

**Submission
Instructions**

Problem statements will be accepted
**October 2–16, 2017**

Completed forms must not exceed three pages, excluding cover and references, and are to be submitted electronically to the applicants [institutional CARTEEH lead](https://www.carteeh.org/research/call-for-problem-statements/) or their designated representative.

Principal Investigators of projects chosen for further consideration will be notified by the last week of October, and invited to submit a detailed research plan and budget.

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**CARTEEH Problem Statement**

**Proposed Project Title**

**CHARACTERIZING INDOOR AIR QUALITY IN HEAVY DUTY DIESEL CONSTRUCTION EQUIPMENT CABS**

**Problem Statement**

This proposal aligns with three of the five CARTEEH focus areas. It aligns with *Emissions and Energy Estimation* by using measurement and modeling of heavy duty diesel construction equipment emissions resulting from diesel fuel consumption, and identifying the implications for air pollution and the health of the equipment operator. The proposal aligns with *Exposure Assessment and Health Impacts* by promoting a better understanding of how exposure to diesel emissions and particulate matter affects the health of equipment operators and how these impacts can be mitigated. Finally, the proposal aligns with *Data Integration* by exploring an existing construction equipment activity and emissions dataset and developing new methods for collecting indoor air quality data in order to analyze the relationships between construction equipment emissions and the health of equipment operators.

Virtually nothing is known about indoor air quality (IAQ) in heavy duty diesel (HDD) construction equipment cabs. Previous research, however, found that self-pollution (intrusion of the vehicle’s own exhaust into the cab after emission from the tailpipe) is a significant source of passenger exposure to diesel-related pollutants in school buses. Furthermore, the study found that most exposure to diesel-related pollutants occurred from commuting on the bus and not while the passengers were getting on or off the bus [1, 2]. These findings pose serious questions regarding IAQ for HDD equipment operators.

Research regarding IAQ for HDD equipment operators is very limited. A previous study was sponsored by the National Institute of Occupational Safety and Health (NIOSH) and was entitled “Environmental Tractor Cab System Integrity Testing” [3]. The objective of the study was to provide a link in the process of determining the causes of hazardous particulate exposure within enclosed heavy equipment cabs. This work yielded three papers in the *Journal of Occupational and Environmental Hygiene* [4-6]. The focus of the papers was on the integrity and effectiveness of enclosed cab filtration systems to reduce operator exposure to dust and respirable particles. Gaseous pollutants were not included in the study.

This research addresses an important problem because the current number of HDD equipment operators is expected to grow by 19% (faster than the national average for other occupations) to approximately 500,000 operators in 2022 [7]. Those that can operate various types of equipment will have the best career opportunities but they may also have the greatest exposure to poor IAQ; hence, HDD equipment operators may have a disproportionate risk of poor IAQ compared to other workers.

This research is significant because the Environmental Protection Agency (EPA) identifies IAQ as one of the five most urgent risks to public health [8]. Given that equipment operators spend most of their day inside the equipment cab, IAQ is a significant issue. Furthermore, HDD equipment operates in a harsh environment including temperature and humidity extremes, dusty conditions, and in close proximity to a high pollution source – the tailpipe of the equipment. For a typical IAQ scenario inside of a building, opening a door or window introduces fresh air which helps dilute pollutants; however, opening the door to the equipment cab may worsen the problem by allowing in even more diesel exhaust (DE) and particulate matter (PM). IAQ in HDD equipment must be characterized in order to determine the severity of the problem.

This research is also significant because exposure to DE is an important human health concern. EPA assessed the possible health hazards associated with DE exposure and concluded that there are effects from short-term and/or acute exposures, as well as long-term chronic exposures, including repeated occupational exposures (such as HDD equipment operation) [9]. EPA states there is enough evidence to indicate that inhalation of DE causes acute and chronic health effects. Acute exposure may cause irritation to the eyes, nose, throat and lungs, as well as neurological effects such as lightheadedness. Acute exposure also may elicit coughs or nausea as well as exacerbate asthma. These effects may lead to lost work days for HDD equipment operators which decreases construction productivity. Characterizing IAQ for HDD equipment operators is an important first step towards mitigating these effects.

This research may potentially shift paradigms concerning IAQ for HDD equipment operators. Since older models of HDD equipment did not have enclosed cabs, a common misconception is that today’s operators are protected and safe in an enclosed cab that reduces their exposure to heat, cold, humidity, wind, dust, and DE; however, no empirical evidence exists to support that claim. We hypothesize that enclosed cabs have actually created an IAQ problem for equipment operators. If this research determines that IAQ hazards do exist for equipment operators, new mitigation plans must be investigated in the future. A better understanding of the relationships between equipment activity, engine activity, and DE is needed to improve IAQ for HDD equipment operators. Furthermore, results of this research may provide a basis for developing new IAQ standards or regulations for HDD equipment since none currently exist. This research may be expanded to include all diesel vehicles used in the mining and agriculture industries, as well as on-road HDD vehicles such as trucks and buses.

**Research Objectives and Plan**

Specific research objectives include:

1. *Analyze an existing dataset of tailpipe pollutant emissions from HDD equipment.* We own an extensive dataset of real-world tailpipe pollutant emissions data from 34 items of in-use HDD equipment. This dataset includes mass per time (grams per second) emissions data for nitrogen oxides, hydrocarbons, carbon monoxide, carbon dioxide, and particulate matter. Mass per time and mass per fuel used (grams per gallon) tailpipe emissions rates for each pollutant and each item of equipment were thoroughly analyzed and the results were published; however, the dataset also includes second-by-second pollutant concentration data for each pollutant and each item of equipment which has not been analyzed. We will characterize the pollutant concentration data based on time, engine performance measures, and equipment activity. The *expected result* is a rigorous assessment of the relationships between tailpipe pollutant concentrations and equipment use. The *expected outcome* is a preliminary indication of whether or not tailpipe emissions have the potential to adversely affect indoor air quality inside construction equipment cabs.
2. *Collect preliminary data related to IAQ inside of HDD equipment cabs.* We will collect IAQ measurements inside the equipment cab including temperature and relative humidity, as well as pollutant concentrations of nitrogen dioxide, carbon monoxide, carbon dioxide, and particulate matter. The *expected result* is a quality assured dataset of real world IAQ parameter measurements for HDD equipment. We will characterize trends in the IAQ data over the duration of equipment activity. The *expected outcome* is a preliminary indication of IAQ inside the cab of HDD equipment that will help determine whether or not additional research is needed.
3. *Develop a research methodology for simultaneously measuring tailpipe pollutant emissions and IAQ parameters inside the equipment cab.* We will develop data collection, data quality assurance, and data analysis protocols for evaluating IAQ parameters simultaneously with tailpipe pollutant emissions. We will collect and analyze preliminary data to demonstrate the efficacy of the new methodology. The *expected result* is a set of well-defined, repeatable data collection and analysis protocols for collecting tailpipe emissions and IAQ parameters simultaneously from HDD equipment. The *expected outcome* is that the new methodology will be used for future research to better understand the relationships between HDD equipment activity, tailpipe emissions, and IAQ in the equipment cabin.
4. *Examine the current literature on the health effects of diesel particulates.* The health effects of particulate matter (PM) from internal combustion engines has recently been the subject of several epidemiological studies. These studies have linked exposure to PM to cancers, cardiovascular disease and increased mortality. However, there is no consensus on these health effects, which are not yet well understood, especially with regard to PM exposure regulations in occupational health environments. Health effects from exposure to PM alone is extremely difficult to separate. We will review the literature to separate the toxic effects of gaseous and particulate pollution from various combustion sources. This knowledge will be essential to policy makers in order to establish regulations to maximize the public health benefit through control of PM emissions.

**Student Involvement and Technology Transfer Plans**

This project will serve as the basis for at least two master’s theses in the Department of Construction Science. The students will be involved in data collection, management, and analysis. They will also help disseminate the results of the research through conference proceedings and journal papers. The results will have broad appeal to the construction, environmental, and public health communities. The data will be made available to organizations such as the Transportation Research Board, Environmental Protection Agency, and National Institute of Occupational Safety and Health.

**Project Duration**

Depending on the final scope of work, the expected project duration is 18 months. The work will commence by February 1, 2018 and conclude no later than July 31, 2019.

**Cost Estimate**

Depending on the final scope of work, the estimated cost for the project is $100,000. Although there are no plans at this time for direct cost sharing, there are opportunities to leverage resources available to the Department of Construction Science. These resources include access to approximately 200 construction companies in the Department’s Construction Industry Advisory Council (CIAC). The research team will work with these companies to recruit construction equipment for testing and data collection.

**Research Team Member Information**

Provide the following information regarding the Principal Investigator:

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Other members of the research team include Dr. Ryan Ahn and Dr. Kunhee Choi, both of the Department of Construction Science at Texas A&M University and Dr. Andrea Strzelec of the Texas A&M Transportation Institute. We also plan to recruit a team member from one of the CARTEEH member institutions with expertise in human health and exposure assessment.

**References**

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