two factors which usually have little relation to thermal requirements. Return air grilles usually can and should be located so as to aid both the distribution and control of the system.

A further aid to both distribution and control is the provision of adequate facilities for exhausting air from the building. The larger the percentage of outdoor air introduced the more important becomes the provi-