useful material is held to a minimum (Fig 29-19)

Internal combustion engine ventilation

Gasoline, diesel, and natural gas engines are being used in increasing numbers and sizes inside factory buildings They are run not only in garages, where maintenance checks and repairs are made, but also in warehouses, storage spaces, loading docks, aisleways, and other indoor areas They are being used as drives for air conditioning and electric generating equipment Their products of combustion contain toxic materials aldehydes, carbon monoxide, and nitrogen oxides

The threshold limit for aldehydes in air is only 5 parts per million (ppm) They may be generated if the engine is in poor operating condition, is burning oil, or has a smoky exhaust Usually, however, they are of less importance, from the industrial hygiene standpoint, than the carbon monoxide released

For an 8-hour exposure, the permissible limit of carbon monoxide gas in air is 50 ppm, but a ventilating system should be designed to keep a much lower level of carbon monoxide (CO) This value should not be over 250 ppm of CO for one hour's exposure

Exhaust gases as released from a gasoline engine contain from 1 to over 10 per cent CO (1 per cent = 10,000 ppm) If the engine is operating at full rated horsepower, its exhaust gases will contain about 3 per cent CO When idling, they may contain over 10 per cent

Gasoline engines are built in many sizes, ranging from fractional to more than 200 hp Lift trucks commonly have a maximum delivery of 35 to 50 hp Since the engine normally discharges about one cubic foot per minute of exhaust gases per operating horsepower, a lift truck when operating near its maximum rated horsepower would release 0 03 *times* 50 or 1 5 cfm CO The quantity of fresh air that would be needed to dilute this CO output so the concentration would be below the threshold limit value would depend on many factors (See "References" at end of this chapter Dept of National Health and Welfare, Michigan Health Department, and Milton Sheinbaum)

Fully as important as the ventilation rate is the distribution of the incoming fresh air throughout the building A warehouse, for example, may have a central runway, with ware piled on each side in bays Dead-end alleys or aisles may lead into these bays and sometimes these constitute stagnant pockets The CO concentration may build up to excessive levels in an aisle when a truck is doing a stacking operation there, and still be negligible along the central runway Such a situation can best be solved by introducing the fresh air by a duct having discharge grilles in the pocketed regions, rather than along the central runway The latter generally receives adequate ventilation from the building doors

Improvement is sometimes made by extending the tailpipe of a warehouse truck upward so it discharges vertically at a point above the operator's head This solution is effective, too, in a situation where a dump truck backs up to a pit hopper, at the bottom of which there may be a conveyor Sometimes a man stands across the pit where the conveyor controls are located and he can get the full blast of the truck exhaust A vertical discharge pipe would prevent this

There are areas where it may not be practical or economical to ventilate for the prevention of objectionable concentrations of CO— such an area is frozen food storage rooms Electric trucks are recommended for these areas

Finally, there is the garage which has fixed automobile repair stations Here the answer is a local exhaust system Three-inch flexible ducts are fitted over the tailpipes The flexible ducts join 4-in branches, which in turn are connected to a header located below floor level or overhead Exhaust requirements are shown in Table 29-G

The fan should be capable of exhausting the required air volume at 1¼ in static pressure, water gauge

For general garage ventilation, where cars are in motion or are idling outside of the repair stall, the following ventilation should be provided to dilute the carbon monoxide

- Per running auto—5,000 cfm,
- Per running truck—10,000 cfm (or more),
- Per horsepower for diesel—75 cfm

Air sampling. The ultimate effectiveness of any ventilation procedure for controlling CO should be verified by checking air sam-