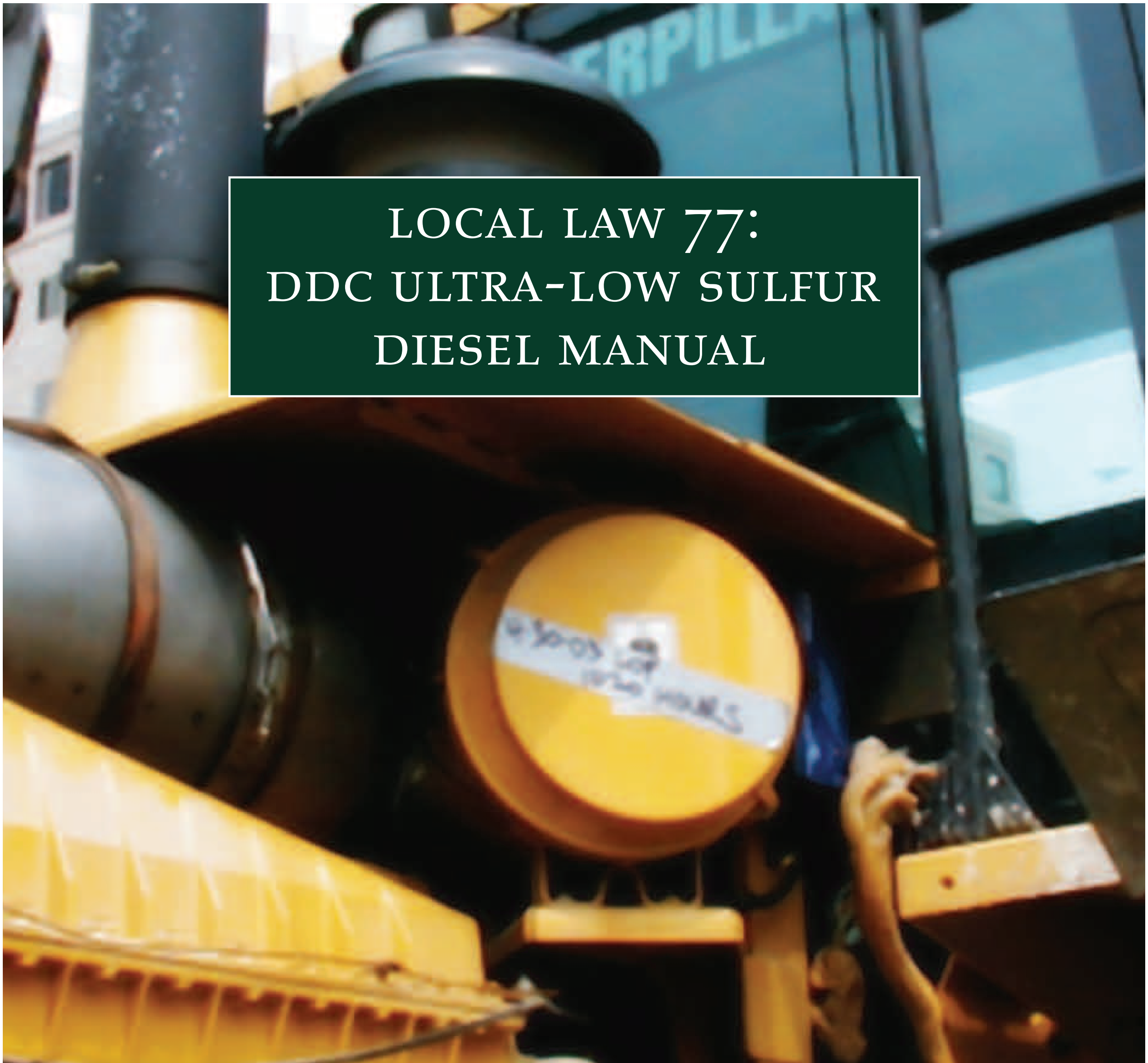
LOCAL LAW 77: DDC ULTRA-LOW SULFUR DIESEL MANUAL



City of New York
DDC
Department of Design and Construction

Prepared for
NYC Department of Design & Construction by

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This document is an introduction and resource handbook for understanding New York City Local Law 77. This law requires the use of ultra-low sulfur diesel fuel (ULSD) and "best available technology" (BAT) for reducing emissions form non-road equipment used on City construction projects. The handbook is addressed to all the participants in the projects for the New York City Department of Design and Construction (DDC), but especially the administrators and managers from DDC, construction managers and contractors. Its goal is to assist these professionals to understand and meet the requirements of NYC Local Law 77.

EXECUTIVE ACKNOWLEDGEMENTS

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EXECUTIVE SUMMARY

It has become increasingly clear that diesel exhaust is a serious air pollutant, causing significant adverse health effects nation-wide, but particularly in dense urban areas. According to New York City's Local Law 77, these health effects include "an increased risk of cancer... decreased lung function, aggravated asthma, respiratory symptoms, and premature death." Much of this pollution comes from cars and trucks, but a significant and growing proportion is emitted by non-road sources, including construction equipment. While new vehicle and fuel standards for on-road cars and trucks have become more stringent in recent years, standards for non-road equipment have lagged. Consequently, non-road sources are becoming a more important contributor to over-all vehicle emissions.

In response, New York City has recently passed legislation, Local Law 77, that requires the use of ultra low sulfur diesel fuel (ULSD) and "best available technology" (BAT) for reducing emissions from non-road equipment used on City construction projects. This legislation was specifically introduced to off-set increased emissions from the significant construction activity that will take place around the World Trade Center site over the next few years, and initially applies only to projects in lower Manhattan. Starting in 2004, however, these requirements will be phased in to all City construction projects city-wide. Consequently, this law will have an impact on many DDC projects in the very near future.

In addition, the US Environmental Protection Agency recently passed strict new emission regulations for both on- and non-road diesel vehicles and equipment in an effort to improve air quality in the United States. The focus of these new regulations, which take effect between 2006 and 2010, is the reduction of oxides of nitrogen (NOx), a smog forming ozone pre-cursor, and the reduction of particulate matter (PM) emissions that impair visibility and damage the health of individuals, particularly construction workers, children and the elderly. To facilitate these new emission control levels the EPA is also requiring the use of ULSD, with a sulfur content no greater than 15-ppm, beginning in June 2006 for on-road vehicles and June 2010 for non-road vehicles and engines. Current (2004) EPA regulated on-road diesel fuel is allowed to have up to 500-ppm sulfur and off-road diesel fuel is allowed to have up to 3,000-ppm sulfur.

While the new fuel rules will apply to all vehicles, the EPA vehicle regulations only apply to new diesel vehicles and engines. Given the significant inventory of existing diesel vehicles in use and their propensity for long life, the full benefits of the new EPA regulations will be delayed for several decades. It is in this context that New York City passed Local Law 77. This law mandates early use of cleaner ULSD as well as engine and retrofit technologies that have been developed to meet the more stringent future EPA mandates. Without the new EPA rules in place, it is unlikely that the requirements of Local Law 77 could be enacted because appropriate fuels and emissions reduction technologies would not be available. But without Local Law 77 it would be many years before most of the diesel construction equipment used in NYC would be significantly cleaned up.

This requirement to use ULSD and BAT applies to all city-owned non-road diesel vehicles and engines, as well as any privately-owned diesel vehicles and engines used on construction projects funded by the City. In order to comply with this new law, the DDC is writing this requirement into its General Conditions for future DDC sponsored projects, and will be required to monitor Contractor compliance. Failure to comply will subject the Contractor to significant civilian fines, which will be assessed by the New York City Department of Environmental Protection.

The requirements of Local Law 77 will have a modest impact on construction costs. The current price per gallon for ULSD can be expected to be about $0.10 to $0.19 per gallon higher than standard #1 on-highway diesel fuel, due in part to the dedicated infrastructure necessary to prevent contamination. This price gap is expected to shrink to roughly 10 cents as ULSD becomes standard for all on-road vehicles after 2006. The cost of BAT retrofit is highly variable, ranging form $3,000 to over $20,000 for each piece of equipment, depending on the technology and the equipment size.

The New York City Department of Environmental Protection is also required under the law to develop and publish regularly updated lists of BAT for various types of non-road vehicles and engines. While the requirement to use ULSD is already in effect, the BAT requirements will not take effect until DEP publishes the BAT lists, which will be posted on the DEP web site. Once BAT determinations have been made, DDC sponsored projects will be required to make sure that their projects comply with the requisite emission controls or BAT's, as they are updated by DEP.

Diesel engine technology has changed significantly over the last 20 years, and new engines delivered today, especially those used in on-road vehicles, are significantly different that those in older vehicles. Many of these changes have reduced NOx and PM emissions significantly compared to the older engines. In general, there are three ways that emissions from diesel engines can be reduced: 1) make changes to the design of the engine itself, 2) install an "after-treatment" device which does not affect the way the engine operates, but instead cleans up the exhaust after it has left the engine, and 3) use a non-standard alternative diesel fuel which burns more cleanly in the existing diesel engine. At this point in time, ULSD is considered to be a non-standard, cleaner diesel fuel, but it is not the only one available.

The above three approaches to emissions reduction are not mutually exclusive. In fact, some after-treatment technologies work better with alternative diesel fuels, or may even require the use of a non-standard fuel to be effective. Likewise, some fuels or after-treatment technologies may work better in combination with engine modifications. In addition, each fuel and technology option has a different cost, and some may pose significant implementation challenges on particular engines or vehicles where space is at a premium.

These factors, combined with the sheer variety of diesel equipment used on construction sites, make it a virtual certainty that DEP's lists of BAT will include a variety of options. It is highly unlikely that any one fuel and/or technology approach will be designated as the best available technology for all diesel vehicles and engines used in construction activities in NYC. In fact, for some vehicle types DEP may determine that the use of ULSD by itself constitutes the best available technology. For other vehicle types, DEP may determine that some form of engine modification, engine replacement, or after-treatment retrofit will be required to bring the vehicle to the point that it incorporates the best available technology. For other vehicle types, DEP may determine that there is more than one equivalent option, and the BAT list may include several alternatives to choose from. In this latter case, the alternatives may include the use of a non-standard fuel blend with ULSD, which provides even greater emissions reductions than ULSD by itself.

The purpose of this report is to provide DDC Project Managers and City Contractors with information to help them implement Local Law 77 on NYC construction projects. The report provides background information on diesel engine emissions, health effects and regulations. It also includes information on ULSD and how it is different than standard diesel fuel, plus a primer on all of the commercially available alternative diesel fuels and retrofit technologies that are likely to appear as NYSDEP BAT. Finally, it provides specific information about the responsibilities of DDC project managers in implementing Local Law 77, and information about real and perceived obstacles to implementation. Several DDC projects – both Infrastructure and Structure – will serve as pilot projects to help DDC identify any difficulties with implementation.

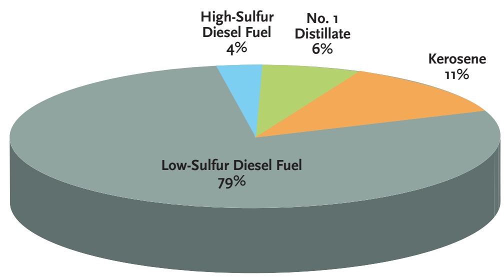
2
OVERVIEW

OVERVIEW

CURRENT SITUATION

Prior to Local Law 77 the most common fuels used in New York City construction equipment have been diesel fuels and kerosene. The (500-3000 ppm) sulfur diesel fuel category includes No. 1 Distillate, No. 2 Distillate, High-Sulfur Diesel and Low Sulfur Diesel (<500 ppm). These fuels have been used at the discretion of the contractors, usually determined by availability and economics. It turns out that, although non-road equipment is currently allowed to use high sulfur diesel, approximately 85% of the diesel currently purchased for this equipment is low-sulfur diesel. This is because low-sulfur diesel is less corrosive to the engines.

Figure 1
New York State 2002 Daily Average Fuel Use



Source: Energy Information Administration, Petroleum Marketing Annual 2002

For the purposes of emissions regulations, the US Environmental Protection Agency (EPA) makes a distinction between on-road and non-road vehicles. Various types of equipment are labeled as non-road, including outdoor power equipment, recreational vehicles, farm and construction machinery, lawn and garden equipment, marine vessels and locomotives. The non-road classification applies to equipment and vehicles that are not driven on public roads and highways. Much of the equipment used on construction sites, including dozers, loaders, and cranes are classified as non-road equipment.

Until the mid-1990s, emissions from these non-road vehicles were largely uncontrolled. Emissions regulations for on-road vehicles started earlier and continue to set more stringent requirements than those for non-road equipment, so that most on-road equipment is significantly cleaner than non-road equipment produced in the same model year. Non-road diesel equipment accounts for one fifth of NOx emissions and almost half the PM emissions from diesel, nationwide, as illustrated in Figures 2 and 3, and these figures are likely to be similar in New York City. As shown in Table 1, construction equipment accounts for a majority of non-road PM10 and NOx emissions in New York City. (PM10 is the "coarse" portion of particulate matter, defined as having a particle size between 2.5 and 10 microns in diameter.) Taking Figures 2 and 3 and Table 1 together, we see that construction equipment may account for as much as 13% of NOx and 30% of PM emissions form all diesel fuel in NYC.

The EPA regulates allowable levels of six "criteria pollutants" from all new engines/vehicles, but with respect to diesel engines the three primary pollutants of greatest concern are Particulate Matter (PM), Nitrogen Oxides (NOx), and Ozone.

PARTICULATE MATTER EMISSIONS

Particulate Matter (PM)[1] from internal combustion engines is primarily composed of carbon particles, which absorb organic hydrocarbon compounds on their surfaces. Most carbon in motor vehicle fuels is oxidized to gaseous carbon dioxide (CO_2) during combustion, however, diesel engines can produce carbon particles in their exhaust as a result of incomplete combustion in addition to other hydrocarbons and carbon monoxide. If there is sulfur in the fuel, sulfur compounds will also be present in the particulate, along with some metals from the fuel, lubricating oil and engine wear products. While sulfur compound emissions are a concern, it is the adsorbed organic fraction that poses the largest toxic risk associated with the particulate. Because the carbon particles are generally less than 2.5 microns in diameter (greater than 90 percent, by mass, are typically less than 1 micron), they remain airborne and can be inhaled deep into the lungs where the adsorbed organic compounds can lead to respiratory problems,

[1] *There are two categories of particulate matter: PM-10 and PM-2.5. PM-10 represents all particulate matter sized at or below 10 microns and PM-2.5 is all PM less than 2.5 microns in size.*

such as asthma. The relative amount of PM produced by any engine, as well as the organic fraction of the PM produced, is dependent upon the fuel combusted, its combustion residence time, combustion temperature, and engine lubricant. Several things can initiate the formation of carbon particulate emissions, either separately or in combination, including incomplete combustion from engine over-fueling, engine misfiring, lubricant combustion and impurities in the fuel. As a corrective, some engine installations include after-treatment in the exhaust system (an oxidation catalyst or diesel particulate filter) which can reduce PM emissions by further oxidizing some portion of the PM's.

NITROGEN OXIDES

The two most toxicologically harmful nitrogen oxides (NOx), and the two most prevalent in vehicle exhaust, are nitric oxide (NO) and nitrogen dioxide (NO2), both of which are formed at the high temperatures present during combustion. These two gases are both nonflammable and colorless to brown at room temperature. Nitric oxide is a sharp sweet-smelling gas at room temperature, whereas nitrogen dioxide has a strong, harsh odor and is a liquid at room temperature, becoming a reddish-brown gas above 70°F. Both NO and NO2 are respiratory irritants, and NO2 is an ozone precursor (see below).

All internal combustion engines, regardless of the fuel used, produce NOx emissions as a result of oxidation of nitrogen in the combustion air. The primary factors affecting the amount of NOx produced are peak combustion temperature and the duration of combustion at that temperature. Higher combustion temperatures result in higher NOx emissions. Changes to the combustion cycle, as well as some alternative fuel formulations, can reduce peak combustion temperature, thus reducing NOx emissions.

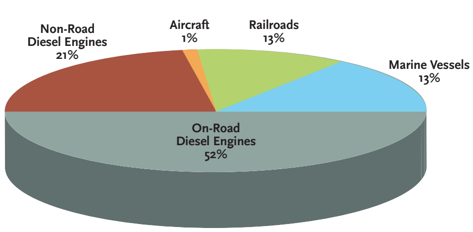
OZONE

Ozone is not directly emitted from vehicle exhaust. It is formed in the atmosphere via a chemical reaction between NOx and Volatile Organic Compounds (VOC) in the presence of heat and sunlight. Both NOx and VOC's are present in vehicle exhaust and are therefore regulated as precursors for ozone.

Ozone at ground level is a respiratory irritant that has been shown to exacerbate asthma symptoms and to cause lung tissue damage. Many urban regions of the U.S., including NY City, have ozone in excess of the National Ambient Air Quality limits, and are therefore considered by EPA to be in "non-attainment."

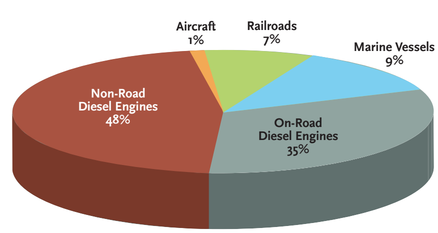
Because both NOx and VOCs are considered ozone precursors it is important that reductions in emissions of one of these compounds are not achieved at the expense of the other, as this would partially negate the desired effect from an air quality standpoint.

Figure 2
2001 NO_x Emmisions



Source: http://www.epa.gov/ttn/chief/trends/index.html

Figure 3
2001 PM Emmisions



Source: http://www.epa.gov/ttn/chief/trends/index.html

TABLE 1: COMPARISON OF HEAVY DIESEL NON-ROAD EQUIPMENT WITHIN THE 5 COUNTIES OF NEW YORK CITY FOR 1999

	PM_{10}		NO_x	
	TONS/YEAR	% SHARE	TONS/YEAR	% SHARE
Agricultural Equipment	0.0	0%	0.0	0%
Airport Ground Support Equipment	53.3	2%	589.5	2%
Commercial Equipment	386.4	13%	2701.5	9%
Construction (and Mining Equipment)	1916.8	66%	19251.6	61%
Diesel (Harbor Vessels, Inboard, Outboard, Railway Maintenance, & Yard Locomotives)a	275.7	9%	6763.2a	21%
Industrial Equipment	258.2	9%	2275.8	7%
Lawn and Garden Equipment	15.8	1%	127.5	0%
Recreational Equipment	1.1	0%	4.9	0%
Diesel Non-road Total	2907.3		31714.1	

Source: Air Pollutant Emissions Trends, EPA's National Emissions Inventory 1999
[a] NOx and PM emissions from the Trends inventory were adjusted with updated 2000 year information from the Commercial Marine Vessel Emission Inventory (CMVEI) by Starcrest Consulting, April 2003.

ENVIRONMENTAL AND HEALTH IMPACTS

Emissions of PM and NOx from the operation of non-road equipment negatively affect the environment and the health of project workers and the general public, and the health impacts of diesel pollution can be severe. Under the Clean Air Act (CAA), the U.S. EPA is responsible to set National Ambient Air Quality Standards (NAAQS) for six criteria pollutants: nitrogen dioxide (NO_2), carbon monoxide (CO), particulate matter (PM), sulfur dioxide (SO_2), ground-level ozone (O_3), and lead (Pb). These criteria pollutants create the greatest concerns to the environment from fuel burning sources.

There are health concerns over both short-term and long-term exposure to air pollution. Acute exposure to certain air contaminants can cause immediate reactions such as coughing, wheezing, or watery eyes. Chronic contact over the long-term can cause permanent effects such as asthma, emphysema, and cancer. Additional detail can be found in Table 2. Reducing diesel emissions will result in positive health benefits for the general public, particularly children and the elderly, and even more for workers who use diesel equipment, by reducing their exposure.

TABLE 2: HEALTH CONCERNS BY POLLUTANT

POLLUTANT	HEALTH CONCERN
Nitrogen Oxides	Lung irritation, respiratory illness, & premature death
Carbon Monoxide	Headaches & reduced mental alertness
Particulate Matter	Increased respiratory disease, lung damage, cancer & premature death
Sulfur Dioxide	Increase in existing heart disease, breathing difficulties, & respiratory illness
Ozone	Breathing difficulties, respiratory infections, & lung tissue damage

Note: Lead is not a component of diesel fuel.

For gasoline and diesel vehicles, the pollutants of primary concern are particulate matter (PM), nitrogen oxides (NOx), and ozone produced from the NOx and VOC's that their engines emit. All three of these pollutants can have primary negative health effects. There have been various studies performed demonstrating a link between exposure to diesel exhaust and increased lung cancer occurrences.[2,3] A national estimate of cancer risk from diesel exhaust found that it is the #1 air toxics cancer risk in the U.S.[4] Breathing particulate matter (PM) in the most polluted U.S. cities poses the same risk as living with a smoker according to a 2002 American Cancer Society study.[5]

[2] *Bhatia R, Lopipero P, Smith AH. Diesel exhaust exposure and lung cancer. Epidemiol, 9: 84-91, 1998.*
[3] *www.dieselnet.com/papers/0203watts/#health*
[4] *U.S. PIRG (2002). Dangers of Diesel. , http://uspirg.org/reports/dangersofdiesel2002/dangersofdieselreport2002.pdf*
[5] *Clean Air Task Force, Diesel Engines: Health and Environmental Impacts*

Non-road diesel-fueled equipment can significantly increase ambient particulate matter concentrations in areas close to the source. In some cases it has increased the exposure levels for workers and nearby residents to 16 times above the average ambient concentrations normally recorded in the area without non-road equipment operating.[7] Because of these high exposures, construction workers can experience health concerns such as redness in eyes, decreased pulmonary function, and shortness of breath. There is evidence that exposure will exacerbate existing asthma and allergy symptoms. EPA has concluded that long-term (i.e., chronic) inhalation exposure is likely to pose a lung cancer hazard to humans, and to damage the lung in other ways depending on exposure.[6] These reactions have an impact on worker productivity.[8] Consequently, there is a potential financial benefit to society from decreasing the exposure of workers and nearby residents to diesel pollution, thereby reducing long-term costs associated with health care and lost productivity.

In New York City, concern over diesel pollution is particularly acute due to its potential to cause or exacerbate serious respiratory conditions such as asthma. For a number of years, the City has had a serious epidemic of asthma, especially among school children. According to the American Lung Association, in 2000, there were 26,868 asthma-related hospitalizations in NYC, representing significant human suffering, as well as a significant cost for health care expenditures and lost productivity.

WHAT CAN BE DONE

There are three ways to reduce emissions from diesel vehicles: 1) make changes to the design of the engine itself, 2) install an "after-treatment" device which does not effect the way the engine operates, but which cleans up the exhaust after it has left the engine, and 3) use a non-standard alternative fuel which burns more cleanly in the existing engine. The first option is the most expensive, so in response to increasingly stringent regulation (see next section), diesel engine manufacturers and others have developed a number of fuel and technology options that can now be applied to existing and new diesel engines to make them cleaner.

As seen in Figure 1, there is no statistically significant use of cleaner diesel fuel alternatives in New York State. One of the most widely used alternatives to standard diesel fuel in New York City right now is Ultra Low Sulfur Diesel fuel (ULSD). ULSD is petroleum diesel that has been refined to reduce its sulfur content to very low levels, typically less than 15 parts per mission (ppm), compared to 350-500 ppm for standard on-road diesel fuel and up to 3,000 ppm for standard ("low-sulfur") off-road diesel fuel. While the use of ULSD alone provides only modest emissions benefits, when used in conjunction with certain after-treatment technologies, it can reduce particulate emissions from diesel engines by up to 90%. Currently, MTA New York City Transit is the largest single user of ULSD in the country, consuming about 47 million gallons of ULSD annually in its transit bus fleet, although even this level of use is not large enough to be visible in Figure 1. The current price per gallon for ULSD can be expected to be about $0.10 to $0.19 per gallon higher than standard on-road #1 diesel fuel, due in part to the dedicated infrastructure necessary to prevent contamination by higher sulfur fuels during delivery from the refinery to the end user.

ULSD can also be blended with small volumes of other substances such as alcohol, water, or diesel-like fuel derived from biological sources (bio-diesel). These alternative ULSD fuel blends have a variety of environmental benefits over and above the use of pure ULSD, as well as some disadvantages discussed in later sections of this report. There are also clean alternatives to diesel such as natural gas engines,

[6] *EPA, Health Assessment Document For Diesel Engine Exhaust, EPA/600/8-90/057F, May 2002*
[7] *NESCAUM, Evaluating the Occupational and Environmental Impact of Nonroad Diesel Equipment in the Northeast , Interim Report June 9, 2003*
[8] *www.cdc.gov/niosh/88116_50.html , Carcinogenic Effects of Exposure to Diesel Exhaust, August 1998*

although given the cost and complexity of conversion natural gas would typically be used on a new piece of equipment rather than a retrofit.

In addition to ULSD and alternative ULSD fuel blends, a variety of technology options can be applied to new engines, or retrofitted to existing engines to significantly reduce PM and/or NOx emissions. The most common of these technologies that are commercially available today, or will be soon, include: diesel oxidation catalysts (DOC), catalyzed diesel particulate filters (DPF), active diesel particulate filters, exhaust gas recirculation (EGR), selective catalytic reduction (SCR), NOx adsorbers, and Lean NOx catalysts. As with the alternative fuels mentioned above, all of these technology options have both advantages and disadvantages which will be discussed in later sections of this report.

REGULATORY CLIMATE

New local, state and federal regulations are driving changes in the way heavy-duty vehicles and construction equipment are manufactured and used. Fuel- and technology-based solutions either have been, or are in the process of being, devised to meet the new requirements.

NEW YORK CITY REGULATIONS

On December 22, 2003, New York City adopted Local Law 77, which mandates the use of ultra low sulfur diesel fuel and best available technology by non-road vehicles in city construction. This law will require ultra-low sulfur diesel (ULSD) fuel and best available technology (BAT) to be used in heavy diesel construction equipment above 50 horsepower (hp) on all construction contracts funded by the City. These requirements are being phased in, starting in lower Manhattan in June 2004 and expanding to include the entire city of New York by December 2004. It will be in effect for equipment "owned by, operated by or on behalf of, or leased by a city agency."[9,10] The requirements of this law are discussed in greater detail in Section 3, and the full text is in Appendix C. (see NYC DEP's website at http://nyc.gov/html/news/notices.html for information on the schedule of the phase-in and the BAT's they will require.) Finally, the specific application of this law to DDC projects is discussed in greater detail in sections 8 and 9 of this report.

NEW YORK STATE REGULATIONS

The Federal Clean Air Act Amendments (CAAA) of 1990 requires New York State to follow a comprehensive approach to reducing emissions from mobile (on-road and non-road) and stationary sources. The New York State Department of Environmental Conservation (NYS DEC) is charged with developing programs and enforcing the state regulations to help achieve air quality standards and maintain compliance with the CAAA.

Mobile Sources

As noted above, many of the state regulatory actions for mobile sources have been precipitated by Federal law and policies. While NYS DEC has had an inspection and maintenance program for light duty cars and trucks for the better part of the past two decades, only in recent years has attention been given to heavy-duty diesel engines. The two programs NYS DEC has developed to date apply only to on-road heavy-duty diesel vehicles (HDDV) and they place limits on exhaust opacity and on unproductive engine idling. To date, NYS DEC has not implemented any regulations that apply to non-road diesel vehicles.

Anti-Idling

As part of NYS DEC's approach to reducing emissions, an anti-idling regulation has been adopted for heavy duty diesel vehicles (HDDVs). Since idling contributes significantly to localized air pollution problems, it is not allowed for more than five consecutive minutes. However, there are practical exceptions

[9] *Taken from the text of Intro 191A. Also, a city agency is defined by the law as "a city, county, borough, administration, department, division, bureau, board or commission, or a corporation, institution or agency of government, the expenses of which are paid in whole or in part from the city treasury.*

[10] *See Appendix C for the complete law.*

to this rule. Exceptions that might be encountered on construction sites are during maintenance, while stopped in traffic, and in cold weather conditions below 25°F.

Opacity

Annually, all on-road heavy-duty diesel vehicles (HDDVs) (>8,500 lb GVW) are required to have an opacity, or smoke, test at the same time as the vehicle receives the New York State Department of Motor Vehicles safety inspection. In addition, random roadside opacity testing is performed by the New York State Department of Transportation and New York State Police. NYS DEC also has the authority to require a random roadside inspection.

TABLE 3: NEW YORK STATE OPACITY STANDARDS

HDDV ENGINE MODEL YEAR	OPACITY STANDARD
1973 and older	70 %
1974 – 1990	55 %
1991 and newer	40 %

Opacity is a measure of how much light can pass through a vehicle exhaust stream, and is measured using an opacity meter. An opacity meter directs a light source of known frequency and intensity across the HDDV exhaust stream to a sensor. The higher the opacity of the exhaust, the more PM is contained in the exhaust, becuase solid PM blocks light transmission. An opacity test is a snapshot of the vehicle exhaust over a period of free engine acceleration from idle. Three tests are performed in quick succession and averaged to determine the vehicle exhaust opacity. NYS Opacity limits are presented in Table 3.

The NYS opacity standards are consistent with the standards of other Northeast states. These standards are not particularly stringent given modern diesel engine technology, and stationary sources are typically held to a 20% opacity standard in the same states in which new diesel vehicles are held to the less stringent 40% standard noted in Table 3.

Generators

One special category of equipment that can be regulated as either a non-road or stationary source, depending upon how it is used, is a diesel-electric generator. During the construction phase, the generators on-site are regulated as non-road equipment; however, if used for main, auxiliary, or emergency power at a completed building, they are regulated as stationary sources. NYS DEC has implemented regulations that require Reasonably Available Control Technology for stationary source generators. The RACT regulations do not apply to generators used for purely emergency purposes, but they would apply if the City decided to use these generators for peak load shaving and/or as part of its distributed generation strategy. See section on "Relevance to DDC" for further discussion of this subject. Further detail regarding RACT for generators is provided in Appendix G.

FEDERAL REGULATION

On-Road

In heavy-duty trucks and buses, diesel engines dominate the market, with nearly 90 percent of the fuel used in heavy-duty vehicles being diesel. Over the last twenty years, the number of heavy duty vehicles on the road has increased by roughly 25%, and the number of miles driven by them annually has doubled.[11] With many of these engines lasting for many years and several hundreds of thousands of miles, their environmental impact is significant. For the most recent year where data is available (2001), heavy-duty diesel vehicles contributed nearly 24 percent of all particulate matter (PM) from the transportation sector.[12]

In 1970, the United States Environmental Protection Agency (EPA) acknowledged that reducing emissions from heavy-duty vehicles would significantly improve air quality. EPA first enacted opacity-based standards followed by standards, for hydrocarbons (HC), carbon monoxide (CO), nitrogen oxides (NOx), and PM. More recently EPA has focused more closely on reducing NOx and PM emissions from heavy-

[11] *Source: Transportation Energy Data Booth, Edition 23, US Department of Energy, Center for Transportation Analysis, Oak Ridge National Laboratory.*
[12] *Ibid*

duty vehicles. During the eight-year period after passage of the Clean Air Act Amendments of 1990 EPA lowered NOx and PM emission standards for new heavy-duty vehicles by 37 percent and 83 percent, respectively. And, starting in 2007, the emission standards will be lowered even more as shown in Table 4.

TABLE 4: EPA EMISSION STANDARDS FOR ON-ROAD HEAVY-DUTY ENGINES (G/BHP-HR) [a]

YEAR	NO_x	NMHC [b]	PM	
	HEAVY-DUTY & URBAN BUS ENGINES		HEAVY-DUTY ENGINES	URBAN BUS ENGINES
1991	5.0	1.3	0.25	0.1
1994	5.0	1.3	0.1	0.07
1998	4.0	1.3	0.1	0.05
2004	2.4 [c]		0.1	0.05
2007+	0.2	0.14	0.01	0.01

a – gram per brake horsepower-hour (g/bhp-hr)
b – Non-Methane Hydrocarbons
c – Manufacturers also have the option of meeting a combined 2.5 g/bhp-hr for NOx plus NMHC provided NMHC does not exceed 0.5 g/bhp-hr.

In order to meet these, diesel engines will have to be certified with exhaust after-treatment technologies, having already integrated nearly every internal engine upgrade option possible. Because control technologies such as diesel particulate filters and NOx catalysts can't function with high sulfur fuels, they essentially require the use of ultra-low sulfur diesel (ULSD) fuel. EPA has issued regulations that require on-road fuel sold after 2006 (mid-year) to have a maximum sulfur content of 15 parts per million (ppm).

Over the last fifteen years, manufacturers have made strides in producing cleaner diesel engines, relying primarily on engine modifications such as high-pressure injectors, pre-injection techniques, and exhaust gas re-circulation (EGR). Diesel oxidation catalysts have also been used, but are currently typically only required on urban buses.

NON-ROAD

EPA first began regulating emissions from non-road engines in 1996. This broad category includes construction and farm equipment, locomotives, marine vessels and aircraft. The first non-road emission standards were based on technologies used in on-road engines, but the standards were less strict.

Because on-road emissions are being dramatically reduced based on the earlier and more stringent regulation, non-road equipment is becoming a larger contributor, on a percentage basis, to local, regional, and national emissions inventories. For this reason, more attention is now being given to reducing emissions from non-road engines.

The early non-road standards focused primarily on nitrogen oxides (NOx), and smoke opacity. For larger engines, these standards also included limits on carbon monoxide (CO), hydrocarbons (HC), and particulate matter (PM). As with the on-road standards, the non-road regulations are being phased in over time. These emission standards are categorized in Tiers, with higher Tier numbers representing stricter emission requirements. For some equipment Tier 2 standards are already in effect and Tier 3 standards will take effect soon. For others, less stringent Tier 1 standards are currently in effect, with Tier 2 standards set to go into effect soon, and Tier 3 standards to become effective several years in the future.

In mid-2003, EPA proposed significantly stricter Tier 4 standards, scheduled to be phased in between 2008 and 2010. Also, following the most recent changes to on-road standards, they proposed regulations to limit the allowable sulfur content of diesel fuel used in non-road equipment to no more than 500-ppm by June 2007 and no more than 15-ppm by June 2010.

A summary of past, current, and proposed non-road emission standards is provided in Table 5. Note that for non-road equipment the allowable emission levels actually increase as the diesel engine rating decreases. Generally speaking this means that a smaller piece of equipment can and will emit more pollution than a larger piece of equipment performing the same activity. Also, since these regulations apply only to new equipment, their full effect will not be felt for many years, as all older equipment is replaced.

RELEVANCE TO THE DDC

CONSTRUCTION EQUIPMENT

Like other New York City Agencies, the DDC will be subject to the requirements of Local Law 77 for both its Structures and Infrastructures projects. Contractors will be required to use ultra-low sulfur diesel fuel in their heavy-duty diesel construction equipment, at a minimum, and incorporate Best Available Technology (BAT) modifications as they are identified by DEP. Although Local Law 77 is initially effective in lower Manhattan only, the phase-in to all of NYC by late-2004 means that essentially all future DDC projects will begin to be subject to these regulations. Local Law 77 specifically requires DDC to monitor Contractor compliance with the requirements of Local Law 77. The requirements of Local Law 77 are discussed in more detail in Section 3 of this document, and the full text of the law is included at Appendix C.

ON-ROAD VEHICLES

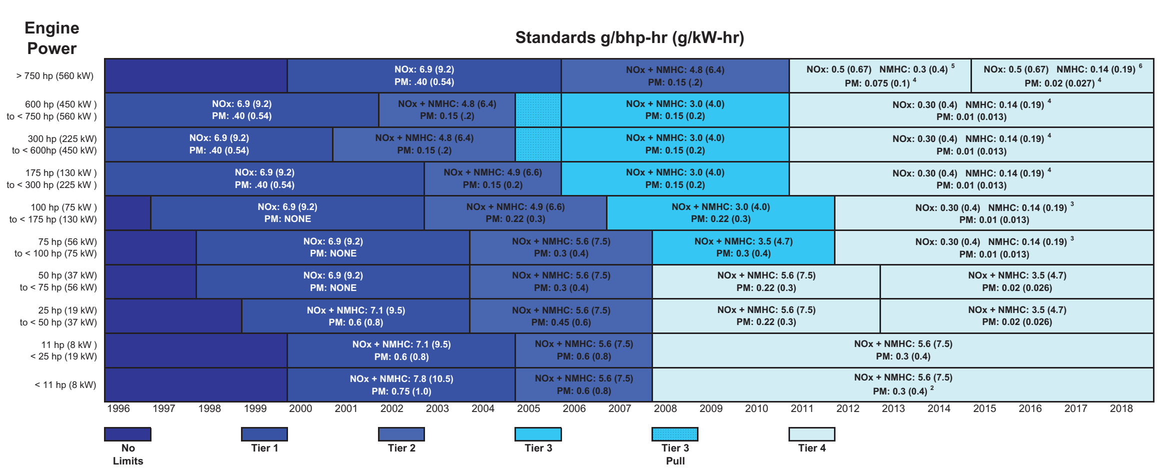
New York State regulations on opacity and idling do not directly affect non-road construction equipment used on DDC construction projects, but they do apply to on-road vehicles used in construction (ie. dump trucks). However, DDC has no specific requirement to enforce Contractor compliance with these regulations on construction sites. Vehicles owned or leased by DDC directly and operated by DDC employees are subject to these regulations, and may not idle for more than five consecutive minutes except under certain specific conditions as described above.

As with federal non-road vehicle regulations, federal on-road regulations will only affect DDC indirectly, and DDC is not required to enforce them. These regulations primarily apply to manufacturers of new engines and vehicles.

EMERGENCY GENERATORS

Generators used during construction are regulated as non-road equipment and as such are unaffected by New York State Regulations, but are subject to Local Law 77. Emergency generators, however, when incorporated as a permanent feature of DDC buildings, are subject to New York State regulations applicable to stationary sources. These regulations do not impose any special requirements on generators that are used solely for emergency power. However, emergency generators that are used for peak load shaving and/or as part of a distributed generation strategy are subject to Reasonably Available Control Technology (RACT) requirements to reduce NOx emissions, as further discussed in Appendix E These RACT requirements can be costly, and must be taken into account when evaluating peak shaving or distributed generation schemes. DDC will explore this further in the future, especially in the context of rebate programs from the New York Power Authority or New York State Independent System Operator that might be used to offset the increased cost.

TABLE 5: NON-ROAD EMISSION STANDARDS



1 - "Tier 3 Pull Ahead" standards must be met by seven of the largest engine manufacturers as part of consent decree settlements between the manufacturers, EPA, and the Department of Justice.
2 - Manufacturers may delay implementation until 2010 and comply with a PM standard of 0.45 g/bhp-hr at that time. This exception is available due to the recognized difficulties in optimizing engines of this size for low emissions.
3 - Phase-in schedule: 50% in 2012, 50% in 2013, 100% by 2014.
4 - Phase-in schedule: 50% in 2011, 50% in 2012, 50% in 2013, 100% by 2014.
5 - Standard varies by equipment type (NOx varies from 0.5 to 2.6 g/bhp-hr)
6 - Standard varies by equipment type (NOx varies from 0.5 to 2.6; PM varies from 0.02 to 0.03 g/bhp-hr)

For the time being, switching to ultra-low sulfur diesel fuel for existing and planned emergency generators in DDC buildings, while not technically required, is a prudent and sensible approach in the spirit of Local Law 77 that will help to mitigate the City's environmental and health impacts.

FEDERAL STANDARDS

DDC is also only indirectly affected by Federal emissions regulations. As new Tier 2, 3 and 4 non-road standards become effective over the next few years, newly purchased construction equipment will be required to incorporate new engine and after-treatment technology to meet them. This will happen without DDC having to enforce anything. These new regulations do not apply to existing construction equipment, and unlike Local Law 77 do not require retrofits with best available technology. The nationwide requirement to use ULSD for on-road diesel fuel beginning in 2006 is driving increased availability of this fuel, and will make compliance with the ULSD requirements of Local Law 77 easier for contractors.

HOW TO USE THIS DOCUMENT

The primary objective of this report is information dissemination so that DDC personnel and contractors can effectively implement the requirements of Local Law 77 on DDC construction projects. To that end, the report provides basic information so that DDC project teams and contractors can speak the same language and have the same baseline understanding of fuel and technology options for reducing the environmental impact from diesel engines. The secondary objective of the report is to facilitate informed decision making among contractors so that they implement the most effective emission controls on both a performance and cost basis.

- The Overview sections of this report include background information on diesel emissions and their health effects, as well as information on how diesel emissions are regulated at the Federal, State, and local level.
- Section 3 addresses the specific requirements of Local Law 77 with respect to the use of ultra low sulfur diesel fuel and Best Available Technology on City construction contracts.
- Section 4 discusses in general terms the concept of Best Available Technology, as well NYC DEP's BAT lists for construction equipment, as required by Local Law 77. See DEP's website for BAT lists.
- Sections 5 and 6 detail all of the technology and fuel options that are currently commercially available for application to diesel engines. It is expected that many of these fuel and technology options will be included on NYC DEP's present and future BAT lists for various pieces of construction equipment used in NYC. This information is provided to help DDC Construction Managers and Contractors to evaluate future BAT lists when they are published.
- Section 7 discusses recent experience of other NYC agencies who have implemented ULSD and emissions reduction technologies
- Section 8 highlights some of the real and perceived implementation issues that may be encountered with ULSD and BAT technologies, and
- Section 9 discusses the detailed responsibilities of DDC construction managers concerning compliance with Local Law 77

The appendixes to this report include more detailed technical information on various subjects of relevance to Local Law 77 and diesel emissions reduction efforts, including: an acronym list, the full text of Local Law 77, a detailed discussion of diesel fuel properties and specifications, and a discussion of Reasonable Available Control technology applicable to permanent emergency generators in DDC buildings. Local Law 77 compliance forms and General Conditions language can be found on DDC's website at : http://nyc.gov/html/ddc/html/ddcgreen/

3
LOCAL LAW 77

LOCAL LAW 77: USE OF ULSD

In December 2003, New York City passed Local Law 77, which seeks to reduce emissions from off-road construction equipment on City projects. The law passed because significant construction activities that will take place in and around the World Trade Center site in lower Manhattan will result in additional diesel emissions from construction equipment, which will harm local air quality and the health of workers and nearby residents. Also, New York City is facing a building boom with numerous mega-projects on the boards, so it made sense to extend these requirements throughout the City, particularly in light of the City's asthma problems.

This law has two main parts. First, it requires that all diesel engines of greater than 50 hp used on City construction projects operate on Ultra-low Sulfur Diesel Fuel (ULSD) with sulfur content no greater than 15 ppm. Second, it requires that these same diesel engines incorporate the "Best Available Technology (BAT)" to reduce emissions. The law applies to "any diesel-powered non-road vehicle that is owned by, operated by or on behalf of, or leased by a City agency".

The law designates the NYC Department of Environmental Protection (NYC DEP) as the agency with enforcement powers. The targets of this law are private Contractors who operate diesel equipment as part of construction activity funded by the City and City agencies that own, lease and/or operate their own construction equipment. Failure to comply subjects Contractors to significant civilian penalties. While the penalties under the law apply directly to Contractors, the law also requires that all City agencies specifically write into future construction contracts the requirements of the law, and act to enforce compliance. Finally, it requires DEP to report on the City's annual use of diesel fuel. To facilitate this, DDC will be requiring the regular submission of compliance forms, which list the types and amounts of fuel consumed and the BAT's that have been implemented.

The requirements of the law will be phased in. The following discussion summarizes the time-line for construction equipment used in NYC contracts; the schedule and requirements for equipment owned, operated by, or leased by a City agency is slightly different. Please consult DEP's website for information on the latter. The ULSD and BAT requirements apply to all non-road diesel construction vehicles used in Lower Manhattan (below 14th Street) on projects awarded or renewed after June 19, 2004, including equipment used by private Contractors. The ULSD requirements extend to all diesel construction vehicles used on projects awarded city-wide as of December 19, 2004. Except as otherwise noted below, the BAT requirements apply to all diesel construction vehicles used on projects city-wide with a value of more than $2 million and awarded as of June 19, 2005, and for all projects as of December 19, 2005. See table 6. Note that the law allows for the use of ULSD with up to 30 ppm sulfur until, potentially, September 2006, given possible problems with availability during the initial period.

TABLE 6: PHASE-IN OF LOCAL LAW 77 REQUIREMENTS

CONSTRUCTION PROJECTS	LOCAL LAW 77 REQUIREMENTS FOR CONTRACTS AWARDED AFTER:			
	JUNE 19, 2004	DECEMBER 19, 2004	JUNE 19, 2005	DECEMBER 19, 2005
In Lower Manhattan	ULSD & BAT	ULSD & BAT	ULSD & BAT	ULSD & BAT
Projects > $2M City-Wide	Not Applicable	ULSD	ULSD & BAT	ULSD & BAT
Projects < $2M City-Wide	Not Applicable	ULSD	ULSD	ULSD & BAT

In order for the BAT provisions of the law to become effective, the Commissioner of NYC DEP must issue specific lists of the Best Available Technology that applies to "each type of diesel powered non-road vehicle". These lists are to be updated at least every six months. To date, NYC DEP has produced only a preliminary BAT list for review, and it is not clear when the final one will be available. Although, the BAT list will be updated every six months, the law specifies that, for other than fuel changes, contractors who have upgraded a piece of equipment based on DEP's BAT list will not be required to upgrade again for at least three years, even if DEP issues an updated BAT list with new requirements in the interim.

4
BEST AVAILABLE TECHNOLOGY

EXPLANATION OF BEST AVAILABLE TECHNOLOGY CONCEPT

BEST AVAILABLE TECHNOLOGY / FUEL CHOICES

ULSD does not, by itself, do much to reduce NOx and PM emissions. It does, however, allow the use of technologies that can produce dramatic reductions. These technologies fall into two general categories: 1) making changes to the design of the engine itself, or 2) installing an "after-treatment" device which does not affect the way the engine operates, but which cleans up the exhaust after it has left the engine. Alternately, there are additives/modifications that can be made to ULSD, to create a "non-standard" fuel that can also effectively reduce emissions.

The above three approaches to emissions reduction are not mutually exclusive. In fact, some after-treatment technologies work better with different fuels, or may even require the use of a non-standard fuel to be effective. Likewise, some fuels may work better in combination with engine modifications. In addition, each fuel and technology option has a different cost, and some may pose significant implementation challenges on particular engines or vehicles.

These factors, combined with the sheer variety of diesel equipment used on construction sites, make it a virtual certainty that DEP's final lists of "best available technology" to reduce emissions from construction equipment will include a variety of options. It is highly unlikely that any one fuel and/or technology approach will be designated as the best available technology for all diesel vehicles and engines used in construction activities in NYC. In fact, for some vehicle types DEP may determine that the use of ULSD by itself constitutes the best available technology. For other vehicle types, DEP may determine that some form of engine modification, engine replacement, or after-treatment retrofit will be required to bring the vehicle to the point that it incorporates the best available technology. For other vehicle types, DEP may determine that there is more than one equivalent option, and the BAT list may include several alternatives to choose from. In this latter case, the alternatives may include the use of a non-standard ULSD fuel blend other than neat ULSD, which provides even greater emissions reductions than ULSD by itself.

In fact, DEP did issue an initial draft BAT list on June 18, 2004. For various pieces of equipment, this list specified use of emulsified diesel fuel, use of a fuel-borne catalyst in conjunction with a diesel oxidation catalyst, use of a catalyzed diesel particulate filter, or use of a diesel oxidation catalyst alone. All of these technologies and others are discussed in more detail below. DEP has invited public comment on the draft list until July 12, 2004, but has not indicated when they will issue a final list. The draft list specified general solutions for very broad categories of equipment, and implied that these solutions might not be practical on some specific vehicles within each category. It is likely that this draft list will generate significant public comment, and that the final list will be significantly different than the current draft.

Table 7 provides a matrix of available fuel/technology options that can be implemented with diesel vehicles and equipment. Each of these options will be described in more detail in Sections 5 and 6 of this report.

TABLE 7: FUEL/TECHNOLOGY OPTIONS AVAILABLE

FUEL OPTIONS	NOX TECHNOLOGY	PM TECHNOLOGY
ULSD	SCR	Diesel Oxidation Catalyst
Water/ULSD Emulsion	NOx Adsorber	
ULSD/Biodiesel Blend	Lean NOx Catalyst	Catalyzed Diesel Particulate Filter
Oxygenated ULSD	EGR	Active Diesel Particulate Filter
ULSD w/ Fuel Borne Catalyst		

For relative efficiencies of these methods, see Tables 8 & 9

Generally speaking the cost of installing control devices that reduce PM from diesel engines range from $1,500 to $15,000 per vehicle, depending upon engine HP and PM control performance. The cost of NOx emission control devices can range from $20,000 to $200,000 per vehicle, once again depending upon engine HP and performance. In comparison, many of the diesel fuel alternatives discussed in this report have emission benefits equivalent to and sometimes better than hardware emission control devices. All of these alternative fuels will cost more than standard diesel fuel, and their overall life-cycle cost may be the same or greater than the hardware options, but fuel options allow the contractor to spread the cost out over time with less inherent risk (loss of contract, etc.). Many contractors may also determine that a fuel option will reduce their total costs for City and non-city projects compared to a retrofit option, since it will allow them to switch back and forth between standard and non-standard fuel as equipment is moved between job sites, whereas it would be impractical to remove retrofit equipment for non-city jobs. The practicality of such an approach will depend on the specific requirements of each job. For many applications, particularly in the 50 to 200 horsepower range, the alternative fuels are the only practical option since retrofit equipment is not commercially available. As a result, fuel options may be considered more cost effective and easier to implement from a Contractor's perspective. Note that per Local Law 77 any diesel fuel alternative must still meet the sulfur content limits and as a result they are all essentially blends with ULSD.

Different types of construction equipment will have different BAT solutions. If the final BAT lists offer more that one option for a particular piece of equipment, deciding which is best will be based both on the total cost and on ease of implementation. For example, a large portable generator (2MW) would be a good candidate for diesel particulate filter or even selective catalytic reduction technology provided it operates at sufficient capacity; however, the shear size of the catalysts associated with these technologies may make these options less feasible. Another issue to consider is fuel consistency at the jobsite. Choosing different fueling options for different equipment will present a challenge of continuously segregating equipment and fuel, putting a squeeze on space if storage is on site, and adding activity to the site if different fuel trucks are entering.

When evaluating the best approach at any particular job site, defining the fleet profile will go a long way towards determining what technology/fueling options will work best. Conducting a comprehensive survey of the fleet and establishing equipment type, size and age of engine, emission profile, and duty cycle will provide the basic building blocks for evaluating emission reduction options. Generally speaking, a disparate fleet with numerous different vehicles may lend itself better to diesel fuel alternatives rather than hardware options, especially in the short term where hardware options are not widely available without extensive data logging.

In general, implementing BAT on all construction equipment is feasible. For smaller equipment (<50 hp), the solution is typically fuel-based only and this small equipment is exempt from Local Law 77 in any event. As larger equipment is considered, options including diesel oxidation catalysts, diesel particulate filters, and selective catalytic reduction in addition to fuels become more feasible. One factor that will influence the cost and feasibility of an after-treatment option are space and safety requirements. It may be technically feasible to deploy a diesel particulate filter on a Bobcat®, for example, but the cost of design and potential reconfiguration to maintain rollover safety, if the diesel particulate filter is not a direct replacement for the muffler in size, may make this option cost-prohibitive.

5
TECHNOLOGIES

TECHNOLOGIES FOR REDUCING DIESEL EMISSIONS

ENGINE MODIFICATIONS

In response to increasingly stringent regulation over the last 15 years, diesel engine manufacturers have made many changes to new diesel engines that significantly reduce emissions. On-road engines have made greater progress, but engine manufacturers are now introducing non-road engines that meet the stiffer Tier 2 and Tier 3 regulations.

Usually, it is impractical to upgrade existing engines with the technologies designed to reduce emissions, including improved cylinder designs, electronic fuel control, higher injection pressures, and turbo-charging. Therefore, using engine modifications to comply with the BAT requirements of Local Law 77 would likely require a wholesale engine change-out, replacing an older engine with a cleaner Tier 2- or Tier 3-compliant engine. Such an approach is likely to be very expensive for most construction vehicles, and while this may in some cases be allowed as an alternative on DEP's BAT lists, it is unlikely that DEP will require engine changes in order to comply with Local Law 77. For this reason, this report will not describe this approach in detail. Typically, the fuel and after-treatment approach described will be easier and less costly to implement than engine replacements.

AFTER-TREATMENT RETROFITS

"After-treatment" refers to a device or technology installed in a vehicle's exhaust system to reduce emissions. Unlike in-engine and fuel technologies, these devices do not reduce the emissions produced by the engine. Rather, they act to clean up the exhaust after it has left the engine, but before it enters the atmosphere.

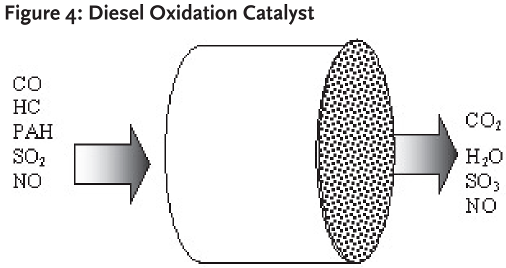
There are a number of different approaches to after-treatment, but most include a precious metal catalyst that promotes chemical reactions in the exhaust, oxidizing the hydrocarbons and PM to carbon dioxide and water, or reducing nitrogen oxides (NOx) to elemental nitrogen (N2).

Below, the seven most common options are described in more detail, including diesel oxidation catalysts (DOC), catalyzed diesel particulate filters (DPF), active diesel particulate filters (Active DPF), selective catalytic reduction (SCR), exhaust gas recirculation (EGR), Lean NOx Catalysts, and NOx adsorbers. All of these technologies are commercially available for retrofit on some diesel engines. The emissions reductions available from the use of these technologies are shown in Table 8.

DIESEL OXIDATION CATALYST (DOC)

A diesel oxidation catalyst is a flow-thru metal or ceramic substrate coated with a precious metal catalyst and packaged into a metal container similar to an exhaust muffler/resonator. The DOC sits in the exhaust stream of a vehicle and all exhaust from the engine passes through it. The catalyst promotes the oxidation of unburned hydrocarbons and carbon monoxide in the exhaust, producing carbon dioxide and water. See Figure 4.

Figure 4: Diesel Oxidation Catalyst



Key Benefit: DOCs significantly reduce HC and CO emissions. They also reduce PM emissions, primarily by oxidizing the “wet” portion of the PM, composed of liquid hydrocarbons adsorbed onto the solid carbon particles. No effect on NOx.

Down Side: There is virtually no down side to the use of DOC, other than their cost. If properly sized, with an appropriate catalyst formulation, they are very durable on many different types of diesel engines, causing few operational issues. DOCs do slightly increase back-pressure on the engine, but this can be minimized through proper design. It is possible for the flow-thru substrate of the DOC to plug with excess PM if engine operation is severely degraded, but this has proven to be a minimal problem.

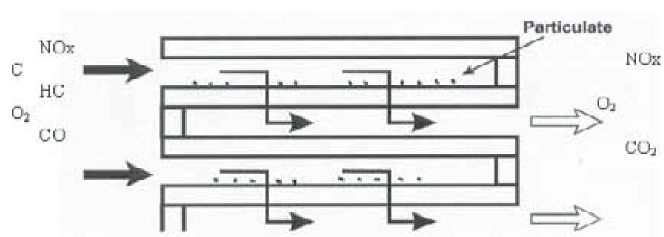
Implementation Issues: For retrofits, DOCs must be properly sized for each engine, and must fit within the existing exhaust piping configuration and engine compartment. For many non-road engines and vehicles, an existing DOC design may exist that can be purchased off-the-shelf and installed. For other vehicles, it may be necessary to evaluate the requirements and either adapt an existing DOC or develop an entirely new DOC design. This will ideally involve the participation of the DOC manufacturer and the engine manufacturer. Once the DOC installation has been designed, installation on a vehicle is generally straight-forward.

Cost: DOC catalysts include platinum or other precious metals. Cost can vary significantly depending on the rated horsepower of the diesel engine, with larger engines requiring larger, more expensive DOCs. Purchase cost of an off-the-shelf device will be on the order of $300-$1,500 for a 250 hp engine, and will require 2 -8 hours for installation in the vehicle, depending on space availability and existing exhaust piping configuration.

CATALYZED DIESEL PARTICULATE FILTER (CATALIZED DPF)

A catalyzed diesel particulate filter combines a diesel oxidation catalyst with a porous ceramic, metal mesh or silicon carbide filter in a metal container similar to a muffler. There are several variations on the design; some DPFs have a separate flow-through catalyst section in series with an un-catalyzed filter, while others use a filter with the catalyst applied directly to it. The DPF sits in the exhaust stream of a vehicle and all the exhaust passes through it. The gaseous components of the exhaust pass through the porous walls of the filter, while the solid PM particles are trapped on and in its walls. The catalyst section oxidizes the trapped PM (carbon and hydrocarbons) which then exit the filter as gaseous CO2 and H2O. The catalyst also oxidizes gaseous HC and CO in the exhaust. See Figure 5.

Figure 5: Diesel Particulate Filter Schematic



DPF Schematic courtesy of Manufacturers of Emission Controls Association

Benefit: DPFs significanty reduce CO, HC, and PM emissions. No effect on NOx. (See Table 8.)

Down Side: DPFs can significantly increase back-pressure on the engine, and must be carefully designed to minimize this impact. Back-pressure will rise if PM from the engine collects faster than it can be oxidized. Continual operation of a diesel engine at high levels of back-pressure will accelerate engine wear and may lead to premature failure of the engine or the turbocharger. Very high levels of back-pressure will significantly degrade engine performance. To maintain existing engine warranties, most engine manufacturers require that DPFs be used with a continuous back-pressure monitor that will signal the need for maintenance if back-pressure rises to high, shuting down the engine if back-pressure continues to rise.

In any engine, small amounts of engine lube oil are burned along with the fuel. This lube oil contains components that can not oxidize and therefore collect as ash. Approximately annually, DPFs must be removed from the vehicle and cleaned to remove this collected ash. This cleaning process is straightforward, but adds to maintenance costs.

Implementation Issues: High levels of sulfer in the fuel impede proper operation of the DPF's catalysts, resulting in less efficient oxidation of PM. The lower the fuel sulfur level the better the devices work, with 50-ppm sulfur the upper limit, so the use of DPFs requires the use of ULSD.

DPFs will not work on all engines. The higher the engine-out PM level, the larger the filter and catalyst must be to work without plugging. For some very old, very dirty engines it may not be practical to design a DPF that will work consistently. Also, to work properly, DPFs require that the exhaust temperature be at least 300 degrees C for 30% - 40% of the time that the engine is operating. This is easily achievable for many vehicles, but certain engines and certain duty cycles may not have sufficient exhaust temperature. In general, DPFs can be used for duty cycles in which the diesel engine operates for a majority of the time under high loads. Lightly loaded duty cycles may not be appropriate for DPFs. Data-logging to determine the exhaust temperature profile of the engine/duty cycle is recommended prior to DPF installation.

As with DOCs, DPFs must be properly sized for each engine, and must fit within the existing exhaust piping configuration and space envelope within the engine compartment. The above discussion on applications engineering requirements for DOCs also applies to DPFs.

Cost: As with DOC's the cost of a DPF will increase as engine horsepower increases. The cost of a DPF device and back-pressure monitoring system will be on the order of $5,000-$7,000 for a 250 hp engine, and will require 4 -12 hours for installation, depending on space availability and existing exhaust piping configuration. Annual DPF cleaning will cost $200-300 if performed by a third party, plus 1 – 8 hours for DPF removal and replacement. One can expect some DPF plugging (back-pressure increase) based on engine degradation/upset (ie. failed injectors) which increases engine-out PM. With a properly designed system and good vehicle maintenance, this problem can be minimized.

ACTIVE DIESEL PARTICULATE FILTER (ACTIVE DPF)

An active diesel particulate filter system uses the same porous ceramic filter used in catalyzed DPFs, but does not use a catalyst to oxidize the collected PM. Instead, it uses an active system to raise the temperature inside the filter to approximately 600 degrees C, at which point carbon will oxidize directly. In general, active DPFs are designed to accumulate a certain amount of PM, at which point the active system is turned on to oxidize the carbon. After all of the collected carbon has been oxidized, the active system is turned off and the cycle starts over.

The most common method used to raise the temperature in the filter is to inject additional diesel fuel into the exhaust stream across a small catalyst, down-stream of the engine but in front of the filter. Oxidation of the fuel raises the temperature.

Benefit: Active DPFs significantly reduce CO, HC, and PM emissions. No effect on NOx. (See Table 8)

Down Side: The above discussion of engine back-pressure caused by catalyzed DPFs also applies to active DPFs. Active DPF systems add significant equipment to the engine system, increasing the possibility of failures and increasing on-going maintenance costs. There is also a modest fuel penalty associated with active DPF systems.

Implementation Issues: Unlike catalyzed DPFs, the use of active DPFs does not require ULSD. In addition, an active DPF system can theoretically be used on any engine, regardless of engine-out PM levels, and regardless of engine duty-cycle. However, active DPF systems are significantly more complicated than catalyzed DPFs. In addition to the filter element, an active DPF system will typically contain a fuel pump, a fuel injector into the exhaust, a separate catalyst, back-pressure and temperature monitors, and an electronic control module. Use of these systems also typically increases net fuel usage by 5-10%, because of the fuel used for filter regeneration.

Cost: As with DPFs and DOCs, the cost of a system will increase with engine size. In general, active DPF systems can be expected to cost at least twice as much as a catalyzed DPF for the same vehicle.

SELECTIVE CATALYTIC REDUCTION (SCR)

SCR uses a reductant (typically ammonia or more commonly Urea in mobile sources), with a special SCR catalyst, to reduce the nitrogen oxide in diesel exhaust to N_2. The SCR catalyst sits in the exhaust stream much like a DOC or DPF, and the reductant is injected into the exhaust ahead of the catalyst, much like the diesel fuel in an active DPF system. The preferred reductant is urea, which is kept in a separate tank on the vehicle. Once injected the Urea becomes ammonia and the chemical reduction reaction between the ammonia and the NO takes place across the SCR catalyst. There is the potential for some ammonia to "slip" through the catalyst, so most SCR systems also include an ammonia "clean-up" catalyst. While there are currently SCR demonstrations taking place on both electric generator sets as well as trucks, no SCR systems have been verified by EPA.

Benefit: SCR systems can significantly reduce NOx emissions and also offers some modest PM reductions. (See Table 8)

Down Side: An improperly functioning SCR system can create excess ammonia emissions. SCR systems add significant equipment to the engine system, increasing the possibility of failures and increasing on-going maintenance costs.

Implementation Issues: SCR requires the use of urea reductant. While urea is plentiful as an industrial chemical (it is used in the production of nitrogen fertilizer) and relatively inexpensive (about $0.40 per gallon) there is no retail distribution infrastructure in place anywhere in the US and as a result delivery costs can vary widely. SCR systems on construction equipment would typically use one gallon of urea for every 20 gallons of diesel fuel burned in the engine.

Like active DPF systems, SCR systems are quite complicated. In addition to the SCR catalyst, an SCR system is likely to include a urea tank, a urea pump, a urea injector in the exhaust, various sensors, an electronic control system, and an ammonia clean-up catalyst. To work effectively, the amount of urea metered into the exhaust must be carefully controlled. Too little urea and NOx will not be reduced; too much urea and ammonia emissions will rise. SCR technology has been used extensively with stationary sources such as electric generating stations, which operate primarily at steady-state for many years. Use in mobile-source applications with transient engine operation requires much more complicated control algorithms and smaller packaging.

Cost: As with the other retrofit technologies described above, the cost of SCR systems increases with engine horsepower. An SCR system will typically cost $20,000 to $40,000 for a 250 HP engine and as much as $200,000 for a 2MW generator set. Installation times will depend on the specific vehicle application, but would be on the order of 30-50 hours or more per vehicle.

LEAN NOX OR NOX REDUCING CATALYST (NRC)

Lean NOx catalyst systems work like SCR's, but in lieu of Urea use a hydrocarbon reductant (typically the base engine fuel) with a special catalyst, to reduce the nitrogen oxide to N_2. The NRC catalyst sits in the exhaust stream much like a DOC or DPF, and the reductant is injected into the exhaust ahead of the catalyst. Once injected, the extra fuel takes part in a chemical reaction between the HCs and the NO, across the NRC catalyst. Unburned hydrocarbon and Carbon monoxide can be emitted, so most NRC systems also include an oxidation catalyst down-stream from the NRC catalyst. While there are currently several NRC demonstrations in truck fleet applications, no NRC systems have been verified by EPA.

Benefit: NRC systems can reduce NOx emissions by 25% to 35% and also offers CO, HC and PM reductions when coupled with a DPF, which is typical.

Down Side: NRC systems add significant equipment to the engine system, increasing the possibility of failures and maintenance costs. There is also a 5-10% fuel penalty associated with the use of fuel as the reductant.

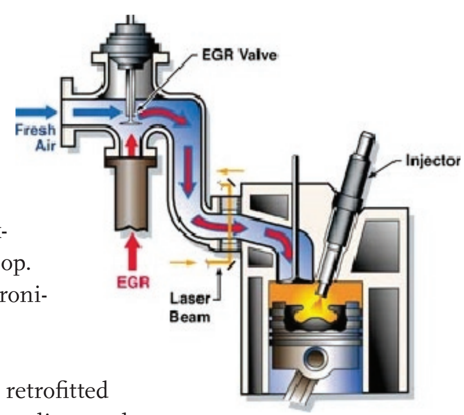
Implementation Issues: An NRC system can theoretically be used on any engine, regardless of engine-out PM or NOx levels, and regardless of engine duty-cycle. However, NRC systems are complicated and contain many of the same components as an active DPF system. In addition to the Lean NOx and DPF element, an NRC system will typically contain a fuel pump, a fuel injector into the exhaust, as well as back-pressure and temperature monitors, and an electronic control module.

Cost: As with the other retrofit technologies described above, the cost of NRC systems generally increases with engine horsepower. An NCR system will typically cost $15,000 to $30,000 for a 250 HP engine.

EXHAUST GAS RECIRCULATION (EGR)

In an EGR system some of the exhaust gas from the diesel engine is rerouted back to the engine intake manifold and mixed with the intake air before it enters the cylinder. This introduces inert gas (carbon dioxide) into the cylinder that absorbs heat and reduces peak combustion temperature in the engine, thus reducing the production of NOx during combustion. Technically, EGR is not an "after-treatment" technology because it fundamentally affects the engine's combustion cycle and reduces engine-out emissions.

Figure 5: Exhaust Gas Recirculation



Most on-road diesel engines are now being delivered with high-pressure cooled EGR systems that redirect exhaust flow to the air intake using an electronically controlled valve mounted in the exhaust circuit just down-stream of the engine turbo-charger. Control of this exhaust valve is accomplished using the engine's electronic control module (ECM). Prior to entering the air intake, the redirected exhaust flow is cooled using a separate heat exchanger that is installed in the normal engine cooling loop. Theoretically, a retrofit of these system types on any electronically controlled engine is possible.

Low-pressure EGR systems are also available that can be retrofitted onto virtually any diesel engine. These systems typically redirect exhaust flow to the air intake using a valve mounted much further back in the exhaust stream and they control this valve with an electronic control module separate from the engine ECM. The EGR valve is often located down stream of a DPF, so that the redirected exhaust is much cleaner than in high-pressure EGR systems. Low pressure EGR systems also do not typically include a heat exchanger to cool the redirected exhaust before it enters the air intake.

Benefit: Both high-pressure and low-pressure EGR systems can significantly reduce NOx emissions from diesel engines. (See Table 8)

Down Side: EGR systems add significant equipment to a diesel engine, increasing the possibility of failures and maintenance costs. High-pressure EGR systems also force more PM into the engine oil, reducing effective oil life.

Implementation Issues: The design of a retrofit high-pressure EGR system will definitely require the participation of the engine manufacturer, and will probably be based on systems being delivered on new on-road engines. Off-the-shelf low-pressure EGR systems may be adaptable to a range of engine/vehicle types, but will require engine mapping to develop appropriate control algorithms when being applied to a new application. Both low and high pressure systems add equipment to the engine that may be difficult to fit in existing engine compartments. Retrofit of a high pressure system may also require upgrading the engine cooling system since the EGR cooler can add up to 40% additional heating load to the engine cooling loop.

Cost: EGR applied to a new engine adds a modest amount to the price of the engine, but retrofits are expected to be more expensive because of the need to amortize significant engineering effort over a small number of sales. These systems will probably be roughly the same cost as an active DPF system, but probably less than the cost of an SCR system.

NOX ADSORBERS

Unlike the catalyst systems mentioned earlier in this report, which continually reduce NOx to elemental nitrogen by combining the oxygen in NOx with hydrocarbons, the materials in a NOx adsorber chemically combine with NOx under lean (low oxygen content) conditions typical of diesel engine exhaust. In this way, the NOx adsorber collects nitrogen over time. Eventually, the nitrogen must be released in order to make room to collect more. This is done by creating rich (low oxygen, high hydrocarbon) conditions in the exhaust. Since rich operation is not typical of diesel engine operation, this is accomplished in a manner similar to a Lean NOx catalyst, by injecting fuel into the exhaust. However, the systems are typically set up with a more complicated dual bed system and a series of dampers to minimize the fuel penalty. Over-all NOx reduction can exceed 90%. Unfortunately, NOx adsorber technology also captures and stores sulfur compounds that can only be released with a very high temperature cycle, and for this reason ULSD fuel must be used. NOx adsorber technology is expected to take a leading role in complying with the new on-road emission standards. However, at this time it appears that due to the high level of engine integration necessary to make the system work, NOx adsorber technology will not be available as a retrofit technology.

TABLE 8: IMPROVEMENT PERCENTAGES WITH THE USE OF DIESEL AFTER-TREATMENT TECHNOLOGIES

TECHNOLOGY	NOX	PM
Diesel Oxidation Catalyst (DOC)	No Effect	-20% to -33%[a]
Catalyzed Diesel Particulate Filter (DPF)	No Effect	-60% to -90%[a]
Active Diesel Particulate Filter (DPF)	No Effect	-60% to -90%
Selective Catalytic Reduction (SCR)	-70% to -90%[c]	-10% to -25%
Exhaust Gas Recirculation (EGR)	-30% to -50%[c]	No Effect[b]
Lean NOx catalyst (NRC)	-25% to -35%[c]	No Effect[b]
NOx Adsorbers	>-90%[c]	No Effect[b]

a List of EPA verified retrofit technologies; http://www.epa.gov/OMS/retrofit/retroverifiedlist.htm

b These technologies have little to no direct effect on PM emissions, but are typically installed in conjunction with a diesel oxidation catalyst or diesel particulate filter, in which case these additional devices would provide PM reductions as noted in the table.

c MT Bradley & Association estimates based on prior proved experience and review of various manufacture and third party test reports.

Note 1: For each technology, the specific percentage reduction of NOx or PM is effected by a number of factors, including the technology level of the base engine, the aggrssiveness of the catalysts involved, and the specific control strategies used. Design of after-treatment for a particular engine often involves trade-offs, and after-treatment manufacturers seek to optimize emissions reductions in the context of technical and economic factors.

Note 2: Technolgies that are targeted primarily toward NOx reduction can be combined with others that are targeted primarily toward PM reduction. For example, SCR, EGR, NRC, and NOx Adsorbers can be combined with a DOC or DPF to acheive both the NOx and PM reductions noted in the table.

6
ALTERNATIVE FUELS

ALTERNATIVE FUELS FOR REDUCING DIESEL EMISSIONS

ALTERNATIVE AND CLEANER FUELS

Local Law 77 requires the use of ULSD in all construction equipment used on city projects. As shown in Table 9 there are other, alternative diesel fuel formulations available for use in non-road diesel engines, which will result in even lower emissions than using ULSD alone and therefore might qualify as BAT's. All of these diesel fuels mix base diesel fuel with another substance. In some US markets, these alternative formulations are marketed using standard on-road diesel fuel as the base blending stock. To comply with Local Law 77, any alternative diesel fuel formulation would be required to use ULSD as the base blending stock. Below, the four most readily available alternatives are described, including: biodiesel, emulsified diesel, oxygenated diesel, and diesel with a fuel-borne catalyst. The advantages of alternative diesel fuels as BAT's are that they do not require complex and expensive technologies, they work with all diesel engines (a significant advantage given the variety of construction equiptment), and they can significantly reduce PM's and/or NO_x. The downside is that they cost more than ULSD, so they can be considered as a "pay as you go" strategy.

EMULSIFIED DIESEL

Emulsified fuel is ULSD diesel fuel blended with up to 20% water and proprietary additives to create an emulsion that will not separate, with the water molecules completely enclosed by fuel molecules. This prevents water from coming into contact with engine and fuel system components, to prevent corrosion and maintain lubricity. During combustion, evaporation of the water contained in the fuel decreases peak combustion temperatures, lowering NO_x and also resulting in greater atomization of the fuel, which reduces PM emissions.

Benefit: Emulsified fuel lowers peak combustion temperature, significantly reducing NOx emissions, and slightly reducing PM emissions. The higher the water content, the greater the emissions reductions. (See Table 9)

Down side: The water in the fuel does not contribute any energy toward combustion, and its evaporation absorbs energy during combustion. The result is that the same volume of emulsified diesel will have 10-30% lower effective energy content, depending on how much water is in the blend, than the base fuel. Since fuel is typically metered into an engine's cylinder by volume, this will result in a 10-30% reduction in power output at the same throttle setting. In electronically controlled engines this could theoretically be compensated for, but would require development of a new engine calibration program, as well as EPA emissions certification testing. In many applications, this would not cause a significant problem, but could create concerns for vehicles with existing engines with marginal power ratings. In all cases, vehicles operating with emulsified fuel would have lower fuel economy (ie. they would burn more gallons of emulsified fuel per engine hour or per mile than they would otherwise burn of standard diesel fuel.

Implementation Issues: While emulsified fuel is very stable it can partially stratify over time with higher water content emulsion settling toward the bottom of the tank and lower water content emulsion toward the top of the tank, resulting in a non-homogeneous fuel with a variation in energy content. Therefore, emulsified fuel would not be appropriate for vehicles that sit for extended periods (months) without use. In addition, it would be necessary to ensure that there was sufficient turn-over in centralized fuel storage tanks that the fuel would not sit for months without being used. Alternatives for permanent installations include systems for continuously mixing the fuel in the tank, or on site blending.

Creation of the emulsion requires specialized blending equipment. Blending could be done at the fuel supplier's terminal prior to being loaded into trucks for delivery to the user, or it could be done on-site at the user's facility as the fuel is delivered into centralized storage tanks or as the fuel is distributed from the tank into the vehicles. The most practical scenario for fuel used on construction sites is likely to be centralized blending at the fuel supplier's terminal.

Cost: In NYC, emulsified diesel fuel typically costs $0.10 gallon more than the base fuel (ULSD). In addition, the effective fuel energy content will be 10-30% lower than if the base fuel were used, depending on total water content of the mixture - resulting in the use of more fuel, which will further increase costs.

BIODIESEL

Biodiesel is a renewable low-sulfur fuel with high oxygen content and low sulfur content that is derived from vegetable oils or animal fat. Biodiesel can be used by itself (B100), but it is typically blended with petroleum diesel. Oxygenates in biodiesel lower PM emissions by supplying additional combustion oxygen within the fuel during combustion. It is generally recommended that biodiesel not comprise greater than 20% of the total fuel mix because this B20 blend achieves much of the potential PM reduction benefit while minimizing potential NOx emission increases associated with moderately higher combustion temperatures. With respect to compliance with Local Law 77, B20 biodiesel would consist of 20% biodiesel blended with 80% ULSD.

Benefit: Biodiesel provides moderate reductions in PM emissions. Biodiesel is also a renewable fuel, thus resulting in net reductions in greenhouse gases when used in place of 100% petroleum diesel. Biodiesel has naturally low sulfur content, and does not require additional sulfur removal to meet the definition of ULSD (less than 15-ppm sulfur). Biodiesel offers safety benefits over oxygenated diesel (discussed below) because it is less combustible, with a flashpoint greater than 150°C, compared to 77°C for petroleum diesel.

Down Side: The main down side of biodiesel is its increased cost. Local Law 77 does prohibit the use of options that would increase one type of emissions at the expense of another, and as a result of the NOx/PM trade off associated with B20, biodiesel blends used to comply with Local Law 77 would need to contain a fuel-borne catalyst, further increasing the cost. In addition, fuel-borne catalysts can result in other pollutants. (See section below on Fuel-Borne Catalysts.)

Implementation Issues: While reducing PM emissions, the use of B20 biodiesel typically increases NOx emissions slightly. When used with a fuel-borne catalyst (discussed below) both PM and NOx emissions can be reduced.

Biodiesel is a more robust solvent than petroleum diesel, and can loosen accumulated deposits within the fuel system. Some users have experienced fuel filter plugging shortly after switching to biodiesel. This issue can be controlled by scheduling a fuel filter change shortly after the fuel change.

Cost: It is difficult to estimate the cost of B20 in New York City because its use is so limited. In parts of the country with greater biodiesel use, 100% biodiesel is typically 1.5 – 2.0 times as expensive per gallon as petroleum diesel, so that a B20 blend is 10-20% more expensive than standard on-road diesel. In areas with low usage such as NYC, costs could be expected to be higher based on greater costs for transporting and handling small volumes of specialty product.

OXYGENATED DIESEL

Oxygenated diesel is a blend of diesel fuel with a small amount of an alcohol (up to 10%), either ethanol or methanol, and proprietary hydrocarbon additives that keep the alcohol from separating out of the diesel. In a diesel engine, the alcohol provides increased combustion oxygen similar to biodiesel, with similar results. Ethanol is lower in reactivity and higher in oxygen content, making it preferred over methanol, which could also be used. For the purposes of compliance with the BAT provisions of Local Law 77, ULSD would have to be used as the base fuel for production of oxygenated diesel.

Benefit: Oxygenated diesel fuel provides similar PM reductions as biodiesel. Ethanol is also renewable, being derived from corn or sugar feedstock, so it would result in net reductions in greenhouse gases when used in place of 100% petroleum diesel. Given the small volume of the fuel typically used, this reduction would be modest. Methanol is typically produced using natural gas, and is domestic but not renewable.

Down Side: : Both methanol and ethanol are significantly more volatile than diesel fuel, and can produce explosive vapors in the event of a fuel spill or as a result of fuel tank heating. This hazard is similar to the hazard posed by gasoline, and it is much greater in a confined space. This should not be a problem on the typical construction site, but may require different procedures for vehicle maintenance inside buildings that currently handle only diesel vehicles. As with biodiesel, NOx emissions may actually increase, prompting the need for additional additives such as fuel-borne catalyst.

Key Implementation Issues: The alcohol oxygenate is typically blended with diesel at the fuel distribution terminal and should be transparent to the end user.

Cost: As with biodiesel, cost information for oxygenated diesel fuel is limited however, the cost of the oxygenate itself is similar to biodiesel.

FUEL-BORNE CATALYSTS

Metal-based powdered catalysts in a liquid suspension added to diesel in very low concentrations can promote more complete combustion, reducing emissions of both NOx and PM. Various companies sell proprietary catalyst packages, which may include small amounts of platinum, cerium, other precious metals, or iron compounds. Theoretically, the addition of a catalyst to any base fuel stock could provide some benefit. As noted above, many biodiesel blends must contain a fuel borne catalyst to reduce NOx emissions.

Benefit: Modest reductions in NOx and PM emissions with little to no capital investment.

Down Side: Some catalyst metals are hazardous when emitted to the atmosphere and therefore these catalysts, such as Cerium, are recommended only when used with a diesel particulate filter that prevents their emission to the atmosphere. There is also the potential for over or under-dosing of vehicles if the fuel tank is topped off before it is empty.

Implementation Issues: : Catalyst formulations can be added to bulk fuel by the supplier at his terminal prior to delivery to the end user, or in many cases can be added by the operator directly to the fuel tank on individual pieces of equipment. In general it is better to purchase the additives in bulk fuel, as it is easier to control and monitor dosage. Documentation of compliance may also be virtually impossible when administering additive directly to vehicle fuel tanks, as there are no standardized test methods for catalyst additives that could be used in a fuel sampling program. Fuels of this type should only be procured from fuel suppliers that have received EPA verification.

Cost: There is insufficient data for fuel borne catalysts at this time, but given the low quantities necessary, the cost per gallon is expected to be relatively low, and of the same order of magnitude as other alternative diesel fuel options.

Table 9 provides an overview of alternative fuels and their environmental impact on emissions of NOx and PM.

TABLE 9: EFFECT OF ALTERNATIVE DIESEL FUEL FORMULATIONS ON EMISSIONS

FUEL CATEGORIES	NOX	PM
Low Sulfur On-road Diesel 500 ppm	Baseline	Baseline
Ultra Low Sulfur Diesel 15 ppm	No Effect	0% to -20%[a]
Emulsified Fuel	-9% to -20% [c]	-17% to -23%[c]
Biodiesel (1- 100%)	0 to +10% [c]	0 to -47%[c]
Ethanol/Methanol Oxygenated	+10%[b]	-20%[b]
In-Situ Catalyst Fuels	0% to –5%[c]	0% to –15%[c]

a Estimated based on sulfate conversion, varies depending upon final after treatment technology
b Clean Alternative Fuels: Ethanol, EPA420-F-00-035, March 2002
c List of EPA verified retrofit technologies; http://www.epa.gov/OMS/retrofit/retroverifiedlist.htm

Note 1: For each technology, the specific percentage reduction of NOx or PM is effected by a number of factors, including the technology level of the base engine and the amount of additive (water, biodiesel, ethanol, catalyst) added to the base fuel.

7
PRECEDENTS & PILOTS

PRECEDENTS & PILOT PROJECTS IN NYC

RECENT EXPERIENCE OF OTHER NYC USERS

In September of 2000, MTA New York City Transit, the largest municipal bus fleet in North America, began using ULSD in all 4,500 buses in their fleet, the first fleet operator in the country to do so. Since then, they have used approximately 47 million gallons of ULSD annually. Since they began to use ULSD, they have not reported any engine or fuel system problems related to ULSD use, and have not experienced a change in fuel economy from the fleet. Their first contract for supply of ULSD was negotiated with their existing fuel supplier. The negotiated price was $0.12 per gallon greater than the price they had been paying for standard #1 on-road fuel (approximately a 10% increase at the time). In the fall of 2003, NYCT successfully bid a new five-year contract for supply of ULSD. The price under the new contract was $0.02 per gallon less than the original negotiated price. NYCT now uses roughly 47 million gallons of ULSD annually.

Shortly after switching to ULSD, NYCT began to install diesel particulate filters on all of their diesel buses. To date, they have installed over 2,800 units, some of which have been in service for over 3 years. Prior to beginning the DPF retrofit, every diesel bus in the fleet had been equipped with a diesel oxidation catalyst, which have been required by EPA regulation on new transit buses since 1994. While not done in response to Local Law 77, the actions of NYCT to retrofit DPF on their buses is analogous to implementing BAT on these vehicles.

Over the last several years, a number of other New York City agencies, as well as private companies, have begun to use ULSD as well. Currently the NYC Department of Sanitation uses ULSD in their refuse trucks in two boroughs, and they plan to expand city-wide in the future. The NYC Department of Transportation, NYC Police Department, and NYC Parks Department have also begun to use ULSD in some of their diesel equipment. These NYC agencies now use 3-4 million gallons of ULSD annually. Some of these city agencies have also begun to retrofit small numbers of vehicles with DPF, in the context of pilot programs, as discussed below.

Some of the private companies currently using ULSD in all or a portion of their diesel equipment include Liberty Bus Lines in the Bronx, several school bus contractors, and a private hospital which uses ULSD to power a cogeneration plant.

In addition, construction equipment used to construct the temporary PATH station at the World Trade Center site and currently being used to construct a new building at the former 7 World Trade Center site are using ULSD. The Metropolitan Transportation Agency (MTA) also currently specifies the use of ULSD and retrofit technology for diesel equipment used on all of their construction projects city-wide.

PILOT PROJECTS

When implementing an emission reduction program, a small portion of the fleet (usually less than 10) is often singled out to act as a pilot group. A pilot group may not be necessary if a sufficient number of similar projects have already occurred under the same application. If yours is the first application for a particular type of diesel fuel alternative or emission control hardware, a pilot is generally recommended before making a fleet-wide commitment.

In certain cases, a pilot program for a fuel switch may be necessary, especially if the vehicle or equipment manufacturer has not had experience with the fuel and it may have the potential to impact warranty. A recent example of this was Caterpillar's experience with ULSD supplied by Sprague Energy at the 7 World Trade Center site. Caterpillar had experienced fuel injector failure problems under high ambient temperatures due to a breakdown of the lubricity additive with a particular ULSD supplier in California. Because they had no experience previously with Sprague's fuel, there was concern from Caterpillar.

To move the project forward, the ULSD was deployed at the same time Caterpillar rigorously tested the fuel in their controlled laboratory environment. No problems occurred and Caterpillar determined that the fuel met or exceeded their specification standards and was acceptable to use.

Several other pilot projects in the New York City area have involved deploying ULSD in part of the New York City Department of Sanitation (DSNY) fleet and retrofitting with diesel oxidation catalysts or diesel particulate filters. Two of these projects originated out of heavy-duty diesel engine manufacturer consent decrees with the US Department of Justice and EPA. Both Cummins and MACK Trucks provided technical support and resources to DSNY as part of their consent decree projects.

An important consideration of any project is timing. The longer the pilot program, the greater the confidence is that the application will be successful. However, to maximize the benefits and emission reductions as quickly as possible, planning and procurement for a full-scale project typically occurs in parallel to the pilot program.

8

IMPLEMENTATION

IMPLEMENTATION ISSUES

ULSD & BAT IMPLEMENTATION

Both real and perceived problems will arise as contractors are asked to switch to new fuels and new technologies for their diesel equipment. Based on the experience of other early adopters in NYC, the switch to ULSD should be relatively easy. This section will discuss issues that might concern the contracting community related to ULSD including availability, compatibility with existing equipment, and cost.

The issues and problems that may arise as contractors are asked to incorporate Best Available Technology to their equipment, over and above the use of ULSD, are likely to be more significant, particularly given the variety of construction equipment. These are discussed in Sections 5 and 6 of this report, in connection with each technology.

EXISTING EQUIPMENT AND WARRANTY CONCERNS

Construction equipment is a significant investment for contractors, and they will naturally be concerned that the switch to ULSD not negatively effect the performance or longevity of their engines. Manufacturer engine warranties typically have detailed requirements that need to be followed during the warranty period, including minimum fuel specifications. The many potential issues involved, such as cetane number, lubricity and cloud point, are discussed in greater detail in Appendix D. The most significant issue of concern with ULSD is fuel lubricity. Removal of sulfur from standard fuel reduces the fuel's lubricity and ULSD without lubricity enhancement could violate the minimum requirements recommended by most engine manufacturers. Operation of diesel engines with ULSD with insufficient lubricity could lead to premature wear of various engine components.

Lubricity additives are available that can increase the lubricity of ULSD to levels compliant with engine manufacturers' recommendations. These additives are typically added after refining, at the fuel distribution terminal. When purchasing fuel, Contractors should be careful to specify and confirm that it meet the appropriate minimum standards for lubricity. See Appendix D for minimum fuel specifications from three different engine manufacturers: Caterpillar, Cummins and Detroit Diesel.

In practice, the current specification for ULSD fuel readily available in NYC is controlled by the largest fleet users, in particular MTA New York City Transit, which currently uses approximately 47 million gallons per year. A small user that seeks to purchase small quantities of ULSD in NYC today at a reasonable price will likely receive fuel based on the NYCT specification. This specification is also included in Appendix D. This specification is based on standard on-road #1 diesel, but with sulfur content no greater than 30-ppm, and it incorporates the engine manufacturers' minimum standards for all fuel properties including lubricity. Because this fuel is based on a #1 distillate, it will have slightly lower energy content than the fuels typically used in construction equipment, which are typically based on a #2 distillate. This could result in a 5-10% power loss from certain engines and/or a 5-10% decrease in fuel economy compared to standard non-road fuel. For virtually all applications, this should not create any practical problems, but could slightly increase Contractor fuel costs. It is important to note that this effect is based on the specification of the fuel stock from which the ULSD is produced, not the reduction in sulfur per se. Over time, as more ULSD is used in both on-road and non-road applications, it is likely that refiners will begin producing ULSD from #2 distillate.

Contractors may also want to periodically test delivered fuel to ensure that it is meeting the specification for minimum lubricity. The appropriate test to use for fuel with a lubricity additive is D-6079, as defined by the American Society for Testing & Materials (ASTM). There are a number of independent laboratories that can perform fuel testing. The cost to perform ASTM D-6079 is approximately $500 per sample.

FUEL GELLING

Some contractors may have heard stories about fuel gelling, injector plugging, and engine failure attributed to the use of ULSD. One component of diesel fuel is paraffin-type hydrocarbons, or wax. At low ambient temperatures, the paraffin comes out of the fuel solution, causing the fuel to gel. This gelling reduces the fuel's ability to flow freely. The term Cloud Point (noted in degrees centigrade) identifies the temperature at which wax first becomes visible in the fuel as it cools. Pour point identifies the lowest ambient temperature at which the fuel will still flow.

Since the ULSD that is most easily available in NYC is produced from a #1 distillate fuel stock, it is very unlikely that fuel gelling will be a problem when switching to ULSD. Most non-road fuel and much of the on-road fuel used today is produced using the #2 distillate fraction, which is heavier and contains a higher percentage of paraffin than the #1 distillate fraction (also referred to as kerosene). Number 2 diesel has a higher cloud point and pour point than # 1 diesel. In the Northeast, most fuel providers blend #1 distillate fuel with #2 distillate fuel in the winter to maintain acceptable cloud and pour points during the cold months. Removal of sulfur from both #1 and #2 distillate fuel to produce ULSD has no direct effect on the Cloud Point of Pour Point of the fuel. In the event that fuel gelling was an issue with a particular batch of ULSD, it is likely that the base fuel was produced using a #2 distillate and the fuel provider did not adequately anticipate the need for fuel blending with #1 distillate.

As with lubricity, the Pour Point and Cloud Point of any batch of fuel can be easily determined by an independent laboratory based on standard ASTM tests (ASTM D-2500). If there is any concern, these tests can easily be added to a fuel sampling and testing program.

COST

During the interim period prior to 2006, when EPA's rules go into effect, ULSD will cost more to purchase than the fuels typically used by Contractors in non-road equipment. Since standard on-road diesel is more expensive than non-road diesel, the up-change will depend on what fuel the contractor currently uses. Since 80% of construction equipment in NYC currently uses on-road fuel because it's less corrosive, the generally applicable comparison is with on-road, or low-sulfur, diesel. Beginning in 2006, ULSD will become the standard fuel used in all on-road vehicles, but is still likely to be more expensive that non-road fuel. The current price per gallon for ULSD can be expected to be about $0.10 to $0.19 per gallon higher than on-road diesel. Almost half of this is attributable to the cost of keeping the currently small amounts of ULSD from getting contaminated. As ULSD comes into more general use, contamination will pose less of a problem, and the cost premium for ULSD should settle at roughly $.10 per gallon, or even less.

Taxation

The New York State Diesel Motor Fuel tax rate as of January 1, 2003 was 20.85¢ per gallon and the Federal tax rate was 24.4¢ per gallon. The state tax applies to all fuel, but the federal tax applies only to diesel fuel that is intended for use in on-road motor vehicles. Contracts that include the purchase of diesel for non-road equipment typically either do not include tax, or maintain a provision for refunding. Untaxed fuel is dyed to prevent its use in the on-road vehicles. This dye is usually added at the point that fuel is loaded into trucks for delivery to a customer.

Most of the ULSD currently commercially available in NYC is used in on-road vehicles. So while most fuel suppliers should have adequate procedures in place to dye and administratively track even small batches of ULSD for non-road use, a Contractor may find it difficult to purchase small quantities of dyed, untaxed ULSD for non-road use from their existing fuel supplier. If Contractors must substitute taxed on-road ULSD for the untaxed non-road fuel they have been using, the incremental cost will be significant. As the full impact of Local Law 77 hits the marketplace, this issue should ease as fuel providers develop the infrastructure to market non-road ULSD to the contracting community.

FUEL AVAILABILITY

As noted previously, ULSD is commercially available in NYC from more than one supplier. In the marketplace, diesel fuel is typically sold in bulk by refiners to third-party marketing companies who own and operate distribution terminals, typically located along waterways accessible to ocean-going barges. The fuel is delivered to the terminal by barge, where it is held in storage tanks and dispensed into trucks for delivery to the final user.

Because of its low sulfur content, ULSD must be segregated from other types of fuel to avoid contamination. As such it requires an investment by fuel terminal operators in additional tankage and segregated distribution lines. Given the relatively low volume of ULSD currently used in the NYC market, not all fuel marketers have yet made this investment.

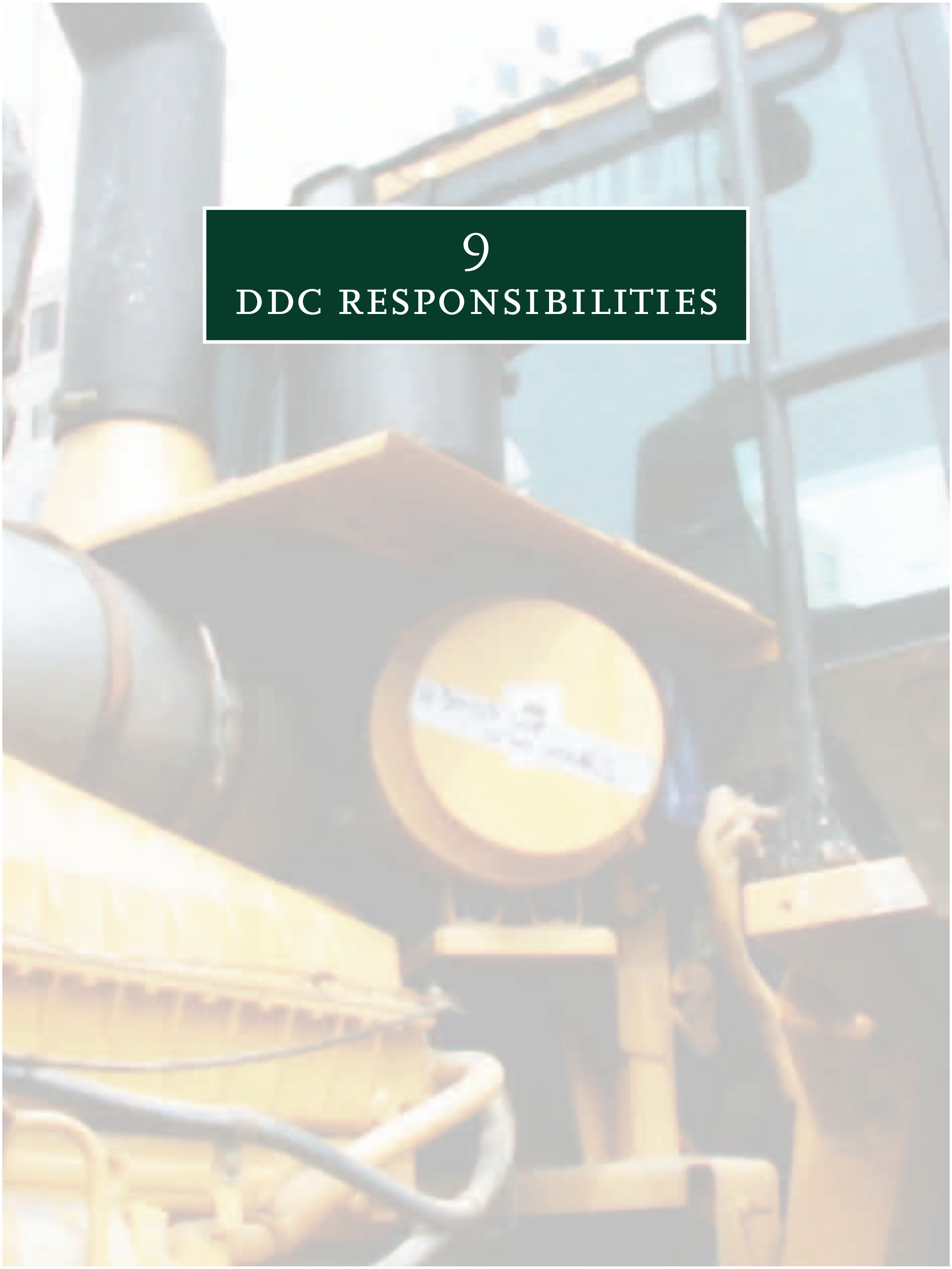
Some contractors may therefore experience disruptions to their operations, and higher than expected administrative costs in the short term, if their current fuel supplier does not currently offer ULSD and they need to form relationships with new suppliers. This problem will undoubtedly ease over time as demand for the fuel increases, especially as the on-road regulations take effect. However, in the short term it may be of significant concern to Contractors.

Local Law 77 specifically requires the use of ULSD with sulfur content no greater than 15-ppm. As discussed previously, currently available ULSD in the NYC market currently has sulfur content up to 30-ppm. Local Law 77 allows the Commissioner of NYC DEP to provide a waiver of the 15-ppm requirement in favor of 30-ppm fuel, if he determines that 15-ppm fuel is not readily available. This waiver must be renewed every six months.

DIFFERING REQUIREMENTS

Because using ULSD is not yet a universal requirement for construction equipment, DDC may experience some initial contractor confusion or reluctance to comply with the Local Law 77. The law applies to equipment used on projects by/for New York City Agencies, but not to private construction within the City. As a result, a contractor may have projects that both do and don't require compliance, and may use the same equipment for all. In addition, many contractors lease equipment for short periods of time, rather than owning their own. One approach would be for the Contractors, and leasing companies, to switch to ULSD on all projects, regardless of whether it is required or not. Given the differential cost of ULSD, however, many will be reluctant to do so unless they can recover their additional costs. This may mean that bids on City projects will be higher than bids on private work, at least for the short-term.

9
DDC RESPONSIBILITIES



RESPONSIBILITIES OF DDC ADMINISTRATORS & PROJECT MANAGERS

DDC Administrators and Project Managers should understand the implications of Local Law 77 and make sure that their City projects comply. Future DDC contracts will include language in the General Conditions that specify the requirements of the local law with respect to use of ULSD and BAT, and DDC contract management practices must include appropriate activities to monitor compliance. The new ULSD requirements stipulated will result in increased fuel costs for contractors that will be passed on to DDC, and future BAT rules are likely to add even more significant costs for equipment retrofits. While these costs are not expected to be significant in relation to total project costs, they may result in construction contract price increases.

The DDC's project managers are responsible to ensure that the design and construction teams understand the new fuel and technology requirements and implement them during the construction process, including filing the required Compliance Forms to document the compliance. The compliance forms can be found on DDC's website at http://www.nyc.gov/html/ddc/html/ddcgreen/forms.html

DESIGN PHASE RESPONSIBILITIES

Plan for possible project impacts of these regulations

- Anticipate that some contractors may not bid on City projects in the short term because compliance is difficult or expensive for them
- Budget for a modest cost increase because of the Contractors overhead expenses for fuel and equipment retrofit.
- Understand that ensuring that the contractor is in compliance will require review and follow-up by the construction manager, and budget accordingly.

Reference the requirements in the Construction Documents

- Make sure to use the latest version of DDC's General Requirements requiring Local Law 77 compliance, including use of ULSD and BAT.
- Note that the General Conditions require the regular submission of Compliance Forms indicating compliance, the amount of ULSD consumed, BAT's utilized and so forth. Forms are available on DDC's website.
- Discuss the requirement at the initial construction meeting, and at subsequent key meetings.

Specify emergency generators that meet or exceed requirements

- Urge Agencies with existing generators to use ultra-low sulfur diesel fuel at a minimum, and to consider a technology retrofit.
- Alert the design team, if the generator will be used for peak shaving or other extended use, that there are NYS regulations covering stationary sources. It is important that compliant generators be specified, and their characteristics be considered. This would be especially important if an existing emergency generator were being upgraded, because some technology options require extra space.

Collect Current NYC DEP Guidance on Local Law 77 Implementation

- Determine whether NYC DEP has issued a current written determination that ULSD with sulfur content of 15-ppm is unavailable, thus allowing the use of ULSD with 30-ppm sulfur content to comply with Local Law 77. Such a determination must be re-issued at least every six months
- Direct the contractor to the website of the NYC DEP for the latest listing of the BAT's. The BAT's utilized should be as per posting on DEP's website at the contract date, with the exception that any emission reduction device installed as per previous DEP BAT lists can be used for three years.

CONSTRUCTION PHASE RESPONSIBILITIES- CONTRACTOR REPORTING AND COMPLIANCE

Enforcement of Local Law 77 is the responsibility of the New York City Department of Environmental Protection. Under the law, NYC DEP also has a duty to annually report to the City Comptroller and the Speaker of the New York City Council on the use of ULSD and BAT on City construction projects. So that NYC DEP can comply with its reporting duties, City agencies have the responsibility to collect relevant information on the use of ULSD and BAT on their projects, and forward it to NYC DEP.

City agencies, including DDC, also have a responsibility to monitor contractor compliance with Local Law 77 and to notify NYC DEP of suspected non-compliance. DDC project managers do not have responsibility or authority to impose penalties on Contractors for non-complance. DDC project managers have an obligation to cooperate with NYC DEP in any investigation of contractor non-complance with Local Law 77.

For the purposes of both monitoring complance and collecting the required information, all contractors on DDC construcion projects will be required to submit and initial *Local Law 77 Compliance Plan*, and to regularly submit a *Local Law 77 Contractor Compliance Form*. DEP's BAT list may be organized into hierarchy of categories of BAT's. If a project needs to use a BAT from any of the less than optimal categories, it may be required to procure a waiver from DEP. If so, the project team should first consult DDC's website to see if an umbrella waiver for that technology has already been obtained by DDC. Information on submission requirements and updated versions of the forms will be available on the DDC website under the Office of Sustainable Design (http://www.nyc.gov/html/ddc/html/ddcgreen/forms.html).

This form requires the Contractor to provide an inventory of all diesel equipment used on the project during the reporting period, with identifying information such as equipment make/model, engine make/model, and engine HP rating. For each piece of equipment, the Contractor also must identify what BAT was used. The form also requires the Contractor to note how many gallons of diesel fuel were used on the project during the reporting period, and cumulatively for the year, and to make a definitive statement that all fuel used was ULSD. This form must be signed by the Contractor.

Project Managers should review the forms for accuracy with respect to what equipment was on the site during the reporting period. Inaccurate forms should be returned to the Contractor for submittal of corrected forms that include all equipment. Project Managers should randomly spot-check equipment to ensure that the BAT listed on the forms is actually in place. Project Managers should randomly spot-check fuel invoices during on-site fuel deliveries to ensure that the fuel bing delivered is actually ULSD. If there is any question as to what fuel is being delivered, Project Managers may request copies of all fuel invoices from the Contractor.

Project Managers should keep a copy of each submitted *Local Law 77 Contractor Compliance Form* in their project files, and forward a copy to a central office, as directed on the website. Ultimately, a central office will consolidate reports from all DDC projects and forward the information to NYC DEP. DDC is determining who will collect the information for the Agency and who will be the compliance liason with DEP. This protocol will be posted on the website at http://www.nyc.gov/html/ddc/html/ddcgreen/home.html

If a Project Manager has a reason to suspect that any Contractor has submitted false information on a *Local Law 77 Contractor Complinace Form* or in any other way has failed to comply with Local Law 77, they must fill out a *Suspected Local Law 77 Non-Compliance Form*, and forward it, with supporting information, to the designated compliance office at DDC. The office will forward the information to NYC DEP for their action. Updated versions of this non-compliance form will be available on the website.

Project Managers should note that Local Law 77 exempts "a diesel-powered vehicle that is used to satisfy the requirements of a specific public works contract for fewer than twenty calendar days" from the requirement to use BAT. These vehicles are still required to use ULSD, however. Project Managers should use their professional judgment to determine whether Contractors are using this exemption to subvert the intent of the Law by cycling individual pieces of equipment on and off the job site. If this activity is suspected, Project Managers should discuss the situation with the Contractor and/or notify the designated compliance office, as above.

A contractor may request a waiver of the requirement to use BAT on any individual piece of equipment for one of two reasons: 1) the BAT specified on NYC DEP's BAT list is unavailable for that piece of equipment, or 2) use of the specified BAT will endanger the equipment operator or persons working nearby due to engine malfunction. In both cases, the waiver must be approved in writing by the Commissioner of NYC DEP to be effective. Contractor requests for wiavers should be forwarded to NYC DEP through the DDC's designated compliance office. Project Managers should keep a copy of all approved waivers in their project files.

Any noncompliance with the provisions of Local Law 77 subject the Contractor to civil penalties of $1,000 - $10,000 per occurrence, plus twice the amount that the Contractor saved by not complying. In addition, any false claims made by the Contactor with respect to Local Law 77 Compliance (for example, by submitting false information on a *Local Law 77 Contractor Compliance Form*) will subject the Contractor to a civil penalty of $20,000 per occurrence, plus twice the amount that the Contractor saved by not complying.

10 APPENDICES

APPENDIX A
ACRONYMS

API	American Petroleum Institute
ASTM	American Society for Testing & Materials
BACT	Best Available Control Technology
BAT	Best Available Technology
BTU	British Thermal Units
CAA	Clean Air Act
CAAA	Clear Air Act Amendments
CEMS	Continuous Emission Monitoring System
CO	Carbon Monoxide
CO2	Carbon Dioxide
DDC	Department of Design and Construction (City of New York)
DEP	Department of Environmental Protection
DOC	Diesel Oxidation Catalysts
DPF	Diesel Particulate Filters
ECM	Electric Control Module
EGR	Exhaust Gas Recirculation
EPA	Environmental Protection Agency
GVW	Gross Vehicle Weight
HC	Hydrocarbons
HP	Horse Power
HDDV	Heavy Duty Diesel Vehicles
HFRR	High Frequency Reciprocating Wear Rig
LHV	Lower Heating Value
MW	MegaWatt
N2	Nitrogen
NAAQS	National Ambient Air Quality Standards
NOX	Nitrogen Oxides
NO	Nitric Oxide
NO2	Nitrogen Dioxide
NRC	Lean NOx or NOx Reducing Catalyst
NYS DEC	New York State Department of Environmental Conservation
O3	Ground Level Ozone
PB	Lead
PM	Particular Matter
PPM	Parts Per Million
RACT	Reasonably Available Control Technology
SCR	Selective Catalyst Reduction
SBOCLE	Ball on Cylinder Lubricity Evaluator
SO2	Sulfur Dioxide
ULSD	Ultra Low Sulfur Diesel
VOC	Volatile Organic Compounds

APPENDIX B
LOCAL LAW 77: NEW YORK CITY NON-ROAD FUEL AND BAT RULE

LOCAL LAWS OF THE CITY OF NEW YORK FOR THE YEAR 2003 NO. 77

Introduced by Council Members Gerson, The Speaker (Council Member Miller), Clarke, Comrie, Jennings, Perkins, Yassky, Avella, Serrano, Koppell, Quinn, Seabrook, Katz, Brewer, Gennaro, Gioia, Gentile, DeBlasio, Moskowitz, Liu, Baez, Lopez, Martinez, James, Weprin, Jackson and Nelson; also Council Members Boyland, Recchia Jr., McMahon and Vallone Jr.

A LOCAL LAW

To amend the administrative code of the city of New York, in relation to the use of ultra low sulfur diesel fuel and the best available technology by nonroad vehicles in city construction.

Be it enacted by the Council as follows:

Section 1. Declaration of Legislative Findings and Intent. The Council finds that diesel emissions, due in large part to their high concentrations of particulate matter, are associated with severe and multiple health risks to the citizens of New York City. Public health organizations, including the National Institute of Occupational Safety and Health, the World Health Organization, the United States Environmental Protection Agency (EPA), the California Environmental Protection Agency and the United States Department of Health and Human Services' National Toxicology Program, have associated diesel exhaust or diesel particulates with an increased risk of cancer. Additionally, the health effects associated with particulate matter include decreased lung function, aggravated asthma, respiratory symptoms and premature death.[1] Nonroad diesel equipment is the single largest mobile sourcebased source of diesel particulate matter.

Diesel exhaust also contains nitrogen oxides, which combine with volatile organic compounds in the air, such as hydrocarbons – also emitted by nonroad vehicles – to form ground-level ozone, or smog, in the presence of heat and sunlight.[2] Ozone may cause a variety of respiratory problems, including aggravated asthma, decreases in lung capacity and increased susceptibility to respiratory illnesses.[3] It is damaging to lung tissue in high concentrations and during long-term exposure.[4] New York City continues to be classified as a "severe-17 nonattainment area" for ozone.[5]

As mentioned above, increased particulate matter concentrations and nitrogen oxides have been positively linked to increases in the aggravation of asthma, which can lead to increased rates of preventable hospitalization and premature death. The Council finds that reducing particulate matter and nitrogen oxide emissions may help to stem the tide of the asthma epidemic in New York City. In the year 2000 alone, there were 26,868 asthma-related hospitalizations in New York City.[6] These hospitalizations resulted in $242,454,056 of medical expenses – an average of $9023.90 per hospitalization – of which 49.4% of the charges, or $119,772,304, was paid by Medicaid and 23.1% of the charges, or $56,006,887, was paid by Medicare.[7]

[1] *United States Environmental Protection Agency, "Health and Environmental Effects of Particulate Matter, Fact Sheet", July 17, 1997, http://www.epa.gov/ttn/oarpg/naaqsfin/pmhealth.html.*
[2] *http://www.epa.gov/otaq/invntory/overview/pollutants/nox.htm.*
[3] *http://www.epa.gov/air/oaqps/airtrans/groundoz.html.*
[4] *American Lung Association of New York State, Inc., "Unhealthful to Breathe: Summer Ozone Levels in New York State", October 2002, p. 6.*
[5] *This classification means that the area does not meet the national primary or secondary ambient air quality standard for ozone; it has a design value of from 0.190 up to 0.280 ppm for ozone; and, it has until 2007 to attain compliance with the standards. http://www.epa.gov/oar/oaqpsd/greenbk/define.html#Designations.*
[6] *New York City Department of Health and Mental Hygiene, "Asthma Facts, Second Edition ("Asthma Facts")", May 2003, Figure 6, p. 12.*
[7] *Asthma Facts, Figure 11, p. 13.*

The EPA, recognizing the harmful effects of diesel emissions from nonroad vehicles, issued a proposed rule on April 15, 2003, which would require that sulfur levels in nonroad diesel fuel be limited to 15 parts per million in 2010. This rule would also require, starting in 2008 for smaller nonroad vehicles, that engines meet more stringent emissions standards.

Nonroad vehicles, such as backhoes, bulldozers, excavation machines, generators and cranes, have been and will be used to perform necessary and important functions at Ground Zero and will play a major role in the rebuilding of the area for years to come. The Council finds, however, that the City has a responsibility toward the people who live, work and attend school in Lower Manhattan, to minimize, wherever practical, the pollution such equipment and machinery emit into the air. The Council finds that the use of ultra low sulfur diesel fuel to power the diesel-powered nonroad vehicles operating at Ground Zero and in other parts of Lower Manhattan would reduce the amount of particulates released into the air by these vehicles, thereby improving air quality in that area. The Council further finds that using nonroad vehicles that utilize the best available technology for reducing the emission of harmful pollutants, such as particulate matter and nitrogen oxides, would have a dramatic impact on the level of pollutants being released in Lower Manhattan.

The Council finds that air quality is a concern in all parts of New York City, as well as in Lower Manhattan, particularly since the City suffers from some of the highest asthma rates in the country. Therefore, the Council finds that it is in the best interest of the health of our City's residents, workers and schoolchildren for the City to use ultra low sulfur diesel fuel and the best available technology for reducing the emission of pollutants in its diesel-powered nonroad vehicles in all areas of the City, in addition to Lower Manhattan. The Council also finds that the City should contract for construction services with contractors who use ultra low sulfur diesel fuel and the best available technology to minimize the release of harmful pollutants in diesel-powered nonroad vehicles. Acting with the discretion allowed any private participant in the market, the City should choose to allocate its purchasing dollars in order to protect the health of its residents, thus decreasing the number of asthma hospitalizations and associated costs to the City, as well.

This legislation requires that any diesel-powered nonroad vehicle, fifty horsepower and greater, that is owned by, operated by or on behalf of, or leased by a City agency be powered by ultra low sulfur diesel fuel and utilize the best available technology for reducing the emission of pollutants. Additionally, this legislation requires that any solicitation for a public works contract and any contract entered into as a result of such solicitation include specifications that all contractors in the performance of such contract use ultra low sulfur diesel fuel and the best available technology for reducing the emission of pollutants for diesel-powered nonroad vehicles. All contractors in the performance of such contract must comply with such specifications. Although these requirements would apply to such vehicles only in Lower Manhattan at first, they would subsequently apply to nonroad vehicles in all other areas of the City. The Council finds that this legislation will have an important impact on improving the air quality throughout New York City and, consequently, may annually save the City millions of dollars in avoided health care costs.

§ 2. Title 24 of the administrative code of the city of New York is hereby amended by adding a new section 24-163.3 to read as follows:

§ 24-163.3 Use of ultra low sulfur diesel fuel and best available technology in nonroad vehicles. a. For purposes of this section only, the following terms shall have the following meanings:

(1) "City agency" means a city, county, borough, administration, department, division, bureau, board or commission, or a corporation, institution or agency of government, the expenses of which are paid in whole or in part from the city treasury.

(2) "Contractor" means any person or entity that enters into a public works contract with a city agency, or any person or entity that enters into an agreement with such person or entity, to perform work or provide labor or services related to such public works contract.

(3) “Lower Manhattan” means the area of New York county consisting of the area to the south of and within Fourteenth street.

(4)“Motor vehicle” means any self-propelled vehicle designed for transporting persons or property on a street or highway.

(5) “Nonroad engine” means an internal combustion engine (including the fuel system) that is not used in a motor vehicle or a vehicle used solely for competition, or that is not subject to standards promulgated under section 7411 or section 7521 of title 42 of the United States code, except that this term shall apply to internal combustion engines used to power generators, compressors or similar equipment used in any construction program or project.

(6) “Nonroad vehicle” means a vehicle that is powered by a nonroad engine, fifty horsepower and greater, and that is not a motor vehicle or a vehicle used solely for competition, which shall include, but not be limited to, excavators, backhoes, cranes, compressors, generators, bulldozers and similar equipment, except that this term shall not apply to horticultural maintenance vehicles used for landscaping purposes that are powered by a nonroad engine of sixty-five horsepower or less and that are not used in any construction program or project.

(7) “Person” means any natural person, co-partnership, firm, company, association, joint stock association, corporation or other like organization.

(8) “Public works contract” means a contract with a city agency for a construction program or project involving the construction, demolition, restoration, rehabilitation, repair, renovation, or abatement of any building, structure, tunnel, excavation, roadway, park or bridge; a contract with a city agency for the preparation for any construction program or project involving the construction, demolition, restoration, rehabilitation, repair, renovation, or abatement of any building, structure, tunnel, excavation, roadway, park or bridge; or a contract with a city agency for any final work involved in the completion of any construction program or project involving the construction, demolition, restoration, rehabilitation, repair, renovation, or abatement of any building, structure, tunnel, excavation, roadway, park or bridge.

(9) “Ultra low sulfur diesel fuel” means diesel fuel that has a sulfur content of no more than fifteen parts per million.

b. (1) Any diesel-powered nonroad vehicle that is owned by, operated by or on behalf of, or leased by a city agency shall be powered by ultra low sulfur diesel fuel. (2) Any diesel-powered nonroad vehicle that is owned by, operated by or on behalf of, or leased by a city agency shall utilize the best available technology for reducing the emission of pollutants.

c. (1) Any solicitation for a public works contract and any contract entered into as a result of such solicitation shall include a specification that all contractors in the performance of such contract shall use ultra low sulfur diesel fuel in diesel-powered nonroad vehicles and all contractors in the performance of such contract shall comply with such specification. (2) Any solicitation for a public works contract and any contract entered into as a result of such solicitation shall include a specification that all contractors in the performance of such contract shall utilize the best available technology for reducing the emission of pollutants for diesel-powered nonroad vehicles and all contractors in the performance of such contract shall comply with such specification.

d. (1) The commissioner shall make determinations, and shall publish a list containing such determinations, as to the best available technology for reducing the emission of pollutants to be used for each type of dieselpowered nonroad vehicle to which this section applies for the purposes of paragraph two of subdivision b and paragraph two of subdivision c of this section. Each such determination, which shall be updated on a regular basis, but in no event less than once every six months, shall be primarily based upon the reduction in emissions of particulate matter and secondarily based upon the reduction in emissions of nitrogen oxides associated with the use of such technology and shall in no event result in an increase in the emissions of either such pollutant. In determining the best available technology for reducing the emission of pollutants, the commissioner shall select technology from that which has been verified by the United States environmental protection agency or the California air resources board for use in nonroad vehicles or onroad vehicles where such technology may also be used in nonroad vehicles, but the commissioner may select technology that is not verified as such as is deemed appropriate. (2) No city agency or contractor shall be required to replace best available technology for reducing the emission of pollutants or other authorized technology utilized for a diesel-powered nonroad vehicle in accordance with the provisions of this section within three years of having first utilized such technology for such vehicle.

e. A city agency shall not enter into a public works contract subject to the provisions of this section unless such contract permits independent monitoring of the contractor's compliance with the requirements of this section and requires that the contractor comply with section 24-163 of this code. If it is determined that the contractor has failed to comply with any provision of this section, any costs associated with any independent monitoring incurred by the city shall be reimbursed by the contractor.

f. (1) The provisions of subdivision b of this section shall apply to any diesel-powered nonroad vehicle in use in Lower Manhattan that is owned by, operated by or on behalf of, or leased by a city agency and the provisions of subdivision c of this section shall apply to any public works contract for Lower Manhattan upon the effective date of this section. (2) The provisions of paragraph one of subdivision b of this section shall apply to all diesel-powered nonroad vehicles that are owned by, operated by or on behalf of, or leased by a city agency and the provisions of paragraph one of subdivision c of this section shall apply to all public works contracts six months after the effective date of this section. (3) The provisions of paragraph two of subdivision b of this section shall apply to all diesel-powered nonroad vehicles that are owned by, operated by or on behalf of, or leased by a city agency and the provisions of paragraph two of subdivision c of this section shall apply to any public works contract that is valued at two million dollars or more one year after the effective date of this section. (4) The provisions of paragraph two of subdivision c of this section shall apply to all public works contracts eighteen months after the effective date of this section.

g. (1) On or before January 1, 2005, and every succeeding January 1, the commissioner shall report to the comptroller and the speaker of the council on the use of ultra low sulfur diesel fuel in diesel-powered nonroad vehicles and the use of the best available technology for reducing the emission of pollutants and such other authorized technology in accordance with this section for such vehicles by city agencies during the immediately preceeding fiscal year. This report shall include, but not be limited to (i) the total number of diesel-powered nonroad vehicles owned by, operated by or on behalf of, or leased by each city agency or used to fulfill the requirements of a public works contract for each city agency; (ii) the number of such nonroad vehicles that were powered by ultra low sulfur diesel fuel; (iii) the number of such nonroad vehicles that utilized the best available technology for reducing the emission of pollutants, including a breakdown by vehicle model and the type of technology used for each vehicle; (iv) the number of such nonroad vehicles that utilized such other authorized technology in accordance with this section, including a breakdown by vehicle model and the type of technology used for each vehicle; (v) the locations where such nonroad vehicles that were powered by ultra low sulfur diesel fuel and/or utilized the best available technology for reducing the emission of pollutants or such other authorized technology in accordance with this section were used; (vi) all findings, and renewals of such findings, issued pursuant to subdivision j of this section, which shall include, but not be limited to, for each finding and renewal, the quantity of diesel fuel needed by the city agency or contractor to power diesel-powered nonroad vehicles owned by, operated by or on behalf of, or leased by the city agency or used to fulfill the requirements of a public works contract for such agency; specific information concerning the availability of ultra low sulfur diesel fuel or diesel fuel that has a sulfur content of no more than thirty parts per million where a determination is in effect pursuant to subdivision i of this section; and detailed information concerning the city agency's or contractor's efforts to obtain ultra low sulfur diesel fuel or diesel fuel that has a sulfur content of no more than thirty parts per million where a determination is in effect pursuant to subdivision i of this section; and (vii) all findings and waivers, and renewals of such findings and waivers, issued pursuant to paragraph one or paragraph three of subdivision k or subdivision m of this section, which shall include, but not be limited to, all specific information submitted by a city agency or contractor upon which such findings, waivers and renewals are based and the type of such other authorized technology, if any, utilized in accordance with this section in relation to each finding, waiver and renewal, instead of the best available technology for reducing the emission of pollutants. (2) Where a determination is in effect pursuant to subdivision i of this section, information regarding diesel fuel that has a sulfur content of no more than thirty parts per million shall be reported wherever information is requested for ultra low sulfur diesel fuel pursuant to paragraph one of this subdivision.

h. This section shall not apply: (1) where federal or state funding precludes the city from imposing the requirements of this section; or (2) to purchases that are emergency procurements pursuant to section three hundred fifteen of the charter.

i. The commissioner shall issue a written determination that permits the use of diesel fuel that has a sulfur content of no more than thirty parts per million to fulfill the requirements of paragraph one of subdivision b and paragraph one of subdivision c of this section if ultra low sulfur diesel fuel is not available to meet the needs of city agencies and contractors to fulfill the requirements of this section. Such determination shall expire after six months and shall be renewed in writing every six months if ultra low sulfur diesel fuel is not available to meet the needs of city agencies and contractors to fulfill the requirements of this section, but in no event shall be in effect after September 1, 2006.

j. Paragraph one of subdivision b and paragraph one of subdivision c, as that paragraph applies to all contractors' duty to comply with the specification, of this section shall not apply to a city agency or contractor in its fulfillment of the requirements of a public works contract for such agency where such agency makes a written finding, which is approved, in writing, by the commissioner, that a sufficient quantity of ultra low sulfur diesel fuel, or diesel fuel that has a sulfur content of no more than thirty parts per million where a determination is in effect pursuant to subdivision i of this section, is not available to meet the requirements of paragraph one of subdivision b or paragraph one of subdivision c of this section, provided that such agency or contractor in its fulfillment of the requirements of a public works contract for such agency, to the extent practicable, shall use whatever quantity of ultra low sulfur diesel fuel or diesel fuel that has a sulfur content of no more than thirty parts per million is available. Any finding made pursuant to this subdivision shall expire after sixty days, at which time the requirements of paragraph one of subdivision b and paragraph one of subdivision c of this section shall be in full force and effect unless the city agency renews the finding in writing and such renewal is approved by the commissioner.

k. Paragraph two of subdivision b and paragraph two of subdivision c, as that paragraph applies to all contractors' duty to comply with the specification, of this section shall not apply: (1) to a diesel-powered nonroad vehicle where a city agency makes a written finding, which is approved, in writing, by the commissioner, that the best available technology for reducing the emission of pollutants as required by those paragraphs is unavailable for such vehicle, in which case such agency or contractor shall use whatever technology for reducing the emission of pollutants, if any, is available and appropriate for such vehicle; or (2) to a diesel-powered nonroad vehicle that is used to satisfy the requirements of a specific public works contract for fewer than twenty calendar days; or (3) to a diesel-powered nonroad vehicle where the commissioner has issued a written waiver based upon a city agency or contractor having demonstrated to the commissioner that the use of the best available technology for reducing the emission of pollutants might endanger the operator of such vehicle or those working near such vehicle, due to engine malfunction, in which case such city agency or contractor shall use whatever technology for reducing the emission of pollutants, if any, is available and appropriate for such vehicle, which would not endanger the operator of such vehicle or those working near such vehicle.

l. In determining which technology to use for the purposes of paragraph one or paragraph three of subdivision k of this section, a city agency or contractor shall primarily consider the reduction in emissions of particulate matter and secondarily consider the reduction in emissions of nitrogen oxides associated with the use of such technology, which shall in no event result in an increase in the emissions of either such pollutant.

m. Any finding or waiver made or issued pursuant to paragraph one or paragraph three of subdivision k of this section shall expire after one hundred eighty days, at which time the requirements of paragraph two of subdivision b and paragraph two of subdivision c of this section shall be in full force and effect unless the city agency renews the finding, in writing, and the commissioner approves such finding, in writing, or the commissioner renews the waiver, in writing.

n. Any contractor who violates any provision of this section, except as provided in subdivision o of this section, shall be liable for a civil penalty between the amounts of one thousand and ten thousand dollars, in addition to twice the amount of money saved by such contractor for failure to comply with this section.

o. No contractor shall make a false claim with respect to the provisions of this section to a city agency. Where a contractor has been found to have done so, such contractor shall be liable for a civil penalty of twenty thousand dollars, in addition to twice the amount of money saved by such contractor in association with having made such false claim.

p. This section shall not apply to any public works contract entered into or renewed prior to the effective date of this section.

q. Nothing in this section shall be construed to limit the city's authority to cancel or terminate a contract, deny or withdraw approval to perform a subcontract or provide supplies, issue a non-responsibility finding, issue a non-responsiveness finding, deny a person or entity pre-qualification as a vendor, or otherwise deny a person or entity city business.

§ 3. Subparagraph (i) of paragraph 5 of subdivision b of section 24-178 of the administrative code of the city of New York is amended by inserting the following lines in the Table of Civil Penalties, immediately following the line regarding civil penalties for a violation of section 24-163.2 of this chapter: 24-163.3; plus twice the amount of money saved by the contractor for failure to comply with such section; provided that such $1,000 - $10,000 penalty and additional penalty shall not apply to violations of 24-163.3(o).......... 10,000 1,000 24-163.3(o); plus twice the amount of money saved by the contractor in association with having made such false claim 20,000 20,000

§ 4. If any section, subsection, sentence, clause, phrase or other portion of this local law is, for any reason, declared unconstitutional or invalid, in whole or in part, by any court of competent jurisdiction such portion shall be deemed severable, and such unconstitutionality or invalidity shall not effect the validity of the remaining portions of this law, which remaining portions shall continue in full force and effect.

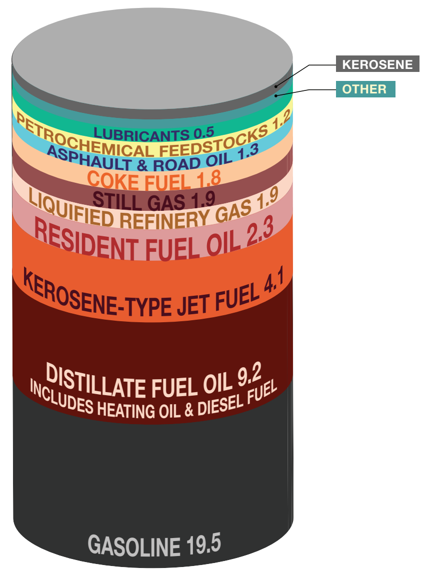
§ 5. This local law shall take effect one hundred eighty days after its enactment, except that the commissioner of environmental protection shall take all actions necessary, including the promulgation of rules, to implement this local law on or before the date upon which it shall take effect.

APPENDIX C
DIESEL FUEL SPECIFICATIONS

DIESEL FUEL: WHAT IS IT?

Diesel fuels consist of a large number of hydrocarbons that have boiling points between 180°C and 370°C.[17] They are obtained by the step-wise distillation of crude oil. Petroleum, or crude oil, contains a complex mixture of hydrocarbons and other compounds like sulfur and nitrogen. Crude oil is found in underground reservoirs and extracted through wells. Two thirds of proven petroleum reserves are found in the Middle East and North Africa, with exploration and advances in technology expected to increase recoverable oil throughout the world. U.S. crude oil production levels have been declining since the 1970s, with only 9.1 million barrels of petroleum products per day produced in 1998.[18] In order to meet 1998 U.S. consumption of 18.68 million barrels of petroleum products, $46.6 billion was spent on petroleum imports.[19] In terms of transportation petroleum consumption, the U.S. utilized 137 percent of domestic production.[20]

Figure 1:
Products Derived from a 42-Gallon Barrel of Petroleum



Source: www.dieselforum.net

At a refinery, crude oil is distilled (heated and condensed) into its various fractions, with the lighter fractions condensing at the top and the heavier ones settling toward the bottom of a distillation column. Products such as gasoline, kerosene and distillate oils can be sold as an end product, or can be further processed. The second processing converts the fractions into different petroleum products through cracking, coking, reforming and alkylation processes. Figure 1 illustrates the gallons of fuel product developed from a 42-gallon barrel drum of crude oil.

Rudolph Diesel (1858-1913) filed the first patent for his "economical heat motor" in 1892. In Mr. Diesel's engine, fuel is directly ignited by the increased temperature as the fuel is compressed in the cylinder (compression ignition), rather than by an electrical spark as in an Otto Cycle (i.e. gasoline) engine. This difference in the method of ignition requires significantly different properties for the fuel used (e.g. "diesel" fuel is used in a compression ignition engine, and "gasoline" is used in a spark-ignited engine.) Since its invention, the diesel engine has become the primary choice of power when it comes to on-road equipment such as heavy-duty trucks, and buses, as well as for non-road equipment such as excavators, cranes,generators, trains, and large ships. Diesel engines require less maintenance and generate energy more efficiently, with less carbon dioxide emissions than equivalent ignition-based gasoline engines. While the combustion cycle of a diesel engine is more efficient than that of a comparable gasoline engine, this is only part of the reason why diesels get better fuel economy on a per gallon basis. A gallon of diesel fuel also has more energy than a gallon of gasoline[21] (128,980 BTU/gal lower heating value (lhv) for diesel vs. 115,400 BTU/gal lhv for gasoline).

The major drawback of diesel engines is that historically they have produced a significantly greater amount of harmful pollutants than gasoline engines. This is partly due to the nature of diesel engine combustion compared to gasoline engine combustion, and partly due to less aggressive federal regulation since the 1970's.

[17] *Bosch, Robert; Automotive Handbook, 4th Edition, October 1996*
[18] *EIA, 1999.*
[19] *EIA, 1999.*
[20] *Davis, 1999.*
[21] *Diesel engines are about 30% more fuel efficient primarily due to higher effective compression and lower throttling losses than gasoline engines.*

Sulfur occurs naturally in crude oil and is often removed in various amounts at the refinery to create different grades of both gasoline and diesel fuel with different levels of sulfur. In order to remove sulfur, the crude oil is heated and put under high pressure in the presence of hydrogen. The sulfur chemically combines with the hydrogen, and is removed as hydrogen sulfides.

US EPA regulates the maximum allowable sulfur content for fuels that are put to different uses. Currently the maximum allowable sulfur level is 3,000 parts per million (ppm) in diesel fuel to be used in non-road equipment and 500-ppm in diesel fuel for on-road use. Typical on-road fuel in NYC has an actual sulfur content of approximately 350-ppm. This 350-ppm on-road fuel is often referred to as "low sulfur diesel" to distinguish it from the higher sulfur non-road fuel.

EPA has issued new rules that will require a significant reduction in sulfur content for on-road fuel, to be phased in between 2006 and 2010. These new rules require the use of "ultra-low sulfur diesel (ULSD)" with a maximum sulfur content of 15-ppm. Early adopters of ULSD have already brought this fuel into the market place, and it is commercially available in certain areas of the country, including the New York City metropolitan region. The ULSD that is most readily available today in NYC is based on an interim specification that allows for a maximum of 30-ppm sulfur, and typically has an actual sulfur content of 20-ppm. This partially relaxed specification accommodates the small amount of contamination associated with today's distillate supply chain. As of June 9, 2006, all refiners in the US will have to start producing some fuel with less than 15-ppm sulfur and by 2010, all on-road diesel produced in this country will have to meet that specification.

ULSD FUEL SPECIFICATIONS

Diesel engine manufacturers design their engines with three factors in mind: power, lifecycle cost, and emissions. The manufacturer's goal is to maximize in-service life and provide predictable power and emission performance throughout the life of the engine. Using the proper fuel is necessary to maintain the long-term health of the diesel engine, and most engine manufacturers use their engine's warranty provisions to enforce the use of appropriate fuel. Failure to use the right fuel will in most cases void the engine's warranty.

There are a number of individual fuel properties for which diesel engine manufacturers have identified minimum standards to ensure proper engine operation and maximum service life. Virtually all commercially available diesel fuel is refined based on these standards.

A full discussion of diesel fuel properties, along with a listing of minimum standards set by three different engine manufacturers is included at the end of this section. Alternative diesel fuel formulations that are intended to reduce emissions can affect one or more of these diesel fuel properties, both negatively and positively. For this reason it is important to have a basic understanding of diesel fuel properties when evaluating fuel options. This is discussed in detail in Section 6 of this report, when reviewing other alternative fuel options that may be designated as Best Available Technology for reducing emissions.

With respect to ULSD, there are only two fuel properties that are of significant interest: fuel sulfur level, and lubricity. Since commercially available ULSD is currently typically derived from standard low sulfur on-road fuel by removing additional sulfur at the refinery, the other fuel properties remain essentially unchanged. After 2006, as ULSD replaces all current low sulfur on-road fuel, the refiners will certainly base their ULSD specifications on current on-road fuel specifications, for fuel properties other than sulfur content. These specifications are sensitive to the engine manufacturer's recommendations.

During this interim period prior to 2006, when ULSD is still a low-volume specialty product, individual fleet users have somewhat greater flexibility to define their own specification for ULSD. In practice, the current specification for ULSD fuel readily available in NYC is controlled by the largest fleet users, and in particular by MTA New York City Transit, which currently uses approximately 47 million gallons per year of ULSD in its bus fleet. A small user that seeks to purchase small quantities of ULSD in NYC today at a reasonable price (about 10 to 19 cents higher per gallon than on-road #1 distillate) will most likely receive ULSD fuel based on the NYCT specification. This specification is included at the end of this appendix. This specification is based on standard on-road #1 diesel, but with sulfur content no greater than 30-ppm, and it incorporates the engine manufacturers' minimum standards for all fuel properties including lubricity.

Fuel sulfur and lubricity are discussed below along with other fuel properties.

FUEL PROPERTIES

The following sections describe the major fuel properties that are typically specified for diesel fuel, and highlight how changes in these properties can affect engine operation and emissions:

CETANE NUMBER (OR CETANE INDEX)

Cetane number is an indication of how easily diesel fuel wills combust. Diesel engines rely on compression ignition and because there is no spark as with a gasoline engine, the fuel itself governs how well the engine will perform. Cetane Index is also used as another way of indicating a fuel's ability to combust and is calculated based on fuel properties including density and volatility.

A range of acceptable cetane numbers have been established because either too low or too high a cetane number can affect engine operation. With a cetane number that is too low, cold starts become more difficult and emissions and noise will increase because more fuel is needed to get the engine started. Low cetane also affects the engine injection timing by effectively delaying combustion. High cetane is generally not a problem and in fact cold starting can be dramatically improved. High cetane fuels are typically produced by removing aromatic components such that the fuel contains higher and higher concentrations of paraffin components. Left alone, the higher paraffin content can lead to adverse pour and cloud points and fuel gelling as discussed earlier. Additives such as oxygenates can effectively alleviate this issue.

LUBRICITY

Diesel engines are designed to be lubricated not only by the lubrication oil, but also the fuel (i.e. fuel pump components). How well the fuel acts as a lubricant is termed lubricity. Lubricity can be measured by two test methods, High Frequency Reciprocating Wear Rig (HFRR – ASTM D6079), and Ball on Cylinder Lubricity Evaluator (SBOCLE- ASTM D6078). These methods are slightly different and provide various metrics for the evaluation of lubricity. For testing the natural lubricity of petroleum fuels, the SBOCLE test should be sufficient, but it is not recommended for testing fuels treated with a lubricity additive. For these fuels, the HFRR test should be used.

A primary lubricant in diesel fuel is sulfur. When sulfur is substantially removed as is the case with ULSD, the lubricating properties of the fuel are compromised. To retain the lubricating quality of the fuel, manufacturers typically supply the fuel with lubricity additives. Different manufacturers provide proprietary formulations for these additives, most of which are based on various organic compounds.

SULFUR

As discussed in the lubricity section, sulfur is a natural lubricant in diesel fuel, and its removal to very low levels can cause problems unless the lubricating property of the removed sulfur is replaced by a lubricity enhancing additive. However, sulfur removal from fuel does provide some engine benefits as well. Fuel-borne sulfur can oxidize in the combustion chamber to produce sulfuric acid and other sulfur compounds that can increase internal engine and exhaust component corrosion. While non-road diesel engines are designed to withstand the relatively high level of sulfur in non-road fuel, significant reductions in fuel sulfur level may increase oil drain intervals and/or prolong engine life in these engines. Sulfuric acid in the atmosphere also contributes to environmental degradation when it enters lakes and streams in rain water (ie "acid rain"). However, vehicle emissions of sulfur are not a significant source of acid rain. The primary source of acid rain problems are sulfur emissions from electric power plants, particularly those that burn coal with high sulfur content.

HEAT OF COMBUSTION

Heat of combustion, or heat value is a measure of how much energy is available from the diesel fuel. Alternate fuels available for diesel engines, although based upon regular diesel, do have different heat values as a result of additional refining, or by using additives. For example, ULSD has a lower heat of combustion than regular diesel, by a few percent, which translates into a slightly lower fuel economy because more fuel is needed to perform the same amount of work. This is a direct function of sulfur removal from the fuel with the combustion energy normally garnered from the oxidation of sulfur to sulfur dioxide no longer available.

Also note that many specifications list both the lower and higher heating values of the fuel in question. Fuel combustion products consist primarily of carbon dioxide (the oxidized carbon from the fuel) and water (oxidized hydrogen in the fuel) along with some undesirable components such as sulfur dioxide, particulate and NOx . The difference between lower and higher heating values reflects the energy necessary to vaporize the water combustion component. This additional energy cannot be captured in a diesel engine (it typically can be recaptured only in condensing heating units) and for diesel engines the lower heating value is the relevant parameter.

DENSITY AND API GRAVITY

The density of diesel fuel is a good indicator of its energy content. Generally, the higher the density, the higher the energy content. Density can affect performance of the fuel by causing greater PM emissions if too high, while a low density can lead to decreased power. Specific gravity is closely related to density and is the ratio between the weight of a known volume of diesel fuel compared to the weight of the same volume of a standard liquid, usually water. API gravity, a standard metric of liquid fuels has an inverse relationship to specific gravity and is a scale developed by the American Petroleum Insitute.

CLOUD POINT AND POUR POINT

One component of diesel fuel is paraffin, or wax. At low ambient temperatures, the paraffin comes out of the fuel solution causing the fuel to gel. This gelling reduces the fuel's ability to flow freely through the fuel system. Cloud point identifies the point at which wax first becomes visible in the fuel as it cools. Pour point identifies the lowest ambient temperature at which the fuel will still flow. As noted earlier most diesel fuel alternatives with low sulfur content have the potential for higher cloud and pour points (will cloud at higher temperatures) that need to be managed.

FLASH POINT

Flash point, although related to combustion of the fuel, is of concern with safety and storage. The flash point is the temperature at which evaporated fuel vapors will ignite in the presence of a flame or spark. If localized conditions around the fuel storage, either in storage tanks or the vehicle fuel tank, reach the level of the flash point, a dangerous condition may result. Many diesel engines recirculate some percentage of fuel from the engine back to the fuel tank as a function of fuel pressure regulation. In cold weather this has a beneficial effect of warming the fuel to prevent fuel gelling. In warm weather with a relatively low fuel volume this can lead to fuel tank overheating and Flash Point becomes the dominant concern. This may be more of a concern with oxygenated fuels utilizing ethanol or methanol.

DISTILLATION

Distillation is also referred to as boiling point and represents a range of temperatures at which different amounts of the fuel is boiled off. Similar to flash point in that ambient and working temperatures in the vicinity of the fuel have an affect, the distillation is a measure of how much fuel may be lost to evaporation at different temperatures.

ASH CONTENT

When diesel fuel is combusted the nonorganic components of the fuel (i.e. metals) create ash residue as a byproduct. The ash content (%) refers to the amount of material in the fuel that contributes to ash after it is combusted. It is of concern for diesel fuel because ash deposits can cause excessive engine wear and influence PM emissions.

WATER AND SEDIMENT

These two elements, similar to ash content, can cause internal engine wear as well as fuel filter plugging. The water content of fuel is minimized throughout the refining, transport and storage process; however, there are still many opportunities for water and sediment to get into the fuel. Because of this, engine manufacturers concede that some will exist, but have set a maximum water content. Note that free water content is essentially different than emulsified fuel, which has surfactants to maintain the water content suspended and enveloped within the fuel. Free water is typically removed from the vehicle fuel tank using a bottom mounted water drain. Within the tank itself the fuel pickup is typically located a small distance above the bottom of the tank where water collects so that water is not typically drawn into the engine. It bears mention that tanks that have consistently contained free water will have rust in the fuel tank. The addition of oxygenates such as biodiesel will dissolve and suspend these contaminates in the fuel, where they can be drawn into the engine. The most common issue is fuel filter plugging, and this can be alleviated by replacing the fuel filters on a more aggressive basis for the first few months after switching to the new fuel.

KINEMATIC VISCOSITY

Viscosity is a measure of how easily a fuel can flow; the higher the viscosity (thick), the harder it is for the fuel to flow and conversely the lower the viscosity (thin), the easier it flows. How well the fuel flows through the fuel delivery system and into the engine via the injectors will influence both performance and emissions. This is a result of the injector delivery system designed to operate at certain pressure. If the fuel is too “thin”, the very high injection pressure will cause more fuel to be introduced, leading to higher emissions. If the fuel is too “thick”, not enough fuel will be injected and power and performance will suffer. For these reasons, manufacturers specify a range of viscosity with lower and upper limits.

COPPER CORROSION

Corrosion is a concern where sulfur compounds in the fuel can lead to deterioration of copper and copper alloy components of the engine fueling system. By maintaining a low corrosivity of the fuel, manufacturer-designed maintenance and service life intervals can be achieved.

SPECIFICATION COMPARISON

Table 1 compares the recommended fuel specification from three different diesel engine manufacturers, Detroit Diesel, Caterpillar, and Cummins, to the standard specification used by MTA New York City Transit to purchase ULSD. Virtually all ULSD commercially available in NYC will meet the NYCT specification.

APPENDIX C, TABLE 1: COMPARISON OF MANUFACTURER'S RECOMMENDED FUEL SPECIFICATIONS TO NYCT ULSD

			ENGINE MANUFACTURER'S SPECIFICATIONS			NYCT ULSD
PROPERTY	METHOD (ASTM)	UNITS	DETROIT DIESEL	CUMMINS	CATERPILLAR	PURCHASE SPECIFICATION
Color	D-1500	Rating	NA	NA	N A	Max 2.0
API Gravity @ 60 °F	D-287	API min-max	40 - 44, D1 Fuel 34 - 38, D2 Fuel	NA	30 - 45	40 - 44
Specific Gravity @ 60 °F	D-1298	g/ml	NA	NA	NA	0.806-0.825
Flash Point	D-93	°F	100, D1 Fuel 125, D2 Fuel	NA	NA	Min 100
Sulfur	D-2622	ppm	Max 500	Max 5000	Max 3000	Max 30
Cu Corrosion	D-130	Rating	No. 3a	NA	Max 3	Max 3
Carbon Residue on 10% Bottom	D-524	%wt	Max 0.15, D1 Fuel Max 0.35, D2 Fuel	Max 0.35	Max 0.35	Max 0.15
Water	D-2709	ppm	Max 200	Max 500, water & sediment	Max 1000	Max 200
Sediment> 1 µm	D-2276	ppm	Max 10	Max 500, water & sediment	Max 500	Max 10
Ash	D-482	%wt	Max 0.01	Max 0.02	Max 0.02	Max 0.01
Initial Boiling Point	D-86	o F	NA	NA	NA	Typical 350
Distillation, 10% Recovery	D-86	o F	385, D1 Fuel 430, D2 Fuel	Distillation curve must be smooth & continuous	Max 540	Typical 385
Distillation, 50% Recovery	D-86	o F	NA	See 10% recovery	NA	Typical 425
Distillation, 90% Recovery	D-86	o F	500, D1 Fuel 625, D2 Fuel	See 10% recovery	Max 680	Typical 500

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			ENGINE MANUFACTURER'S SPECIFICATIONS			NYCT ULSD
PROPERTY	METHOD (ASTM)	UNITS	DETROIT DIESEL	CUMMINS	CATERPILLAR	PURCHASE SPECIFICATION
Distillation, 95% Recovery	D-86	o F	NA	See 10% recovery	NA	Max 550
Recovered Volume	D-86	%v	NA	NA	NA	Min 98
Cloud Point	D-2500	o F	10 below lowest expected ambient	10 below lowest expected ambient	< Lowest expected ambient	Max -10
Kinematic Viscosity @ 40°C	D-445	cSt min-max	1.3 – 2.4, D1 Fuel 1.9 – 4.1, D2 Fuel	1.3 -5.84	1.4 – 20.0	1.3-2.4
Cetane Index	D-4737	Value	Min 40	NA	Min 40	Min 40
Cetane Number	D-613	Value	Min 45	Min 45	Min 40	Min 45
Thermal Stability 190 min @ 150°C	D-6468	Refl %	NA	NA	NA	Min 70
Accelerated Storage Stability	D-2274	mg/L	NA	NA	NA	Max 15
Lubricity, WSD @ 60°C	D-6079	mm	Max 0.46	Max 0.45	Max 0.45	Max 0.45
Density @ 15°C		g/cc	NA	0.816 – 0.876	NA	NA
Aromatics	D-1319	%wt	NA	NA	Max 35	NA
Pour Point	D-97	°F	N A	NA	Min 10 below ambient temperature	NA
Gums & Resins	D-381	Mg/100ml	NA	NA	Max 10	NA

APPENDIX D
REASONABLY AVAILABLE CONTROL TECHNOLOGY FOR GENERATORS

GENERATORS — CONSTRUCTION AND PERMANENT

There are a host of regulations for diesel generators in permanent applications, with a few exclusions. Generally speaking if the permanent generator will only be used for emergency purposes, with less than 300-hours per year of operation, the only requirement will be that the unit utilize low-sulfur diesel fuel (less than 500-ppm sulfur). Units with hours of operation in excess of 300 hours will need to be equipped with Best Available Control Technology "BACT".

TEMPORARY GENERATORS

In general, any of the fuel and technology options to reduce emissions discussed in this report can be applied to diesel generators. However, gensets present two hurdles to effective pollution reduction. The first is operational profile; if the genset does not operate at or near capacity, the choices are limited. Closely related to this is how often the genset is used (i.e., continuously or for a few hours every few days). If a portable genset is used during construction essentially continuously and near capacity, selective catalytic reduction is a viable emissions reduction option and will reduce NOx significantly and PM slightly. If the genset is not used as much, the selective catalytic reduction will still provide benefits, but the cost-effectiveness is diminished because the capital investment cost is fixed.

It is less cost-effective to combine NOx-reducing technologies such as selective catalytic reduction and emulsified fuel, as the emulsified fuel by itself can provide approximately 30% NOx reduction, but when combined with selective catalytic reduction only adds an incremental benefit. Selective catalytic reduction can, however, effectively be combined with ULSD and other fueling and technology options targeted at PM reductions.

The second challenge presented by gensets in considering emission controls is size. A portable genset such as a 2 MW trailer-mounted unit uses nearly every inch of available space within the trailer. This means that any after-treatment would have to be in a separate trailer or mounted on top. Although this presents an engineering challenge, Caterpillar, as an example, has successfully designed and deployed a rooftop-mounted selective catalytic reduction system for their 2 MW gensets. Other technologies such as diesel oxidation catalysts, and diesel particulate filters will probably require custom-manufactured applications.

PERMANENT GENERATORS

Permanent genset installations are a consideration after completion of the construction project. The two generic uses for a permanent genset are for emergency power (used less than 300 hours of operation per year) or main site power. Controlling emissions from permanent gensets will present the same operational and space considerations as temporary gensets, and how frequently the genset is used will directly influence the cost-effectiveness of any pollution reduction strategy. Ultra-low sulfur diesel can be used in existing generators without any modifications to the generator or its engine.

In an emergency power capacity, selective catalytic reduction and diesel particulate filter technologies are generally not cost-effective, with diesel particulate filters potentially not technically feasible. Other strategies such as emulsified fuel may be possible, however, long-term fuel storage could present a challenge because the fuel is not being consumed regularly. Possibly the most feasible solution for an emergency genset would be either a diesel oxidation catalyst or an active diesel particulate filter combined with ULSD.

Because NYC is expected to be in non-attainment for both Ozone and PM2.5, BAT for a diesel generator is expected to include both SCR and DOC technology in conjunction with ULSD fuel. Catalyzed DPF technology may also be an option that is considered going forward, but the sheer size of the DPF for these genset applications has prevented their widespread use. There are several actively regenerated DPF technologies that are expected to be verified in the coming years. Widespread use of these technologies on PM2.5 non-attainment areas is expected. However, a technical engineering and cost-effectiveness analysis will define what level of control is considered BACT.

NEW YORK STATE LAW

New York State has implemented NOx RACT requirements for sources of combustion under Part 227-2.4. The text of the appropriate sections of this law are as follows:

(F) INTERNAL COMBUSTION ENGINES

Effective May 31, 1995, any owner or operator of a stationary internal combustion engine of 225 horsepower or larger in the severe non-attainment area, and 400 horsepower in the rest of the State, which provides primary power or is used for peak shaving generation, must comply with the following emission limit:

(1) For rich burn engines, 2.0 grams per brake horsepower-hour.
(2) For lean burn engines:

(i) 3.0 grams per brake horsepower-hour for gas only fired units; or
(ii) 9.0 grams per brake horsepower-hour for units firing other fuels.

Compliance with these emission limits shall be determined with a one hour average in accordance with paragraph 227-2.6(a)(7) unless the owner/operator opts to utilize CEMS under the provisions of section 227-2.6(a)(2) of this Subpart. If CEMS are utilized, the requirements of section 227-2.6(b) apply, including the use of a 24 hour averaging period.

(3) Centrally dispatched emergency power generating units and facility specific emergency power generating units are exempt from the terms of this subdivision.

NOTE: The emission limits for the rich burn engines are based on the use of air/fuel ratio control and post combustion control (i.e. three-way catalysts). The emission limits for the lean burn engines are based on the use of combustion modifications. This includes, but is not limited to, the use of low emission combustion, retarded engine timing, and separate circuit after-cooling. Alternative control technology will be considered by the department when the emission limit cannot be met. When utilizing an alternative technology, a clear and convincing demonstration that the control employed is RACT, including technical and economic advantages to combustion modifications, must be made to the department. The use of post combustion control (selective catalytic reduction) on lean burn engines is not necessary, but may be utilized to comply with the May 31, 1995 requirements.