Ralphs Grocery EC-Diesel™ Truck Fleet

Start-Up Experience

Ralphs

Produced for the U.S. Department of Energy (DOE) by the National Renewable Energy Laboratory (NREL), a U.S. DOE national laboratory

DOE/NREL Truck Evaluation Project

DELIVERING CLEANER AIR WITH THE GROCERIES

The drivers of the grocery trucks say "the exhaust is a whole lot cleaner." Their manager comments that "this is the future." What they're referring to is the special fleet of trucks from Ralphs Grocery Company currently delivering cleaner air along with the groceries in southern California.

EC-Diesel™ Technology Validation Program

		Number of Vehicles Operating On				
		ARCO ECD™			CARB Fuel	
Fleet Managers	Fleets Participating	With Johnson Matthey CRT™ Filter Retrofit	With Engelhard DPX™ Filter Retrofit	Without Filter Retrofit	Without Filter Retrofit	Total Vehicles
International	San Diego School District	5	5	10	10	30
ARCO	ARCO Distribution	5	5	9	10	29
NREL	Ralphs Grocery	5	5	5	5	20
Cummins	LA City Sanitation	5	5	2	3	15
Detroit Diesel	Shuttle Vehicles	5	5	10	0	20
ARCO	Los Angeles MTA	2	2	8	8	20
Ford	Hertz Equipment Rental (LA)	5	5	5	5	20
	Total Vehicles	32	32	49	41	154

Ralphs volunteered to participate in the ARCO EC-Diesel™ Technology Validation Program, which is being conducted with the National Renewable Energy Laboratory (NREL) in collaboration with federal and state agencies and industry partners. NREL is a U.S. Department of Energy (DOE) laboratory. The program is supported by DOE's Office of Transportation Technologies (OTT), Office of Heavy Vehicle Technologies (OHVT).

The purpose of the validation program is to evaluate trucks retrofitted with catalyzed diesel particulate filters and fueled with a new ultra-low sulfur diesel fuel called ECD™, which was developed by ARCO, a BP Company*. The objectives are to:

- Assess the performance and emissions of the retrofitted trucks fueled with ECD
- Collect maintenance, mileage accumulation, fuel economy, and operating cost data for the retrofitted trucks fueled with ECD over twelve months of service
- Compare the retrofitted trucks with control trucks equipped with the original factory muffler and fueled with a typical California diesel fuel.

"Everyone's in favor of having clean air," said Jim O'Day, Ralphs Group Vice President of Distribution. "The quandary is how—practically—to do that."

"It's the future of trucks—cleaner diesel and new technologies," said Greg Peterson, Ralphs manager of fleet services. Tom Anderson, Ralphs fleet manager at the Riverside facilities added: "The demonstration test has gone very smoothly from our point of view—the type of fuel and the catalyzed filters have been essentially transparent to the drivers."

ARCO was recently acquired by BP Amoco, now BP, and plans to continue to provide ultra-low sulfur diesel fuel in California.

Ralphs, a 450-store grocery chain headquartered in Compton, CA, is a division of the Kroger Company, the largest supermarket chain in the United States. The Kroger Company is based in Cincinnati, Ohio. Ralphs employs approximately 25,000 people.

Ralphs has three operating facilities in the Los Angeles area—in Compton, Glendale, and Riverside. The validation program includes 20 Ralphs delivery trucks based at the Riverside facility. Each truck is used seven days a week, makes two to three trips per day, and is driven by two or three drivers a day on separate routes.

Trucks leave the Riverside distribution center loaded with products and groceries destined for Ralphs-owned stores in the Los Angeles area. These trucks average from 7,000 to 12,000 miles per month and have average speeds of 37 to 39 miles per hour. They return to the distribution center at Riverside nearly empty, except for empty pallets and products being returned because of spoilage or damage.

Ralphs test fleet is divided into four groups of five vehicles each, operating on (1) typical California diesel fuel (CARB diesel) without a filter, (2) ARCO ECD™ fuel without a filter, (3) ECD™ fuel and equipped with Engelhard DPX™ filters, (4) ECD™ fuel and equipped with Johnson Matthey CRT™ filters.

All 20 trucks are 1999 Sterling Class 8 trucks equipped with Detroit Diesel Series 60 engines. Fifteen trucks in the Ralphs test fleet began using the ECD™ fuel in mid-January 2000. The filters were installed on 10 trucks during January and February 2000 and the official start of the evaluation was March 1, 2000. The evaluations continued through February 2001.

The start-up phase and early experiences provided several lessons learned by Ralphs transportation and maintenance managers and by engineers conducting the test. Key lessons learned were: (1) the need to obtain and maintain upper management support; (2) the value of a committed, multidisciplined team; and (3) the importance of investigating other possible funding sources to help defray some of the start-up costs.

"A strong team approach has led to a successful fleet start-up experience," said NREL's Keith Vertin. "Ralph's commitment to the project has been outstanding, our government and industry partners have been very cooperative."

"From the beginning of our discussions, Ralphs management and staff said this program looked like an appropriate and cost-effective way to reduce emissions from heavy-duty trucks," Mr. Vertin said, "and all the partners see this as a practical way to improve air quality."

Once Ralphs executives gave the green light, fleet managers and maintenance personnel expedited on-site changes, from selecting the trucks and drivers to allocating space for the new ECD™ fuel storage tank and the mobile emissions laboratory from West Virginia University (WVU). The fuel storage tank was required for test purposes only and would not be required if the entire truck fleet was operated on ECD™.

Ralphs agreed to have 10 of the trucks in the test retrofitted with diesel particulate filters. Ralphs staff ensured that maintenance and fuel data needed for the analysis were easily retrievable from the company's computerized maintenance database system. Access to maintenance worksheets and other information was also provided.

Another major contribution was the fuel. ARCO Products developed the first commercially available ultra-low sulfur diesel fuel in California—called ARCO ECD™—and guaranteed to provide ample quantities for the evaluation program. ARCO ECD™ is produced from a typical crude oil using a conventional refining process and has a maximum sulfur content of 15 parts per million (ppm).

ARCO's goal is to meet today's environmental challenges by engineering cleaner fuels that improve air quality while ensuring vehicle and fuel performance.

ARCO points to studies indicating that catalyzed particulate filters operate

Fuel Properties

Property	ARCO ECD™	Typical CARB Diesel
Sulfur, ppm	15 Max	120
Aromatics, %v	12 Max	18.9
PNA, %wt	1.0 Max	2
Natural Cetane Number	57 Min	53.2
Nitrogen, ppmw	10 Max	98
API Gravity	42.5 Max	36.3
Distillation IBP (D-86), deg. F	350 Min	358
Cloud Point, deg. F	32	10.4

more efficiently when sulfur in the diesel is limited to 15 ppm.

The company coordinated the installation of the on-site refueling infrastructure, including the 2,000-gallon temporary fuel storage for ECD™ fuel. ARCO agreed to absorb the difference in cost between its ECD™ fuel and regular CARB diesel, approximately 5 to 10 cents per gallon. Fuel for the fifteen test trucks is provided "on demand," with deliveries scheduled four to five times a week. The temporary tank would not be required if the entire Ralphs fleet had been converted to ECD™.

ARCO is currently marketing an ultra-low sulfur diesel fuel called ECD-1™ in California. ECD-1™ is a different fuel formulation then the ECD™ test fuel being used in the DOE/NREL Evaluation Project, but it also has a maximum sulfur content of 15ppm.

The catalyzed filters used in the Ralphs test fleet were provided by Engelhard (model DPX™) and Johnson Matthey (the Continuous Regenerating Technology, CRT™). Both types of filters, which were custom-designed for the grocery trucks, are passive devices installed in place of the factory muffler system, without any modification to the engines. The function of the catalyzed filter is to remove particulate matter (or soot), carbon monoxide, and hydrocarbons from diesel exhaust. The particulate filters virtually eliminate odor and visible smoke.

Emissions data on the 20 trucks are being collected at Ralphs Riverside facility by West Virginia University's transportable chassis dynamometer. The purpose of using the dynamometer is to allow for "real world" testing of vehicles at sites around the country.

The mobile laboratory uses sampling and measurement practices developed for heavy-duty engine certification labs to analyze exhaust emissions from heavy-duty vehicles. The lab measures PM, HC, CO, CO_2 , and NO_x.

Start-up Lessons Learned

Obtain corporate commitment to support participation in the program. Earlier test sites have found that the benefits of converting to cleaner fuels may not be immediate or universally recognizable.

Identify a "champion" in the company. The Riverside operations staff received the initial go-ahead from the group vice president. Periodic updates are provided to the group vice president and line managers.

Be prepared to explain the value of participating in a cleaner fuels demonstration. Check Web sites for other active companies and projects (http://www.ctts.nrel.gov/heavy_vehicle, http://www.ott.doe.gov or http://www.afdc.doe.gov).

Take a "team approach." Select drivers interested in the test program and build a support team (e.g., drivers, maintenance crew, managers) willing to work together.

Ensure the site's maintenance data systems are adequate to report new information. Periodically review hard-copy maintenance reports for early warnings of new fuel-related issues.

Analyze the refueling requirements for your fleet. In some cases, ultra-low sulfur diesel fuel may need to be segregated from other fuels. If a separate storage tank is required, the type of tank, size, location, and local ordinances should be carefully considered.

Work with dealerships and technical reps to understand the capabilities and limitations of the diesel particulate filters. The operation of particulate filters can be affected by the climate, engine type, age, vehicle duty cycle, fuel, and lube oil formulations.

Consider retrofit effects, e.g., the size requirements of the particulate filters, which were heavier and larger than the factory mufflers. The larger filters may require a different mounting bracket design, and the possible visual obstruction of the right-side mirrors had to be considered.

Use lockable fuel caps to avoid accidental refueling with any other fuel, because high-sulfur content in other fuels can "poison" the catalyst and cause unscheduled maintenance or repairs.

Consider particulate filter maintenance procedures and work with the filter suppliers to determine service intervals and procedures for the fleet.

Establish early and continuing communications with drivers, refuelers, maintenance, and scheduling personnel. Initially, at Ralphs, memos were sent to crews explaining the program and periodic updates have been provided. "Everyone involved here knows what's happening," said the fleet manager.

Provide information to drivers, refuelers, and others concerned about different handling practices or risks. In the case of Ralphs, the ultra low-sulfur diesel fuels were handled essentially the same as the previous fuel. "Transparent to drivers" is how a Ralphs fleet manager summed up drivers' reactions.

Periodically survey participating drivers for their evaluation of the fuels and vehicle performance. "The exhaust is a whole lot cleaner," one of the drivers said.

Inform your key stakeholders about your company's role in improving air quality—it adds to the company's positive image.

Consider other funding sources to reduce the costs to the participating company.

Develop a process to measure how trucks performed after their conversions, compared with their normal performance.

SPECIFICATIONS

- Twenty 1999 Sterling trucks, Class 8
  - –15 trucks using ECD™ fuel
  - –10 trucks using particulate filters
- 10 speed manual transmission
- Gross Combined Weight Rating: 80,000 pounds
- Average 7,000 to 12,000 miles per month per truck

DETROIT DIESEL CORPORATION

- Model: Series 60 Diesel Engine
- Year: 1998
- Rated Power: 430 hp @ 1800 rpm
- Peak Torque: 1550 lb-ft @ 1200 rpm
- Number of Cylinders: 6, inline
- Bore and Stroke, mm: 130 x 139
- Displacement, L: 12.7
- Compression Ratio: 15.0:1
- Aspiration: Turbocharged
- Aftercooler: Air to Air Charge Cooling
- Dry Weight without clutch, lb: 2,610

Project Participants

Agency and industry partners helping in the Ralphs Grocery Fleet test and their major contributions are:

ARCO Products, a BP company: developed ECD™ fuel; provided this fuel, as well as a temporary fuel storage tank, and fuel distribution.

Ralphs Grocery Co.: host site; allocated space for the mobile emissions lab, ECD™ fueling station; briefed drivers and maintenance staff; provided access to data management system and maintenance records.

U.S. Department of Energy (DOE): provided funding and overall guidance.

National Renewable Energy Laboratory (NREL): project manager, prepared test work plan, coordinated emissions tests, and will provide final reports and a data repository.

Battelle supported NREL in working with the Ralphs fleet, and will collect and evaluate the operations data.

Detroit Diesel Corporation (DDC) and its Valley DDA affiliate provided retrofit services, i.e., installing and providing maintenance service for the particulate filters.

Engelhard: supplied the DPX™ particulate filters.

Johnson Matthey: supplied the CRT™ particulate filters.

California Air Resources Board (CARB): sponsored research leading to CARB diesel; issued the permit to Ralphs allowing the company to "conduct experimental testing" for one year (Executive Order C-375). Co-funded exhaust speciation study. Provided technical support to the overall EC-Diesel Technology Validation Program.

Other agencies were involved in developing test plans and reviewing data, including the South Coast Air Quality Management District (SCAQMD), California Energy Commission (CEC), and the U.S. Environmental Protection Agency (EPA).

ENGELHARD

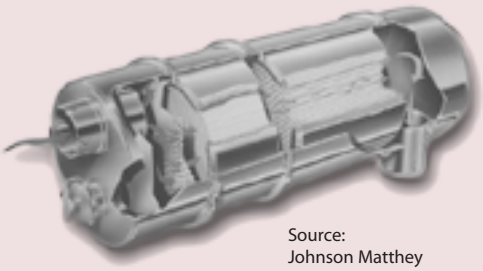
Filter Specifications

- DPX™ catalytic soot filter
- Platinum-coated ceramic wall-flow filter
- Catalyst coating is impregnated into the porous filter walls
- Promotes oxidation of collected PM, HC, and CO

JM Johnson Matthey

Filter Specifications

- CRT™ two-stage system
- First stage is platinum-loaded oxidation catalyst
- Second stage is uncoated ceramic wall-flow filter
- Almost completely removes PM, CO, and HC, according to company tests



Source: Johnson Matthey

Interim Results for Ralphs Test Fleet

Based on the start-up experience and five months of truck operation, through July 31, 2000, several interim results can be reported.

The ECD™-fueled trucks, and trucks retrofitted with DPX and CRT™ particle filters, have operated reliably during the initial five-months of the 12-month test period. The trucks have accumulated approximately 50,000 miles per truck.

There is no evidence of a fuel economy penalty for the retrofitted trucks. The four truck groups had essentially the same fuel economy during the five months of service.

Trucks retrofitted with catalyzed particulate filters and fueled with ECD™ emitted 91% to 99% less particulate matter (PM) compared to the CARB-fueled control trucks having no exhaust filter equipment.

Hydrocarbon (HC) and carbon monoxide (CO) emissions were also significantly reduced for trucks using ECD™ with particulate filters.

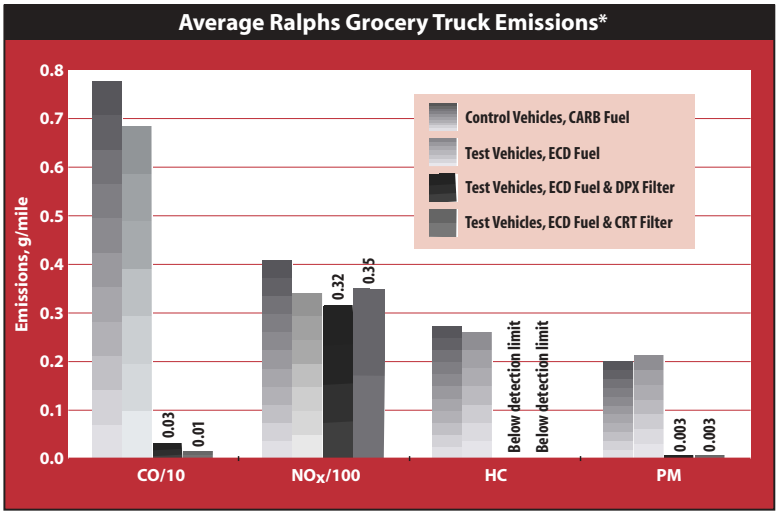
Two trucks retrofitted with particulate filters had minor repairs. Adjustments were made to mounting brackets, but this did not affect the catalyst's operation or damage the catalyst. However, it did provide a valuable lesson learned: some up-front engineering of the particulate filter installation may be required, as well as follow-up checks by maintenance staff.

The data collected and analyses of the data will be provided to partners in the EC-Diesel Technology Validation Program for review and comment. A final report on the evaluation of the EC-Diesel program will be available during the first quarter of 2002.

"As the initial results indicate, this evaluation is going very well," said Chuck LeTavec, principal engineer at BP's Global Fuels Technology Group, LaPalma, CA, "and all of the participants should know they are helping pave the way for commercialization of new, cleaner fuels and effective emission control technologies."

More Information

- "Class 8 Trucks Operating on Ultra-Low Sulfur Diesel with Particulate Filter Systems: A Fleet Start-Up Experience," SAE Technical Paper 2000-01-2821, 2000.
- "EC-Diesel Technology Validation Program Interim Report," SAE Technical Paper 2000-01-1854, 2000.
- "Class 8 Trucks Operating on Ultra-Low Sulfur Diesel with Particulate Filter Systems: Regulated Emissions," SAE Technical Paper 2000-01-2815, 2000.



Each bar represents the average emissions from five trucks.
**Driving schedule for testing results was the WVU City Suburban Heavy Vehicle Route (CSHVR)*

Why Ultra-Low Sulfur Diesel Fuel?

In 1999, the U.S. Environmental Protection Agency (EPA) announced a phase-in of stricter emissions standards for light-duty vehicles beginning in 2004.

On December 21, 2000, the EPA issued a final rule to dramatically reduce pollution from heavy-duty trucks and buses. EPA will require a maximum sulfur content of 15ppm for highway diesel fuels by mid-2006, which is 97% below the current limit of 500ppm. EPA will also require heavy-duty engine emissions standards of 0.01 g/bhp-hr for PM in 2007, and 0.2 g/bhp-hr for NOx to be phased in from 2007 to 2010. These emissions levels are 90% and 95% below the current standards, respectively. The new rule is intended to protect public health and the environment, and to reduce smog in urban areas. Additional information is available at http://www.epa.gov/otaq/diesel.htm.

In 1998, the California Air Resources Board (CARB) designated diesel particulate matter (PM) as a toxic air contaminate (TAC).

On September 28, 2000, CARB approved a comprehensive Diesel Risk Reduction Plan identifying 14 measures over the next several years to reduce diesel emissions from both new and existing diesel-fueled engines and vehicles by 75% in 2010 and by 85% or more by 2020. To accomplish these goals, CARB will (1) establish more stringent emission standards for new diesel-fueled engines and vehicles and (2) require that existing engines and vehicles be retrofitted with particulate filters, where filters are determined to be technically feasible and cost-effective. The plan and fact sheet are available at the CARB web site: http://www.arb.ca.gov/diesel/dieselrrp.htm.

Improved fuels and emission control equipment are necessary to comply with EPA's future engine emissions standards and California's PM mitigation strategy. Ultra-low sulfur diesel fuels are needed to enable the use of catalysts in the exhaust stream to greatly reduce engine-out emissions. Many types of catalysts can be poisoned or made less effective if exposed to high sulfur emissions that are produced when using today's market diesel fuel (typical sulfur content is about 300ppm).

Fuel Supply, Vehicle Testing

ARCO supplied the ECD™ fuel and coordinated installation of the temporary fuel storage tank at Ralphs (insert). If the entire fleet were being powered by ECD™, the temporary tank would not be necessary. Emission tests are performed by West Virginia University's on-site, mobile laboratory (bottom).

The Truck Evaluation Project

The U.S. Department of Energy's (DOE) National Renewable Energy Laboratory (NREL) has been testing and evaluating new fuels and technologies for nearly a decade. NREL is currently conducting the DOE Truck Evaluation Project which includes the testing of advanced fuels, alternative fuels, and emission control technologies. Data are being collected on the operational, maintenance, performance, and emissions characteristics of trucks using cleaner diesel fuel, and new catalysts. The results are compared to data from trucks serving as controls within the same fleet.

In 1993, NREL began a similar program to evaluate transit bus use. The defined and proven data collection and analysis system from the bus study has been adapted for heavy truck use. The sites in the DOE Truck Evaluation Project are selected according to the type of trucks and engines, the availability of control vehicles, and the site's interest in participating. Specific criteria must be met, such as vehicle class (Class 6, 7, or 8 trucks with a gross vehicle weight of at least 19,500 pounds) and number of trucks (at least five).

This report highlights the start-up experience of the project's demonstration at Ralphs Grocery Company's distribution facility in Riverside, California. After collecting and analyzing 12 months of data from the site, NREL and Battelle, NREL's support contractor for the project, will prepare a final report and analysis in early 2002. Information from these projects is made available on web sites (http://www.ctts.nrel.gov/heavy_vehicle, http://www.ott.doe.gov, and http://www.afdc.doe.gov). If you want to know more about this project, its components, new technology vehicles, or incentive programs, contact any of the following individuals:

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For more information and for copies of project reports, visit the Alternative Fuels Data Center on the World Wide Web at http://www.afdc.doe.gov, or call the Alternative Fuels Hotline at 1-800-423-1DOE.

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