MEASURING AIR POLLUTION INSIDE AND OUTSIDE OF DIESEL TRUCK CABS

Report Prepared for the U.S. Environmental Protection Agency

by

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

Federal safety regulations limit daily and weekly hours that long-haul truck drivers can drive their vehicles. When truck drivers reach their mandated hours of service they are required to rest for a certain amount of time. Many truck drivers rest inside the truck's sleeper berth. In order to operate the cab heating, air conditioning, and electrical systems truck drivers frequently idle the truck engines. This practice is referred to as "hoteling". Rest periods often last 8 hours or more, during which the truck continuously idles and burns approximately one gallon of diesel fuel per hour.

Commercial truck stops and interstate rest areas have of trucks parked alongside each other often with the engines idling. This can produce significant air pollution emissions within a confined area, with the potential for high air pollution exposures to the truck drivers who are sleeping in their cabs as well as employees of the truck stop or rest area. The pollutants of interest include nitrogen oxides, particulate matter and various toxic organic species. Nitrogen oxides are important precursors to ground level ozone formation. These compounds are usually associated with lung irritation and respiratory discomfort. Diesel Particulate Matter (DPM) is believed to contain more than 40 different hazardous air pollutants and carbon particulate matter. A significant fraction of the DPM has been found to be $PM_{2.5}$. Important organic species include benzene, 1,3-butadiene, soot, formaldehyde and polyaromatic hydrocarbons (EHHI, 2002). Exposures to particulate matter have been associated with asthma, reduced lung function and respiratory illness. Carbon monoxide emissions from heavy-duty diesel trucks are typically low due to the high excess air used in the diesel engine's combustion process.

Previous studies have shown possible self-contamination inside the truck cabs as a result of the idling of the truck's engine. A study done in 1977 measured ambient and in-cab concentrations of NO, NO_2 and CO. The study showed that in-cab levels of NO and NO_2

were high under idling conditions. Tracer studies revealed openings in the cab floor to be a major pathway for engine compartment gas leakage into the cab (Ziskind et al., 1977). Recent studies conducted in diesel school buses show elevated levels of diesel particle concentrations during travel (Solomon et al., 2001). Other studies have compared exposures in various modes of travel (Gulliver and Briggs, 2004). While most studies focus on exposures during travel, little work has been done in recent years in measuring exposures while vehicles are parked idling.

This study focused on measurements of air pollutant concentrations during idling conditions. Air conditioning and air re-circulation systems on trucks may or may not be effective in reducing air pollution levels inside the truck cab when compared to air pollution concentrations outside the truck. Some truck drivers sleep with their truck engines off, with no air re-circulation. Air pollutant concentrations inside these cabs may be higher or lower than in trucks with the engine idling and air re-circulation systems functioning. The overall objective of this research was to identify levels of air pollutants inside and outside truck cabs in a travel center parking area where "hoteling" is practiced. This was accomplished by measuring air quality inside and outside the truck cab, for different models/makes of trucks, and under various environmental conditions.

2 METHODOLOGY

This section describes the detailed procedures followed in measuring air pollutant concentrations inside and outside of idling trucks. Overall, six different trucks were tested at a commercial truck stop under different modes of operation and at different times of the day. The concentrations of nitrogen oxides (NOx), carbon monoxide (CO) and particulate matter less than 2.5 microns in aerodynamic diameter ($PM_{2.5}$) were measured inside and outside the truck cab.

2.1 Location of Sampling

The tests were conducted at a commercial truck stop in Knox County, TN, located at the intersection of interstate I-40 and Watt Road. Three commercial truck stops are located in that region with a total of about 700 parking spaces. Figure 2-1 shows an overview of the locations of these truck stops. The testing was conducted at a truck stop with about 225 parking spaces. An aerial view of the truck stop is shown in Figure 2-2. As seen in Figure 2-2, the truck stop has a restaurant onsite in addition to the fueling stations. The parking spots closer to the restaurant were occupied for most of the day. Hence those spots are referred to as the "high end." The parking spots further away from the restaurant usually exhibited lower occupancy, and were used more when the "high end" spots were unavailable, and hence are referred to as the "low end." The trucks that were tested in this study were parked in one of the parking spaces in the "High End North", since that was the location that was heavily occupied with trucks idling at most times of the day. A mobile laboratory was also stationed at the travel center for immediate analysis of gas samples that were collected. The mobile laboratory was setup in a trailer maintained at approximately 65 F. The trailer contained all the analytical instruments necessary for the analysis. Calibration gases were also stored inside the trailer.

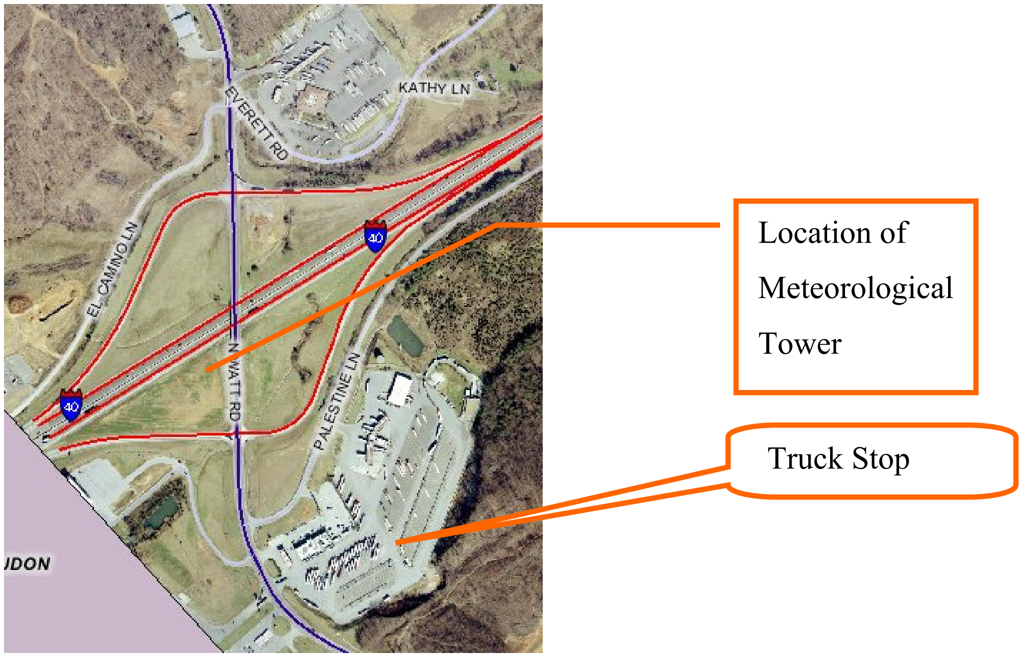


Figure 2-1. Aerial View of the I-40 Watt Road Interchange showing the Truck Stops

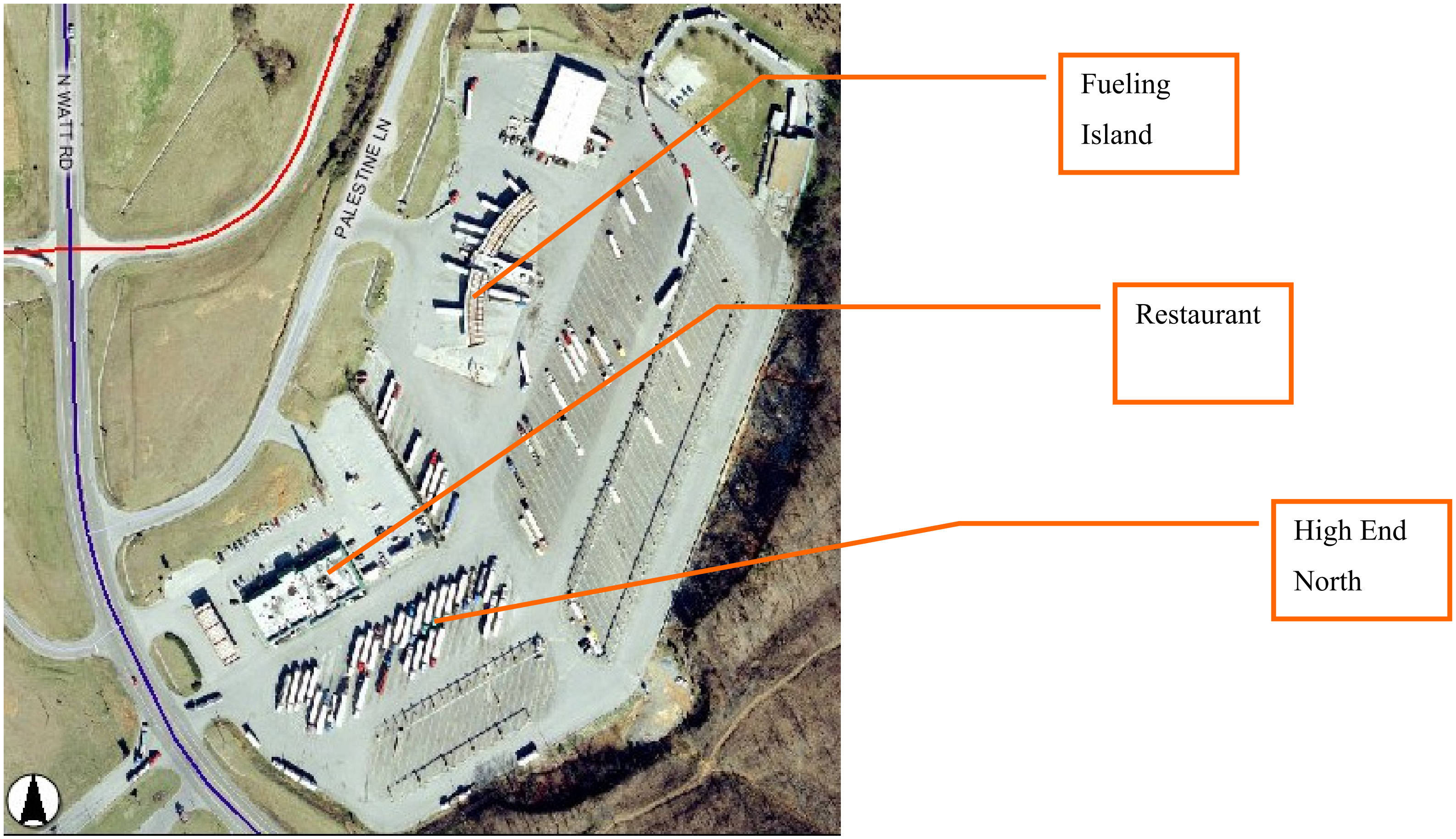


Figure 2-2. Aerial View of Truck Stop at which Measurements were Conducted

In addition, a computer was stationed inside the trailer for downloading data from the portable $PM_{2.5}$ instruments and for data entry purposes.

2.2 Sampling Procedure

Six trucks were individually tested as part of this research study. Each truck was rented and driven to the truck stop for conducting air quality measurements. The diesel truck to be tested was parked in one of the parking spots in the "High End North" section, preferably somewhere in the middle. Each truck was tested for a minimum of two days, covering periods of day and night, as per a preset sampling matrix. The sampling schedule was completed in two phases. The first three trucks were tested during December 2004 and the remaining three trucks were tested in January 2005. The pollutants measured included nitrogen oxides (NOx), carbon monoxide (CO) and particulate matter less than or equal to 2.5 microns in aerodynamic diameter ($PM_{2.5}$).

2.2.1 Experimental Setup

$PM_{2.5}$ concentrations of outside and in-cab air were measured using two identical portable optical monitors, the DataRAM model DR-4000. One DataRAM was owned by the University of Tennessee and is referred to in this report as the "UTK DataRAM". The other identical instrument was obtained from the manufacturer and is referred to as the "MIE DataRAM". Gas samples were collected continuously for one hour in 16 L Tedlar® bags using battery operated BGI low flow pumps. The low flow pumps were capable of sampling as low as 200 cc/min. The gas samples collected in the Tedlar® bags were later analyzed for NOx and CO concentrations. More information on gas and PM measurements is presented later in this section. All of the instruments for sample collection were placed inside the truck cab. The optical monitor and the low flow pump for sampling the outside air were placed on the front passenger seat. The probes for sampling the outside air were run out of the passenger side window through a template

(Figure 2-3 and Figure 2-4). The probes consisted of ¼ inch (ID) Teflon® tubing for gas sampling and ¼ inch ID Tygon® tubing for PM sampling. Each tube was about 8 ft long. The template consisted of a clear transparent circular fitting (made of a polycarbonate material) that was fit onto a second window fitting. The window fitting snapped into the passenger side window of any truck and provided a well-sealed fitting. Small holes were drilled into the circular template to accommodate the sampling lines that went from the sampling bags and PM monitor to the outside of the truck for measurement of the outside air concentrations. The ambient air inlets of the outside sample probes were placed in front of the windshield just above the vent openings through which the trucks pulled in outside air. The inlets were supported using a combination of right angle and burette clamps, such that they were at least a foot away from the windshield and the surface of truck hood. The objective of this was to sample the outside air that the truck would pull into its ventilation system during the air conditioning modes, allowing a comparison of outside and inside concentrations.

The instruments (optical monitor and the low flow pump) for sampling the in-cab air were placed on the bed inside the sleeper portion of the cab (Figure 2-5). The in-cab sampling probes were identical to the outside sample probes in length and materials of construction. The in-cab probes were placed such that the inlets were approximately in the middle of the cab, and approximately two feet above the bed, to be representative of the air that a truck driver would breathe in the sleeping area.

Both these inlets are for measuring outside air sample. One tube pulls in the sample for the $PM_{2.5}$ measurement and the other tube pulls a sample into the Tedlar® bag for gas analysis.

Figure 2-3. Setup Showing Outside Air Sample Probes

One tube is connected to the $PM_{2.5}$ instrument and the other tube goes to the low flow pump which pumps the air to a Tedlar® bag.

Figure 2-4. Outside Air Sample Probes Connected to DataRAM and Pump for Gas Sample

Figure 2-5. Experimental Setup Showing In-Cab Sample Collection

2.2.2 Sampling Operation

Each truck was tested for a minimum of two days according to a preset matrix of the different modes of operation. The modes of operation included the following settings:

a. Off Mode: The truck engine was off. All windows were closed.
b. Re-circulation Mode: The truck engine was turned on and set to idle at a constant speed, in the range of 750 to 1000 revolutions per minute (RPM). The RPM was maintained constant using the cruise control option in the truck. The air conditioning was turned on and the fan speed was set at the maximum speed setting. The vent position was set to re-circulate the inside air, typically denoted by a curved arrow in most trucks. In some models, this would be the “Max A/C” setting.
c. Fresh Air Mode: The truck engine was turned on and set to idle at a constant speed. The air conditioning was turned on and the fan speed was set at the maximum speed setting. The vent position was set to pull in outside air.
d. Engine on, Fan Off Mode: The truck engine was turned on and set to idle at a constant speed. The air conditioning was turned off.

It should be noted that, depending on the truck configuration, the Fresh Air Mode (or the Re-circulation Mode) may not be 100 percent outside air (or 100 percent internal air re-circulation) and may involve a mix of both. During truck idling and air conditioning, the temperature inside the cab was set to suit the comfort of the individual collecting the data, typically around 70 F. While a reasonable attempt was made to maintain the in-cab temperature around 70 F using the analog climate control settings in the truck, these controls were not fine enough to enable accurate temperature setting inside the cab. Hence, a small change in the temperature-setting tab changed the in-cab temperature to a great extent, particularly with the fans operating at maximum speed. During the “Off” mode when the engine was shut off, as it should be obvious, it was not possible to control the in-cab temperature.

Prior to the start of sampling, both the DataRAMs with the $PM_{2.5}$ cyclones were placed adjacent to each other on the bed inside the cab. The DataRAMs were initialized and turned on and the concentration readings were noted with a high efficiency filter at the inlet (GELMAN 0.2 µm pore size capsule filter, product no 12112). The DataRAMs were then zeroed using the instruments' zero feature. Following this, the concentrations were read with the filter at the inlet and then without the filter. At the end of the sampling schedule for a particular shift, the DataRAMs were again placed adjacent to each other on the bed and readings were noted with the filter at the inlet and without the filter at the inlet. This was done to evaluate any zero drifts in the $PM_{2.5}$ instruments.

One dedicated set of instruments (namely, the UTK DataRAM $PM_{2.5}$ monitor, the low-flow pump for gas sample and the respective sample probes) was maintained for outside sample collection only. Similarly, the other identical set was dedicated for in-cab sample collection alone. The instruments were not interchanged throughout the project. For each truck, the instruments were set up as explained before and remained in the truck between shifts, until the testing of that truck was completed. All of the Tedlar® gas sampling bags were numbered. Each new bag was purged with zero air twice and was measured for concentrations of NO_x and CO. The NO_x and CO concentrations measured at that instant were zero within instrument uncertainty. The valve was then closed, until it was ready to be used. The DataRAMs were powered by the cigarette lighter in the truck through the use of a DC to AC power inverter. This ensured continuous operation of the DataRAMs without relying on the instrument's internal battery.

For each truck, the following parameters were noted: the vehicle identification number, model year of the truck, name of the manufacturer, the mileage on the truck and a visual observation on the condition of the truck. This is shown in Table 2-1. In addition, a note was also made on whether the truck had any kind of HVAC (Heating, Ventilation and Air Conditioning) filter, either at the air intake under the hood and/or inside the cab. Approximate dimensions of the cab were also noted. At the start of each hour, associated with the change of truck's mode of operation, the temperature and relative humidity inside the cab were measured using an Extech (model 45160) anemometer. Table 2-2 lists the average temperature and relative humidity recorded for each shift. In addition, during the modes of "Re-circulation" and "Fresh Air", the velocity, temperature and relative humidity of the air from the vents were measured. The dimensions of the vents were also measured using a ruler. Gas sampling was conducted for one hour after which the sampling valve was closed. The mode of operation was changed each hour as per a preset schedule and fresh bags were then connected to the sample probes. The collected bags were stored in a black polyethylene trash bag to minimize the effect of light and then taken to the mobile laboratory for analysis. The bags were analyzed for NOx and CO typically within a period of 2 hours from the time of collection. The NOx concentration was measured using a continuous chemiluminescence analyzer. The CO concentration was measured using a continuous infrared analyzer. After analysis, the bags were emptied, purged with zero air twice and the valve closed, ready to be reused. While the purged bags were not re-tested for NO_x and CO, it is unlikely that that there were any gaseous traces left in the bag, since the gases being measured are not known to be adsorbing onto Tedlar® bags. Approximately every two hours, the number of trucks parked in the travel center was counted. In addition, the number of trucks idling was also noted. These counts were made for each section of the truck stop. At the end of each shift, the data from both DataRAMs were downloaded to a computer in the mobile laboratory. The DataRAMs were placed on electric charge ready to be used in the next shift. Since the gas concentrations were measured within a window of about 2 hours, shelf life studies were also conducted on those bags that read concentrations above an arbitrarily set value (NOx > 500 ppb or CO > 0.5 ppm). The bags with high concentrations of CO or NOx were stored in the mobile laboratory for further analysis and the concentrations were measured after every 1.5 to 2 hours.

Table 2-1. Model Information of Trucks Tested

Truck #	Model Year	Mileage	Comments
Truck 1	1996	444,870	Caterpillar engine, 14.6L, 410 HP
Truck 2	1999	379,368	Detroit Diesel, 12.7L, 430 HP
Truck 3	1998	072,704	Detroit Diesel, 12.7L, 430 HP, single exhaust behind passenger side
Truck 4	1999	496,019	
Truck 5	1999	478,555	430 HP
Truck 6	2003	139,240	435 HP; Has air intake filter under the hood.

2.2.3 Incense Testing

Additional testing was conducted on each of the trucks using incense sticks, to help determine the exchange rate of the air. Incense sticks were used to raise the in-cab $PM_{2.5}$ concentration to a value at least twice as high as the outside $PM_{2.5}$ concentration. The incense fumes were fanned manually to create a relatively uniform concentration. The incense sticks were then extinguished and the in-cab $PM_{2.5}$ concentration was monitored over time for about an hour. The testing was conducted in three different modes of operation in the following order: Re-circulation followed by Fresh Air followed by Off mode, each for about an hour. After each hour, the mode of operation was changed and if necessary, incense sticks were lit up momentarily, to again increase the in-cab concentration to a value twice as high as the outside. The recorded $PM_{2.5}$ concentrations were analyzed to determine the approximate air exchange rates.

Table 2-2. Average Temperature and Relative Humidity inside the Truck Cab

Shift	Truck Number	Shift Code	In-Cab Temperature* (°F) Mean	In-Cab Temperature* (°F) Std Dev	In-Cab Relative Humidity* (%) Mean	In-Cab Relative Humidity* (%) Std Dev
Dec 15 Day	1	1_1	75	9	29	21
Dec 15 Night	1	1_2	67	18	37	31
Dec 16 Day	1	1_3	68	14	29	18
Dec 16 Night	1	1_4	75	10	30	19
Dec 17 Day	1	1_5	62	13	34	16
Dec 17 Night	2	2_1	76	12	28	14
Dec 18 Day	2	2_2	70	7	23	5
Dec 18 Night	2	2_3	57	3	55	6
Dec 19 Day	2	2_4	66	20	39	25
Dec 19 Night	2	2_5	59	20	26	20
Dec 20 Day	3	3_1	62	10	38	21
Dec 20 Night	3	3_2	58	23	28	20
Dec 21 Day	3	3_3	78	8	17	11
Dec 21 Night	3	3_4	73	6	24	8
Jan 6 Night	4	4_1	67	4	51	12
Jan 7 Day	4	4_2	73	4	32	4
Jan 8 Day	4	4_3	71	14	48	27
Jan 8 Night	4	4_4	61	8	48	13
Jan 9 Day	4	4_5	74	15	33	18
Jan 9 Night	4	4_6	73	10	34	13
Jan 10 Day	5	5_1	70	6	46	20
Jan 10 Night	5	5_2	71	10	41	18
Jan 11 Day	5	5_3	72	3	36	8
Jan 11 Night	5	5_4	74	10	43	19
Jan 12 Day	6	6_1	79	9	49	21
Jan 12 Night	6	6_2	82	7	38	15
Jan 13 Day	6	6_3	84	4	35	6
Jan 13 Night	6	6_4	71	12	51	27
Jan 20 Day	7	7_1	68	17	41	26
		Mean	*70*		*37*	

* In-Cab Temperature and Relative Humidity measured using Extech anemometer

2.3 Instrumentation

2.3.1 $PM_{2.5}$ Measurements

The particle concentrations were measured continuously using two similar optical $PM_{2.5}$ monitors: Thermo MIE DataRAM, model DR-4000. The DataRAM is a dual wavelength nephelometer that measures light scattering coefficient and calculates concentration based on an internal calibration curve. This is based on the assumption that the magnitude of light scatter sensed by the detector is directly proportional to the amount of particles in the gas stream. The air sample inlet consisted of a Tygon® 2275 high purity tubing about 8 ft long and ¼ inch in diameter. This tubing was used to avoid any electrostatic effects and to minimize particle entrapment. The Tygon® tube was connected to a cyclonic impactor designed to provide a 2.5 µm cut-point. The $PM_{2.5}$ impactor was connected directly to the DataRAM. The settings on both the DataRAM instruments were set identically. Each DataRAM was operated as a single wavelength nephelometer. The wavelength of the light source was 880 nm. The DataRAMs were set to record 15- second averages. The humidity correction was disabled in both the DataRAMs. The flow setting on the DataRAMs were initially set at 2 liters per minute. However, when the flow rate in each of the DataRAMs was measured using a BIOS DryCal DC-Lite flow meter, it read 1.85 Liters per minute (L/min) for the UTK DataRAM and 2.24 L/min for the MIE DataRAM. Hence, the settings on the DataRAMs had to be changed such that the measured flow rate was 2 L/min. Thus, the flow setting on the UTK DataRAM was set at 2.09 L/min and that for the MIE DataRAM, at 1.77 L/min.

A short piece (~2.5 ft) of the new Tygon® tubing was tested at the lab to determine if any particle entrapment occurred. The room was filled with incense fumes and mixed well with a fan. The $PM_{2.5}$ concentrations were then measured with a DataRAM. The measurement sequence consisted of concentration readings with and without the tube at the inlet alternated every 5 to 7 minutes. The results showed that the concentrations measured with the tube were, on average, 2.7% lower than the concentrations measured without the tube, indicating some particulate removal by the tube. Thus, on average, the particle loss was ~1.1% per foot of tube used, which translates to less than 10% loss for the 8 ft long tubing used in the study. Since both the UTK and MIE DataRAMs used identical tubing of same length (8 ft), the extent of underestimation would be the same in both samples, having no effect on a relative basis.

2.3.2 NOx Measurements

The NOx concentration was measured using a Teledyne Model 200E Nitrogen Oxides analyzer. It determines the concentration of nitric oxide (NO), total nitrogen oxides (the sum of NO and NO_2) and nitrogen dioxide (NO_2) in a sample gas. The basic principle of operation of this analyzer is to detect the chemiluminescence, which occurs when nitric oxide (NO) reacts with ozone (O_3). The sample gas is supplied at ambient atmospheric pressure in order to establish a constant gas flow through the reaction cell. The sample gas is pulled in typically at a rate of about 0.5 liter per minute. In the reaction cell, the sample gas is exposed to ozone, initiating a chemical reaction between NO and O_3 that gives off light (chemiluminescence). A catalytic converter converts any NO_2 in the sample gas to NO, which is then reported as NOx. NO_2 is calculated as a difference between NOx and NO.

2.3.3 CO Measurements

The carbon monoxide (CO) concentration was measured using a Thermo Electron Model 48C Gas Filter Correlation Analyzer. This is based on the principle that CO absorbs infrared (IR) radiation at a wavelength of 4.6 microns and the presence and amount of CO can be determined by the amount of absorption of IR. The analyzer pulls in sample at a flow rate of 1 liter per minute. The carbon monoxide analyzer uses gas filter correlation technology to measure low concentrations of CO. This instrument utilizes an infrared radiation source located behind a rotating gas filter correlation wheel. The correlation wheel has two gas filled "cells". One cell contains CO which removes all IR energy in the CO absorption wavelengths, thereby creating a reference beam, which cannot be further attenuated by the CO in the sample. The other cell contains nitrogen which allows the CO absorption spectral bands to be measured with the sample gas. The radiation from the IR source is passed through the gas filter alternating between the CO and N_2 cells. Both IR beams pass sequentially through the multiple path measurement cell where the energy is absorbed by the sample gas. The difference in IR energy sensed by the solid-state detector during measurement and reference cycles is proportional to the CO present in the measurement cell.

2.3.4 Calibration and Calibration Checks

The NOx and CO analyzers were initially calibrated in December 2004 prior to the start of the sampling period. After the testing of the first three trucks in December 2004, the analyzers were turned off during the break. Hence, prior to the start of second phase of testing (trucks 4 through 6), the analyzers were again calibrated in January 2005. The NOx analyzer was calibrated for NO by diluting an EPA protocol gas from 200 ppm NO down to 400 ppb NO. The CO analyzer was calibrated by diluting a 50 ppm CO EPA protocol gas to 2 ppm CO. The dilutions were done using a Teledyne Model 700 Dynamic Dilution Calibrator by mixing the EPA protocol gas with zero air (ultra zero grade) from a cylinder.

Calibration checks were performed on the NOx and CO analyzers approximately every 2 to 4 days, coinciding with the testing of a new truck. The analyzers were checked using calibration gases of various concentrations that were prepared by mixing EPA protocol standard gases with ultra-grade zero air. NOx concentrations of 0 to 1600 ppb were generated in intervals of about 200 ppb. The analyzer reading for each was noted. Similarly, CO concentrations of 0 to 2 ppm were generated in intervals of 0.5 ppm. The instrument response was noted in each case. These data were used to generate calibration curves and to adjust the analyzer reading in each case. This is explained in section 3.1.1.

The portable $PM_{2.5}$ instruments were collocated with a TEOM (Tapered Element Oscillating Microbalance) at the Watt Road intersection located next to the meteorological tower continuously for a period of 48 hours. This provided a correlation of both the DataRAMs, as well as a correlation of the DataRAMs against the TEOM. The TEOM (Series 1400a) was equipped with a $PM_{2.5}$ inlet placed in an outdoor enclosure. The TEOM was operated at 50 ^{o}C and did not employ any drying technology. The settings on both the DataRAMs were identical and were same as that used during the actual testing phase. Prior to the start of the collocation, the $PM_{2.5}$ concentration readings from the DataRAMs were checked with the filter at the inlet. The UTK DataRAM read 3.5 $\mu g/m^3$ with the filter at the inlet while the MIE instrument read zero. At the end of the collocation period (approximately 48 hours), both the DataRAMs read zero with the filter at the inlet.

The typical factory calibration involves calibrating the DataRAM using SAE fine dust. Sioutas et al. (2000) reported that the aerosol mass median diameter (MMD) was the single most important factor that affected the response of the DataRAM. In addition, it is important that the nephelometer be calibrated against the aerosol of interest (Howard-Reed et al., 2000). Since the aerosol of interest in this study was dominated mainly by diesel combustion particles, the investigators chose to calibrate the DataRAMs against the TEOM that measured the aerosol in the near vicinity of the truck stop rather than SAE fine dust (or Arizona road dust), whose particle characteristics differ from combustion-generated aerosols (for example, mass median diameter [MMD] of SAE fine dust = 2-3 µm, while MMD of combustion aerosols < 1 µm).

During Dec 2004, after the completion of the first three trucks, the UTK DataRAM was run continuously in the truck stop for ~ 12 days, with a pre-weighed filter (instead of the

High Efficiency Particulate (HEPA) filter cartridge) at the exit of the DataRAM. This was done to provide an independent correction factor to calibrate the DataRAM readings.

2.4 Ambient Meteorological Data Collection

Ambient meteorological data were collected at a site close to the interstate near the ramp, about 1100 feet from the travel center (Figure 2-1). The following parameters were measured at this site: temperature, wind speed, wind direction, precipitation and solar intensity.

3 RESULTS AND DISCUSSION

3.1 Calibration of Measured Concentrations

3.1.1 Calibration of Gaseous Concentration Data

NOx and CO concentrations were adjusted using calibration curves. Calibration checks were performed on the NOx and CO analyzers approximately every 2 to 4 days, coinciding with the testing of a new truck. These data are tabulated in Table 3-1 and Table 3-2. The response of the NOx analyzer appeared to be stable over the whole testing period. Hence, a single calibration curve was used for the NOx analyzer (Figure 3-1). For the CO analyzer, there was a slight zero drift with time, while holding the span calibration constant. Hence, only a zero drift adjustment was made. Since the CO concentrations in the truck stop were already low, an hourly zero drift adjustment was made. The zero drift adjustment was 0.0043 ppm per hour for the first three trucks tested (Dec 15 to Dec 20) and 0.0035 ppm per hour for the last three trucks (Jan 6 – Jan 10) as shown in Figure 3-2. All values that were less than the detectable limit of the analyzer (0.04 ppm) after adjustment of the zero drift were replaced with 0.02 ppm (half of the detection limit of the instrument).

3.1.2 $PM_{2.5}$ Calibration

The portable $PM_{2.5}$ instruments were collocated against a TEOM at the Watt Road intersection for about 48 hours. Figure 3-3 shows the plot of the $PM_{2.5}$ concentrations read by all the three instruments. As seen in the figure, the two DataRAMs tracked each other closely. The $PM_{2.5}$ concentrations measured by the TEOM were always lower

Table 3-1. NO Calibration Checks

Nitric Oxide (NO) Concentration (ppb)							
Span Gas	Analyzer Reading During Each Calibration Check (Dec 2004 – Jan 2005)						
	Dec 15	Dec 17	Dec 20	Jan 6	Jan 10	Jan 14	Average
1600		1783.2	1758.5	1804.5	1785.7	1756.7	1778
1400		1559.9	1524.1	1567	1549.1	1536.1	1547
1200		1321	1303.4	1340.8	1320.7	1292.7	1316
1000		1089	1069.7	1100.7	1084.6	1070.2	1083
800		863.8	836.8	867.9	853.3	842	853
600		622.3	610.8	624.6	620.3	610.2	618
400	400.3	394	383.7	392.5	390.5	378.3	390
300	285.3	276	272.2	279.4	273.2	266	275
200	165	156.1	153.6	155.5	150.7	146.4	155
100	65.7	56	53.9	48.1	41.1	40.2	51
0	0.4	2.1	1.9	0.2	-3.3	-0.7	0

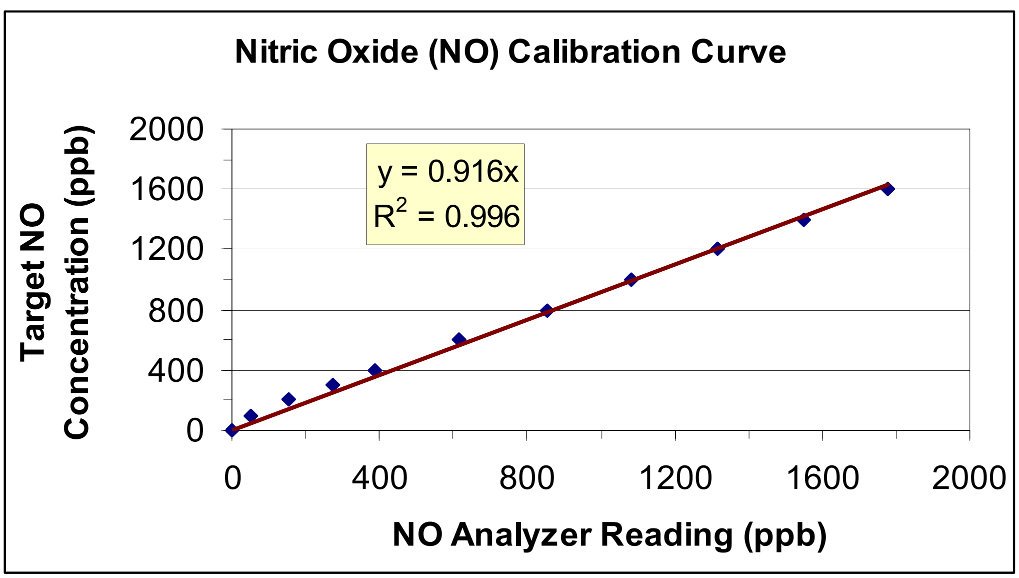


Figure 3-1. NO Calibration Curve

Table 3-2. CO Calibration Check

CO Concentration (ppm)						
Span Gas	Analyzer Reading During Each Calibration Check (Dec 2004 – Jan 2005)					
	Dec 15	Dec 17	Dec 20	Jan 06	Jan 10	Jan 14
2.5				2.54		
2		2.47	2.83	2.04	2.38	2.72
1.5				1.546	1.877	2.2
1	1.304	1.47	1.809	0.994	1.374	1.676
0.5	0.8	0.945	1.287	0.5	0.849	1.159
0	0.311	0.47	0.796	0.023	0.373	0.673
	Approx. time of zero check					
	6 pm	7 pm	11:30 am	12:30 pm	10:15 pm	8:30 am

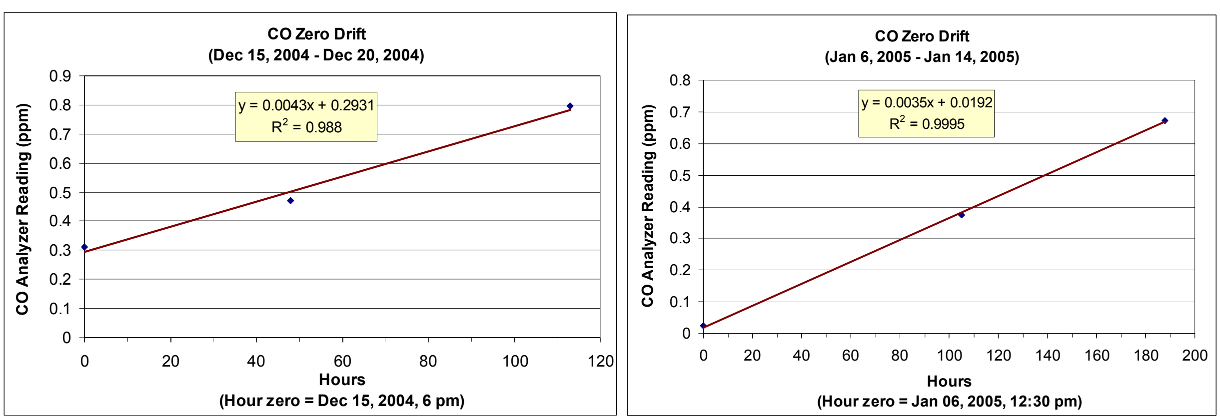


Figure 3-2. CO Zero Drift During Testing Period

than either of the DataRAMs. In addition, the concentrations measured by both the DataRAMs continued to increase from about 8 pm and reached a peak at about 8 am in the morning, while the concentrations measured by the TEOM relatively remained flat during the same interval. For purpose of comparison, the relative humidity (RH), as measured by the meteorological tower, for the same time period is plotted. It may be noted that the trend of RH variation matched the pattern of $PM_{2.5}$ concentrations measured by the DataRAMs. The RH measured by the DataRAMs (not shown in the figure) were lower than that reported by the meteorological data (possibly due to internal heating of the DataRAMs, as indicated by DataRAM temperatures higher than the ambient temperature). While the meteorological data showed RH values ranging from ~30% to 90%, the RH measured by DataRAMs ranged from 20% to 44%. The effect of RH on the particles is not apparent, because of this changing environment between the ambient and the measurement chamber inside the DataRAM. With the changing dynamics that the particles are exposed to, it is doubtful if the particles were fully conditioned to the surrounding environment. Hence, the effect of RH on the particles may be in-between that associated with ambient RH and the RH inside the measurement chamber. Hence, an accurate correction for the effect of RH was not easily determined and no RH adjustment was performed on the data presented in this report to avoid introducing further uncertainties in the data. The resultant effect is quantified below.

It is possible that the relatively flat trend measured by the TEOM could be due to the heated inlet maintained at 50 C, which could result in loss of moisture from the particles. The DataRAM inlets, on the other hand, were at ambient temperatures and hence could reflect the effect of relative humidity on the particles. Hence, the concentrations measured by the DataRAMs may be over estimated due to this effect. Moreover, the correlation of both the DataRAMs was very high ($R^2 = 0.985$), while that with the TEOM was reasonable ($R^2= 0.67$). Since both the DataRAMs correlated well, the concentrations measured by the UTK instrument were converted to a MIE basis using the correlation equation (Figure 3-4), in order to enable comparison of in-cab and outside concentrations on a same basis. These concentrations were not adjusted to a TEOM equivalent due to the wide scatter involved. Hence, it must be realized that these absolute concentrations may be over estimated. The correlation equation of MIE versus TEOM is shown in Figure A-1.1 in Appendix A-1, if one wishes to convert the concentrations to a TEOM basis. Based on the equation, it may be noted that, on average, the concentrations measured by the MIE DataRAM was about 1.8 times the concentrations measured by the TEOM.

As mentioned earlier, the UTK DataRAM was run continuously for ~12 days with a pre-weighed filter. The results showed that the ratio of the DataRAM-measured concentration to the gravimetric mass concentration from the filter (after blank correction) was 2.0. This value is similar to the regression slope obtained by comparing the concentrations measured by the UTK DataRAM against the TEOM (UTK $PM_{2.5}$ = 2.4 TEOM $PM_{2.5}$). Note that Figure A-1.1 shows the comparison of the MIE DataRAM against the TEOM and not the UTK DataRAM. The gravimetric measurement provided an independent estimate of the correction factor for the DataRAM. However, this is a single value. Since this value was close to the TEOM collocated calibration factor (i.e., regression slope), the approach of using the TEOM collocation to provide a point of reference was chosen, because of the number of data points which were used in obtaining a regression derived slope rather than just a single data point of gravimetric correction. Thus, the data indicates that the DataRAM $PM_{2.5}$ concentrations may be over-estimated by a factor of 2. This factor is similar to that reported by Sioutas et al. (2000), who showed a factor of ~2.3 at RH of ~90%.

In Section 2.3.4, it was noted that the UTK DataRAM read 3.5 $\mu g/m^3$ with the filter at the inlet at the start of the collocation period and read zero at the end of the collocation period. The MIE instrument read zero at both instances. Zero readings with the filter were also taken during the regular measurement schedule (Section 2.2.2), during which, similar drifts in zero readings were observed (Table A-1.1). It is apparent that there were two types of zero error problems. First, the instruments displayed the zero offset error, which arises from not reading zero with the filter in place at the beginning of each measurement schedule. Secondly, the instruments also experienced a drift in the zero level (zero drift error) between the beginning and end of each shift. While the direction of the zero drift was negative during the collocation period (i.e., a decrease from 3.5 $\mu g/m^3$ to zero), this was not always the case during the sampling phase. Moreover, the MIE instrument also exhibited zero drifts in addition to the UTK instrument. The zero drifts, however, were not present at all times and the magnitude of drift differed each shift. It apparently depended on the particle loading that the instruments were exposed to. It is possible that some particle entrapment occurred in the nozzle of the $PM_{2.5}$ impactor during high particle loadings. It is also possible that some semi-volatile organic compounds condensed onto the impactor and the tubing during regular measurements. These entrapped particles and organics were probably released at a later instant. The combination of these processes (entrapment and release) probably led to the shift in zero readings observed. A comparison of the drift concentration with measured concentrations indicated that the particle entrapment/release was probably not present uniformly over the entire shift; hence a flat subtraction of the zero drift each shift was not appropriate. An examination of the ratio of UTK/MIE of the collocated measurements taken immediately after the zero readings before and after each shift showed that the ratios were similar regardless of whether the zero adjustment was made or not, indicating that the zero drifts did not affect the response of the instruments relative to each other (Table A-1.1). While this artifact may have affected the absolute mass concentrations at some instances, the relative comparison statistics of UTK versus MIE would be valid. No visual particle entrapment was observed in the sample tubes. Although it is possible for semi-volatile organic compounds to have adsorbed to the tubing, it was disconnected during zero reading measurements and hence could not have contributed to the drift measurements recorded. The correlation equation of UTK versus MIE DataRAM appeared to incorporate the zero drift in the equation. That is, if the MIE concentration were zero (i.e., $y = 0$), the UTK concentration would be 4.7 $\mu g/m^3$, which is similar

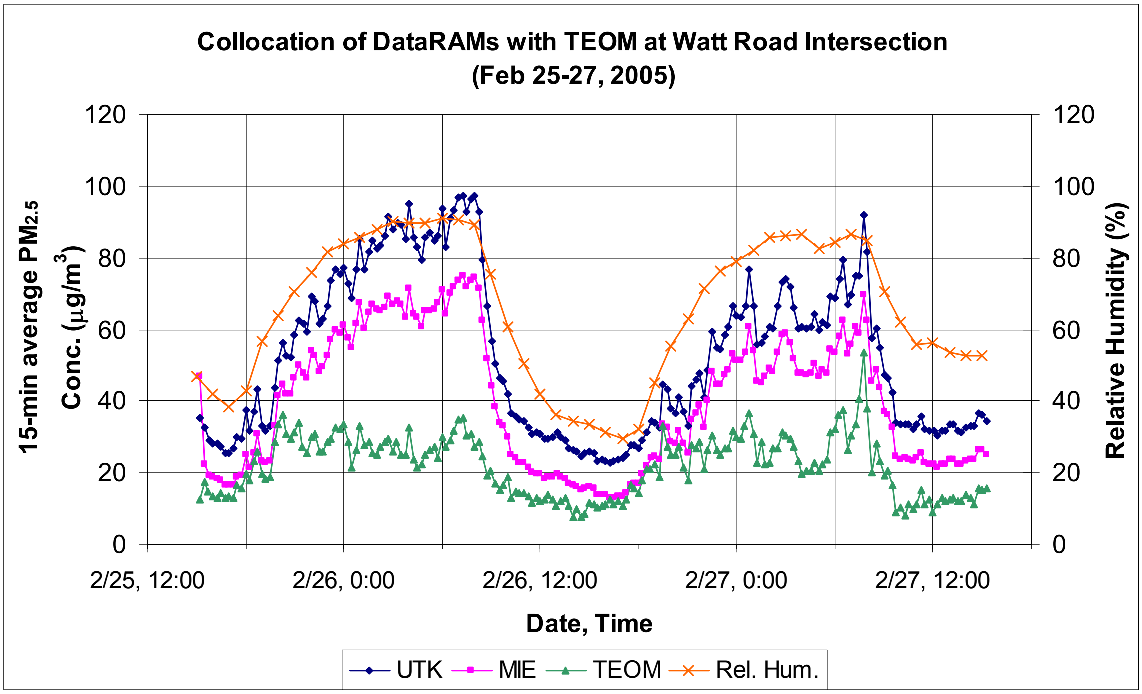


Figure 3-3. Collocation of DataRAMs with TEOM: $PM_{2.5}$ Measurements

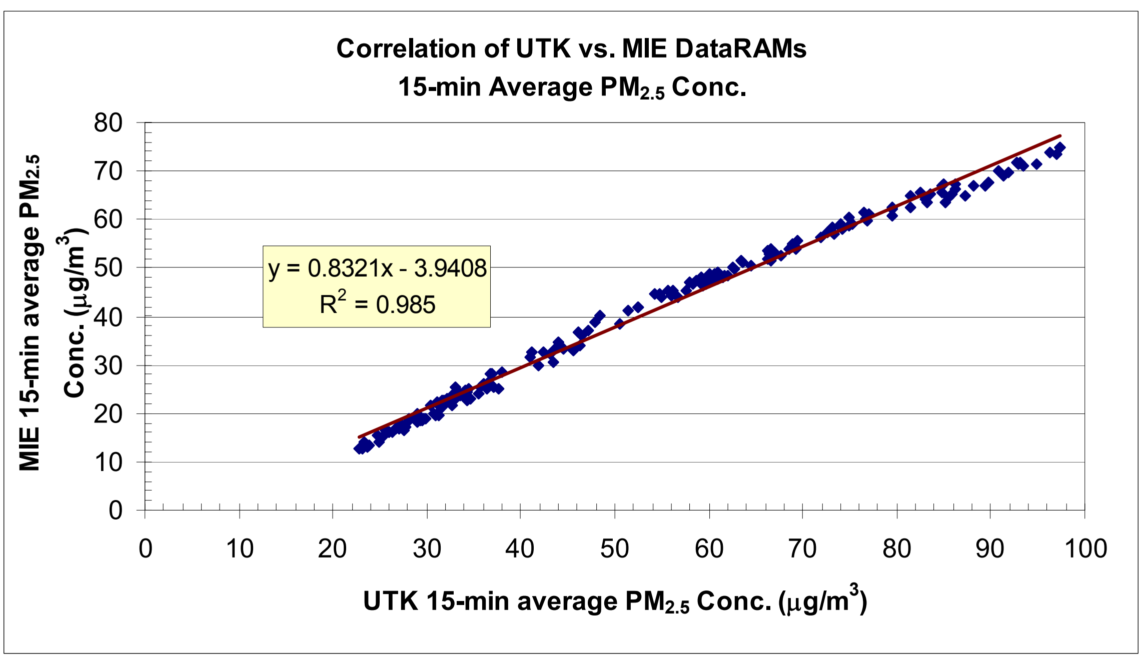


Figure 3-4. Correlation of UTK DataRAM vs. MIE DataRAM

to the UTK zero reading of 3.5 μg/m^3. Hence, no separate adjustments of zero drifts were made. The magnitude of the instrument zero-offset and zero –drift errors are small in comparison to the concentrations measured in the cab, and are insignificant with respect to the basic findings of this study.

3.2 Air Exchange Rates in Trucks

An attempt was made to estimate the approximate air exchange rate of each of the trucks that were tested. The air exchange rates were estimated using two different methods. The first method was using the $PM_{2.5}$ concentration data measured during the incense tests. The second method was to use the measured flow through the vents and the cab volume to estimate the air exchange rates. The Fresh air and Re-circulation modes may involve some fraction of internal re-circulation and some fraction of external air mixed together, which may vary with the truck. The air exchange rates estimated by either of the two approaches do not account for this fraction directly and hence, the air exchange rate estimates would be approximate. The air exchange rates for only Fresh air and Off modes are presented in this report. The AAER (Apparent Air Exchange Rate) for the Re-circulation mode is expected to be in-between the "Off" and "Fresh" air modes.

As mentioned earlier, incense sticks were used to generate particulate matter inside the truck and the $PM_{2.5}$ concentrations inside the truck were recorded over a period of time in the three different modes: Off, Re-circulation and Fresh air. The particles generated by the incense sticks are assumed to be tracers for purpose of estimating the air exchange rates. Many particles, however, tend to adsorb to the surfaces and be retained. They may also deposit relatively quicker than gases. This implies that the air exchange rates measured by this method may be overestimated. Hence, the air exchange rates calculated in this study are labeled as "Apparent Air Exchange Rates". Assuming the behavior of particles to be that of a tracer and that the volume is well mixed, the rate of change of tracer mass inside the cab is the difference between the tracer introduced into the cab and the tracer leaving the cab through exfiltration (or entering the cab through infiltration). This may be represented by the following equation (ASHRAE, 1985):

$$V\left(\frac{dc}{dt}\right)=F-Qc$$

where

c = tracer concentration, μg/m^3

V = truck cab volume, m^3

F = tracer injection mass flow rate, μg/min

Q = exfiltration (or infiltration) flow rate, m^3/min

t = time, min

In the incense test sequence, the incense was lit initially until the concentration inside the cab was raised to a value at least twice as high as the outside concentration, after which the incense stick was extinguished. Hence, the source of tracer was shut off after the initial injection. This represents a pulse injection system and hence F equals zero once the incense stick is extinguished.

Hence, the equation reduces to

$$V\left(\frac{dc}{dt}\right)=(-Qc)$$

where, all terms are the same as noted earlier.

Rearranging the equation,

$$\left(\frac{1}{c}\right)dc=\left(-\frac{Q}{V}\right)dt$$

The solution of the above equation is

$$c(t)=c_0e^{-\left(\frac{Q}{V}\right)t}$$

where,

$c(t)$ = concentration at time "t"

c_0 = concentration at time "t = 0"; that is, at start of measurement after the tracer injection is stopped.

The ratio of the exfiltration (or infiltration) flow rate, Q, to the volume of the cab, V, is equal to the number air changes per unit time. A plot of the natural logarithm of concentration versus time gives a straight line, if the tracer follows the exponential decay pattern. The slope of the line is the air exchange rate. The data for the "Off" mode followed an exponential decay and plotted as a perfect straight line. For the "Fresh Air" mode, the data exhibited an exponential decay only for the first few minutes indicative of the time it took for outside air to replace the air inside the cab, after which, the inside cab concentrations tend to follow outside air concentrations. Hence, only the linear portion was used in estimating the apparent air exchange rates. Figure 3-5 shows the estimation process for Truck 2. In the Fresh air mode, only the first 9 minutes of the test was used to fit a straight line to the data. For the Off mode, the complete data set fell on a straight line. The slope of the line gives the exchange rate in inverse minutes, which is then multiplied by 60 to obtain the AAER in hr^{-1}.

In the second method, the inflow of air through the vents during Fresh air mode was calculated. Since the velocity measurements were made at the center of the vents, they would be representative of the peak velocity through the vent. The average velocity through the vent was calculated by applying a coefficient of 0.6. In addition, the total area available for air flow is reduced by the horizontal and vertical supports in the vents. Based on typical vent dimensions, it was estimated the total area maybe reduced by 20 to 35% depending on the vent size. In this report, a factor of 20% was used to reduce the total area. The cab volume was calculated based on measurements of height, length and width of the cab. This volume was adjusted for the volume of the bed inside the cab. Hence, the apparent air exchange rate was calculated using the following equation:

$$AAER = \frac{A_{vent} f_{Avent} v f_{vel} (3600)}{V_{cab}}$$

where,

AAER = Apparent air exchange rate, hr^{-1}

A_{vent} = Area of the vent, m^2

f_{Avent} = factor for correcting area, equal to 0.80 (Total area – 20% area reduction = 80%)

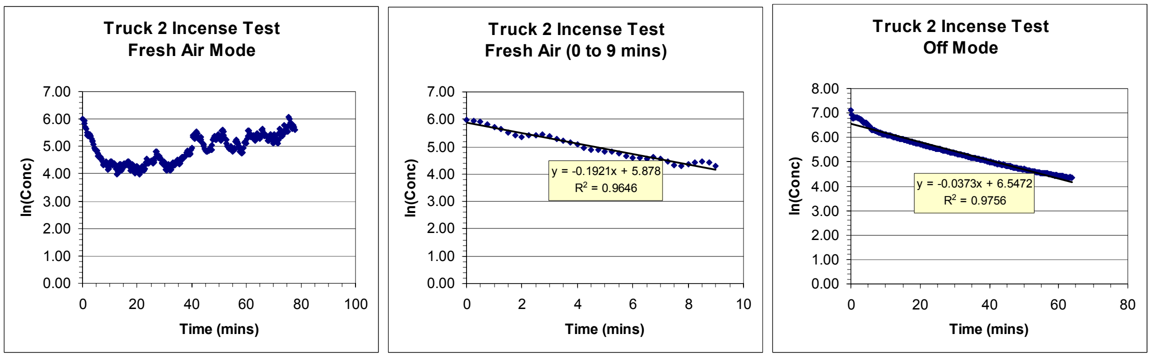
v = velocity through the vent, m/s

f_{vel} = factor to convert peak velocity to average velocity = 0.6

V_{cab} = Available volume of cab after adjustment for bed volume, m^3

3600 = conversion from time units of seconds to hours.

The results are presented in Table 3-3. Truck 1was a small integral sleeper cab model, and hence it takes less time to exchange the air volume inside the cab, compared to the other trucks that were tested. Based on the air flow through the vents, it is estimated that this truck has one air exchange approximately every minute in the Fresh air mode. The apparent air exchange rates for the other trucks varied from 20 to 40 exchanges per hour. The estimates based on incense tests showed lower values, particularly for trucks 2 and 5. The apparent air exchange rates for the "Off" mode varied from 1 to 2 exchanges per hour. The differences in AAERs between the two approaches are probably due to the reasons mentioned earlier. The AAERs based on incense tests may be subjected to particle adsorption artifacts. The estimates based on the air flow through the vents take into account only the flow coming into the truck cab. It does not take into account the actual flow that is vented out, and thus, does not consider the fraction of air that is recirculated versus the fraction that is vented out. In addition, any presence of leaks in the cab would have affected the incense test data while not influencing the air flow AAER. Hence, it must be realized that these estimates are approximate. However, they do indicate the range of exchange rates that may be expected. Thus, in a "Fresh air" mode, an exchange may occur every minute to about 8 minutes, and in an "Off" mode, it may take about 30 minutes to an hour for an exchange to take place.



$\ln C(t) = (-kt) + \ln C(0)$
Slope = k = Air exchange rate in min^{-1}
Fresh Air Mode: k = 0.1921; AAER = k(60) = 11.5 hr^{-1}
Off Mode: k = 0.0373; AAER = 2.2 hr^{-1}

Figure 3-5. Estimation of Air Exchange Rate for Truck 2 using Incense Test Data

Table 3-3. Apparent Air Exchange Rates for Each Truck

Truck #	**Mode of Operation**	**Apparent Air Exchange Rate (AAER, in hr^{-1}) and Time for one exchange (in min) in parenthesis, calculated using the following methods,**	
		Incense Test Data	**Vent Flow**
1	Fresh Air	No test conducted	55 (1.1 min/exchange)
2	Fresh Air	12 (5 min/exchange)	39 (1.5 min/exchange)
3	Fresh Air	25 (2.4 min/exchange)	33 (1.8 min/exchange)
4	Fresh Air	23 (2.6 min/exchange)	27 (2.2 min/exchange)
5	Fresh Air	8 (7.5 min/exchange)	22 (2.7 min/exchange)
6	Fresh Air	26 (2.3 min/exchange)	26 (2.3 min/exchange)
1	Off	No test conducted	Not applicable
2	Off	2.2 (27 min/exchange)	
3	Off	2.2 (27 min/exchange)	
4	Off	1.3 (46 min/exchange)	
5	Off	1.0 (60 min/exchange)	
6	Off	1.8 (33 min/exchange)	

3.3 Analysis of Particulate and Gaseous Concentrations by Truck Mode of Operation

The advantage of the particulate concentration data is the availability of the continuous time series that helps visualize the particle dynamics inside the cab. Since the gaseous samples are one hour bag samples, that does not allow one to analyze at such detail. The $PM_{2.5}$ concentrations are plotted as a function of time for each shift during which the trucks were tested. For each hour, an apparent "steady-state" concentration was calculated for the in-cab $PM_{2.5}$ concentrations. For the Off mode of operation, the steady state concentration would be the average concentration at which it stabilizes. In-cab concentrations during Re-circulation and Fresh air modes depend on the outside concentration and the type of truck. In the Fresh air mode, the in-cab concentrations try to "seek" or equilibrate with the outside air and hence it is difficult to calculate a "steady state" concentration, since the outside concentrations vary continuously. Fresh air steady state concentrations are typically the whole hour of data.

Depending on the fraction of external air versus internally re-circulated air, the extent to which the in-cab concentrations respond to the outside concentration may differ. It also depends on the effectiveness of the sealing of the truck cab. In general, for any mode, if it appeared to stabilize at a particular value with occasional peaks, then the average for that time period (at which the concentration stabilized) was determined. Otherwise, the average for the whole hour was determined. The "steady-state" outside concentration refers to the average concentration for the time period for which the in-cab steady state concentration was determined. The steady state concentrations are labeled as "SS" on the graphs and the hourly averages are labeled as "HR". The gaseous concentrations are plotted as bar charts, showing the concentrations for each hour sampled.

Since the in-cab concentrations (both gas and $PM_{2.5}$) vary based on the mode of operation, the average concentration during an Off mode following a Fresh air mode, for example, would not be representative of the typical concentrations encountered in that mode. This is because the concentration would decay over a period of time depending on the air exchange rate. Moreover, from AAER calculations, it is known that, in some cases, there might be only one air exchange each hour in the “Off” mode. Hence, for the purpose of summarizing, data were chosen such that the residual effect would not affect the analysis, by neglecting the hour of data for a mode that immediately followed a different operating mode. Only in cases where an idle mode (Fresh air or Re-circulation) followed an Off mode, was the data used in the analysis, because the in-cab concentrations in an Off mode would not affect an idle mode following it. Appendix A-2 lists all the shifts and modes for each truck. It also indicates which set of data was used in the analysis for summaries.

3.3.1 PM concentrations

The plots of $PM_{2.5}$ concentration data for the complete sampling period are shown in the appendix (Appendix A-3). These plots have not been adjusted for the effect of relative humidity (RH) typically experienced by the DataRAMs at RH values greater than ~70%. Appendix A-2 lists the inside cab temperature and RH at the start of each mode, as measured by the Extech anemometer. As may be noted, there were 8 values that were in-between 70% and 80% RH and one value of 93%, so a total of 9 modes that may have been potentially affected. Since these were measured at the start of each mode, the RH values represent the condition at the end of the previous mode. These high RH values were either during or at the end of the "Off" mode, during which the concentrations were already low compared to the PM concentrations measured during the fresh air mode and (in some cases, the recirculation mode), and would not cause any significant difference in the results.

In addition, both the DataRAMs were located inside the cab. While the ambient and in-cab RH may affect the overall nature of the aerosol, what is important is the temperature and RH at the point of measurement inside the instrument. Both the DataRAMs recorded the temperature and RH inside the instrument. The average temperature and RH recorded by the DataRAMs are summarized in Table 3-4. It may be noted that both the DataRAMs recorded, on average, similar RH values. While not shown here, the temperature and RH recorded by both the DataRAMs at the start of a shift (when the DataRAMs where first switched on from rest) were similar, suggesting that the RH and temperature measurements were comparable to each other. The degree to which the instrument heated up during operation probably depended on the individual instrument characteristics, their proximity to the vents, the differential exposure to sunlight through the wind shield etc., thus resulting in slightly differential temperature and RH during operation. These suggest that the influence of RH artifact, if any, would be negligible and to a similar extent on both the DataRAMs. Hence, comparisons of in-cab versus outside concentrations would be valid.

As seen in the graphs in Appendix A-3, the outside concentrations vary every moment. This is dependent on various factors including the wind direction, wind speed, stability of the atmosphere, the number of idling trucks in the immediate vicinity of the sample truck and mode of operation of the sample truck. Most often, the truck being tested contributed to a major extent to its outside concentration (and hence, its in-cab concentrations). For the very first hour of sampling on Dec 15, 2004, an observer was inside the sample truck noting the truck activity in and around the sample truck. This is tabulated in Table 3-5. Note that the test truck was in "Off" mode during that hour of sampling. From Figure 3-6, it may be noted that each event associated with any truck idling activity just around the sample truck, showed a peak in the outside $PM_{2.5}$ concentration measured at that instant. This illustrates that the peaks observed in the outside concentrations are highly correlated with the truck activity at that instant.

For truck 1, the graphs in Appendix A-3 show the variation of in-cab and outside $PM_{2.5}$ concentrations for different modes of operation. Typically, the in-cab $PM_{2.5}$ concentrations were the lowest when the truck was in the "Off" mode of operation. Using shift 1-2 as an example, the in-cab concentrations stabilized around 18 $\mu g/m^3$. Once the engine was started and the mode was switched to Re-circulation (at 12:08 am), the in-cab concentrations started to rise and averaged around 49.5 $\mu g/m^3$. The in-cab concentration continued to fluctuate slightly and rise. When the mode was switched to Fresh air mode, the in-cab concentration tried to equilibrate with the outside

Table 3-4. Measurement Temperature and Relative Humidity inside DataRAMs

Shift	Truck	Shift Code	Temperature (F)				Relative Humidity (%)			
			UTK DataRAM		MIE DataRAM		UTK DataRAM		MIE DataRAM	
			Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Dec 15 Day	1	1_1	83	3	84	6	23	1	25	7
Dec 15 Night	1	1_2	69	11	70	13	27	3	25	6
Dec 16 Day	1	1_3	81	12	74	10	22	3	22	4
Dec 16 Night	1	1_4	82	7	82	8	24	4	23	7
Dec 17 Day	1	1_5	73	8	67	6	25	2	26	3
Dec 17 Night	2	2_1	85	11	82	10	22	3	23	5
Dec 18 Day	2	2_2	78	6	75	5	22	1	23	2
Dec 18 Night	2	2_3	68	4	65	3	29	1	32	2
Dec 19 Day	2	2_4	72	16	67	13	31	4	34	5
Dec 19 Night	2	2_5	69	13	66	13	21	4	18	6
Dec 20 Day	3	3_1	76	8	66	5	19	2	24	6
Dec 20 Night	3	3_2	72	20	69	19	18	2	19	5
Dec 21 Day	3	3_3	87	5	85	5	16	1	16	3
Dec 21 Night	3	3_4	83	4	80	4	20	1	20	2
Jan 6 Night	4	4_1	77	6	71	3	37	5	40	4
Jan 7 Day	4	4_2	81	3	73	2	31	1	36	2
Jan 8 Day	4	4_3	81	9	73	7	38	9	45	9
Jan 8 Night	4	4_4	71	7	66	5	34	5	37	4
Jan 9 Day	4	4_5	93	17	82	10	26	6	29	5
Jan 9 Night	4	4_6	82	10	79	9	27	4	29	5
Jan 10 Day	5	5_1	82	6	77	4	34	5	38	10
Jan 10 Night	5	5_2	79	8	76	7	32	3	34	6
Jan 11 Day	5	5_3	81	2	77	1	30	1	31	2
Jan 11 Night	5	5_4	82	7	80	7	38	7	36	10
Jan 12 Day	6	6_1	89	7	87	7	39	7	42	12
Jan 12 Night	6	6_2	87	6	86	6	36	4	37	7
Jan 13 Day	6	6_3	92	4	90	3	35	2	36	2
Jan 13 Night	6	6_4	78	8	80	10	41	9	38	14
Jan 20 Day	7	7_1	78	16	77	17	29	6	30	11
		Mean	80		76		29		30	

Table 3-5. Log of Truck Activity around Test Truck on Dec 15, 2004 (1:30 pm to 2:45 pm)

Time	Activity around sample truck
13:38	PM measurements initiated in "Off mode"
Around 13:55	Truck parked in front of sample truck departed the parking lot. Another truck pulled into the parking space located across the sample truck to the right. The truck parked to the immediate left of the sample truck turned on the engine and departed the space.
14:00	A truck pulled in to the space to the immediate left of the sample truck.
14:03	The truck to the immediate left turned off its engine
14:04	The truck to the immediate right of the sample truck pulled out of the space
14:05 – 14:06	Another truck pulled in to the immediate right of the sample truck and turned off its engine.
14:13 – 14:14	A truck pulled into the parking space exactly across the sample truck
14:23	The truck across the sample truck turned off its engine.
14:39	End of "Off mode"
14:44	Sample truck was started and set to idle at 750 rpm to collect samples in Re-circulation mode.

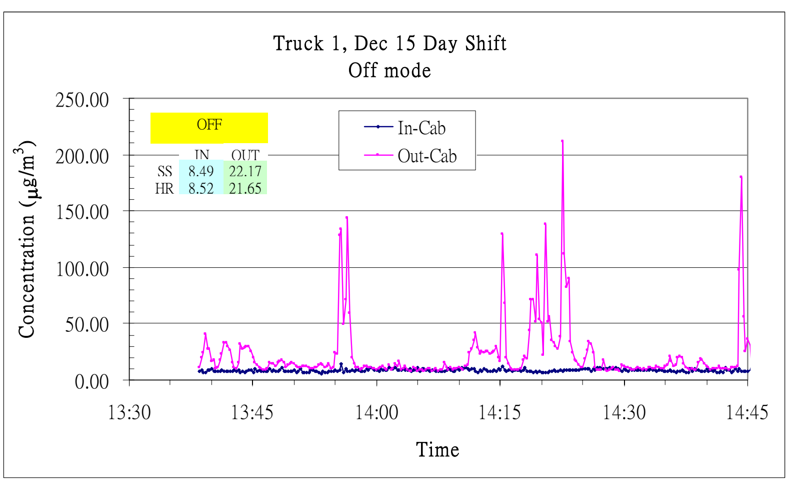


Figure 3-6. $PM_{2.5}$ Concentrations on Dec 15, 2004 (1:30 pm – 2:45 pm)

concentration, and reached an average concentration of 92.5 μg/m^3. The increase in the in-cab concentration when switching from re-circulation to fresh air, is however dependent on the outside concentration. In shift 1-3, there was a decrease in the in-cab concentration when switching from Re-circulation to Fresh air mode. This was due to a concomitant decrease in the outside concentration measured during that period.

The mode "Engine on fan off" in shift 1-4 is of particular interest. During this mode, the engine was left idling, while the air condition was turned off and the fan speed set to zero. It may be noted that the in-cab $PM_{2.5}$ concentration, initially at about 40 μg/m^3, continued to increase during the whole hour reaching a value of around 430 μg/m^3, almost a 12-fold increase in one hour. This implies that there are routes through which the particles entered the truck cab other than the air condition vents. Once the engine was turned off at 9:10 pm, the in-cab concentrations started to decline and followed an exponential decay pattern. There was a concern as to whether the increase in $PM_{2.5}$ concentration observed during this mode was related to any possible increase in RH because of absence of air-conditioning. While there was a slight change in the in-cab RH between the start and end of the "Engine on fan off" mode, the absolute RH values at the end of the mode were all below 70%, except for truck 6. In addition, the instrument (DataRAM) RH values were lower than the in-cab values. As seen in Figure 3-3, the effect of RH on $PM_{2.5}$ measurements was apparent only above ~70%. Although truck 6 measured 81% RH at the end of the mode, this alone would not account for the increase in $PM_{2.5}$ concentrations measured in the cab. Typical values in the literature suggest that the effect of RH on nephelometer measurements may result in an increase of concentrations by a maximum factor of 2.5 (Sioutas et al., 2000). On the other hand, measured concentrations in this study in the "Engine On, Fan Off" mode showed a 2 to 30 fold increase in 1 hour. This confirms the infiltration of particles into the cab.

Trucks 2 and 3 appeared to be similar in their behavior. The Re-circulation mode showed in-cab concentrations that were almost stable and did not appear to respond to the outside variations significantly. The Re-circulation mode may typically involve a mix of internal re-circulation and a fraction of outside air. It appears that the fraction of external air in this mode was minimal, which might explain the stable trend during Re-circulation modes. Any residual particles in the air inside the cab probably deposited onto the surfaces inside the cab and the ductwork, accounting for the decrease in the in-cab concentration immediately after switching to a Re-circulation mode, such as in shifts 2-5 and 3-4. After this initial decrease, the concentration tends to stay stable because of minimal influence from external air. Similar results were found by Riediker et al. (2003) in their study of PM concentrations inside patrol cars. The Fresh air modes showed in-cab concentrations that almost tracked the outside air concentrations. The in-cab concentrations in Truck 4 appeared to respond to the outside variations slightly more than trucks 2 and 3 in the Re-circulation mode. The in-cab concentration during the Fresh air mode, as for other trucks, tracked the outside air concentration very well. It is interesting to note that all the trucks, similar to truck 1, showed a continuous increase in the in-cab concentration in the "Engine on, Fan off" mode (Table 3-6), again indicating possible entry routes in addition to the vents. However, the level of increase differed with each truck. Truck 2 showed about a 4-fold increase in the concentration from its initial value, while truck 3 showed about a 2-fold increase in approximately one hour. Truck 4 had concentrations about 30 times its initial concentration. Truck 5 showed a 9-fold increase and truck 6 showed a 5-fold increase. This implies that truck 3 had relatively better sealing, compared to other trucks. As mentioned earlier, Ziskind et al. (1977) noted entry of engine compartment gases into the cab through the openings on the cab floor. It is believed that the major source of this might be the exhaust emissions from the crankcase ("blow-by emissions"), although further study would be necessary to identify the source(s).

As seen in figures in Appendix A-3, the in-cab $PM_{2.5}$ concentrations during the Fresh air mode approached the outside concentrations within a short time (2 to 5 min) after mode change, consistent with the apparent air exchange rates (AAERs). During the Off mode,

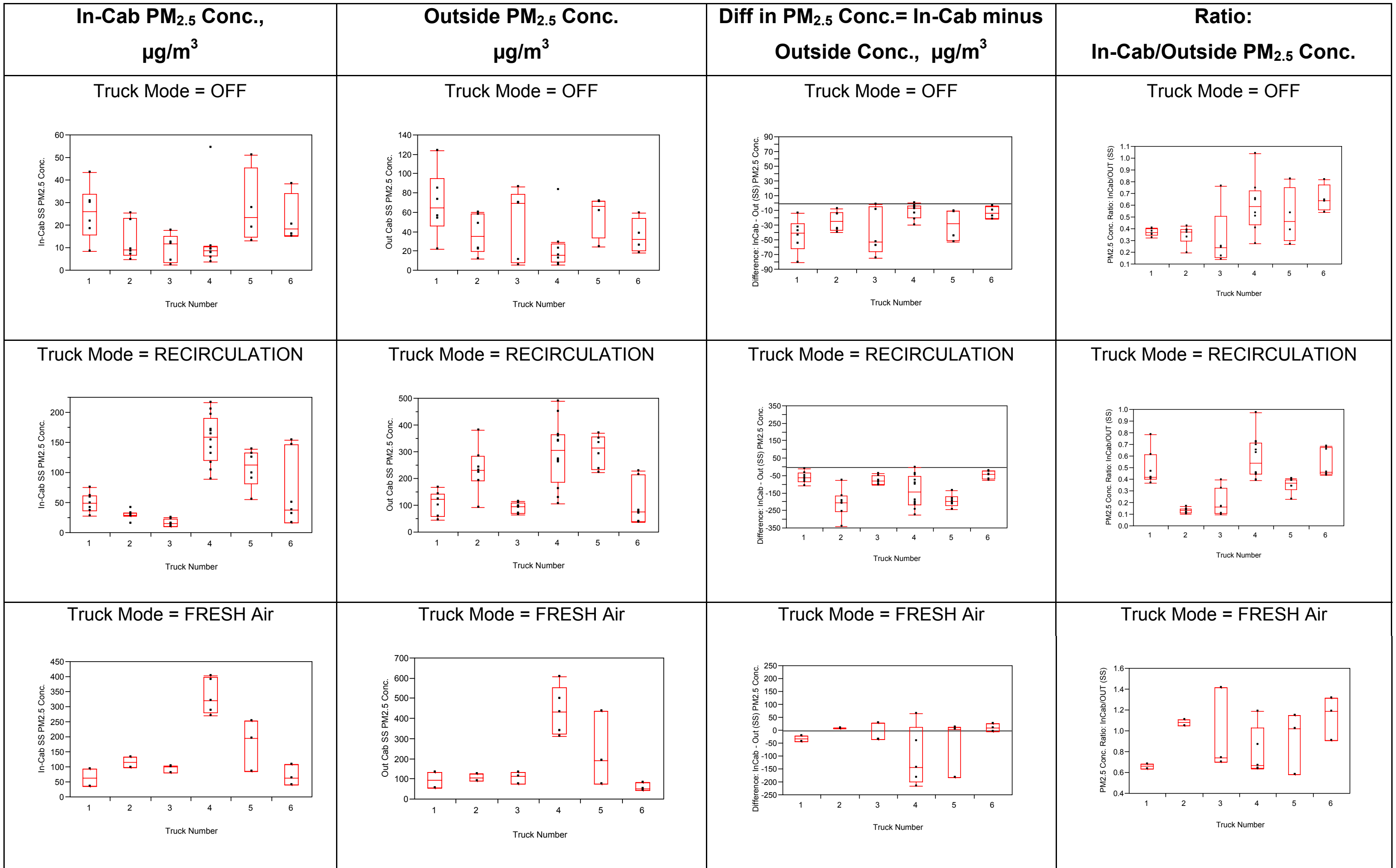
Table 3-6. In-Cab $PM_{2.5}$ Concentration during "Engine On, Fan Off" Mode

Truck #	Initial In-Cab Conc. at the beginning of the hour	In-Cab Conc. at the end of hour	Final Conc./Initial Conc.
1	40	430	11
2	30	128	4
3	50	100	2
4	12	370	31
5	20	180	9
6	9	45	5

the in-cab concentrations either remained uniform or decayed exponentially without noticeable influence from the outside concentrations. As seen in Table 3-3, the time for a complete exchange is estimated to range from approximately 30 min to an hour during the Off mode. This is evident from the graphs in Appendix A-3, where the in-cab concentration profile was either relatively flat (in case of an Off mode at the beginning of a shift) or it decayed exponentially (in the case of an Off mode following a truck idle mode, typically the Fresh air mode) to less than half of its initial concentration in a time frame similar to the AAERs. In the Fresh air mode, due to a very short AAER the influence of outside concentration on the in-cab concentration is obvious because of an almost instantaneous complete replacement of in-cab air with the outside air. However, with a long AAER seen during the "Off" mode (30 to 60 min), the influence of the outside concentration on the in-cab concentration is not evident because of the extremely slow infiltration/ exfiltration of air between the cab and the outside air.

Figure 3-7 shows box plots of $PM_{2.5}$ concentrations inside and outside the cab for each truck under different modes of operation. The box plots show an overview of the range of concentrations measured in each truck. The data included in these plots were chosen so as to eliminate the residual effects of any transition from one mode to the next. The horizontal line in the middle of each box represents the median value. The ends of the box refer to the 25th and 75th percentiles. It is clear that the range of in-cab concentrations in any particular mode of operation differed from truck to truck. This is dependent on the type of truck, its age, its emission characteristics, effectiveness of sealing and the outside concentrations. The test truck itself played an important role in the outside concentration in addition to other factors such as number of trucks idling in close proximity and the weather conditions. The ratio of the in-cab concentration to the outside concentration is also an appropriate parameter to analyze and may be indicative of characteristic of each truck such as the sealing effectiveness, given other conditions remain unchanged. Table 3-7 summarizes the data that were graphically shown in Figure 3-7. The in-cab concentrations were the lowest when the truck was off. The highest mean in-cab $PM_{2.5}$ concentrations were observed when the truck was operated in "Fresh air" mode. In the Off mode, the average in-cab concentrations ranged from about 10 to 28 $\mu g/m^3$. Among the 6 trucks tested, the maximum in-cab concentration (about 54 $\mu g/m^3$) in the "Off" mode was observed in truck 4. In the Re-circulation mode, the mean in-cab concentrations ranged from 16 $\mu g/m^3$ to 155 $\mu g/m^3$, with truck 4 showing the maximum concentration of 217 $\mu g/m^3$. In the Fresh air mode, the mean concentrations ranged from 64 $\mu g/m^3$ to about 336 $\mu g/m^3$ with the truck 4 again recording the maximum concentration (404 $\mu g/m^3$). In most cases, the in-cab concentration was lower than the outside concentration when the truck was off or when it was operated in Re-circulation mode. In the Fresh air mode, trucks 2 and 6 showed in-cab concentrations slightly higher than the outside concentrations. Based on the ratio of in-cab to outside concentration, it appears that trucks 2 and 3 were cleaner than the rest. Under "Off" and Re-circulation modes the in-cab concentrations of trucks 2 and 3 were only 10 to 30% of the outside concentration.

Comparing the in-cab concentrations between the different modes of operation, the "Off" mode had the lowest in-cab concentration. Based on the data in Table 3-7, the mean in-cab concentration during the "Off" mode was about half of the concentration observed in the Re-circulation mode for truck 1 (Table 3-8). For other trucks, the ratio ranged from 0.09 to about 0.61. For the Fresh air mode, the ratios varied from 0.04 to about 0.40.



*SS refers to apparent steady state. These concentrations are average concentrations for periods where the in-cab concentrations stabilized as in Off mode for all trucks and in Re-circulation mode for some trucks during each hour of testing. For other cases, these are hourly average concentrations. SS for outside air refers to the average concentration for the same time period for which the in-cab SS concentration was determined.

Figure 3-7. Box Plots of $PM_{2.5}$ Concentration Data for Each Truck by Mode of Operation

Table 3-7. Summary of $PM_{2.5}$ Concentration Measured in Each Truck

Mode	Truck #	In-Cab $PM_{2.5}$ Concentration ($\mu g/m^3$)					Outside $PM_{2.5}$ Concentration ($\mu g/m^3$)					Ratio of Mean In-Cab/Out
		Mean	Std Dev	Min	Median	Max	Mean	Std Dev	Min	Median	Max	
OFF	1	25.6	12.1	8.5	26.0	43.5	69.3	34.3	22.2	65.0	123.9	0.4
	2	13.0	8.7	4.8	9.0	25.5	37.4	20.9	12.3	35.7	60.3	0.3
	3	9.9	6.3	2.7	11.9	17.9	48.7	37.6	5.7	69.4	87.0	0.2
	4	13.7	16.5	4.0	8.8	54.3	24.2	25.3	5.7	15.9	83.8	0.6
	5	27.9	16.7	13.2	23.7	51.3	57.5	22.4	24.6	66.7	72.0	0.5
	6	22.7	10.9	15.2	18.5	38.6	35.6	18.1	18.6	32.0	59.8	0.6
RECIRCULATION	1	50.6	16.2	28.5	49.6	75.5	109.5	43.5	46.7	123.2	168.2	0.5
	2	29.8	7.9	16.0	29.4	42.4	235.8	87.6	92.9	232.0	382.0	0.1
	3	16.2	5.8	10.6	15.5	25.3	92.4	18.9	63.9	94.9	116.4	0.2
	4	155.3	40.0	90.0	159.2	217.0	295.5	119.8	106.8	306.0	489.3	0.5
	5	107.1	31.6	55.2	112.9	138.8	302.1	61.1	223.9	313.9	370.4	0.4
	6	65.3	59.7	16.7	38.3	154.9	107.5	80.1	37.4	77.5	229.5	0.6
FRESH AIR	1	63.8	40.6	35.1	63.8	92.5	95.1	56.7	55.0	95.1	135.2	0.7
	2	117.0	24.7	99.6	117.0	134.5	108.7	27.1	89.5	108.7	127.9	1.1
	3	95.4	12.1	81.6	100.0	104.5	108.0	31.0	73.9	115.6	134.6	0.9
	4	335.6	59.9	271.8	320.4	403.8	438.9	120.4	313.3	432.6	607.3	0.8
	5	179.2	85.6	86.1	197.0	254.4	234.3	184.1	74.8	192.2	435.8	0.8
	6	71.1	34.3	41.6	62.8	108.9	60.3	19.6	45.6	52.7	82.6	1.2

Table 3-8. Comparison of In-Cab $PM_{2.5}$ Concentrations with Off mode

Truck #	Off mode/ Recirculation mode	Off mode/Fresh air mode
1	0.51	0.40
2	0.44	0.11
3	0.61	0.10
4	0.09	0.04
5	0.26	0.16
6	0.35	0.32

A ratio closer to 1.0 implies that the concentrations in the "Off" mode and the respective idle (Re-circulation or Fresh air) mode were similar (close to each other).

3.3.2 Gas Concentrations

3.3.2.1 NOx Concentration

Appendix A-4 shows bar charts of nitrogen oxides (NOx) concentrations for each truck under different modes of operation. The plots also show the fraction of nitric oxide (NO) versus nitrogen dioxide (NO_2) in each sample. These concentrations represent composite hourly samples. Truck 1 showed in-cab concentrations that differed depending on the mode of operation. Under the Off mode, the in cab concentrations were either slightly less or close to outside the concentration. The in-cab concentrations during re-circulation were always higher than the outside concentrations during all the shifts tested. During the Fresh air mode, the in-cab and outside concentrations were closer. Trucks 2 and 3 did not show any consistent pattern for in-cab concentrations under the various modes. The in-cab concentrations appeared to be closer to the outside concentration in all cases. The Re-circulation mode did not always show higher in-cab concentrations as seen in Truck

1. Trucks 4 through 6 typically showed higher in-cab concentrations under both Re-circulation and Fresh air modes. The "Engine on/fan off" mode sometimes showed in-cab concentrations higher than the outside concentration, while in other cases, it did not. The presence of only an hourly concentration does not allow one to visualize the dynamics that were observed in the case of the continuous particle concentration measurements.

Figure 3-8 shows box plots of nitrogen oxides (NOx) concentrations observed in each truck under various modes of operation, and Table 3-9 summarizes the concentrations observed in each of the trucks tested in tabular form. As seen from the box plots, the in-cab concentrations were the lowest in the "Off" mode and the highest in the Re-circulation mode. The mean in-cab concentrations in the "Off" mode ranged from 167 ppb to about 418 ppb. The Re-circulation mode recorded the highest in-cab concentrations for all the trucks and the mean concentration ranged from 505 ppb to as high as 1884 ppb. In the Fresh air mode, the mean in-cab concentration ranged from 353 ppb to about 1400 ppb. The maximum in-cab concentration in the "Off" mode ranged from 269 ppb to about 672 ppb. This typically coincided with the highest concentrations observed in the outside air.

Also shown in the figure are box plots of the differences between in-cab and outside concentrations and the ratio of in-cab to outside concentration. For trucks 1 through 4, the in-cab concentrations in the "Off" mode typically ranged from 70 to 90% of the outside air concentration. Trucks 5 and 6 showed in-cab concentrations that were about 1.1 and 1.8 times the outside air concentration.

Table 3-10 summarizes the nitrogen dioxide (NO_2) concentrations measured during each test. Average in-cab NO_2 concentrations for all trucks tested varied by mode. The highest in-cab NO_2 concentrations were measured for the Recirculation and Fresh air modes. The mean NO_2 concentrations during the Recirculation mode varied from 19 ppb

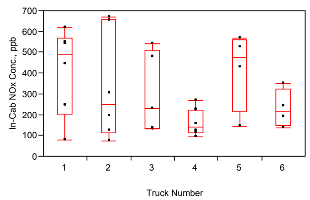
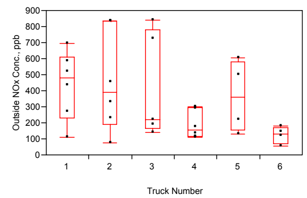
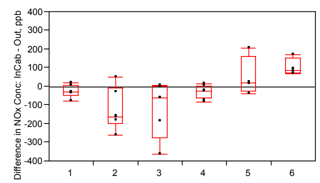
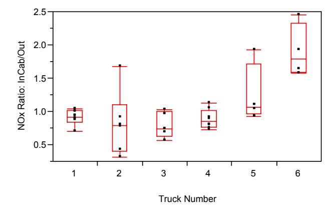
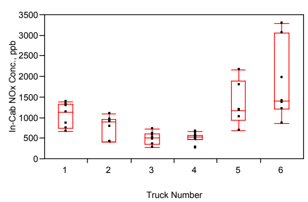
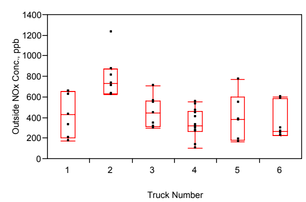
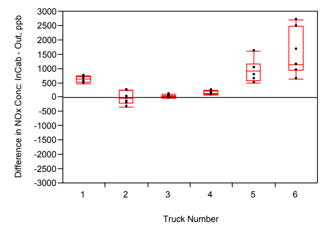
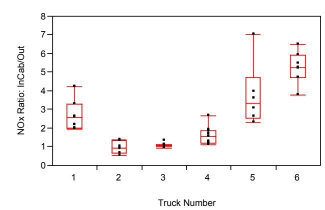
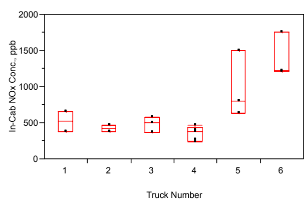
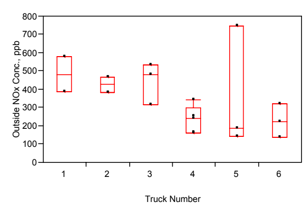
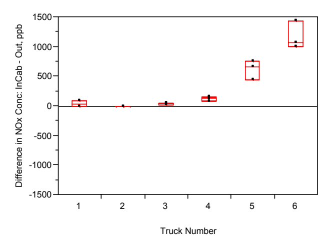
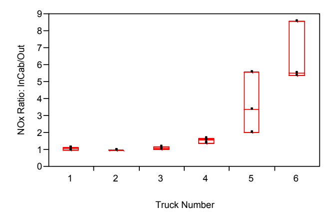
In-Cab NOx Conc., ppb	Outside NOx Conc., ppb	Diff in NOx Conc.= In-Cab minus Outside Conc., ppb	Ratio: In-Cab/Outside NOx Conc.
Truck Mode = OFF 	Truck Mode = OFF 	Truck Mode = OFF 	Truck Mode = OFF 
Truck Mode = RECIRCULATION 	Truck Mode = RECIRCULATION 	Truck Mode = RECIRCULATION 	Truck Mode = RECIRCULATION 
Truck Mode = FRESH Air 	Truck Mode = FRESH Air 	Truck Mode = FRESH Air 	Truck Mode = FRESH Air 

Figure 3-8. Box Plots of NOx Concentration Data for Each Truck by Mode of Operation

Table 3-9. Summary of NOx Concentrations Measured in Each Truck

Mode	Truck #	In-Cab NOx Concentration (ppb)					Outside NOx Concentration (ppb)					Ratio of Mean In-Cab/Out
		Mean	Std Dev	Min	Median	Max	Mean	Std Dev	Min	Median	Max	
OFF	1	414	208	81	493	620	439	214	114	480	699	0.9
	2	339	264	75	251	672	462	315	76	395	836	0.7
	3	305	193	135	232	541	425	332	141	223	842	0.7
	4	167	64	96	142	269	194	89	111	159	305	0.9
	5	418	191	146	478	571	367	226	133	362	610	1.1
	6	231	92	138	217	353	127	53	56	134	182	1.8
RECIRCULATION	1	1064	299	675	1144	1392	441	211	176	431	658	2.4
	2	785	269	409	899	1108	804	210	624	735	1234	1.0
	3	505	151	285	515	729	462	153	299	448	711	1.1
	4	505	122	259	532	669	345	143	105	321	556	1.5
	5	1341	548	682	1182	2173	408	229	170	382	777	3.3
	6	1884	947	859	1417	3296	353	166	226	270	599	5.3
FRESH AIR	1	523	198	383	523	663	484	134	390	484	579	1.1
	2	423	64	378	423	468	428	61	385	428	471	1.0
	3	486	107	372	502	584	446	113	319	484	535	1.1
	4	353	96	238	379	468	234	75	161	240	344	1.5
	5	980	462	635	801	1505	360	336	143	189	747	2.7
	6	1400	313	1216	1223	1762	230	89	142	227	320	6.1

Table 3-10. Summary of NO_2 Concentrations Measured in Each Truck

Mode	Truck #	In-Cab NO_2 Concentration (ppb)				In-Cab NO_2/NOx	Outside NO_2 Concentration (ppb)				Outside NO_2/NOx	Ratio of Mean In-Cab/Out
		Mean	Std Dev	Min	Max		Mean	Std Dev	Min	Max		
OFF	1	30	16	9	55	0.07	44	19	18	68	0.10	0.7
	2	18	10	8	35	0.05	67	24	27	97	0.15	0.3
	3	24	10	17	42	0.08	55	40	5	99	0.13	0.4
	4	3	3	0	8	0.02	31	12	12	47	0.16	0.1
	5	13	15	0	26	0.03	42	22	22	69	0.11	0.3
	6	3	1	1	3	0.01	28	8	17	35	0.22	0.1
RECIRCULATION	1	82	32	38	141	0.08	46	11	27	56	0.10	1.8
	2	36	15	17	60	0.05	92	32	63	153	0.11	0.4
	3	40	7	32	50	0.08	71	13	52	87	0.15	0.6
	4	19	9	3	39	0.04	36	13	16	57	0.10	0.5
	5	70	62	16	169	0.05	45	16	30	74	0.11	1.6
	6	141	98	38	287	0.07	41	21	10	73	0.12	3.4
FRESH AIR	1	38	9	32	45	0.07	42	3	40	44	0.09	0.9
	2	46	7	41	51	0.11	51	12	43	60	0.12	0.9
	3	67	24	47	93	0.14	74	34	50	113	0.17	0.9
	4	27	6	20	35	0.08	24	2	20	26	0.10	1.1
	5	77	53	35	136	0.08	49	33	27	88	0.14	1.6
	6	93	59	58	161	0.07	33	9	26	44	0.14	2.8

to 141 ppb, with an all-truck average of 65 ppb. During Fresh air mode, it ranged from 27 to 93 ppb, with an average of 58 ppb. The "Off" mode recorded much lower NO_2 concentrations, averaging only 15 ppb for all trucks combined. The maximum in-cab concentration of 287 ppb was observed during Recirculation mode. Table 3-10 also shows calculated ratios of NO_2 to NOx concentrations. In the fresh air mode, NO_2 averaged 9% of total NOx, while in the Recirculation mode NO_2 averaged only 6% of total NOx. In the "Off" mode NO_2 averaged 5% of total measured NOx. Overall, the in-cab NO_2 concentration was, on average, 7% of the total NOx. In the outside air, NO_2 concentrations averaged 13% of total NOx concentrations.

Table 3-11 shows the ratio of mean in-cab concentrations in the "Off" mode to the idle mode (Re-circulation or Fresh air mode). It may be seen that the in-cab concentrations are significantly lower compared to the concentrations in Re-circulation or Fresh air mode. These ratios ranged from as low as 0.1 to as high as 0.6 in the Re-circulation mode and from 0.2 to 0.8 in the Fresh air mode. In other words, the in-cab concentrations in the "Off" mode ranged from 10 to 60% of the in-cab concentrations measured in the Re-circulation mode.

Table 3-11. Comparison of In-Cab NOx Concentration with Off Mode

Truck #	**Off mode/ Re-circulation mode**	**Off mode/Fresh air mode**
1	0.4	0.8
2	0.4	0.8
3	0.6	0.6
4	0.3	0.5
5	0.3	0.4
6	0.1	0.2

3.3.2.2 CO Concentration

Appendix A-5 shows the bar plots of carbon monoxide (CO) concentrations for each truck under different modes of operation. These concentrations represent composite hourly samples. CO concentrations were typically less than 2 ppm in all the modes of operation. The Re-circulation mode showed concentrations that were slightly higher than the outside air. In some cases, the CO concentrations were below the detectable limit of the instrument (0.04 ppm). In these cases, a value of 0.02 ppm was used in the plots. Figure 3-9 summarizes the data in the form of box plots. These data will not be discussed in detail since the concentrations are well below the National Ambient Air Quality Standard of 35 ppm for one-hour exposure.

3.4 Additional Testing in a Parking Lot without Idling Trucks

Given the high concentrations that were measured inside the cabs of the diesel trucks, a question was raised as to whether contributions within the cabs were from the test truck itself or from other trucks idling in the truck stop. In order to provide more insight into this question, additional testing was conducted on one of the trucks in an empty parking lot, far removed from the influence of any other idling trucks. Truck 4 was retested as part of this effort. This repeat test of Truck 4 is denoted as Truck 7 in this report.

The $PM_{2.5}$ concentration profile is shown in the last figure in Appendix A-3, labeled as "Truck 7, Jan 20 Day Shift (7-1)". As shown in the figure, the in-cab $PM_{2.5}$ concentration was the lowest in the "Off" mode (22μg/m^3) compared to the outside concentration of about 30μg/m^3. When the truck was then turned on, and operated in the Re-circulation mode, the concentrations outside increased to about 100 μg/m^3 and the in-cab concentration increased to about 45 μg/m^3. During the Re-circulation mode, the in-cab concentration averaged around 95μg/m^3 during the 2nd hour in this mode compared to

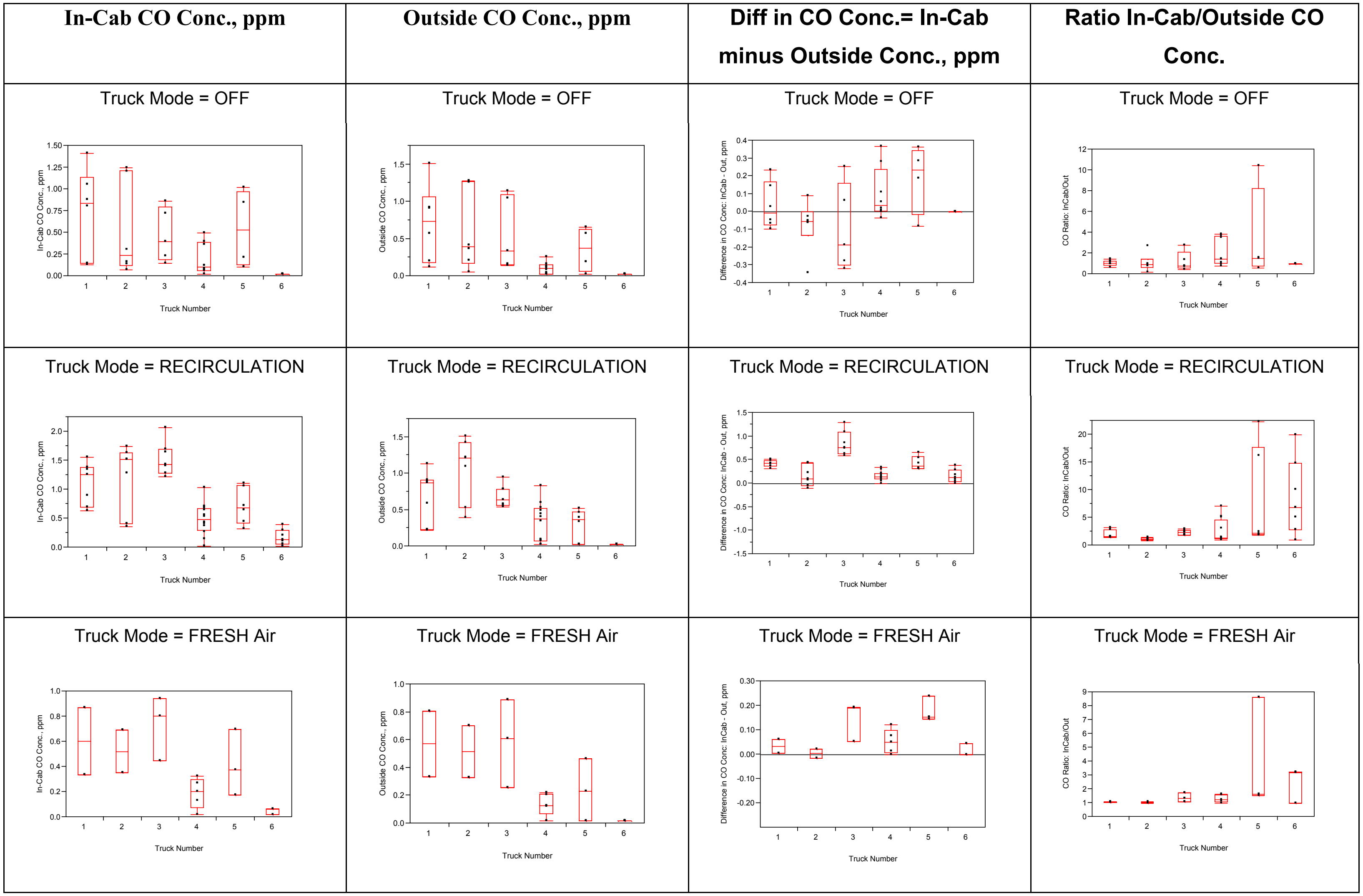


Figure 3-9. Box Plots of CO Concentration Data Measured in Each Truck under Various Modes of Operation

over 200 μg/m^3 outside the truck. On average, the in-cab concentration in the Re-circulation mode was about 45% of the outside concentration. In the Fresh air mode, the in-cab concentration continued to vary with the outside concentration and ranged from about 64% to 104% of the outside concentration. All these concentrations are similar to those measured for Truck 4 at the truck stop. This indicates that, while the presence of other idling trucks in the vicinity may affect the concentrations, the test truck itself is a major contributor to the observed concentrations.

The behavior of NOx concentrations was also similar. It must be noted that the gas sample bags for Truck 7 were measured for NOx and CO concentrations after a holding period of almost 24 hours, due to problems with instrument calibration. However, all sample bags were held under similar conditions during this holding period and were stored inside the mobile laboratory. Hence, while the absolute values may not be representative, the data would still help visualize the relative differences between modes of operation and between in-cab and outside concentrations. The in-cab NOx concentrations were higher than the outside concentration for Re-circulation and Fresh air modes (Appendix A-4 and A-5, Data for Truck 7). The ratio of in-cab to outside concentration was also similar to the values measured for Truck 4 at the truck stop.

An analysis of the ratio of the outside concentration during idle mode (Re-circulation/Fresh air mode) to the outside concentration during Off mode shows that this ratio is greater than 1.0, indicating that the outside concentration measured in front of the windshield was higher when the truck was idling than when the truck was off. This also implies that the test truck contributes to a major extent to the outside concentration when it is idling (and hence contributes to its in-cab concentrations). For truck 7 tested at the parking lot with no other idling trucks, this ratio, for $PM_{2.5}$ concentration, ranged from 3 to 7 when the truck was in Re-circulation mode, and from 10 to 16 when the truck was in Fresh air mode. Similar ratios were also seen with trucks tested at the truck stop.

3.5 Comparison of Measured Concentrations to Various Standards

Table 3-12 lists the standards associated with work place exposures and ambient air quality for comparison to the pollutant concentrations measured in this study. The nitric oxide (NO) concentrations measured in this study were all lower than any of the limits set by the different agencies. The permissible exposure limit (PEL) set by the Occupational Safety and Health Administration (OSHA) for NO is 25 ppm (25,000 ppb) based on an 8-hr average exposure and is same as the levels set by the other agencies. The maximum 1-hr average NO concentration measured in this study was around 3009 ppb.

The recommended exposure limit set by the National Institute of Occupational Safety and Health (NIOSH) for NO_2 is 1 ppm based on a 15-minute average exposure. The measured 1-hr average NO_2 concentrations were always lower than 1000 ppb (1 ppm). However, the 1-hr average NO_2 concentration was, at times, greater than annual average ambient air quality standard of 100 $\mu g/m^3$ (53 ppb). The maximum in-cab NO_2 concentration was 287 ppb (9% of total NOx) in the Re-circulation mode. The maximum ambient (outside air) NO_2 concentration measured was around 153 ppb (12% of total NOx). The average NO_2 concentration inside truck cabs for the complete study was 42 ppb (6% of total NOx). During Fresh air and Recirculation modes the NO_2 concentration averaged 58 ppb and 65 ppb, respectively. While these concentrations are one-hour averages and cannot be compared to an annual standard directly, it does indicate the potential for the NO_2 concentrations to be closer to the ambient standard. In a related study conducted by the University of Tennessee, it was found that the 24-hr average NO_2 concentrations observed in the vicinity of the travel center were closer to the annual standard and that NO_2 concentrations were higher in summer than winter (G. T. Indale and T. L. Miller, 2004). All tests conducted during this study were performed during the winter season.

The 1-hr average CO concentrations were less than 2 ppm, which is much lower than the NIOSH/OSHA exposure limits and the 1-hr and 8-hr ambient air quality CO standards.

Table 3-12. Various Standards on Occupational Exposures

Pollutant	ACGIH (TLV)	NIOSH (REL)	OSHA (PEL)	EPA (NAAQS)
NO	25 ppm TWA	25 ppmTWA	25 ppm TWA	None
NO_2	3 ppm TWA 5 ppm STEL	1 ppm STEL	1 ppm STEL 5 ppm ceiling (transitional limit)	0.053 ppm annual mean
CO	50 ppm TWA 400 ppm STEL	35 ppm TWA with a ceiling of 200 ppm	50 ppm TWA	9 ppm: 8-hr average 35 ppm: 1-hr average
$PM_{2.5}$				15 $\mu g/m^3$ annual average 65 $\mu g/m^3$, 24-hr average

ACGIH: American Conference of Governmental Industrial Hygienists
TLV: Threshold Limit Value
NIOSH: National Institute of Occupational Safety and Health
REL: Recommended Exposure Limit
OSHA: Occupational Safety and Health Administration
PEL: Permissible Exposure Limit
EPA: Environmental Protection Agency
NAAQS: National Ambient Air Quality Standards
TWA: Time Weighted Average (typically 8-hr average)
STEL: Short Term Exposure Limit (15 minutes)

While there is no data on exposure limits for $PM_{2.5}$, the concentrations can be compared to the 24-hr average and annual average ambient fine particle standards. Under idling conditions, the outside air $PM_{2.5}$ concentrations were always higher than the annual $PM_{2.5}$ standard of 15 $\mu g/m^3$. The typical concentrations measured in this study exceeded the 24-hr standard of 65 $\mu g/m^3$ more than 50% of the time. The in-cab concentrations varied with the mode of operation and the truck. Under the Fresh air mode, the in-cab concentrations were greater than the annual standard in all the trucks tested. The effect of the Re-circulation mode differed between trucks.

4 CONCLUSIONS AND RECOMMENDATIONS

The overall objective of this study was to measure the air pollutant concentrations inside and outside of a truck cab under conditions of extended idling at a truck stop. The measurements were conducted under different modes of operation covering different periods of day. Based on the study, the following conclusions were reached:

1. The estimated apparent air exchange rates in the trucks in the Off mode varied from 1.0 per hour to about 2.2 per hour. In the Fresh air mode, the air exchange rate varied from 8 per hour to as high 55 exchanges per hour. Actual air exchange rates will depend on the heat, air conditioning and fan settings used by the driver, with typical values ranging from 1 to 20 per hour.
2. The $PM_{2.5}$ concentrations inside the truck cab varied with the mode of operation and the type of truck. In general, the in-cab $PM_{2.5}$ concentrations were the lowest for the "Off" mode of operation and the highest for the Fresh air mode of operation. In the Fresh air mode, the in-cab $PM_{2.5}$ concentrations tend to equilibrate with the outside air. Outside air $PM_{2.5}$ concentrations were frequently high because of the emissions of idling trucks at the truck stop. In the Re-circulation mode, the response varied with the truck. In some trucks, the inside concentrations varied with the outside air concentration, while with others, the in-cab concentrations were much lower than the outside and did not respond quickly to changes in the outside concentration. This is probably dependent on the characteristic of the truck design and the fraction of outside air versus internal re-circulation, as well as the degree of in-leakage into the truck in each case.
3. The "Engine on, Fan off" mode showed a continuous increase in the in-cab $PM_{2.5}$ concentrations in all the trucks tested. This implies that there are routes of entry of engine emissions other than just the air intake vents. It is possible that in-cab air quality is affected significantly by the exhaust emissions from the crankcase

("blow-by" emissions) that are released into the engine compartment and probably enter into the cab through openings on the floor. Furthermore, any leaks of exhaust products into the engine compartment may contaminate the in-cab air by leaking into the cab or by migrating to open windows or to the fresh air intakes located at the base of the windshield.

4. The mean in-cab $PM_{2.5}$ concentrations in the "Off" mode ranged from 10 to 28 $\mu g/m^3$. In the Re-circulation mode, the means concentrations varied from 16 to 155 $\mu g/m^3$. The maximum in-cab concentration in the Re-circulation mode was about 217 $\mu g/m^3$. Fresh air showed the highest in-cab concentrations ranging from 64 to 336 $\mu g/m^3$ with a maximum concentration of about 404 $\mu g/m^3$. The possibility of RH artifact on PM measurements is expected to be minimal given the conditions of sampling. However, it is recommended that caution be exercised while applying the $PM_{2.5}$ mass concentrations in absolute terms. Based on collocation with TEOM and a gravimetric calibration, it appears that the DataRAM concentrations may be overestimated by a factor of 2.
5. The in-cab $PM_{2.5}$ concentrations were lower than the outside concentration in the "Off" and Re-circulation modes. In the Fresh air mode, the concentrations were closer to the outside air and were slightly higher for a couple of trucks tested.
6. The ratio of the in-cab $PM_{2.5}$ concentrations during the "Off" mode to that in the Re-circulation mode ranged from 0.09 to 0.61. The ratio of "Off" to Fresh air mode concentrations ranged from 0.04 to 0.40. These results indicate that air quality in the cab is poorer whenever the engine is running and that some engine emissions migrate somehow into the cab.
7. The behavior of gases was similar to that of particles in that the lowest in-cab concentrations were observed in the Off mode. The NO_x concentrations were the lowest in the "Off" mode of operation and the highest in the Re-circulation mode. For particle concentrations, the Fresh air mode had the highest in-cab concentrations.

8. The mean in-cab NO_x concentration in the "Off" mode ranged from 167 ppb to about 418 ppb. During Re-circulation mode, the mean concentration ranged from 505 ppb to as high as 1884 ppb, while in the Fresh air mode it ranged from 353 to about 1400 ppb. The maximum in-cab concentration in the Re-circulation mode was around 3296 ppb. The mean in-cab NO_2 concentrations were the greatest during the Fresh air and Recirculation modes. The maximum in-cab NO_2 concentration was 287 ppb in the Re-circulation mode. On average, NO_2 was 7% of total NO_x inside the cab, while forming a higher fraction (13%) of NOx in the outside air.
9. The ratio of the in-cab NO_x concentration in "Off" mode to that of Re-circulation mode ranged from as low as 0.1 to about 0.6. Similarly, the ratio of "Off" to Fresh air mode ranged from 0.2 to 0.8. Thus, the in-cab concentrations were significantly lower in the "Off" mode compared to Re-circulation or Fresh air mode. These results indicate that air quality in the cab is poorer whenever the engine is running and that some engine emissions migrate somehow into the cab.
10. The in-cab CO concentrations in the truck stop were typically less than 2 ppm in all modes of operation.
11. An additional test of a truck in an empty parking lot without other idling trucks nearby showed similar behavior as that observed in the truck stop, indicating that the truck by itself plays a major role in contributing to the concentrations of pollutants observed both outside and inside the truck cab. This implies that there are probably exhaust emissions occurring from locations other than the truck smokestack. While the influence of smokestack emissions on in-cab air is highly dependent on wind direction and atmospheric stability, a more likely persistent source of in-cab air contamination, under idling conditions, would be the leaks in the engine compartment. It is possible that exhaust emissions from the crankcase vent (i.e. "blow-by" emissions) are released into the engine compartment and, to some extent, enter the cab through openings on the floor, etc. Any leaks of exhaust products into the engine compartment may contaminate the in-cab air by

leaking into the cab or by migrating to the fresh air intakes located at the base of the windshield and subsequently drawn into the cab. As shown in Figure 3-8 and Figure 3-9, in-cab concentrations of NOx and CO during the Re-circulation and Fresh air modes were consistently higher than outside concentrations, implicating the truck itself as a source of in-cab air contamination.

12. The nitric oxide (NO) concentrations measured in this study were always lower than any of the exposure limits set by the regulatory agencies. The measured NO_2 concentrations were also lower than the PEL set by the NIOSH. However, they were at times, greater than USEPA's annual ambient air quality standard of 53 ppb. The maximum in-cab NO_2 concentration was 287 ppb in the Re-circulation mode. The maximum ambient (outside air) NO_2 concentration measured was around 153 ppb. The average NO_2 concentration measured inside the cabs of all 6 trucks combined was 58 ppb and 65 ppb for Fresh air and Recirculation modes, respectively. While these concentrations are one-hour averages and cannot be compared to an annual standard directly, it does indicate the potential for the NO_2 concentrations to be close to the ambient standard. The CO concentrations were much lower than any of the standards.
13. For $PM_{2.5}$, under idling conditions, the outside air $PM_{2.5}$ concentrations were always higher than the annual $PM_{2.5}$ standard of 15 $\mu g/m^3$. The outside concentrations exceeded the 24-hr standard of 65 $\mu g/m^3$ more than 50% of the time. The in-cab concentrations during Fresh air mode were greater than the annual standard in all the trucks tested. The effect of the Re-circulation mode differed between trucks.

All trucks showed some level of in-cab air contamination. In-cab concentrations were almost always lower when the truck engine was off. When the engines were running, some trucks showed in-cab concentrations higher than outside, indicating pollutant leakage into the cab directly from the exhaust or engine compartment. Other trucks showed higher outside concentrations when the engine was idling which subsequently entered the cab through the fresh air vents and other normal in-leakage, raising in-cab concentrations gradually. Emissions from other nearby idling trucks also affected outside concentrations, and subsequently in-cab concentrations.

Based on the study, it may be concluded that particle concentrations may be of concern both inside and outside of the truck, depending on the mode of operation. It is obvious that the in-cab concentrations are the lowest in the "Off" mode of operation compared to any of the idle modes. It was noted that there might be routes of entry other than just the fresh air intake vents and that it may arise from crankcase emissions or other leaks inside the engine compartment. Hence, it is recommended that a follow-up study should focus on identifying the sources of contamination. Air sampling inside the engine compartment might be useful in identifying the magnitude of exhaust leakage. In addition, this study focused on NOx, CO and $PM_{2.5}$. It is known that diesel exhaust consists of various toxic gaseous species, which may remain in gas phase or be adsorbed onto the particles. It is recommended that future research should focus on quantifying the exposure levels to important toxic species. The results of the gaseous sampling may be a more reliable measure of truck self-contamination than particulate matter measurements because during re-circulation the air conditioning fan, cooling coils, and ductwork will likely remove some particulate matter.

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APPENDIX

A-1: Calibration and Calibration Checks of DataRAMs

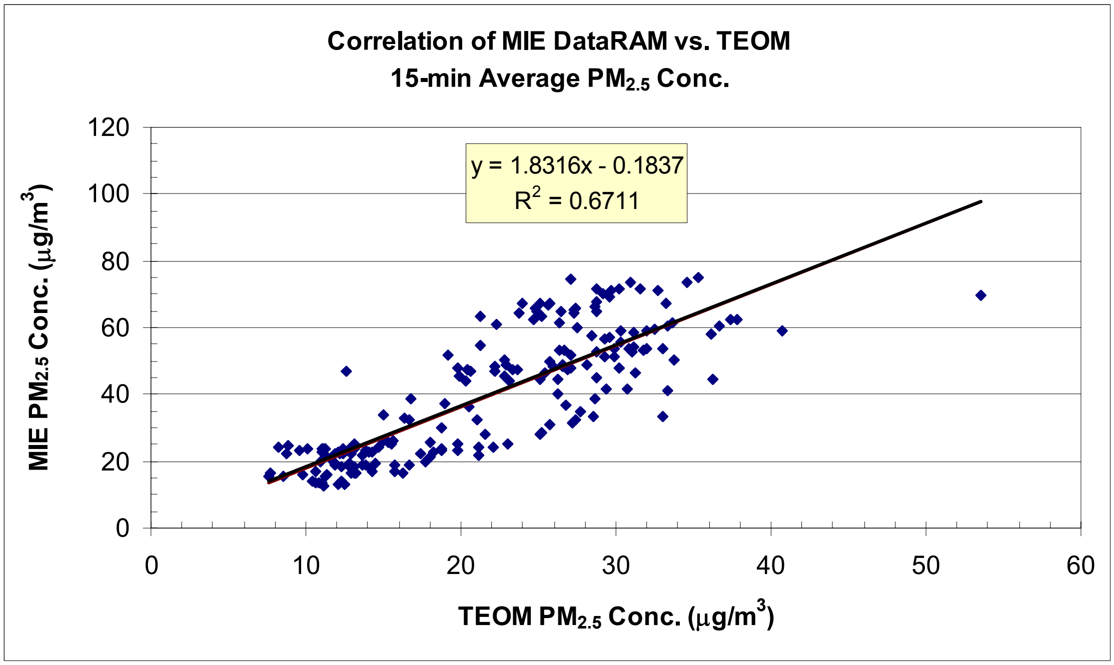


Figure A-1.1. Correlation of MIE DataRAM vs. TEOM

Table A-1.1. Zero Drift Measurements of DataRAMs

Date	Shift	Truck	Shift code	Shift Start/End	PM$_{2.5}$ conc reading after instrument auto-zero				UTK/MIE Ratio		Zero Drift	
					With Filter at Inlet		Without Filter		"Without Filter" ratio	"Without filter" minus "With filter" ratio	UTK	MIE
					UTK	MIE	UTK	MIE			(End - Start)	
12/15/2004	day	1	1_1	start	0.1	0	15.2	12.5	1.22	1.21		
12/15/2004	night	1	1_2	start	0.5	0	39.3	26.4	1.49	1.47		
12/15/2004	night	1	1_2	end	5.7	0	147.3	91.2	1.62	1.55	5.2	0
12/16/2004	day	1	1_3	start	1.5	0	52.4	30.5	1.72	1.67		
12/16/2004	day	1	1_3	end	1.9	0	37.7	23	1.64	1.56	0.4	0
12/16/2004	night	1	1_4	start	3.2	1	56.1	37.2	1.51	1.46		
12/16/2004	night	1	1_4	end	2	0	44	27.9	1.58	1.51	-1.2	-1
12/17/2004	day	1	1_5	start	1.9	0	41.8	26.5	1.58	1.51		
12/17/2004	day	1	1_5	end	1.2	0.4	67	43.1	1.55	1.54	-0.7	0.4
12/17/2004	night	2	2_1	start	0	0.2	50.1	34.5	1.45	1.46		
12/17/2004	night	2	2_1	end	7.7	11	327	193.4	1.69	1.75	7.7	10.8
12/18/2004	day	2	2_2	start	2.7	0.4	37.4	22.2	1.68	1.59		
12/18/2004	day	2	2_2	end	2.5	0	14.4	7.2	2.00	1.65	-0.2	-0.4
12/18/2004	night	2	2_3	start	1	0	46.6	30.5	1.53	1.50		
12/18/2004	night	2	2_3	end	10.5	4.6	213	134.5	1.58	1.56	9.5	4.6
12/19/2004	day	2	2_4	start	1.1	0	17.2	10.1	1.70	1.59		
12/19/2004	day	2	2_4	end	4.7	0	38.4	22.5	1.71	1.50	3.6	0
12/19/2004	night	2	2_5	start	0	0	8.4	4.9	1.71	1.71		
12/19/2004	night	2	2_5	end	0	0	12.6	7.4	1.70	1.70	0	0
12/20/2004	day	3	3_1	start	0	0	13.7	7.6	1.80	1.80		
12/20/2004	day	3	3_1	end	4	5.7	114	71.8	1.59	1.66	4	5.7
12/20/2004	night	3	3_2	start	0.1	0	24.2	14.2	1.70	1.70		
12/20/2004	night	3	3_2	end	6.3	0.4	124.3	74.3	1.67	1.60	6.2	0.4
12/21/2004	day	3	3_3	start	0.1	0	17.7	10.1	1.75	1.74		
12/21/2004	day	3	3_3	end	0	1	29.8	17.5	1.70	1.81	-0.1	1
12/21/2004	night	3	3_4	start	0	0	18.8	9.8	1.92	1.92		
12/21/2004	night	3	3_4	end	1.9	0	41.9	26.8	1.56	1.49	1.9	0
1/6/2005	night	4	incense	start	0.2	0	20.1	16.8	1.20	1.18		
1/6/2005	night	4	test	end	5.6	2.1	98	64.3	1.52	1.49	5.4	2.1
1/6/2005	night	4	4_1	start	7	3.5	158	95.9	1.65	1.63		
1/6/2005	night	4	4_1	end	39.8	18.8	743.8	491.1	1.51	1.49	32.8	15.3
1/7/2005	day	4	4_2	start	0	0	17.5	13.5	1.30	1.30		
1/7/2005	day	4	4_2	end	0	0.4	49.1	31.8	1.54	1.56	0	0.4
1/8/2005	day	4	4_3	start	0.3	0	7.9	4.1	1.93	1.85		
1/8/2005	day	4	4_3	end	28	10.8	460.6	304.9	1.51	1.47	27.7	10.8
1/8/2005	night	4	4_4	start	0.7	0	14	10	1.40	1.33		
1/8/2005	night	4	4_4	end	30.3	13.1	636.4	405.5	1.57	1.54	29.6	13.1
1/9/2005	day	4	4_5	start	2.1	0	26.2	18.1	1.45	1.33		
1/9/2005	day	4	4_5	end	0.6	0	28.3	8.7	3.25	3.18	-1.5	0
1/9/2005	night	4	4_6	start	1.5	0.2	21.9	12.5	1.75	1.66		
1/9/2005	night	4	4_6	end	3.3	0.2	39.3	23.6	1.67	1.54	1.8	0
1/10/2005	day	5	5_1	start	2.9	1.5	57.7	44.3	1.30	1.28		
1/10/2005	day	5	5_1	end	6	3.5	208.5	126.3	1.65	1.65	3.1	2
1/10/2005	day	5	incense	start	8.4	5	231	153.6	1.50	1.50		
1/10/2005	day	5	test	end	21.3	8.1	363.6	234.4	1.55	1.51	12.9	3.1
1/10/2005	night	5	5_2	start	5.2	1.2	93.4	62.6	1.49	1.44		
1/10/2005	night	5	5_2	end	24.3	8.6	312.5	198.4	1.58	1.52	19.1	7.4
1/11/2005	day	5	5_3	start	2.4	0.7	51.2	35.7	1.43	1.39		
1/11/2005	day	5	5_3	end	2.9	1.4	69	46.6	1.48	1.46	0.5	0.7
1/11/2005	night	5	5_4	start	1.3	0	32.3	21.1	1.53	1.47		
1/11/2005	night	5	5_4	end	3.2	0	50.3	33.9	1.48	1.39	1.9	0
1/12/2005	day	6	6_1	start	0	2.2	63.3	42.3	1.50	1.58		
1/12/2005	day	6	6_1	end	19.4	3.2	177.7	113.7	1.56	1.43	19.4	1
1/12/2005	night	6	6_2	start	2.3	0	35.2	22.3	1.58	1.48		
1/12/2005	night	6	6_2	end	3.5	0	32.7	19.8	1.65	1.47	1.2	0
1/13/2005	day	6	6_3	start	0	0	20	11.9	1.68	1.68		
1/13/2005	day	6	6_3	end	1.6	0.8	13.2	6.7	1.97	1.97	1.6	0.8
1/13/2005	night	6	6_4	start	1.1	0	**3.8**	**8.2**	0.46	0.33		
1/13/2005	night	6	6_4	end	0	0	13.9	7.4	1.88	1.88	-1.1	0
1/14/2005	day	6	incense	start	1.6	0	11.4	6	1.90	1.63		
1/14/2005	day	6	test	end	4.5	0	42.2	27.2	1.55	1.39	2.9	0
1/20/2005	day	7	7_1	start	2.4	1	43	32	1.34	1.31		
1/20/2005	day	7	7_1	end	58	26	809.1	586.5	1.38	1.34	55.6	25
2/25/2005	day	TEOM		start	3.5	0	29.2	22.5	1.30	1.14		
2/27/2005	day	Collocation		end	0	0	35.7	23.6	1.51	1.51	-3.5	0
Mean					5.47	2.11	104.2	67.8	1.60	1.55	7.68	3.23
Median					2.00	0.00	41.8	26.5	1.58	1.51	2.40	0.40

A-2: Shifts and Modes for Each Truck

Shift	TRUCK	SHIFT_CODE	TIME_PERIOD	DAY_NIGHT	Date	Start Time	End Time	Truck Mode of Operation	Inside Cab Temperature (F)	Inside Cab Relative Humidity (%)	Used in Summary Analysis ?
Dec 15 Day	1	1_1	1	Day	12/15/2004	1:38 PM	2:39 PM	OFF	64.7	51	Yes
Dec 15 Day	1	1_1	2	Day	12/15/2004	2:47 PM	3:50 PM	Recirculation	76	26	Yes
Dec 15 Day	1	1_1	3	Day	12/15/2004	3:54 PM	5:02 PM	Fresh Air	83	9.5	No
Dec 15 Night	1	1_2	1	Night	12/15/2004	9:38 PM	10:40 PM	OFF	49	56	Yes
Dec 15 Night	1	1_2	2	Night	12/15/2004	10:46 PM	11:48 PM	OFF	45.9	92.5	Yes
Dec 15 Night	1	1_2	3	Night	12/16/2004	12:04 AM	1:06 AM	Recirculation	52.3	48.1	Yes
Dec 15 Night	1	1_2	4	Night	12/16/2004	1:19 AM	2:17 AM	Recirculation	67.8	34.5	Yes
Dec 15 Night	1	1_2	5	Night	12/16/2004	2:21 AM	3:22 AM	Recirculation	87.8	15.1	Yes
Dec 15 Night	1	1_2	6	Night	12/16/2004	3:24 AM	4:25 AM	Fresh Air	82.8	8.6	No
Dec 15 Night	1	1_2	7	Night	12/16/2004	4:27 AM	5:27 AM	Fresh Air	84.8	6.7	Yes
Dec 16 Day	1	1_3	1	Day	12/16/2004	8:05 AM	9:06 AM	OFF	54.3	48.7	Yes
Dec 16 Day	1	1_3	2	Day	12/16/2004	9:08 AM	10:25 AM	Recirculation	48.4	59.8	Yes
Dec 16 Day	1	1_3	3	Day	12/16/2004	10:30 AM	11:31 AM	Recirculation	84.5	13.5	Yes
Dec 16 Day	1	1_3	4	Day	12/16/2004	11:33 AM	12:33 PM	Fresh Air	67.9	23.2	No
Dec 16 Day	1	1_3	5	Day	12/16/2004	12:35 PM	1:38 PM	Fresh Air	81.4	13.5	Yes
Dec 16 Day	1	1_3	6	Day	12/16/2004	1:41 PM	2:42 PM	OFF	64.3	26	No
Dec 16 Day	1	1_3	7	Day	12/16/2004	2:45 PM	3:47 PM	OFF	76.3	20.3	Yes
Dec 16 Night	1	1_4	1	Night	12/16/2004	8:09 PM	9:09 PM	Engine On, Fan Off	66.7	58.5	Yes
Dec 16 Night	1	1_4	2	Night	12/16/2004	9:12 PM	10:12 PM	OFF	63.7	50.5	No
Dec 16 Night	1	1_4	3	Night	12/16/2004	10:14 PM	11:18 PM	Fresh Air	61	46.1	No
Dec 16 Night	1	1_4	4	Night	12/16/2004	11:20 PM	12:18 AM	Recirculation	77.2	20.5	No
Dec 16 Night	1	1_4	5	Night	12/17/2004	12:20 AM	1:20 AM	Fresh Air	83.6	15.4	No
Dec 16 Night	1	1_4	6	Night	12/17/2004	1:22 AM	2:22 AM	Recirculation	83	17.4	No
Dec 16 Night	1	1_4	7	Night	12/17/2004	2:24 AM	3:24 AM	Fresh Air	83.7	11.7	No
Dec 16 Night	1	1_4	8	Night	12/17/2004	3:26 AM	4:26 AM	OFF	82.9	19.6	No
Dec 17 Day	1	1_5	1	Day	12/17/2004	8:57 AM	9:59 AM	OFF	52.6	46.7	Yes
Dec 17 Day	1	1_5	2	Day	12/17/2004	10:02 AM	11:02 AM	Recirculation	57.8	39.1	Yes
Dec 17 Day	1	1_5	3	Day	12/17/2004	11:04 AM	12:03 PM	Fresh Air	76.5	16.5	No

Note: Inside cab temperature and RH values summarized in these tables were measured using the Extech anemometer.

Shift	TRUCK	SHIFT_CODE	TIME_PERIOD	DAY_NIGHT	Date	Start Time	End Time	Truck Mode of Operation	Inside Cab Temperature (F)	Inside Cab Relative Humidity (%)	Used in Summary Analysis ?
Dec 17 Night	2	2_1	1	Night	12/17/2004	9:08 PM	10:08 PM	OFF	72.1	46	Yes
Dec 17 Night	2	2_1	2	Night	12/17/2004	10:08 PM	11:08 PM	OFF	64.4	33.7	Yes
Dec 17 Night	2	2_1	3	Night	12/17/2004	11:09 PM	12:09 AM	Recirculation	58.2	43.9	Yes
Dec 17 Night	2	2_1	4	Night	12/18/2004	12:09 AM	1:09 AM	Recirculation	81.5	24.3	Yes
Dec 17 Night	2	2_1	5	Night	12/18/2004	1:09 AM	2:09 AM	Recirculation	92.2	12.9	Yes
Dec 17 Night	2	2_1	6	Night	12/18/2004	2:09 AM	3:10 AM	Fresh Air	87.4	18	No
Dec 17 Night	2	2_1	7	Night	12/18/2004	3:10 AM	4:10 AM	Fresh Air	77.9	14.1	Yes
Dec 18 Day	2	2_2	1	Day	12/18/2004	6:58 AM	7:58 AM	Recirculation	67.5	21.5	Yes
Dec 18 Day	2	2_2	2	Day	12/18/2004	8:00 AM	9:00 AM	Recirculation	82	13.8	Yes
Dec 18 Day	2	2_2	3	Day	12/18/2004	9:02 AM	10:02 AM	Fresh Air	60.4	30.2	No
Dec 18 Day	2	2_2	4	Day	12/18/2004	10:03 AM	11:03 AM	Fresh Air	67.5	24.9	Yes
Dec 18 Day	2	2_2	5	Day	12/18/2004	11:04 AM	12:07 PM	OFF	73.1	21.6	No
Dec 18 Day	2	2_2	6	Day	12/18/2004	12:08 PM	1:08 PM	OFF	71	25.3	Yes
Dec 18 Night	2	2_3	1	Night	12/18/2004	8:12 PM	9:12 PM	Engine On, Fan Off	53.8	56	Yes
Dec 18 Night	2	2_3	2	Night	12/18/2004	9:13 PM	10:13 PM	OFF	55.9	60.4	No
Dec 18 Night	2	2_3	3	Night	12/18/2004	10:13 PM	11:13 PM	Fresh Air	60	48.4	No
Dec 19 Day	2	2_4	1	Day	12/19/2004	11:04 AM	12:04 PM	OFF	46	66.4	Yes
Dec 19 Day	2	2_4	2	Day	12/19/2004	12:07 PM	1:11 PM	Recirculation	65.3	31.9	Yes
Dec 19 Day	2	2_4	3	Day	12/19/2004	1:17 PM	2:17 PM	Recirculation	86.6	18.7	Yes
Dec 19 Night	2	2_5	1	Night	12/19/2004	8:46 PM	9:46 PM	OFF	32.9	50.9	Yes
Dec 19 Night	2	2_5	2	Night	12/19/2004	9:50 PM	10:50 PM	Recirculation	28.2	54.5	No
Dec 19 Night	2	2_5	3	Night	12/19/2004	10:52 PM	11:53 PM	Fresh Air	71.9	14	No
Dec 19 Night	2	2_5	4	Night	12/19/2004	11:55 PM	12:56 AM	Recirculation	72.9	6.8	No
Dec 19 Night	2	2_5	5	Night	12/20/2004	12:58 AM	2:00 AM	Fresh Air	75.1	3.7	No
Dec 19 Night	2	2_5	6	Night	12/20/2004	2:03 AM	3:04 AM	OFF	74.3	26.9	No
Dec 19 Night	2	2_5	7	Night	12/20/2004	3:07 AM	4:08 AM	OFF	55.1	24.6	Yes

Note: Inside cab temperature and RH values summarized in these tables were measured using the Extech anemometer.

Shift	TRUCK	SHIFT_CODE	TIME_PERIOD	DAY_NIGHT	Date	Start Time	End Time	Truck Mode of Operation	Inside Cab Temperature (F)	Inside Cab Relative Humidity (%)	Used in Summary Analysis ?
Dec 20 Day	3	3_1	1	Day	12/20/2004	10:51 AM	11:51 AM	OFF	46.8	70.8	Yes
Dec 20 Day	3	3_1	2	Day	12/20/2004	11:51 AM	12:51 PM	OFF	54.8	54.3	Yes
Dec 20 Day	3	3_1	3	Day	12/20/2004	1:01 PM	2:01 PM	Recirculation	62.6	28.8	Yes
Dec 20 Day	3	3_1	4	Day	12/20/2004	2:01 PM	3:01 PM	Recirculation	74.4	24	Yes
Dec 20 Day	3	3_1	5	Day	12/20/2004	3:02 PM	4:02 PM	Fresh Air	65.7	32.7	No
Dec 20 Day	3	3_1	6	Day	12/20/2004	4:02 PM	5:02 PM	Fresh Air	67.6	14.8	Yes
Dec 20 Night	3	3_2	1	Night	12/20/2004	9:51 PM	10:51 PM	OFF	37.3	42.5	Yes
Dec 20 Night	3	3_2	2	Night	12/20/2004	10:52 PM	11:58 PM	OFF	33.1	50.2	Yes
Dec 20 Night	3	3_2	3	Night	12/21/2004	12:04 AM	1:07 AM	Recirculation	32.2	51.2	Yes
Dec 20 Night	3	3_2	4	Night	12/21/2004	1:09 AM	2:18 AM	Recirculation	62.3	29.4	Yes
Dec 20 Night	3	3_2	5	Night	12/21/2004	2:20 AM	3:28 AM	Recirculation	80.3	14.3	Yes
Dec 20 Night	3	3_2	6	Night	12/21/2004	3:30 AM	4:38 AM	Fresh Air	80.5	5.2	No
Dec 20 Night	3	3_2	7	Night	12/21/2004	4:41 AM	5:41 AM	Fresh Air	78.9	6	Yes
Dec 21 Day	3	3_3	1	Day	12/21/2004	7:21 AM	8:21 AM	Recirculation	65.4	30.5	Yes
Dec 21 Day	3	3_3	2	Day	12/21/2004	8:21 AM	9:21 AM	Recirculation	77.8	18.1	Yes
Dec 21 Day	3	3_3	3	Day	12/21/2004	9:21 AM	10:21 AM	Fresh Air	85.6	23.4	No
Dec 21 Day	3	3_3	4	Day	12/21/2004	10:21 AM	11:21 AM	Fresh Air	82.7	2	Yes
Dec 21 Day	3	3_3	5	Day	12/21/2004	11:22 AM	12:22 PM	OFF	84.8	4.3	No
Dec 21 Day	3	3_3	6	Day	12/21/2004	12:22 PM	1:22 PM	OFF	74.1	22	Yes
Dec 21 Night	3	3_4	1	Night	12/21/2004	8:41 PM	9:41 PM	Engine On, Fan Off	70.9	28	Yes
Dec 21 Night	3	3_4	2	Night	12/21/2004	9:43 PM	10:47 PM	OFF	65.2	31.1	No
Dec 21 Night	3	3_4	3	Night	12/21/2004	10:51 PM	11:54 PM	Fresh Air	62.4	38.2	No
Dec 21 Night	3	3_4	4	Night	12/21/2004	11:56 PM	12:57 AM	Recirculation	78	19.3	No
Dec 21 Night	3	3_4	5	Night	12/22/2004	12:59 AM	2:05 AM	Fresh Air	77.6	19.5	No
Dec 21 Night	3	3_4	6	Night	12/22/2004	2:07 AM	3:07 AM	Recirculation	77.9	16.1	No
Dec 21 Night	3	3_4	7	Night	12/22/2004	3:07 AM	4:10 AM	Fresh Air	76.4	18.8	No
Dec 21 Night	3	3_4	8	Night	12/22/2004	4:13 AM	5:13 AM	OFF	74	20.7	No

Note: Inside cab temperature and RH values summarized in these tables were measured using the Extech anemometer.

Shift	TRUCK	SHIFT_CODE	TIME_PERIOD	DAY_NIGHT	Date	Start Time	End Time	Truck Mode of Operation	Inside Cab Temperature (F)	Inside Cab Relative Humidity (%)	Used in Summary Analysis ?
Jan 6 Night	4	4_1	1	Night	1/6/2005	9:35 PM	10:35 PM	OFF	63.8	51.5	No
Jan 6 Night	4	4_1	2	Night	1/6/2005	10:35 PM	11:35 PM	OFF	63.6	62.5	Yes
Jan 6 Night	4	4_1	3	Night	1/6/2005	11:35 PM	12:35 AM	Recirculation	60	70.4	Yes
Jan 6 Night	4	4_1	4	Night	1/7/2005	12:35 AM	1:35 AM	Recirculation	66.5	54	Yes
Jan 6 Night	4	4_1	5	Night	1/7/2005	1:35 AM	2:35 AM	Recirculation	68.8	46.4	Yes
Jan 6 Night	4	4_1	6	Night	1/7/2005	2:35 AM	3:35 AM	Fresh Air	71.5	37	No
Jan 6 Night	4	4_1	7	Night	1/7/2005	3:35 AM	4:35 AM	Fresh Air	72	37.2	Yes
Jan 7 Day	4	4_2	1	Day	1/7/2005	6:56 AM	7:58 AM	Recirculation	67.5	36.5	Yes
Jan 7 Day	4	4_2	2	Day	1/7/2005	8:01 AM	9:01 AM	Recirculation	76.1	31.4	Yes
Jan 7 Day	4	4_2	3	Day	1/7/2005	9:02 AM	10:04 AM	Fresh Air	74.5	30.1	No
Jan 7 Day	4	4_2	4	Day	1/7/2005	10:05 AM	11:07 AM	Fresh Air	77.3	26.5	Yes
Jan 7 Day	4	4_2	5	Day	1/7/2005	11:09 AM	12:09 PM	OFF	75.7	30.8	No
Jan 7 Day	4	4_2	6	Day	1/7/2005	12:10 PM	1:10 PM	OFF	68.6	38.7	Yes
Jan 8 Day	4	4_3	1	Day	1/8/2005	8:50 AM	9:50 AM	OFF	54.5	76	Yes
Jan 8 Day	4	4_3	2	Day	1/8/2005	9:51 AM	10:51 AM	OFF	55.1	79.3	Yes
Jan 8 Day	4	4_3	3	Day	1/8/2005	10:53 AM	11:54 AM	OFF	61	72	Yes
Jan 8 Day	4	4_3	4	Day	1/8/2005	11:58 AM	12:59 PM	Recirculation	72.1	42.3	Yes
Jan 8 Day	4	4_3	5	Day	1/8/2005	1:00 PM	2:00 PM	Recirculation	88.8	21.9	Yes
Jan 8 Day	4	4_3	6	Day	1/8/2005	2:01 PM	3:01 PM	Fresh Air	83	22.6	No
Jan 8 Day	4	4_3	7	Day	1/8/2005	3:02 PM	4:05 PM	Fresh Air	79.8	24	Yes
Jan 8 Night	4	4_4	1	Night	1/8/2005	9:03 PM	10:03 PM	OFF	55	60.1	Yes
Jan 8 Night	4	4_4	2	Night	1/8/2005	10:03 PM	11:03 PM	OFF	53.4	52.3	Yes
Jan 8 Night	4	4_4	3	Night	1/8/2005	11:03 PM	12:03 AM	Recirculation	50.5	67.8	Yes
Jan 8 Night	4	4_4	4	Night	1/9/2005	12:03 AM	1:03 AM	Recirculation	61.5	47.1	Yes
Jan 8 Night	4	4_4	5	Night	1/9/2005	1:03 AM	2:03 AM	Recirculation	67.5	40.5	Yes
Jan 8 Night	4	4_4	6	Night	1/9/2005	2:04 AM	3:04 AM	Fresh Air	68.8	36.4	No
Jan 8 Night	4	4_4	7	Night	1/9/2005	3:04 AM	4:04 AM	Fresh Air	68.1	30.6	Yes
Jan 9 Day	4	4_5	1	Day	1/9/2005	7:48 AM	8:55 AM	Recirculation	46.4	68	Yes
Jan 9 Day	4	4_5	2	Day	1/9/2005	8:57 AM	9:57 AM	Recirculation	68.4	37.3	Yes
Jan 9 Day	4	4_5	3	Day	1/9/2005	9:58 AM	11:03 AM	Fresh Air	77.8	27	No
Jan 9 Day	4	4_5	4	Day	1/9/2005	11:04 AM	12:06 PM	Fresh Air	83	19.6	Yes
Jan 9 Day	4	4_5	5	Day	1/9/2005	12:12 PM	1:21 PM	OFF	83	26.4	No
Jan 9 Day	4	4_5	6	Day	1/9/2005	1:22 PM	2:31 PM	OFF	85	20.7	Yes

Note: Inside cab temperature and RH values summarized in these tables were measured using the Extech anemometer.

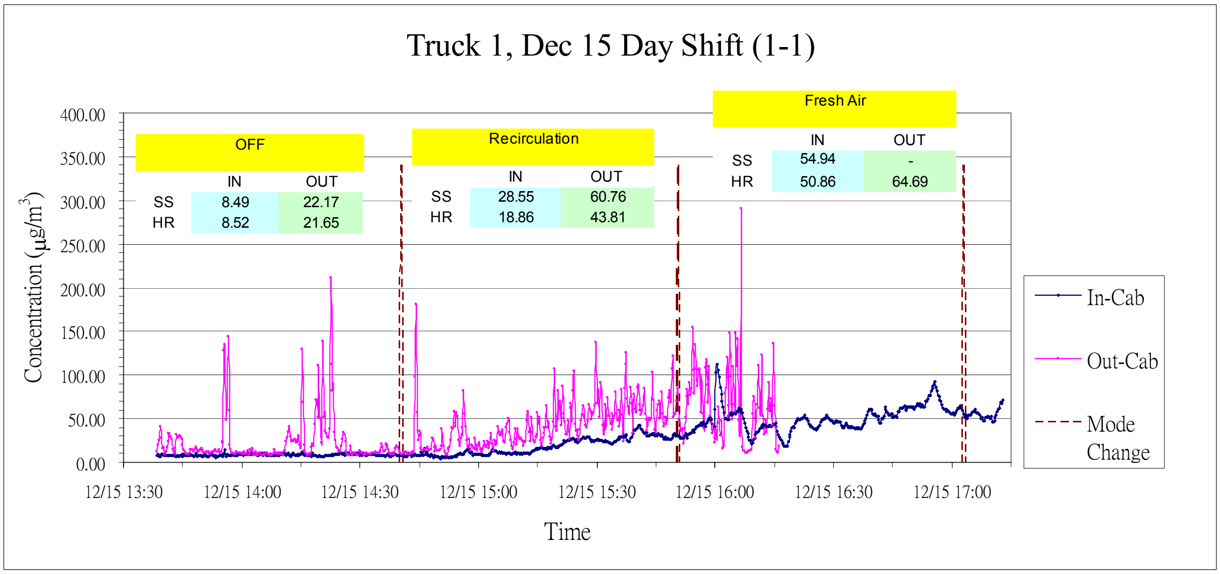
Shift	TRUCK	SHIFT_CODE	TIME_PERIOD	DAY_NIGHT	Date	Start Time	End Time	Truck Mode of Operation	Inside Cab Temperature (F)	Inside Cab Relative Humidity (%)	Used in Summary Analysis ?
Jan 9 Night	4	4_6	1	Night	1/9/2005	8:11 PM	9:11 PM	Engine On, Fan Off	62.5	55.4	Yes
Jan 9 Night	4	4_6	2	Night	1/9/2005	9:11 PM	10:11 PM	OFF	60.8	43.5	No
Jan 9 Night	4	4_6	3	Night	1/9/2005	10:11 PM	11:11 PM	Fresh Air	60.9	47.7	No
Jan 9 Night	4	4_6	4	Night	1/9/2005	11:11 PM	12:11 AM	Recirculation	71.8	35.6	No
Jan 9 Night	4	4_6	5	Night	1/10/2005	12:12 AM	1:12 AM	Fresh Air	79.8	25.2	No
Jan 9 Night	4	4_6	6	Night	1/10/2005	1:12 AM	2:12 AM	Recirculation	81.6	25.8	No
Jan 9 Night	4	4_6	7	Night	1/10/2005	2:12 AM	3:12 AM	Fresh Air	82.8	19.6	No
Jan 9 Night	4	4_6	8	Night	1/10/2005	3:12 AM	4:12 AM	OFF	83.2	20.9	No
Jan 10 Day	5	5_1	1	Day	1/10/2005	10:55 AM	12:05 PM	OFF	61.8	71.3	No
Jan 10 Day	5	5_1	2	Day	1/10/2005	12:06 PM	1:16 PM	OFF	64.8	67.8	Yes
Jan 10 Day	5	5_1	3	Day	1/10/2005	1:20 PM	2:20 PM	Recirculation	70.1	47.6	Yes
Jan 10 Day	5	5_1	4	Day	1/10/2005	2:21 PM	3:23 PM	Recirculation	72.5	30.6	Yes
Jan 10 Day	5	5_1	5	Day	1/10/2005	3:25 PM	4:32 PM	Fresh Air	77.4	25.8	No
Jan 10 Day	5	5_1	6	Day	1/10/2005	4:33 PM	5:36 PM	Fresh Air	72.1	30.7	Yes
Jan 10 Night	5	5_2	1	Night	1/10/2005	10:40 PM	11:44 PM	OFF	64.8	55.2	Yes
Jan 10 Night	5	5_2	2	Night	1/10/2005	11:47 PM	12:49 AM	OFF	61.1	53.2	Yes
Jan 10 Night	5	5_2	3	Night	1/11/2005	12:52 AM	1:59 AM	Recirculation	58.4	61.3	Yes
Jan 10 Night	5	5_2	4	Night	1/11/2005	2:02 AM	3:08 AM	Recirculation	78.4	28.7	Yes
Jan 10 Night	5	5_2	5	Night	1/11/2005	3:10 AM	4:15 AM	Fresh Air	80.4	27.8	No
Jan 10 Night	5	5_2	6	Night	1/11/2005	4:29 AM	5:30 AM	Fresh Air	80	19.1	Yes
Jan 11 Day	5	5_3	1	Day	1/11/2005	7:45 AM	8:45 AM	Recirculation	71.9	36	Yes
Jan 11 Day	5	5_3	2	Day	1/11/2005	8:46 AM	9:46 AM	Recirculation	76.7	24.7	Yes
Jan 11 Day	5	5_3	3	Day	1/11/2005	9:47 AM	10:48 AM	Fresh Air	66.6	39.4	No
Jan 11 Day	5	5_3	4	Day	1/11/2005	10:50 AM	11:53 AM	Fresh Air	71.1	33.3	Yes
Jan 11 Day	5	5_3	5	Day	1/11/2005	11:55 AM	12:55 PM	OFF	73.2	32.1	No
Jan 11 Day	5	5_3	6	Day	1/11/2005	12:56 PM	2:00 PM	OFF	71.4	47.7	Yes
Jan 11 Night	5	5_4	1	Night	1/11/2005	8:30 PM	9:38 PM	Engine On, Fan Off	62.4	67.9	Yes
Jan 11 Night	5	5_4	2	Night	1/11/2005	9:40 PM	10:48 PM	OFF	64.3	70.5	No
Jan 11 Night	5	5_4	3	Night	1/11/2005	10:52 PM	12:00 AM	Fresh Air	65.2	53.6	No
Jan 11 Night	5	5_4	4	Night	1/12/2005	12:03 AM	1:13 AM	Recirculation	73.6	39.5	No
Jan 11 Night	5	5_4	5	Night	1/12/2005	1:15 AM	2:16 AM	Fresh Air	80.8	27.1	No
Jan 11 Night	5	5_4	6	Night	1/12/2005	2:21 AM	3:32 AM	Recirculation	85.5	21.1	No
Jan 11 Night	5	5_4	7	Night	1/12/2005	3:35 AM	4:44 AM	Fresh Air	70	35.2	No
Jan 11 Night	5	5_4	8	Night	1/12/2005	4:46 AM	5:50 AM	OFF	88.2	29.2	No

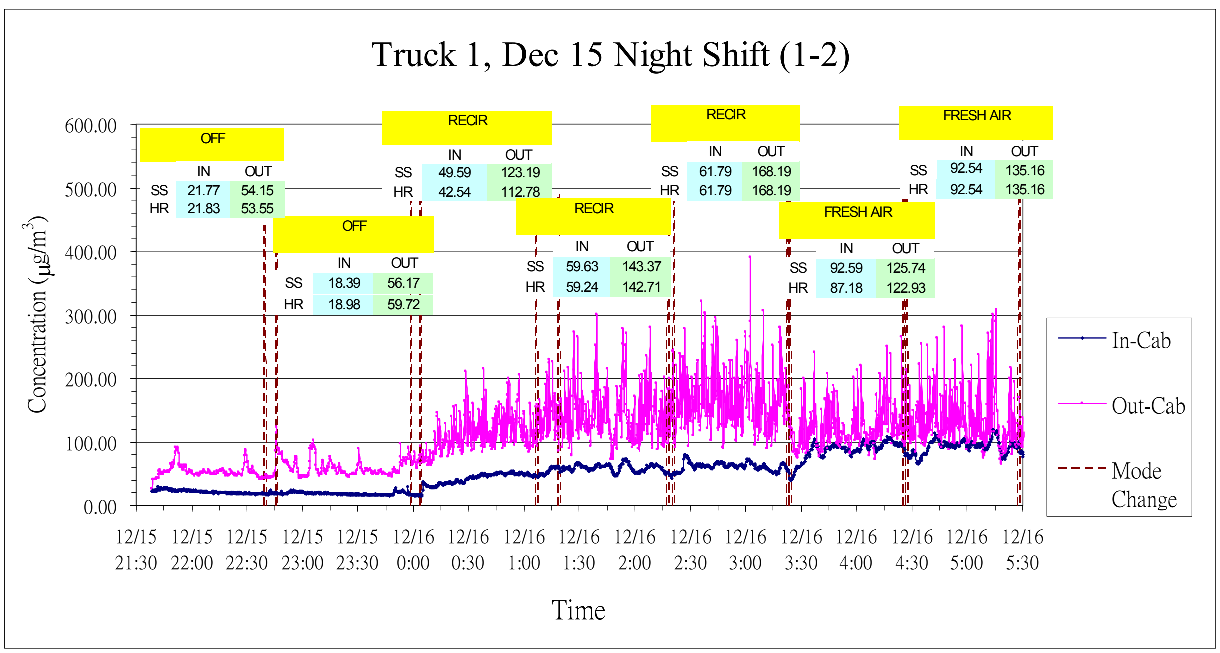
Note: Inside cab temperature and RH values summarized in these tables were measured using the Extech anemometer.

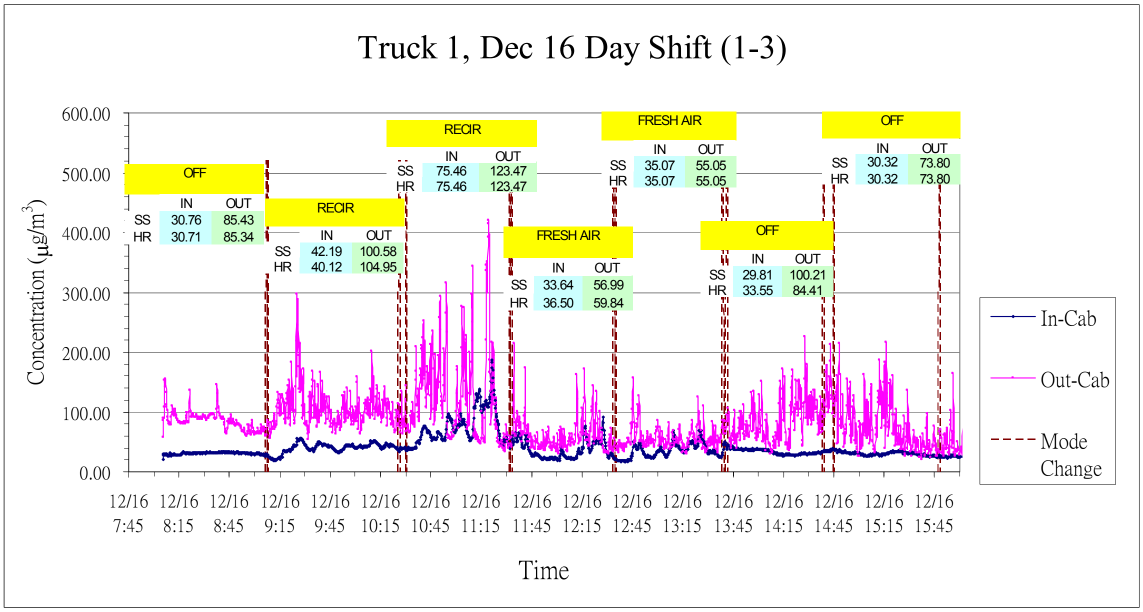
Shift	TRUCK	SHIFT_CODE	TIME_PERIOD	DAY_NIGHT	Date	Start Time	End Time	Truck Mode of Operation	Inside Cab Temperature (F)	Inside Cab Relative Humidity (%)	Used in Summary Analysis ?
Jan 12 Day	6	6_1	1	Day	1/12/2005	10:53 AM	11:53 AM	OFF	69.6	71.8	Yes
Jan 12 Day	6	6_1	2	Day	1/12/2005	11:53 AM	12:54 PM	Recirculation	71.1	70.6	Yes
Jan 12 Day	6	6_1	3	Day	1/12/2005	12:54 PM	1:54 PM	Recirculation	81.9	43.6	Yes
Jan 12 Day	6	6_1	4	Day	1/12/2005	1:54 PM	2:54 PM	Fresh Air	87.3	33.4	No
Jan 12 Day	6	6_1	5	Day	1/12/2005	2:54 PM	3:54 PM	Fresh Air	86.9	25	Yes
Jan 12 Night	6	6_2	1	Night	1/12/2005	9:12 PM	10:15 PM	OFF	73.3	62.5	Yes
Jan 12 Night	6	6_2	2	Night	1/12/2005	10:15 PM	11:20 PM	OFF	71.3	53.3	Yes
Jan 12 Night	6	6_2	3	Night	1/12/2005	11:20 PM	12:21 AM	Recirculation	88.1	30.3	Yes
Jan 12 Night	6	6_2	4	Night	1/13/2005	12:21 AM	1:19 AM	Recirculation	80.4	35.3	Yes
Jan 12 Night	6	6_2	5	Night	1/13/2005	1:19 AM	2:17 AM	Recirculation	86	33.7	Yes
Jan 12 Night	6	6_2	6	Night	1/13/2005	2:17 AM	3:15 AM	Fresh Air	88.3	24.3	No
Jan 12 Night	6	6_2	7	Night	1/13/2005	3:15 AM	4:15 AM	Fresh Air	86.8	25.5	Yes
Jan 13 Day	6	6_3	1	Day	1/13/2005	6:53 AM	7:56 AM	Recirculation	78.8	42.2	Yes
Jan 13 Day	6	6_3	2	Day	1/13/2005	7:58 AM	8:59 AM	Recirculation	82.9	35.5	Yes
Jan 13 Day	6	6_3	3	Day	1/13/2005	9:00 AM	10:00 AM	Fresh Air	85.4	30.9	No
Jan 13 Day	6	6_3	4	Day	1/13/2005	10:01 AM	11:01 AM	Fresh Air	81.9	41.3	Yes
Jan 13 Day	6	6_3	5	Day	1/13/2005	11:02 AM	12:02 PM	OFF	87.4	33.3	No
Jan 13 Day	6	6_3	6	Day	1/13/2005	12:03 PM	1:03 PM	OFF	90.2	28.5	Yes
Jan 13 Night	6	6_4	1	Night	1/14/2005	12:11 AM	1:08 AM	Engine On, Fan Off	60.8	76.2	Yes
Jan 13 Night	6	6_4	2	Night	1/14/2005	1:10 AM	2:10 AM	OFF	59.2	80.9	No
Jan 13 Night	6	6_4	3	Night	1/14/2005	2:11 AM	3:06 AM	Fresh Air	60.2	70.7	No
Jan 13 Night	6	6_4	4	Night	1/14/2005	3:08 AM	4:11 AM	Recirculation	80.1	27.5	No
Jan 13 Night	6	6_4	5	Night	1/14/2005	4:14 AM	5:10 AM	Fresh Air	84	21.4	No
Jan 13 Night	6	6_4	6	Night	1/14/2005	5:10 AM	6:10 AM	OFF	82.4	31.8	No
Jan 20 Day	7	7_1	1	Day	1/20/2005	1:03 PM	2:03 PM	OFF	46.7	78.8	Yes
Jan 20 Day	7	7_1	2	Day	1/20/2005	2:03 PM	3:03 PM	Recirculation	54.8	52	Yes
Jan 20 Day	7	7_1	3	Day	1/20/2005	3:03 PM	4:03 PM	Recirculation	71.3	39.9	Yes
Jan 20 Day	7	7_1	4	Day	1/20/2005	4:03 PM	5:03 PM	Fresh Air	79.9	22.4	No
Jan 20 Day	7	7_1	5	Day	1/20/2005	5:06 PM	6:13 PM	Fresh Air	85.8	12.2	Yes

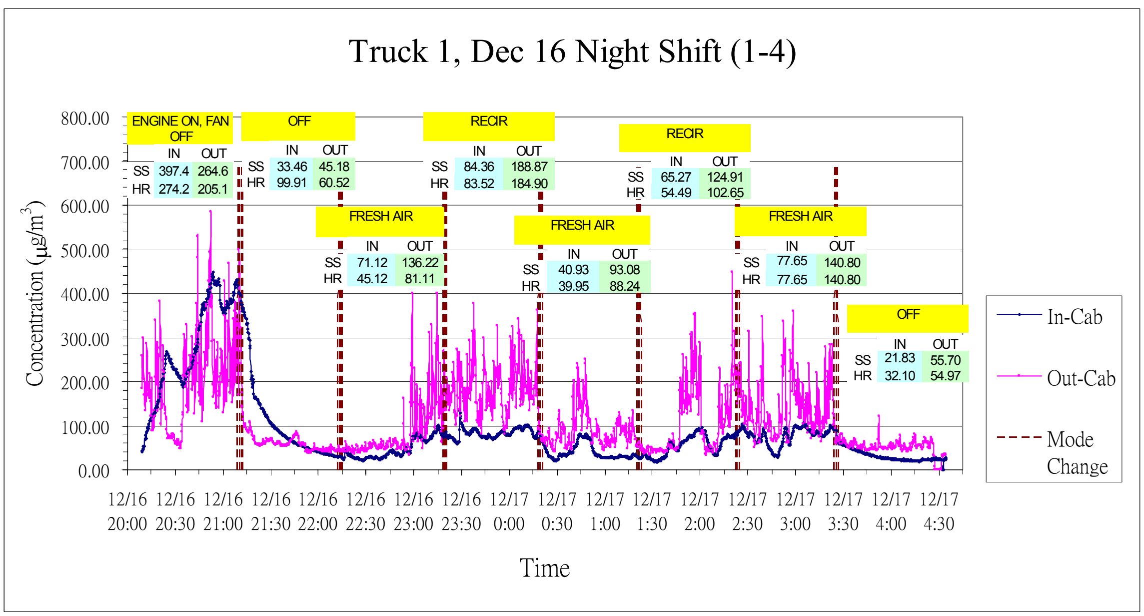
Note: Inside cab temperature and RH values summarized in these tables were measured using the Extech anemometer.

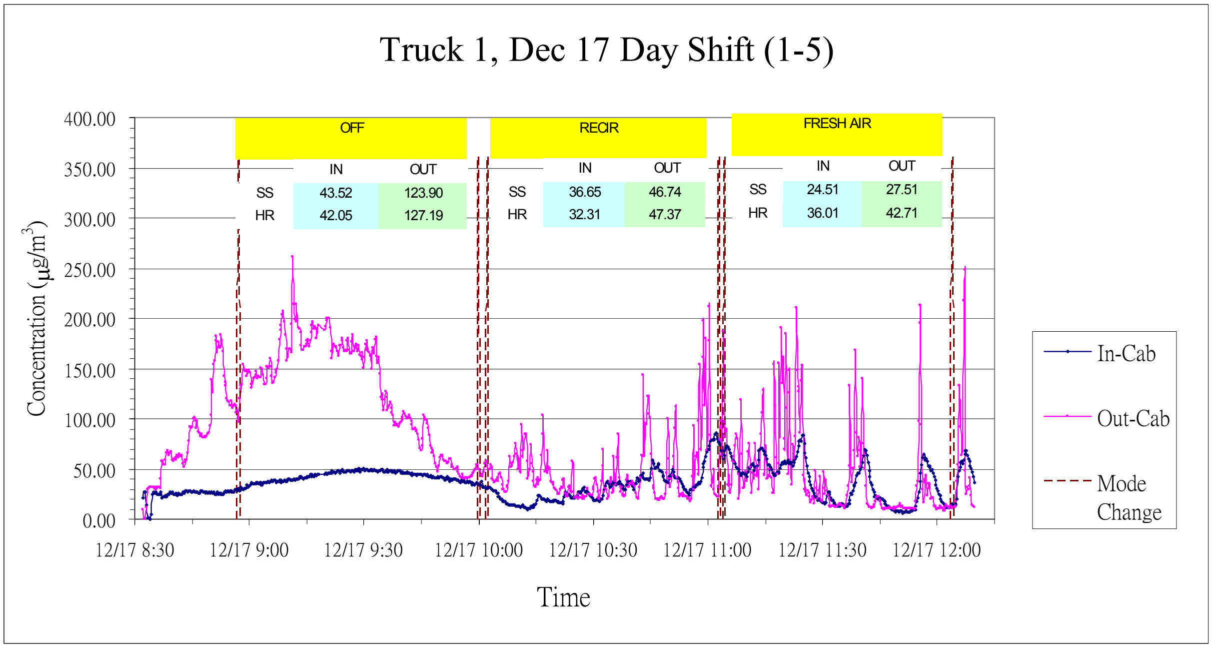
A-3: $PM_{2.5}$ Concentration Measurements

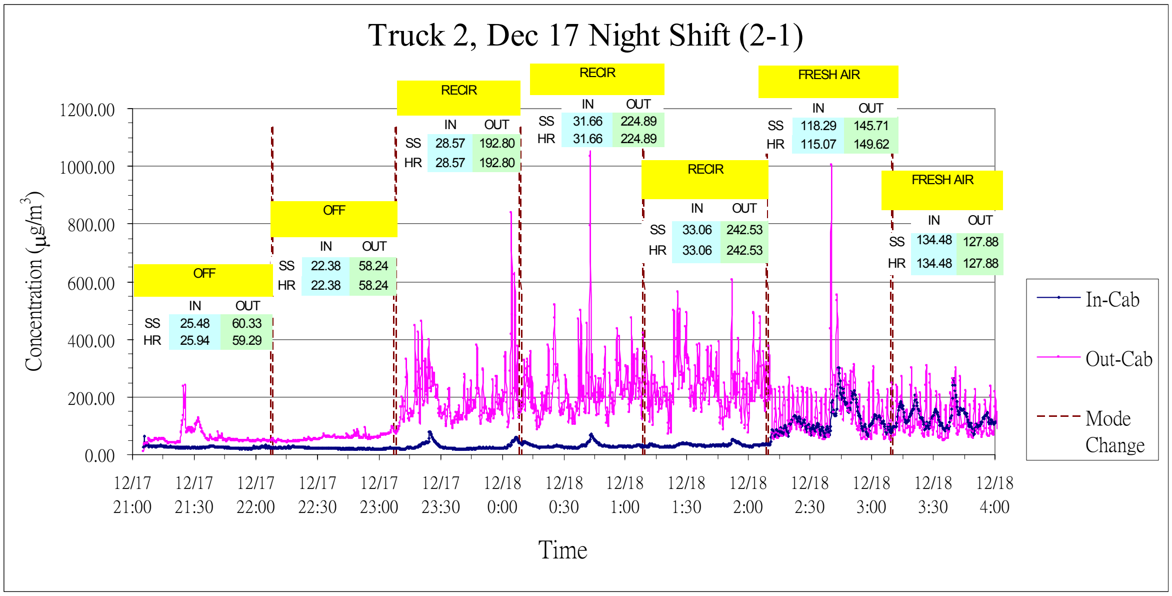

Truck 1, Dec 15 Day Shift (1-1)
OFF
IN OUT
SS 8.49 22.17
HR 8.52 21.65
Recirculation
IN OUT
SS 28.55 60.76
HR 18.86 43.81
Fresh Air
IN OUT
SS 54.94 -
HR 50.86 64.69
Concentration (μg/m3)
Time
In-Cab
Out-Cab
Mode Change

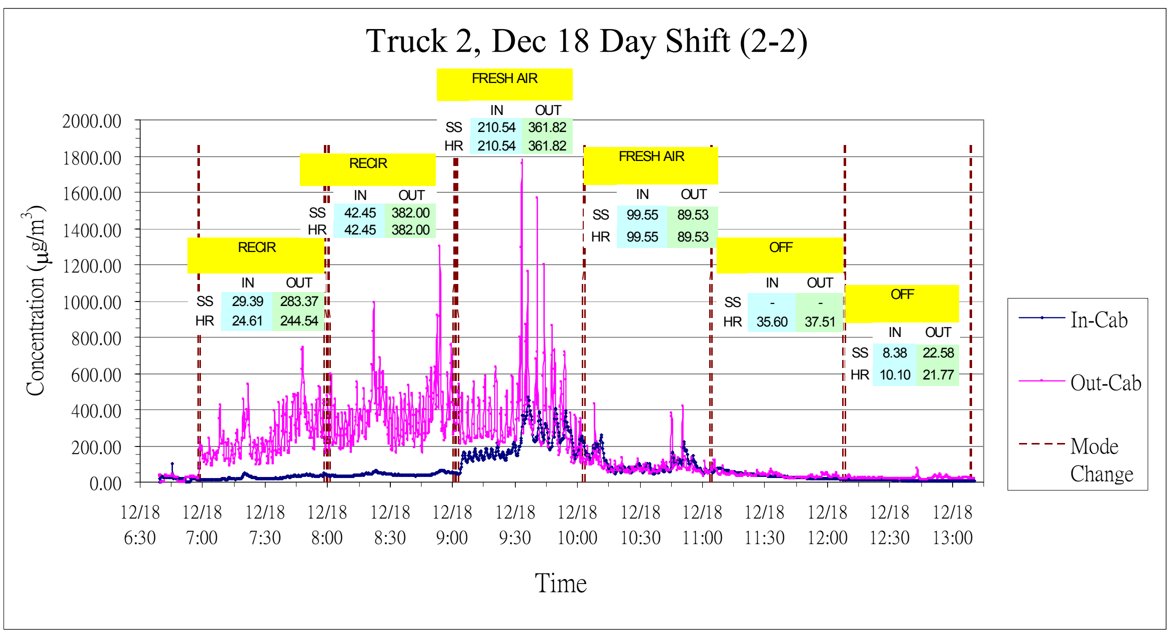

Truck 1, Dec 15 Night Shift (1-2)
OFF
IN OUT
SS 21.77 54.15
HR 21.83 53.55
OFF
IN OUT
SS 18.39 56.17
HR 18.98 59.72
RECIR
IN OUT
SS 49.59 123.19
HR 42.54 112.78
RECIR
IN OUT
SS 59.63 143.37
HR 59.24 142.71
RECIR
IN OUT
SS 61.79 168.19
HR 61.79 168.19
FRESH AIR
IN OUT
SS 92.59 125.74
HR 87.18 122.93
FRESH AIR
IN OUT
SS 92.54 135.16
HR 92.54 135.16
Concentration (μg/m3)
Time
In-Cab
Out-Cab
Mode Change

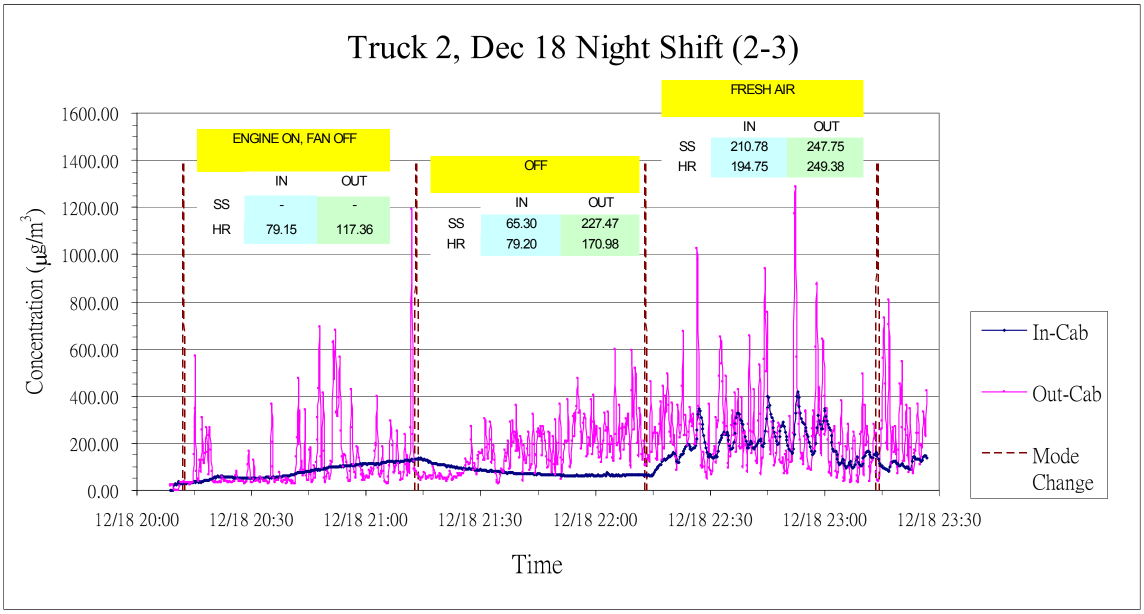

Truck 1, Dec 16 Day Shift (1-3)
Concentration (μg/m3)
Time
OFF
IN OUT
SS 30.76 85.43
HR 30.71 85.34
RECIR
IN OUT
SS 42.19 100.58
HR 40.12 104.95
RECIR
IN OUT
SS 75.46 123.47
HR 75.46 123.47
FRESH AIR
IN OUT
SS 33.64 56.99
HR 36.50 59.84
FRESH AIR
IN OUT
SS 35.07 55.05
HR 35.07 55.05
OFF
IN OUT
SS 29.81 100.21
HR 33.55 84.41
OFF
IN OUT
SS 30.32 73.80
HR 30.32 73.80
In-Cab
Out-Cab
Mode Change


Truck 1, Dec 16 Night Shift (1-4)
Concentration (μg/m3)
Time
ENGINE ON, FAN OFF
IN OUT
SS 397.4 264.6
HR 274.2 205.1
OFF
IN OUT
SS 33.46 45.18
HR 99.91 60.52
FRESH AIR
IN OUT
SS 71.12 136.22
HR 45.12 81.11
RECIR
IN OUT
SS 84.36 188.87
HR 83.52 184.90
FRESH AIR
IN OUT
SS 40.93 93.08
HR 39.95 88.24
RECIR
IN OUT
SS 65.27 124.91
HR 54.49 102.65
FRESH AIR
IN OUT
SS 77.65 140.80
HR 77.65 140.80
OFF
IN OUT
SS 21.83 55.70
HR 32.10 54.97
In-Cab
Out-Cab
Mode Change

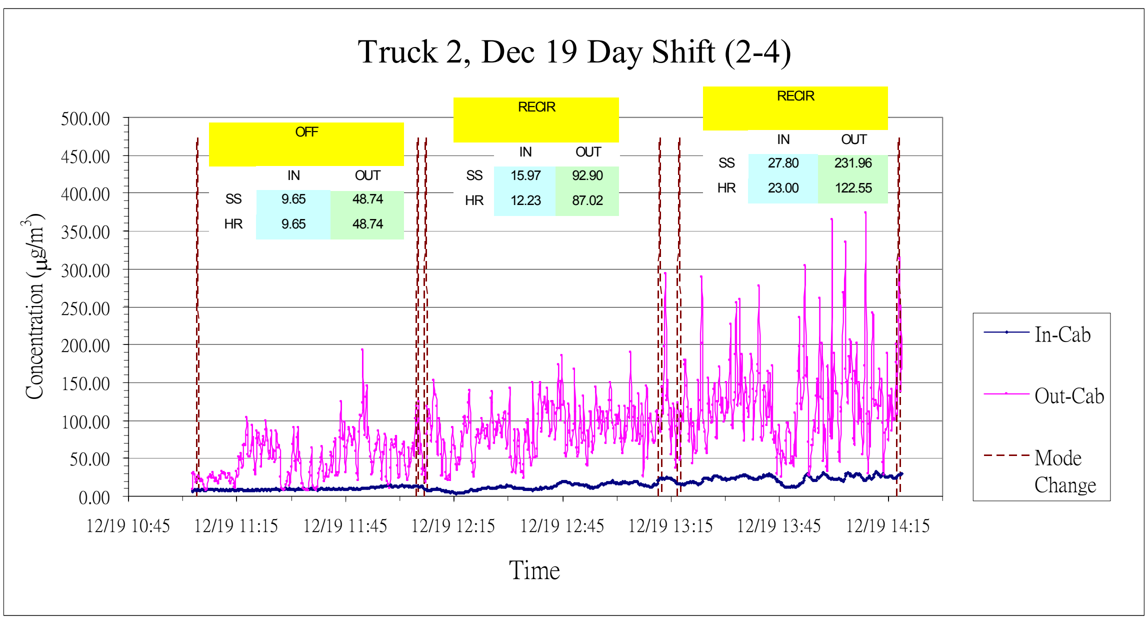

Truck 1, Dec 17 Day Shift (1-5)
OFF
IN
OUT
SS
43.52
123.90
HR
42.05
127.19
RECIR
IN
OUT
SS
36.65
46.74
HR
32.31
47.37
FRESH AIR
IN
OUT
SS
24.51
27.51
HR
36.01
42.71
Concentration (μg/m3)
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
12/17 8:30
12/17 9:00
12/17 9:30
12/17 10:00
12/17 10:30
12/17 11:00
12/17 11:30
12/17 12:00
Time
In-Cab
Out-Cab
Mode Change


Truck 2, Dec 17 Night Shift (2-1)
OFF
IN OUT
SS 25.48 60.33
HR 25.94 59.29
OFF
IN OUT
SS 22.38 58.24
HR 22.38 58.24
RECIR
IN OUT
SS 28.57 192.80
HR 28.57 192.80
RECIR
IN OUT
SS 31.66 224.89
HR 31.66 224.89
RECIR
IN OUT
SS 33.06 242.53
HR 33.06 242.53
FRESH AIR
IN OUT
SS 118.29 145.71
HR 115.07 149.62
FRESH AIR
IN OUT
SS 134.48 127.88
HR 134.48 127.88
Concentration (µg/m3)
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
12/17 21:00
12/17 21:30
12/17 22:00
12/17 22:30
12/17 23:00
12/17 23:30
12/18 0:00
12/18 0:30
12/18 1:00
12/18 1:30
12/18 2:00
12/18 2:30
12/18 3:00
12/18 3:30
12/18 4:00
Time
In-Cab
Out-Cab
Mode Change

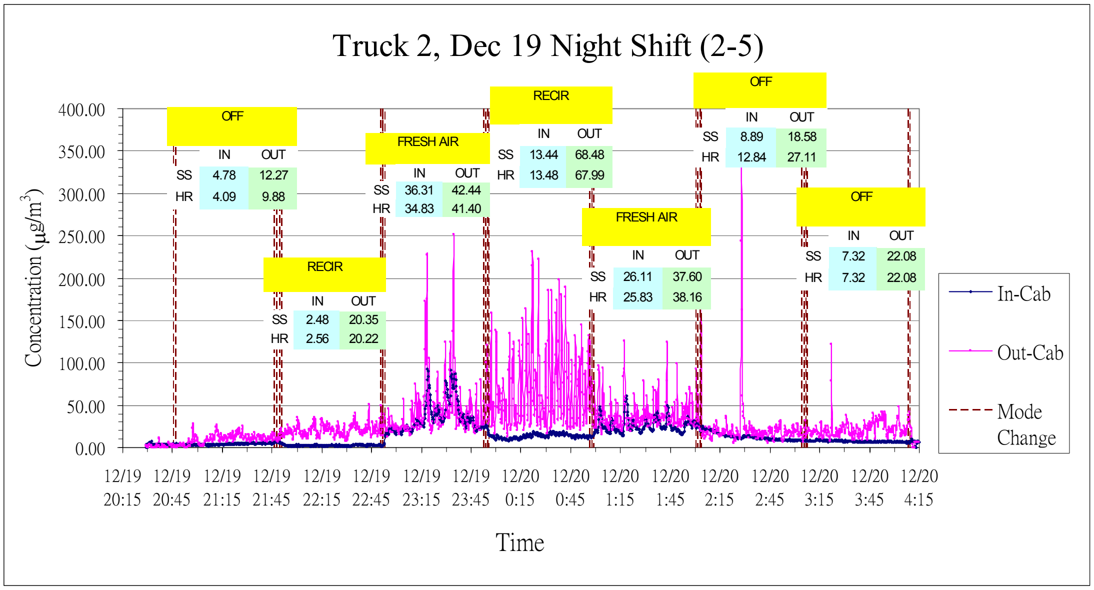

Truck 2, Dec 18 Day Shift (2-2)
RECIR
IN OUT
SS 29.39 283.37
HR 24.61 244.54
RECIR
IN OUT
SS 42.45 382.00
HR 42.45 382.00
FRESH AIR
IN OUT
SS 210.54 361.82
HR 210.54 361.82
FRESH AIR
IN OUT
SS 99.55 89.53
HR 99.55 89.53
OFF
IN OUT
SS - -
HR 35.60 37.51
OFF
IN OUT
SS 8.38 22.58
HR 10.10 21.77
Concentration (µg/m3)
2000.00
1800.00
1600.00
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
12/18 6:30
12/18 7:00
12/18 7:30
12/18 8:00
12/18 8:30
12/18 9:00
12/18 9:30
12/18 10:00
12/18 10:30
12/18 11:00
12/18 11:30
12/18 12:00
12/18 12:30
12/18 13:00
Time
In-Cab
Out-Cab
Mode Change



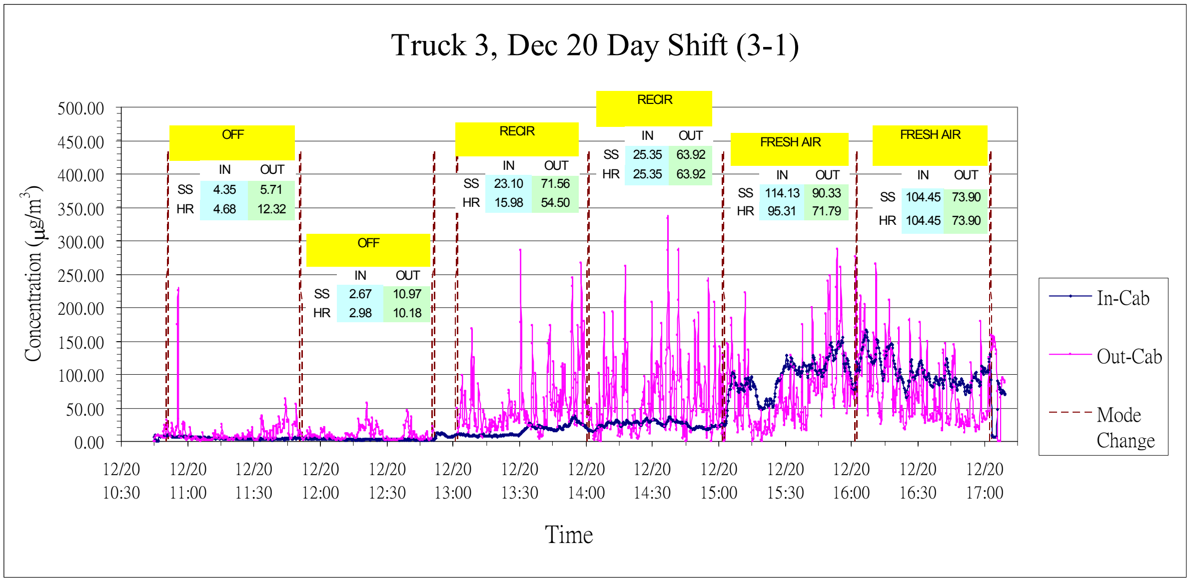
Truck 2, Dec 18 Night Shift (2-3)
ENGINE ON, FAN OFF
IN OUT
SS - -
HR 79.15 117.36
OFF
IN OUT
SS 65.30 227.47
HR 79.20 170.98
FRESH AIR
IN OUT
SS 210.78 247.75
HR 194.75 249.38
Concentration (μg/m3)
1600.00
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
12/18 20:00
12/18 20:30
12/18 21:00
12/18 21:30
12/18 22:00
12/18 22:30
12/18 23:00
12/18 23:30
Time
In-Cab
Out-Cab
Mode Change

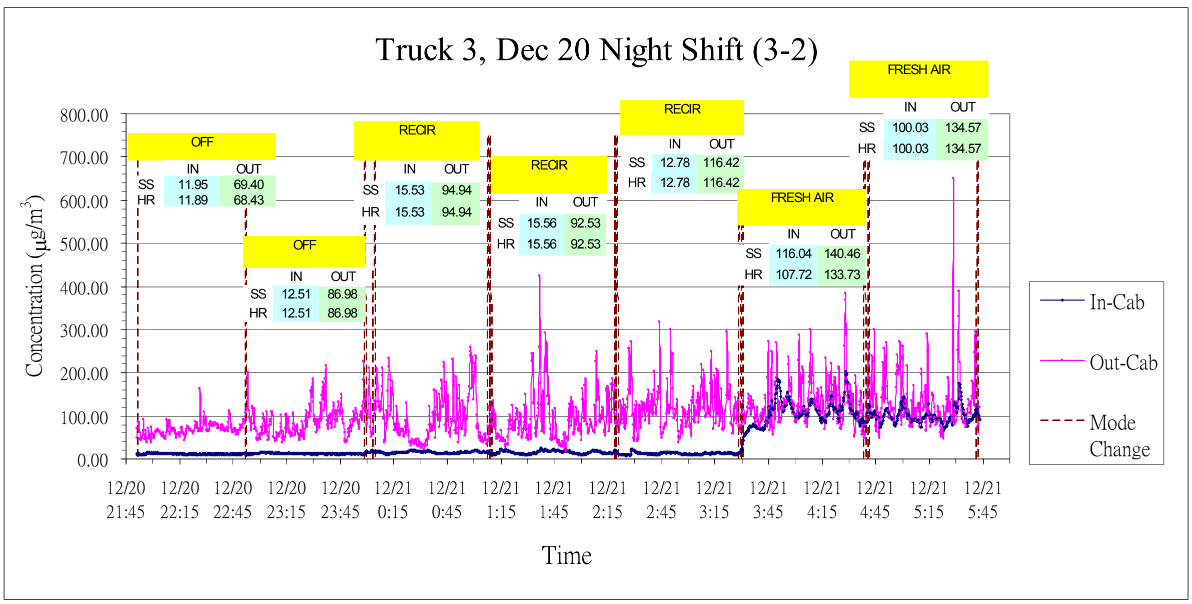


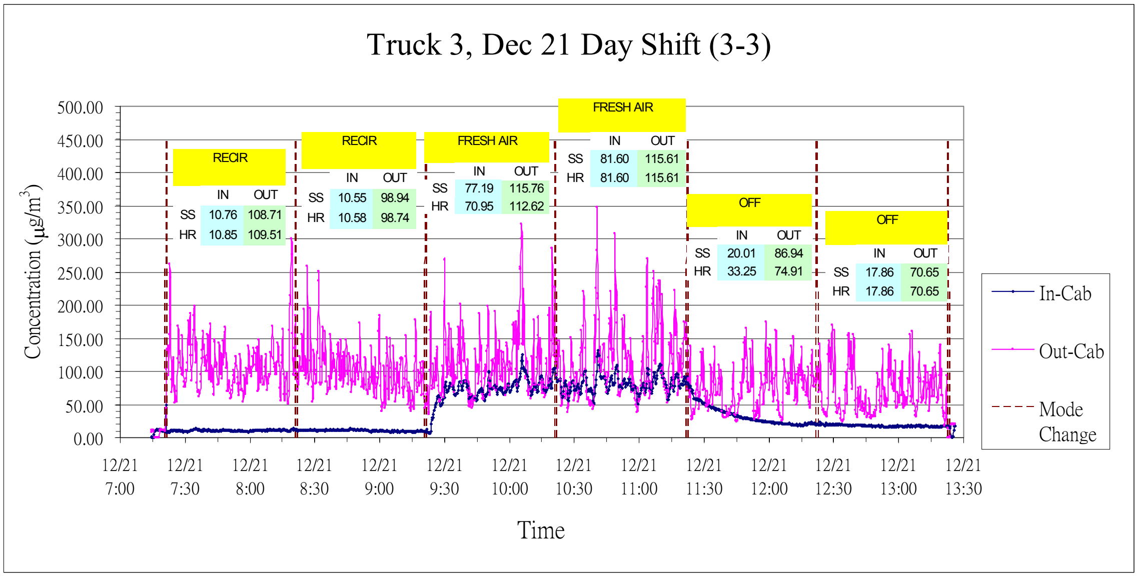
Truck 2, Dec 19 Day Shift (2-4)
OFF
IN OUT
SS 9.65 48.74
HR 9.65 48.74
RECIR
IN OUT
SS 15.97 92.90
HR 12.23 87.02
RECIR
IN OUT
SS 27.80 231.96
HR 23.00 122.55
Concentration (μg/m3)
500.00
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
12/19 10:45
12/19 11:15
12/19 11:45
12/19 12:15
12/19 12:45
12/19 13:15
12/19 13:45
12/19 14:15
Time
In-Cab
Out-Cab
Mode Change



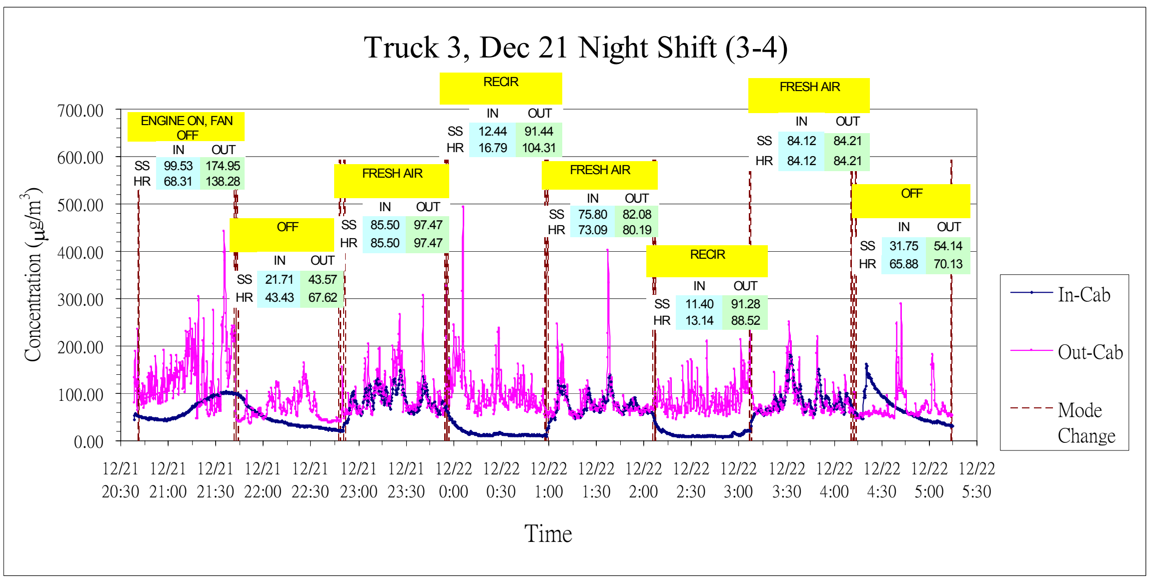
Truck 2, Dec 19 Night Shift (2-5)
Concentration (μg/m3)
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
OFF
IN OUT
SS 4.78 12.27
HR 4.09 9.88
RECIR
IN OUT
SS 2.48 20.35
HR 2.56 20.22
FRESH AIR
IN OUT
SS 36.31 42.44
HR 34.83 41.40
RECIR
IN OUT
SS 13.44 68.48
HR 13.48 67.99
FRESH AIR
IN OUT
SS 26.11 37.60
HR 25.83 38.16
OFF
IN OUT
SS 8.89 18.58
HR 12.84 27.11
OFF
IN OUT
SS 7.32 22.08
HR 7.32 22.08
12/19 20:15
12/19 20:45
12/19 21:15
12/19 21:45
12/19 22:15
12/19 22:45
12/19 23:15
12/19 23:45
12/20 0:15
12/20 0:45
12/20 1:15
12/20 1:45
12/20 2:15
12/20 2:45
12/20 3:15
12/20 3:45
12/20 4:15
Time
In-Cab
Out-Cab
Mode Change


Truck 3, Dec 20 Day Shift (3-1)
Concentration (µg/m3)
Time
OFF
IN OUT
SS 4.35 5.71
HR 4.68 12.32
OFF
IN OUT
SS 2.67 10.97
HR 2.98 10.18
RECIR
IN OUT
SS 23.10 71.56
HR 15.98 54.50
RECIR
IN OUT
SS 25.35 63.92
HR 25.35 63.92
FRESH AIR
IN OUT
SS 114.13 90.33
HR 95.31 71.79
FRESH AIR
IN OUT
SS 104.45 73.90
HR 104.45 73.90
In-Cab
Out-Cab
Mode Change

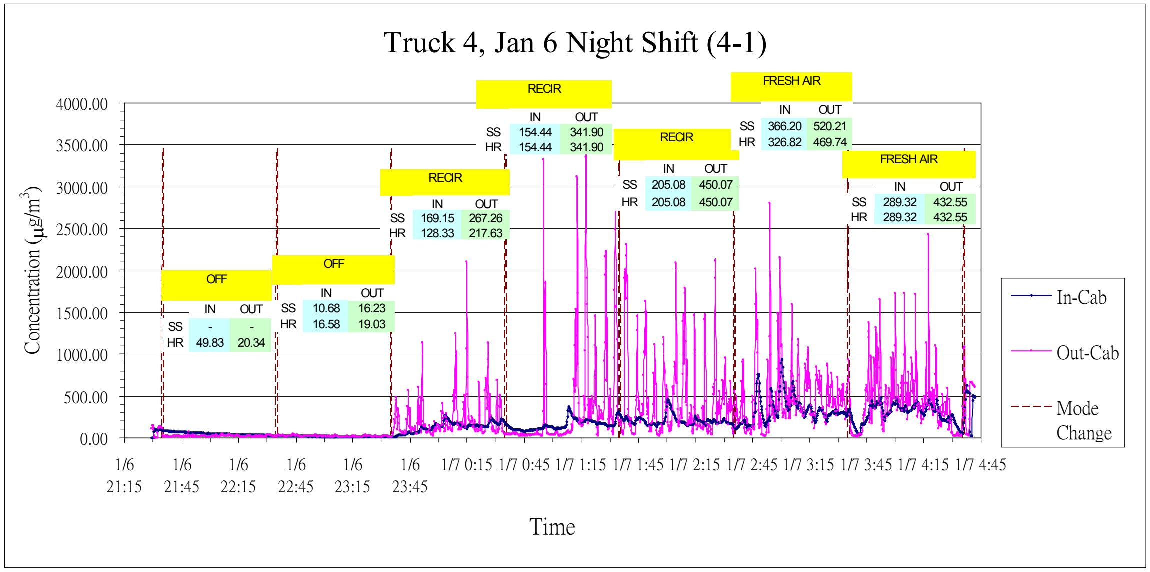

Truck 3, Dec 20 Night Shift (3-2)
Concentration (µg/m3)
Time
OFF
IN OUT
SS 11.95 69.40
HR 11.89 68.43
OFF
IN OUT
SS 12.51 86.98
HR 12.51 86.98
RECIR
IN OUT
SS 15.53 94.94
HR 15.53 94.94
RECIR
IN OUT
SS 15.56 92.53
HR 15.56 92.53
RECIR
IN OUT
SS 12.78 116.42
HR 12.78 116.42
FRESH AIR
IN OUT
SS 116.04 140.46
HR 107.72 133.73
FRESH AIR
IN OUT
SS 100.03 134.57
HR 100.03 134.57
In-Cab
Out-Cab
Mode Change

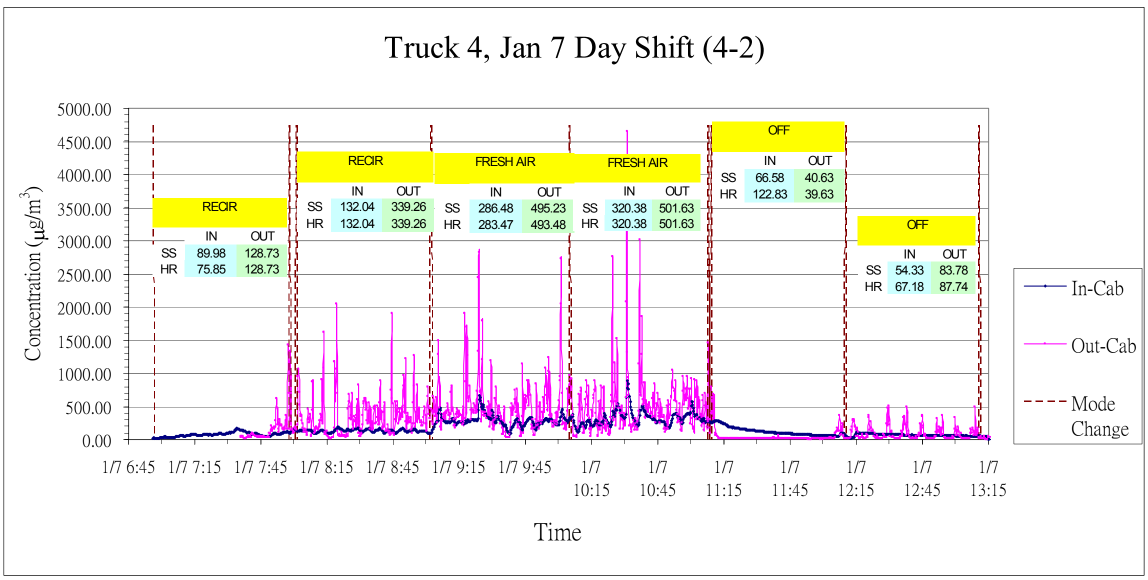


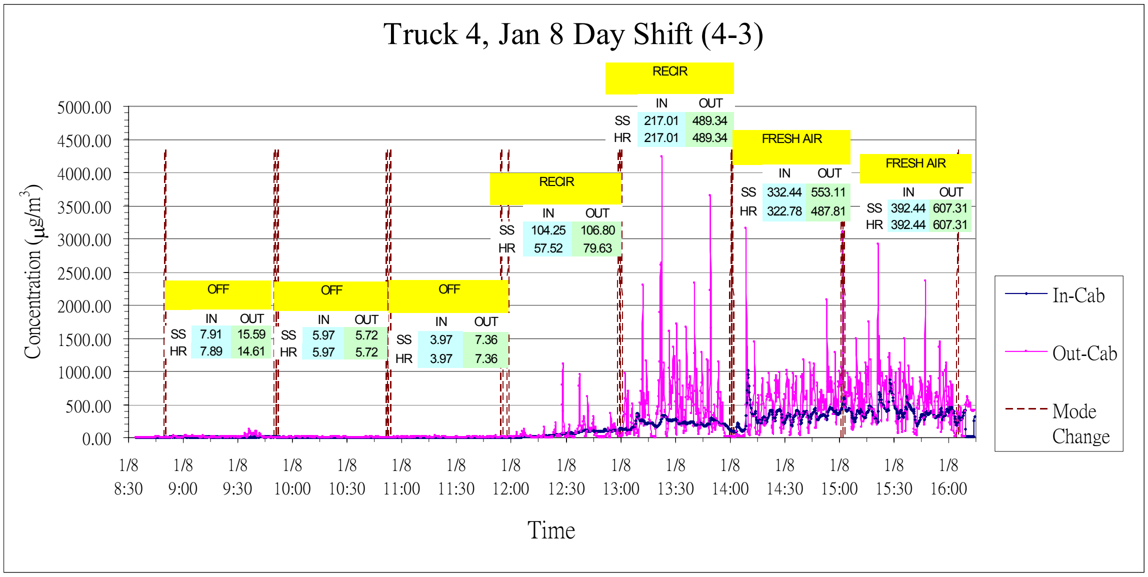
Truck 3, Dec 21 Day Shift (3-3)
RECIR
IN OUT
SS 10.76 108.71
HR 10.85 109.51
RECIR
IN OUT
SS 10.55 98.94
HR 10.58 98.74
FRESH AIR
IN OUT
SS 77.19 115.76
HR 70.95 112.62
FRESH AIR
IN OUT
SS 81.60 115.61
HR 81.60 115.61
OFF
IN OUT
SS 20.01 86.94
HR 33.25 74.91
OFF
IN OUT
SS 17.86 70.65
HR 17.86 70.65
Concentration (μg/m3)
Time
In-Cab
Out-Cab
Mode Change

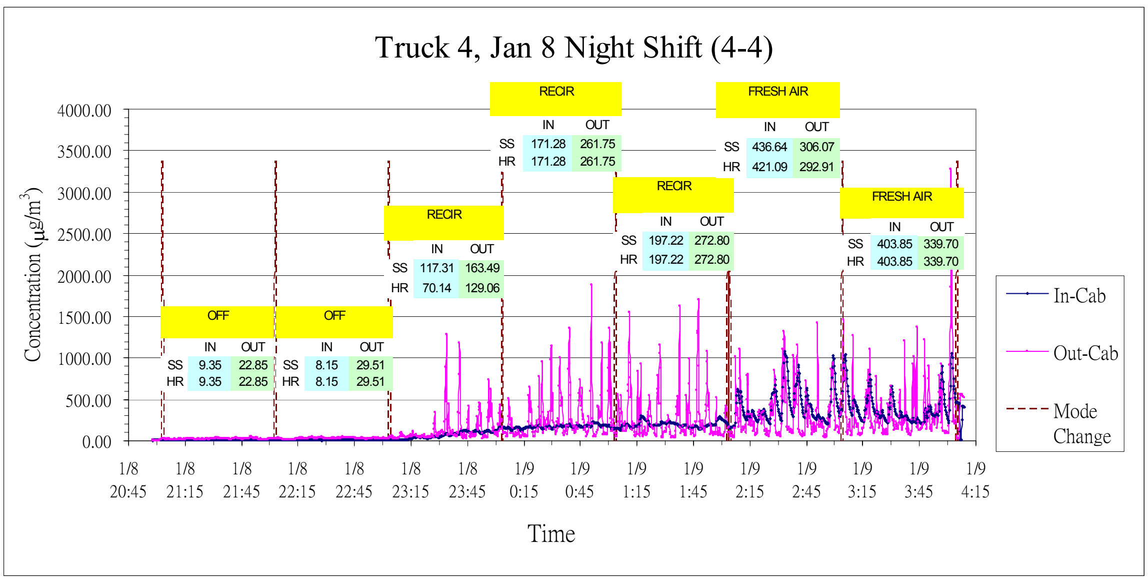


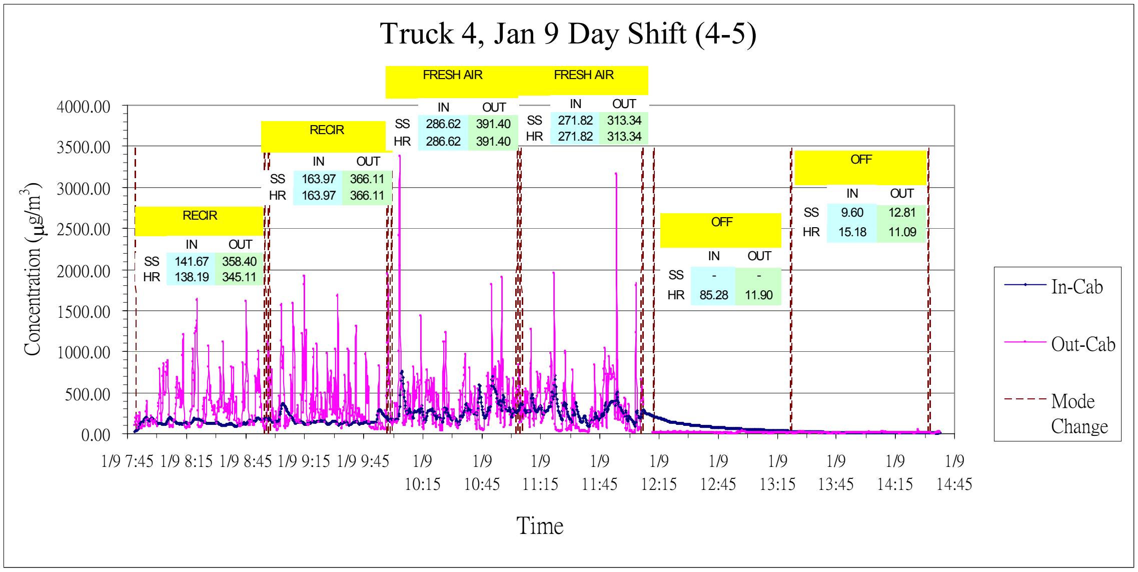
Truck 3, Dec 21 Night Shift (3-4)
ENGINE ON, FAN OFF
IN OUT
SS 99.53 174.95
HR 68.31 138.28
OFF
IN OUT
SS 21.71 43.57
HR 43.43 67.62
FRESH AIR
IN OUT
SS 85.50 97.47
HR 85.50 97.47
RECIR
IN OUT
SS 12.44 91.44
HR 16.79 104.31
FRESH AIR
IN OUT
SS 75.80 82.08
HR 73.09 80.19
RECIR
IN OUT
SS 11.40 91.28
HR 13.14 88.52
FRESH AIR
IN OUT
SS 84.12 84.21
HR 84.12 84.21
OFF
IN OUT
SS 31.75 54.14
HR 65.88 70.13
Concentration (μg/m3)
Time
In-Cab
Out-Cab
Mode Change

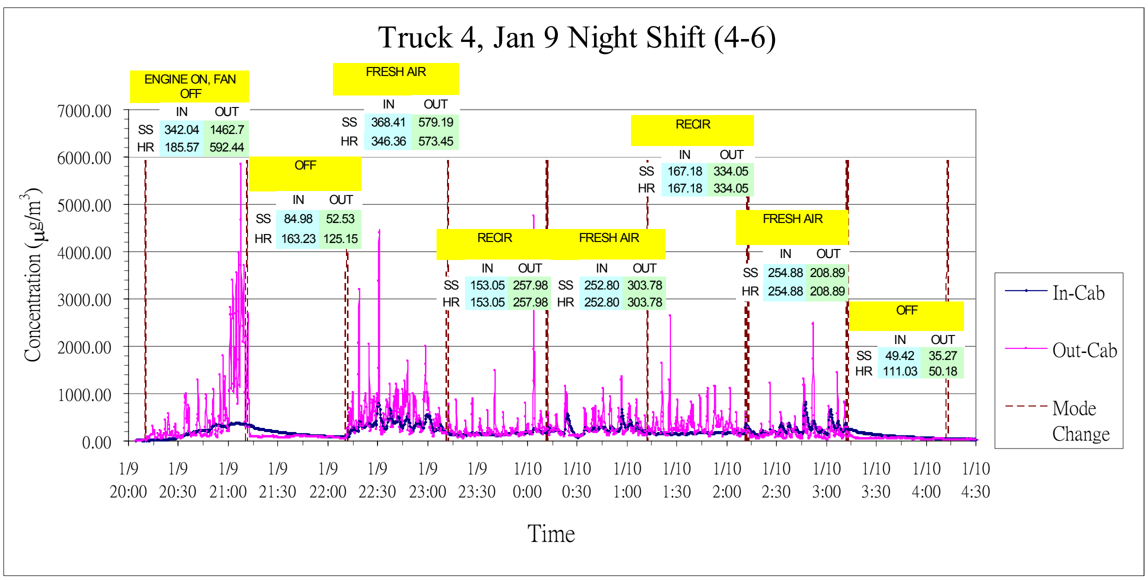

Truck 4, Jan 6 Night Shift (4-1)
OFF
IN OUT
SS - -
HR 49.83 20.34
OFF
IN OUT
SS 10.68 16.23
HR 16.58 19.03
RECIR
IN OUT
SS 169.15 267.26
HR 128.33 217.63
RECIR
IN OUT
SS 154.44 341.90
HR 154.44 341.90
RECIR
IN OUT
SS 205.08 450.07
HR 205.08 450.07
FRESH AIR
IN OUT
SS 366.20 520.21
HR 326.82 469.74
FRESH AIR
IN OUT
SS 289.32 432.55
HR 289.32 432.55
Concentration (μg/m3)
Time
In-Cab
Out-Cab
Mode Change

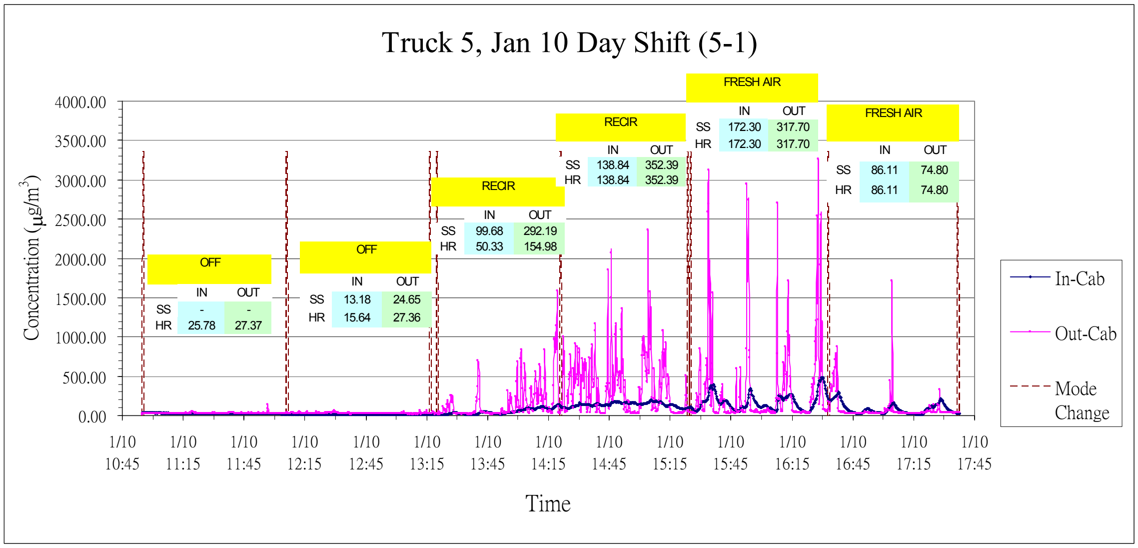

Truck 4, Jan 7 Day Shift (4-2)
RECIR
IN OUT
SS 89.98 128.73
HR 75.85 128.73
RECIR
IN OUT
SS 132.04 339.26
HR 132.04 339.26
FRESH AIR
IN OUT
SS 286.48 495.23
HR 283.47 493.48
FRESH AIR
IN OUT
SS 320.38 501.63
HR 320.38 501.63
OFF
IN OUT
SS 66.58 40.63
HR 122.83 39.63
OFF
IN OUT
SS 54.33 83.78
HR 67.18 87.74
Concentration (μg/m3)
Time
In-Cab
Out-Cab
Mode Change

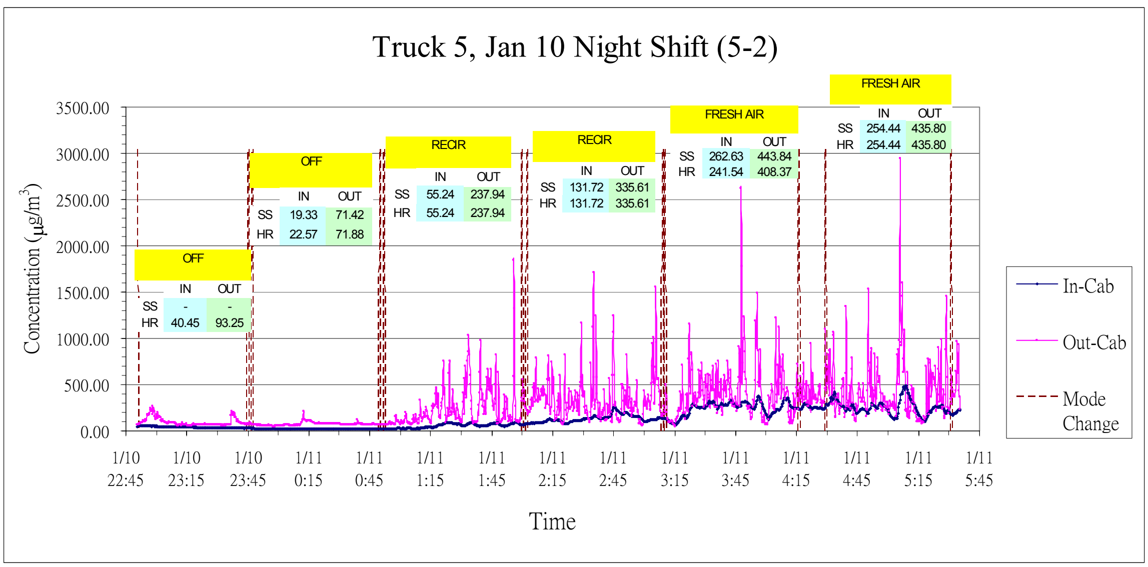

Truck 4, Jan 8 Day Shift (4-3)
Concentration (μg/m3)
Time
OFF
IN OUT
SS 7.91 15.59
HR 7.89 14.61
OFF
IN OUT
SS 5.97 5.72
HR 5.97 5.72
OFF
IN OUT
SS 3.97 7.36
HR 3.97 7.36
RECIR
IN OUT
SS 104.25 106.80
HR 57.52 79.63
RECIR
IN OUT
SS 217.01 489.34
HR 217.01 489.34
FRESH AIR
IN OUT
SS 332.44 553.11
HR 322.78 487.81
FRESH AIR
IN OUT
SS 392.44 607.31
HR 392.44 607.31
In-Cab
Out-Cab
Mode Change

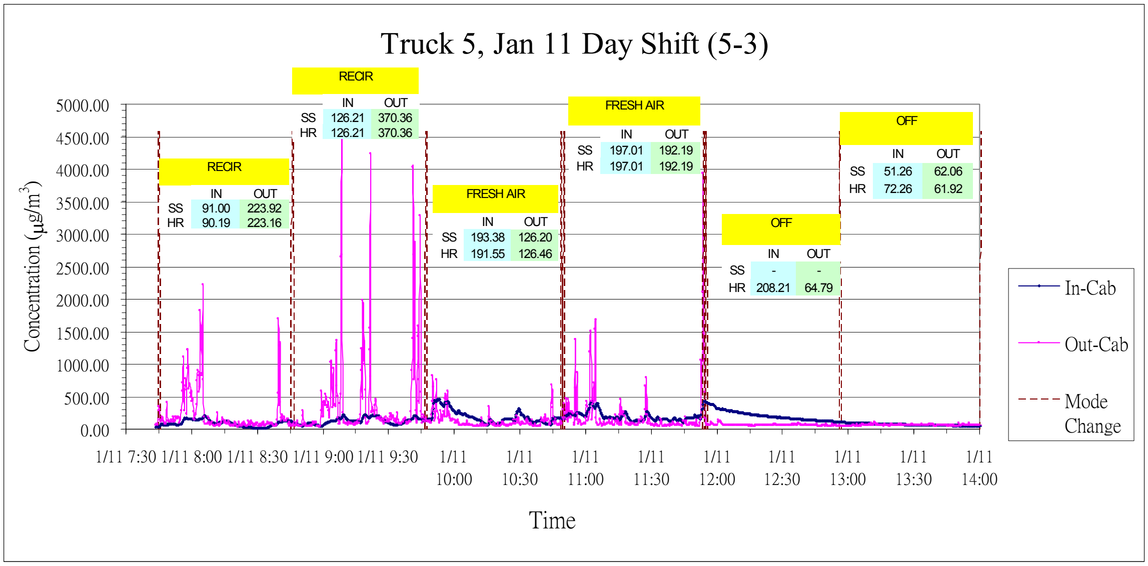

Truck 4, Jan 8 Night Shift (4-4)
Concentration (μg/m3)
Time
OFF
IN OUT
SS 9.35 22.85
HR 9.35 22.85
OFF
IN OUT
SS 8.15 29.51
HR 8.15 29.51
RECIR
IN OUT
SS 117.31 163.49
HR 70.14 129.06
RECIR
IN OUT
SS 171.28 261.75
HR 171.28 261.75
RECIR
IN OUT
SS 197.22 272.80
HR 197.22 272.80
FRESH AIR
IN OUT
SS 436.64 306.07
HR 421.09 292.91
FRESH AIR
IN OUT
SS 403.85 339.70
HR 403.85 339.70
In-Cab
Out-Cab
Mode Change


Truck 4, Jan 9 Day Shift (4-5)
RECIR
IN OUT
SS 141.67 358.40
HR 138.19 345.11
RECIR
IN OUT
SS 163.97 366.11
HR 163.97 366.11
FRESH AIR
IN OUT
SS 286.62 391.40
HR 286.62 391.40
FRESH AIR
IN OUT
SS 271.82 313.34
HR 271.82 313.34
OFF
IN OUT
SS - -
HR 85.28 11.90
OFF
IN OUT
SS 9.60 12.81
HR 15.18 11.09
Concentration (μg/m3)
Time
In-Cab
Out-Cab
Mode Change

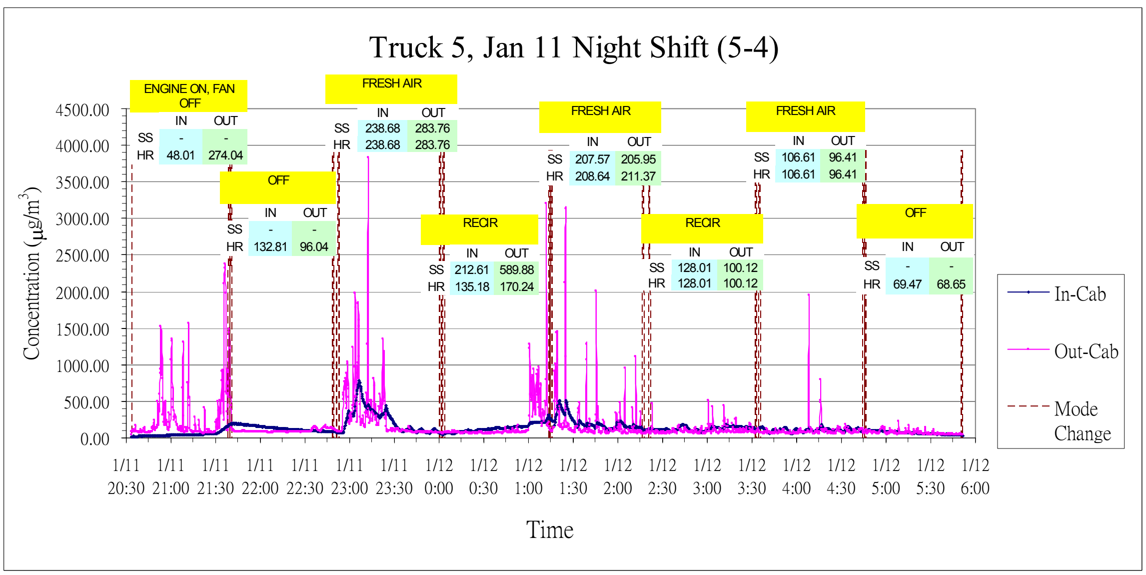

Truck 4, Jan 9 Night Shift (4-6)
ENGINE ON, FAN OFF
IN OUT
SS 342.04 1462.7
HR 185.57 592.44
OFF
IN OUT
SS 84.98 52.53
HR 163.23 125.15
FRESH AIR
IN OUT
SS 368.41 579.19
HR 346.36 573.45
RECIR
IN OUT
SS 153.05 257.98
HR 153.05 257.98
FRESH AIR
IN OUT
SS 252.80 303.78
HR 252.80 303.78
RECIR
IN OUT
SS 167.18 334.05
HR 167.18 334.05
FRESH AIR
IN OUT
SS 254.88 208.89
HR 254.88 208.89
OFF
IN OUT
SS 49.42 35.27
HR 111.03 50.18
Concentration (μg/m3)
Time
In-Cab
Out-Cab
Mode Change


Truck 5, Jan 10 Day Shift (5-1)
Concentration (μg/m3)
Time
OFF
OFF
RECIR
RECIR
FRESH AIR
FRESH AIR
IN
OUT
SS
HR
In-Cab
Out-Cab
Mode Change

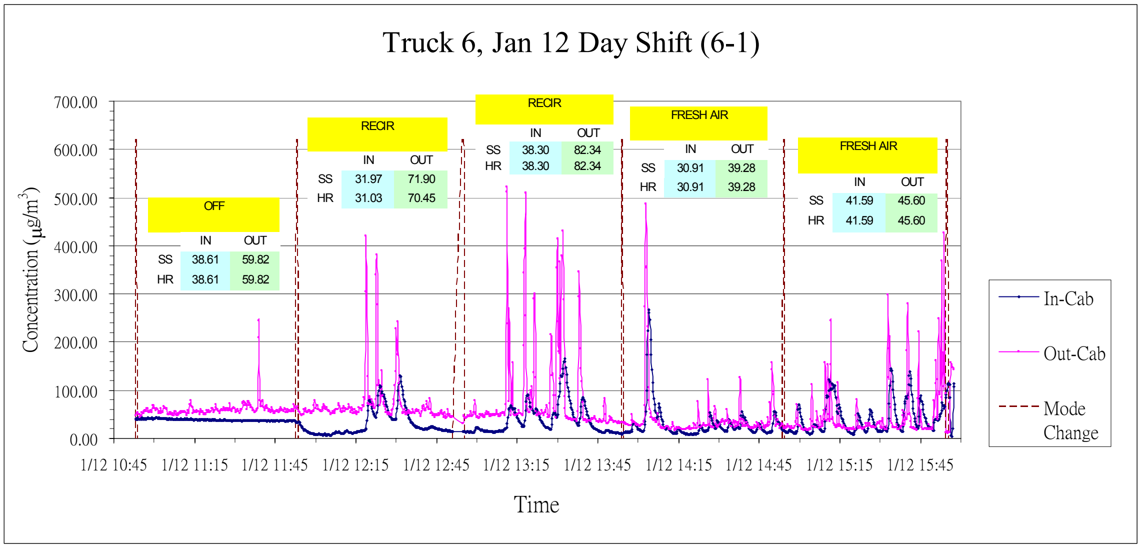

Truck 5, Jan 10 Night Shift (5-2)
Concentration (μg/m3)
Time
OFF
OFF
RECIR
RECIR
FRESH AIR
FRESH AIR
IN
OUT
SS
HR
In-Cab
Out-Cab
Mode Change



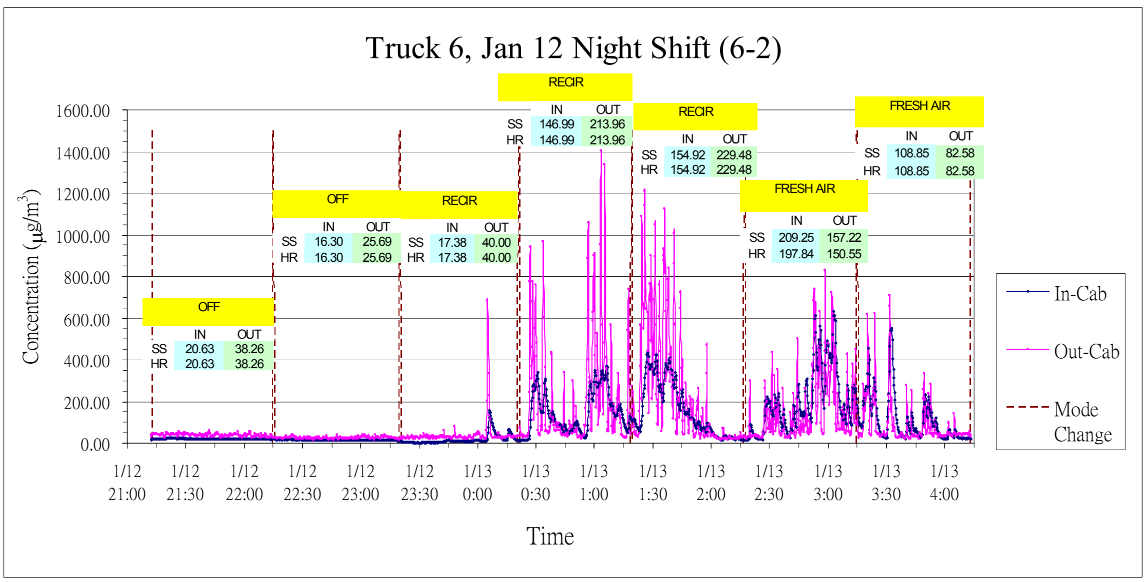
Truck 5, Jan 11 Day Shift (5-3)
RECIR
IN OUT
SS 91.00 223.92
HR 90.19 223.16
RECIR
IN OUT
SS 126.21 370.36
HR 126.21 370.36
FRESH AIR
IN OUT
SS 193.38 126.20
HR 191.55 126.46
FRESH AIR
IN OUT
SS 197.01 192.19
HR 197.01 192.19
OFF
IN OUT
SS - -
HR 208.21 64.79
OFF
IN OUT
SS 51.26 62.06
HR 72.26 61.92
Concentration (μg/m3)
Time
In-Cab
Out-Cab
Mode Change



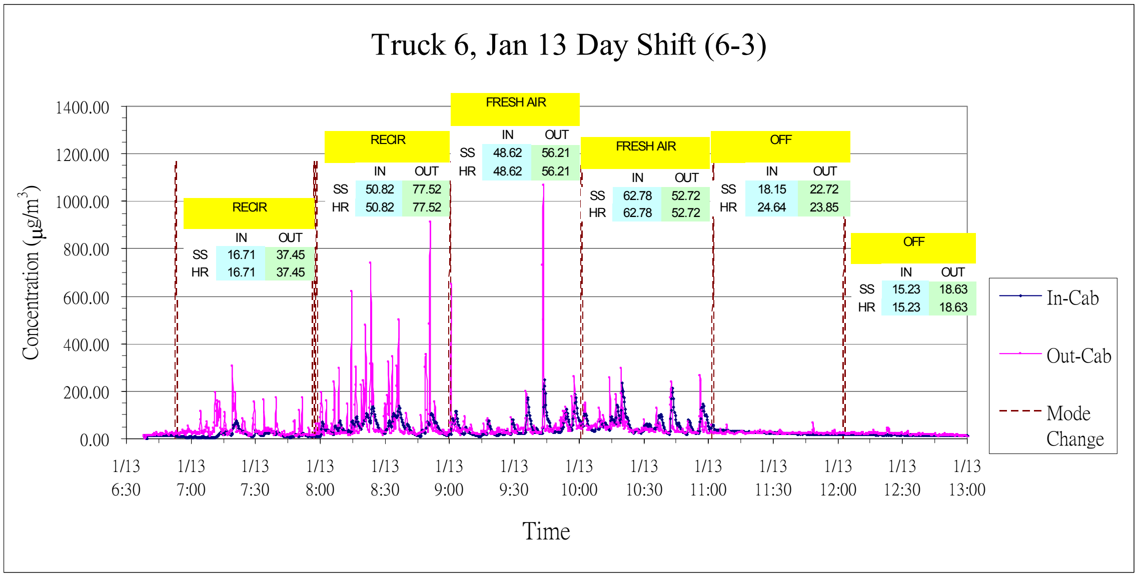
Truck 5, Jan 11 Night Shift (5-4)
ENGINE ON, FAN OFF
IN OUT
SS - -
HR 48.01 274.04
OFF
IN OUT
SS - -
HR 132.81 96.04
FRESH AIR
IN OUT
SS 238.68 283.76
HR 238.68 283.76
RECIR
IN OUT
SS 212.61 589.88
HR 135.18 170.24
FRESH AIR
IN OUT
SS 207.57 205.95
HR 208.64 211.37
RECIR
IN OUT
SS 128.01 100.12
HR 128.01 100.12
FRESH AIR
IN OUT
SS 106.61 96.41
HR 106.61 96.41
OFF
IN OUT
SS - -
HR 69.47 68.65
Concentration (μg/m3)
Time
In-Cab
Out-Cab
Mode Change

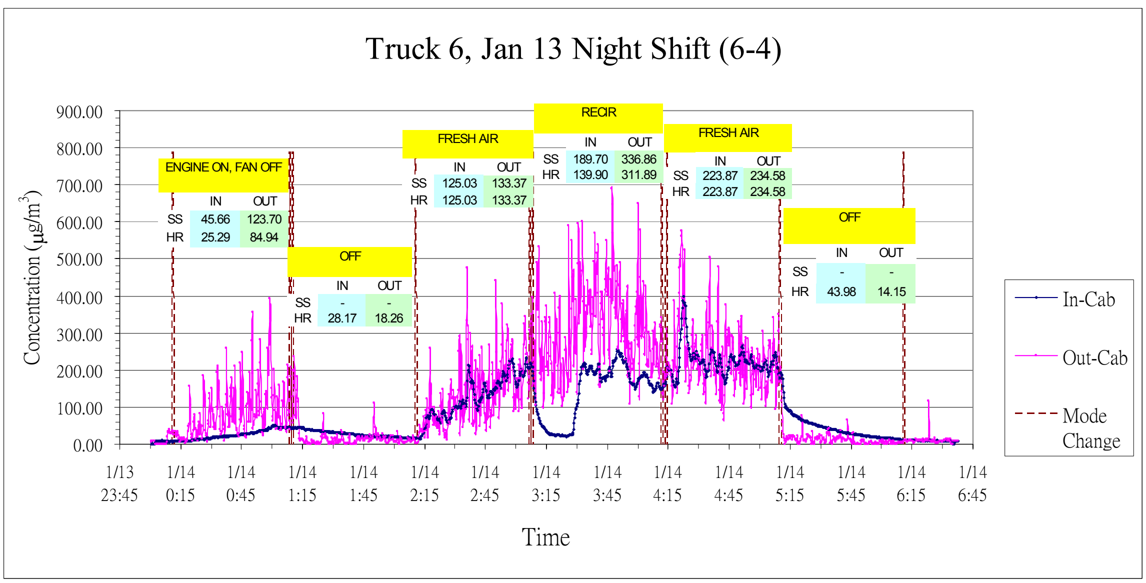


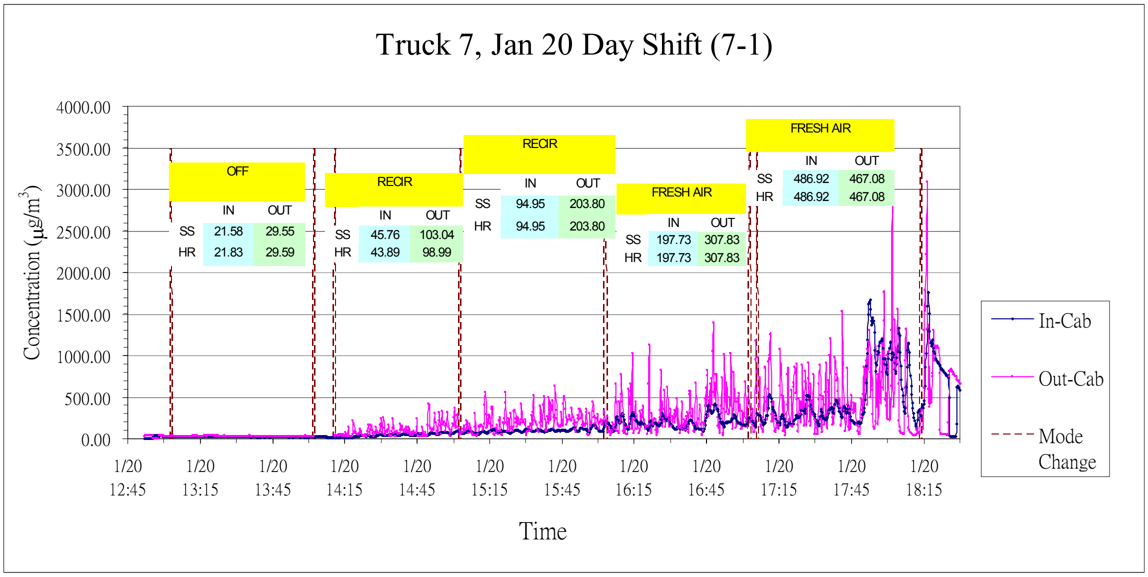
Truck 6, Jan 12 Day Shift (6-1)
Concentration (μg/m3)
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
OFF
IN OUT
SS 38.61 59.82
HR 38.61 59.82
RECIR
IN OUT
SS 31.97 71.90
HR 31.03 70.45
RECIR
IN OUT
SS 38.30 82.34
HR 38.30 82.34
FRESH AIR
IN OUT
SS 30.91 39.28
HR 30.91 39.28
FRESH AIR
IN OUT
SS 41.59 45.60
HR 41.59 45.60
1/12 10:45
1/12 11:15
1/12 11:45
1/12 12:15
1/12 12:45
1/12 13:15
1/12 13:45
1/12 14:15
1/12 14:45
1/12 15:15
1/12 15:45
Time
In-Cab
Out-Cab
Mode Change



Truck 6, Jan 12 Night Shift (6-2)
Concentration (μg/m3)
1600.00
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
OFF
IN OUT
SS 20.63 38.26
HR 20.63 38.26
OFF
IN OUT
SS 16.30 25.69
HR 16.30 25.69
RECIR
IN OUT
SS 17.38 40.00
HR 17.38 40.00
RECIR
IN OUT
SS 146.99 213.96
HR 146.99 213.96
RECIR
IN OUT
SS 154.92 229.48
HR 154.92 229.48
FRESH AIR
IN OUT
SS 209.25 157.22
HR 197.84 150.55
FRESH AIR
IN OUT
SS 108.85 82.58
HR 108.85 82.58
1/12 21:00
1/12 21:30
1/12 22:00
1/12 22:30
1/12 23:00
1/12 23:30
1/13 0:00
1/13 0:30
1/13 1:00
1/13 1:30
1/13 2:00
1/13 2:30
1/13 3:00
1/13 3:30
1/13 4:00
Time
In-Cab
Out-Cab
Mode Change


Truck 6, Jan 13 Day Shift (6-3)
Concentration (μg/m3)
Time
In-Cab
Out-Cab
Mode Change
RECIR
IN OUT
SS 16.71 37.45
HR 16.71 37.45
RECIR
IN OUT
SS 50.82 77.52
HR 50.82 77.52
FRESH AIR
IN OUT
SS 48.62 56.21
HR 48.62 56.21
FRESH AIR
IN OUT
SS 62.78 52.72
HR 62.78 52.72
OFF
IN OUT
SS 18.15 22.72
HR 24.64 23.85
OFF
IN OUT
SS 15.23 18.63
HR 15.23 18.63

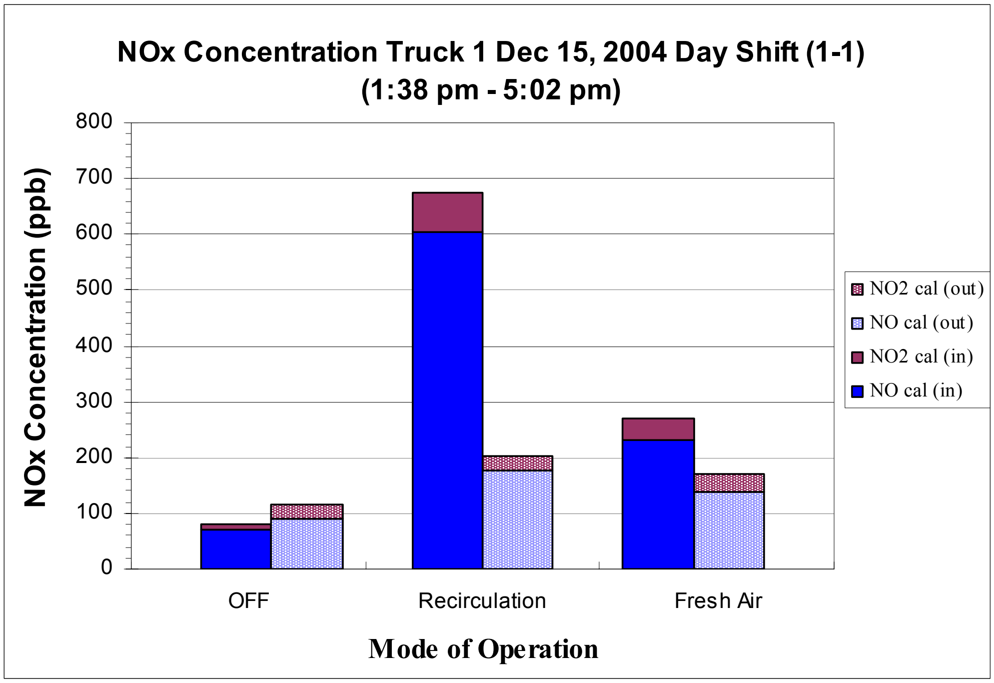

Truck 6, Jan 13 Night Shift (6-4)
Concentration (μg/m3)
Time
In-Cab
Out-Cab
Mode Change
ENGINE ON, FAN OFF
IN OUT
SS 45.66 123.70
HR 25.29 84.94
OFF
IN OUT
SS - -
HR 28.17 18.26
FRESH AIR
IN OUT
SS 125.03 133.37
HR 125.03 133.37
RECIR
IN OUT
SS 189.70 336.86
HR 139.90 311.89
FRESH AIR
IN OUT
SS 223.87 234.58
HR 223.87 234.58
OFF
IN OUT
SS - -
HR 43.98 14.15



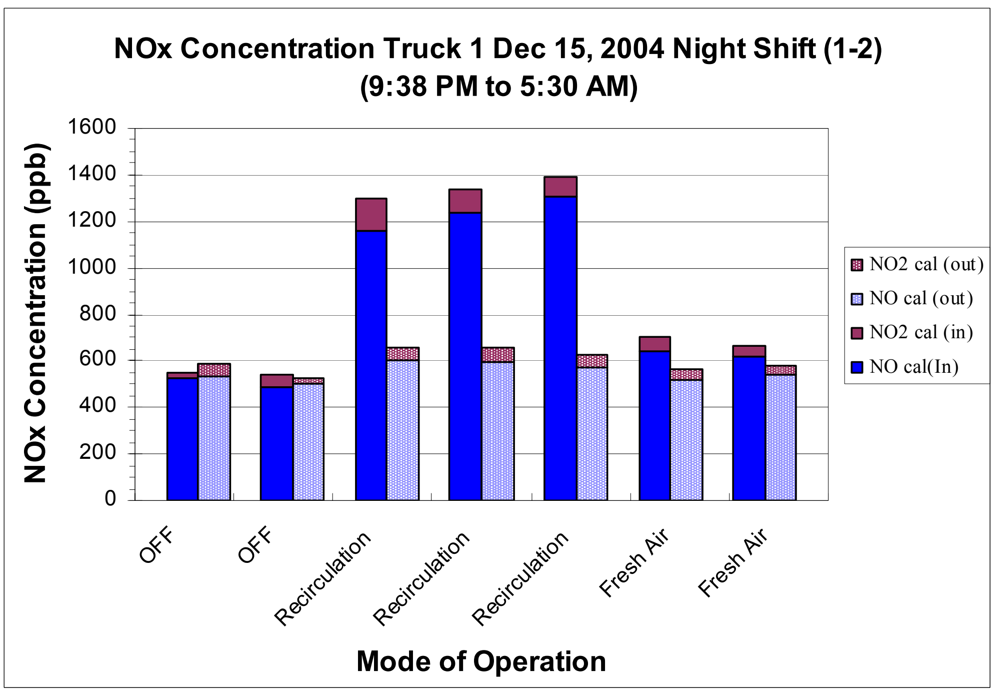
Truck 7, Jan 20 Day Shift (7-1)
Concentration (μg/m3)
4000.00
3500.00
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
OFF
IN OUT
SS 21.58 29.55
HR 21.83 29.59
RECIR
IN OUT
SS 45.76 103.04
HR 43.89 98.99
RECIR
IN OUT
SS 94.95 203.80
HR 94.95 203.80
FRESH AIR
IN OUT
SS 197.73 307.83
HR 197.73 307.83
FRESH AIR
IN OUT
SS 486.92 467.08
HR 486.92 467.08
1/20 12:45
1/20 13:15
1/20 13:45
1/20 14:15
1/20 14:45
1/20 15:15
1/20 15:45
1/20 16:15
1/20 16:45
1/20 17:15
1/20 17:45
1/20 18:15
Time
In-Cab
Out-Cab
Mode Change

A-4: NOx Concentration Measurements

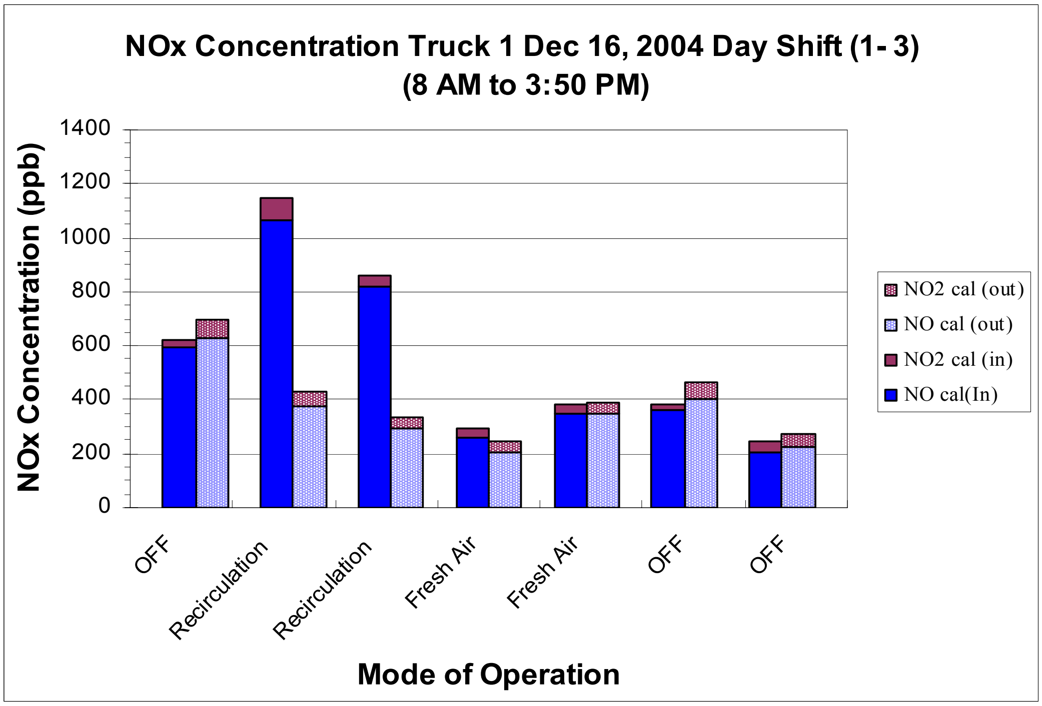
(The word “cal” in the legends refers to “calibrated” concentrations)

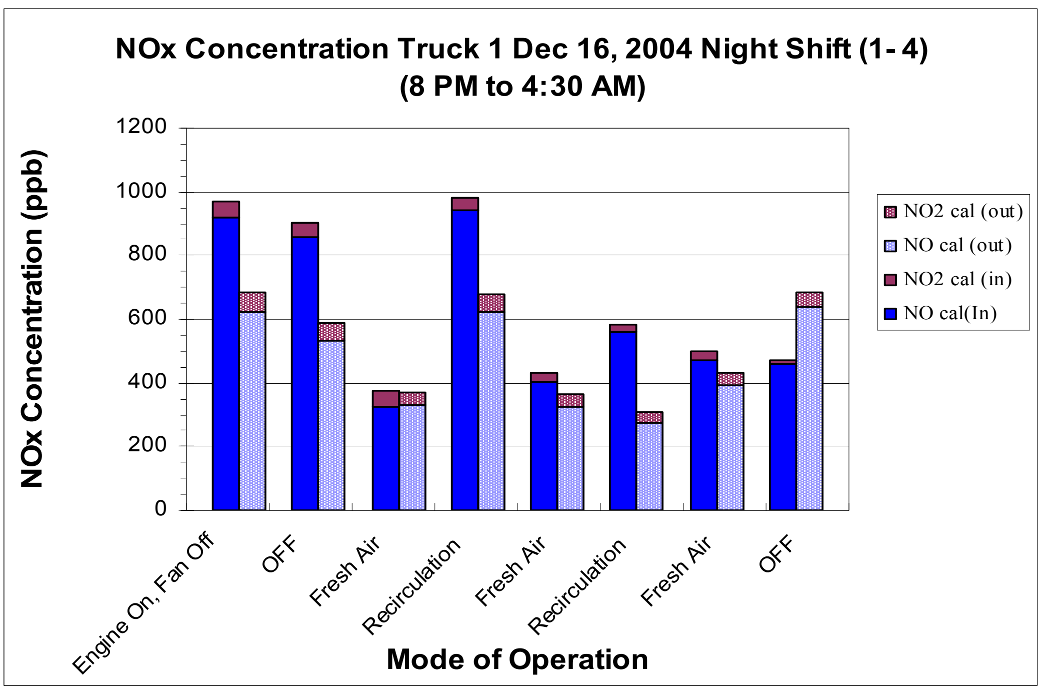


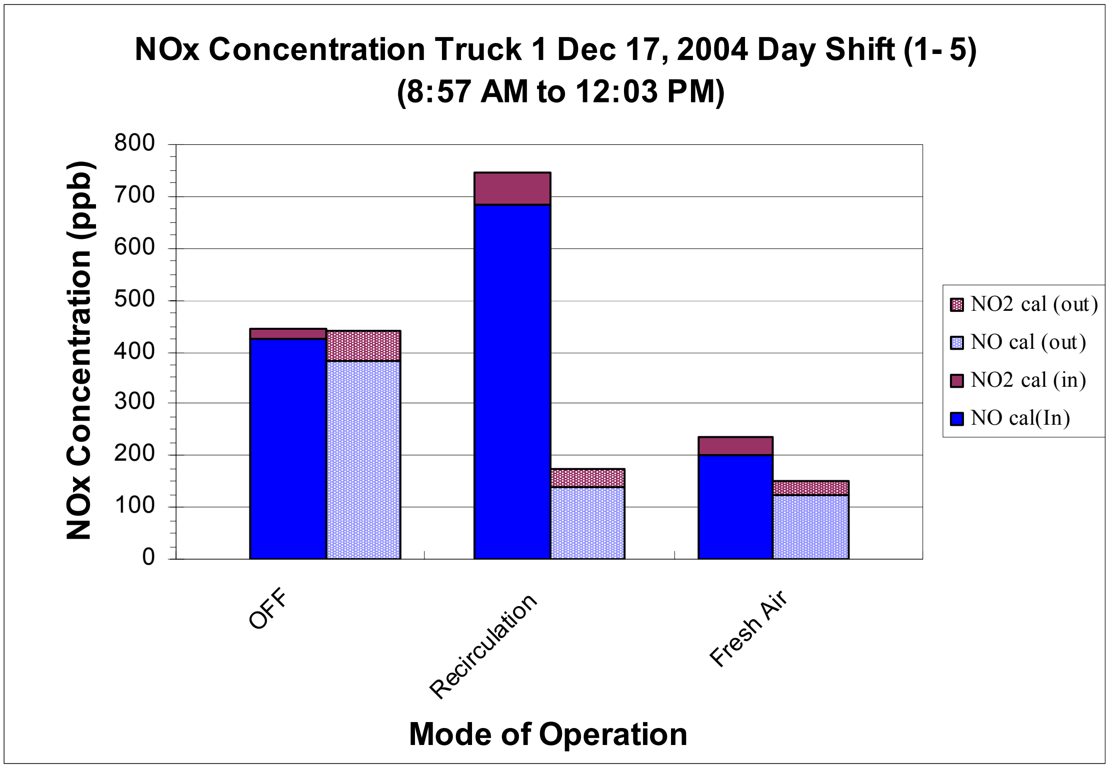
NOx Concentration Truck 1 Dec 15, 2004 Day Shift (1-1)
(1:38 pm - 5:02 pm)
NOx Concentration (ppb)
800
700
600
500
400
300
200
100
0
OFF
Recirculation
Fresh Air
Mode of Operation
NO2 cal (out)
NO cal (out)
NO2 cal (in)
NO cal (in)



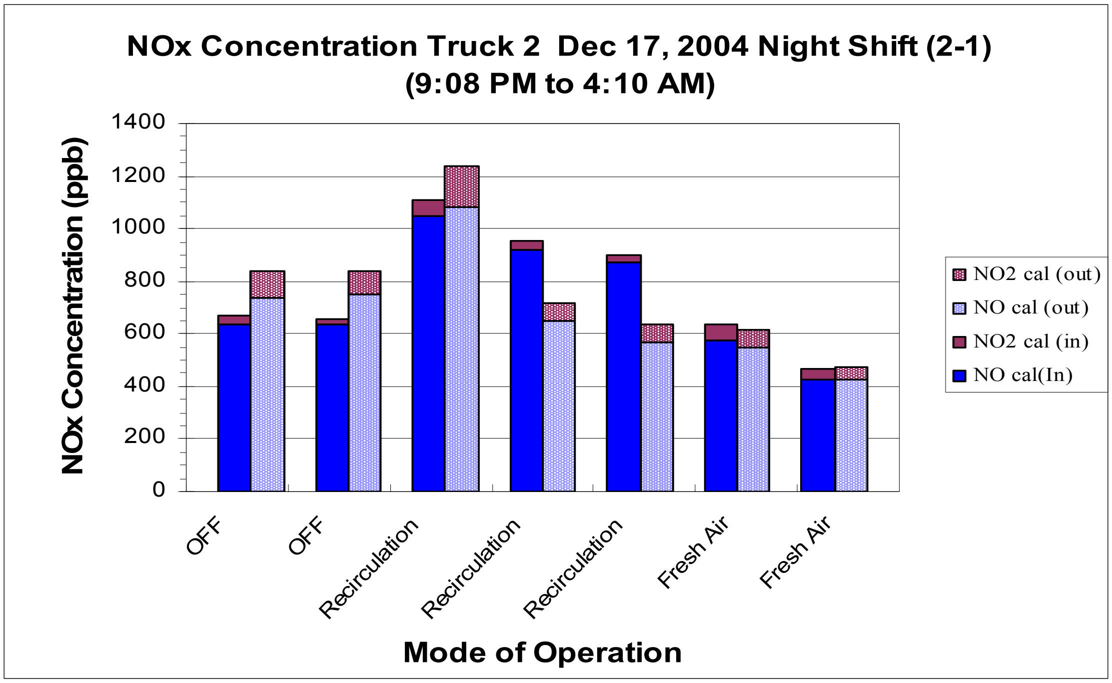
NOx Concentration Truck 1 Dec 15, 2004 Night Shift (1-2)
(9:38 PM to 5:30 AM)
NOx Concentration (ppb)
1600
1400
1200
1000
800
600
400
200
0
OFF
OFF
Recirculation
Recirculation
Recirculation
Fresh Air
Fresh Air
Mode of Operation
NO2 cal (out)
NO cal (out)
NO2 cal (in)
NO cal(In)

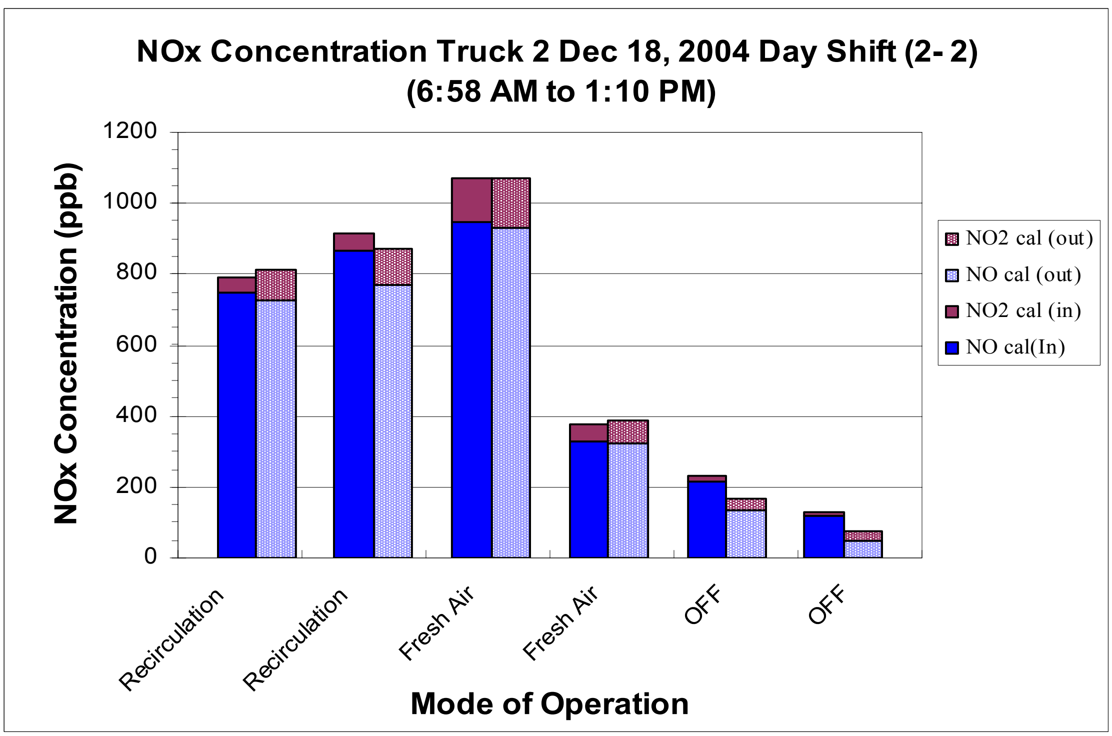

NOx Concentration Truck 1 Dec 16, 2004 Day Shift (1- 3)
(8 AM to 3:50 PM)
NOx Concentration (ppb)
1400
1200
1000
800
600
400
200
0
OFF
Recirculation
Recirculation
Fresh Air
Fresh Air
OFF
OFF
Mode of Operation
NO2 cal (out)
NO cal (out)
NO2 cal (in)
NO cal(In)

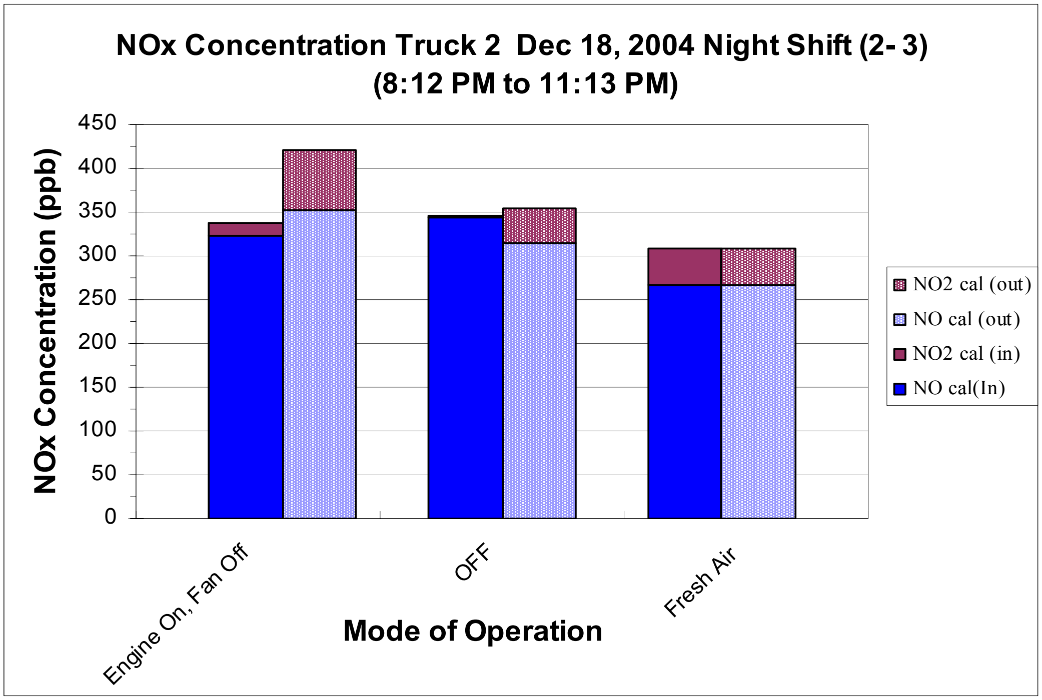

NOx Concentration Truck 1 Dec 16, 2004 Night Shift (1- 4)
(8 PM to 4:30 AM)
NOx Concentration (ppb)
1200
1000
800
600
400
200
0
Engine On, Fan Off
OFF
Fresh Air
Recirculation
Fresh Air
Recirculation
Fresh Air
OFF
Mode of Operation
NO2 cal (out)
NO cal (out)
NO2 cal (in)
NO cal(In)

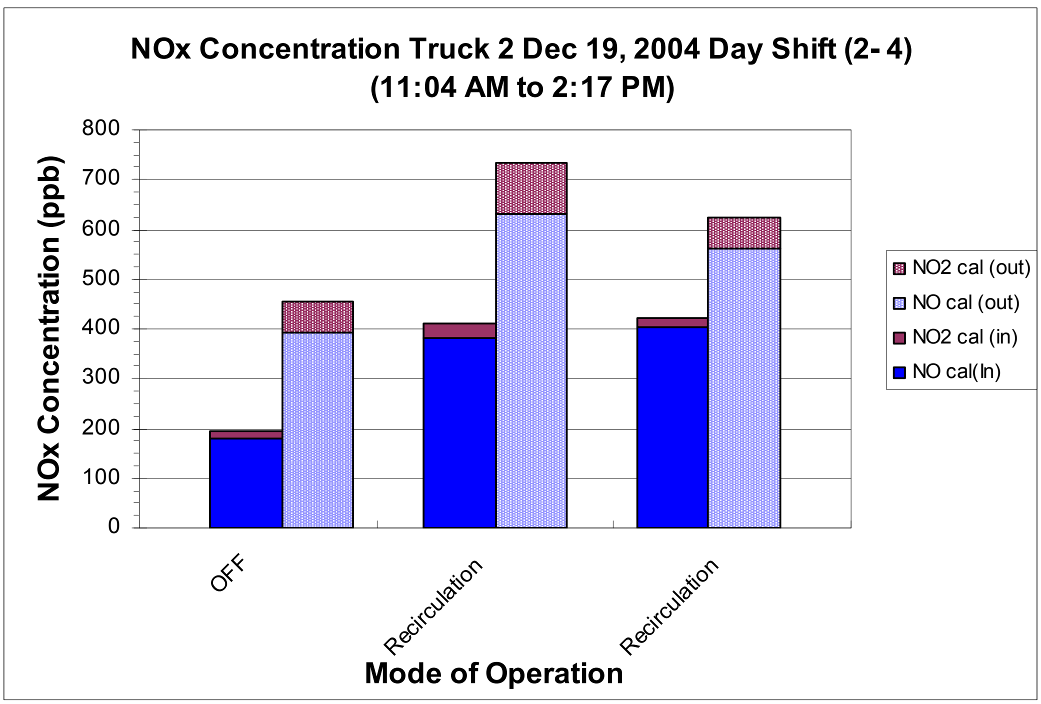


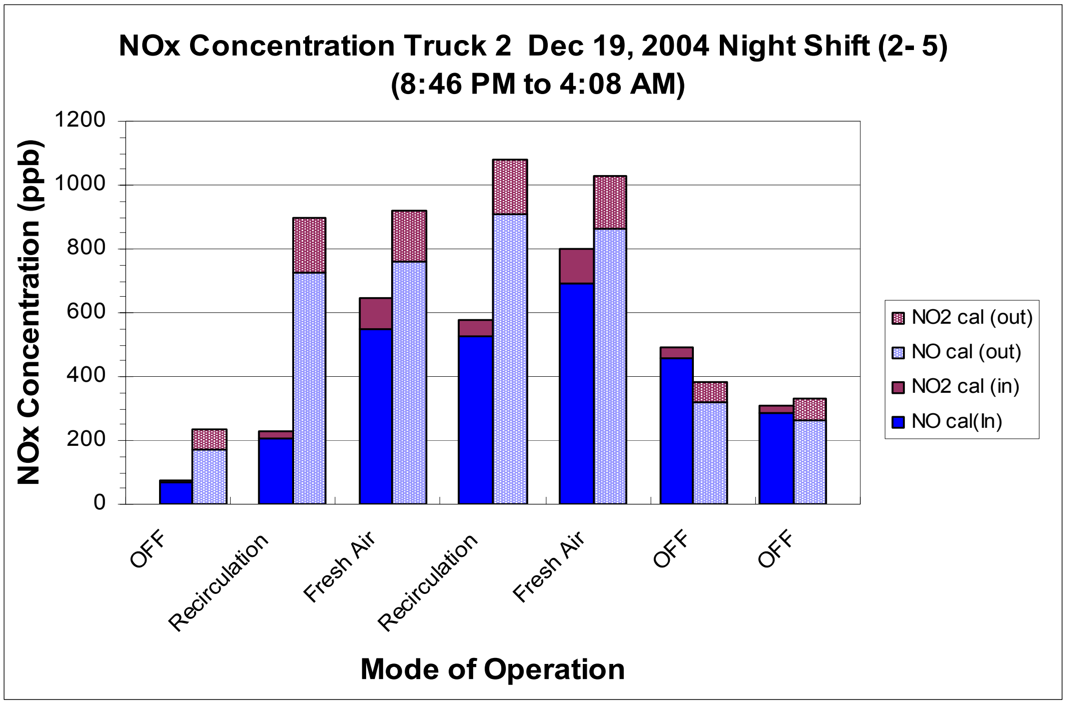
NOx Concentration Truck 1 Dec 17, 2004 Day Shift (1- 5)
(8:57 AM to 12:03 PM)
NOx Concentration (ppb)
800
700
600
500
400
300
200
100
0
OFF
Recirculation
Fresh Air
Mode of Operation
NO2 cal (out)
NO cal (out)
NO2 cal (in)
NO cal(In)

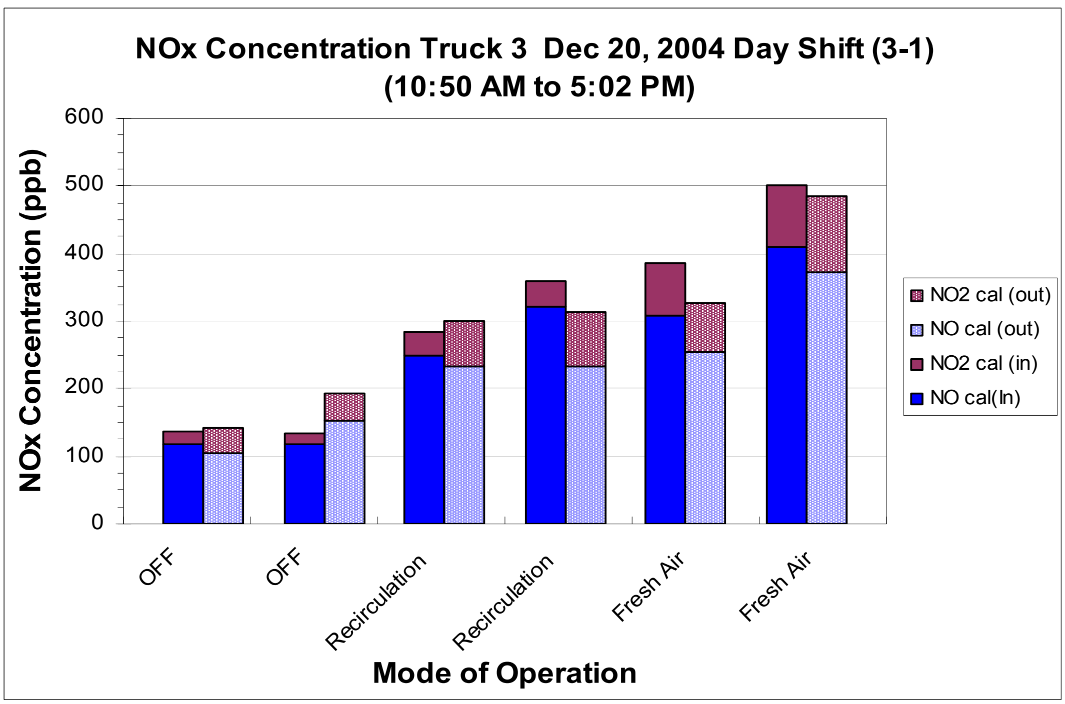

NOx Concentration Truck 2 Dec 17, 2004 Night Shift (2-1)
(9:08 PM to 4:10 AM)
NOx Concentration (ppb)
1400
1200
1000
800
600
400
200
0
OFF
OFF
Recirculation
Recirculation
Recirculation
Fresh Air
Fresh Air
Mode of Operation
NO2 cal (out)
NO cal (out)
NO2 cal (in)
NO cal(In)

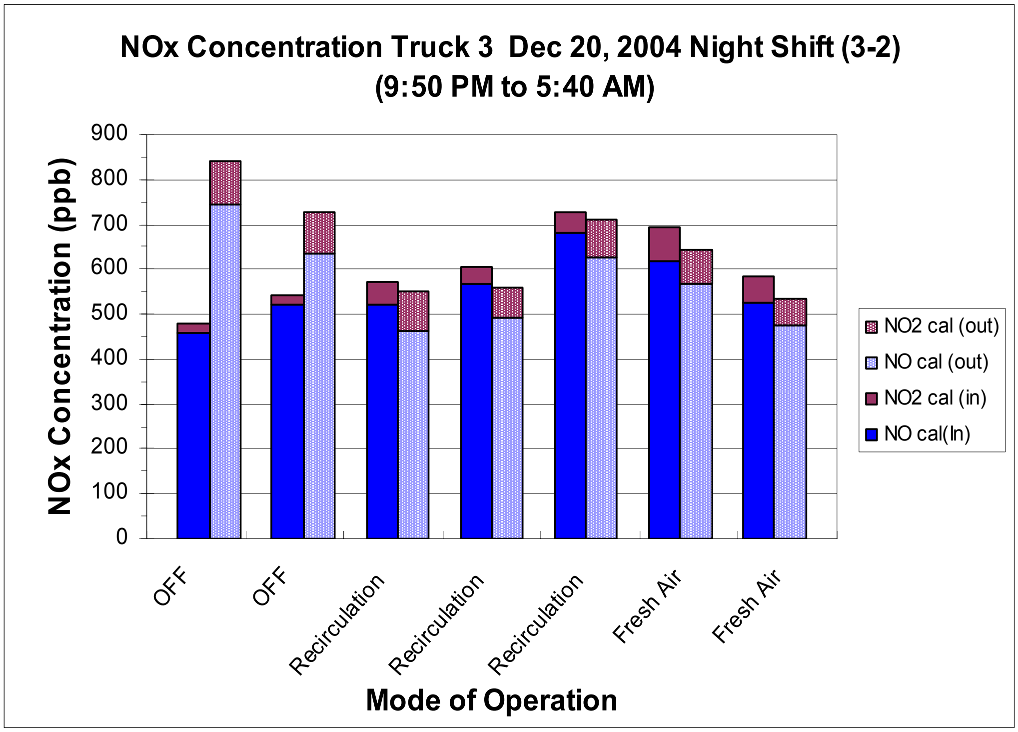

NOx Concentration Truck 2 Dec 18, 2004 Day Shift (2- 2)
(6:58 AM to 1:10 PM)
NOx Concentration (ppb)
1200
1000
800
600
400
200
0
Recirculation
Recirculation
Fresh Air
Fresh Air
OFF
OFF
Mode of Operation
NO2 cal (out)
NO cal (out)
NO2 cal (in)
NO cal(In)

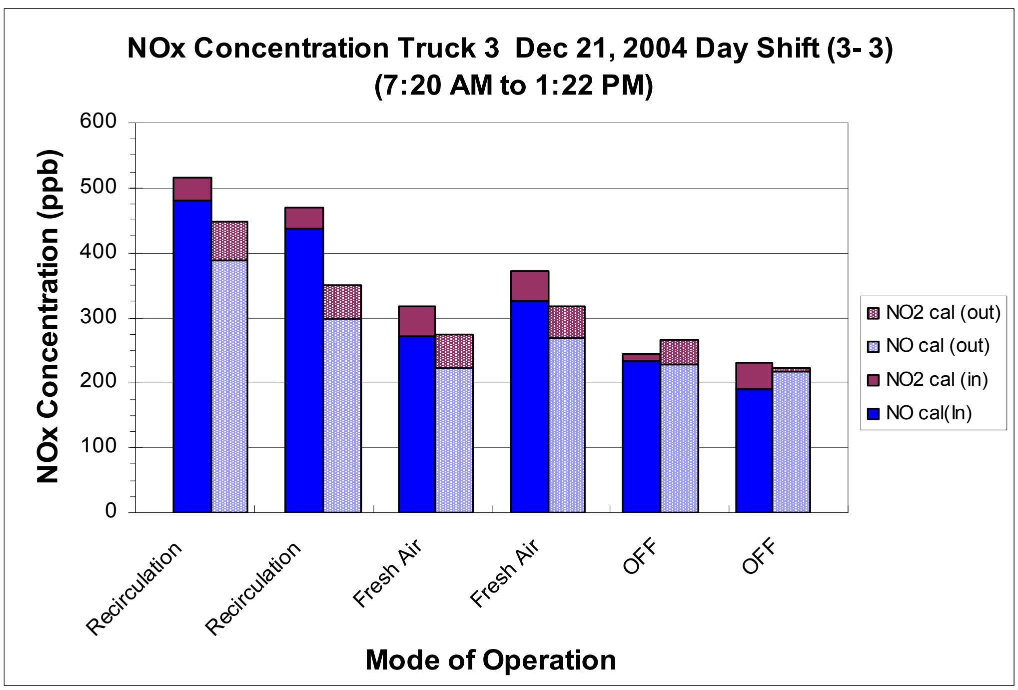

NOx Concentration Truck 2 Dec 18, 2004 Night Shift (2- 3)
(8:12 PM to 11:13 PM)
NOx Concentration (ppb)
450
400
350
300
250
200
150
100
50
0
Engine On, Fan Off
OFF
Fresh Air
Mode of Operation
NO2 cal (out)
NO cal (out)
NO2 cal (in)
NO cal(In)

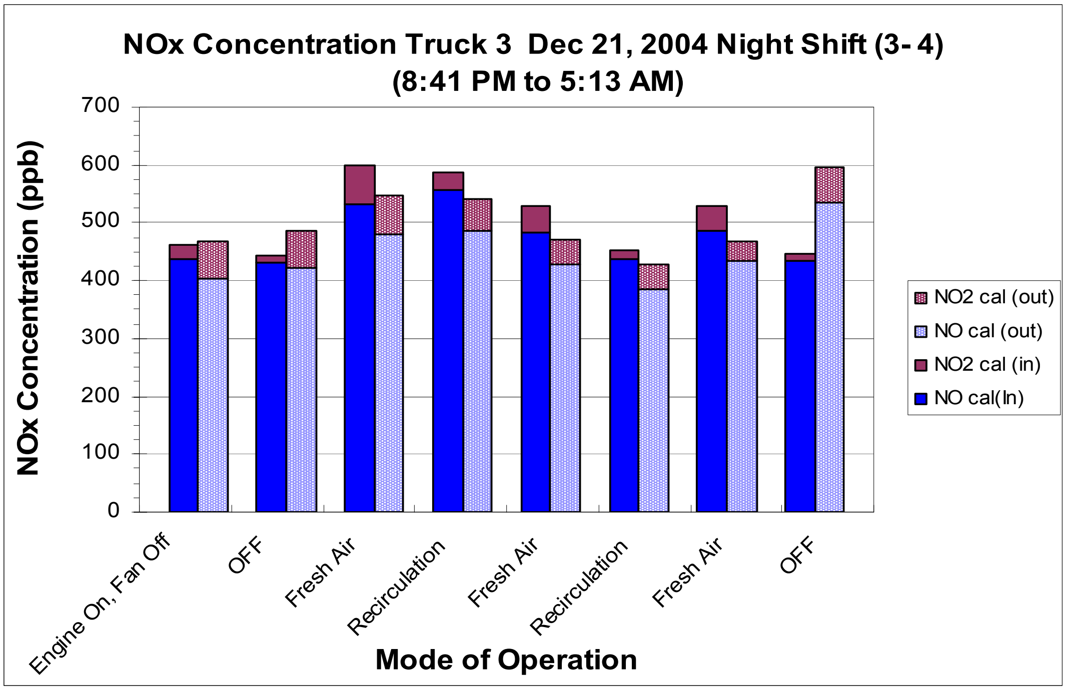

NOx Concentration Truck 2 Dec 19, 2004 Day Shift (2- 4)
(11:04 AM to 2:17 PM)
NOx Concentration (ppb)
800
700
600
500
400
300
200
100
0
OFF
Recirculation
Recirculation
Mode of Operation
NO2 cal (out)
NO cal (out)
NO2 cal (in)
NO cal(In)

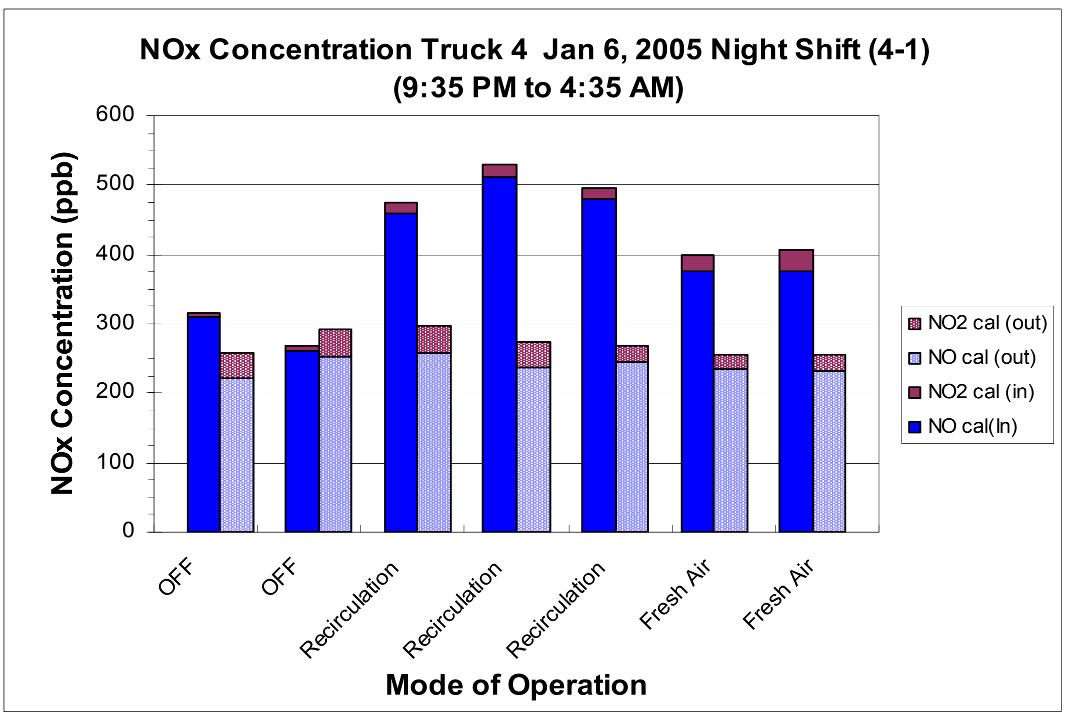

NOx Concentration Truck 2 Dec 19, 2004 Night Shift (2- 5)
(8:46 PM to 4:08 AM)
NOx Concentration (ppb)
1200
1000
800
600
400
200
0
OFF
Recirculation
Fresh Air
Recirculation
Fresh Air
OFF
OFF
Mode of Operation
NO2 cal (out)
NO cal (out)
NO2 cal (in)
NO cal(In)

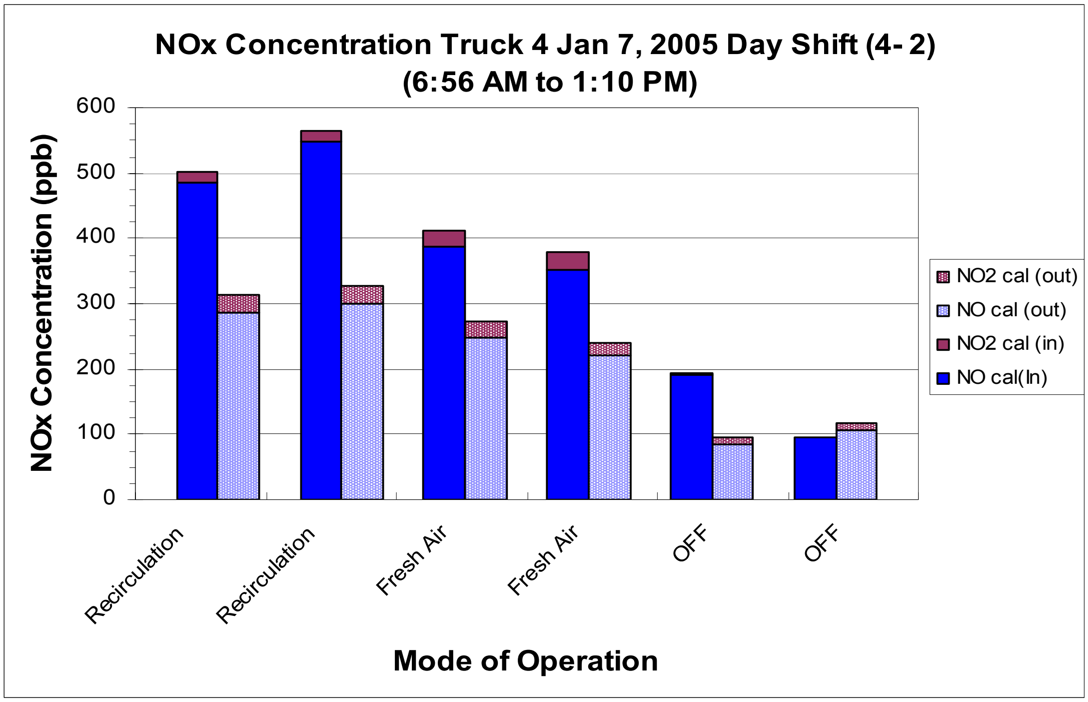

NOx Concentration Truck 3 Dec 20, 2004 Day Shift (3-1)
(10:50 AM to 5:02 PM)
NOx Concentration (ppb)
600
500
400
300
200
100
0
OFF
OFF
Recirculation
Recirculation
Fresh Air
Fresh Air
Mode of Operation
NO2 cal (out)
NO cal (out)
NO2 cal (in)
NO cal(In)

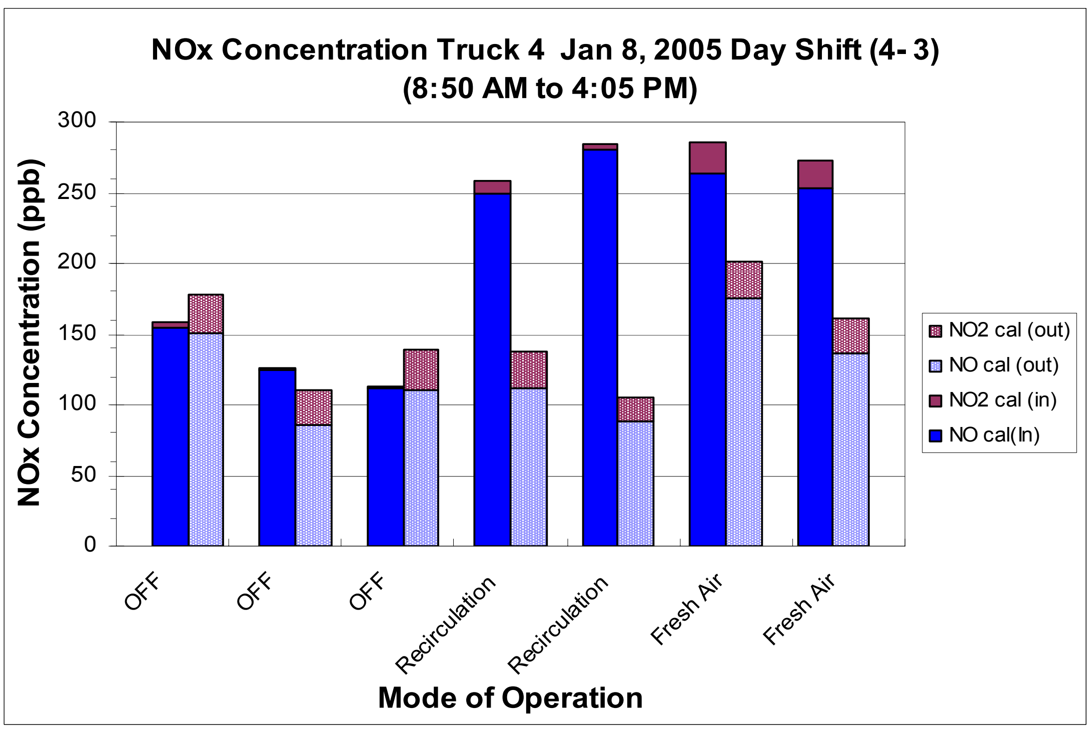

NOx Concentration Truck 3 Dec 20, 2004 Night Shift (3-2)
(9:50 PM to 5:40 AM)
NOx Concentration (ppb)
0
100
200
300
400
500
600
700
800
900
OFF
OFF
Recirculation
Recirculation
Recirculation
Fresh Air
Fresh Air
Mode of Operation
NO2 cal (out)
NO cal (out)
NO2 cal (in)
NO cal(In)

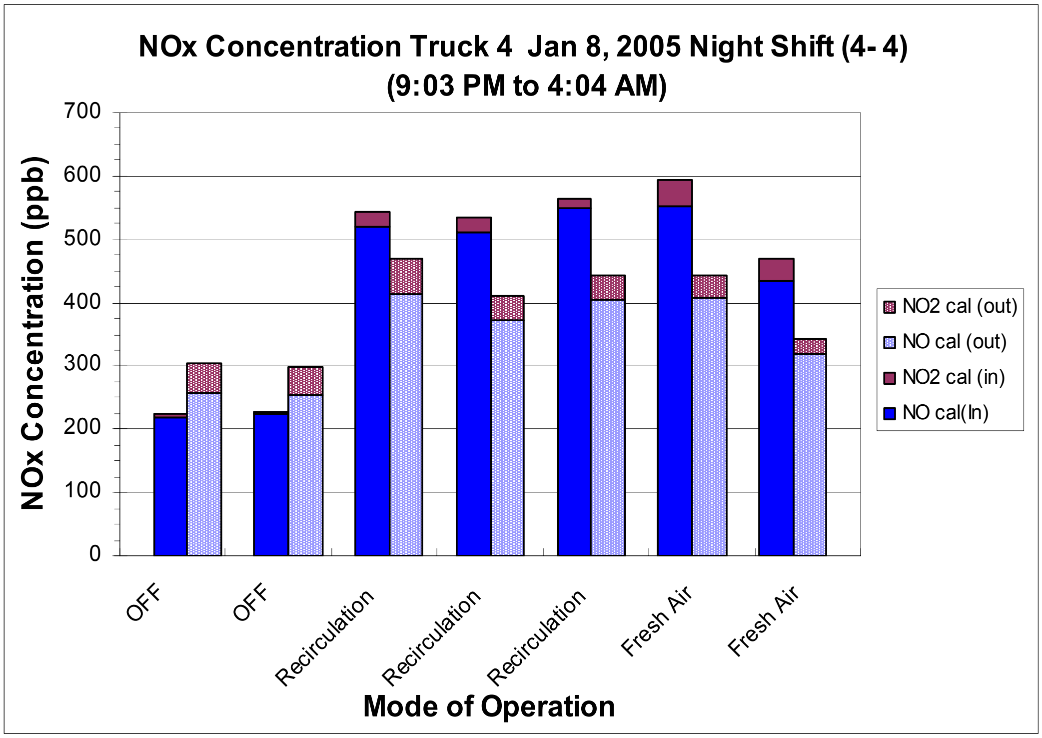

NOx Concentration Truck 3 Dec 21, 2004 Day Shift (3- 3)
(7:20 AM to 1:22 PM)
NOx Concentration (ppb)
0
100
200
300
400
500
600
Recirculation
Recirculation
Fresh Air
Fresh Air
OFF
OFF
Mode of Operation
NO2 cal (out)
NO cal (out)
NO2 cal (in)
NO cal(In)

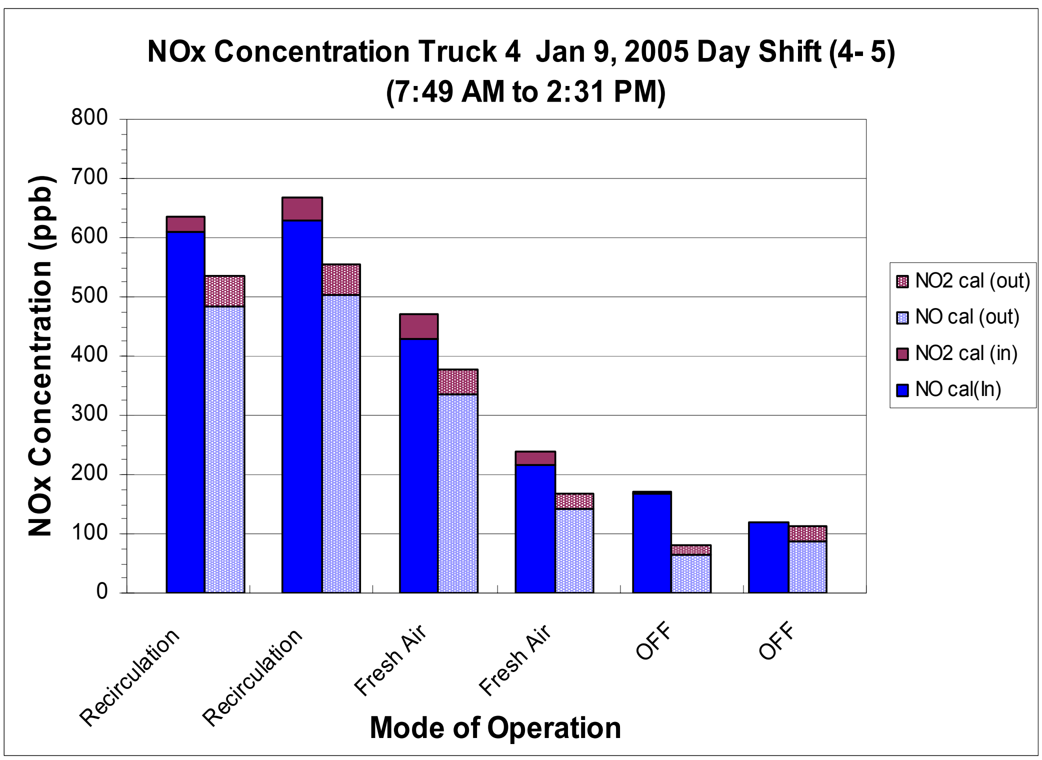

NOx Concentration Truck 3 Dec 21, 2004 Night Shift (3- 4)
(8:41 PM to 5:13 AM)
NOx Concentration (ppb)
0
100
200
300
400
500
600
700
Engine On, Fan Off
OFF
Fresh Air
Recirculation
Fresh Air
Recirculation
Fresh Air
OFF
Mode of Operation
NO2 cal (out)
NO cal (out)
NO2 cal (in)
NO cal(In)

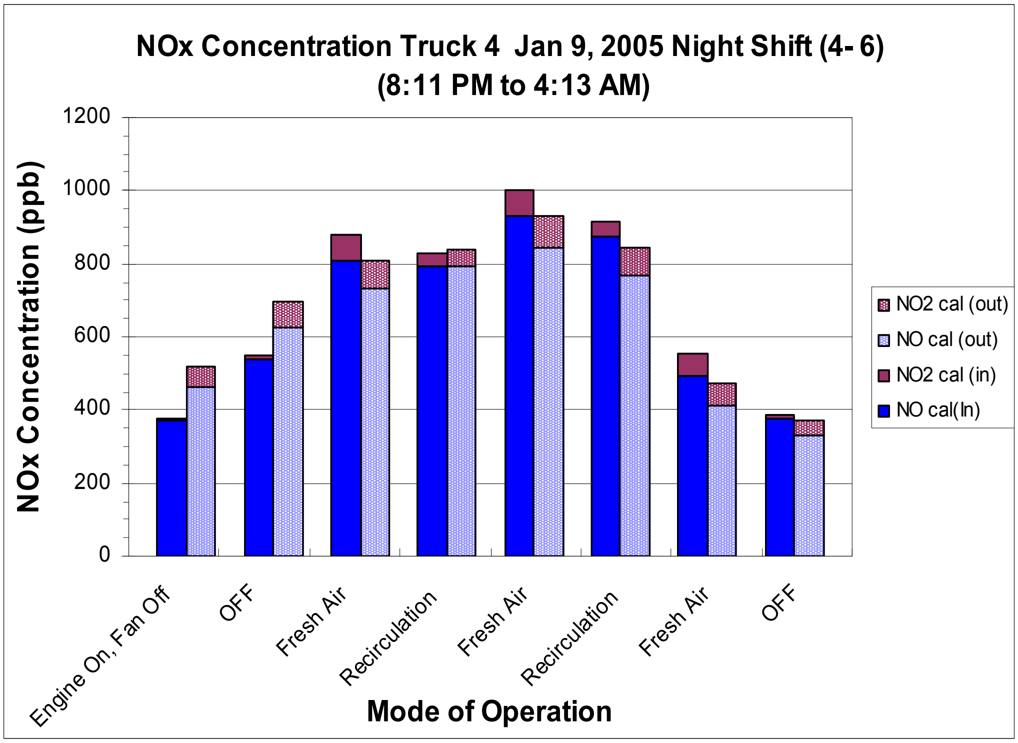

NOx Concentration Truck 4 Jan 6, 2005 Night Shift (4-1)
(9:35 PM to 4:35 AM)
NOx Concentration (ppb)
0
100
200
300
400
500
600
OFF
OFF
Recirculation
Recirculation
Recirculation
Fresh Air
Fresh Air
Mode of Operation
NO2 cal (out)
NO cal (out)
NO2 cal (in)
NO cal(In)

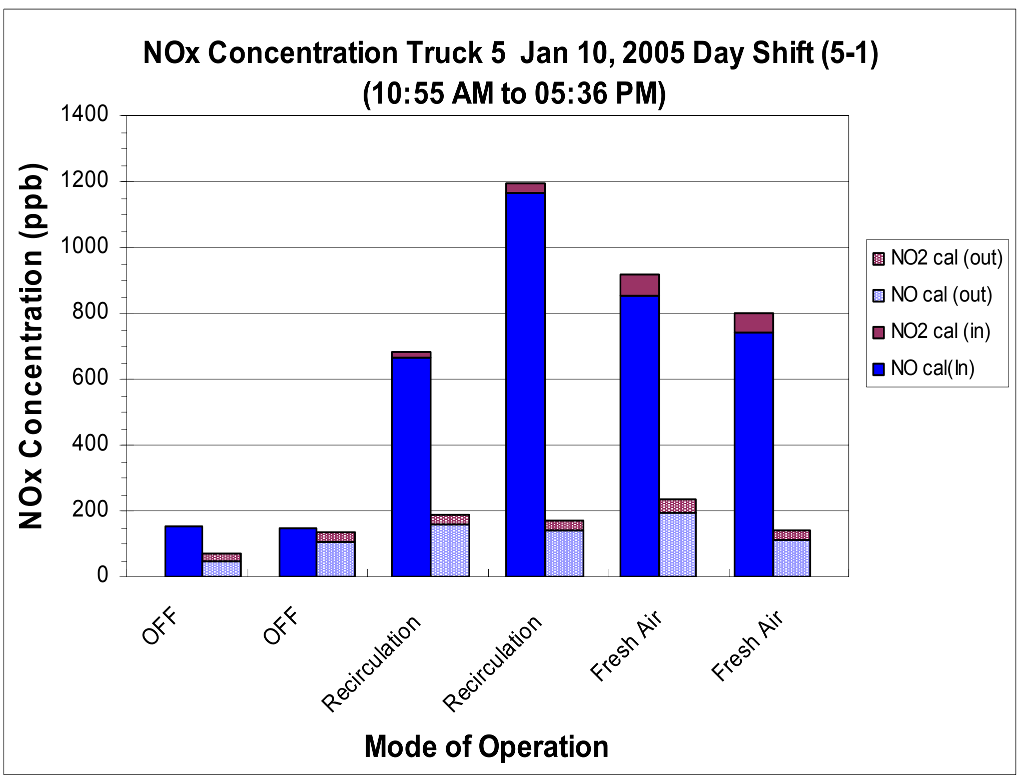

NOx Concentration Truck 4 Jan 7, 2005 Day Shift (4- 2)
(6:56 AM to 1:10 PM)
NOx Concentration (ppb)
600
500
400
300
200
100
0
Recirculation
Recirculation
Fresh Air
Fresh Air
OFF
OFF
Mode of Operation
NO2 cal (out)
NO cal (out)
NO2 cal (in)
NO cal(In)

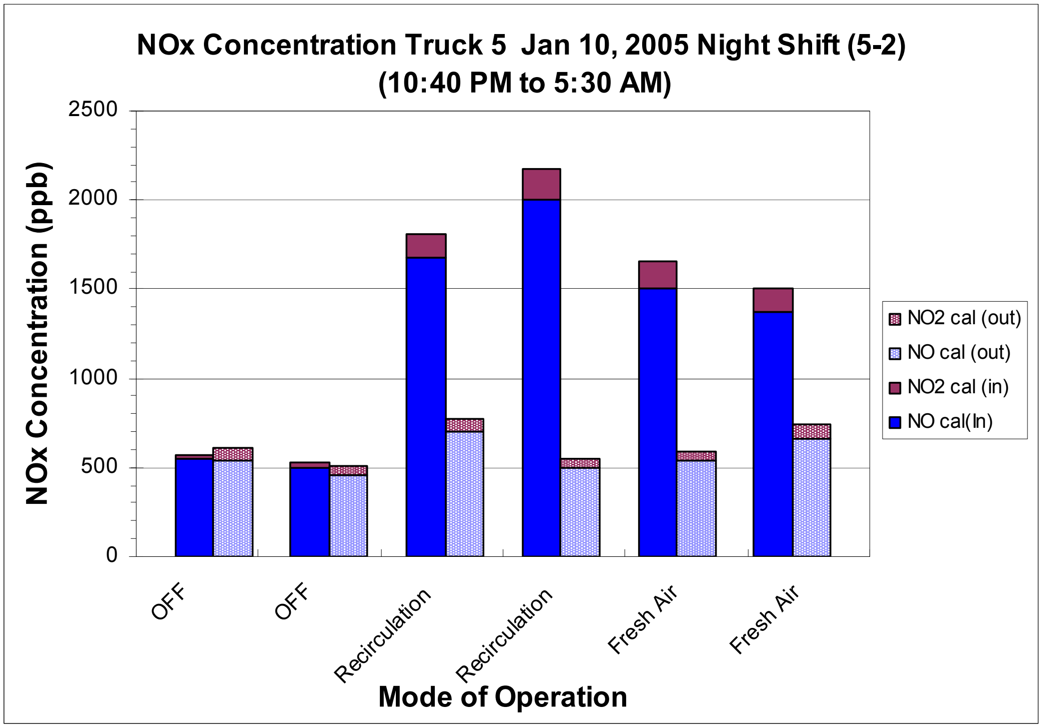

NOx Concentration Truck 4 Jan 8, 2005 Day Shift (4- 3)
(8:50 AM to 4:05 PM)
NOx Concentration (ppb)
300
250
200
150
100
50
0
OFF
OFF
OFF
Recirculation
Recirculation
Fresh Air
Fresh Air
Mode of Operation
NO2 cal (out)
NO cal (out)
NO2 cal (in)
NO cal(In)


NOx Concentration Truck 4 Jan 8, 2005 Night Shift (4- 4)
(9:03 PM to 4:04 AM)
NOx Concentration (ppb)
700
600
500
400
300
200
100
0
OFF
OFF
Recirculation
Recirculation
Recirculation
Fresh Air
Fresh Air
Mode of Operation
NO2 cal (out)
NO cal (out)
NO2 cal (in)
NO cal(In)

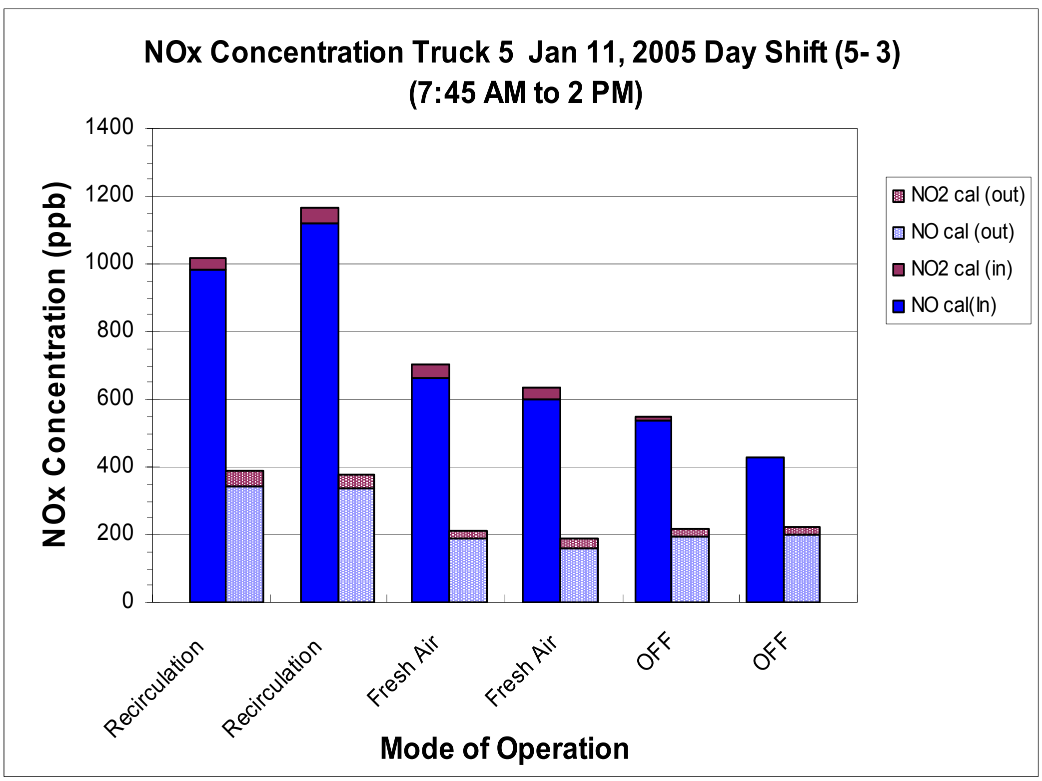

NOx Concentration Truck 4 Jan 9, 2005 Day Shift (4- 5)
(7:49 AM to 2:31 PM)
NOx Concentration (ppb)
800
700
600
500
400
300
200
100
0
Recirculation
Recirculation
Fresh Air
Fresh Air
OFF
OFF
Mode of Operation
NO2 cal (out)
NO cal (out)
NO2 cal (in)
NO cal(In)


NOx Concentration Truck 4 Jan 9, 2005 Night Shift (4- 6)
(8:11 PM to 4:13 AM)
NOx Concentration (ppb)
1200
1000
800
600
400
200
0
Engine On, Fan Off
OFF
Fresh Air
Recirculation
Fresh Air
Recirculation
Fresh Air
OFF
Mode of Operation
NO2 cal (out)
NO cal (out)
NO2 cal (in)
NO cal(In)

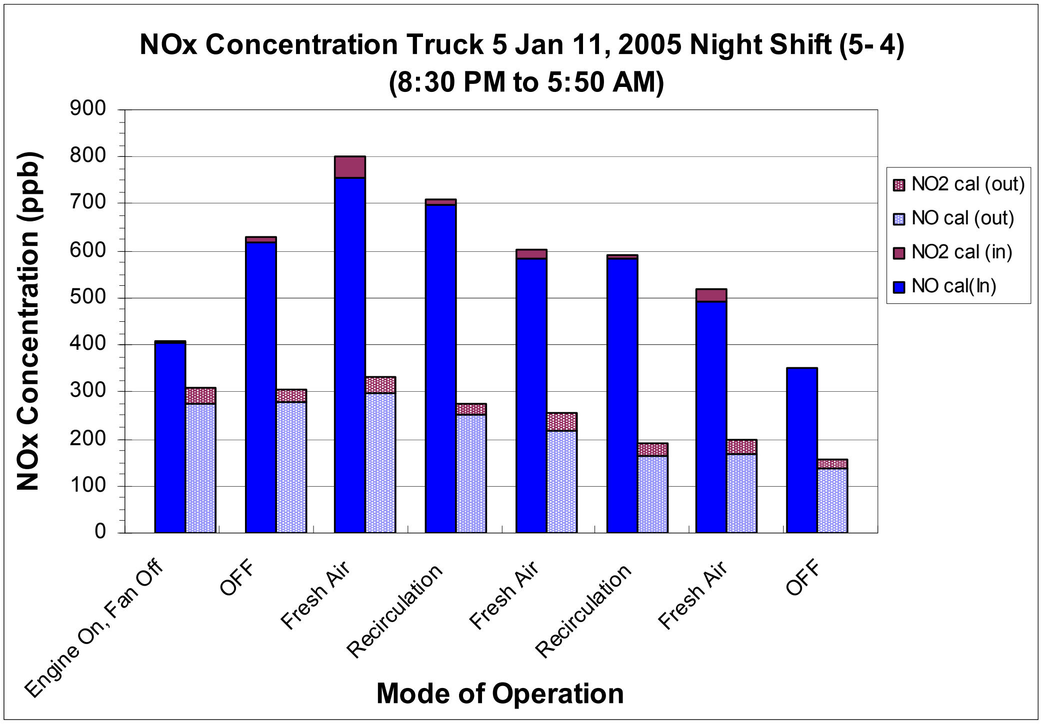

NOx Concentration Truck 5 Jan 10, 2005 Day Shift (5-1)
(10:55 AM to 05:36 PM)
NOx Concentration (ppb)
1400
1200
1000
800
600
400
200
0
OFF
OFF
Recirculation
Recirculation
Fresh Air
Fresh Air
Mode of Operation
NO2 cal (out)
NO cal (out)
NO2 cal (in)
NO cal(In)

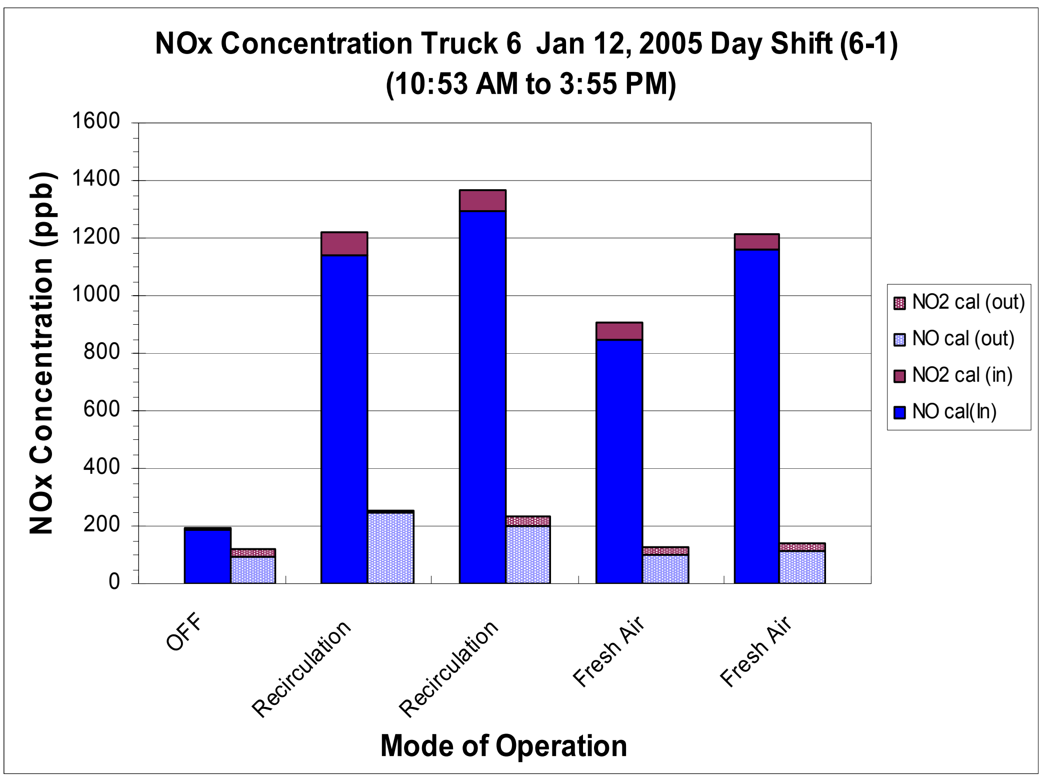


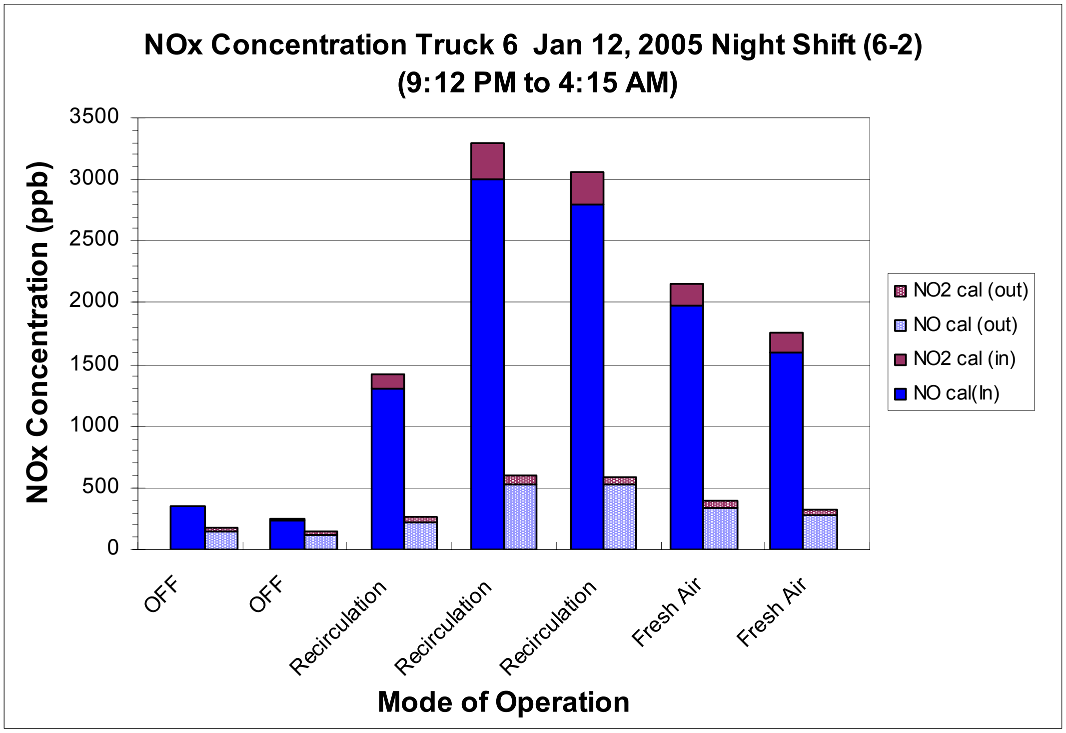
NOx Concentration Truck 5 Jan 10, 2005 Night Shift (5-2)
(10:40 PM to 5:30 AM)
NOx Concentration (ppb)
2500
2000
1500
1000
500
0
OFF
OFF
Recirculation
Recirculation
Fresh Air
Fresh Air
Mode of Operation
NO2 cal (out)
NO cal (out)
NO2 cal (in)
NO cal(In)

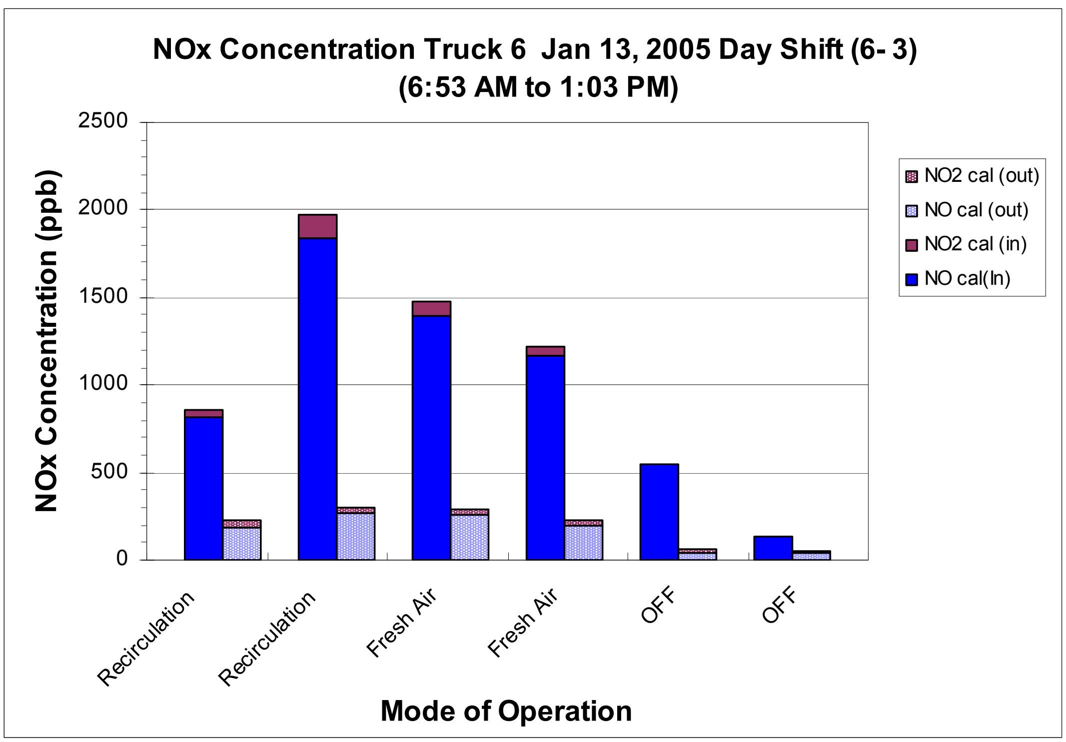


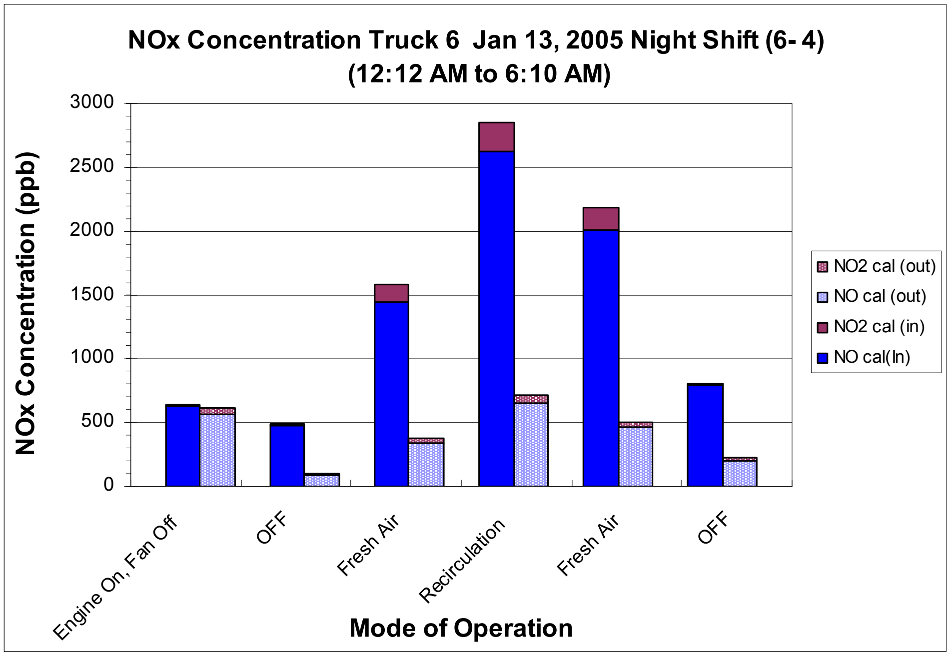
NOx Concentration Truck 5 Jan 11, 2005 Day Shift (5- 3)
(7:45 AM to 2 PM)
NOx Concentration (ppb)
1400
1200
1000
800
600
400
200
0
Recirculation
Recirculation
Fresh Air
Fresh Air
OFF
OFF
Mode of Operation
NO2 cal (out)
NO cal (out)
NO2 cal (in)
NO cal(In)

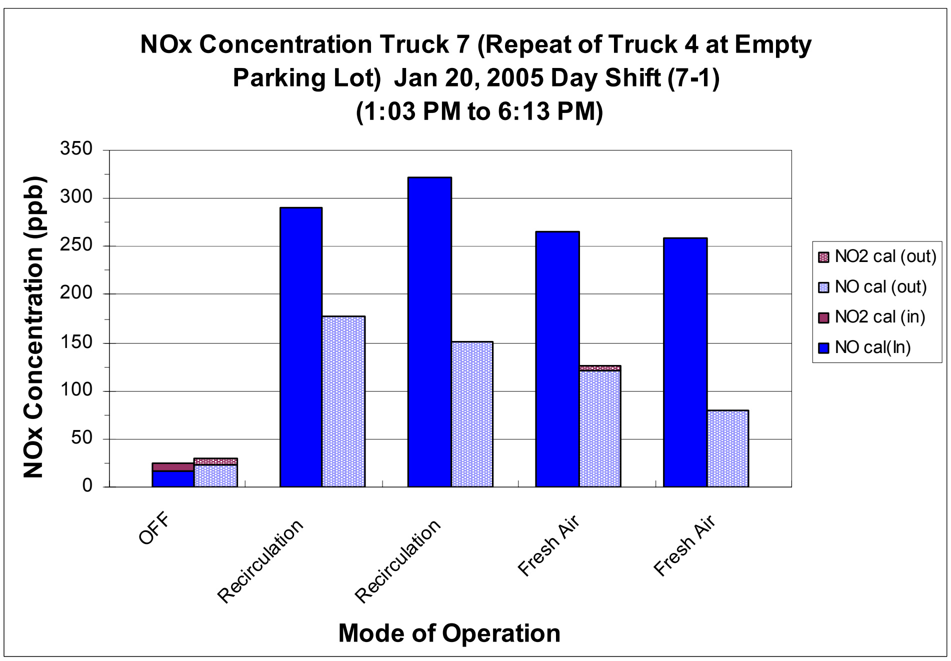

NOx Concentration Truck 5 Jan 11, 2005 Night Shift (5- 4)
(8:30 PM to 5:50 AM)
900
800
700
600
500
400
300
200
100
0
NOx Concentration (ppb)
NO2 cal (out)
NO cal (out)
NO2 cal (in)
NO cal(In)
Engine On, Fan Off
OFF
Fresh Air
Recirculation
Fresh Air
Recirculation
Fresh Air
OFF
Mode of Operation


NOx Concentration Truck 6 Jan 12, 2005 Day Shift (6-1)
(10:53 AM to 3:55 PM)
1600
1400
1200
1000
800
600
400
200
0
NOx Concentration (ppb)
NO2 cal (out)
NO cal (out)
NO2 cal (in)
NO cal(In)
OFF
Recirculation
Recirculation
Fresh Air
Fresh Air
Mode of Operation

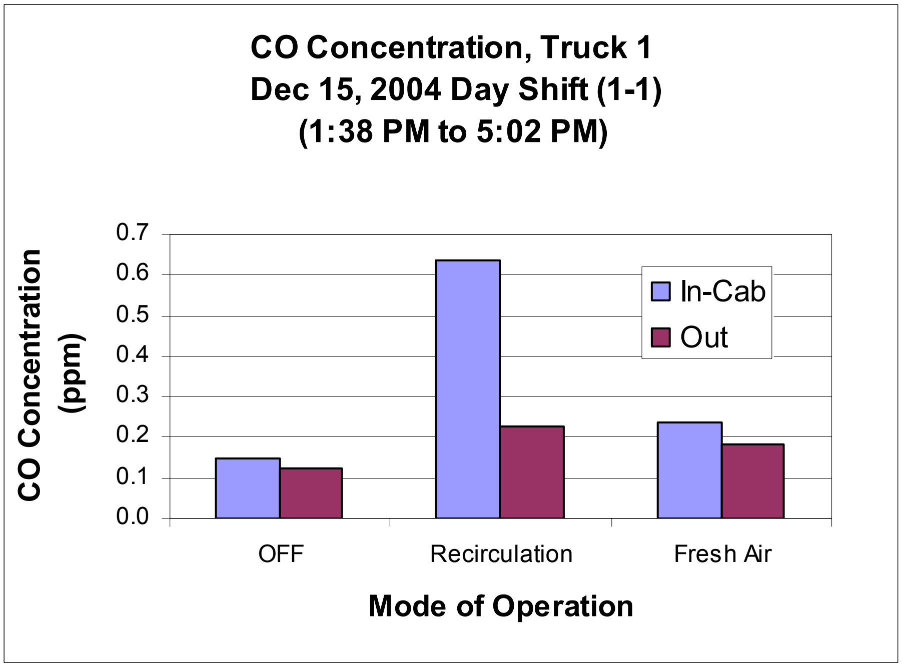

NOx Concentration Truck 6 Jan 12, 2005 Night Shift (6-2)
(9:12 PM to 4:15 AM)
NOx Concentration (ppb)
3500
3000
2500
2000
1500
1000
500
0
OFF
OFF
Recirculation
Recirculation
Recirculation
Fresh Air
Fresh Air
Mode of Operation
NO2 cal (out)
NO cal (out)
NO2 cal (in)
NO cal(In)

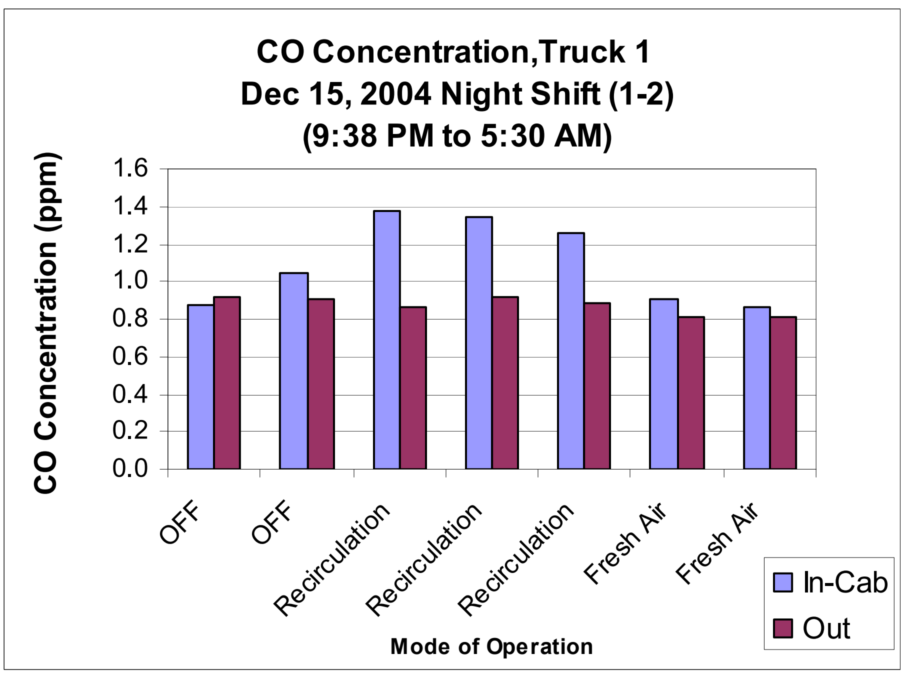

NOx Concentration Truck 6 Jan 13, 2005 Day Shift (6- 3)
(6:53 AM to 1:03 PM)
NOx Concentration (ppb)
2500
2000
1500
1000
500
0
Recirculation
Recirculation
Fresh Air
Fresh Air
OFF
OFF
Mode of Operation
NO2 cal (out)
NO cal (out)
NO2 cal (in)
NO cal(In)

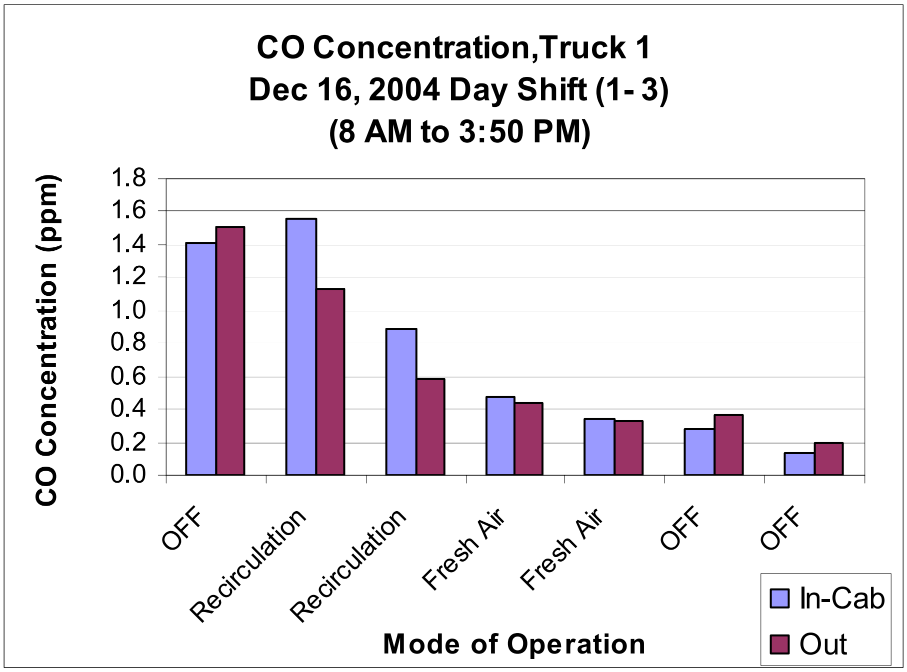

NOx Concentration Truck 6 Jan 13, 2005 Night Shift (6- 4)
(12:12 AM to 6:10 AM)
NOx Concentration (ppb)
3000
2500
2000
1500
1000
500
0
Engine On, Fan Off
OFF
Fresh Air
Recirculation
Fresh Air
OFF
Mode of Operation
NO2 cal (out)
NO cal (out)
NO2 cal (in)
NO cal(In)


NOx Concentration Truck 7 (Repeat of Truck 4 at Empty Parking Lot) Jan 20, 2005 Day Shift (7-1)
(1:03 PM to 6:13 PM)
NOx Concentration (ppb)
350
300
250
200
150
100
50
0
OFF
Recirculation
Recirculation
Fresh Air
Fresh Air
Mode of Operation
NO2 cal (out)
NO cal (out)
NO2 cal (in)
NO cal(In)

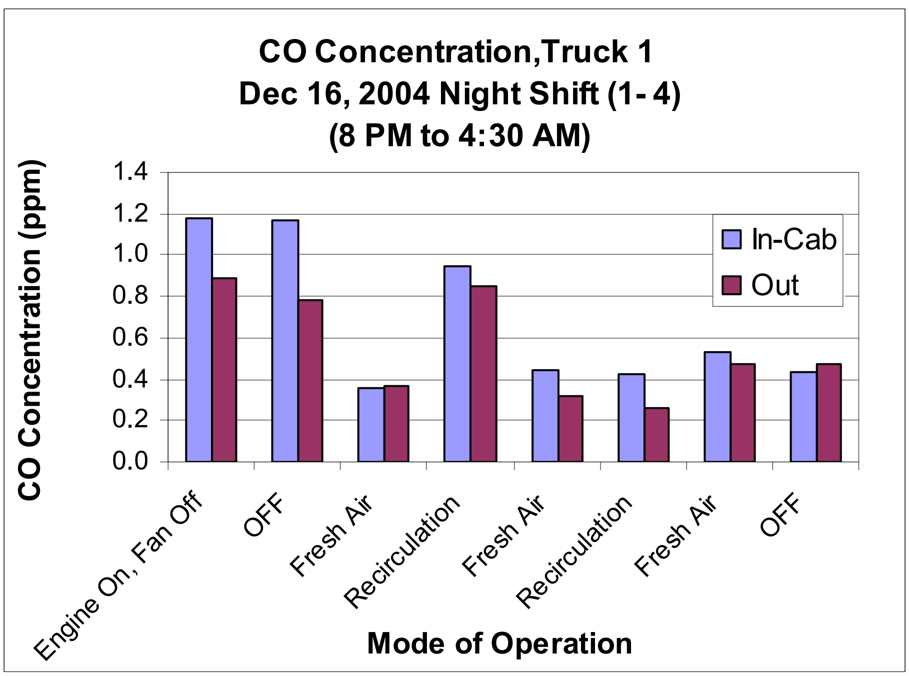
A-5: CO Concentration Measurements


CO Concentration, Truck 1
Dec 15, 2004 Day Shift (1-1)
(1:38 PM to 5:02 PM)
CO Concentration (ppm)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
In-Cab
Out
OFF
Recirculation
Fresh Air
Mode of Operation

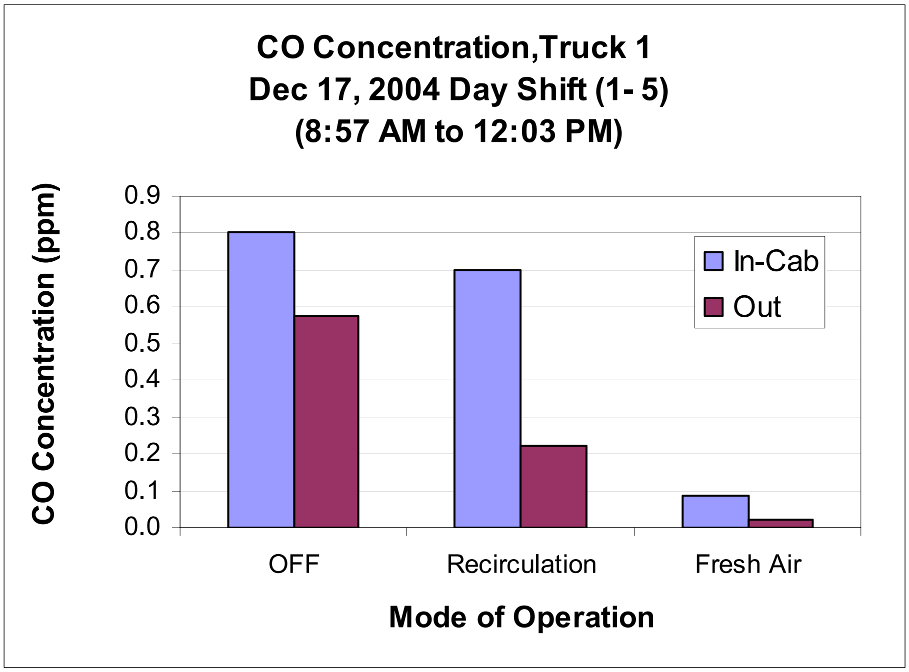

CO Concentration,Truck 1
Dec 15, 2004 Night Shift (1-2)
(9:38 PM to 5:30 AM)
CO Concentration (ppm)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
OFF
OFF
Recirculation
Recirculation
Recirculation
Fresh Air
Fresh Air
In-Cab
Out
Mode of Operation

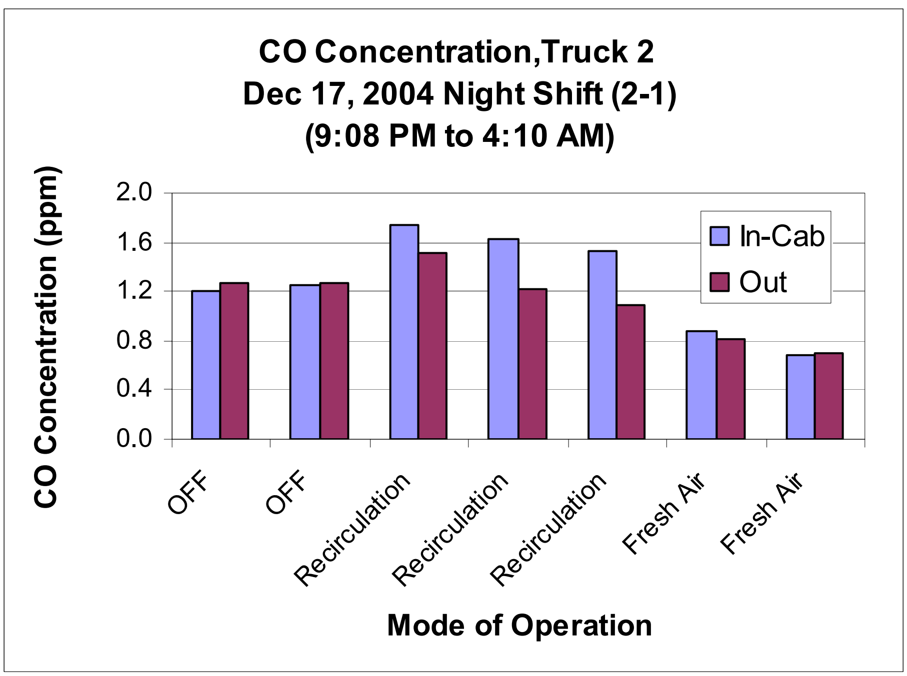


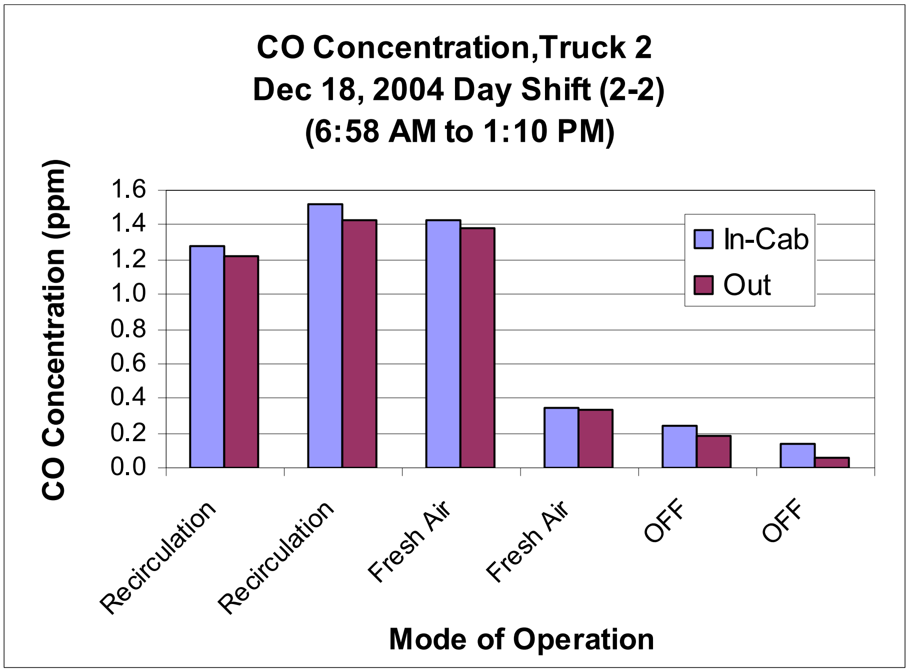
CO Concentration,Truck 1
Dec 16, 2004 Day Shift (1- 3)
(8 AM to 3:50 PM)
CO Concentration (ppm)
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
OFF
Recirculation
Recirculation
Fresh Air
Fresh Air
OFF
OFF
Mode of Operation
In-Cab
Out

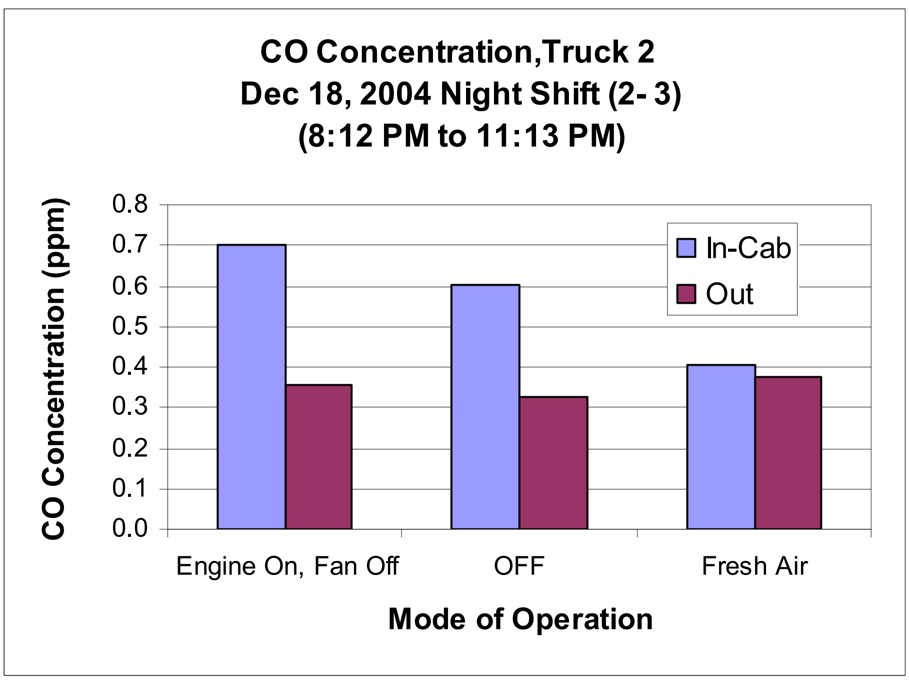


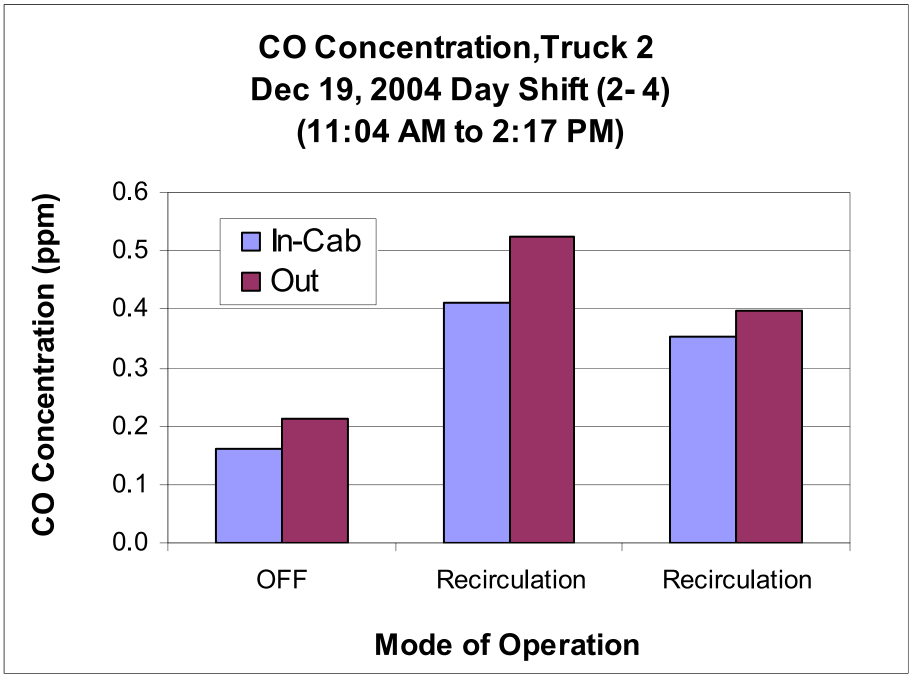
CO Concentration,Truck 1
Dec 16, 2004 Night Shift (1- 4)
(8 PM to 4:30 AM)
CO Concentration (ppm)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Engine On, Fan Off
OFF
Fresh Air
Recirculation
Fresh Air
Recirculation
Fresh Air
OFF
Mode of Operation
In-Cab
Out

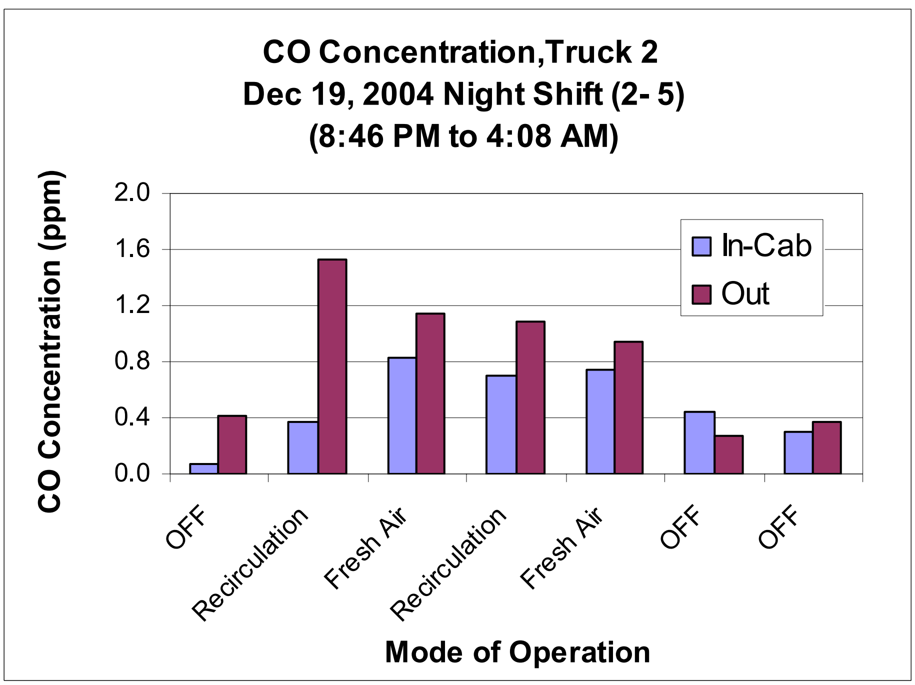

CO Concentration,Truck 1
Dec 17, 2004 Day Shift (1- 5)
(8:57 AM to 12:03 PM)
CO Concentration (ppm)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
In-Cab
Out
OFF
Recirculation
Fresh Air
Mode of Operation

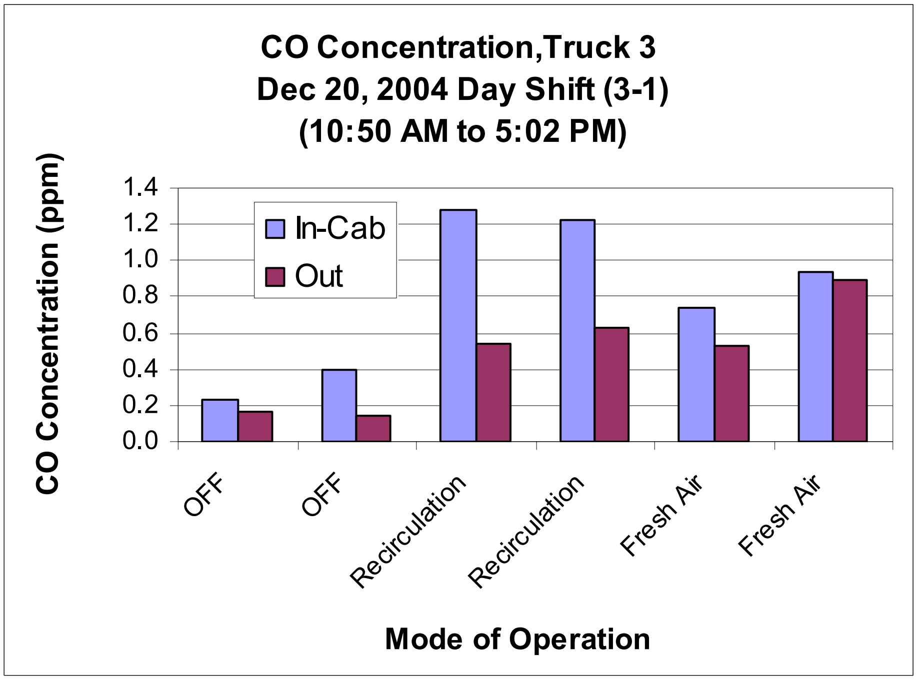

CO Concentration,Truck 2
Dec 17, 2004 Night Shift (2-1)
(9:08 PM to 4:10 AM)
CO Concentration (ppm)
2.0
1.6
1.2
0.8
0.4
0.0
In-Cab
Out
OFF
OFF
Recirculation
Recirculation
Recirculation
Fresh Air
Fresh Air
Mode of Operation

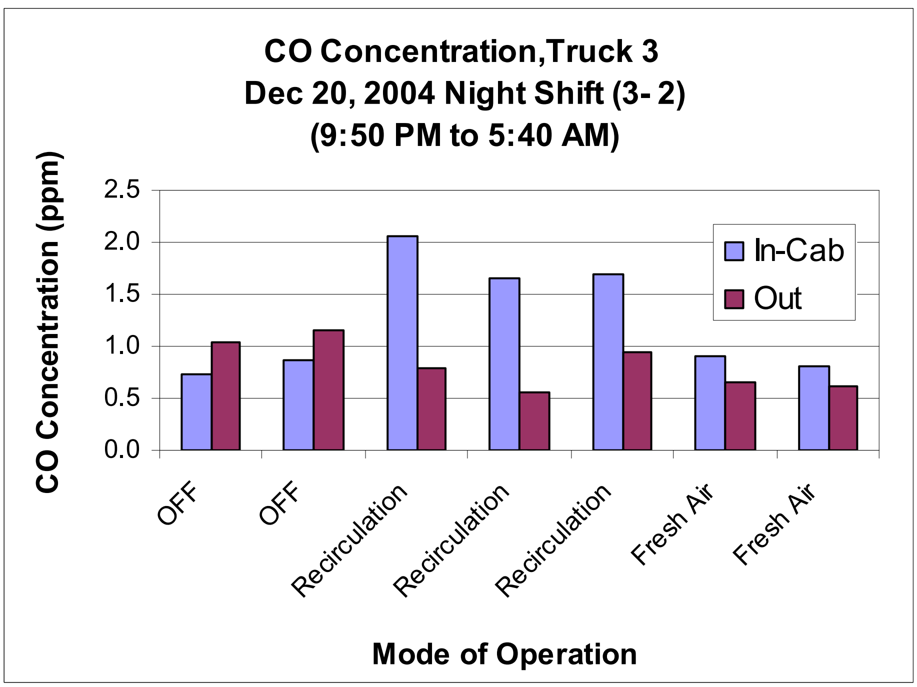

CO Concentration,Truck 2
Dec 18, 2004 Day Shift (2-2)
(6:58 AM to 1:10 PM)
CO Concentration (ppm)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
In-Cab
Out
Recirculation
Recirculation
Fresh Air
Fresh Air
OFF
OFF
Mode of Operation

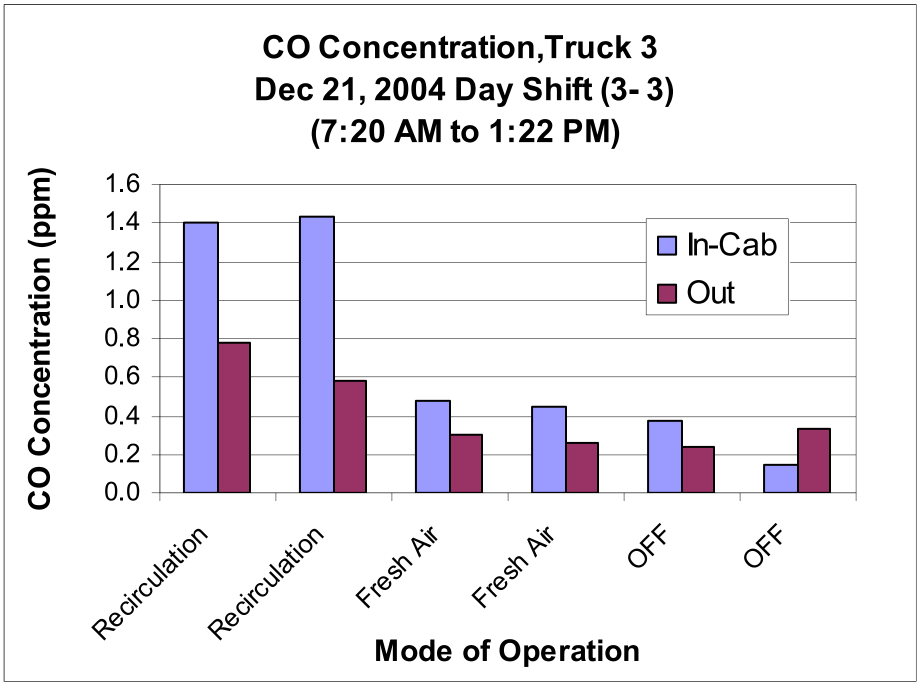

CO Concentration,Truck 2
Dec 18, 2004 Night Shift (2- 3)
(8:12 PM to 11:13 PM)
CO Concentration (ppm)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
In-Cab
Out
Engine On, Fan Off
OFF
Fresh Air
Mode of Operation

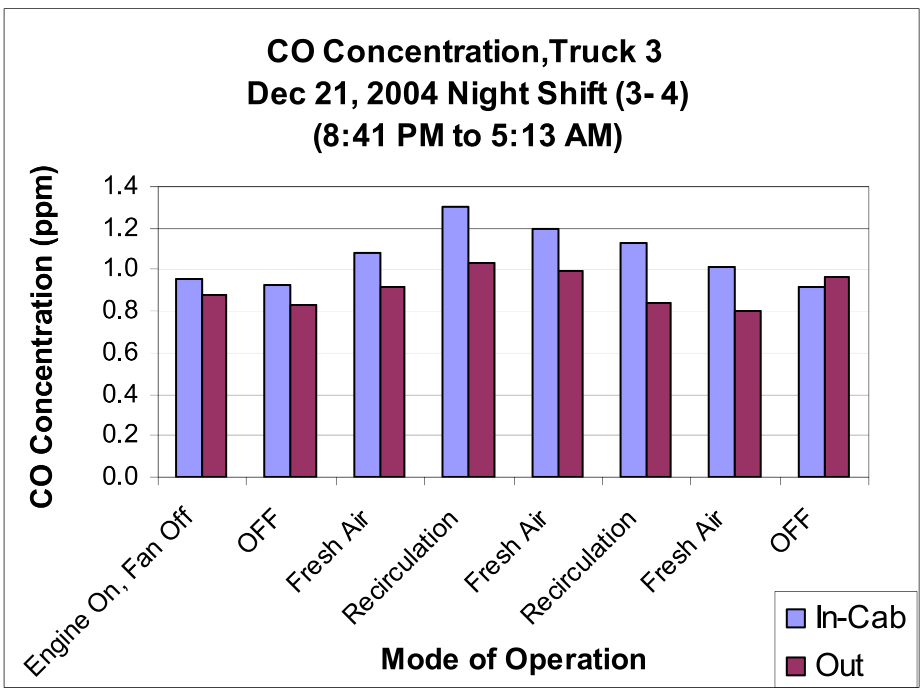

CO Concentration,Truck 2
Dec 19, 2004 Day Shift (2- 4)
(11:04 AM to 2:17 PM)
CO Concentration (ppm)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
In-Cab
Out
OFF
Recirculation
Recirculation
Mode of Operation

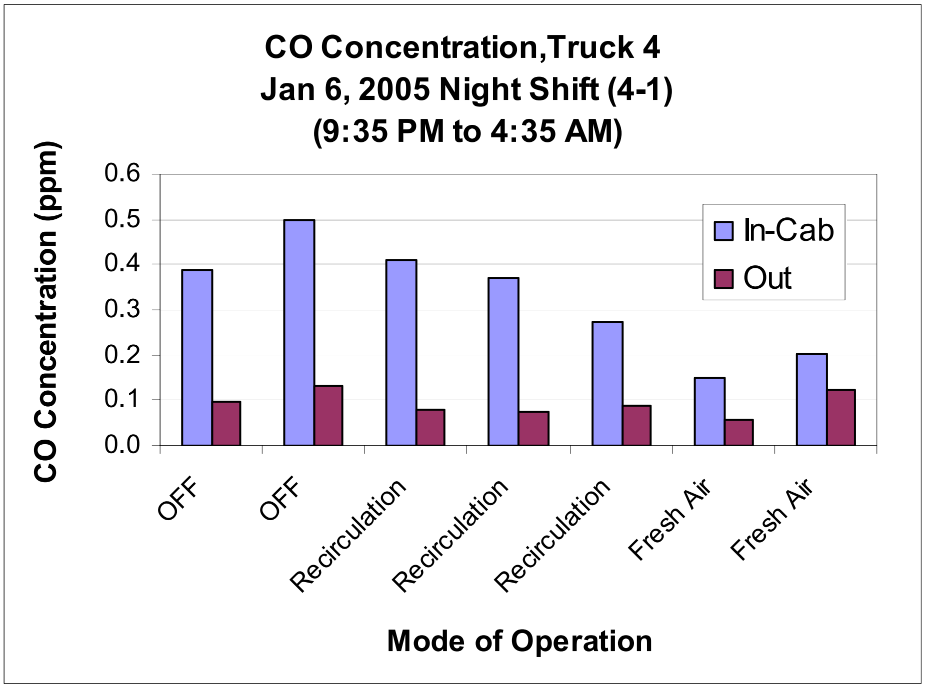

CO Concentration,Truck 2
Dec 19, 2004 Night Shift (2- 5)
(8:46 PM to 4:08 AM)
CO Concentration (ppm)
2.0
1.6
1.2
0.8
0.4
0.0
In-Cab
Out
OFF
Recirculation
Fresh Air
Recirculation
Fresh Air
OFF
OFF
Mode of Operation

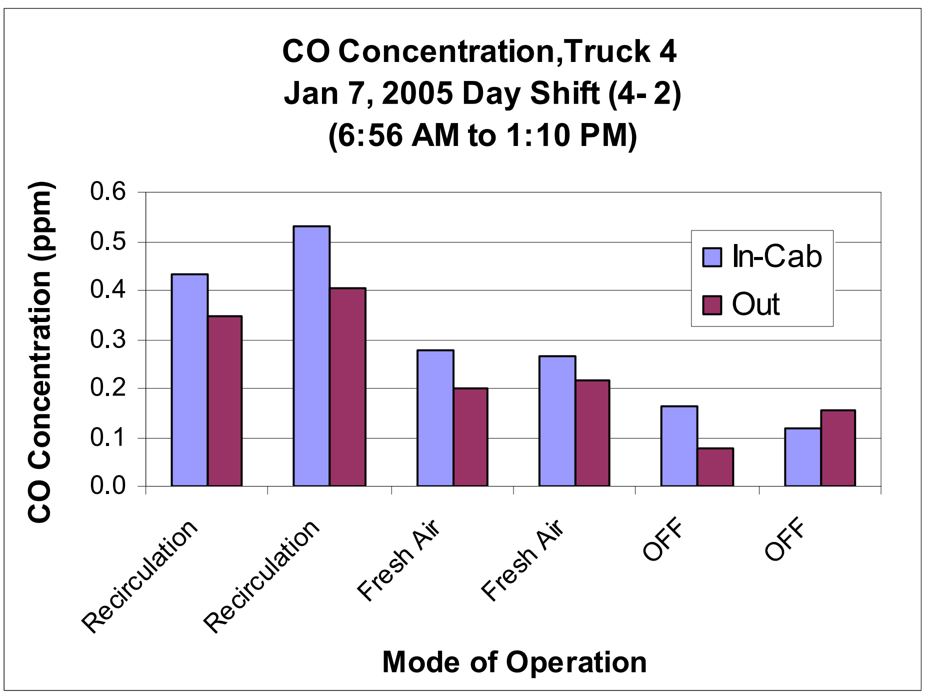

CO Concentration,Truck 3
Dec 20, 2004 Day Shift (3-1)
(10:50 AM to 5:02 PM)
CO Concentration (ppm)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
In-Cab
Out
OFF
OFF
Recirculation
Recirculation
Fresh Air
Fresh Air
Mode of Operation

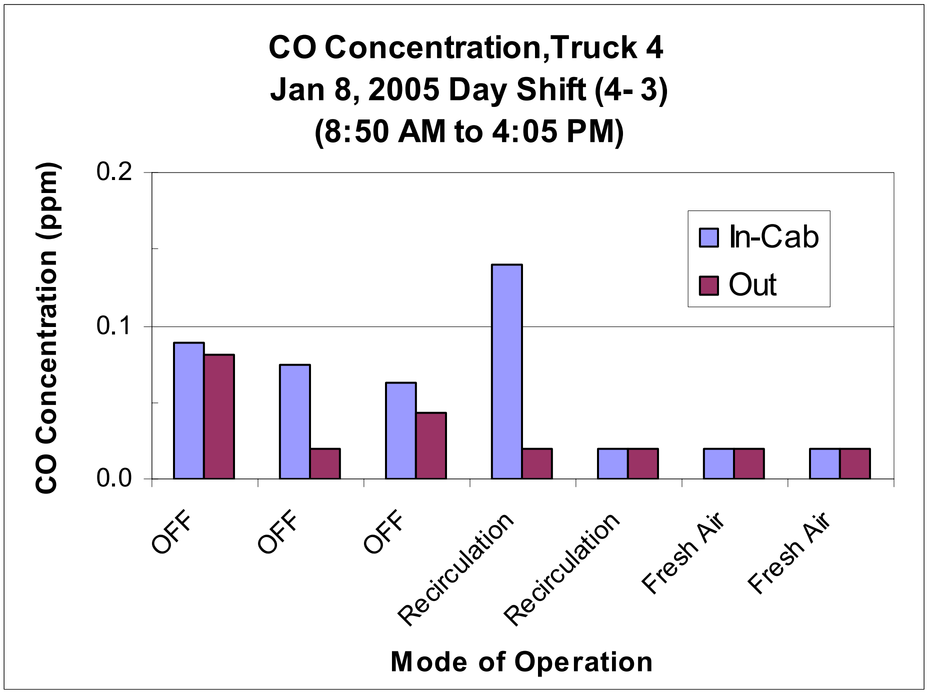

CO Concentration,Truck 3
Dec 20, 2004 Night Shift (3- 2)
(9:50 PM to 5:40 AM)
CO Concentration (ppm)
2.5
2.0
1.5
1.0
0.5
0.0
In-Cab
Out
OFF
OFF
Recirculation
Recirculation
Recirculation
Fresh Air
Fresh Air
Mode of Operation

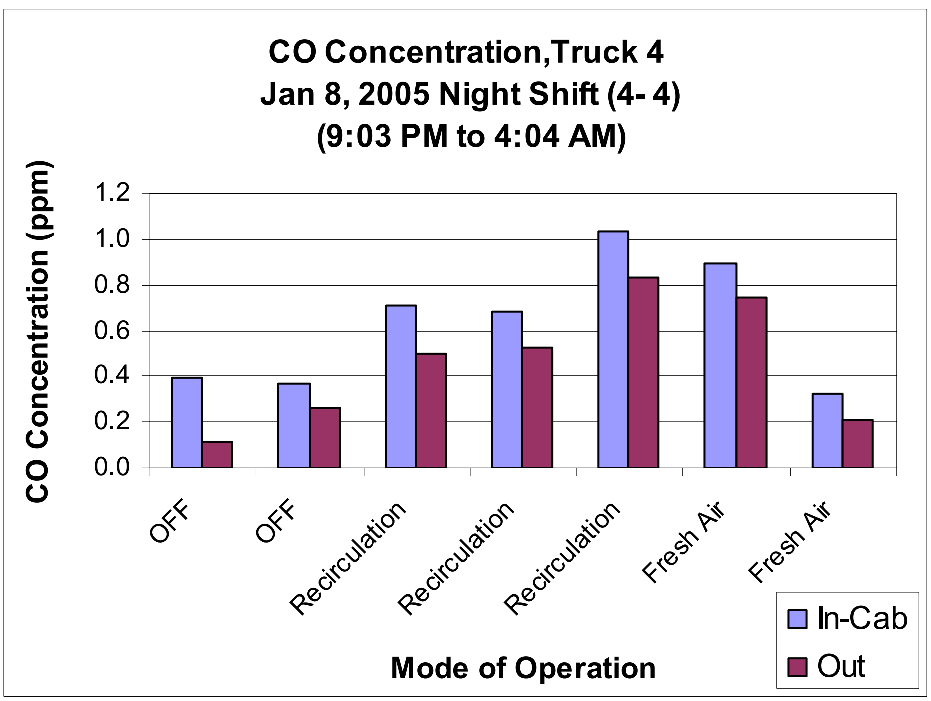

CO Concentration,Truck 3
Dec 21, 2004 Day Shift (3- 3)
(7:20 AM to 1:22 PM)
CO Concentration (ppm)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
In-Cab
Out
Recirculation
Recirculation
Fresh Air
Fresh Air
OFF
OFF
Mode of Operation

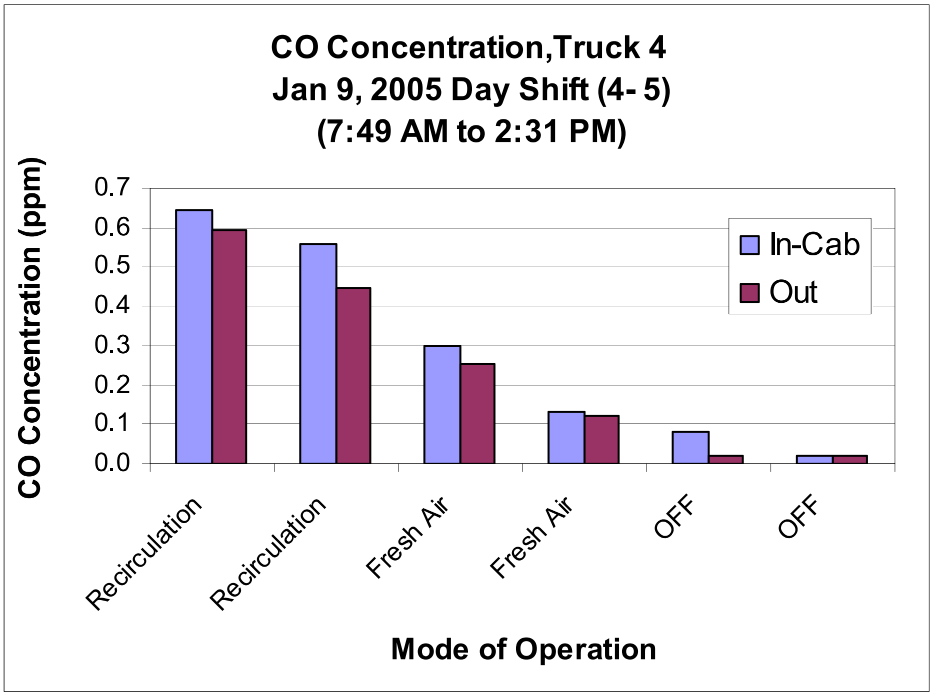

CO Concentration,Truck 3
Dec 21, 2004 Night Shift (3- 4)
(8:41 PM to 5:13 AM)
CO Concentration (ppm)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Engine On, Fan Off
OFF
Fresh Air
Recirculation
Fresh Air
Recirculation
Fresh Air
OFF
Mode of Operation
In-Cab
Out

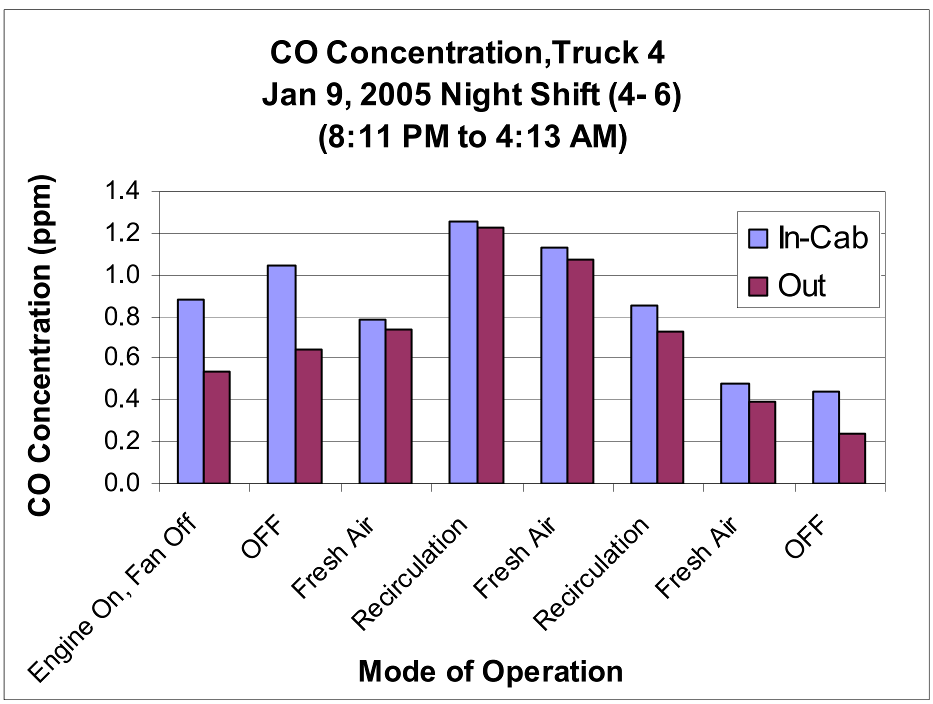

CO Concentration,Truck 4
Jan 6, 2005 Night Shift (4-1)
(9:35 PM to 4:35 AM)
CO Concentration (ppm)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
In-Cab
Out
OFF
OFF
Recirculation
Recirculation
Recirculation
Fresh Air
Fresh Air
Mode of Operation

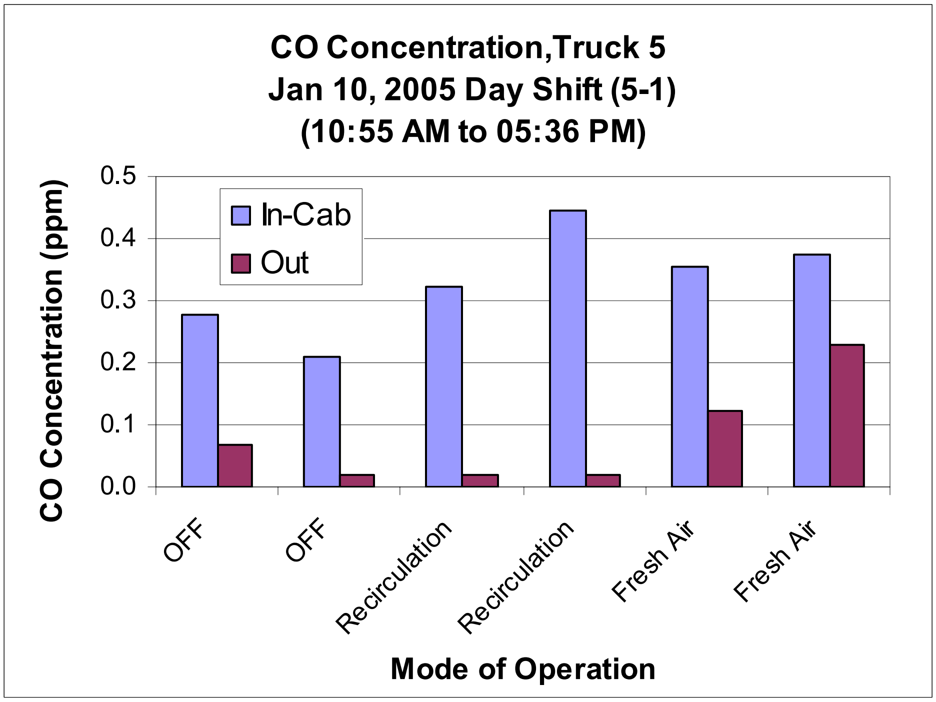

CO Concentration,Truck 4
Jan 7, 2005 Day Shift (4- 2)
(6:56 AM to 1:10 PM)
CO Concentration (ppm)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
In-Cab
Out
Recirculation
Recirculation
Fresh Air
Fresh Air
OFF
OFF
Mode of Operation

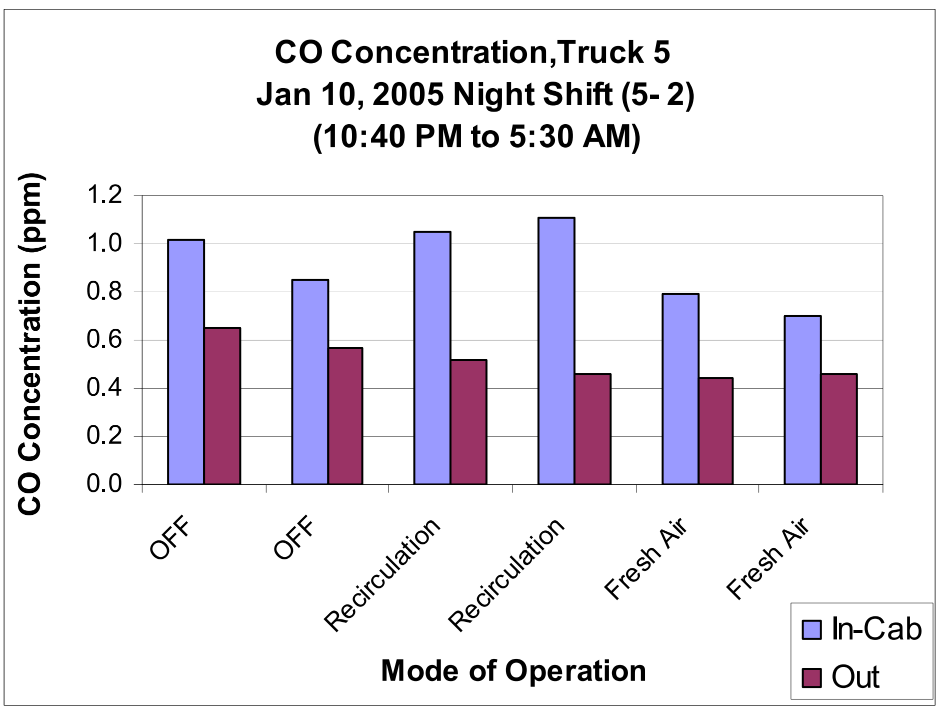

CO Concentration,Truck 4
Jan 8, 2005 Day Shift (4- 3)
(8:50 AM to 4:05 PM)
CO Concentration (ppm)
0.2
0.1
0.0
In-Cab
Out
OFF
OFF
OFF
Recirculation
Recirculation
Fresh Air
Fresh Air
Mode of Operation

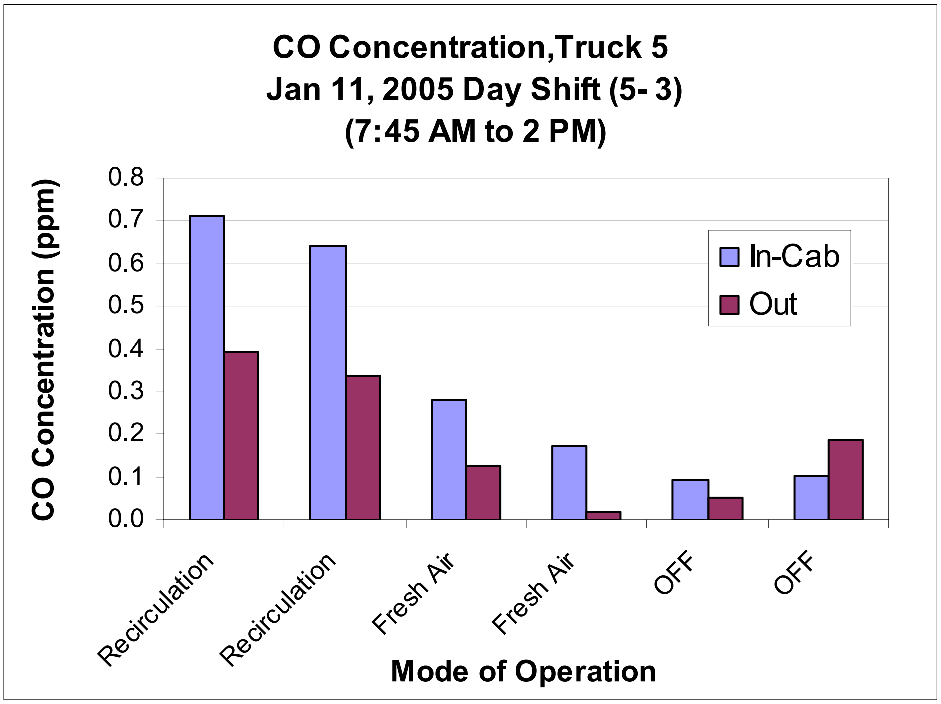

CO Concentration,Truck 4
Jan 8, 2005 Night Shift (4- 4)
(9:03 PM to 4:04 AM)
CO Concentration (ppm)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
OFF
OFF
Recirculation
Recirculation
Recirculation
Fresh Air
Fresh Air
Mode of Operation
In-Cab
Out

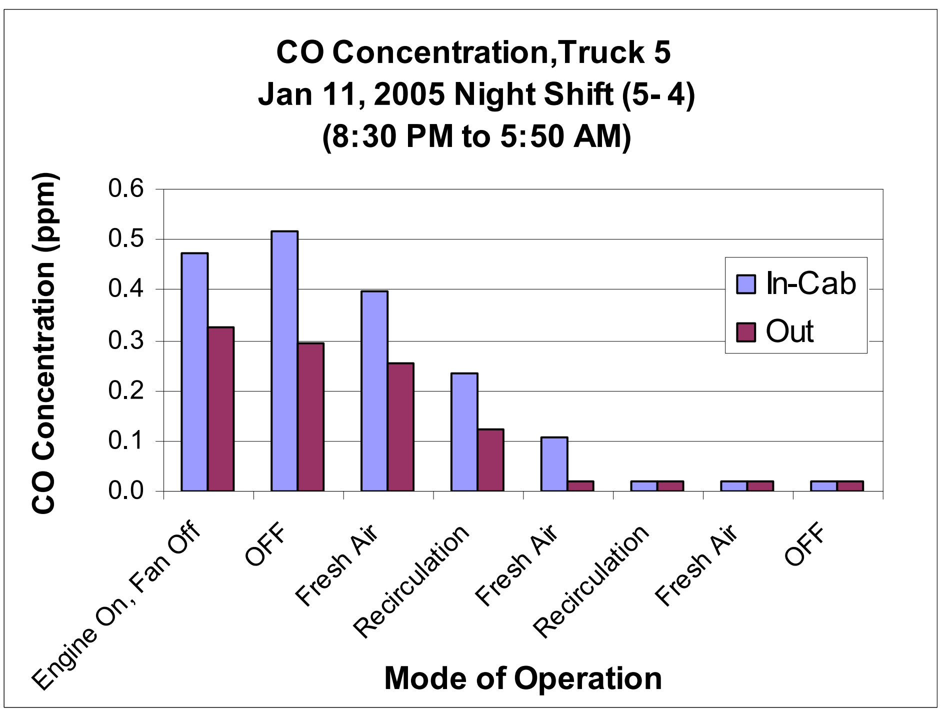

CO Concentration,Truck 4
Jan 9, 2005 Day Shift (4- 5)
(7:49 AM to 2:31 PM)
CO Concentration (ppm)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
In-Cab
Out
Recirculation
Recirculation
Fresh Air
Fresh Air
OFF
OFF
Mode of Operation

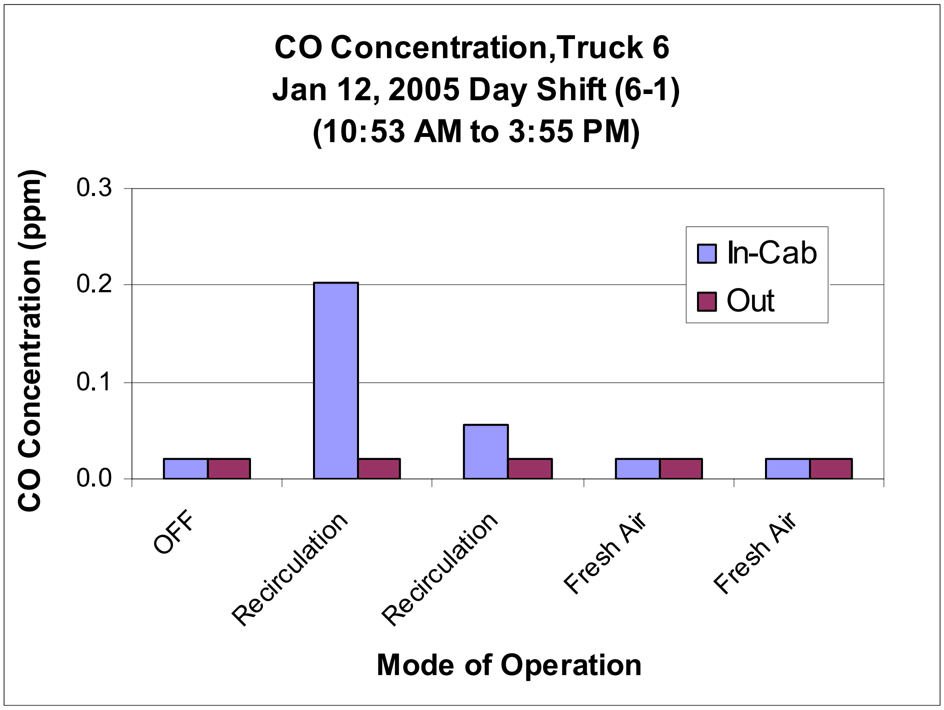

CO Concentration,Truck 4
Jan 9, 2005 Night Shift (4- 6)
(8:11 PM to 4:13 AM)
CO Concentration (ppm)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
In-Cab
Out
Engine On, Fan Off
OFF
Fresh Air
Recirculation
Fresh Air
Recirculation
Fresh Air
OFF
Mode of Operation

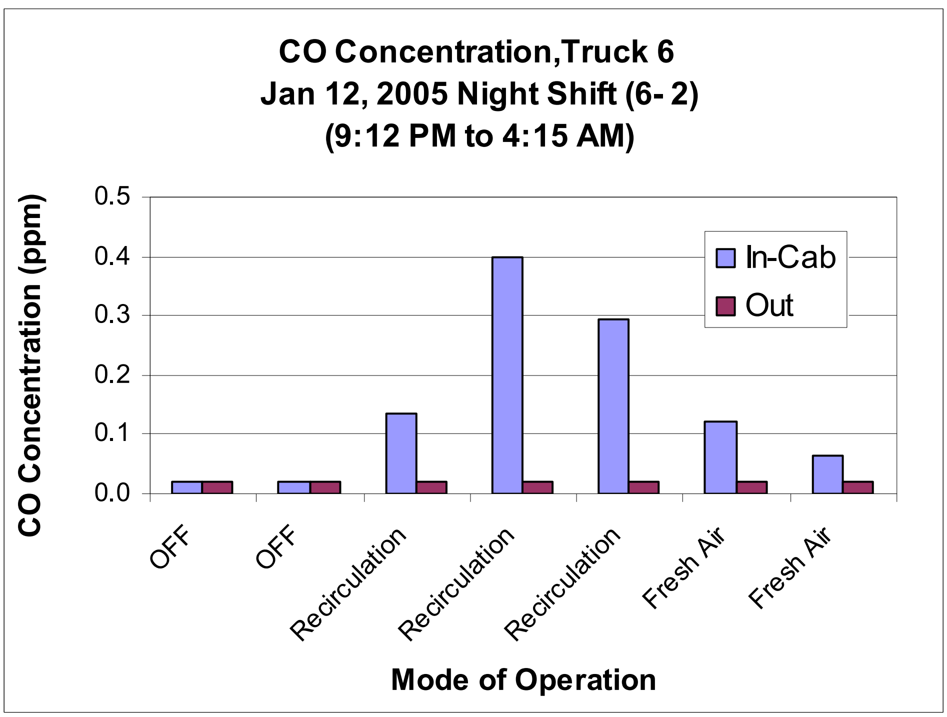

CO Concentration,Truck 5
Jan 10, 2005 Day Shift (5-1)
(10:55 AM to 05:36 PM)
CO Concentration (ppm)
0.5
0.4
0.3
0.2
0.1
0.0
In-Cab
Out
OFF
OFF
Recirculation
Recirculation
Fresh Air
Fresh Air
Mode of Operation

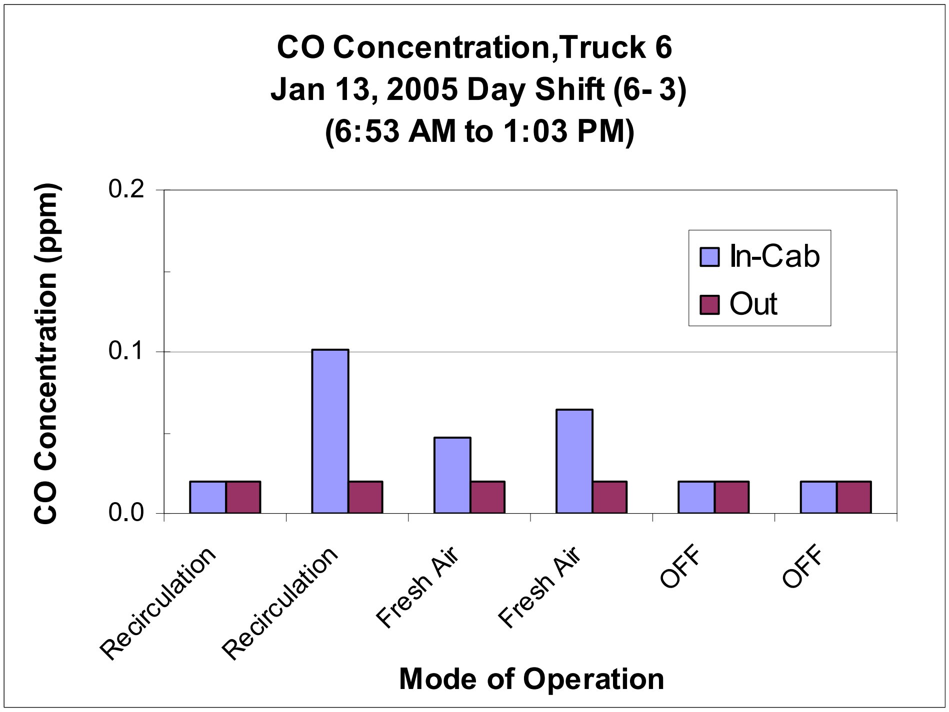

CO Concentration,Truck 5
Jan 10, 2005 Night Shift (5- 2)
(10:40 PM to 5:30 AM)
CO Concentration (ppm)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
OFF
OFF
Recirculation
Recirculation
Fresh Air
Fresh Air
Mode of Operation
In-Cab
Out

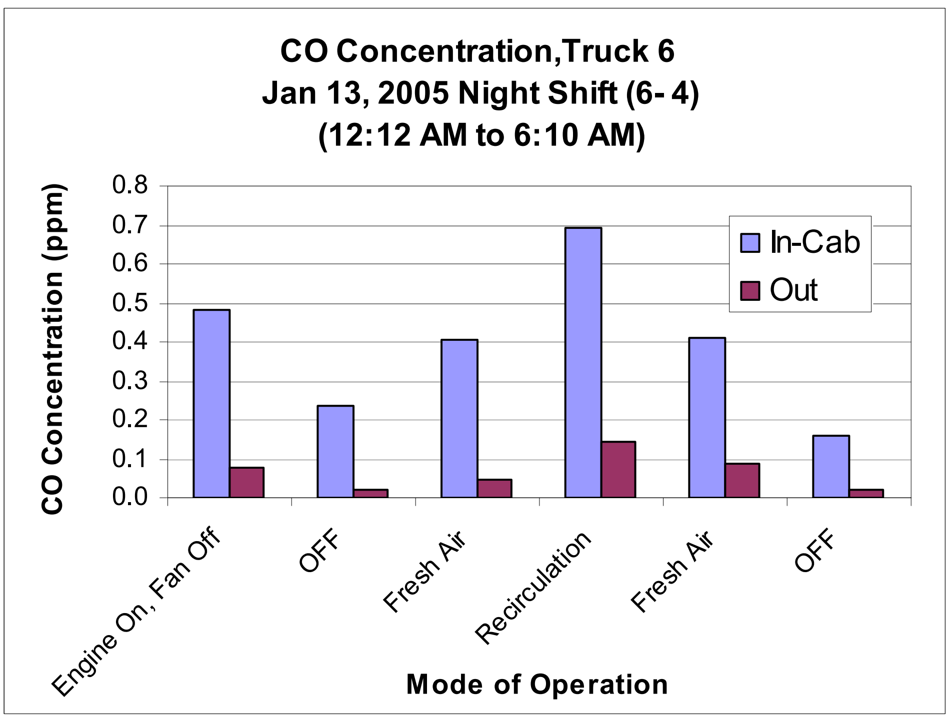

CO Concentration,Truck 5
Jan 11, 2005 Day Shift (5- 3)
(7:45 AM to 2 PM)
CO Concentration (ppm)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
In-Cab
Out
Recirculation
Recirculation
Fresh Air
Fresh Air
OFF
OFF
Mode of Operation

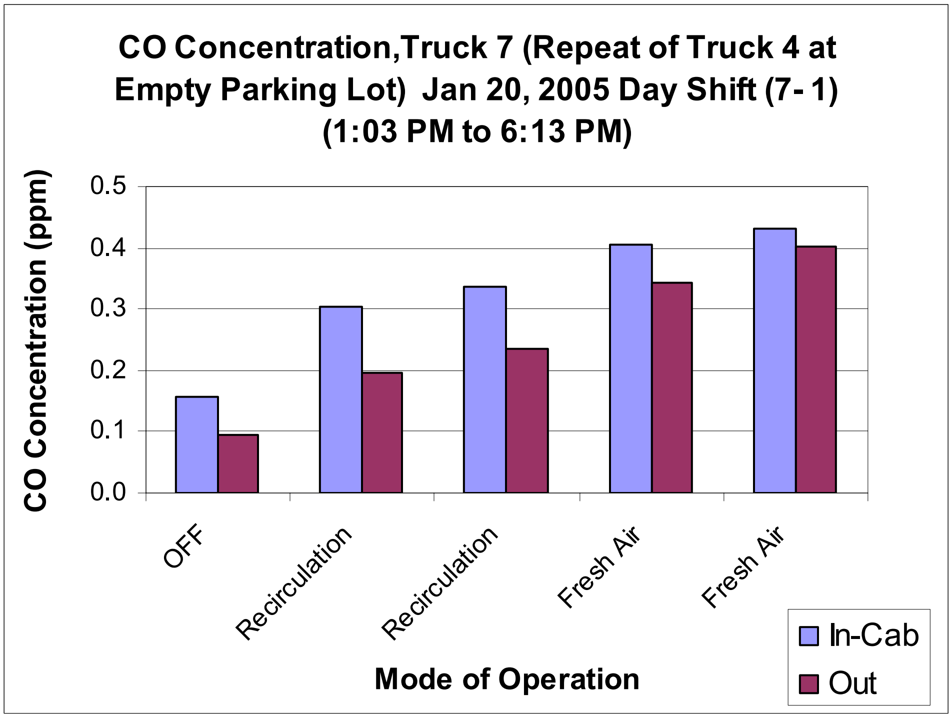

CO Concentration,Truck 5
Jan 11, 2005 Night Shift (5- 4)
(8:30 PM to 5:50 AM)
CO Concentration (ppm)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
In-Cab
Out
Engine On, Fan Off
OFF
Fresh Air
Recirculation
Fresh Air
Recirculation
Fresh Air
OFF
Mode of Operation


CO Concentration,Truck 6
Jan 12, 2005 Day Shift (6-1)
(10:53 AM to 3:55 PM)
CO Concentration (ppm)
0.3
0.2
0.1
0.0
In-Cab
Out
OFF
Recirculation
Recirculation
Fresh Air
Fresh Air
Mode of Operation


CO Concentration,Truck 6
Jan 12, 2005 Night Shift (6- 2)
(9:12 PM to 4:15 AM)
CO Concentration (ppm)
0.5
0.4
0.3
0.2
0.1
0.0
In-Cab
Out
OFF
OFF
Recirculation
Recirculation
Recirculation
Fresh Air
Fresh Air
Mode of Operation


CO Concentration,Truck 6
Jan 13, 2005 Day Shift (6- 3)
(6:53 AM to 1:03 PM)
CO Concentration (ppm)
0.2
0.1
0.0
In-Cab
Out
Recirculation
Recirculation
Fresh Air
Fresh Air
OFF
OFF
Mode of Operation


CO Concentration,Truck 6
Jan 13, 2005 Night Shift (6- 4)
(12:12 AM to 6:10 AM)
CO Concentration (ppm)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
In-Cab
Out
Engine On, Fan Off
OFF
Fresh Air
Recirculation
Fresh Air
OFF
Mode of Operation

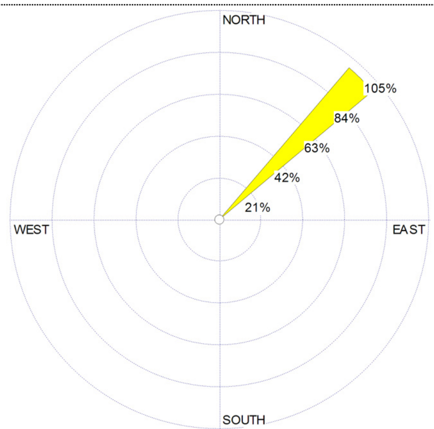

CO Concentration,Truck 7 (Repeat of Truck 4 at Empty Parking Lot) Jan 20, 2005 Day Shift (7- 1) (1:03 PM to 6:13 PM)
CO Concentration (ppm)
0.5
0.4
0.3
0.2
0.1
0.0
OFF
Recirculation
Recirculation
Fresh Air
Fresh Air
Mode of Operation
In-Cab
Out

A-6: Wind Rose Plots during the Period of Testing

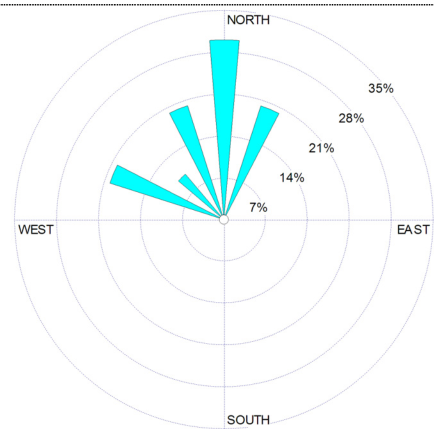
The meteorological data was analyzed for the time periods that the sampling was conducted. The wind speed and direction for each shift is shown as a wind rose. They are grouped by truck tested. The plots indicate the percent of time that the wind blew from the specific direction. Also shown in color code are the wind speeds. As may be seen, the wind direction may vary within a shift. As a reference, the test truck may be approximated as being parked in North-North East quadrant. In general, no significant relationship was found between wind direction and ambient concentrations measured in the travel center.

TRUCK 1

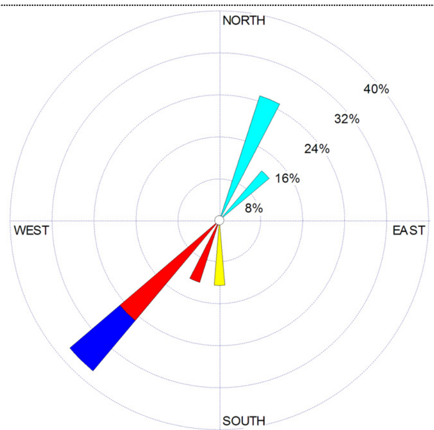
Dec 15, 2004: 2 pm to 4 pm



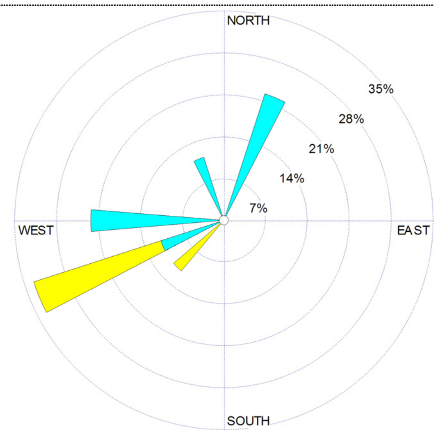
Dec 15, 2004 9 pm to Dec 16, 2004 5 am



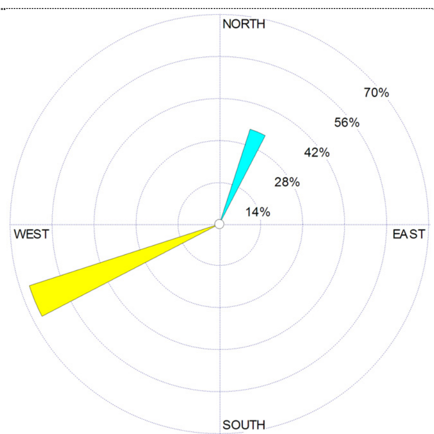
Dec 16, 2004: 8 am to 3 pm



Dec 16, 2004 8 pm to Dec 17, 2004 4 am



Dec 17, 2004: 9 am to 11 am



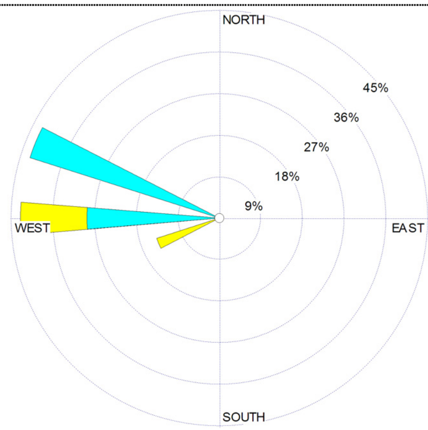
WIND SPEED
(m/s)

- >= 4.0
- 3.0 - 4.0
- 2.0 - 3.0
- 1.0 - 2.0
- 0.0 - 1.0

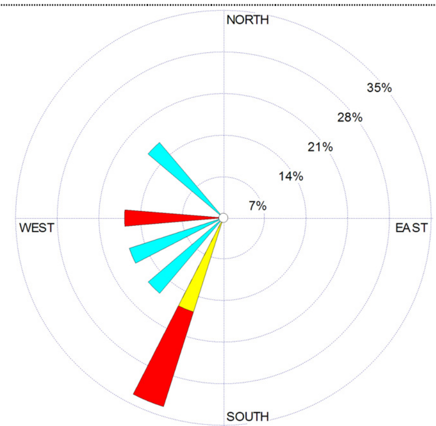
Calms: 0.00%

TRUCK 2

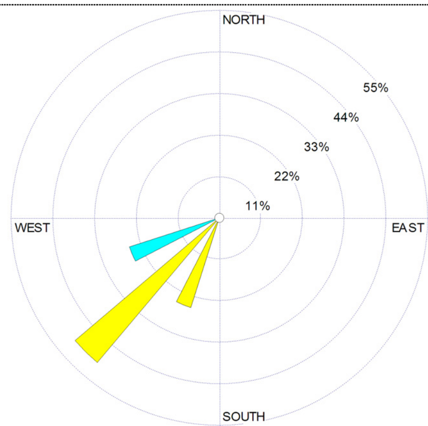
Dec 17, 2004 9 pm to Dec 18, 2004 3am



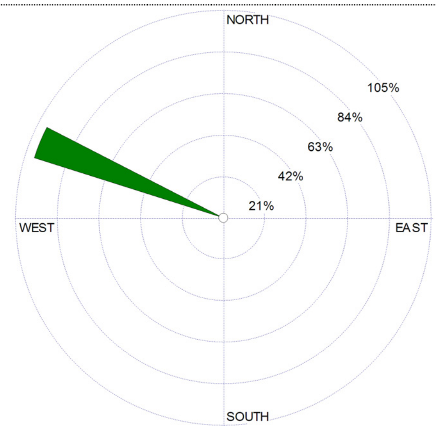
Dec 18, 2004: 7 am to 12 pm



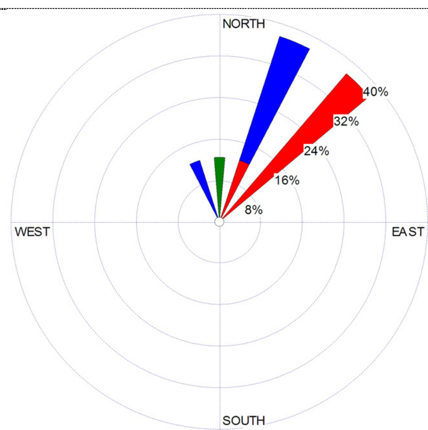
Dec 18, 2004: 8 pm to 11 pm

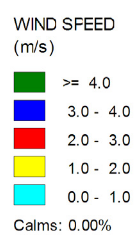


Dec 19, 2004: 11 am to 1 pm



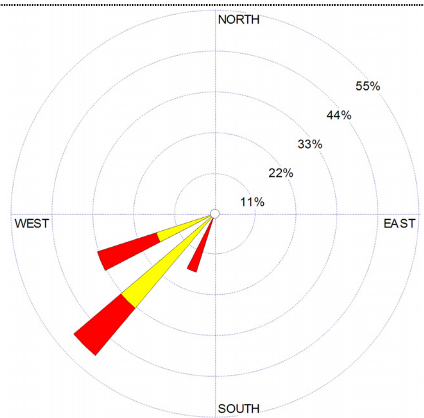
Dec 19, 2004 8 pm to Dec 19, 2004 3 am



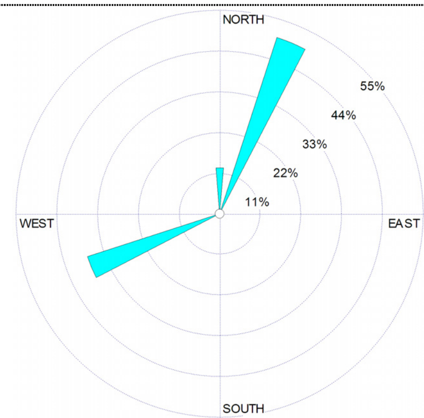


TRUCK 3

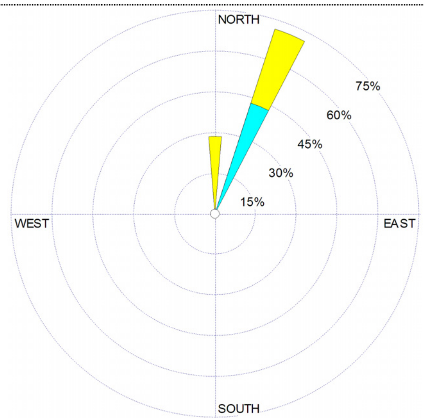
Dec 20, 2004: 11 am to 4 pm



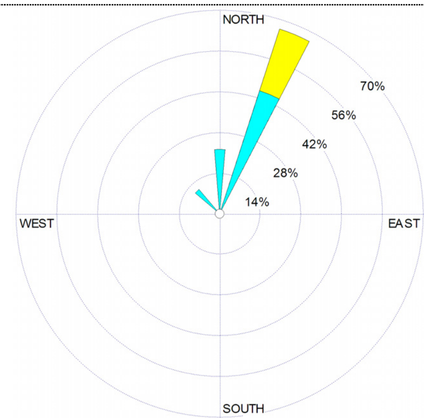
Dec 20, 2004 10 pm to Dec 21, 2004 5 am

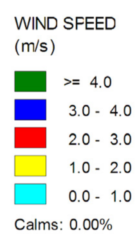


Dec 21, 2004: 7 am to 1 pm



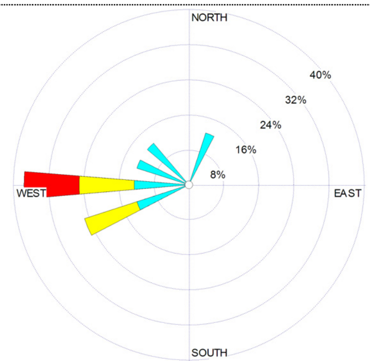
Dec 21, 2004 8 pm to Dec 22, 2004 4 am



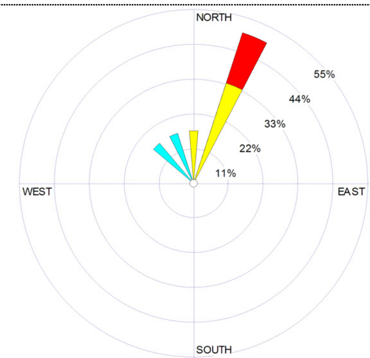


TRUCK 4

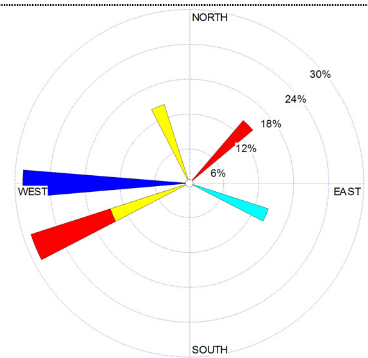
Jan 6, 2005 9 pm to Jan 7, 2005 4 am



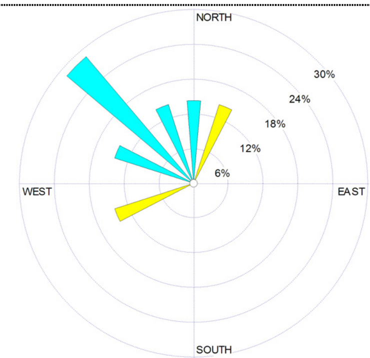
Jan 7, 2005: 7 am to 12 pm



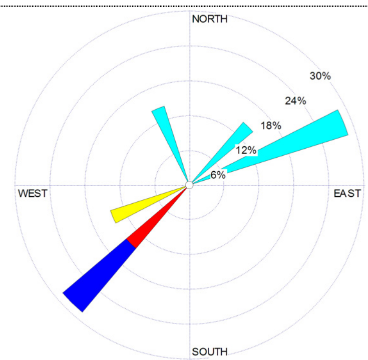
Jan 8, 2005: 9 am to 3 pm



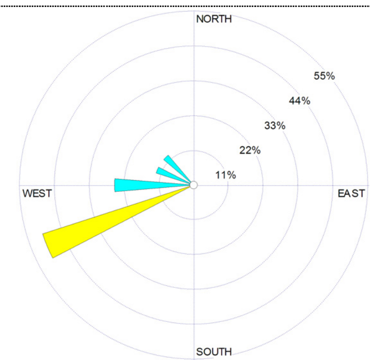
Jan 8, 2005 9 pm to Jan 9, 2005 3 am



Jan 9, 2005: 8 am to 2 pm



Jan 9, 2005 8 pm to Jan 10, 2005 3 am



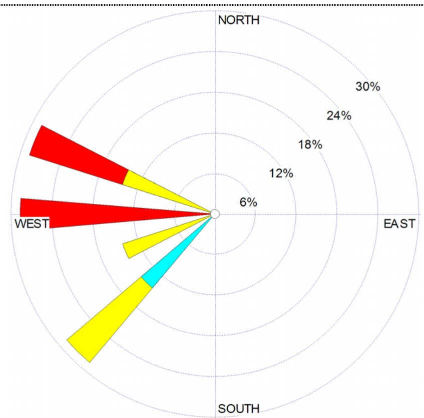
WIND SPEED
(m/s)

- >= 4.0
- 3.0 - 4.0
- 2.0 - 3.0
- 1.0 - 2.0
- 0.0 - 1.0

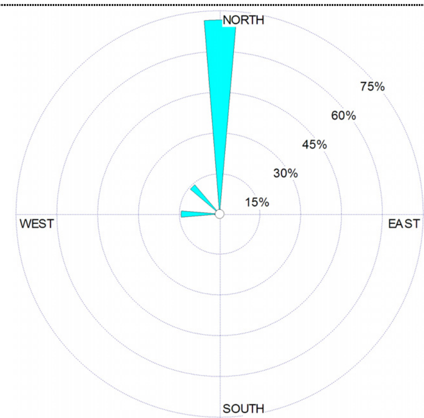
Calms: 0.00%

TRUCK 5

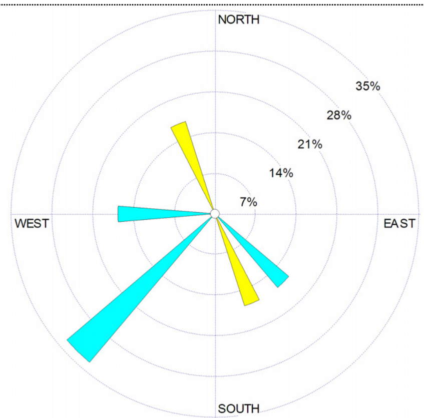
Jan 10, 2005: 11 am to 5 pm



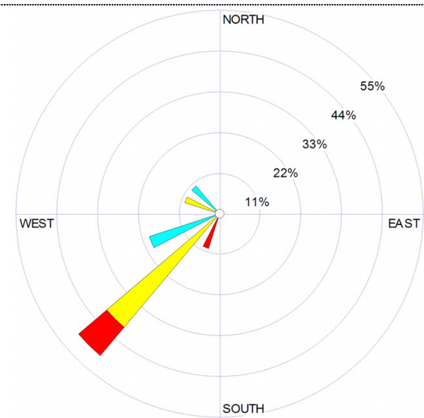
Jan 10, 2005 11 pm to Jan 11, 2005 5 am

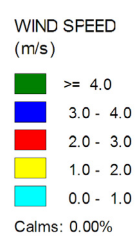


Jan 11, 2005: 8 am to 1 pm



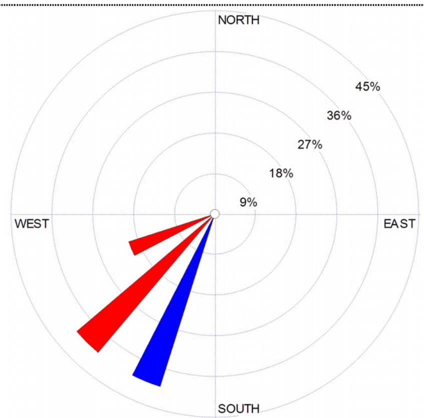
Jan 11, 2005 8 pm to Jan 12, 2005 5 am



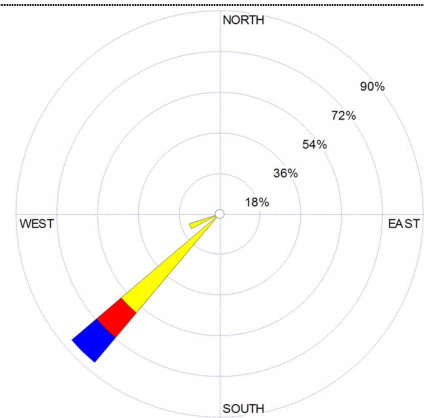


TRUCK 6

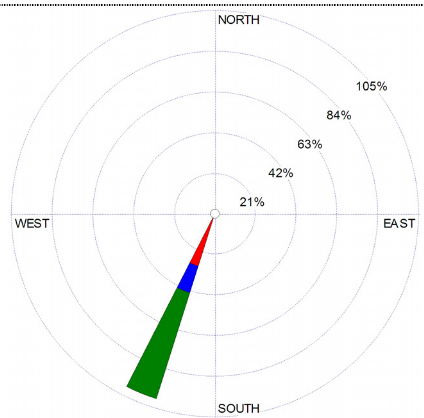
Jan 12, 2005: 11 am to 3 pm



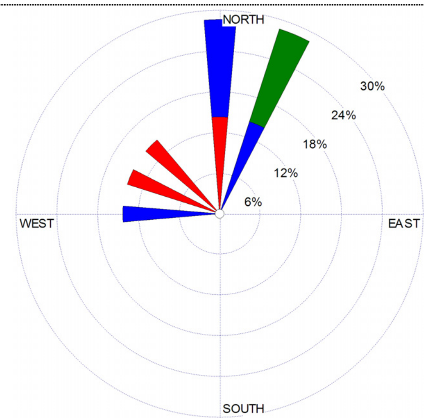
Jan 12, 2005 9 pm to Jan 13, 2005 3 am

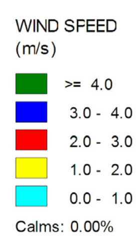


Jan 13, 2005: 6 am to 12 pm



Jan 14, 2005: 12 am to 6 am





A-7: Gaseous Concentration Data: NOx and CO Concentrations for All Trucks and All Shifts

Shift	Date	TRUCK	SHIFT CODE	TIME PERIOD	DAY/ NIGHT	Start Time	End Time	Truck Mode of Operation	NO (In)	NO (Out)	NOx (in)	NOx (out)	NO2 (in)	NO2 (out)	CO (in)	CO (out)	Used in Summary Analysis ?
Dec 15 Day	12/15/2004	1	1_1	1	Day	1:38 PM	2:39 PM	OFF	72.2	89.4	81.1	114.2	8.9	24.8	0.147	0.121	Yes
Dec 15 Day	12/15/2004	1	1_1	2	Day	2:47 PM	3:50 PM	Recirculation	602.8	176.0	675.5	203.2	72.7	27.1	0.637	0.229	Yes
Dec 15 Day	12/15/2004	1	1_1	3	Day	3:54 PM	5:02 PM	Fresh Air	232.9	137.1	270.3	170.6	37.4	33.5	0.236	0.182	No
Dec 15 Night	12/15/2004	1	1_2	1	Night	9:38 PM	10:40 PM	OFF	524.4	535.3	550.8	585.8	26.3	50.5	0.876	0.921	Yes
Dec 15 Night	12/15/2004	1	1_2	2	Night	10:46 PM	11:48 PM	OFF	486.7	504.1	541.4	521.8	54.7	17.7	1.050	0.904	Yes
Dec 15 Night	12/16/2004	1	1_2	3	Night	12:04 AM	1:06 AM	Recirculation	1159.5	603.9	1300.1	658.3	140.6	54.4	1.381	0.866	Yes
Dec 15 Night	12/16/2004	1	1_2	4	Night	1:19 AM	2:17 AM	Recirculation	1235.6	599.0	1334.9	654.7	99.4	55.7	1.339	0.912	Yes
Dec 15 Night	12/16/2004	1	1_2	5	Night	2:21 AM	3:22 AM	Recirculation	1308.1	574.9	1392.0	628.8	83.9	54.0	1.258	0.886	Yes
Dec 15 Night	12/16/2004	1	1_2	6	Night	3:24 AM	4:25 AM	Fresh Air	645.3	519.2	700.4	567.9	55.2	48.7	0.908	0.815	No
Dec 15 Night	12/16/2004	1	1_2	7	Night	4:27 AM	5:27 AM	Fresh Air	618.1	539.0	662.7	578.9	44.5	39.9	0.868	0.807	Yes
Dec 16 Day	12/16/2004	1	1_3	1	Day	8:05 AM	9:06 AM	OFF	591.7	630.8	619.9	698.8	28.2	68.0	1.414	1.512	Yes
Dec 16 Day	12/16/2004	1	1_3	2	Day	9:08 AM	10:25 AM	Recirculation	1064.9	378.5	1144.5	430.7	79.6	52.1	1.557	1.131	Yes
Dec 16 Day	12/16/2004	1	1_3	3	Day	10:30 AM	11:31 AM	Recirculation	820.2	293.4	858.5	332.6	38.3	39.2	0.893	0.584	Yes
Dec 16 Day	12/16/2004	1	1_3	4	Day	11:33 AM	12:33 PM	Fresh Air	259.9	203.6	293.7	242.5	33.9	38.9	0.480	0.434	No
Dec 16 Day	12/16/2004	1	1_3	5	Day	12:35 PM	1:38 PM	Fresh Air	350.9	345.9	382.8	389.6	31.9	43.7	0.337	0.333	Yes
Dec 16 Day	12/16/2004	1	1_3	6	Day	1:41 PM	2:42 PM	OFF	358.9	399.9	383.9	466.1	25.0	66.2	0.279	0.364	No
Dec 16 Day	12/16/2004	1	1_3	7	Day	2:45 PM	3:47 PM	OFF	206.9	227.1	246.8	273.5	39.9	46.3	0.129	0.197	Yes
Dec 16 Night	12/16/2004	1	1_4	1	Night	8:09 PM	9:09 PM	Engine On, Fan Off	918.4	620.3	972.1	682.3	53.8	62.0	1.180	0.888	Yes
Dec 16 Night	12/16/2004	1	1_4	2	Night	9:12 PM	10:12 PM	OFF	860.6	532.9	901.7	587.2	41.2	54.3	1.166	0.782	No
Dec 16 Night	12/16/2004	1	1_4	3	Night	10:14 PM	11:18 PM	Fresh Air	323.0	333.6	373.1	371.8	50.1	38.2	0.357	0.369	No
Dec 16 Night	12/17/2004	1	1_4	4	Night	11:20 PM	12:18 AM	Recirculation	943.3	621.4	981.3	677.7	38.1	56.3	0.947	0.848	No
Dec 16 Night	12/17/2004	1	1_4	5	Night	12:20 AM	1:20 AM	Fresh Air	402.9	325.2	431.7	367.1	28.9	42.0	0.448	0.318	No
Dec 16 Night	12/17/2004	1	1_4	6	Night	1:22 AM	2:22 AM	Recirculation	563.0	272.8	582.2	310.6	19.2	37.8	0.427	0.265	No
Dec 16 Night	12/17/2004	1	1_4	7	Night	2:24 AM	3:24 AM	Fresh Air	470.3	394.6	500.8	434.2	30.5	39.6	0.532	0.475	No
Dec 16 Night	12/17/2004	1	1_4	8	Night	3:26 AM	4:26 AM	OFF	460.1	637.7	471.7	686.2	11.6	48.5	0.431	0.473	No
Dec 17 Day	12/17/2004	1	1_5	1	Day	8:57 AM	9:59 AM	OFF	424.4	383.0	443.7	438.9	19.2	55.9	0.805	0.572	Yes
Dec 17 Day	12/17/2004	1	1_5	2	Day	10:02 AM	11:02 AM	Recirculation	685.4	138.3	745.3	175.7	59.9	37.4	0.697	0.221	Yes
Dec 17 Day	12/17/2004	1	1_5	3	Day	11:04 AM	12:03 PM	Fresh Air	199.8	122.0	234.8	150.6	35.0	28.6	0.084	0.020	No

Note: CO concentrations less than the minimum detectable limit of the instrument (0.04 ppm) were replaced with 0.02 ppm.

Shift	Date	TRUCK	SHIFT CODE	TIME PERIOD	DAY/ NIGHT	Start Time	End Time	Truck Mode of Operation	NO (In)	NO (Out)	NOx (in)	NOx (out)	NO2 (in)	NO2 (out)	CO (in)	CO (out)	Used in Summary Analysis ?
Dec 17 Night	12/17/2004	2	2_1	1	Night	9:08 PM	10:08 PM	OFF	637.2	738.5	672.0	835.4	34.8	96.9	1.204	1.261	Yes
Dec 17 Night	12/17/2004	2	2_1	2	Night	10:08 PM	11:08 PM	OFF	632.9	749.6	657.1	836.2	24.2	86.7	1.247	1.275	Yes
Dec 17 Night	12/18/2004	2	2_1	3	Night	11:09 PM	12:09 AM	Recirculation	1048.2	1081.5	1107.7	1234.3	59.5	152.8	1.743	1.517	Yes
Dec 17 Night	12/18/2004	2	2_1	4	Night	12:09 AM	1:09 AM	Recirculation	922.6	647.1	954.7	715.3	32.0	68.2	1.633	1.212	Yes
Dec 17 Night	12/18/2004	2	2_1	5	Night	1:09 AM	2:09 AM	Recirculation	870.5	570.9	898.8	633.9	28.3	63.1	1.523	1.090	Yes
Dec 17 Night	12/18/2004	2	2_1	6	Night	2:09 AM	3:10 AM	Fresh Air	577.0	546.0	636.4	614.4	59.4	68.4	0.875	0.815	No
Dec 17 Night	12/18/2004	2	2_1	7	Night	3:10 AM	4:10 AM	Fresh Air	427.2	428.0	468.5	470.8	41.2	42.8	0.689	0.704	Yes
Dec 18 Day	12/18/2004	2	2_2	1	Day	6:58 AM	7:58 AM	Recirculation	749.5	727.3	790.0	815.2	40.5	87.9	1.279	1.217	Yes
Dec 18 Day	12/18/2004	2	2_2	2	Day	8:00 AM	9:00 AM	Recirculation	864.4	769.0	913.0	872.1	48.6	103.0	1.515	1.424	Yes
Dec 18 Day	12/18/2004	2	2_2	3	Day	9:02 AM	10:02 AM	Fresh Air	949.3	930.1	1072.3	1072.3	123.0	142.2	1.430	1.377	No
Dec 18 Day	12/18/2004	2	2_2	4	Day	10:03 AM	11:03 AM	Fresh Air	326.9	325.4	378.0	385.1	51.1	59.7	0.351	0.329	Yes
Dec 18 Day	12/18/2004	2	2_2	5	Day	11:04 AM	12:07 PM	OFF	213.9	132.5	229.2	165.1	15.3	32.6	0.239	0.189	No
Dec 18 Day	12/18/2004	2	2_2	6	Day	12:08 PM	1:08 PM	OFF	119.0	48.4	127.2	75.8	8.2	27.3	0.141	0.052	Yes
Dec 18 Night	12/18/2004	2	2_3	1	Night	8:12 PM	9:12 PM	Engine On, Fan Off	321.9	351.5	337.4	421.5	15.4	70.0	0.702	0.355	Yes
Dec 18 Night	12/18/2004	2	2_3	2	Night	9:13 PM	10:13 PM	OFF	343.0	315.4	345.4	353.6	2.4	38.3	0.604	0.328	No
Dec 18 Night	12/18/2004	2	2_3	3	Night	10:13 PM	11:13 PM	Fresh Air	267.1	266.5	307.5	308.8	40.4	42.3	0.407	0.374	No
Dec 19 Day	12/19/2004	2	2_4	1	Day	11:04 AM	12:04 PM	OFF	180.1	391.1	195.5	455.8	15.4	64.7	0.163	0.213	Yes
Dec 19 Day	12/19/2004	2	2_4	2	Day	12:07 PM	1:11 PM	Recirculation	382.8	630.9	409.2	734.7	26.3	103.8	0.411	0.525	Yes
Dec 19 Day	12/19/2004	2	2_4	3	Day	1:17 PM	2:17 PM	Recirculation	405.0	559.8	421.8	624.5	16.7	64.7	0.354	0.398	Yes
Dec 19 Night	12/19/2004	2	2_5	1	Night	8:46 PM	9:46 PM	OFF	66.7	173.7	75.1	233.5	8.4	59.8	0.069	0.412	Yes
Dec 19 Night	12/19/2004	2	2_5	2	Night	9:50 PM	10:50 PM	Recirculation	206.2	723.3	229.3	897.3	23.0	174.1	0.371	1.525	No
Dec 19 Night	12/19/2004	2	2_5	3	Night	10:52 PM	11:53 PM	Fresh Air	548.0	761.3	643.3	920.3	95.4	159.0	0.835	1.146	No
Dec 19 Night	12/20/2004	2	2_5	4	Night	11:55 PM	12:56 AM	Recirculation	525.2	908.5	576.3	1082.4	51.2	173.9	0.699	1.089	No
Dec 19 Night	12/20/2004	2	2_5	5	Night	12:58 AM	2:00 AM	Fresh Air	693.6	863.1	797.7	1030.9	104.1	167.8	0.740	0.941	No
Dec 19 Night	12/20/2004	2	2_5	6	Night	2:03 AM	3:04 AM	OFF	457.3	320.1	491.3	383.4	33.9	63.3	0.442	0.269	No
Dec 19 Night	12/20/2004	2	2_5	7	Night	3:07 AM	4:08 AM	OFF	287.6	264.2	306.3	333.5	18.7	69.3	0.304	0.367	Yes

Note: CO concentrations less than the minimum detectable limit of the instrument (0.04 ppm) were replaced with 0.02 ppm.

Shift	Date	TRUCK	SHIFT CODE	TIME PERIOD	DAY/ NIGHT	Start Time	End Time	Truck Mode of Operation	NO (In)	NO (Out)	NOx (in)	NOx (out)	NO2 (in)	NO2 (out)	CO (in)	CO (out)	Used in Summary Analysis ?
Dec 20 Day	12/20/2004	3	3_1	1	Day	10:51 AM	11:51 AM	OFF	119.0	105.7	136.6	140.8	17.6	35.1	0.226	0.162	Yes
Dec 20 Day	12/20/2004	3	3_1	2	Day	11:51 AM	12:51 PM	OFF	117.6	151.7	135.1	193.2	17.4	41.5	0.398	0.143	Yes
Dec 20 Day	12/20/2004	3	3_1	3	Day	1:01 PM	2:01 PM	Recirculation	250.1	234.3	285.2	299.3	35.1	65.0	1.283	0.543	Yes
Dec 20 Day	12/20/2004	3	3_1	4	Day	2:01 PM	3:01 PM	Recirculation	322.6	233.5	359.9	314.7	37.3	81.2	1.220	0.633	Yes
Dec 20 Day	12/20/2004	3	3_1	5	Day	3:02 PM	4:02 PM	Fresh Air	309.0	253.5	384.8	325.9	75.8	72.3	0.741	0.531	No
Dec 20 Day	12/20/2004	3	3_1	6	Day	4:02 PM	5:02 PM	Fresh Air	408.6	371.1	501.7	483.7	93.0	112.6	0.942	0.888	Yes
Dec 20 Night	12/20/2004	3	3_2	1	Night	9:51 PM	10:51 PM	OFF	458.8	742.7	480.6	841.6	21.8	98.9	0.722	1.041	Yes
Dec 20 Night	12/20/2004	3	3_2	2	Night	10:52 PM	11:58 PM	OFF	520.0	636.4	541.5	727.9	21.5	91.5	0.866	1.145	Yes
Dec 20 Night	12/21/2004	3	3_2	3	Night	12:04 AM	1:07 AM	Recirculation	522.0	462.5	571.8	549.3	49.9	86.8	2.067	0.782	Yes
Dec 20 Night	12/21/2004	3	3_2	4	Night	1:09 AM	2:18 AM	Recirculation	566.2	493.7	606.8	560.9	40.6	67.2	1.647	0.557	Yes
Dec 20 Night	12/21/2004	3	3_2	5	Night	2:20 AM	3:28 AM	Recirculation	680.8	628.4	729.3	711.3	48.5	82.9	1.697	0.945	Yes
Dec 20 Night	12/21/2004	3	3_2	6	Night	3:30 AM	4:38 AM	Fresh Air	619.8	568.5	694.0	641.9	74.2	73.4	0.895	0.656	No
Dec 20 Night	12/21/2004	3	3_2	7	Night	4:41 AM	5:41 AM	Fresh Air	523.9	475.8	583.7	535.0	59.8	59.2	0.803	0.609	Yes
Dec 21 Day	12/21/2004	3	3_3	1	Day	7:21 AM	8:21 AM	Recirculation	480.9	389.4	515.4	447.7	34.5	58.3	1.407	0.778	Yes
Dec 21 Day	12/21/2004	3	3_3	2	Day	8:21 AM	9:21 AM	Recirculation	438.0	297.4	469.6	349.6	31.6	52.3	1.437	0.578	Yes
Dec 21 Day	12/21/2004	3	3_3	3	Day	9:21 AM	10:21 AM	Fresh Air	272.7	223.9	318.8	273.6	46.1	49.7	0.481	0.301	No
Dec 21 Day	12/21/2004	3	3_3	4	Day	10:21 AM	11:21 AM	Fresh Air	324.7	269.4	371.9	319.0	47.1	49.6	0.448	0.258	Yes
Dec 21 Day	12/21/2004	3	3_3	5	Day	11:22 AM	12:22 PM	OFF	234.8	229.2	245.6	265.8	10.8	36.7	0.373	0.243	No
Dec 21 Day	12/21/2004	3	3_3	6	Day	12:22 PM	1:22 PM	OFF	189.7	217.8	231.7	223.3	42.0	5.5	0.147	0.335	Yes
Dec 21 Night	12/21/2004	3	3_4	1	Night	8:41 PM	9:41 PM	Engine On, Fan Off	437.3	402.8	460.2	466.8	22.8	64.0	0.961	0.875	Yes
Dec 21 Night	12/21/2004	3	3_4	2	Night	9:43 PM	10:47 PM	OFF	431.4	423.4	442.6	485.0	11.2	61.6	0.926	0.831	No
Dec 21 Night	12/21/2004	3	3_4	3	Night	10:51 PM	11:54 PM	Fresh Air	530.8	480.2	597.7	547.2	66.9	67.0	1.080	0.913	No
Dec 21 Night	12/22/2004	3	3_4	4	Night	11:56 PM	12:57 AM	Recirculation	557.2	486.8	586.3	540.4	29.1	53.7	1.307	1.034	No
Dec 21 Night	12/22/2004	3	3_4	5	Night	12:59 AM	2:05 AM	Fresh Air	483.1	427.0	529.9	469.4	46.8	42.4	1.197	0.995	No
Dec 21 Night	12/22/2004	3	3_4	6	Night	2:07 AM	3:07 AM	Recirculation	436.9	384.0	453.8	427.4	16.9	43.4	1.133	0.842	No
Dec 21 Night	12/22/2004	3	3_4	7	Night	3:07 AM	4:10 AM	Fresh Air	486.1	433.4	530.1	469.1	44.1	35.7	1.015	0.805	No
Dec 21 Night	12/22/2004	3	3_4	8	Night	4:13 AM	5:13 AM	OFF	432.6	534.4	447.7	595.7	15.1	61.3	0.915	0.966	No

Note: CO concentrations less than the minimum detectable limit of the instrument (0.04 ppm) were replaced with 0.02 ppm.

Shift	Date	TRUCK	SHIFT CODE	TIME PERIOD	DAY/ NIGHT	Start Time	End Time	Truck Mode of Operation	NO (In)	NO (Out)	NOx (in)	NOx (out)	NO2 (in)	NO2 (out)	CO (in)	CO (out)	Used in Summary Analysis ?
Jan 6 Night	1/6/2005	4	4_1	1	Night	9:35 PM	10:35 PM	OFF	310.2	221.5	316.8	259.4	6.6	37.9	0.390	0.095	No
Jan 6 Night	1/6/2005	4	4_1	2	Night	10:35 PM	11:35 PM	OFF	260.9	254.0	268.6	292.1	7.8	38.2	0.499	0.131	Yes
Jan 6 Night	1/6/2005	4	4_1	3	Night	11:35 PM	12:35 AM	Recirculation	459.0	258.8	475.9	297.5	16.8	38.7	0.412	0.079	Yes
Jan 6 Night	1/6/2005	4	4_1	4	Night	12:35 AM	1:35 AM	Recirculation	510.2	238.1	528.3	272.8	18.1	34.8	0.372	0.074	Yes
Jan 6 Night	1/6/2005	4	4_1	5	Night	1:35 AM	2:35 AM	Recirculation	479.0	246.3	495.9	268.5	16.9	22.1	0.275	0.089	Yes
Jan 6 Night	1/6/2005	4	4_1	6	Night	2:35 AM	3:35 AM	Fresh Air	375.1	234.1	399.0	255.2	23.9	21.1	0.152	0.058	No
Jan 6 Night	1/6/2005	4	4_1	7	Night	3:35 AM	4:35 AM	Fresh Air	376.7	232.5	406.9	256.3	30.2	23.9	0.202	0.125	Yes
Jan 7 Day	1/7/2005	4	4_2	1	Day	6:56 AM	7:58 AM	Recirculation	485.2	285.6	501.2	313.4	16.1	27.9	0.431	0.347	Yes
Jan 7 Day	1/7/2005	4	4_2	2	Day	8:01 AM	9:01 AM	Recirculation	548.6	299.6	563.9	327.8	15.4	28.2	0.529	0.404	Yes
Jan 7 Day	1/7/2005	4	4_2	3	Day	9:02 AM	10:04 AM	Fresh Air	386.0	247.9	412.6	273.1	26.6	25.2	0.276	0.198	No
Jan 7 Day	1/7/2005	4	4_2	4	Day	10:05 AM	11:07 AM	Fresh Air	353.0	220.2	379.4	240.5	26.4	20.2	0.267	0.218	Yes
Jan 7 Day	1/7/2005	4	4_2	5	Day	11:09 AM	12:09 PM	OFF	191.0	85.3	192.8	94.2	1.8	8.8	0.165	0.077	No
Jan 7 Day	1/7/2005	4	4_2	6	Day	12:10 PM	1:10 PM	OFF	96.0	106.4	96.0	118.4	0.0	12.1	0.120	0.156	Yes
Jan 8 Day	1/8/2005	4	4_3	1	Day	8:50 AM	9:50 AM	OFF	154.4	150.7	159.0	178.2	4.6	27.5	0.089	0.081	Yes
Jan 8 Day	1/8/2005	4	4_3	2	Day	9:51 AM	10:51 AM	OFF	124.5	86.2	125.9	111.0	1.3	24.7	0.075	0.020	Yes
Jan 8 Day	1/8/2005	4	4_3	3	Day	10:53 AM	11:54 AM	OFF	111.1	110.7	113.1	139.4	2.0	28.7	0.063	0.044	Yes
Jan 8 Day	1/8/2005	4	4_3	4	Day	11:58 AM	12:59 PM	Recirculation	249.6	112.3	258.5	137.8	9.0	25.5	0.140	0.020	Yes
Jan 8 Day	1/8/2005	4	4_3	5	Day	1:00 PM	2:00 PM	Recirculation	280.5	88.7	283.8	104.9	3.3	16.2	0.020	0.020	Yes
Jan 8 Day	1/8/2005	4	4_3	6	Day	2:01 PM	3:01 PM	Fresh Air	264.0	175.8	285.2	201.8	21.2	26.1	0.020	0.020	No
Jan 8 Day	1/8/2005	4	4_3	7	Day	3:02 PM	4:05 PM	Fresh Air	252.6	136.5	272.3	160.7	19.7	24.2	0.020	0.020	Yes
Jan 8 Night	1/9/2005	4	4_4	1	Night	9:03 PM	10:03 PM	OFF	219.2	257.5	223.7	304.9	4.5	47.4	0.396	0.113	Yes
Jan 8 Night	1/9/2005	4	4_4	2	Night	10:03 PM	11:03 PM	OFF	225.0	253.5	226.1	297.7	1.1	44.2	0.366	0.259	Yes
Jan 8 Night	1/9/2005	4	4_4	3	Night	11:03 PM	12:03 AM	Recirculation	518.7	413.8	544.0	471.0	25.3	57.2	0.707	0.495	Yes
Jan 8 Night	1/9/2005	4	4_4	4	Night	12:03 AM	1:03 AM	Recirculation	509.6	371.8	535.7	411.2	26.1	39.4	0.681	0.529	Yes
Jan 8 Night	1/9/2005	4	4_4	5	Night	1:03 AM	2:03 AM	Recirculation	548.3	405.8	565.4	444.2	17.1	38.4	1.035	0.832	Yes
Jan 8 Night	1/9/2005	4	4_4	6	Night	2:04 AM	3:04 AM	Fresh Air	553.0	406.2	593.6	442.5	40.7	36.2	0.890	0.746	No
Jan 8 Night	1/9/2005	4	4_4	7	Night	3:04 AM	4:04 AM	Fresh Air	433.1	317.8	468.3	343.6	35.2	25.8	0.327	0.206	Yes

Note: CO concentrations less than the minimum detectable limit of the instrument (0.04 ppm) were replaced with 0.02 ppm.

Shift	Date	TRUCK	SHIFT CODE	TIME PERIOD	DAY/ NIGHT	Start Time	End Time	Truck Mode of Operation	NO (In)	NO (Out)	NOx (in)	NOx (out)	NO2 (in)	NO2 (out)	CO (in)	CO (out)	Used in Summary Analysis ?
Jan 9 Day	1/9/2005	4	4_5	1	Day	7:48 AM	8:55 AM	Recirculation	608.4	484.9	636.9	534.7	28.5	49.8	0.646	0.594	Yes
Jan 9 Day	1/9/2005	4	4_5	2	Day	8:57 AM	9:57 AM	Recirculation	629.3	502.5	668.7	556.4	39.3	53.9	0.556	0.446	Yes
Jan 9 Day	1/9/2005	4	4_5	3	Day	9:58 AM	11:03 AM	Fresh Air	428.2	334.4	469.7	376.3	41.5	41.9	0.301	0.255	No
Jan 9 Day	1/9/2005	4	4_5	4	Day	11:04 AM	12:06 PM	Fresh Air	216.1	142.0	237.9	166.5	21.8	24.6	0.133	0.121	Yes
Jan 9 Day	1/9/2005	4	4_5	5	Day	12:12 PM	1:21 PM	OFF	166.6	65.9	170.3	81.3	3.7	15.4	0.081	0.020	No
Jan 9 Day	1/9/2005	4	4_5	6	Day	1:22 PM	2:31 PM	OFF	119.6	88.3	120.9	114.1	1.3	25.8	0.020	0.020	Yes
Jan 9 Night	1/9/2005	4	4_6	1	Night	8:11 PM	9:11 PM	Engine On, Fan Off	369.6	460.6	374.9	520.0	5.3	59.3	0.879	0.534	Yes
Jan 9 Night	1/9/2005	4	4_6	2	Night	9:11 PM	10:11 PM	OFF	541.4	623.2	550.0	697.0	8.7	73.8	1.044	0.645	No
Jan 9 Night	1/9/2005	4	4_6	3	Night	10:11 PM	11:11 PM	Fresh Air	809.1	734.5	881.1	807.2	72.0	72.7	0.782	0.743	No
Jan 9 Night	1/9/2005	4	4_6	4	Night	11:11 PM	12:11 AM	Recirculation	792.7	794.1	829.1	839.3	36.4	45.2	1.254	1.226	No
Jan 9 Night	1/9/2005	4	4_6	5	Night	12:12 AM	1:12 AM	Fresh Air	928.4	845.0	1003.7	930.7	75.3	85.7	1.134	1.071	No
Jan 9 Night	1/9/2005	4	4_6	6	Night	1:12 AM	2:12 AM	Recirculation	876.2	767.7	913.5	842.6	37.3	74.9	0.853	0.732	No
Jan 9 Night	1/9/2005	4	4_6	7	Night	2:12 AM	3:12 AM	Fresh Air	494.7	414.2	554.1	473.0	59.3	58.9	0.475	0.394	No
Jan 9 Night	1/9/2005	4	4_6	8	Night	3:12 AM	4:12 AM	OFF	378.4	329.1	387.5	370.3	9.1	41.1	0.440	0.240	No

Note: CO concentrations less than the minimum detectable limit of the instrument (0.04 ppm) were replaced with 0.02 ppm.

Shift	Date	TRUCK	SHIFT CODE	TIME PERIOD	DAY/ NIGHT	Start Time	End Time	Truck Mode of Operation	NO (In)	NO (Out)	NOx (in)	NOx (out)	NO2 (in)	NO2 (out)	CO (in)	CO (out)	Used in Summary Analysis ?
Jan 10 Day	1/10/2005	5	5_1	1	Day	10:55 AM	12:05 PM	OFF	153.6	49.6	154.0	68.5	0.4	18.9	0.278	0.069	No
Jan 10 Day	1/10/2005	5	5_1	2	Day	12:06 PM	1:16 PM	OFF	146.3	105.8	146.3	132.8	0.0	27.0	0.209	0.020	Yes
Jan 10 Day	1/10/2005	5	5_1	3	Day	1:20 PM	2:20 PM	Recirculation	665.8	156.0	681.7	187.1	15.9	31.1	0.324	0.020	Yes
Jan 10 Day	1/10/2005	5	5_1	4	Day	2:21 PM	3:23 PM	Recirculation	1164.0	139.6	1196.0	169.5	32.0	29.9	0.446	0.020	Yes
Jan 10 Day	1/10/2005	5	5_1	5	Day	3:25 PM	4:32 PM	Fresh Air	854.2	192.6	915.3	237.8	61.1	45.2	0.354	0.123	No
Jan 10 Day	1/10/2005	5	5_1	6	Day	4:33 PM	5:36 PM	Fresh Air	740.1	110.9	800.8	143.3	60.7	32.4	0.374	0.230	Yes
Jan 10 Night	1/10/2005	5	5_2	1	Night	10:40 PM	11:44 PM	OFF	545.1	540.8	571.0	609.8	25.9	69.0	1.017	0.652	Yes
Jan 10 Night	1/10/2005	5	5_2	2	Night	11:47 PM	12:49 AM	OFF	500.8	454.7	527.0	503.1	26.2	48.5	0.848	0.565	Yes
Jan 10 Night	1/10/2005	5	5_2	3	Night	12:52 AM	1:59 AM	Recirculation	1681.2	703.2	1807.5	777.1	126.3	73.9	1.054	0.519	Yes
Jan 10 Night	1/10/2005	5	5_2	4	Night	2:02 AM	3:08 AM	Recirculation	2004.0	499.0	2172.7	549.1	168.7	50.1	1.111	0.458	Yes
Jan 10 Night	1/10/2005	5	5_2	5	Night	3:10 AM	4:15 AM	Fresh Air	1504.4	535.9	1661.2	588.2	156.8	52.3	0.792	0.441	No
Jan 10 Night	1/10/2005	5	5_2	6	Night	4:29 AM	5:30 AM	Fresh Air	1368.5	659.3	1504.8	746.8	136.3	87.5	0.699	0.461	Yes
Jan 11 Day	1/11/2005	5	5_3	1	Day	7:45 AM	8:45 AM	Recirculation	984.0	345.3	1017.5	386.4	33.5	41.1	0.713	0.395	Yes
Jan 11 Day	1/11/2005	5	5_3	2	Day	8:46 AM	9:46 AM	Recirculation	1121.9	335.6	1167.8	376.7	45.9	41.1	0.642	0.336	Yes
Jan 11 Day	1/11/2005	5	5_3	3	Day	9:47 AM	10:48 AM	Fresh Air	664.7	189.4	705.2	211.9	40.4	22.5	0.279	0.126	No
Jan 11 Day	1/11/2005	5	5_3	4	Day	10:50 AM	11:53 AM	Fresh Air	600.2	161.9	635.1	189.1	34.9	27.2	0.173	0.020	Yes
Jan 11 Day	1/11/2005	5	5_3	5	Day	11:55 AM	12:55 PM	OFF	538.1	191.7	545.9	216.7	7.8	25.0	0.093	0.053	No
Jan 11 Day	1/11/2005	5	5_3	6	Day	12:56 PM	2:00 PM	OFF	428.2	199.7	428.2	221.6	0.0	22.0	0.105	0.187	Yes
Jan 11 Night	1/11/2005	5	5_4	1	Night	8:30 PM	9:38 PM	Engine On, Fan Off	404.2	275.5	407.0	309.6	2.9	34.0	0.473	0.327	Yes
Jan 11 Night	1/11/2005	5	5_4	2	Night	9:40 PM	10:48 PM	OFF	616.5	279.1	627.3	304.1	10.9	25.0	0.516	0.293	No
Jan 11 Night	1/11/2005	5	5_4	3	Night	10:52 PM	12:00 AM	Fresh Air	756.1	298.0	802.0	330.5	45.9	32.5	0.396	0.253	No
Jan 11 Night	1/11/2005	5	5_4	4	Night	12:03 AM	1:13 AM	Recirculation	697.0	251.3	710.3	276.1	13.3	24.8	0.236	0.122	No
Jan 11 Night	1/11/2005	5	5_4	5	Night	1:15 AM	2:16 AM	Fresh Air	584.9	216.4	602.4	254.3	17.5	37.9	0.109	0.020	No
Jan 11 Night	1/11/2005	5	5_4	6	Night	2:21 AM	3:32 AM	Recirculation	585.3	162.3	591.6	192.0	6.2	29.7	0.020	0.020	No
Jan 11 Night	1/11/2005	5	5_4	7	Night	3:35 AM	4:44 AM	Fresh Air	491.7	166.7	516.9	197.7	25.2	31.0	0.020	0.020	No
Jan 11 Night	1/11/2005	5	5_4	8	Night	4:46 AM	5:50 AM	OFF	352.7	135.5	352.7	157.2	0.0	21.7	0.020	0.020	No

Note: CO concentrations less than the minimum detectable limit of the instrument (0.04 ppm) were replaced with 0.02 ppm.

Shift	Date	TRUCK	SHIFT CODE	TIME PERIOD	DAY/ NIGHT	Start Time	End Time	Truck Mode of Operation	NO (In)	NO (Out)	NOx (in)	NOx (out)	NO2 (in)	NO2 (out)	CO (in)	CO (out)	Used in Summary Analysis ?
Jan 12 Day	1/12/2005	6	6_1	1	Day	10:53 AM	11:53 AM	OFF	187.8	93.4	191.0	120.6	3.3	27.2	0.020	0.020	Yes
Jan 12 Day	1/12/2005	6	6_1	2	Day	11:53 AM	12:54 PM	Recirculation	1141.6	246.2	1217.5	256.6	75.8	10.4	0.202	0.020	Yes
Jan 12 Day	1/12/2005	6	6_1	3	Day	12:54 PM	1:54 PM	Recirculation	1292.0	199.3	1364.7	230.6	72.6	31.3	0.056	0.020	Yes
Jan 12 Day	1/12/2005	6	6_1	4	Day	1:54 PM	2:54 PM	Fresh Air	844.9	101.1	909.0	126.7	64.1	25.5	0.020	0.020	No
Jan 12 Day	1/12/2005	6	6_1	5	Day	2:54 PM	3:54 PM	Fresh Air	1156.9	116.1	1215.9	142.0	59.1	25.9	0.020	0.020	Yes
Jan 12 Night	1/12/2005	6	6_2	1	Night	9:12 PM	10:15 PM	OFF	349.5	147.5	352.9	182.2	3.4	34.7	0.020	0.020	Yes
Jan 12 Night	1/12/2005	6	6_2	2	Night	10:15 PM	11:20 PM	OFF	240.9	116.9	243.6	148.0	2.8	31.1	0.020	0.020	Yes
Jan 12 Night	1/12/2005	6	6_2	3	Night	11:20 PM	12:21 AM	Recirculation	1301.0	223.2	1417.4	269.7	116.4	46.4	0.137	0.020	Yes
Jan 12 Night	1/12/2005	6	6_2	4	Night	12:21 AM	1:19 AM	Recirculation	3008.9	526.0	3296.4	599.1	287.4	73.2	0.398	0.020	Yes
Jan 12 Night	1/12/2005	6	6_2	5	Night	1:19 AM	2:17 AM	Recirculation	2798.4	528.0	3066.1	587.2	267.7	59.3	0.295	0.020	Yes
Jan 12 Night	1/12/2005	6	6_2	6	Night	2:17 AM	3:15 AM	Fresh Air	1978.4	342.3	2159.9	393.5	181.5	51.2	0.122	0.020	No
Jan 12 Night	1/12/2005	6	6_2	7	Night	3:15 AM	4:15 AM	Fresh Air	1600.4	276.3	1761.8	320.1	161.4	43.8	0.063	0.020	Yes
Jan 13 Day	1/13/2005	6	6_3	1	Day	6:53 AM	7:56 AM	Recirculation	820.3	188.4	858.5	226.0	38.3	37.7	0.020	0.020	Yes
Jan 13 Day	1/13/2005	6	6_3	2	Day	7:58 AM	8:59 AM	Recirculation	1838.2	270.8	1968.3	302.7	130.2	31.9	0.101	0.020	Yes
Jan 13 Day	1/13/2005	6	6_3	3	Day	9:00 AM	10:00 AM	Fresh Air	1395.5	253.2	1482.1	287.7	86.6	34.5	0.046	0.020	No
Jan 13 Day	1/13/2005	6	6_3	4	Day	10:01 AM	11:01 AM	Fresh Air	1164.2	196.5	1222.7	226.6	58.5	30.1	0.064	0.020	Yes
Jan 13 Day	1/13/2005	6	6_3	5	Day	11:02 AM	12:02 PM	OFF	545.0	43.9	545.0	59.3	0.0	15.4	0.020	0.020	No
Jan 13 Day	1/13/2005	6	6_3	6	Day	12:03 PM	1:03 PM	OFF	137.2	39.2	138.0	56.2	0.8	17.0	0.020	0.020	Yes
Jan 13 Night	1/13/2005	6	6_4	1	Night	12:11 AM	1:08 AM	Engine On, Fan Off	627.8	565.8	637.1	618.4	9.3	52.6	0.481	0.075	Yes
Jan 13 Night	1/13/2005	6	6_4	2	Night	1:10 AM	2:10 AM	OFF	482.2	91.6	488.7	104.4	6.6	12.8	0.238	0.020	No
Jan 13 Night	1/13/2005	6	6_4	3	Night	2:11 AM	3:06 AM	Fresh Air	1442.6	341.9	1586.1	377.0	143.5	35.1	0.407	0.044	No
Jan 13 Night	1/13/2005	6	6_4	4	Night	3:08 AM	4:11 AM	Recirculation	2623.2	658.9	2852.0	712.1	228.8	53.2	0.692	0.146	No
Jan 13 Night	1/13/2005	6	6_4	5	Night	4:14 AM	5:10 AM	Fresh Air	2008.6	459.4	2180.1	500.2	171.5	40.8	0.408	0.085	No
Jan 13 Night	1/13/2005	6	6_4	6	Night	5:10 AM	6:10 AM	OFF	790.1	199.1	808.8	223.3	18.7	24.2	0.157	0.020	No
Jan 20 Day	1/20/2005	7	7_1	1	Day	1:03 PM	2:03 PM	OFF	15.2	20.5	22.1	26.8	7.0	6.3	0.156	0.096	Yes
Jan 20 Day	1/20/2005	7	7_1	2	Day	2:03 PM	3:03 PM	Recirculation	258.1	157.9	258.1	158.1	0.0	0.2	0.304	0.197	Yes
Jan 20 Day	1/20/2005	7	7_1	3	Day	3:03 PM	4:03 PM	Recirculation	286.3	135.1	286.3	135.1	0.0	0.0	0.336	0.236	Yes
Jan 20 Day	1/20/2005	7	7_1	4	Day	4:03 PM	5:03 PM	Fresh Air	235.9	108.7	235.9	112.0	0.0	3.4	0.406	0.343	No
Jan 20 Day	1/20/2005	7	7_1	5	Day	5:06 PM	6:13 PM	Fresh Air	230.5	70.6	230.5	70.6	0.0	0.0	0.433	0.402	Yes

Note: CO concentrations less than the minimum detectable limit of the instrument (0.04 ppm) were replaced with 0.02 ppm.

A-8: $PM_{2.5}$ Concentration Data for All Trucks and All Shifts

Shift	Date	Truck	Shift	Time period	DAY/ NIGHT	Start Time for SS calculation	End Time for SS	Mode	In-Cab Steady State (SS)	Out-Cab for SS period	In-Cab (hourly Average)	Out-Cab (hourly Average)	Used in summary analysis
Dec 15 Day	12/15/2004	1	1_1	1	Day	1:38 PM	2:25 PM	OFF	8.5	22.2	8.5	21.6	Yes
Dec 15 Day	12/15/2004	1	1_1	2	Day	3:23 PM	3:50 PM	RECIR	28.5	60.8	18.9	43.8	Yes
Dec 15 Day	12/15/2004	1	1_1	3	Day	4:21 PM	5:02 PM	FRESH AIR	54.9	-	50.9	64.7	No
Dec 15 Night	12/15/2004	1	1_2	1	Night	9:41 PM	10:39 PM	OFF	21.8	54.2	21.8	53.5	Yes
Dec 15 Night	12/15/2004	1	1_2	2	Night	10:56 PM	11:48 PM	OFF	18.4	56.2	19.0	59.7	Yes
Dec 15 Night	12/16/2004	1	1_2	3	Night	12:37 AM	1:06 AM	RECIR	49.6	123.2	42.5	112.8	Yes
Dec 15 Night	12/16/2004	1	1_2	4	Night	1:19 AM	2:14 AM	RECIR	59.6	143.4	59.2	142.7	Yes
Dec 15 Night	12/16/2004	1	1_2	5	Night	2:21 AM	3:22 AM	RECIR	61.8	168.2	61.8	168.2	Yes
Dec 15 Night	12/16/2004	1	1_2	6	Night	3:37 AM	4:25 AM	FRESH AIR	92.6	125.7	87.2	122.9	No
Dec 15 Night	12/16/2004	1	1_2	7	Night	4:21 AM	5:27 AM	FRESH AIR	92.5	135.2	92.5	135.2	Yes
Dec 16 Day	12/16/2004	1	1_3	1	Day	8:06 AM	9:06 AM	OFF	30.8	85.4	30.7	85.3	Yes
Dec 16 Day	12/16/2004	1	1_3	2	Day	9:29 AM	10:25 AM	RECIR	42.2	100.6	40.1	104.9	Yes
Dec 16 Day	12/16/2004	1	1_3	3	Day	10:30 AM	11:31 AM	RECIR	75.5	123.5	75.5	123.5	Yes
Dec 16 Day	12/16/2004	1	1_3	4	Day	11:49 AM	12:33 PM	FRESH AIR	33.6	57.0	36.5	59.8	No
Dec 16 Day	12/16/2004	1	1_3	5	Day	12:35 PM	1:38 PM	FRESH AIR	35.1	55.0	35.1	55.0	Yes
Dec 16 Day	12/16/2004	1	1_3	6	Day	2:11 PM	2:37 PM	OFF	29.8	100.2	33.6	84.4	No
Dec 16 Day	12/16/2004	1	1_3	7	Day	2:45 PM	3:47 PM	OFF	30.3	73.8	30.3	73.8	Yes
Dec 16 Night	12/16/2004	1	1_4	1	Night	8:48 PM	9:09 PM	ENGINE ON, FAN OFF	397.4	264.6	274.3	205.1	Yes
Dec 16 Night	12/16/2004	1	1_4	2	Night	10:03 PM	10:12 PM	OFF	33.5	45.2	99.9	60.5	No
Dec 16 Night	12/16/2004	1	1_4	3	Night	10:54 PM	11:18 PM	FRESH AIR	71.1	136.2	45.1	81.1	No
Dec 16 Night	12/17/2004	1	1_4	4	Night	11:33 PM	12:18 AM	RECIR	84.4	188.9	83.5	184.9	No
Dec 16 Night	12/17/2004	1	1_4	5	Night	12:33 AM	1:20 AM	FRESH AIR	40.9	93.1	40.0	88.2	No
Dec 16 Night	12/17/2004	1	1_4	6	Night	1:38 AM	2:22 AM	RECIR	65.3	124.9	54.5	102.6	No
Dec 16 Night	12/17/2004	1	1_4	7	Night	2:46 AM	3:24 AM	FRESH AIR	77.7	140.8	77.7	140.8	No
Dec 16 Night	12/17/2004	1	1_4	8	Night	4:09 AM	4:26 AM	OFF	21.8	55.7	32.1	55.0	No
Dec 17 Day	12/17/2004	1	1_5	1	Day	9:00 AM	9:59 AM	OFF	43.5	123.9	42.1	127.2	Yes
Dec 17 Day	12/17/2004	1	1_5	2	Day	10:15 AM	11:02 AM	RECIR	36.6	46.7	32.3	47.4	Yes
Dec 17 Day	12/17/2004	1	1_5	3	Day	11:27 AM	12:03 PM	FRESH AIR	24.5	27.5	36.0	42.7	No

Shift	Date	Truck	Shift	Time period	DAY/ NIGHT	Start Time for SS calculation	End Time for SS	Mode	In-Cab Steady State (SS)	Out-Cab for SS period	In-Cab (hourly Average)	Out-Cab (hourly Average)	Used in summary analysis
Dec 17 Night	12/17/2004	2	2_1	1	Night	9:08 PM	10:07 PM	OFF	25.5	60.3	25.9	59.3	Yes
Dec 17 Night	12/17/2004	2	2_1	2	Night	10:08 PM	11:07 PM	OFF	22.4	58.2	22.4	58.2	Yes
Dec 17 Night	12/18/2004	2	2_1	3	Night	11:09 PM	12:08 PM	RECIR	28.6	192.8	28.6	192.8	Yes
Dec 17 Night	12/18/2004	2	2_1	4	Night	12:09 AM	1:08 AM	RECIR	31.7	224.9	31.7	224.9	Yes
Dec 17 Night	12/18/2004	2	2_1	5	Night	1:09 AM	2:08 AM	RECIR	33.1	242.5	33.1	242.5	Yes
Dec 17 Night	12/18/2004	2	2_1	6	Night	2:11 AM	3:09 AM	FRESH AIR	118.3	145.7	115.1	149.6	No
Dec 17 Night	12/18/2004	2	2_1	7	Night	3:10 AM	4:10 AM	FRESH AIR	134.5	127.9	134.5	127.9	Yes
Dec 18 Day	12/18/2004	2	2_2	1	Day	7:20 AM	7:58 AM	RECIR	29.4	283.4	24.6	244.5	Yes
Dec 18 Day	12/18/2004	2	2_2	2	Day	8:00 AM	9:00 AM	RECIR	42.4	382.0	42.4	382.0	Yes
Dec 18 Day	12/18/2004	2	2_2	3	Day	9:02 AM	10:02 AM	FRESH AIR	210.5	361.8	210.5	361.8	No
Dec 18 Day	12/18/2004	2	2_2	4	Day	10:03 AM	11:03 AM	FRESH AIR	99.6	89.5	99.6	89.5	Yes
Dec 18 Day	12/18/2004	2	2_2	5	Day	-	-	OFF	-	-	35.6	37.5	No
Dec 18 Day	12/18/2004	2	2_2	6	Day	12:35 PM	1:08 PM	OFF	8.4	22.6	10.1	21.8	Yes
Dec 18 Night	12/18/2004	2	2_3	1	Night	-	-	ENGINE ON, FAN OFF	-	-	79.2	117.4	Yes
Dec 18 Night	12/18/2004	2	2_3	2	Night	9:42 PM	10:12 PM	OFF	65.3	227.5	79.2	171.0	No
Dec 18 Night	12/18/2004	2	2_3	3	Night	10:23 PM	11:13 PM	FRESH AIR	210.8	247.8	194.7	249.4	No
Dec 19 Day	12/19/2004	2	2_4	1	Day	11:04 AM	12:04 PM	OFF	9.6	48.7	9.6	48.7	Yes
Dec 19 Day	12/19/2004	2	2_4	2	Day	12:45 PM	1:11 PM	RECIR	16.0	92.9	12.2	87.0	Yes
Dec 19 Day	12/19/2004	2	2_4	3	Day	1:27 AM	2:17 PM	RECIR	27.8	232.0	23.0	122.5	Yes
Dec 19 Night	12/19/2004	2	2_5	1	Night	9:16 PM	9:46 PM	OFF	4.8	12.3	4.1	9.9	Yes
Dec 19 Night	12/19/2004	2	2_5	2	Night	9:54 PM	10:50 PM	RECIR	2.5	20.3	2.6	20.2	No
Dec 19 Night	12/19/2004	2	2_5	3	Night	10:56 PM	11:52 PM	FRESH AIR	36.3	42.4	34.8	41.4	No
Dec 19 Night	12/20/2004	2	2_5	4	Night	11:56 PM	12:56 AM	RECIR	13.4	68.5	13.5	68.0	No
Dec 19 Night	12/20/2004	2	2_5	5	Night	1:02 AM	2:00 AM	FRESH AIR	26.1	37.6	25.8	38.2	No
Dec 19 Night	12/20/2004	2	2_5	6	Night	2:47 AM	3:04 AM	OFF	8.9	18.6	12.8	27.1	No
Dec 19 Night	12/20/2004	2	2_5	7	Night	3:16 AM	4:08 AM	OFF	7.3	22.1	7.3	22.1	Yes

Shift	Date	Truck	Shift	Time period	DAY/ NIGHT	Start Time for SS calculation	End Time for SS	Mode	In-Cab Steady State (SS)	Out-Cab for SS period	In-Cab (hourly Average)	Out-Cab (hourly Average)	Used in summary analysis
Dec 20 Day	12/20/2004	3	3_1	1	Day	11:09 AM	11:50 AM	OFF	4.3	5.7	4.7	12.3	Yes
Dec 20 Day	12/20/2004	3	3_1	2	Day	12:08 PM	12:51 PM	OFF	2.7	11.0	3.0	10.2	Yes
Dec 20 Day	12/20/2004	3	3_1	3	Day	1:35 PM	2:00 PM	RECIR	23.1	71.6	16.0	54.5	Yes
Dec 20 Day	12/20/2004	3	3_1	4	Day	2:01 PM	3:01 PM	RECIR	25.3	63.9	25.3	63.9	Yes
Dec 20 Day	12/20/2004	3	3_1	5	Day	3:28 PM	4:01 PM	FRESH AIR	114.1	90.3	95.3	71.8	No
Dec 20 Day	12/20/2004	3	3_1	6	Day	4:02 PM	5:02 PM	FRESH AIR	104.5	73.9	104.5	73.9	Yes
Dec 20 Night	12/20/2004	3	3_2	1	Night	9:57 PM	10:51 PM	OFF	11.9	69.4	11.9	68.4	Yes
Dec 20 Night	12/20/2004	3	3_2	2	Night	10:52 PM	11:58 PM	OFF	12.5	87.0	12.5	87.0	Yes
Dec 20 Night	12/21/2004	3	3_2	3	Night	12:04 AM	1:07 AM	RECIR	15.5	94.9	15.5	94.9	Yes
Dec 20 Night	12/21/2004	3	3_2	4	Night	1:09 AM	2:18 AM	RECIR	15.6	92.5	15.6	92.5	Yes
Dec 20 Night	12/21/2004	3	3_2	5	Night	2:20 AM	3:28 AM	RECIR	12.8	116.4	12.8	116.4	Yes
Dec 20 Night	12/21/2004	3	3_2	6	Night	3:50 AM	4:38 AM	FRESH AIR	116.0	140.5	107.7	133.7	No
Dec 20 Night	12/21/2004	3	3_2	7	Night	4:41 AM	5:41 AM	FRESH AIR	100.0	134.6	100.0	134.6	Yes
Dec 21 Day	12/21/2004	3	3_3	1	Day	7:23 AM	8:20 AM	RECIR	10.8	108.7	10.9	109.5	Yes
Dec 21 Day	12/21/2004	3	3_3	2	Day	8:23 AM	9:20 AM	RECIR	10.6	98.9	10.6	98.7	Yes
Dec 21 Day	12/21/2004	3	3_3	3	Day	9:32 AM	10:20 AM	FRESH AIR	77.2	115.8	71.0	112.6	No
Dec 21 Day	12/21/2004	3	3_3	4	Day	10:21 AM	11:21 AM	FRESH AIR	81.6	115.6	81.6	115.6	Yes
Dec 21 Day	12/21/2004	3	3_3	5	Day	12:07 PM	12:21 PM	OFF	20.0	86.9	33.3	74.9	No
Dec 21 Day	12/21/2004	3	3_3	6	Day	12:22 PM	1:22 PM	OFF	17.9	70.6	17.9	70.6	Yes
Dec 21 Night	12/21/2004	3	3_4	1	Night	9:29 PM	9:42 PM	ENGINE ON, FAN OFF	99.5	174.9	68.3	138.3	Yes
Dec 21 Night	12/21/2004	3	3_4	2	Night	10:46 PM	10:48 PM	OFF	21.7	43.6	43.4	67.6	No
Dec 21 Night	12/21/2004	3	3_4	3	Night	10:51 PM	11:55 PM	FRESH AIR	85.5	97.5	85.5	97.5	No
Dec 21 Night	12/22/2004	3	3_4	4	Night	12:13 AM	12:58 AM	RECIR	12.4	91.4	16.8	104.3	No
Dec 21 Night	12/22/2004	3	3_4	5	Night	1:05 AM	2:06 AM	FRESH AIR	75.8	82.1	73.1	80.2	No
Dec 21 Night	12/22/2004	3	3_4	6	Night	2:21 AM	3:07 AM	RECIR	11.4	91.3	13.1	88.5	No
Dec 21 Night	12/22/2004	3	3_4	7	Night	3:07 AM	4:11 AM	FRESH AIR	84.1	84.2	84.1	84.2	No
Dec 21 Night	12/22/2004	3	3_4	8	Night	5:13 AM	5:13 AM	OFF	31.8	54.1	65.9	70.1	No

Shift	Date	Truck	Shift	Time period	DAY/ NIGHT	Start Time for SS calculation	End Time for SS	Mode	In-Cab Steady State (SS)	Out-Cab for SS period	In-Cab (hourly Average)	Out-Cab (hourly Average)	Used in summary analysis
Jan 6 Night	1/6/2005	4	4_1	1	Night	-	-	OFF	-	-	49.8	20.3	No
Jan 6 Night	1/6/2005	4	4_1	2	Night	11:27 PM	11:34 PM	OFF	10.7	16.2	16.6	19.0	Yes
Jan 6 Night	1/6/2005	4	4_1	3	Night	12:02 AM	12:34 AM	RECIR	169.1	267.3	128.3	217.6	Yes
Jan 6 Night	1/6/2005	4	4_1	4	Night	12:35 AM	1:34 AM	RECIR	154.4	341.9	154.4	341.9	Yes
Jan 6 Night	1/6/2005	4	4_1	5	Night	1:35 AM	2:34 AM	RECIR	205.1	450.1	205.1	450.1	Yes
Jan 6 Night	1/6/2005	4	4_1	6	Night	2:46 AM	3:34 AM	FRESH AIR	366.2	520.2	326.8	469.7	No
Jan 6 Night	1/6/2005	4	4_1	7	Night	3:35 AM	4:35 AM	FRESH AIR	289.3	432.6	289.3	432.6	Yes
Jan 7 Day	1/7/2005	4	4_2	1	Day	7:14 AM	7:57 AM	RECIR	90.0	128.7	75.9	128.7	Yes
Jan 7 Day	1/7/2005	4	4_2	2	Day	8:01 AM	9:01 AM	RECIR	132.0	339.3	132.0	339.3	Yes
Jan 7 Day	1/7/2005	4	4_2	3	Day	9:03 AM	10:04 AM	FRESH AIR	286.5	495.2	283.5	493.5	No
Jan 7 Day	1/7/2005	4	4_2	4	Day	10:05 AM	11:07 AM	FRESH AIR	320.4	501.6	320.4	501.6	Yes
Jan 7 Day	1/7/2005	4	4_2	5	Day	11:52 AM	12:09 PM	OFF	66.6	40.6	122.8	39.6	No
Jan 7 Day	1/7/2005	4	4_2	6	Day	12:59 PM	1:10 PM	OFF	54.3	83.8	67.2	87.7	Yes
Jan 8 Day	1/8/2005	4	4_3	1	Day	8:54 AM	9:50 AM	OFF	7.9	15.6	7.9	14.6	Yes
Jan 8 Day	1/8/2005	4	4_3	2	Day	9:51 AM	10:51 AM	OFF	6.0	5.7	6.0	5.7	Yes
Jan 8 Day	1/8/2005	4	4_3	3	Day	10:53 AM	10:54 AM	OFF	4.0	7.4	4.0	7.4	Yes
Jan 8 Day	1/8/2005	4	4_3	4	Day	12:40 PM	12:59 PM	RECIR	104.2	106.8	57.5	79.6	Yes
Jan 8 Day	1/8/2005	4	4_3	5	Day	1:00 PM	2:00 PM	RECIR	217.0	489.3	217.0	489.3	Yes
Jan 8 Day	1/8/2005	4	4_3	6	Day	2:12 PM	3:01 PM	FRESH AIR	332.4	553.1	322.8	487.8	No
Jan 8 Day	1/8/2005	4	4_3	7	Day	3:02 PM	4:05 PM	FRESH AIR	392.4	607.3	392.4	607.3	Yes

Shift	Date	Truck	Shift	Time period	DAY/ NIGHT	Start Time for SS calculation	End Time for SS	Mode	In-Cab Steady State (SS)	Out-Cab for SS period	In-Cab (hourly Average)	Out-Cab (hourly Average)	Used in summary analysis
Jan 8 Night	1/9/2005	4	4_4	1	Night	9:03 PM	10:02 PM	OFF	9.3	22.9	9.3	22.9	Yes
Jan 8 Night	1/9/2005	4	4_4	2	Night	10:03 PM	11:03 PM	OFF	8.2	29.5	8.2	29.5	Yes
Jan 8 Night	1/9/2005	4	4_4	3	Night	11:41 PM	12:03 AM	RECIR	117.3	163.5	70.1	129.1	Yes
Jan 8 Night	1/9/2005	4	4_4	4	Night	12:03 AM	1:03 AM	RECIR	171.3	261.7	171.3	261.7	Yes
Jan 8 Night	1/9/2005	4	4_4	5	Night	1:03 AM	2:03 AM	RECIR	197.2	272.8	197.2	272.8	Yes
Jan 8 Night	1/9/2005	4	4_4	6	Night	2:07 AM	3:03 AM	FRESH AIR	436.6	306.1	421.1	292.9	No
Jan 8 Night	1/9/2005	4	4_4	7	Night	3:04 AM	4:04 AM	FRESH AIR	403.8	339.7	403.8	339.7	Yes
Jan 9 Day	1/9/2005	4	4_5	1	Day	7:52 AM	8:54 AM	RECIR	141.7	358.4	138.2	345.1	Yes
Jan 9 Day	1/9/2005	4	4_5	2	Day	8:57 AM	9:57 AM	RECIR	164.0	366.1	164.0	366.1	Yes
Jan 9 Day	1/9/2005	4	4_5	3	Day	9:59 AM	11:03 AM	FRESH AIR	286.6	391.4	286.6	391.4	No
Jan 9 Day	1/9/2005	4	4_5	4	Day	11:04 AM	12:06 PM	FRESH AIR	271.8	313.3	271.8	313.3	Yes
Jan 9 Day	1/9/2005	4	4_5	5	Day	-	-	OFF	-	-	85.3	11.9	No
Jan 9 Day	1/9/2005	4	4_5	6	Day	2:20 PM	2:31 PM	OFF	9.6	12.8	15.2	11.1	Yes
Jan 9 Night	1/9/2005	4	4_6	1	Night	8:52 PM	9:10 PM	ENGINE ON, FAN OFF	342.0	1462.8	185.6	592.4	Yes
Jan 9 Night	1/9/2005	4	4_6	2	Night	10:05 PM	10:10 PM	OFF	85.0	52.5	163.2	125.2	No
Jan 9 Night	1/9/2005	4	4_6	3	Night	10:19 PM	11:11 PM	FRESH AIR	368.4	579.2	346.4	573.4	No
Jan 9 Night	1/9/2005	4	4_6	4	Night	11:11 PM	12:11 PM	RECIR	153.1	258.0	153.1	258.0	No
Jan 9 Night	1/9/2005	4	4_6	5	Night	12:12 AM	1:11 AM	FRESH AIR	252.8	303.8	252.8	303.8	No
Jan 9 Night	1/9/2005	4	4_6	6	Night	1:12 AM	2:12 AM	RECIR	167.2	334.0	167.2	334.0	No
Jan 9 Night	1/9/2005	4	4_6	7	Night	2:12 AM	3:12 AM	FRESH AIR	254.9	208.9	254.9	208.9	No
Jan 9 Night	1/9/2005	4	4_6	8	Night	12:08 AM	4:12 AM	OFF	49.4	35.3	111.0	50.2	No

Shift	Date	Truck	Shift	Time period	DAY/ NIGHT	Start Time for SS calculation	End Time for SS	Mode	In-Cab Steady State (SS)	Out-Cab for SS period	In-Cab (hourly Average)	Out-Cab (hourly Average)	Used in summary analysis
Jan 10 Day	1/10/2005	5	5_1	1	Day	-	-	OFF	-	-	25.8	27.4	No
Jan 10 Day	1/10/2005	5	5_1	2	Day	12:58 PM	1:16 PM	OFF	13.2	24.6	15.6	27.4	Yes
Jan 10 Day	1/10/2005	5	5_1	3	Day	2:04 PM	2:20 PM	RECIR	99.7	292.2	50.3	155.0	Yes
Jan 10 Day	1/10/2005	5	5_1	4	Day	2:21 PM	3:23 PM	RECIR	138.8	352.4	138.8	352.4	Yes
Jan 10 Day	1/10/2005	5	5_1	5	Day	3:25 PM	4:32 PM	FRESH AIR	172.3	317.7	172.3	317.7	No
Jan 10 Day	1/10/2005	5	5_1	6	Day	4:33 PM	5:36 PM	FRESH AIR	86.1	74.8	86.1	74.8	Yes
Jan 10 Night	1/10/2005	5	5_2	1	Night	-	-	OFF	-	-	40.4	93.2	Yes
Jan 10 Night	1/10/2005	5	5_2	2	Night	12:34 AM	12:49 AM	OFF	19.3	71.4	22.6	71.9	Yes
Jan 10 Night	1/10/2005	5	5_2	3	Night	1:18 AM	1:59 AM	RECIR	55.2	237.9	55.2	237.9	Yes
Jan 10 Night	1/10/2005	5	5_2	4	Night	2:02 AM	3:08 AM	RECIR	131.7	335.6	131.7	335.6	Yes
Jan 10 Night	1/10/2005	5	5_2	5	Night	3:18 AM	4:15 AM	FRESH AIR	262.6	443.8	241.5	408.4	No
Jan 10 Night	1/10/2005	5	5_2	6	Night	4:29 AM	5:30 AM	FRESH AIR	254.4	435.8	254.4	435.8	Yes
Jan 11 Day	1/11/2005	5	5_3	1	Day	7:46 AM	8:45 AM	RECIR	91.0	223.9	90.2	223.2	Yes
Jan 11 Day	1/11/2005	5	5_3	2	Day	8:46 AM	9:46 AM	RECIR	126.2	370.4	126.2	370.4	Yes
Jan 11 Day	1/11/2005	5	5_3	3	Day	9:49 AM	10:48 AM	FRESH AIR	193.4	126.2	191.6	126.5	No
Jan 11 Day	1/11/2005	5	5_3	4	Day	10:50 AM	11:53 AM	FRESH AIR	197.0	192.2	197.0	192.2	Yes
Jan 11 Day	1/11/2005	5	5_3	5	Day	-	-	OFF	-	-	208.2	64.8	No
Jan 11 Day	1/11/2005	5	5_3	6	Day	1:55 PM	2:00 PM	OFF	51.3	62.1	72.3	61.9	Yes
Jan 11 Night	1/11/2005	5	5_4	1	Night	-	-	ENGINE ON, FAN OFF	-	-	48.0	274.0	Yes
Jan 11 Night	1/11/2005	5	5_4	2	Night	-	-	OFF	-	-	132.8	96.0	No
Jan 11 Night	1/11/2005	5	5_4	3	Night	10:52 PM	12:00 AM	FRESH AIR	238.7	283.8	238.7	283.8	No
Jan 11 Night	1/11/2005	5	5_4	4	Night	1:01 AM	1:12 AM	RECIR	212.6	589.9	135.2	170.2	No
Jan 11 Night	1/11/2005	5	5_4	5	Night	1:18 AM	2:16 AM	FRESH AIR	207.6	206.0	208.6	211.4	No
Jan 11 Night	1/11/2005	5	5_4	6	Night	2:21 AM	3:32 AM	RECIR	128.0	100.1	128.0	100.1	No
Jan 11 Night	1/11/2005	5	5_4	7	Night	3:35 AM	4:44 AM	FRESH AIR	106.6	96.4	106.6	96.4	No
Jan 11 Night	1/11/2005	5	5_4	8	Night	-	-	OFF	-	-	69.5	68.7	No

Shift	Date	Truck	Shift	Time period	DAY/ NIGHT	Start Time for SS calculation	End Time for SS	Mode	In-Cab Steady State (SS)	Out-Cab for SS period	In-Cab (hourly Average)	Out-Cab (hourly Average)	Used in summary analysis
Jan 12 Day	1/12/2005	6	6_1	1	Day	10:53 AM	11:52 AM	OFF	38.6	59.8	38.6	59.8	Yes
Jan 12 Day	1/12/2005	6	6_1	2	Day	11:58 AM	12:51 PM	RECIR	32.0	71.9	31.0	70.5	Yes
Jan 12 Day	1/12/2005	6	6_1	3	Day	12:54 PM	1:53 PM	RECIR	38.3	82.3	38.3	82.3	Yes
Jan 12 Day	1/12/2005	6	6_1	4	Day	1:54 PM	2:53 PM	FRESH AIR	30.9	39.3	30.9	39.3	No
Jan 12 Day	1/12/2005	6	6_1	5	Day	2:54 PM	3:54 PM	FRESH AIR	41.6	45.6	41.6	45.6	Yes
Jan 12 Night	1/12/2005	6	6_2	1	Night	9:12 PM	10:14 PM	OFF	20.6	38.3	20.6	38.3	Yes
Jan 12 Night	1/12/2005	6	6_2	2	Night	10:15 PM	11:19 PM	OFF	16.3	25.7	16.3	25.7	Yes
Jan 12 Night	1/12/2005	6	6_2	3	Night	11:20 PM	12:20 AM	RECIR	17.4	40.0	17.4	40.0	Yes
Jan 12 Night	1/12/2005	6	6_2	4	Night	12:21 AM	1:18 AM	RECIR	147.0	214.0	147.0	214.0	Yes
Jan 12 Night	1/12/2005	6	6_2	5	Night	1:19 AM	2:16 AM	RECIR	154.9	229.5	154.9	229.5	Yes
Jan 12 Night	1/12/2005	6	6_2	6	Night	2:20 AM	3:14 AM	FRESH AIR	209.2	157.2	197.8	150.5	No
Jan 12 Night	1/12/2005	6	6_2	7	Night	3:15 AM	4:13 AM	FRESH AIR	108.9	82.6	108.9	82.6	Yes
Jan 13 Day	1/13/2005	6	6_3	1	Day	6:53 AM	7:56 AM	RECIR	16.7	37.4	16.7	37.4	Yes
Jan 13 Day	1/13/2005	6	6_3	2	Day	7:58 AM	8:59 AM	RECIR	50.8	77.5	50.8	77.5	Yes
Jan 13 Day	1/13/2005	6	6_3	3	Day	9:00 AM	10:00 AM	FRESH AIR	48.6	56.2	48.6	56.2	No
Jan 13 Day	1/13/2005	6	6_3	4	Day	10:01 AM	11:01 AM	FRESH AIR	62.8	52.7	62.8	52.7	Yes
Jan 13 Day	1/13/2005	6	6_3	5	Day	11:55 AM	12:02 PM	OFF	18.2	22.7	24.6	23.9	No
Jan 13 Day	1/13/2005	6	6_3	6	Day	12:03 PM	1:03 PM	OFF	15.2	18.6	15.2	18.6	Yes
Jan 13 Night	1/13/2005	6	6_4	1	Night	12:58 AM	1:08 AM	ENGINE ON, FAN OFF	45.7	123.7	25.3	84.9	Yes
Jan 13 Night	1/13/2005	6	6_4	2	Night	-	-	OFF	-	-	28.2	18.3	No
Jan 13 Night	1/13/2005	6	6_4	3	Night	2:10 AM	3:06 AM	FRESH AIR	125.0	133.4	125.0	133.4	No
Jan 13 Night	1/13/2005	6	6_4	4	Night	3:31 AM	4:11 AM	RECIR	189.7	336.9	139.9	311.9	No
Jan 13 Night	1/13/2005	6	6_4	5	Night	4:14 AM	5:09 AM	FRESH AIR	223.9	234.6	223.9	234.6	No
Jan 13 Night	1/13/2005	6	6_4	6	Night	-	-	OFF	-	-	44.0	14.2	No

Shift	Date	Truck	Shift	Time period	DAY/ NIGHT	Start Time for SS calculation	End Time for SS	Mode	In-Cab Steady State (SS)	Out-Cab for SS period	In-Cab (hourly Average)	Out-Cab (hourly Average)	Used in summary analysis
Jan 20 Day	1/20/2005	7	7_1	1	Day	1:04 PM	2:02 PM	OFF	21.6	29.6	21.8	29.6	Yes
Jan 20 Day	1/20/2005	7	7_1	2	Day	2:24 PM	3:02 PM	RECIR	45.8	103.0	43.9	99.0	Yes
Jan 20 Day	1/20/2005	7	7_1	3	Day	3:02 PM	4:02 PM	RECIR	95.0	203.8	95.0	203.8	Yes
Jan 20 Day	1/20/2005	7	7_1	4	Day	4:03 PM	5:02 PM	FRESH AIR	197.7	307.8	197.7	307.8	No
Jan 20 Day	1/20/2005	7	7_1	5	Day	5:06 PM	6:13 PM	FRESH AIR	486.9	467.1	486.9	467.1	Yes

A-9. Stability of Gaseous Samples: Shelf Life Study

Gaseous samples were analyzed for their stability over time. Based on the analysis, it is seen that the nitrogen oxide concentrations (and its components) may change over time. The percent change in the NO, NO_2 and NOx concentrations over time are shown in Figure A-9.1. A negative value indicates that the concentration decreases over time. It is apparent that the nitric oxide (NO) concentrations decreased over time. Much of the data showed decreases in NO concentration of less than 8% over a two to three hour shelf life study. Nitrogen dioxide (NO_2), on the other hand, showed an increase in concentration over time. This is indicative of a possible conversion of NO to NO_2 over time. Most of the NO_2 concentrations showed less than 100% increase. Overall, the NO_x concentration showed a decrease of less than 6 to 8% over the two to three hour period.

The CO concentrations appeared to be stable and differences of less than 0.1 ppm were observed (Figure A-9.2).

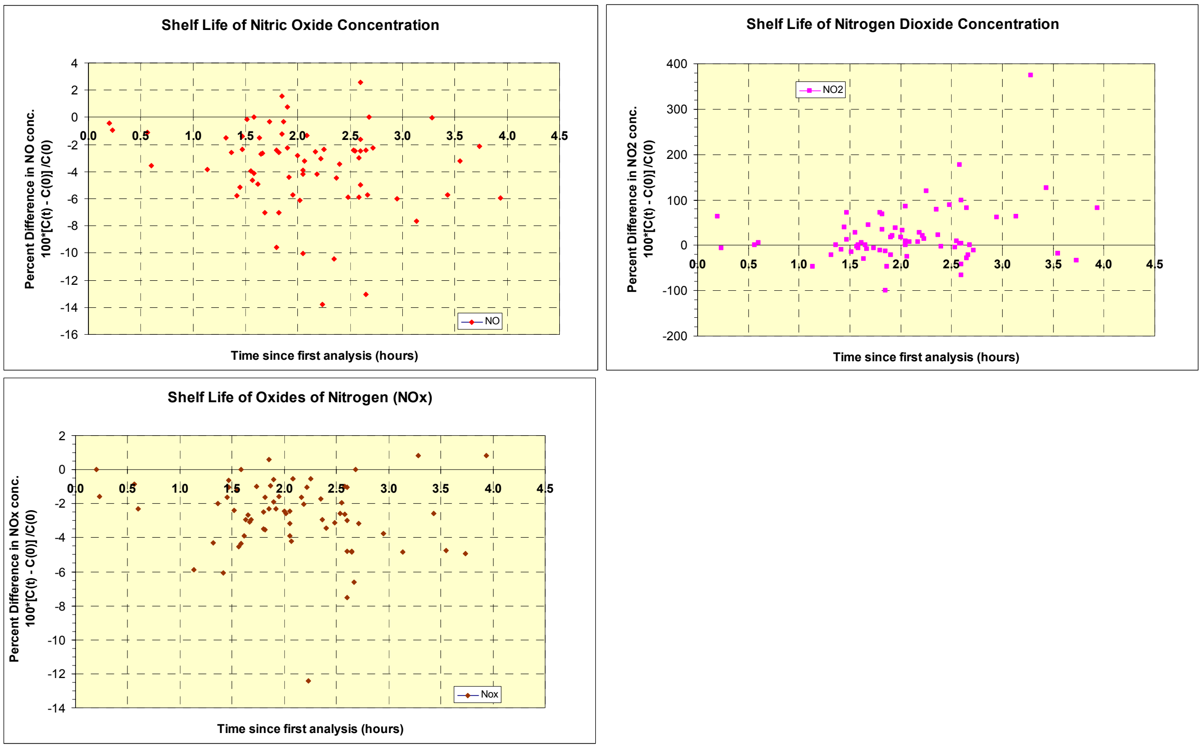


Figure A-9.1 Stability of Oxides of Nitrogen and its Components over Time

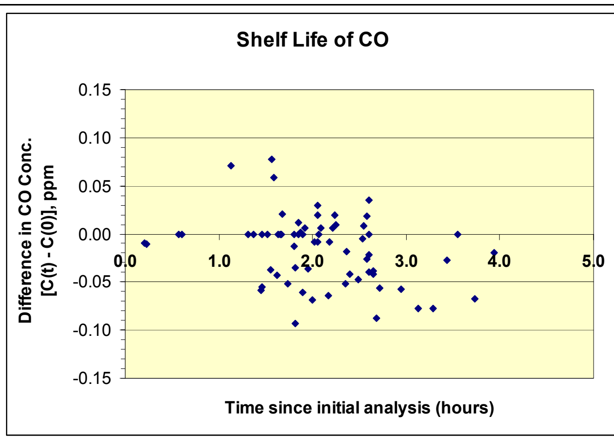
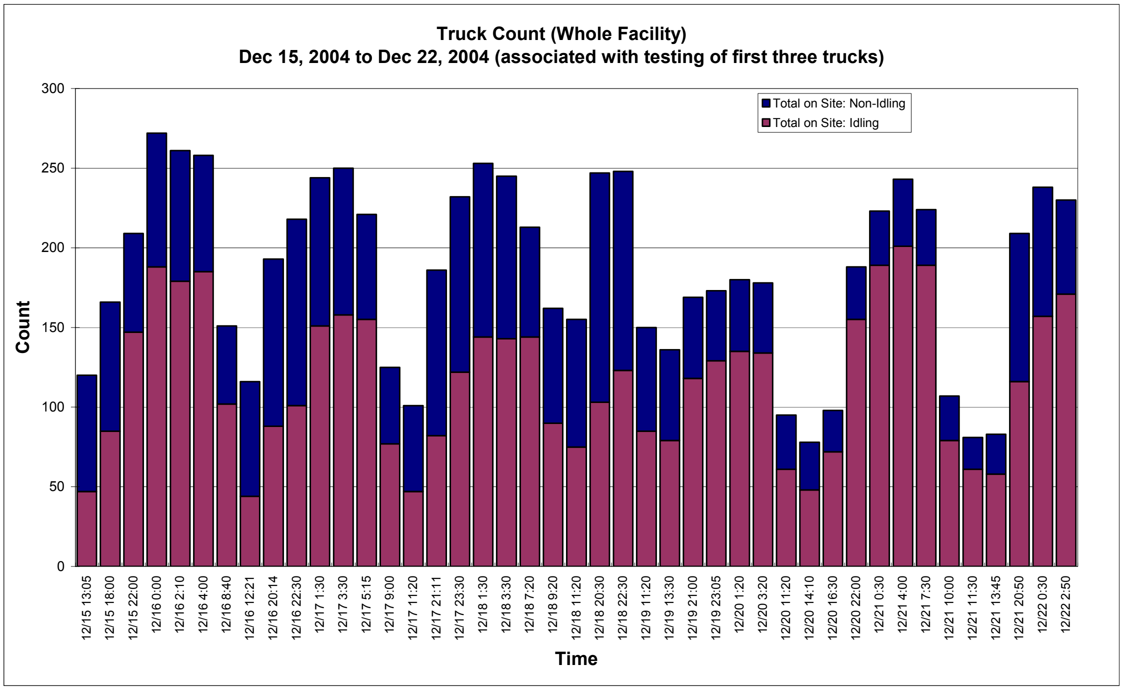


Figure A-9.2. Stability of CO over Time

A-10. Truck Counts

Trucks counts were plotted for the whole truck stop and for the “High End North” section where the test truck was parked (Figures A-10.1 and A-10.2). As seen, the number of trucks parked in the truck stop was lowest around midday and was the greatest at night. Similarly, the number of idling trucks also increased at night. Compared to the overall site, the high-end north section showed less variation in the diurnal profile of number of trucks parked. The fraction of idling trucks was also dependent on the weather. In general, the $PM_{2.5}$ and NO_x concentrations were higher at night, when there were more trucks idling in the travel center.



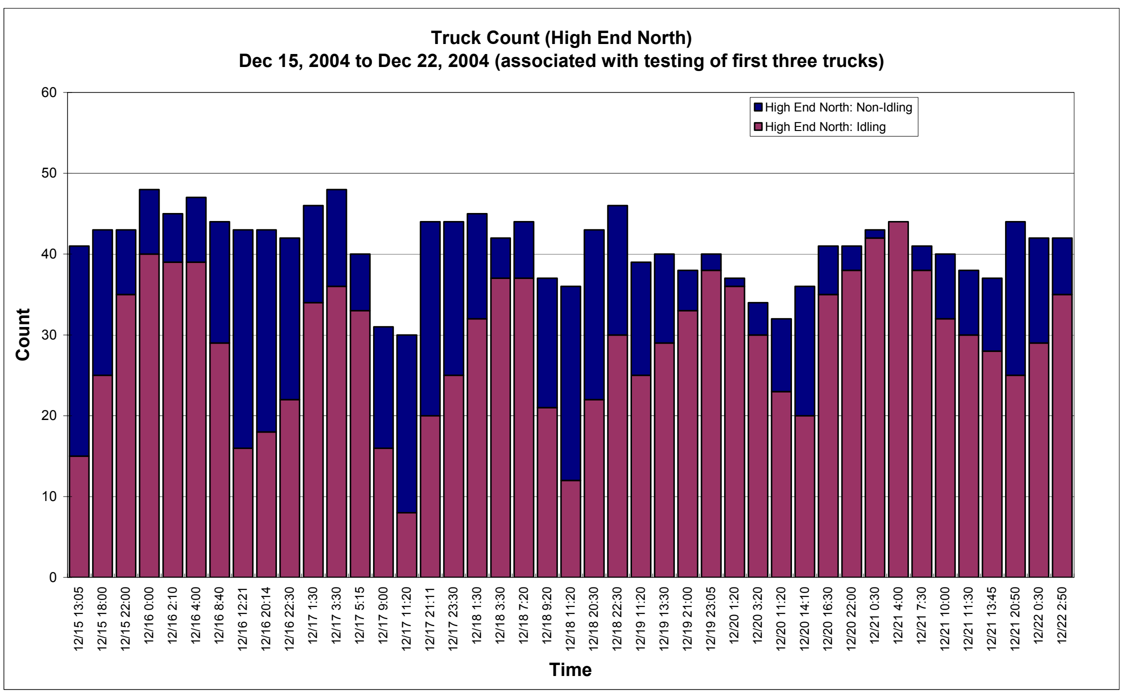
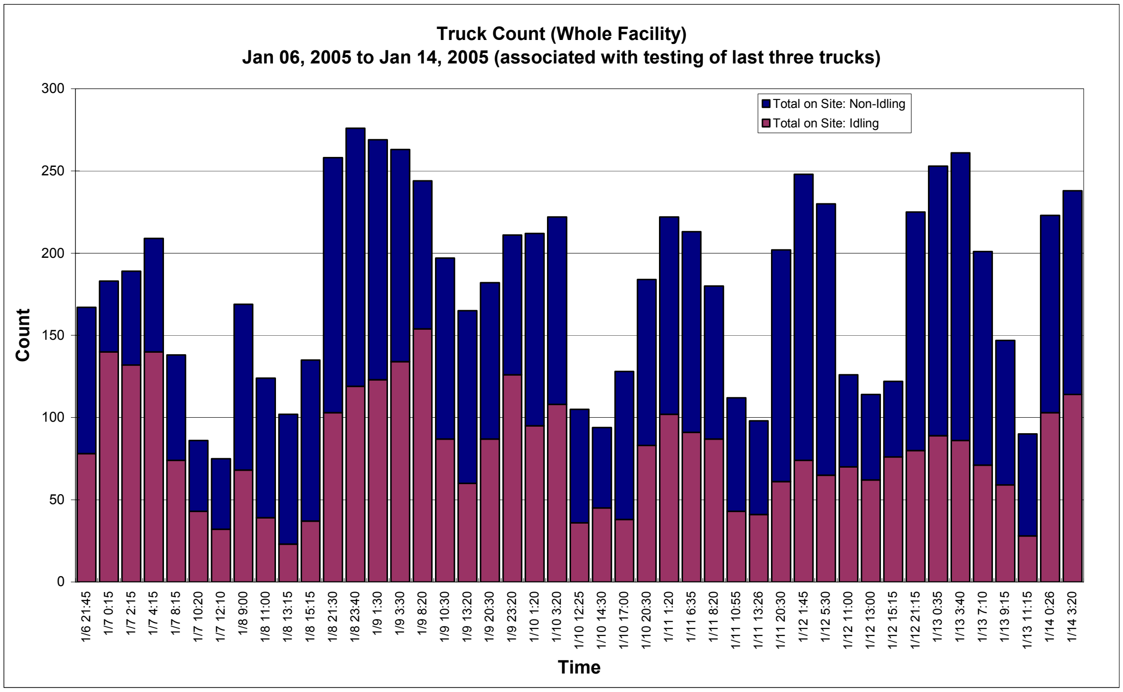


Figure A-10.1. Counts of Idling and Non-Idling Trucks: Dec 15-22, 2004



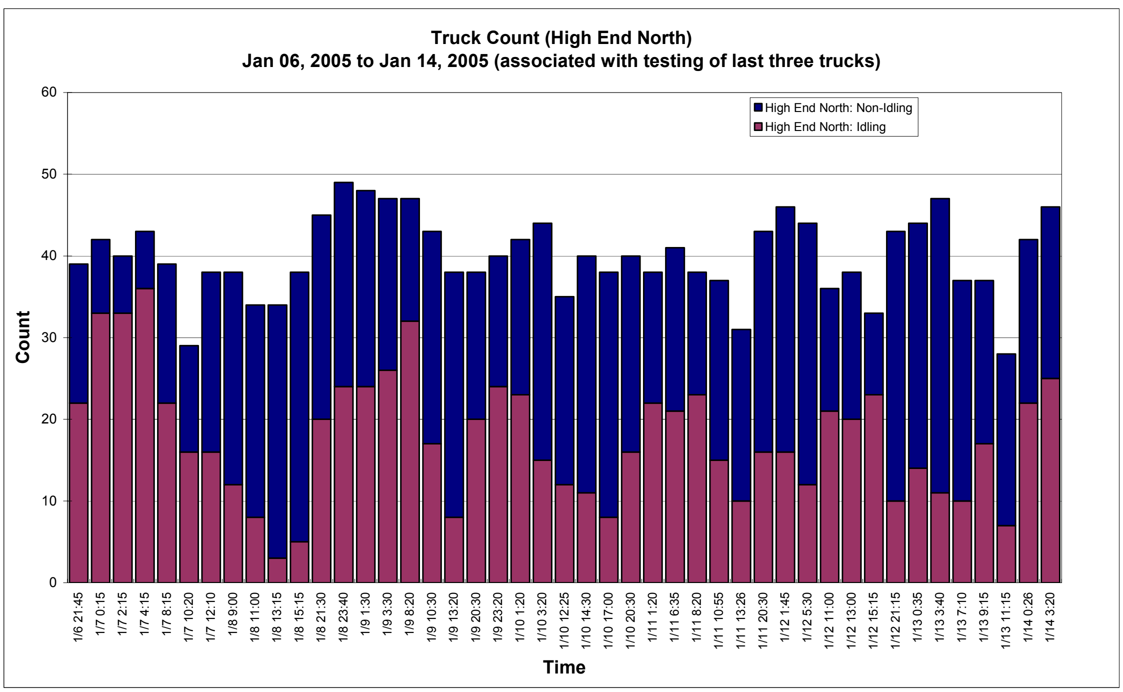


Figure A-10.2. Counts of Idling and Non-Idling Trucks: Jan 06-14, 2005