

Welding Fume Data Historical Statistical Analysis

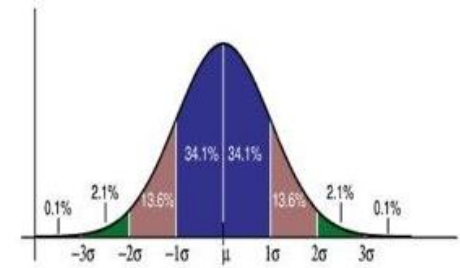
Manganese Advisory Committee

February 1, 2018



References

DON'T BE MEAN



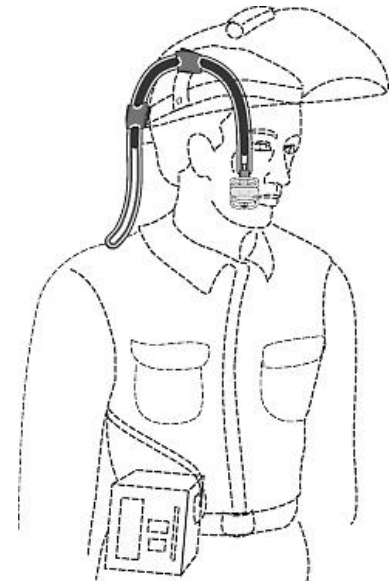
BE ABOVE AVERAGE

© WORDS & UNWORDS

- **Statistic Modeling Reference**
 - **Statistical Modeling to Determine Sources of Variability in Exposures to Welding Fumes**, *The Annals of Occupational Hygiene*, Volume 55, Issue 3, 1 April 2011, Pages 305–318, <https://doi.org/10.1093/annhyg/meq088>
- AIHA & EPA Guides for Statistical Modeling of Occupational Exposures
- AIHA IHSTAT Software
 - Oregon OSHA Lab confirmed statistical results using separate software

Oregon OSHA & Washington DOSH

- 6628 raw data points
 - (5140 from WA; 1488 from OR) spanning 1998-2017
- 3508 coded data points analyzed
 - (2160 from WA; 1348 from OR)
- Sampling beneath the welding helmet
 - [Federal OSHA Requirement](#) since 1999
 - Sample outside of PAPR hood



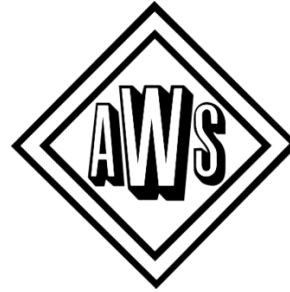
Evaluated Mild Steel, Carbon Steel and Stainless Welding Operations

- Excluded Data from the Assessment
 - Foundries
 - Abrasive blasting
 - Area samples and attendants
 - Spot resistance welding
 - Aluminum welding
 - Carbide steel welding
 - Nickel carbonyl welding
 - Plasma Cutting Tables
 - Metal Spray Operations
 - Samples with no measurable exposure

Exposure During Task vs 8-hour TWA

- Study criteria was to code individual samples without regard to the 8-hour TWA
- This was based on confirming previous studies and theoretical calculations of manganese exposure.
- Determine exposure during actual welding to calculate the duration to exceed the ACGIH
 - 0.02 mg/m³ and 0.1 mg/m³
- 8-hour TWAs were not used because of the potential dilution of actual fume exposure due to other tasks not related to welding activity.

Welding Type Terminology: ANSI/AWS



**American
Welding Society**

- TIG Welding
- MIG Solid Wire
- Flux-Core Welding
- Stick Welding
- Grinding Associated with Welding Task
- Hand Torch Burning (Oxy-Acetylene)
- Hand-held Plasma Cutting
- Carbon Arcing/Scarfig/Arc Gouging
- Unclassified Welding



TIG Welding



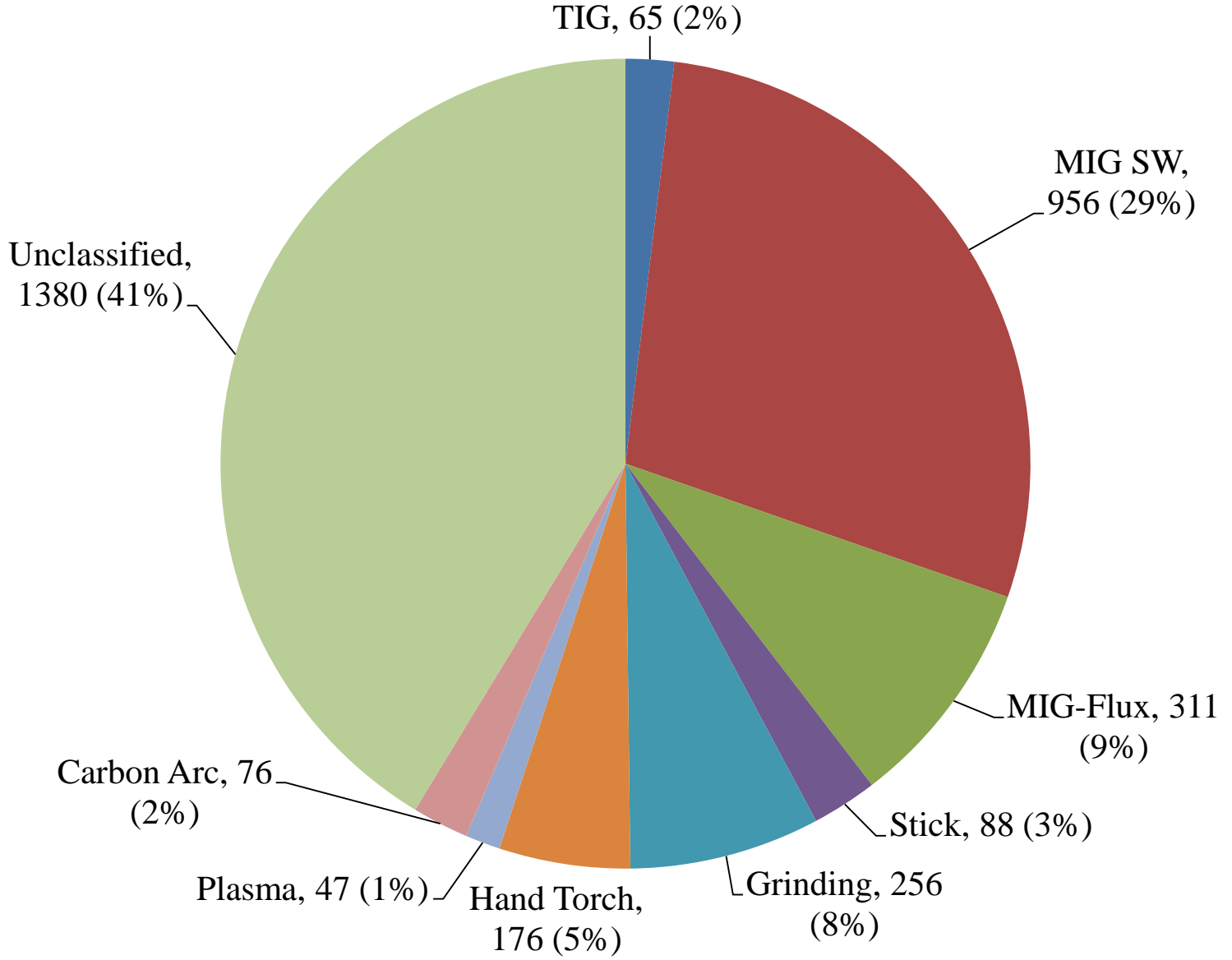
MIG Solid Wire



Flux Core Wire



Air Arc Gouging

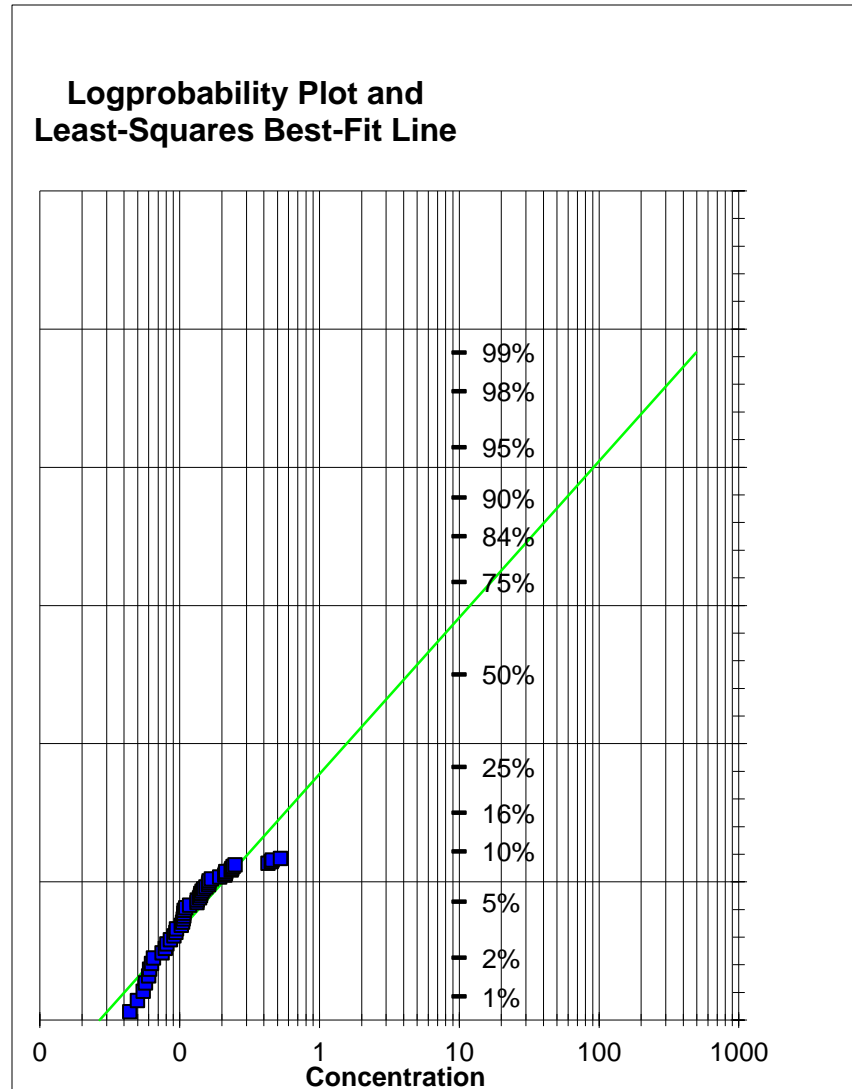


IHSTAT Software: Output

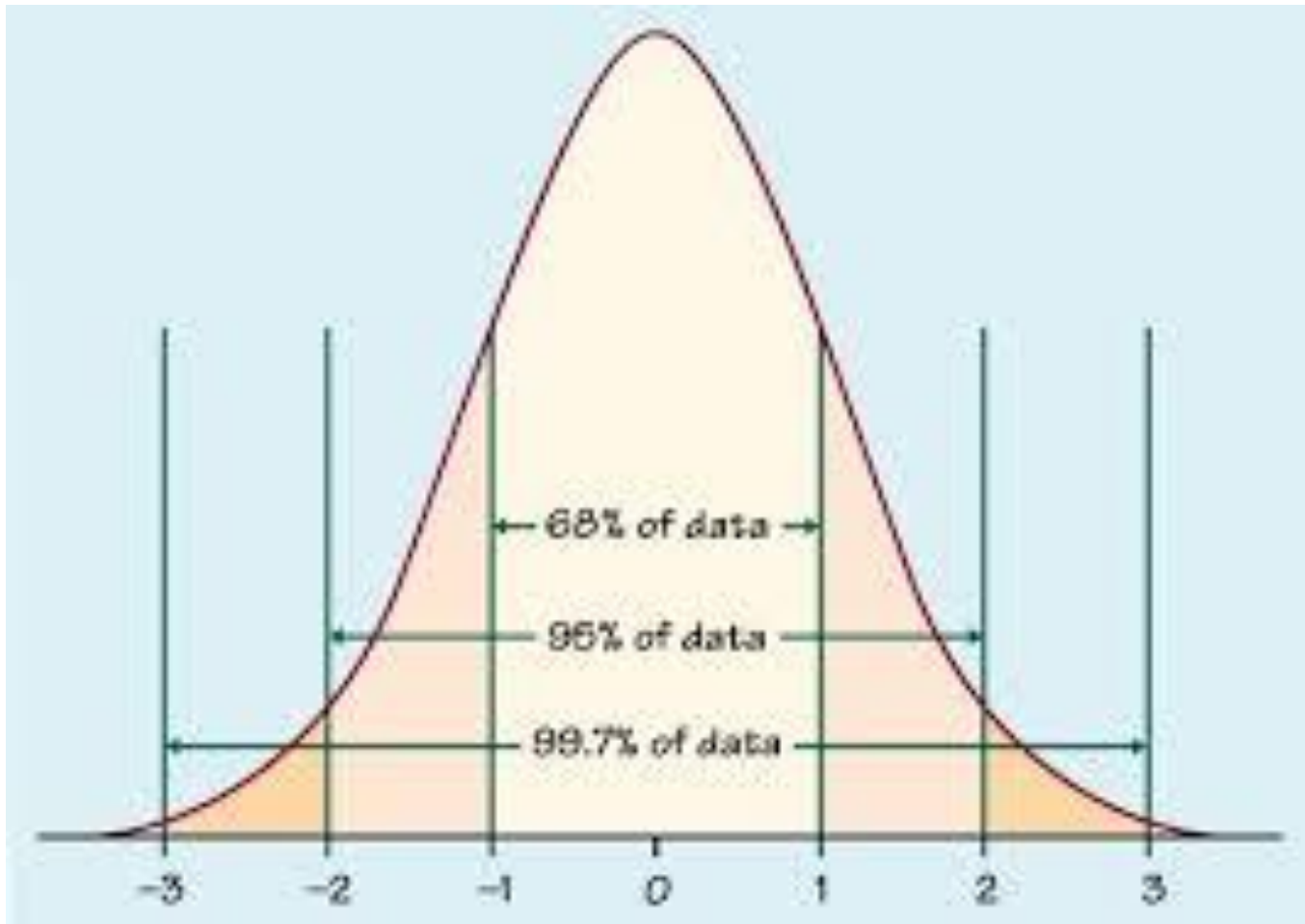
DESCRIPTIVE STATISTICS	
Number of samples (n)	546
Maximum (max)	5.44
Minimum (min)	0.005
Range	5.435
Percent above OEL (%>OEL)	0.000
Mean	0.271
Median	0.140
Standard deviation (s)	0.450
Mean of logtransformed data (LN)	-2.149
Std. deviation of logtransformed data (LN)	0.732
Geometric mean (GM)	0.117
Geometric standard deviation (GSD)	2.079

LOGNORMAL PARAMETRIC STATISTICS	
Estimated Arithmetic Mean - MVUE	0.152
LCL _{1,95%} - Land's "Exact"	0.144
UCL _{1,95%} - Land's "Exact"	0.162
95th Percentile	0.388
UTL _{95%,95%}	0.528
Percent above OEL (%>OEL)	0.000
LCL _{1,95%} %>OEL	<0.1
UCL _{1,95%} %>OEL	<0.1

Each Data Set Evaluated To Ensure Lognormal Distribution



Upper and Lower Confidence Limits



Calculated Exposure Durations to Exceed $0.02\text{mg}/\text{m}^3$ and $0.1\text{ mg}/\text{m}^3$

- How long to exceed the 8-hour average with no exposure for the remainder of the work-shift.
- Based on the exposure during welding and grinding tasks.
 - If performing multiple tasks you would use of the shortest duration task for determining need for respiratory protection

Respirator Calculations

95% Upper Confidence Limit

- Calculation for Determination of APF 10 (Table A2)
 - $0.1 \text{ TLV} \cdot 8 \text{ hr} / \text{Upper Confidence Limit} = \text{Minutes}$
 - $(0.1 \text{ mg/mg}^3 \cdot 480 \text{ minutes}) / \text{UCI}$
 - e.g. MIG-Flux Core / Dual Shielding (Table A1, A2)
 - $(0.1 \text{ mg/mg}^3 \cdot 480 \text{ minutes}) / 0.780 = 61.5 \text{ minutes}$

- Calculation for Determination of APF 25 (Table A2)
 - $(1.0 \text{ mg/m}^3 \cdot 8 \text{-hr}) / \text{Upper Confidence Limit} = \text{Minutes}$
 - $(1.0 \text{ mg/mg}^3 \cdot 480 \text{ minutes}) / \text{UCI}$
 - e.g. Carbon Arc Gauging / Scarfing (Table A1, A2)
 - $(1.0 \text{ mg/mg}^3 \cdot 480 \text{ minutes}) / 1.251 = 383.6 \text{ minutes}$

Calculation for Determination of Engineering Controls
(Table A2)
Lower Confidence Limit

- $(0.1 \text{ TLV} * 8 \text{ hours}) / \text{Lower Confidence Limit} = \text{Minutes}$
 - $(0.1 \text{ mg/mg}^3 * 480 \text{ minutes}) / \text{LCI}$
- e.g. Hand-Held Torch Cutting (Table A1, A2)
 - $(0.1 \text{ mg/mg}^3 * 480 \text{ minutes}) / 0.154 = 311.6 \text{ minutes}$

OR-OSHA 2/Q Welding Standard

- *When welding or cutting operations are being performed on the following materials (Table OR Q 1), the protective measures indicated are required unless atmospheric samples taken in the welder's breathing zone indicate that the concentration does not exceed the limits specified in Division 2/Z, OAR 437-002-0382, Oregon Rules for Air Contaminants.*

Table OR Q-1: Current Standard

Material	Condition	Protective Measures
• Manganese	Confined Space	Airline Respirator or Local Exhaust Ventilation
• Manganese	Indoors	Fume Respirator or Local Exhaust Ventilation
• Zinc	Confined Space	Airline Respirator or Local Exhaust Ventilation
• Zinc	Indoors or Outdoors	Fume Respirator or Local Exhaust Ventilation
• Lead	Confined Space	Airline Respirator or Local Exhaust Ventilation
• Lead	Indoors or Outdoors	Fume Respirator or Local Exhaust Ventilation
• Lead	Other workers	Local Exhaust or Airline Respirator
• Cadmium	Confined Space or Indoors	Airline Respirator or Local Exhaust Ventilation
• Cadmium	Outdoors	Fume Respirator
• Cadmium	Confined Space	Local Exhaust and Airline Respirator
• Mercury	Confined Space or Indoors	Airline Respirator or Local Exhaust Ventilation
• Mercury	Outdoors	Approved Respirator
• Beryllium	Confined Space	Airline Respirator or Local Exhaust Ventilation
• Manganese	Confined Space	Airline Respirator or Local Exhaust Ventilation
• Beryllium	Indoors or Outdoors	Airline Respirator and Local Exhaust Ventilation
• Beryllium	Other Workers	Local Exhaust or Airline Respirator in Immediate Vicinity
• Fluorine)	Indoors or Outdoors	Fume Respirator or Comp. Local Exhaust Ventilation

Oregon OSHA Ventilation Requirement

- Local Exhaust Ventilation
 - 100 feet per minute capture velocity
 - Preliminary data support that this reduces exposure to less than 0.1 mg/m³ but may be above 0.02 mg/m³.
- Dilution ventilation for general shop area
 - 2000cfm per welder if less than 10,000 ft² or 16 foot ceiling
- Confined space flagged but not included in the current evaluation



Data Summary: OR/WA draft

Welding Process	Sample Size (n)	Mean (mg/m ³)	S.D. (mg/m ³)	% Population Overexposed PEL = 0.1 mg/m ³	% Population Overexposed TLV = 0.02 mg/m ³	Minutes to Overexposure Based on PEL & (95% UCI mg/m ³)	Minutes to Overexposure Based on PEL & (95% LCI mg/m ³)
TIG	65	0.044	0.054	12%	59%	>480 mins (0.057)	>480 mins (0.031)
MIG (Solid Wire)	956	0.332	0.643	61%	93%	132 mins (0.363)	171 mins (0.281)
MIG-Flux Core /Dual Shield	311	0.665	1.034	81%	97%	62 mins (0.780)	87 mins (0.550)
Stick	88	0.631	1.514	57%	99%	50 mins (0.952)	155 mins (0.310)
Grinding tasks related to the welding process	256	0.438	0.821	54%	85%	89 mins (0.539)	142 mins (0.337)
Hand Torch Cutting	176	0.369	1.447	31%	70%	82 mins (0.584)	312 mins (0.154)
Hand Held Plasma Cutting	47	0.223	0.345	53%	92%	140 mins (0.342)	393 mins (0.122)
Carbon Arc Gauging /Scarfig	76	1.172	1.948	95%	97%	38 mins (1.251)	44 mins (1.093)
Unclassified Welding	1390	0.335	0.998	56%	90%	124 mins (0.388)	170 mins (0.282)

Respirator Selection: 0.1 mg/m³

Draft

Welding Process	Respirator with APF=10	Respirator with APF=25	Engineering Controls
TIG (T) GTAW	Not Required	Not Required	Not Required
MIG-Solid Wire (M) SMAW	>2 hr	–	>3 hr
MIG-Flux Core (F) FCAW	>1 hr	–	>1.5 hr
Stick (S) SMAW	>1 hr	–	>2.5 hr
Grinding Tasks directly related to Welding (G)	>1.5 hr	–	>2.5 hr
Hand-Held Torch Cutting (H)	>1.5 hr	–	>5 hr
Hand-Held Plasma Cutting (P)	>2.5 hr	–	>6.5 hr
Carbon Arcing (C)	>30 mins	>6 hr	>1 hr

Respirator Section: 0.02 mg/m³ Draft

Welding Process	Respirator with APF=10	Respirator with APF=25
TIG (T) GTAW	>2.5 hrs	NA
MIG-Solid Wire (M) SMAW	>30 min	>4.5 hours
MIG-Flux Core (F) FCAW	>15 min	> 2 hrs
Stick (S) SMAW	>10 min	>1.5 hrs
Grinding Tasks directly related to Welding (G)	>15 min	> 3 hrs
Hand-Held Torch Cutting (H)	>15 min	>2.5 hrs
Hand-Held Plasma Cutting (P)	>30 min	>5hrs
Carbon Arcing (C)	>5 min	> 1hr