

LA Checks Refuse Truck Emissions at the Curb

Emissions results are compared among diesel refuse trucks.

Los Angeles falls within the jurisdiction of the South Coast Air Quality Management District (AQMD), the air pollution control agency for a four-county region in California. The AQMD Multiple Air Toxics Exposure Study suggested that emissions from diesel combustion are carcinogenic. In 2000, AQMD Rule 1193 was adopted, requiring refuse fleets to begin purchasing alternative fuel trucks by July 2001.

Acting on its own almost a year before the AQMD study and in a desire to improve air quality, in 1999 the Los Angeles Bureau of Sanitation conducted its own field study on refuse trucks equipped with various types of alternative fuel engines, including dedicated compressed natural gas, dedicated LNG, and Dual-Fuel™ LNG.

The study showed that the trucks with Dual-Fuel engines were best suited to meet the operational requirements of refuse collection. Specifically, the Dual-Fuel trucks had adequate horsepower and torque and could be operated safely over all terrains covered by the bureau's refuse collection service.

More than a year before AQMD's required date, with a partial grant from AQMD, the Los Angeles Bureau of Sanitation took delivery of an initial order of ten Dual-Fuel refuse trucks. Since then, the bureau's fleet of Dual-Fuel refuse trucks grew to 160 before reaching 250 by the middle of last year. The Fleet Test & Evaluation team at the National Renewable Energy Laboratory (NREL) measured emissions from ten Dual-Fuel trucks and three diesel con-

trol trucks in 2003 (See box). NREL compared emissions results from the three diesel control trucks with those from four Dual-Fuel trucks that had the same exhaust aftertreatment as the diesel trucks (the six other Dual-Fuel trucks tested did not have exhaust aftertreatment.)

Commercially available Dual-Fuel technology used in the refuse trucks was

supplied by Clean Air Power Inc. (www.cleanairpower.com). The Dual-Fuel engines are based on new commercially available diesel engines with natural gas injectors installed in the intake manifold and an additional engine controller connected to the diesel electronic control unit. In these engines, natural gas enters the cylinder with the intake air. A small quantity of diesel is injected directly into

	Dual Fuel Trucks	Diesel Trucks
Truck	Peterbilt Model 320	Peterbilt Model 320
Model Year	2003	2000-2001
Wheelbase	164 in.	164 in.
GVWR	51,000 lb	51,000 lb
Curb Weight	32,077 lb	32,077 lb
Service	Curbside refuse pickup, automated side loader	Curbside refuse pickup, automated side loader
Engine	Caterpillar C10	Caterpillar C10
Model Year	2002	2000
Rating	315 hp, 1,050 ft-lb	315 hp, 1050 ft-lb
Displacement	10.3 L	10.3 L
Ignition	Compression ignition	Compression ignition
Fuels	LNG and Ultra-Low Sulfur Diesel*	Ultra-Low Sulfur Diesel*
Storage	LNG: 110 gal Diesel: 48 gal	65 gal
Range	80 to 110 mi	80 to 110 mi
Emissions on Simulated Curbside Pickup Cycle	Clean Air Power CPF Aftertreatment	Englehard DPX Aftertreatment
CO**	0.60 g/mi	0.94 g/mi
NO _x	94.6 g/mi	122 g/mi
NMHC/THC***	0.30 g/mi	0.0 g/mi
PM**	0.07 g/mi	0.01 g/mi
CO ₂	8,875 g/mi	10,620 g/mi

* Less than 15-ppm sulfur.
 ** Differences in CO and PM measurements between the Dual-Fuel and diesel trucks were not statistically significant.
 *** NMHC reported for Dual-Fuel trucks, THC reported for diesel trucks.

the cylinder to provide compression ignition. At full load, up to 95 percent of the engine's operating energy is supplied by natural gas, with the remaining five percent supplied by the diesel charge. These engines use a skip-fire technique to increase the proportion of natural gas used and reduce emissions at light loads. This technique introduces the fuel mixture into some, but not all, cylinders and continues to use additional cylinders in response to throttle demand until full power is achieved.

The four Dual-Fuel trucks were each equipped with a Clean Air Power catalyzed particulate filter (CPF™). The three diesel trucks were equipped with an Engelhard Corporation (www.engelhard.com) DPX™ catalyzed particulate filter. The CPF is also manufactured by Engelhard and uses the same technology as the DPX, but it is certified and marketed for use with natural gas vehicles.

Emissions Testing Laboratory

The West Virginia University transportable heavy-duty vehicle emissions testing laboratory was used to collect emissions data. The laboratory consists of two trailers: one with rollers, flywheels, and power absorbers for the dynamometer function and the other with controls and emissions measurement equipment. The trucks were driven onto the chassis dynamometer and positioned on two sets of rollers. The outer wheel of the dual wheel set on each side of the vehicle was removed and replaced with hub adapters that couple the drive axle directly to the dynamometer units on each side of the vehicle.

A driver operated the vehicles through the AQMD Refuse Truck Cycle, which is based on the William H. Martin Cycle, developed by West Virginia University. The cycle includes highway operation (to represent driving between the pickup area and the dump site), curbside refuse pickup operation, and refuse compaction. Results of the curbside mode are shown in Figure 1 because typical residential refuse trucks spend most of their time and consume most of their fuel in this mode.

All tailpipe exhaust was ducted to a full-flow exhaust dilution tunnel, where

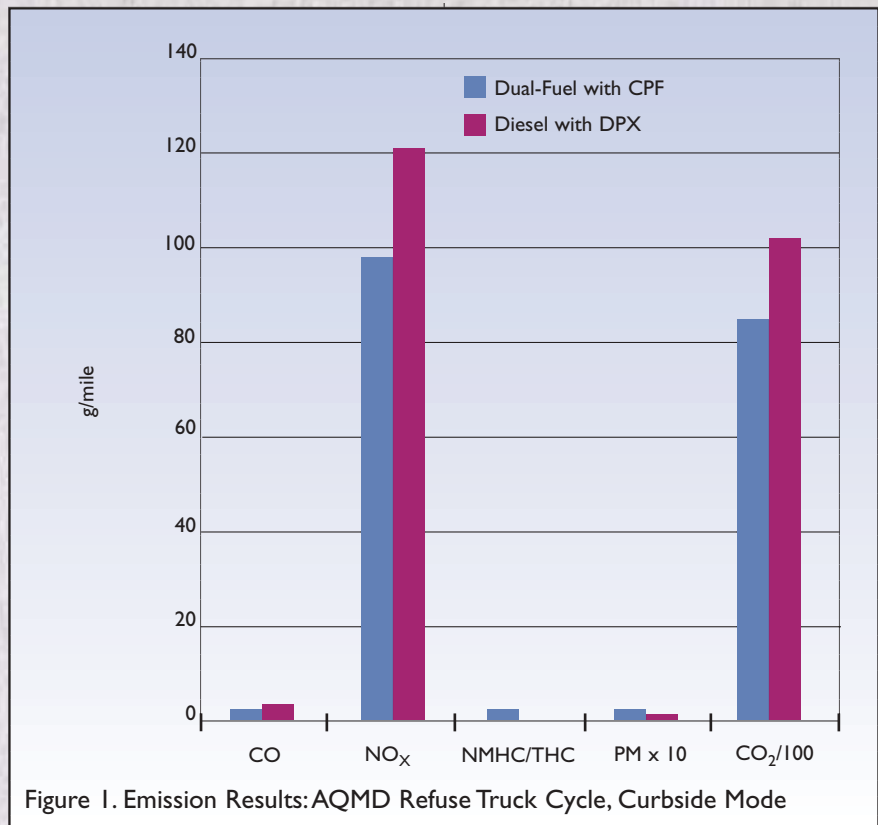


Figure 1. Emission Results: AQMD Refuse Truck Cycle, Curbside Mode


it was mixed with filtered dilution air. The quantity of diluted exhaust was measured precisely with a critical flow venturi system. Samples of the diluted exhaust were analyzed for carbon monoxide (CO), carbon dioxide (CO₂), oxides of nitrogen (NO_x), total hydrocarbons (THC), non-methane hydrocarbons (NMHC), and total particulate matter (PM).

During the curbside mode, the Dual-Fuel trucks reduced average emissions of NO_x by 23 percent and CO₂ by 16 percent compared with the diesel trucks.



Because all trucks used catalyzed particulate filters, emissions of PM and CO were very low (near detectable limits), and differences in the average emissions between the Dual-Fuel and diesel trucks were not statistically significant.

Overall, the Los Angeles Bureau of Sanitation has been satisfied with the ability of the Dual-Fuel trucks to meet the operational requirements of residential refuse collection. As with most new technologies, some initial problems were encountered, such as engine overheating and loss of fuel from on-board LNG tanks. However, the problems were overcome and the bureau continues to add Dual-Fuel trucks to its fleet.

For further information, contact Alex Helou, Division Manager, City of Los Angeles, Bureau of Sanitation, ahelou@san.lacity.org or Kenneth Proc, Project Leader, NREL Fleet Test & Evaluation Team, kenneth_proc@nrel.gov 

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