

## Running Engines In-Doors

Operating internal combustion engines in a warehouse, underground mine or other enclosed environment can be dangerous and should be avoided if possible. Your company's health and safety officer should be consulted before conducting any activities.

If it is necessary to run an engine in an enclosed environment, ensure adequate ventilation of air, and that the engine is well maintained. An exhaust purifier (**oxidation catalyst** or **three-way catalyst** with air-fuel ratio controller) will significantly reduce some of the engine-out exhaust pollutants.

### Summary of Health Effects

Pollutant	Effects
Carbon Monoxide	Dizziness and headaches. Lethal in large doses.
Hydrocarbons	Odor, throat and eye irritation.
Particulates (diesel)	Respiratory illnesses, likely carcinogen.

### Typical Emission Levels from engines without exhaust after-treatment.

Emission	Description	Why Do You Have This Emission?	Untreated Diesel Exhaust	Untreated Gaseous Fueled Exhaust	Health Effects	Catalyst Performance
Carbon Monoxide (CO)	Colorless, odorless gas with density close to that of air.	Product of incomplete combustion of fuel.	500-1000 ppm	2000-20000 ppm	Affects the respiratory system by blocking oxygen uptake. Causes headaches and lethargy in lower doses; lethal in larger doses.	Typically exceeds 50% removal at 160°C (320°F). Typically exceeds 90% removal at above 260°C (500°F).
Hydrocarbons (HC)	A mixture of various hydrocarbons, including aromatics hydrocarbons and hydrocarbons with oxygen, sulfur and nitrogen.	Unburned or partially burned components of fuel and lube oil.	300-500 ppm C <sub>1</sub>	50-750 ppm C <sub>1</sub>	Some hydrocarbons in diesel engines have a harsh odor and cause eye and throat irritation, or are toxic or carcinogenic.	Typically exceeds 50% removal at 250°C (482°F) in diesel applications. Typically exceeds 70% removal at above 300°C (572°F).
Oxides of Nitrogen (NOx)	Includes nitric oxide (NO) and nitrogen dioxide (NO <sub>2</sub> ). NO is colorless and odorless. NO <sub>2</sub> is a toxic red-brown gas of unpleasant odor.	Formed due to a reaction between oxygen and nitrogen during high in-cylinder combustion temperatures and pressures.	700-1500 ppm	250-3000 ppm	Respiratory tract irritant. Ozone precursor.	<b>Three-Way:</b> Typically exceeds 50% removal at 160°C (320°F). Typically exceeds 90% removal at above 260°C (500°F). <b>Oxidation:</b> No significant change.
Diesel Particulate Matter (DPM)	The black, blue and white smoke commonly seen in diesel powered equipment (soot). Consists of sub-micron size carbon particles that adsorb unburned fuel, engine lubricants, water vapor and sulfur oxides. The liquid hydrocarbon components are commonly measured under the category of volatile organic fraction (VOF).	Formed due the heterogeneous in-cylinder mixture of air and fuel occurring in the compression ignition process. <b>Significant only in diesel engines.</b>	25-150 mg/m <sup>3</sup>	-	Most of the diesel particulates are small enough to be inhaled with detrimental effects on respiratory tissues. Classified as a probable human carcinogen by the US EPA.	The removal efficiency of the volatile organic fraction (VOF) is similar to that of hydrocarbons. The net result on DPM measurements is highly dependent on sulfur levels in the fuel.

### Summary of Regulations for In-Door Engines

Country	Application	Regulating Body	Recommendations
United States	Underground mining	Mining Safety and Health Association (MSHA)	MSHA strictly regulates the requirements for air ventilation rates, in order to achieve air quality targets. Regulations are focused on minimizing diesel particulates and NO <sub>2</sub> . DCL generally recommends the MINE-X® BM Sootfilter, or the MINE-X® Bluesky Sootfilter. In some cases a MINE-X® exhaust purifier is suitable.
	Warehouses and other in-door environments	Occupational Safety and Health Administration (OSHA)	OSHA regulates ambient air pollutants, mostly based on the guidelines established by the American Conference of Governmental Industrial Hygienists (ACGIH). The TLVs are time-weighted averages for an 8-hour workday. TLVs for carbon monoxide vary in different jurisdictions between 25 and 50 ppm. Carbon monoxide is typically the primary concern with LPG vehicles, and DCL recommends an <b>oxidation catalyst</b> or <b>three-way catalyst</b> . With diesel engines, the primary concern is diesel smell and DCL recommends a <b>diesel oxidation catalyst</b> .