# HETA 92-0311
# CSX Transportation, Inc

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# PREFACE

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# ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

Primary investigators were Chris Piacitelli and Margaret Filios of the Division of Respiratory Disease Studies (DRDS). Other DRDS staff were involved. Joseph Burkhart, Stephen Berardinelli, Daniel Hewett, Kurt Vandestouwe, Alwin Dieffenbach, Silvia Saltzstein (visiting fellow), and Michelle Canham (visiting fellow) provided industrial hygiene field assistance.

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**Health Hazard Evaluation Report 92-0311**
**CSX Transportation, Inc**
**January 2001**

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# SUMMARY

In June 1992, the Dixie Federation of the Brotherhood of Maintenance of Way Employees (BMWE) requested a National Institute for Occupational Safety and Health (NIOSH) health hazard evaluation (HHE) of railroad track maintenance operations conducted by CSX Transportation, Incorporated (CSXT). The request concerned respiratory hazards to maintenance of way (MOW) employees from dusts generated while these operations are performed "in and around Radnor Yard in Nashville, Tennessee and at most trackage in Tennessee as well as other southern states." Subsequent to the request, the Dixie Federation merged with other federations and assumed the name of the Allied Eastern Federation of BMWE.

On November 9, 1992, NIOSH representatives met with company and union representatives for an initial meeting and brief site visit near Radnor Yard. NIOSH then conducted environmental air sampling at eight sites during track maintenance activities between August 1993 and April 1997. Twenty-two area samples and 185 personal samples were collected for respirable dust and respirable crystalline silica. Area and personal respirable dust 10-hour time-weighted average (TWA) concentrations ranged from "not detected" to 1.04 mg/m$^3$ and "not detected" to 2.05 mg/m$^3$, respectively. The range of 10-hour TWA respirable crystalline silica (as quartz) concentrations for the area samples was "not detected" to 0.30 mg/m$^3$ and was "not detected" to 0.43 mg/m$^3$ for the personal samples. Cristobalite, another form of crystalline silica, was not detected on any of the samples. Eighteen of the personal sample concentrations exceeded the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) for respirable dust, and 28 exceeded the NIOSH Recommended Exposure Limit (REL) for respirable quartz; these samples were obtained on ballast regulator, broom, and tamper operators as well as track repairmen engaged in ballast dumping.

In an effort to reduce worker exposure, the company was modifying operator cabs on equipment. The cabs were being rebuilt with air-conditioning and pressurization systems, and seals were being provided around doors, windows, and levers. Real-time dust measurements showed the effectiveness of these modifications to one such cab. Manual control of ballast car hopper doors was being replaced with radio remote control. NIOSH recommendations include substitution with ballast that contains less crystalline silica, wetting of the ballast to prevent dust, and maintenance of the operator cabs .

NIOSH investigators determined that a health hazard existed for railroad track maintenance workers from occupational exposure to crystalline silica. The presence of this risk was indicated by personal measurements of airborne respirable crystalline silica that exceeded occupational exposure guidelines. The hazard was greatest for workers who operated ballast regulating, broom, and tamping machines and for track repairman who dumped ballast. Reduction of worker exposure to airborne dust is recommended to protect the health of the workers engaged in these activities.

Keywords: SIC 4011 (Railroads, Line-Haul Operating), Pneumoconiosis, Silicosis, Crystalline Silica, Quartz, Granite, Ballast, Railroad Maintenance Gangs.

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# INTRODUCTION

In June 1992, the Dixie Federation of the Brotherhood of Maintenance of Way Employees (BMWE) requested a National Institute for Occupational Safety and Health (NIOSH) health hazard evaluation (HHE) of railroad track maintenance operations conducted by CSX Transportation, Incorporated (CSXT). The request concerned respiratory hazards to maintenance of way (MOW) employees from dusts generated while these operations are performed "in and around Radnor Yard in Nashville, Tennessee and at most trackage in Tennessee as well as other southern states." Subsequent to the request, the Dixie Federation merged with other federations and assumed the name of the Allied Eastern Federation of BMWE.

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# BACKGROUND

MOW employees maintain the rails, ties, ballast, and other components associated with the railroad track right-of-way (ROW). Ballast is the crushed rock foundation upon which the ties and tracks are set. It provides support, stability, and drainage, and is usually comprised of crushed granite at CSXT operations, although limestone is used occasionally. When ballast is moved or disturbed during maintenance activities, it may generate airborne dust, which can be inhaled and potentially cause respiratory disease, including silicosis.

Many types of machines are utilized in the MOW operations - each with a distinct task such as pulling spikes, placing ties, sweeping ballast, etc. Most are equipped only with metal wheels for track-mounted use and are thus restricted to the tracks. After being placed on the tracks in a specific order according to function, the series of machines operates while rolling along a section of track but sometimes moves to a side track to allow trains to pass. Although some operators walk with their machines, most are seated upon the machine–many within enclosed cabs.

Some types of maintenance equipment directly manipulate the ballast. Upon arrival from a mine site, ballast is dumped from the moving hopper cars onto the side of, and/or in between, the tracks by ballast dumpers who walk alongside and open the hopper doors manually or by radio remote control. Ballast regulator machines level the ballast with large adjustable front- and side-mounted blades and sweep ballast from ties and tracks with a rear-mounted rotary broom. There are also large broom machines dedicated to the sweeping task. Tamping machines lift the tracks and ties to a desired grade as they tamp the ballast below. Undercutting machines lift the track and ties while scooping ballast out from underneath; they can also remove ballast from the sides of the tracks. Sometimes a stabilizing machine vibrates the track and underlying ballast to simulate the action upon the trackbed of many passing trains. Yard cleaning machines sweep loose material from the tracks onto a conveyor that dumps into a hopper car.

The MOW workers and equipment are utilized in several types of operations. During tie replacement operations, the machines remove spikes, anchors, deteriorated wooden ties, and tie plates and replace them in reverse order. A group of surfacing (smoothing) machines -- tampers, ballast regulators, and brooms -- completes the operation. Generally the fresh replacement ballast is dumped alongside the track prior to the operation, so it is available for use when required. Concrete tie replacement is an activity during which all wooden ties on a section of track are replaced with concrete ties. A large machine, operated by a contract company, simultaneously lifts the existing rail, removes and stacks the wooden ties, places concrete ties, and lays new rail. CSXT gangs support this activity by removing spikes, applying clips (rather than spikes as used on wooded ties), dumping ballast, and smoothing the ballast track bed with tampers, ballast regulators, and brooms. Undercutting operations remove ballast from under and along the sides of tracks for drainage improvement or rail level modification. Because the machine lifts the rail and ties as it scoops underneath, tie removal and replacement are not necessary. Fresh ballast is placed and smoothed after a section of track has been undercut. Undercutting machines are operated by a contract company, under CSXT supervision, in conjunction with CSXT gang activities. At yard cleaning operations, the yard cleaning machine is operated by a contract company. CSXT employees work in conjunction with the yard cleaning as magnet crane operators, backhoe operators, foremen, etc.

Stationary gangs are dispatched to sites in the immediate vicinity of their home bases. Roving gangs work anywhere within the jurisdictional limits of their respective federation of the BMWE, and system production gangs perform maintenance activities at any site that is part of the CSXT railroad system. The gangs generally work four 10-hour shifts each week. Work shifts include travel time to and from the maintenance sites.

# METHODS

Environmental surveys were limited to track maintenance activities at sites within the jurisdiction of the Dixie Federation of the BMWE. Based on information obtained from company and union representatives, activities described as generating large amounts of dust were chosen for sampling. Schedules of activities were obtained from the company to aid in site selection. Survey site details are presented in Table 1.

Personal breathing zone air samples were collected to evaluate worker exposure to respirable dust and respirable crystalline silica. Sampling devices were placed on the workers immediately prior to the start of their maintenance task at the site and were removed upon completion for the day. Unsampled periods were considered to be times of no exposure. Area samples were obtained inside the cabs of some maintenance equipment within approximately three feet of the operator's breathing zone to evaluate their potential exposure. A few area samples were obtained simultaneously inside and outside of the equipment operator cabs for comparison of concentrations. A consultant firm for CSXT concurrently collected air samples.

Respirable dust samples were collected on preweighed (tared) 37-millimeter (mm) diameter, 5-micrometer (µm) pore size, polyvinyl chloride (PVC) membrane filters with 10-mm nylon cyclone pre-separators. Air was drawn through the filters at a flow rate of 1.7 liters per minute (L/min) using portable battery-powered constant flow pumps. The samples were analyzed for particulate weight by gravimetric analysis using NIOSH Method 0600.[1] The samples were also analyzed for crystalline silica (quartz and cristobalite) using x-ray diffraction. NIOSH Method 7500[1] was used for that analysis.

Limited direct-reading respirable dust measurements were collected with real-time light-scattering aerosol monitors.

# RESULTS

The Appendix provides information on the environmental evaluation criteria used for exposure assessment.

Summary results from area and personal respirable dust and respirable crystalline silica (as quartz) sampling are shown in Tables 2 and 3, while a listing of the complete sample data is given in Table 4. Twenty-two area samples and 185 personal samples were collected. Of the area samples, five respirable and silica dust samples were voided. Four of the personal respirable dust samples were voided and six of the personal silica samples. Area and personal respirable dust 10-hour TWA concentrations ranged from "not detected" to 1.04 mg/m$^3$ and "not detected" to 2.05 mg/m$^3$, respectively. The range of 10-hour time-weighted average (TWA) respirable crystalline silica (as quartz) concentrations for the area samples was "not detected" to 0.30 mg/m$^3$ while it was "not detected" to 0.43 mg/m$^3$ for the personal samples. Cristobalite was not detected on any of the samples. As shown in Tables 3 and 4, eighteen of the personal sample concentrations exceeded the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) for respirable dust, and 28 exceeded the NIOSH Recommended Exposure Limit (REL) for respirable quartz; these samples were obtained on ballast regulator, broom, and tamper operators as well as track repairmen engaged in ballast dumping.

To minimize exposure for equipment operators, the company had initiated a cab modification program for their ballast regulator, tamper, and broom machines. The operator cabs of the ballast regulators and tampers were being rebuilt with air-conditioning and pressurization systems, and seals were being provided around doors, windows, and levers. All broom machines had been purchased with, and all new replacement ballast regulators and tampers were being ordered with, cab specifications similar to those being modified. Samples from machines that had modified cabs at the time of sampling are noted in Table 4. Correspondence with CSXT since sampling was conducted indicated that all machines still in operation had received modified cabs.

Figure 1 shows the real-time dust concentrations inside and outside the cab of a ballast regulator that had recently been modified to isolate the operator from dust. The TWA concentration outside the cab was more than 50 times that measured inside the cab.

# DISCUSSION AND CONCLUSIONS

A primary health concern associated with inhalation of rock dust is silicosis. Silicosis is a chronic fibrotic pulmonary disease caused by the lungs reaction to inhaled crystalline silica dust.[2] Silicosis is usually diagnosed through examination of chest x-rays, together with an occupational history of exposure to silica-containing dust. Three forms of silicosis are recognized: acute silicosis, accelerated silicosis, and chronic silicosis. Each form is differentiated by time to onset of clinically apparent disease after initial exposure (induction period), intensity of exposure, and the rate at which the disease progresses.[2-5] The percentage of crystalline silica in the dust, size of the dust particle, form of crystalline silica, and length of exposure affect disease onset and progression.[3,6,7] The disease is caused by particles of respirable size ($\leq$10 micrometers, and invisible to the naked eye) which deposit in the lungs' alveoli.[8] Freshly ground, or fractured, crystalline silica may be more toxic or fibrogenic (i.e., produce more scarring of the lungs) than aged silica.[9-11]

*Acute silicosis* may develop in a few weeks to 4 or 5 years after initial exposure, and is associated with exposures to extremely high concentrations of crystalline silica.[2,12,13] Respiratory impairment is severe with acute silicosis, and the disease is usually fatal within a year of diagnosis.[5,6] *Accelerated silicosis* is associated with high exposures to crystalline silica and has a longer induction period than acute silicosis. Chest x-ray abnormalities usually appear within 5-10 years.[13] This form of silicosis often progresses after exposure has been discontinued. *Chronic silicosis* (the presence of detectable, discrete, nodules <1 centimeter in diameter on chest x-ray) is the most common form of silicosis and usually becomes evident after 10 years or more of exposure to dust containing crystalline silica.[2,12,13] There may be few, if any, clinical symptoms initially; the most common symptoms are cough, with or without sputum production, and shortness of breath. There may also be little or no decrement in pulmonary function initially.

Both chronic and accelerated silicosis can become complicated by the development of infection (e.g., tuberculosis and/or fungal infections) and/or progressive massive fibrosis (PMF). PMF, often called "complicated" silicosis, results from the silicotic nodules fusing into large masses, and frequently leads to disability and premature death.

Silica exposure may also lead to obstructive lung disease. Moreover, the International Agency for Research on Cancer (IARC) has classified crystalline silica (quartz or cristobalite) from occupational sources as a substance "carcinogenic to humans" NIOSH currently recommends that crystalline silica be considered a potential occupational carcinogen.[14,15]

NIOSH sampling indicated the potential for overexposure to silica dust among ROW workers. This risk appears to be greatest among employees who work alongside the track, rather than among those situated in cabs. At the time of sampling, the company was in the process of converting the majority of the ballast car hopper doors from manual to remote control operation. Even during remote operation, workers were observed walking within dust clouds alongside the moving cars -- a result of the confines of some of the right-of-ways and the need to observe the dumping operations up close. The real-time sampling showed that modified operator cabs can reduce risk of exposure for the workers. However, some samples did show that overexposure can still occur in cabs that have been modified. One of those cabs had a broken window covered with plastic that may have compromised its effectiveness in preventing exposure. Reportedly it had been in disrepair for at least a month.

CSXT requires that ballast be washed before it is loaded into hopper cars at the quarries. Although this provides a cleaner product at the point of purchase, it is likely that additional fine material is created as it is loaded and hauled in the cars and then when it is dumped and manipulated at the dumping site. Some ballast was wet as it was dumped -- especially the bottom ballast that first fell as the hopper doors were opened -- but pockets of dry ballast were usually present, and dust formed as it fell from the cars. Most cars of ballast were dry, and clouds of dust formed as the ballast was dumped. Ballast that was wet as it was dumped often dried by the time it was manipulated by maintenance equipment.

Overexposure to crystalline silica was not measured for workers performing undercutting or yard cleaning operations. However, the large amounts of ballast manipulated by the machines and heavy clouds of dust created by those activities indicated that there was potential for the machine operators and adjacent workers to experience overexposure.

Respirator use was required of workers while working in ballast dust. Some workers operating ballast regulators were observed wearing respirators -- mostly single-use respirators but some half-face respirators with cartridges. Some wore respirators different from those with which they had been fit tested, so there was no guarantee that the respirator was effective. Workers who were dumping ballast, a very physically-exerting task, wore single-use respirators which became very wet from perspiration. This was undesirable because the wet respiratory material increased breathing resistance and sometimes tore. The increased breathing resistance exemplifies the need to ensure workers are medically fit to wear respirators. Several workers were seen wearing respirators over beards, an undesirable practice because of air leakage past the respirator. During a couple days of sampling, NIOSH investigators brought helmeted powered air-purifying respirators (PAPR) for some of the ballast dumping workers to test. Generally the workers were very pleased with the respirators and were impressed by the cooling effect of the respirators on the very hot days.

# RECOMMENDATIONS

Whenever there is a potential for a hazardous exposure to toxic substances, traditional industrial hygiene practice dictates that the following hierarchy of controls, in decreasing order of desirability and effectiveness, be implemented to protect worker health:

A. Elimination of the toxic substance from the workplace.

B. Substitution of the toxic substance with a less toxic substance.

C. Installation of engineering controls to reduce exposure.

D. Use of administrative controls to reduce exposure.

E. Use of personal protective equipment to reduce exposure.

In many instances, it is not possible to eliminate or substitute a toxic substance without altering the integrity of the desired product. Thus, most strategies for reducing exposure center on the use of the other control methods. Personal protective equipment should only be used when engineering controls are not feasible, in the interim when engineering controls are being installed or repaired, or when engineering controls have not sufficiently reduced exposures. With these strategies in mind, the following recommendations are provided:

Ballast Material

Investigate substitution of the ballast material with other rock materials that possess suitable physical characteristics but contain less crystalline silica. Ensure suppliers provide ballast as free of fine material as possible.

Ballast Dumping

Require that the supplier wet the ballast while loading hopper cars. An alternative method, although it may not guarantee as complete a wetting of the material, would be to pour water over loaded hopper cars. If there is a substantial time period between loading and dumping, much of the ballast that was wetted at the supplier's site could dry, and wetting of the ballast at the dumping site would become necessary. Water, which would likely be available near most work sites, could be used to wet the ballast. Another consideration would be to retrofit the ballast hopper cars to hold water for release onto the ballast immediately prior to or during ballast dumping.

Ballast Regulating, Sweeping, and Tamping

Wet the ballast material along the tracks before it is manipulated by machinery. Water tank cars within the series of maintenance machines could provide this function. Continue to order machinery equipped with operator cabs designed to prevent worker exposure to dust. Make certain that the integrity of the cab structures, seals, and air-conditioning / pressurization systems is maintained and that appropriate filters are used for elimination of fine particles. Ensure machines with cabs in need of repair are removed from operation until they are serviced.

Respirators

When respirator use is required, strictly enforce the policy, and ensure workers are provided and wear only the respirators that were found to fit them during fit testing. Only allow those determined to be medically fit to wear respirators. Disallow beards on workers who must wear respirators unless they wear helmeted PAPRs.

Air Sampling

Conduct air sampling on a regular basis to verify effectiveness of controls.

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Table 1
Sampling Sites
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| Site and Dates | Maintenance Operation | Maintenance Activities Sampled |
|---|---|---|
| 1 - Brentwood, TN<br>August 10-12, 1993 | Tie and surfacing | Tie replacement<br>Surfacing |
| 2 - Cornersville, TN<br>September 21-22, 1993 | Surfacing | Undercutting<br>Ballast dumping (manual)<br>Surfacing |
| 3 - Dalton, GA<br>November 9-10, 1993 | Surfacing | Undercutting<br>Ballast dumping (manual)<br>Surfacing |
| 4 - Graysville, GA<br>August 9-11, 1994 | Concrete tie replacement | Undercutting<br>Ballast dumping (manual)<br>Surfacing |
| 5 - Ford, KY<br>September 7-8, 1994 | Concrete tie replacement | Undercutting<br>Ballast dumping (manual & remote)<br>Surfacing |
| 6 - Clinchco, VA<br>September 20-21, 1994 | Tie and surfacing | Tie replacement<br>Surfacing |
| 7 - Ft. Blackmore, VA<br>September 22, 1994 | Surfacing | Surfacing<br>Ballast dumping (manual) |
| 8 - Nashville, TN<br>(Radnor Yard)<br>April 8-9, 1997 | Yard cleaning | Yard cleaning |

Table 2
Summary of Area Respirable Dust and Respirable Quartz Sampling Results
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| Title | Respirable Dust Samples | | | | Respirable Quartz Samples | | | | Occupational Exposure Criteria Exceeded |
|---|---|---|---|---|---|---|---|---|---|
| | Number of Samples | 10-hour TWA Concentration (mg/$m^3$) | | | Number of Samples | 10-hour TWA Concentration (mg/$m^3$) | | | |
| | | Range | Geometric Mean and *Standard Deviation* | | | Range | Geometric Mean and *Standard Deviation* | | |
| Ballast Regulator (inside cab) | 6 | nd - 0.37 | 0.14 | *3.86* | 6 | nd - 0.06 | 0.01 | *2.31* | 1 REL Only |
| Ballast Regulator (outside cab) | 1 | 1.04 | 1.04 | | 1 | 0.30 | 0.30 | | 1 PEL & REL |
| Contractor Undercutter (small)-in cab | 3 | 0.03 - 0.15 | 0.07 | *2.25* | 3 | nd - loq | loq | | |
| Contractor Undercutter (small)-outside cab | 1 | 0.18 | 0.18 | | 1 | loq | loq | | |
| Contractor Yard Cleaner (outside cab) | 1 | 0.31 | 0.31 | | 1 | 0.11 | 0.11 | | 1 PEL & REL |
| Tamper (inside cab) | 1 | 0.08 | 0.08 | | 1 | nd | nd | | |
| Tunnel | 4 | 0.13 - 0.36 | 0.21 | *1.72* | 4 | nd - 0.03 | 0.01 | *1.97* | |

nd = for respirable dust samples, mass was less than the limit of detection of 0.02 mg
for respirable quartz samples, mass was less than the limit of detection of 0.01 mg
loq = mass was detected but less than the limit of quantitation of 0.03 mg
mg/$m^3$ = milligrams per cubic meter
PEL = OSHA Permissible Exposure Limit
REL = NIOSH Recommended Exposure Limit
TWA = time-weighted average

Table 3
Summary of Personal Respirable Dust and Respirable Quartz Sampling Results
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| Title | Respirable Dust Samples: Number of Samples | Respirable Dust Samples: 10-hour TWA Concentration ($mg/m^3$) Range | Respirable Dust Samples: Geometric Mean and *Standard Deviation* | | Respirable Quartz Samples: Number of Samples | Respirable Quartz Samples: 10-hour TWA Concentration ($mg/m^3$) Range | Respirable Quartz Samples: Geometric Mean and *Standard Deviation* | | Occupational Exposure Criteria Exceeded |
|---|---|---|---|---|---|---|---|---|---|
| Anchor Spreader Operator | 1 | 0.04 | 0.04 | | 1 | nd | nd | | |
| Anchor Tightener Operator | 2 | 0.05 - 0.07 | 0.06 | *1.27* | 2 | nd | nd | | |
| Assistant Foreman | 2 | 0.07 - 0.07 | 0.07 | *1.00* | 2 | nd - loq | loq | | |
| Backhoe Operator | 3 | nd - 0.04 | 0.02 | *2.23* | 3 | nd | nd | | |
| Ballast Regulator Operator | 31 | nd - 1.31 | 0.16 | *4.17* | 30 | nd - 0.37 | 0.02 | *4.91* | 7 PEL & REL, 3 REL Only |
| Contractor-Undercutter (Large) Helper | 2 | 0.10 - 0.14 | 0.12 | *1.27* | 2 | nd - loq | loq | | |
| Contractor-Undercutter (Small) Helper | 3 | nd - 0.15 | 0.06 | *4.78* | 3 | nd - loq | loq | | |
| Contractor-Undercutter (Small) Operator | 2 | 0.02 - 0.21 | 0.06 | *5.27* | 2 | nd - loq | loq | | |
| Contractor-Yard Cleaner Operator | 1 | 0.26 | 0.26 | | 1 | 0.02 | 0.02 | | |
| Double Broom Operator | 7 | 0.05 - 1.44 | 0.16 | *3.30* | 7 | nd - 0.43 | 0.02 | *5.01* | 1 PEL & REL, 1 REL Only |
| Foreman | 2 | nd | nd | | 2 | nd | nd | | |
| Fuel Truck Driver | 1 | nd | nd | | 1 | nd | nd | | |
| Laborer | 6 | nd - 0.26 | 0.06 | *4.41* | 6 | nd - 0.03 | 0.01 | *2.02* | |
| Locomotive Engineer | 1 | nd | nd | | 1 | nd | nd | | |
| Magnet Crane Operator | 2 | nd - 0.03 | 0.02 | *2.17* | 2 | nd | nd | | |
| Maintenance Foreman | 2 | 0.04 - 0.05 | 0.04 | *1.17* | 2 | nd | nd | | |
| NIOSH Investigator w/ Ballast Dumping | 2 | 0.03 - 0.18 | 0.07 | *3.55* | 2 | nd - 0.06 | 0.02 | *5.80* | 1 REL Only |
| Pin Driver Operator | 1 | 0.02 | 0.02 | | 1 | nd | nd | | |
| Plate Remover (walking) | 4 | nd - 0.15 | 0.02 | *3.87* | 4 | nd | nd | | |
| Rail Gager | 1 | 0.06 | 0.06 | | 1 | nd | nd | | |
| Rail Lifter Operator (walking) | 3 | 0.04 - 0.15 | 0.08 | *1.97* | 3 | nd | nd | | |
| Repairman | 1 | 0.05 | 0.05 | | 1 | nd | nd | | |
| Spike Driver Operator | 3 | nd - 0.11 | 0.03 | *3.43* | 3 | nd | nd | | |
| Spike Puller Operator | 3 | nd - 0.02 | 0.02 | *1.49* | 3 | nd | nd | | |
| Spike Reclaimer Operator | 3 | 0.09 - 0.24 | 0.15 | *1.64* | 3 | nd - loq | loq | | |
| Tamper Assistant | 1 | 0.06 | 0.06 | | 1 | loq | nd | | |
| Tamper Foreman | 8 | 0.04 - 0.56 | 0.10 | *2.51* | 8 | nd - 0.18 | 0.01 | *3.15* | 1 PEL & REL |
| Tamper Operator | 24 | nd - 0.71 | 0.10 | *2.83* | 24 | nd - 0.25 | 0.01 | *2.73* | 3 PEL & REL, 1 REL Only |
| Tie Crane Operator | 1 | 0.04 | 0.04 | | 1 | nd | nd | | |
| Tie Puller Operator | 3 | 0.03 - 0.16 | 0.07 | *2.34* | 3 | nd - loq | loq | | |
| Tie Remover Assistant | 1 | 0.03 | 0.03 | | 1 | nd | nd | | |
| Tie Remover Operator | 3 | nd - 0.12 | 0.04 | *3.79* | 3 | nd | nd | | |
| Track Repairman/Ballast Dumper | 50 | nd - 2.05 | 0.07 | *4.19* | 49 | nd - 0.31 | 0.01 | *3.99* | 6 PEL & REL, 4 REL Only |

nd = for respirable dust samples, mass was less than the limit of detection of 0.02 mg
for respirable quartz samples, mass was less than the limit of detection of 0.01 mg
loq = mass was detected but less than the limit of quantitation of 0.03 mg
$mg/m^3$ = milligrams per cubic meter
PEL = OSHA Permissible Exposure Limit
REL = NIOSH Recommended Exposure Limit
TWA = time-weighted average

Table 4
Respirable Dust and Respirable Quartz Sampling Results
HETA 92-0311

| Title | Site * | Sample Duration (hours) | Air Volume ($m^3$) | Respirable Dust Mass (mg) | Respirable Dust Concentration During Sampling ($mg/m^3$) | Respirable Dust Concentration 10-hour TWA ($mg/m^3$) | PEL $\frac{10}{\%Qz + 2}$ | Respirable Quartz Mass (mg) | Respirable Quartz Concentration During Sampling ($mg/m^3$) | Respirable Quartz Concentration 10-hour TWA ($mg/m^3$) | Occupational Criteria Exceeded | Modified Cab |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **AREA SAMPLES** | | | | | | | | | | | | |
| Ballast Regulator (inside cab) | 1 | | | VOID | | | | VOID | | | | |
| Ballast Regulator (inside cab) | 3 | | | VOID | | | | VOID | | | | |
| Ballast Regulator (inside cab) | 6 | | | VOID | | | | VOID | | | | |
| Ballast Regulator (outside cab) | 6 | | | VOID | | | | VOID | | | | |
| Ballast Regulator (inside cab) | 1 | 7.77 | 0.79 | 0.13 | 0.16 | 0.13 | 5.00 | loq | loq | loq | | |
| Ballast Regulator (inside cab) | 1 | 10.10 | 1.03 | 0.20 | 0.19 | 0.19 | 5.00 | loq | loq | loq | | |
| Ballast Regulator (inside cab) | 3 | 8.72 | 0.89 | 0.25 | 0.28 | 0.25 | 0.38 | 0.06 | 0.07 | 0.06 | REL | |
| Ballast Regulator (inside cab) | 4 | 7.63 | 0.78 | 0.32 | 0.41 | 0.31 | 5.00 | loq | loq | loq | | |
| Ballast Regulator (inside cab) | 4 | 9.13 | 0.93 | 0.38 | 0.41 | 0.37 | 5.00 | loq | loq | loq | | Modified Cab |
| Ballast Regulator (inside cab) | 7 | 6.90 | 0.70 | nd | nd | nd | 5.00 | nd | nd | nd | | Modified Cab |
| Ballast Regulator (outside cab) | 7 | 6.90 | 0.70 | 1.06 | 1.51 | 1.04 | 0.32 | 0.31 | 0.44 | 0.30 | PEL & REL | Modified Cab |
| Contractor-Undercutter (small)-in cab | 3 | 7.35 | 0.75 | 0.03 | 0.04 | 0.03 | 5.00 | nd | nd | nd | | |
| Contractor-Undercutter (small)-in cab | 3 | 5.05 | 0.52 | 0.08 | 0.16 | 0.08 | 5.00 | nd | nd | nd | | |
| Contractor-Undercutter (small)-in cab | 4 | 7.60 | 0.78 | 0.15 | 0.19 | 0.15 | 5.00 | loq | loq | loq | | |
| Contractor-Undercutter (small)-outside cab | 5 | 7.17 | 0.73 | 0.18 | 0.25 | 0.18 | 5.00 | loq | loq | loq | | |
| Contractor-Yard Cleaner (outside cab) | 8 | | | VOID | | | | VOID | | | | |
| Contractor-Yard Cleaner (outside cab) | 8 | 9.57 | 0.98 | 0.32 | 0.33 | 0.31 | 0.27 | 0.11 | 0.11 | 0.11 | PEL & REL | |
| Tamper (inside cab) | 3 | 8.97 | 0.91 | 0.08 | 0.09 | 0.08 | 5.00 | nd | nd | nd | | |
| Tunnel-Middle | 5 | 7.58 | 0.77 | 0.37 | 0.48 | 0.36 | 5.00 | loq | loq | loq | | |
| Tunnel-Middle | 5 | 11.53 | 1.18 | 0.38 | 0.32 | 0.32 | 1.01 | 0.03 | 0.03 | 0.03 | | |
| Tunnel-North End | 5 | 7.08 | 0.72 | 0.14 | 0.19 | 0.14 | 5.00 | nd | nd | nd | | |
| Tunnel-North End | 5 | 11.15 | 1.14 | 0.15 | 0.13 | 0.13 | 5.00 | loq | loq | loq | | |
| **PERSONAL SAMPLES** | | | | | | | | | | | | |
| Anchor Spreader Operator | 1 | 7.87 | 0.80 | 0.04 | 0.05 | 0.04 | 5.00 | nd | nd | nd | | |
| Anchor Tightener Operator | 1 | 6.45 | 0.66 | 0.07 | 0.11 | 0.07 | 5.00 | nd | nd | nd | | |
| Anchor Tightener Operator | 1 | 9.65 | 0.98 | 0.05 | 0.05 | 0.05 | 5.00 | nd | nd | nd | | |
| Assistant Foreman | 1 | 8.90 | 0.91 | 0.07 | 0.08 | 0.07 | 5.00 | loq | loq | loq | | |
| Assistant Foreman | 1 | 8.78 | 0.90 | 0.07 | 0.08 | 0.07 | 5.00 | nd | nd | nd | | |
| Backhoe Operator | 1 | 8.97 | 0.91 | nd | nd | nd | 5.00 | nd | nd | nd | | |
| Backhoe Operator | 3 | 6.35 | 0.65 | 0.04 | 0.06 | 0.04 | 5.00 | nd | nd | nd | | |
| Backhoe Operator | 8 | 7.02 | 0.72 | nd | nd | nd | 5.00 | nd | nd | nd | | |
| Ballast Regulator Operator | 1 | 6.73 | 0.69 | 0.41 | 0.60 | 0.40 | 1.07 | 0.03 | 0.04 | 0.03 | | |

Table 4 (continued)
Respirable Dust and Respirable Quartz Sampling Results
HETA 92-0311

| Title | Site * | Sample Duration (hours) | Air Volume ($m^3$) | Respirable Dust Mass (mg) | Respirable Dust Concentration During Sampling ($mg/m^3$) | Respirable Dust Concentration 10-hour TWA ($mg/m^3$) | PEL $\frac{10}{\%Qz + 2}$ | Respirable Quartz Mass (mg) | Respirable Quartz Concentration During Sampling ($mg/m^3$) | Respirable Quartz Concentration 10-hour TWA ($mg/m^3$) | Occupational Criteria Exceeded | Modified Cab |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ballast Regulator Operator | 1 | 10.60 | 1.08 | 1.42 | 1.31 | 1.31 | 0.33 | 0.40 | 0.37 | 0.37 | PEL & REL | |
| Ballast Regulator Operator | 1 | 10.00 | 1.02 | 1.25 | 1.23 | 1.23 | 0.34 | 0.34 | 0.33 | 0.33 | PEL & REL | |
| Ballast Regulator Operator | 1 | 7.18 | 0.73 | nd | nd | nd | 5.00 | nd | nd | nd | | |
| Ballast Regulator Operator | 1 | 8.97 | 0.91 | 0.26 | 0.28 | 0.25 | 0.58 | 0.04 | 0.04 | 0.04 | | |
| Ballast Regulator Operator | 1 | 10.02 | 1.02 | 0.08 | 0.08 | 0.08 | 5.00 | loq | loq | loq | | |
| Ballast Regulator Operator | 1 | 9.12 | 0.93 | 0.45 | 0.48 | 0.44 | 0.51 | 0.08 | 0.09 | 0.08 | REL | |
| Ballast Regulator Operator | 1 | 10.65 | 1.09 | 1.25 | 1.15 | 1.15 | 0.32 | 0.36 | 0.33 | 0.33 | PEL & REL | |
| Ballast Regulator Operator | 1 | 9.73 | 0.99 | 0.86 | 0.87 | 0.84 | 0.63 | 0.12 | 0.12 | 0.12 | PEL & REL | |
| Ballast Regulator Operator | 2 | 5.92 | 0.60 | 0.06 | 0.10 | 0.06 | 5.00 | nd | nd | nd | | |
| Ballast Regulator Operator | 2 | 7.17 | 0.73 | 0.03 | 0.04 | 0.03 | 5.00 | nd | nd | nd | | |
| Ballast Regulator Operator | 3 | 10.07 | 1.03 | 0.27 | 0.26 | 0.26 | 5.00 | loq | loq | loq | | |
| Ballast Regulator Operator | 3 | 8.72 | 0.89 | 0.38 | 0.43 | 0.37 | 5.00 | VOID | | | | |
| Ballast Regulator Operator | 4 | 6.77 | 0.69 | 0.17 | 0.25 | 0.17 | 0.51 | 0.03 | 0.04 | 0.03 | | Modified Cab |
| Ballast Regulator Operator | 4 | 6.95 | 0.71 | 0.10 | 0.14 | 0.10 | 5.00 | nd | nd | nd | | |
| Ballast Regulator Operator | 4 | 8.45 | 0.86 | 0.03 | 0.03 | 0.03 | 5.00 | nd | nd | nd | | Modified Cab |
| Ballast Regulator Operator | 4 | 9.13 | 0.93 | 0.14 | 0.15 | 0.14 | 5.00 | loq | loq | loq | | Modified Cab |
| Ballast Regulator Operator | 4 | 10.53 | 1.07 | nd | nd | nd | 5.00 | nd | nd | nd | | Modified Cab |
| Ballast Regulator Operator | 4 | 11.15 | 1.14 | 1.25 | 1.10 | 1.10 | 0.30 | 0.39 | 0.34 | 0.34 | PEL & REL | |
| Ballast Regulator Operator | 4 | 10.53 | 1.07 | 0.35 | 0.33 | 0.33 | 0.45 | 0.07 | 0.07 | 0.07 | REL | |
| Ballast Regulator Operator | 4 | 9.45 | 0.96 | 0.14 | 0.15 | 0.14 | 5.00 | nd | nd | nd | | Modified Cab |
| Ballast Regulator Operator | 4 | 10.27 | 1.05 | 0.30 | 0.29 | 0.29 | 5.00 | loq | loq | loq | | Modified Cab |
| Ballast Regulator Operator | 5 | 7.37 | 0.75 | 0.03 | 0.04 | 0.03 | 5.00 | loq | loq | loq | | Modified Cab |
| Ballast Regulator Operator | 5 | 5.08 | 0.52 | 0.11 | 0.21 | 0.11 | 5.00 | nd | nd | nd | | Modified Cab |
| Ballast Regulator Operator | 5 | 9.90 | 1.01 | 0.03 | 0.03 | 0.03 | 5.00 | nd | nd | nd | | Modified Cab |
| Ballast Regulator Operator | 5 | 8.63 | 0.88 | 0.07 | 0.08 | 0.07 | 5.00 | loq | loq | loq | | Modified Cab |
| Ballast Regulator Operator | 6 | 8.37 | 0.85 | 0.89 | 1.04 | 0.87 | 0.65 | 0.12 | 0.14 | 0.12 | PEL & REL | Modified Cab |
| Ballast Regulator Operator | 6 | 7.50 | 0.77 | 0.09 | 0.12 | 0.09 | 5.00 | loq | loq | loq | | Modified Cab |
| Ballast Regulator Operator | 6 | | | VOID | | | | VOID | | | | Modified Cab |
| Ballast Regulator Operator | 7 | 6.78 | 0.69 | 0.44 | 0.64 | 0.43 | 0.45 | 0.09 | 0.13 | 0.09 | REL | Modified Cab |
| Ballast Regulator Operator | 7 | 6.90 | 0.70 | 0.03 | 0.04 | 0.03 | 5.00 | nd | nd | nd | | Modified Cab |
| Ballast Regulator Operator | 7 | 6.57 | 0.67 | 0.55 | 0.82 | 0.54 | 0.24 | 0.22 | 0.33 | 0.22 | PEL & REL | Modified Cab |
| Contractor-Undercutter (Large) Helper | 3 | 5.72 | 0.58 | 0.14 | 0.24 | 0.14 | 5.00 | nd | nd | nd | | |
| Contractor-Undercutter (Large) Helper | 3 | 5.63 | 0.57 | 0.10 | 0.17 | 0.10 | 5.00 | loq | loq | loq | | |
| Contractor-Undercutter (Small) Helper | 3 | 6.88 | 0.70 | 0.15 | 0.21 | 0.15 | 5.00 | nd | nd | nd | | |
| Contractor-Undercutter (Small) Helper | 3 | 4.68 | 0.48 | nd | nd | nd | 5.00 | nd | nd | nd | | |
| Contractor-Undercutter (Small) Helper | 4 | 7.57 | 0.77 | 0.15 | 0.19 | 0.15 | 5.00 | loq | loq | loq | | |

Table 4 (continued)
Respirable Dust and Respirable Quartz Sampling Results
HETA 92-0311

| Title | Site * | Sample Duration (hours) | Air Volume ($m^3$) | Respirable Dust Mass (mg) | Respirable Dust Concentration During Sampling ($mg/m^3$) | Respirable Dust Concentration 10-hour TWA ($mg/m^3$) | PEL $\frac{10}{\%Qz + 2}$ | Respirable Quartz Mass (mg) | Respirable Quartz Concentration During Sampling ($mg/m^3$) | Respirable Quartz Concentration 10-hour TWA ($mg/m^3$) | Occupational Criteria Exceeded | Modified Cab |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Contractor-Undercutter (Small) Operator | 5 | 8.53 | 0.87 | 0.21 | 0.24 | 0.21 | 5.00 | loq | loq | loq | | |
| Contractor-Undercutter (Small) Operator | 5 | 4.73 | 0.48 | 0.02 | 0.04 | 0.02 | 5.00 | nd | nd | nd | | |
| Contractor-Yard Cleaner Operator | 8 | 8.95 | | VOID | | | | VOID | | | | |
| Contractor-Yard Cleaner Operator | 8 | 9.57 | 0.98 | 0.27 | 0.28 | 0.26 | 1.06 | 0.02 | 0.02 | 0.02 | | |
| Double Broom Operator | 1 | 9.18 | 0.94 | 0.05 | 0.05 | 0.05 | 5.00 | loq | loq | loq | | Modified Cab |
| Double Broom Operator | 1 | 10.67 | 1.09 | 0.46 | 0.42 | 0.42 | 0.66 | 0.06 | 0.06 | 0.06 | REL | Modified Cab |
| Double Broom Operator | 1 | 9.77 | 1.00 | 1.47 | 1.48 | 1.44 | 0.31 | 0.44 | 0.44 | 0.43 | PEL & REL | Modified Cab |
| Double Broom Operator | 4 | 9.57 | 0.98 | 0.07 | 0.07 | 0.07 | 5.00 | nd | nd | nd | | Modified Cab |
| Double Broom Operator | 4 | 10.18 | 1.04 | 0.11 | 0.11 | 0.11 | 5.00 | loq | loq | loq | | Modified Cab |
| Double Broom Operator | 5 | 6.33 | 0.65 | 0.08 | 0.12 | 0.08 | 5.00 | nd | nd | nd | | Modified Cab |
| Double Broom Operator | 6 | 7.40 | 0.75 | 0.16 | 0.21 | 0.16 | 0.48 | 0.03 | 0.04 | 0.03 | | Modified Cab |
| Double Broom Operator | 6 | | | VOID | | | | VOID | | | | |
| Foreman | 8 | 9.28 | 0.95 | nd | nd | nd | 5.00 | nd | nd | nd | | |
| Foreman | 8 | 9.77 | 1.00 | nd | nd | nd | 5.00 | nd | nd | nd | | |
| Fuel Truck Driver | 1 | 5.28 | 0.54 | nd | nd | nd | 5.00 | nd | nd | nd | | |
| Laborer | 1 | 6.88 | 0.70 | 0.05 | 0.07 | 0.05 | 5.00 | nd | nd | nd | | |
| Laborer | 1 | 7.97 | 0.81 | 0.13 | 0.16 | 0.13 | 5.00 | loq | loq | loq | | |
| Laborer | 1 | 7.83 | 0.80 | 0.27 | 0.34 | 0.26 | 5.00 | loq | loq | loq | | |
| Laborer | 1 | 6.87 | 0.70 | 0.22 | 0.31 | 0.22 | 0.64 | 0.03 | 0.04 | 0.03 | | |
| Laborer | 8 | 6.68 | 0.68 | nd | nd | nd | 5.00 | nd | nd | nd | | |
| Laborer | 8 | 5.88 | 0.60 | nd | nd | nd | 5.00 | nd | nd | nd | | |
| Locomotive Engineer | 2 | 4.75 | 0.48 | nd | nd | nd | 5.00 | nd | nd | nd | | |
| Magnet Crane Operator | 8 | 9.33 | 0.95 | nd | nd | nd | 5.00 | nd | nd | nd | | |
| Magnet Crane Operator | 8 | 9.82 | 1.00 | 0.03 | 0.03 | 0.03 | 5.00 | nd | nd | nd | | |
| Maintenance Foreman | 2 | 5.25 | 0.54 | 0.04 | 0.07 | 0.04 | 5.00 | nd | nd | nd | | |
| Maintenance Foreman | 2 | 6.43 | 0.66 | 0.05 | 0.08 | 0.05 | 5.00 | nd | nd | nd | | |
| NIOSH Investigator w/ Ballast Dumping | 4 | 6.22 | 0.63 | 0.18 | 0.28 | 0.18 | 0.28 | 0.06 | 0.09 | 0.06 | REL | |
| NIOSH Investigator w/ Ballast Dumping | 7 | 1.33 | 0.14 | 0.03 | 0.22 | 0.03 | 5.00 | nd | nd | nd | | |
| Pin Driver Operator | 6 | 8.15 | 0.83 | 0.02 | 0.02 | 0.02 | 5.00 | nd | nd | nd | | |
| Plate Remover (walking) | 1 | 7.57 | 0.77 | nd | nd | nd | 5.00 | nd | nd | nd | | |
| Plate Remover (walking) | 1 | 8.10 | 0.83 | nd | nd | nd | 5.00 | nd | nd | nd | | |
| Plate Remover (walking) | 1 | 9.88 | 1.01 | 0.15 | 0.15 | 0.15 | 5.00 | nd | nd | nd | | |
| Plate Remover (walking) | 1 | 7.62 | 0.78 | nd | nd | nd | 5.00 | nd | nd | nd | | |
| Rail Gager | 1 | 8.63 | 0.88 | 0.06 | 0.07 | 0.06 | 5.00 | nd | nd | nd | | |
| Rail Lifter Operator (walking) | 1 | 6.90 | 0.70 | 0.04 | 0.06 | 0.04 | 5.00 | nd | nd | nd | | |
| Rail Lifter Operator (walking) | 1 | 9.60 | 0.98 | 0.15 | 0.15 | 0.15 | 5.00 | nd | nd | nd | | |

Table 4 (continued)
Respirable Dust and Respirable Quartz Sampling Results
HETA 92-0311

| Title | Site * | Sample Duration (hours) | Air Volume ($m^3$) | Respirable Dust Mass (mg) | Respirable Dust Concentration During Sampling ($mg/m^3$) | Respirable Dust Concentration 10-hour TWA ($mg/m^3$) | PEL $\frac{10}{\%Qz + 2}$ | Respirable Quartz Mass (mg) | Respirable Quartz Concentration During Sampling ($mg/m^3$) | Respirable Quartz Concentration 10-hour TWA ($mg/m^3$) | Occupational Criteria Exceeded | Modified Cab |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rail Lifter Operator (walking) | 1 | 6.93 | 0.71 | 0.10 | 0.14 | 0.10 | 5.00 | nd | nd | nd | | |
| Repairman | 1 | 9.78 | 1.00 | 0.05 | 0.05 | 0.05 | 5.00 | nd | nd | nd | | |
| Spike Driver Operator | 1 | 6.88 | 0.70 | 0.11 | 0.16 | 0.11 | 5.00 | nd | nd | nd | | |
| Spike Driver Operator | 1 | 9.50 | 0.97 | nd | nd | nd | 5.00 | nd | nd | nd | | |
| Spike Driver Operator | 1 | 6.77 | 0.69 | 0.02 | 0.03 | 0.02 | 5.00 | nd | nd | nd | | |
| Spike Puller Operator | 1 | 8.23 | 0.84 | nd | nd | nd | 5.00 | nd | nd | nd | | |
| Spike Puller Operator | 1 | 8.15 | 0.83 | 0.02 | 0.02 | 0.02 | 5.00 | nd | nd | nd | | |
| Spike Puller Operator | 1 | 8.52 | 0.87 | 0.02 | 0.02 | 0.02 | 5.00 | nd | nd | nd | | |
| Spike Reclaimer Operator | 1 | 8.07 | 0.82 | 0.17 | 0.21 | 0.17 | 5.00 | nd | nd | nd | | |
| Spike Reclaimer Operator | 1 | 8.47 | 0.86 | 0.24 | 0.28 | 0.24 | 5.00 | loq | loq | loq | | |
| Spike Reclaimer Operator | 1 | 9.92 | 1.01 | 0.09 | 0.09 | 0.09 | 5.00 | nd | nd | nd | | |
| Tamper Assistant | 6 | 6.95 | 0.71 | 0.06 | 0.08 | 0.06 | 5.00 | loq | loq | loq | | |
| Tamper Foreman | 1 | 6.62 | 0.67 | 0.06 | 0.09 | 0.06 | 5.00 | nd | nd | nd | | |
| Tamper Foreman | 4 | 8.63 | 0.88 | 0.24 | 0.27 | 0.24 | 5.00 | loq | loq | loq | | |
| Tamper Foreman | 4 | 11.40 | 1.16 | 0.16 | 0.14 | 0.14 | 5.00 | loq | loq | loq | | |
| Tamper Foreman | 4 | 9.70 | 0.99 | 0.10 | 0.10 | 0.10 | 5.00 | loq | loq | loq | | |
| Tamper Foreman | 5 | 5.02 | 0.51 | 0.08 | 0.16 | 0.08 | 5.00 | loq | loq | loq | | |
| Tamper Foreman | 5 | 7.35 | 0.75 | 0.04 | 0.05 | 0.04 | 5.00 | loq | loq | loq | | |
| Tamper Foreman | 6 | 10.78 | 1.10 | 0.62 | 0.56 | 0.56 | 0.29 | 0.20 | 0.18 | 0.18 | PEL & REL | |
| Tamper Foreman | 7 | 6.48 | 0.66 | 0.04 | 0.06 | 0.04 | 5.00 | nd | nd | nd | | |
| Tamper Operator | 1 | 9.00 | 0.92 | 0.05 | 0.05 | 0.05 | 5.00 | nd | nd | nd | | |
| Tamper Operator | 1 | 10.55 | 1.08 | 0.14 | 0.13 | 0.13 | 5.00 | nd | nd | nd | | |
| Tamper Operator | 1 | 10.17 | 1.04 | 0.07 | 0.07 | 0.07 | 5.00 | nd | nd | nd | | |
| Tamper Operator | 1 | 6.45 | 0.66 | 0.11 | 0.17 | 0.11 | 5.00 | loq | loq | loq | | |
| Tamper Operator | 1 | 10.60 | 1.08 | 0.47 | 0.43 | 0.43 | 0.68 | 0.06 | 0.06 | 0.06 | REL | |
| Tamper Operator | 1 | 9.87 | 1.01 | 0.09 | 0.09 | 0.09 | 5.00 | nd | nd | nd | | |
| Tamper Operator | 2 | 7.45 | 0.76 | 0.05 | 0.07 | 0.05 | 5.00 | nd | nd | nd | | |
| Tamper Operator | 2 | 7.17 | 0.73 | 0.02 | 0.03 | 0.02 | 5.00 | nd | nd | nd | | |
| Tamper Operator | 3 | 10.00 | 1.02 | 0.06 | 0.06 | 0.06 | 5.00 | nd | nd | nd | | |
| Tamper Operator | 4 | 9.30 | 0.95 | 0.20 | 0.21 | 0.20 | 0.59 | 0.03 | 0.03 | 0.03 | | |
| Tamper Operator | 4 | 11.43 | 1.17 | 0.18 | 0.15 | 0.15 | 0.41 | 0.04 | 0.03 | 0.03 | | |
| Tamper Operator | 4 | 9.68 | 0.99 | 0.33 | 0.33 | 0.32 | 0.19 | 0.17 | 0.17 | 0.17 | PEL & REL | |
| Tamper Operator | 4 | 8.17 | 0.83 | 0.72 | 0.86 | 0.71 | 0.26 | 0.26 | 0.31 | 0.25 | PEL & REL | |
| Tamper Operator | 4 | 9.75 | 0.99 | 0.38 | 0.38 | 0.37 | 1.01 | 0.03 | 0.03 | 0.03 | | |
| Tamper Operator | 4 | | | VOID | | | | VOID | | | | |
| Tamper Operator | 4 | 9.27 | 0.95 | 0.42 | 0.44 | 0.41 | 0.19 | 0.21 | 0.22 | 0.21 | PEL & REL | |

Table 4 (continued)
Respirable Dust and Respirable Quartz Sampling Results
HETA 92-0311

| Title | Site * | Sample Duration (hours) | Air Volume ($m^3$) | Respirable Dust Mass (mg) | Respirable Dust Concentration During Sampling ($mg/m^3$) | Respirable Dust Concentration 10-hour TWA ($mg/m^3$) | PEL $\frac{10}{\%Qz + 2}$ | Respirable Quartz Mass (mg) | Respirable Quartz Concentration During Sampling ($mg/m^3$) | Respirable Quartz Concentration 10-hour TWA ($mg/m^3$) | Occupational Criteria Exceeded | Modified Cab |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tamper Operator | 4 | 10.25 | 1.05 | 0.11 | 0.11 | 0.11 | 0.34 | 0.03 | 0.03 | 0.03 | | |
| Tamper Operator | 5 | 8.12 | 0.83 | 0.28 | 0.34 | 0.27 | 0.61 | 0.04 | 0.05 | 0.04 | | |
| Tamper Operator | 5 | 5.07 | 0.52 | 0.11 | 0.21 | 0.11 | 0.34 | 0.03 | 0.06 | 0.03 | | |
| Tamper Operator | 5 | 10.60 | 1.08 | nd | nd | nd | 5.00 | nd | nd | nd | | |
| Tamper Operator | 5 | 6.43 | 0.66 | 0.02 | 0.03 | 0.02 | 5.00 | nd | nd | nd | | |
| Tamper Operator | 6 | 10.87 | 1.11 | 0.21 | 0.19 | 0.19 | 0.48 | 0.04 | 0.04 | 0.04 | | |
| Tamper Operator | 6 | 6.93 | 0.71 | 0.13 | 0.18 | 0.13 | 0.40 | 0.03 | 0.04 | 0.03 | | |
| Tamper Operator | 7 | 6.60 | 0.67 | 0.42 | 0.62 | 0.41 | 0.87 | 0.04 | 0.06 | 0.04 | | Modified Cab |
| Tamper Operator | 7 | 6.00 | 0.61 | 0.02 | 0.03 | 0.02 | 5.00 | nd | nd | nd | | |
| Tamper Operator | 7 | 6.38 | 0.65 | 0.10 | 0.15 | 0.10 | 5.00 | loq | loq | loq | | |
| Tie Crane Operator | 1 | 7.57 | 0.77 | 0.04 | 0.05 | 0.04 | 5.00 | nd | nd | nd | | |
| Tie Puller Operator | 1 | 7.60 | 0.78 | 0.03 | 0.04 | 0.03 | 5.00 | nd | nd | nd | | |
| Tie Puller Operator | 1 | 8.40 | 0.86 | 0.09 | 0.11 | 0.09 | 5.00 | nd | nd | nd | | |
| Tie Puller Operator | 1 | 9.80 | 1.00 | 0.16 | 0.16 | 0.16 | 5.00 | loq | loq | loq | | |
| Tie Remover Assistant | 6 | 8.05 | 0.82 | 0.03 | 0.04 | 0.03 | 5.00 | nd | nd | nd | | |
| Tie Remover Operator | 6 | 8.12 | 0.83 | 0.08 | 0.10 | 0.08 | 5.00 | nd | nd | nd | | |
| Tie Replacer Operator | 1 | 6.88 | 0.70 | nd | nd | nd | 5.00 | nd | nd | nd | | |
| Tie Replacer Operator | 1 | 9.93 | 1.01 | 0.12 | 0.12 | 0.12 | 5.00 | nd | nd | nd | | |
| Track Repairman/Ballast Dumper | 2 | 5.52 | 0.56 | 0.03 | 0.05 | 0.03 | 5.00 | nd | nd | nd | | |
| Track Repairman/Ballast Dumper | 2 | 6.03 | 0.62 | 0.03 | 0.05 | 0.03 | 5.00 | nd | nd | nd | | |
| Track Repairman/Ballast Dumper | 2 | 4.47 | 0.46 | 0.02 | 0.04 | 0.02 | 5.00 | nd | nd | nd | | |
| Track Repairman/Ballast Dumper | 2 | 6.05 | 0.62 | nd | nd | nd | 5.00 | nd | nd | nd | | |
| Track Repairman/Ballast Dumper | 2 | 5.83 | 0.60 | 0.04 | 0.07 | 0.04 | 5.00 | nd | nd | nd | | |
| Track Repairman/Ballast Dumper | 2 | 5.32 | 0.54 | nd | nd | nd | 5.00 | nd | nd | nd | | |
| Track Repairman/Ballast Dumper | 2 | 6.08 | 0.62 | 0.04 | 0.06 | 0.04 | 5.00 | nd | nd | nd | | |
| Track Repairman/Ballast Dumper | 3 | 8.53 | 0.87 | 0.04 | 0.05 | 0.04 | 5.00 | nd | nd | nd | | |
| Track Repairman/Ballast Dumper | 3 | 8.65 | 0.88 | 0.08 | 0.09 | 0.08 | 5.00 | nd | nd | nd | | |
| Track Repairman/Ballast Dumper | 3 | 8.53 | 0.87 | nd | nd | nd | 5.00 | nd | nd | nd | | |
| Track Repairman/Ballast Dumper | 3 | 8.75 | 0.89 | 0.07 | 0.08 | 0.07 | 5.00 | nd | nd | nd | | |
| Track Repairman/Ballast Dumper | 3 | 8.58 | 0.88 | 0.02 | 0.02 | 0.02 | 5.00 | nd | nd | nd | | |
| Track Repairman/Ballast Dumper | 3 | 8.63 | 0.88 | 0.12 | 0.14 | 0.12 | 5.00 | nd | nd | nd | | |
| Track Repairman/Ballast Dumper | 3 | 8.67 | 0.88 | 0.02 | 0.02 | 0.02 | 5.00 | nd | nd | nd | | |
| Track Repairman/Ballast Dumper | 3 | 8.63 | 0.88 | 0.09 | 0.10 | 0.09 | 5.00 | nd | nd | nd | | |
| Track Repairman/Ballast Dumper | 3 | 8.62 | 0.88 | 0.10 | 0.11 | 0.10 | 5.00 | loq | loq | loq | | |
| Track Repairman/Ballast Dumper | 3 | 8.65 | 0.88 | 0.02 | 0.02 | 0.02 | 5.00 | nd | nd | nd | | |
| Track Repairman/Ballast Dumper | 4 | 6.28 | 0.64 | 0.04 | 0.06 | 0.04 | 0.13 | 0.03 | 0.05 | 0.03 | | |
| Track Repairman/Ballast Dumper | 4 | 6.33 | 0.65 | nd | nd | nd | 5.00 | nd | nd | nd | | |

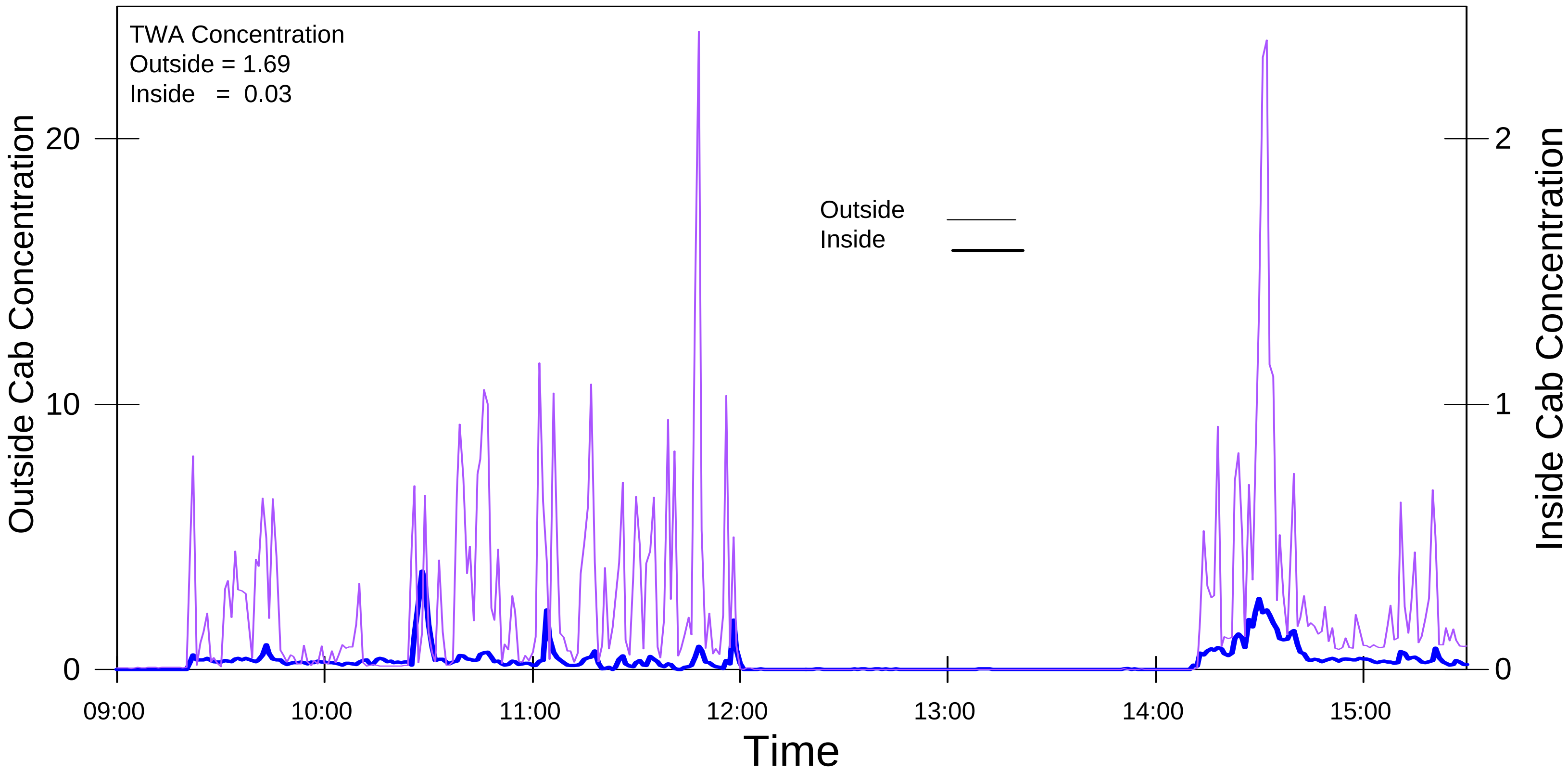
Table 4 (continued)
Respirable Dust and Respirable Quartz Sampling Results
HETA 92-0311

| Title | Site * | Sample Duration (hours) | Air Volume ($m^3$) | Respirable Dust Mass (mg) | Respirable Dust Concentration During Sampling ($mg/m^3$) | Respirable Dust Concentration 10-hour TWA ($mg/m^3$) | PEL $\frac{10}{\%Qz + 2}$ | Respirable Quartz Mass (mg) | Respirable Quartz Concentration During Sampling ($mg/m^3$) | Respirable Quartz Concentration 10-hour TWA ($mg/m^3$) | Occupational Criteria Exceeded | Modified Cab |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Track Repairman/Ballast Dumper | 4 | 6.35 | 0.65 | 0.16 | 0.25 | 0.16 | 0.48 | 0.03 | 0.05 | 0.03 | | |
| Track Repairman/Ballast Dumper | 4 | 5.78 | 0.59 | 0.70 | 1.19 | 0.69 | 5.00 | loq | loq | loq | | |
| Track Repairman/Ballast Dumper | 4 | 3.50 | 0.36 | 0.05 | 0.14 | 0.05 | 5.00 | nd | nd | nd | | |
| Track Repairman/Ballast Dumper | 4 | 6.22 | 0.63 | 0.08 | 0.13 | 0.08 | 5.00 | loq | loq | loq | | |
| Track Repairman/Ballast Dumper | 4 | 5.45 | 0.56 | 0.37 | 0.67 | 0.36 | 0.55 | 0.06 | 0.11 | 0.06 | REL | |
| Track Repairman/Ballast Dumper | 4 | 3.55 | 0.36 | 0.09 | 0.25 | 0.09 | 5.00 | nd | nd | nd | | |
| Track Repairman/Ballast Dumper | 4 | 5.52 | 0.56 | 0.29 | 0.52 | 0.28 | 0.34 | 0.08 | 0.14 | 0.08 | REL | |
| Track Repairman/Ballast Dumper | 4 | 3.48 | 0.36 | 0.12 | 0.34 | 0.12 | 5.00 | loq | loq | loq | | |
| Track Repairman/Ballast Dumper | 4 | 5.62 | 0.57 | 0.89 | 1.55 | 0.87 | 0.26 | 0.32 | 0.56 | 0.31 | PEL & REL | |
| Track Repairman/Ballast Dumper | 4 | 3.52 | 0.36 | 0.10 | 0.28 | 0.10 | 5.00 | VOID | | | | |
| Track Repairman/Ballast Dumper | 4 | 6.32 | 0.64 | 0.09 | 0.14 | 0.09 | 0.28 | 0.03 | 0.05 | 0.03 | | |
| Track Repairman/Ballast Dumper | 4 | 6.27 | 0.64 | 0.20 | 0.31 | 0.20 | 0.31 | 0.06 | 0.09 | 0.06 | REL | |
| Track Repairman/Ballast Dumper | 4 | 5.65 | 0.58 | 0.37 | 0.64 | 0.36 | 0.48 | 0.07 | 0.12 | 0.07 | REL | |
| Track Repairman/Ballast Dumper | 4 | 3.53 | 0.36 | 0.16 | 0.44 | 0.16 | 0.37 | 0.04 | 0.11 | 0.04 | | |
| Track Repairman/Ballast Dumper | 5 | 3.75 | 0.38 | nd | nd | nd | 5.00 | nd | nd | nd | | |
| Track Repairman/Ballast Dumper | 5 | 8.07 | 0.82 | 0.45 | 0.55 | 0.44 | 0.23 | 0.19 | 0.23 | 0.19 | PEL & REL | |
| Track Repairman/Ballast Dumper | 5 | 3.63 | 0.37 | 0.10 | 0.27 | 0.10 | 0.31 | 0.03 | 0.08 | 0.03 | | |
| Track Repairman/Ballast Dumper | 5 | 8.00 | 0.82 | 0.25 | 0.31 | 0.25 | 0.45 | 0.05 | 0.06 | 0.05 | | |
| Track Repairman/Ballast Dumper | 5 | 3.75 | 0.38 | 2.09 | 5.46 | 2.05 | 2.28 | 0.05 | 0.13 | 0.05 | | |
| Track Repairman/Ballast Dumper | 5 | 8.00 | 0.82 | 0.72 | 0.88 | 0.71 | 0.23 | 0.30 | 0.37 | 0.29 | PEL & REL | |
| Track Repairman/Ballast Dumper | 5 | 3.68 | 0.38 | 0.06 | 0.16 | 0.06 | 5.00 | nd | nd | nd | | |
| Track Repairman/Ballast Dumper | 5 | 8.02 | 0.82 | 0.12 | 0.15 | 0.12 | 5.00 | loq | loq | loq | | |
| Track Repairman/Ballast Dumper | 5 | 3.75 | 0.38 | 0.04 | 0.10 | 0.04 | 5.00 | nd | nd | nd | | |
| Track Repairman/Ballast Dumper | 5 | 7.95 | 0.81 | 0.60 | 0.74 | 0.59 | 0.24 | 0.24 | 0.30 | 0.24 | PEL & REL | |
| Track Repairman/Ballast Dumper | 5 | 8.05 | 0.82 | 0.08 | 0.10 | 0.08 | 0.25 | 0.03 | 0.04 | 0.03 | | |
| Track Repairman/Ballast Dumper | 5 | 3.63 | 0.37 | 0.34 | 0.92 | 0.33 | 0.18 | 0.18 | 0.49 | 0.18 | PEL & REL | |
| Track Repairman/Ballast Dumper | 5 | 3.75 | 0.38 | nd | nd | nd | 5.00 | nd | nd | nd | | |
| Track Repairman/Ballast Dumper | 5 | 8.00 | 0.82 | 0.61 | 0.75 | 0.60 | 0.29 | 0.20 | 0.25 | 0.20 | PEL & REL | |
| Track Repairman/Ballast Dumper | 7 | 4.15 | 0.42 | nd | nd | nd | 5.00 | loq | loq | loq | | |
| Track Repairman/Ballast Dumper | 7 | 4.15 | 0.42 | nd | nd | nd | 5.00 | nd | nd | nd | | |
| Track Repairman/Ballast Dumper | 7 | 4.15 | 0.42 | nd | nd | nd | 5.00 | nd | nd | nd | | |

nd = for respirable dust analysis, mass was less than the limit of detection of 0.02 mg
for respirable quartz analysis, mass was less than the limit of detection of 0.01 mg
loq = mass was detected but less than the limit of quantitation of 0.03 mg
$mg/m^3$ = milligrams per cubic meter
PEL = OSHA Permissible Exposure Limit
REL = NIOSH Recommended Exposure Limit
TWA = time-weighted average

* Sites
1 - Brentwood, TN
2 - Cornersville, TN
3 - Dalton, GA
4 - Graysville, GA
5 - Ford, KY
6 - Clinchco, VA
7 - Ft. Blackmore, VA

Figure 1
Real-Time Dust Measurements* during Ballast Regulation
HETA 92-0311




* All concentrations are in photometric units

# APPENDIX

## EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects even though their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increases the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH Recommended Exposure Limits (RELs),[A1] (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVs®),[A2] and (3) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs).[A3] Employers are encouraged to follow the OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever are the more protective criterion. OSHA requires an employer to furnish employees a place of employment that is free from recognized hazards that are causing or are likely to cause death or serious physical harm [Occupational Safety and Health Act of 1970, Public Law 95–596, sec. 5.(a)(1)]. Thus, employers should understand that not all hazardous chemicals have specific OSHA exposure limits such as PELs and short-term exposure limits (STELs). An employer is still required by OSHA to protect their employees from hazards, even in the absence of a specific OSHA PEL.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8-to-10-hour workday. Some substances have recommended STEL or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from higher exposures over the short-term.

NIOSH and ACGIH recommend that exposure to respirable crystalline silica (as quartz or cristobalite) be controlled so that no worker is exposed to a TWA concentration greater than 0.05 mg/m$^3$. The OSHA permissible exposure limit (PEL) for respirable dust containing crystalline silica is based on the type of silica (e.g., quartz or cristobalite) and the percentage of silica found in respirable airborne samples. With this information the PEL is calculated for each sample using the following formula:

$$\mathbf{PEL}_{\substack{\text{respirable dust}\\ \text{containing quartz}}} = \frac{10\ \text{mg/m}^3}{\%\ \text{Quartz} + 2}$$

For respirable dust containing cristobalite, the PEL is ½ the value calculated from the quartz formula.

### APPENDIX REFERENCES


A1. NIOSH [1992]. NIOSH recommendations for occupational safety and health: compendium of policy documents and statements. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 92-100.

A2. ACGIH [2000]. 2000 TLVs® and BEIs®: Threshold limit values for chemical substances and physical agents and biological exposure indices. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

A3. CFR [1999]. 29 CFR 1910.1000. Code of Federal Regulations. Washington, DC: U.S. Government Printing Office, Office of the Federal Register.

For Information on Other
Occupational Safety and Health Concerns

Call NIOSH at:
1–800–35–NIOSH (356–4674)
or visit the NIOSH Web site at:
www.cdc.gov/niosh

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