Sampling and Monitoring of Particles in Metal Inert Gas (MIG) Welding Fumes

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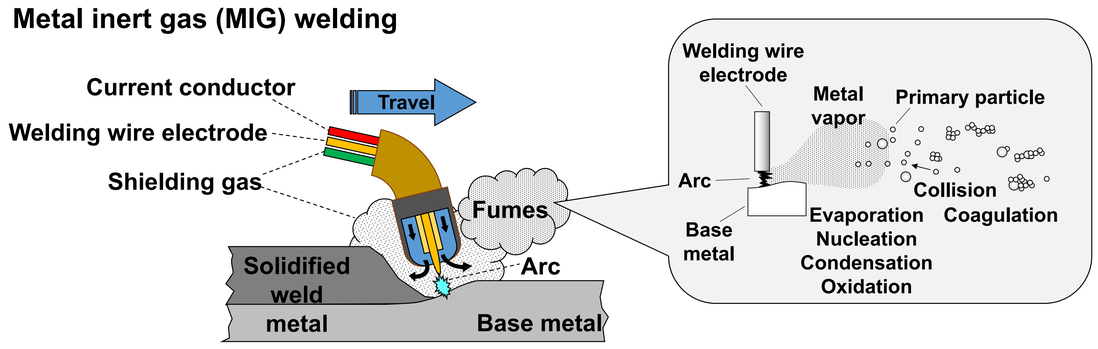
Abstract

Welders can be exposed to welding fumes containing nanoparticles via inhalation, ingestion, or by skin contact, which are important contributors to diseases and illnesses. In this study, the exposure to welding fumes was monitored at a trailer manufacturing facility in Indiana. The respirable particle concentration in MIG welding and non-welding locations were measured. The personal and area samplings were conducted at both these locations as well. A respirable cyclone attached to a cassette housing a mixed cellulose ester (MCE) filter was used for both samplings. Respirable concentrations were measured by gravimetric analysis. Size distributions of particles found in area sampling location were also monitored using a scanning mobility particle sizer (SMPS) and an optical particle sizer (OPS) for every one minute. The composition of the welding wires was analyzed by X-ray fluorescence. From the personal sampling, respirable particle concentration in the welding location was 37 times higher than one in the none-welding location. The geometric mean diameters of particles at welding and non-welding locations were 100 nm and 52 nm, respectively. This information may be useful in future toxicology studies that pertain to evaluating the health effects of nanoparticles from welding fumes.

Introduction

- Welding fumes
  - Mixture of particulate and gases
  - Contains hazardous metals (e.g., manganese)
- Size of particles in welding fumes
  - 0.005- 20 μm, large proportion fine (<2.0 μm) and nano (<100 nm) particles
- Nanoparticles in welding fumes
  - Generated by heating (>2000℃) base metal and welding consumable.
  - Nanoparticles deposit deeper in the lungs and can translocate to other organs.
  - Nanoparticles can cause differing health effects than larger sized particles.
- Metal inert gas (MIG) welding

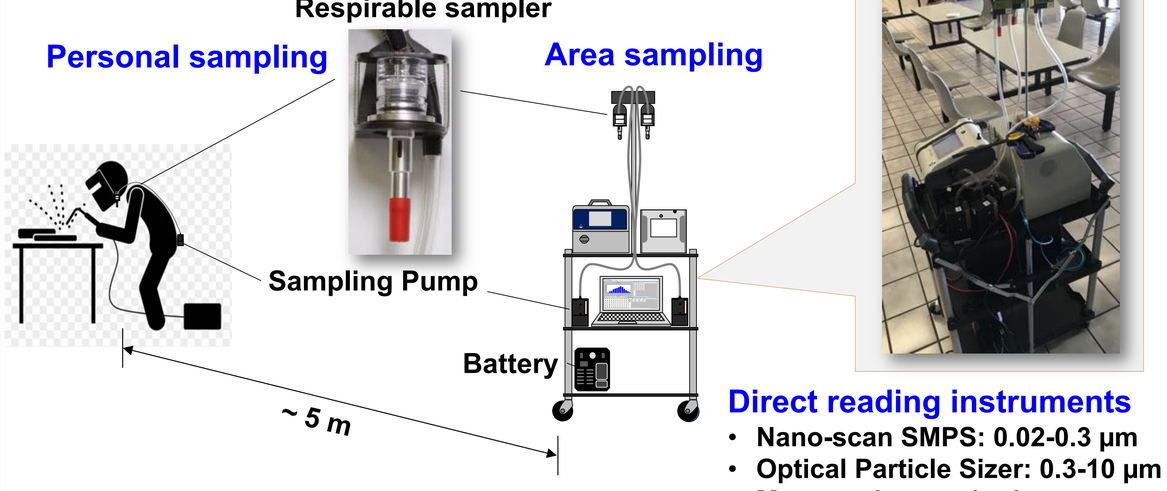


- Monitoring welding fumes
  - First step for controlling air quality, assessing the exposure, evaluating the control systems, and eventually protecting workers' health.
  - Methods
    - Personal sampling for assessing individual exposure
    - Area sampling for assessing background level of exposure

Objectives

- Measure the mass concentrations of respirable dust collected from welder and non-welder.
- Compare the results from personal and area samplings.
- Evaluate airborne particle size and number concentration collected from welding and non-welding locations.
- Hypothesis: higher total number concentrations and larger particle sizes in welding locations.

Methods

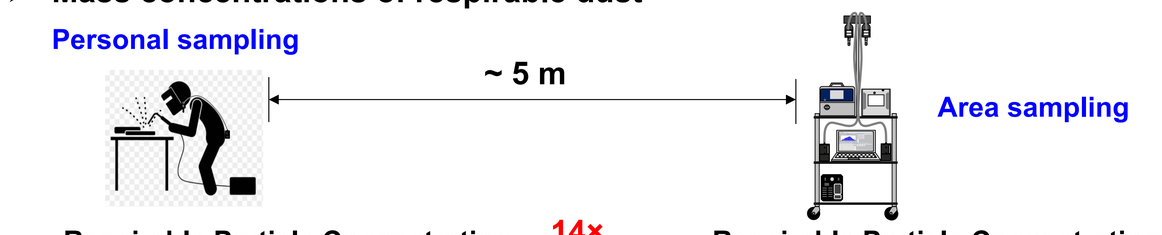


- Respirable dust sampling
  - An aluminum respirable cyclone was attached on a sampling cassette (25 mm).
  - Sampling filter: mixed cellulose ester filter (diameter: 25 mm, pore size: 0.8 μm)
  - Sampling time: 400-470 min, Sampling flow rate: 2.5 L/min
  - Both personal and area samplings were conducted at locations A and B.
  - Conducted gravimetric analysis after sampling.
  - Mass concentration was calculated from the total sampling volume and mass of particles collected on the filters.
- Welding wire was analyzed using X-ray fluorescence before sampling.
  - Fe: 86.1%, Cu: 12.4%, Mn: 1.1%, Etc.: 0.4%

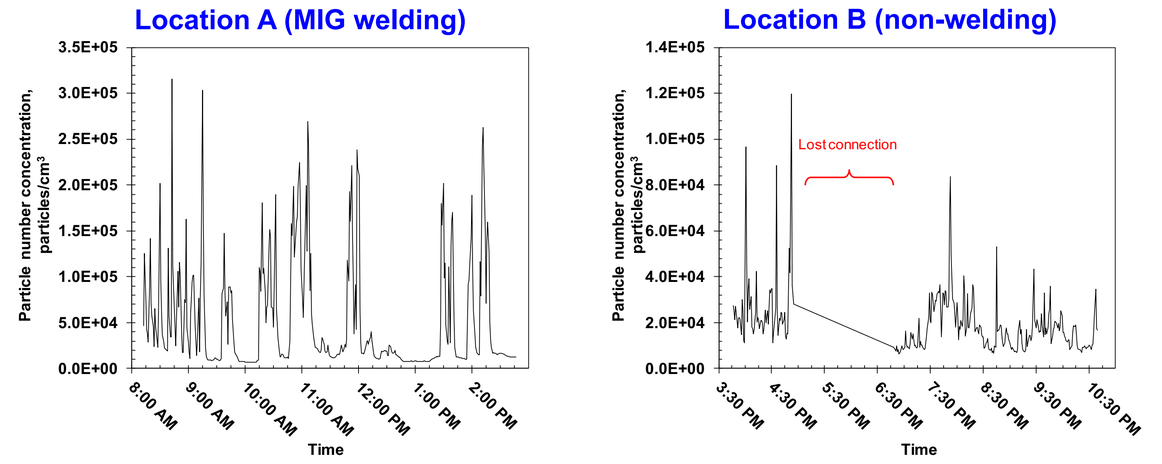
- Sampling locations
  - Trailer manufacturing facility in Indiana
  - Location A: MIG welding process
  - Location B: non-welding process

Results and Discussion

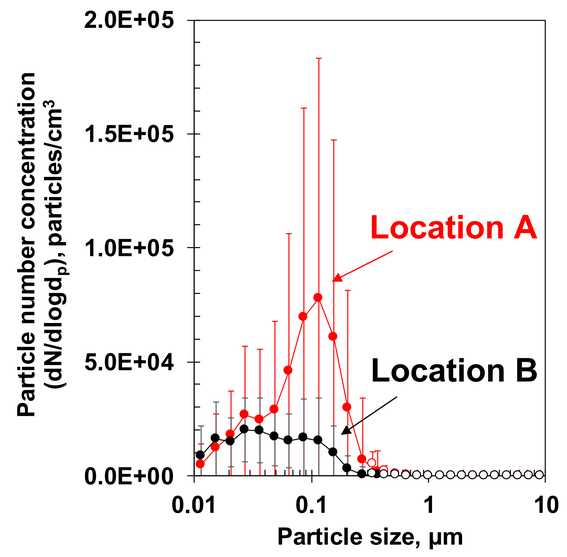
- Mass concentrations of respirable dust



- Total number concentrations



- Size distributions and statistics



	Location A	Location B
Total number concentration, particles/cm^3	5.1×10^4	2.0×10^4
Mode diameter, μm	0.100	0.052
Geometric mean diameter, μm	0.045	0.070
Geometric standard deviation	2.1	2.1

Conclusions

- The larger particle sizes in location A could be due to the greater concentrate of metal gas released during MIG welding.
- Metal nanoparticles can nucleate, coagulate, and condense to form larger particles above 100 nm.
  - The higher concentrations of the finer metal particles in Location A have a higher probability of depositing into the lungs.
- The heating of welding electrode resulted in a mixed chemical alloy that can be further analyzed by XRF.
- Future directions
  - Analyze metal contents in particles collected on MCE filters.
  - Conduct TEM analysis to quantify and visualize the chemical composition of welding fumes.
  - Test from different types of welding, such as shielded metal arc welding and tungsten inert gas welding.

References

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