SURVEY REPORT: EVALUATION OF AN AIR SHOWER FOR REDUCING EXPOSURE TO CARBON MONOXIDE

AT

United States Port of Entry
Calexico, California

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EXECUTIVE SUMMARY

From July through December 2002, an engineering control evaluation was conducted to assess the effectiveness of a redesigned external air supply installed in two lanes at the Calexico West Port of Entry Air diffusers, known as air showers, delivered roof top air to primary inspection lanes 5 and 7 at a height of 10 feet above ground This improved delivery system was expected to provide cleaner, roof top air closer to the inspectors breathing zone resulting in reduced exposure to carbon monoxide In the initial in-depth survey, carbon monoxide (CO) concentrations measured on the inspectors and in the lane area for those lanes outfitted with the air shower (primary lanes 5 and 7) were compared to those with existing ventilation (primary lanes 4, 6, and 8) Following the initial survey, fixed area CO monitors were installed in primary inspection lanes 4 through 8 to provide long term measurement of area CO concentrations The long term data was collected over several months to assess seasonal environmental variations and the effect of variable traffic flow among the primary inspection lanes The results of the in-depth and long term surveys showed that the air showers, as installed, did not result in lower personal or area CO concentrations

During the in-depth survey, shift average area CO concentrations, in the lanes with the air shower installed, ranged from 8 4 ppm-17 3 ppm (Lane 5) and from 5 8 -13 6 ppm (Lane 7) In the lanes without the air shower, shift average CO concentrations ranged from 6 1-10 9 ppm (Lane 4), 5 6-10 9 ppm (Lane 6) and 4 8-9 0 ppm (Lane 8) The shift average CO concentrations measured on the inspectors during the in-depth survey, in the lanes with the air shower installed, ranged from 6 2 ppm-13 9 ppm (Lane 5) and from 5 9 -11 3 ppm (Lane 7) In the lanes without the air shower, shift average personal CO concentrations ranged from 7 6-10 8 ppm (Lane 4), 4 8-10 7 ppm (Lane 6) and 6 1-7 3 ppm (Lane 8) While these average personal CO concentrations do not exceed applicable occupational exposure limits, some instantaneous peak CO concentrations exceeded the NIOSH ceiling limit of 200 ppm with a small number approaching the level considered Immediately Dangerous to Life and Health (IDLH), 1200 ppm It is important to note that although these peaks exceeded the NIOSH recommended ceiling, they were very brief in duration (1 minute or less), thus resulting in low shift-average concentrations Long term average CO measurements also showed no substantial difference in primary area CO concentrations between those lanes outfitted with the air shower compared to those with existing ventilation systems

The ability to achieve significant reductions in shift average CO concentrations will likely be difficult due to a variety of factors affecting exposure, including multiple CO sources (significant car congestion), environmental factors (poor ambient wind dilution due to blockages surrounding the primary inspection area), required work activities (inspection requires workers to walk around the vehicle removing them from the ventilated booth and placing them closer to the tailpipe) and current work practices (car on vs off, proximity of idling cars) Based on the CO concentrations measured during this evaluation, major changes at the Calexico Port of Entry may not be warranted However, further worker monitoring should be continued to help understand

and mitigate the peak exposures and to assess changes in exposures based on traffic volume, operational procedures and work practices, as well as facility changes and ventilation system changes Additionally, the use of real time personal CO monitors (with audible alarms) and possibly video exposure monitoring should be considered to investigate factors, including work practices, which may be leading to exposure to instantaneous CO concentrations above the NIOSH ceiling

Background

On September 17-19, 1997, the National Institute for Occupational Safety and Health (NIOSH) conducted a site visit at the San Ysidro Port of Entry (POE) in response to a Health Hazard Evaluation (HHE) request received from the United States Immigration and Naturalization Service (INS) Personal air samples were collected for carbon monoxide (CO), hydrocarbons, and lead particulate matter Personal and area air samples for lead, carbon dioxide and hydrocarbons were all within acceptable occupational exposure criteria Personal and area air samples for CO were within acceptable occupational health criteria for full shift exposures however, peak exposures exceeded the NIOSH recommended ceiling concentration of 200 parts per million [1]

Based on these results, the NIOSH HHE team made several recommendations that included modifying the local exhaust ventilation systems, incorporating administrative controls, and elimination of some tasks Following the release of the report, the INS made administrative changes and eliminated the practice of pre-primary vehicle inspections Subsequently, the Engineering and Physical Hazards Branch of the NIOSH Division of Applied Research and Technology was contacted by the General Services Administration (GSA) and asked to review the current ventilation systems and propose a course of action to reduce inspector's exposure to CO

Following this request, a team of engineers from the NIOSH Engineering and Physical Hazards branch visited two ports of entry along the border between California and Mexico This team initially published 2 reports providing some exposure control concepts for consideration for both the Calexico and San Ysidro POEs [2,3] A third follow-on report was completed for Calexico [4] The recommendations included ventilation and procedural changes for consideration for the reduction of inspectors exposure to vehicle exhaust After discussions were held between NIOSH, INS, U S Customs Service and GSA, concerning these concepts, the use of external air showers was determined to be the most feasible option Other options including procedural and more significant facility changes were rejected due to cost and concern for impact to port operations

INTRODUCTION

In the summer of 2002, GSA installed laminar flow air showers, provided by NIOSH, on the exterior of two primary inspection lanes These air showers were mated to the existing air delivery system using a transition piece and associated ducting On July 15-18, 2002, NIOSH conducted an in-depth engineering control survey at the Calexico POE This survey involved the measurement of personal and area CO concentrations The goal of this survey was to evaluate the effect of these air showers by comparing exposures and area concentrations on lanes with air showers to adjacent lanes with existing ventilation systems

After the completion of this survey, long term monitoring of area CO concentrations was initiated to evaluate the performance of the air showers compared to existing ventilation schemes in other lanes Fixed area monitors were mounted to the outside of primary inspection booths 4-8, under the area served by the air shower These monitors were downloaded by INS personnel at the port and followed for approximately 6 months (July through December 2002) This long term monitoring allowed for the evaluation of the ventilation schemes over many weeks to account for variations in lane traffic volume, ambient temperature, wind speed and direction, and other environmental effects Overall, the monitors collected over 76,000 ambient area CO concentrations over 240 work shifts

FACILITY/VENTILATION SYSTEM OVERVIEW

The Calexico Port of Entry (P O E) serves as the gateway between Mexicali, Mexico and the United States Over 20,000 vehicles enter the U S through the Calexico Port of Entry every 24 hours[5] The border vehicle inspection area consists of 11 primary inspection lanes and a vehicle secondary inspection area All traffic enters the Calexico Port of Entry through one of the primary inspection lanes If a more thorough inspection is necessary, cars are directed to the secondary inspection area and the engines are turned off during vehicle searches Each primary inspection lane has one inspector who may be employed by the U S Customs Service or the U S Immigration and Naturalization Service (INS) Each agency typically provides half of the inspectors during each shift

Inspectors for both agencies are rotated among primary inspection lanes, vehicle secondary, pedestrian lane, pedestrian secondary, and operations[6] The 8 hour work shift is divided into 30 minute intervals Inspectors do not stay in the primary inspection lane for more than two 30-minute periods before they are assigned to another location which is either inside of the office building or out of the lane area They have to spend at least one hour away from the lanes before starting another assignment in the primary inspection area Each inspector can spend a maximum time of 3 5 hours in primary inspection lanes per shift

Primary Inspection Area Ventilation

A site plan for the Calexico facility is shown in Figure 1 A large canopy roof extends over lanes 4-8 with smaller canopy roofs over lanes 1-3 (see Figure 2) and lanes 9-11 The area directly above the large canopy over inspection lanes 4-8 includes offices and meeting rooms utilized by both Customs and the INS The site has a solid brick wall on the North and a wall, fencing and buildings on the East and West

There are several ventilation systems which provide air for each of the lanes Table 1 shows a list of the primary blowers and the areas that they service The intakes for most of these fans are located at various locations on the roof of the main facility HP-1 and EC-1 are located adjacent to each other on the canopy over lanes 1-3 (see Figure 3) The intake for S-2 is located in the penthouse mechanical room which pulls air in from the roof over the main building The inlet for SF-1 is located at ground level in an area adjacent to lanes 1-3

Tempered air is supplied to the inside of each booth through a group of four supply registers Directly outside of the booth, air is supplied from overhead to the lanes where the inspectors perform most of their duties The booth outer air supply has been re-worked over the years and varies from lane to lane In lanes 1-3, the outside air supply is directly above the booth and is louvered such that the air is directed towards the vehicle In lane 4, the supply is configured as an air shower approximately 10 feet above ground and provides air outside of the booth between the car and booth (see Figure 4) In lanes 5-11, the supply register has been moved to the top of the canopy above the booth at a height of 15-20 feet (see Figure 5) The air shower supply registers were originally installed at a height of approximately 10 feet at all booths but were raised in lanes 5-11 due to vehicle clearance problems The air showers in lanes 5-11 consist of a register measuring 72 inches in length by 10 inches in width Also, a series of general exhaust air registers are installed in the canopy roof and are connected to exhaust fan, S-3 The soffit fans exhaust the contaminated air under the canopy to a stack on the roof over the main building

A pedestal supply air blower installed at the front of each lane originally directed air towards the vehicle tailpipe to dilute and disperse the exhaust gases (See Figure 6) The pedestal supply blowers were in operation during the site visit but have not been in operation consistently throughout the years A damper on the pedestal allows the inspectors to reduce or shutoff airflow from the pedestal supply register A central supply fan, SF-1, provides the airflow to all of the pedestals with ducts running underground to each lane This fan is housed in a brick building at the North end of the primary inspection area (next to lane 1) The inlet to SF-1 is located at ground level and faces the area around lanes 1-3

Description of the Air Shower

A unidirectional air shower was installed ten feet above the pavement directly outside of the primary inspection booths in lanes 5 and 7 (See Figures 7 and 8) This unit was manufactured by Tuttle and Bailey (Richardson, TX) and measured 2 feet in width by 4 feet in length The Radian® critical room diffuser is designed to provide unidirectional, uniformly distributed, low speed airflow over the entire face of the diffuser The diffuser was mated to the existing external booth air supply and included a damper to allow for the adjustment of air flow The critical room air diffuser is designed to minimize excessive drafts and mixing of the conditioned air with external air These units are typically used for applications such as clean rooms, laboratories, and surgical operating rooms where emphasis is placed on maintaining a region of controlled clean air

The concept behind the use of the air shower was to improve upon the existing external air supplies in the primary inspection lane area The existing air supplies in lane 5 through 11 are located 20 feet above the pavement and blow high velocity air out into the primary inspection lane area These fans tend to result in mixing of the contaminated ground level air with the cleaner rooftop air supplied by the registers Air showers were used in industrial plants and mining applications to provide an envelope of clean air around the worker In these applications, the showers reduced worker exposure to ambient dusts[7]

EVALUATION METHODS

Data were collected to evaluate worker exposures to CO and to assess the performance of the air showers for reducing the CO concentrations in the area immediately outside of the inspection booth A review of limited videotape taken on previous visits to Calexico indicated that on average approximately 90% of the inspectors time was spent either inside the booth or immediately outside of the booth where the air shower was placed

Two sets of data were collected

1) An initial in-depth survey was conducted from July 15-18, 2002, and,
2) Long Term area CO measurements were collected from July 19-December 10, 2002

Personal and Area CO monitoring during initial survey—July 2002

Personal air samples for CO exposure were collected in the breathing zone of the workers using ToxiUltra atmospheric monitors (Biosystems, Inc) with CO sensors (See Figure 9) Personal CO samples were collected on the inspectors in the primary inspection area of lanes 4-8 with matching area samples collected outside of the respective inspection booth The area samples were collected to give an indication of the protective nature of the air shower (installed on lanes 5 and 7) and for comparison with the existing ventilation configuration in Lanes 4, 6, and 8 (see Figure 9) Roof top samples were collected near the inlet to the supply fans to provide information on the CO concentration in the supply air for the inside and outside of the booths Five inspection lane area samples and 5 personal samples were monitored during the July in-depth survey There were also 2 "front" area samples taken in the front of primary inspection lanes to give an indication of area CO levels in the awaiting traffic (see Figure 10) Air sampling was performed for CO and used as a surrogate for the many other air contaminants generated by automobile exhaust such as oxides of nitrogen, hydrocarbons, and particulates

All ToxiUltra CO monitors were calibrated every 24 hours These monitors are direct-reading instruments with data logging capabilities The instruments were operated in the passive diffusion mode, with a logging interval of 20 seconds The instruments have a nominal range from 0 to 999 parts per million (ppm) Some concentrations are reported above this range—when this occurs, the actual concentration may be greater than the number reported The CO monitors collect data over the entire sampling period and report a peak concentration, a 15-minute peak Short Term Exposure Limit (STEL), and an average over the entire sampling period Personal and area samples were collected in the primary inspection lanes 4, 5, 6, 7, and 8 The ToxiUltra CO monitor was attached to the shoulder epaulet or shirt pocket of the inspectors (see Figure 9) This placed the monitor within 12 inches of the inspector's mouth and nose The inspectors shift for any specific primary inspection lane lasted 30-60 minutes At the end of each shift, the inspector completing a shift was instructed to place the CO monitor on the inspector starting the new shift Due to communication problems, occasionally, the inspector beginning a shift in the lane did not don the CO monitor Also, the inspector completing the shift occasionally forgot to remove the monitor prior to leaving the primary inspection lane area Spot checks were performed by the industrial hygienist on site to minimize the impacts of these disturbances However, the fact that these instances did occur during the survey makes the interpretation of the personal samples difficult

Area samples were collected using the ToxiUltra CO monitors outside of the primary inspection booths 4, 5, 6, 7, and 8 and approximately 10 feet in front of booths 5 and 8 The area samples outside of the booth were collected under the area serviced by the air shower at breathing zone height (see Figure 9) Rooftop area CO concentrations were measured over the penthouse area above the Main Building where air for booths 4-7 is drawn by supply fan, S-2

Long Term Area CO Monitoring from July-December 2002

Due to the inherent variability in environmental conditions (wind speed and direction, atmospheric inversions, etc), long term CO measurements were collected Fixed area monitors were placed outside of the booths to collect data for an extended period of time HOBO Carbon Monoxide monitors/data loggers manufactured by the Onset Computer Corporation (Bourne, MA) were used during the long term evaluation These monitors feature user selectable ranges-- The ranges which were activated during the evaluation were 0-125 ppm and 0-500 ppm Each range has a specific resolution and accuracy associated with the readings The unit is an electrochemical cell sensor which requires recalibration on a yearly basis according to the manufacturer

These primary inspection area measurements were used to determine the overall effectiveness of the air showers compared to the existing air supplies across a period of months helping to account for traffic flow, environmental conditions or any other variables These units were fixed to the structure of the primary inspection booth in locations similar to those monitored during the July survey The monitors were placed directly outside of the booth at a height of approximately 5 feet from the ground These units were moved occasionally by the on site facility contractor to investigate specific conditions CO concentrations were logged every 90 seconds and downloaded to computer every week Table II shows the dates, monitor locations and conditions associated with this phase of testing Comparisons for the differences in CO concentrations were made for the individual lanes 4-8 (weeks 1-7 and 18), and inside versus outside the primary inspection booths in lanes 4 and 5 (weeks 11-17)

Ventilation System Evaluation

The ventilation system was evaluated by visual inspection and through the use of a TSI Accubalance model 8370 Air Capture Hood (St Paul, MN) The Accubalance is a flow hood typically used for determining flow through diffusers, registers, or grilles The unit consists of a fabric hood with a molded plastic base containing a flow sensing manifold Air flowing through the fabric hood is measured by a hot film sensor which senses flow through 24 pairs of flow sensing ports The unit comes with different sized fabric hoods to accommodate air outlets of varying sizes The flow hood is pressed against the outlet to provide a tight seal minimizing leaks during flow measurement

The air flow rates from the air supplies outside of the booths located in primary inspection lanes 4, 5, 6, 7 and 8 were measured before the start of the survey and again after blast gates were installed The air showers installed on primary inspection lanes 5 and 7 were measured using a 2 foot by 4 foot flow hood The flow measurements for primary inspection lanes 4, 6, and 8 were taken with a 1 foot by 4 foot flow hood Since the area of the supply outlets in lane exceeded the largest flow hood (supply outlet size was approximately 1 foot by 5 foot), the outlet had to be measured in 2 sections (each section was 1 foot by 3 foot) and the total flow through each section was summed to give an overall supply air flow rate Five measurements were taken sequentially in time and averaged to yield an overall supply airflow rate

Prior to the start of the July 2002 survey, the airflow to each of the exterior air supplies for primary inspection lanes 4, 5, 6, 7, and 8 was measured The results of these measurements are shown in Table III The original butterfly damper valves which were installed with the air showers (in lanes 5 and 7) exhibited considerable flutter and variation in flow rate over time These valves were subsequently replaced with blast gates on September 16 After the blast gates were installed, a second set of flow measurements, taken on November 4, showed that the flow rate had decreased from about 1220 cfm to 900 cfm The flow rate to the air showers was adjusted back up to a value of 1250 cfm for both units

<u>RESULTS/FINDINGS</u>

<u>Initial In-Depth Survey-July 15-18, 2002</u>

Tables IV through VI show the results of the CO measurements from all personal and area monitors Data shown in these tables include sample location, arithmetic mean, standard deviation, maximum values, number of shifts sampled, number of CO measurements taken, and number of measurements above the NIOSH ceiling of 200 ppm Figures 11 to 13 show the average CO concentrations by shift for all sample locations

Day Shift- July 16-18, 2002
During the day shift monitoring period, there were twenty-two peaks measured on the inspectors (also referred to as personal samples) that were above the NIOSH ceiling of 200 ppm with one peak exceeding the upper range of the instrument (999 ppm) The personal concentrations greater than the NIOSH ceiling were spread across each lane with the highest number of excursions (8) above the ceiling measured in Lane 7 (see table IV) Since the instrument logged concentration every 20 seconds, these peaks represent a maximum exposure time of 20 seconds for each peak measurement No continuous high exposures (concentration >200 ppm) greater than one minute were identified during the July survey The 8-hour shift average personal and area CO concentrations for the day shift are shown in Table IV and Figure 11 The personal averages ranged from a low of 7 3 ppm in primary inspection lane 8 to a high of 10 4 ppm in Lane 5 Similarly, the shift average area samples taken directly outside of the inspector's booths ranged from 8 1 ppm in Lane 8 to 14 2 ppm in Lane 5 There were thirty six area instantaneous CO concentrations above the NIOSH ceiling of 200 ppm with the greatest number of excursions in Lane 5 (n=15)

Swing Shift- July 15-17, 2002
During the swing shift monitoring period, there were eight peaks measured on the inspectors that were above the NIOSH ceiling of 200 ppm Peak personal concentrations greater than the NIOSH ceiling were measured in lanes 4, 6, and 8 with the highest number of excursions (4) above the ceiling measured in Lane 8 (see table V) The 8-hour shift average personal and area CO concentrations for the swing shift are shown in Table V and Figure 12 The personal averages ranged from a low of 4 8 ppm in primary inspection lane 6 to a high of 7 6 ppm in Lane 4 The shift average area samples taken directly outside of the inspector's booths ranged from 4 8 ppm in Lane 8 to 8 4 ppm in Lane 5 There were nine area instantaneous CO concentrations above the NIOSH ceiling of 200 ppm with the greatest number of excursions in Lane 8 (n=5)

Graveyard Shift- July 16-18, 2002
During the graveyard shift monitoring period, there were sixty peaks measured on the inspectors that were above the NIOSH ceiling of 200 ppm The personal concentrations greater than the NIOSH ceiling were spread across each lane with the highest number of excursions (26) above the ceiling measured in Lane 7 (see table VI) The 8-hour shift average personal and area CO concentrations for the swing shift are shown in Table VI and Figure 13 The personal averages ranged from a low of 6 9 ppm in primary inspection lane 8 to a high of 13 9 ppm in Lane 5 The shift average area samples taken directly outside of the inspector's booths ranged from 9 0 ppm in Lane 8 to 17 3 ppm in Lane 5 There were seventy-eight area instantaneous CO concentrations above the NIOSH ceiling of 200 ppm with the greatest number of excursions in Lane 7 (n=39)

Long Term CO Monitoring-July-December

The results from the long term area monitors are shown in Tables VII through IX and Figures 14 to 16 Over 127,000 individual measurements were taken during the monitoring period in Tables

VII-IX The extended sampling over a period of months helps to average out differences by lane due to traffic patterns Also, overall control effectiveness can be judged under varying ambient conditions including temperature, wind speed and direction and atmospheric inversions

Table VII and Figure 14 show the area CO average concentration by lane The highest area average CO concentration was in lane 5 (6 0 ppm) and the lowest average concentration was in Lane 7 (4 0 ppm) These measurements were taken over 146 shifts and include over 46,000 observations Table VIII and Figure 15 show the average CO concentration by shift The highest shift average was for the graveyard shift (24 00-07 59) while the lowest average was on the swing shift (16 00-23 59) Finally, the facility was configured with a monitor on the interior of booths 4 and 5 while another monitor was installed directly outside of those booths This helped assess the difference in protective nature of the booth versus the air shower These results are shown in Table IX and Figure 16

Ventilation System Measurements

The results from measurements made at each external air supply for primary inspection lanes 4 through 8 are shown in Table III Initially, the flowrate to the air showers were adjusted to approximately 1200 cfm on both primary inspection lanes 5 and 7 The air flowrates to primary inspection lanes 4, 6 and 8 were also measured and varied from 2090 cfm to 3300 cfm These measurements were made while air supply fan, S-2, was set at the high flow rate This setting is typically used only in the summer and is switched to the low flow setting during the winter The low flow setting is used in the winter to decrease impingement velocities thereby minimizing cold drafts Testing performed prior to the installation of the air showers indicated that the switch from high flow mode to low flow mode reduced the booth external air supply volume flow rate by approximately 40%

DISCUSSION/OBSERVATIONS

During the July survey, average personal CO exposures were less than the OSHA PEL (50 ppm)[8], NIOSH REL (35 ppm)[9], and ACGIH TWA-TLV (25 ppm)[10] These personal averages, however, represent an aggregate of in-lane exposure from several inspectors in each lane and thus are not a true "Time Weighted Average" exposure for any one inspector The true exposure profile for any given inspector is based on many factors including the emission rates of vehicles in the primary inspection lane as well as surrounding lanes, ambient environmental conditions, the amount of time spent in primary and secondary inspection and in the office, and work practices The way that an inspector conducts his vehicle investigation will greatly affect his exposure These "personal" average concentrations are likely higher than the typical inspectors 8 hour Time Weighted Average (TWA) exposure which requires at least half of their shift be spent in office areas If these periods of low exposure are factored in to the inspector's exposure profile, the true TWA exposure would likely be substantially reduced

From Tables IV through VI and Figures 11 to 13, it can be seen that the highest average concentrations and number of peak concentrations above 200 ppm were typically measured in primary inspection lane 5, across all shifts Also, the lowest average CO concentrations were normally seen in the outside lanes, primary inspection lanes 7 and 8 These results from the July survey were consistent with the long term CO monitoring results for the inside versus outside lane comparison and the higher CO levels during the graveyard shift Long term average CO concentrations ranged from 4 0 ppm in lane 7 to 6 0 ppm in lane 5 Long term average CO concentrations in Table VII averaged 28% higher in inside lanes compared to outside lane averages (statistically significant at 5% level) The average concentration differences between the interior of the booths and the area directly outside the booths varied between the different lanes The ratio of the average CO concentration outside to inside the booth in lane 5 (with the air shower) was about 1 31 (significant at the 5% level), and in lane 4 was 0 93 (significant at the 5% level) A description of the statistical model is footnoted in Table VII

Results from the comparison of long term monitoring by shift (Table VIII) indicated that ambient CO concentrations during the graveyard shift (24 00-07 59) were higher than both the day and swing shift These results agree with the results of previous industrial hygiene surveys which have been conducted at both Calexico and San Ysidro POEs This difference has been hypothesized to be due to the atmospheric inversion which results in the subsidence of winds during the overnight hours

Air Shower Effectiveness

The use of the air shower, as installed, did not provide a significant level of protection beyond the existing ventilation system This may be due to several design and functional limitations The air shower was placed at a height of 10 feet over the base of the lane Initially, a height of 8 feet was requested but was rejected due to concerns about clearance problems for large vehicles and officer safety The air shower is expected to be most effective the closer the supply is to the workers breathing zone As the air shower is pushed further and further from the inspectors head, the more it acts like a dilution fan and serves to mix clean air supplied from the roof with contaminated ground level air This is the concept behind the remaining booth outside air supplies as they are currently installed This concept does provide some protection as can be seen in Figures 11 and 13 The average CO concentration measured in the traffic approximately 10 feet in front of lanes 5 and 8 is substantially higher than that measured directly outside of the inspection booths

CONCLUSIONS/RECOMMENDATIONS

Industrial hygiene surveys have been conducted at both San Ysidro and Calexico by NIOSH and the San Francisco Office of Federal Occupation Health (FOH)[1 6, 11-12] The last known survey conducted at Calexico in December 1999, sampled 59 INS inspectors 24 hours/day over a 3 day period[6] The results of this survey did not find any time weighted average exposures in excess of any applicable occupational exposure limits (range of TWAs 0 1-11 4 ppm) However, transient excursions in CO above the NIOSH ceiling of 200 ppm have been documented in that report as well as during the in-depth survey conducted as a part of this study A few very high CO concentrations were measured on inspectors during this survey These concentrations exceeded the upper range of the CO monitor (999 ppm) and approached the NIOSH Immediately Dangerous to Life and Health (IDLH) limit It is important to note that although these peaks exceeded the NIOSH recommended ceiling, they were very brief in duration (less than 1 minute), thus resulting in low shift-average concentrations

The health of any employee is related to many workplace and other factors A recent study of bridge and tunnel officers in New York indicated that risk of coronary heart disease was positively associated with years of employment[13] Although no association was observed between the low levels of post-shift carboxyhemoglobin levels that were measured in the workers, the authors suggested that adverse factors other than exposure to CO may have contributed to the observed prevalence of coronary heart disease These factors include job strain, physical inactivity on the job and possible exposure to other toxic components of vehicular exhaust Some of these same factors may be present in the border crossing inspector population

The control of border inspector's exposure to vehicle exhaust is a complex issue Currently, the combination of engineering and administrative controls appears likely to maintain average exposures below established occupational exposure criteria based on this study and other surveys Long term area averages inside and outside the booth were low ranging from 4 0 to 6 0 ppm outside the booths and 2 6-2 7 ppm inside the booths The ability to further reduce these average concentrations would likely be difficult However, some instantaneous exposures above the NIOSH ceiling do occur The ability to effectively control peak exposures below this level depends on the ability to control emissions from the large number of cars both at the inspection booth and those awaiting inspection Several environmental and operational constraints make effectively dealing with these exposure issues difficult

Those constraints include,

1 **Varying environmental conditions**—wind conditions affect both exposure and the ability to mitigate exposure through ventilation The ambient environment presents challenges to the engineer in design controls which can effectively control exposure under a wide range of unpredictable conditions However, the environment can also provide the most efficient control schemes including use of ambient winds to dilute and remove contaminants
2 **Multiple sources**—the Calexico Port of Entry services approximately 20,000 vehicles per day These vehicles are of many different ages and mechanical conditions including some without catalytic oxidizers The exposure of the border inspector is affected by not only the vehicle being inspected but also by the hundreds of vehicles waiting for inspection A system which only deals with the vehicle being inspected will not be sufficient to control exposure Therefore a more holistic approach is necessary One

approach that has been suggested in previous reports has been to establish a vehicle buffer zone which pushes the wall of vehicles back away from the primary inspection area thus reducing the number of CO sources in the immediate area

3. **Operational Constraints**—the inspector's duties require that they have mobility to effectively inspect the vehicles. This makes the use of fixed controls such as ventilated inspection booths and fixed air supplies only partially successful since the inspector is required to spend a portion of his/her time outside of the protected zone. However, a time study performed from videotapes of inspector operation conducted during previous visits to Calexico by NIOSH showed that inspectors spent a significant portion of their time inside the booth (approximately 41%). Therefore, providing the best environment within the booths should significantly affect inspector exposure to vehicle exhaust.
4. **Facility Design Issues**—the facilities at both Calexico and San Ysidro were constructed in an enclosed, congested area and the primary inspection booths are located under a large canopy which serves to trap vehicle emissions. Also, the buildings, walls and fencing on all sides of the complex inhibit flow of winds which would help dilute and remove vehicle exhaust. At the same time, the large volume of cars awaiting inspection serves as active sources of contaminants near the workers.

Recommendations for Future Consideration

Monitoring of CO Concentrations

The monitoring of the exposure of border inspectors to vehicle exhaust should be continued. The U.S. Customs Service had utilized an area CO monitoring system in previous years but this system has since become obsolete. While the use of primary inspection CO monitoring does provide important data on area concentrations, it is not solely sufficient for assessment of personal exposures. The U.S. Customs service had reportedly planned to replace this system with a new more user-friendly CO monitoring system. The installation of such a system will continue to require periodic maintenance and calibration to avoid instrument electronic drift and assure accurate measurement. In addition, the results of any monitoring should be routinely summarized and given to the inspectors and management to provide on-going dialogue and understanding of the area concentrations and their relevance to employee health.

As an additional measure, inspectors could benefit from periodically wearing small, portable, carbon monoxide (CO) monitors with legible concentration readouts. CO is an invisible, odorless gas and it is not always possible to tell where CO concentration build-ups may occur. Using this tool, officers could observe the CO concentration levels in real-time. Also, real time, video exposure monitoring might be useful in providing some indication of work practices which result in increased CO exposure. This technique uses a video camera to record worker activities while real-time exposure data was collected. Special software allows the instantaneous CO concentrations to be overlaid onto the videotape. The video can then be used to analyze tasks and to determine which work activities resulted in the highest exposures.

Many portable monitors also contain features such as logging of exposure data and the real-time calculation of the officer's daily time weighted average exposure These additional features could prove instrumental in assessing the existing administrative rotation schedule based upon a more thorough documentation of exposure conditions throughout the year An audible alarm on the portable monitor could be set to warn the officers when an area contains excessively high levels of CO When concentrations were elevated, the officer could potentially move to a different location, assuming that the immediate inspection activities allowed such mobility While real time CO monitors are not a panacea and inspectors may occasionally be required to work in areas with elevated levels of CO, the monitors could serve as one more tool to remind and educate the officers about an invisible hazard within their working environment

Finally, and most importantly, periodic monitoring of inspectors exposure should be continued through comprehensive industrial hygiene surveys These surveys should assess the worker's exposure over a full shift and should compare these results with applicable occupational exposure limits Surveys conducted at Calexico in the past have not shown elevated exposure to CO However, changes in ambient conditions, vehicle traffic, work practices and a variety of other variables could greatly affect these results

Operational/Engineering Control Options

Due to the inherent difficulties in controlling inspectors exposure to vehicle exhaust, several techniques should be considered when designing and implementing controls It is likely that a combination of many of these controls may be required to be employed to significantly reduce exposure to vehicle exhaust At the levels seen in this report, major changes at the Calexico Port of Entry may not be warranted However, further worker monitoring should be continued to help assess changes in exposures based on traffic volume, operational and work practices, facility changes and ventilation system changes

As with all engineering controls requiring facility or procedural changes, a team including representation from the inspectors, management, and health and safety from INS, Customs and GSA facility management should review any proposed changes for potential adverse impacts to inspector safety This team should also consider project benefits and technical and operational feasibility Finally, any project should be evaluated on a pilot scale to assess effectiveness before fully incorporating any facility or procedural modifications

The use of several source control methods has been recommended in previous reports and is reiterated here With these methods, emphasis is placed on the mitigation of sources of CO (car exhausts) including allowing improved dilution of exhausts by establishing a vehicle free buffer zone to provide more opportunity for ambient wind dilution, by redesigning Port of Entry facility layout to minimize obstruction to ambient air flows, and using local exhaust ventilation to capture vehicle exhausts close to the source Procedural changes should also be considered including establishing a standard operating procedure for poorly maintained automobiles and trucks and even considering requiring cars to shut down their engines during inspection and only allowing them to restart after the inspector has returned to the inspection booth Some options for future consideration include the following

1 **Establish a Vehicle Buffer Zone**–Vehicle density is the most obvious variable contributing to elevated exposures to vehicle exhaust constituents (see Figure 17) By contrast, ambient winds provide the most obvious factor to reduce vehicle exhaust concentrations The intentional back up of vehicles near the inspection station allows the canine units an opportunity to move around the waiting vehicles and it prevents border runners from having a full head of steam as they approach the inspection booth From the exhaust exposure perspective, however, the negative effect of this activity is to create a concentrated source of contaminant emissions, a parking lot of idling vehicles, located close to the individual workstations Ambient air dilution of vehicle exhaust is potentially the most effective, and the most cost-effective, means to reduce worker exposures to vehicle exhausts Any increased separation distance will likely be beneficial In general, the greater the separation, the greater the potential benefit

   A proposed alternative is to position the idling vehicles further away from the individual inspection stations, thus creating a vehicle-free buffer zone of open area that increases separation distance between the workers and the source of exhaust and allows the ambient wind an increased opportunity to dilute and evacuate the contaminated air Vehicles would advance one-at-a-time to the inspection both If room permitted, an "on-deck" system could be used to push the majority of vehicles even farther back while allowing closer vehicles for the canine units to patrol Vehicle advancements could be controlled through the use of lights, gates, or cylindrical hydraulic roadblocks Additionally, hydraulic roadblocks could be strategically placed for protection against speeding vehicles

2 **Establish Procedures to Handle Poorly Maintained Vehicles**–There are a great number of poorly maintained vehicles (AKA "smoker" vehicles) which cross the border daily On a normal, well maintained vehicle, most of the emissions come from the tailpipe of the automobile, however, a significant number of vehicles crossing through the Calexico POE were observed to be emitting air contaminants from the engine and the sides of the vehicle in addition to the tailpipe These vehicles, that are in obvious need of maintenance, are a significant source of vehicle emissions that inspectors are exposed to The establishment of a standard operating procedure (SOP) to handle "smoker" vehicles which cause elevated exposures to CO and other air contaminants should be considered This SOP should involve channeling smoker vehicles to an outside lane (such as lane 10) and requiring that these vehicles shut down their engine during inspection These techniques would more effectively isolate these vehicles from other inspectors by not passing directly through the center lanes

3 **Maintain Positive Pressure and Optimal Flow Patterns in Primary Inspection Booths**—To reduce the infiltration of CO contaminated air from the lane into the primary inspection booth, it is important to establish a positive pressure and optimal flow pattern within the booth The results of the testing during the long term evaluations of the air showers showed that the air inside the booth did not differ significantly from that directly outside of the booth (see Table IX) This is likely due to the mixing and infiltration of air from outside the booth into the booth The use of laminar flow supply diffusers is a primary method of contamination control in many industries The main principle behind the laminar flow elements is to provide an envelope of clean air around the worker at the individual inspection booths The key to minimizing infiltration of CO laden air from outside of the booth is to create an optimized unidirectional airflow pattern with minimal turbulence In this case, the goal of the system is to minimize contaminant migration from the outside air into the inspection booth To achieve this flow pattern, a laminar flow supply register could be installed in the ceiling of the primary inspection booths and sufficient airflow would be supplied to maintain a positive pressure from the inside of the booth to the outside A smoke tracer test could be performed to evaluate the effectiveness of this installation Smoke released from outside of the booth should not enter the booth if proper flow patterns and positive pressure are maintained

4 **Utilize local exhaust hoods on cars in the inspection lanes** – A tailpipe exhaust capture hood could be designed to capture exhaust near the tailpipe region of the car This exhaust hood would need to be close to the tailpipe to assure good contaminant capture Such systems are currently used in vehicle emissions testing and maintenance shops across the United States These systems require that a local exhaust ventilation hood/collection hose be placed over the tailpipe to collect the exhaust and remove it from the vicinity of the worker While this system would help reduce inspector exposure to the car being inspected, it would not address the contribution of CO from cars awaiting inspection Therefore, this approach would require that additional source control methods such as the vehicle buffer zone be employed to account for the cars awaiting inspection

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Table I Facility Ventilation/Blower Configuration

Ventilation Unit	Supplies Air to	Comments
Heat Pump, HP-1	Booths 1,2,3	Conditioned air for inside of booth 20 ton unit with non-contact evaporative cooling
Supply Fan, S-2	Booths 4,5,6,7	Provides air from air handler in the penthouse with heating/cooling provided to each booth
Evaporative Cooler, EC-1	Booths 8,9,10 and overhead air supplied above all primary inspection booths	Provides air to inside of booths 8-10 and outside air for all booths with evap and furnace sections for heating/cooling
Supply Fan, SF-1	Pedestal supply registers for all lanes	Located in brick building at ground level with intake near lanes 1,2,3
Supply Fan, S-3	Soffit Fan Exhaust	Provides exhaust from top of canopy through distributed supply registers

Table II Long Term Survey Test Conditions

Dates	CO Monitor Locations	Test Conditions	Notes
7/18-9/6 (weeks 1-7)	Outside of Booths 4, 5, 6, 7,and 8	Test long term effectiveness of air showers compared to other lanes	
9/7-9/27 (weeks 8-11)	Outside of Booths 4, 5, and 6 Inside of Booths 4 and 5	Compare differences between inside booth and outside of booth	
9/27-11/15 (weeks 11-17)	Outside of Booths 4, 5, and roof Inside of Booths 4 and 5	Compare differences between inside booth and outside of booth	Test the quality of supply air from roof
11/15-11/22 (week 18)	Outside of Booths 4, 5, 6, 7,and 8	Test effectiveness of air showers compared to other lanes	
11/22-11/29 (week 19)	Outside of Booths 4, 5, 6, 7,and 8	Test the effect of shutting off pedestal supplies	Shutoff pedestal supplies to lanes 5 and 7
11/29-12/10 (week 20-21)	Outside of Booths 4, 5, 6, 7,and 8	Test effectiveness of air showers compared to other lanes	Air shower air supplies opened fully—Max airflow*

*Max air flow to lanes 5 and 7 was measured as 1510 cfm for Lane 5 and 1720 cfm for Lane 7 Originally these were adjusted to 1240 cfm for both lanes

Table III External air supply measurements

Lane No	Initial Measurement (cfm), 7/16	Second Measurement (cfm), 11/4
4	2380	
5—Air Shower	1250	875*
6	3300	
7—Air Shower	1230	880*
8	2090	

*Adjusted to 1240 on November 4, 2002

Table IV CO summary measurements for the day shift during the July 2002 survey Note the highest values for area measurements are highlighted

CO Monitor Location	Average CO Concentration, ppm (Std Deviation)	Peak CO Concentration, ppm	Number of Shifts Sampled (No total CO measurements)	Number of peaks >200 ppm
Lane 4-Area	9 3(1 2)	93	3 (4406)	0
Lane 4-Inspector	10 0 (1 15)	213	3 (3964)	1
Lane 5-Area	**14 2 (3 7)**	**747**	3 (3985)	**15**
Lane 5-Inspector	10 4 (1 41)	201	3 (3964)	1
Lane 5-Front	23 2 (3 7)	700	3 (2868)	13
Lane 6-Area	9 5 (1 3)	506	3(3963)	8
Lane 6-Inspector	8 5 (3 1)	982	3 (3942)	7
Lane 7-Area	9 8 (0 6)	544	3(3928)	11
Lane 7 – Inspector	9 8 (1 8)	1173	3 (3926)	8
Lane 8 – Area	8 1 (0 71)	287	3 (3906)	2
Lane 8 – Inspector	7 3 (1 8)	247	3 (3903)	5
Lane 8 – Front	18 4	815	1 (1381)	11
Roof	5 2 (2 2)	23	2 (2008)	0

Table V CO summary measurements for the swing shift during the July 2002 survey Note the highest values for area measurements are highlighted

CO Monitor Location	Average CO Concentration, ppm (Std Deviation)	Peak CO Concentration, ppm	Number of Shifts Sampled (No total CO measurements)	Number of peaks >200 ppm
Lane 4-Area	6 1 (2 0)	72	3 (4335)	0
Lane 4-Inspector	7 6 (1 5)	244	3 (4330)	2
Lane 5-Area	**8.4** (2 7)	**575**	3 (4369)	3
Lane 5-Inspector	6 2 (1 5)	168	3 (4364)	0
Lane 5-Front	16 4 (5 8)	1176	3 (4379)	16
Lane 6-Area	5 6 (1 5)	193	3 (4344)	0
Lane 6-Inspector	4 8 (1 4)	466	3 (4339)	2
Lane 7-Area	5 8 (3 1)	214	3 (4390)	1
Lane 7 – Inspector	5 9 (1 6)	195	3 (4383)	0
Lane 8 – Area	4 8 (1 3)	538	3 (4410)	**5**
Lane 8 – Inspector	6 1 (2 7)	326	3 (4404)	4
Lane 8 – Front	8 5 (3 1)	408	3 (5887)	11
Roof	5 0 (0 0)	26	2 (2205)	0

Table VI CO summary measurements for the graveyard shift during the July 2002 survey Note the highest values for area measurements are highlighted

CO Monitor Location	Average CO Concentration, ppm (Std Deviation)	Peak CO Concentration, ppm	Number of Shifts Sampled (No total CO measurements)	Number of peaks >200 ppm
Lane 4-Area	10 9 (2 0)	622	3 (4540)	2
Lane 4-Inspector	10 8 (2 1)	321	3 (4547)	2
Lane 5-Area	**17.3** (1 8)	539	3 (4538)	22
Lane 5-Inspector	13 9 (4 9)	976	3 (4524)	16
Lane 5-Front	21 4 (1 6)	429	3 (4511)	11
Lane 6-Area	10 9 (0 9)	687	3 (4531)	5
Lane 6-Inspector	10 7 (2 9)	1020	3 (4524)	12
Lane 7-Area	13 6 (0 6)	444	3 (4543)	**39**
Lane 7 – Inspector	11 3 (5 0)	1216	3 (4516)	26
Lane 8 – Area	9 0 (0 2)	**915**	3 (4550)	10
Lane 8 – Inspector	6 9 (1 8)	241	3 (4530)	4
Lane 8 – Front	11 0 (2 7)	367	3 (4443)	5
Roof	4 9	20	1 (640)	0

Table VII Long Term survey results-Comparison of Average Area CO concentrations by lane (Data from weeks 1, 2, 4-7, 18)

Monitor location	*Average CO Concentration, ppm (Std Deviation)	Number of Shifts Sampled (No total CO measurements)
Lane 4	4 6 (2 3)	146 (46667)
Lane 5	6 0 (3 5)	146 (46662)
Lane 6	5 0 (2 2)	146 (46661)
Lane 7	4 0 (2 3)	146 (46645)
Lane 8	4 1 (2 0)	146 (46645)

*The average from each shift was computed for each lane From this data, averages and standard deviations were calculated and are shown in the table At 5% significance level, lanes (4, 5, 6) average > lanes (7, 8) average (Ratio (4, 5, 6)/ (7, 8) =1 28) Statistical significance here and in the following tables was determined by a statistical linear model adjusting for means for shift, lane, and shift by lane combinations, and including random components for the correlation of shifts taken in succession [14] The response in the model was the average of the natural log of the measurements for each (lane, shift) combination

Tables VIII A, B   Long term survey results- Comparison of Average Area CO concentrations by shift

A Weeks 1, 2, 4-7, 18

Shift (time of day)	*Average CO Concentration, ppm (Std Deviation)	Number of Shifts Sampled (No total CO measurements)
Day (08 00-15 49)	4 5 (2 2)	240 (76245)
Swing (16 00-23 59)	3 8 (1 8)	245 (78400)
Graveyard (24 00-07 59)	5 9 (3 1)	245 (78645)

* Averages for each (lane, shift) combination were computed, and these were used to obtain shift averages and standard deviations shown in the table   Although differences are not statistically significant at 5% level, when ratios of graveyard average to other two shift averages were computed separately for inside and outside lanes, ratio for inside lanes was about 20% higher than that for the outside lanes (1 51 for inside lanes compared to 1 26 for outside lanes, significant at 5% level)

B Weeks 11-13, 15-17

Shift (time of day)	*Average CO Concentration, ppm (Std Deviation)	Number of Shifts Sampled (No total CO measurements)
Day (08 00-15 49)	2 3(1 9)	164(51507)
Swing (16 00-23 59)	2 5(2 1)	164(52480)
Graveyard (24 00-07 59)	3 5(3 2)	168(53878)

* Means for each (lane, shift) combination were computed, and these were used to obtain shift averages and standard deviations shown in the table   Differences between shifts are not statistically significant at 5% level

Table IX   Long term survey results- Comparison of inside booth vs outside booth

Weeks 11-13, 15-17

Monitor Location	*Average CO Concentration, ppm (Std Deviation)	Number of Shifts Sampled (No total CO measurements)
Lane 4 –outside booth	2 5 (2 2)	126 (40170)
Lane 4 –inside booth	2 7 (2 4)	126 (40164)
Lane 5 –outside booth	3 3 (2 6)	126 (40158)
Lane 5 –inside booth	2 6 (2 8)	126 (39929)
Roof	1 0 (0 7)	126 (40097)

* With 95% confidence, the ratio of outside booth to inside booth is (1 07, 1 14)   However, as the data in the table indicate, the estimated ratio is 0 93 for lane 4 (95% confidence interval (0 89, 0 97)) and is 1 31 for lane 5 (95% confidence interval (1 25, 1 37))

Figure 1 Calexico Site Plan/Layout

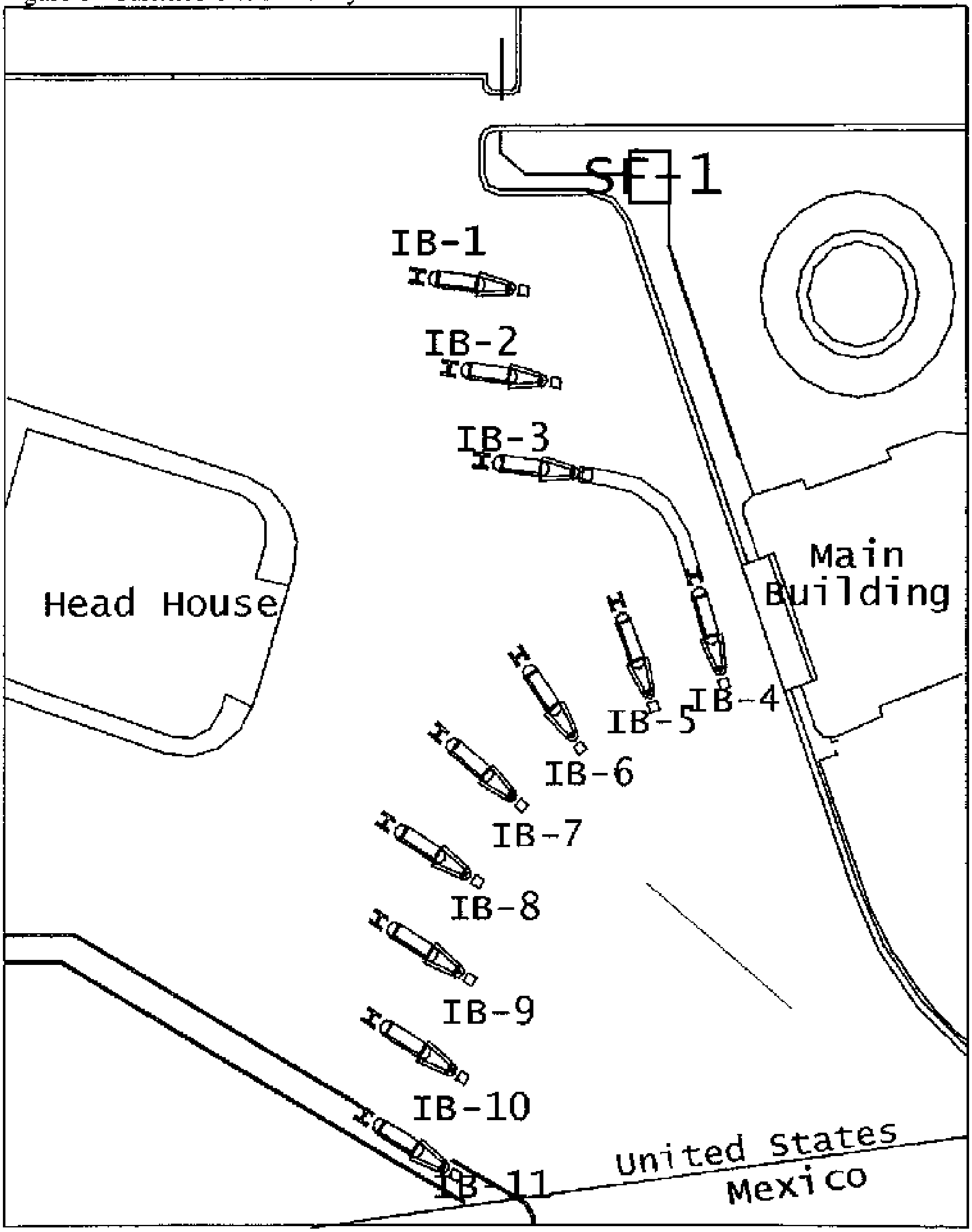

Figure 2 Calexico primary inspection area with canopy roof

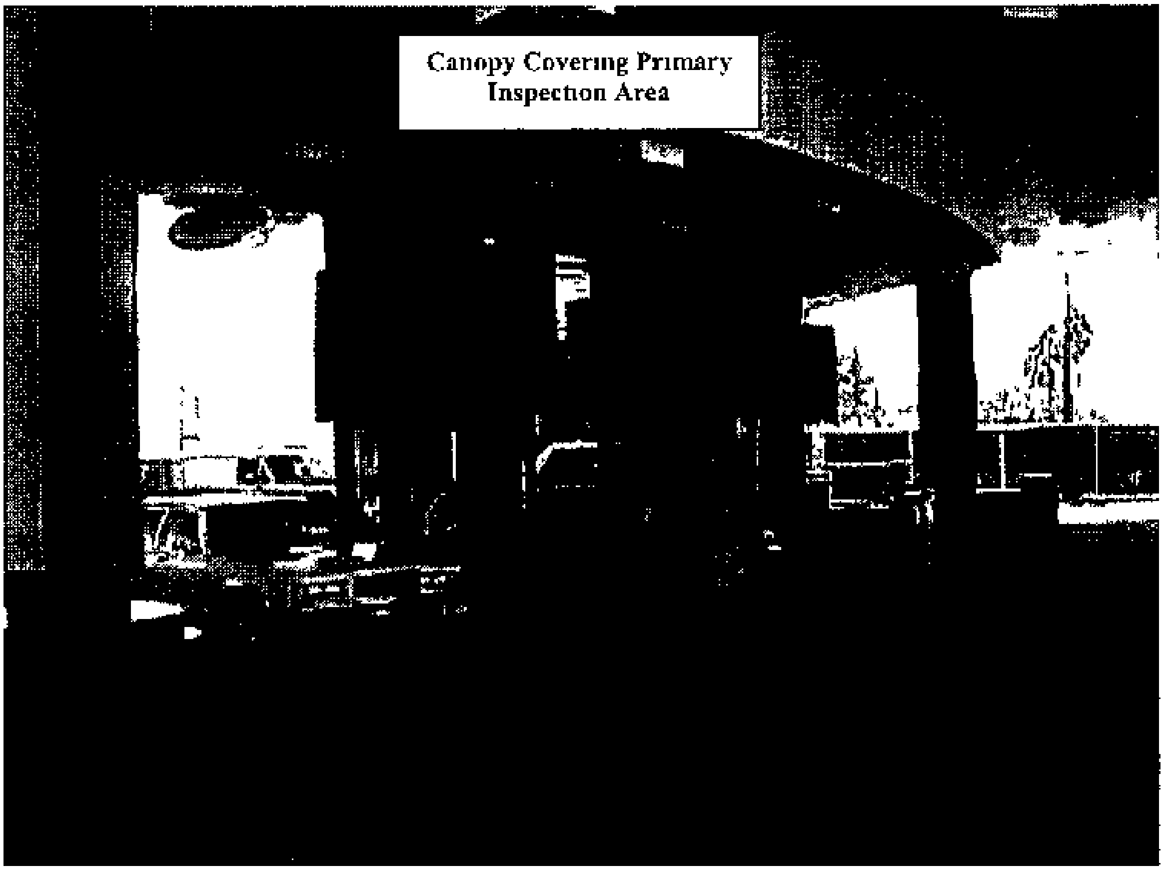

Figure 3 Blower units installed on roof over primary inspection area for Lanes 1-3

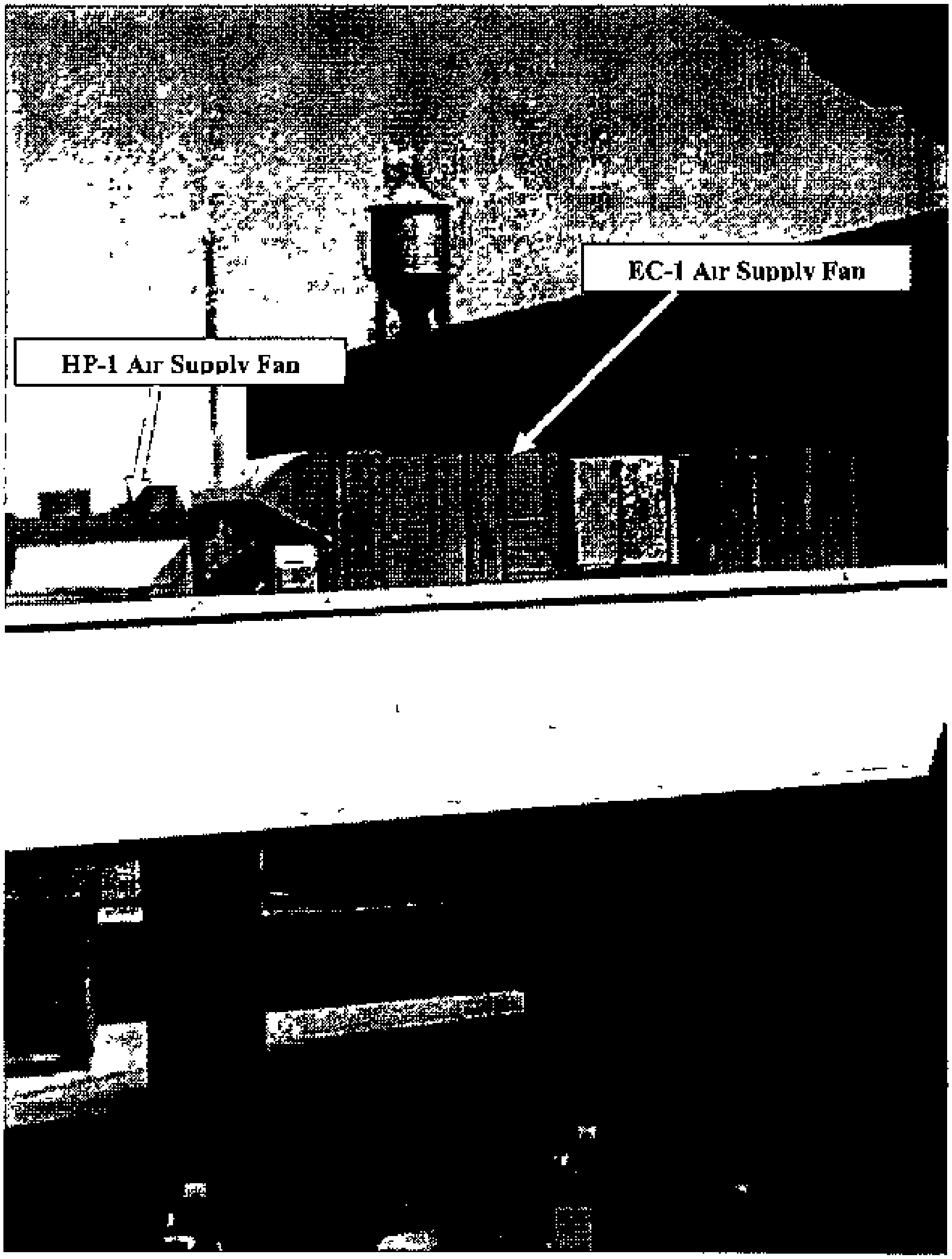

Figure 4 Air shower as installed in primary inspection lane 4

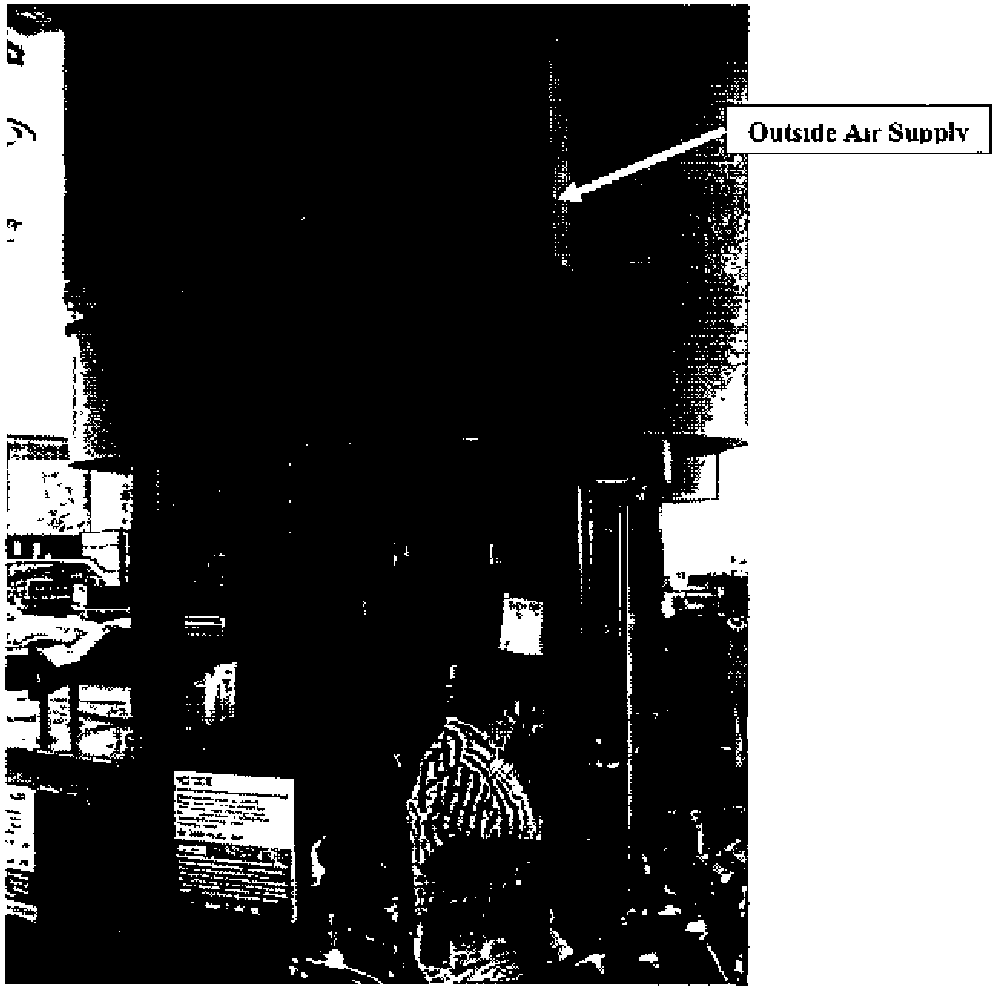

Figure 5 Outside booth air supply for primary inspection lanes 5 through 11

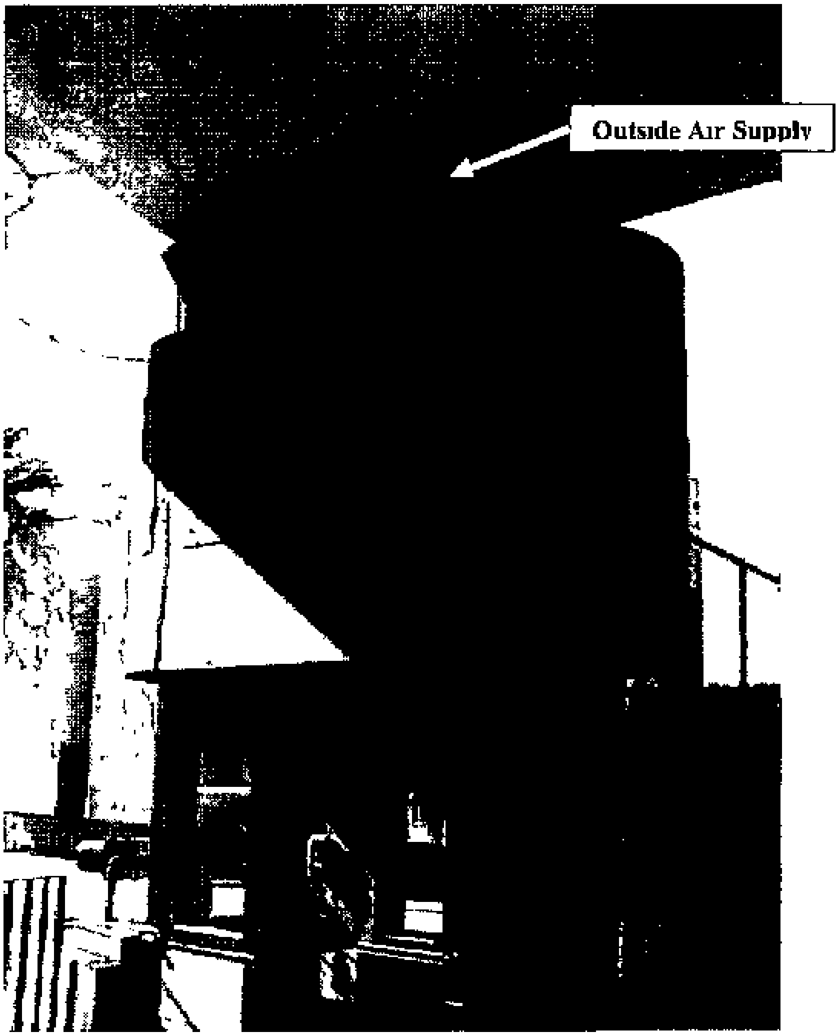

Figure 6 Pedestal air supply used to dilute the exhausts from the tailpipe

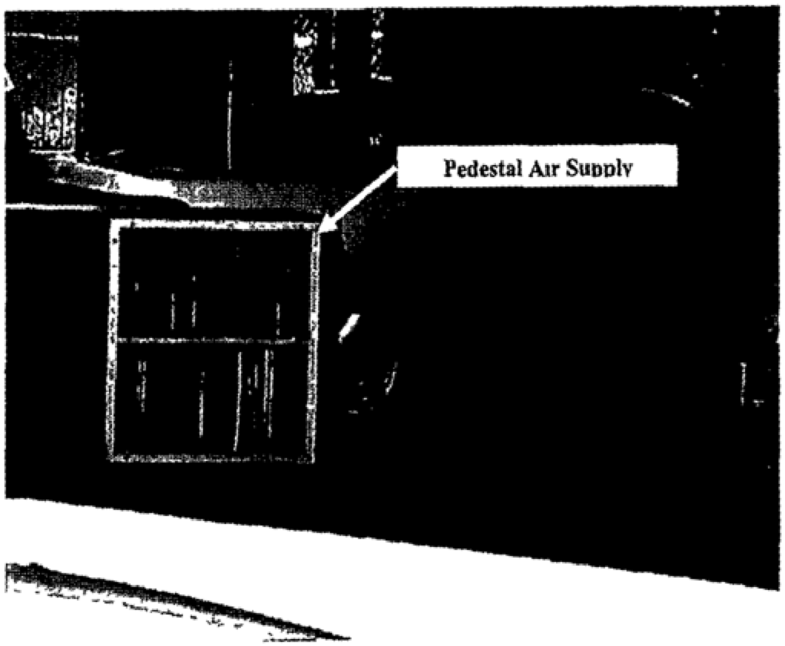

Figure 7 Unidirectional air shower as installed in primary inspection lane 7 Note the transition from the existing air supply outlet

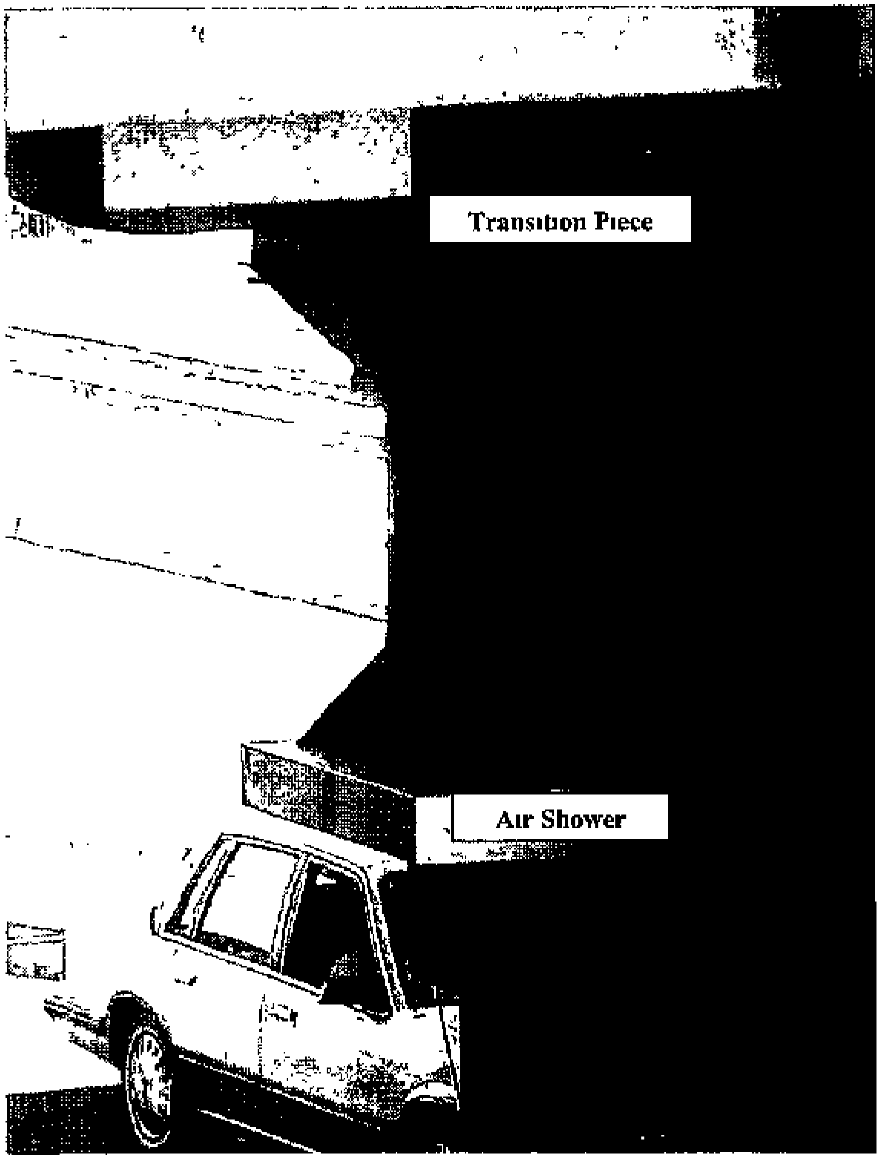

Figure 8 Unidirectional air shower shown here in place during the engineering evaluation

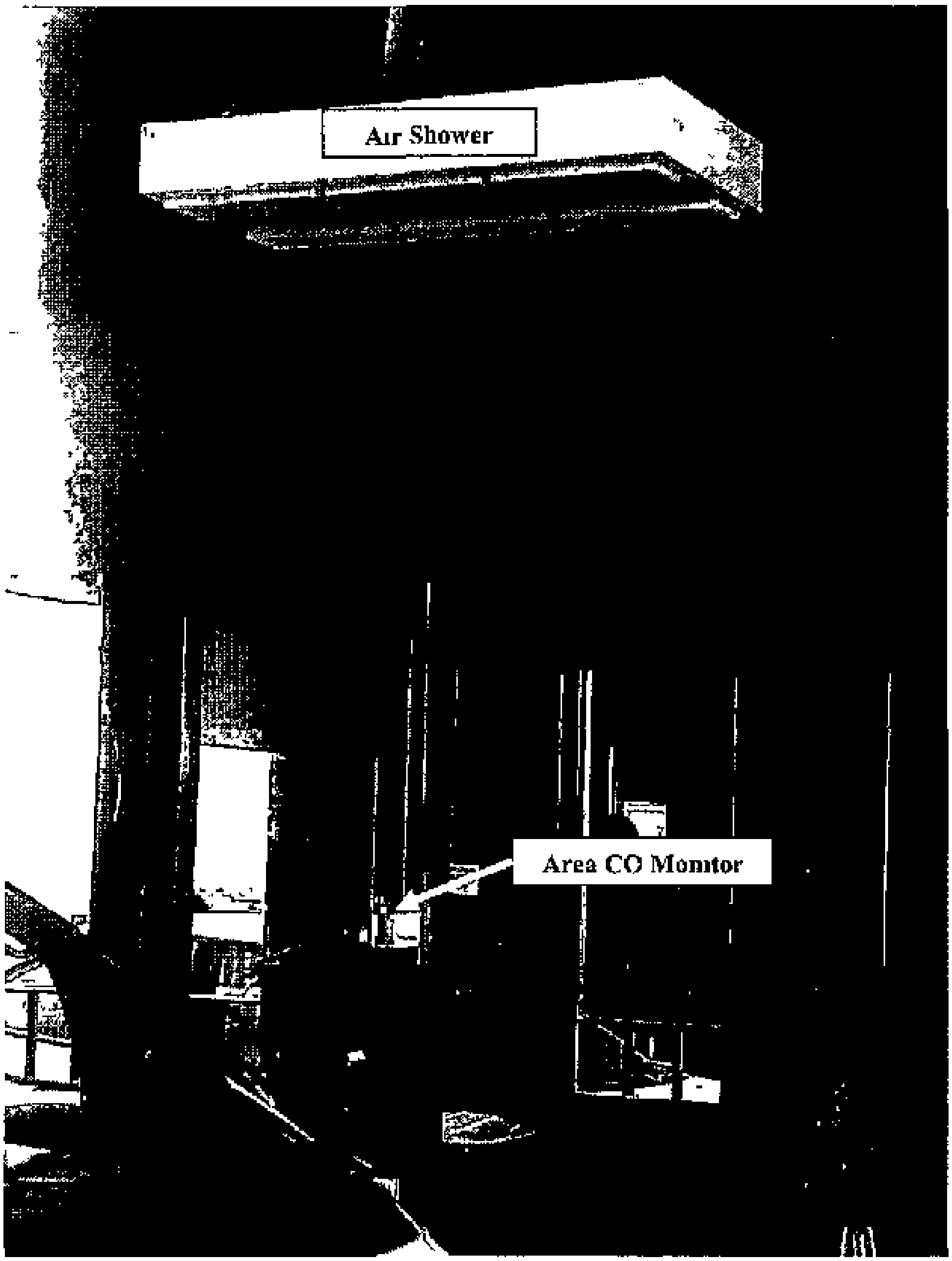

Figure 9 Personal and area monitors used during the July 2002 survey Note the area monitor located just outside of inspection booth

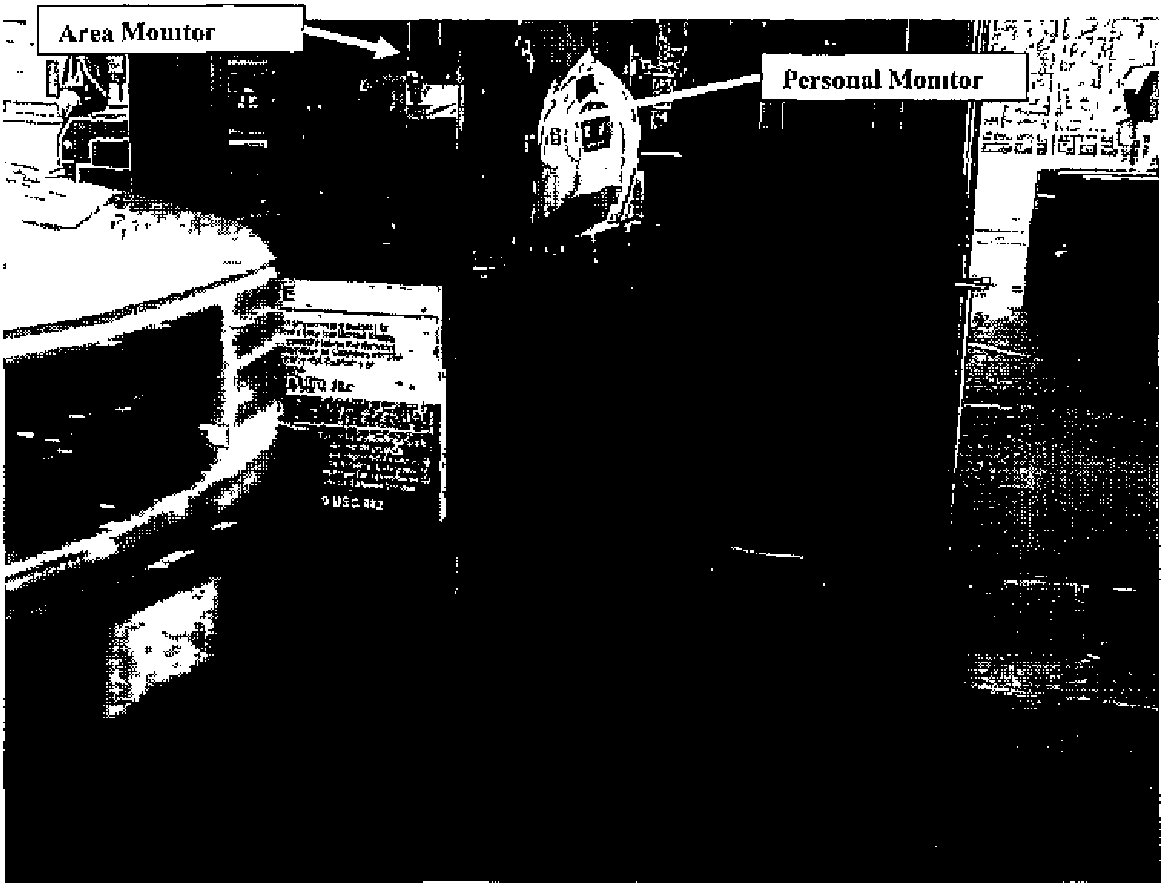

Figure 10 Front area monitor used during the July 2002 survey Note the area monitor located approximately 10 feet of inspection booth

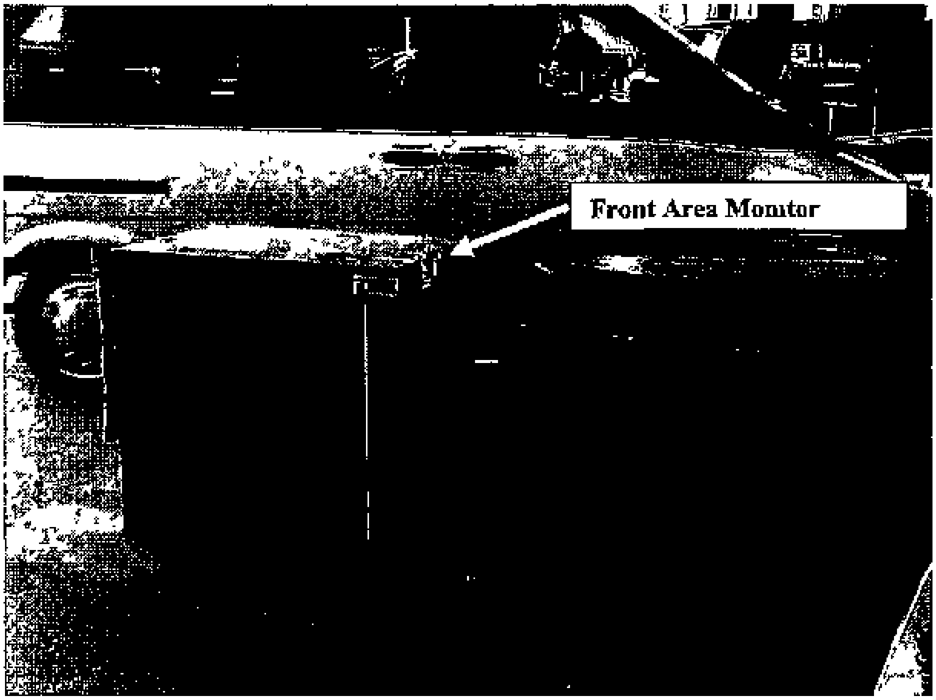

Figure 11 Comparison of area and personal average CO concentrations for the day shift from the July survey

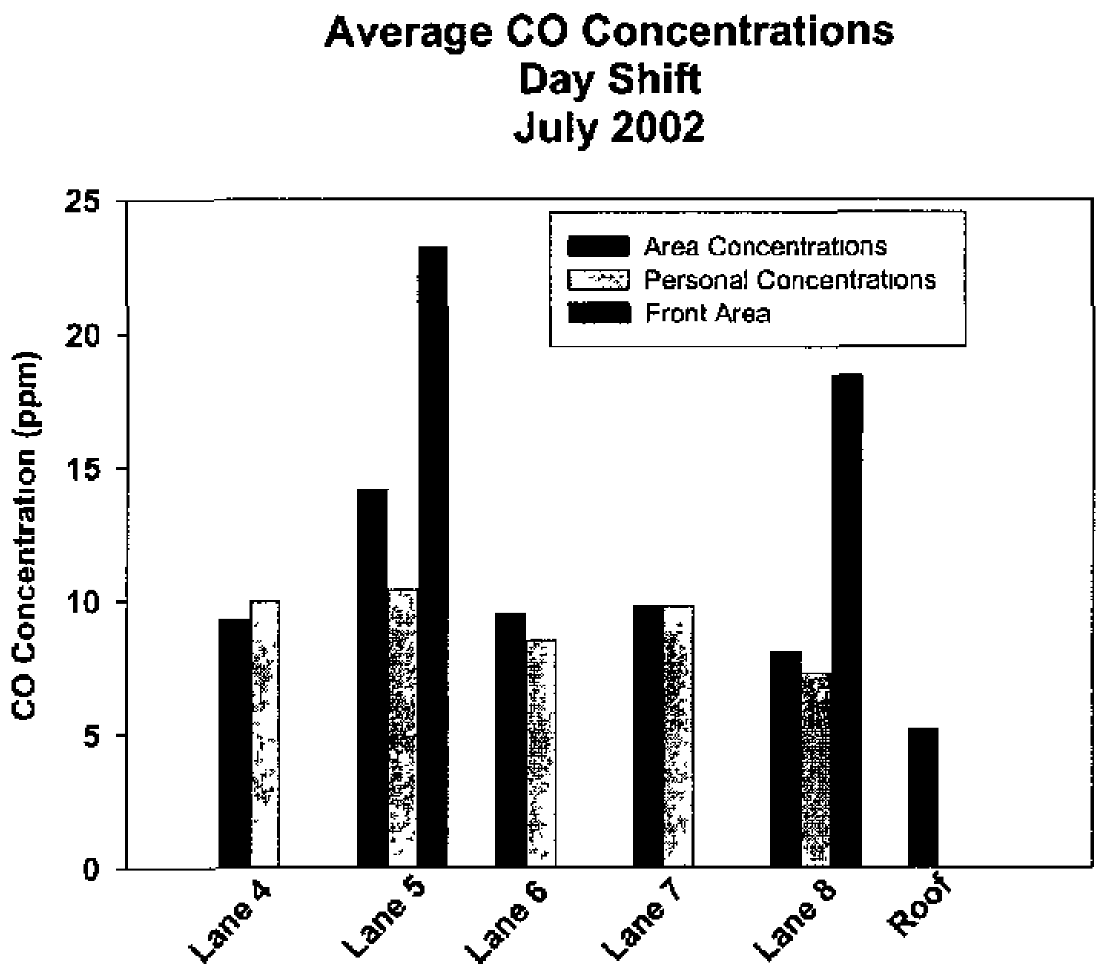

Figure 12 Comparison of area and personal average CO concentrations for the swing shift from the July survey

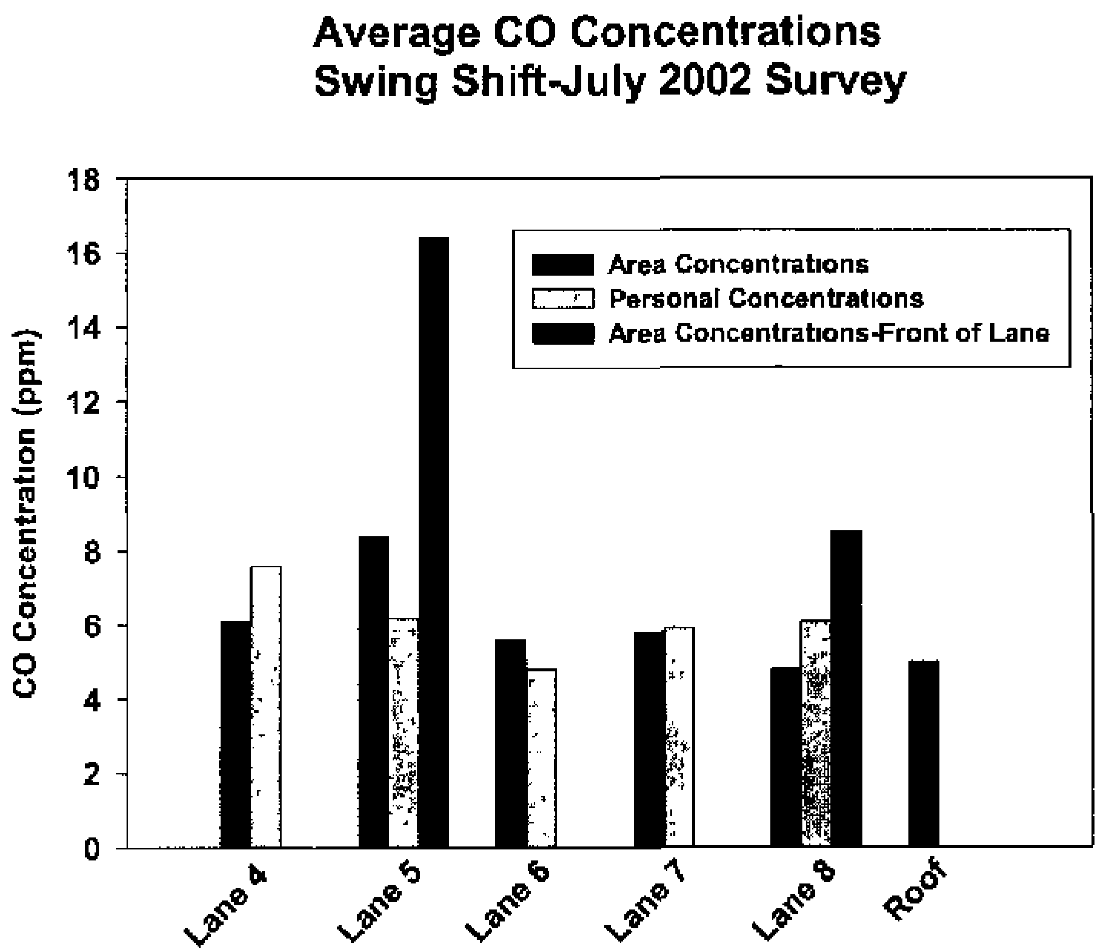

Figure13 Comparison of area and personal average CO concentrations for the graveyard shift from the July survey

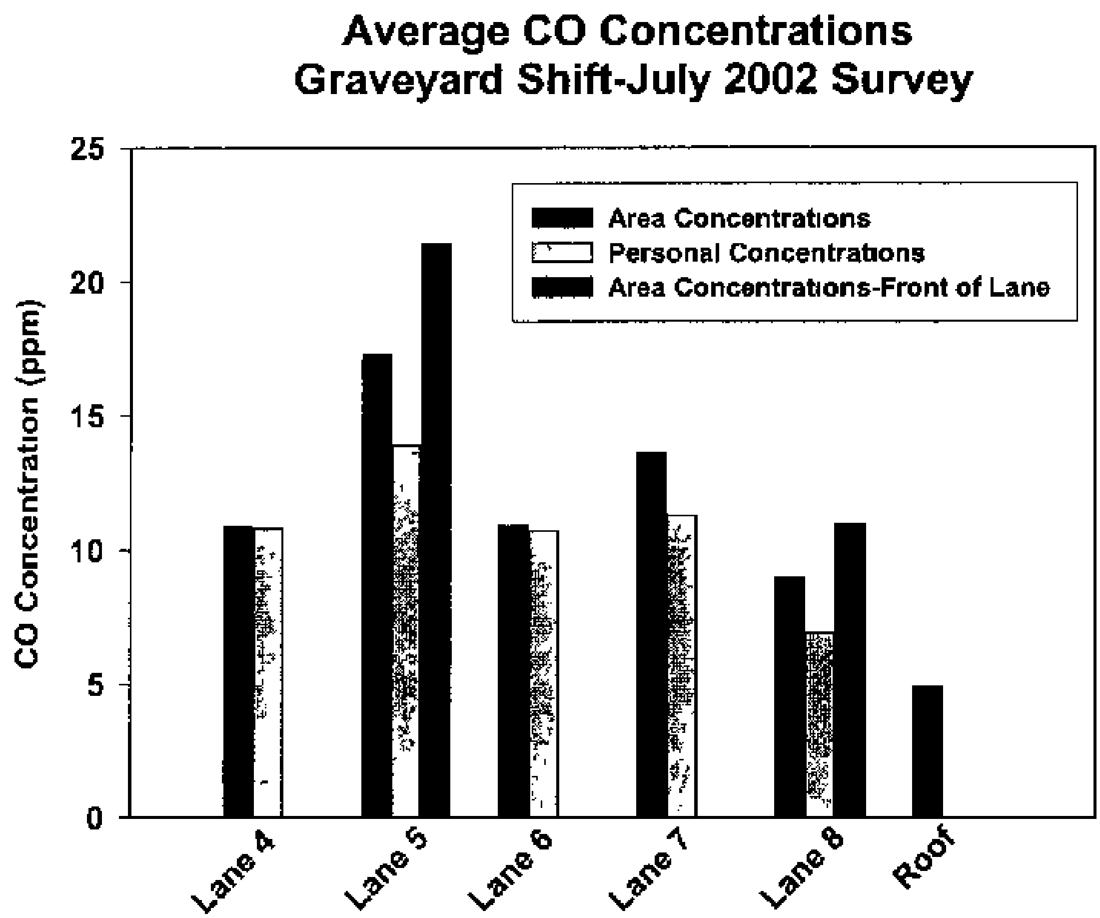

Figure 14 Comparison of long term average CO concentrations by lane for data collected from July-December 2002

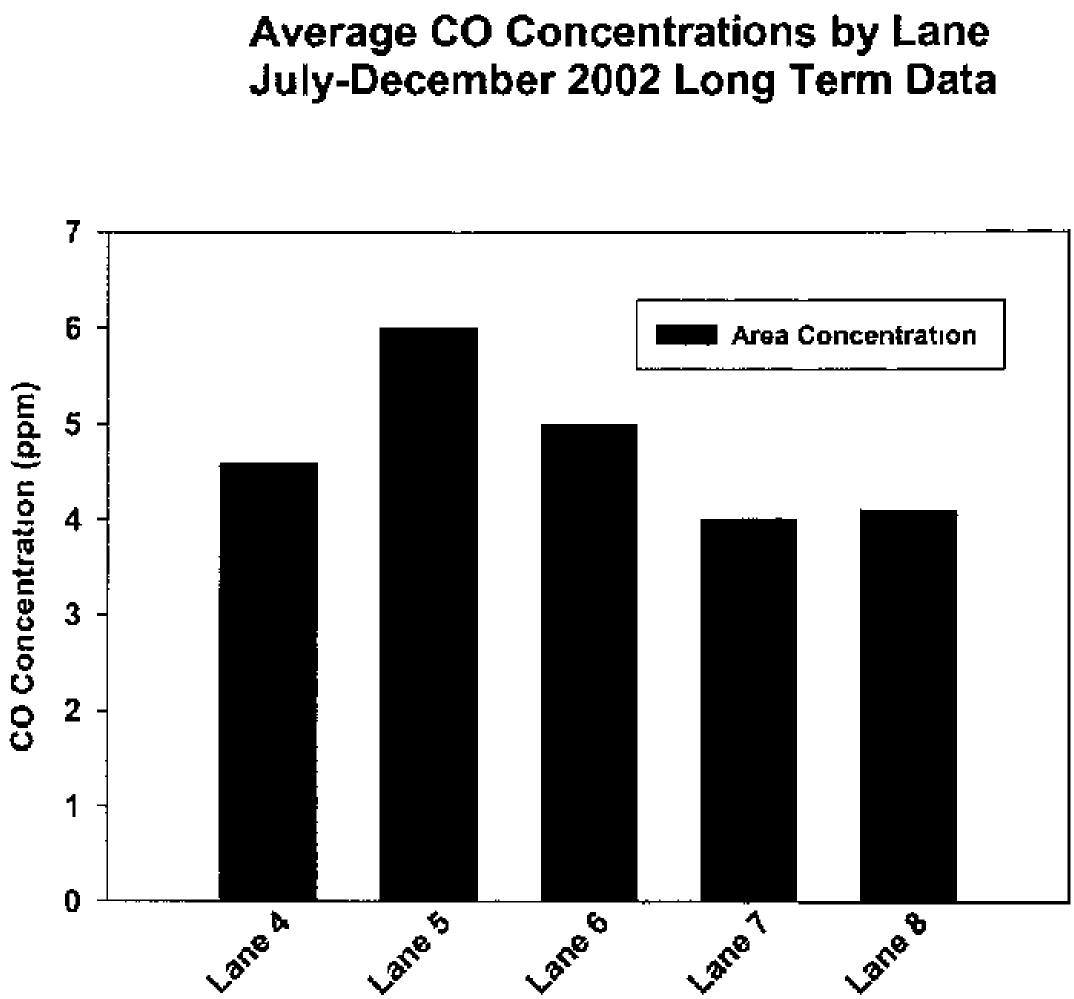

Figure 15 Comparison of long term average CO concentrations by shift for data collected from July-December 2002

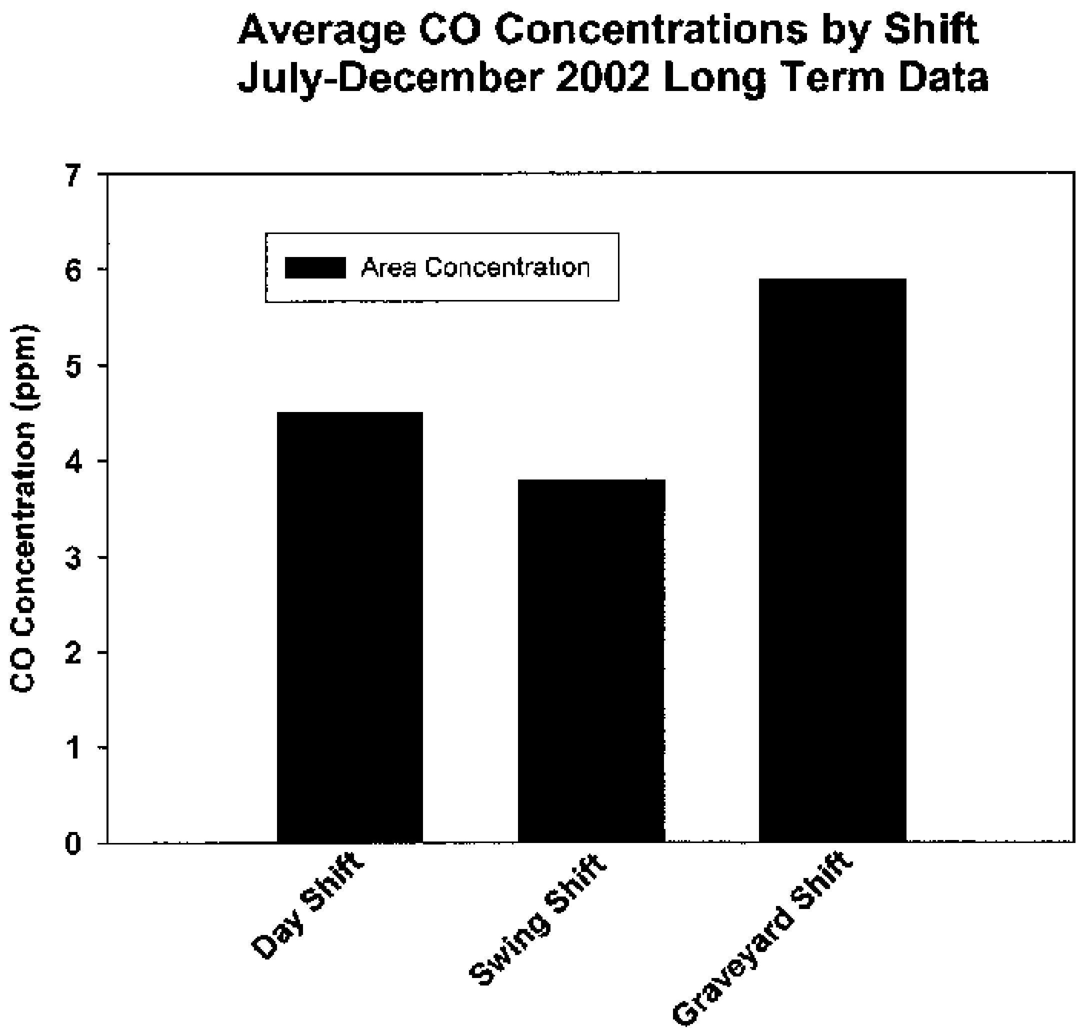

Figure16 Comparison of area average concentration inside the booth to directly outside of booth underneath the air showers

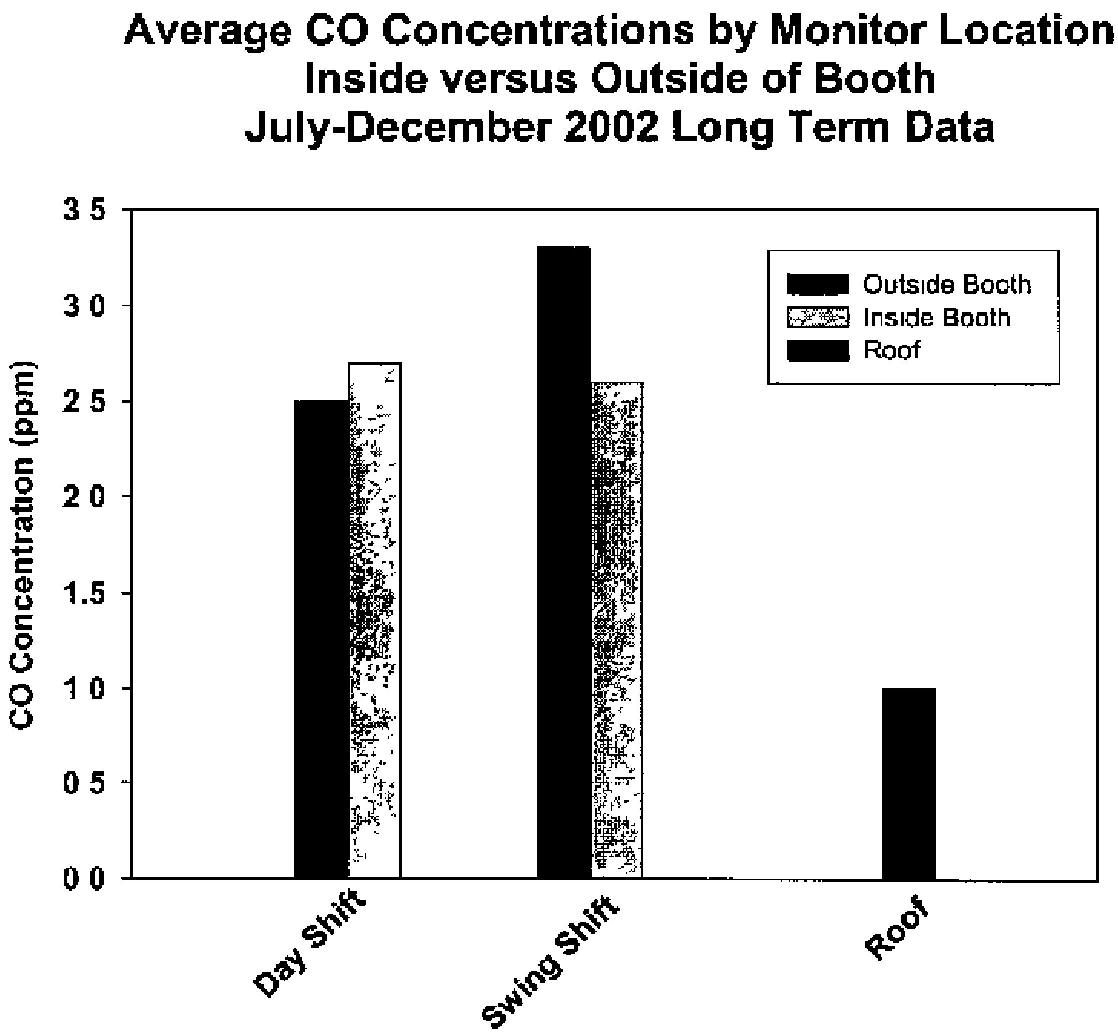

Figure 17 Backup of cars at the Calexico Port of Entry