INDUSTRIAL VENTILATION

A Manual of Recommended Practice *for Design*

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13.85 VEHICLE EXHAUST VENTILATION

The objective of providing ventilation for vehicles in an environment is to keep a worker's exposure to toxic exhaust fumes and gases below the TLV®, the TWA and STEL, or other appropriate guidelines or standards. This can be achieved either by dilution or local exhaust ventilation.

It is difficult to establish dilution ventilation requirements accurately for the operating vehicles in a plant. For an existing facility, the designer has the opportunity to measure the emission in the field. Standard techniques can be used to measure gas flow rates, composition, temperatures, and contaminant levels. Using the equations in Chapter 4 and the measurements, the dilution rates can be calculated. However, it is not always possible to accurately determine the contaminant generation rate because generation is not uniform. Moreover, no such data are available to the designer for new vehicles.

The use of dilution ventilation is usually considered only after rejection of the source capture concept. Common reasons for rejecting source capture (local exhaust) are operating interference problems or layout constraints. For lift trucks or cars in motion or idling outside of stalls, local exhaust is not feasible. Hence the only method for control of health hazards is dilution ventilation.

Over the years, some empirical rates have been developed and applied successfully to achieve contaminant control. The recommended dilution rates based on average operating conditions are:

10,000 acfm [5.00 am^3/s] per propane fueled lift truck

16,000 acfm [8.00 am^3/s] per gasoline fueled lift truck

10,000 acfm [5.00 am^3/s] per operating automobile

20,000 acfm [10.00 am^3/s] (or more) per operating truck

100 acfm [0.05 am^3/s] per horsepower for diesel fueled vehicle

The above dilution rates for lift trucks apply under the following conditions:(13.85.1)

1) A regular maintenance program incorporating final engine tuning through carbon monoxide (CO) analysis of exhaust gas must be provided. Carbon monoxide gas concentrations should be limited to 1% for propane fueled trucks; 2% for gasoline fueled trucks (lift trucks manufactured after 2006 can be tuned to 0.5% CO output). If no regularly scheduled maintenance program, increase the design ventilation rates by a factor of three. A maintenance program must address CO emission testing, proper fuel-to-air (A/F) ratios (15.2:1 for newer model propane powered engines and 14.7:1 for gas powered engines), and the proper function of any installed catalytic converter technology. Note that richer A/F ratios (i.e., less than specified) will result in poorer combustion and high CO levels. Leaner A/F ratios (i.e., greater than specified) may result in the increased production of nitrogen oxides (NO_X). Proper engine maintenance on propane powered lift trucks may result in fuel savings ranging from $375 to $750 per shift, per year, per lift truck (assuming propane fuel prices range from $1 to $2 per gallon).
2) The periods of lift truck engine operation do not exceed 50% of the working day (total engine operation of lift truck equal to or less than 4 hours in an 8-hour shift). If the operating time is greater than 50%, multiply the design flow rate by the actual operating percentage divided by 50%. Prevent unnecessary idling of lift trucks when possible.
3) A reasonably good distribution of airflow must be provided. If there is poor air distribution, lift truck operation is not recommended.
4) The volume of space must amount to 150,000 ft^3 [13,500 m^3] per lift truck or more. If the building volume is less than 150,000 ft^3 [13,500 m^3], apply the following: 75,000 ft^3 [6,750 m^3] use 150% of design flow rate; 30,000 ft^3 [2,700 m^3] use double the design flow rate. If the space is less than 25,000 ft^3 [2250 m^3], lift truck operation is not recommended.
5) The lift truck is powered by an engine of less than 60 HP [745 watts].

Where actual operating conditions vary from the above, the ventilation rate should be increased. On the other hand, mechanical ventilation may not be required in large buildings where lift truck operation is intermittent and where natural infiltration based on a maximum of one air change/hour for the net building volume exceeds the recommended dilution ventilation rate. The above-mentioned rates may be reduced when newer lift truck technology is being used. Air monitoring to assess employee exposure to CO is recommended periodically to assess whether or not lift truck emissions are properly controlled.

It should also be noted that prior to installing dilution ventilation to control CO generated by industrial lift trucks, one should first explore the feasibility of switching to electric lift truck technologies. While vehicle costs for electric lift trucks are initially higher than their combustion powered counterparts, savings can be realized in lower operating costs and longer vehicle operating life. Additionally, while electric trucks possess slower acceleration speeds, benefits can be realized from a decreased tire wear, pedestrian accidents and load tip-over concerns.

The above recommendations were established for older model, combustion powered lift trucks built prior to 2003 (many which are still in use today) whose fuel delivery systems commonly relied on the use of carburetors to deliver fuel to the engine. Further, many of these lacked oxygen sensors and catalytic converters to further aid in reducing carbon monoxide output. Lift trucks built after 2006 offer greener low- or no-emission, energy efficient technologies, which substantially reduce CO output and meet the more stringent U.S. Environmental Protection Agency (EPA) Tier 2 CO emission requirements implemented in 2007.[13.85.2] Current emission control technologies rely on: the use of electronic fuel delivery systems combined with post-oxygen sensors; warning mechanisms to indicate malfunctioning emission control systems; and newer three-stage catalytic converters to significantly reduce carbon monoxide levels in the exhaust gas.

Remember, while today's newer lift truck technology produces significantly less CO than their older counterparts, they may still be capable of producing toxic levels of CO in non- or poorly-ventilated enclosed spaces. This hazard can only be truly eliminated by switching to electric powered devices. (Note that battery recharging areas may require ventilation to prevent the excessive buildup of hydrogen gases during the recharging cycle. Battery maintenance/charging areas also require access to emergency eyewash and safety showers when exposure to sulfuric acid is a possibility.)

The alternative to dilution ventilation is to capture the contaminant at the source by installing local exhaust ventilation. For stationary vehicles in service garages, effective systems are shown in VS-85-01 (overhead and under floor). Exhaust volumes are shown on VS-85-02. The systems should be connected directly to the vehicle exhaust and should terminate outdoors above the roof. The design procedure outlined in Chapter 5 must be followed. For friction loss data of flexible ducts, manufacturers should be contacted. As with all flexible systems, the length of flexible duct must be minimized, and non-collapsible duct should be used. Unnecessary and/or sharp bends should be avoided.

REFERENCES

13.85.1 Hama, G.M.; Butler, K.E.: Ventilation for Lift Truck Operation. Heating, Piping and Air Conditioning (January 1970).

13.85.2 Washington State Department of Labor and Industries: Prevent Carbon Monoxide Poisoning from Forklifts (October 2009).