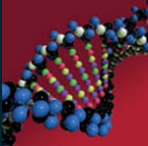



**Data Quality Evaluation:  
Welding Fume Exposure Prediction based on  
Anecdotal Derived  
vs. Field Based Empirical  
Generation Rates**




BOHS Occupational Hygiene 2010  
27-29 April 2010  
Harrogate, UK

C.E. Simmons, CIH  
F.W. Boelter, CIH, PE, BCEE  
ENVIRON International Corporation

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## Problem/Situation

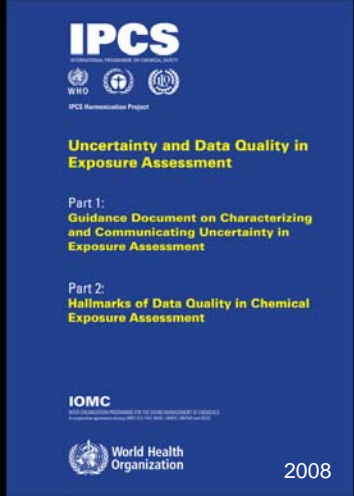
- **Welding**
  - > 80 types of welding processes
  - Electric arc welding most common
- **Welding Exposure Assessment**
  - Worker exposure is typically determined in field assessments
  - Few published data sets
  - Published fume generation rates are predominately laboratory derived data
  - Exposure data collected for one purpose and applied to another
- **Modeling Personal Exposures**
  - Knowledge of environmental conditions and activities
  - Generation rates needed
- **Data Quality**
  - Laboratory derived emission rates
  - Field derived emission rates
  - Anecdotal derived data
  - World Health Organization's (WHO) 2008 document, "Uncertainty and Data Quality in Exposure Assessment".

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## DATA QUALITY



**IPCS**  
INTERNATIONAL PROGRAMME ON CHEMICAL SAFETY  
WHO  
IPCS Harmonization Project

**Uncertainty and Data Quality in Exposure Assessment**

Part 1:  
**Guidance Document on Characterizing and Communicating Uncertainty in Exposure Assessment**


Part 2:  
**Hallmarks of Data Quality in Chemical Exposure Assessment**

IOMC  
INTERNATIONAL ORGANIZATION FOR THE EVALUATION OF THE HUMAN HEALTH CONSEQUENCES OF MIXTURES OF CHEMICALS  
World Health Organization  
2008

<http://www.who.int/ipcs/methods/en/>

“In the field of methodology, the work of the IPCS aims at promoting the development, harmonization and use of generally acceptable, scientifically sound methodologies for the evaluation of risks to human health and the environment from exposure to chemicals.”

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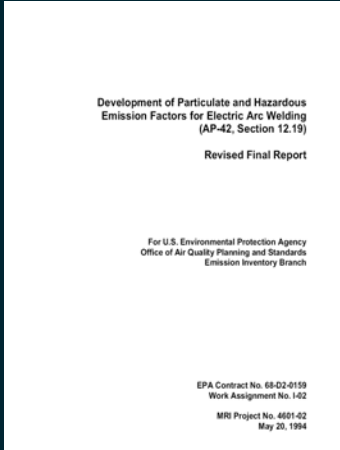


## Judging Data Quality

- **Appropriateness**
- **Accuracy**
- **Integrity**
- **Transparency**

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## Emission Factors



Development of Particulate and Hazardous  
Emission Factors for Electric Arc Welding  
(AP-42, Section 12.19)  
Revised Final Report

For U.S. Environmental Protection Agency  
Office of Air Quality Planning and Standards  
Emission Inventory Branch

EPA Contract No. 68-D2-0159  
Work Assignment No. 142  
MIR Project No. 4601-02  
May 20, 1994


AP-42 emissions factors:

- Estimate area-wide emissions
- Estimate emissions for a specific facility
- Evaluate emissions relative to ambient air quality

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## Emission Factors – Lab Studies

| Process | Electrode | Total Fume g/kg of electrode consumed | Mn g/kg of electrode consumed |
|---------|-----------|---------------------------------------|-------------------------------|
| SMAW    | E6010     | 25.6                                  | 0.991                         |
| SMAW    | E7018     | 18.4                                  | 1.03                          |
| GMAW    | E70S      | 5.2                                   | 3.18                          |
| FCAW    | E71T      | 12.2                                  | 6.62                          |



EPA  
COMPILATION  
OF  
AIR POLLUTANT  
EMISSION FACTORS  
VOLUME I:  
STATIONARY POINT  
AND AREA SOURCES  
FIFTH EDITION

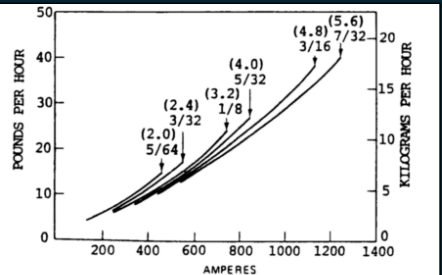
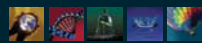


Figure 10-62. Deposition rates for single electrodes.

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## Lab Studies – Data Quality Evaluation

- Emissions data must be from a primary reference
- The report must contain sufficient data to:
  - evaluate the testing procedures
  - evaluate source operating conditions

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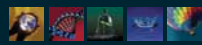
## Lab Studies – Data Quality Evaluation

### Quality rating

- Multiple tests using sound methodology and reported in detail for adequate validation.
- Tests using a sound methodology but lack detail.
- Tests based on an untested or new methodology or that lack significant background data.
- Tests based on a generally unacceptable method, but may provide an order-of-magnitude value for the source.

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## Lab Studies – Data Quality Evaluation

Criteria to evaluate source test reports

- Source operation
  - well documented
  - operating within typical parameters
- Sampling procedures
  - accepted methodology
  - deviations well documented
- Sampling and process data
  - adequate data
- Analysis and calculations
  - contain original raw data sheets

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## Lab Studies – Data Quality Evaluation

The following test data were always excluded from consideration:

- units that cannot be converted
- incompatible test methods
- control device (or equipment) not specified
- welding process not clearly identified and described

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## Lab Studies – Data Quality Evaluation

- McIlwain & Neumeier (1987)


G = 523 mg/min

- Heile & Hill (1975)


G = 280 to 650 mg/min

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## Field Studies – Data Quality Evaluation



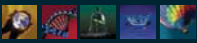
- Capture the information as it arrives
- Variables are not controlled
- Conditions may change



| Workplace                                                                                               | Materials                                                                                                                | Work Methods                                                                                                                             | Environment                                                                                                 |
|---------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|
| ventilation<br>temperature<br>pressure<br>process<br>enclosure<br>continuous vs. batch,<br>housekeeping | physical state,<br>vapor pressure,<br>% composition,<br>quantity used,<br>warning<br>properties,<br>other agents<br>used | worker rotation,<br>task frequency<br>and duration,<br>distance from<br>source,<br>direction from<br>source,<br>PPE use and<br>condition | especially if<br>outside ...<br>temperature,<br>humidity,<br>wind velocity,<br>wind direction,<br>enclosure |

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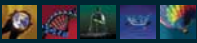
 **Field Studies – Data Quality Evaluation**


Boelter et. al. 2009 (work conducted in 2005)

Purpose - To develop field emission rates and compare to laboratory emission rates


- Data collected by manuscript authors
- Characterized exposure in 2 locations
  - Personal and area full-shift and personal short-term sample results
  - Validated sampling methods
  - Detailed time activity recorded - % Arc Time reported
  - Accredited Laboratory and quality control procedures

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 **Field Studies – Data Quality Evaluation**



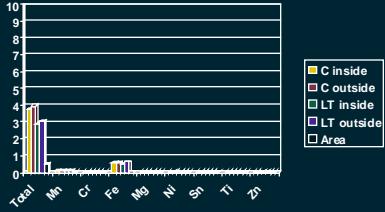
Outside the Building

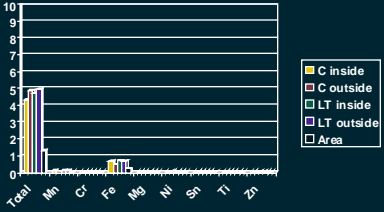


Inside the Building

Observe and document

- time and motion
- work practice
- tools and equipment
- environmental conditions
- interferences







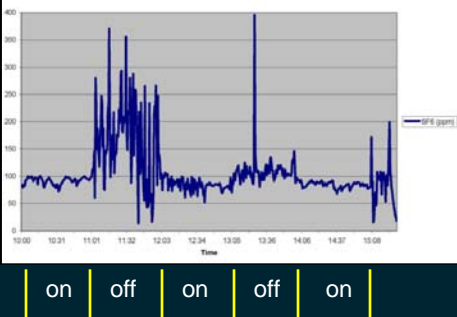
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## Ventilation Measurements

ASTM Method E 741-00

Volume room = 2845 ft<sup>3</sup>  
 G of SF6 = 3 LPM  
 Average ACH by SF6 =  
 - fans on = 24 ACH  
 - fans off = 22 ACH



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## Field Studies Results – Data Quality Evaluation

| Sample Location | Analyte | C <sub>f</sub><br>(mg/m <sup>3</sup> ) | Avg Q<br>(m <sup>3</sup> /min) | G<br>(mg/min) | C <sub>n</sub><br>(mg/m <sup>3</sup> ) | Est. B<br>(m <sup>3</sup> /min) | Near Field:<br>Far Field<br>Ratio |
|-----------------|---------|----------------------------------------|--------------------------------|---------------|----------------------------------------|---------------------------------|-----------------------------------|
| Breezeway       | TP      | 0.57                                   | 79.3                           | 40.0          | 4.04                                   | 11.5                            | 7.1                               |
| Breezeway       | Fe      | 0.06                                   | 79.3                           | 6.6           | 0.59                                   | 14.7                            | 10.0                              |
| Breezeway       | Mn      | 0.01                                   | 79.3                           | 1.2           | 0.11                                   | 14.1                            | 9.1                               |
| Boiler Room     | TP      | 1.25                                   | 30.9                           | 39.2          | 5.36                                   | 9.5                             | 4.2                               |
| Boiler Room     | Fe      | 0.21                                   | 30.9                           | 6.4           | 0.47                                   | 22.8                            | 2.8                               |
| Boiler Room     | Mn      | 0.04                                   | 30.9                           | 1.3           | 0.07                                   | 30.8                            | 2.2                               |

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## Lab v Field - Summary of Results

E7018 rod studies

- Lab
  - McIlwain & Neumeier (1987)
    - G = 523 mg/min (at 100% Arc time)
    - (105 to 157 mg/min at 20 to 30% Arc time)
  - Heile & Hill (1975)
    - G = 280 to 650 mg/min (at 100% Arc time)
    - (56 to 195 mg/min at 20 to 30% Arc time)
- Field
  - Boelter et.al. (2009) G = 40 mg/min
  - Franke & Wadden (1987) G = 24 ± 11 mg/min

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## Compliance and Anecdotal Data – Data Quality Evaluation

**TABLE 1**  
Exposure Assessment: Compliance Air Sampling for Full Shift Total Mn (Milligram per Cubic Meter) and Estimated Levels, During 2003 to 2004

|                             | January to June 2003 |       | July to December 2003 |       | January to June 2004 |       | July to December 2004 |       | All* |       |
|-----------------------------|----------------------|-------|-----------------------|-------|----------------------|-------|-----------------------|-------|------|-------|
|                             | n†                   | Mean‡ | n                     | Mean  | n                    | Mean  | n                     | Mean  | n    | Mean  |
| <b>Box/chamber</b>          |                      |       |                       |       |                      |       |                       |       |      |       |
| Automatic welding           | 5                    | 0.228 | 5                     | 0.195 | 74                   | 0.449 | 37                    | 0.171 | 121  | 0.344 |
| Manual welding              |                      | 0.114 |                       | 0.098 |                      | 0.161 |                       | 0.085 | 8    | 0.131 |
| Carbon arc                  |                      | 0.131 | 6                     | 0.134 | 2                    | 0.122 |                       | 0.131 |      | 0.131 |
| Torch                       |                      | 0.131 |                       | 0.134 |                      | 0.122 |                       | 0.131 | 1    | 0.060 |
| Other                       |                      | 0.060 |                       | 0.060 | 1                    | 0.060 |                       | 0.060 |      |       |
| <b>Pile</b>                 |                      |       |                       |       |                      |       |                       |       |      |       |
| Automatic welding           | 2                    | 0.205 | 9                     | 0.102 | 8                    | 0.039 | 3                     | 0.024 | 22   | 0.076 |
| Manual welding              | 1                    | 0.110 | 3                     | 0.054 | 1                    | 0.190 |                       | 0.093 | 5    | 0.093 |
| Carbon arc                  |                      | 0.130 |                       | 0.103 |                      | 0.077 |                       | 0.050 |      | 0.090 |
| Torch                       |                      | 0.130 |                       | 0.103 |                      | 0.077 |                       | 0.050 |      | 0.090 |
| Other                       |                      | 0.040 |                       | 0.036 |                      | 0.033 |                       | 0.030 |      | 0.035 |
| <b>Other confined space</b> |                      |       |                       |       |                      |       |                       |       |      |       |
| Automatic welding           |                      | 0.200 |                       | 0.170 |                      | 0.140 |                       | 0.110 | 1    | 0.155 |
| Manual welding              |                      | 0.100 |                       | 0.080 | 1                    | 0.041 |                       | 0.060 | 1    | 0.041 |
| Carbon arc                  |                      | 0.070 |                       | 0.065 |                      | 0.060 |                       | 0.055 |      | 0.063 |
| Torch                       |                      | 0.070 |                       | 0.065 |                      | 0.060 |                       | 0.055 |      | 0.063 |
| Other                       |                      | 0.024 |                       | 0.024 | 1                    | 0.024 |                       | 0.024 | 1    | 0.024 |

\*Breathing zone (n = 116) and area (n = 43) samples; most samples ~8 hr; some half-shift samples. Short-term samples excluded (n = 21).  
 †When no samples were available (n: blank), means were estimated from available data (see Methods).  
 ‡Arithmetic mean concentration (milligrams of Mn per cubic meter).

Park et. al. 2009, JOEM

15 Categories

7 Compliance Air Monitoring

3 with 1 air sample

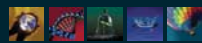
1 with 5 samples

3 with > 6 samples

8 Anecdotal Estimates

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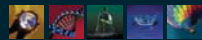


## Compliance and Anecdotal Data – Data Quality Evaluation

- Not collected by researchers
- Compliance driven
- No information on sampling methods
- Exposure Estimates of activities not sampled were derived from samples collected of perceived high concentrations

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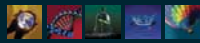


## Compliance and Anecdotal Data – Data Quality Evaluation

- Researchers estimated exposure data based on anecdotal information:
  - Automatic welding in piles resulted in double the concentration of manual welding.
  - Air concentrations declined over time in pile but not chamber locations.
  - Torch cutting exposures = carbon arc exposures.
  - Area samples (collected in chambers only) were combined with personal samples to estimate mean Mn concentrations.
  - Respirable samples were combined with total particulate samples for exposure estimates.

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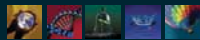
## Compliance and Anecdotal Data – Data Quality Evaluation

### Application of Compliance and Anecdotal Exposure Data

- Exposure-response relationship and risk assessment
- Limitations stated
- Limitations require confirmation

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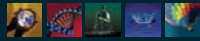


## Judging Data Quality for Use in Worker Exposure Assessment

| Study                      | Appropriateness | Accuracy | Integrity | Transparency |
|----------------------------|-----------------|----------|-----------|--------------|
| McIlwain & Neumeier (1987) |                 | ✓        | ✓         | ✓            |
| Heile & Hill (1975)        |                 | ✓        | ✓         | ✓            |
| Boelter et.al. (2009)      | ✓               | ✓        | ✓         | ✓            |
| Franke & Wadden (1987)     | ✓               | ✓        | ✓         | ✓            |
| Park et. al. 2009          |                 | ✓        | ✓         |              |

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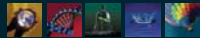


## Conclusions

- Hallmarks of data quality are available
  - should be applied when making decisions regarding use of exposure assessment data
- Using quality laboratory derived emission rates for potential worker welding fume exposures may overestimate exposures
- Modeling welding fume worker exposures requires sophisticated methods
- Risk may be overstated by using poor quality data

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## References

Boelter FW, Simmons CE, Berman L, and Scheff P(2009) : Two-zone model application to breathing zone and area welding fume concentration data. *J. Occup. Environ. Hyg.* 6:298-306 (2009).

Franke JE, and Wadden RA (1987): Indoor contaminant emission rates characterized by source activity factors. *Environ Sci Technol* 21:45-51.

Heile RF, and Hill DC. (1975) Particulate fume generation in arc welding processes. *Welding Research Supplement* July:201s-210s.

McIlwain & Neumeier (1987) Fumes from shielded metal arc welding electrodes. U.S. Department of the Interior, Bureau of Mines.

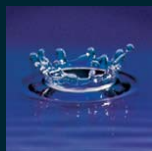
USEPA. (1994) Development of particulate and hazardous emission factors for electric arc welding (AP-42, Section 12.9). Revised Final Report by Lance Henning, with assistance from John Kinsey (EPA Contract No. 68-D2-0159), Research Triangle Park, NC: *United States Environmental Protection Agency, Office of Air Quality Planning and Standards Emission Inventory Branch*, 1994. p 1 – 247.

Park R.M., Bowler R.M., Roels H.A. (2009) Exposure-response relationship and risk assessment for cognitive deficits in early welding-induced manganese. *JOEM*, Vol 51:10, October 2008

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## Thank You



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