VIII. CLOSED CRANKCASE VENTILATION (CCV) EMISSION CONTROL

A. Technology Overview and Description

OVERVIEW

Diesel engines (as well as gasoline engines) leak some combustion gases through the engine piston rings. These gases are often referred to as "blow-by" and they pressurize the engine crankcase, which serves as the reservoir for the engine lubricating oil, picking up engine oil mist as they exit the crankcase vent. Blow-by gases that leave the crankcase also are referred to as "crankcase emissions" and they contain products of fuel combustion, partially combusted engine lubricating oil, and oil droplets.

Crankcase emissions from diesel engines can be substantial. To control these emissions, some diesel engine manufacturers make closed crankcase ventilation (CCV) systems, which return the crankcase blow-by gases to engine for combustion. CCV systems prevent crankcase emissions from entering the atmosphere. Aftermarket open crankcase ventilations (OCV) are available which provide incremental improvements over engines with no crankcase controls, but they still allow crankcase emissions to be released into the atmosphere.

A retrofit CCV crankcase emission control (CCV) system has been introduced and verified for on-road applications by both the U.S EPA and CARB (see www.epa.gov/otaq/retrofit/retroverifiedlist.htm, and www.arb.ca.gov/diesel/verdev/verdev.htm) in combination with a DOC. In the U.S., this verified CCV/DOC system has been applied to such applications as school buses and offroad equipment used at marine ports. The filter in the CCV system must be replaced periodically. The CCV/DOC system does not impact vehicle/equipment performance or fuel economy.

Properly installed and maintained CCV crankcase controls in both OE and retrofit applications, including the verified CCV/DOC system, have performed effectively in on-road and offroad applications. Also, they do not adversely impact vehicle/equipment performance or fuel economy. If, however, the disposable filter is not replaced at the appropriate interval, the filter can clog. This can cause a pressure buildup in the crankcase and can lead to crankcase seal leakage and possible reduction in engine performance.

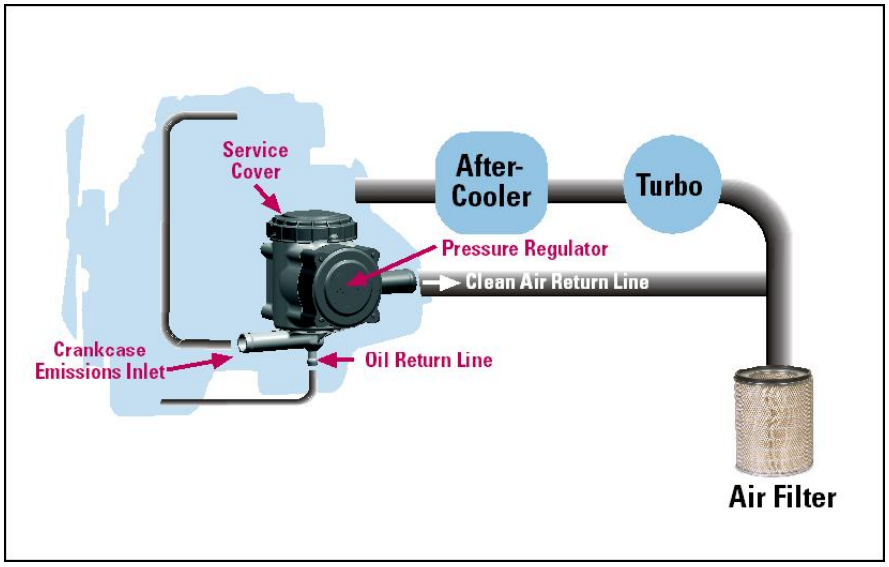
TECHNOLOGY DESCRIPTION

Crankcase emissions from diesel engines without CCV controls can be substantial, as much as 0.7 g/bhp-hr during idle conditions, even on relatively recent model year engines. Crankcase emissions include pollutants related to fuel combustion (e.g., PM), hydrocarbon aerosols, heavy HC materials and non-organic material from engine lubricating oil.

The closed crankcase ventilation system, which is part of the CCV/DOC verified system, virtually eliminates crankcase emissions (over 90%) during all engine-operating modes. The CCV system consists of a filter housing with a disposable filter that must be periodically replaced, a pressure regulator, a pressure release valve, and an oil check valve. A schematic

illustration of the system is shown in Figure 8-1. A picture of the CCV filter housing is shown in Figure 8-2.

Figure 8-1, Schematic Illustration of a CCV System



Courtesy of Donaldson Company

Figure 8-2, Picture of CCV Filter Housing

Courtesy of Donaldson Company

B. Emission Reduction

Crankcase emissions range from 10% to 25% of the total engine emissions, depending on the engine and the operating duty cycle. Crankcase emissions typically contribute to a higher percentage (up to 50%) of total engine emissions when the engine is idling. As noted above, the verified CCV technology is designed to virtually eliminate the crankcase emissions. The combined CCV/DOC system, according the U.S. verification documents, controls PM emissions by up to 33%, CO emissions by up to 23% and HC emissions by up to 66%. A recent program

assessed the impact of CCV /DOC systems on the in-cabin air quality of a school bus. The study reported that the system reduced the particle count by 54% to 62%, depending on the DOC technology used.

C. Status and Availability

STATUS

CCV crankcase emission control technology is currently being used in OE applications in Europe and the U.S. In the future, CCV crankcase controls in the U.S. will be required on on-road HDEs beginning in 2007 and to meet the Tier 4 nonroad emission standards that will be phased in beginning in 2011.

The verified closed crankcase ventilation CCVC/DOC retrofit system has been applied to both on-road and nonroad applications. In the U.S. alone, over2,000 diesel engines have been equipped with this system. For example, a number of school districts have equipped school buses with CCV/DOC systems. The State of Washington will treat both CCV/DOC and CCV/DPF systems as eligible for state funding under its school bus retrofit program. Several marine ports located on the west coast of the U.S. are in the process of retrofitting up to 500 pieces of equipment, such as yard hustlers, with CCV/DOC systems

AVAILABILTY

There are currently several suppliers of open and closed crankcase ventilations systems, however, only one has been EPA-and CARB-verified with a DOC as a system.

D. Selection and Use Criteria

The application of CCV emission controls is quite broad. For example, the verified CCV/DOC system is approved for use on 1991-2003 on-road medium-duty and heavy-duty 4-cycle, non-EGR, and either turbocharged or naturally aspirated (175 horsepower to over 250 horsepower) engines. This technology has also been applied to a variety of offroad applications and a specially designed CCV emission control system can be applied to engines over 500 horsepower. Nevertheless, care should be taken to ensure that the appropriate CCV technology matches the specific engine application. Installing the wrong CCV design can affect the filter efficiency/durability and could affect engine performance. Also, the equipment should be inspected to insure that adequate space exists to properly install the retrofit CCV system. Lack of available space on the vehicle or equipment has precluded the use of the CCV/DOC system in some applications.

E. Installation and Vehicle Modifications

The retrofit CCV emission control is typically installed by the technology supplier. While the filter housing in some cases has been installed on the engine, to avoid problems with engine vibration or movement, it may be advisable to mount the housing on some other part of the vehicle such as the frame rail. The filter housing should also be mounted in a location that is easily accessible for servicing the filter.

F. Fuel Requirements

There are no special fuel requirements for use with CCV systems.

G. Maintenance

Replacement of the disposable filter is very straightforward and can be performed as part of the engine oil change servicing. Recommended filter replacement intervals vary based on the number of hours the vehicle/equipment is operated. For high mileage on-road engines, the maximum recommended interval between replacements is every 25,000 miles. For low-mileage vehicles, lower mileage intervals are recommended and replacement at least annually may be appropriate.

H. Costs

The cost of the retrofit CCV emission control product is in the range of $450 and the costs of the verified CCV/DOC system ranges from about $1,200 to slightly over $2,000, depending on the engine application and the number of units sold under a given purchase order. The CCV/DOC retrofit system installation typically requires two to three hours, but in some cases more time is required. Installation costs are typically charged on an hourly basis. The disposable filters are replaced at recommended intervals and the filter cost ranges from $30 to over $40.