

wall having a low heat capacity to obtain a fairly rapid heat dissipation. This results in more comfortable conditions on warm sunny days, but also imposes a requirement for more heating capacity on cool cloudy days. The roof constructions for these buildings are also designed for low heat capacity, but do require insulation because of the extended period of sun exposure. The exposed surfaces should be light in color for maximum reflection, and the under surfaces must be arranged so that the ventilation will remove the heat which penetrates through the construction. All parts of the structure must avoid high heat retention so that the heat of the afternoon sun will not be released into the building during the following morning.

The time of use, number of occupants, temperatures required, and degree or quantity of ventilation to be provided should of necessity be studied for each space, and equipment provided to maintain proper conditions. A complete analysis should be made of the requirements, and methods should be adopted that will provide for as many of the following functions as are indicated to be necessary: heating, ventilating, cooling, odor control, humidity control (to prevent or limit condensation).

Schools are usually constructed only after permissive referendums approved by the taxpayers. School districts are mostly local public enterprises under state regulation but operating more or less individually in raising funds by taxation for school construction and operation. Most school district boards of education consider one of their greatest problems that of having the citizens of their communities vote the necessary taxes. Most boards are very susceptible to criticism from their constituents for seemingly (if not actually) spending large sums of money for *luxury* items. This one consideration alone has been a great factor leading to economy in construction and design. Heating and ventilating design is still strongly influenced by this consideration.

It should also be remembered by the designer of heating and ventilating equipment for school buildings that such equipment requires maintenance. The maintenance required may vary from merely dusting and cleaning to wholesale replacement of parts. The trend of modern architecture to reduce *wasted* space is frequently over-emphasized, and causes the spaces wherein mechanical equipment is to be installed to be so classified and consequently inadequate or inaccessible. The designer should always bear in mind that lengthy repairs to heating and ventilating equipment are always considered expensive nuisances.

FACTORS AFFECTING DESIGN

Some of the factors affecting design are the type and use of classrooms, types of other spaces, governmental and fire safety regulations, and economic considerations.

Classrooms

The number of occupants and sudden changes in occupancy should receive adequate consideration. In departmentalized schools, rooms may be unoccupied for a period and then be filled to over-ideal capacity within a few minutes. All rooms should be at the desired temperature when the students enter at the start of the school day. They should maintain such temperature when an internal heat gain is suddenly introduced in the form of body heat and lights.

Lighting in a typical classroom can be the equivalent of at least 8150 to 10,000 Btuh, depending on the type of lighting. Maximum heat gain from lighting will not coincide with maximum sun load, but the modern tendency is to keep at least the row of lights farthest from the window on in order to compensate for loss of illumination.

Because of the large glass areas, solar heat is usually the largest single item of heat

gain. Classrooms usually have separate shades for tops and bottoms of windows. In the South sunshades are increasingly being provided in the building construction. These shades often take the form of horizontal louvers, particularly on south exposures, and are so arranged that little, if any, direct sun rays reach the glass surfaces. The louver windows on the south exposure are often shielded from the sun by an outside corridor. Tinted glass, heat reflective glass, and glass blocks arranged with light reflective prisms are used to some extent.

The orientation of these windows requires careful study in order to take the greatest advantage of the shading devices during the normal period of occupancy. Some serious consideration must be given to the direction of the prevailing wind during the school term. Where there is a wide variation of direction during the school months, provision should be made to take advantage of the changes in wind direction.

In all climates the problem of compensation for lighting loads, sun loads, and occupant loads impose a variable demand on all heating and ventilating systems. These can only be compensated for by adequate thermostatic controls.

It should be noted that while the heat gains are not too much affected by the passage of the seasons the heat losses mentioned are for the design condition only.

Due to the fact that there is no sun load on cloudy days and that before school opens in the morning there are no lights or occupants, none of the heat gains mentioned can be deducted from the required design load. It is very desirable to have a classroom at required temperature when school starts, but these loads must be compensated for by control of the heating and ventilating equipment or by manual adjustment of windows.

Humidity conditioning is typical of dense occupancy applications, except that larger than average areas of low temperature surfaces make failure to control in cold weather more serious. Even in a room with an ideal occupancy of about 25, an hourly moisture gain of almost 26,000 grains must be removed.

Odor control is also required of dense occupancy applications with the additional sources of wet coats and packed lunches, if brought. It is advisable to locate exhaust inlets or relief openings adjacent to coat racks. Where wardrobes are used, their doors are undercut, and these inlets should be located in the wardrobes. This problem is particularly acute in schools of the *campus plan* type.

For the foregoing reasons classrooms should be provided with heating and ventilating installations that will respond rapidly to rapid changes in load.

Other Spaces

Auditoriums, laboratories, shops, office areas, service areas, kitchens (cafeteria and home economics), janitor's closets, swimming-pool rooms, toilets and locker rooms, present problems that are typical of similar spaces in other types of buildings. Chemical laboratories in high schools usually are equipped with fume hoods and have storage rooms that should be adequately ventilated. Shops in high schools may have special requirements, such as dust-collecting systems in woodworking shops, explosion-proof exhaust systems in wood-finishing rooms, and underfloor exhaust gas conveying systems in automobile shops. Locker rooms and toilets may be used in connection with outdoor sports activities during the summer.

Gymnasiums require lower temperatures and adequate ventilation without drafts. Ventilating and heating systems should take into account the ability to divide the gymnasium in half by means of folding partition, if provided. High school gymnasiums are often furnished with collapsible bleachers, indicating a greater occupancy and higher levels at which drafts should be avoided. Combination gymnasium-auditoriums (*general purpose* rooms) and gymnasium-cafeterias (*eating space*) should be treated so as to meet the requirements of each use. Football uniform drying rooms present a special problem of drying and odor control.

Listening rooms (for listening to records), an adjunct to the library, are usually interior rooms and, because of sound transmission, must be soundproofed as well as ventilated. Visual-aid rooms should receive careful attention in ventilating or air conditioning because of the necessity for excluding light during use.

Panel heating is frequently used in kindergarten floors, since so much of the activity in these rooms takes place on the floor.

The room used by the board of education for its meetings is often air conditioned even in the northern part of the country, and even when it is the only space so treated. This is necessary because the board works during all months of the year. This room should be ventilated as recommended elsewhere for *smoking* conditions.