NATIONAL SHIPBUILDING RESEARCH PROGRAM
ADVANCED SHIPBUILDING ENTERPRISE
Reducing Naval Ship Construction & Repair Costs

Reduction of Weld Fume Risk in Naval and Commercial Shipyards

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Reduction of Weld Fume Risk in Naval and Commercial Shipyards
Final Report

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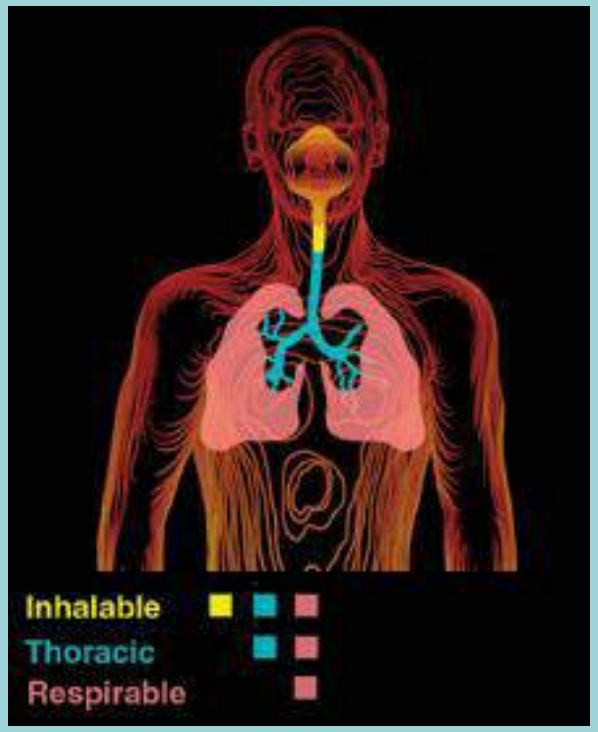
Reduction of Weld Fume Risk in Naval and Commercial Shipyards

- Newly proposed TLV for Mn included a 10-fold reduction and new testing for Respirable and Inhalable particle sizes.
- No previous testing had measured the impact of these changes.
- Completed side-by-side testing for Total, Respirable and Inhalable Mn in 3 shipyards and one ship component manufacturer site; 7 metalworking processes.
- New methods for Respirable and Inhalable Mn produced wildly variable results without correlation to established OSHA Method for Total Mn.
- Should the proposed change to TLV for Mn be withdrawn?

Reduction of Weld Fume Risk in Naval and Commercial Shipyards

ACGIH recommends that particle-size selective TLV's be expressed in three possible forms:



Inhalable Particulate Mass

Dust particles having a 50% cut-point of 100 µm. These dust particles are hazardous when deposited anywhere in the respiratory tract.

Thoracic Particulate Mass

Dust particles having a 50% cut-point of 10 µm. These dust particles are hazardous when deposited anywhere in the lung airways and gas-exchange regions.

Respirable Particulate Mass

Dust particles having a 50% cut-point of 4 µm. These dust particles are hazardous when deposited anywhere in the gas-exchange regions.

Particle Size-Selective TLV's. (Summary from www.skcinc.com).

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MANGANESE, ELEMENTAL and INORGANIC COMPOUNDS

CAS number: 7439-96-5 (Manganese)

Empirical formula: Mn

TLV–TWA, 0.02 mg/m^3, as Mn, Respirable particulate matter
0.2 mg/m^3, as Mn, Inhalable particulate matter

A4 — Not Classifiable as a Human Carcinogen

TLV® Recommendation

concluded that an eight-hour TWA exposure of approximately 1.0 mg Mn/m^3 (total dust) could lead

Reduction of Weld Fume Risk in Naval and Commercial Shipyards

Why Did They Do This?

- TLV Basis - Central Nervous System Impairment (p.2, TLV Documentation)
- Justification is selective and flawed - unknown or inconsistent methods; self-reported symptoms, lack of controls, selection bias.
- NIOSH (Antonini, et.al;) Reports that any link between Mn in welding and movement disorders remains unproven. [“Health Effects of Welding” was published in the journal Critical Reviews in Toxicology, 33(1):61-103 (2003).]
- Santamaria (2007), Fored (2006), Fryzek (2005)
- ACGIH does not provide listing of literature reviewed or available, only literature cited to justify their position.

Reduction of Weld Fume Risk in Naval and Commercial Shipyards

What's the Problem?

- Previous testing has always collected "Total" airborne Mn.
- The OSHA PEL for Mn is 5.0mg/m^3 as a Ceiling limit. (Total Mn)
- No validated method to correlate previous testing for "Total" Mn to the newly proposed limits for Respirable and Inhalable Mn, therefore any evaluation to determine compliance will require new air monitoring in accordance with the appropriate methods.
- As a consequence of these changes, the baseline Mn exposure data for welding and other metalworking processes collected at shipyards and previous NSRP studies cannot provide a measure of how much "Respirable" or "Inhalable" Mn may be released.
- Impact on Shipyard Welding is Unknown.

Reduction of Weld Fume Risk in Naval and Commercial Shipyards

Why should we Care?

- TLV's are not regulations or enforceable standards
- TLV's are not required to be measurable, feasible or achievable
- They are proprietary "expressions of scientific opinion"
- Closed committee of volunteers limited to academic institutions and government agencies
- Manufacturers and businesses cannot participate as TLV committee members
- Initiated in 1940's in the absence of other standards or guidelines
- Since 1970, OSHA and NIOSH continuously research, review and enforce occupational exposure standards
- OSHA and NIOSH now have annual budgets of approximately $1 Billion per year and thousands of full-time employees and dedicated contractors
- Practitioners are unclear what TLV's are, creating confusion and miscommunication
- TLV's can provide the basis for plaintiffs to support claims of injury
- Navy recognizes TLV's as OEL in OPNAVINST 5100.23G, Chapter 16, Part 1603 c.(3)

Project Goals and Objectives:

The goal of this project was to conduct particle-size air sampling for Mn during representative shipyard welding processes in advance of the effective date of this new occupational exposure limit to allow the shipyard industry to evaluate the compliance impact and prepare a practical and focused response.

This project will allow shipbuilding and ship repair activities to:

a) Establish responsive baseline welding exposure data at an early stage to avoid time consuming and costly exposure monitoring at each site where industry-wide representative data will suffice;

b) Allow shipyards to identify potential non-compliance areas early to allow cost-effective and proactive compliance decisions, and

c) Provide the data necessary to prepare and submit a focused and accurate shipyard-industry response where a challenge, rebuttal or alternative proposal is warranted.

Reduction of Weld Fume Risk in Naval and Commercial Shipyards

One-year Project (January 2011 – January 2012)

Shipyard Participants:

- BAE Systems – Jacksonville
- Bath Iron Works
- Norfolk Naval Shipyard

Project Prime/Lead; POC:

Atrium Environmental Health and Safety Services; Dan Chute

Participant Subcontractors:

Applied Thermal Sciences, Inc., Navy and Marine Corps Public Health Center

Field Testing and Analysis

- Perform side-by-side fume measurement for Total, Respirable and Inhalable Mn during selected shipyard welding processes, such as SMAW, TIG, FCAW and GMAW-P (pulse-arc)
- Evaluate HLAW as a “Green Shipyard” option for reduced energy consumption, less waste and lower emissions
- Review results to determine need for additional testing in focused areas

Deliverable: Written report summarizing all field testing and evaluations, providing a complete description of methods followed, laboratory analysis and comparison to existing and proposed occupational exposure standards for Manganese.

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Findings:

- Is any previous data available to define the relationship between Total, Inhalable and Respirable Mn in welding fume generated by common ship yard welding processes? NO

  Sources Examined:

  a. Navy NOED Database (3866 air samples for Mn; 1982-2007)
  b. OSHA IMIS Database (1248 samples for Mn fume in Shipyards, 1984-2009)
  c. NIOSH Studies and discussions with researchers, Dr. James Antonini and Dr. Martin Harper.
  d. Review of the ACGIH TLV Documentation for Manganese and Inorganic Compounds (2010)
  e. Discussion and correspondence with ACGIH Chemical Substance Committee Chair, Dr. Terry Gordon and ACGIH Staff Science and Education Manager, Ryan Peltier.
  f. Review of extensive technical literature including previous NSRP studies and research published by the American Welding Society.

Reduction of Weld Fume Risk in Naval and Commercial Shipyards

Summary of Literature Search:

1. TLV NIC for Mn (0.02 mg/m^3 of air Respirable fraction, 0.2 mg/m^3 Inhalable fraction) requires totally different air sampling methods from the historical OSHA compliance methods.
2. No valid means of comparison to determine what correlation may be drawn between previous air sampling data for Mn and compliance with the new and drastically lowered occupational exposure limit.
3. No body of data has been identified which has previously studied this relationship, which would allow employers to determine if their previously “compliant” welding operations are operating above or below the new limits.
4. This data gap requires field evaluation to measure exposure and determine what correlation, if any, may exist between historical air sampling data for Total Mn and new air sampling data for Inhalable and Respirable Mn.

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Field Testing Plan – Collect data in three shipyards and one manufacturing facility in order to meet the following objectives:

1. Perform side-by-side fume measurements for Total, Respirable and Inhalable Mn during selected shipyard welding processes, such as SMAW, TIG, FCAW and GMAW.

2. Evaluate Hybrid Laser Arc Welding (HLAW) as a “Green Shipyard” option for reduced energy consumption, less waste and lower emissions.

3. Review results to define patterns and determine if additional testing is recommended.

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Field Testing and Analysis:

- BAE Systems Southeast shipyard; April 12-14, 2011
- GD-Bath Iron Works; April 25-27, 2011
- Norfolk Naval Shipyard; May 2-4, 2011
- Applied Thermal Sciences facility (Sanford, ME); June 8-10, 2011

Reduction of Weld Fume Risk in Naval and Commercial Shipyards

Collected 96 air samples using “triple-pump” approach

32= Total Mn 32= Inhalable Mn 32= Respirable Mn

7 Metal Working Processes Tested:

- FCAW
- TIG
- SMAW
- MIG-Pulse-Arc
- Carbon Arc Gouging
- Grinding
- HLAW

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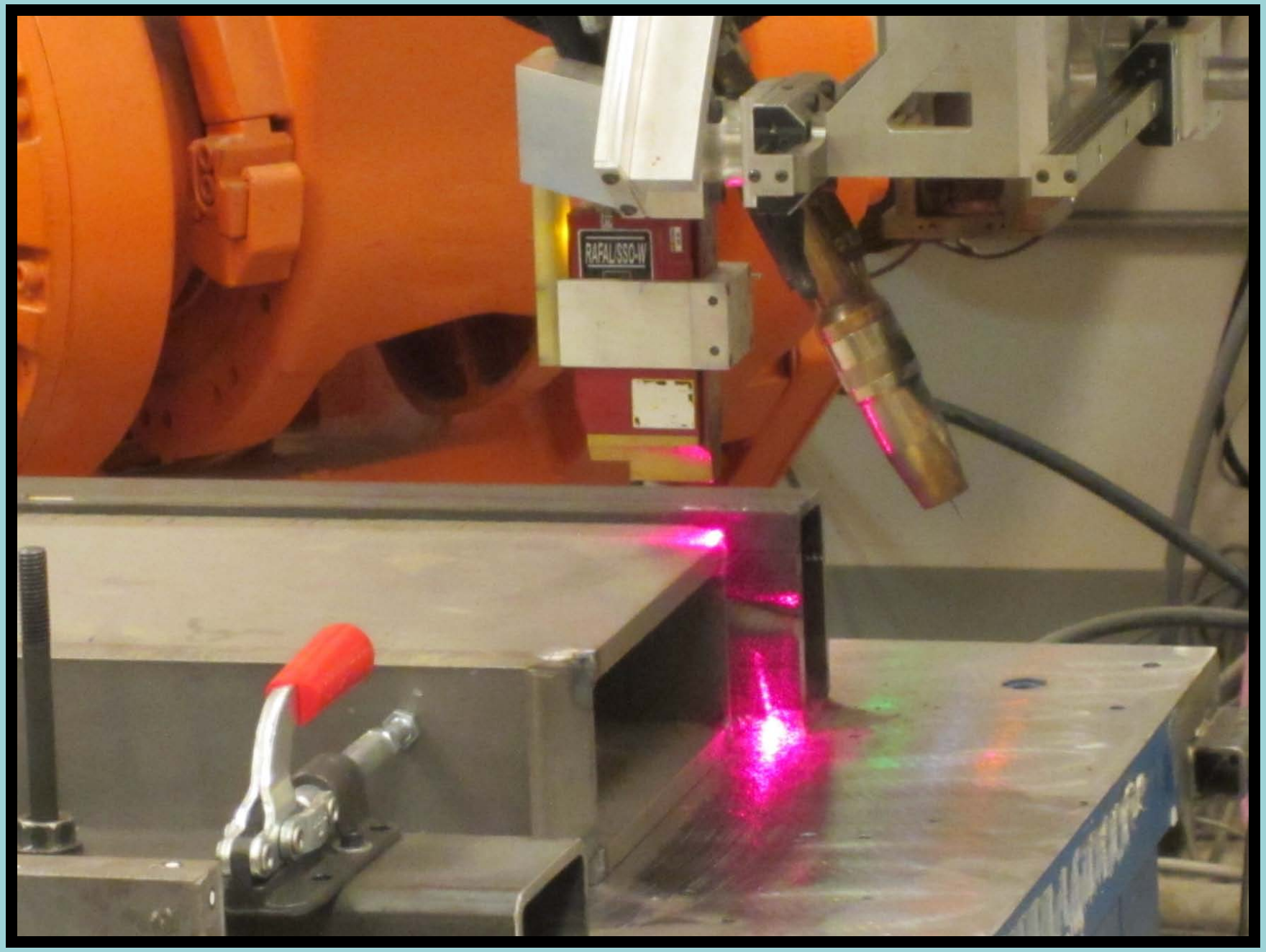
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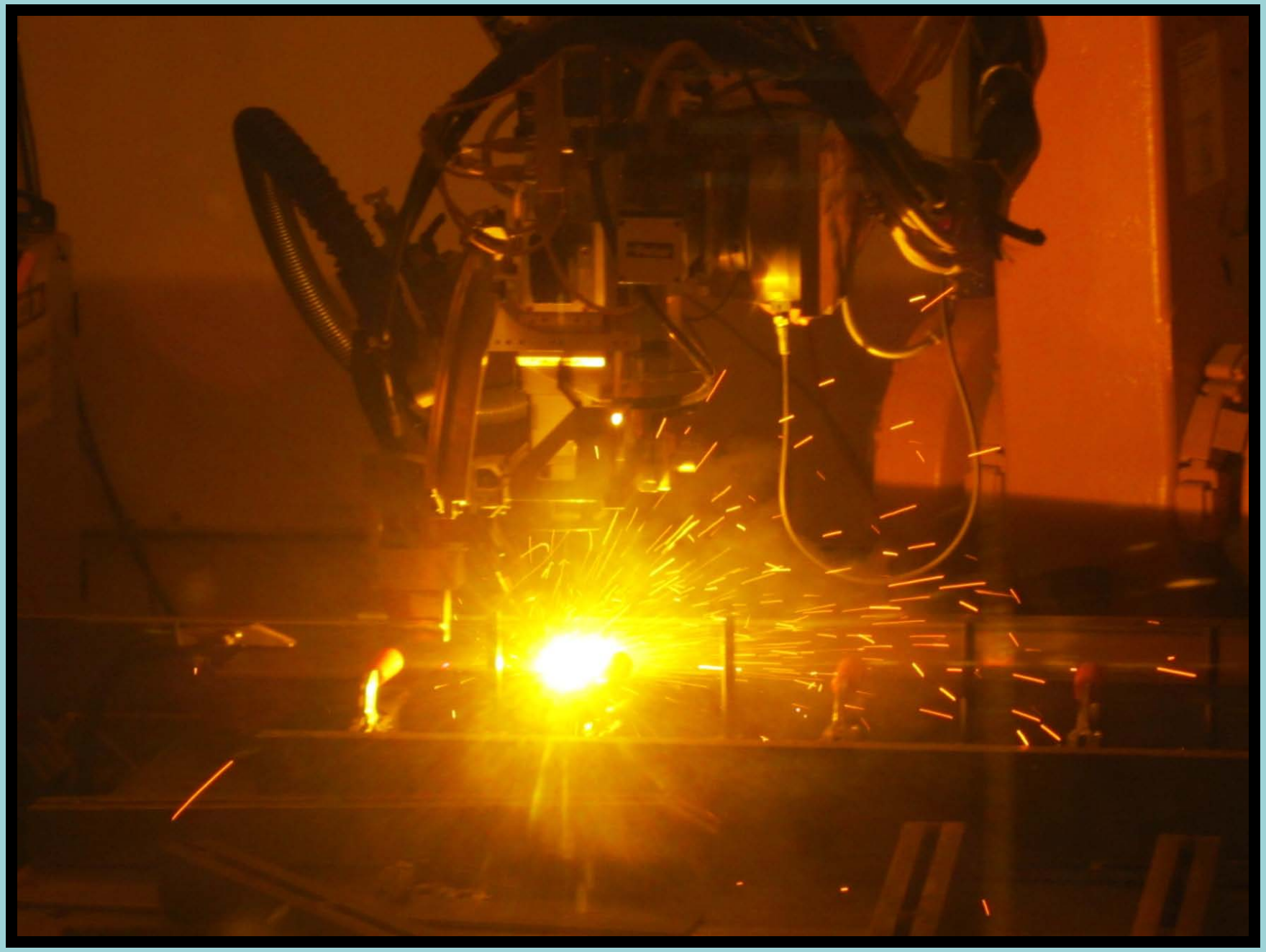
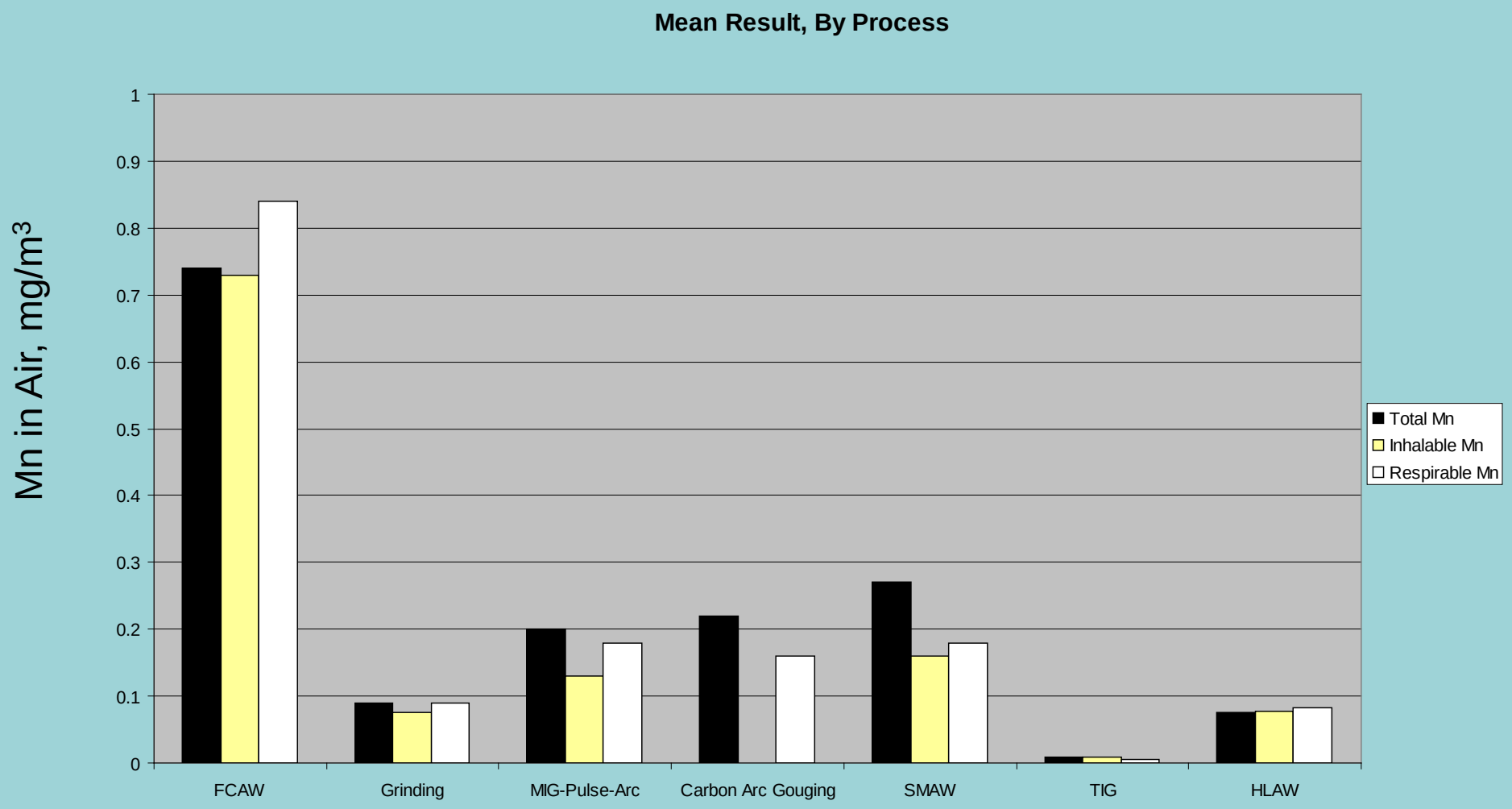


				Total			Inhalable				Respirable			
Total	Total	Process	Sample Type Personal (P) Area (A)	Minutes	Result (Mn, mg/m^3)	8-HR TWA		Minutes	Result (Mn, mg/m^3)	8-HR TWA		Minutes	Result (Mn, mg/m^3)	8-HR TWA
T1	Total(2)	FCAW	P	439	0.60	0.549	Inhal(IM459)	376	0.52	0.407	Resp(21)	–	–	
T2	Total(10)	FCAW	P	x	–	–	Inhal(IM408)	x	–	–	Resp(26)	x	–	
T3	Total(4)	FCAW	A	399	0.41	0.341	Inhal(IM401)	399	0.31	0.258	Resp(24)	398	0.46	0.381
T4	Total(5)	FCAW	A	390	0.58	0.471	Inhal(IM475)	391	0.87	0.709	Resp(13)	391	0.58	0.472
T5	Total(19)	Grinding	P	374	0.23	0.179	Inhal(IM504)	374	0.24	0.187	Resp(17)	272	0.13	*
T6	Total(11)	FCAW	P	368	0.47	0.360	Inhal(IM405)	153	0.52	*	Resp(30)	359	0.49	0.366
T7	Total(7)	Grinding	A	304	0.32	0.203	Inhal(IM385)	303	0.11	0.069	Resp(20)	304	0.30	0.190
T8	Total(16)	FCAW	A	320	0.50	0.333	Inhal(IM076)	320	0.62	0.413	Resp(23)	185	0.40	*
T9	Total(15)	MIG PulseArc	P	466	0.39	0.379	Inhal(IM357)	390	0.37	0.301	Resp(14)	243	0.17	*
T10	Total(11)	MIG/CAG	A	398	0.55	0.456	Inhal(IM332)	303	0.21	0.133	Resp(7)	461	0.68	0.653
T11	Total(4)	Carbon ArcGouging	P	415	0.22	0.190	Inhal(IM478)	x	–	–	Resp(13)	94	0.18	*
T12	Total(3)	MIG/CAG	A	448	0.044	0.041	Inhal(IM435)	448	0.028	0.026	Resp(9)	448	0.037	0.035
T13	Total(10)	MIG PulseArc	P	459	0.013	0.012	Inhal(IM319)	459	0.012	0.011	Resp(L21209-1)	459	0.0082	0.008
T14	Total(TW-1)	MIG PulseArc	A	446	0.0056	0.005	Inhal(IM041)	446	0.0063	0.006	Resp(L21209-13)	446	0.0049	0.005
T15	Total(12)	FCAW	P	173	2.50	*	Inhal(IM422)	90	2.2	*	Resp(L21209-7)	137	3.0	*
T16	Total(5)	FCAW	A	169	0.098	*	Inhal(IM353)	169	0.090	*	Resp(L21209-9)	169	0.083	*
T17	Total(6)	SMAW	P	189	0.86	*	Inhal(IM497)	113	0.41	*	Resp(11)	275	0.53	*
T18	Total(3)	SMAW	A	399	0.033	0.027	Inhal(IM458)	399	0.027	0.022	Resp(23)	399	0.029	0.024
T19	Total(14)	TIG Stainless	P	275	0.027	*	Inhal(IM329)	174	0.022	*	Resp(4)	275	0.011	*
T20	Total(25)	TIG Stainless	A	345	0.0022	0.002	Inhal(IM482	345	0.0026	0.002	Resp(20)	345	0.0020	0.001
T21	Total(17)	SMAW	P	286	0.13	0.077	Inhal(IM512)	286	0.14	*	Resp(21)	286	0.12	*
T22	Total(18)	SMAW	A	390	0.046	*	Inhal(IM372)	390	0.051	0.041	Resp(24)	390	0.043	0.035
T23	Total(7)	TIG Stainless	P	295	0.0060	*	Inhal(IM320)	295	0.0078	*	Resp(8)	295	0.0058	*
T24	Total(22)	TIG Stainless	A	360	0.0015	0.001	Inhal(IM385)	360	0.0015	0.001	Resp(15)	300	0.0013	0.001
T25	Total(13)	HLAW	P	477	0.010		Inhal(IM392)	477	0.0091		Resp(12)	322	0.011	
T26	Total(4)	HLAW	A	477	0.0075		Inhal(IM315)	477	0.0083		Resp(2)	477	0.0076	
T27	Total(5)	HLAW	P	58	0.19		Inhal(IM060)	58	0.20		Resp(3)	58	0.22	
T28	Total(8)	TIG	P	460	0.010		Inhal(IM161)	460	0.010		Resp(1)	460	0.0091	
T29	Total(25)	Grinding	P	360	0.0020		Inhal(IM507)	149	0.0061		Resp(20)	360	0.00048	
T30	Total(22)	Grinding	A	345	0.00084		Inhal(IM041)	345	0.00089		Resp(16)	345	0.00044	
T31	Total(21)	Grinding	P	355	0.0025		Inhal(IM510)	355	0.0066		Resp(23)	355	0.0020	
T32	Total(26)	HLAW	P	110	0.091		Inhal(IM489)	110	0.095		Resp(24)	110	0.091	

*Specific task-related sample. Does not represent an 8-hr TWA

AIR SAMPLING DATA



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Conclusions:

- There is a wide variation in airborne Mn concentrations found in shipyard welding and metalworking processes. Results ranged from 3.0 mg/m3 to 0.00044 mg/m3 of air, for a greater than 6800-fold difference.
- All results were well below the OSHA Permissible Exposure Limit for Manganese of 5.0 mg/m3 of air, expressed as a Ceiling value.
- Only TIG (Gas Tungsten Arc Welding) was observed to be consistently below the ACGIH Notice of Intended Changes TLV for Mn of 0.02 mg/m3 as Respirable particulate. All other processes tested provided results which exceeded this limit.
- The relationship between Total, Inhalable and Respirable Mn does not follow any regular or predictable pattern. Side by side air samples will often yield results with smaller size fractions exceeding Total Mn concentration or Respirable Mn greater than Inhalable Mn. These finding raise questions about the technical merits of the proposed testing process, especially when evaluation requires a 3-fold increase in labor, equipment and laboratory resources.
- Clearly, more work will be required in the area of test equipment design and methods validation in order to provide meaningful and relevant data on which to base future standards and compliance activities.

Reduction of Weld Fume Risk in Naval and Commercial Shipyards

Report Submitted to ACGIH – TLV Committee in January 2012

1. Has anyone ever effectively measured Inhalable or Respirable Mn in Welding Fume?

2. Is there a proven relationship between Mn in welding fume and neurological disease?

No answer yet

Reduction of Weld Fume Risk in Naval and Commercial Shipyards

MANGANESE, ELEMENTAL AND INORGANIC COMPOUNDS

CAS number: 7439-96-5 (Manganese)

Molecular formula: Mn

TLV–TWA, 0.02 mg/m^3, as Mn, Respirable particulate matter
0.1 mg/m^3, as Mn, Inhalable particulate matter

A4 — Not Classifiable as a Human Carcinogen

Whiskey Tango ……? What’s Going On?

Questions?