SURVEY REPORT

POTENTIAL OPTIONS FOR THE CONTROL OF BORDER AGENTS EXPOSURE TO VEHICLE EMISSIONS

AT

United States Port of Entry
San Ysidro, California

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Plant Surveyed:	San Ysidro Port of Entry San Ysidro, CA
SIC Code:	9721
Survey Dates:	August 18-97, 1998
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Background

On September 17-19, 1997, the National Institute for Occupational Safety and Health (NIOSH) conducted a site visit 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 Control Technology Branch of the Division of Physical Sciences and Engineering was contacted by the General Services Administration (GSA) and asked to review the current systems and propose a course of action to reduce agents exposure to CO.

Introduction

On August 18-20, 1998, Mr. Kevin Dunn, Mr. Ken Mead, and Dr. William Heitbrink visited the San Ysidro, Otey Mesa, and Calexico border crossing stations. An opening meeting was held with representatives of the United States Customs Service, INS, and GSA. A list of attendees is included as attachment 1. In this meeting, the objectives of the visit were discussed and introductions were made between the NIOSH team and the INS, GSA, and Customs personnel. The purpose of the site visit was to review the facility layout, observe the operations, and to identify potential options to minimize border agent exposure to CO. Following the meeting, a tour of the facility and operations was conducted by Tom Carsons (GSA). During the visit, the NIOSH representatives were escorted by Alan Belauskas (INS), Bob Barron (INS), and Gerald Stachowitz (Customs). A limited number of environmental measurements were taken at San Ysidro and Calexico including ambient CO concentrations, exhaust and supply system airspeeds, and ambient wind speed.

This report contains an overview assessment of the existing ventilation systems and presents a list of potential control options which may lower border agent exposure to car exhaust gases if designed and implemented properly. The list includes work practice and administrative controls as well as ventilation control strategies. Presentation order has been established by indicating those options that require minor changes to those requiring more significant facility modifications.

Current Ventilation Systems

There are 24 inspection booths at the San Ysidro border crossing with supply and exhaust ventilation provided by systems located in the east and west mechanical rooms. An automobile exhaust ventilation system is located in each of the inspection lanes and consists of a pavement and pedestal exhaust (see figure 1). The pedestal exhaust is located on either side of the car several feet from the rear of the car. The pavement exhaust is located under the car in between the front and rear axles. The initial design concept for the overall exhaust system was for the pedestal exhaust to capture the idling vehicle exhaust while the car was under inspection at the booth and for the pavement exhaust to capture the vehicle exhaust as the car exited the inspection station. A 100 horsepower (hp) exhaust fan is located in both the east and west mechanical rooms. Each fan services 12 lanes with 5000 cubic feet per minute (cfm) of exhaust flow pulled from each lane. 2000 cfm is exhausted from the pavement grate with the additional 3000 cfm pulled from the pedestal exhaust. Exhaust registers lose their capture velocity inversely with the square of the distance from the register face. This means that the velocity of air at a distance of 2 feet is approximately 25% of the velocity at a distance of 1 foot from the register face[2]. Due to this fundamental of airflow, the pedestal exhausts exhibit little effect on the tailpipe emissions. In addition, the placement of the pavement exhaust grate under the center of the car rather than directly under the tailpipe greatly reduces any potential for exhaust capture by the pavement exhaust portion of the collection system during inspection.

Each inspection booth has supply air ventilation that provides filtered ambient air through ceiling vents. There are two slotted ceiling vents per booth with one located on each side of the overhead light. Each booth receives a nominal airflow of 4000 cfm with supply air originating from four 25 hp fans (6 booths per fan). Two supply fans are located in each of the east and west mechanical room. Heating coils located at the booth provide some climate control however no cooling is provided for the supply air. The 1998 HHE report noted that many of the ceiling vents had been totally or partially closed resulting in air velocities that varied between 333 and 2300 fpm[1]. These high velocities contribute to turbulence within the booth that might entrain air from the outside and actually pull in CO from the contaminated ambient air surrounding the booth.

There are six overhead fans that exhaust air from the beneath the canopy adjacent to the primary inspection area. These six fans support 3 exhaust registers each for a total of 18 exhaust registers located throughout the soffit. Six adjacent CO monitors mounted on the canopy ceiling control the activation of the fans. Each fan exhausts 20,000 cfm nominal airflow providing approximately 6670 cfm of flow per register. Currently, the soffit fans are programmed to pull air from under the canopy and exhaust through roof mounted stacks when concentrations of CO reach 35 parts per million (ppm) or greater. There are two concerns with this approach: 1) exhausting flows from the soffit draws contaminated makeup air into the canopy from the "sea" of idling cars waiting to be inspected, and 2) the soffit fans are controlled by CO sensors which are not routinely calibrated or checked due to difficult accessibility. These sensors typically require calibration at least quarterly due to zero drift. They should be checked more often than quarterly to ensure that they are registering accurate readings. They have reportedly not been calibrated or checked since installation.

The U.S. Customs Service operates a continuous real time monitoring system designed to monitor CO concentration in the primary inspection area. The system consists of a Bruel and Kjær (B&K) model 1302 multi-gas monitor with a B&K model 1309 multi-point sampler (California Analytics, Orange CA). The CO monitoring system is designed to sequentially sample and record CO concentrations from seven locations within the primary inspection area. The manufacturer recommends that the B&K be calibrated on a quarterly basis with a zero point, span, and humidity interference calibration[3]. The calibration sequence is moderately difficult and may require outside professional assistance. It is important to calibrate the instrument on a regular scheduled basis to verify that the readings are accurate. At the time of the visit, B&K operating instructions were provided in a simplified Users Manual that covered day-to-day operation of the system. In addition to the Users Manual, on-site personnel should have copies of the manufacturer's operating manuals that they can reference under unusual circumstances. During the visit, the unit was not functional and required recalibration.

Proposed Options for Reducing Agent's Exposure to Exhaust

The options discussed in this section, if implemented properly, could assist in lowering border agents' exposure to automobile exhaust constituents. The options have been separated into three categories including those requiring minimal, moderate, or significant changes to facilities or operations. They have been grouped as such to present a wide range of options for consideration with due regard to the amount of resources required for design and implementation.

Minimal Change to Facility/Operations

Administrative Controls

The mobility requirements of the canine enforcement officers and rovers prohibit the use of stationary engineering controls to reduce exposures. One key to controlling these officers' exposures is through the use an administrative rotation schedule that rotates officers out of the traffic areas after a prescribed working duration among the idling vehicles. Currently, San Yisdro customs officials recommend a rotation schedule that prescribes 30 minutes out of traffic following every 30 minutes within traffic. A review of exposure measurements and recommendations resulting from a recent survey of the San Ysidro canine enforcement operations indicates that continuation of this rotation schedule should maintain the time weighted average exposures to the canine unit officers below 12.5 ppm (50% of the most stringent occupational exposure limit of 25 ppm - a common target used to safeguard against worker exposures above established criteria)[4]. As additional exposure data become available under a wider variety of environmental conditions, the administrative rotation schedule could be adjusted accordingly. If desired, NIOSH can assist Customs personnel in re-calculating the administrative rotation schedule once such data become available. The rovers and canine enforcement officers are motivated and dedicated personnel who recognize the positive contribution of the canine units to achieving the overall customs mission. In the face of this enthusiasm, it is important that U.S. Customs management clearly emphasize the importance of adherence to an established administrative control schedule and require this adherence by the officers who participate with the rover and canine enforcement units.

As an additional measure, canine officers who are actively engaged in vehicle patrol activities among idling vehicles could benefit from 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. 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 accurately establishing an administrative rotation schedule based upon a more thorough documentation of typical exposure conditions. 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. If the officer was engaged in a search activity anticipated to continue for an extended period, they could redirect the vehicle to the secondary inspection area where the vehicle could be turned-off prior to a more thorough inspection. While real time CO monitors are not a panacea and customs agents 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.

Administrative controls are not recommended for use in the practice of pre-primary inspections (also known as a double push). This is primarily due to the fact that while engineering controls are not feasible for the canine enforcement officers due to their mobility requirements, they are feasible for routine inspection duties. Also, the fact that the CEOs and rovers are mobile increases natural ventilation and allows the officer to leave an area of suspected high exposure. Instead, we recommend the installation of fixed workstations, like booths for pre-primary inspections. Recommendations for pre-primary inspection are discussed later in this document.

Moderate Change to Facility/Operations

Vehicle Free Buffer Zone

Vehicle density is the most obvious variable contributing to elevated exposures to vehicle exhaust constituents. By contrast, ambient winds provide the most obvious factor to reduce vehicle exhaust concentrations. The design and work practice procedures of the San Ysidro border crossing work to increase the negative influence of vehicle density while minimizing the protective potential of the ambient wind. Reportedly (and observed during the NIOSH visit), the current practice for border operations is to intentionally create a moderate back up of vehicles waiting to enter the United States. This back up 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. The intentional congestion is accomplished through opening and closing inspection lanes according to traffic demand. From the exhaust exposure perspective, 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.

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 similar to those at Otey Mesa. Additionally, hydraulic roadblocks could be strategically placed for protection against speeding vehicles.

Ambient air dilution of vehicle exhaust is potentially the most effective, and the most cost-effective, means to reduce worker exposures to vehicle exhausts. However, NIOSH recognizes that there may be unaddressed safety issues associated with this proposed concept. It is our hope that any such issues can be resolved without compromising worker safety and without abandoning the concept of the vehicle-free buffer zone. Any increased separation distance will likely be beneficial. In general, the greater the separation, the greater the potential benefit.

Soffit Fans Flow Reversal

The soffit fans exhaust air from the canopy area between the administrative office, also known as the "fishbowl", and the primary inspection booth. We would recommend that the direction of fan airflow be reversed. This could be accomplished by inverting the fan such that the direction of flow is into the canopy area rather than out of the area. To do this, the manufacturer recommends that the fans be physically inverted rather than simply reversing the motor leads (personal communication with American Fan Company, Fairfield, OH). By reversing the flow direction, there would be a nominal increase in supply air ventilation of 120,000 cfm. Currently, the air exhausts through a stack that could be used as a clean air inlet for the supply. This increase in airflow would assist in providing dilution and movement of air in the canopy area during stagnant wind conditions. It is entirely possible that operating these fans full-time would be more protective than operating the existing exhaust grate and pedestal exhaust systems. This concept could be tested once the fans are reversed. Smoke visualization or tracer gas techniques could be used to provide an indication of the effectiveness of this scheme prior to full-scale implementation. In the interim, regardless of airflow direction, if the CO sensors are to be used for control they should be recalibrated, located near the ground, and incorporated into a regular calibration and maintenance schedule.

Laminar Flow Booth Supply

The use of laminar downdraft flow is a primary method of contamination control in many industries. The main principle behind the downdraft flow 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. In a standard downflow booth configuration, clean air is provided at the top of the booth and sweeps downward across the booth and exhausts through the door or at vent slots at the bottom of the booth. The key to maintaining an optimized flow path with minimal turbulence is to distribute low velocity airflow evenly at the supply. The low velocity air should reduce draftiness while providing clean air to the worker. This concept has been used successfully in many applications including controlling the infiltration of dust into a work zone in mining applications[5]. This option would require reconfiguration of the booth supply registers including the installation of a laminar flow element at the booth ceiling and cutting vents in the lower side of the booth to allow for the exit of booth air. Vent location and size should be strategically selected to maximize the control efficiency.

Significant Change to Facility/Operations

Supply Air at Car Exhaust

The primary problem with the current vehicle exhaust ventilation system is the placement of the pedestal and pavement grates with respect to the tailpipe. Exhaust registers lose their capture efficiency rapidly as the contaminant source moves away from the register face. The pavement exhaust grate might produce a greater contribution to controlling vehicle exhaust if relocated to the area directly under the tailpipe region of the car. However, due to the inherent design constraints, we doubt that this change alone would have a significant effect on exposures. Currently, the pedestal exhausts are placed so far from the tailpipe that they exhibit little effect on the automobile exhausts. A computational fluid dynamics (CFD) analytical model was used to predict the effect of the pedestal exhausts on the vehicle emissions. Figure 2 shows the reach of the pedestal exhaust at a design flowrate of 5000 cfm per pedestal (greater than the current pedestal design flowrate). In this figure, the red area is the area of highest air velocity (625 fpm) and extends only a few inches from the face of the pedestal on the right side of the lane. The velocity quickly decays to approximately 10 fpm (shown here as dark blue) before even reaching the closest side of the automobile. These air velocities are typical of the face velocities measured during our visit however, the pedestal exhaust velocities varied significantly from lane to lane. Unfortunately, the pedestal exhausts cannot be effective as an exhaust hood without increasing the airflow to unacceptably large flowrates.

An alternate approach to dealing with tailpipe exhausts would be to implement a system that blows the vehicle exhaust away from the inspection stations and dilutes the contaminants. The influence of a jet extends far beyond the effect of an exhaust with the same airflow rates. Figure 3 shows a supply flow (out of the pedestal) of 5000 cfm. The supply jet velocity maintains high airspeeds far away from the pedestal face. In figure 3, the red area shown at the far-left side of the lane represents a velocity of 100 fpm away from the pedestal face. While the exhaust velocity decayed to 10 fpm within a couple of feet from the pedestal face (figure 2), the supply jet maintains a velocity of over 100 fpm at a distance of several feet from the pedestal face (figure 3). A supply jet near the car exhaust could be implemented by a variety of ways, either through reconfiguration of the existing system or through the addition of new equipment. While we expect this approach to have much promise, we recommend further testing of this control approach before significant expenditures are spent to adopt it. Testing of the control approach could be conducted in individual lanes using portable fans and equipment.

Down Draft Ventilation

The use of air showers to prevent the migration of contamination into the standard work area of the agents is a viable option for minimizing agent exposure. The air shower could be implemented as a downdraft air supply register that extends outside of the booth where agents spend a major portion of their time (see figure 4). The air shower provides an envelope of clean air around the agent. This concept was used successfully in minimizing dust contamination at two industrial sand plants and produced significant reductions in dust concentrations at operator workstations[5]. The use of the air shower might require a work practice change of sending all high clearance vehicles (such as recreational vehicles or trucks) through a specified lane area to minimize damage to the supply plenum. The option would likely require the installation of an additional ducting and air movement system to provide the supply air to the booth. Also, the reconfiguration of the pavement level exhaust might increase effectiveness of the downdraft design. This configuration would also likely require a higher capacity fan capable of providing an additional 5000-10000 cfm per booth. A lower cost possible option to be evaluated would to be to use the existing ducting for the booth supply air and branch off for the down draft supply plenum. An analysis of duct sizes and layout would be necessary before using the existing system to verify that the additional flow required would not result in excessive pressure losses.

Retractable Exhaust Capture Hood

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. A ventilation hood which "pops up" from the ground after the car has entered the inspection booth (see figure 5) would provide a method of capturing the vehicle exhaust close to the tailpipe. A position detector could be utilized to signal when the car has reached an appropriate location. The hood would then automatically rise from the pavement and begin to capture the vehicle exhausts. The close vicinity of the hood to the exhaust and the momentum imparted to the exhaust gases towards the hood would assist in good contaminant capture effectiveness. The existing ducting and air movement system could possibly be used as the core of this system. This option would however require a construction effort as the ducting for the pedestal and grate exhausts are currently underground and would need to be relocated to an area at the rear of the automobile. Also, the variability in the tailpipe location on different automobile models would need to be considered during the design process.

Pre-primary Inspection

In the past, increased traffic levels have resulted in the use of pre-primary inspection activities to increase the flow of traffic through the border crossing. Previous exposure studies have indicated that officers who conduct pre-primary inspections may be at higher risk for exposures to elevated levels of CO. NIOSH understands that there are several issues involved when discussing the preprimary activities. Our recommendations are based solely upon defining means that may reduce the potential hazard to carbon monoxide for officers engaged in preprimary activities. In that regard, the NIOSH recommendations should be evaluated by experts within the Customs and Immigration departments for their potential impact upon officer safety.

NIOSH recommends the selection of one or more of the following options related to pre-primary inspections at the U.S.-Mexico border crossings:

1. Maintain current policy of not conducting pre-primary inspections.

2. Provide fixed workstations that provide pre-primary inspecting officers with protection against elevated exposures to vehicle exhausts and to elevated ambient temperatures.

3. In addition to option #2 above, alter current work practices to allow a vehicle-free buffer between the vehicle under pre-primary inspection and the preceding or following vehicles. The vehicle free buffer will increase the ability of ambient winds to capture and remove vehicle exhausts before they enter the officers breathing zones. When this option was discussed with Customs and INS personnel during the NIOSH visit, officers discussed the importance of vehicle congestion as a deterrent to "runners" who could potentially use the vehicle-free buffer to accelerate and thus increase the potential danger for the officer. One option to eliminate this threat is through the use of hydraulic roadblocks, similar to those used at the Otey Mesa.

Any issues surrounding the implementation of pre-primary booths/vehicle–free buffer zones, personnel safety or facility space limitations should be carefully evaluated by Customs, INS, and GSA.

Recommended Course of Action
The recommendations contained within this report are based on the observations from the 2-day NIOSH visit. These options need to be evaluated by each agency for operational and cost feasibility prior to going forward with any test or implementation plans. There have been several industrial hygiene surveys that can be used to establish targets for exposure reduction. A cursory look at the current system that includes the pedestal and exhaust grates indicates that these collection systems are ineffective for control of tailpipe exhaust gases due to the reasons stated previously. Based on this ineffectiveness, NIOSH recommends that the INS and GSA cease installing this ineffective control design in future retrofit or new construction designs.
NIOSH also recommends consideration of the following options to reduce worker exposure to CO:

<u>Minimal Change to Facility/Operations</u>

- Implement strict administrative rotation schedules for canine enforcement officers and rovers consistent with the current policy of 30 minutes out of traffic following every 30 minutes in traffic.

- Implement the use of portable CO monitors to be worn by canine enforcement officers and rovers during their rotations among idling vehicles.

Moderate Change to Facility/Operations

- Establish a vehicle-free buffer zone to increase the distance between the sources of CO (vehicles) and the inspection booths. This increased distance will enhance the opportunity for ambient winds to dilute and evacuate the contaminated air.

- Reverse the flow of the soffit fans to provide fresh dilution air into the canopy area. An increase of 120,000 cubic feet per minute (CFM) of fresh air could be delivered to the canopy simply by reversing the soffit fans flow.

- Reconfigure inspection booths by installing laminar flow elements on the supply air and adding vents to the floor of the booths. These changes would minimize turbulence and increase the effectiveness of supply air in providing a clean air shower to the booth.

Significant Change to Facility/Operations

- Install supply air registers at the vehicle tailpipe locations to evacuate/dilute vehicle exhausts. This could possibly be accomplished by reconfiguring the existing system or through the addition of new equipment.

- Install down draft air showers outside of the inspection booths. A downdraft ventilation system will provide an envelope of clean air around the agent and reduce CO concentration in the primary work area.

- Consider the design and installation of a retractable exhaust capture hood which would pop up from the ground behind the vehicle and collect exhaust during primary inspection.

Pre-Primary Inspection

- Maintain the policy of not conducting pre-primary inspections or consider the following option: Provide pre-primary inspection booths and alter current work practices to implement a vehicle-free buffer zone.

NIOSH recommends that a pilot study be performed before making any significant changes to the existing configuration. This study should include only those options that are determined to be feasible for implementation by the GSA, INS, and Customs Service. Engineering controls for the pilot study could be manufactured and implemented on a single lane and evaluated using tracer gas and smoke visualization techniques to get qualitative and semi-quantitative data. Tests should be run during the evening and morning hours consistent with the periods of highest ambient CO concentration over the course of several days.

References

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5. Volkwein, J.C.; Engle, M.R.; Raether, T.D.: Dust Control with Clean Air from an Overhead Air Supply Island (OASIS). Appl. Ind. Hyg. 3(8): 236-239 (1988).

Attachment 1

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Tina Bran	USBP	619/662-7233 x572
Peter S. Saldana	INS	619/662-7314
Karen Phius	INS	619/662-7314

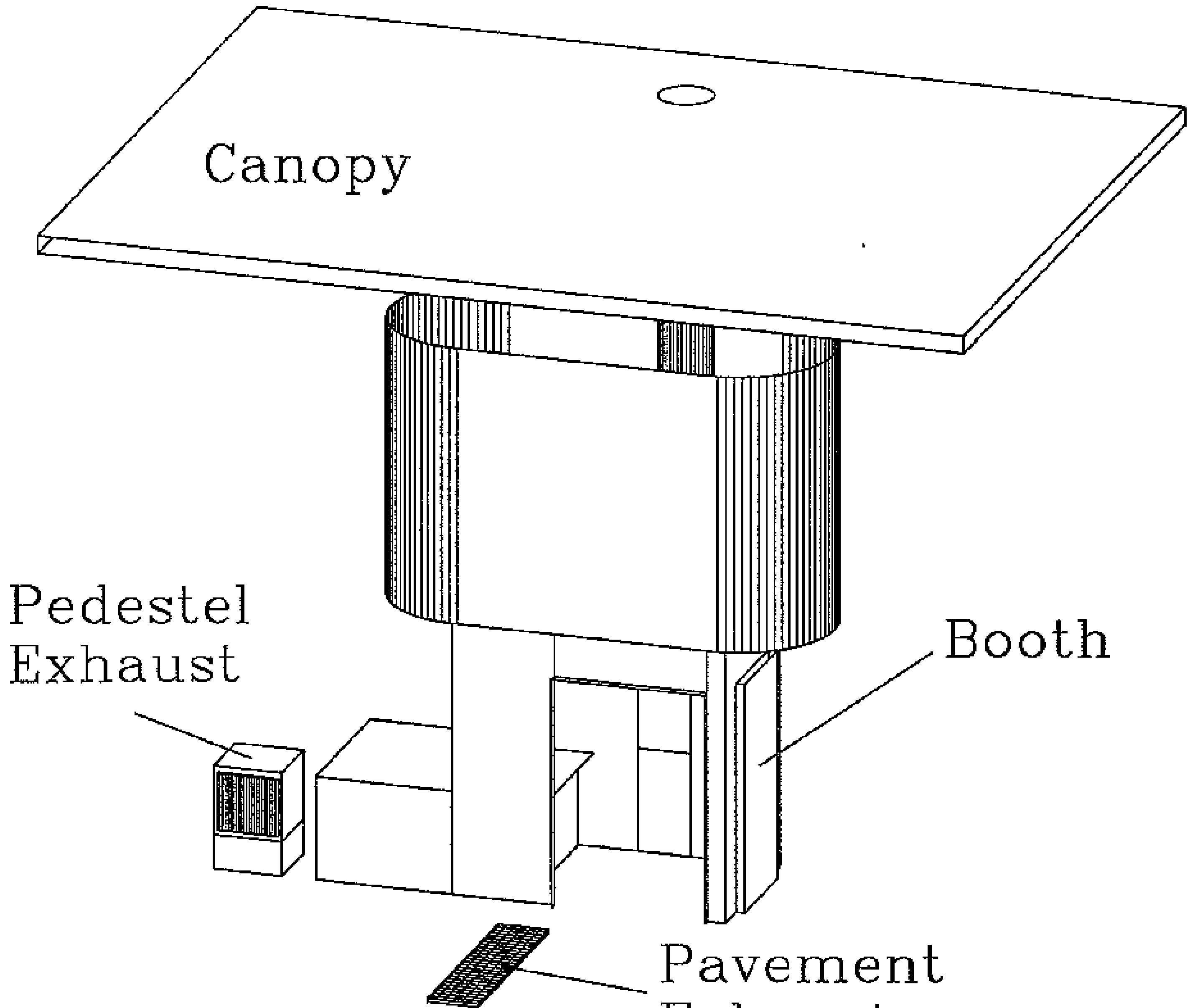

Figure 1. Ventilation System for Inspection Booth

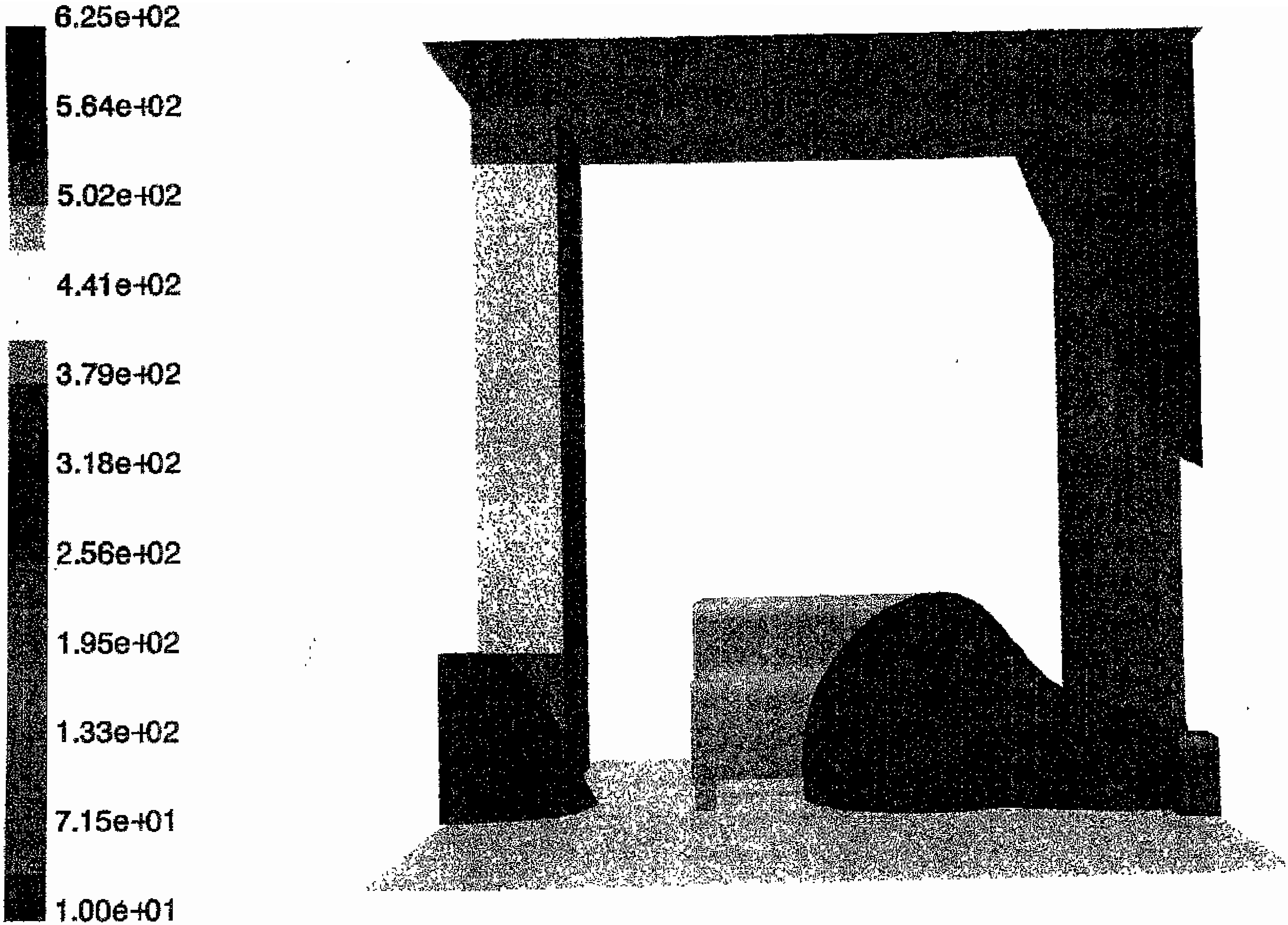

Figure 2. Predicted velocity contours - pulling air into pedestal

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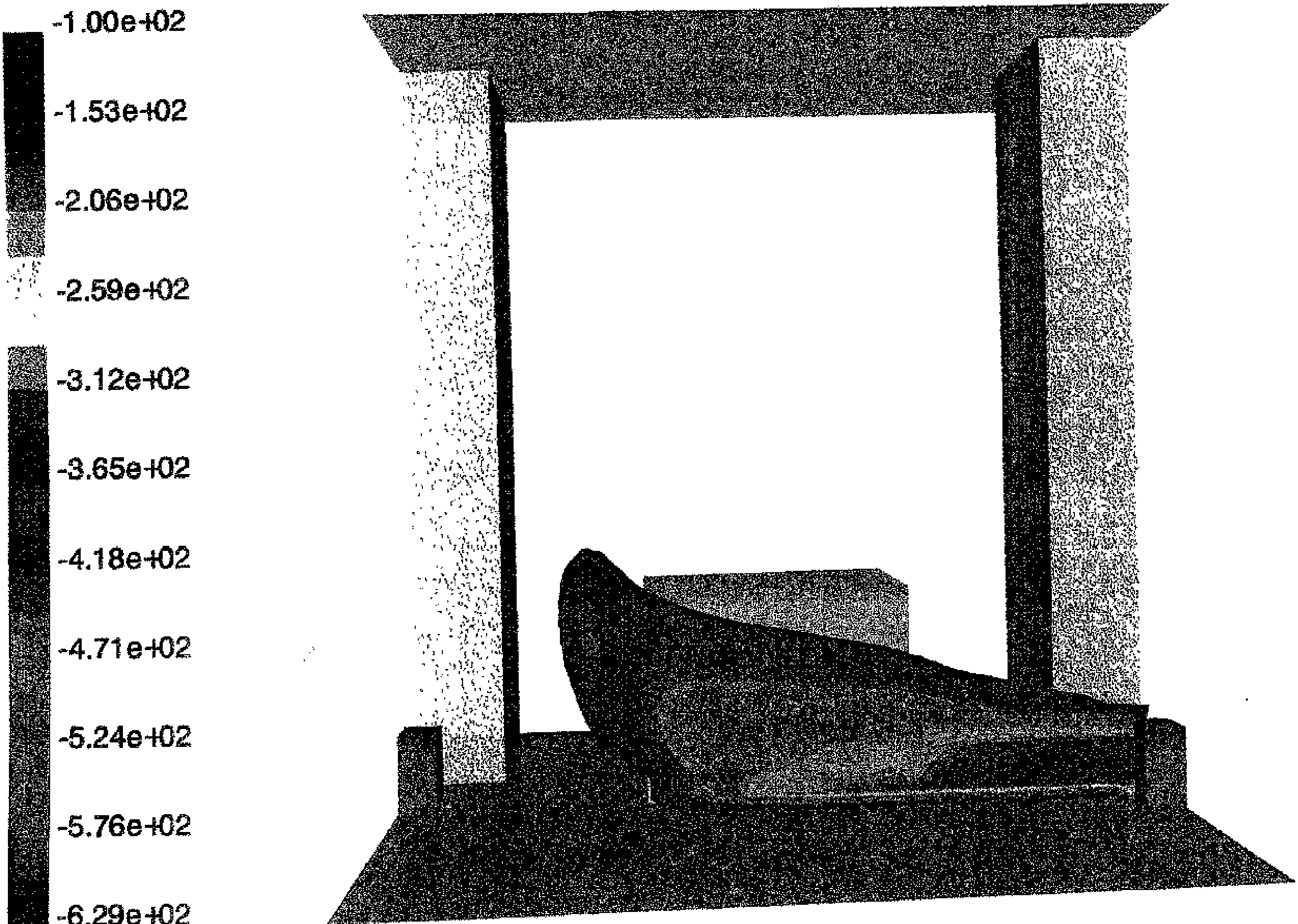

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Figure 3. Predicted velocity contours - pushing air out of pedestal

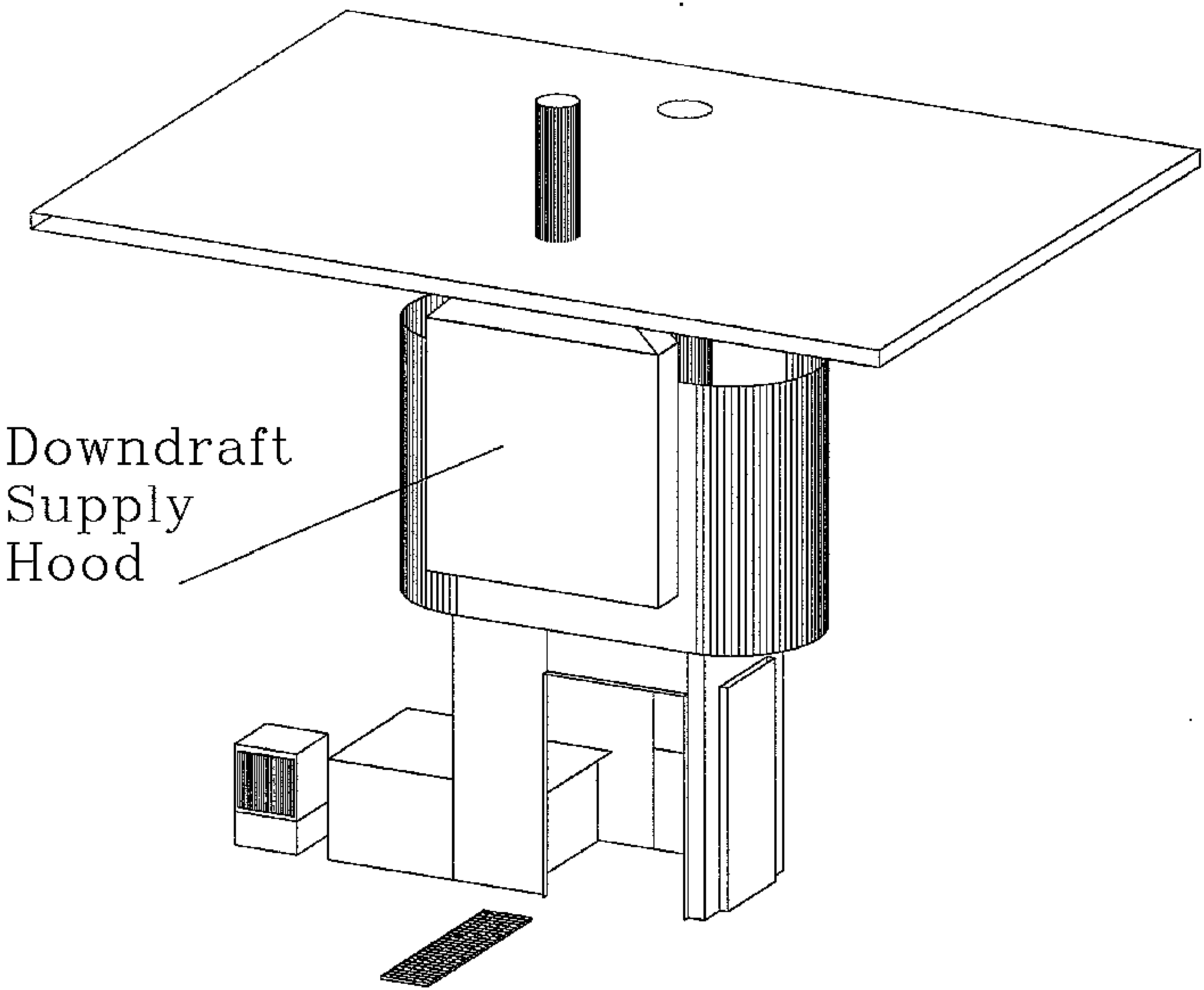

Figure 4. Downdraft Ventilation Supply Hood

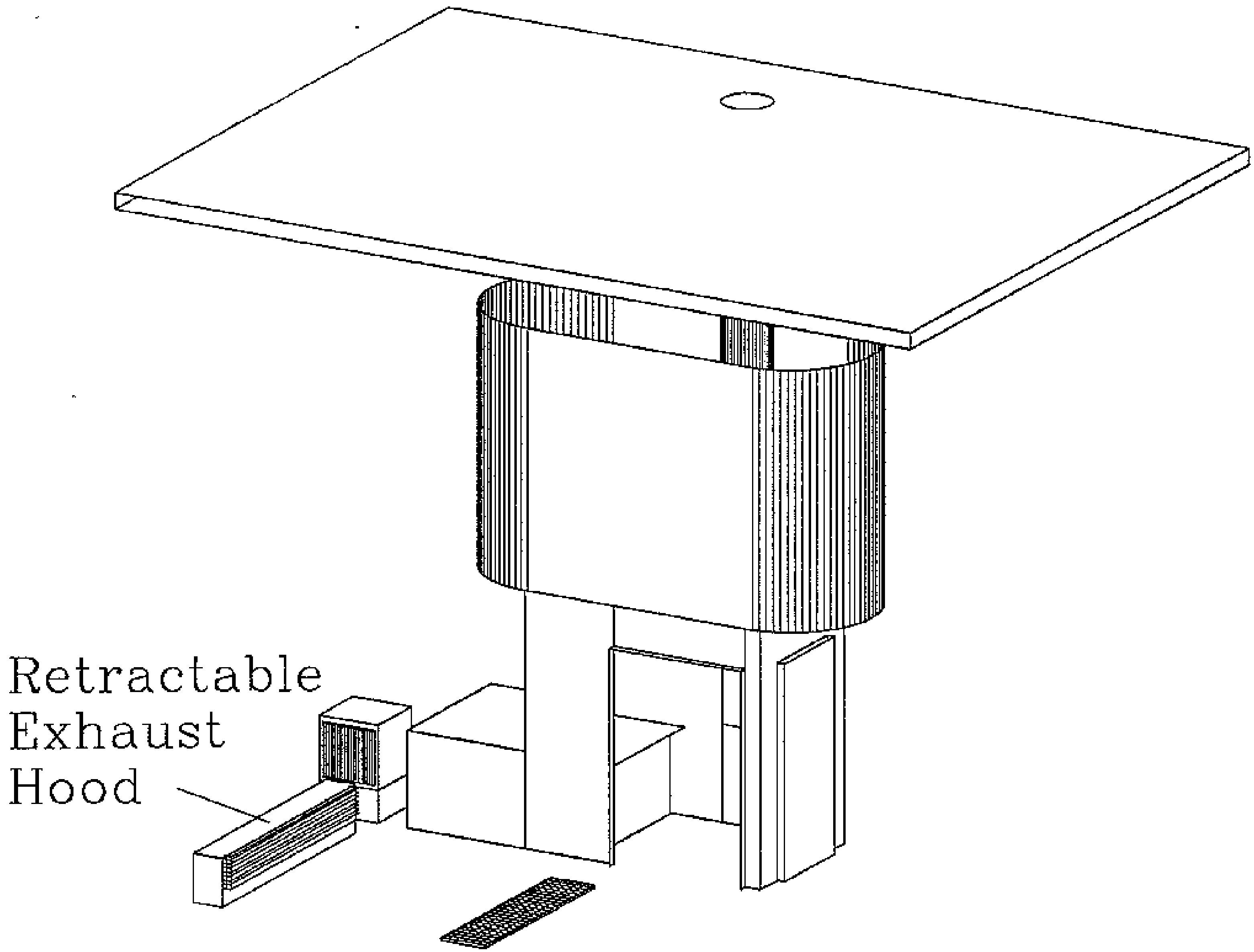

Figure 5. Retractable Tailpipe Exhaust Capture Hood