and stacks, the continuous ventilation monitor is most effective for removal of substantial and concentrated heat loads. This may be in the form of an elevated length of roof ridge with extended overhang and no rain louvers. Such structures are commonly employed over open hearth furnaces and soaking pit buildings but, in practice they give uncertain performance. A more efficient type is a streamlined, water-tight monitor constructed of non-corrosive metals or protected metals. Its capacity increases with wind velocity and it can be readily closed in winter to conserve building heat. Both types have tremendous capacity and are limited only by roof area and proper relation of low-level air inlets.

Next in capacity are the (1) round gravity or windband ventilator (2) round gravity type with fan and motor added (3) low-hood powered ventilator and (4) vertical upblast powered ventilator. Popular modifications of these include the rotary type and the turbine ventilator.

Minimum-capacity ventilators of the gravity type are applicable to warehouses with light heat loads, and to manufacturing areas having high roofs and light loads. Non-mechanical ventilators are desired here because the wide spacing makes electrical wiring and maintenance of fans and motors a matter of concern.

Streamlined continuous ventilators must be able to operate effectively in the absence of mechanical power. While it is difficult to predict performance accurately, it can safely be said that efficient ventilator operation is generally obtained when difference in elevation between the average air inlet level and the roof ventilation is not less than 30 ft and the exit temperature is 25 F deg above the prevailing outdoor temperature. See Chapter 11, Infiltration and Ventilation. Under these conditions and with a wind velocity of 5 mph, the ventilator throat velocity will be about 375 fpm. It will thus remove 10,000 Btu (per hr) (sq ft of throat area):

$$25 \text{ deg} \times 1.08 \times 375 \text{ cfm} = 10{,}000 \text{ Btu}$$

To insure this level of performance it is essential that sufficient low-level openings be provided for the incoming air; otherwise the gravity ventilator becomes starved for air and capacity falls off. The manufacturers recommend 250 fpm to 450 fpm inlet velocity. Lack of adequate inlet area is the most common cause of failure of gravity-type roof ventilators. A positive supply of air to ensure direct ventilation around the hot equipment may be necessary within buildings of considerable area where the external wall inlets are remote from the equipment.

A decision between gravity and mechanical ventilators may be difficult to reach. The electrical power required for fan operation may be a deterring factor but this is offset by the advantage of constant ventilation capacity given by fan operation. Mechanical ventilators will also function despite inadequate fresh air inlets. In many cases there is justification for a mechanical supply (make-up air) which will positively supply air to the work zone.

LOCAL RELIEF

General

The methods required for general ventilation of industrial areas have been described. Such ventilation may have to be supplemented, or in some cases replaced by local ventilation in large industrial areas having substantial heat loads, high ceilings, and scattered work stations. Provision must be made for local relief, to provide tolerable working conditions around the several operations where the heat loads are concentrated.

The methods indicated to be described for local relief are based on the assumption that exhaust ventilation, radiation shielding, equipment insulation, and possible changes in process design have been fully utilized to minimize the heat loads.

Methods of Providing Relief

Relief in local industrial work areas may be provided by any of the following three methods (or a combination of the three):

1. Provide a complete enclosure around the worker with separate ventilation in order to maintain cooler working conditions. This may be in the form of a control room, small shelter booth, or ventilated crane cab. In effect, this is "localized" general ventilation, differing only in the conditions of air temperature, humidity, and motion required.
2. Surround the worker with a relatively cool atmosphere by a direct supply of air introduced at a low level over a small area of the plant. In such cases we are not concerned with the temperature at higher levels in the space so long as adjacent structures do not become hot and thus return radiant heat into the work space.
3. Direct a high velocity air stream at the worker to increase the evaporative cooling effect. This method, commonly called *spot cooling* will incorporate varying degrees of Method 2, depending upon the number of employees and the distribution of the work stations.

Method Number 1, in the form of a work station enclosure, is the most desirable because it permits complete control of the environment. The second method is effective in large areas with many work stations, such as machine shops and assembly lines. The last method is used to provide *spot cooling* in large spaces where scattered work stations and localized sources of heat make it highly impracticable to maintain a tolerable environment throughout the building.

Physiological Aspects of System Design

Two different situations in respect to heat load are encountered: (1) where radiant heat sources are not important, and (2) where radiant heat sources are important. These two situations must be treated differently in design.

Where Radiant Heat is Not Important. Where no important sources of radiant heat are located within or close to the work area, it is only necessary to introduce the relief air into the work space in such a way as to displace the hot air and thus surround the worker with an acceptable atmosphere, consistent with his own needs.

Where Radiant Heat is Important. Where important sources of radiant heat are present and cannot be entirely controlled by radiation shielding, the air supplied for relief must do more than simply displace the hot air. It must also provide convective cooling to offset the radiant heat load. This requires that the air be supplied at a lower temperature and with sufficient velocity. Contrariwise, if the temperature of the relief air exceeds skin temperature, a convective load is added to the radiative load and these, together with the metabolic heat must be removed by evaporative cooling. As the temperature of the air impinging on the worker rises above the skin temperature, a critical point is approached where too high an air velocity will add to the body heat load and too low a velocity will fail to evaporate the sweat, and thus fail to provide the maximum evaporative cooling effect.[3, 4]

The level of air motion provided at the work station should be low, approaching normal room velocities, or about 50 fpm for light activity in a fixed position, and particularly when the individual is seated at a desk or bench. The maximum velocity around the worker should not exceed