

circulating chilled water through spray type or finned-coil surface dehumidifiers.

4. In some restaurants it is convenient to use storage systems involving the use of a smaller refrigeration plant in connection with ice accumulating coils submerged in an insulated tank of water. This arrangement is usually only worth considering in connection with restaurants having a high peak of short duration, particularly in a locality where the power demand rate is high.

5. Solid adsorption dehydration equipment, while usually more costly, produces superior results where latent heat loads are especially high. This is particularly true of dance floors, where it is difficult to maintain humidities below 60 percent with conventional refrigerating equipment alone. Where cheap and abundant well water of sufficiently low temperature is available for aftercooling, absorption or adsorption dehumidifiers may often be economically applied.

6. The odor and smoke problem in many restaurant and kindred applications can be mitigated either by ample ventilation or by odor absorption equipment. The economics of the latter may be quite favorable, since it permits selection of a smaller re-

frigerating plant, and achieves a reduction in both summer and winter operating cost. It is also possible to utilize electrostatic smoke abatement to decrease outside make-up air with resultant economy.

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SCHOOL AIR CONDITIONING

General Considerations, Criteria for Design, Design Considerations, Preliminary Design, Mechanical Plant Design, Types of Ventilating Systems, Types of Heating and Cooling Systems, Automatic Control, Operation, Maintenance

THE purpose of this chapter is to outline the factors affecting the selection of heating, ventilating, and air-conditioning systems for schools. The components of these systems are the same as used for other types of buildings. Their combination in school systems, in some cases, will be the same as for other buildings, but may differ considerably in others in order to provide optimum conditions for effective school work and to comply with local regulations.

GENERAL CONSIDERATIONS

Some of the factors involved in providing proper heating and ventilating plants are often not recognized fully. They include indoor temperature levels required for best learning and instruction, ventilation, arrangements and periods of use of school plants, advantages of automatic control, and proper perspective of costs.

Many designers and school administrators approach the problem of providing proper indoor conditions as one of heating, whereas analysis may show and experience confirms that cooling rather than heating, is required during periods of occupancy most of the year. Often administrators have remarked "Our problem is not heating. It is to get rid of heat." Temperatures become excessive, particularly in classrooms, because of the heat gains from occupants, adequate lighting, and sun effects.

The optimum environment for learning has not been established by basic research, though such research is currently in progress. Numerous surveys have been made in commerce and industry and in government on the increase in efficiency; i.e., in the amount and quality of work accomplished; of office and factory workers when temperatures are held downward to comfortable limits. They show increases in efficiency of roughly 30 percent and reduction of absenteeism of 20 percent.

Few surveys have been made on the effect of cooling in classrooms. Conclusions of a recent comprehensive statistical type of survey¹ of 150 teachers in the middle and south middle region of the United States included the following:

1. Much improved grades, 23 percent.
2. Much greater facility in learning new subjects and skills, 50 percent.
3. Much more willingness to do more research, 38 percent.
4. Much greater ability to concentrate, 85 percent.
5. Much more effective use of skills already learned, 30 percent.
6. Much more effective use of study time, 59 percent.

From this and other like surveys, it seems clear and definite that substantial improvement in learning will result from air conditioning the classroom. The effect in providing a better society and an improved economy in years to come follows with equal assurance. This is now generally recognized. As a result, cooling or air conditioning was provided in more than 200 new U. S. schools by the close of 1959.² Costs of schools arranged for and provided with air conditioning have been

¹ Says air conditioning experiment may revolutionize school design (*Air Conditioning, Heating and Ventilating*, July 1960, p. 14).

less than those for conventional arrangements and systems. The need for cooling is discussed in the following section.

With regard to ventilation, code requirements vary from acceptance of natural ventilation, such as obtained by opening of windows, to a requirement of mechanical supply of a specified quantity of air, which sometimes is as high as 30 cfm of outdoor air per occupant. The variations in quantity of outdoor air specified usually are due to the lack of a uniform understanding of the reason for ventilation. Research has established that ventilation air is required, not to replace oxygen for breathing, but to dilute body odors, which become intensified in densely occupied spaces. A discussion of air requirements will be found in Chapter 8 of the 1961 GUIDE AND DATA BOOK.

Elementary schools of recent design are generally single-story buildings, often placed at considerable distance from each other. Windows 7 ft or more in height and extending the full length of one or more classroom walls, often raise great problems in maintenance of an optimum indoor atmospheric environment and in prevention of eye strain.

Secondary or high schools are more often two- and three-story structures but present problems only slightly less severe than grade schools. Separation of school buildings results in increased cost of the mechanical systems.

A further characteristic of school buildings is a wide variation in use and occupancy. Classrooms (the largest single group of occupancies), lecture rooms, assembly rooms, auditoriums, and other similar areas have uniformly dense occupancies. Gymnasiums, cafeterias, laboratories, shops, and similar functional spaces have lighter occupancies and also have different and varying ventilation and temperature requirements. Many schools include multipurpose rooms serving as auditoriums, gymnasiums, and community centers.

The normal periods of operation are five days per week for nine months per year, with complete shut down during week-ends and vacation periods. Systems for administration areas, gymnasiums, auditoriums, and multipurpose rooms, suitable for community activities, will often be operated at times when the systems for classrooms and other general educational areas may not be in operation.

Automatic control of temperature and system equipment is a necessity if comfortable conditions are to be obtained. Proper application of controls may return the cost of investment by savings in labor and fuel within a year or two.

School boards are often criticized by their constituents for spending large sums of money for so-called luxury items, with the result that economy in construction and design becomes a paramount factor. This often tends to limit the mechanical equipment selected below that required to maintain a proper indoor atmospheric environment.

CRITERIA FOR DESIGN

Comfort, cleanliness, reduction of odors, maintenance of alertness, compliance with codes, installation cost, ease and cost of upkeep, cost of operation, and adaptability to con-