Energy Efficiency In Welding Shops

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Introduction

- Welding and cutting are an integral part of different manufacturing, construction and repair processes
- This presentation describes different engineering strategies which can be used to reduce
  - Worker exposure to welding and cutting fumes; and
  - Allow energy conservation in manufacturing and repair with a positive impact on productivity and production costs
- These strategies include modification of welding processes and selection of welding materials, improved process and local exhaust ventilation, demand controlled ventilation strategies
- The suggested strategies can be used individually or in combination to meet the user’s needs.
Contaminants Generated in Welding Shops

- Fumes and gases from welding and cutting operations
- Airborne metal particles
- Abrasive particles from grinding and polishing operations
- Burned oil fumes
- Fumes from heated adhesives and sealants, and
- Heat
Factors Affecting Fume Generation Rate

Welding fume generation rates depend on a number of factors, including:

- The welding process being used,
- The base metal being welded,
- Composition of the welding electrode and shielding gas composition (if used),
- Welding parameters (e.g., welding current, voltage, wire feed speed), and other process factors.
Process Modifications to Reduce Fume

- Select process with lowest fume
- Use pulsed current GMAW
- Use low-fume FCAW electrodes
- Use low-$\text{CO}_2$ content shielding gases
- Use pulsed current and metal cored electrodes
- Use PAC with Argon-Hydrogen gas
Typical Fume Generation Rate (FGR) for Arc Welding Processes

Select the welding process that produces the least fume, consistent with other application considerations.

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Effect of Shielding Gas on Fume Generation of FCAW with (E71T-1) Electrode
Effect of electrode composition

Standard and Low Fume E7XT-X Flux Cored Electrodes (CO₂ Shielding), and Very Low Fume E71T-1(C5 Shielding)

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Typical U-shaped generation rate curves generated by EWI show, that there is an optimum voltage that minimizes fumes for GMAW and GMAW-P. These voltage values result in the maximum arc stability and operability as well as minimum fume.

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Effect of Pulsed GMAW

- Use of modern inverter welding power sources can reduce the fume generation for pulsed gas metal arc welding (GMAW-P) compared to conventional GMAW procedures.
- Pulsed GMAW also offers the opportunity to reduce fumes and increase weld deposition rate, arc time, and productivity compared to the SMAW process.
- The costs of implementing pulsed GMAW include the costs to purchase inverter power sources and wire feeders, and to train workers.
- Results of tests conducted at John Deere indicate that pulsed GMAW welding power sources reduced fumes by ~80% compared to the constant voltage GMAW welding on clean parts and by ~60% on oily parts.
Ventilation Strategies

• Exhaust from the total welding process enclosure when automatic welding machines are used

• Exhaust from the welding area enclosure, when robotic welding and material handling are used

• Local exhausts which captures the contaminants at or near their source (e.g., local exhausts built-in welding fixtures, or attached to the suspended and pedestal spot welding machines)

• General ventilation
Totally Enclosed Welding Process

American Axle and Manufacturing Plant in Detroit, USA
Enclosed Robotic Spot Welding Area at the DaimlerChrysler North Jefferson Plant, Detroit
Robotic Welding Area Enclosure

Canopy hood with a plastic curtain and rapid doors enclosing the robotic welding area at Nissan Plant in Sunderland, UK
Enclosures Reducing Residual Fume Emission

Total enclosure over a container with welded small parts connected to exhaust system to control residual weld fumes release into the building. Fiat Plant in Turin, Italy

An overhead hood with a perimeter plastic curtain above the conveyor transporting welded parts. The exhaust from the enclosure evacuates residual weld fumes. American Axle and Manufacturing Plant in Detroit, USA.
Specially Engineered Exhaust Systems Built-in the Weld Fixture

DaimlerChrysler Plant in Bremen, Germany
Examples of Built-in Local Exhausts
Attached local exhausts
Canopy Hood over Welding Robots at Volvo Car Body Shop, Goteborg
General Supply Ventilation System

- Provides make-up air for process and local exhausts
- Supplies outside air required for building pressure management and dilution of contaminants not captured by local and process ventilation systems
- Can be used for building heating and cooling (optional)
Examples of Welding Shop Ventilation Systems
Welding Shop at John Deer
Harvest Works Plant, East Moline
General and Process Ventilation at the Daimler Chrysler Jefferson North Assembly Plant, Detroit
DaimlerChrysler Body Shop, Sindelfingen
Active Displacement Ventilation at the VW Body Shop, Germany
Displacement Ventilation in the Welding Shop of Scania Cabin Plant in Oskarshamn
Welding Shop at Sierra Army Depot
Rock Island Arsenal, USA
Normal Ranges of Duty Cycles

OFW = oxyfuel welding
SMAW = shielded metal arc welding
RW = resistance welding
GMAW = gas metal arc welding
FCAW = flux cored arc welding
SAW = submerged arc welding

NORMAL RANGE OF DUTY CYCLES FOR COMMON WELDING PROCESSES AND MODE OF OPERATION
Principle of Demand Controlled Ventilation System
Conclusions

• Information on welding processes used and their mix and contaminant emission rates is essential for good ventilation design

• Building ventilation systems should be designed considering needs of process and local ventilation systems for make-up air, and the airflow rate required for building pressure management

• Dilution ventilation system shall be sized based on the type of air distribution system used, information on capture efficiency by process and local ventilation and the amount of not captured contaminants
Conclusions (Continued)

• Demand controlled local and general ventilation systems are recommended for welding shops with a high diversity of the manufacturing process, low duty cycle and variable work load

• Also, VAV supply and exhaust systems can be recommended to reduce energy costs, given no solid process data is available during the building ventilation systems design stage