Advanced Impact Analysis
–
Potential Changes to Weld Fume Carcinogenicity Designation (Risk Management Panel PROJECT - NSRP SUBCONTRACT NO: 2019-473)

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ADVANCED IMPACT ANALYSIS – POTENTIAL CHANGES TO WELD FUME CARCINOGENICITY DESIGNATION

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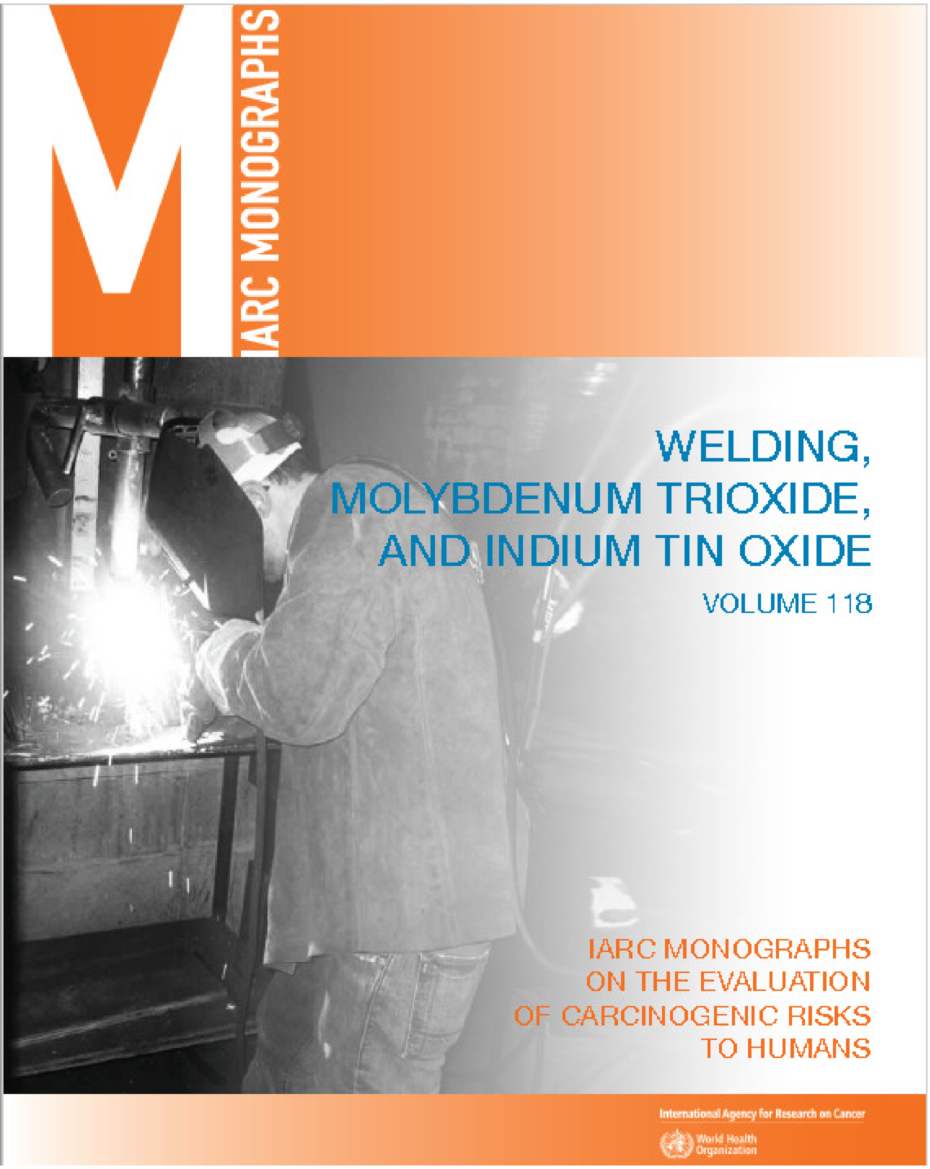
- US NAVY
  - NAVMEDCEN INDUSTRIAL HYGIENE, PORTSMOUTH, VA;
- SHIPYARD PARTICIPANTS:
  - BATH IRON WORKS – BATH, ME
  - NEWPORT NEWS SHIPBUILDING, NEWPORT NEWS, VA
  - NORFOLK NAVAL SHIPYARD, PORTSMOUTH, VA



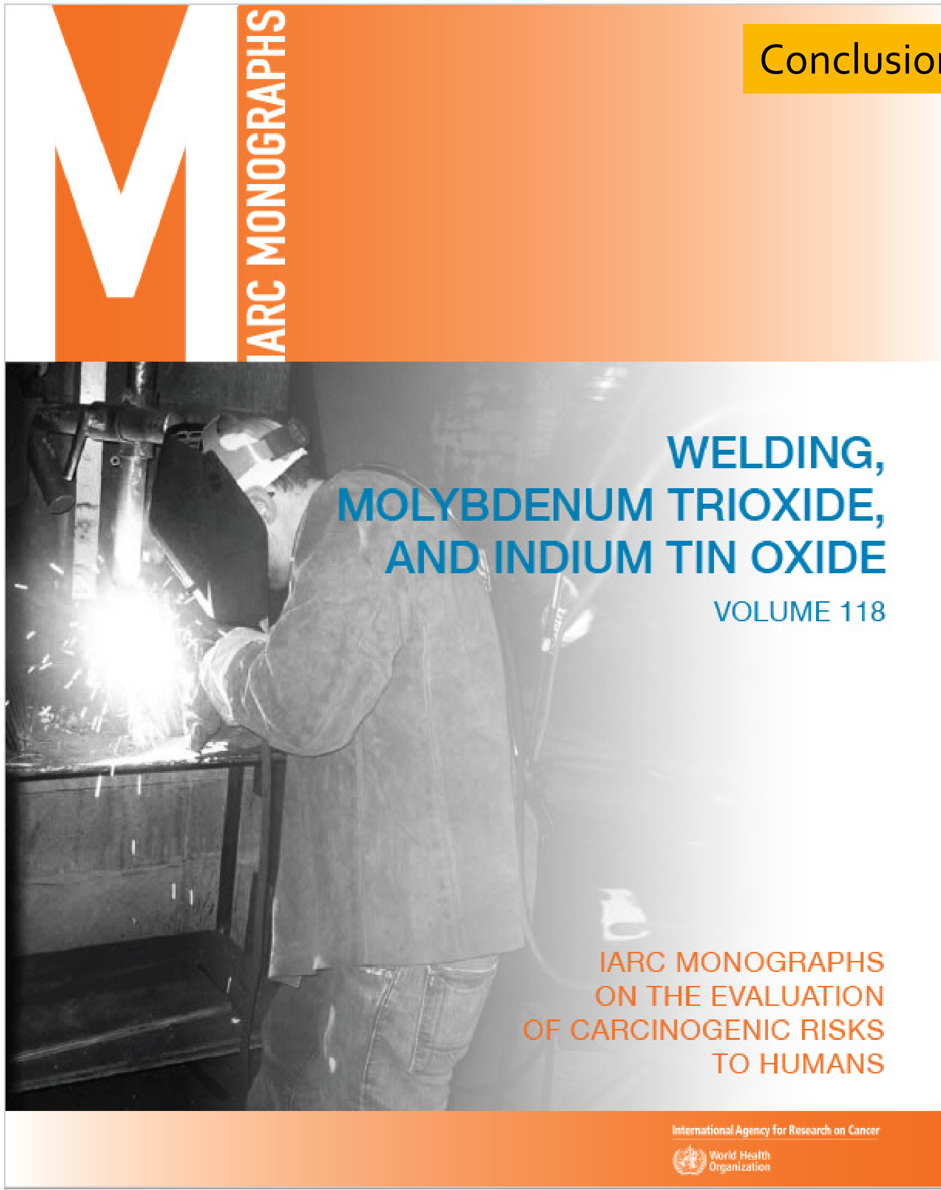
International Agency Research on Cancer

World Health Organization

IARC – International Agency Research on Cancer –a specialized cancer agency of the World Health Organization.

In March 2017, seventeen scientists from ten countries met at the International Agency for Research on Cancer in Lyon, France to evaluate the carcinogenicity of welding, molybdenum trioxide, and indium tin oxide.

IARC review of literatures linked welding, molybdenum trioxide, and indium tin oxide to certain cancers.



Conclusions: Why the NSRP is reviewing relevance to shipyard work

6.1 Cancer in humans
There is sufficient evidence in humans for the carcinogenicity of welding fumes. Welding fumes cause cancer of the lung. Positive associations have been observed with cancer of the kidney.
There is sufficient evidence in humans for the carcinogenicity of ultraviolet radiation from welding. Ultraviolet radiation from welding causes ocular melanoma.

6.2 Cancer in experimental animals
There is limited evidence in experimental animals for the carcinogenicity of gas metal arc stainless steel welding fumes.

6.3 Overall evaluation
Welding fumes are carcinogenic to humans (Group 1).
Ultraviolet radiation from welding is carcinogenic to humans (Group 1).

IARC Group 1: The agent is carcinogenic to humans.
This category is used when there is sufficient evidence of carcinogenicity in humans

the synergist September 2018

The American Industrial Hygiene Association (AIHA) stated in the September 2018 issue of the Synergist that according to the (IARC) monograph **"welding fumes cause lung cancer"..**

Occupational Exposure Limit under study July 2019

The American Conference of Governmental Industrial Hygienists (ACGIH) reported that Welding Fumes will be added to the list of agents "under study" for update of Threshold Limit Values (TLVs)

https://synergist.aiha.org/201909-acgih-under-study-list

NEWSWATCH

HAZARD RECOGNITION AND EVALUATION

RISK ASSESSMENT

NIOSH REQUESTS COMMENTS ON DRAFT RISK ASSESSMENT DOCUMENT

NIOSH has published a request for comments on a draft document that describes its researchers' approach to assessing workplace hazards. The document, *Current Intelligence Bulletin: NIOSH Practices in Occupational Risk Assessment*, focuses on chemical risk assessments and outlines the logic NIOSH uses to evaluate scientific evidence. The agency asks that reviewers provide feedback on whether the document is consistent with current scientific knowledge in toxicology, epidemiology, industrial hygiene, and risk assessment.

The draft document is available as a PDF on the NIOSH website at **http://bit.ly/draftriskassessment**. An online meeting to discuss the document will be held on Sept. 13. Comments are due Oct. 15. For information about how to attend the meeting or submit comments, visit the *Federal Register* at **http://bit.ly/frriskassessment**.

IARC Evaluates Carcinogenic Risks Related to Welding Exposures

Three new monographs published by the International Agency for Research on Cancer address the carcinogenic risks to humans of welding, molybdenum trioxide, and indium tin oxide.

IARC classifies both welding fumes and ultraviolet radiation from welding as Group 1 carcinogens, the agency's designation for agents that carry sufficient evidence of carcinogenicity in humans. According to the monograph, welding fumes cause lung cancer, and positive associations have been observed with kidney cancer. UV radiation from welding can cause ocular melanoma.

For all other cancers, studies considered by IARC presented inadequate evidence for the carcinogenicity of welding fumes.

IARC had previously classified welding fumes as "possibly carcinogenic to humans," or Group 2B, in 1989. The agency stated that the new classification is based on "substantial new evidence" from observational and experimental studies. Exposure to asbestos and tobacco smoking, which can confound associations with cancer, were determined to be insufficient to explain the excess risk of lung cancer for welders observed in the studies.

The hazards presented by welding fume depend on the welding process. Many different welding processes exist. Welding fume consists of fine solid particles with a diameter of less than 1 μm. Exposures can vary significantly among welders based on the type of welding process used, the presence of local exhaust ventilation, and the work practices of individual welders. According to IARC, studies suggest that novice welders or those with minimal training may have greater exposures than experienced welders.

Approximately 11 million people worldwide have the title of welder, and an additional 110 million engage in welding activities, according to IARC.

The agency stated that the new classification is based on "substantial new evidence" from observational and experimental studies.

Molybdenum trioxide, a related chemical that is mainly used in steel manufacture, is classified in Group 2B as a chemical that is possibly carcinogenic to humans. IARC's classification is based on "sufficient evidence" of the chemical's carcinogenicity in experimental animals. The agency notes that most occupational exposures to molybdenum trioxide occur in mining and metallurgy, steel foundries, welding, and other high-temperature processes using steel.

IARC also classifies indium tin oxide in Group 2B. According to the agency, exposures to indium tin oxide occur mainly in its sintered form in occupational settings. Sintering is a process that uses heat and pressure to combine indium oxide and tin oxide powders. Workers can be exposed during the production, processing, and recycling of elemental indium. Exposures to indium in low- and middle-income countries where informal recycling of electronics occurs are also of concern because the chemical is used to produce transparent conductive films on glass or plastic panels used in electronic devices.

Volume 118 of the IARC Monographs, available at **http://bit.ly/iarcvol118**, includes the evaluations of the carcinogenicity of welding and welding fumes, molybdenum trioxide, and indium tin oxide. A summary of IARC's evaluations is available online in *The Lancet Oncology* at **http://bit.ly/lancetwelding**. The full article is available free of charge to registered users (registration is also free).

IARC monographs identify and evaluate environmental factors that can increase carcinogenic risks to humans. IARC is the specialized cancer agency of the World Health Organization, and government agencies worldwide use its monographs as scientific support for their actions to prevent exposure to potential carcinogens.

Advanced Impact Analysis – Impact of Changes to Weld Fume Carcinogenicity Designation

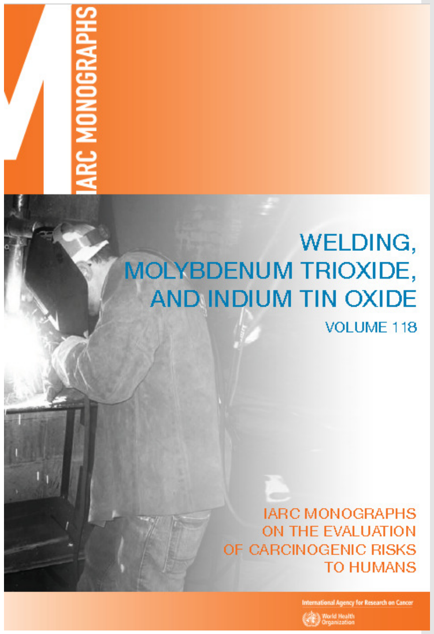
- Review the IARC Monograph Volume 118 (2018) relative to shipyard welding.
- Review existing representative occupational exposure air monitoring data for work comparable to welding processes cited by IARC for elevated cancer risk.
- Determine exposure ranges, by process, to compare to exposure categories cited in the IARC report.
- Prepare a summary report to inform shipyards:
  - What potential cancer risks have been identified in the IARC report?
  - What shipyard welding work is most likely to create welding fume exposures at or above levels of concern?
  - What air monitoring and testing methods are recommended for further evaluation?
  - What existing training, process control and protective measures are shown to be effective for elimination or reduction of these potential hazards?
- Provide recommendations for follow up action.

Milestone	Deliverable	Due Date
1	Project Plan & Schedule	31-May-19
2	Project Status Report 1	30-Jul-19
3	**Presentation at NSRP Risk Management Panel Meeting**	**12 Sep-19**
4	Project Status Report 2	30-Sep-19
5	Final Report	31-Oct-19

How does IARC Review Cancer Risk?

IARC Process

- Working Group-(listed in report) develops specific monographs
- Information includes
    - Exposure data (overview of process and use)
    - Studies of cancer in humans
        - Epidemiology
        - Limited use of individual case studies
    - Studies of cancer in experimental animals
    - Mechanistic and other relevant data (how an agent may cause cancer)
    - Summary
    - Evaluation and rationale



IARC Findings & Exposure Limit Values

Agents	Organ site/type of cancer	Source
Welding Fumes	Lung; Kidney; Urinary bladder; Prostate; Mesothelioma	Welding – Arc, gas
UV radiation	Ocular melanoma	Arc from welding guns
Molybdenum trioxide	No data available for human but causes lung tumor in experimental animal animals	Welding – Arc, gas

Country	Welding fumes limit value (8-TWA)
Generally used for respirable particulate Not otherwise classified	5 mg/m3
China	4mg/m3
Netherlands	1mg/m3
USA, UK, Germany	Use limits for specific metals in welding fumes or respirable dust
ACGIH TLV for insoluble or poorly soluble respirable particles not otherwise classified	3 mg/m^3

Strengths and Limitations of IARC Approach

Strengths

- Number of studies reviewed
- Morbidity/mortality studies have less ambiguous outcomes than exposure evaluations (and are cheaper to conduct)
- Use of both human population and animal studies
- Identification of shipyard studies (>10)
- Process separation where feasible
  - Typically Stainless Steel versus Mild Steel Welding
  - Attempts to normalize/compensate for smoking and asbestos exposures
- Seeks to describe mechanisms of action (metabolic pathways) for cancer

  \+ Benefit- Provides some predictive capability

  \- Limitation-We don't fully understand mechanisms so real outcomes may trump theoretical analysis

Limitations

- Didn't address non-carcinogenic effects, especially with-regard-to the coincidence of non-cancer and cancer effects
- Most studies didn't include occupational exposures and/or medical monitoring outcomes
- Limited correlation of material exposures with potential mechanisms of carcinogenesis
- IARC doesn't quantify the level of risk
- IARC doesn't provide regulatory recommendations or guidance for exposure limits

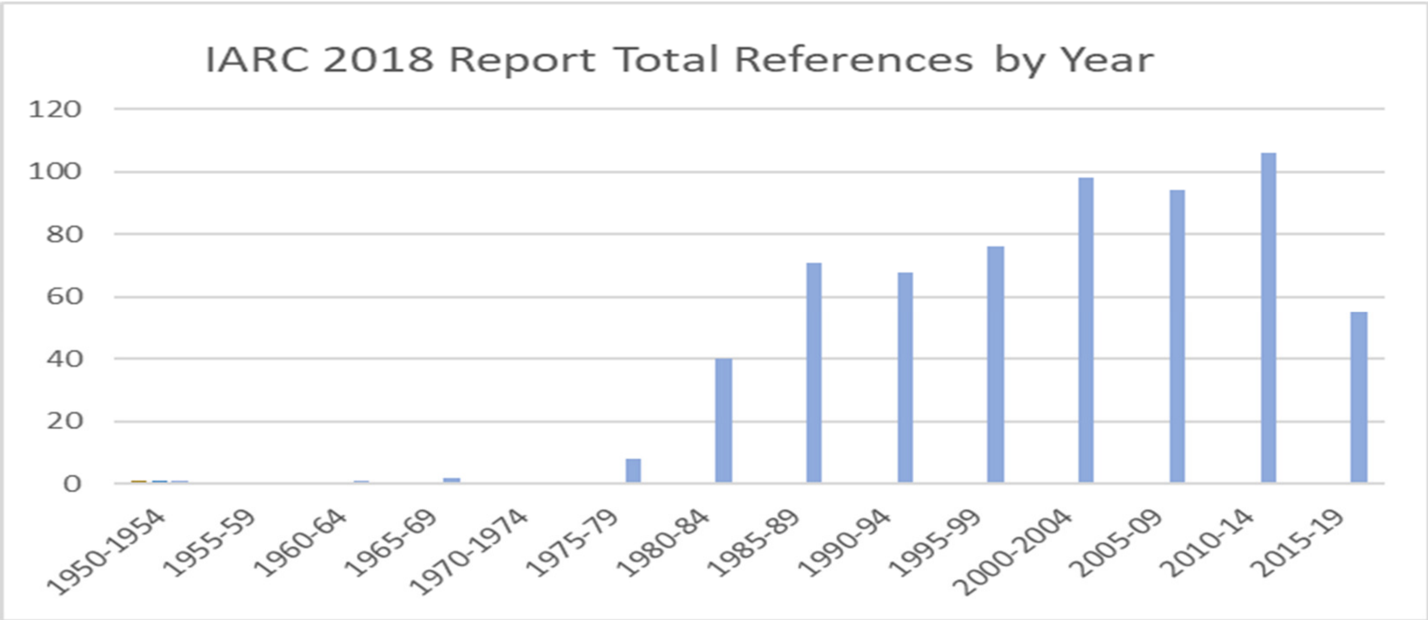
Impact of Limitations

- Lack of correlation between exposures, biological effects (especially non-carcinogenic/ early impacts, and outcomes (later cancer) makes it difficult to establish safe levels for potential exposures.
- Lack of exposure limits make control implementations difficult (when are exposures suitably controlled)?

Scope of IARC 2018 Review of Cancer Risks in Welding –

Work Experts – Monograph of 330 pages with almost 600 references

Preamble Describes the IARC Process	General/ Welding	Welding Exposure Data (Mostly epi studies)	Cancer in Humans	Cancer in Animals	Mechanistic data total	Total References
46	9	149	245	9	187	574



Limitations of IARC Approach

1. Didn't address non-carcinogenic effects

- Most non-carcinogenic effects occur sooner
- Early warning and potential interventions neglected
- Non-carcinogenic effects may be significant health outcomes (and may impact victims for a prolonged period)
- Similar mechanisms and/or metabolic pathways may be involved in both carcinogenic and non-carcinogenic effects
  - Example irritant gases as causing oxidative stress

2. Most studies didn't include occupational exposures and/or medical monitoring outcomes

- Lack of early warning and potential for intervention
- Limited, if any, evaluation of process controls

3. Limited correlation of material exposures with potential mechanisms of carcinogenesis

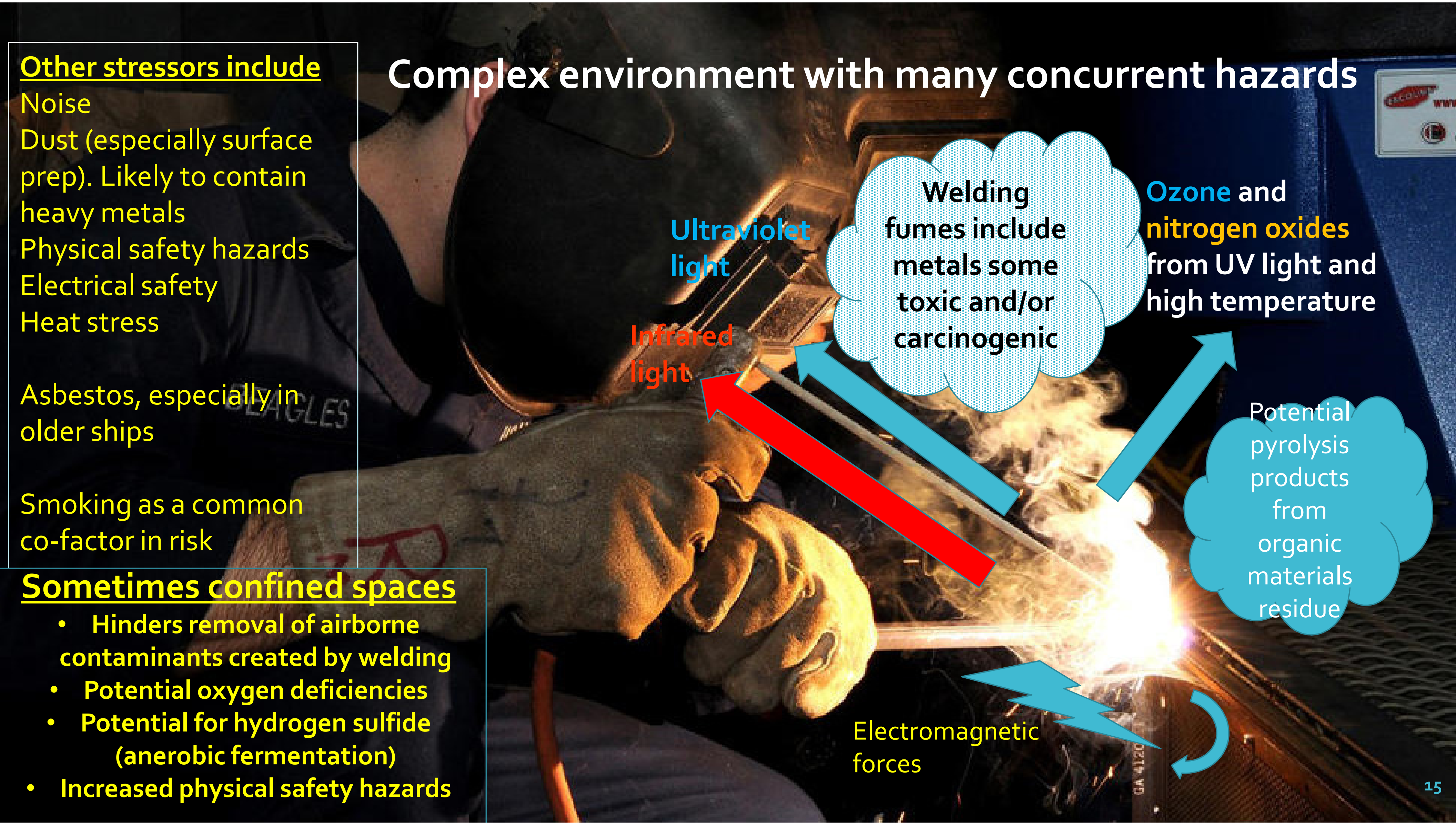
\- Lack of predictive capability

\+ We don't fully understand mechanisms, so real outcomes may not match theoretical analysis

Project Activities

BSI/
NSRP
Review

- Reviewed IARC Monograph
- Summarized Studies
- Reviewed Key References
- Provided more detailed analysis of shipyard studies
- Described Strengths and Limitations of Approaches
- Suggested approaches for shipyards
    - Process evaluation
    - Control measures


Other stressors include
Noise
Dust (especially surface prep). Likely to contain heavy metals
Physical safety hazards
Electrical safety
Heat stress
Asbestos, especially in older ships
Smoking as a common co-factor in risk
Sometimes confined spaces
• Hinders removal of airborne contaminants created by welding
• Potential oxygen deficiencies
• Potential for hydrogen sulfide (anerobic fermentation)
• Increased physical safety hazards
Complex environment with many concurrent hazards
Ultraviolet light
Infrared light
Welding fumes include metals some toxic and/or carcinogenic
Ozone and nitrogen oxides from UV light and high temperature
Potential pyrolysis products from organic materials residue
Electromagnetic forces

Summary of IARC Epidemiology Studies Evaluated

Study type	Number of studies	Cohort Size(s)	Study date	Shipyard/ Maritime focus	US	Europe or north America	Occ hx	Key sub-groups	Type of Cancer	Exposures Measured?	Non-cancer effects evaluated *
Epidemiology (Table 1.3 Exposure Assess. In Key studies	9	Vary, smallest 4539 welders, largest 11092)	Vary – The best Pukka et al 2009 with 1960-1990 data	1	1	9	3	By occupation welders and shipyard welders in several	9 Yes, mainly lung and meso-thelioma	No, exposure categories in 4	No
Cancer of the lung case–control studies Table 1.4	10	Vary 90 to 15483	Vary best Vallieries 2012 1945-96); Kendzia 85-2010	0	1	9	7	By occupation	6 lung cancer, 3 other type	No, exposure categories 7	No
Population-based cohort studies on cancer and welding or exposure to welding fumes Table 2.1	11	Vary 878 to 58279 Lung Ca 12 (67 to 524), prostate 12/58279	Vary Kromhout et al 1992 ('77-'85)	0 (4 had breakdown allowing identification of shipyard)	1 (1 Canadian)	11	3	By occupation	7 Lung Ca, 1 type of lung Ca 2 prostate, 2 leukemia, 1 multiple cancer types	No	No
Summary	30	Vary		1 (4 had breakdown	3	29	13	Vary	22 lung Ca 7 other types 1 multiple types	No	No

Studies did not include measurement of occupational exposures

Cabasag, Citadel Jungco (2016) Cancer Risks in Shipyard welders Exposed to Asbestos and Welding Fumes, PhD Dissertation in Epidemiology, University of California, Irvine. https://escholarship.org/uc/item/2bc115d9

Ratio of Observed versus Anticipated Cancer Cases Long Beach Naval Shipyard (based on California population)* (more than 5 years of employment)						
Cohort Evaluated/ number	**Exposure Category**	**Colerectal**	**Digestive (except colorectal)**	**Lung**	**Meso-thelioma**	**prostate**
I 837	No asbestos or welding	1.9	1.67	2.90	1/ 0.1 (1 case)	3.26
II 2824	Asbestos, no welding	2.1	1.9	2.47	15	2.6
III 2157	Asbestos and welding	1.6	1.85	2.73	2 cases 6.90	2.6

- Colorectal, other digestive cancers and mesothelioma have been associated with asbestos exposure. However, the odds ratio of colorectal and digestive cancer appears higher than might be anticipated.
- The number of prostate cancers is higher than would be predicted. Cadmium, a commonly used material in shipyards, has been linked with prostate cancer.

Comparison of welding on stainless and mild steel

Derived from IARC Table 1.9

Base Metal	Welding Process	Industry	Number of studies	Total Cr* (ug/m3)	CrVI* (ug/m3)	Ni* (ug/m3)
Stainless	Multiple	Shipbuilding/ Fabrication	19	137	35	70
Mild Steel	Multiple	Shipbuilding/ fabrication	6	4.5	2	4

Karlsen et al 1994 (Norway) Exposure comparison among industries and processes conducting stainless steel welding (ug/M3)

Base Metal	Welding Process	Industry	Cohort size	Total Cr*	CrVI*	Ni*
Stainless	MMA, shipyard	Shipyard		230	140	50
Stainless	MMA, offshore module	Fabrication		185	3.7	-
Stainless	MMA, welding shops	Fabrication		50	12	14
Stainless	Grinding, small shop	Fabrication		1100	<LOD	250

* Average of study results in ug/m3
* (range of measured exposures and/or SD also where available)

Welding Exposures in British Shipyards

McMillan 1983

Taken from Table B11 Air Sampling Results Average Concentrations over Working Time

	Total fume mg/m^3	Respirable fume mg/m^3	Total Fe2O3 mg/m3	Average CO conc. ppm	Average NOx conc. ppm
Mean	26.7	17.1	7.3	6.23	0.65
Standard Deviation	18.7	12.8	5.2	4.82	0.56
Range	2.5 – 69.4	1.9-45.4	1.1 – 20.0	0-19.1	0-2.2

N=25 samples

The health of welders in Her Majesty's Dockyards at Devonport, Portsmouth, Rosyth and Chatham : a review of the literature relating to the sources, nature, control, actual and potential biological effects of particulate and gaseous pollutants arising from welding processes used in HM Dockyards
McMillan, G.H.G. (1983) Doctoral Thesis
https://pdfs.semanticscholar.org/be4f/e56351c3d626bb6a5d7d66caf1347fd23ad1.pdf
http://theses.gla.ac.uk/2554/2/1983mcmillan2md.pdf

Welding Exposures in two Korean Shipyards

Welding fume exposure and chronic obstructive pulmonary disease in welders

D.-H. Koh,[1] J.-I. Kim,[2] K.-H. Kim[3] and S.-W. Yoo,[4] on behalf of the Korea Welders Cohort Group

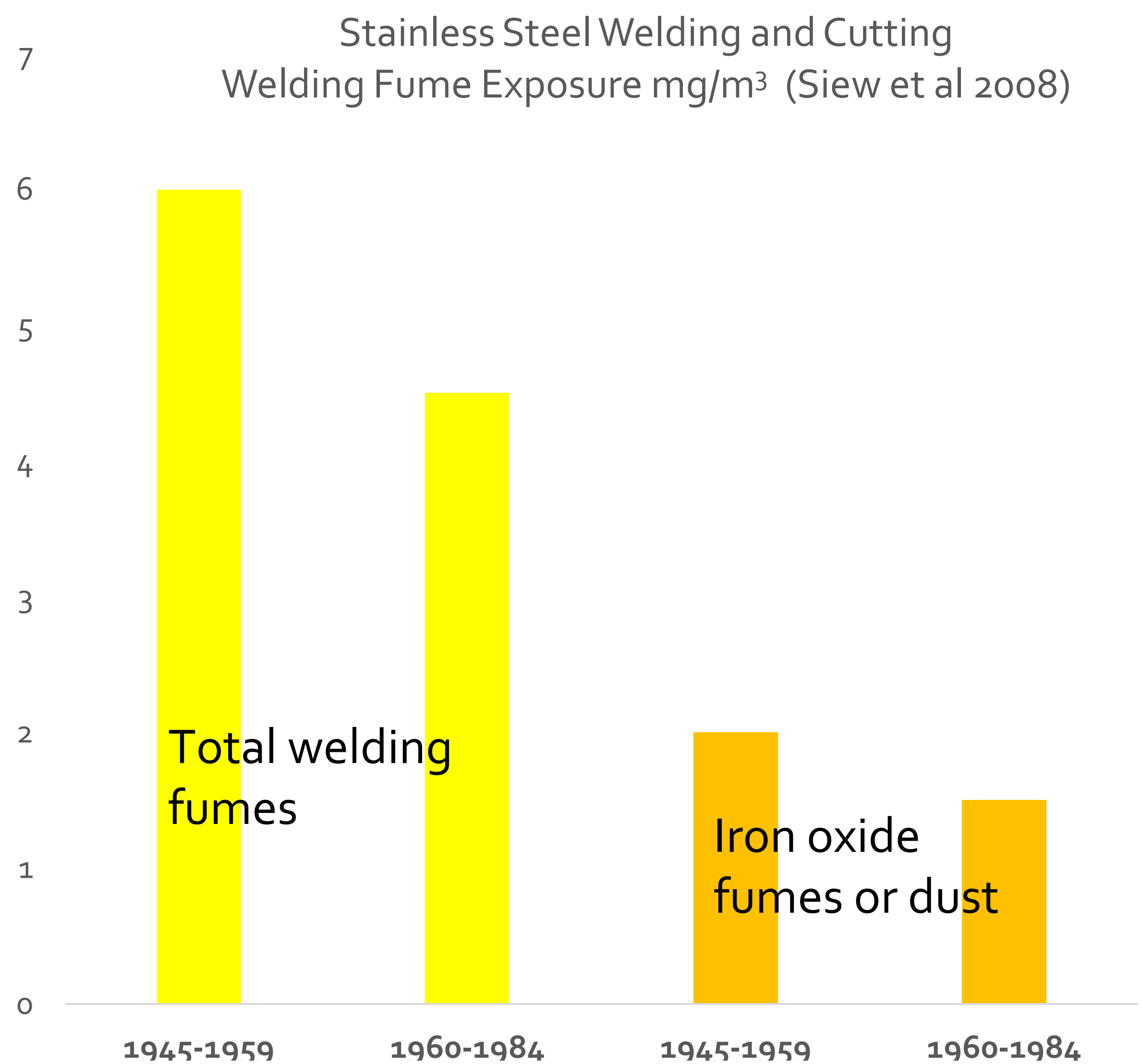
Advance Access publication 16 October 2014 doi:10.1093/occmed/kqu136

Table 1. Metal fume concentrations by job title (mg/m^3)

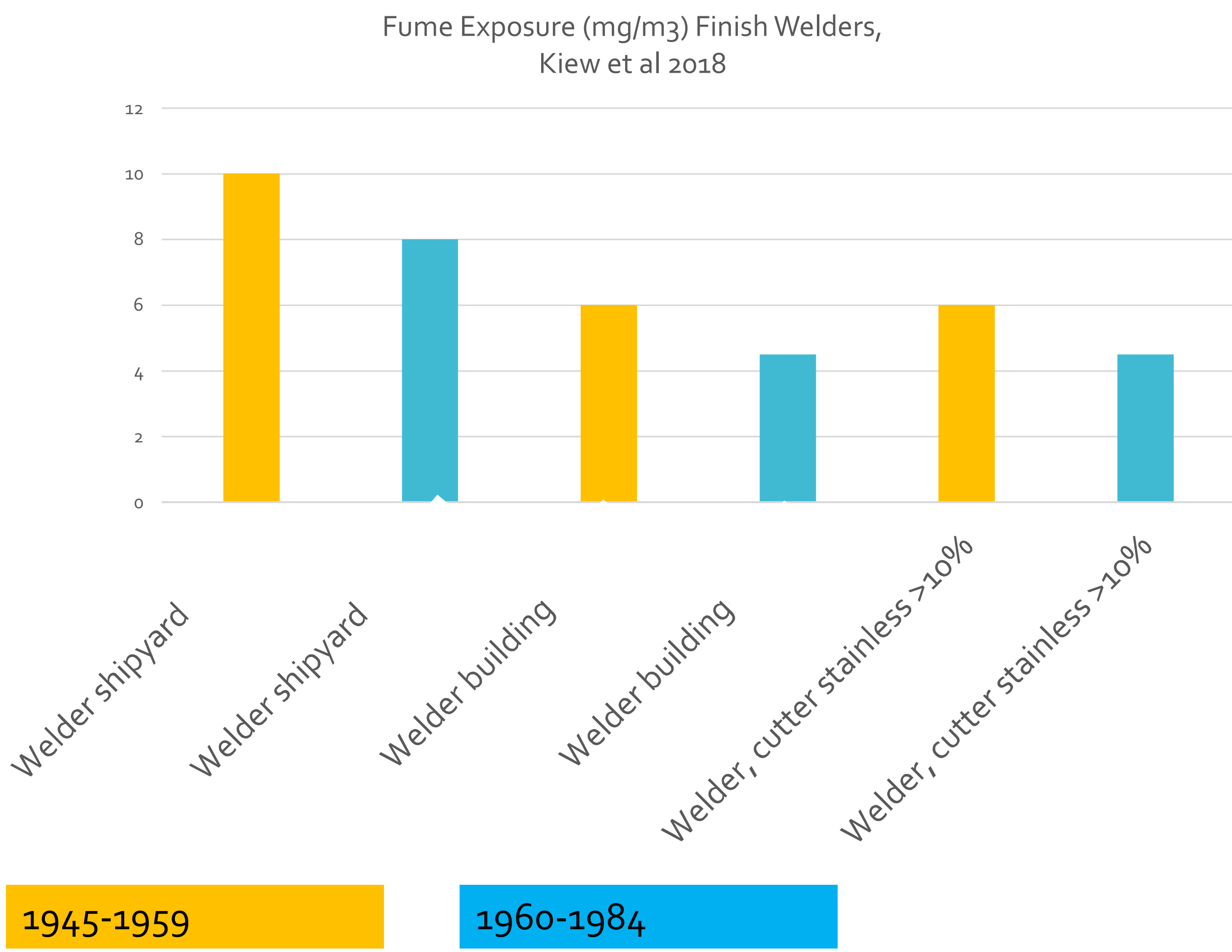
Task	*n*	Mean	SD	GM	GSD	Median	Min	Max
Arc welding	528	2.7	10.7	0.6	6.2	0.6	0.01	223.7
Tack welding	318	1.6	3.4	0.4	6.2	0.4	<0.01	35.3
Cutting	38	1.2	1.7	0.4	5.6	0.4	0.01	5.8

n, number of measurements; SD, standard deviation, GM, geometric mean; GSD, geometric deviation; Min, minimum concentration; Max, maximum concentration.

Past Historical Data, Stainless steel welding



Past Historical Data, welding Finnish welders



Additional data sources

Navy Marine Corps Public Health Center Welding Data

- Defense Occupational Health Readiness System DOHRS 2008-2018
- 409 personal breathing zone samples of total welding fume reviewed
- No clear trends over time

- Occupational Safety and Health (OSHA)
  - Compliance database using SIC/NAICS codes for shipyards
  - Didn't describe process source of exposures
  - Estimated to represent higher categories of exposures
  - Iron oxide fume 488 sample –evaluated with welding estimated to be the main source
  - Total respirable particulate 501 samples <u>not</u> further evaluated due to potential range of sources
  - No apparent time-associated trends

SIC Standard Industrial Classification	Industry area	NAICS North American Industrial Classification System	Description
3731	Shipbuilding and Ship Repairing	33661	Ship building and ship repair done in a shipyard

OSHA Public Compliance Database

IMS Analyte Code	Substance	Operations plausibly associated with IMS code	Number of personal samples 1988-2018
689	Chromium CrVI	Welding on Stainless, cutting on stainless and/or paints w chromate primer, electroplating	11
1980	Ozone	Arc welding (varied process), carbon arc gouging	3
2587	Welding fumes, total particulate	Arc welding, cutting	0
731	Copper fumes as copper	brazing, some soldering, possibly electroplating or brush electroplating, non-ferrous foundaries	280
3731	nitrogen dioxide	torch cutting, brazing, diesel engines	3
9130	particulate, respirable fraction	most welding, cutting processes, grinding, blasting, potentially wood dust, handling bulk materials	501*
1520	Iron Oxide Fume	most welding on steel, cutting processes, some overlap with grinding and foundry work	488

* Not further analyzed due to range of potential sources

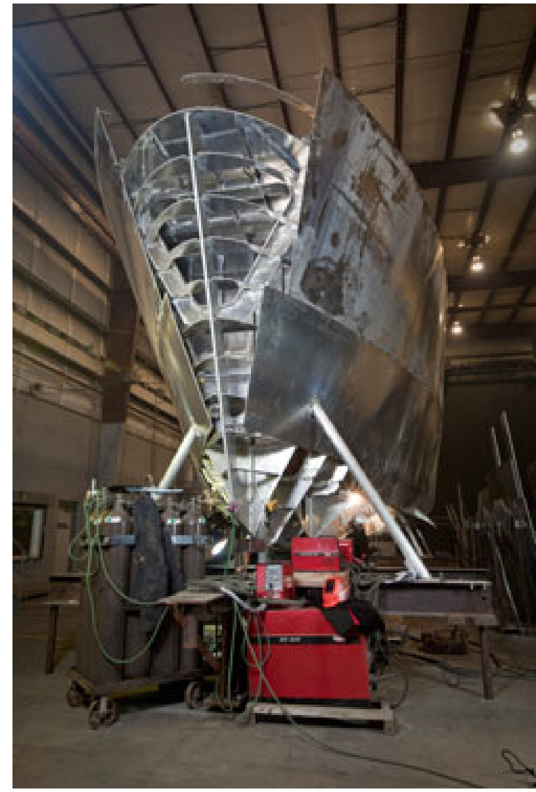
Navy Marine Corps Public Health Data 2008 to 2018 Welding fume mg/m^3						
Process	**Number samples**	**Time span**	**low**	**high**	**geometric mean**	**Process**
Brazing (varied)	10	2008-2016	0.14	1.68	0.41	higher 2008, decline, higher 2015-2016
TIG	138	2009-20018				
TIG on Aluminum	34	2009-2018	0.04	2.13	0.38	none apparent. 2 high samples appear to include grinding
TIG on carbon steel	1				0.47 single value	N/A
TG on copper nickel	1				1.07 single value	N/A
TIG on Stainless	15	2016-2018	0.07	1.27	0.45	not apparent
TIG on Inconel	2	2016-2018	0.33	2.33	1.33 average	N/A
TIG on unk metal	64	2016-2018	0.02	7.33	0.17	none apparent. 2 high samples appear to include grinding

Navy Marine Corps Public Health Data 2008 to 2018 welding fume mg/m^3						
Process	**Number samples**	**Time span**	**low**	**high**	**geometric mean**	**Process**
Carbon arc gauging/cutting	5	2008-2017	3.77	21	8.21	none apparent
Plasma arc cutting	23	2010-2016	0.01	1653	5.79	Decrease in major excursions over time. Exclude 4 lowest samples as outliers
Flux Core welding	1	2018			0.19 single sample	
SMAW (Stick)	88	2008-2018	0.008	70	1.4	no pattern apparent
Unknown base metal	19	2008-2015	0.38	9	1.345	appears to increase over time

Navy Marine Corps Public Health Data 2008 to 2018 welding fume mg/m^3						
Process	Number samples	Time span	low	high	geometric mean	Process
SMAW (Stick)	88	2008-2018	0.008	70	1.4	no pattern apparent
GMAW (MIG)	39					
Aluminum base metal	5	2008-2016	0.59	13.7	2.16	appears to decrease
Galvanized	1	2016			0.92 1 sample	N/A
Mild steel	6	2015-2016	0.42	12	0.88	possible decrease
Stainless or presumed stainless	8	2008-2016	0.61	2.14	0.81	possible decrease
Unknown base metal	19	2008-2015	0.38	9	1.345	appears to increase over time
Torch Cutting	18	2008-2018	0.27	6.9	1.27	no apparent pattern
Welding not otherwise described	108	2008-2018	0.008	9.2	0.5	highest levels cluster in middle of period about 2012-2014

Factors which may reduce cancer risks in current shipyard operations

- Automation of welding processes, especially in fabrication and construction
  - Commonly includes remote operation with increased distance between welders and source of welding, as well as other welder's operations
- Typical use of GMAW (MIG) versus SMAW (stick) welding for large scale fabrication
- Improved tolerances, often necessitated by modular construction
  - Reduced "filler" operations (= less welding)
  - Pre-heating of welding surfaces- reduce welding time and improve precision. (also reduce distortion which would require heat treating and bending of metal surfaces)
- Modular construction with work in large open areas, versus enclosed shipyard compartment
- Attention to pre-welding/cutting removal of paints and coatings
  - Reduced exposure to many heavy metals in paints (chrome, lead)
  - Specialized methods for removal of paint and coatings
    - Increased used of grinders with low-volume/high velocity local exhaust
    - Developing processes such as Atmospheric Plasma Coatings Removal



Protective Measures Likely to Reduce Occupational Exposures and Cancer/ non-Cancer Disease Risks

Recommendations based on review of shipyard industry processes

Protective Measure(s)	Operations affected	Exposures Controlled/ reduced	Notes/ remarks
Process changes			
Increased automation	Fabrication and some cutting	Mild steel and aluminum, NOx, O_3	Improved productivity and quality
GMAW (MIG) vs SMAW ("stick")	Fabrication	Fluorides, total fume	Improved productivity
Material Substitution/Elimination			
Paint pigment changes	Cutting/ burning, grinding/ surface prep	Chrome, lead	Environmental benefits
Training			
Process quality, PPE use, hazard recognition	All	All	Can be linked with OSHA HAZCOM
Protective Equipment			
Respiratory protection	Arc welding, grinding, torch cutting	Metal fumes and dusts	Ineffective for irritant gases, very training dependent
Hearing protection	Carbon arc gouging/ torch cutting, grinding	Noise	Very training-dependent
Process monitoring and Medical evaluation			
IH and Medical surveillance	Prioritized by exposures and regulations	Metal and noise, vibration	Issue: Commonly limited link between airborne exposure monitoring and medical monitoring
General process monitoring and quality assurance measures			

Ocular Melanoma
–
A rare cancer with possible link to welding

IARC 2018 report describes welding as a risk for development of a rare cancer, ocular melanoma*
Paragraph 6.1 Cancer in humans

> *"There is sufficient evidence in humans for the carcinogenicity of ultraviolet radiation from welding. Ultraviolet radiation from welding causes ocular melanoma."*

Ocular Melanoma – A rare cancer with possible link to welding

Some Considerations for Shipyard Evaluation and Risk Assessment/ Control

- Most studies are case-controlled (retrospective) evaluations due to rarity of the disease
- Limited occupational history in most evaluations
- No quantification of exposures or work practices
- Other variables may not be evaluated
- Very different evaluations of relative risk (odds ratio for probability of welders versus non-welders having this disease)
- Odds Ratios range from non-significant to 7.3 (Guénel et al, 2001)
- Report with the smallest cohort 50 cases , Guénel et al (2001), had the most sweeping conclusion:

  Following the present study, the existence of an excess risk of ocular melanoma in welders may now be considered as established. Exposure to ultraviolet light is a likely causal agent, but a possible role of other exposures in the welding processes should not be overlooked….

Evaluation/ Control/ Recommendations - Ocular Melanoma – A rare cancer with possible link to welding

Factors demanding consideration

- High levels of measured UV exposures, relative to occupational exposure standards,
- IARC report analysis
- Commonality of physical eye injuries among welders and associated trades,

Immediate control measures suggested

- Ventilation for control of irritant gases with concurrent measurements
- Attention to protective equipment use- including bystanders/helpers
- Painting of work areas with UV absorbent paints.
  - Avoid paints with pigments reflecting UV light, use pigments containing titanium dioxde.

Long-term evaluation and control recommendations

- Additional measurement of EMF and IR
- Evaluation of "bystander" exposures and controls

Protective Measures Likely to Reduce Occupational Exposures and Cancer/ non-Cancer Disease Risks

Recommendations based on review of shipyard industry processes

Protective Measure(s)	Operations affected	Exposures Controlled/ reduced	Notes/ remarks
Process changes			
Increased automation	Fabrication and some cutting	Mild steel and aluminum, NO_x, O_3	Improved productivity and quality
MIG vs GMAW	Fabrication	Fluorides, total fume	Improved productivity
Material Substitution/Elimination			
Paint pigment changes	Cutting/ burning, grinding/ surface prep	Chrome, lead	Environmental benefits
Training			
Process quality, PPE use, hazard recognition	All	All	Can be linked with OSHA HAZCOM
Protective Equipment			
Respiratory protection	Arc welding, grinding, torch cutting	Metal fumes and dusts	Ineffective for irritant gases, very training dependent
Hearing protection	Carbon arc gouging/ torch cutting, grinding	Noise	Very training-dependent
Process monitoring and Medical evaluation			
IH and Medical surveillance	Prioritized by exposures and regulations	Metal and noise, vibration	Issue: Commonly limited link between airborne exposure monitoring and medical monitoring
General process monitoring and quality control			

Considerations in Potential Standard Setting Parallels between IARC and ACGIH TLV Process

- Discussions derived from review of manganese 2013 TLV and reviews by varied authors regarding mandate for standards update, risk and feasibility stimulated this comparison

Factor	ACGIH TLV Process	IARC Process
Regulatory Impact	Not a standard or regulation	Not developed or adapted by a regulatory body. Role in European Standards setting may need review
Consensus of industrial hygiene profession	Limitations on TLV committee membership	Limitations of IARC committee members. Many technical organizations and professionals may be granted observer status
Completeness and balanced overview of knowledge	No- May summarize illness claims for others to sort out. (Potential link between manganese exposure and neurological effects as an example)	Primary focus on carcinogenic effects. Limited linkage with other potential health impacts and cancer. Most data is from epidemiological studies with limited exposure evaluation.
Methods to ensure/ support compliance	Does not address methods to evaluate or control exposures	Limited guidance regarding exposure assessment and controls
Guidance for exposure standard	TLV guidance (also used internationally)	Does not establish exposure criteria
Economic and technical feasibility	Specifically excluded from consideration in the TLV process	Not addressed by IARC

Limitations of IARC Findings

<u>International Association for Cancer Research</u>

- Many studies are epidemiology evaluation focused on post-disease diagnosis/even post-mortem evaluation of cancer
  - Time between initial exposures and outcome is long and uncertain
- Potential early warning information, such as levels of heavy metal exposures, generally not collected or available
- Non-cancerous effects (also potential "early warnings") not considered (and/or not available)
- Limited subset of shipyard welders and US operations

Summary

Analysis and suggested actions

Any links between IARC and current shipyard operations?

- IARC generally doesn't quantitatively link exposure and cancer-related outcome (except in animal studies)
- Many process changes which tend to reduce exposure
- Increased attention to safety and health improves protective equipment use and other control measures
- Analysis of US Navy and OSHA shipyard data shows no apparent trends
- Analysis of other published data suggests trend toward reduction of exposures, especially in shipyards.

Summary

Analysis and suggested actions

Interim Recommendations for Additional Control and Future Evaluations

- Continue to minimize exposures through process controls and protective equipment
- Explore concurrent hazard potential of associated operations, especially grinding and surface preparation.
- Educate and inform welders
- Consolidation of existing data to improve predictive ability
  - Medical monitoring and industrial hygiene data
  - Total Fume (NOS) and Metals – Any correlations?
- Collection of some additional air monitoring data and ongoing compilation/ tracking recommended
- Monitor the TLV process for updated reports