


CANMET Mining and Mineral Sciences Laboratories




## Comparison of the Respirable Combustible Dust (RCD) and the NIOSH 5040 Methods in Metal Mines and in Bus Garages



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## Background

- In the province of Québec exposure to DPM is limited to  $0.6 \text{ mg/m}^3$  and the analytical method used is the Respirable Combustible Dust (RCD) method
- Any potential future reduction of this number will require an alternative analytical procedure



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## Objectives

- Establish a correlation between RCD and Total as well as Elemental Carbon in Québec mines and bus garages
- Get miner DPM exposure data using the NIOSH 5040 method


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## Study


- Funded jointly by the IRSST and CANMET
- Beginning of 2005
- Targeted 2 Québec gold operations as well as 9 city bus garages
- 458 samples
  - 72 RCD and 72 NIOSH 5040 area samples in mines
  - 52 NIOSH 5040 personnel samples in mines
  - 131 RCD and 131 NIOSH 5040 samples in bus garages




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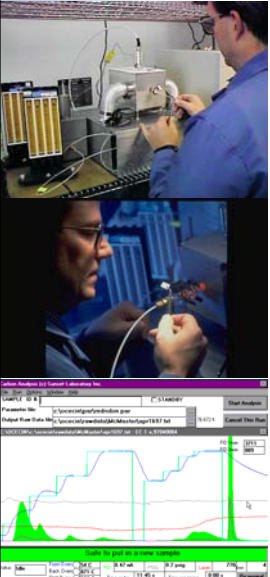


## RCD Method

- Respirable combustible dust method
- Detection limit 0.04 mg
- Basic principle: determine sample mass loss on ashing for 2 hours at 400°C
- Limitations: interference from carbon and sulphide dusts, comparatively lower precision and accuracy



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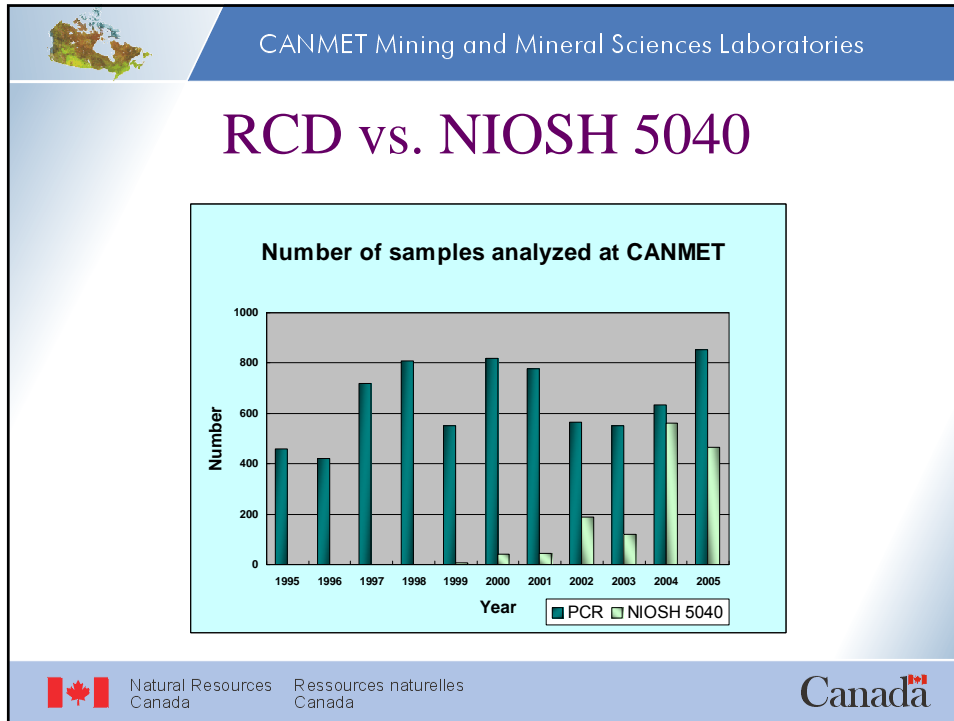
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## NIOSH 5040 Method


- Yields Elemental (EC), Organic (OC) and Total Carbon (TC)
- $TC = EC + OC$
- Detection limits: 0.001 mg (EC) and 0.005 mg (OC)
- Basic principles: two-step analysis of evolved gases while heating the sample
- Limitations: possible interference from other sources of carbon dust in the workplace

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## Study Equipment



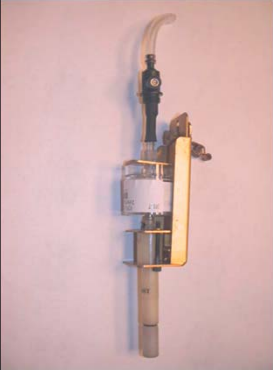
- Gast model 3032 pump (1/6 HP)
- 12 samplers per site, 6 of each RCD and NIOSH 5040, alternating
- Calibrated on-site using Dry-Cal flow calibrators
- Additional flow check and adjustment if needed at intervals during the shift

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## Study Equipment



- RCD – 25mm, 0.8 micron SM filters
- NIOSH 5040 – 37mm quartz fibre filters
- 3-piece plastic cassettes
- 10-mm nylon cyclone
- No single-stage impactor
- Critical orifice on each sampler


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## Procedure

- Mines:
  - 2 mines, 3 sites each
  - 26 personnel each
  - Try to target low, medium and high concentrations
  - Near full-shift sampling sessions
- Garages:
  - Include bus warm-up period at beginning of shift
  - No personnel sampling

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## Results Overview

- Comparison of the precision of both methods
- Area samples in garages
- Area samples in mines
- Personnel samples in mines

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## Precision Comparison

- NIOSH analysis at least 10 times more sensitive compared to RCD
- How does that impact the precision of the exposure measurement - variability
- Exposure is calculated from mass collected, sampling time and flow rate
- Use Standard Deviation calculated on the average of six samples

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## Variability Calculations

Location	Sets of six samples	% Standard Deviation			Ratio	
		RCD	TC	EC	RCD/TC	RCD/EC
Mine A	6	5.5	2.1	1.9	2.6	2.9
Mine B	6	5.8	1.9	2.5	3.1	2.3
Garage A	6	10.9	7.1	5.8	1.5	1.9
Garage B	6	6.4	2.5	1.9	2.6	3.4
Garage C	6	11.7	3.1	2.9	3.8	4.0
				AVG	2.7	2.9

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## Concentration Ranges in Garages

- EC: 10 to 95 µg/m<sup>3</sup>
- TC: 74 to 402 µg/m<sup>3</sup>
- RCD: 110 to 625 µg/m<sup>3</sup>
- Ratio TC/EC: 5.0 (2-3 times higher than in mines)
- Ratio RCD/TC: 1.2 (same as in mines)


Jurisdiction	Method	Substance	Limit of Exposure (µg/m <sup>3</sup> )
Québec	RCD	RCD	600
Ontario	RCD	RCD	1500
USA (provisional)	NIOSH 5040	EC	308
USA (final - May 2008)	NIOSH 5040	TC	160



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## Garages Results

- High TC/EC ratio (5.0) implies a relatively higher OC carbon percentage
- Reasons may include:
  - Warm-up procedure may favour high OC production
  - Comparatively older engines
  - Maintenance issues
  - Urban air contribution






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## Concentration Ranges in Mines Area Samples

- EC: 99 to 282  $\mu\text{g}/\text{m}^3$
- TC: 162 to 626  $\mu\text{g}/\text{m}^3$
- RCD: 210 to 755  $\mu\text{g}/\text{m}^3$
- Ratio TC/EC: 1.8
- Ratio RCD/TC: 1.2 (same as in garages)

Jurisdiction	Method	Substance	Limit of Exposure ( $\mu\text{g}/\text{m}^3$ )
Québec	RCD	RCD	600
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USA (provisional)	NIOSH 5040	EC	308
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## Mine Area Sampling Results

- TC/EC ratio (1.8) is higher than the 1.3 value used in the USA but very similar to the 1.7 value measured during the DEEP Brunswick Study
- Data from both mines were very similar






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## Mine Worker Exposure

- Mine A – 25 samples, 1 spoiled
  - EC: 38 to 434  $\mu\text{g}/\text{m}^3$
  - TC: 145 to 702  $\mu\text{g}/\text{m}^3$
- Mine B – 23 samples, 3 spoiled
  - EC: 25 to 398  $\mu\text{g}/\text{m}^3$
  - TC: 69 to 723  $\mu\text{g}/\text{m}^3$
- TC/EC Ratio: 1.9

Jurisdiction	Method	Substance	Limit of Exposure ( $\mu\text{g}/\text{m}^3$ )
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## Miner Exposure Results

- Mine A made use of air conditioned cabs (deep and hot mine)
- Day 1 – of 10 production vehicles, 5 had air conditioned cabs
- Avg. conc. with A/C: 151  $\mu\text{g}/\text{m}^3$
- Avg. conc. w/o A/C: 287  $\mu\text{g}/\text{m}^3$
- Not a controlled experiment to measure the impact of A/C cabs
- Ventilation, area, presence of other vehicles could impact




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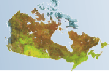
## Conclusions

- NIOSH 5040 method is at least 10 times more precise than the RCD method and when other variables associated with sampling are taken into account concentrations values measured using EC or TC are still nearly three times more precise than RCD values
- In mines, EC and OC values are nearly the same, in the bus garages sampled, OC is on average 4X higher in value than EC



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## Conclusions

- RCD is approximately 1.2X TC both in mines and in bus garages
- RCD is approximately 2.2X EC in mines
- 4 of 48 personnel exposures were over the present limit of  $308 \mu\text{m}/\text{m}^3$
- Over-exposures were all heavy equipment operators working under auxiliary ventilation
- Because it is specifically associated with diesel particulate EC is more representative of worker exposure to DPM

