

humidity-controlling device located in one of the living rooms, so that the washer will operate at all times when the fan is in operation, unless the relative humidity should rise beyond a desirable percentage. Sprays used in connection with commercial or heavy duty plants should be a regulation type of commercial spray. In all cases provision must be made to flush out accumulation of lime and dirt.

Principles underlying humidity requirements and limitations for residences have been summarized in a bulletin⁸ and are enumerated herewith:

1. Optimum comfort is the most tangible criterion for determining the air conditions within a residence.
2. An effective temperature of 66 deg⁹ represents the optimum comfort for the majority of people. Under the conditions in the average residence a dry-bulb temperature of 72 F with relative humidity of 30 per cent is the most practical for the attainment of 66 deg effective temperature.
3. Evaporation requirements to maintain a relative humidity of 40 per cent in zero weather depend on the amount of air leakage to the average residence, and vary from practically nothing to 24 gal of water per 24 hours.
4. Relative humidity of 40 per cent indoors cannot be maintained in rigorous climates without excessive condensation on the windows unless tight-fitting storm sash or the equivalent is installed.
5. The problems of humidity requirements and limitations cannot be separated from building construction, and the latter should receive serious attention in the installation of humidifying apparatus.
6. None of the types of gravity warm air furnace water pans tested proved adequate to evaporate sufficient water to maintain 40 per cent relative humidity in the Research Residence except in moderately cold weather.
7. The water pans used in the radiator shields tested did not prove adequate to maintain 40 per cent relative humidity in a residence similar to the Research Residence when the outdoor temperature approximated zero degrees Fahrenheit.

COOLING METHODS

A slight cooling effect may be obtained under certain conditions by the use of the cooler basement air. A more positive-cooling effect may be obtained by the use of an air washer where the temperature of the city or well water is sufficiently low (55 F or lower), and where a sufficient volume of water can be provided. Unless the temperature of the leaving water is below the dew-point temperature of the indoor air at the time the washer is started, both the relative and absolute humidities will be somewhat increased.

Coils of copper finned tubing through which cold water is pumped are available for cooling. They require less space than air washers and have the advantage that no moisture is added to the air when the temperature of the water rises above the dew-point. Ample coil surface and fan capacity are necessary with this type of cooling.

It is thoroughly feasible to use ice or mechanical refrigeration in connection with a warm air system and to cool the building by this method, provided the building is reasonably well constructed and insulated.

⁸Humidification for Residences, by A. P. Kratz (University of Illinois, *Engineering Experiment Station Bulletin* No. 230).

⁹The optimum winter effective temperature is 66 deg as recommended by the A.S.H.V.E. Committee on Ventilation Standards. (See Chapter 2.)

Windows and doors should be tight, and awnings should be supplied on the sunny side of the building. (See also Chapters 21, 24 and 25.)

Conclusions that may be drawn from studies¹⁰ conducted in the University of Illinois Research Residence, subject to the limitations of the test are:

1. An uninsulated building of ordinary residential type may require the equivalent of three tons of ice in 24 hours on days when the maximum outdoor temperature reaches 100 F if an effective temperature of approximately 72 deg is maintained indoors.
2. The use of awnings at all windows in east, south, and west exposures may result in savings of from 20 to 30 per cent in the required cooling load.
3. The cooling load per degree difference in temperature is not constant but increases as the outdoor temperature increases.
4. The heat lag of the building complicates the estimation of the cooling load under any specified conditions and makes such estimates, based on the usual methods of computation, of doubtful value.
5. The seasonal cooling requirements are extremely variable from year to year, and the ratio between the degree-hours of any two seasons occurring within a 10-year period may be as high as 7.5 to 1. Hence an average value of the degree-hours cooling per season is comparatively meaningless.
6. The duct system in a forced-air heating installation can be successfully converted to a system for conveying cool air for the purpose of cooling the structure. No condensation of moisture was observed when the duct temperatures were not less than 65 F.
7. Cooling by means of water at a temperature of 60 F is not satisfactory unless an indoor temperature of less than 80 F is maintained.
8. In the selection of cooling coils, the additional frictional resistance of the coil to flow of air must be given consideration.
9. Cooling the structure by introducing large quantities of air from outdoors at night tended to reduce the amount of cooling required on the following day and was a practical means of providing more comfortable conditions in those homes where cooling systems were not available.

METHOD OF DESIGNING COOLING SYSTEM

The general procedure which may be used for the design of a summer cooling system in a forced-air installation is:

1. Calculate heat gain for each room or space to be conditioned. (See Chapters 4 and 7.) Allowance for addition of outside air must be included in this calculation.
2. Select a temperature of air leaving supply inlets. In Research Residence tests a value of from 65 to 70 F was found satisfactory.
3. Determine indoor conditions to be maintained. In Research Residence 80 F dry-bulb and 45 per cent relative humidity were found satisfactory.
4. Determine the quantity of air to be introduced into each room. (See Chapter 21.)
5. Estimate heat loss in duct system between cooling unit and supply registers.
6. Calculate the heat to be removed by the cooling unit, in the form of sensible heat and latent heat.
7. Determine size of ducts in duct system and size of registers, as explained in this chapter under the heading of Method of Designing Forced-Air Heating Systems.

¹⁰Summer Cooling in the Research Residence, by A. P. Kratz, S. Konzo, M. K. Fahnestock and E. L. Broderick (University of Illinois *Engineering Experiment Station Bulletin* Nos. 290, 305 and 321). A.S.H.V.E. RESEARCH REPORT No. 1177—Summer Cooling in the Research Residence with a Gas-Fired Dehydration Cooling Unit, by A. P. Kratz, S. Konzo and E. L. Broderick (A.S.H.V.E. TRANSACTIONS, Vol. 47, 1941, p. 203).