HealthHazard Evaluation Program

Evaluation of Potential Exposures to Railway Hazardous Material Inspectors

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August 2023

Centers for Disease Control and Prevention
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Disclaimer

The Health Hazard Evaluation Program investigates possible health hazards in the workplace under the authority of the Occupational Safety and Health Act of 1970 [29 USC 669a(6)]. The Health Hazard Evaluation Program also provides, upon request, technical assistance to federal, state, and local agencies to investigate occupational health hazards and to prevent occupational disease or injury. Regulations guiding the Program can be found in Title 42, Code of Federal Regulations, Part 85; Requests for Health Hazard Evaluations [42 CFR Part 85].

Availability of Report

Copies of this report have been sent to the employer, employees, and union at the plant. The state and local health departments and the Occupational Safety and Health Administration Regional Office have also received a copy.

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Introduction

Request

Representatives of the American Federation of Government Employees Local 2814 requested a health hazard evaluation concerning potential exposures to hazardous material inspectors. Inspectors became concerned after experiencing accidental exposures to hazardous materials while inspecting railway shipping containers. The union wanted to find the best way to keep inspectors safe while they carried out their duties.

Workplace

As part of hazardous material rail transportation protocols, federal hazardous material inspectors located throughout the nation perform random, unannounced inspections of the hazardous material shipping containers at railyards within their regions. The hazardous material inspectors will examine containers, including boxes, barrels, drums, tank cars, railcars, intermodal shipping containers, and other bulk containers, to determine compliance with regulations. Inspections include evaluating the classification and documentation of hazardous material shipments, as well as how they are packaged, marked, labeled, placarded, and loaded. Inspections may occur at the manufacturing site or at various railway transfer points (Figure 1).

Figure 1. Rows of tank cars at the railyard, some containing hazardous materials, surrounded by active tracks. Photo by NIOSH.

To learn more about the workplace, go to Section A in the Supporting Technical Information

Our Approach

We visited four railyards to learn more about the job and employee health concerns. In August 2022, we visited two railyards near Chicago, Illinois, and another near Indianapolis, Indiana; and in October 2022, we visited a railyard near Cincinnati, Ohio. We completed the following activities during our evaluation:

- Observed work practices.
- Evaluated for the presence and levels of oxygen, hydrogen sulfide, and carbon monoxide, as well as the lower explosive limit (the meter senses the concentration of flammable or explosive gases to find the risk of fire or explosions) using a 4-gas meter.

- Tested for the presence of hazardous gases using a Dräger® pump with colorimetric indicator tubes that work for various hazardous materials.

To learn more about our methods, go to [Section B in the Supporting Technical Information]

Our Key Findings

Inspectors could potentially be exposed to hazardous materials while inspecting railway shipping containers

- Hazardous material inspectors encounter a wide variety of hazardous material.
- Inspectors could be exposed if the hazardous material is not sealed correctly.
- Inspectors cannot always predict the type of hazardous material to be inspected. However, to be better prepared, they can request the shipping manifest before the inspection.

Four-gas meters would not reduce the inspectors' risk of hazardous material exposure

- Inspectors could carry 4-gas meters while inspecting hazardous materials, but the meters are cumbersome and may provide a false sense of security.
- Four-gas meters may encounter problems associated with cross-sensitivity with other materials. Plus, too many types of hazardous materials exist for the meters to be useful for this workplace.

Dräger pump and colorimetric indicator tubes would not reduce the risk of hazardous material exposure

- Inspectors encounter too many hazardous materials on a daily basis for the colorimetric indicator tubes to be useful.

To learn more about our results, go to [Section B in the Supporting Technical Information]

Our Recommendations

The Occupational Safety and Health Act requires employers to provide a safe workplace.

Potential Benefits of Improving Workplace Health and Safety:

↑ Improved worker health and well-being	↑ Enhanced image and reputation
↑ Better workplace morale	↑ Superior products, processes, and services
↑ Easier employee recruiting and retention	↑ May increase overall cost savings

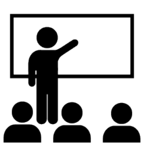
The recommendations below are based on the findings of our evaluation. For each recommendation, we list a series of actions you can take to address the issue at your workplace. The actions at the beginning of each list are preferable to the ones listed later. The list order is based on a well-accepted approach called the "hierarchy of controls." The hierarchy of controls groups actions by their likely effectiveness in reducing or removing hazards. In most cases, the preferred approach is to eliminate hazardous materials or processes and install engineering controls to reduce exposure or shield employees. Until such controls are in place, or if they are not effective or practical, administrative measures and personal protective equipment might be needed. Read more about the hierarchy of controls at https://www.cdc.gov/niosh/topics/hierarchy/.

We encourage the company to use a health and safety committee to discuss our recommendations and develop an action plan. Both employee representatives and management representatives should be included on the committee. Helpful guidance can be found in *Recommended Practices for Safety and Health Programs* at https://www.osha.gov/shpguidelines/index.html.

Recommendation 1: Improve and standardize inspectors' hazardous material education and training on materials they might encounter

Why? Providing inspectors with more information about the hazardous materials they might encounter can help protect them because they could be exposed to the materials they inspect. All the inspectors we observed had different procedures for carrying out their inspections.

How? At your workplace, we recommend these specific actions:



Improve inspector education and training about the hazardous material they might encounter.

- Standardize the inspection approach that hazardous material inspectors follow to train on best practices and reduce potential exposures.
- Train and require inspectors to accurately identify the type of hazardous material contained in the tank car or intermodal containers before inspecting.
- Work with occupational safety and health professionals to develop a plan in case of an accidental exposure with hazardous material.
- Train all inspectors on the new inspection approach.

Recommendation 2: Improve policies and procedures for emergency situations

Why? Providing inspectors with policies and procedures for emergency situations involving hazardous materials can help prepare and protect them. Understanding policies and procedures specific to the emergency situations encountered (for example, accidentally breathing in hazardous materials or having contact with skin) could keep the hazardous material inspectors safer.

How? At your workplace, we recommend these specific actions:

Develop policies and procedures for emergency situations.

- Define the types of emergency situations being planned for, such as a spill or hazardous material release, then develop policies and procedures specifically for these emergency situations.
- Include these types of emergency situations in the Job Hazard Analysis (which are written procedures to help workers understand and lower hazards in job tasks) for hazardous material inspectors. This should be specific to the hazardous material inspectors' work, and include details of additional precautions that should be taken in an emergency.
- Train inspectors at least annually on how to respond to an emergency, including details of how and when to evacuate the area. Identify and practice specific response strategies for the most likely exposure scenarios.

Supporting Technical Information

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Section A: Workplace Information

History of Issue at Workplace

In 2008, an inspector was inspecting railroad tank cars containing hazardous material (HM) when a partially open ball valve sprayed methylene diphenyl diisocyanate in the inspector's face. An additional report of exposure occurred in 2019 when an inspector inhaled methyl isobutyl carbinol vapors while inspecting a tank car and became ill. Lastly, in 2020, an inspector opened the protective housing cover while inspecting a railroad tank car and inhaled anhydrous ammonia.

To address these exposures and prevent future incidents, a union representative suggested the possibility of inspectors using 4-gas meters to evaluate the air around the tank cars before they begin their inspections. The 4-gas meter detects oxygen (O_2), carbon monoxide (CO), hydrogen sulfide (H_2S), and lower explosive limit (LEL); however, they are typically used for confined space entry. In 2021, the federal railroad industrial hygiene team accompanied HM inspectors in four districts on 152 tank car inspections. The HM inspectors wore either a 4-gas meter or a 4-gas meter with a photoionization detector (PID). In addition to the previously mentioned four gases, the PID also detects certain volatile organic compounds (VOCs) that can be ionized by ultraviolet photons. No alarm events occurred during their evaluation, even when a tank car had a noticeable ethanol leak.

Process Description

At the time of our evaluation, there were about 48 HM inspectors located throughout the United States. During our evaluation, we worked with four HM inspectors at four railyards: two near Chicago, Illinois, one near Indianapolis, Indiana, and one near Cincinnati, Ohio. The railcars containing HM that the inspectors examined during our evaluation included pressure tank cars, non- or low-pressure tank cars, and intermodal shipping containers. The list of types of HM in the tank cars was vast and included the following (identification number followed by name):

- 1010 butadiene
- 1017 chlorine
- 1075 liquified petroleum gas
- 1110 n-amyl methyl ketone
- 1123 butyl acetates
- 1129 butyraldehyde
- 1173 ethyl acetate
- 1247 methyl methacrylate
- 1789 hydrochloric acid
- 1814 potassium hydroxide, solution

- 1830 sulfuric acid
- 1831 sulfuric acid, fuming
- 1942 ammonium nitrate
- 1987 alcohols (ethanol)
- 1993 flammable liquids, not otherwise stated (nos)
- 3265 corrosive liquid, nos
- 3272 esters, nos
- 3295 hydrocarbons, liquid nos

Tank Cars

To complete the HM inspection of the tank car, inspectors first identified a train track that had HM-containing tank cars. Railroad tank cars (pressurized, non-pressurized, or low-pressure) were typically cylindrical and included top fittings with filling and inspection ports located inside a protective housing (Figure A2). In addition, most of the cars had a bottom outlet valve. Another type of tank car was more rectangular with multiple outlets on the bottom of the car (Figure A3).

Figure A2. Cylindrical hazardous materials tank car. Photo by NIOSH.

Figure A3. Squared tank car containing ammonium nitrate. Photo by NIOSH.

All inspectors scanned the railyard for Department of Transportation (DOT) placards that indicated the presence of HM. Only one of the inspectors we observed went to the railyard main office to request the Hazmat Training listing, a report that contained the specific chemical name and required safety precautions for the types of HM in the yard. After identifying the cars, the inspector requested the track be "blue flagged," meaning that no rolling stock may be moved past that point. This was done to protect the inspector's safety while performing the inspection.

All inspectors noted the United Nations (UN) classification. The inspector verified that the DOT Placard with the UN number was visible on all sides of the railcar. They then ensured that the outlet valves on the bottom of the car were hand tight (Figure A4). After a visual inspection of the outside of the car (for rust, damage, leaks, etc.) the inspector proceeded to climb to the top the car. Inspectors noted the wind direction and tried to stand upwind of the top fitting housing. They removed the sealing tag, opened the housing, and waited for an unspecified time to allow for off-gassing. They then evaluated the valves inside of the housing to ensure they were in good condition and sealed hand tight (Figures A5 and A6). Lastly, they closed the housing and reaffixed a metallic zip tie to show that it had been inspected and was now resealed.

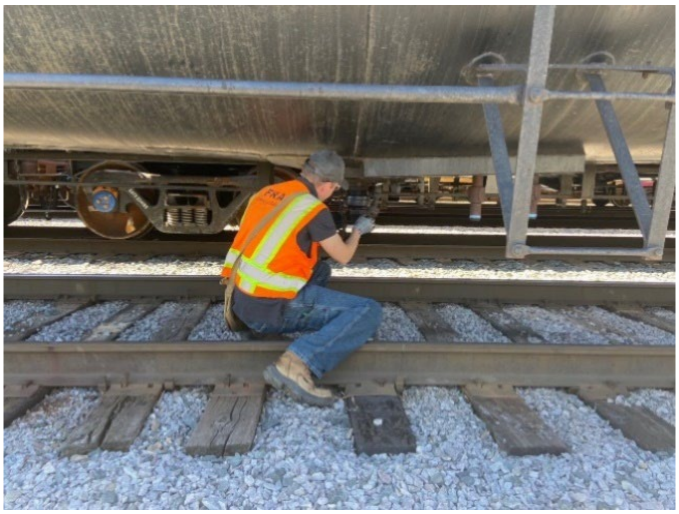

Figure A4. The hazardous materials inspector examines valves at the bottom of the tank car. Photo by NIOSH.

Figure A5. Inside the valve housing on top of the tank railcar containing hazardous materials. Photo by NIOSH.

Figure A6. Inside the protective housing on the top of the tank car. Photo by NIOSH.

Intermodal Shipping Containers

After the inspector identified an intermodal container with HM, the inspector noted the DOT Placard and UN number. The inspector attached a strap to the back of the container so that when it opened, the contents (which may have shifted during transportation) did not fall onto the inspector (Figure A7). The inspector then removed the metallic zip tie and opened the container. All intermodal containers are inspected from the outside because they are considered confined space, and the inspectors are not permitted to enter (Figure A8). After inspection, the inspector resealed the intermodal container with a zip tie.

Figure A7. HM inspector affixing a strap to the back of the intermodal container. Photo by NIOSH.

Figure A8. Inspection of an intermodal shipping container containing hazardous materials. Photo by NIOSH.

Section B: Methods, Results, and Discussion

Methods: Document Review and Observations of Work Processes, Practices, and Conditions

Prior to our visit, we reviewed the Hazard Communication Program, Job Hazard Analysis for the inspectors, Field Orientation Training Guide, Hazardous Materials Compliance Manual, "Safe at Work," and the OSHA 301 forms. During our visits to the four different railyards, we observed the work processes, individual practices, personal protective equipment usage, and workplace conditions as the HM inspectors conducted unannounced inspections of railway tank cars and intermodal shipping containers.

Results: Document Review and Observations of Work Processes, Practices, and Conditions

Document Review

The Hazard Communication Program appropriately recognized HM inspectors as requiring Hazard Communication Training. The Field Orientation Training Guide had descriptions of which inspectors were required to receive DOT Hazmat Training (regarding packaging and shipping of HM), and these included HM inspectors. The Hazardous Materials Compliance Manual outlined the job duties, types of investigations, and basic safety practices that HM inspectors were to follow. For intermodal containers, these practices included using a safety strap before opening the door, waiting several minutes for an air exchange to take place inside of cars, not entering permit-required confined spaces, and not handling leaking HM packages. For tank cars, basic safety practices included allowing 15 to 20 seconds to pass for built-up HM vapor to escape the housing. Inspectors were instructed not to proceed with the inspection if the inspector felt unsafe to do so (e.g., slippery surfaces).

The "Safe at Work" document described required personal protective equipment, including this statement regarding respiratory protection: "Inspectors are presently not assigned to tasks that would require the use of respirators due to exposure on the job." This document also stated to stand upwind from the valves and to "guard yourself as you begin to lift a protective housing cover" due to vapor accumulation. This document also stated that inspectors should "rely on your senses when approaching any container," and that "visible leakage, detectable odors, or audible sounds" may help identify the presence of problems relating to HM.

The Job Hazard Analysis document included a section on how to react to a "respiratory injury" if a leak or spill was discovered on cars carrying hazardous chemicals. Although the HM inspectors are not first or emergency responders, the Job Hazard Analysis recommended that inspectors access information about spilled materials in the Emergency Response Guidebook found at https://www.phmsa.dot.gov/sites/phmsa.dot.gov/files/docs/ERG2016.pdf. Lastly, the OSHA 301 forms described two incidents of accidental exposure to HM. We did not review any document that recommended HM inspectors identify the specific type of HM in the container prior to the inspection.

Observations of Work Process, Practices, and Conditions

During the inspection of tank cars containing HM, an inspector encountered a damaged valve that could cause leakage around the seal (Figure B9). During another tank inspection, the inspector found a valve that was not closed "hand tight." Upon further inspection, it was discovered that the valve threading had been stripped, likely because someone had used a tool to attempt to seal the valve. This damaged valve could no longer seal tightly, allowing fumes and vapors from inside the tank to expose the HM inspector (Figure B10). During this inspection, a prominent odor was detected. The inspector notified the yard master of these noncompliant cars to prevent them from departing.

Figure B9. Valve inside the housing with a damaged seal on the valve cover. Photo by NIOSH.

Figure B10. An open valve inside of the housing. Photo by NIOSH.

Some cars that contained inhalation hazards were clearly labeled as such (e.g., the chlorine car in Figure B11). However, for other tank cars that contained inhalation hazards, the information was not as obvious. For example, Figure B12 shows a tank car filled with fuming sulfuric acid, which is both corrosive and an acute inhalation toxicity. However, for this tank, the "fuming" label was covered with a magnet (Figure B13). Therefore, the only way to know that the contents were fuming sulfuric acid was to look up the UN number (1831) on the DOT placard. Because these tank cars can be used to transport both fuming and non-fuming sulfuric acid, the magnet was likely in place for a previous time when the car was filled with non-fuming sulfuric acid.

Figure B11. Chlorine tank car labeled inhalation hazard, including the inhalation pictogram on the DOT placard. Photo by NIOSH.

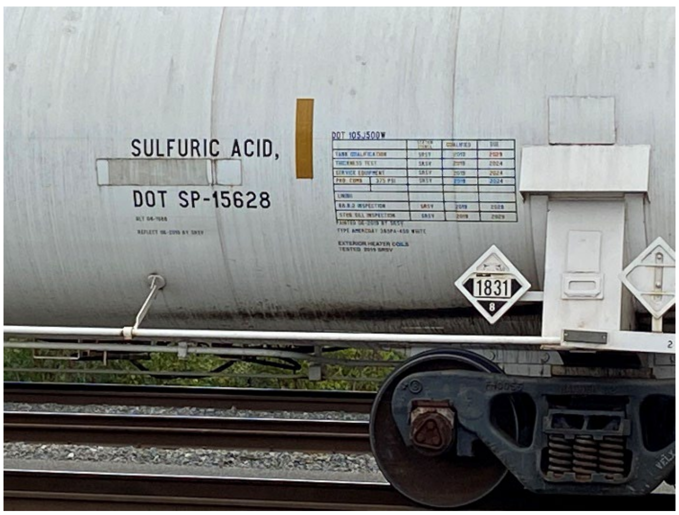

Figure B12. A tank car labeled “Sulfuric Acid” displaying a DOT placard with UN Number 1831 and the corrosive chemical pictogram. Photo by NIOSH.

Figure B13. A magnet covering the word “fuming” on the label of the tank car. Photo by NIOSH.

Methods: 4-Gas Meter

We used the Gas-Clip® Technologies 4-gas meter with sensors for O_2, CO, H_2S, and LEL. Oxygen meters alert for both oxygen-rich and oxygen-deficient environments. When sensors for toxic gases such as CO and H_2S are installed, an alert will sound well before preset hazardous concentrations are reached. The LEL sensor detects the concentration of flammable or explosive gases to determine the risk of fire or explosions.

Results: 4-Gas Meter

There were no alarm events during any of the HM inspections. The LEL sensor never detected anything above zero, even when there were detectable odors.

Methods: Colorimetric Indicator Tubes

We used Dräger® colorimetric single-gas detector tubes with a bellows pump to collect air samples inside the protective housings on top of the railcars. Colorimetric indicator tubes are chemical specific and are manufactured for over 350 different gases and vapors. The detector tubes have a standard measuring range based on the chemical of interest. We inserted the tip of the indicator tube into closed housing through a "viewport" and used the bellows pump to pull a calibrated quantity of air through the tube. If the chemical of interest was detected within the standard range, the chemical reagent inside the tube would change colors, measuring the concentration present in the housing. We used the five "hydrocarbon" indicator tubes, ranging from 10–300 parts per million (ppm), for railcars containing petroleum hydrocarbons. We also used two "ethanol" indicator tubes for alcohols (100–3,000 ppm) for railcars containing alcohols.

Results: Colorimetric Indicator Tubes

One of the five hydrocarbon indicator tubes had a detectable result of approximately 50 ppm (Figure B14). Once the housing was opened, there was a strong odor that dissipated after about 2 minutes. This was the inspection that had the stripped valves. None of the other indicator tubes showed a color change.

Figure B14. Colorimetric indicator tube for petroleum hydrocarbons showing ~50 ppm. Photo by NIOSH.

Discussion

The transportation of HM throughout the United States is essential to the economy. Therefore, hazardous material inspectors can expect to encounter a wide variety of HM each day. No device can detect every type of HM to which the inspector could potentially be exposed. For example, 4-gas meters can only detect the chemicals or conditions corresponding with the installed sensors (e.g., O_2, CO, H_2S, and LEL). In addition, 4-gas meters are typically used for contained activities such as confined space entry. The open-air environment on top of a tank car would likely dilute the sample, making concentrations below the detectable limit even if the chemicals were present. Although the 4-gas meters provide real-time monitoring for the specified gases in the environment, the possibility exists for compounds in the environment to interfere with the electrochemical sensors, resulting in erroneously high or low readings due to cross sensitivity.

Although the PID detects a wider range of VOCs, it does not measure common toxic gases (e.g., CO, hydrogen cyanide, sulfur dioxide), natural gas (methane and ethane), acid gases (hydrochloric acid, hydrogen fluoride, nitric acid, etc.), and non-VOCs such as polychlorinated biphenyls. In addition, the accuracy of the sensor can be affected by rain and humidity, potentially causing false readings.

Considering the previously mentioned limitations, we do not recommend inspectors carry a 4-gas meter or PID. Carrying the device would add to the burden of the HM inspector and could provide a false sense of security while performing inspections.

Limitations

This evaluation is subject to limitations. During the assessment we could not recreate a HM release; therefore, we do not know if the LEL sensor would detect an actively leaking flammable chemical. In addition, we could not evaluate all the types of HM that inspectors might encounter nor all the environments and weather conditions in which they work.

Conclusions

It is possible for HM inspectors to be exposed to a variety of HM while inspecting shipping containers, which includes tank cars and box cars. Using a 4-gas meter, with or without a PID, or using colorimetric indicator tubes, would not protect inspectors during these inspections. Increasing hazard communication training, anticipating the type of HM they will be inspecting, and preplanning emergency response scenarios would better protect the inspectors.

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