Reducing Diesel Emissions in the Denver Region

Report to the Regional Air Quality Council and the Air Quality Control Commission

Diesel Stakeholders Work Group
May 2002

We wish to thank all the individuals who participated in the Diesel Stakeholders Work Group and offered their time, expertise, and assistance to this effort.

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Glossary of Abbreviations & Acronyms

APCD	Air Pollution Control Division
AQCC	Air Quality Control Commission
CARB	California Air Resources Board
CDPHE	Colorado Department of Public Health and Environment
CMCA	Colorado Motor Carriers Association
CNG	compressed natural gas
CO	Carbon monoxide
CY	calendar year
DFSCP	Diesel Fleet Self-Certification Program
DOIP	Diesel Opacity Inspection Program
DRCOG	Denver Regional Council of Governments
EPA	Environmental Protection Agency
G/BHP-HR	grams per brake horsepower hour
G/Mi	grams per mile
GVWR	gross vehicle weight rating
HC	Hydrocarbon
HDDT	heavy-duty diesel truck
HDDV	heavy-duty diesel vehicle
I/M	Inspection/Maintenance
LDDT	light-duty diesel truck
LDDV	light-duty diesel vehicle
LDGT	light-duty gasoline truck
LDGV	light-duty gasoline vehicle
MY	model year
MOBILE6	EPA's new emissions estimation model
NA	Naturally-aspirated (diesel engine)
NAAQS	National Ambient Air Quality Standards
NEMPPA	Northeast Metro Pollution Prevention Alliance
NFRAQS	Northern Front Range Air Quality Study
NOV	notice of violation
NO_x	Oxides of nitrogen
OEM	original equipment manufacturer
PART5	EPA's mobile source particulate emissions model
PM	Particulate matter
PM-2.5	particulate matter less than 2.5 microns in diameter
PM-10	particulate matter less than 10 microns in diameter
PPB	parts per billion
PPM	parts per million
PSIP	Periodic Smoke Inspection Program (California)
RAQC	Regional Air Quality Council
RPM	revolutions per minute
RSD	Remote Sensing Device technology
SCR	selective catalytic reduction
SIP	State Implementation Plan
TC	turbo-charged (diesel engine)
TPD	tons per day
VMT	vehicle miles traveled

Chapter I. Executive Summary

Diesel Emissions Overview

Diesel engines play an important role in the U.S. economy

Diesel engines have long been an important part of the American landscape and a critical part of the U.S. economy. From trucks on our roadways to buses in our urban areas to off-road equipment in major construction projects, diesel engines provide a reliable, economical, and durable source of power for many commercial, industrial and transportation applications. Many parts of the nation's economy – agriculture, freight movement, bus transportation, construction, mining – depend on diesel engines to provide the necessary power and performance to get the job done efficiently and effectively.

Diesel engines power 94% of all freight movement in the U.S., through trucks, rail, barge or tractor. Nationwide, diesel trucks haul 73% of all freight shipments, while in Colorado 90% of all freight manufactured in the state is moved by truck.

Diesel fuel contains more energy per unit volume than gasoline. Combined with their more efficient combustion process, diesel engines provide for as much as 45-60% better fuel economy than gasoline engines. Because of the greater efficiency of diesel engines and greater fuel economy, diesel engines emit 30-35% fewer greenhouse gas emissions.

Air quality and public health implications

Despite many of the inherent advantages of diesel engines, diesel emissions have important air quality and public health implications in many urban areas around the country, including the Denver area.

The Denver area has achieved remarkable success in improving its air quality and achieving EPA's health-based air quality standards. The region has been in compliance with EPA standards for carbon monoxide, ozone (1-hour standard) and PM-10 for a number of years and is on the verge and gaining official attainment designation for all three pollutants.

In 1997 EPA set new, tougher standards for ozone (8-hour standard) and fine particulate matter (PM-2.5). While the Denver region currently attains these standards, there is little room to spare and these standards will likely provide continued challenges in coming years.

In addition, the Denver area has long been plagued by its infamous "Brown Cloud." The region typically exceeds the state's urban visibility standard, which establishes acceptable visual air quality, 50-85 days per winter season.

Diesel engines are important contributors to these air quality challenges. While there is uncertainty to the precise contribution, diesel emissions contribute:

- ✓ 10-16% of regional primary PM-2.5 emissions
- ✓ 20-30% of regional NOx emissions, which contribute to PM-2.5, ozone and visibility impairment
- ✓ 15-23% of regional total PM-2.5 (primary and secondary)
- ✓ 25-40% of regional visibility impairment

Small particles and diesel emissions have also been associated with a variety of public health effects, including respiratory and cardiovascular disease, aggravation of existing asthma, acute respiratory illnesses, chronic bronchitis, decreased lung function and even premature death and other toxic effects. The effect on children, the elderly and those with preexisting illnesses is of particular concern. In addition, EPA has classified diesel emissions as a "likely" human carcinogen.

See Chapter II for more detailed information on air quality impacts of diesel emissions.

Significant advances in diesel technology will reduce emissions

Over the last decade, there have been significant improvements in diesel technology that have resulted in significant reductions in emissions from new diesel engines. Improvements in engine design, after-treatment technology, and diesel fuel have all contributed to improved emission performance. The Diesel Technology Forum estimates that total emissions of PM and NOx from diesel engines have been reduced by 25-35% through the 1990s.

Even more dramatic improvements in diesel technology will result in significant emissions reductions when new on-road engine standards take effect in 2004. In 2007, even tighter new engine standards, coupled with the introduction of ultra-low sulfur diesel fuel, will reduce emissions of PM and NOx by more than 90% for new engines.

EPA also set tighter emission standards for off-road diesel engines in 1998 and expects to propose more stringent standards in the near future that will take effect later this decade.

While these new standards for on-road and off-road engines are significant, they will not have an immediate effect. Since diesel engines are very durable

and remain in operation for many years, it take many years to realize the full impact of these new standards as the diesel fleet gradually turns over.

Nonetheless, significant opportunities exist to introduce new technology into the in-use fleet and take advantage of these emission reduction gains sooner.

See Chapter II for more detailed information on new diesel engine standards and diesel emission trends.

Work Group Overview

Colorado first established a diesel emissions program in the mid-1980's. A diesel inspection/maintenance program resulted from the Governor's Blue-Ribbon Diesel Task Force in 1987 and has remained in operation, essentially unchanged, even since.

The Regional Air Quality Council, the Denver region's lead agency for air quality planning, and Colorado Air Quality Control Commission both have an interest in the effective control of diesel emissions, not only along the Front Range but throughout Colorado. Concern over the potential impact of diesel emissions, coupled with recognition of recent and future advances in diesel engine technology, led the RAQC and AQCC to form a joint Diesel Stakeholders Work Group in August 2001. The RAQC and AQCC charged the Work Group with four primary tasks:

- ✓ Determine the impact of diesel emissions on Denver area air quality and assess the impact of future programs;
- ✓ Review the current Diesel Inspection/Maintenance Program and recommend improvements to make the program more efficient and effective;
- ✓ Explore opportunities and incentives for advancing clean diesel technology and other emission reduction techniques in the marketplace sooner;
- ✓ Assess contribution of off-road diesel engines and recommend opportunities for emission reductions.

The Work Group was open to all interested parties. Participants included representatives from the trucking industry, public and private fleet operators, engine manufacturers, oil companies, emission testing operators, state and local governments, and environmental organizations.

The Work Group met 10 times between October 2001 and May 2002 to hear relevant presentations on diesel topics and discuss the issues. Presentations were made by a number of interested and knowledgeable groups:

- Regional Air Quality Council
- Colorado Motor Carriers Association
- Diesel Technology Forum
- Colorado Institute for Fuels and Engine Research
- Colorado Contractors Association
- Environmental Defense
- Colorado Diesel Emissions Inspection and Maintenance Assoc.
- California Air Resources Board
- CO Dept. of Public Health and Environment, Air Pollution Control Division
- Northeast Metro Pollution Prevention Partnership
- Cummins Engine Rocky Mountain
- Wagner Equipment Co.
- IdleAire Corp.
- EPA Voluntary Diesel Retrofit Program

Recommendations

The Work Group is pleased to present the result of its review of diesel issues in the Denver region and offers recommendations for consideration by the Regional Air Quality Council and Air Quality Control Commission. While every Work Group member may not necessarily agree with every recommendation, the recommendations and conclusions presented in this report represent the strong consensus of the Work Group. Likewise, some members may feel strongly about some issues that they feel are not addressed adequately in the report. Even though most agree more work needs to be done, this report represents a solid starting point for addressing diesel issues and programs.

Members of the Work Group stand ready to assist the RAQC, AQCC, Colorado Department of Health and Environment, the Governor's office, and the General Assembly with implementing these recommendations.

On-Road Diesel Vehicles

See Chapter III for more detail and background on these recommendations

#1 ***Fleet outreach and awareness program***

Establish a Fleet Outreach and Awareness Program to encourage voluntary initiatives by fleet operators to reduce diesel emissions from the current in-use fleet. This program could result in significant emissions reductions well in advance of new federal engine and fuel standards

The program would launch a significant outreach and awareness effort with private and public fleets in the Denver region and recognize fleet operators that undertake voluntary programs to reduce emissions from their fleet of diesel vehicles. Outreach to fleet operators would be accomplished through development and distribution of written information, workshops and training seminars, one-on-one visits, and awards programs. The program would include elements outlined below.

#2 ***Fleet recognition program***
Provide public recognition of voluntary efforts by fleet operators to reduce emissions as an incentive to consider programs that will benefit public health and air quality.

#3 ***Best practices program for vehicle maintenance***
Encourage fleets to utilize best practices for vehicle maintenance by working with the Northeast Metro Pollution Prevention Alliance (NEMPPA) to expand NEMPPA's best practices maintenance program region wide.

#4 ***Strategies to reduce vehicle idling***
Work with industry experts to develop and distribute educational materials, conduct workshops, and implement pilot projects on measures to reduce idling and the economic and environmental benefits that could be derived.

#5 ***Accelerated vehicle retirement, retrofit, and alternative fuel projects***
Work with fleet operators, engine manufacturers, fuel suppliers**,** and others to encourage early introduction of advanced diesel technology in in-use fleets, including accelerated engine replacement, retrofits, and cleaner fuels.

#6 ***Diesel fleet survey***
Conduct a survey of public and private fleets in the region to determine the current composition of diesel vehicles in the area and to identify those fleets with innovative programs to reduce emissions.

#7 ***Clearinghouse of incentive programs and emission requirements***
Establish a web-based information clearinghouse to serve as a central repository locally where companies and potential users may quickly find current and accurate information relating to emission requirements, new technology, and potential incentives at the state and federal level to reduce emissions.

Diesel Inspection/ Maintenance Program

See Chapter IV for more detail and background on these recommendations

#1 ***Evaluation of program effectiveness***
Review the Diesel Inspection/Maintenance program within the next two years to determine if further improvements are necessary and feasible. Develop a research protocol and necessary funding to conduct periodic evaluations of program effectiveness. Identify further specific information and data needs and questions that need to be answered.

#2 ***Automated data reporting***
Automate data reporting and analysis and develop an internet-based system for information exchange.

#3 ***On-road enforcement***
Add an on-road enforcement element to the program, either through remote sensing, smoking vehicle hotlines, or limited roadside pullovers (based on probable cause).

#4 ***Weight definition***
Define heavy-duty diesel vehicles as those greater than 14,000 pounds gross vehicle weight (GVWR) and eliminate the reference to empty weight or curb weight in Regulation No. 12.

#5 ***Model year exemptions and biennial testing***
Increase model year exemptions to four years for heavy-duty diesel vehicles and decrease test frequency to biennial testing for HDDV 10 model years and newer (beginning with MY 1995) under both programs.

#6 ***Testing of vehicles operating in area***
Modify state statute to require testing of all diesel vehicles routinely operated in the program area, not just those registered, required to be registered or housed in the program area as currently required.

#7 ***Testing protocols***
Maintain current testing protocols with the following changes:

- allow SAE J1667 (or other future automated testing protocol) as an option for all HDDV 10 model years and newer in the fleet program;
- require lugdown test for all HDDV older than 10 model years in both programs; and
- eliminate visual testing, during a two-year phase in period, as an option for all HDDV in the fleet program older than 10 model years.

#8 ***Emissions-based testing***
Since opacity is not a good measure of emissions for newer technology vehicles, Colorado should work in a joint effort with the Environmental Protection Agency (EPA) and other states to conduct research and pilot studies to develop appropriate emissions-based testing methods for future consideration.

#9 ***Focus audit program***
Improve audit program by focusing on HDDV fleets with higher than normal out-of-service ratings or fail rates.

#10 ***Technician training***
Expand repair technician training and technical assistance similar to the efforts for the gasoline vehicle program.

#11 ***Clean screen remote sensing***
Investigate using remote sensing technology to clean screen light-duty diesel vehicles and identify high-emitting vehicles.

#12 ***Repair cost waiver***
Eliminate or increase the current repair cost waiver for failed diesel vehicles.

Off-Road Diesel Vehicles

See Chapter V for more detail and background on these recommendations.

#1 ***Fleet Outreach and Awareness Program***
Include off-road fleets and engines in the *fleet* outreach, awareness and recognition program to encourage voluntary initiatives by fleet and engine operators to reduce diesel emissions from the current in-use equipment.

#2 ***Use of low-sulfur fuel***
Improve the understanding of the current use of low sulfur fuel (500 ppm) and the population of off road diesel equipment in the Denver metro area.

#3 ***Incentives to encourage use of low-emitting fuels***
Based on the need, investigate incentives to encourage the use of low sulfur fuel (500 ppm) and other low emitting fuels and investigate the possibilities of early introduction of ultra-low sulfur fuels (15 ppm).

#4 ***Best management practices***
Encourage best management practices regarding engine maintenance, idling and use.

#5 ***Programs for large-scale construction projects***
Encourage low-emitting fuels, retrofits and other low-emitting technology in large-scale construction projects.

Implementation of Recommendations

Implementation of the Work Group's recommendations will take a concerted and coordinated effort by a number of parties. Effective implementation will involve many parties, including CDPHE, AQCC, RAQC, the General Assembly, local governments, industry groups, fleet operators, and engine manufacturers.

Specific implementation steps and responsibilities are addressed for each recommendation in Chapter III, IV, and V. The following list summarizes the implementation responsibilities *(with a reference to each recommendation #)*.

The Work Group recommends the Regional Air Quality Council coordinate the implementation of the recommendations. While the RAQC is not responsible for directly implementing many of the recommendations, the Work Group members believed the RAQC should be the organization responsible for facilitating the implementation of the recommendations and bringing the various parties together.

Colorado General Assembly

Diesel I/M Program

- P Authorize effective on-road identification and enforcement program *(#3)*
- **P** Redefine HDDV/LDDV weight classification *(#4)*
- **P** Increase model year exemptions and authorize biennial testing for newer HDDV *(#5)*
- **P** Require testing of diesel vehicles that routinely operate in the program area *(#6)*
- **P** Allow SAE J1667 or other automated testing for newer fleet vehicles *(#7)*
- **P** Authorize clean screen remote sensing for LDDV *(#11)*
- **P** Eliminate or increase current repair cost waiver *(#12)*
- **P** Provide adequate funding for periodic evaluation of program effectiveness, automated data reporting, fleet audits, and technician training *(#1,2,9,10)*

Fleet Outreach and Awareness Program

- **P** Provide funding or tax incentives for upgrading and modernizing equipment through accelerated engine replacements, retrofits, or clean fuel use *(#5)*

Colorado Department of Public Health and Environment

Off-Road Vehicles

- P Provide funding or tax incentives for upgrading and modernizing equipment through accelerated engine replacements, retrofits, or clean fuel use *(#1,3)*
- P Require or encourage large state-sponsored construction contracts to include specifications for upgrading and modernizing equipment through clean engine requirements, retrofits, or clean fuel use *(#5*)

Diesel I/M Program

- P Develop program evaluation protocol and seek appropriation for necessary funding *(#1)*
- P Develop automated data reporting system with Department of Revenue and seek appropriation for necessary funding *(#2)*
- P Evaluate on-road identification and enforcement approaches for consideration by General Assembly *(#3)*
- P Participate in national efforts to evaluate emissions-based testing methods *(#8)*
- P Implement procedures to improve fleet audit program and seek appropriation for additional funding if necessary *(#9)*
- P Expand repair technician training and technical assistance program and seek appropriation for additional funding if necessary *(#10)*
- P Evaluate feasibility of remote sensing clean screen program for LDDV *(#11)*

Fleet Outreach and Awareness Program

- P Provide technical assistance and possibly grant support to *Green Fleets* program *(#1-7)*

Off-Road Vehicles

- P Provide technical assistance and possibly grant support to *Green Fleets* program as it relates to off-road fleets *(#1-4)*
- P Encourage state agencies to consider, in large state-sponsored construction contracts, specifications for upgrading and modernizing equipment through clean engine requirements, retrofits, or clean fuel use *(#5*)

Air Quality Control Commission

Diesel I/M Program (Revisions to Regulation 12)

- **P** Conduct an annual review of the Diesel I/M program *(#1)*
- **P** Define and require compliance with automated data reporting *(#2)*
- **P** Eliminate visual testing, during a two-year phase in period, as an option for all HDDV in the fleet program older than 10 model years *(#7)*
- **P** Promulgate regulation revisions for items enacted by General Assembly *(#1-7,11,12)*

Fleet Outreach and Awareness Program

- **P** Provide recognition for exemplary fleets under fleet recognition program *(#2)*

Off-Road Vehicles

- **P** Encourage state agencies to consider, in large state-sponsored construction contracts, specifications for upgrading and modernizing equipment through clean engine requirements, retrofits, or clean fuel use *(#5*)

Regional Air Quality Council

Overall

- **P** Coordinate implementation of Work Group recommendations endorsed by RAQC and AQCC *(all)*

Diesel I/M Program

- **P** Publicize review by Work Group and recommendations endorsed by RAQC and AQCC *(all)*
- **P** Assist CDPHE, AQCC, and General Assembly, as necessary, with evaluating implementing recommendations *(all)*

Fleet Outreach and Awareness Program

- **P** Take the lead in working with other program sponsors and supporters to establish and implement the *Fleet Outreach and Awareness Program (#1-7)*
- **P** Coordinate fleet recognition program *(#2)*
- **P** Develop materials and outreach approaches for program *(#1-7)*
- **P** Establish a web-based information clearinghouse *(#7)*
- **P** Seek necessary funding from grants and private contributions to implement the *Fleet Outreach and Awareness Program* and associated pilot projects *(#1-7)*

Off-Road Vehicles

- **P** Take the lead in working with other program sponsors and supporters to establish and implement the *Fleet Outreach and Awareness Program*, which includes off-road fleets *(#1-4)*
- **P** Work with industry associations to determine the use of low-sulfur diesel fuel and the population off-road diesel equipment in the Denver metro area *(#2)*
- **P** Encourage local governments and private develops to consider, in large-scale construction projects, specifications for upgrading and modernizing equipment through clean engine requirements, retrofits, or clean fuel use *(#5*)

Chapter II. Overview

Current Air Quality And Emissions

Due to considerable local effort in woodburning, street sanding/sweeping, industrial source control regulation and inspection/maintenance programs for gas vehicles and federal standards the Denver metro area is currently in attainment for all federal air quality standards. At this time, it appears that the area will most likely attain the new federal 8-hour ozone and PM-2.5 standards. The State Visibility Standard is consistently exceeded 50-85 times each winter season.

Denver Area Air Quality Status

Existing federal standards

The Denver area is currently attaining all federal air quality standards, including carbon monoxide (CO), PM-10, and one-hour ozone.

The Denver area achieved official attainment redesignation status from EPA for one-hour ozone in October 2001 and carbon monoxide in effective January 2002.

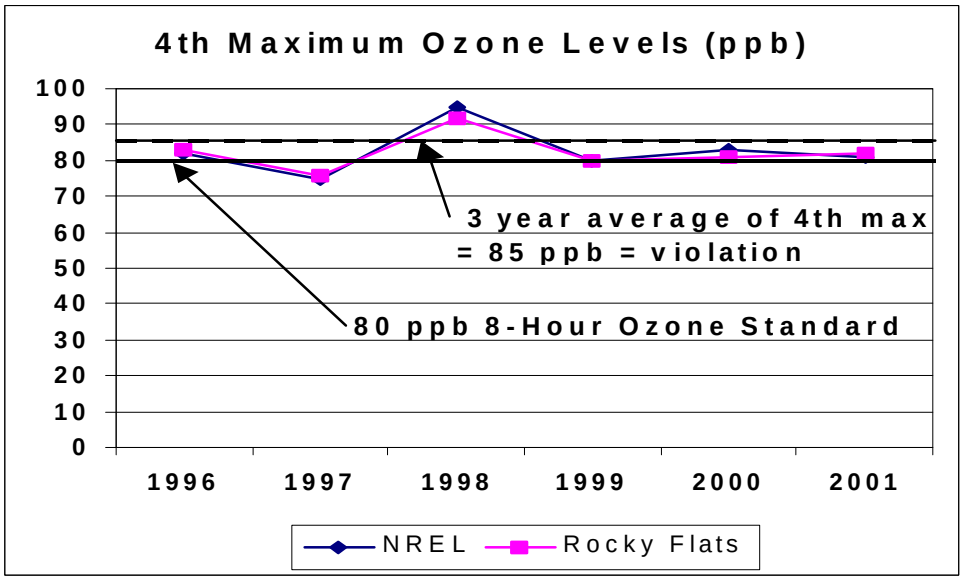
The attainment redesignation request for PM-10 is pending before the Environmental Protection Agency (EPA), which plans to propose approval of the region's plan and request shortly.

New federal standards

The Denver area currently attains EPA's new 8-hour ozone standard, but by only a small margin (less than five percent). In 1998, the Denver area recorded elevated levels of ozone throughout the region, jeopardizing the area's continued attainment of the standard. However, during the last three summers (1999-2001), ozone readings returned to normal levels. Though the 8-hour standard is 80 ppb, violation of the standard occurs when a three-year rolling average of the 4th maximum readings at a monitor in the region is equal or greater than 85 ppb.

8-hour Ozone

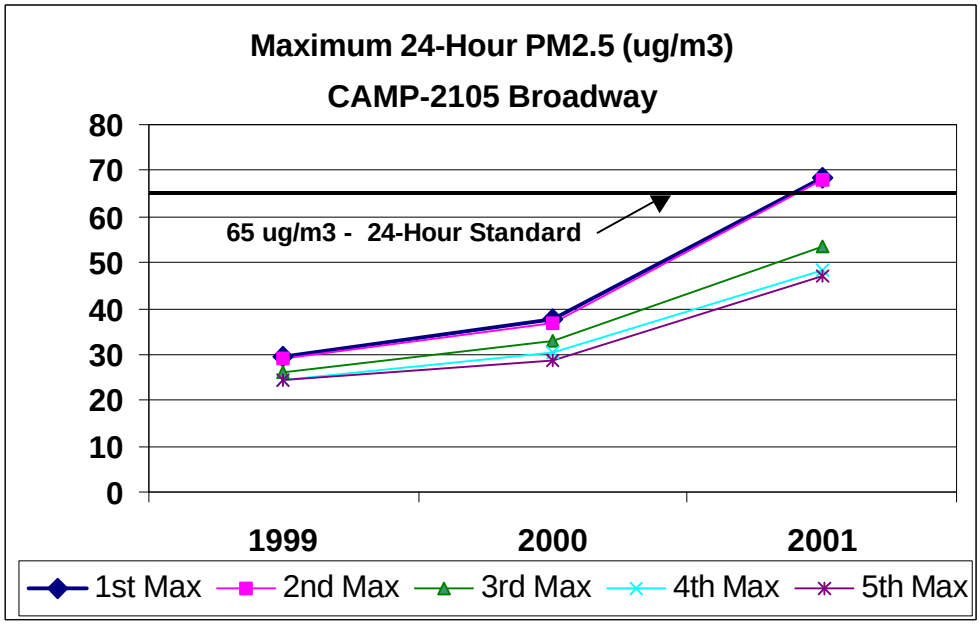
The following chart presents the annual 4th maximum readings of the two (of eight) monitors (NREL and Rocky Flats) each with the current (1999-2001) highest 3 year average of 81 ppb.



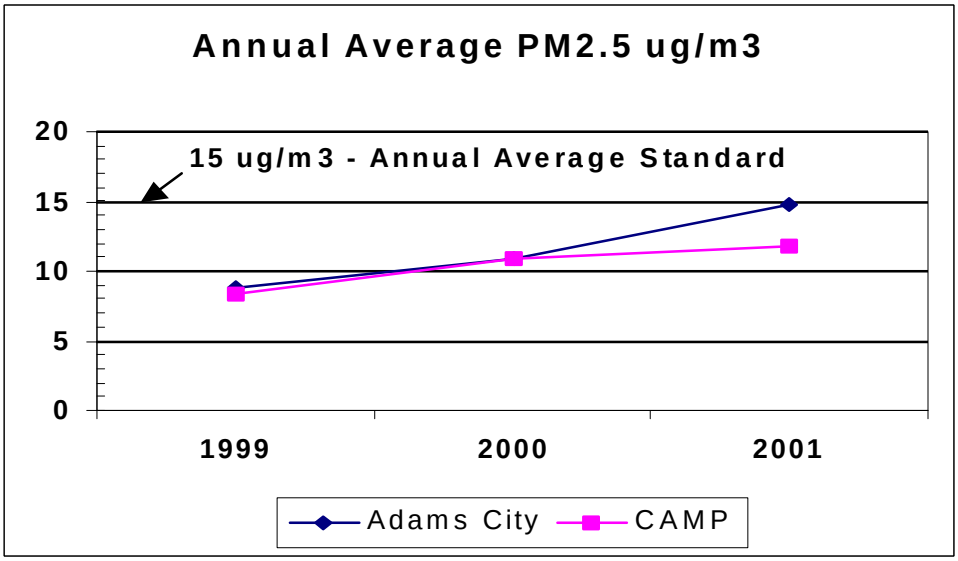
PM-2.5

PM-2.5 monitoring using EPA's new federal reference method only began in 1999 and therefore a complete, fully representative set of data from the 7 monitoring sites is not available to judge the Denver area's ultimate attainment status.

Violation of the 24-hour standard occurs when the 3 year average of the 7th maximum is 65 ug/m^3 or greater. The current 3 year average (1999-2001) of the 5th maximum readings at CAMP is 33 ug/m^3. The maximum 24-Hour PM-2.5 levels at CAMP are presented in the following chart.

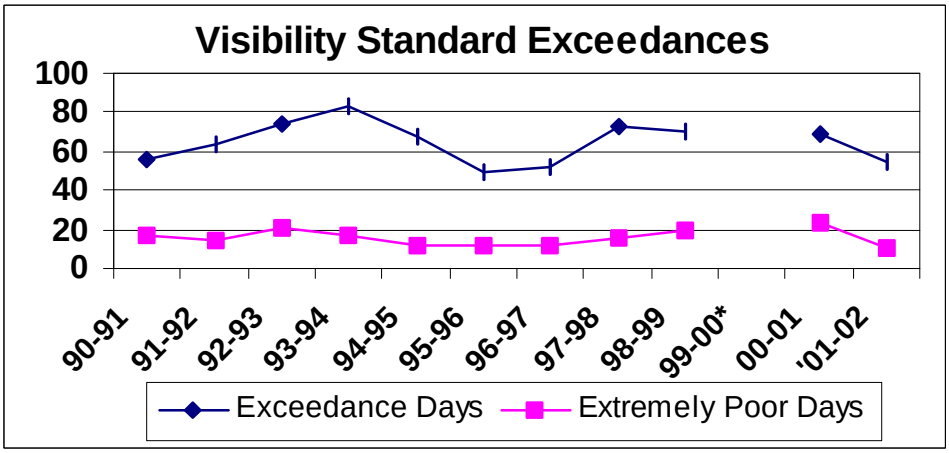


Violation of the annual standard occurs when the 3 year average of the annual averages of a monitor is 15 ug/m^3 or greater. The current 3 year average (1999-2001) of the annual average readings at Adams City is 11.5 ug/m^3. The annual average PM-2.5 levels at Adams City and CAMP are presented in the following chart.



State visibility standard

In 1990 the Colorado Air Quality Control Commission (AQCC) established an urban visibility standard (0.076/km) to serve as a goal and a measure of visual air quality (i.e., the Brown Cloud). The Denver area typically exceeds the visibility standard during 50-85 days per winter season, with 10-20 of those days in the extremely poor category (greater than twice the standard).



* Monitoring Equipment out of service for repair at this time.

Estimated Diesel Contribution to PM-2.5, NOx, and Visibility Impairment

Diesel emissions contribute to both PM and NO_X. The following presents a range of potential diesel contribution to the total PM-2.5 and NOx for all sources, based on different analytical approaches:

	NO_X*	Primary PM-2.5*	Sec. PM-2.5*	Total PM-2.5*	Visibility
On-road diesel	10-15%	3-12%	3%	10-15%	15-25%
Off-road diesel	10-15%	3-5%	2-4%	5-8%	10-15%
Total diesel	20-30%	10-16%	5-7%	15-23%	25-40%

*Expressed in percent of total PM-2.5 and NOx from all sources. Totals for primary PM-2.5 do not add since the ranges come from different sources.

Range of diesel contribution estimates come from a variety of local and national sources based on different analytical approaches. The on-road diesel contribution is approximately 97% heavy-duty diesel vehicle (HDDV) and 3% light-duty diesel vehicle (LDDV) emissions. Considerable uncertainty exists on the total diesel contribution and the relative contribution of on-road and off-road sources, but the ranges capture the uncertainty.

The lower end of the ranges for primary PM-2.5 come from the 1998 Northern Front Range Air Quality Study (NFRAQS), which was a PM-2.5 apportionment study that based its estimates on emission factors derived for the study, ambient measurements of various components, and chemical mass balance modeling. NFRAQS concluded that diesel engine emissions contribute approximately 15% to total PM-2.5 (primary and secondary) while gasoline engine emissions contribute approximately 38% to total PM-2.5.

The higher end of the ranges come from local and/or national emission inventories. Local inventories are based on NFRAQS emission factors for diesel vehicles, local diesel fuel usage, and local activity factor estimates. The local/national inventory data suggest that diesel engine emissions contribute approximately 23% to total PM-2.5 while gasoline engine emissions contribute approximately 15% to total PM-2.5.

Secondary PM-2.5 estimates are further derived from NO_X emission inventory estimates and NFRAQS measurements of ammonium nitrate. Under stagnant inversion conditions, the contribution to secondary PM-2.5 from gasoline and diesel vehicles may in fact be higher since mobile NOx emissions will contribute disproportionately to ground-level nitrate concentrations.

Estimates of potential visibility impairment are based on light extinction coefficients for various compounds. Primary diesel emissions are composed of about 80% elemental carbon, which has the greatest light extinction efficiency and about double the contribution of nitrate and organic mass and about 10-20 times greater than dust or other coarse particles.

Diesel vehicles and equipment are relatively insignificant contributors to carbon monoxide (CO), hydrocarbons (HC) and total PM-10 (3% or less).

Historical and Future Diesel Engine Standards

On-Road Heavy Duty Diesel Emissions Standards

Historical Certified Emissions Standards

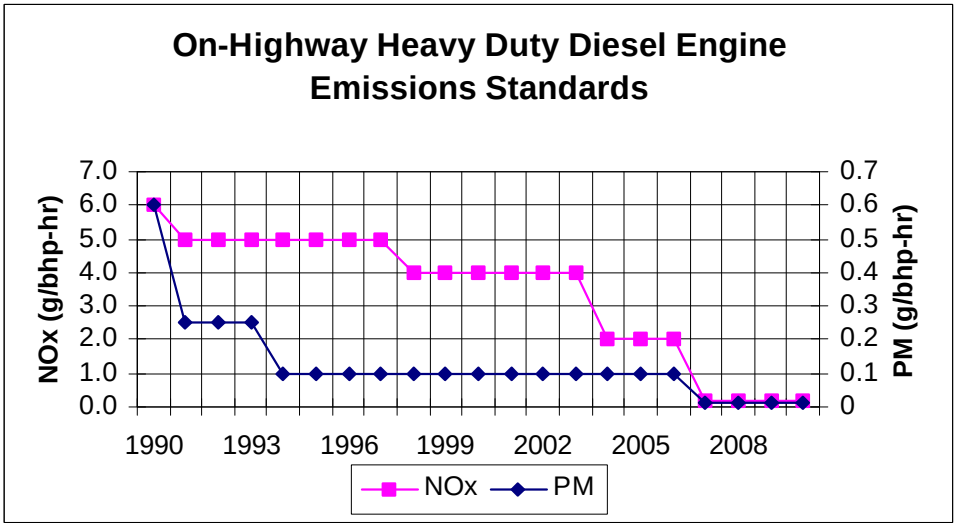
1970-85 - Emissions standards for heavy-duty diesel engines were introduced in 1970 with a 13 mode steady-state test procedure which continued through the 1983 model year. In 1974 HC+NOx and CO standards were introduced. Additionally, opacity smoke standards were tightened to levels (Accel=20%, Lug=15% and Peak=50%) which are current today. The first NOx emissions standard (10.7 g/bhp-hr) and an optional transient test were added in 1984. The steady state test was eliminated in 1985.

1988-98 - A PM standard (0.6 g/bhp-hr) was added in 1988 and PM and NOx standards continued to be tightened (6.0 g/bhp-hr) in 1990 and 5.0 g/bhp-hr in 1991) to their current levels (4.0 g/bhp-hr in 1998) through this period as shown in the chart on the following page. Technological changes began in 1990 with turbocharging, retarded fuel injection timing, etc., initial use of electronic controls started in 1991 and was used on most engines by 1994 and nearly all engines by 1998. Oxidation catalysts and improvements to combustion chamber design were introduced in 1994. Further improvements in turbocharging continued through 1998.

Future Certified Emissions Standards

2002-04 - In 2004 a NOx + HC standard of 2.5 g/bhp-hr, with a HC limit of 0.5 g/bhp-hr was introduced. In a Consent Decree with the federal government, six engine manufacturers agreed to produce engines meeting the 2004 standard by October 2002.

2007 - The emissions standards for PM and NOx continue to be lowered in 2007 to 0.01 g/bhp-hr for PM and 0.20 g/bhp-hr for NOx as shown on the following chart. To achieve 2007 standards an ultra-low sulfur fuel (sulfur
content 15 ppm) is required. Also, technology to achieve the 2007 standards includes catalyzed traps, oxidation catalysts, NOx absorbers, and selective catalytic reduction systems.



On-Road Light-Duty Diesel Emissions Standards

Tier 1 Standards (promulgated 1990)

Light-duty diesel vehicles (LDDV) and light-duty diesel trucks (LDDT) through 2003 require a 1.0 gram/mile (g/m) NOx standard. By contrast gasoline fueled vehicles were required to meet a 0.6 g/mi (light-duty gas vehicle (LDGV) & light light-duty gas trucks (Light LDGT) and 1.53 g/mi (Heavy LDGT) NOx standard in 1994. In 1999 NOX standards were further lowered for 0.3 g/mi (LDGV), 0.5 g/mi (Light LDGT).

Particulate standards of 0.10-0.12 g/m applicable to all light-duty cars and trucks were set to accommodate diesel engine technology. At the time diesel vehicle could just make the standard, while gasoline-fueled vehicles could easily achieve 0.01 g/mi.

Tier 2 Standards (promulgated 1999)

All light-duty cars and trucks, including the heavier, light-duty trucks, and regardless of fuel will be required to achieve the same standards during a phase-in period beginning in 2004 and ending in 2009.

The light-duty cars and trucks will begin phase in (25% per year) to meet a 0.07 g/mi NOx standard in 2004. The heavier light-duty trucks will begin phase in (50% per year) to meet a 0.07 g/m NOx standard in 2008.

During phase in those vehicles not meeting the ultimate standard will meet an interim standard. The light-duty cars and trucks will meet an average 0.3 g/mi interim NOx standard. The heavier light-duty trucks will meet an average 0.2 g/mi interim NOx standard beginning in 2004.

The light-duty cars and trucks will meet a PM standard 0.01 to 0.02 g/mi in 2004 depending on the "bin" selection of the manufacturer. Particulate standards for the heavier light-duty trucks will be in the range of 0.08 to 0.06 g/mi from 2004 until 2006. Ultimately by 2007 the PM standard of 0.01 to g/mi is required.

Off-Road Heavy-duty Diesel Emissions Standards

Tier 1 Standards (promulgated 1994)

Tier 1 Standards for off-road engines were established in 1994 and began to be phased in for various horsepower ratings in 1996 through 2000. As shown in the following table, Tier 1 standards will remain in effect until the Tier 2 and/or Tier 3 standards take effect.

Tier 2 and Tier 3 Standards (promulgated 1998)

Tier 2 and Tier 3 standards were established in 1998 to be phased in for various horsepower ratings between 2001 and 2008 as shown in the following table.

Off-Road Heavy-Duty Engines
NOx+HC and PM Emissions Standards (g/bhp-hr)
(NOx + HC / *PM*)

HP	2000	2001	2002	2003	2004	2005	2006	2007	2008
<11	7.8 / *0.75*					5.6 / *0.60*			
11<25	7.1 / *0.60*					5.6 / *0.60*			
25<50	7.1 / *0.60*				5.6 / *0.45*				
50<100	7.6 / *0.72*				5.6 / *0.30*				3.5 / -
100<175	7.3 / *0.40*			4.9 / *0.22*				3.0 / -	
175<300	7.3 / *0.40*			4.9 / *0.15*			3.0 / -		
300<600	7.3 / *0.40*	4.8 / *0.15*					3.0 / -		
600<750	7.3 / *0.40*		4.8 / *0.15*				3.0 / -		
>750	N.A. / *0.40*						4.8 / *0.15*		
	Tier 1			Tier 2			Tier 3		

Off-Road Fuel Standards

Current off-road fuel standards allow 5000 ppm in sulfur content. Work group discussion indicates that most public works and private construction companies are using fuel with 500 ppm sulfur content in off-road equipment.

Unlike the current (2006-07) on-road standards that call for a reduction in fuel sulfur content (from 500 ppm to 15 ppm) to help meet stringent new engine standards, the current Tier 2 & 3 off-road standards do not incorporate lowered fuel sulfur content standards. Tier 2 & 3 standards are well above the established on-road standards for the same 2006-07 time frame.

Future Diesel Emissions Trends

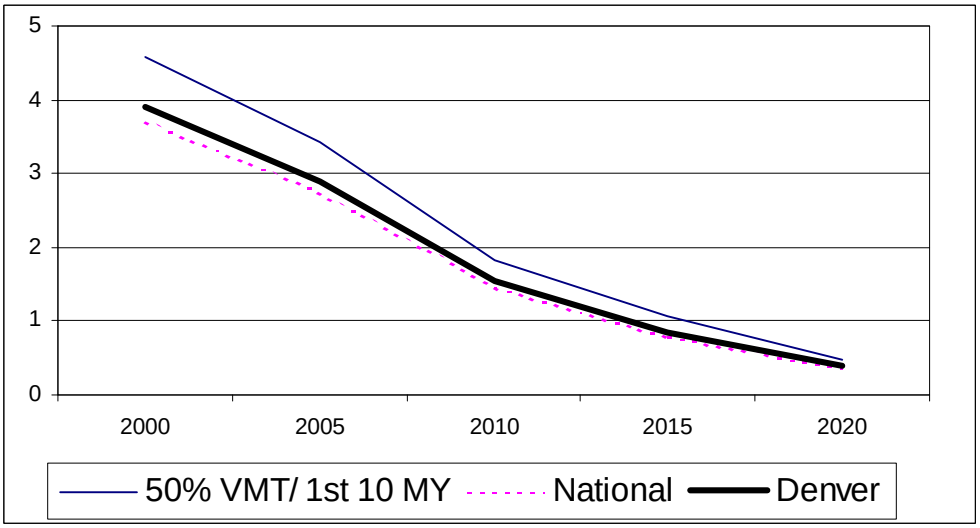
On-Road PM

Baseline diesel primary PM-2.5 emissions for on-road for the Denver metro area have been taken from the 1995 inventories developed by the RAQC for the *Blueprint for Clean Air* planning process (1996-98). The trend curves however start at the year 2000 since at that time monitored emissions indicated attainment of the PM standards. Emissions were based on emissions factors developed during testing of 33 HDDV operating in the metro area for the *Northern Front Range Air Quality Study, 1998* and Denver Regional Council of Governments (DRCOG) vehicle miles traveled (VMT) estimates.

Trends in future on-road emissions were developed using certified emissions factors and diesel VMT mix over time from MOBILE6.1 support data and VMT growth rates from the recent PM-10 Maintenance Plan, 2001.

MOBILE6.1 national data indicate approximately 70% of the VMT is caused by vehicles in the first 10 MY, while the remaining 30% of the VMT is caused by vehicles in the 11th through 30th model year (MY). Data from the Air Pollution Control Division (APCD) and the Colorado Motor Carriers Association (CMCA) indicates that the Denver metro area may have a 67%/33% split in VMT. Additionally, difficult economic times for the trucking industry slowing the purchase of newer vehicles was analyzed by assuming 50% of the VMT was produced by the first 10 MY and 50% produced by the 11th through 30th MY. The trends are presented in the following chart.

PM-2.5 Emissions Trend - tons per day



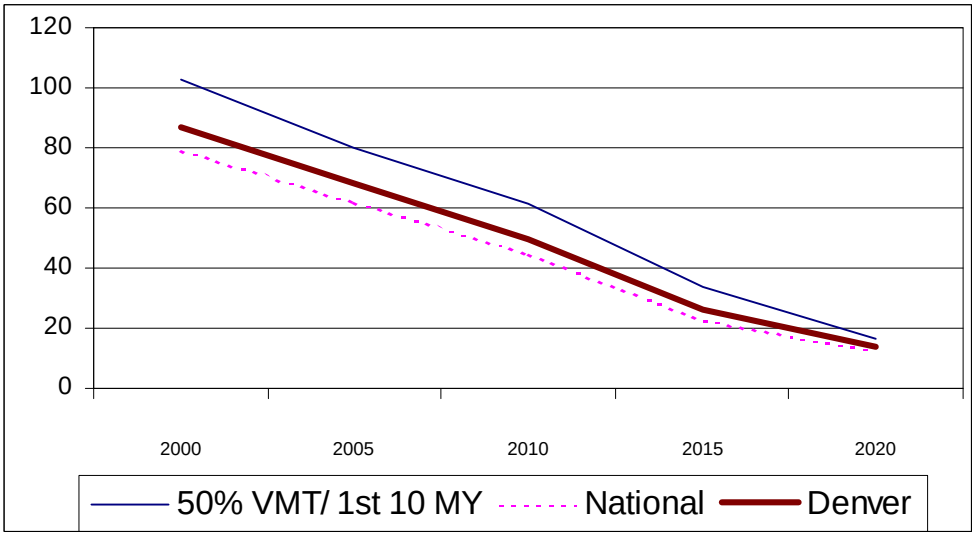
On-Road NOx

Baseline diesel NOx emissions for on-road for the Denver metro area in 1995 are based on a recent analysis of MOBILE6.0 by the APCD using certified NOx emissions factors and DRCOG VMT estimates.

Trends in on-road emissions were developed using certified emissions factors and diesel VMT mix over time from MOBILE6.0 support data and VMT growth rates from the recent PM-10 Maintenance Plan, 2001.

As discussed above for PM, NOx emissions trends based on the EPA national data, Denver metro data and an assumed hardship condition in the trucking industry slowing the rate of newer vehicles entering the fleet are presented in the following chart.

NOx Emissions Trend - Tons per day

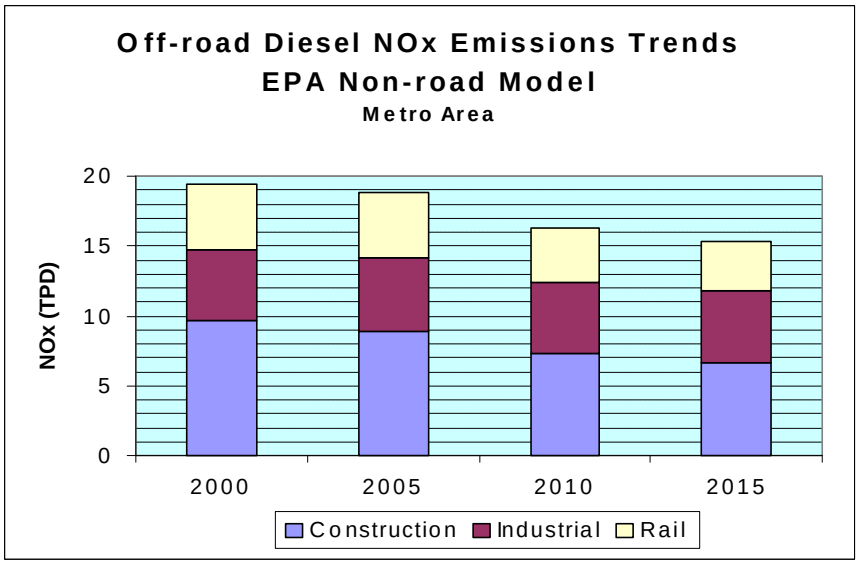


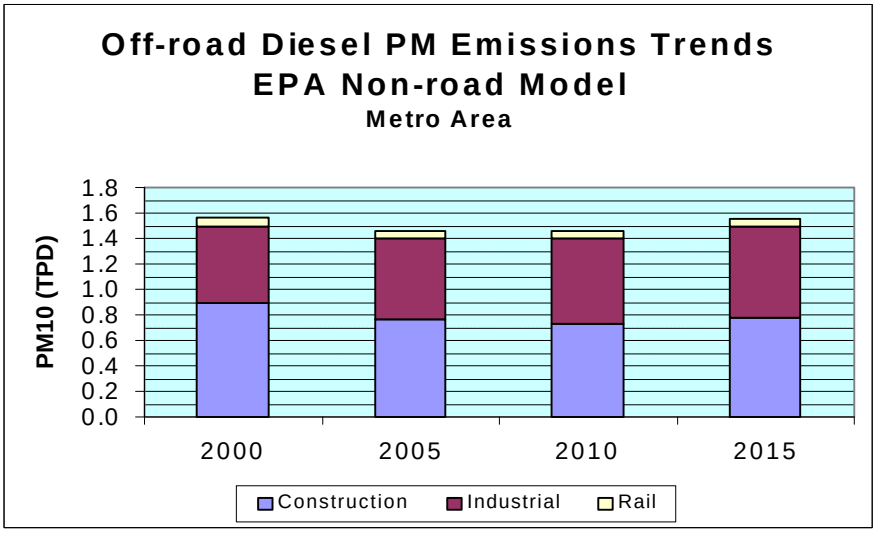
Off-Road PM and NOx

The 1995 baseline PM and NOx emissions are consistent with inventories from the *Blueprint for Clean Air* planning process, which are based on the *20 Cities Study, EPA, 1990*. The trend curves start with the year 2000 since the region was attaining all NAAQS at that time.

The trends for construction, industrial and rail are based on population, activity and certified emissions factors developed from the EPA Non Road Model by the APCD for the recent PM-10 Maintenance Plan, 2001.

The trends for PM and NOx are presented in the following charts.





Chapter III. On-Road Diesel Vehicles

Overview

As indicated earlier, significant advances in diesel engine technology have led to considerable reductions in diesel emissions over the last two decades. Diesel engine manufacturers and fuel suppliers have worked together to dramatically reduce emissions from diesel engines while at the same time improving reliability, durability, and fuel efficiency. Tighter future standards for new diesel engines will continue to reduce emissions over the next 10-20 years.

Despite these gains, the turnover of the diesel fleet to cleaner engines can take many years because of the durability and long road life of diesel engines. There are still opportunities to reduce emissions from the in-use fleet through proper maintenance, reductions in vehicle idling, accelerated vehicle retirement, add-on equipment retrofits, and use of cleaner diesel fuels.

Fleet operators in many areas of the country are currently implementing a variety of programs to introduce new technology sooner and reduce diesel emissions. EPA has established a national Voluntary Diesel Retrofit Program to help build partnerships among industry, community groups, and state and local officials to implement retrofit projects that result in cleaner, healthier air for their communities. The Diesel Technology Forum, an organization of diesel engine and emission control manufacturers and petroleum refiners, has also been an active promoter of the concept of retrofitting existing diesel engines to reduce emissions as a cornerstone of the Forum's overall program to advance clean diesel technology.

Recommendations

Establish a Fleet Outreach and Awareness Program

To take advantage of these opportunities to reduce diesel emissions in innovative ways, establish a ***Fleet Outreach and Awareness Program*** to encourage voluntary initiatives by fleet operations to reduce diesel emissions from the current in-use fleet.

The ***Fleet Outreach and Awareness Program*** would launch a significant outreach and awareness effort with private and public fleets in the Denver region and recognize fleet operators that undertake voluntary programs to reduce emissions from their fleet of diesel vehicles. Outreach to fleet operators would be accomplished through development and distribution of written information, workshops and training seminars, one-on-one visits, and awards programs. The ***Fleet Outreach and Awareness Program*** would include elements outlined below.

Fleet Recognition Program

Many fleets operators nationally and in the Denver area are implementing or planning a variety of voluntary programs to reduce emissions from their existing diesel fleet. Public recognition of these efforts can give fleet operators an incentive to consider programs that will benefit public health and air quality.

Implementation: A special recognition program would be established to highlight public and private fleets and supporting companies that have undertaken significant voluntary efforts to reduce diesel vehicle emissions. Criteria would be established for recognition and nominations will be solicited for judging by an independent panel.

Exemplary fleets would be recognized at a special ceremony with an award and would be allowed to display a program logo. Fleets would also be recognized through advertising, media placements, on appropriate web sites, and in promotional materials.

The fleet recognition program would be a cooperative effort of the Governor's Office, the Regional Air Quality Council (RAQC), the Colorado Department of Public Health and Environment (CDPHE), the Colorado Motor Carriers Association (CMCA), and other sponsoring organizations.

Best Practices Program for Vehicle Maintenance

Well-maintained diesel vehicles produce less pollution than vehicles that are not rigorously maintained. By implementing best practices for vehicle maintenance, fleet operators not only will reduce vehicle emissions but will also reduce operating and long-term maintenance costs.

Implementation: Building upon a program initiated by the Northeast Metro Pollution Prevention Alliance (NEMPPA), the ***Fleet Outreach and Awareness Program*** will assist with expanding the best practices maintenance program region wide. Using NEMPPA's Best Practices Manual, the outreach effort will assist companies and truck owners in developing an effective vehicle maintenance program that will reduce diesel emissions. Particular attention will be given to individual truck owners and

smaller fleets who do not possess the expertise or resources associated with maintaining vehicles in optimal running order. The effort will also be coordinated with CDPHE's training program for repair technicians.

Strategies to Reduce Vehicle Idling

One area where significant emission reductions can be realized is in the area of excessive vehicle idling. Advances in engine technology and other types of technology makes excessive vehicle idling unnecessary and costly to the truck owner.

Excessive engine idling increases fuels costs, maintenance costs and engine wear for truck owners. According to information provided by Cummins Rocky Mountain, engine idling costs a truck owner $0.75-1.12 per hour, or $4.50-6.75 per day in wasted fuel, and can result in two additional oil maintenance intervals per year at a cost of at least $200. In addition, since oil additive packages tend to degrade more quickly during idling, excessive idling will tend to accelerate the accepted normal rate of engine wear.

There are several strategies that can be employed to reduce vehicle idling. One of the first steps is greater education on the economic and environmental impacts of excessive idling. There are also engine control systems that monitor and control the idling of engines while maintaining block temperature, battery voltage and/or cab temperature. In addition, truck owners can employ management strategies, such as fuel economy incentives, to encourage drivers to reduce idle time.

Another promising strategy to reduce engine idling is truck stop electrification, where systems are installed at truck stops, rest areas, or terminals. Such systems provide heat and air conditioning as well as electrical shore power inside and outside stationary trucks, allowing drivers to turn off their truck engines while they rest or wait to load and unload. Pilot projects are underway in several areas of the country, including New York and southeast U.S.

Implementation: Greater education on the economic and environmental impact of excessive idling and on idling reduction strategies and equipment could inform truck operators and help reduce emissions. As part of this effort, the ***Fleet Outreach and Awareness Program*** will work with industry experts to develop and distribute educational materials and conduct workshops on measures to reduce idling and the benefits that could be derived. The program could also work with a local truck stop to implement a pilot project to reduce vehicle idling, including truck stop electrification.

Accelerated Vehicle Retirement, Retrofit, and Alternative Fuel Projects

New diesel engine technology, control devices, and fuel changes continue to result in remarkable reductions in diesel emissions. Opportunities exist to introduce these technological advances into the marketplace sooner through voluntary programs that encourage:

- accelerated retirement of pre-1990 trucks and buses and replacement with newer, cleaner engines;
- retrofits with after-treatment (post-combustion) control devices, such as catalytic converters and particulate traps;
- installation of low-NOx calibration devices in advance of engine rebuild as required by federal consent decree;
- use ultra-low sulfur fuel in combination with after-treatment control devices; and
- use of alternative fuels, such as compressed natural gas (CNG) and biodiesel.

The U.S. Environmental Protection Agency (EPA) has developed the Voluntary Diesel Retrofit Program as an immediate solution to reducing emissions from existing diesel construction equipment and heavy-duty vehicles operating on the road today. EPA's goal is to reduce emissions from the existing fleet until new diesel standards take effect in 2007.

According to the Diesel Technology Forum, the initial, narrow definition of retrofits has been expanded to include the "5 R's" of upgrading and modernizing diesel equipment – repowering, rebuilding, retirement, refueling, and retrofitting.

The goal of the EPA's program was to secure, by the end of 2001, commitments to retrofit 100,000 trucks, buses, and construction vehicles with commercially available emission control technologies. As of the end of 2001, EPA calculated over 70,000 vehicles committed to retrofit equipment. See Appendix A for a summary of current voluntary retrofit projects around the nation.

As part of the immediate effort to reduce diesel emissions, EPA developed a web site – www.epa.gov/otaq/retrofit – devoted to helping fleet operators, air quality planners in state/local government, and retrofit manufacturers understand the voluntary program and obtain the information needed to implement voluntary retrofit projects.

In addition, the web site explains the economic incentives to the program and emissions credit trading. Also, the web site lists verified retrofit technologies, including retrofit manufacturers, type of technology, and the percentage of emissions reductions.

For more information on EPA's Voluntary Diesel Retrofit Program, visit the EPA's OTAQ web site at www.epa.gov/otaq/retrofit. Also consult the Diesel Technology Forum's web site at www.dieselforum.org for more information.

Implementation: As part of the outreach effort with fleet operators, the ***Fleet Outreach and Awareness Program*** will provide information on retrofit/retirement options for reducing emissions and maintain a data base of pilot projects around the country. Materials will provide information on the costs and benefits of these actions.

The program will work with truck owners, vehicle manufacturers, and government agencies on public-private partnerships to fund such projects. Such incentives could come from grants, tax exemptions or rebates, manufacturers' rebates, and other sources.

Diesel Fleet Survey

A survey of diesel fleets operating in the Denver area, and possibly along the Front Range, is needed to determine the current composition of diesel vehicles in the area. The survey will be useful for the recognition program by identifying those fleets with innovative programs to reduce emissions. The survey will also be used to target fleets for particular outreach efforts.

Implementation: The RAQC will work with the CMCA and its members to prepare and distribute the survey and compile the results.

Clearinghouse of Incentive Programs and Emission Requirements

A number of programs exist at the state and federal level which provide incentives for acquiring low emission vehicles or equipment related to retrofitting vehicles to reduce emissions. There are also a myriad of new and existing emission requirements for diesel vehicles. According to the industry, truck owners and operators have difficulty finding current and comprehensive information on incentive programs and regulatory requirements.

Implementation: The ***Fleet Outreach and Awareness Program*** will serve as a central repository locally where companies and potential users may quickly find current and accurate information relating to emission requirements, new technology, and potential incentives at the state and federal level to reduce emissions.

A web site will be developed to serve as a clearinghouse of information on the fleet program including:

- dates, times, and locations of workshops and annual awards ceremony;
- recognition of exemplary fleets;

- access to NEMPPA's *Best Practices Manual*;
- information on vehicle idling reduction strategies;
- access to database highlighting nationwide pilot projects using accelerated retirement, retrofit, ultra-low sulfur fuel, and alternative fuels;
- access to a database containing information relating to emission requirements and potential incentives at the state and federal level to reduce emissions;
- access to all promotional materials created from the fleet program; and
- access to the final report put together at the end of the first year, including survey results.

Cost and Funding Sources

The RAQC staff estimates the first year of the ***Fleet Outreach and Awareness Program*** will cost approximately $125,000. This includes the staff time to develop materials, coordinate events and workshops, visit fleet operators, and document the results. It also includes costs to produce materials, establish the web site, prepare awards, sponsor workshops and recognition events, and promote the program.

The RAQC will take the lead in seeking sources of funding for the program and preparing funding proposals and applications. Potential sources of funding include various EPA grant programs (including the Voluntary Diesel Retrofit Program, which has expressed significant interest in a retrofit project in the Denver area), private sector contributions, other public sector grant programs, and foundations.

Chapter IV. Diesel Inspection and Maintenance

Background

In the mid-1980s concern for the Denver area's "Brown Cloud" led the state legislature to launch diesel emission control activities in the State of Colorado. Legislation passed in 1986 required all diesel vehicle owners in the AIR Program area to pay a $10 per vehicle registration to fund diesel vehicle emissions control activities of the CDPHE and Department of Revenue. The fee, which remains in effect today, is deposited into the AIR account of the highway users tax fund, subject to annual appropriation. The fee is used to fund the state's diesel inspection program as well as other related studies.

In 1986, the Air Pollution Control Division Mobile Source Program studied the use of a loaded mode test on 13 excessively smoking light-duty diesel vehicles to determine the impacts of maintenance on opacity and emissions reduction. The Metropolitan Air Quality council, the lead local air quality planning agency at that time, recommended a diesel inspection and maintenance program in a lengthy report (January 1987) to "help significantly reduce "Brown Cloud"-causing particulate emissions from metro area diesel vehicles". In 1987 the EPA designated the Denver metro area as a "Group 1" PM-10 nonattainment area due to high levels of total suspended particulates in the air. In September 1987 a Governor's Blue Ribbon Panel was convened to address excess diesel smoke emissions from on-road vehicles.

The Diesel Fleet Self Certification Program, a self-test program for fleets of nine or more heavy-duty vehicles, was established in 1987. The Diesel Opacity Inspection Program (DOIP) for all other diesel vehicles including light-duty cars and trucks and heavy-duty vehicles was established in 1990 and included a $5 fee per tested vehicle to provide support of the diesel portion of the APCD's Mobile Source Program. Historically, diesel I/M programs have focused on smoke emissions not only because of their apparent direct link to air pollution but also because of nuisance and public perception issues.

The Colorado Diesel I/M program was included in the initial PM-10 State Implementation Plan (SIP) adopted by the AQCC and approved by EPA. However, the AQCC removed the program from the PM-10 maintenance plan that was submitted to EPA in July 2001. Upon final approval of the maintenance plan by EPA, the Diesel I/M program will no longer be part of the federally-enforceable SIP and changes to the program will not require EPA review and approval.

Current Colorado Programs

Light-duty Diesel Opacity Inspection Program (DOIP)

Vehicles - State statute (42-4-406, C.R.S.) and Colorado Air Quality Control Regulation 12 (Regulation No. 12) requires light-duty diesel vehicles registered or required to be registered or operating from a facility in the nine-county AIR Program area to be inspected annually at a state licensed decentralized light-duty diesel testing station under the DOIP. There are currently 31 state licensed (decentralized) inspection stations in nine-county Front Range AIR Program area. A two model year exemption is currently allowed.

State statute and Colorado Regulation No. 12 defines a light-duty diesel vehicle as a vehicle weighing 7,500 pounds empty weight (curb weight) or less. Such vehicles could have a gross vehicle weight (GVWR) up to 16,000 pounds.

Test Procedure - The inspection includes a full-load lugdown test on a light-duty diesel dynamometer with an opacity meter used to measure visible smoke in the exhaust. The opacity cut point for naturally aspirated vehicles is 40% and turbo charged vehicles is 35%. Approximately 1-2% of the vehicles tested in calendar years (CY) 2000 and 2001 failed their first test. Mandatory repairs are required for failing vehicles.

Costs - In CY 2000 approximately 18,000 vehicles were inspected/tested at an average of $44 per vehicle, which includes a $5/vehicle fee sent to the state. Also, $10 of the vehicle registration fee is sent to the state AIR account. The mean repair costs for a failed LDDV was reported to be $217.

Heavy-duty Diesel Opacity Inspection Program (DOIP)

Vehicles - State statute (42-4-406, C.R.S.) and Regulation No. 12 requires heavy-duty diesel vehicles registered or required to be registered or operating from a facility in the AIR program area to be inspected annually at a state licensed decentralized heavy-duty diesel testing station under the DOIP. There are 31 state licensed (decentralized) inspection stations in the nine-county Front Range AIR Program area. A two model year exemption is allowed.

State statute and Colorado Regulation No. 12 defines a heavy-duty diesel vehicle as vehicle weighing greater than 7,500 pounds empty weight. Such vehicles probably will have a GVWR greater than 16,000 pounds.

Test Procedure - The inspection includes a full-load lugdown test on a heavy-duty diesel dynamometer with an opacity meter used to measure visible smoke in the exhaust. The opacity cut point for naturally aspirated vehicles is 35% and turbo charged vehicles is 20%. Approximately 1-2% of the vehicles tested in CYs 2000 and 2001 failed their test. Mandatory repairs are required for failing vehicles.

Costs - In CY 2000 approximately 13,000 vehicles were inspected/tested at an average of $65 per vehicle, which includes a $5/vehicle fee sent to the state. Also, $10 of the vehicle registration fee is sent to the state AIR account. The mean repair costs for a failed HDDV was reported to be $571.

The RAQC staff estimated indirect cost to an owner at $50 per vehicle to take the vehicle in for inspection and return to home base, assuming a total of 2 hours at $25 per hour for a shagger/driver.

Heavy-duty Diesel Fleet Self-Certification Program (DFSCP)

Vehicles - State statute (42-4-414, C.R.S.) and Regulation No. 12 requires heavy-duty diesel vehicles in fleets of nine heavy-duty vehicles or greater, registered or required to be registered in the AIR program area, to be inspected annually. Fleets are allowed to provide an annual self-inspection prior to registration under the Diesel Fleet Self-Certification Program. A two model year exemption is allowed.

Test Procedure - A full load test is required, but lugdown, stall or acceleration options are allowed, and the test can be done on-road or with a dynamometer. Opacity meter measurement or visual assessment of smoke is allowed during the testing. The opacity cut point for naturally aspirated vehicles is 35% and turbo charged vehicles is 20%. Approximately 0.5% of the vehicles tested in CYs 2000 and 2001 failed their first test. Mandatory repairs are required for failing vehicles.

Costs - Fleets in the self-certification program do not pay a vehicle inspection fee to the state. However, $10 of the vehicle registration fee is sent to the state AIR account. There are approximately 22,000 fleet vehicles in the AIR Program area.

In CY 2000 approximately 14,580 vehicles were self inspected/tested. The RAQC staff estimated indirect cost to an owner at $25-30 per vehicle for an inspection, assuming a total of 45 minutes per inspection at a $35 per hour
rate for an inspector-technician. The mean repair costs for a failed HDDV

was reported to be $927. No estimate has been made of indirect costs for training of inspection officer, test equipment or out of service vehicles.

Additional Program Observations

The continued use of visual observers in the self-certification fleet program is considered questionable.

The continued use of opacity as a surrogate measurement tool to identify high- emitting vehicles is questionable in light of the poor correlation between opacity and PM emissions. At best opacity levels identify some but not all high-emitting engines.

The data reporting and analysis system is considered to be inadequate because the in-use optical mark reader/fill-in-the-bubble paper forms are time consuming, limited, and subject to inaccuracy and error. The computer system where the data is stored and analyzed is obsolete, cannot be updated, and cannot communicate with other interrelated databases (e.g. the self cert fleet audit database etc.).

Migration and registration outside AIR Program area is an issue because a diesel vehicle normally housed and serviced outside the AIR Program area, but normally operated within the AIR Program area is not currently required by statute to be inspected. The interpretation of “required to be registered or operating from a facility in the AIR Program area” by the APCD is that a vehicle normally housed and serviced in the AIR Program area should either be registered in the program area (and therefore inspected annually) or be inspected annually regardless of location of registration.

Data from a 1998-99 DRCOG study at the borders of the metro area indicate approximately 7,000 large diesel vehicles (greater than 7,500 lbs. GVWR) registered in Colorado, displaying no inspection sticker and starting and ending the day at the owner’s lot/terminal enter/leave the metro area on a daily basis. Using the reported 13,000 DOIP inspected vehicles, the 22,000 DFSCP vehicles and the up to 7,000 vehicles noted above, it can be estimated that approximately 17% (7,000/42,000) of the Colorado HDDV vehicles operated in the metro area on a week day basis are not currently annually inspected. This does not include out-of-state vehicles.

Diesel I/M Testing Procedures

Colorado Lugdown

The Colorado I/M programs utilize a full load test, which measures stabilized full power operation, similar to “pulling a grade” with a load. Vehicles are tested at full power load applied on a dynamometer; or using vehicle brakes or transmission. Colorado uses a full power-load applied test on a

dynamometer for the DOIP. The DFSCP utilizes a full power-load applied test but allows an option of using a dynamometer, vehicle brakes or transmission.

The current federal opacity certification level for a lug test is 15%, which was established in 1974. Most vehicles today are tested at certification well below 10% opacity. The lugdown test on a dynamometer is considered a better test for diagnosis of problems in failing vehicles. It is also a time-consuming and costly test compared to a J1667 snap acceleration test. The current Colorado opacity cut points (20% for turbo charged vehicles) do not fail approximately 10%-15% of the heavy-duty fleet that would fail the current J1667 test procedure.

Currently, two other states, Arizona and Utah, with mature diesel I/M programs, utilize a full-load test. At such time that shop grade PM measurement equipment is available (some estimate two years hence), a loaded test on a dynamometer will most probably return to favor. Although California's roadside pullover program currently uses the J1667 snap test, California is actively testing a roadside dynamometer.

SAE J1667

The SAE J1667 procedure is a no load test, where the engine throttle is "snapped" wide open from idle speed to governed revolutions per minute (RPM) in a series of three clean out snaps and a series of three snap tests averaged together. The test measures transient acceleration smoke opacity. The EPA recommended opacity cut points are 55% for MY 1991 and older and 40% for MY 1992 and newer.

The test is inexpensive requiring only an opacity meter. The test is completed very quickly, taking approximately 5 to 10 minutes. EPA is currently recommending the SAE J1667 test procedure to states considering heavy-duty diesel I/M programs, until such time that shop grade PM emissions testing technology is available. At that time, EPA will review its position on the J1667 test and opacity testing in general.

California uses the J1667 test procedure for both their Roadside Program and Fleet (Periodic Smoke Inspection) Program.

Comparison: Colorado Lugdown and SAE J1667

A study in Colorado Springs, CO in 1997 applied the J1667 test with EPA recommended cut points to a group of approximately 120 HDDV that had just completed the Colorado lugdown test at the current program cut points in the DOIP. It was found that the approximately 17% of the vehicles failed the J1667 test while only 1.7% of the same vehicles failed the Colorado lugdown test. Rather than suggesting that one test is better than the other this study suggests that the cut points are not set appropriately for an equivalent test.

A study in New York by EEA in 2000 using 37 HDDV, J1667 testing, and the Radian malperformance model demonstrated that lugdown testing and repair with appropriate opacity cut points (15% for pre-1991 vehicles and 10% for post-1991 vehicles) would result in equivalent PM reduction found in a J1667 testing and repair program with EPA-recommended cut points.

Programs in Other States

California Programs

California operates two vehicle inspection programs that are distinct in that they are codified in different parts of state statute. They were also adopted in different years. However, the Roadside Program is a stand alone program adopted in 1988, while the Periodic Program adopted in 1990 derives its enforcement authority from the legislation that established the Roadside Program.

California Heavy-Duty Vehicle Inspection Program (HDVIP)

Vehicles & Test - All (570,600 estimated) HDDV traveling California's roads - interstate, intrastate, international - are subject to roadside enforcement based on visual observation followed by an immediate SAE J1667 (snap-accel.) test.The opacity cut point for the J1667 test for pre 1991 HDDV is 55%; while for 1991+ HDDV it is 40%.

Penalties - Pre-1991 HDDV with opacity measurements between 55 and 70% are given a Notice of Violation ("fix it ticket") requiring repair within 45 days without penalty; failure to repair vehicle results in a citation ($300) plus added penalty of $500. Citations are issued to all others vehicles (pre-1991 vehicles above 70% and all post-1991 failing the cut points). The penalties are $300 to $1800 and possible vehicle impoundment depending on number of citations issued before compliance.

Fail Rate - In California's testing program 64,648 visual Inspections were performed between June 1998-September 2001. During this time frame 1,154 notice of violation (NOVs) and 3,384 citations were issued. This established a fail rate of 7% of visually inspected vehicles. Program managers indicate that they currently test approximately 20,000 vehicles annually and continue to expect a 7% fail rate, which equates to approximately 1,400 vehicles failed annually.

Cost - Estimates of cost of repairs and fuel saved are approximately equal. The total program costs are estimated at $5.6 million annually based on vehicle owners cost estimated at $1.9 million for increased maintenance

and lost opportunity cost of time and the State cost of $3.7 million annually
to inspect the vehicles. Highway Patrol cost in support of the inspection program is not included. The annual program cost is estimated at $280 per vehicle inspected.

California Periodic Smoke Inspection Program (PSIP)

Vehicles & Test - All fleets of 2 or more California-registered HDDV, approximately 291,600 HDDV, are subject to an annual self-inspection which includes the SAE J1667 (snap-acceleration) test. A 4 model year exemption is allowed, which is estimated at 26% of the fleet vehicles.The opacity cut point for pre-1991 HDDV is 55% and for 1991+ HDDV the cut point is 40%.

Compliance Audit - The California Air Resources Board (CARB) audits fleets for compliance - less than 1% of the fleets require formal action. State cost for auditing the fleets is approximately $0.5 million annually.

Fail Rate - A 7% failure rate of the inspected vehicles is estimated by program managers.

Cost - Estimates of cost of repairs and fuel saved are approximately equal. The cost of self testing is borne solely by the vehicles owners and is estimated at $18.1 million annually based on costs for labor, test equipment, contract testing and increased maintenance costs. The annual program cost is estimated at $84 per vehicle inspected.

Summary of Programs in Other States and Provinces

Currently 17 states and two Canadian provinces have some of type of diesel I/M program. Many have a road side testing element while several have fleet self-certification programs. The following table, excerpted from a report prepared by Environment Canada, summarizes the various programs in North America.

States & Provinces	SAE J1667 Test Procedure			Lug-Down Test	
	Road Side	Fleet Self Cert.	Traditional I/M	Fleet Self Cert.	Traditional I/M
Arizona					X
British Columbia	X				
California	X	X			
Colorado				X	X
Connecticut	X				
Illinois	X	X			
Indiana (vol.)	X				
Maine	X				
Maryland	X				
Massachusetts	X	X			
Nevada	X				
New York City		X	X		
New York (outside NYC)	X				
New Hampshire	X				
New Jersey	X				
Ontario	X	X			
Rhode Island		X	X		
Utah (Davis Co.)					X
Utah (Utah Co.)			X		
Vermont	X				
Washington		X	X		

Recommendations

Since Colorado's diesel inspection/maintenance (I/M) program was first established nearly 15 years ago, diesel vehicle technology has changed dramatically and emissions from light-duty diesel vehicles and heavy-duty trucks and buses have been reduced significantly. These technological changes are not reflected in the current program.

Taking into account the advances that have occurred in the last 15 years, the Diesel Stakeholder Work Group clearly recognized the current program is not as efficient or as effective as it could be. There are no quantitative data available to judge how effective the current program is reducing diesel emissions. However, many program observers believe the program provides undeniable benefits as an incentive for good maintenance and as a deterrent to vehicle tampering.

Through in-depth discussions over a period covering six meetings, the Work Group considered changes to make the program both more efficient and more effective. The recommendations outlined below are intended to reduce the burden of the program on vehicle owners, particularly those who have invested in new engine and vehicle technology. Other recommendations will help ensure the program identifies high-emitting vehicles that require repair and maintenance to reduce diesel emissions.

It is important to remember that a diesel inspection/maintenance program is a particulate matter (PM) reduction strategy. The program identifies vehicles with high levels of smoke that indicate excessive particulate emissions. An I/M program cannot be viewed as a NOx reduction strategy since poorly performing diesel vehicles generally lower NOx emissions and repairs and maintenance to make the engine operate properly increase NOx emissions. Studies have shown, however, that NOx emissions after repairs are still within certified limits for the vehicles. Necessary NOx emission reductions therefore need to be addressed through other types of diesel strategies, such as engine replacement and retrofits, idling strategies, and fuel strategies.

Maintain the basic structure of the current program

The Work Group concluded current structure of Colorado's diesel inspection/maintenance program is well-established and accepted by diesel vehicle owners. However, there are changes that can be made within the current structure that will make the current program more efficient and effective.

The discussion below presents the recommendations from the Work Group, explains the rationale, and indicates the implementation steps that are need to accomplish the recommendation. Following the discussion are tables that summarize the net effect of the recommendations and summarize what will need to be addressed through statutory changes and what can be handled with current regulatory and administrative authority.

Recommendation #1

Review the Diesel Inspection/Maintenance program within the next two years to determine if further improvements are necessary and feasible. Develop a research protocol and necessary funding to conduct periodic evaluations of program effectiveness. Identify further specific information and data needs and questions that need to be answered.

A strong feeling by the Work Group was expressed concerning the lack of a diesel I/M program review in the past 15 years since the start of the program. It is obvious that the current program has not kept pace with changing standards and diesel technology since shortly after program inception. A review in the next two years seemed appropriate to review what has been accomplished and what is needed in the future in light of more stringent standards taking effect in 2004 and 2007.

Once the direction of the diesel emissions program is reestablished, a means to track progress toward that goal should be included in the program redesign. This applies regardless of what type of program -

periodic inspection, roadside enforcement etc; or the goal of the program - PM, opacity, citizen complaints, etc. A pre-changeover baseline measure should be taken, with periodic evaluation by the same measure to ensure progress is being made. Measurement tools need to be in place before the changeover. This would provide a tool for assessing program effectiveness.

The discussion of program needs has been open ended. Often the data are available, but are not easily accessible or need to be looked at in a different way. Specific information and data need to be obtained that can provide answers to questions and issues that have not been addressed.

Implementation – Currently there is no requirement or process for a systematic, regular review of the Diesel I/M program. Existing statute requires the AQCC to review the Diesel I/M program fail rates annually, but this has not been an in-depth review that would provide a critical analysis of the performance and effectiveness of the program.

Within the next two years, the RAQC and AQCC should undertake another stakeholder process to perform as additional review of the program, assess implementation of current recommendations, and determine future program needs. In the meantime, technical staff with the CDPHE Mobile Sources Program, with assistance from the RAQC, should initiate studies or data analyses to answer some questions remaining after the current stakeholder process.

Funding from the General Assembly will be needed to conduct a more rigorous periodic evaluation of program effectiveness. CDPHE should determine the cost of such an effort and seek an appropriation from the legislature during the next legislative session.

Recommendation #2

Automate data reporting and analysis and develop an internet-based system for information exchange.

The in-use optical mark reader/fill-in-the-bubble paper forms are time consuming, limited, and subject to inaccuracy and error. The computer system where the data is stored and analyzed is limited in its capabilities, obsolete, cannot be updated, and cannot communicate with other interrelated databases (e.g. the self-cert fleet audit database etc.).

Data collection, storage, analysis, and reporting need to be redesigned from front to back as an integrated system, fully accessible to program staff.

On-line data collection may be an attractive option - Inspector enters inspection data directly into a keyboard, eliminating handling of paper forms.

No current cost estimate has been developed for an up-to-date system.

Implementation – The APCD Mobile Source Program will have to analyze program data and management needs, reporting needs for fleet and non-fleet vehicle inspectors and develop cost estimates for an up-to-date and expandable data management and analysis system that will be useful into the future. The CDPHE will have to seek legislative appropriation of funds from the AIR account to implement such a system.

Recommendation #3

Add an on-road enforcement element to the program, either through remote sensing, smoking vehicle hotlines, or limited roadside pullovers (based on probable cause).

In California and other states, on-road enforcement has proven to be an effective supplement to the state's fleet inspection program. The threat of on-road enforcement has encouraged proper maintenance on diesel vehicles and improved compliance with the periodic inspection program. On-road enforcement will also identify vehicles with excessive smoke and emissions that have either fallen into disrepair or somehow escaped periodic inspections.

California's on-road enforcement program involves roadside pullovers of heavy-duty diesel vehicles with excessive smoke. State police and trained inspectors identify vehicles on the road and conduct an on-the-spot roadside SAE J1667 test. Vehicles that fail the test are issued a citation and required to bring the vehicle into compliance with necessary repairs. California's program costs $5.6 million per year and identifies 1,400 vehicles per year.

An on-road pull over program in Colorado would most likely use the SAE J1667 test procedure. A confirmatory test would be required at a state licensed inspection station, which uses the Colorado lug down test procedure. To provide a consistent evaluation of the vehicle, the current difference in fail rates due current cut points of the two tests, discussed previously in this report, will have to be addressed.

Other methods for on-road vehicle identification exist, including smoking vehicle hotlines, identification by trained personnel, and remote sensing. Smoking vehicle hotlines use citizen complaints to identify problem vehicles, but owner compliance tends to be voluntary. The City and County of Denver operates an effective smoking vehicle program whereby trained city staff identify smoking vehicles on the road. Vehicle owners are issued a citation where they are required to fix vehicle or face legal action.

Remote sensing technology (RSD) is under development to identify both heavy-duty and light-duty diesel vehicles. An improved version of RSD that can take accurate opacity readings for light-duty vehicles is close to commercial application. However, remote sensing for heavy-duty vehicles is more challenging since their exhaust points vary and are more difficult to measure.

It is envisioned by the Work Group that any on-road enforcement program will start out on a small scale and be phased in gradually over time. This will provide the opportunity to implement the program efficiently by working through the pitfalls of such a new approach.

Implementation – Statutory authority (42-4-413, C.R.S.) for on-road identification and enforcement currently exists, but it proved insufficient to withstand initial challenges in court by owners of vehicles involved in an enforcement action in the late 1980's. Since that time law enforcement officers have not given on road enforcement a high priority. Therefore new legislation likely will be necessary to strengthen statutory authority to identify vehicles on the road and provide an effective mechanism for enforcement.

Recommendation #4

Define heavy-duty diesel vehicles as those greater than 14,000 pounds gross vehicle weight (GVWR) and eliminate the reference to empty weight or curb weight in Regulation No. 12.

The current definition of light-duty vs. heavy-duty vehicles is based on the 7,500 pounds empty weight (curb weight) limit, which means the weight of the vehicle at the curb filled with all of its required fluids. Such light-weight vehicles can then be outfitted to do specific work and may in fact have a GVWR up to 16,000 pounds. This recommendation seeks to separate the transportation vehicles (driven to a job site or office and left to the end of the day, or pulling a boat on the weekend) from the working vehicles (outfitted as a tow truck, for instance).

Implementation – Since the current definition of light and heavy-duty vehicles is currently in state statute a statutory change will be required. Since the current Air Quality Regulation also defines and describes the testing of light and heavy-duty vehicles, a regulatory change will also be required.

Recommendation #5

Increase model year exemptions to four years for heavy-duty diesel vehicles and decrease test frequency to biennial testing for HDDV 10 model years and newer (beginning with MY 1995) under both programs.

The technology for light-duty diesel vehicles has also improved and new Tier 2 standards affecting light-duty vehicles will take effect within two years. However, the Work Group does not recommend increasing the model year exemptions for these vehicles beyond the current two-year exemption.

Anecdotal information provided from actual observations by emission-testing representatives indicates light-duty diesel vehicles used for personal use may not be as well-maintained continuously like commercial vehicles. Unlike gasoline vehicles, diesel vehicles may experience emission problems while performing acceptably to the owner. In addition, after-market add-on equipment is more prevalent with light-duty vehicles and may change the emission performance of these vehicles. Without annual inspections, these vehicles may be emitting high levels of pollution without the owner realizing the condition. Maintaining a two-year model year exemption and an annual inspection cycle for light-duty vehicles will ensure these vehicles continue to operate at their designed low emission levels.

The net effect of the increased model year exemptions and biennial testing for newer vehicles is that heavy-duty diesel vehicles will be tested three times during their first 10 years, compared to eight times under the current program. This will save vehicle owners at least $300 per vehicle in testing costs over this time period.

Current statute also requires heavy- and light-duty diesel vehicles to pass an emissions test before they can be registered upon change of ownership. The same requirement applies for the gasoline vehicle emissions testing program. The Work Group does not recommend changing this requirement in current statute. Requiring an emissions test upon change of ownership is a consumer protection issue and protects vehicle purchasers from hidden emission problems. The General Assembly has considered this on several occasions for the gasoline program and has resisted attempts to alter the requirement.

Implementation – Since current statute specifies a two-year exemption and an annual testing requirement after the initial exemption, legislation will be necessary to increase the model years exemptions and decreasing the testing frequency for newer heavy-duty vehicles. Legislation can be introduced as early as the 2003 session of the General Assembly.

Recommendation #6

Modify state statute to require testing of all diesel vehicles routinely operated in the program area, not just those registered, required to be registered or housed in the program area as currently required.

Current statute (42-4-406, C.R.S.) requires emissions testing for all diesel vehicles that are registered, required to be registered or are principally operated from a terminal, maintenance facility, branch or division located within the program area. Still, it is believed that many vehicles that routinely and continuously operate in the program area avoid the testing requirement either by ignoring (intentionally or unintentionally) the law or by registering and/or housing the vehicles outside the program area.

The Work Group recommends closing the loophole by requiring all vehicles that routinely operate in the program area be subject to emission testing requirements, as similarly required of vehicles in the gas program, regardless of where they are registered or housed. There will also be a need for greater education on and enforcement of this and the current requirement so that vehicle owners comply with the law. Currently there is no requirement for a windshield inspection sticker, but proof of emissions inspection is required to be carried in the vehicle. An on-road enforcement program will also help identify problem vehicles that are avoiding the requirement.

Implementation – Legislation will be necessary to modify current statute (42-4-406 & 414, C.R.S.) to require testing for vehicles that routinely and continuously operate in the program area, regardless of where they are registered or housed. The APCD will also need to increase its education and compliance efforts so vehicle owners do not avoid the requirement.

Recommendation #7

Maintain current testing protocols with the following changes:

- **allow SAE J1667 (or other future automated testing protocol) as an option for all HDDV 10 model years and newer in the fleet program;**
- **require lugdown test for all HDDV older than 10 model years in both programs; and**
- **eliminate visual testing, during a two-year phase in period, as an option for all HDDV in the fleet program older than 10 model years.**

The lugdown emissions test is currently required for both the fleet and DOIP programs. The test is generally performed on a dynamometer and is considered an effective test for measuring opacity from diesel vehicles.

SAE J1667 is a relatively new test that is being used in many states, including California. The test is an automated acceleration test that is generally easier and less costly to perform. However, it measures a different operating condition than the current lugdown test.

The Work Group recommends allowing fleet operators the option to use the J1667 test, or some other approved automated testing procedure, on heavy-duty vehicles that are 10 years old and newer. The fleet operator would have to choose J1667 or lugdown for *all* its newer vehicles and would not be able to pick and choose. Again, since these newer vehicles are inherently cleaner, J1667 should be able to identify emission-related problems in these vehicles, especially during acceleration. The lugdown test, which "exercises" the engine more, is still recommended and considered best for older vehicles. The lugdown test would also still be required for all vehicles in the DOIP.

The Work Group also recommends eliminating visual observation as an option for the lugdown test for fleet vehicles older than 10 years. Current regulation allows fleet operators to measure opacity either though visual observations or with an opacity meter. The use of an opacity meter is required in the DOIP and most fleet operators as well already use an opacity meter, which is more accurate and reliable than visual observation. The mandatory use of opacity meters would be phased in over a two-year period.

Visual observations would still be allowed in the fleet program for newer vehicles, which should be smokeless and for which visual observation should be satisfactory.

Implementation – Current statutory language concerning testing methods is fairly specific and does not allow J1667. Legislation will be necessary to allow J1667 and other automated testing protocols. The testing provisions should be less specific so the Air Quality Control Commission (AQCC) has authority to modify testing protocols and requirements as new protocols are developed and become more appropriate.

Eliminating visual observations for tests of older vehicles does not appear to be constrained by current statute, so the AQCC can make necessary revisions to Regulation No. 12 to address this issue. However, the AQCC may want direct legislative authority to change this requirement.

Recommendation #8

Since opacity is not a good measure of emissions for newer technology vehicles, Colorado should work in a joint effort with EPA and other states to conduct research and pilot studies to develop appropriate emissions-based testing methods for future consideration.

Opacity testing is currently the measurement of choice for all diesel I/M programs. Measurement is based on a light extinction opacity meter or visual observation by a trained smoke inspector. Although high opacity readings will indicate high PM emissions; low opacity does not necessarily indicate low PM.

The current diesel engines are clean, virtually smokeless at certification and durable through their expected life. This has been accomplished through changes in engine design. However, lugdown testing still finds some newer engines that have excessive smoke above the 20% opacity standard. Engines designed for 2006 and beyond will include environmental control equipment such as catalyzed traps, selective catalatic reaction (SCR) systems, oxidation catalysts, and NOx absorbers that potentially will fail without increasing smoke. Emissions based testing will be needed at that time to identify vehicles not operating at near certification levels.

CO and/or CO + HC emissions measurement under peak operating conditions may be a better surrogate for PM emissions than opacity. Shop grade measurement equipment is currently available. Direct PM emissions measurement technology is still under development; possibly available within a year or two.

No estimate of required funding has been made.

Implementation – Because the current statutes reflect an opacity-based program for the Diesel I/M programs, a statutory change may be required or desired to fully investigate this issue. In the interim the RAQC/APCD should participate in national diesel conferences, EPA work groups and committees, and activities in California diesel I/M development to monitor the direction of criteria pollutant diesel emissions based I/M programs. Identified required research will require funding.

Recommendation #9

Improve audit program by focusing on HDDV fleets with higher than normal out-of-service ratings or fail rates.

The APCD staff currently visit every DFSCP terminal or yard at least once per year to audit the testing programs. However, failure rates overall of the DFCSP vehicles are in the range of 0.5 %, while the DOIP vehicles have a 2% fail rate.

It has been suggested that more effort should be focused on those fleets (large and small) that have a poor safety record. There is a strong feeling that vehicles that are not meeting safety standards are more than likely those that are also not meeting current opacity standards. Additionally, an emphasis should be made to address the fleets that have high fail rates regardless of size.

It has been suggested that the Federal Motor Carriers Safety Administration Motor Carrier Safety Profiles Out Of Service (OOS) rating, which is internet accessible, be used to help focus audit efforts.

The current staffing level can now barely meet the current regulatory requirement for the DFSCP audit.

Implementation – This recommendation may be handled administratively by the Mobile Sources Program by directing and focusing resources on problem fleets. If additional resources are necessary, an additional appropriation from the General Assembly will be necessary.

Recommendation #10

Expand repair technician training and technical assistance similar to the efforts for the gasoline vehicle program.

The APCD Mobile Source Program currently does not have a Diesel repair training program, although a "tech night" for the diesel repair industry has been held recently wherein diesel repair issues were addressed by APCD staff and repair experts. Original Equipment Manufacturers (OEMs) also provide diesel technician training programs, but these are generally only available to those working for larger fleets.

A diesel repair training program should be similar to the existing APCD Mobile Sources (MS) gasoline I/M repair industry outreach/training system and should include:

- Emissions Technical Centers acting as a clearinghouse for specific diesel repair/diagnostic information;
- repair information to be made available to involved parties via print, phone, 'Tech Night', training classes, web site etc. This repair information is not intended for the general public - liability; and
- basic electronic/electrical training.

Requires resource commitment by CDPHE as well as a commitment by fleets, repair shops, manufacturers, and inspection stations to share repair/diagnostic information. The effectiveness of this project depends on the level of industry participation.

Implementation – This recommendation may be handled administratively by the Mobile Sources Program by directing and focusing resources on training and technical assistance. If additional resources are necessary, an additional appropriation from the General Assembly will be necessary.

Recommendation #11

Investigate using remote sensing technology to clean screen light-duty diesel vehicles or identify high-emitting vehicles.

Advances in remote sensing technology may soon allow more accurate opacity measurements for light-duty vehicles. Therefore, the technology may exist to screen out clean (low-opacity), light-duty diesel vehicles and exempt them from routine emission tests. This could operate similar to the approach envisioned for the gasoline inspection program. High emitting vehicles could also be identified by the same technology.

Implementation of such an approach would exempt clean vehicles that do not need be tested and would focus efforts on vehicles that are more likely to have emission problems. It would significantly decrease the burden of testing on diesel vehicle owners.

Implementation – Given the current state of remote sensing technology, APCD and RAQC should investigate the feasibility of implementing a clean screen and/or high emitter program for diesel vehicles and integrating it with the gasoline vehicle remote sensing clean screen program. If a clean screen or high emitter program is determined to be feasible, legislation will be necessary to authorize implementation of such a program and provide for the mechanism administer the program consistent with the gasoline program.

Recommendation #12

Eliminate or increase the current repair cost waiver for failed diesel vehicles.

The highest number of waivers requested per year in the past two years has been four. Keeping the waiver limit is unnecessary. If the waiver limit is retained it should be raised to an appropriate level and adjusted to an index annually.

There is a strong feeling that failing vehicles need to be repaired. Repair data indicates that partial repairs do not fix the problem.

Implementation – A statutory change is required to eliminate the concept of a waiver rate. A regulatory change is required to increase the waiver rate.

Summary of Diesel I/M Recommendations

The following list summarizes the Work Group's recommendations by indicating those that will make the current program more efficient, those that will make the current program more effective, and those that keep current program elements the same.

Recommendations making the program more efficient

- Define HDDV as those >14,000 pounds GVWR
- Increase model year (MY) exemption for HDDV to 4 years (both programs)
- Decrease test frequency to biennially for HDDV 10-MY and newer (both programs)
- Allow choice of J1667 or lugdown test for HDDV 10-MY and newer in fleet program
- Automate data reporting and analysis
- Investigate using RSD technology to clean-screen LDDV
- Expand repair technician training
- Conduct periodic evaluations of program effectiveness

Recommendations maintaining current elements

- Maintain basic structure of Diesel Opacity Inspection Program (DOIP) and Diesel Fleet Self-Certification Program (DFSCP)
- Maintain 2 model year (MY) exemption for LDDV
- Maintain annual testing for all LDDV
- Maintain annual testing for HDDV older than 10 MY (both programs)
- Maintain change of ownership testing requirement for all LDDV and HDDV
- Maintain visual observation testing option for HDDV 10 MY and newer in the fleet program
- Maintain lugdown tests for HDDV older than 10 MY in the fleet program and for all HDDV in DOIP

Recommendations making the program more effective

- Require all vehicles operating (not just registered or housed) in the program area to participate in the program
- Add an on-road enforcement element to the program
- Eliminate visual testing, over two-year period, for fleet HDDV older than 10 MY in the fleet program
- Investigate emissions-based testing methods for future consideration
- Improve audits of fleet programs
- Expand repair technician training
- Eliminate or increase the current repair ost waiver for failed vehicles
- Conduct periodic evaluations of program effectiveness

Comparison of Recommendations Affecting Newer and Older Vehicles
(10 Model Year Break Point)

	Newer Vehicles (10 MY and newer)	***Older Vehicles*** (> 10 MY)
DFSCP HDDV **14,001 & greater GVWR**	• Allow visual test • **Allow** either **J1667** or the current lug-down test • **Biennial testing for 10 MY and newer (beginning w/1995 MY**) • **4 MY exemption**	• **No visual test allowed after a two-year phase in period; opacity meter required** • Require the current lug-down test • Annual testing
DOIP HDDV **14,001 & greater GVWR**	• No visual test allowed; opacity meter required • Require the current lug-down test • **Biennial testing for 10 MY and newer (beginning w/1995 MY**) • **4 MY exemption**	• No visual test allowed; opacity meter required • Require the current lug-down test • Annual testing
DOIP LDDV **14,000 & less GVWR**	• Require current lug-down test • Annual test • 2 MY exemption	• Require current lug-down test • Annual test

Note: Changes to current program are in **bold**.

Opacity Cutpoints

The Work Group spent considerable time discussing the opacity cutpoints for the current program and whether lowering cutpoints was feasible or advisable at this time. The Work Group could not come to consensus on this issues and therefore could not make any specific recommendations. However, the members agreed cutpoints are an issue and presented the arguments on both sides.

Arguments for considering lower cutpoints

- The current opacity cutpoints for the various types and classes of diesel vehicles has remained unchanged since the program began in the late 1980's.
- Diesel engine technology has improved dramatically since that time, so current cutpoints for newer vehicles are no longer valid.
- The current low failure rate in the program, particularly for new vehicles, indicates that current cutpoints are not appropriate.
- A 20% opacity standard for newer turbo-charged LDDV would be justified since none of these vehicles fail the current 35% standard (which correlates to black smoke) and only 7% would fail a 20% standard.

- Very few turbo-charged HDDV fail the current 20% standard and all are certified at levels well below that level. Only 3-5% for 1992 and newer HDDV would fail a 15% opacity limit.
- Lower cutpoints for naturally-aspirated vehicles are probably not justified because of the technology and the declining number of vehicles in the fleet. Between 30-40% of the current naturally-aspirated light- and heavy-duty fleet would fail a 20% standard.

Arguments against considering lower cutpoints

- Data are not available to quantify the PM emissions reduction that would result from lower cutpoints.
- Merely lowering cutpoints does not necessarily make the program more effective.
- Because diesel emission data are skewed, lowering cutpoints may not result in a correlating reduction in emissions and there will be diminishing returns with lower cutpoints as a result.
- Since the Denver region is currently meeting all federal air quality standards and since diesel trends are expected to continue downward with the introduction of new vehicle standards, more stringent program requirements such as lower cutpoints cannot be justified at this time.
- There are more effective ways, such as on-road enforcement, to identify high-emitting vehicles rather than lowering cutpoints.

Light-duty Diesel Vehicles Fail Rates

Light-duty engine technology is separated into naturally aspirated (40% opacity cut point), which is considered an older technology, and the newer turbo-charged (35% opacity cut point) technology which started in 1990. The 1992 MY is somewhat arbitrarily established as the year when turbo-charged engine design was well understood and dominant. The results of approximately 19,500 light-duty opacity inspection tests in 2001 are presented in the following table:

2001 LDDV Failure Rate

			Failures		
Technology & Age	**Total Valid Tests**	**Percent of Fleet**	**# Failed**	**% of Fleet**	**% of Failed**
NA < 92	2,600	13.4%	156	0.8%	68.9%
NA > 92	338	1.7%	30	0.2%	13.4%
TC < 92	2,000	10.3%	40	0.2%	17.7%
TC > 92	14,500	74.6%	Negligible	0.0%	0.0%
Totals	**19,438**	**100.0%**	**226**	**1.2%**	**100.0%**

Naturally Aspirated Vehicles

Naturally aspirated vehicles have an exhaust plume that is basically black at the 40% opacity (passing) standard. Naturally aspirated vehicles are 15% of the fleet and represent 82% of the failed vehicles. Few naturally aspirated vehicles are being produced and fewer yet are being operated along the Front Range. Review of failures at lower cut points for all naturally aspirated vehicles suggests not much improvement in the technology in newer vehicles.

Turbo-charged Vehicles

Turbo-charged vehicles have an exhaust plume that is basically black at the 35% opacity (passing) standard. Turbo-charged vehicles are 85% of the fleet and represent 18% of the failed vehicles, mostly from the pre-1992 vehicles.

Heavy-duty Diesel Vehicles Fail Rates

Heavy-duty engine technology is separated into naturally aspirated (35% opacity cut point), which is considered an older technology, and the newer turbo-charged (20% opacity cut point) technology, which started in 1990. The 1992 MY is somewhat arbitrarily established as the year when turbo-charged engine design was well understood and dominant. The results of approximately 26,000 light-duty opacity inspection tests in 2001 are presented in the following table:

2001 HDDV Failure Rates

			Failures		
Technology & Age	**Total Valid Tests**	**Percent of Fleet**	**# Failed**	**% of Fleet**	**% of Failed**
NA < 92	900	3.5%	87	0.3%	27.8%
NA > 92	225	0.9%	34	0.1%	10.9%
TC < 92	7,300	28.4%	110	0.4%	35.1%
TC > 92	17,300	67.2%	82	0.3%	26.2%
Totals	**25,725**	**100.0%**	**313**	**1.2%**	**100.0%**

Naturally Aspirated Vehicles

Naturally Aspirated Vehicles have an exhaust plume that is basically black at the 35% opacity (passing) standard. Naturally aspirated vehicles are 5% of the Fleet and represent 40% of the failed vehicles. Few naturally aspirated vehicles are being produced and fewer yet are being operated along the Front Range.

Review of failure rates at lower cut points for all naturally aspirated vehicles suggests the technology in newer naturally aspirated vehicles has not improved with time. The data indicate a significantly higher fail rates for older and newer vehicles in the DOIP compared to the DFSCP, suggesting a need for better maintenance/repair for the DOIP vehicles

and/or improved testing methods and procedures in the DFSCP.

Turbo-charged Vehicles

Turbo-charged vehicles have an exhaust plume that is wispy black at the 20% opacity (passing) standard. Turbo-charged vehicles are 95% of the fleet and represent 60% of the failed vehicles. Based on review of the failures at lower cut points, newer vehicles fail at approximately one-quarter (DFSCP) to one-third (DOIP) of the rate that older vehicles fail, suggesting improvement in turbo-charged technology. As was the case with naturally-aspirated HDDV, the data indicate a higher fail rate for older and newer vehicles in the DOIP compared to the DFSCP.

Impact of Adjusting Smoke Opacity Limits

The fail rates of diesel vehicles during CY 2001 at different opacity cut points has been analyzed by the APCD staff for the DOIP and DFSCP by vehicle technology and age. The results are presented in the following table.

Impact of Adjusting Smoke Opacity Limits
- 2001 Diesel Opacity Inspection Program Fleet -

DOIP Class	I-Tests	40%	35%	30%	25%	20%	15%	10%
DOIP LD/NA								
<92	2,600	6%	11%	19%	28%	38%	53%	71%
≥ 92	338	9%	14%	18%	23%	28%	43%	66%
DOIP LD/TC								
<92	2,000		2%	7%	13%	23%	36%	59%
≥ 92	14,500		0%	2%	4%	7%	14%	30%
DOIP HD/NA								
<92	600		14%	21%	27%	37%	50%	70%
≥ 92	125		26%	31%	35%	42%	56%	67%
DOIP HD/TC								
<92	3,700					2%	10%	29%
≥ 92	8,200					1%	3%	8%

Impact of Adjusting Smoke Opacity Limits
- 2001 Diesel Self Certification Fleet -

Self-Cert Class	I-Tests	40%	35%	30%	25%	20%	15%	10%
HD/NA								
< 92	300		1%	3%	12%	16%	53%	70%
≥ 92	100		1%	3%	6%	6%	26%	41%
HD/TC								
< 92	3,600					1%	21%	42%
≥ 92	9,100					0%	5%	11%

NOTES and EXPLANATION:

-This information was requested for comparison and analysis purposes.
-These data are applicable to the Colorado full-load lugdown test cycle.
-Opacity limits are the horizontal axis, with vehicle classes on the vertical axis
-I-Tests = the number of initial emissions tests deemed valid for the class (representative of the size of the affected fleet)
-LD = Light-duty Vehicle = < 7,500 # empty weight; HD = Heavy-duty Vehicle = > 7,500 # empty weight
-NA = Naturally Aspirated (i.e. non-turbocharged); TC = Turbocharged
-<92 = Model years 1991 and earlier; ≥92 = Model years 1992 and newer
-Shaded boxes denote existing opacity limits e.g. HD /TC opacity limit is 20%
-Statute currently prohibits opacity limits less than 20%; any change to less than 20% requires legislation.

Chapter V. Off-Road Diesel Vehicles

Overview

As noted in Chapter II, changes in off-road (Tier 1) emissions standards passed in 1994 were phased in between 1996 and 2000. The standards adopted in 1998 (Tier 2) are being phased in between 2001 and 2005. The manufacturer's improvements in technology to meet and exceed Tier 1 standards and the continued growth in equipment population and activity has served to slightly reduce PM-10 emissions growth and flatten NOx emissions growth through 1999.

Current EPA standards

In 2001 EPA assessed the standards adopted in 1998 for non-road diesel engines, in particular to determine if the Tier 3 portion (and the Tier 2 emissions standards for engines under 50 hp) were, indeed feasible. Based on information to date, EPA has affirmed the feasibility of these standards. This has been reinforced by the certification data from the Tier 1 engines in the power ranges of interest that demonstrate many of the engines are already meeting Tier 2 standards.

The 1998 rule did not establish a new Tier 3 program for PM emissions reductions because of critical unresolved issues connected with the appropriate test procedure for characterizing transient operating conditions. Instead the EPA made a commitment in the rule to establish an effective program for controlling PM emissions beyond the limited control achieved under Tier 2 standards, and to consider adopting measures to better ensure in-use emissions control in-use.

The recent regulations that dramatically reduce on-road diesel emissions leaves the non-road diesel engines, already a significant source of PM and NOx, as a dominant source of these emissions in the future. The emissions trend curves for PM and NOx for on-road and off-road engines for the Denver metro area presented in Chapter II of this report affirms this observation.

Future EPA Rulemaking

The EPA is preparing proposed rulemaking in 2002 for further reduction of PM (and NOx if warranted) through a "systems" approach that regulates off-road diesel engines and fuel, similar to the recent on-road regulations. This approach continues the pattern of modeling off-road emissions reduction programs after on-road programs, with some additional lead time provided for adaptation of on-road technologies to off-road applications.

Some analysis of the fuel required to complement the "system" envisioned above indicates a 15 -30 ppm sulfur content, which is definitely in the range of the ultra-low sulfur fuel required for the on-road fleet in 2006. However, in 2007 a new HDDV will be 15 times cleaner than a off-road engine under the current Tier 3 off-road standards. The lead time allowed for adaptation of on-road technologies will be important in determining the timing of the impact of the yet to be proposed new regulations. The impact at this time could be estimated to be seen in 10-15 years depending on the rulemaking process and equipment turnover.

Opportunities exist to reduce emissions

The turnover of diesel engines can take many years because of the durability and long life of diesel engines. However, there are still opportunities to reduce emissions from the in-use engines through proper maintenance, reductions in engine idling, accelerated retirement, add-on equipment retrofits, which are facilitated by the availability of ultra low sulfur fuel, and use of cleaner diesel fuels.

Recommendations

The Work Group is cognizant of the changes in on-road and off-road standards, the future trends and the related impacts. There does not appear to be any local regulatory action that would be considered appropriate at this time for the off-road sector. However, there does appear to be opportunities for voluntary activities to encourage the retrofit of equipment as broadly defined in the EPA's Voluntary Diesel Retrofit Program.

Some questions or observations of the work group are related to emissions inventory development issues, the amount of low sulfur (500 ppm) currently used in the metro area, incentives for retrofit programs and the need for some recognition for those entities that are doing their part to improve air quality.

To take advantage of these opportunities to reduce diesel emissions in innovative ways, the Diesel Stakeholder Work Group recommends the following:

Recommendation #1

Include off-road fleets and engines in the *Fleet Outreach and Awareness Program* to encourage voluntary initiatives by fleet and engine operators to reduce diesel emissions from the current in-use equipment.

As noted above there are currently off-road fleet and engine operators that are planning or implementing voluntary programs that reduce emissions from existing diesel equipment. Public recognition of those programs can provide an incentive for others to consider similar programs.

Implementation -The fleet special recognition program is outlined in Chapter III. All elements offer an opportunity for inclusion of off-road equipment in one way or another.

Recommendation #2

Improve the understanding of the current use of low sulfur fuel and the population of off road diesel equipment in the Denver metro area.

There is an opinion by Work Group members that there is a significant percentage of low sulfur fuel used in the metro area although there is also a significant amount high sulfur fuel sold. Also, there is a concern about the emissions inventory when equipment population and activity levels are compared with fuel sales.

Implementation - A survey of fuel use/sales and equipment population/activity in the metro area is necessary to resolve the questions. The Colorado Contractors Association (CCA) has indicated that it could assist in collecting this kind of data. The APCD/RAQC will investigate additional sources of information and develop inventories.

Recommendation #3

Based on the need, investigate incentives to encourage the use of low sulfur fuel (500 ppm) and other low emitting fuels and investigate the possibilities of early introduction of ultra-low sulfur fuels (15 ppm).

Depending on the results of the survey discussed above investigate the incentives (economic, recognition, or regulatory) for encouraging the use of low sulfur (500 ppm) and other low emitting diesel fuels, such as biodiesel. Ultra-low sulfur (15 ppm) diesel fuels is necessary to fully realize the benefits of after market emissions control equipment. The availability and lead time for introduction of ultra-low sulfur fuel is an important consideration.

Implementation - The RAQC will lead a cooperative effort including the Colorado Contractors Association, Environmental Defense, local refiners, EPA Voluntary Retrofit Program staff and other interested parties to address these issues.

Recommendation #4

Encourage best management practices regarding engine maintenance, idling, and use, similar to the best maintenance practices program developed for on-road fleets.

Equipment manufacturer's representatives are very aware of the importance of best management practices and often offer training for their clients. Many operating entities currently follow a variety of enlightened management practices.

Implementation - Using the model program described for on-road vehicles in Chapter III, develop an off-road diesel engine best management practices program. The development of a clearinghouse for information and outreach to smaller operators is an additional avenue.

Recommendation #5

Encourage low-emitting fuels, retrofits, and other low-emitting technology in large-scale construction projects.

Large construction projects offer the opportunity to include in contract specifications the requirement or requirement with incentives of lower sulfur fuels, other low emitting fuels, retrofits, early retirement or replacement of existing equipment, or the use of equipment meeting the latest standards.

Implementation - An outreach program to state and local agencies and large corporate entities in the region concerning the possibilities of improvements to heath and air quality in the region through encouraging these activities.

Appendix A

National and Local Voluntary Diesel Retrofit Pilot Programs

Source: www.epa.gov/otaq/retrofit.

State	City/State	Entity	Retrofit Technology	Number of Retrofits Committed
AL	Birmingham	Birmingham School District	Catalyst	35
CA	State of California	Agricultural Pumps	Engine Re-power	430
CA	State of California	Bay Area, South Coast, Santa Barbara, San Diego	Early engine retirement	6901
CA	State of California	BP Fuel Transport Trucks	Particulate Filter, Low Sulfur Fuel	29
CA	State of California	CARB School Bus Retrofit Program	Particulate Filter, Low Sulfur Fuel	1900
CA	State of California	CALTRANS - California Department of Transportation	Low Sulfur Fuel	14000
CA	State of California	Ralph's Grocery Company	Particulate Filter, Low Sulfur Fuel	20
CA	State of California	Urban Transit Agencies	Particulate Filter, Low Sulfur Fuel	4500
CA	Los Angeles	City of Los Angeles	Particulate Filter, Low Sulfur Fuel	2300
CA	Los Angeles	Hertz Equipment Fleet	Particulate Filter, Low Sulfur Fuel	20
CA	Los Angeles	Los Angeles City Sanitation	Particulate Filter, Low Sulfur Fuel	15
CA	Los Angeles	Los Angeles County	Low Sulfur Fuel	160
CA	Los Angeles	Metro Transit Authority	Particulate Filter, Low Sulfur Fuel	20
CA	Los Angeles	School Districts - Los Angeles, Anaheim Union, Hemet Unified	Particulate Filter, Low Sulfur Fuel	39
CA	San Diego	San Diego School District	Particulate Filter, Low Sulfur Fuel	30
CA	San Diego	Various private and transit fleets	Particulate Filter, Low Sulfur Fuel	6000
CT	State of Connecticut	CT Transit Agency	Particulate Filter, Low Sulfur Fuel	390
DC	Washington	WMATA - Washington Metropolitan Area Transit Authority	Particulate Filter, Low Sulfur Fuel	1460
GA	Atlanta	Hartsfield International Airport	Various oxides of nitrogen (NOx) technologies	10
ID	Boise	Ada County Highway District	Catalyst, Low Sulfur Fuel	19

IL	Chicago	Locomotive Switch Yard	Auxiliary Power Unit	7
IN	Hammond	Hammond City School District	Catalyst	25
MA	Boston	Mass Turnpike Authority	Catalyst	220
MA	Boston	Mass Bay Area Transit	Low Sulfur Fuel	475
MA	Woburn	Waste Management	Catalyst	40
NJ	State of New Jersey	NJ Transit Authority	Low Sulfur Fuel	2000
NJ	State of New Jersey	Department of Transportation	Various oxides of nitrogen (NOx) technologies	30
NV	Las Vegas	Construction equipment	Catalyst	100
NY	New York	New York City Transit Authority	Particulate filter, Low Sulfur Fuel	4400
NY	New York	New York City DOS	Particulate Filter, Low Sulfur Fuel	260
NY	New York	New York City School Bus Fleet	Particulate Filter, Low Sulfur Fuel	1000
NY	Westchester County	Westchester County DOT	Particulate Filter, Low Sulfur Fuel	360
OH	Cleveland	Community Transit	Particulate Filter, Low Sulfur Fuel	10
PA	Philadelphia	Area School District	Particulate Filter, Low Sulfur Fuel	120
PA	Philadelphia	U.S. Naval Base	Unknown	10
PA	Philadelphia	Southeastern Pennsylvania Transit Authority	Particulate Filter, Low Sulfur Fuel	1300
TX	Houston	City of Houston	Various NOx technologies	29
TX	Houston	Port of Houston Authority	Fuel emulsion, selective catalytic reduction (SCR), Low Sulfur Fuel	59
TX	State of Texas	Various Transit Agencies & Construction Companies	Various oxides of nitrogen (NOx) & particulate matter (PM) technologies	10000
WA	Seattle	Transit, School District & City Vehicles	Particulate Filter Catalyst Low Sulfur Fuel	5000

TOTAL NUMBER OF RETROFITS COMMITTED: 70,229

Summary of National and Local Voluntary Diesel Retrofit Pilot Programs

San Diego School Bus Retrofit Demonstration Program

Project location:	San Diego, Calif.
Project participants:	San Diego Unified School District, ARCO Products, Engelhard, Johnson Matthey, Inc., Navistar, California Air Resources Board, and South Coast Air Quality Management District
Project date:	January 1999 – June 2000
Project funding:	Federal/State and Industry
Retrofitted equipment:	30 Navistar Diesel School Buses
Retrofit devices:	ARCO's Emission Control Diesel (ECD) fuel California Air Resources Board (CARB) fuel Continuously Regenerating Technology (CRT) Diesel Particulate Filter (DPX)
Retrofit technology:	Johnson Matthey CRT System – an emission control system combining oxidation catalyst and filter Engelhard DPX System – a catalytic soot filter for controlling PM emissions (replaces muffler) ARCO ECD fuel – ultra low sulfur diesel fuel (contains only 15 parts per million of sulfur as opposed to 500 parts per million in diesel)
Emissions reductions:	CRT System – 90 percent particulate matter (PM) removed along with hydrocarbons (HC) and carbon monoxide (CO) DPX System – 90 percent PM, 80 percent HC, and 80 percent CO emissions reduction
Future:	Since the program ended in June, the San Diego School District has implemented a plan to discard 375 buses older than 1977. In addition the district has equipped 10 of their buses with the particulate traps and two others with the traps and engines to fully cut emissions. An additional 1,875 buses will have filters installed to reduce emissions.

Sources: US EPA web site - www.epa.gov/otaq/retrofit/exsandiego.htm, Diesel Technology Forum web site - www.dieselforum.org, and Education Week web site - www.edweek.org.

The "Big Dig" or The Boston Central Artery/Tunnel Voluntary Diesel Retrofit Program

Project location: Boston, Mass.

Project participants: Massachusetts Turnpike Authority (MTA), Massachusetts Department of Environmental Protection (DEP), and the Northeast States for Coordinated Air Use Management (NESCAUM)

Project date: September 1998 - December 2004

Project funding: Massachusetts Highway Department has and will continue to provide funding to contractors to purchase emission control devices.

Retrofitted equipment: 70 large, off-road diesel construction machines used for the construction of the "Big Dig" project such as front-end loaders, bulldozers, backhoes, cranes, air compressors, and excavators.

Retrofit devices: Catalytic converters
Particulate filters

Retrofit technology: Oxidation Catalyst – used to reduce diesel emissions by oxidizing diesel pollutants, such as PM, HC, and CO, to less harmful emissions such as H_2O and CO_2.

Diesel Particulate Filters – used to control PM emissions

Emissions reductions: Approximately 3 tons per year for PM, 12 tons per year for HC, and 36 tons per year for CO. Project sponsors estimate that they will reduce 203 tons of pollutants over the six-year project period.

Future: Due to the air quality benefits achieved thus far, the CA/T Project will continue to require that all off-road diesel equipment be equipped with oxidation catalysts until the end of the project.

Other: In addition to retrofit technology, the project has required all contractors to minimize diesel emissions impacts on people living and working near the construction zones by:

- turning off diesel combustion engines on construction equipment not in active use and on dump trucks that are idling while waiting to load or unload material for five minutes or more;

- establishing a staging zone for trucks that are waiting to load or unload material at the work zone in a location where diesel emissions from the trucks will not be noticeable to the public; and

- locating construction equipment away from sensitive receptors such as fresh air intakes to buildings, air conditioners, and windows.

Sources: US EPA web site - www.epa.gov/otaq/retrofit/exbigdig.htm, The Big Dig

The New York City Transit (NYCT) Clean Diesel Vehicle Air Quality Project

Project location:	New York, N.Y.
Project participants:	NYC Transit Authority, NYS DEC, Johnson Matthey. Inc., Corning, Inc., Equilon Enterprises LLC, Environmental Canada, and Emissions Research and Measurement Division
Project date:	February – November 2000
Project funding:	New York State Environmental Bond Act
Retrofitted equipment:	50 New York City Transit urban diesel buses
Retrofit devices:	Continuously Regenerating Technology (CRT) combined with reduced sulfur diesel fuel
Retrofit technology:	Johnson Matthey CRT System - an emission control system combining oxidation catalyst and filter to reduce PM emissions to compressed natural gas (CNG) levels
Emissions reductions:	CRT System combined with reduced sulfur diesel fuel – up to 90 percent reduction in PM, HC, and CO
Future:	The project sponsors concluded that the use of very low sulfur diesel was a key component to the outcome. Due to the success in reductions of the three pollutants, the NYCT has continued the program.

Sources: US EPA web site - www.epa.gov/otaq/retrofit/exnyproject.htm, Diesel Technology Forum web site - www.dieselforum.org, and DieselNet web site - www.dieselnet.com.

Diesel Solutions

Project location: Seattle, Wash.

Project participants: The Puget Sound Clean Air Agency, U.S. Environmental Protection Agency Region 10, King County, City of Seattle, Boeing, Everett Public Schools & Durham Transportation, Pacific Rim Enterprise Center & Emerald City Disposal, Washington State Department of Transportation, Port of Seattle, Tosco Refining, Washington State Department of Ecology, The Diesel Technology Forum, Manufacturers of Emission Controls Association (MECA), Cummins, Detroit Diesel Corporation, Johnson Matthey, Inc., and CleanAIR Systems.

Project date: Began in Summer/Fall 2001

Project funding: EPA has leveraged about $1 million in funding to support this program. More grant funding is expected over the next several years. EPA's Diesel Retrofit project is providing substantial grant funding and technical support to help implement the program. Other funding partners include the Puget Sound Clean Air Agency, the Washington State Department of Ecology and Region 10 of EPA.

Retrofitted equipment/ devices/technology:

The below equipment is equipped with particulate filter traps and oxidizing catalysts in conjunction with Tosco Refining ultra-low sulfur diesel fuel.

King County – 1,100 diesel-powered buses will use ultra-low sulfur diesel between 2001 and 2003; 800 buses will be equipped with retrofit hardware over the next 2 ½ years; new vehicle and equipment purchases will come equipped with ultra-low sulfur diesel emission hardware

City of Seattle – switch to ultra-low sulfur diesel throughout its diesel fleet; switch to ultra-low sulfur diesel in its fueling stations; retrofit heavy-duty diesel fleet beginning in 2001 and finishing in 2003

Boeing – fuel 70 heavy-duty diesel fleet vehicles with ultra-low sulfur diesel; equip 70 heavy-duty diesel trucks with retrofit hardware; demonstrate viability of retrofit hardware and fuel to other private sector fleet operators

Everett Public Schools and Durham Transportation – equip 25-30 International DTA 360, Cummins B series, and Caterpillar 3126 B school buses with retrofit technology; refuel buses with ultra-low sulfur diesel fuel

Emerald City Disposal and the Pacific Rim Enterprise Center – equip 25-30 refuse trucks with retrofit technology; refuel trucks with ultra-low sulfur diesel fuel

The Washington State Department of Transportation – develop pilot project to install retrofit technology on highway maintenance vehicles in Northwest region; refuel vehicles with ultra-low sulfur diesel fuel

Port of Seattle – develop program to install retrofit technology on diesel vehicles associated with its expansion project at Sea-Tac Airport; refuel diesel vehicles using ultra-low sulfur diesel fuel

Emissions reductions: The program coordinators expect to see at least a 90 percent reduction in fine particle emissions, more than a 90 percent reduction in toxic emissions, and undetectable levels of HC emissions using the retrofit devices combined with the ultra-low sulfur diesel fuel.

Future: The program will continue for the next few years with other private and public partners joining.

Sources: US EPA web site - www.epa.gov/otaq/retrofit/exeverettwa.htm, Puget Sound Clean Air Agency web site - www.pscleanair.org/dieselsolutions/index.shtml, and Diesel Technology Forum web site - www.dieselforum.org/retrofit/publicprivate.html.

Ralph's Grocery Company EC-Diesel Truck Fleet Start-up Experience

Project location:	Riverside, Calif.
Project participants:	ARCO Products, U.S. Department of Energy, National Renewable Energy Laboratory, Detroit Diesel Corporation, Engelhard, Johnson Matthey, California Air Resources Board, South Coast Air Quality Management District, California Energy Commission, and the U.S. Environmental Protection Agency
Project date:	March 2000 – February 2001
Project funding:	U.S. Department of Energy
Retrofitted equipment:	20 – 1999 Sterling Class 8 with Detroit Diesel Series 60 engines
Retrofit devices:	ARCO's Emission Control Diesel (ECD) fuel California Air Resources Board (CARB) fuel Continuously Regenerating Technology Diesel Particulate Filter (DPX)
Retrofit technology:	Five trucks operating on CARB fuel without a filter Five trucks operating on ECD fuel without a filter Five trucks operating on ECD fuel with Engelhard DPX Five trucks operating on ECD fuel with Johnson Matthey CRT
Emissions reductions:	Final results and evaluation for this project is expected before the end of the first quarter 2002. However results from the first five months are as follows: The trucks equipped with the catalyzed particulate filters and ECD fuel emitted 91-99 percent less particulate matter compared to the CARB-fueled trucks with no filter equipment.

Sources: Report issued by DOE - www.afdc.doe.gov/pdfs/Ralphs_ECD.pdf and the Diesel Technology Forum web site - www.dieselforum.org.

California Air Resources Board's (ARB) Lower-Emission School Bus Program

Project location:	California
Project participants:	California Energy Commission, South Coast Air Quality Management District, Bay Area Air Quality Management District, Monterey Bay Unified Air Pollution Control District, San Diego County Air Pollution Control District, Sacramento Metropolitan Air Quality Management District, and the San Joaquin Valley Unified Air Pollution Control District
Project date:	2001 – 2002 school year
Project funding:	$50 million in state funds to California EPA's Air Resources Board, who will distribute grants to school districts
Retrofitted equipment:	2,000 diesel school buses for retrofit technology and 350 pre-1976 diesel school buses to be replaced
Retrofit technology:	Engelhard Diesel Particulate Filter (DPX) and Johnson Matthey CRT System – $12.5 million, new alternative fuel buses (primarily natural gas) – $25 million, new, cleaner diesel buses – $12.5 million. All buses equipped with filters are required to use ultra-low sulfur fuel.
Emissions reductions:	The program began with the 2001 school year in August and will continue through summer of 2002. Program administrators expect to see at least 85 percent reductions in PM. The ARB staff estimates that this program will reduce PM emissions by approximately 150 tons from the year 2001 – 2010. This equals about 82 pounds per day.

Sources: California Air Resources Board web site - www.arb.ca.gov.

New York State Thruway Truck Stop Electrification (TSE) Pilot Program

Project location:	New York State Thruway – DeWitt and Chittenango Travel Plazas (near Syracuse)
Project participants:	New York State Thruway Authority, New York State Energy Research and Development Authority (NYSERDA), and Niagara Mohawk
Project date:	2001 – 2003
Project funding:	$500,000 shared by the NYS Thruway Authority, NYSERDA, and Niagara Mohawk Power Corporation.
Technology:	44 Truck Stop Electrification (TSE) units manufactured by IdleAir Technologies Corporation in Knoxville, Tenn. These stand-alone electrical power hookups provide drivers with local television, basic cable, telephone service, and basic internet service. Drivers will have easy access to the above services by swiping a credit card into a module that easily fits into their window.
Emissions reductions:	TSE units will help reduce both air and noise pollution. The program will continue through 2003. Emissions reductions have not yet been determined. However, according to the Argonne National Laboratory, a single truck engine idles an average of six hours a day and 1,830 hours per year. It is estimated that a single truck emits an estimated 220 pounds of nitrogen oxide and 380 pounds of CO each year. In addition to air quality benefits, installing the TSE units at the two demonstration sites alone could reduce diesel fuel usage by 470,000 gallons per year, according to a NYS Thruway press release.

Sources: New York State Thruway Authority web site -www.thruway.state.ny.us.

International Truck and Engine Corporation – Green Diesel Technology School Buses

School bus distribution: Several California school districts

Distribution dates: December 2001 – March 2002

Funding: School districts apply for state grants from the California Low Emission School Bus Program to replace old buses with new Green Diesel Technology buses.

Technology: The Green Diesel Technology buses use catalyzed diesel particulate filters and BP's low-sulfur diesel fuel in combination with an engine, built by International, designed to lower diesel emissions.

Emissions reductions: The Green Diesel Technology buses achieve a 90 percent reduction in PM and HC emissions. In addition, the odor associated with diesel fuel is eliminated and the buses use 40 – 60 percent less fuel per mile.

Sources: International web site - www.internationaldelivers.com, Green Diesel Technology web site - www.greendieseltechnology.com.

Regional Transportation District's (RTD) Emissions Inspections and Electric Mall Shuttles

Project location: Seven-county metropolitan Denver area

Emissions inspections: All buses tested annually to insure they meet State and RTD standards, which are twice as strict as State standards.

Supervisors make on-street visual evaluations which may result in immediate removal from service if State standards are exceeded. Vehicles are scheduled for repair within five days of reported violations.

Retrofit: RTD opts to replace old engines with advanced, clean-burning, low emission, electronically-controlled engines from Detroit Diesel and Cummins. The engines reduce PM emissions by 70 percent. RTD has replaced 830 buses over the past five years (about 2/3 of its fleet). The oldest bus in operation is a 1991 bus.

Other: Hybrid/CNG Mall Shuttles – RTD pioneered transit use of electric vehicles in 1982 on the 16th Street Mall. There are currently 34 running today. RTD is researching the use of hybrid-electric buses to replace the existing shuttles in the future. Hybrid-electric buses contain a clean-burning, CNG-fueled engine, which drives an electric generator.

Sources: RTD web site - www.rtd-denver.org.

FedEx Express – Low Emission Vehicle Purchases	**Project date:**	July 1999 to present
	Project funding:	FedEx Corp. with assistance from Colorado sales tax waiver
	Affected equipment:	106 diesel-fueled package delivery vehicles in the last 2-1/2 years. About 80 percent of FedEx's new vehicle purchases in the Denver-Boulder area have been certified Low Emission Vehicles (LEV). With a fleet of 449 vehicles in the area, nearly 25 percent are now Low Emission ehicles.
	Technology:	Modified Cummins engines certified for LEV
	Emission reductions:	Up to 25 percent reduction in NO_x emissions compared to current non-LEV vehicles.
FedEx Express and the Alliance for Environmental Innovation – The Future Vehicle Project	**Project participants:**	FedEx Express, Alliance for Environmental Innovation (an initiative of Environmental Defense), Allison Transmission Division of General Motors, BAE SYSTEMS Controls, and Eaton Corporation.
	Project date:	Prototype testing begins October 2002; new delivery trucks on road by 2004
	Technology:	Three competing teams, headed by the companies listed above, will develop prototype diesel-electric delivery vehicles for the next generation of FedEx Express delivery trucks. The prototypes will be tested in October against a current baseline 1999 diesel delivery truck.
	Emissions reductions:	FedEx Express and Alliance for Environmental Innovation asked companies to submit proposals for a diesel-electric delivery truck that will increase fuel efficiency by 50 percent and reduce PM and NO_x emissions by 90 percent.
	Future:	FedEx Express expects to have the new delivery trucks on the road by 2004