Occupational Health Clinics for Ontario Workers Inc.

2nd Annual Mining Vehicle Powertrain Conference (MVPC) 2024

Other hazards in mining in addition to diesel emissions.

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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

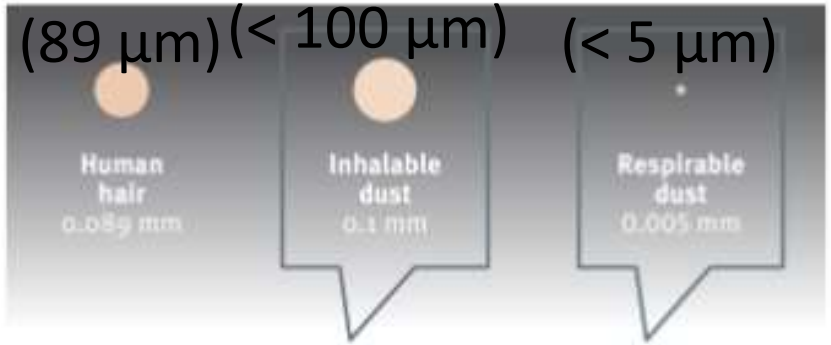
Dust is a word often used to describe fine, dry particles on the ground and in the air.

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

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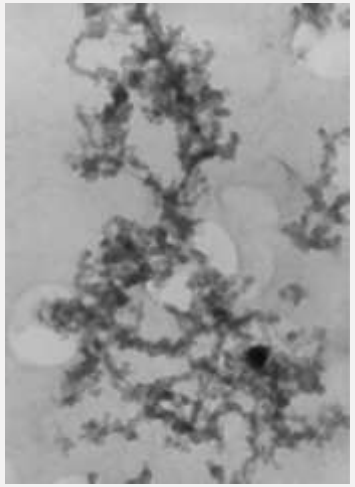
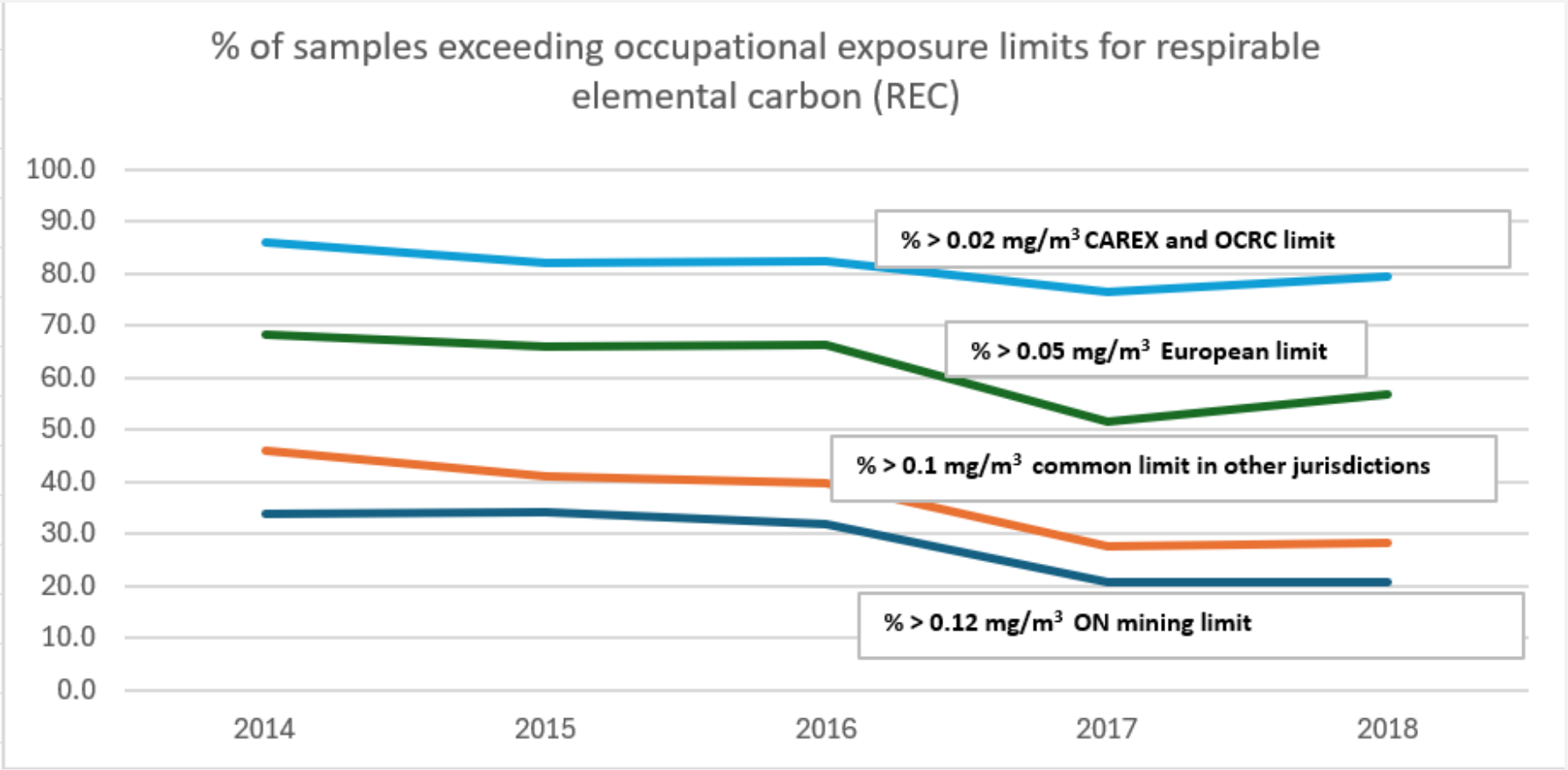
PM 2.5 (< 2.5 µm) typically associated with air pollution – an environmental measure
https://www.iqair.com/newsroom/pm2-5

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



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



The Ontario Mining occupational esposure 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 0.12mg/m^3 EC, and well above the health-based limit suggested by the Health Council of the Netherlands (0.00001mg/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

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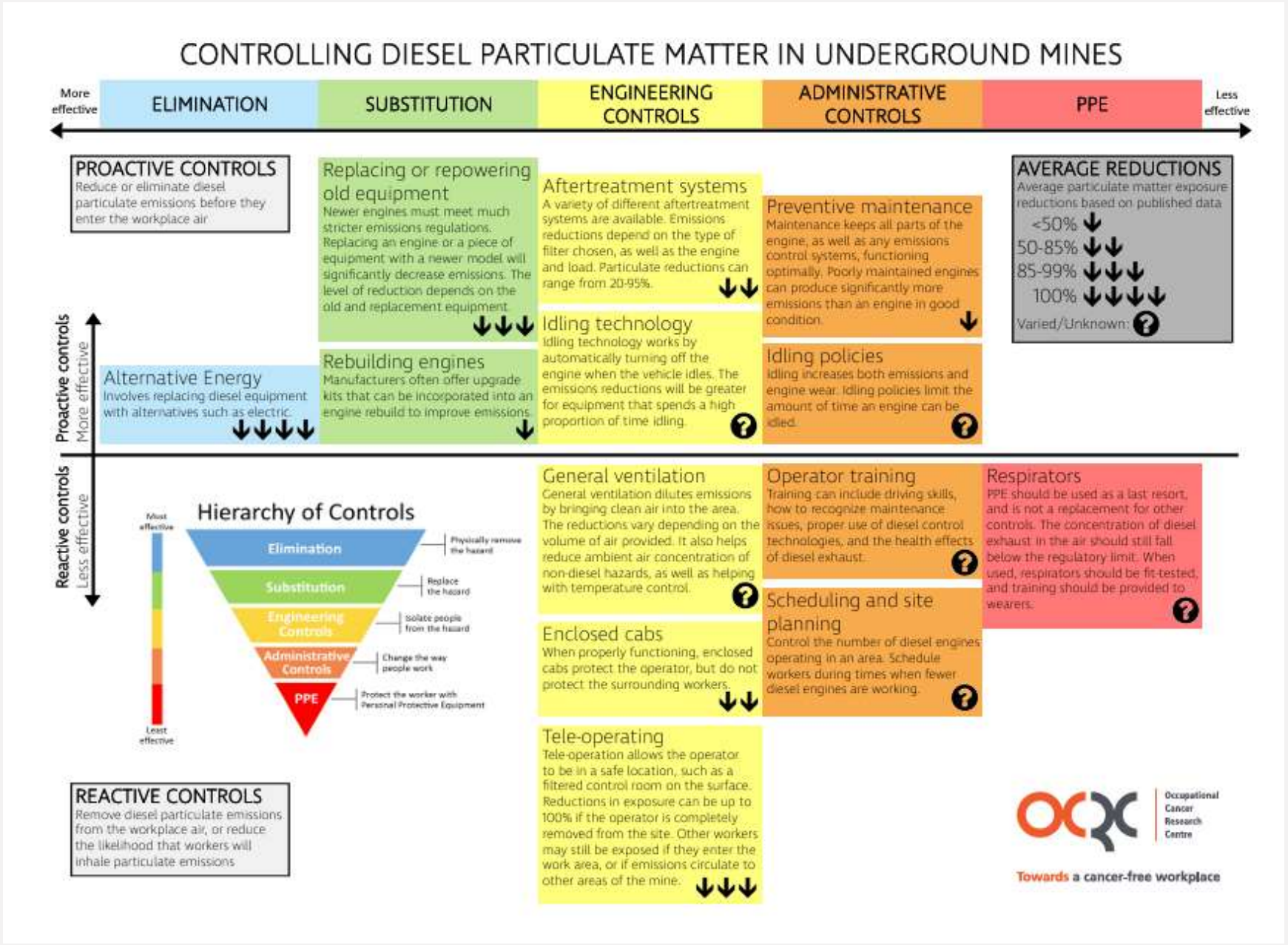
CROSH CRRST
OHCOW
USW

https://www.ohcow.on.ca/posts/occ-tober-worker-focused-science-prevention-webinars-kickoff-event-2/

What Now ?

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



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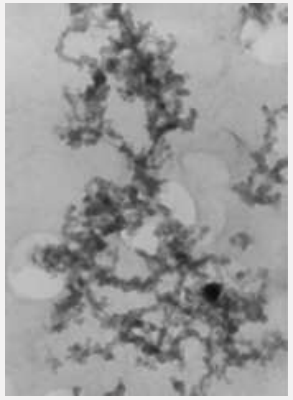
https://www.occupationalcancer.ca/wp-content/uploads/2023/04/Mining_Diesel-Particulate-Control-Strategies.pdf

Respirators

Full protection offered by filtering face piece **respirators** against diesel particulate matter, containing **ultrafine particles** (particle midpoint diameter <100nm) **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/

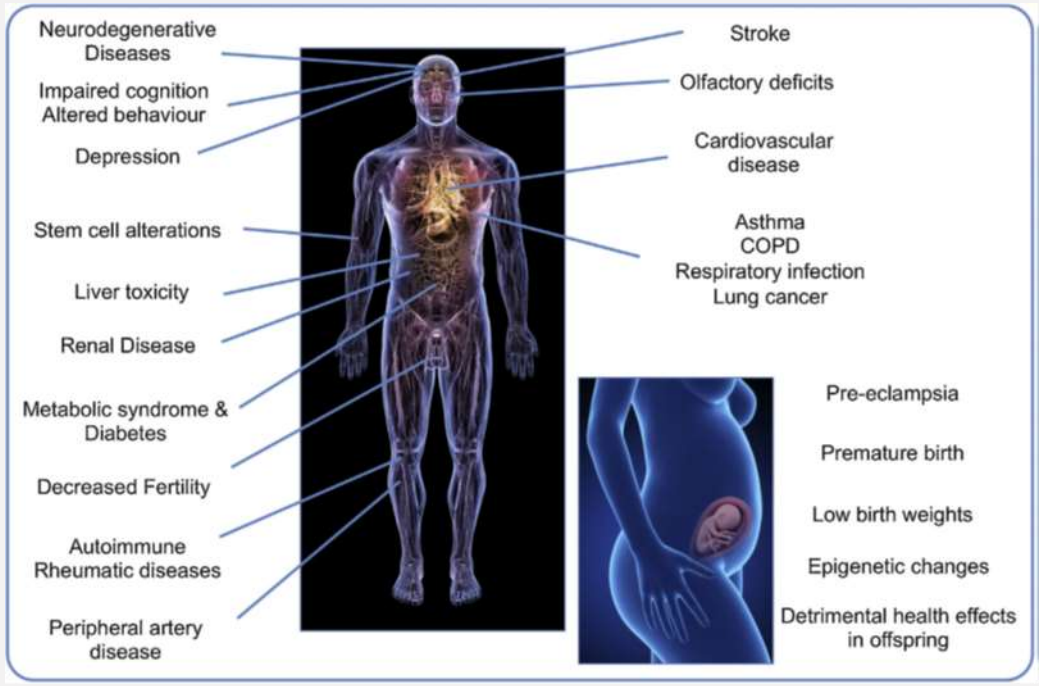
Even Respirators May Not Be Completely Effective



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

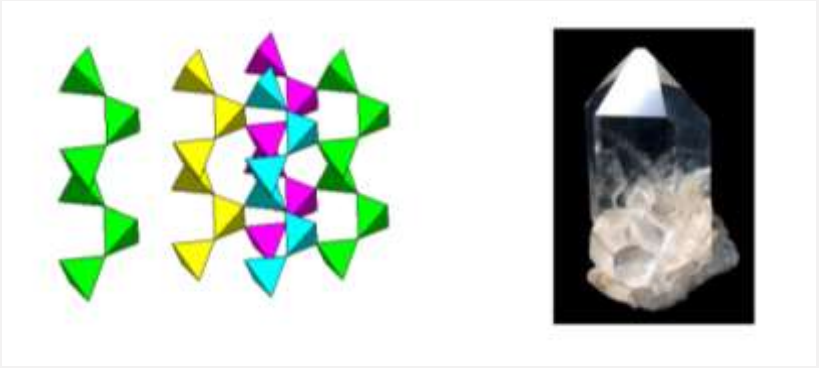
Nano Today, Vol. 26, pp.8 – 12

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.

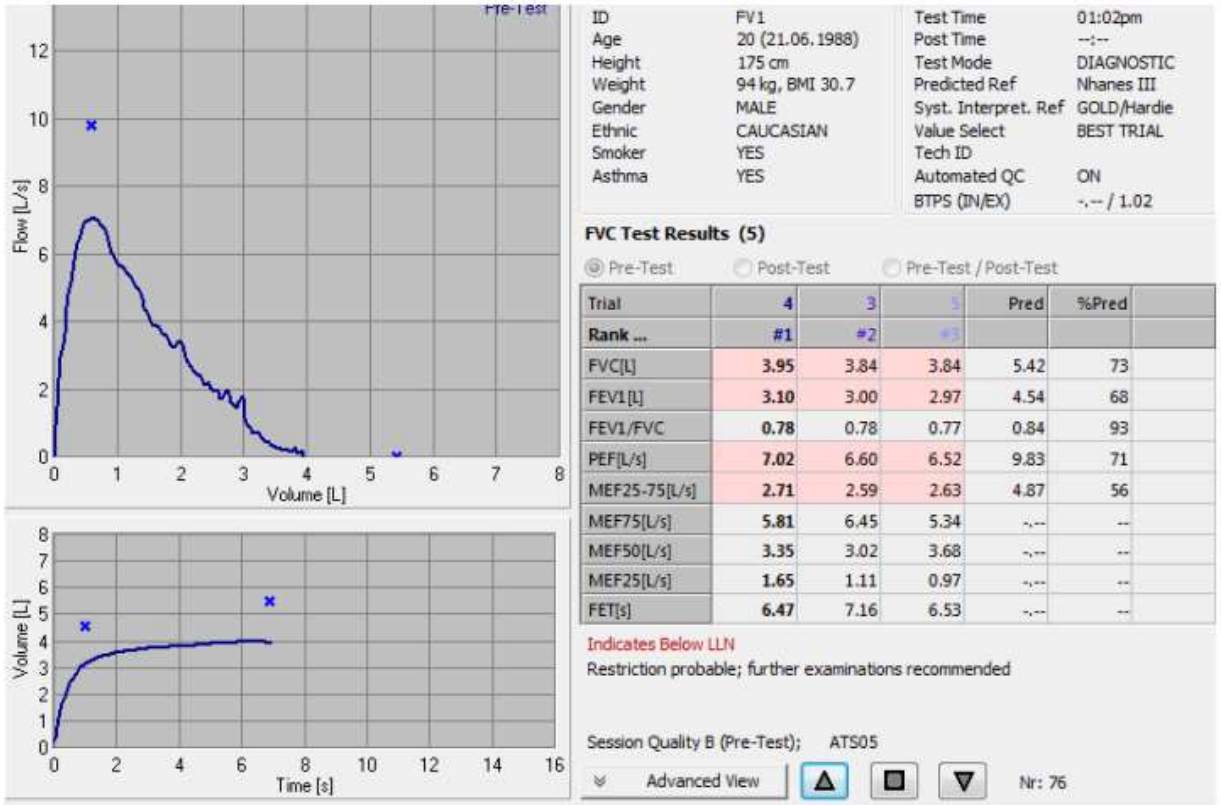
Spirometer evaluating lung health

Cyclone for personal exposure monitoring

Spirometer

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



ID	FV1	Test Time	01:02pm
Age	20 (21.06.1988)	Post Time	--:--
Height	175 cm	Test Mode	DIAGNOSTIC
Weight	94 kg, BMI 30.7	Predicted Ref	Nhanes III
Gender	MALE	Syst. Interpret. Ref	GOLD/Hardie
Ethnic	CAUCASIAN	Value Select	BEST TRIAL
Smoker	YES	Tech ID	
Asthma	YES	Automated QC	ON
		BTPS (IN/EX)	-.-- / 1.02

FVC Test Results (5)

Pre-Test Post-Test Pre-Test / Post-Test

Trial	4	3	5	Pred	%Pred
Rank ...	#1	#2	#3		
FVC[L]	3.95	3.84	3.84	5.42	73
FEV1[L]	3.10	3.00	2.97	4.54	68
FEV1/FVC	0.78	0.78	0.77	0.84	93
PEF[L/s]	7.02	6.60	6.52	9.83	71
MEF25-75[L/s]	2.71	2.59	2.63	4.87	56
MEF75[L/s]	5.81	6.45	5.34	-.--	--
MEF50[L/s]	3.35	3.02	3.68	-.--	--
MEF25[L/s]	1.65	1.11	0.97	-.--	--
FET[s]	6.47	7.16	6.53	-.--	--

Indicates Below LLN
Restriction probable; further examinations recommended

Session Quality B (Pre-Test); ATS05

Advanced View Nr: 76

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

2 years in quarrying industry
Symptoms reported by worker FV1 included:

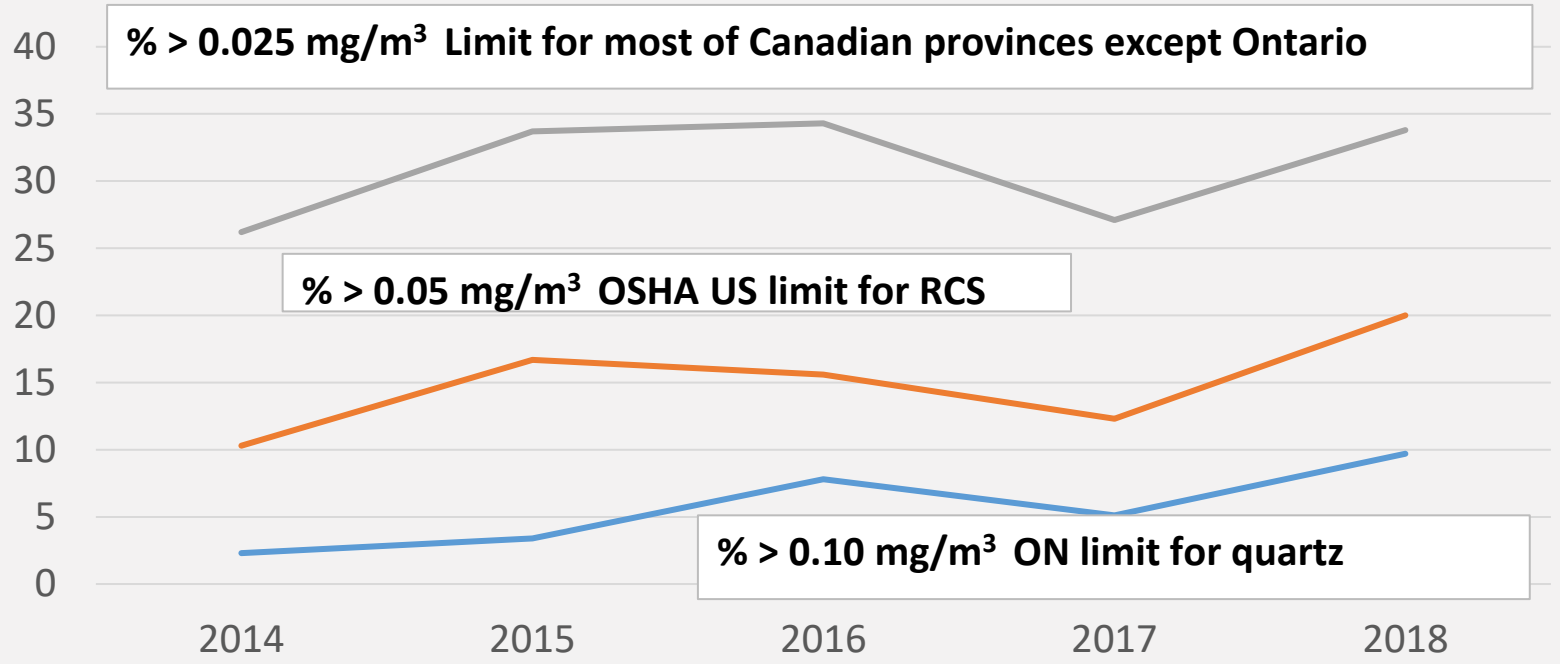
- Cough & wheeze if run or climb stairs fast (4a&4b).
- Wake up in the morning with wheeze (6a).
- Wheeze in a smoky room (7).
- Usually cough first thing in the morning in winter (9)
- and during the day or night in winter (10).
- Cough on most days as much as three months a year (11).
- Usually bring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



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In addition, exposure to vapours, dusts, gases and fumes (VDGF) are 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".

Spirometer

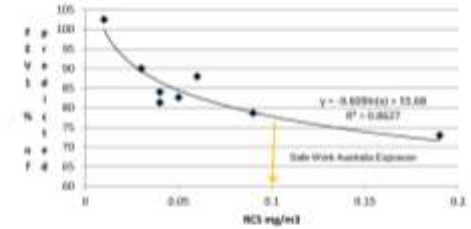

Figure 5.3 Estimated (MVUE) full shift exposures pooled for each SEG < 0.2mg/m³ with 6 or more RCS samples (refer to appendix K), correlated with lung function measured as FEV1 % of predicted (p<0.05 as confirmed by the Kolmogorov goodness of fit test).

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

This is now 0.05 mg/m^3 and may be reduced further as of Oct 2024.

https://researchdirect.westernsydney.edu.au/islandora/object/uws:36593 Hedges K (2016).

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

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

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.

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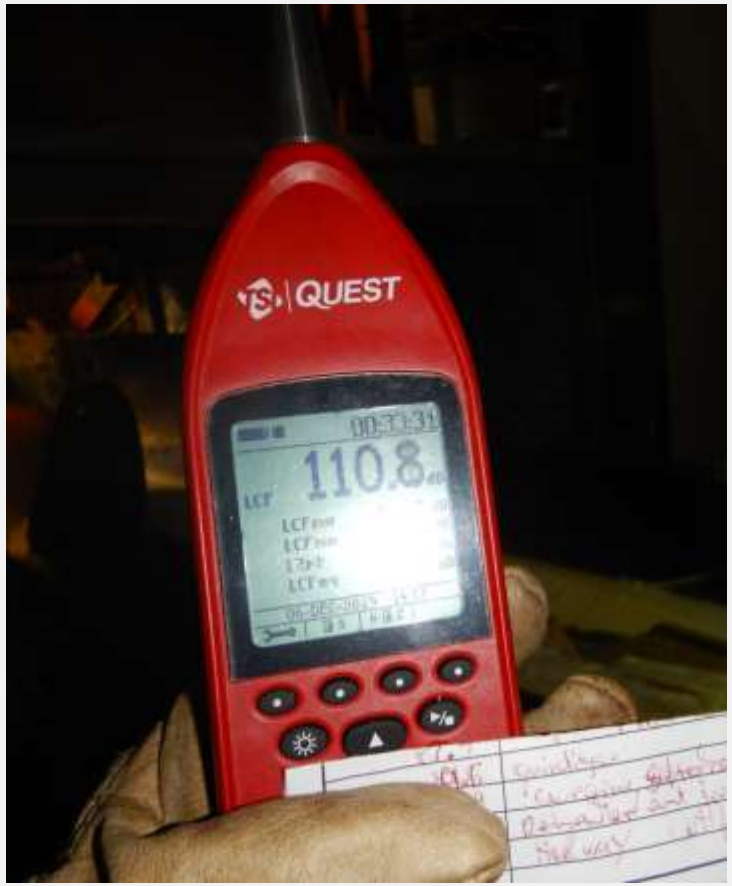
An in-depth look at disease surveillance and prevention in Ontario
On October 2, 2024, Workplace Safety North (WSN) hosted a webinar focused on occupational disease risks in key industries such as mining, forestry, and pulp and paper. View webinar recording: Webinar: Occupational disease risks in key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

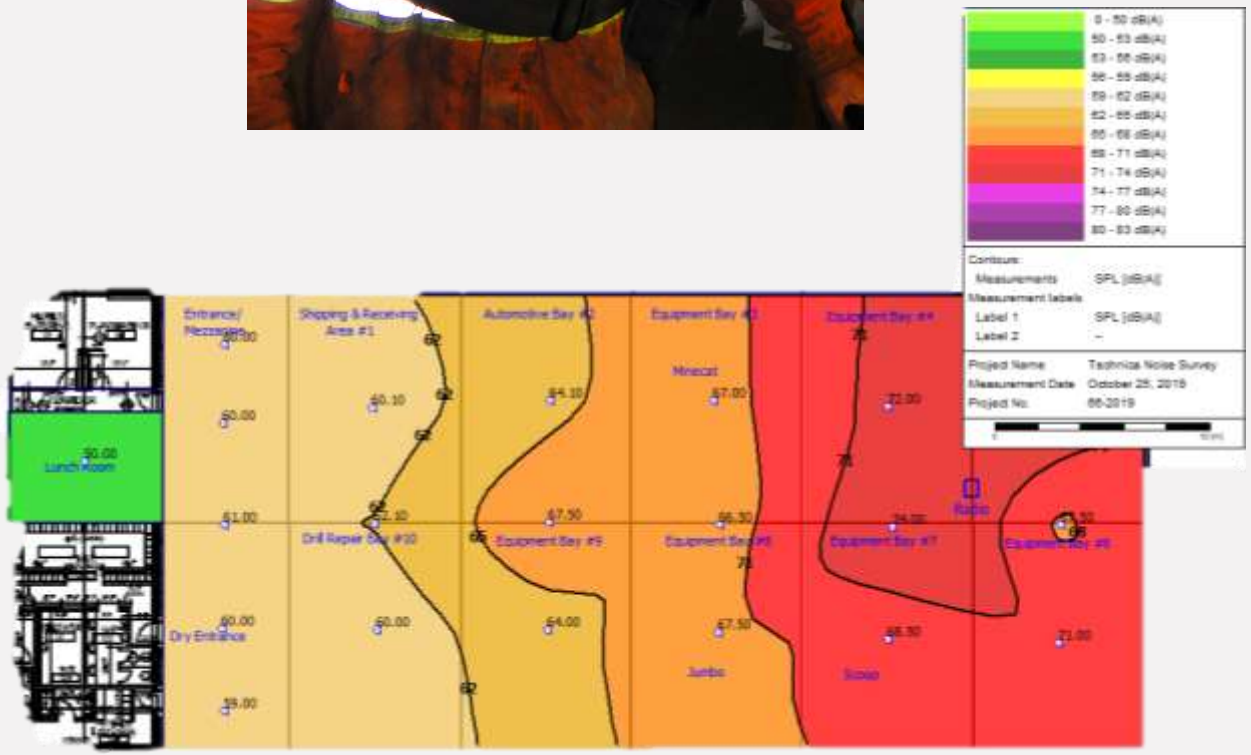
Isocyanate Resin N=C=O Isocyanate Exposure

- 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

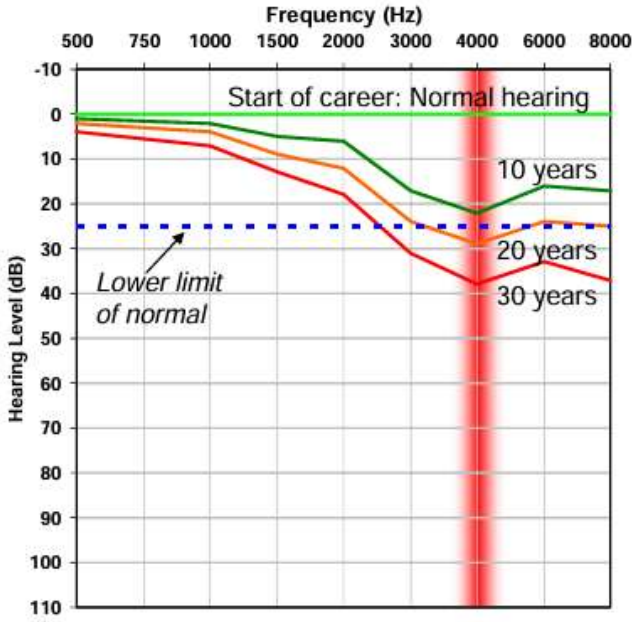




Audiometry

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)

https://www.cdc.gov/niosh/mining/UserFiles/workshops/hlp2/01-MateticIntroduction.pdf

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

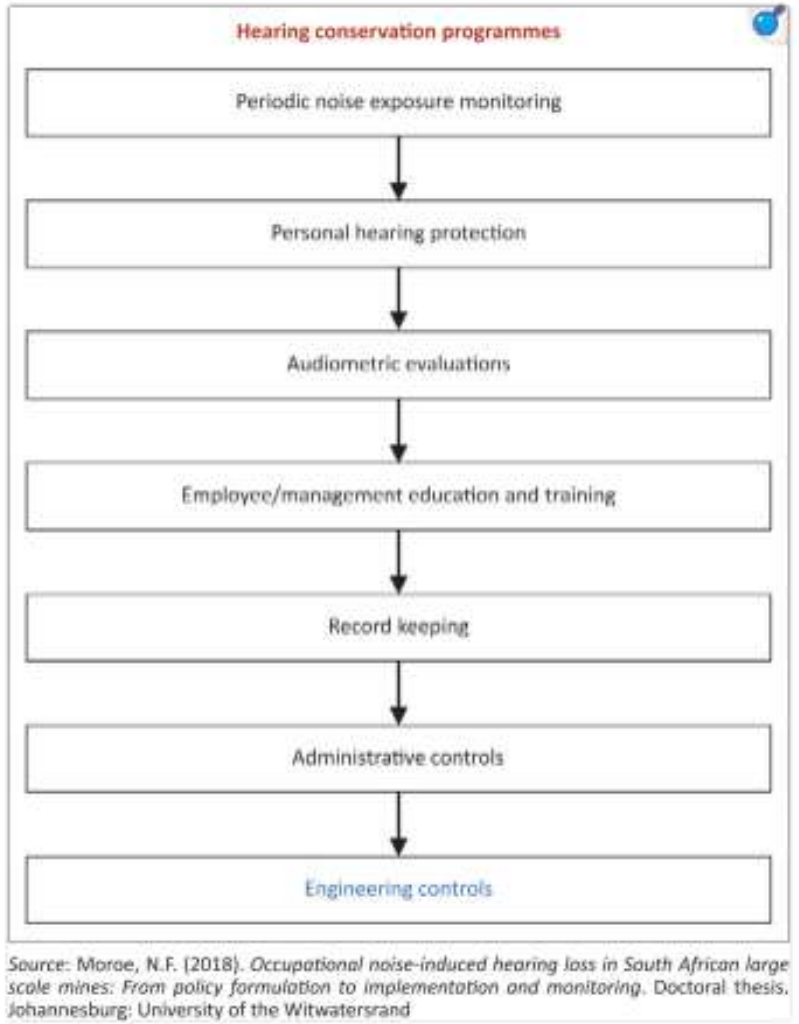
The effectiveness of Hearing Protection Devices heavily on proper usage and fit. Ill-fitting earplugs are a common challenge faced by workers, compromising their ability to adequately protect their hearing.

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*

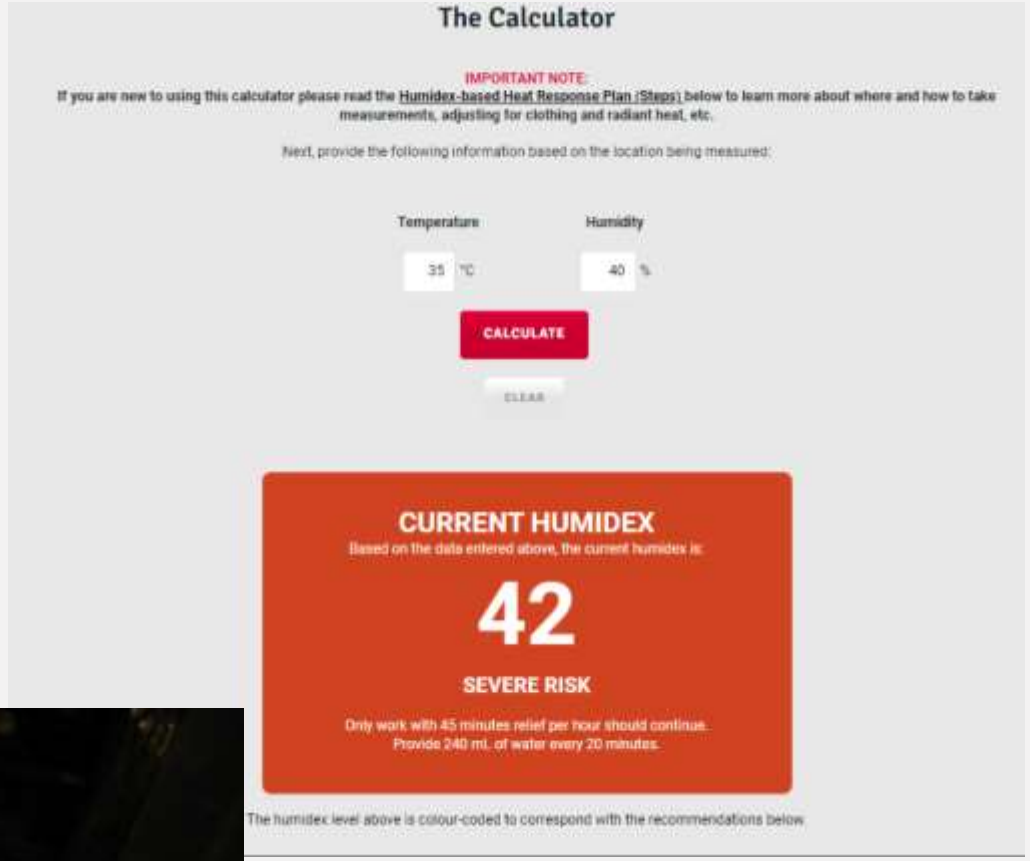
Working in extreme conditions can be hazardous to your health.
Heat and humidex are no exception.

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 h… workers who are not working in the shade, will ***under-estimate*** the…



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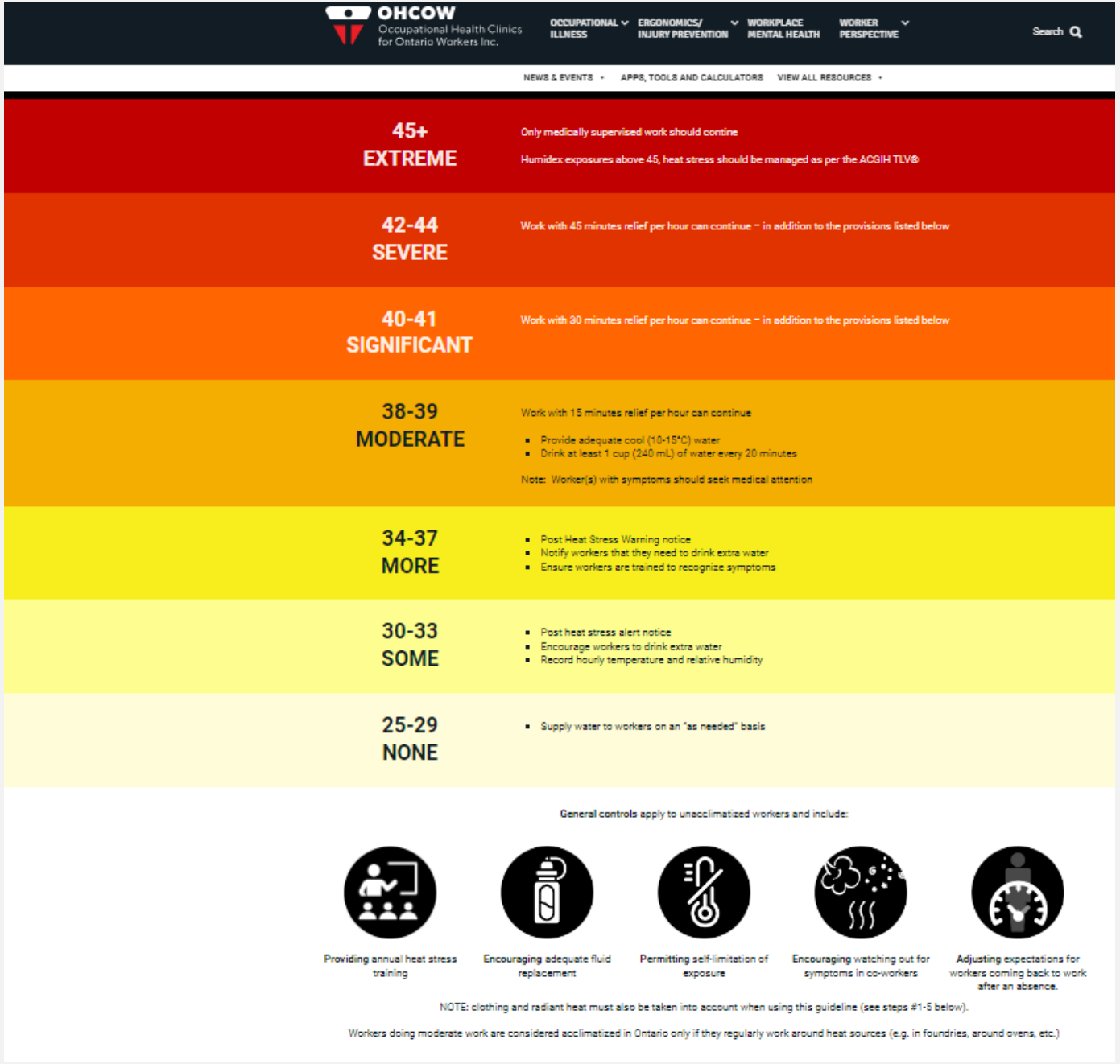
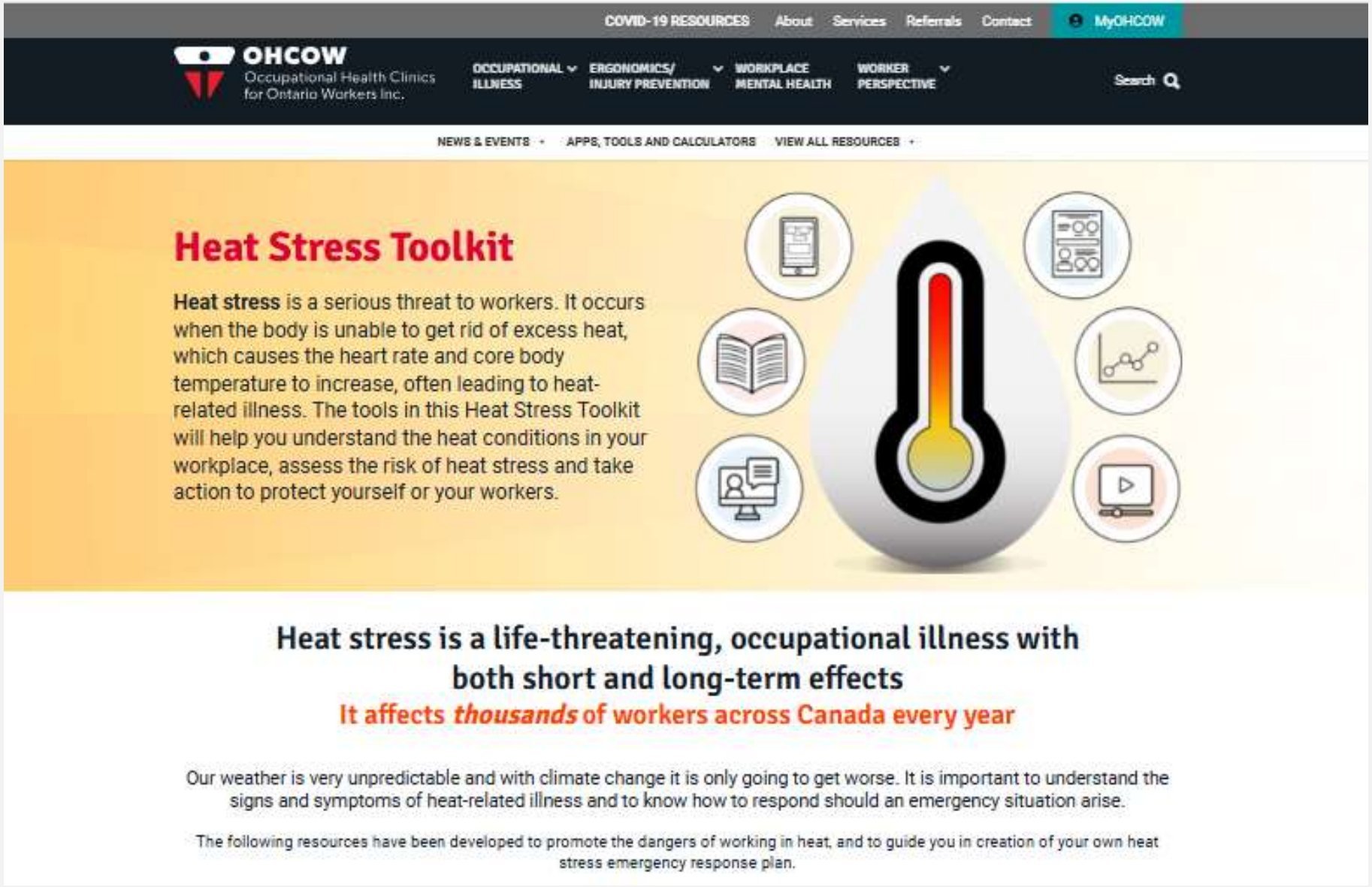
HUMIDEX RISK
RECOMMENDED ACTIONS / RECOMMENDATIONS





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

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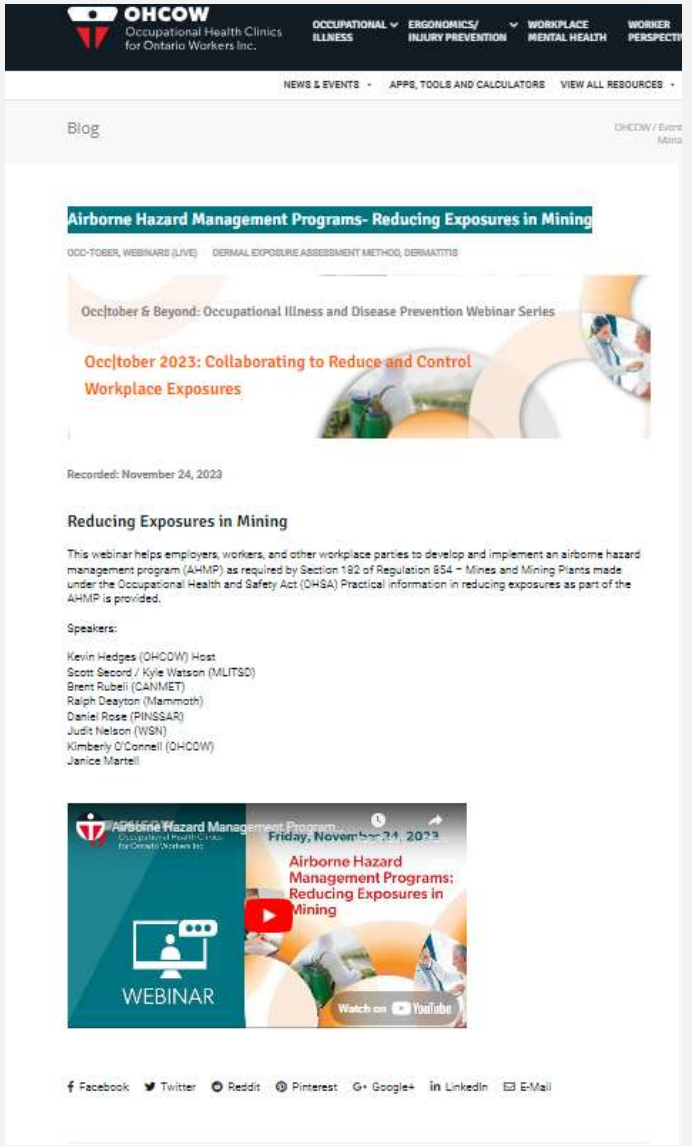
See also:



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