



Occupational Health Clinics for Ontario Workers Inc.

2nd Annual Mining Vehicle Powertrain Conference (MVPC) 2024

Other hazards in mining in addition to
diesel emissions.



Kevin Hedges, PhD., M. App. Sc., BSc., FAIOH, COH, CIH

khedges@ohcow.on.ca

Occupational Hygienist

Occupational Health Clinics for Ontario Workers Inc.

<http://www.ohcow.on.ca/>

Judit Nelson, CRSP

Juditnelson@workplacesafetynorth.ca

Industrial Hygiene Specialist

Workplace Safety North (WSN)

<https://www.workplacesafetynorth.ca/en>



What this presentation will cover:

- i) Diesel engine exhaust (DEE) and other hazards and risks in mining including exposure to:
- ii) Inhalable / respirable dust (ISO 7708 - 1995)
- iii) respirable crystalline silica (RCS) mainly quartz,
- iv) isocyanate,
- v) noise and
- vi) heat.



Dust particles

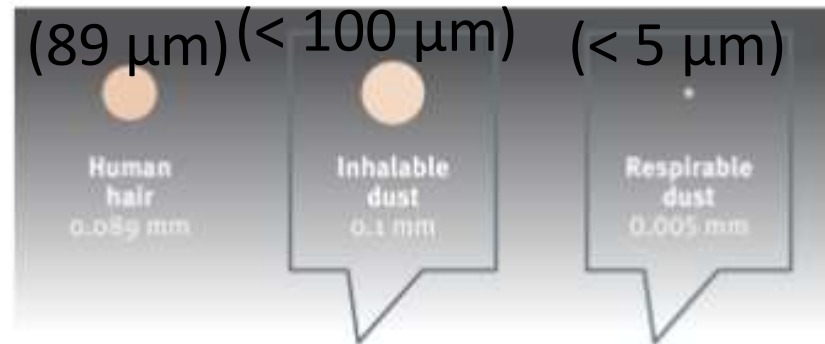
Dust is a word often used to describe fine, dry particles on the ground and in the air.

Dust particles fall into two categories, according to their size:

- *inhalable dust* (less than 0.1 mm or 100 μm diameter)
- *respirable dust* (less than 0.005 mm or 5 μm diameter).

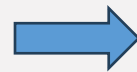
To give you an idea of these sizes, the following diagram compares both types of dust with the diameter of a single human hair.

Dust particle size comparison



	Inhalable dust	Respirable dust
Size	Dust particles of all sizes (typically less than 0.1 mm diameter)	Smallest dust particles (typically less than 0.005 mm diameter)
Visibility	Can be seen with the naked eye	Cannot be seen with the naked eye

<https://www.rshq.qld.gov.au/miners-health-matters/media/documents/airborne-dust-exposure.pdf>

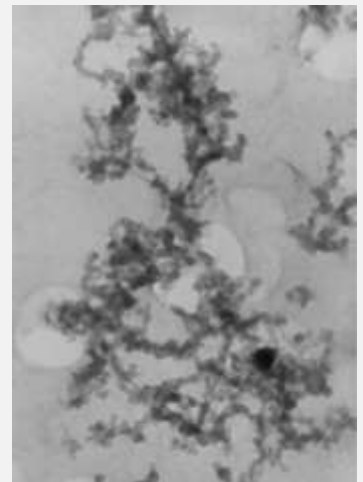


PM 2.5 (< 2.5 μm) typically associated with air pollution – an environmental measure

<https://www.igair.com/newsroom/pm2-5>



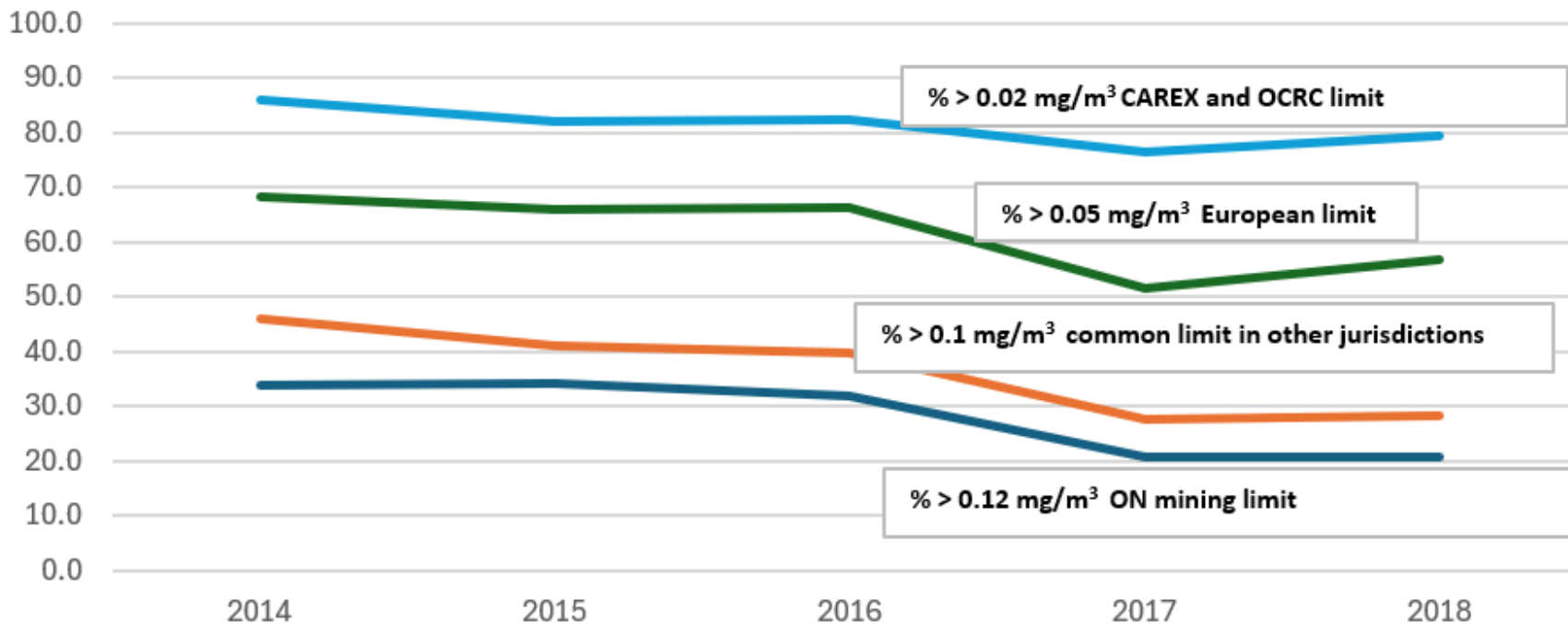
PM 0.1 (< 0.1 μm or 100 nm) are also called nanoparticles / ultra fines



Diesel Engine Exhaust (DEE) as respirable elemental carbon (REC)



% of samples exceeding occupational exposure limits for respirable elemental carbon (REC)



The Ontario Mining occupational exposure limit of 0.12 mg/m³ is

6 X

the Occupational Cancer Research Centre (OCRC) [policy recommended limit](#) of 0.02 mg/m³.

Exposure to - [vapours, dusts, gases and fumes](#) (VDGF) is also getting much more attention.

Refer to Arrandale et al. 2024 "[Exposure to Vapours, Gases, Dusts, and Fumes at Work in Relation to Chronic Bronchitis, Emphysema, and Chronic Obstructive Pulmonary Disease: A Systematic Review With Meta-analyses](#)".



The annual decrease in EC concentration was significant, suggesting approximately a 10% decrease per year. This is encouraging and may reflect the focus on reducing exposure to diesel engine exhaust in mining specifically.

However, many measurements were still above the current exposure limit for mining in Ontario which is set at $0.12\text{mg}/\text{m}^3$ EC, and well above the health-based limit suggested by the Health Council of the Netherlands ($0.00001\text{mg}/\text{m}^3$) (Vermeulen & Portengen, 2016).

The Ontario mining occupational exposure limit is

12,000 X

higher than the Netherlands health based suggested limit.

Vermeulen, R., & Portengen, L. (2016). Is diesel equipment in the workplace safe or not? *Occupational and Environmental Medicine*, 73(12), 846–848. <https://doi.org/10.1136/oemed-2016-103977>



[OCC-TOBER 2022: Diesel Exhaust Exposure – Influencing Change](https://www.ohcow.on.ca/posts/occ-tober-worker-focused-science-prevention-webinars-kickoff-event-2/)

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New guideline for reducing diesel particulate matter in underground mines

Monday, February 14, 2022
Two successful examples of control strategies for airborne hazards


 [Reducing diesel particulate matter in underground mines: Two successful examples](#)

A new guideline document for controlling diesel emissions in underground mines was introduced by the Ontario mining industry technical advisory committee.

"Diesel engine exhaust, including the diesel particulate matter, has been classified as carcinogenic to humans by the World Health Organization," says Keith Birnie, Industrial Hygienist and Ventilation Specialist at Workplace Safety North (WSN) and committee chair and coordinator. "For many years, diesel engines have been the workhorse in a large number of industries including mining, and diesel exhaust exposure presents an inhalation health hazard to workers."

In 2021, mining industry volunteers who make up the WSN Workplace Environment Technical Advisory Committee developed a practical reference document, "[Reducing diesel particulate matter in underground mines: Two successful examples](#)," for Ontario mining operations. The guide has information about the hazards of diesel engine exhaust along with examples on controlling diesel emissions, with a focus on diesel particulate matter.

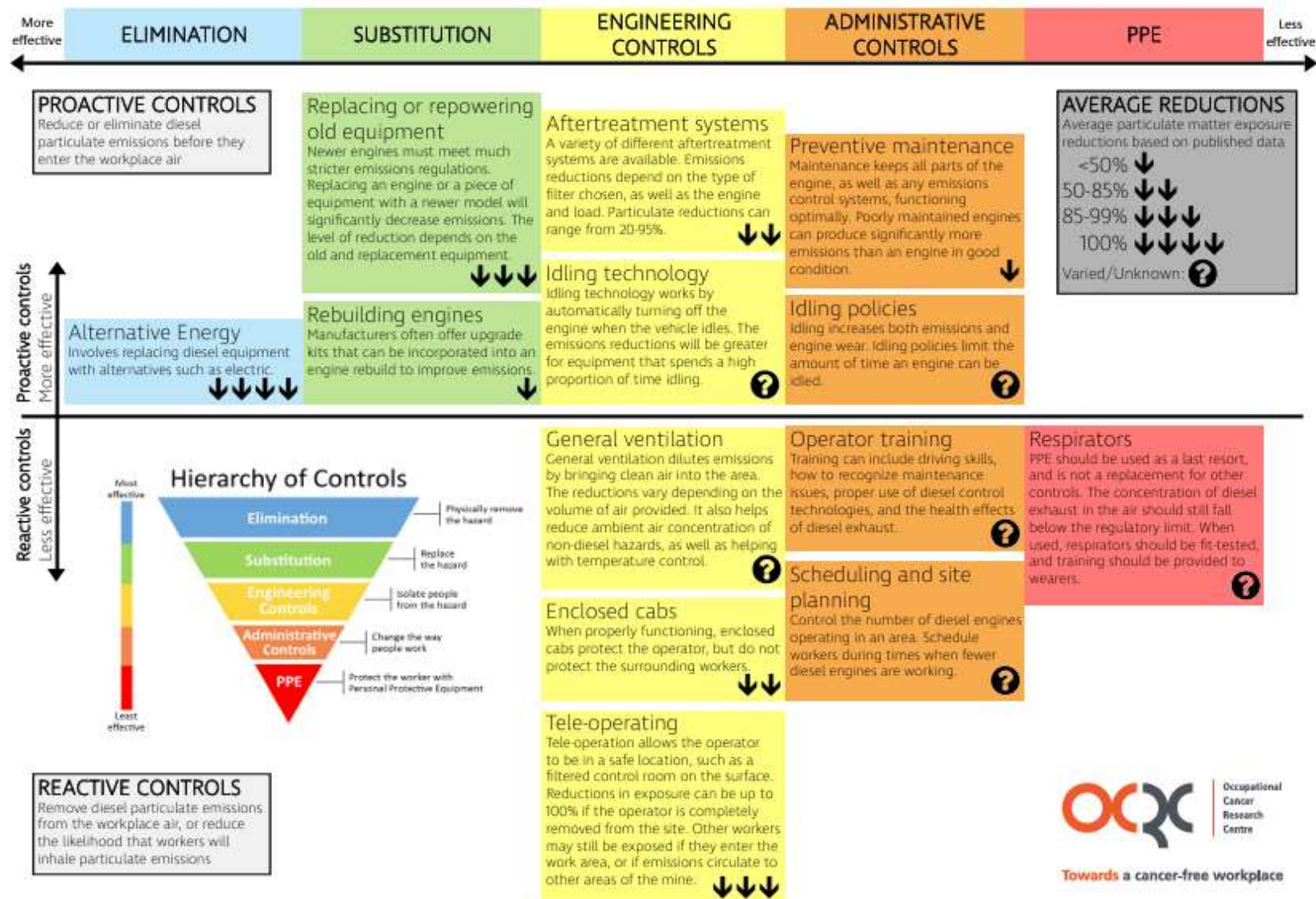
Occupations with potential exposure to diesel emissions include miners, construction workers, heavy equipment operators, bridge and tunnel workers, railroad workers, oil and gas workers, loading dock workers, truck drivers, material handling operators, farmworkers, long-shoring workers, and auto, truck and bus maintenance garage workers.



WSN (2022)
[Guideline for reducing diesel particulate matter in underground mines](#)



CONTROLLING DIESEL PARTICULATE MATTER IN UNDERGROUND MINES



Respirators



Full protection offered by filtering face piece respirators against diesel particulate matter, containing **ultrafine particles** (particle midpoint diameter $<100\text{nm}$) **is questionable.**

Burton K A (2023), PhD., thesis;

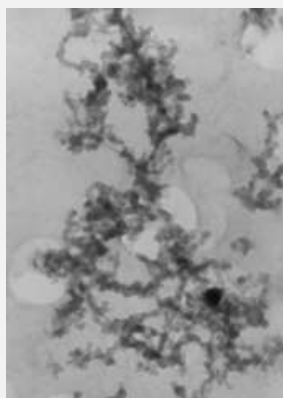
Do AS/NZS Respiratory Protection Standards for Filter Penetration Ensure that Worker Health is Protected Against Nanoparticle Sized Diesel

Particulate Matter? <https://ro.uow.edu.au/theses1/1563/>

Even Respirators May Not Be Completely Effective



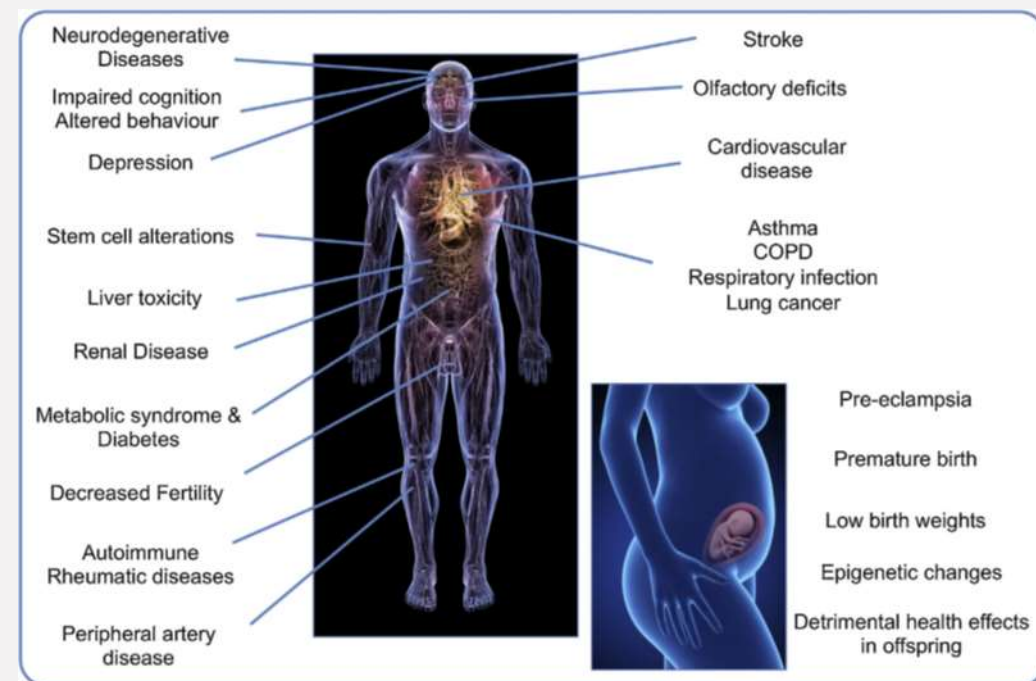
Figure 3.10: NIOSH 5040 filter canisters post sampling. 30428 - pre-filter sample, 30429, 403, 404 and 405 - post filter samples, 95% tests



Jennifer B. Raftis, Mark R. Miller (2019)
University/BHF Centre for Cardiovascular Science,
University of Edinburgh, Edinburgh, United Kingdom

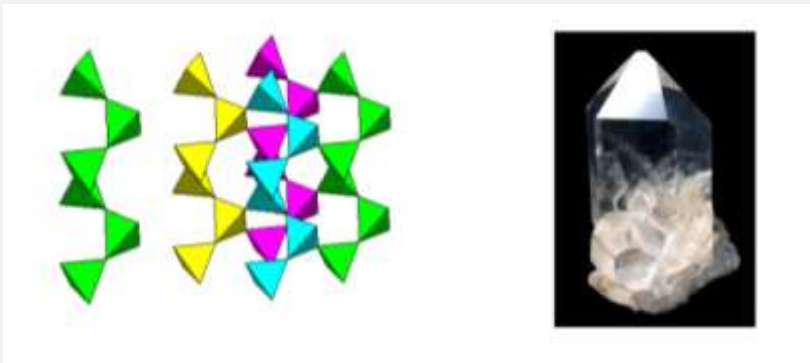
Nano Today, Vol. 26, pp.8 – 12

[Nanoparticle translocation and multi-organ toxicity: A particularly small problem](#)



Other hazards in mining

What about very freshly cut / crushed dry respirable crystalline silica (RCS) (Quartz)



Known health effects of respirable crystalline silica (RCS) among others.

- Lung cancer.
- Silicosis.
- Chronic obstructive pulmonary disease (COPD).
- Autoimmune diseases.
- **Sarcoidosis** (Occupational exposures for which associations are strongest and most consistent are silica and other inorganic dusts, Zarnke et al. 2022), [Sarcoidosis in Northern Ontario hard-rock miners: A case series](#)

What about if we compare results from spirometry with exposure monitoring for respirable crystalline silica.

Spirometer evaluating lung health



Cyclone for personal exposure monitoring



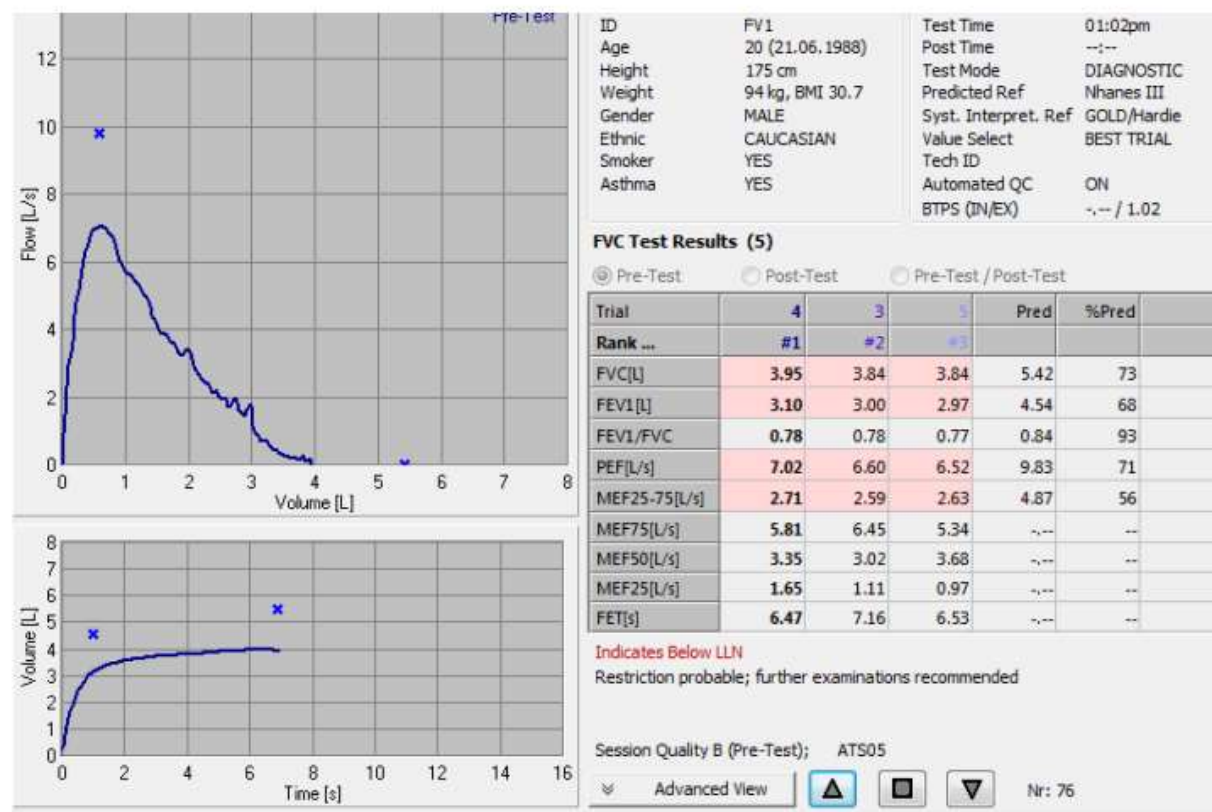
Worker FV1

Loader operator (Restriction probable – further examination recommended)

FEV1 % of predicted 68

Maximum RCS individual exposure 0.06 mg/m³

SEG MVUE RCS exposure 0.04 mg/m³



Spirometer

Figure 5.17 – Individual spirometry for a worker (FV1) driving loader.

2 years in quarrying industry

Symptoms reported by worker FV1 included:

- Cough & wheeze if run or climb stairs fast (4a&4b).
- Wake up in the morning with wheeze (6a).
- Wheeze in a smoky room (7).
- Usually cough first thing in the morning in winter (9)
- and during the day or night in winter (10).
- Cough on most days as much as three months a year (11).
- Usually bring up phlegm in the morning in winter (12)
- and during the day or at night in winter (13).
- Bring up phlegm like this on most days for at least three months a year (14)

This operator drives the loader and doesn't normally wear a respirator inside the cabin. Symptoms are consistent with asthma and chronic bronchitis. A restrictive disease pattern is indicative of silicosis.

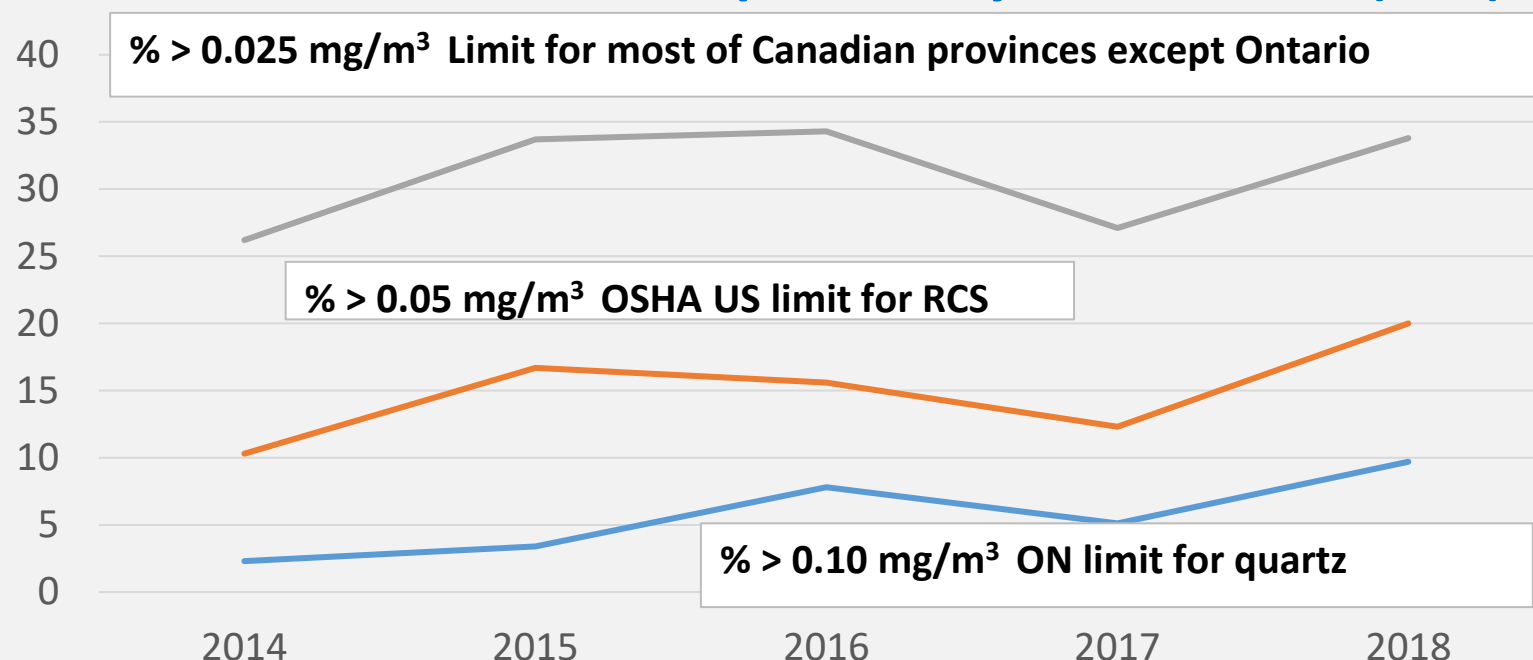
<https://researchdirect.westernsydney.edu.au/isl/andora/object/uws:36593> Hedges K (2016).



Exposure trend for RCS between 2014 and 2018 for selected mines



% of samples exceeding occupational exposure limits for respirable crystalline silica (RCS)





← Spirometer

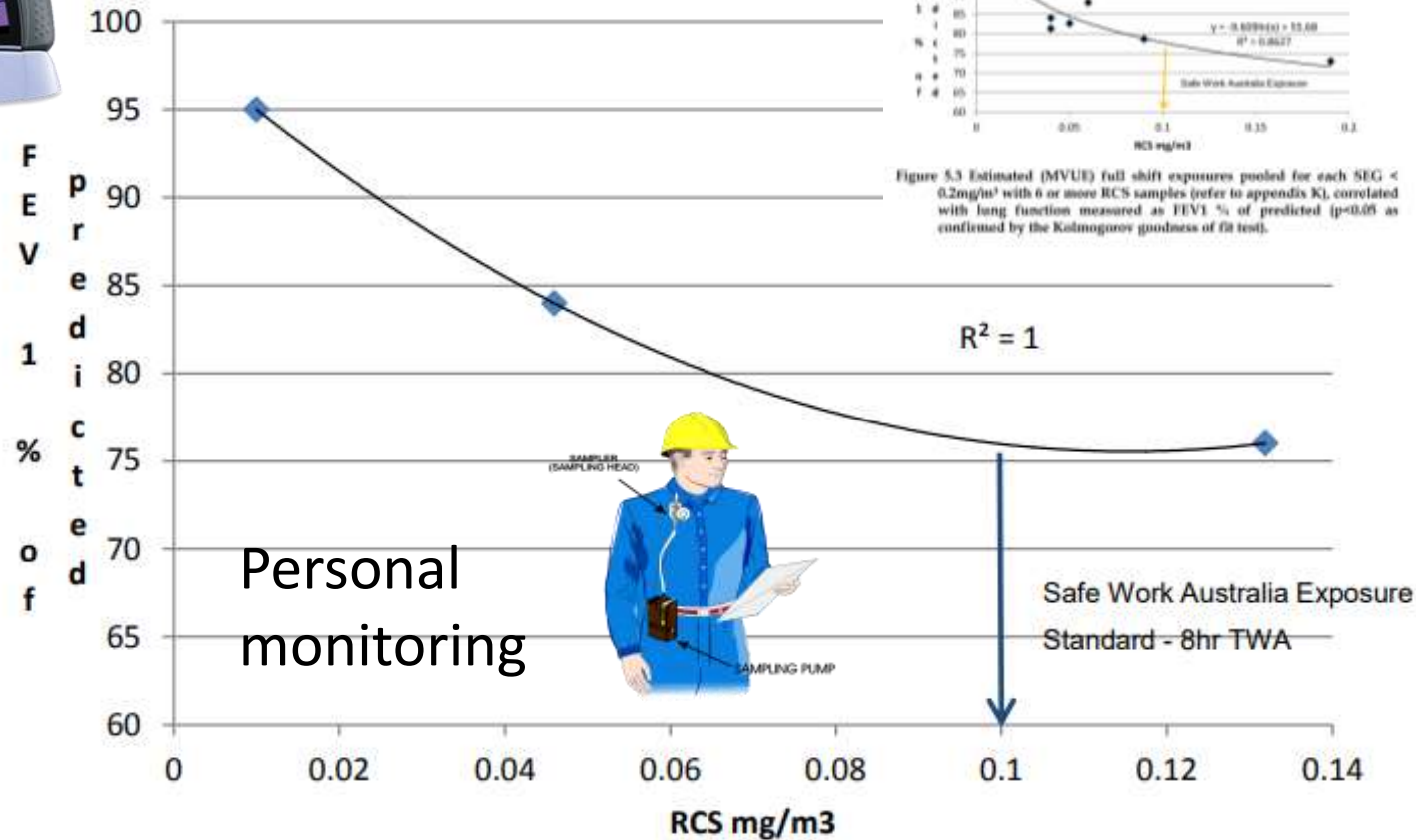


Figure 5.11 Average maximum FEV1 % of predicted for each group correlated with RCS group average exposures.

This is now 0.05 mg/m³ and may be reduced further as of Oct 2024.

In addition, as respirable crystalline silica (RCS) and diesel particulate matter (DPM) are both confirmed lung carcinogens a mixture formula should apply.

$$\frac{\text{Exposure to DPM}}{(\text{OEL})} + \frac{\text{Exposure to RCS}}{(\text{OEL})} \text{ Must be } < 1$$

If > 1 “*the occupational exposure limit of the mixture should be considered as exceeded*” (ACGIH Threshold Limit Values)

It is difficult to know whether miners are being impacted by silica-related diseases as there is no public medical surveillance for miners in Ontario; these programs are required to be offered by the employer, but they are optional for individual workers and the resulting records are not compiled or evaluated. Historically there was a mandatory surveillance program for underground miners; this ceased in the mid-1980s.

It is very important that a mandatory medical surveillance program be re-introduced in mining.



The impact from exposure and health effects can be measured.



Joanna McNeill • 1st

Advocate for Silica dust awareness

1w • Edited •

🔥 Silicosis warriors 🔥

I'm thrilled that the team at [Monash University](#) has developed an innovative device that could save countless lives. This non-invasive breath test can detect early signs of silicosis, enhancing screening and health outcomes for workers exposed to silica dust.

Your participation will involve:

✅ 15 minutes of normal breathing into a mouthpiece

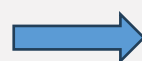
✅ A small blood sample

✅ Total time commitment: approx. 1 hour

📍 Location: Monash University, Clayton

For more details or to participate, contact: 📞 Paris Papagianis: 0433 927 197

✉️ paris.papagianis@monash.edu



Key Occupational Diseases in Mining to Target for Prevention Purposes

	HR (95% CI)
Lung Cancer	1.40 (1.31-1.51)
Chronic Obstructive Pulmonary Disease (COPD)	1.24 (1.13-1.35)
Silicosis	10.6 (6.98-16.1)
Idiopathic Pulmonary Fibrosis	1.84 (1.34-2.51)
Acute Myocardial Infarction (AMI)	1.15 (1.04-1.27)
Carpal Tunnel Syndrome (CTS)	1.59 (1.42-1.78)
Raynaud's Syndrome	1.18 (1.07-1.30)

HR = Hazard Ratio, CI = Confidence Interval

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An in-depth look at disease surveillance and prevention in Ontario

On October 2, 2024, Workplace Safety North (WSN) hosted a webinar focused on occupational disease risks in key industries such as mining, forestry, and pulp and paper. View webinar recording: Webinar: Occupational disease risks in key industries. <https://www.youtube.com/watch?v=Esb6pQ9fKJc>

Isocyanate Resin $\text{N}=\text{C}=\text{O}$ Isocyanate Exposure



- Used extensively in mining and construction to fill cavities and reinforce or stabilize strata in the underground environment
- Methylene diphenyl isocyanate (MDI) is a common ingredient and is a known **respiratory sensitizer** and skin allergen which can be inhaled or absorbed through direct skin contact. **After sensitization, any exposure, even to levels below existing occupational exposure limits or standards, can produce an asthma-like response that may be life threatening.**

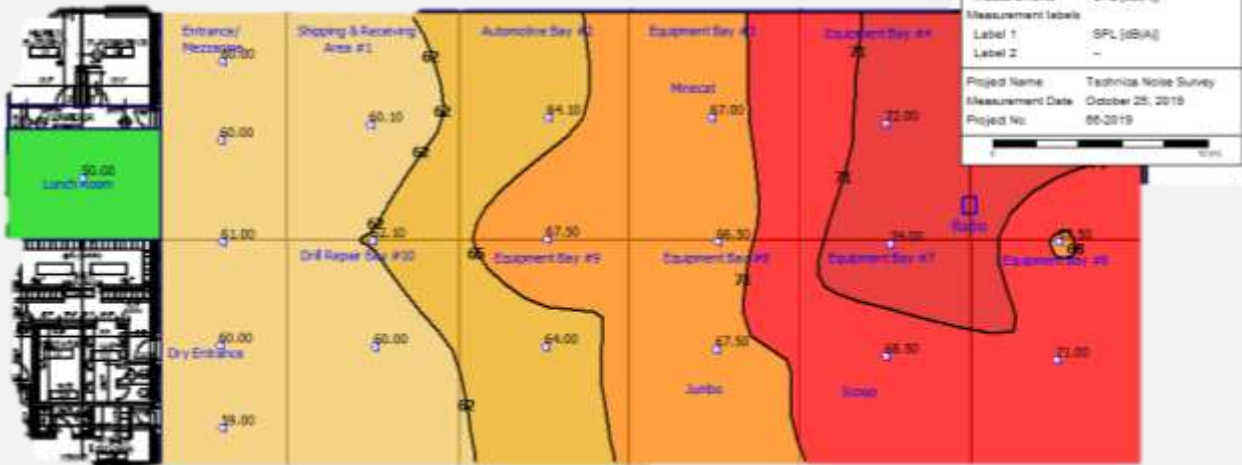
Streicher et al. 1998, "DETERMINATION OF AIRBORNE ISOCYANATE EXPOSURE". <https://www.cdc.gov/niosh/docs/2003-154/pdfs/chapter-k.pdf>

- Testing results from Queensland Australia have identified and confirmed the **presence of unexpected organo-isocyanate species** and variants of MDI that are not detected by current biological sampling or atmospheric monitoring methods. **Just because it is not detected doesn't mean that it is not present.** https://www.aioh.org.au/video_library/webinar-recording-isocyanate-resins-exposure-monitoring-recording-22-03-2024/

- Awareness of skin exposure and risk as a significant route of exposure and absorption is **VERY IMPORTANT** Bello et al. 2006, [Skin Exposure to Isocyanates: Reasons for Concern](#).

Noise

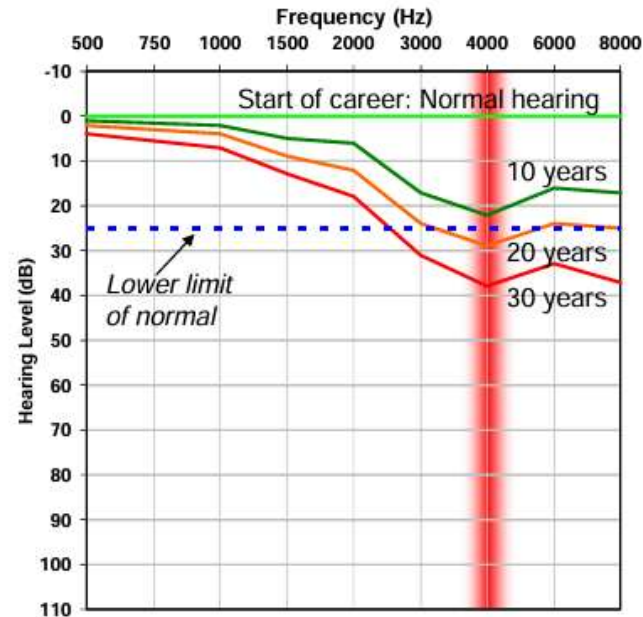
It can be measured



Audiometry

Effect of loud [95dB(A)] noise over a career*

- Noise-induced loss greatest at 4000 Hz
- Some of this hearing loss is due to aging, but **most** is due to **noise**



*(estimated based on ANSI S3.44 standard)

Enhancing Workplace Safety: A Systematic Review of Hearing Protection Fit-Testing Systems and Training



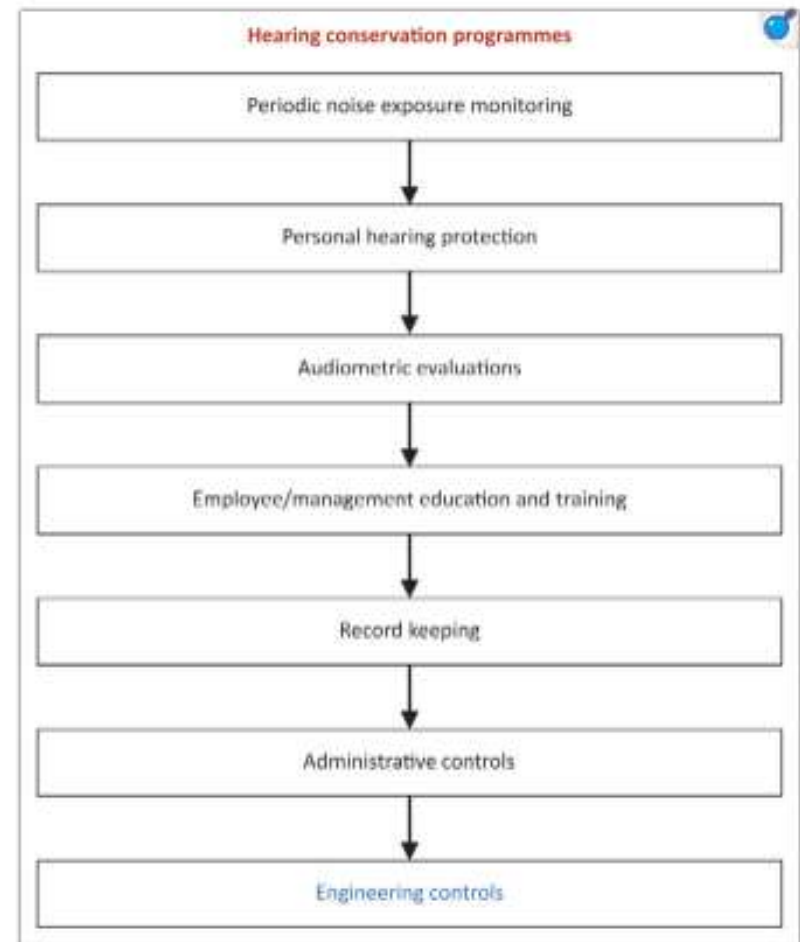
The effectiveness of Hearing Protection Devices heavily on proper usage and fit. Ill-fitting earplugs are a common challenge faced by workers, compromising their ability to adequately protect their hearing.

Have you incorporated fit testing hearing protection at your work?

<https://blogs.cdc.gov/niosh-science-blog/2024/07/30/hearing-protection-fit-testing/>

Engineering noise control for mines: Lessons from the world (Madahana et al. 2020).

<https://pmc.ncbi.nlm.nih.gov/articles/PMC7136811/>



Source: Moroe, N.F. (2018). Occupational noise-induced hearing loss in South African large scale mines: From policy formulation to implementation and monitoring. Doctoral thesis. Johannesburg: University of the Witwatersrand

Seven pillars of an effective hearing conservation programme.

Exposure to heat leading to heat stress and heat stroke

HUMIDEX-BASED HEAT STRESS CALCULATOR and PLAN*

Working in extreme conditions can be hazardous to your health.
Heat and humidex are no exception.

Symptoms of heat stress include:



Weakness



Fatigue



Dizziness

The following Humidex-Based Heat Stress Calculator uses temperature and humidity percentage (%)
to calculate humidex and provides recommended actions.

*NOTE: This works for workplaces where workers are wearing regular work clothes (i.e., no extra clothing or PPE to reduce sweat evaporation rates), and have no significant sources of radiant heat (e.g., sunlight, process heat, etc.). Outdoor workers may have a radiant heat exposure that workers who are not working in the shade, will under-estimate the

The Calculator

IMPORTANT NOTE:
If you are new to using this calculator please read the [Humidex-based Heat Response Plan \(Steps\)](#) below to learn more about where and how to take measurements, adjusting for clothing and radiant heat, etc.

Next, provide the following information based on the location being measured:

Temperature

35 °C

Humidity

40 %

CALCULATE

CLEAR

CURRENT HUMIDEX
Based on the data entered above, the current humidex is:
42
SEVERE RISK
Only work with 45 minutes relief per hour should continue.
Provide 240 ml. of water every 20 minutes.

The humidex level above is colour-coded to correspond with the recommendations below



HUMIDEX RISK RECOMMENDED ACTIONS / RECOMMENDATIONS

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REMEMBER – Never ignore anyone's symptoms – despite what the measurements indicate

The (Humidex-based Heat Response) Plan

A Simplified Method of Protecting Workers from Heat Stress

Based on the 2009 ACGIH Heat Stress Threshold Limit Values (TLV®), it uses Wet Bulb Globe Temperature (WBGT) to estimate heat strain. These WBGTs are then converted into Humidex. The ACGIH specifies an Action Limit and a TLV to prevent workers' body temperature from exceeding 38.5°C (101.3°F) to minimize illness.

Below the Action Limit (Humidex 1): For most of exposed physical activity, most workers will not experience heat stress.

Between Humidex 1 and Humidex 2: general heat stress controls are to be provided.

Above Humidex 2, job-specific controls are needed for acclimatized workers.

For unacclimatized workers, job-specific controls may also be needed to reduce heat strain below the TLV (Humidex 2) criteria.

The TLV (Humidex 2) only applies to healthy, well-hydrated, acclimatized workers who are not on medication.

STEP 1: Training

STEP 2: Adjusting for Clothing

STEP 3: Measurement Location

STEP 4: Measurement Devices

STEP 5: Adjusting for Radiant Heat

Additional Considerations

Health Effects of Heat Stress*

The health effects of heat stress include:

- Heat Rash
- Fainting*
- Heat Cramps
- Heat Exhaustion*
- Heat Stroke*

***EMERGENCY! MEDICAL ASSISTANCE REQUIRED!**

The terms regarding heat cramps, heat exhaustion, and heat stroke are copyright Mayo Foundation for Medical Education and Research. All rights reserved. Used with permission from www.mayoclinic.org.

Heat Rash and Fatigue adapted from Ontario Ministry of Labour Heat Stress Guideline (revised January 2017).

For printing purposes, you can also download the [Humidex-based Heat Response Plan](#) as a PDF.

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45+ EXTREME	Only medically supervised work should continue. Humidex exposures above 45, heat stress should be managed as per the ACGIH TLV®.
42-44 SEVERE	Work with 45 minutes relief per hour can continue – in addition to the provisions listed below.
40-41 SIGNIFICANT	Work with 30 minutes relief per hour can continue – in addition to the provisions listed below.
38-39 MODERATE	Work with 15 minutes relief per hour can continue. <ul style="list-style-type: none"> Provide adequate cool (10-15°C) water. Drink at least 1 cup (240 mL) of water every 20 minutes. Note: Worker(s) with symptoms should seek medical attention.
34-37 MORE	<ul style="list-style-type: none"> Post Heat Stress Warning notice. Notify workers that they need to drink extra water. Ensure workers are trained to recognize symptoms.
30-33 SOME	<ul style="list-style-type: none"> Post heat stress alert notice. Encourage workers to drink extra water. Record hourly temperature and relative humidity.
25-29 NONE	<ul style="list-style-type: none"> Supply water to workers on an "as needed" basis.

General controls apply to unacclimatized workers and include:

- Providing annual heat stress training
- Encouraging adequate fluid replacement
- Permitting self-limitation of exposure
- Encouraging watching out for symptoms in co-workers
- Adjusting expectations for workers coming back to work after an absence.

NOTE: clothing and radiant heat must also be taken into account when using this guideline (see steps #1-5 below).

Workers doing moderate work are considered acclimatized in Ontario only if they regularly work around heat sources (e.g. in foundries, around ovens, etc.)

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Heat Stress Toolkit

Heat stress is a serious threat to workers. It occurs when the body is unable to get rid of excess heat, which causes the heart rate and core body temperature to increase, often leading to heat-related illness. The tools in this Heat Stress Toolkit will help you understand the heat conditions in your workplace, assess the risk of heat stress and take action to protect yourself or your workers.



Heat stress is a life-threatening, occupational illness with both short and long-term effects

It affects *thousands* of workers across Canada every year

Our weather is very unpredictable and with climate change it is only going to get worse. It is important to understand the signs and symptoms of heat-related illness and to know how to respond should an emergency situation arise.

The following resources have been developed to promote the dangers of working in heat, and to guide you in creation of your own heat stress emergency response plan.

<https://www.ohcow.on.ca/heat-stress-toolkit/>

- With climate change **heat stress management programs** are becoming increasingly important for protecting the health and safety of workers in the Canadian mining industry (Tetzlaff EJ, O'Connor FK, Meade RD, Kenny GP 2024, An exploratory survey of on-site heat stress management practices in the Canadian mining industry. J Occup Environ Hyg 2024 May-Jun;21(6):409-422. doi: 10.1080/15459624.2024.2332722. <https://www.tandfonline.com/doi/full/10.1080/15459624.2024.2332722>)
- There needs to be a [sense of urgency](#) to further develop policies, procedures, programs (including measurement) to manage heat stress.
- Mine ventilation systems are important for the safe operation of underground mines and provide fresh airflow and remove the contaminated air but also lower the heat and humidity (Nie et al. 2018, [Heat Treatment and Ventilation Optimization in a Deep Mine](#)).
- **Heat stroke can kill or cause damage to the brain and other internal organs.** [Heat Stroke Isn't Just a Short-Term Danger.](#)

Supporting references

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- Tetzlaff EJ, O'Connor FK, Meade RD, Kenny GP 2024, An exploratory survey of on-site heat stress management practices in the Canadian mining industry. J Occup Environ Hyg 2024 May-Jun; 21(6): 409-422. doi: 10.1080/15459624.2024.2332722. <https://www.tandfonline.com/doi/full/10.1080/15459624.2024.2332722>
- University of Arizona nd. Hazardous Noise. <https://miningsh.arizona.edu/safety-and-health/hazardous-noise>

If you need more information, please contact us

Kevin Hedges, PhD., M. App. Sc., BSc., FAIOH, COH, CIH

khedges@ohcow.on.ca

Occupational Hygienist

Occupational Health Clinics for Ontario Workers Inc.

<http://www.ohcow.on.ca/>

Judit Nelson, CRSP

Juditnelson@workplacesafetynorth.ca

Industrial Hygiene Specialist

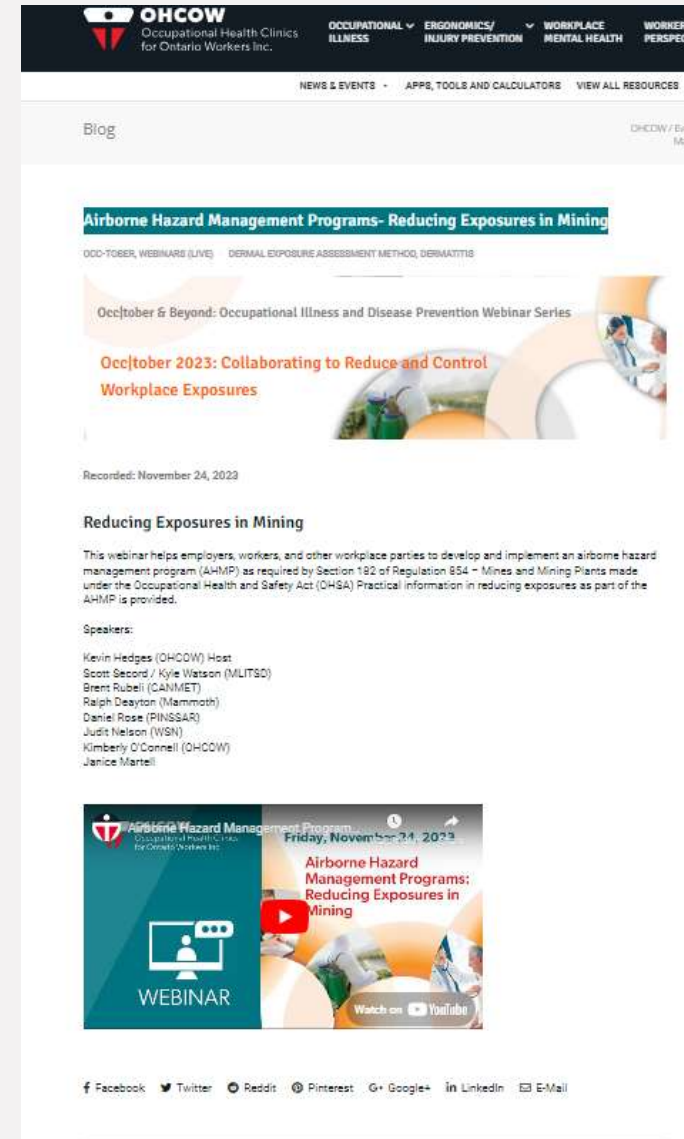
Workplace Safety North (WSN)

<https://www.workplacesafetynorth.ca/en>



Occupational Health Clinics for Ontario Workers Inc.
Prevention Through Intervention

See also:



<https://www.ohcow.on.ca/posts/airborne-hazard-management-programs-reducing-exposures-in-mining/>