equipment, thus reducing the labor required. The unitary type installation generally is less expensive, and maintenance is made easier and faster. Responsibility for the proper operation of the system is more easily fixed because the system has been designed and assembled by the manufacturer with the components properly sized and balanced (see Chapter 35 of the 1961 GUIDE AND DATA BOOK).

DESIGN CONSIDERATIONS

The basic consideration in designing an air conditioning system for a supermarket is to obtain an economical, efficient system with as much simplification as practicable.

Load Calculations

Heating and cooling loads usually should be calculated using the methods given in Chapters 25 and 26 of the 1961 GUIDE AND DATA BOOK. Data for calculating the loads from people, lights, motors, and special heat-producing equipment should be obtained from the store owner or manager. A minimum quantity of outdoor air (often established by local building code) is introduced through the air-conditioning unit, because the infiltration through the entrance and delivery doors is often high enough to prevent pressurization of the building.

Many supermarkets are units of a large chain owned or operated by one company. Standardized construction, layout and equipment used in designing many similar stores simplifies the load calculations.

One large chain has developed load charts which show the heating and cooling requirements for any size of building (of their standard construction) in various areas of the country.[3] From experience, load factors have been determined based on the area of the entire store, including sales and stock areas. The average cooling load for a store in the central part of the country would be 1 ton per 350 sq ft. In the southern sections, the area per ton would be 300, while in the northern section the value rises to 400 sq ft per ton. If the store is located in a shopping center with other types of stores adjoining, the area per ton requirements for cooling may be increased. The heating load would also be decreased.

Air Distribution

With air-conditioning equipment located outside the sales area, a duct system is used to distribute the air to the sales space. If the units are located in back rooms, ducts are usually run along the side walls to the front of the store. No return air ducts are used, and air returns to the unit through the back room, thus cooling that area.

If the units are on the roof, the duct system includes supply and return ducts, often using combination supply and return type diffusers installed in the ceiling over the sales, stock, and back room areas to be conditioned.

The front section of a supermarket generally has the greatest load, due to large glass area, entrances, and customer concentration at the checkout stations. Many designers overcome this concentrated load by discharging at least 50 percent of the total air supply into the front third of the sales area.

EQUIPMENT

Heating

In most modern supermarkets the same air handling equipment and distribution system is used for both cooling and heating. Boilers may be used to supply hot water or steam to coils in the air handling unit, or direct-fired equipment such as duct heaters, blower-type unit heaters, or horizontal furnaces may be used.

The direct-fired equipment is more commonly used because of lower cost and reduced maintenance requirements.

The entrance area of a supermarket is the most difficult section to heat. Many stores in the northern part of the United States are built with vestibules, which are provided with separate heating equipment to temper the cold air entering from outdoors. Auxiliary heat may also be provided at the checkout area which is usually close to the front entrance.

Other methods being used to heat entrance areas include: (1) air entrances, (2) infra-red radiant heating, using gas-fired or electric heaters, and (3) the use of waste heat from the refrigeration condensers.

Air-Cooled Condensers

In recent years the use of air-cooled condensers has increased greatly. Most installations are made on the roof of the supermarket, although local codes or architectural design may prohibit such locations. If air-cooled condensers are located at ground level outside the store, protection must be provided against vandalism, as well as truck and customer traffic.

Cooling Towers

If water-cooled condensers are used on the air-conditioning equipment, and a cooling tower is required, provision should be made to prevent freezing during winter operation. See Chapter 37 in the 1961 GUIDE AND DATA BOOK.

Controls

The control system should be as simple as practicable, so that store personnel are required only to change the position of a selector switch in order to start, stop, or change the system from heating to cooling, or cooling to heating. A typical control system used by one large chain is given in Reference 3.

PART IV: DEPARTMENT STORES

Department stores vary in size, type, and area of location so that the design of an air-conditioning system requires an individual solution for each store. However, the individual solution can be simplified when the designer is fully aware of the various factors to be considered, and their proper importance in the final analysis of store requirements. Special consideration must be given to economic principles.

Year-round air conditioning provides filtered air to the store, reducing stock spoilage and building maintenance costs. An ample minimum quantity of outdoor air reduces or eliminates odor problems. Essential features of the quality system include: (1) an automatic control system properly designed to compensate for load fluctuations, (2) zoned air distribution to maintain uniform conditions under shifting loads, and (3) use of outdoor air for cooling during intermediate seasons and peak season (Christmas and Easter) sales periods. It is also desirable to adjust indoor temperatures for variations in outdoor temperatures. While the control of humidity to close tolerances is not necessary, the properly designed system should operate to maintain relative humidity of not over 50 percent with a corresponding dry-bulb temperature of 78 F. The low humidity eliminates musty odors and retards perspiration, particularly in fitting rooms, which should receive special consideration.

DESIGN CONSIDERATIONS

Before making load calculations, the designer should examine the store arrangement to determine the various items which will affect the load, as well as the system design.

For existing buildings, a survey can be made of actual construction, floor arrangement and load sources. For new buildings, examination of the drawings and discussion with the architect or owner, or both, will be required.

The survey should include consideration of location for elevators, escalators, service areas, fitting rooms, specialty shops, and other areas or enclosures which may require special treatment. Location of columns and ceiling beams should be noted with regard to duct arrangement and possible location of equipment. If central station or unitary equipment is to be located on the roof or suspended from ceilings, the resulting structural or architectural problems should be considered. Service areas should be checked for possible location of duct and pipe risers.

Larger stores usually have beauty parlors, restaurants, lunch counters, and auditoriums. These special areas may operate during all the time the store is open. Where the load from one of these areas is small in proportion to the total, this load may be included in the portion of the air-conditioning system serving the same floor. If, for any reason, present or future operation of the plant may be compromised by such a method, a separate air-conditioning system could serve this space, with refrigeration supplied by the main plant or a separate system. A separate air distribution system should be provided for the beauty parlor, due to the concentrated load in this area.

The restaurant, because of the required service facilities, is seldom relocated to another part of the store. However, it is generally used only during the noon hours. For these reasons, and also for control of odors, a separate air handling system and sometimes a separate refrigeration system should be considered. In some dining areas, it is advisable to provide a forced exhaust equivalent to the supply in the restaurant area, because of the possibility of odor leakage.

An important item which should not be overlooked during the building survey is the determination of future plans for the store by direct consultation with the architect and owner. This factor can have a great effect on the final decision of the type of air-conditioning system to be employed.

LOAD DETERMINATION

The load calculations should be made in accordance with the methods described in Chapters 25 and 26 of the 1961 GUIDE AND DATA BOOK.

Indoor Conditions

Because the occupancy (except for store personnel) is transient, indoor conditions are commonly established not to exceed 78 F dry-bulb and 50 percent relative humidity at maximum outdoor summer design conditions, and 73 F dry-bulb at minimum outdoor winter conditions. Winter humidification is seldom employed in store air conditioning, due to the problem of moisture condensation on windows. Indoor summer conditions of 78 F dry-bulb and not over 50 percent relative humidity are used for high quality installations.

Internal Loads

Estimates should be obtained from the store management of the number of customers and store personnel normally found on each floor being conditioned. Particular attention should be paid to specialty departments or other areas which may have greater than average concentrations of occupants. The electric lights should be checked for wattage and type (fluorescent, cold cathode or incandescent). Table 2 gives approximate values for lighting in various areas, while Table 3 gives approximate occupancies.

Where the collected data shows a wide divergence from the approximate check values of Tables 2 and 3, the differences should be reconciled with the store management to insure complete understanding between designer and owner.

Other sources of load, such as motors, beauty parlor and restaurant equipment, and any special display or merchandising equipment, should be determined.

Table 2 .... Approximate Lighting Loads for Department Stores

Area	Watts Per Sq Ft
Basement	3–5
First Floor	4–7
Upper Floors, Women's Wear	3–5
Upper Floors, House Furnishings	2–3

Table 3 .... Approximate Occupancy for Department Stores

Area	Sq Ft per Person
Basement, Metropolitan Area	15
Basement, other with occasional peak	20–40
First Floor, Metropolitan Area	20–25
First Floor, Suburban	25–50
Upper Floors, Women's Wear	50–75
Upper Floors, House Furnishings	100 or more

Ventilation

In general, the use of artificial light is increasing, with the result that the internal sensible load is substantially independent of outdoor temperature. The minimum requirement is one air change per hour to overcome infiltration by producing a slight positive pressure within the structure. The minimum ventilation standard is 5 cfm per person, but 7½ cfm per person is preferred. However, the air change rate must not be less than one per hour. These standards have been found generally acceptable and adequate for removing odors and keeping the building atmosphere fresh. However, local ventilation ordinances may require greater quantities of outdoor air.

Paint shops, alteration rooms, rest rooms, eating places and locker rooms should be provided with positive exhaust ventilation, and their requirements must be checked against minimum outdoor air.

SYSTEM DESIGN

Air-conditioning systems are generally of the unitary or central station type. The unitary systems may range from completely self-contained equipment to factory-assembled air-conditioning units with separate air-cooled condensing units. For further information on unitary equipment, see Chapter 57 of the 1961 GUIDE AND DATA BOOK. Central station systems are discussed in Chapter 1 of this volume.

A central station system may be provided for a particular store area, such as an entire floor, or it may provide conditioned air to booster units which are field-assembled units containing a fan and drive, dehumidified air and bypass dampers, filters, and sometimes a heating coil.

Heat pumps, either water- or air-source, are also used in department store air conditioning, where favorable electric rates are available, and where a suitable location can be found for the equipment.

The selection of the system type should be based on an