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# CLEAN DIESEL PLAN

## SUNRISE MOUNTAIN LANDFILL

## CLARK COUNTY, NEVADA

## REVISION 1, AUGUST 5, 2009

*Prepared for:*

Republic Services of Southern Nevada
770 East Sahara Avenue
Las Vegas, Nevada 89104

*Prepared by:*

August 2009

093-97436

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## ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| CO | carbon monoxide |
| EPA | U.S. Environmental Protection Agency |
| HC | hydrocarbons |
| $NO_x$ | nitrogen oxide |
| PM | particulate matter |
| RSSN | Republic Dumpco, Inc. and Republic Silver State Disposal, Inc., d/b/a - Republic Services of Southern Nevada |

## 1.0 INTRODUCTION

This Clean Diesel Work Plan (Plan) specifies the clean diesel technologies that will be implemented during the construction activities associated with the closure of the Sunrise Mountain Landfill. The closure is being completed in accordance with Appendix A of *United States v. Republic Dumpco, Inc., Civ. Action No. 2:08-cv-01024-PMP-PAL (D. Nev.)* (EPA, 2008a). Republic Dumpco, Inc. and Republic Silver State Disposal, Inc., d/b/a - Republic Services of Southern Nevada (collectively "RSSN"), with its consultants, has prepared this Plan to meet the requirements of the Administrative Order.

RSSN is aware of the impact that diesel emissions have on human health and the environment and understands the importance of reducing those emissions.

The purpose of this Plan is to present the measures that will be taken to mitigate the potential health risks associated with diesel exhaust from all diesel powered engines greater than 25 horsepower that will be used on site for greater than 14 days. These health risks will be mitigated by applying clean fuels, clean diesel technologies and or clean construction practices. RSSN plans to have its construction contractor implement and adhere to this plan during the closure activities. However, if the contractor has suggestions which can enhance this plan, RSSN reserves the right to revise this plan with EPA's prior approval.

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## 2.0 MITIGATION METHODS

There are several methods that can be implemented to mitigate the exhaust emissions of diesel engines. RSSN will use a combination of the following methods:

- Use of ultra low sulfur diesel fuel (ULSDF)
- Use of Tier II engines on all off road construction equipment
- Equip 25 percent of all Tier II engines with exhaust gas aftertreatment technologies (a.k.a. retrofitted)
- Implementation of clean construction practices

These methods are detailed in Sections 0 through 0.

### 2.1 Ultra Low Sulfur Diesel Fuel

ULSDF contains no more than 15 parts per million sulfur. The use of ULSDF reduces particulate matter content of the exhaust and enhances the effectiveness of retrofit technologies.

### 2.2 Tier II Diesel Engines

Tier II diesel engines meet the emission standards that were promulgated by the EPA in 1998 and phased into the field between 2000 and 2008. The emission standards for Tier II engines are met through advanced engine design with no exhaust gas aftertreatment.

### 2.3 Aftertreatment Emission Control Technologies (Retrofitting)

Aftertreatment emission control technologies are installed on existing engines in order to reduce particulate matter (PM), nitrogen oxides (NOx), carbon monoxide (CO), and hydrocarbons (HC). The technologies include the following

- Diesel Particulate Filters
- Diesel Oxidation Catalysts
- Selective Catalytic Reduction

- Exhaust Gas Recirculation

Appendix A, taken from the California EPA Air Resources Board's internet site, http:/www.arb.ca.gov/diesel/verdev/vt/cvt.htm, summarizes available retrofit technologies and associated technology type, pollution reduction, and applicability.

## 2.4 Clean Construction Practices

Clean construction practices include the following items:

- Minimizing idling; heavy construction equipment will not be permitted to idle unattended
- Maintaining equipment within manufacturer's recommended specifications

## 3.0 MITIGATION METHOD IMPLEMENTATION

The mitigation measures listed above will be incorporated into RSSN's contract with the closure contractor. The contractor will be responsible for implementing those methods listed above as a condition for payment. This will ensure that the contractor will comply with these mitigation measures. RSSN will implement the following inspections and submittal reviews to confirm that all measures will be implemented:

- **ULSDF**—RSSN will require the contractor to provide delivery receipts to ensure that all off-road diesel fuel delivered to the site meets the requirements of ULSDF. RSSN also will reserve the right to sample the fuel to determine compliance.

- **Use of Tier II Engines**—Prior to mobilization, RSSN will require the contractor to submit the engine specifications for each piece of off-road construction equipment greater than 25 horsepower that will be used on site for greater than 14 days. RSSN will review the data to confirm the use of Tier II engines. If the contractor cannot supply a piece of equipment with a Tier II engine, then RSSN will require an explanation as to why the specification cannot be met (e.g., availability, schedule constraints). RSSN will review each noncompliance on a case by case basis to determine if the noncompliant equipment is acceptable. RSSN will make every effort to reasonably achieve 100 percent compliance. RSSN reserves the right to request the removal of any noncompliant equipment

- **Aftertreatment Technologies**—RSSN will require the contractor to apply the highest level of verified diesel emission controls strategy ("VDECS") to 75% of the sum of the maximum power of all diesel engines subject to control at the Site under this Work Plan. VDECS may include diesel particulate filters, diesel oxidation catalysts or other diesel control. Control devices are only required, where technically feasible, which is based on: whether there is reduced normal availability of the construction equipment due to increased downtime and/or power output, whether there may be significant damage caused to the construction equipment engine or body, or whether there may be a significant risk to nearby workers or to the public. If VDECS is not applied, or the control device is not the highest level of VDECS, RSSN will provide the EPA an explanation as to why the specification cannot be met and the decision will be subject to review and approval by EPA. RSSN will make every effort to reasonably achieve the required percentage of compliance.

- **Clean Construction Practices**—RSSN will stress the importance of minimizing the time that vehicles are left idling during the daily safety briefings on site. The contractor will be notified if any equipment is found idling unattended for any period greater than 5 minutes (e.g., break time, lunch time, etc.), and RSSN will direct the contractor to shut the equipment down. **RSSN will require the contra**ctor to submit a maintenance schedule and submit certifications that the off-road construction equipment is maintained to operate within the

manufacturer's recommended specifications. Clean Diesel Implementation issues will be evaluated, as appropriate, in Quarterly Reports, to address: a) any equipment/control/fuel related issues, b) violations of the anti-idling policy, c) any engines not tuned to manufacturers' specifications in accordance with a defined maintenance schedule, d) reports of any tampering with engines to increase horsepower, e) the status of implementation of a policy to establish work limitations such as minimizing trafficking trips, providing staging areas for trucks located away from sensitive receptors, etc., f) the extent to which ultra low sulfur diesel or another clean fuel was not used and the reason why, and g) explanations for why VDECS was not applied to specific pieces of off-road, on-road and stationary diesel powered equipment. The Quarterly Reports will be included in the appropriate Monthly Progress Report.

## 4.0 MITIGATION METHOD DOCUMENTATION

RSSN will maintain files on site that contain all documentation confirming that the mitigation measures listed in Section 0 are followed.

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## 5.0 CERTIFICATION

I certify under penalty of law that I have examined and am familiar with the information submitted in this document and all attachments and that this document and its attachments were prepared either by me personally or under my direction or supervision in a manner designed to ensure that qualified and knowledgeable personnel properly gather and present the information contained therein. I further certify, based on my personal knowledge or on my inquiry of those individuals immediately responsible for obtaining the information, that the information is true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowingly and willfully submitting a materially false statement.

D. Ford Whittlet — 8/3/09

RSSN Representative — Date

AREA ENVIRONMENTAL MANAGER

Title

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## 6.0 REFERENCES

California Environmental Protection Agency Air Resources Board Internet Site, 2009, Verified Diesel Emission Control Strategies http://www.arb.ca.gov/diesel/verdev/vt/cvt.htm (July 2009).

U.S. Environmental Protection Agency, 2008a, *United States v. Republic Dumpco, Inc., Civ. Action No. 2:08-cv-01024-PMP-PAL (D. Nev.).*

U.S. Environmental Protection Agency, 2008b, *Smart Energy Resources Guide* (EPA/600/R-08/049), Chapter 8, "Cleaner Diesel," March, <http://www.epa.gov/nrmrl/pubs/600r08049/600r08049.pdf> (October 2008).

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# APPENDIX A

# DIESEL EMISSION CONTROL STRATEGIES

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**Verified Diesel Emission Control Strategies**
**California Environmental Protection Agency Air Resources Board**
**July 13, 2009**
**http://www.arb.ca.gov/diesel/verdev/vt/cvt.htm**

| PM Level | Product Name | PLUS | Technology Type | PM Reduction | NOx Reduction | Applicability |
|---|---|---|---|---|---|---|
| LEVEL 3 | Catalytic Exhaust Products Ltd. Dieselytic SXS-SC DPF | + | DPF | 85% | N/A | Stationary prime and emergency standby generators and pumps with Tier 1, Tier 2, or Tier 3 certified off-road engines meeting 0.2 g/bhp-hr or less diesel PM |
| | Caterpillar | + | DPF | 85% | N/A | Specific 1996-2008 model years; off-road; CARB diesel; biodiesel.* |
| | Cleaire Horizon | + | DPF | 85% | N/A | Most on-road diesel engines through 2006 model year; Certain MY 2006 and 1993 or older engines with OEM diesel oxidation catalysts; CARB diesel; biodiesel.* Conditionally verified for off-road engines. |
| | Cleaire Lonestar | + | Lean NOx Catalyst and DPF | 85% | 40% | Conditionally verified for 1996 through 2009 model year; rubber-tired off-road vehicles; CARB diesel; biodiesel.* |
| | Cleaire Longview (reformulated) | + | Lean NOx Catalyst and DPF | 85% | 25% | 1993-2006 model year on-road; CARB diesel; biodiesel.* |
| | Cleaire Phoenix | + | DPF | 85% | N/A | Conditionally verified for 1996-2009 model year rubber-tired off-road vehicles. CARB diesel; biodiesel.* |
| | Cleaire Vista | + | DPF | 85% | N/A | 1993-2006 model year on-road; CARB diesel; biodiesel.* |
| | CleanAIR Systems PERMIT | + | DPF | 85% | N/A | Stationary emergency and prime generators; CARB diesel; biodiesel.* |
| | Dinex DiSiC | + | DPF | 85% | N/A | Most trailer TRUs using 1999-2005 model year engines; CARB diesel. |
| | Donaldson LNF | + | DPF | 85% | N/A | 1993-2003 model year on-road; CARB diesel; biodiesel.* |
| | Donaldson SEF | + | DPF | 85% | N/A | 1991-2006 model year on-road; CARB diesel; biodiesel.* |
| | DCL International Inc. | + | DPF | 85% | N/A | Conditionally verified for 1996-2008 model year, rubber tired off-road; CARB diesel; biodiesel.* |
| | DCL International Inc. | + | DPF | 85% | N/A | Stationary prime and emergency standby generators, pumps, and |

| PM Level | Product Name | PLUS | Technology Type | PM Reduction | NOx Reduction | Applicability |
|---|---|---|---|---|---|---|
| | | | | | | compressors; Tier 1, 2, or 3 off-road engines certified to < 0.15 g/bhp-hr PM; CARB diesel; biodiesel.* |
| | Engine Control System Purifilter (Low Load) | + | DPF | 85% | N/A | 1994-2004 on-road;CARB diesel; biodiesel.* |
| | Engine Control System Purifilter (High Load) | + | DPF | 85% | N/A | Conditional verification for off-road for specific engines; model years 1996-2008; CARB diesel; biodiesel.* |
| | Engine Control System Purifilter (High Load) | + | DPF | 85% | N/A | 1993-2006 CA certified engines; Specific 1994-2006 Federally certified engines; on-road; CARB diesel; biodiesel.* |
| | Engine Control System Combifilter | + | DPF | 85% | N/A | 2007 or older off-road; CARB diesel; biodiesel.* |
| | Engine Control Systems Purifilter Plus | + | DPF | 85% | N/A | 1993 and 2006 on-road; CARB diesel; biodiesel.* |
| | ESW Canada | + | DPF | 85% | N/A | 1996-2009; off-road; CARB diesel; biodiesel.* |
| | HUSS Umwelttechnik FS-MK | + | DPF | 85% | N/A | Most on-road diesel engines through 2006 MY and most off-road through 2008 MY; CARB diesel; biodiesel. * |
| | Johnson Matthey ACCRT | + | DPF | 85% | N/A | Specifc 2002-2006; on-road; CARB diesel |
| | Johnson Matthey CRTreformulated | + | DPF | 85% | N/A | 1994 - 2006; on-road; CARB diesel |
| | Johnson Matthey CRT | + | DPF | 85% | N/A. | Stationary emergency/standby generators; conditionally verified for stationary prime generators. CARB diesel; biodiesel.* |
| | Johnson Matthey EGRT | + | EGR/DPF | 85% | 40% | 2000 International DT-466, 2000 Cummins ISM 2001 Cummins ISB, 1998-2002 Cummins ISC, 2001 Cummins ISL, 2001 MY DDC - 50, and 2001 DDC - 60. on-road; CARB diesel. |
| | MIRATECH Corporation combiKat | + | DPF | 85% | N/A | Stationary emergency and prime generators with a PM emission rate of 0.2 g/bhp-hr or less. |
| | Rypos, Inc. HDPF/C™ | + | Hybrid DPF | 85% | N/A | 1996-2007 stationary emergency standby generators and pumps with a PM emission rate of 0.2 g/bhp-hr or less and certified to Tier 1, Tier 2, |

| PM Level | Product Name | PLUS | Technology Type | PM Reduction | NOx Reduction | Applicability |
|---|---|---|---|---|---|---|
| | | | | | | or Tier 3 off-road diesel engine standards; CARB diesel; biodiesel.* |
| | SK Energy Co. Econix DPF -A | + | DPF | 85% | N/A | 1994-2006; on-road; CARB diesel. |
| | Süd-Chemie Inc EnviCat-DPF™ | + | DPF | 85% | N/A | Stationary prime and emergency standby generators and pumps; CARB diesel; biodiesel.* |
| | Teleflex Clear Sky DPF | + | DPF | 85% | N/A | With the Comfort Pro APU, powered by select Kubota Z482 diesel engines with model years between 2005 and 2008. |
| | Thermo King eDPF | + | DPF | 85% | N/A | 2006-2008 Thermo King auxilary power units; CARB diesel. |
| LEVEL 2 | Donaldson | + | Flow Through Filter | 50% | N/A | 1991-2002 on-road; CARB diesel; biodiesel.* |
| | Engine Control System AZ Purimuffler/Purifier | + | DOC + Alt Fuel | 50% | 20% | 1996-2002 off-road; PuriNOx |
| | Lubrizol PuriNOx | + | Emulsified Fuel | 50% | 15% | 1988-2003 on-road. |
| | Proventia FTF TM | + | FTF | 50% | N/A | Most Thermo King trailer TRUs using 1985 through 2002 model year engines; CARB diesel; biodiesel.* |
| | Proventia Bobtail FTF ™ | + | FTF | 50% | N/A | Select Thermo King truck TRUs using 1987 to 2002 model year engines. CARB diesel; biodiesel* |
| | Rypos ADPF | + | DPF | 50% | N/A | 1996-2008 stationary engines (certified to Tier 1, 2, or 3 off-road PM emission level); CARB diesel; biodiesel*; no EGR, DOC or pre-existing DPF. |
| | Rypos, Inc. DPF/LETRU™ | + | DPF | 50% | N/A | Applicability: Most trailer TRUs using 2002 and older model year engines; ULSD CARB diesel (less than 15 ppm sulfur). |
| | Thermo King PDPF™ | + | FTF | 50% | N/A | 1985-2002 transport refrigeration unit engines; CARB diesel. |

| PM Level | Product Name | PLUS | Technology Type | PM Reduction | NOx Reduction | Applicability |
|---|---|---|---|---|---|---|
| | Rypos, Inc. ADPF | + | DPF | 50% | N/A | Marine Harbor Craft |
| LEVEL 1 | Donaldson DCM 6000 | + | DOC | 25% | N/A | 1988-1990 on-road; CARB diesel; biodiesel.* |
| | Donaldson 6000 + Spiracle | + | DOC + crankcase filter | 25% | N/A | 1988-2002 on-road; CARB diesel; biodiesel.* |
| | Donaldson DCM 6100 + Spiracle | + | DOC + crankcase filter | 25% | N/A | 1991-2002; CARB diesel; biodiesel.* |
| | Donaldson DCM 6100 | + | DOC | 25% | N/A | 1994-2002; CARB diesel; biodiesel.* |
| | Donaldson 6000 + Spiracle (off-road) | + | DOC + crankcase filter | 25% | N/A | Off-road port equipment; CARB diesel; biodiesel.* |
| | Engine Control System AZ Purifier & Purifmuffler | + | DOC | 25% | N/A | 1991-2003 Cummins and Navistar on-road; 1973-1993 DDC 2 stroke; 1991-2002 HHD certain model Cummins and DDC; CARB diesel; biodiesel.* |
| | Engine Control System AZ Purifier & Purifmuffler | + | DOC | 25% | N/A | 1996-2002 off-road; CARB diesel; biodiesel.* |
| | Extengine | + | DOC + SCR | 25% | 80% | 1991-1995 Cummins 5.9 liter off-road; CARB diesel. |
| | Vycon REGEN System | + | Energy Storage System | 25% | 30% | Pre-1996 model year or Tier 1, 2, or 3 certified off-road diesel engines on rubber-tired gantry cranes; biodiesel.* |

PLUS Systems (+) indicate 2009 N02 compliance.

* These systems have been verified for use with biodiesel blends subject to certain requirements.

# APPENDIX B

# CLEANER DIESEL

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# CHAPTER 8: CLEANER DIESEL

On cleanup and redevelopment sites, diesel engines are commonly used in soil removals and construction. Common construction equipment includes wheel loaders, skid steer loaders, wheel dozers, landfill compactors, excavators, backhoes, drill rigs, scrapers, and trucks. Diesel engines are highly durable and can last for about 30 years. While stringent diesel emissions rules are reducing emissions from newly manufactured engines, in-use older engines can continue to operate for many years. Diesel emissions, especially PM, are highly toxic, potentially exposing site workers and surrounding communities to increased health risks. Clean diesel technologies and alternative fuels can reduce harmful emissions from older, higher polluting engines. Clean diesel technologies include replacing, repowering, or retrofitting older engines with advanced emission control devices that significantly reduce harmful pollutants. The two most widely used retrofit technologies are diesel particulate filters (DPFs) and diesel oxidation catalysts (DOCs). Cleaner fuels like ultra-low-sulfur diesel (ULSD), and alternative fuels such as biodiesel, also reduce emissions. In addition, simple measures like idle reduction and engine maintenance can be practiced as fundamental components of reducing diesel pollution.

**Chapter 8 Table of Contents**



## 8.1 IMPORTANCE OF REDUCING DIESEL EMISSIONS

Reducing emissions from diesel engines is one of the most important air quality challenges facing the country. Diesel engines emit a complex mixture of air pollutants including both solid and gaseous materials that have serious human and environmental impacts (Table 7). EPA has deemed diesel exhaust as a "likely human carcinogen."[202] California has also classified over 40 diesel exhaust pollutants as "toxic air contaminants."[203] Diesel activities occurring at cleanup sites may expose workers and surrounding communities to diesel pollution. The diesel pollutants that cause the most public health concerns are PM and $NO_x$.

Table 7 Human and Environmental Health Risks from Diesel Pollutants[201]

| Particulate Matter (PM) | Nitrogen Oxides ($NO_x$) |
|---|---|
| • Irritation of airways<br>• Coughing<br>• Difficulty breathing<br>• Aggravated asthma<br>• Decreased lung function<br>• Lung and heart disease<br>• Acute and chronic bronchitis<br>• Irregular heartbeat<br>• Heart attacks | • Acid Rain<br>• Global warming<br>• Water quality deterioration<br>• Visibility impairments<br>• Smog/precursor to ground-level ozone<br>• Formation of toxic chemicals<br>• Asthma in children<br>• Increases lung susceptibility to toxins and microorganisms |

Diesel pollution is a serious public health problem facing our country. The following are a few statistics that show the nationwide impacts of diesel emissions.

- In 2002, off-road diesel construction equipment emitted roughly 71,000 short tons of $PM_{10}$. About 95 percent of it was PM $_{2.5}$.[204]
- PM causes about 15,000 premature deaths a year. This is comparable to the number of deaths from 2nd-hand smoke and traffic accidents in California.[205]
- Diesel emissions result in approximately 6,000 children's asthma-related emergency room visits every year.[206]
- PM causes about 15,000 heart attacks per year.[207]
- In 2002, off-road diesel construction vehicles emitted about 764,000 tons of $NO_x$ into our air.[208]
- EPA estimates that every $1 invested in diesel emissions reductions generates up to $13 in health-related benefits.[209]

For more information on EPA engine emissions standards, see the document *Reducing Air Pollution from Non-Road Engines* published in May 2003 by the EPA Office of Air and Radiation (www.epa.gov/OMS/cleaner-nonroad/f03011.pdf).

### *Key Diesel Pollutants*

Particulate matter is the general term for a mixture of solid particles and liquid droplets found in the air.[211] Diesel engines emit particles smaller than 10 micrometers (μm) ($PM_{10}$) in diameter and nearly all are under 2.5 μm ($PM_{2.5}$) (Fig. 41). Human exposure to $PM_{2.5}$ is especially dangerous because these particles can penetrate deep into the lungs and cause serious problems including asthma, heart attacks, and even premature death.[212]

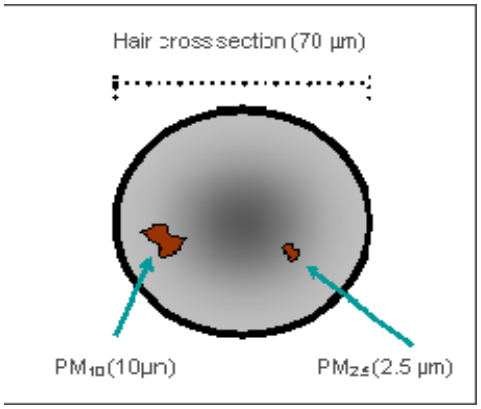


Figure 41 Size of diesel PM compared to a cross section of a human hair. Image courtesy EPA[210]

Nitrogen oxides ($NO_x$) is the term for a group of highly reactive gases that contain nitrogen and oxygen in varying amounts. $NO_x$ form when fuel is burned at high temperatures, such as in a diesel engine. $NO_x$ contribute to human health and environmental problems including asthma, smog, and acid rain (Table 7).

CO and $SO_x$ pollutants are present in lower amounts in diesel exhaust compared to PM and $NO_x$ but may also pose a risk to human health. CO can cause fatigue in healthy people and chest pain in people with heart disease. Exposure to moderate concentrations may cause angina, impaired vision, and reduced brain function. Higher concentrations can cause headaches, dizziness, confusion, nausea, and even death. $SO_x$ can cause breathing problems for people with asthma. $SO_x$ can also aggravate heart disease and induce respiratory illness and is a major component of

ambient PM. In addition, this pollutant is a major component in acid rain formation, which harms ecosystems and degrades buildings and statues. Hydrocarbons (HC) are a precursor to ground-level ozone.

Go to the American Lung Association of California's website for more technical information on the health effects of diesel pollution (www.californialung.org/spotlight/cleanair03_research.html).

## 8.2 APPROACHES TO REDUCE DIESEL EMISSIONS

There are many technologies and practices that reduce diesel emissions. The following are some examples. More details on retrofits and cleaner fuels follow. See Section 10.10 (page 121) to calculate emissions and emissions reductions.

Retrofit engines with EPA or California Air Resources Board (CARB) verified diesel emission control technologies. Alternatively, try to select contractors or rental companies that have retrofitted or newer engines.

Maintain engines in accordance with engine manual (e.g., change air filters, check engine timing, fuel injectors and pumps) and keep engines well tuned.

Refuel with biodiesel, other alternative fuels, or with cleaner fuels such as ULSD. See page 74.

Modify Operations by reducing operating and idle time. A mid-sized off-road tractor may consume as much as one gallon of diesel fuel per hour of idling.[213] Reducing just one hour of idling from a typical back hoe loader can avoid about 13 grams of PM emissions, 155 grams of $NO_x$ emissions, 65 grams of CO emissions, and 65 grams of $CO_2$ emissions.[214] For more details, go to www.epa.gov/otaq/smartway/idlingtechnologies.htm.

Replace/Repower existing engines with new cleaner diesel engines, hybrid engines, or engines compatible with alternative fuels.

See EPA's March 2007 publication, *Cleaner Diesels: Low Cost Ways to Reduce Emissions from Construction Equipment* (www.epa.gov/sectors/pdf/emission_0307.pdf) for more information on methods of reducing diesel pollution.

### *Diesel Engine Retrofits*

Engines can be retrofitted with many kinds of emissions control devices. This section describes the most widely used technologies (Table 8). See Appendix VIII (page 150) to see which verified retrofit technologies may be applicable for off-road equipment used at your site.

### Diesel Particulate Filters (DPFs)

DPFs use ceramic filters to collect diesel PM from engine exhaust (Fig. 42, Fig. 43). Over time, PM builds up on the filters and they must be cleaned or "regenerated."[217] For some DPFs, high enough engine exhaust temperatures can clean the filters by oxidizing (breaking down) the PM into less harmful components of $CO_2$ and water vapor.[218] These DPFs are called passive DPFs. Active DPFs require more maintenance because they must be removed for regeneration. DPFs require ULSD since sulfur reduces the effectiveness of DPFs.

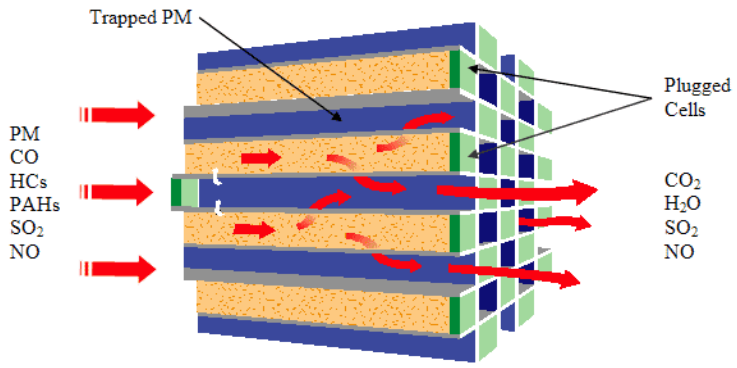


Figure 42 Schematic of DPF. Image courtesy MECA[215]


Figure 43 Dozer installed with DPF. Image courtesy EPA,[216]

### Diesel Oxidation Catalysts (DOCs)

DOCs have been installed in off-road engines for over 30 years to reduce PM emissions. DOCs usually consist of a stainless steel container that holds a honeycomb structure (Fig. 44, Fig. 45). The interior surfaces are coated with catalytic metals such as platinum or palladium. Chemical oxidation reactions convert exhaust gas pollutants into less harmful gases. While many older engines are not compatible with passive DPFs, DOCs are able to work with these higher polluting engines.


Figure 44 Schematic of DOC. Image courtesy MECA[219]

### Selective Catalytic Reduction (SCR)[221]

While DOCs and DPFs concentrate on reducing PM emissions, SCRs are best at reducing $NO_x$ emissions and reduce PM and HC as well. $NO_x$ are converted to molecular nitrogen and oxygen in the SCR. A stream of ammonia or urea added to the exhaust gases pass over an SCR catalyst and cause chemical reactions that reduce $NO_x$ emissions. SCRs greatly reduce odor caused by diesel engines and diesel smoke. SCR catalysts may also be combined with DOCs or DPFs for additional PM emissions reductions.

Figure 45 Dozer with DOC retrofit.
Image courtesy Schattanek[220]

### Exhaust Gas Recirculation (EGR)

Diesel engines may be equipped with EGR devices to lower $NO_x$ formation. Engine combustion chambers can reach temperatures greater than 2,500°F. At these temperatures, nitrogen and oxygen react to form $NO_X$ which contribute to smog. An EGR device recirculates exhaust into the air intake stream. These gases displace some of the normal intake, lowering the peak temperature of the combustion process by hundreds of degrees and reduce the amount of oxygen available to form $NO_x$.[222] However, EGR increases PM emissions and are not compatible with many verified DOCs and DPFs for off-road engines.[223]

Table 8 Diesel Engine Retrofit Options

| | Diesel Particulate Filter (DPF) | Diesel Oxidation Catalyst (DOC) | Selective Catalytic Reduction (SCR) |
|---|---|---|---|
| **Technology Description** | Wall-flow type filter installed in the exhaust system, much like a muffler, in which PM emissions are trapped. Active DPFs require regular maintenance to regenerate or burn off accumulated PM, when the engine is not in use. Passive DPFs regenerate during engine operation if exhaust temperature requirements are met. | Canister-like device containing a honeycomb structure that is installed in the exhaust system. A catalyst oxidizes CO and HC as the exhaust flows through, which breaks them down into less harmful components. | Device that injects urea, or some form of ammonia, into the exhaust stream and reacts over a catalyst to reduce $NO_x$ emissions. |
| **Cost per retrofit** | $7,000—$10,000[224] | $500—$2,000[225] | $12,000 with DOC<br>$20,000 with DPF[226] |
| **Emissions Reductions** | PM reduced 60%-90%[227]<br>HC reduced 60%-90%[228]<br>CO reduced 60%-90%[229] | PM reduced 40%-50%[230] | SCR without DOC or DPF<br>PM reduced 30%-50%[231]<br>$NO_x$ reduced 75%-90%<br>HC reduced 50%-90% |
| **Benefits** | Can be coupled with an exhaust gas recirculation system (page 71) to further reduce $NO_x$ (up to 40%) and PM (up to 85%) though may not be compatible with currently verified DPFs[232]<br>Can also be coupled with a SCR to reduce $NO_x$ and PM | Should not decrease fuel economy, shorten engine life, nor adversely affect drivability<br>Less restrictive than DPF because DOCs are less affected by exhaust buildup in the filter<br>Works well with older, higher emitting engines<br>Use of ULSD increases efficiency | Commonly used in stationary applications.<br>Often used with a DOC or catalyzed DPF to achieve greater PM reductions |
| **Considerations** | Annual maintenance costs approximately $150-$310[233]<br>Active DPFs require maintenance to keep filters clean. Passive DPFs oxidize PM via catalysts or high exhaust temperatures<br>Off-road engines may require active DPFs<br>Diesel equipment needs to meet minimum temperature requirements specific to individual filter technologies<br>Slight fuel economy penalty from pressure buildup in the exhaust system, pressure and temperature monitors are necessary<br>Requires ULSD<br>1995 and older engines may overload passive filters but may be compatible with active regeneration systems | May suffer thermal degradation when exposed to temperatures above 650˚C for prolonged periods of time but these are unlikely conditions during normal operation[234]<br>Requires normal exhaust maintenance | Requires periodic refilling of an ammonia or urea tank<br>Requires low-sulfur diesel or ULSD |

**Retrofitting a Fleet**

The following steps provide an approach to retrofitting a fleet.

*Step 1*

Inventory the fleet for each engine and determine the following:

- Type of equipment (backhoe, generator, etc.)
- Engine year, make, model, horsepower, displacement
- Engine family name (See Appendix VIII page 152)
- If a diesel emissions reduction device is already in place. New engines may have one installed.
- Turbocharged or naturally aspirated
- Mechanically or electrically controlled
- If it employs exhaust gas recirculation (page 71)

*Step 2*

Visit the EPA (www.epa.gov/otaq/retrofit/verif-list.htm) and CARB (www.arb.ca.gov/diesel/verdev/vt/cvt.htm) verification websites to determine compatible retrofit devices. See Appendix VIII (page 150) for verified retrofit technologies for off-road mobile engines.

*Step 3*

Work with vendors to assess the compatibility of your diesel equipment with a retrofit. They may need additional information such as: location for mounting retrofit device (on the muffler or on the side of the vehicle), size of the exhaust system, and if any changes will be made to the exhaust system (sometimes the retrofit device does not replace the muffler).

*Step 4*

Typically, datalogging is required before installing a DPF to determine if the exhaust temperatures are sufficient for passive DPF systems. Passive filters require high exhaust temperatures to oxidize the soot that accumulates on the filter. Vendors will datalog temperature information for a few days on each engine to see if required temperature minimums are met. Datalogging may cost about $200-$300 for two to three days of monitoring. Active DPF systems do not require high exhaust temperatures but do require maintenance.

*Important Notes on Retrofitting*

- Equipment retrofitted with DPFs should always include a device to monitor the increased pressure buildup in the exhaust system. These devices, called back-pressure monitoring systems, may also be installed with DOCs. A warning light in the cab will notify the equipment operator if the pressure becomes too high and maintenance is necessary.

- Retrofits may take place on-site or at the dealership, depending on the contract with the dealer.
- It is generally not recommended to remove a retrofit device from an engine for which it was designed and use it on another engine. Though this is possible if the engines are similar, it may not be in proper verified use, and may result in damage to the engine or retrofit device.
- DPFs may take from 1.5 hours to a full day to install. DOCs usually take 1.5-4 hours to install. Installations cost from $170 to $500 for each engine for both DOCs and DPFs.[235]
- SCRs require installation of a tank for ammonia (or other reagent), as well as the necessary catalyst and associated piping and controls. These retrofits can be much more involved compared to DPFs or DOCs. A dependable source of ammonia or urea supply is also required.

## *Cleaner and Alternative Fuels*

Using cleaner and alternative fuels also helps to minimize diesel pollution. Most retrofit technologies require the use of low- or ultra-low-sulfur diesel. Many retrofits are also compatible with low blends of biodiesel. The following are commonly used cleaner and alternative fuels (Table 9). For information on where these fuels are available, go to www.eere.energy.gov/afdc/fuels/stations.html.

### Ultra-Low-Sulfur Diesel (ULSD)

EPA's Clean Air Highway Diesel rule, finalized in 2001, requires a 97 percent reduction in the sulfur content of highway diesel fuel, from 500 ppm in low-sulfur diesel (LSD), to 15 ppm in ULSD (Fig. 46). While on-road diesel vehicles are already required to fuel with ULSD, off-road equipment ULSD fueling requirements begin in 2010. Highway model year 2007 and later engines must use ULSD to function properly. California's stricter rules already require ULSD in both off- and on-road engines.[237] Use ULSD in both on-road and off-road equipment used in site cleanup and redevelopment activities to reduce PM emissions by about 13 percent compared to LSD.[238] ULSD costs about 4-5 cents more per gallon to produce and distribute.[239] Some diesel fuel may be colored red. The red dye is added to non-taxed off-road diesel to distinguish it from clear, or "white," taxed on-road diesel.[240]

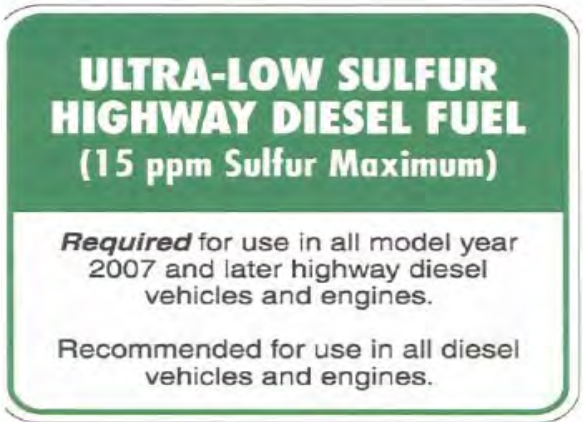


Figure 46 ULSD pump label. Image courtesy EPA[236]

### Biodiesel

Biodiesel is a renewable fuel made from agricultural products such as vegetable oils. While most biodiesel is made from soybean oil in the United States, biodiesel made with canola oil and sunflower oil are also available. Biodiesel can also be produced from recycled cooking oils and animal fats, which is less energy-intensive than biofuel made from virgin crops. Biodiesel is

not pure vegetable oil or animal fats. The oil must be refined through a process called *esterification* in which an industrial alcohol and a catalyst convert the oil into biodiesel.[241] Use biodiesel that conforms to ASTM standards to ensure that it performs properly.*

Biodiesel is often blended with conventional diesel in varying amounts. Biodiesel labeled "B20" is composed of 20 percent biodiesel and 80 percent conventional diesel and "B5" biodiesel is 5 percent biodiesel and 95 percent conventional diesel, etc. Biodiesel blends with ULSD will yield greater emission reductions. Most engines are compatible with biodiesel blends up to B20. Check with the manufacturer or rental company for recommendations and/or warranty issues. Biodiesel may release accumulated deposits from fuel tank walls and pipes, potentially causing clogs in the fuel filter. The fuel filter should be changed after the first tank of biodiesel. Some rubber fuel system components may also need to be replaced with biodiesel-compatible rubber, especially in older engines.

Compared to petrodiesel, biodiesel reduces PM, GHGs, sulfates, and HC. Go to Section 10.10 (page 121) to calculate your emissions reductions. Some DPFs may be compatible with biodiesel and may provide additional reductions compared with using ULSD.[242] As a consideration, some studies have shown a slight increase in $NO_x$ while others show a slight decrease $NO_x$ emissions from using biodiesel compared with conventional diesel. Further investigation is planned to yield more conclusive results.[243] Also, using B20 may result in a slight fuel economy loss of around one to two percent compared to fueling with petrodiesel.[244]

Go to www.epa.gov/smartway/growandgo/documents/factsheet-biodiesel.htm for more information on benefits of biodiesel and how it is produced.

Find biodiesel fueling stations at the National Biodiesel Board website (www.biodiesel.org/buyingbiodiesel/distributors/).

**Natural Gas**

Natural gas burns cleaner than gasoline or diesel but must be used in vehicles with specially-designed engines. It emits 90 percent less PM and CO compared to diesel. However, natural gas is mostly $CH_4$, a GHG. Some studies show that there are no GHG reductions from using natural gas—the $CO_2$ reductions are offset by escaping $CH_4$.[245] It is important to ensure that there are no leaks in the tanks. Natural gas can be used in vehicles as compressed natural gas (CNG) or liquefied natural gas (LNG). CNG is natural gas pressurized to 3,600 pounds per square inch and LNG is natural gas condensed to its liquid state by cooling it to -260°F.[246]

A wide range of light-duty vehicles that run on CNG are available. While natural gas engines are not available for off-road heavy-duty equipment, there are natural gas options for hauling-trucks. Search

* ASTM International is an international organization that develops standards for a wide variety of materials and products. Biodiesel should comply with ASTM D6751 standards.

for natural gas vehicles at the EERE Alternative Fuels and Advanced Vehicles Data Center website (www.eere.energy.gov/afdc/afv/afdc_vehicle_search.php).

CNG is a cleaner burning fuel which reduces maintenance costs compared with conventional diesel engines.[247] Note that CNG cylinders must be inspected every 36 months or 36,000 miles. Go to the Clean Vehicle Education Foundation website for more information on natural gas vehicles (www.cleanvehicle.org/technology/cylinder.shtml).

Go to www.eere.energy.gov/afdc/fuels/natural_gas.html for more information on natural gas.

**Emulsified Diesel Fuel**

Emulsified diesel is a mixture of diesel fuel, water, and other additives which lowers combustion temperatures to reduce PM and $NO_x$ emissions.[248] The water content in emulsified fuels is between 5 and 30 percent. This fuel can be used in any diesel engine though some power and fuel economy losses may be expected. While emulsified diesel stays well mixed for a fairly long time, the water may settle out after a few months of dormancy. [249]

Find verified emulsified fuels at the following websites:

- EPA Verified Diesel Retrofit Technology www.epa.gov/otaq/retrofit/verif-list.htm
- CARB Verified Diesel Retrofit Technology www.arb.ca.gov/diesel/verdev/vt/cvt.htm

Table 9 Cleaner and Alternative Fuels

| | Ultra-Low-Sulfur Diesel | Biodiesel | Natural Gas | Emulsified Fuel |
|---|---|---|---|---|
| **Fuel Description** | Ultra-low-sulfur diesel (ULSD) has less than 15 ppm sulfur content. Low-sulfur diesel (LSD) contains less than 500 ppm sulfur content. | Renewable fuel made from animal or vegetable fats. Can be blended with conventional diesel. Usually found in 2% (B2), 20% (B20), and 100% (B100) blends. | Gas consisting mainly of methane. In the forms of compressed natural gas and liquefied natural gas. | Fuel that is mixed with water and additives to lower combustion temperatures which reduces $NO_x$ and PM. Refer to the CARB verified list for qualified emulsified fuels. |
| **Emissions Reductions (compared to low-sulfur diesel)** | PM 13%[250]<br>$NO_x$ 3%[251]<br>CO 6%[252]<br>HC 13%[253] | B20<br>PM 10%[254]<br>$NO_x$* -2%[255]<br>CO 10%[256]<br>HC 21%[257]<br>Sulfates 20%[258]<br>$CO_2$ 15%[259] | PM 90%[260]<br>$NO_x$ 50%[261]<br>CO 90%[262]<br>HC 50 to 75%[263]<br>$CO_2$ 25%[264] | PM 16 to 58%[265]<br>$NO_x$ 9 to 20%[266]<br>CO 13%[267]<br>HC -30 to -99%[268] |
| **Cost** | $0.04 -$0.05 more per gallon than low-sulfur diesel[269] | As of July '07, B20 was the same price as conventional diesel[270] | ~15 to 40% less than gasoline per gallon[271] | ~$0.20 more per gallon than conventional diesel[272] |
| **Considerations** | Most verified retrofit technologies require the use of LSD or ULSD. In June 2006, CARB mandated the use of ULSD in both on- and off-road vehicles in California. Nationwide mandates for ULSD use in on-road engines came into effect in 2006 and mandates for LSD use in off-road vehicles came into effect in 2007. | Biodiesel blends lower than B20 experience insignificant difference in torque, horsepower, and fuel economy compared to conventional diesel.<br>Using higher biodiesel blends may require changing fuel filters and replacement of rubber compound fuel system components with compatible rubber.<br>Use biodiesel that meets the ASTM D6751 standard.<br>Monitor performance in cold weather operation and ensure proper additives are used to prevent gelling. | Needs more frequent fueling.<br>Natural gas vehicles cost about $3,500 to $6,000 more than gasoline equivalents.[273] | May affect horsepower in some applications.<br>Can be used in any diesel engine. |

*NREL and EPA are conducting further evaluations to determine potential $NO_x$ increase.

## 8.3 CLEAN DIESEL SAMPLE LANGUAGE AND RELEVANT LAWS AND REGULATIONS[274]

This section includes information on sample language used in contracts that may be useful when writing task orders. Some current state laws and regulations that address diesel emissions are also listed.

### *Sample Cleaner Diesel Language*

Many areas of the country are placing clean diesel language in contracts, codes, laws, rules and other measures to reduce emissions from construction equipment and other diesel sources. Go to www.epa.gov/cleandiesel/construction/contract-lang.htm for examples of language that address air quality issues, particularly diesel emissions, from construction equipment and other diesel sources.

### *Laws and Regulations*

The following are some state incentives and laws concerning alternative fuels and clean diesel practices. As of the writing of this document, no relevant laws were found for Hawaii, Nevada, or the Pacific Islands. Go to www.eere.energy.gov/afdc/laws/incen_laws.html for a more comprehensive list of state and local incentives and rules.

*Arizona*

- Alternative Fuel and Alternative Fuel Vehicle (AFV) Tax Exemption: The Arizona Use-Tax does not apply to the following: natural gas or liquefied petroleum gas used in motor vehicles; AFVs if the AFV was manufactured as a diesel fuel vehicle and converted to operate on an alternative fuel; and equipment that is installed in a conventional diesel fuel motor vehicle to convert the vehicle to operate on an alternative fuel.
- Alternative Fuel Vehicle License Tax: The initial annual vehicle license tax on an AFV is lower than the license tax on conventional vehicles. The vehicle license tax on an AFV is $4 for every $100 in assessed value. The assessed value of the AFV is determined as follows: during the first year after initial registration, the value of the AFV is one percent of the manufacturer's base retail price (as compared to 60 percent for conventional vehicles); during each succeeding year, the value of the AFV is reduced by 15 percent. The minimum amount of the license tax is $5 per year for each motor vehicle subject to the tax.
- Alternative Fuel Vehicle Special License Plate: AFVs must display an AFV license plate. State or agency directors who conduct activities of a confidential nature and have a vehicle powered by an alternative fuel are exempt from the requirement of displaying an AFV special license plate. The Arizona Department of Transportation has the authority to issue regular plates to AFVs that are used by law enforcement and the federal government.
- Clean Fuel Diesel for Heavy-Duty Equipment: Any state agency that contracts for the use of on- or off-road heavy-duty diesel equipment in Maricopa County, Pima County, and Pinal County must construct its Requests for Proposals in a manner that gives incentives to bidders that use:

equipment retrofitted with diesel retrofit kits; newer clean diesel technologies and fuels; or biodiesel or other cleaner petroleum diesel alternatives.

- Idle Reduction Requirement: Heavy-duty diesel vehicles operated in Maricopa County with a gross vehicle weight rating of more than 14,000 pounds must limit idling time to no more than 5 minutes. Exemptions apply for emergency vehicles, certain traffic or weather conditions, certain driver accommodations, and idling necessary for refrigeration equipment.

*California*

- Idle Reduction Requirement – Trucks: The new engine requirements call for 2008 and newer model year heavy duty diesel engines to be equipped with a non-programmable engine shutdown system that automatically shuts down the engine after 5 minutes of idling or optionally meets a 30 gram per hour $NO_x$ idling emission standard. The in-use truck rules require operators of sleeper berth-equipped trucks to manually shut down their engine when idling more than 5 minutes at any location within California beginning in 2008. The penalty for violating this measure is $100 per violation.
- In-Use Off-Road Diesel Vehicle Regulation: This regulation establishes fleet average emission rates for PM and $NO_x$ that decline over time. Each year, the regulation requires each fleet to meet the fleet average emission rate targets for PM or apply the highest level verified diesel emission control system to 20 percent of its total horsepower. In addition, large and medium fleets are required each year to meet the fleet average emission rate targets for $NO_x$ or to "turn over" a certain percent of their horsepower. "Turn over" means repowering with a cleaner engine, retiring a vehicle, replacing a vehicle with a new or used piece, or designating a dirty vehicle as a low-use vehicle. If retrofits that reduce $NO_x$ emissions become available, they may be used in lieu of turnover as long as they achieve the same emission benefits.
    - Large fleet (>5,000 hp) first average compliance date: 2010
    - Medium fleet (2,501 hp – 5,000 hp) first average compliance date: 2013
    - Small fleet (≤2,500 hp) first average compliance date: 2015

  For more information on this regulation, go to www.arb.ca.gov/msprog/ordiesel/ordiesel.htm.

## 8.4 SUCCESS STORIES

**AMCO Superfund Site, Oakland, CA, Region 9**

The AMCO Superfund site was owned and operated by AMCO Chemical as a chemical distribution facility from the 1960s to 1989. Removal of lead soil in residential neighborhoods occurred in the summer of 2007. The mini-excavator and skid-steer used on the site were fueled with a B10 biodiesel blend. The biodiesel was picked up from a biodiesel distributor about 6 miles away from the site. The rental company allowed a maximum of 10 percent biodiesel blend fuel to be used in their equipment, although there are usually no technological barriers to using a higher blend. In total, this removal used 150 gallons of B10. No issues were encountered with the use of B10 in the equipment used at the AMCO removal. The use of biodiesel avoided 45 grams of PM emissions.

Site Contact:
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**Camp Pendleton Marine Corps Base, Superfund Site, about 40 miles north of San Diego, CA, Region 9**

Camp Pendleton Marine Corps Base has nine areas of soil and groundwater contamination due to past disposal practices. From late 2007 to early 2008, 120,000 $ft^3$ of soil were excavated and removed. Camp Pendleton made efforts to use newer engines, biodiesel, and to retrofit engines with DPFs for the excavation. Two pieces of equipment had the latest (Tier 3[†]) technology and were retrofitted with DPFs. Four pieces of equipment had the latest (Tier 3) technology and were fueled with B20. Two pieces of equipment were fueled with B5. The retrofits and DPFs reduced PM emissions by 27 percent. Compared to Tier 1 engines, Tier 3 engines emit 63 percent less PM.

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[†] Tiers are levels of federal emissions standards that vary depending on vehicle type, size, and year of manufacture. Higher tiers are stricter than lower tiers. For more information, go to www.dieselnet.com/standards/.