



Occupational Health Clinics for Ontario Workers Inc.

4th Annual Mining Vehicle Powertrain Workshop
(MVPC) 2026

Breathable particles in the air and the future of measurement.

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



<https://lungfoundation.com.au/protect-your-lungs/protect-your-lungs-at-work/>





What is in the air – what gets measured gets action

Previous presentations / webinars

UNCLASSIFIED / NON CLASSIFIÉ

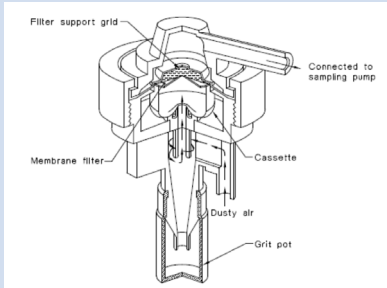


Year	Title
2013	Diesel emission in underground mining—A program for control, shared learning from Queensland, Australia Kevin Hedges, former Senior Principal Occupational Hygienist, Queensland Mines Inspectorate
2017	Is setting a suitably protective occupational exposure limit (OEL) for diesel particulate matter (DPM) a “key driver” to reduce exposure Kevin Hedges, Occupational Health Clinics for Ontario Workers Inc.
2017	Diesel Exhaust - Need to monitor exposure and further reduce occupational exposure limit . WSN Mining Conference.
2018	Occupational disease action plan (ODAP) and collaboration between system partners
2019	Diesel Emission Reduction
2022	The Past, Present & Future: Diesel Exhaust Exposures in Mining – A Tool to Assess Lung Cancer Risk
2022	Diesel Exhaust Exposure – Influencing Change . Collaboration between CROSH, OHCOW & USW presented via OHCOW
2023	Reduction of Diesel Emissions as part of an overall Airborne Hazard Management Program.
2024	Workshop Presentations Introduction to Diesel Emissions Exposure in the Mining Environment
2025	An update on diesel engine emissions regulatory requirements from an international perspective

“Please refer to past presentations through MDEC”



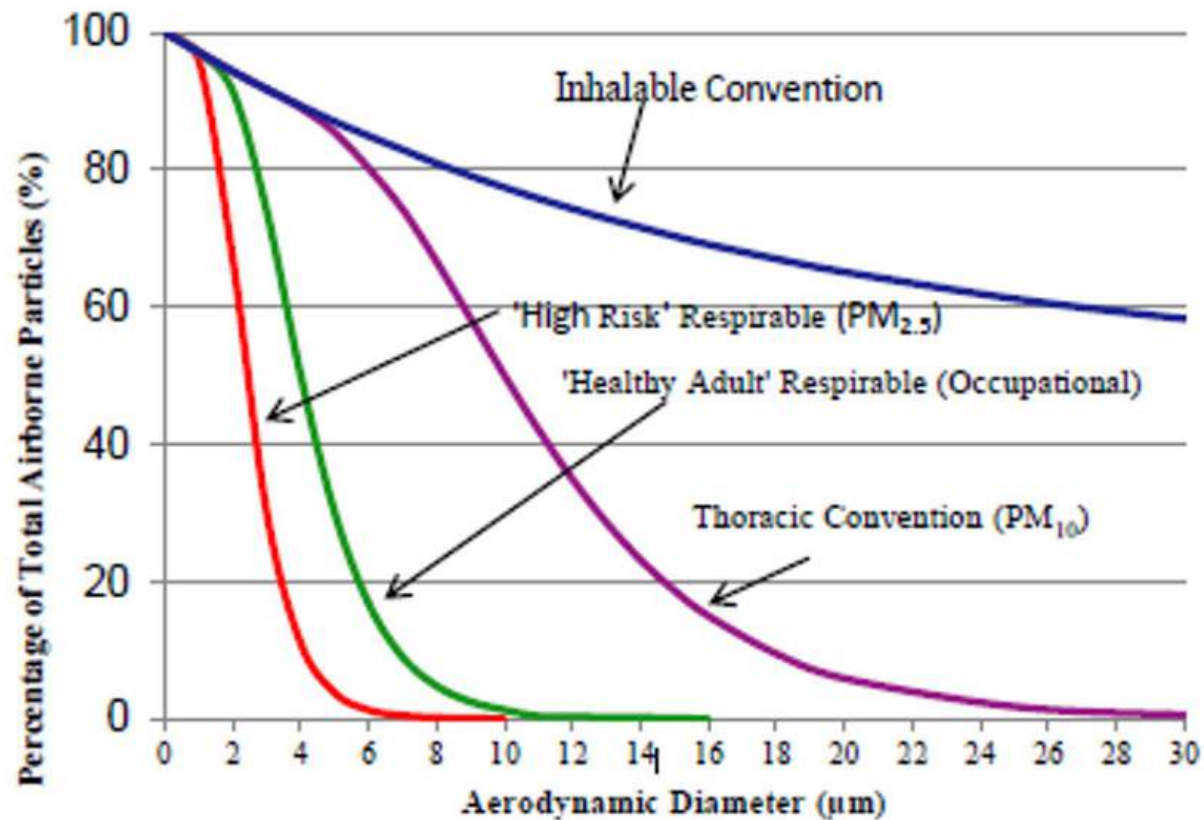
How do we measure exposure to chemicals / fumes / particles

Measure	Sampling device
Airborne particulate matter	 Inhalable (IOM sampler)  (Cyclone)  Respirable (Parallel impactor)  (Cascade impactor)  (Diesel Particulate Matter DPM cyclone)
Skin or dermal exposure	BS EN ISO 13977-1:2026. Workplace air — Assessment of dermal exposure Part 1: Framework for dermal exposure assessment (this is getting a lot more attention)
Biological monitoring of exposure For example, lead in blood & bone	  (all exposure routes)

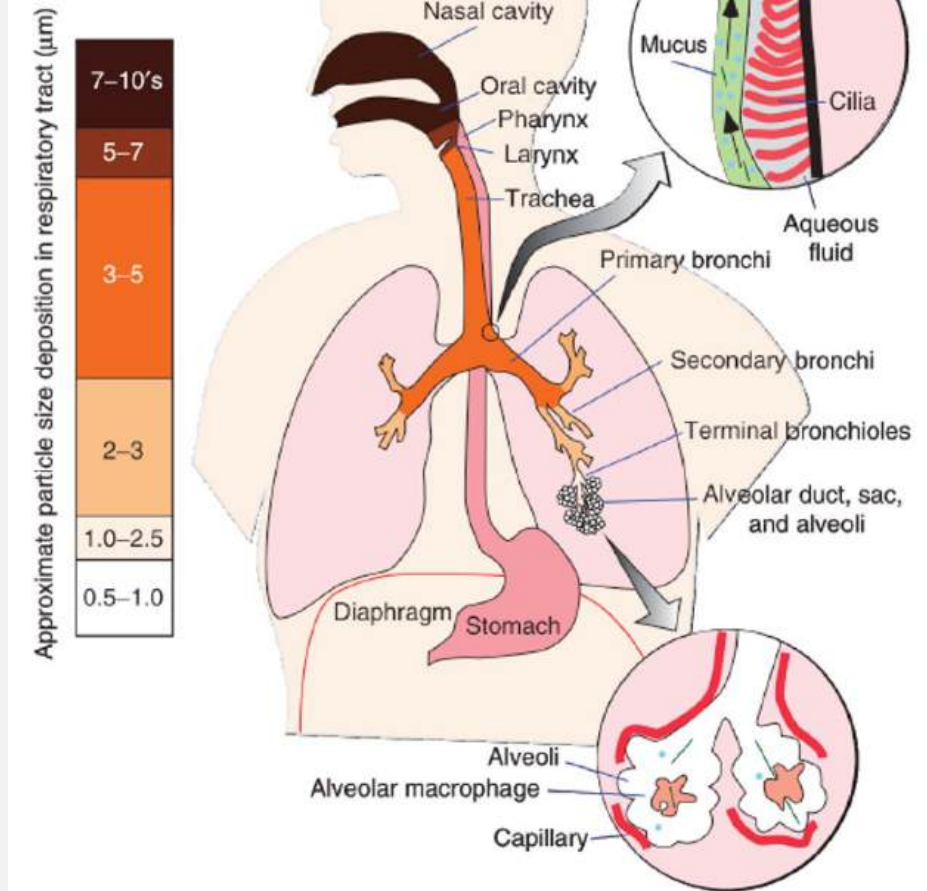


What this presentation will cover:

- Health effects from exposure to different sized particles.
- From global warming wildfires are becoming more frequent. Exposures to **wildfire smoke** should be factored into the health risk assessment along with other exposures such as **diesel particulate matter (DPM)** and **respirable crystalline silica (RCS)**.
- What can be done in the event of a wildfire smoke event.
- What new technology exists to improve measurement for smaller / fine and ultrafine particulate matter.
- Why is it important to characterize particle size analysis and how does this align with controlling exposure.



Particle size distributions and collection efficiency curves according to ISO, 7708 1995 (Adapted from: ISO 1995, p7)



A schematic representation of the respiratory tract showing details of the alveolus and of the muco-ciliary clearance. The colors from brown to pink show the particle size distribution in the respiratory tract (Plumlee & Ziegler 2006, p.276).

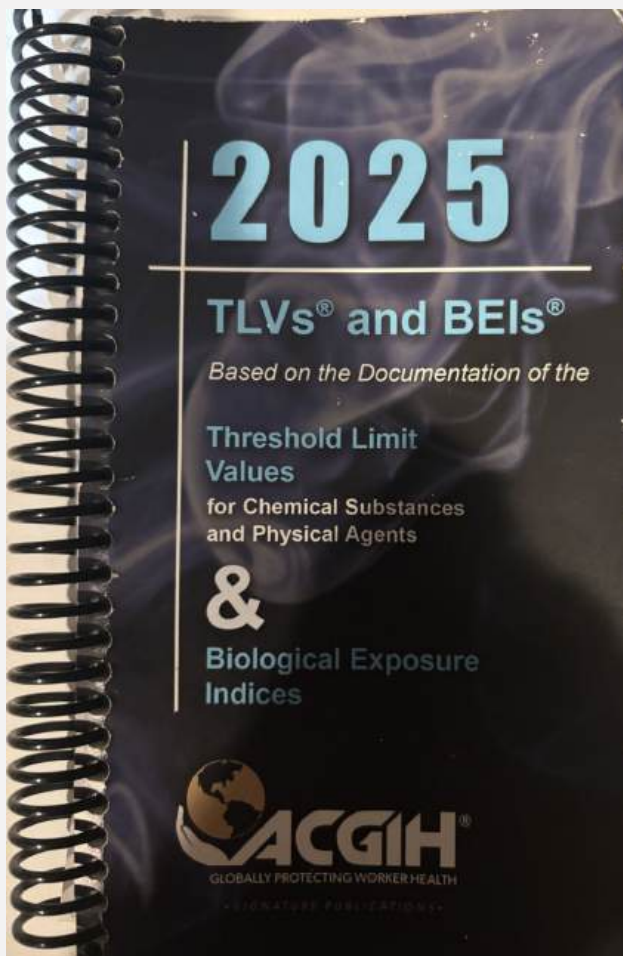


International Organization for Standardization (ISO) 1995, *Air Quality: Particle Size Fraction Definitions for Health-related Sampling*, ISO 7708-1995, International Organization for standardization. Standardization (ISO), Geneva.

The science for this standard is based on information that is at least thirty years old!

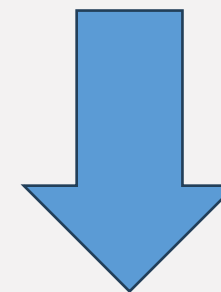


We base our sampling for inhalable and respirable dust on this international standard (ISO 7708)

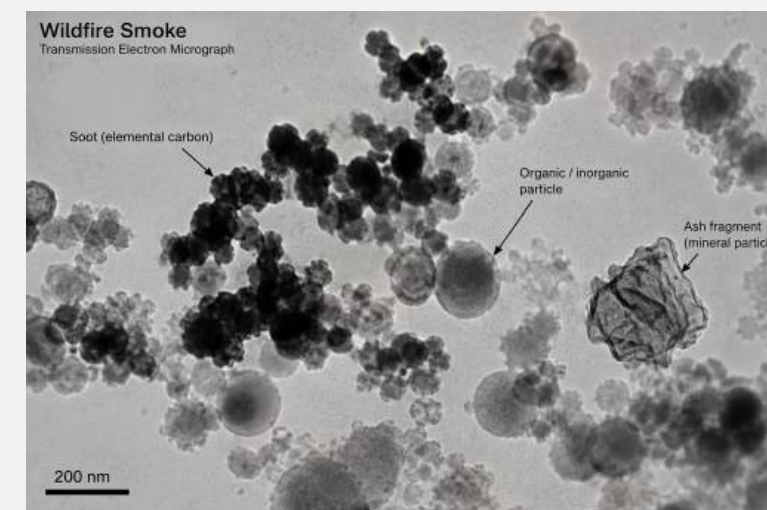
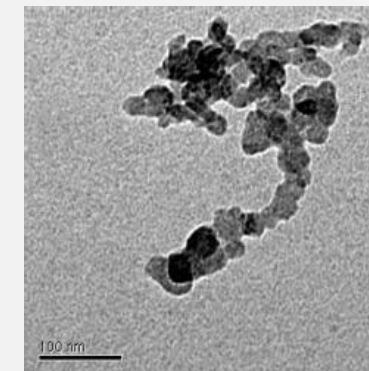
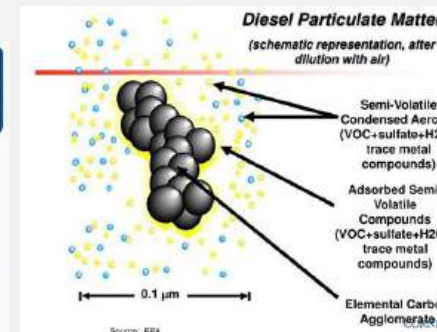
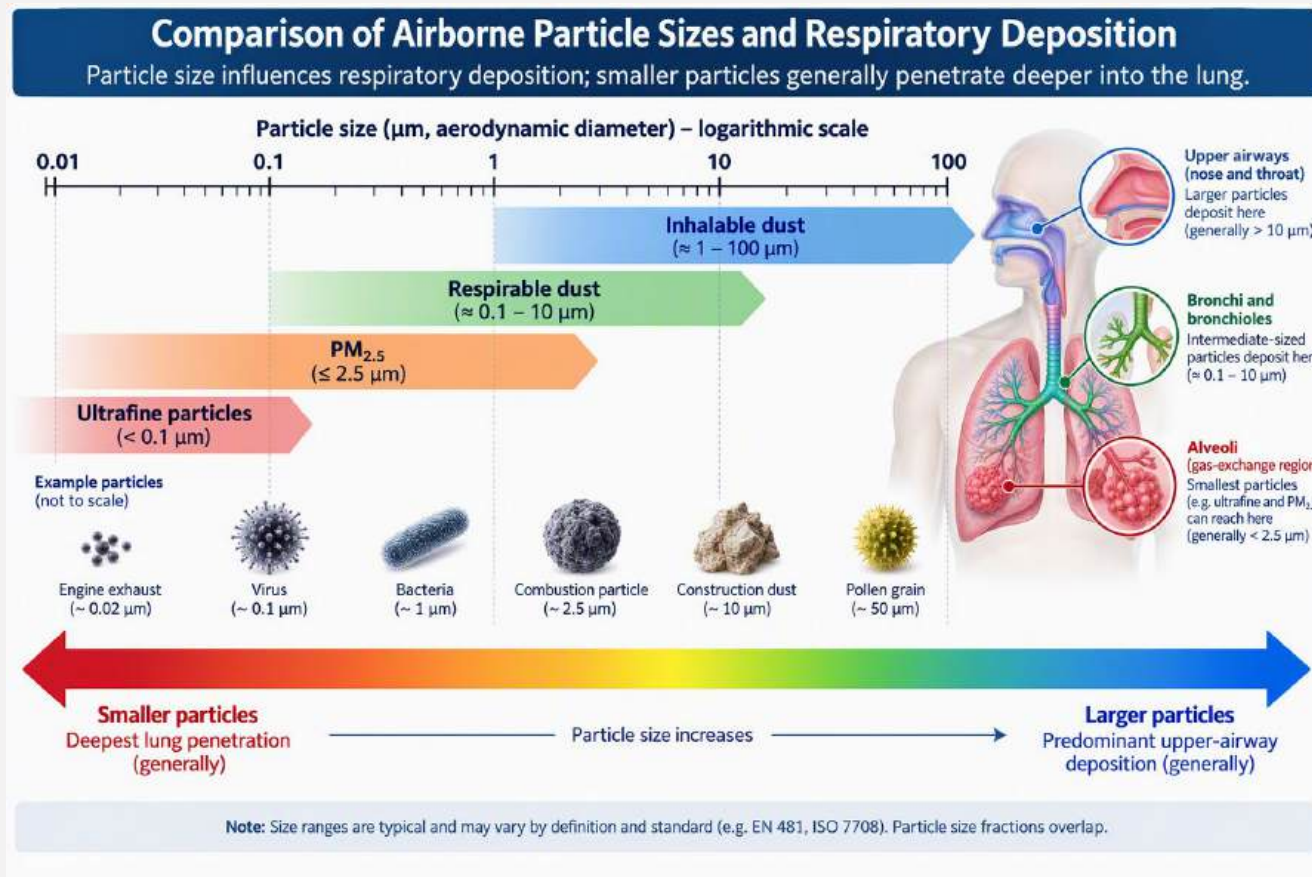


ADOPTED VALUES					
Substance [CAS No.] (Documentation date)	TWA	STEL	Notations	MW	TLV Basis
Propylene glycol ethyl ether [1569-02-4] (2019)	50 ppm	200 ppm	Skin	104.17	CNS impair; eye & URT irr
Propylene oxide [75-56-9] (2014)	2 ppm	—	DSEN, A3	58.08	Eye & URT irr
Propyleneimine [75-55-8] (2009)	0.2 ppm	0.4 ppm	Skin; A3	57.09	URT irr; kidney dam
n-Propyl nitrate [627-13-4] (2022)	5 ppm	—	BE _{1/2}	105.09	Anemia; Meib-emia
Pyrethrum [8003-34-7] (1996)	5 mg/m ³	—	A4	345 (avg.)	Liver dam; URT irr
Pyridine [110-86-1] (2004)	1 ppm	—	A3	79.10	Skin irr; liver & kidney dam
Resin acids, as total resin acids [8050-09-7] (2020)	0.001 mg/m ³ (I)	—	DSEN, RSEN	—	Asthma; resp & eye irr; dermal & resp sens
Resorcinol [108-46-3] (1996)	10 ppm	20 ppm	A4	110.11	Eye & skin irr
Rhodium [7440-16-6], as Rh (1996)	1 mg/m ³	—	A4	102.91	Varies
Metal and insoluble compounds	0.01 mg/m ³	—	A4	Varies	Metal = URT irr; Insoluble = URT irr
Soluble compounds	—	—	A4	Varies	Asthma
Ronnel [299-84-3] (2006)	5 mg/m ³ (FFV)	—	A4; BE _{1/2}	321.57	Cholinesterase inhib
Rotenone (commercial) [83-79-4] (1996)	5 mg/m ³	—	A4	301.41	URT & eye irr; CNS impair
Selenium [782-49-2] and compounds, as Se (1992)	0.2 mg/m ³	—	—	78.96	Eye & URT irr
Selenium hexafluoride [7783-79-1], as Se (2001)	0.05 ppm	—	—	192.96	Pulm edema
Sesone [136-76-7] (1996)	10 mg/m ³	—	A4	309.13	GI irr

ADOPTED VALUES					
Substance [CAS No.] (Documentation date)	TWA	STEL	Notations	MW	TLV Basis
Sevoflurane [28523-86-6] (2023)	50	—	—	—	—
Silica, crystalline — a quartz [1317-95-9; 14808-60-7] and cristobalite [14464-46-1] (2010)	0.0	—	—	—	—
Silicon carbide [409-21-2] (2022)	—	—	—	—	—
Nonfibrous	10	—	—	—	—
Fibrous (including whiskers)	3 n	—	—	—	—
0.1	—	—	—	—	—
Silicon tetrahydride [7803-62-5] (2015)	5 p	—	—	—	—
Silver [7440-22-4], and compounds (1992)	—	—	—	—	—
Metal, dust and fume	0.1 mg/m ³	—	—	107.87	Asthma
Soluble compounds, as Ag	0.01 mg/m ³	—	—	Varies	—
Simazine [122-34-9] (2016)	0.5 mg/m ³ (I)	—	A3	201.60	Hematologic eff
Sodium azide [26628-22-8] (1996)	—	—	—	65.02	Card impair; lung dam
as Sodium azide	—	C 0.29 mg/m ³	A4	—	—
as Hydrazoic acid vapor	—	C 0.11 ppm	A4	—	—
Sodium bisulfite [7631-90-5] (1996)	5 mg/m ³	—	A4	104.07	Skin, eye, & URT irr
Sodium fluorosulfate [62-74-8] (1994)	0.05 mg/m ³	—	Skin	100.02	CNS impair; card impair; nausea
Sodium hydroxide [1310-73-2] (1992)	—	C 2 mg/m ³	—	40.01	URT, eye, & skin irr



What about PM_{2.5} (fine particulate matter) and PM_{0.1} (ultrafine particulate matter)



We should be measuring smaller size fractions!



Health effects of PM_{2.5} and Ultrafine PM_{0.1}

PM_{2.5}



Exposure over a few hours to weeks can trigger **cardiovascular disease-related** heart attacks and death. Longer-term exposure can lead to increased risk of cardiovascular mortality and decreases in life expectancy. For the population short -and long-term exposure has been shown to increase hospitalizations for serious cardiovascular events such as coronary syndrome, arrhythmia, heart failure, stroke, and sudden cardiac death, particularly in people with established heart disease.



<https://www.epa.gov/air-research/air-pollution-and-cardiovascular-disease-basics>

PM_{0.1}

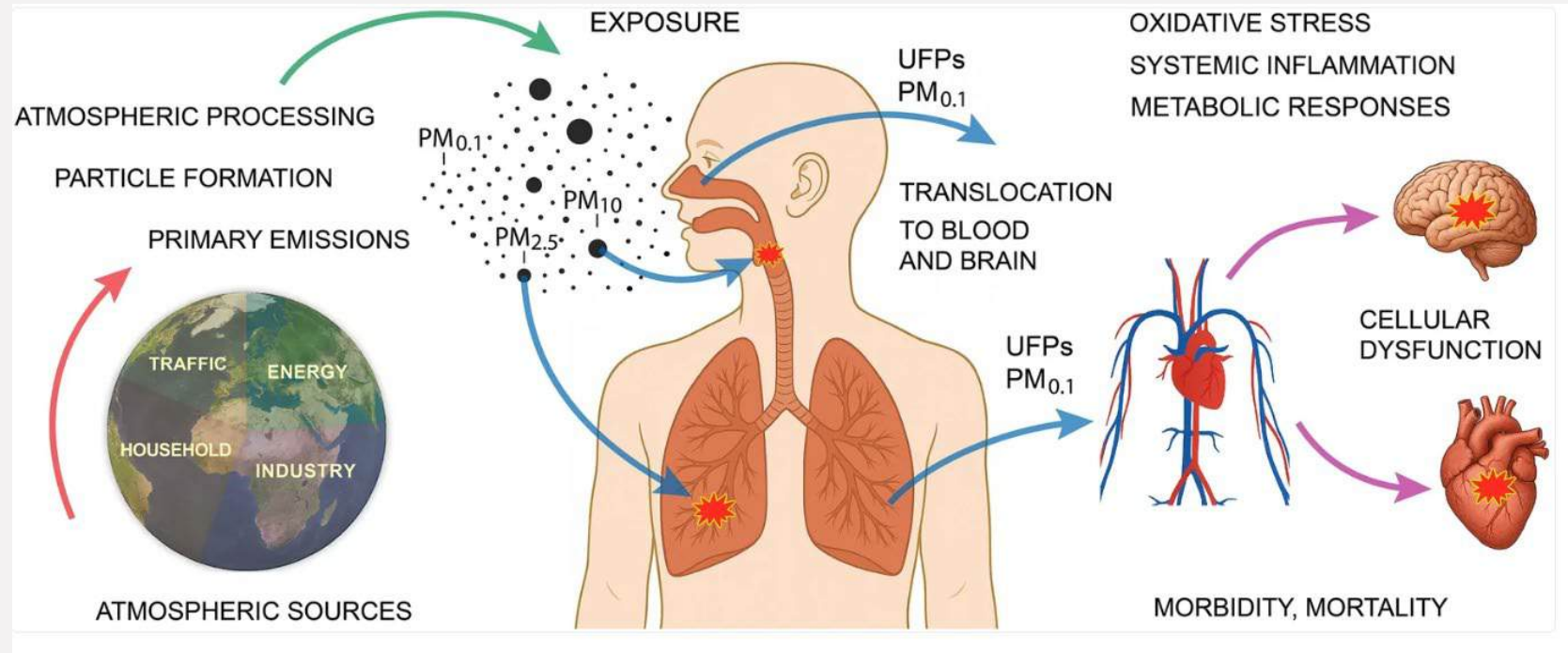


Ultrafine particles (<100 nm) can penetrate deep into the lungs and enter the bloodstream. The strongest evidence links exposure to **cardiovascular disease, respiratory inflammation, and systemic oxidative stress**, with **emerging concerns for neurological and developmental effects**.

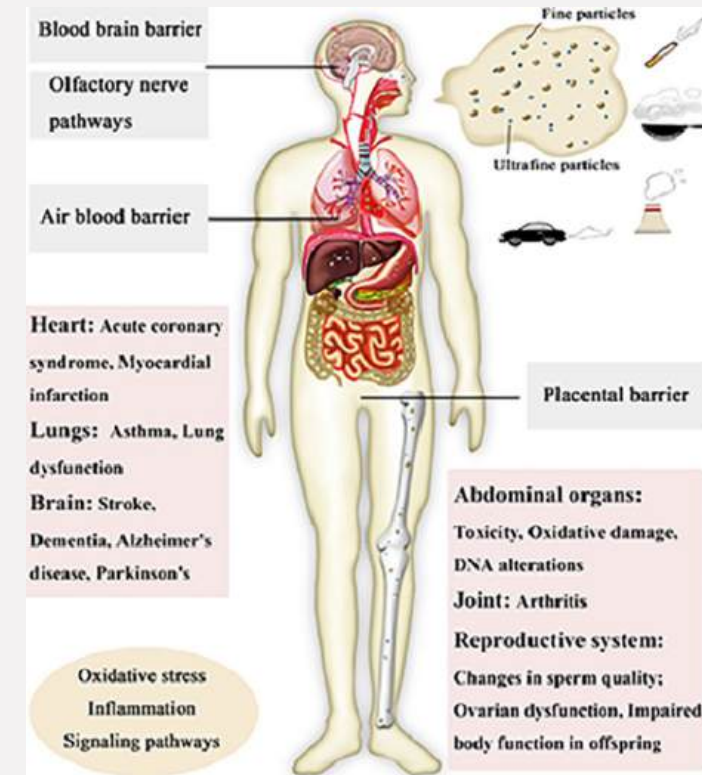
Schraufnagel, D.E. The health effects of ultrafine particles. *Exp Mol Med* **52**, 311–317 (2020).

<https://doi.org/10.1038/s12276-020-0403-3>

Ultrafine particles



Air quality and health implications of exposure to ultrafine particle pollution - PMC



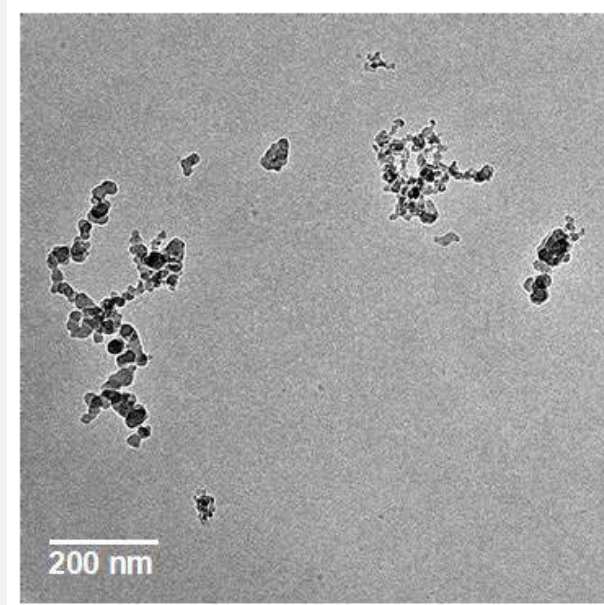
Adverse effects of exposure to fine particles and ultrafine particles in the environment on different organs of organisms

Diesel particulate matter (DPM) are ultrafine particles that exist as chain aggregates

Wils et al. (2025) reported that for **recent diesel engine exhaust (DEE) exposure**, an increased incidence rate ratio (IRR) for acute myocardial infarction was observed only in the **highest exposure quartile among exposed workers**, corresponding to approximately $\geq 5.5 \mu\text{g}/\text{m}^3$ elemental carbon (EC). The paper notes that this level is close to the **$5 \mu\text{g}/\text{m}^3$ EC occupational exposure limit under consideration in Denmark.**

Wils RS, Flachs EM, Stokholm ZA, et al. Occupational exposure to diesel engine exhaust and first-time acute myocardial infarction: a nationwide register-based cohort study 1976–2018. *European Journal of Preventive Cardiology*. 2025;32(8):682-695. doi:10.1093/eurjpc/zwaf022 [Occupational exposure to diesel engine exhaust and first-time acute myocardial infarction: a nationwide register-based cohort study 1976–2018](https://doi.org/10.1093/eurjpc/zwaf022) | *European Journal of Preventive Cardiology* | Oxford Academic .

A myocardial infarction, commonly known as a heart attack.



Rothamer research group –
University of Wisconsin-Madison

<https://rothamer.erc.wisc.edu/research>



Why Ultrafine Particles Are Different

Compared with PM_{2.5} and larger dust particles, ultrafine particles:

- Have **very little mass** but **enormous particle numbers**
- Have a **very high surface area per unit mass**
- Can penetrate deeply into the lungs
- May translocate to the bloodstream and organs

This means that conventional mass-based metrics (mg/m³) may underestimate their biological importance.

Schraufnagel, D.E. The health effects of ultrafine particles. *Exp Mol Med* **52**, 311–317 (2020).
<https://doi.org/10.1038/s12276-020-0403-3>



Underground and surface miners can be exposed to a “cocktail” of airborne hazards including

- **Silica** (KNOWN CARCINOGEN (IARC 1) refer to [CAREX](#))
- **Diesel particulate matter** (DPM) (KNOWN CARCINOGEN (IARC 1) refer to [CAREX](#))
- **During wildfire events – wildfire smoke** refer to [CAREX](#))

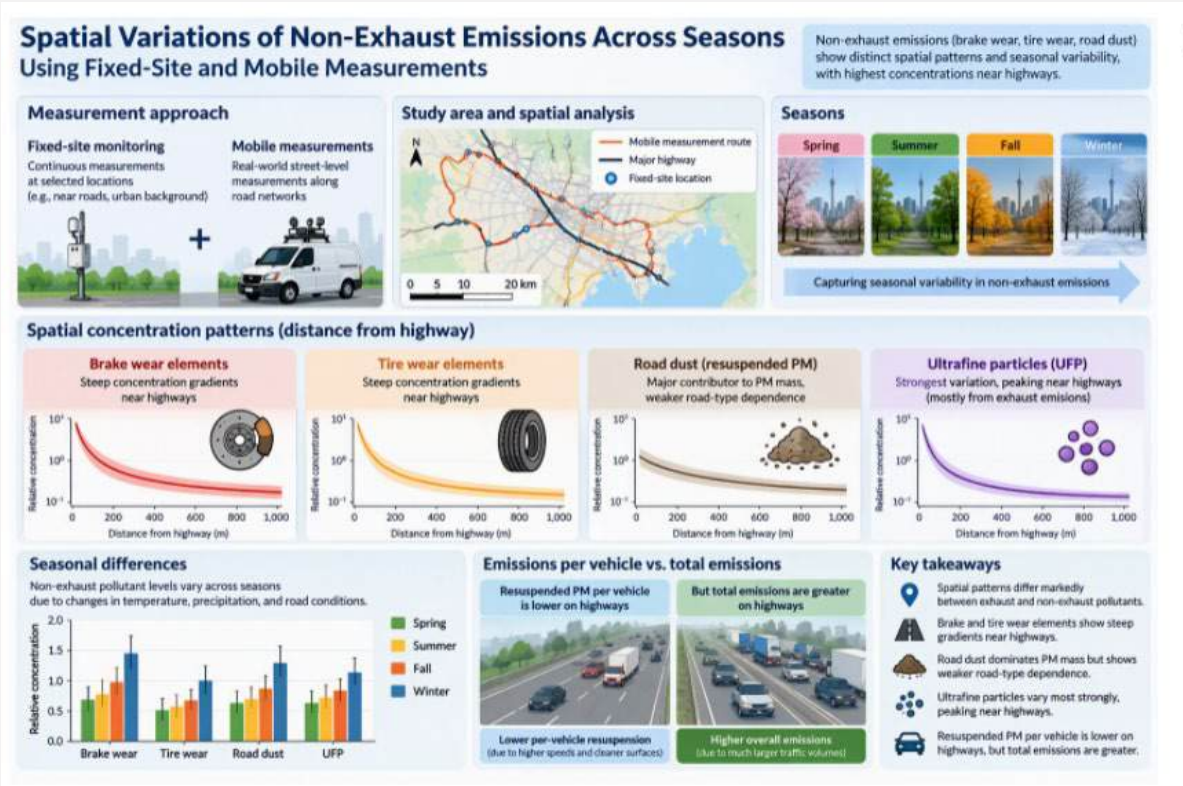
(In June of 2022, the International Agency for Research on Cancer (IARC) reclassified the occupational exposure of structural and **wildland firefighters** as carcinogenic to humans (Group 1))

The Lancet Planetary Health followed more than **2 million Canadians** for almost 20 years and found that people living near wildfires had increased incidence of **lung cancer**. Specifically, individuals exposed to a wildfire within **50 km of their residence during the previous 10 years** had a **4.9% higher incidence of lung cancer** (HR 1.049; 95% CI 1.028-1.071) compared with unexposed populations.

Korsiak J, Pinault L, Christidis T et al. (2022). **Long-term exposure to wildfires and cancer incidence in Canada: a population-based observational cohort study** The Lancet Planetary Health, 6, e400-e409 [https://www.thelancet.com/journals/lanplh/article/PIIS2542-5196\(22\)00067-5/fulltext](https://www.thelancet.com/journals/lanplh/article/PIIS2542-5196(22)00067-5/fulltext)



Road dust, brake and tyre wear dust!

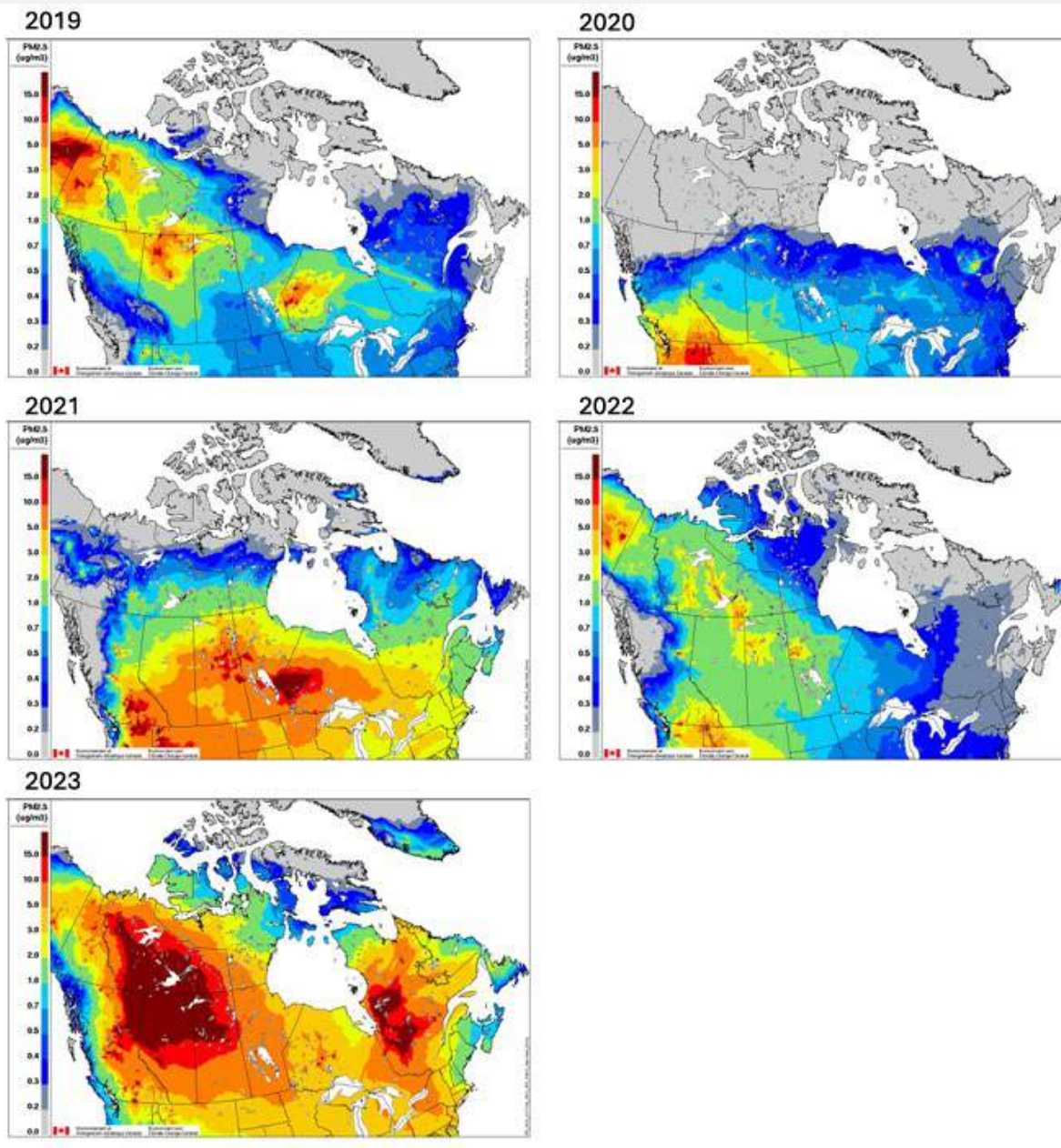


Exposure to particulate matter (PM) from road dust and **brake and tire wear (BTW)** is an emerging health concern Jeong et al. 2026” Spatial variations of non-exhaust emissions across seasons using fixed-site and mobile measurements”

<https://www.sciencedirect.com/science/article/pii/S1361920926004372>



Wildfire smoke



PM 2.5 concentrations
(May–September) for
2019–2023

**attributable to wildfire
sources** based on
FireWork and
GEM-MACH model
results.

<https://doi.org/10.1029/2025GH001565>



From a Field Visit Report by the Ontario Ministry of Labor (MLITSD) on 15 July 2026,
– for an **inspection of an underground mine in Ontario.**

Investigation for compliance with the Occupational Health and Safety Act and associated regulations.

Workers refused work because they believed the employer's wildfire smoke procedures and controls were inadequate to protect worker health.

The Ministry consulted with occupational hygiene specialist noted that:

- Ontario currently has no occupational exposure limit (OEL) specifically for PM2.5 in workplaces. The workplace's PM4 (respirable dust) monitoring likely includes PM2.5 particles and therefore captures wildfire smoke particulate exposure.
- The employer's use of the respirable dust size fraction, which aligns with the current Ontario Occupational Exposure Limit (OEL) for respirable particles not otherwise specified (**R-PNOS**) of 3 mg/m³ (**3,000 µg/m³**).

(Respirable particulate not otherwise specified (R- PNOS)).



APPENDIX B: Particles (insoluble or poorly soluble) Not Otherwise Specified (PNOS)

The goal of the TLV-CS Committee is to recommend TLVs for all substances for which there is evidence of health effects at airborne concentrations encountered in the workplace. When a sufficient body of evidence exists for a particular substance, a TLV is established. Thus, by definition the substances covered by this recommendation are those for which little data exist. The recommendation at the end of this Appendix is supplied as a guideline rather than a TLV because it is not possible to meet the standard level of evidence used to assign a TLV. In addition, the PNOS TLV and its predecessors have been misused in the past and applied to any unlisted particles rather than those meeting the criteria listed below. The recommendations in this Appendix apply to particles that:

- Do not have an applicable TLV;
- Are insoluble or poorly soluble in water (or, preferably, in aqueous lung fluid if data are available); and
- Have low toxicity (i.e., are not cytotoxic, genotoxic, or otherwise chemically reactive with lung tissue, and do not emit ionizing radiation, cause immune sensitization, or cause toxic effects other than by inflammation or the mechanism of "lung overload").

ACGIH believes that even biologically inert, insoluble, or poorly soluble particles may have adverse effects and recommends that airborne concentrations should be kept below 3 mg/m³, respirable particles, and 10 mg/m³, inhalable particles, until such time as a TLV is set for a particular substance.

Particles not otherwise specified (PNOS) have low toxicity (i.e. are not cytotoxic, genotoxic, or otherwise chemically reactive with lung tissue, and do not emit ionizing radiation, cause immune sensitization, or cause toxic effects other than by inflammation or the mechanism of "lung overload" (ACGIH, 2025).

Wildfire Smoke Context

For wildfire smoke, the measurement of PM_{2.5} as a health-risk indicator is analagous with the air quality index (AQI), but there is no Ontario occupational exposure limit specifically for PM_{2.5}



Context<https://cohlabstem.com.au/2021/07/20/wildfire-soot/>

PM_{2.5} Concentration

8.8 µg/m³ -

Canadian annual ambient air standard

27 µg/m³ -

Canadian 24-hour ambient air standard

156 µg/m³ (from the report)-

PM_{2.5} measured at Mine intake during the inspection

3,000 µg/m³ -

Ontario respirable dust OEL (R-PNOS)

(Respirable dust - Particles not otherwise specified (PNOS))



Inspector's Conclusions

The inspector determined that:

- Workers were being held on surface due to elevated carbon monoxide levels at the fresh-air intake and no workers were underground at the time of the inspection.
- Based on the information reviewed and consultation with occupational hygiene expert, the concerns raised by workers were **not likely to endanger** workers under the Occupational Health and Safety Act. There was **no apparent overexposure** to wildfire smoke contaminants when compared with current occupational exposure limits
- The employer should, however, be able to clearly explain the scientific basis for its respirable dust threshold and how it is intended to protect worker health during wildfire smoke events.

Transmission electron micrograph (TEM) of wildfire soot (biomass-burning aerosol).

Similar to diesel exhaust, wildfire soot contains aggregates of **nanometer-scale carbon primary particles**; however, wildfire smoke also contains substantial organic material, tar balls, mineral ash, and coated soot particles that produce a more chemically and morphologically heterogeneous aerosol.

<https://pmc.ncbi.nlm.nih.gov/articles/PMC3715871/>





From the Field Visit Report by the Ontario Ministry of Labor (MLITSD) on **15 July 2026**, – for an inspection of an underground mine in Ontario.

Visit Purpose:

Investigation for compliance with the Occupational Health and Safety Act and associated regulations.

Re “wildfire smoke concerns”

Air Monitoring Results Observed:

CO: 2.7 ppm

PM1: 121 ug/m³

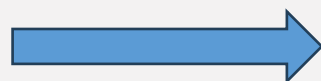
PM2.5: 156 ug/m³

PM4.25: 166 ug/m³

PM10: 168 ug/m³

NO₂: 0.4 ppm

O₂: 20.4%



2024 AQI for Fine Particle Pollution
(Breakpoints are in micrograms per cubic meter)

AQI Category and Index Value	Previous AQI Category Breakpoints	Updated AQI Category Breakpoints	What changed?
Good (0 – 50)	0.0 to 12.0	0.0 to 9.0	EPA updated the breakpoint between Good and Moderate to reflect the updated annual standard of 9 micrograms per cubic meter
Moderate (51 – 100)	12.1 to 35.4	9.1 to 35.4	
Unhealthy for Sensitive Groups (101 – 150)	35.5 to 55.4	35.5 to 55.4	No change, because EPA retained the 24-hour fine PM standard of 35 micrograms per cubic meter.
Unhealthy (151 – 200)	55.5 to 150.4	55.5 to 125.4	EPA updated the breakpoints at the upper end of the unhealthy, very unhealthy, and hazardous categories based on scientific evidence about particle pollution and health. The Agency also combined two sets of breakpoints for the Hazardous category into one.
Very Unhealthy (201 – 300)	150.5 to 250.4	125.5 to 225.4	
Hazardous (301+)	250.5 to 350.4 and 350.5 to 500	225.5+	

• About the columns in the table:

[Updates to the Air Quality Index \(AQI\) for Particulate Matter - Fact Sheet and Common Questions, U.S. Environmental Protection Agency, 2024.](#)



Outcome

- **No orders were issued.**
- The work refusal was effectively dismissed as the Ministry concluded that the circumstances did **not present a likely danger based on available exposure data and current regulatory standards.**





On **July 16, 2026**, Canada Post had a **Red Delivery Service Alert for Sault Ste. Marie** because of wildfires and poor air quality.

Under a red alert, **mail delivery is suspended for the day, delivery agents are not sent out or are recalled, and mail collection is also suspended.** The Sault Ste. Marie alert had reportedly been in place since **July 15**.

Canada Post stated: “The safety of our employees is our number one priority.”

This was not limited to Sault Ste. Marie. On July 16, red alerts were also reported for **Aroland, Armstrong Station and Collins, Windsor, Gull Bay, Belleville, Trenton and Cobourg**, while **Thunder Bay, Sudbury, North Bay, Muskoka and other areas** were under yellow alerts, where delivery was attempted but delays were possible. In the **Quinte region**, Canada Post specifically suspended delivery in **Belleville, Trenton and Cobourg** because poor air quality from wildfire smoke was affecting the region. **Delivery agents were either not sent out or recalled, and mail collection was suspended.**

<https://www.sootoday.com/local-news/mail-service-in-the-sault-on-hold-today-due-to-poor-air-quality-12557867>

<https://www.tbnewswatch.com/local-news/wildfires-delay-canada-post-in-some-communities-12557852>

[Smoke affecting mail and parcel delivery in Quinte region | Quinte News](#)



Applying the respirable particulate not otherwise specified (R-PNOS) Occupational Exposure Limit (OEL) to wildfire smoke is **inappropriate** because wildfire smoke **contains numerous toxic constituents**, including polycyclic aromatic hydrocarbons (PAHs), other organic compounds, and inorganic contaminants.

Relying solely on compliance with existing Occupational Exposure Limits (OELs) may fail to address legitimate worker health concerns because many exposure-related symptoms occur below legal limits.

Use of Section 25(2)(h) of the Ontario Occupational Health and Safety Act, which requires employers to "take every precaution reasonable in the circumstances" to protect workers. This provision could be invoked if evidence demonstrates:

- A **genuine health hazard** from wildfire smoke exposure.
- Reasonable control measures are available.



Potential evidence could include:

- Worker symptom reports.
- First aid or medical records.
- Health surveillance or **symptom surveys** (see as an example Oudyk, J., Haines, A. T., & D'Arcy, J. (2003). Investigating Respiratory Responses to Metalworking Fluid Exposure. Applied Occupational and Environmental Hygiene, 18(11), 939–946. <https://doi.org/10.1080/10473220390237610>)
- **Scientific literature on health effects of PM_{2.5} and wildfire smoke.**



HUMAN HEALTH EFFECTS OF WILDFIRE SMOKE



Increased respiratory problems and premature mortality.

Higher rates of asthma exacerbations, chronic obstructive pulmonary disease (COPD) events, emergency department visits, and hospital admissions during wildfire smoke episodes.

Potential cardiovascular impacts, particularly among older adults, possible effects on pregnancy outcomes and mental health. Certain populations, including children, seniors, **pregnant people**, individuals with **pre-existing health conditions**, and wildfire firefighters, may be at greater risk from exposure to wildfire smoke.

<https://www.canada.ca/content/dam/hc-sc/documents/services/publications/healthy-living/human-health-effects-wildfire-smoke/human-health-effects-wildfire-smoke.pdf>



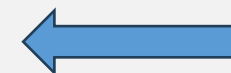
Wildfire Smoke Should Not Be Treated as "Nuisance Dust"

The evidence supports a need for worker protection even when regulatory exposure limits are not exceeded.



What about a banded exposure management framework? (Suggested only)

Colour	PM _{2.5} (µg/m ³)	Interpretation
 Green	<25	Low risk
 Yellow	25-50	Precautionary actions
 Orange	50-100	Increased health concern
 Red	100-250	Significant health concern
 Purple	250-500	Very high health concern
 Black	>500	Emergency conditions



Could 100 µg/m³ PM_{2.5} be the key action threshold (red zone), as a trigger for mandatory controls. This creates an easy-to-communicate message.

January 11, 2024



Washington State Adopts Permanent Workplace Rules for Wildfire Smoke

The wildfire smoke rules call for employers to **train workers** on wildfire smoke before exposing them to PM_{2.5} concentrations of 20.5 µg/m³ or more and then to repeat training at least annually. <https://www.aiha.org/news/240111-washington-state-adopts-permanent-workplace-rules-for-wildfire-smoke> Wildfire Smoke Rulemaking

See also “[Protecting Outdoor Workers Exposed to Smoke from Wildfires](#)” Cal/OSHA



What about combined exposures?

Exposure to wildfire smoke, diesel particulate matter (DPM) and respirable crystalline silica!



Description of RCS and EC levels in Ontario, Canada mines from 2014 to 2018 shown overall, by year and with trends over time.

	<i>n</i>	AM, mg/m ³ (SD)	GM, mg/m ³ (GSD)	Range, mg/m ³	95th percentile	Trend over time ^a
RCS						
Overall (all years)	1,332	0.035 (0.10)	0.016 (3.0)	<0.002–2.32	0.112	$\beta_{\text{year}} = -0.018$ $P\text{-value} = 0.385$ $R^2 = 0.24$
2014	214	0.023 (0.03)	0.015 (2.5)	<0.01–0.24	0.070	
2015	294	0.029 (0.04)	0.017 (2.8)	<0.01–0.48	0.091	
2016	347	0.035 (0.06)	0.018 (3.0)	<0.01–0.51	0.150	
2017	332	0.035 (0.11)	0.015 (2.9)	<0.002–1.50	0.109	
2018	145	0.062 (0.24)	0.015 (4.2)	<0.004–2.32	0.150	
EC						
Overall (all years)	902	0.068 (0.08)	0.034 (4.3)	<0.001–0.65	0.212	$\beta_{\text{year}} = -0.113$ $P\text{-value} = 0.001$ $R^2 = 0.33$
2014	107	0.070 (0.06)	0.042 (3.6)	<0.001–0.25	0.182	
2015	194	0.067 (0.07)	0.037 (3.6)	<0.001–0.39	0.233	
2016	251	0.070 (0.09)	0.031 (4.9)	<0.001–0.65	0.268	
2017	232	0.070 (0.09)	0.032 (4.4)	<0.001–0.58	0.294	
2018	118	0.059 (0.05)	0.030 (4.5)	<0.001–0.32	0.168	

^aResults from linear regression models, adjusted for individual mines with time included as a continuous variable.

Arrandale VH, Shakeel A, Hedges K, O'Connell K, Gorman Ng M.

[Recent trends in respirable crystalline silica and elemental carbon exposure in the Ontario, Canada mining industry.](#)

Ann Work Expo Health. 2025 Feb 25;69(2):220-224. doi: 10.1093/annweh/wxae094. PMID: 39657009; PMCID: PMC11858555.

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DIESEL EXHAUST LUNG CANCER RELATIVE RISK CALCULATOR

[15 Year Lag]

A calculator designed to assist you in determining your risk of developing lung cancer from exposure to diesel fumes.

The [International Agency for Research on Cancer](#) (IARC) has concluded that Diesel Engine Exhaust (DEE) is a cause of lung cancer ([Group 1: carcinogenic to humans](#)). [CAREX Canada](#) estimates that approximately 897,000 Canadians are currently exposed to diesel engine exhaust at work. Approximately 2.4% ([OCRC](#)) to 6% ([Vermeulen et al 2014](#)) of annual lung cancer deaths may be due to DEE exposure.

Combined data from three U.S. occupational cohort studies including more than 40,000 workers in the trucking and mining industries ([Vermeulen et al 2014](#)) have provided a powerful estimate of the risk of lung cancer based on the level and duration of exposure to DEE. The truckers' study [Garshick et al. \(2012\)](#) and miners' studies [Silverman et al. \(2012\)](#), [Attfield et al. 2012](#), [Stewart et al. 2010](#) combined, allows for a determination of the risk of lung cancer based on the level of exposure to diesel particulate matter (DPM). DPM measured as elemental carbon (EC) is the best surrogate of exposure.

The following calculator, created by OHCOW, can be used as a guide to communicate the risk from DEE exposure and lead to prevention.

The tool requires either an *estimate* of exposure, as EC ([NIOSH 5040](#)) and duration of exposure.
Where the only measures available are total carbon ([NIOSH 5040](#)) or Respirable Combustible Dust ([RCD](#)) conversion factors have been provided.



DIESEL EXHAUST LUNG CANCER RELATIVE RISK CALCULATOR

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The [International Agency for Research on Cancer \(IARC\)](#) has concluded that Diesel Engine Exhaust (DEE) is a cause of lung cancer ([Group 1, carcinogenic to humans](#)). [CAREX Canada](#) estimates that approximately 57,000 Canadians are currently exposed to diesel engine exhaust at work. Approximately 2.4% (OCRC) to 6% ([Vennartsen et al 2014](#)) of annual lung cancer deaths may be due to DEE exposure.

Combined data from three U.S. occupational cohort studies including more than 40,000 workers in the trucking and mining industries ([Vennartsen et al 2014](#)) have provided a powerful estimate of the risk of lung cancer based on the level and duration of exposure to DEE. The truckers' study [Gaziano et al. \(2012\)](#) and miners' studies [Schwartz et al. \(2012\)](#), [Aitfield et al. \(2012\)](#), [Stewart et al. \(2010\)](#) combined, allows for a determination of the risk of lung cancer based on the level of exposure to diesel particulate matter (DPM). DPM measured as elemental carbon (EC) is the best surrogate of exposure.

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The Calculator

You can use this calculator in two ways:

1. Let the calculator automatically enter data by selecting an occupation and entering your exposure period.
2. If you have actual readings, you can leave the occupation blank and enter the data manually.

Occupation: Exposure Period: Years

Average Respirable Elemental Carbon (REC) Exposure

22 in µg/m³

[CONVERSION FACTORS for MINING](#)

CALCULATE

CLEAR

15-year Lagged Cumulative Respirable Elemental Carbon Exposure

550 in µg/m³-years

(model based on 0-1000 µg/m³-years)

ESTIMATED RELATIVE RISK (RR)

[What is Relative Risk?](#) | [What is 95% Confidence Interval \(CI\)?](#)

1.87

95% Confidence Interval (CI):

Lower

1.18

Upper

2.99

LEGEND:

EC (in µg/m³)	RR (95% CI)
0.0	RR 1.00 1.0.07 to 1.0.38
200	RR 1.20 1.0.97 to 1.37
400	RR 1.62 1.3.68 to 2.42
600	RR 1.97 1.5.21 to 3.21
800	RR 2.40 1.7.35 to 4.25
1000	RR 2.92 1.9.62 to 5.64

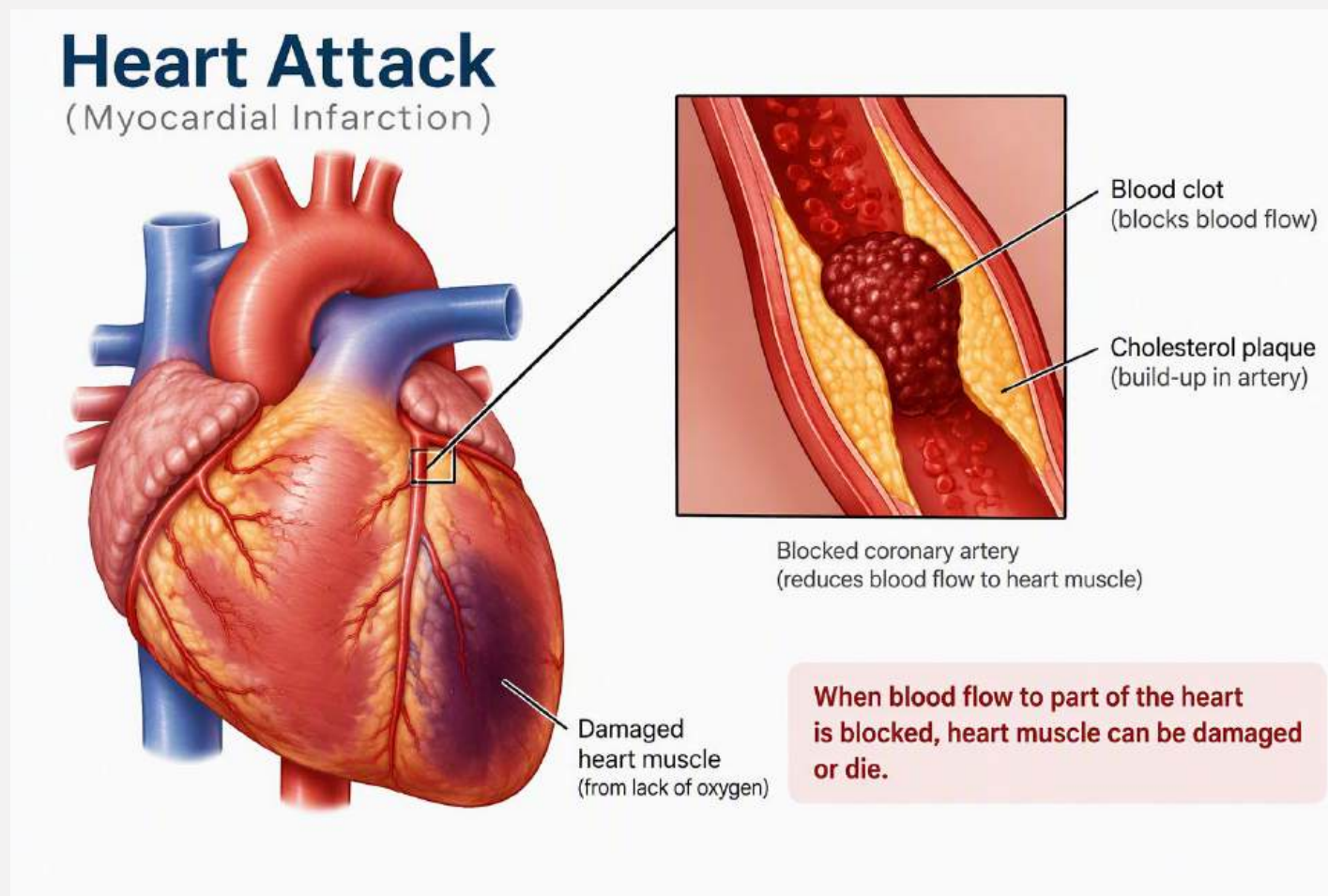
Using the OHCOW calculator

Exposure 0.022 mg / m³ for a working life-time (40 years) - the relative risk is approx. 2 (double the risk of lung cancer compared to not being exposed).

<https://www.ohcow.on.ca/resources/apps-tools-calculators/diesel-exhaust-relative-risk-calculator/>



Exposure to diesel exhaust and **cardiovascular** (including heart attack)





The 8 h occupational exposure limit on diesel exhaust is 10 $\mu\text{g}/\text{m}^3$ EC in Denmark and 50 $\mu\text{g}/\text{m}^3$ EC in the EU. The Danish work regulatory authorities consider further reducing this exposure limit to 5 $\mu\text{g}/\text{m}^3$. The analyses on recent exposure among Diesel Engine Exhaust (DEE) exposed showed increased Incidence rate ratios (IRR) with exposure **at or above 5.5 $\mu\text{g}/\text{m}^3$** (equivalent to 0.0055 mg / m³) for acute myocardial infarction (AMI) (heart attack).



What new technology exists to improve measurement for smaller / fine and ultrafine particulate matter.

- **Lung-deposited surface area (LDSA)** of UFPs in the alveolar region for different occupational exposures, such as chimney sweeps, downstream industrial handling of nanomaterials, waste recycling, and training of firefighters (Lovén et al. 2021, 2023, 2024; Moazami et al. 2024).
- LDSA is an important metric for adverse health effects of particle exposures as it combines the lung deposition and surface area of particles (Liu et al. 2023).

Maria Hedmer, Karin Lovén, Johannes Rex, Carina A Nilsson, Merve Polat, Jakob K Nøjgaard, Joakim Pagels, Bo Strandberg, Lina Hagvall, Characterization of occupational exposure to air pollutants during asphalt milling and paving, *Annals of Work Exposures and Health*, Volume 70, Issue 2, March 2026, wxaf078, <https://doi.org/10.1093/annweh/wxaf078>



Next generation pollution monitoring

AMBIENT ULTRAFINE MONITOR (AUM)

Accurate and affordable sensing of ultrafines, anywhere



Lung-deposited surface area (LDSA) measurement

APPLICATIONS

- Particulate matter sensor, including ultrafines (<100 nm), using novel charging for long-term, stable performance
- Accurate measurement of Number Concentration $\times$ Diameter ($N \times d$) and Lung Deposited Surface Area (LDSA)
- Widely deployable instrument for:
 - Indoor and outdoor air quality monitoring
 - Monitoring of ambient environmental aerosols to inform e.g., wildfire and pollution health risks
 - Workplace health and safety



Lung-deposited surface area (LDSA) estimates the surface area concentration of particles deposited in the alveolar region of human lungs and has gained attention in atmospheric science and public health research ([Yuan, J., et al. 2025](#)).

Particle size affects the toxicity, as a function of decreasing particle size and increasing surface area concentration.

LDSA measures the surface area concentration of particles that **deposit in the lung alveoli**, where the **interaction between the pulmonary circulation and the respiration occurs**. Particles entering the lung alveoli can therefore possibly end up in the blood and other organs like the brain ([Lepitso et al. 2024](#)).



Different Environments. A Shared Goal.

Collaborating on Exposure Methods and Metrics for Healthier People and Cleaner Places.

Occupational Hygienists

Focus on workplace exposures

- Assess and control hazards in the workplace
- Use exposure assessment methods and metrics (e.g., sampling, real-time monitoring, OELs)
- Protect worker health

Shared
Methods

Shared
Metrics

Greater
Impact

Aligning exposure methods, metrics, and monitoring approaches provides a more complete understanding of exposure across settings.

Environmental Scientists

Focus on environmental exposures

- Assess and characterize environmental sources and fate of contaminants
- Use exposure assessment methods and metrics (e.g., ambient monitoring, modeling, standards)
- Inform community and ecosystem health protection

WORKPLACE

Higher and more direct exposures (e.g., industrial processes, chemical handling, diesel)

COMMUNITY

Shared air, water, and soil (e.g., near-roadway, industrial, wildfire smoke)

ENVIRONMENT

Broader and long-term exposures (e.g., ambient air, ecosystems, climate-related hazards)

A CONTINUUM OF EXPOSURE

Stronger Together We Can:



Develop consistent exposure methods and metrics



Improve monitoring and data comparability



Better understand cumulative and multi-environment exposures



Support more effective risk management



Protect the health of workers, communities, and ecosystems

Healthy Workplaces. Healthy Communities. A Healthier Tomorrow.

Bridging Occupational and Environmental Exposure Science

OCCUPATIONAL HYGIENIST

- Personal Sampling
- Diesel Exhaust
- Silica & Dust
- Worker Health

⇌ DATA SHARING ⇌

ENVIRONMENTAL SCIENTIST

- PM_{2.5} Monitoring
- Wildfire Smoke
- Air Modelling
- Community Exposure

SHARED METHODS & METRICS
PM_{2.5} • Ultrafine Particles • Elemental Carbon
Exposure Assessment • Health Risk Models

🌲 Wildfire Smoke → 🏠 Community → 🏭 Workplace

BETTER OUTCOMES

- ✓ Improved Communication
- ✓ Stronger Worker Protection
- ✓ Better Exposure Assessment
- ✓ Community Health Benefits



The importance of particle size analysis.



The importance of understanding and measuring particle number

*“results demonstrated that tested US EPA Tier 4 engine was effective in reducing particulate mass and cumulative emissions of nitrogen oxides, but **not equally effective in reducing particulate number emissions**. The results confirmed that the use of DPFs in advanced exhaust aftertreatment systems would be critical to efforts to reduce contributions of such engines to aerosol number concentrations”*

Bugarski AD, Hummer JA, Vanderslice S, Barone T. Retrofitting and re-powering as a control strategies for curtailment of exposure of underground miners to diesel aerosols. Min Metall Explor. 2020 Apr;37(2):791-802. doi: 10.1007/s42461-019-00146-z. PMID: 32478288; PMCID: PMC7261052.
[Retrofitting and re-powering as a control strategies for curtailment of exposure of underground miners to diesel aerosols – PubMed](#)

“Are we forgetting the smallest, sub 10 nm combustion generated particles (Pedata, P., Stoeger, T., Zimmermann, R. et al. (2015) Are we forgetting the smallest, sub 10 nm combustion generated particles?” . Part Fibre Toxicol 12, 34 (2015). <https://doi.org/10.1186/s12989-015-0107-3>

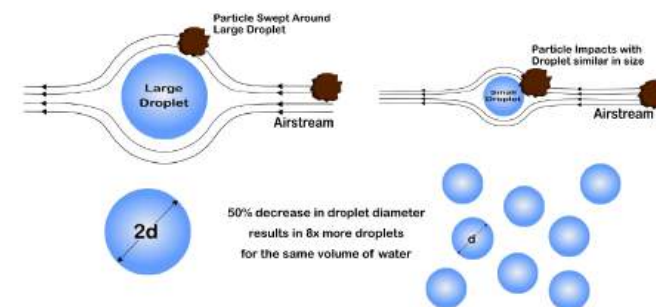


Why is it important to characterize particle size analysis and how does this align with controlling exposure (for dust suppression).



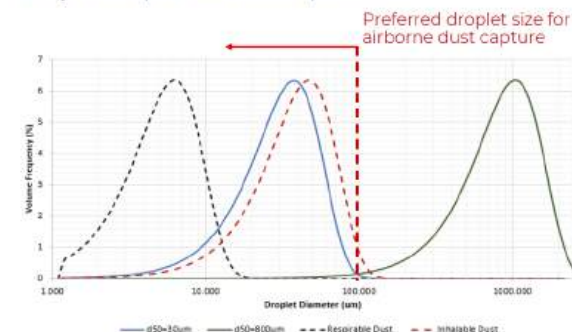
Particle-Droplet Interaction

Why is droplet size so important?



Particle-Droplet Interaction

Why is droplet size so important?



Droplets per 100 ml of water	
Size (micron)	Number (million)
10	190985.9
50	1527.9
100	191.0
500	1.5
1000	0.2

ISO 23875: Standard for Air Quality Control Systems for Operator Enclosures in Mining



UNCLASSIFIED - NON CLASSIFIÉ

Requirements of the Standard

ISO 23875 Standardizes Machine Requirements



Maintain Defined CO₂ Levels

alarm for CO₂ = Ambient
CO₂ + 400ppm
cond alarm is the Action
Level of 2500 ppm



Recirculation Efficiency

Maximum respirable particulate
matter concentration $\leq 25 \mu\text{g}/\text{m}^3$ at
start/end of decay test, maximum
of 120 seconds decay time



Increased Filter Efficiency

A filter that meets more stringent test
criteria, > 94% efficiency at 0.3 μ , that
meets the labelling requirements, and
passes the system leakage and decay
tests



System Maintains Cab Pressurization

Minimum sustained pressurization,
when the machine starting device
moves to the 'on' position shall be ≥ 20
Pa, maximum sustained pressure shall
not exceed 200 Pa



Real-time Operator Cab Monitoring

Cab pressurization and CO₂ levels
monitored by permanently installed
monitoring system

Before

After

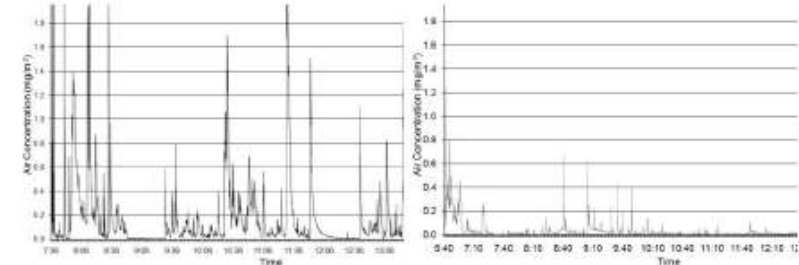


Figure 4.4 Observable reduction in PM₁ concentrations (mg/m³), in real time, measured over six hours during cutting before and after RESPA SD® unit installed.



What this presentation has covered

- Health effects from exposure to different sized particles.
- Exposures to **wildfire smoke** should be factored into the health risk assessment along with other exposures.
- Important to have and clearly communicate a Trigger Action Response Plan (TARP) in the event of a wildfire smoke event. More than compliance against OHS legislation.
- Newer technology to improve measurement for smaller / fine and ultrafine particulate matter.
- Why is it important to characterize particle size.



Useful references

Ganse FG, Ernst LM, Rodríguez C, Ruiz-Meana M, Inserte J, Martínez-González J, Briones AM, García-Redondo AB, Consegal M, Miró-Casas E, Yáñez-Bisbe L, Pomposo A, Prades-Martínez M, Ferreira-González I, Puntos V, Benito B, Rodríguez-Sinovas A. [Insights into the causal role of diesel exhaust particles in ventricular arrhythmogenesis: protective effects of antioxidant cerium oxide nanoparticles](#). Part Fibre Toxicol. 2025 Dec 25;22(1):36. doi: 10.1186/s12989-025-00649-2. PMID: 41444986; PMCID: PMC12739854

Maria Hedmer, Karin Lovén, Johannes Rex, Carina A Nilsson, Merve Polat, Jakob K Nøjgaard, Joakim Pagels, Bo Strandberg, Lina Hagvall, [Characterization of occupational exposure to air pollutants during asphalt milling and paving](#), *Annals of Work Exposures and Health*, Volume 70, Issue 2, March 2026, wxaf078, <https://doi.org/10.1093/annweh/wxaf078>

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[From Traffic Emissions to Urban Secondary PM: Evaluating Particle Emission Prevention and Its Environmental Impact](#) Wojciech Honkisz wojciech.honkisz@bosmal.com.pl | <https://orcid.org/0009-0009-3179-2948> BOSMAL Automotive Research & Development Institute Ltd

<https://dieselnet.com/>



See from OHCOW

Wildfire infographic

<https://www.ohcow.on.ca/wp-content/uploads/2023/06/wildfire-smoke-infographic-06-22-23.pdf>

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OCCUPATIONAL ILLNESS | ERGONOMICS/INJURY PREVENTION | WORKPLACE MENTAL HEALTH | WORKER PERSPECTIVE

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"Where there's smoke..." Understanding Particulate Hazards Indoors and Out
July 21, 2023

Dr. Dave Stieb,
Health Canada Physician
and Epidemiologist

John Oudyk,
OHCOW Occupational Hygienist

**"Where there's smoke..."
Understanding
Particulate Hazards
Indoors and Out**

Watch on YouTube

SLIDE RESOURCES:

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**Where there's smoke... Understanding
Particulate Hazards Inside and Out**
John Oudyk,
Occupational Hygienist, OHCOW

DOWNLOAD PDF:
**Non occupational exposure to wildfire smoke
and health**
Dave Stieb,
Environmental Science and Research Bureau, Health
Canada

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"Where there's smoke..."

OCC-DISEASE, WEBINARS (LIVE), WEBINARS (RECORDED) | CLEAN AIR, INDOOR AIR QUALITY (IAQ), PARTICULATES, PM2.5, WILDFIRE SMOKE

WEBINAR

FRIDAY, JULY 21, 2023
1:30 - 3:00 EST

Dr. Dave Stieb,
Health Canada Physician
and Epidemiologist

John Oudyk,
OHCOW Occupational
Hygienist

Understanding Particulate Hazards Indoors and Out

A key topic (and risk) in occupational and environmental health, affecting thousands of Canadians, at work, at home and everywhere they go.

["Where there's smoke..." Understanding Particulate Hazards Indoors and Out](https://www.ohcow.on.ca/posts/where-theres-smoke/)

<https://www.ohcow.on.ca/posts/where-theres-smoke/>

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Prevention Through Intervention