

The openings in the roof of a greenhouse which serve for ventilation are arranged in a row along the ridge and are spaced uniformly. If pipe coils are arranged lengthwise of the house they must be heated evenly and proportionately to the cooling effect of the ventilation. However, in practice excess radiation must always be placed at the ends of the house to compensate for the extra heat losses at the gable ends. The result is that when the roof ventilation is open, the ends of the building tend to over-heat. Any small leakage of supply valves or return traps also tends to cause over-heating of the ends of the long coils. A curious observation is that the air in a greenhouse tends to move in a direction opposite to that of the wind outside. This causes over-heating of the windward end and under-heating of the leeward end. This reverse interior current also causes a lowered relative humidity at the leeward end and excess moisture at the windward end; since such leakage as there is tends to enter from the leeward end.

In one case when unit heaters with electric fans were installed in a rose greenhouse, observations with thermometers and humidity instruments indicated excellent results, but the roses would not grow until the air velocity from the unit heaters was reduced to a very gentle current. The most recent testimony seems to indicate that in general, when steam is used the electric unit heater is satisfactory, using low velocities of air and rather close spacing of the heaters.

All successful greenhouse operators testify that great manual effort and exceedingly detailed attention must be applied to the air conditioning. There is a demand for very reliable automatic temperature control. One State University reports most favorable results with unit heaters and electric automatic control.

There is no question but that forced circulation hot water heating finds an especial field in greenhouse work, since the heaters may be almost as small as those used with steam, and since the temperature of the heating surface may be controlled within such a wide range either by thermostats or by hand, without the constant adjusting of supply valves necessary when steam is used.

HEATING AND VENTILATING SPECIFICATIONS

The specifications for the installation of heating and ventilating equipment form a contract document and as such they should be as carefully drawn as are the drawings to which they refer. In general, the purpose of the specifications is to describe the character and quality of the work, while the purpose of the drawings is to indicate the location and quantity of the work to be done.

It is well to have the specifications include other standard clauses which are important in a legal sense and which may be needed to clarify some of the conditions under which the work is to be carried on. If difficulties develop and the courts have to be resorted to, the importance of these standard legal clauses will be realized. It is therefore important that they be written carefully and also that they be included in every specification regardless of the character of the work. When the work is extensive or if the bidders are not selective, as in public works, a section on *Instructions to Bidders* should preface the specifications proper.

Chapter 34 of THE GUIDE, 1931, contains a list of major subjects which should usually be covered in a specification for heating and ventilating work. This chapter also contains some important general notes.

TROUBLE SHOOTING

The engineer who is called in to diagnose troubles with heating systems must be an experienced diagnostician. He needs, in many cases, to have intuition, because the basic reasons for trouble are not always easily located. Probably more heating-plant complaints are terminated by achieving cleanness than by means of any other prescription.

It is well known that the perfunctory washing out of core sand which sometimes occurs at the point of manufacture of ferrous castings does not by any means clean the castings. While any system of screwed piping is being fabricated there is a steady application of lubricating oil, and there are continual opportunities for cuttings, sand, plaster, mud, shavings, and other construction debris to enter the piping.

In case of trouble, experienced engineers almost invariably advise cleaning the piping and the heating units before looking elsewhere. Assistance may be given by the introduction into the boiler or system of chemicals which will neutralize some of the foreign elements, but eventually if the surfaces and pockets are clean, and the water is clean, the system will be free of unpleasant noises, and the fuel cost will be reduced.

Where excessive quantities of chemicals have been introduced it is not uncommon to find an acid condition in the condensate, and this may attack copper interiors, return traps and air vents, with the result that floats and expansion elements may develop leaks. Such leakage into any vacuum heating system of course prevents the maintenance of a proper vacuum and results in the necessity of the introduction of a jet of water at the pump. Where such a jet of water is introduced, raw water with its impurities usually must be supplied, calling for more chemicals which aggravate the situation. An examination of the interior parts of traps and air vents often reveals the seat of this sort of trouble.

The best test for water-cleanness usually is to put a sample of the water suspected of being polluted, in a dish on a stove alongside a similar dish containing fresh water. The fresh water usually will be boiling for some time before the higher surface tension of the polluted water can be broken.

When a boiler is blown off at its bottom the water line of course goes down, and much of the foreign matter, especially the oil, lighter in weight than water, which was floating above the water, clings to the boiler interior and contaminates the fresh water supply. The easiest way to get rid of this form of pollution is by the use of a blow-off opening at the water line which can operate as a skimmer. Many cases of supply valves to radiators, of return traps, and of pipes, all of which were suspected of being too small for the work which they were supposed to do, have been solved by a simple cleaning, without making any physical changes.

The removal of air and condensate from steam heated units, especially those in connection with a fan, is of major importance and manufacturers of such equipment offer suggestions in their literature as to the physical structure which should not be ignored. In many cases the real difficulty is by no means evident, and it is very easy to overlook a serious structural