New Weld Fume Chamber Design to Assess HAP Emissions Potential and Promote Cleaner Production

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Presentation Outline

- Introduction
- Background
- Methodology
- Design of Weld Fume Chamber
- Summary and Conclusions
  - Major Outcomes and Scalability
  - Benefits of this Research
- Acknowledgements
Introduction

- Welding application sectors
  - Industrial; Municipal; Commercial; Service

- Industrial sectors
  - Aerospace; Automotive; Rail; Maritime
  - Metals manufacturing: Ferrous and Non-ferrous
  - Oil exploration and refining
  - Chemical
Most commonly used welding technologies in the maritime industry
- FCAW, GMAW, GTAW, SMAW

Air pollutants emitted
- Weld fume; Heavy Metals; Gaseous Pollutants

Heavy metals with cancer and non-cancer toxicity
- Mn, Ni, Pb, Cr, Cr+6
Emission quantities and characteristics depend on:

- The welding process type (e.g., GTAW, GMAW, SMAW, FCAW, SAW)
- Base metal type and composition (e.g., mild steel, stainless steel, aluminum)
- Electrode or filler rod type, composition and manufacturer
- Welding amperage and wire feed speed
- Welding voltage
- Contact tip to work distance (GMAW and FCAW)
- Shielding gas type and flow rate (where applicable)
- Welding power source (for pulsed current GMAW)
- Base metal surface contamination and coatings (paint, zinc, etc.).
Worker exposures:
- Regulated by the U.S. Occupational Health and Safety Administration (US OSHA)
- Regulated by applicable PELs (8-hr TWA) - Permissible Exposure Levels (PELs) for 8-hr Time Weighted Averages

Public exposures:
- No federal ambient standards specific to heavy metals exist at this time
- Regulated by the public health risk criteria
Background

- U.S. EPA’s Maximum Achievable Control Technology (MACT) Program

- Post MACT Analysis – Risk and Technology Review (RTR)

- “Residual Risk” after MACT implementation

- EPA’s results based on 2002 National Emissions Inventory
Background

- Hazardous Air Pollutant (HAPs) from welding processes within the shipbuilding industry
- Emission factor data available in AP-42 document and the quality concerns
- National Shipbuilding Resources Program (NSRP)
- NSRP’s top priority to establish emission factors for HAPs applicable to shipyard welding
Methodology

- EF development challenges due to relatively low mass emissions from welding:
  - Increased error percentage due to low particulate emissions
  - Need for increased sampling time to be able to collect measurable mass on the filter
  - Higher percentage error in case of certain HAPs that have low emission potential
Methodology

- **Weld fume sampling options considered:**
  - **Source sampling**
    - A portion of the air flow in a duct is sampled under iso-kinetic conditions to estimate the total emissions from a process
  - **Weld fume chamber**
    - Total air flow is passed through a filter to capture and measure pollutants collected
Methodology

- Fume chamber advantages
  - Ability to collect the fume from the entire gas flow, thus reducing the errors associated with sampling a portion of the flow (eliminates problems associated with iso-kinetic sampling)
  - Avoidance of long sampling time; because the entire flow is collected on the filter paper, the mass accumulated is considerable and can easily be measured
  - Adequacy of mass of fume collected for most chemical analyses so even the metals with low emission potential can be determined with reasonable accuracy
Weld Fume Chamber Design

- Design criteria depended on:
  - Quality assurance and quality control aspects
  - Specific pollutants to be measured
  - Type of filter media required to measure specific pollutants
  - Filter characteristics such as the air handling capacity, flow resistance, and availability
Fume chamber performance requirements per American Welding Society (AWS) - AWS F1.2:2006

- A conical welding chamber with 12” diameter opening at the top with a glass fiber filter for particle collection

- AWS performance requirements – ability to capture 100% of weld fume generated
Weld Fume Chamber Design

- Filter selection criteria
  - Ability to filter fine fume particulates generated by welding
  - Capacity to handle AWS requirements for high velocity flow rates
  - Suitability for use in the selected OSHA and NIOSH methods for the analysis of heavy metals Cr, Mn, Ni, Pb, Cr+6, and insoluble nickel
  - Availability in sizes large enough for 12” diameter weld fume chamber [Maximum size available was 10” x 8”]
Weld Fume Chamber Design

- Modification from AWS fume chamber design to achieve project goals
  - Change in diameter of the exhaust duct from 12” to 8” to accommodate
    - Glass fiber filters [TF - gravimetrically; Cr, Mn, Ni, Pb – NIOSH 7300; insoluble Ni – NIOSH 7029]
    - Quartz fiber filters [TF – gravimetrically; Cr+6 - OSHA ID 215]
# Weld Fume Chamber Design

## Filter Selection

<table>
<thead>
<tr>
<th>Use/Test Parameter</th>
<th>Filter Type</th>
<th>Filter Size</th>
<th>Specifications and Special Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total mass of fume, total metals (Cr, Mn, Ni, Pb) and insoluble Ni generated in AWS fume chamber</td>
<td>Pall AE glass fiber filter, binder free</td>
<td>8”x10”, cut to 8” diameter</td>
<td>&gt;99.9% of DOP 0.3 μm particulates</td>
</tr>
<tr>
<td>Total mass of fume and hexavalent chromium generated in AWS fume chamber</td>
<td>Pall Tissuquartz™ quartz fiber filter, binder free</td>
<td>8”x10”, cut to 8” diameter</td>
<td>&gt;99.9% of DOP 0.3 μm particulates; pretreated with sodium hydroxide</td>
</tr>
</tbody>
</table>
Filter Handling Sequence
Weld Fume Sampling in Action
Summary and Conclusions: Major Outcomes and Scalability

- Complies with AWS quality requirements to reproduce the results

- Commercially available Pall AE glass fiber filters can be used by cutting to 8-inch diameter size (TF; Cr, Mn, Ni, and Pb - NIOSH analytical methods)

- Commercially available Pall Tissuquartz™ quartz fiber filters can be used by cutting to 8-inch diameter size (TF; Cr\(^{+6}\) using OSHA ID-215)

- Design of easy-to-handle filter cassette allows easy loading and unloading of filters promoting speed and accuracy of sample collection
Summary and Conclusions: Major Outcomes and Scalability

- Portable design (whole unit mounted on wheels) with flow meter, pressure gauge (to measure pressure drop across the filter), and other controls promotes collection of acceptable samples in an efficient manner avoiding sampling errors.

- The extra controls help to track minimum flow rate and maximum pressure drop across the filter to comply with AWS and other data quality requirements.

- This research work improves the efficiency, convenience, and data quality of future research in this area.
Summary and Conclusions: Benefits of this Research

- Emission potential of welding processes, alternative materials, and multiple consumables will assist shipyards in material substitution and cleaner production.
- Avoids control costs (source reduction).
- Minimizes adverse impacts on human health and the environment.
- Improves public image with reduced court litigation, reduced worker compensation, and increased worker commitment and retention.
- Increased environmental compliance including the compliance with health risk criteria.
### Project Team

- **Primary Contractor**
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