NOTE: The measures discussed in this document represent possible controls the OTC is evaluating for potential NOx and VOC emission reductions. No decision has yet been made by the OTC states to pursue these measures for inclusion in a state implementation plan.

Potential NOx and VOC Emissions Controls
Ozone Transport Commission
Mobile Sources Committee
March 16, 2010

Table of Contents:

(Discussion Papers)

Please contact Seth Barna of the OTC staff (sbarna@otcair.org) for additional information on the "Mobile Sources Committee, Potential NOx and VOC Emissions Controls"

NOTE: The measures discussed in this document represent possible controls the OTC is evaluating for potential NOx and VOC emission reductions. No decision has yet been made by the OTC states to pursue these measures for inclusion in a state implementation plan.

Discussion Paper for Potential Measures to Control Lightering
Prepared for the Ozone Transport Commission (OTC)
Prepared by NESCAUM

Name of potential measure: Controlled Lightering Operations

Description of lightering:
In general, "lightering" refers to the bulk transfer of goods from one marine vessel to another. However, in the context of this paper, lightering refers specifically to the bulk transfer of crude oil or refined petroleum products from one marine vessel (the "ship to be lightered," or STBL) to another vessel (the "lightering service vessel").

Over the past few decades, strong economic incentives have led to the use of very large marine tankers (120,000-165,000 deadweight tons (DWT), with a capacity of around 1 million barrels) for the long haul of crude oil from the Persian Gulf and Africa to the United States and other distant destinations. Because these ships are too deep and too wide to approach or enter most U.S. ports safely, some or all of the crude oil is transferred to smaller vessels that deliver it to refineries (NRC, 1998[1]). Currently approximately 25 percent of all imported crude oil is lightered before delivery to U.S. ports. For the United States, offshore lightering (conducted outside the territorial waters, generally three miles from the coastline) accounts for about 80 percent of total lightering volume and inshore lightering (within territorial waters) accounts for about 20 percent of total lightering volume. Most of the U.S. offshore lightering takes place in the Gulf of Mexico. Roughly 15 percent of all U.S. inshore crude oil lightering activity occurs in Delaware Bay (NRC, 1998). Inshore lightering must be conducted in U.S. Coast Guard-approved "lightering zones," often called anchorages.

Small tankers (30,000 to 50,000 DWT, with a capacity of approximately 400,000 barrels) from the Caribbean, the Gulf of Mexico, Canada, Europe, or from within the U.S. transport refined petroleum products to East Coast ports. According to the United States Coast Guard, quantities of refined petroleum products are lightered in New York Harbor, Long Island Sound, Narragansett Bay, and Chesapeake Bay. Lightering of these refined products is performed either because the vessel's draft is too deep to enter the destination port directly or because the product is destined for two or more end points, and it is more economical to transfer the cargo to lightering service vessels for multiple port calls (NRC, 1998). The lightering service vessels may be tankers themselves or barges powered by tugboats.

Table 1. Lightering Emission Factors. *Units are tons of VOCs per million barrels lightered.*

Product	Emission Factor
#2 Diesel	0.20
Crude	19.80
Naphtha	25.90
Gasoline	70.70

EFs derived from AP-42.

In Delaware, the primary product lightered is crude oil. In other East Coast lightering areas, crude oil is not the dominant product being lightered. In New York Harbor, Long Island Sound, Narragansett Bay, and Chesapeake Bay, a variety of refined petroleum products are lightered in addition to small amounts of crude oil. These refined products include gasoline, jet fuel components, diesel fuel, and others. Emission factors from lightering vary with the volatility of the liquid being lightered. Table 1 shows the emission factors of the most commonly lightered products used to estimate emissions from East Coast lightering.

Through the lightering process, VOC vapors form in the service vessel's cargo tank and are compressed as the tank

[1] For more information on lightering, this book can be read online at http://www.nap.edu/catalog.php?record_id=6312.

is filled with liquid. To avoid the dangerous buildup of compressed vapors inside the service vessel, a vapor outlet is necessary. "Uncontrolled" lightering refers to lightering events in which VOCs are vented freely into the atmosphere.

In a "controlled" lightering operation, the transfer of liquid occurs in a closed system and VOC vapors that form within the service vessel are piped back into the STBL. The use of vapor balancing during lightering can greatly reduce the emission of VOC-laden vapors. However, there are times when operating conditions cause an interruption in vapor balancing during a controlled lightering operation. A significant pressure change (caused by a sudden temperature change, for example) may require the system to be vented in order to stabilize the pressure. When this occurs during a controlled lightering operation, VOC vapors escape into the atmosphere. The constant possibility of a sudden increase in pressure requiring venting in the middle of a controlled lightering operation implies that zero VOC emissions from lightering cannot be reasonably expected. However, the possibility that venting will be necessary during a controlled lightering operation is low enough that Delaware's regulation requires any new lightering service company to utilize vapor-balancing technology during lightering operations for at least 95 percent of its annual volumetric total.

Previous programs, model programs or historical significance:
Lightering regulations have already been adopted by the State of Delaware, which hosts the majority of lightering activity in the northeast U.S. in its Delaware Bay (SR1124 §46, May 11, 2007[2]). There is a significant amount of lightering in New York Harbor as well, and there are smaller lightering operations that take place in Long Island Sound, in the Narragansett Bay, and in the Chesapeake Bay. Accordingly, the adoption of Delaware's lightering requirements throughout the entire Ozone Transport Region (OTR) is under consideration.

Delaware's regulation requires:

1) Marine service companies that become licensed to lighter in Delaware after the regulation's effective date ("new lightering services") are limited to a maximum allowable uncontrolled crude oil lightering volume that is equal to 5 percent of the company's total volume of crude oil lightered. Basically, new lightering services must be fully equipped with vapor balancing systems and must use these systems whenever technically possible.
2) All existing services were required to meet a maximum allowable uncontrolled lightering volume equal to 80 percent of the baseline levels[3] beginning May 1, 2008, with further reductions equal to 61 percent of baseline levels beginning May 1, 2010, and to 43 percent by 2012. Lightering service companies existing prior to the regulation's effective date are not regulated as stringently as new lightering services because upgrading existing lightering service vessels to be capable of vapor-balanced lightering requires significant capital investment, making a 5 percent limit impractical for the legacy fleet in the short term.
3) By 2014 and every 5 years thereafter, the Delaware Department of Natural Resources and Environmental Control (DNREC) and owners of existing lightering operations will report on the feasibility of achieving a 5 percent maximum allowable uncontrolled lightering volume for all lightering services.

The requirements of the Delaware regulation apply to the owner or operator of a lightering service that carries out crude oil lightering operations in the waters of the State.

---

[2] Available at: http://regulations.delaware.gov/AdminCode/title7/1000/1100/Split1124/1124-45.shtml.

[3] The baseline lightering volume is the average annual volume lightered in calendar years 2004 and 2005.

NOTE: The measures discussed in this document represent possible controls the OTC is evaluating for potential NOx and VOC emission reductions. No decision has yet been made by the OTC states to pursue these measures for inclusion in a state implementation plan.

Other provisions in the regulation pertain to equipment maintenance, reporting of uncontrolled venting during lightering, compliance plans, emergency conditions when operators are exempt from the requirements, and – importantly – provisions that ban uncontrolled lightering operations on ozone action days as established by the DNREC.

Note that the Delaware regulations apply to the lightering of crude oil, only. This is because in Delaware the majority of lightering-related VOC emissions result from the lightering of crude oil. Outside of Delaware, most lightering is not of crude oil, but of finished petroleum products such as No. 2 fuel oil (heating oil), gasoline, and jet fuel. Lightering of gasoline and jet fuel results in significantly more VOC emissions than lightering of crude oil. If a version of Delaware's regulation is to be adopted throughout the OTC region, it may be appropriate to address those additional refined petroleum products with the potential to emit VOC-laden vapors that are lightered in the region in the OTC version.

Major Issues:

In Delaware, lightering operations are subject to Title V operating permit requirements as stationary sources even though STBLs move in and out of anchorages. Delaware defines a "stationary source" as "any fixed building, structure, facility, installation, equipment or any motor vehicle, waterborne craft, aircraft or diesel locomotive deposited, parked, moored, or otherwise remaining temporarily in place, which emits or may emit any air contaminant" (DE Administrative Code, Title 7, Section 1101[4]).

However, other states may have different definitions of a "stationary source," meaning in other states lightering may be regulated as a different source category. States in the OTR are currently investigating how lightering would be regulated within their respective Administrative Codes.

Other issues that need to be considered in the development of lightering regulations include:

- Enforcement cost; since the potential reductions vary considerably from state to state, the cost of enforcement and administration relative to the emission reduction may be prohibitive in some states.
- Cost to lightering service vessel owners; the cost to industry is outlined below.
- Coordination with other agencies that regulate maritime activities (port authorities, Coast Guard, etc.).
- Enforcement of lightering operations; it is unclear whether states' departments of the environment have the authority to board marine vessels in order to ensure compliance.
- The complexity that may arise from regulating lightering operations of multiple types of petroleum products with the potential to emit VOCs. Regulating multiple types of petroleum products could lead to more regulated entities, and could bring opposition from entities such as the fuel oil industry, whose products are less volatile and emit fewer VOCs than crude oil.

Lightering volume estimates:

This white paper relies on data on "inshore" lightering (lightering occurring inside the boundary of the U.S.' contiguous zone—within 12 miles of shore) from a variety of sources. Annual lightering activity in Delaware comes from the Delaware DNREC. The data presented here was collected in 2004 and 2005. For New York Harbor, records are maintained by the Coast Guard Vessel Traffic Service. The annual figures presented are extrapolated from data collected over a three-month period in 2009. Data for Long Island Sound is taken from the National Research Council report entitled Oil Spill Risks from Tank Vessel Lightering (NRC, 1998). Though the NRC reports that only crude oil is lightered in the Long Island Sound, discussions with the fuel transport industry suggest that currently only finished petroleum products are lightered there. Lightering data for the Chesapeake

---

[4] Available at http://regulations.delaware.gov/AdminCode/title7/1000/1100/1101.shtml.

Bay is maintained by Coast Guard Sector Baltimore, was reported to NESCAUM for the months January to October, 2009 and was normalized to provide an estimate of total lightering in 2009.

Data concerning "off-shore" lightering (that is, lightering that occurs beyond 12 miles of the coastline) also comes from the 1998 NRC report, Oil Spill Risks from Tank Vessel Lightering. The locations where offshore lightering is conducted off the East Coast are Montauk Point, New York; Cape Henlopen, Delaware; Cape Henry, Virginia; and Great Issacs, Bahamas (NRC, 1998).

Lightering emissions estimates:
AP-42 provides emissions factors associated with the lightering of crude oil, gasoline, #2 distillate, jet naphtha, and jet kerosene. However, emissions from lightering these products can vary based on the recipient vessel's size, its previous cargo (which affects the amount of residual vapors), and the ambient temperature. According to AP-42, the emission factors listed are estimates with a probable error of ±30 percent.

For some petroleum products, lightering emission factors are unavailable. For these liquids, we apply an emission range from liquids with a similar volatility. And when the product being lightered is not specified, we apply the emission factor for gasoline lightering, which has the highest lightering emission factor.

Uncertainty within our estimates comes from three stages in the analysis: 1) information on the chemical properties of the products lightered is not exact; 2) information on the lightering conditions during each operation (i.e. type of vessel and residual vapors in the vessel) is unavailable; and 3) the equation from AP-42 used to estimate emissions carries an error bar of +-30%.

The figures in Tables 1 and 2 represent our mid-range estimate. Here are our low-high emission estimates for each region: Long Island Sound, 41-147 tons per year (tpy); New York Harbor, 374-1333 tpy; Chesapeake Bay, 5-16 tpy; and Narragansett Bay, 2-6 tpy.

Emission reduction benefit estimates:
As mentioned above, VOC emissions could theoretically be reduced by up to 99 percent with the use of vapor balancing systems. Practically however, lightering events that commence using vapor balancing may be forced to disconnect the system prematurely due to sudden pressure changes or other circumstances. Delaware is therefore aiming for 95 percent reductions in its future requirements (5 percent maximum allowable uncontrolled lightering; see Delaware's requirement 3 above.)

NOTE: The measures discussed in this document represent possible controls the OTC is evaluating for potential NOx and VOC emission reductions. No decision has yet been made by the OTC states to pursue these measures for inclusion in a state implementation plan.

"Inshore" Lightering (million barrels per year)

Table 2: Potential VOC Emission Reductions with Adoption of the Delaware Lightering Requirements throughout the Entire OTR

				Potential Reductions (tons)	
Area	**Product**	**Volume (million BBLs)**	**VOC Emissions (tons)**	**57%**	**95%**
Long Island Sound	Finished Products	1.4	99	56	94
New York Harbor	Gasoline, Fuel Oil, Other	48.3	889	506	844
Delaware Bay	Crude	98.8	1956	1115	1858
Chesapeake Bay	Gasoline	0.3	11	6	10
Narragansett Bay	Gasoline, Kerosene	0.2	4	2	4
		TOTAL[5]	2959	570	1695

"Offshore" Lightering (million barrels per year)

Table 3: Potential VOC Emission Reductions with Control of "Offshore" Lightering in the OTR

				Potential Reductions (tons)	
Area	**Product**	**Volume (million BBLs)**	**VOC Emissions (tons)**	**57%**	**95%**
Off-shore	Crude Oil	15.5	306	174	291

Delaware has opted to place a steadily decreasing cap on uncontrolled lightering. In 2008 and 2009, this cap requires that approximately 20 percent of lightering is controlled, reducing emissions by approximately 391 tons per year. The stringency of the regulation ramps up in two stages so that 39 percent of lightering will be vapor-balanced beginning May, 2010 and 57 percent will be vapor-balanced beginning May, 2012, reducing emissions by 762 tons and 1,115 tons, respectively. If 95 percent reductions are achieved in Delaware, VOC emissions will be reduced by 1,858 tons per year from the baseline.

In the rest of the OTC region, if VOCs resulting from uncontrolled lightering were reduced by 57 percent, emissions would be reduced by 569 tons per year. If emission reductions reach the technical limit of 95 percent in the OTR, including the additional reductions from Delaware that are not yet written into regulation, a total of 1,691 tons could be reduced.

In addition, we note that "offshore" lightering takes place in U.S. (but not state) waters. Nearly 291 tons of VOC emissions per year could be reduced through federal measures but it is not clear to what extent these emissions affect air quality in northeast states or which agency has jurisdiction to regulate them.

---

[5] Beginning May 1, 2012, Delaware's lightering regulation will reduce annual VOC emissions by 1,115 tons. This quantity is *excluded* from TOTAL potential reductions since these emissions reductions are anticipated to result from existing Delaware regulation.

NOTE: The measures discussed in this document represent possible controls the OTC is evaluating for potential NOx and VOC emission reductions. No decision has yet been made by the OTC states to pursue these measures for inclusion in a state implementation plan.

Control Cost Estimate:
For any tanker transporting volatile chemicals, vapor recovery capability is a function of several factors relating to the vessel's capacity to handle the increased pressure from volatile compounds in its tanks during transfer: the vessels' vapor tightness, the pressure relief threshold of the ships' manifolds, and an inert gas generation system.

During any controlled or uncontrolled lightering operation, the head spaces in the cargo tanks of both the STBL and the lightering service vessel experience increased pressure . In an uncontrolled lightering operation, the gases are vented into the atmosphere to alleviate the pressure. Vapor balancing is utilized to control the release of these gases by closing the system to the atmosphere. In turn, this causes a significant increase in the pressure in each cargo tank. Thus, the feasibility of vapor-balancing during a lightering operation is contingent upon both vessels' cargo tanks withstanding the increased pressure.

Most new tankers are built with the capability to withstand the increased pressure that occurs during vapor-balanced lightering, [1] but older vessels need to be upgraded. The cost to upgrade a lightering service vessel that holds 25,000 barrels would be about $250,000-300,000. The cost to upgrade a vessel capable of holding 100,000 barrels or more would cost approximately $1 million.

Significantly, the Oil Pollution Act of 1990 (OPA 90) requires that all tankers operating in U.S. waters be double-hulled by 2015. Since many new tankers are built with vapor-balancing capability, the fleet upgrade required by OPA 90 will have the co-benefit of making some service vessels and STBLs capable of complying with lightering regulations. Other single-hulled vessels are being retrofitted with a double hull without the upgrades that would enable vapor balanced lightering, meaning that these vessels would require further investment to enable compliance with a lightering regulation. The capital cost relevant to the lightering regulation is the additional expense to build new lightering service vessels earlier than they would have otherwise been built (to meet the requirements of OPA 90) and the cost required to upgrade enough older service vessels and STBLs to achieve the required percentage of vapor-controlled lightering.

In Delaware, three lightering service vessels, owned by OSG America, L.P., are responsible for all of Delaware's lightering activity. To date, one of these service vessels is capable of vapor-balanced lightering operations, which enables OSG to comply with Delaware's regulation. As the maximum allowable uncontrolled lightering volume is reduced in 2010 and 2012, additional service vessels capable of vapor balancing will be brought online.

National program possibilities:
Given that the vast majority of lightering in the eastern U.S. takes place in the Gulf of Mexico, Delaware Bay, and New York State waters, it seems that a state/regional approach to the control of these emissions is the most appropriate means of addressing the problem. However, a significant fraction of lightering occurs in "offshore" waters that are not part of state jurisdiction.

Other Comments:
Two key stakeholders on these issues could be the U.S. Coast Guard, Sector New York (01-37040), 212 Coast Guard Drive, Staten Island, NY 10305, and U.S. Coast Guard, Sector Long Island Sound (01-37030), 120 Woodward Avenue, New Haven, CT 06512-3698 (ph. 203-468-4401).

---

[1] Personal email from Bernie Kelly of Global Partners LP

NOTE: The measures discussed in this document represent possible controls the OTC is evaluating for potential NOx and VOC emission reductions. No decision has yet been made by the OTC states to pursue these measures for inclusion in a state implementation plan.

Lightering in New York is conducted by six companies, four of which are in-state companies: Bouchard Transportation Company, Reinhauer, Moran, K-Sea Transportation, and two of which are out-of-state companies: Vane Brothers and Seaboats. In the Chesapeake Bay, nearly all of the lightering is done by Vane Brothers.

Author Contact info:

Jesse Colman and Gary Kleiman, NESCAUM, jcolman@nescaum.org; gkleiman@nescaum.org, 617-259-2000
Other members of the analysis team: Coralie Cooper ccooper@nescaum.org

References

AP 42**.** AP 42, Fifth Edition. *Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources*. US EPA.

Conversations and emails with Delaware DNREC staff.

Delaware, Code of State Regulations 1124 §46, May 11, 2007.

Personal emails from Bernie Kelly of Global Partners LP.

NRC, 1998. *Oil Spill Risks from Tank Vessel Lightering*, Marine Board, Commission on Engineering and Technical Systems, National Research Council, National Academy Press, Washington, DC.

NOTE: The measures discussed in this document represent possible controls the OTC is evaluating for potential NOx and VOC emission reductions. No decision has yet been made by the OTC states to pursue these measures for inclusion in a state implementation plan.

Discussion Paper for Potential Measures to Control Nonroad Equipment Idling
Prepared for the Ozone Transport Commission (OTC)
Prepared by NESCAUM

Name of potential measure: In-use Nonroad Diesel Equipment Anti-idling Measure

Background:
Nonroad construction equipment are a significant source of pollutant emissions including nitrogen oxides (NO_X), fine particulate matter ($PM_{2.5}$), hydrocarbons (HC), carbon monoxide (CO), and sulfur oxides (SO_2). Emissions from this source contribute a substantial percentage of total diesel emissions and contribute to poor air quality in the Ozone Transport Region (OTR).

Emission control standards for diesel engines, and nonroad diesel engines in particular, have lagged behind standards for other mobile sources such as passenger cars. Because of this, diesel engines contribute disproportionately to the overall mobile source criteria pollutant emissions inventory. Over the last ten years, EPA has introduced a series of highway and nonroad diesel fuel quality and emission standards that when fully implemented will reduce diesel emissions more than 90 percent. Emissions from existing engines, however, will continue to emit high levels of pollution for many years. To begin to address this problem, states and EPA have introduced measures to reduce emissions from existing engines such as retrofit and anti-idling programs.

Little data are available to assist in the development of an emissions inventory for nonroad machine idling. Although in-use hours and emissions from nonroad equipment are estimated by EPA's NONROAD model, the model does not provide an estimate of time spent or emissions resulting from nonroad idling. Anecdotal data and some in-use testing data are available. Some of the in-use testing data indicate that nonroad construction equipment may spend as much as half of in-use hours idling. There are numerous reasons why nonroad construction equipment is left idling for extended periods: to keep the operator warm, to keep the machine ready for work while waiting for supplies and equipment to be moved, union rules, and force of habit.

Existing Regulations Limiting Nonroad Idling:
To date three states in the region (Connecticut, New Jersey, and Rhode Island) place restrictions on nonroad idling. The idling restrictions of Connecticut and Rhode Island apply respectively to "mobile sources" and "diesel engines," both of which include nonroad construction equipment. Connecticut explicitly exempts from its idling regulation nonroad diesel engines in marine and locomotive applications. Conversely, Rhode Island's regulation includes marine vessels and locomotives. New Jersey's restriction applies to "motor vehicles" which are defined as "all vehicles propelled otherwise than by muscular power, excepting motorized bicycles and such vehicles as only run upon rails or tracks." Therefore, New Jersey's regulation applies to nonroad construction equipment and marine engines, but not to locomotives.

Table 1. Application of existing nonroad idling rules.

	Non Road Application		
	Construction Equipment	Marine	Locomotive
CT	A	\	\
NJ	A	A	\
RI	A	A	A

A = Rule applies to the engine application.
/ = Rule does not apply to application.

Description of the policies being considered as models for the OTR:
The Connecticut, New Jersey, and Rhode Island idling limitations provide potential models for the other states in the OTR. In addition, California has put a similar requirement in place. These policies aim to control or limit the time spent idling, by requiring that a machine be shut down after a period of inactivity.

NOTE: The measures discussed in this document represent possible controls the OTC is evaluating for potential NOx and VOC emission reductions. No decision has yet been made by the OTC states to pursue these measures for inclusion in a state implementation plan.

As a part of its off-road retrofit regulation, the California Air Resources Board (CARB) placed a limit on idling, which became effective June 15, 2008. This provision limits idling to 5 minutes and requires owners of medium and large fleets to provide written notice of anti-idling policies to its vehicle operators.

The section of CARB's off-road equipment regulation which applies to idling is excerpted below:

> ***(3) Idling*** - The idling limits in section 2449(d)(3) shall be effective and enforceable immediately upon this regulation being certified by the Secretary of State. Fleets must meet the following idling limits.
> **(A) Idling Limit -** No vehicle or engines subject to this regulation may idle for more than 5 consecutive minutes. Idling of a vehicle that is owned by a rental company is the responsibility of the renter or lessee, and the rental agreement should so indicate. The idling limit does not apply to:
> 1. idling when queuing,
> 2. idling to verify that the vehicle is in safe operating condition,
> 3. idling for testing, servicing, repairing or diagnostic purposes,
> 4. idling necessary to accomplish work for which the vehicle was designed (such as operating a crane),
> 5. idling required to bring the machine system to operating temperature, and
> 6. idling necessary to ensure safe operation of the vehicle.
>
> **(B) Written Idling Policy -** As of March 1, 2009, medium and large fleets must also have a written idling policy that is made available to operators of the vehicles and informs them that idling is limited to 5 consecutive minutes or less.
> **(C) Waiver** - A fleet owner may apply to the Executive Officer for a waiver to allow additional idling in excess of 5 consecutive minutes. The Executive Officer shall grant such a request upon finding that the fleet owner has provided sufficient justification that such idling is necessary.

Connecticut's rule, "*Control of particulate matter and visible emissions,*" took effect April 1, 2004. The regulation limits mobile source operation while "not in motion" to three minutes. The exemptions under Connecticut's rule are similar to those of California (see (A)1 — 5 above), with two additional exemptions: "…[1] when it is necessary to operate defrosting, heating or cooling equipment to ensure the safety or health of the driver or passengers…[and 2] when the outdoor temperature is below twenty degrees Fahrenheit"

The New Jersey rule, which took effect in 1986, also limits idling to three minutes except in certain conditions, similar to those listed in the California rule. Also, if the vehicle has been stopped for more than 3 hours and the temperature is below 25 degrees Fahrenheit, idling up to 15 consecutive minutes is permitted.

The Rhode Island rule took effect July 19, 2007. It includes separate provisions for diesel motor vehicles and for non-road diesel engines. Regarding non-road engines Rhode Island's regulation is more stringent than those of California or Connecticut. In section 45.4 the regulation states, "No person, entity, owner or operator shall cause, suffer, allow or permit the unnecessary idling of non-road diesel engines under its control or on its property." Effectively, unnecessary idling is not allowed for any period of time. The following idling is exempted under Rhode Island's rule:

> Vehicles idling when it is necessary to operate defrosting, heating, or cooling equipment to ensure the health or safety of the driver or passengers. In the case of providing heat, the exemption allows idling for up to 15 minutes per hour when temperatures are between 0 degrees and 32 degrees Fahrenheit. Idling for

the purpose of providing heat will be allowed as needed when temperatures are below 0 degrees Fahrenheit.[6]

These four regulations control idling directly. As yet, no states have taken an indirect approach to curb idling by requiring technology that would reduce the amount of necessary idling. For example, in states where the weather is colder and engines spend significant time running solely to provide heat for the operator, requiring machines to be equipped with cabin heaters or seat warmers or other more efficient heat sources could have a sizeable emissions benefit.

Regulations in these four states have prompted manufacturers of diesel-powered equipment to include automatic shutoff functions that can be set to a range of time thresholds based on the owner's preference.

Emissions reduction benefit of construction equipment idling:
In order to estimate idling emissions in the OTR, NESCAUM determined idling emissions rates (emission factors) and activity (hours spent idling) for different types of nonroad construction equipment. Idling emission rates for nonroad engines are likely to vary with rated power, size class, and emissions tier. NESCAUM analyzed idling PM emissions data for 19 engines tested by Southwest Research Institute (SWRI) for EPA[7,8]. While there are too few data points to draw a firm conclusion, the data suggest that PM emissions increase with power rating for similar engines, that Tier 1 engines have lower emissions than pre-regulation engines of similar size, and that naturally aspirated engines (which were more common prior to the 1989 model year) have higher emissions than those with turbochargers. Also notable (but, again, not conclusive) is that smaller engines, for which emission standards have lagged behind larger engines, seem to emit at higher rates. Similar relationships were apparent in the hydrocarbon (THC) data, so we used the same approach in estimating emission THC factors. For the NOx data, however, there was not as clear a distinction between the categories. We used a single linear trend to estimate NOx emissions as a function of power rating for all size classes and emissions tiers.

In order to account for the likely differences in emission factors for each of the sub-categories described above, we isolated each sub-category within the fleet for further analysis. We used the NONROAD model to estimate populations of 65 nonroad engine types in each of the 13 OTC states in the 2009 baseline year. We then constructed a spreadsheet to further disaggregate the population data by emissions tier and power class, and to calculate the annual activity (hours in operation) for each equipment type and for three size classes and three emissions tiers, using default values contained in NONROAD input data files and supporting documentation. We designed the spreadsheet to accept user-specified inputs for scenario year, idling rate, and percent of idling eligible for reduction. In addition, the spreadsheet can calculate emissions both state-by-state and regionwide. A more detailed description of this method is available upon request.

Data on emissions from idling (idling activity) is scarce. NESCAUM relied on three sources of data for this estimation: the California Air Resources Board (CARB), John Deere, and EPA. To estimate the emissions benefit for its nonroad idling rule, CARB asked individuals with significant experience in the industry to estimate the time off-road construction equipment spends idling unnecessarily. Their inquiry resulted in two estimates: 1) publicly owned fleets idle for 1.8% of the hours they are in use, and 2) privately-owned fleets idle 7.5% of the time. CARB

---

[6] RI Final Regulation. Accessed at: http://www.dem.ri.gov/pubs/regs/regs/air/air45_07.pdf
[7] Fritz, S.G. and M.E. Starr, "Emission Factors for Compression Ignition Nonroad Engines Operated on Number 2 Highway and Nonroad Diesel Fuel," Southwest Research Institute. EPA contract # 68-C5-0077, SwRI 08-7601-822, March 1998.

[8] The actual horsepower ratings were not published in the test results. We estimated the power ratings for each engine.

further assumes that 95% of nonroad equipment is privately owned, giving an average idle rate of 7.2%. Based on these idling activity factors, California estimated fuel savings of 2% from its idling rule. Other information was obtained from John Deere distributors in the Northeast, who collected data from telematic devices installed on 19 construction machines. These devices allow equipment owners to monitor, in real-time, exactly how the machine is operating, including whether it is idling. The average idling rate from the John Deere survey is 42%, considerably higher than CARB's estimate. Table 1 summarizes these two data sets for idling activity used for the NESCAUM estimate of nonroad construction equipment idling emissions in the OTR.

Table 2: Percentage of Total Operating Hours Spent Idling

CARB	7.2%
John Deere	42%

Data collected from EPA correspond to the data obtained from John Deere and because of this, and because the data was only for a very small number of equipment we have not included it in Table 1.

In order to estimate nonroad construction equipment idling emissions in the OTR, NESCAUM developed two cases; the first uses the CARB idling activity estimate and the second uses the idling activity estimates obtained from John Deere dealers. Table 2 shows avoidable idling emissions for each machine type under the 7% (CARB) and 42% (Deere) scenarios, respectively.

Table 3: Emissions from Avoidable Nonroad Idling, OTC States 2009 (Tons per Year)

Idling Rate	NOx	HC	PM
42%	8,188	4,172	803
7.2%	1,474	751	145

Table 2 shows the potential emissions benefit for the OTC states, assuming that all unnecessary idling could be eliminated for both the 7% and 42% cases. As can be seen from Table 2, in either the 7% or the 42% idling rate cases, significant NOx and HC emissions could be reduced if idling beyond 5 minutes is to be eliminated in the OTR for construction equipment machines. Assuming the 42% case a very large amount of NOx and HC – over 12,000 tons per year – could be reduced. PM emissions reductions are also potentially large in both cases. Assuming idling activity is somewhere in between the two cases presented, reducing idling from nonroad construction machines appears to present an important approach for reducing ozone forming pollution and particulate emissions.

Control Cost Estimate:
CARB has not estimated any costs associated with their idling rule. This may be because heating needs in California are much less than in the northeast. Assuming operators are not required to install cabin heaters, auxiliary power units, or other forms of technologies to allow for heat or power while the engine is turned off there may not be any cost associated with limiting idling times. However more research in this area is needed.

Major Issues:
As mentioned above, the existing regulations in the region allow for significant extended idling – for example – to maintain cabin heat for operators and when idling is deemed necessary. Many operators believe that idling is necessary when it may not be. For example, operators believe that an engine needs to keep running to maintain its temperature, although in cold weather, radiator fans blow cold air across the engine and have a net cooling effect

which can be greater than simply turning the engine off. Many operators/equipment owners are unaware or unconcerned by the engine wear, fuel use, and unnecessary emissions that result from leaving their machines running. Operators have been found to leave their machines on through their lunch hour and while working on tasks that do not involve their machines. When interviewed, these same operators report that whenever the engine is running, their equipment is being put to productive use. There seems to be a basic disagreement between some equipment operators and outside observers about how much idling is necessary. This may be the source of the difference between the two emission benefit scenarios described above—one which utilizes California contractors' estimates of emissions and the other which tracks idling directly from on-board computers. Thus, considerable outreach to the industry will be needed in order to put in place restrictions that limit idling to 5 minutes without exceptions.

However, emphasizing the benefits of reduced idling will be important in outreach to the industry. For example, off-road vehicle maintenance schedules are based on hourly usage. For one machine, a 380 horsepower loader manufactured by John Deere, the cost of maintenance recommended by John Deere over the machine's first 5000 hours was estimated at over $20,000, which translates to around $4.00 per hour of engine operation. More generally, the hourly cost of a machine's scheduled maintenance is approximately 1 cent per horsepower per hour.[9] By reducing the time spent idling, the cost to maintain each machine will decrease while the amount of useful work being performed will remain constant. In addition, fewer hours spent idling increases a machine's useful life. By extending the working hours of the machine over a longer time, capital expenditures to replace a fleet will also be spread out over a longer period of time. Finally, fewer hours spent idling will mean the warrantee (which is based on hours used) will apply further into the life of the engine. All of these benefits, if communicated effectively, should provide the necessary incentive to the construction equipment industry to support anti-idling regulations for construction equipment.

Benefit for other pollutants:
This measure will reduce PM, global warming agents CO_2 and black carbon, and toxins such as formaldehyde and acetaldehyde in addition to NOx and HC.

National program possibilities:
There may be regional variation in idling habits and behavior due to regional climate differences. For instance in milder climates heating will be used less frequently than in colder climates. Assuming, however, there is little variability in idling habits among equipment operators nation-wide, scaling up the individual state's rules would have substantial benefits. Since construction equipment operates in all parts of the country, implementing a nation-wide anti-idling rule would achieve substantial reductions in NOx, HC, CO_2, and toxins.

Other policies that could be evaluated:
Other policy approaches are possible, such as requiring the use of auxiliary power to control the cabin temperature. This would obviate the need for running the main engine to maintain the operator's comfort. Instead of reducing unnecessary idling time, this approach could reduce necessary idling, which is idling activity that is exempted from the current anti-idling regulations.

Idling of other types of diesel nonroad engines:
Marine and locomotive engines may spend a significant portion of time idling, but again data on necessary vs. unnecessary idling is hard to find. Discussions with individuals[10] who work with these engines indicate that

[9] John Driscoll from John Deere
[10] Dana Lowell and Tom Balon at MJ Bradley

NOTE: The measures discussed in this document represent possible controls the OTC is evaluating for potential NOx and VOC emission reductions. No decision has yet been made by the OTC states to pursue these measures for inclusion in a state implementation plan.

restricting unnecessary idling may not be effective in reducing idling emissions from these sources. Some types of marine vessels need to maintain power 100% of the time when they are docked, so they constantly run their auxiliary engines. Shore power could be a viable alternative for marine vessels. In rail yards, locomotives spend significant time idling which may be necessary to maintain engine temperature. However, EPA has shown that the use of alternative power units (APUs) for heating and of automatic start/stop systems can reduce idling time by 80%.[11]

New Jersey Transit successfully implemented an Idling Minimization Program recently whereby passenger locomotives are now shut off one hour after returning to the yard each evening and only started up one hour before leaving the yard for the next run. This is a dramatic change from the historical practice of leaving the engines running all night.

Author Contact info:
Jesse Colman, Coralie Cooper, and Matt Solomon, NESCAUM, 617-259-2000

References:
CARB Final Reg: http://www.arb.ca.gov/regact/2007/ordiesl07/frooal.pdf
CARB overview of non-road regulation: http://www.arb.ca.gov/msprog/ordiesel/faq/ordoverview.pdf
CARB Fact Sheet on Anti-idling provisions: http://www.arb.ca.gov/enf/advs/advs377.pdf
Dana Lowell and Tom Balon from MJ Bradley
EPA Case Study: Chicago Locomotive Idle Reduction Project." EPA420-R-04-003. March, 2004
Discussions with John Driscoll from John Deere
RI Final Reg: http://www.dem.ri.gov/pubs/regs/regs/air/air45_07.pdf
RI powerpoint presentation on Anti-idling program: http://www.nhcleancities.org/presentations/stevenson%20RI-Anti-Idling.pdf

[11] "EPA Case Study: Chicago Locomotive Idle Reduction Project." EPA420-R-04-003. March, 2004.

NOTE: The measures discussed in this document represent possible controls the OTC is evaluating for potential NOx and VOC emission reductions. No decision has yet been made by the OTC states to pursue these measures for inclusion in a state implementation plan.

Discussion Paper for Potential Measures to Reduce Drayage Truck Emissions
Prepared for the Ozone Transport Commission (OTC)

Name of potential measure: Port Emission Reduction Measures—Drayage Vehicles

Background:
Marine ports are a major source of pollutant emissions including nitrogen oxides (NO_X), fine particulate matter ($PM_{2.5}$), hydrocarbons (HC), carbon monoxide (CO), and sulfur oxides (SO_2). Port-related emissions contribute to poor air quality in the Ozone Transport Region. In addition, the effects of diminished air quality are experienced disproportionately in areas closer to the ports.

Port emissions can be separated into five main sources: ocean-going vessels, drayage trucks, railroad locomotives, cargo handling equipment, and harbor craft. The measure being considered here addresses emissions from drayage trucks. At the Port Authority of New York and NJ (PANYNJ), drayage trucks contribute 25% of total NOx emissions and 12% of total $PM_{2.5}$ to the total port emissions inventory. They are also responsible for significant CO, VOC, and SO_2 emissions.

Drayage trucks are vehicles over 33,000 pounds GVWR that pick up and deliver containers, bulk, and break-bulk goods to and from ports and intermodal yards. Along with locomotives, drayage trucks connect marine ports to their inland shipping hubs. Drayage truck emissions occur while they are waiting in line to enter port, while idling inside the port awaiting their freight transfer, and in transit between the port and the source or destination of their freight. A survey of truck drivers operating drayage trucks in the PANYNJ found that the average wait time to enter the port is 50 minutes and to on- or off-load their cargo takes an additional 2 hours 20 minutes.[12]

Existing regulations that apply to drayage trucks:
In the OTC region, the emissions regulations that apply to drayage trucks are those that also apply to other heavy-duty motor vehicles. For example, Washington, DC and each state in the OTR have some form of anti-idling regulation for on-road vehicles including drayage trucks. To date, there are no regulations that apply exclusively to drayage trucks.

The PANYNJ has completed its emissions inventory[13] and is considering a suite of regulatory and voluntary measures to achieve emissions reductions. Other states and port authorities are offering financing incentives to truck owners to upgrade their vehicles (see Additional measures, below).

Outside the OTC region, the California Air Resources Board (CARB) has created a Drayage Truck Registry and beginning in 2010 will enforce model year requirements and emission control standards on all trucks calling on the port. CARB's drayage truck rule is similar to the measure described below, with two differences: 1) the first phase begins in 2010, instead of 2011, and 2) during the first phase, MY 1994-2003 trucks must be equipped with verified diesel emission control systems (VDECS) to control PM.

---

[12] Starcrest 2008. "Drayage Truck Characterization Survey at the Port Authority and the Global Marine Terminals." Starcrest Consulting Group, December, 2008.

[13] Available at: http://www.panynj.gov/about/pdf/2006-BASELINE-MULTI-FACILITY-EMISSIONS-INVENTORY.pdf.

NOTE: The measures discussed in this document represent possible controls the OTC is evaluating for potential NOx and VOC emission reductions. No decision has yet been made by the OTC states to pursue these measures for inclusion in a state implementation plan.

Description of the measure being considered:
At the request of PANYNJ, EPA's subcontractor (Eastern Research Group) modeled several options for modernizing the fleet of drayage vehicles calling on PANYNJ. This included a variety of potential MY and emission control requirements and considered different phase-in schedules for their implementation. The measure considered here has two phases. Phase I, which begins in January 2011 would require pre-1994 trucks calling at the PANYNJ to be replaced by 2004 or newer models. Phase II would take effect in January 2017 and require that all pre-2007 trucks be replaced by 2007 or newer trucks.

Emissions estimates:
In the OTC region, an estimate of drayage emissions has been developed for only the PANYNJ and Hampton Roads facilities. NESCAUM has used data from the PANYNJ inventory prepared by Starcrest in 2008.[14] In it, port emissions are broken down into the five sources listed above, and there is considerable detail regarding the data collection and emissions estimates for drayage truck emissions. We use this inventory as a basis to estimate drayage inventories for other ports in the region.

In order to estimate the impact of the measure discussed in this paper, it was necessary to estimate drayage emissions for other ports in the OTR. To do this, we assume a relationship between emissions and tonnage of freight. In this way we established a port drayage emission factor with the unit tons of pollutant per million tons of freight shipped. We apply the PANYNJ's ratio of emissions to tonnage to all OTC ports.[15] This gives a rough idea of port emissions throughout the region, and enables us to estimate potential emission reductions.

Emission benefits from control measure:
The Eastern Research Group analysis mentioned above describes emissions reductions that can be achieved through the introduction of a number of different control strategies at the PANYNJ. One scenario evaluates emissions saved by replacing pre-1994 drayage vehicles with 2004 vehicles in 2011, and subsequently replacing pre-2007 trucks in 2017 with 2007 trucks. The results of the analysis show that with implementation of this strategy, the PANYNJ would realize annual reductions of 17% in NOx and 15% in PM from drayage trucks. The annual benefits continue for 24 years. Table 1 shows NESCAUM's estimated baseline drayage emissions for each port in the OTR as well as the estimated annual and lifetime impacts from expansion of the control measure.

Major Issues:
It will be important to consider whether state air quality agencies or port authorities are better positioned to implement rules that apply to drayage trucks specifically, and to ports in general. One option is for states to take the lead in regulating port activity. This route would ensure equal treatment of all ports within a single state and would provide greater emission reduction benefits, especially if identical measures are adopted throughout the OTR. Another option is to encourage the ports to voluntarily take action such as the drayage truck rule described above. PANYNJ has taken the initiative to create an emissions inventory and examine a broad range of emission reduction options. Because of its size, PANYNJ may be in a unique position among OTR ports to act on its own. Other ports may prefer their autonomy in choosing which measures are most appropriate to curb their emissions. A third option is for states and port authorities to work jointly to reduce emissions. In addition to CARB's drayage truck regulation (see above), the Ports of Los Angeles, Long Beach, and Oakland are charging gate fees to fund cleaner trucks.

---

[14] The PANYNJ, Port Commerce Department, 2006 Baseline Multi-Facility Emissions Inventory.

[15] Tonnage data for all ports comes from the American Association of Port Authorities' (AAPA) "2007 US Port Rankings by Tonnage."

The facilities of different ports in the OTR vary considerably which affects the logistics and feasibility of implementing state- or region-wide port measures. For example, ports without gates would have a hard time charging gate fees or regulating which MY trucks enter port grounds. Therefore, if even if a state-wide regulation is adopted, enforcement cost and capability would vary significantly from port to port within the state, potentially creating a situation where older trucks are merely funneled to the ports without gates, rather than taken off the road.

Opposition to a drayage truck measure will likely come from the trucking industry. The PANYNJ estimates that 15% of its drayage truck engines are MY 1993 or older, all of which would need to be replaced if this regulation is implemented. Discussions with trucking companies suggest that profit margins are very slim, and any requirements forcing owners to make what they consider unnecessary capital investments will likely face resistance. California is currently encountering significant opposition to their truck retrofit rule.

Another concern is the fate of the retired drayage trucks. Though lacking access to the region's ports, they still may be utilized in other shipping activities. A question to consider is whether additional measures need to be taken to ensure that total emissions are reduced not re-categorized.

NOTE: The measures discussed in this document represent possible controls the OTC is evaluating for potential NOx and VOC emission reductions. No decision has yet been made by the OTC states to pursue these measures for inclusion in a state implementation plan.

Table 1. States' port emissions and drayage regulation impact.[16]

STATE	PORTS		NOx			PM		
		Annual freight (mill tons)	2006 Emissions (tpy)	Annual Benefit—10% (tpy)	Lifetime Benefit—24 years (tons)	2006 Emissions (tpy)	Annual Benefit—9% (tpy)[17]	Lifetime Benefit (tons)
NY/NJ	**PANYNJ**	**157**	**1935**	**190**	**4555**	**54**	**5.0**	**131**
CT	New Haven, Bridgeport	17	212	21	499	6	0.5	13
DE	New Castle, Wilmington	11	137	13	324	4	0.4	9
MA	Boston, Fall River	26	320	31	755	9	0.8	20
MD	Baltimore	41	508	50	1197	14	1.3	31
ME	Portland, Searsport	26	320	31	755	9	0.8	20
NH	Portsmouth	4	50	5	117	1	0.1	3
NJ	Paulsboro, Camden-Gloucester	45	553	54	1302	15	1.4	34
NY	Albany, Buffalo, Port Jefferson	10	125	12	295	3	0.3	8
PA	Pittsburgh, Marcus Hook, Penn Manor, Chester	103	1263	124	2976	35	3.3	78
RI	Providence	9	114	11	268	3	0.3	7
VA	Hampton Roads	55	673	66	1587	19	1.7	42
	TOTAL	**504**	**6210**	**610**	**14629**	**173**	**16.0**	**396**

Control Cost Estimate:
EPA has estimated the cost to modernize the PANYNJ fleet according to this plan to be $84 million. This cost will be spread between the two phases of the proposed plan. The first phase which takes effect in 2011 will affect 1,688 vehicles, and the second phase which begins2017 will affect 13,535 vehicles. Lifetime NOx and PM savings as a result of this program are 7,770 tons and 200 tons, respectively. The cost is $10,810 per ton of NOx and $420,000 per ton of PM.

Additional measures in the region:
In Maryland and Virginia, temporary financing programs have been created to retrofit or replace older drayage trucks. In Maryland, the National Clean Diesel Campaign (NCDC) has committed $500,000 to the Port of Baltimore for its retrofit/replacement program. The Port of Virginia's Green Operator (GO) Program has received funding from the Virginia DEQ for 100% rebates on purchases of verified emission control devices, up to $6,000 per device.

Benefit for other pollutants:
In addition to reducing NOx and PM, this measure will reduce HC, global warming agents CO_2 and black carbon, as well as toxins such as formaldehyde and acetaldehyde.

---

[16] PANYNJ drayage emissions were calculated using MOBILE 6.2. According to EPA, NOx emissions for heavy-duty trucks are "higher than previously estimated" by MOBILE 6.2 and PM emissions are "significantly higher." Please see EPA Releases MOVES2010 Mobile Source Emissions Model: Questions and Answers.

[17] One decimal place is shown in this column to indicate non-zero emission levels.

NOTE: The measures discussed in this document represent possible controls the OTC is evaluating for potential NOx and VOC emission reductions. No decision has yet been made by the OTC states to pursue these measures for inclusion in a state implementation plan.

Potential Stakeholders:

American Trucking Association
State motor transport associations
Local port authorities
Port Authority of New York and New Jersey

Author Contact info:

Jesse Colman, Matt Solomon, Coralie Cooper NESCAUM, 617-259-2000

References

CA final regulation order: http://www.arb.ca.gov/regact/2008/truckbus08/regpart2.pdf

CARB, 2007. "Regulation to Control Emissions from In-Use On-Road Heavy Duty Drayage Trucks: Technical Support Document." California Air Resources Board. October, 2009.

EPA report on potential PANYNJ emission reduction strategies. Prepared by the Eastern Research Group.

EPA Releases MOVES2010 Mobile Source Emissions Model: Questions and Answers. EPA OTAQ, December, 2010. Available at: http://www.epa.gov/otaq/models/moves/420f09073.pdf.

PANYNJ, 2009. *A Clean Air Strategy for The Port of New York & New Jersey*, Port Authority of New York and New Jersey, New York, NY. Ross and Associates, October, 2009. Available at: http://www.panynj.gov/about/pdf/CAS-FINAL.pdf.