Face Level Sampling

Jeremy Evans
SKC Sales Development Manager

24th October 2017
Topics

• Welding Fume - Sampling Issues and Requirements
• Typical Sampling Arrangements
• BS EN ISO 10882-1: 2001 & Revision: 2011
• Face Level Sampling Headset & Mini Sampler
  - Development
  - Assessment/ Validation
• Headset – Other Applications
Welders are **190 times** more likely to die due to Workplace Exposure than a Worker in the UK is likely to be fatally injured at work.
Sampling Issues – Welding Fume / Particulates

• **Components**
  - Complex / Highly Variable
  - Fume + Vapours

• **Factors**
  - Welding Materials: *Parent Plate, Plate Coating, Welding Electrodes (Flux), Filler Rods*
  - Welding Type – *MIG, TIG, Arc (Stick)*
  - Arc Welding Current, Shielding Gas flow rate
Carcinogens
Chromium(VI) $\text{Cr}$, Nickel $\text{Ni}$, Cadmium $\text{Cd}$, Beryllium $\text{Be}$

Diseases
Manganism (*Parkinsons*), COPD, Asthma, Metal Fume Fever, Siderosis, Stomach Ulcers, Renal Damage
## Exposure Limits – EH40: 2002

### Welding Fume – Occupational Exposure Standard (OES)

<table>
<thead>
<tr>
<th>Substance</th>
<th>CAS Number</th>
<th>ppm</th>
<th>mg m$^{-3}$</th>
<th>ppm</th>
<th>mg m$^{-3}$</th>
<th>Notes</th>
<th>MDHS</th>
<th>OEL summary and other guidance</th>
<th>Health R phrases (in ASL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welding Fume</td>
<td></td>
<td>-</td>
<td>5</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td>EH54, EH55</td>
<td></td>
</tr>
</tbody>
</table>

### Metals - MEL’s (Maximum Exposure Limit) / OES’s

#### Manganese, Chromium, Nickel, Cadmium

<table>
<thead>
<tr>
<th>Substance</th>
<th>CAS Number</th>
<th>ppm</th>
<th>mg m$^{-3}$</th>
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<th>Notes</th>
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<th>OEL summary and other guidance</th>
<th>Health R phrases (in ASL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manganese, fume (as Mn)</td>
<td>7439-96-5</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>3</td>
<td>CHAN</td>
<td>91</td>
<td>CD157</td>
<td></td>
</tr>
</tbody>
</table>
Exposure Limits – EH40: 2005

- WEL’s only
- Welding Fume – WEL deleted
- Metals WEL’s
  - Manganese, Chromium, Nickel, Cadmium, Iron, etc

<table>
<thead>
<tr>
<th>Substance</th>
<th>CAS Number</th>
<th>Workplace exposure limit</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Long-term exposure limit (8 hour TWA reference period)</td>
<td>Short-term exposure limit (15 minute reference period)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ppm</td>
<td>mg m⁻³</td>
</tr>
<tr>
<td>Manganese and its inorganic compounds (as Mn)</td>
<td></td>
<td>-</td>
<td>0.5</td>
</tr>
</tbody>
</table>
Sampling Issues – Welding Fume / Particulates

• **Representative Sample**
  - Exposure Variability
  - Personal Sample

• **User Acceptance/Comfort**

• **Sampler Location**
  - Inside / Outside Face Shield
  - Breathing Zone
  - *Steep Concentration Gradient in Immediate Vicinity of Plume*

• **Visors**
  - New Designs - *Much Closer Fit to Face*
Sampling Issues – Welding Fume / Particulates

• **Sampler Characteristics**
  - Mounting
  - Size
  - Type
  - Design
  - Performance
10882-1 Sampling of Airborne Particles
- Published 2001

10882-2 Sampling of Gases
- Published 2000

BS EN ISO 10882-1:2001
- Scope: Welding Fume + Particles from Welding Related Operations
- In Breathing Zone: Behind Face Shield
- Not impeding Normal Work Activity
- Sampling only during Welding
BS EN ISO 10882-1:2001

- Part 1
  - Sampler Examples

- IOM Sampler
- Button Sampler
- Custom Sampler
- Cassette
Sampler and Mounting Development

Motivators

• Existing Mounting Arrangement Issues

• Manganese
  – Effects: Neurotoxic (Manganese) + damage to lungs, liver, kidney
  – Prevalence: Mild Steel, Steel Alloys, Electrode Flux

• Welding Fume Studies (2000’s)
  – High Frequency of Mn Overexposure

• 2007 - Occupational Exposure Limit halved
Sampler and Mounting Development

- Göran Lidén (Associate Professor)
  - Dept of Environmental Sciences, Stockholm University, Sweden in Partnership with the Swedish Work Environment Authority

- Small, Personal Air Sampler
- Suitable, Non-Intrusive and Comfortable Mounting
- Outcome - Headset-Mounted Mini Sampler
Sampler and Mounting Development

A Headset-Mounted Mini Sampler for Measuring Exposure to Welding Aerosol in the Breathing Zone

- 2009 Annals of Occupational Hygiene (Göran Lidén & Jouni Surakka)

Basis

- Focus - Manganese
- 5 Manufacturing Sites
- 4 Headsets
- Welding Methods
  - *Mainly:* MIG (Metal Inert Gas) / MAG (Metal Active Gas)
- Static Sampling
  - 118 Samples
  - IOM / Mini Sampler Comparison
- Personal Sampling
  - 43 Samples
  - Mini Sampler
Headset

- Modified Commercial Headsets
- Headband Behind Neck
- Side Beam
- Assessment
  - Comfort
  - Adjustability
  - Vertical & Lateral Stability
  - Leak Free
Mini Sampler

- Based on Swinnex design
- Open Face - Aluminium Entry Nozzle
- 13mm Filter (MCE, 8 micron)
- Flow Rate 0.75 l/min
- Inhalable Fraction
- IOM Comparison
  - Welding Aerosol Mass: Significant Negative Sampling Bias
    - Bias increases as Coarseness increases
  - Manganese: Sampling Bias <0.14 (statistically insignificant)
    - Unaffected by Aerosol Coarseness Ratio
Mini Sampler

- Sealing Cap
- Retaining Ring
- Sampler Inlet
- O Ring
- Filter
- Sampler Body
BS EN ISO 10882-1:2011

• Revision - 31<sup>st</sup> October 2011
• **Key Similarities to 2001**
  - Scope
  - Breathing Zone: Behind Face Shield
  - Not impeding Normal Work Activity
• **Key Differences to 2001**
  - Sampling for Entire Working Period
  - Ideal Mounting Arrangements: Characteristics and Evaluation
### Ideal Mounting Arrangement (*Characteristics*)

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sampler mounted in the operator’s breathing zone, <strong>behind the welder’s face shield</strong></td>
</tr>
<tr>
<td>2</td>
<td>Sampler inlet <strong>within 10cm</strong> of the mouth</td>
</tr>
<tr>
<td>3</td>
<td>Sampler inlet faces <strong>forward</strong></td>
</tr>
<tr>
<td>4</td>
<td>Sampler maintained in the <strong>same position</strong> whether the visor is up or down</td>
</tr>
<tr>
<td>5</td>
<td>Sampler maintained in breathing zone without intervention, <strong>when face shield removed</strong></td>
</tr>
<tr>
<td>6</td>
<td><strong>Mechanical stability</strong> of sampler position</td>
</tr>
<tr>
<td>7</td>
<td>Operators can use their <strong>own face shield</strong></td>
</tr>
<tr>
<td>8</td>
<td>Operator should experience <strong>no discomfort</strong> when using a welder’s face shield that has dimensions that conform to EN175</td>
</tr>
<tr>
<td>9</td>
<td>Sampler can be mounted inside <strong>face shields of all commercially available designs</strong>, including close-fitting types</td>
</tr>
<tr>
<td>10</td>
<td>Sampler mounting arrangement <strong>commercially available</strong></td>
</tr>
<tr>
<td>11</td>
<td>Samplers can be mounted that are designed to collect simultaneously the respirable and <strong>inhalable fractions</strong> of airborne particles</td>
</tr>
<tr>
<td>12</td>
<td>Mounting arrangement <strong>easy to attach</strong></td>
</tr>
<tr>
<td>13</td>
<td><strong>Sampler performance not adversely affected by breathing</strong> when mounted behind the welder’s face shield</td>
</tr>
</tbody>
</table>

*See BS EN ISO 10882-1:2011 Table B.1, page 21 for full details*
**BS EN ISO 10882-1:2011 - Mounting Arrangements (Evaluation)**

<table>
<thead>
<tr>
<th>Mounting Arrangement</th>
<th>Characteristic of Ideal Mounting Arrangement*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Clip Type</td>
<td>✓</td>
</tr>
<tr>
<td>Bracket Type</td>
<td>✓</td>
</tr>
<tr>
<td>Tube Type</td>
<td>✓</td>
</tr>
<tr>
<td>Collar Clip Type</td>
<td>✓</td>
</tr>
<tr>
<td>AWS Type</td>
<td>✓</td>
</tr>
<tr>
<td>Built-in Type</td>
<td>✓</td>
</tr>
<tr>
<td>Mini Sampler Type</td>
<td>✓</td>
</tr>
<tr>
<td>Sampler Suspended</td>
<td>✓</td>
</tr>
<tr>
<td>from the Operator’s</td>
<td></td>
</tr>
<tr>
<td>Neck</td>
<td></td>
</tr>
</tbody>
</table>

*See BS EN ISO 10882-1:2011 Table B.2, page 23 for full details. Note that ideal characteristic 13 (effect of breathing on performance of sampler) is unknown and therefore this characteristic is not assessed.
• Mounting Arrangements (8 examples)
  - Types: Clip, Bracket, Tube, Collar Clip, Mini Sampler, Built-in, etc.

• Evaluation of Characteristics
  - Mini Sampler and Headset: *Meets 11 out of 12 Ideal Characteristics*
    - Respirable/Inhalable Fractions Simultaneously
  - Other Types: Meet 6-8 out of 12 Ideal Characteristics
• The face level sampler is designed to measure manganese in welding aerosol according to ISO 10882.

• It allows exposure measurements to be made close to the worker’s mouth and can also be worn comfortably inside face visors.

• It can also be used for the analysis of other metals in welding aerosol and gravimetric analysis of welding aerosol, but with reduced sampling efficiency for particles larger than 20 μm.
In instances where workers wear face visors, lapel- or collar-mounted samplers are effectively **outside** the breathing zone of the worker.
Headset – Other Applications

**HSE: MDHS 83/3, 2015**
*Resin Acids in Rosin (Colophony) Solder Flux Fume*

- **Sampling Head:**
  - 13mm Swinnex Type & MCE Filter

- **Position:**
  - “mounted in a sampling head, close to the breathing zone”
  - “attach the sampling head containing the filter to the worker as shown”
HSE: MDHS 83/3, 2015

• Mounting: Behind Eye
• Face Level Sampling Headset + Swinnex

“Position the Sampling Head on the”

− “Right Side - for right handed workers”
− “Left Side - for left handed workers”

? Left or Right: Consistency
Headset – Other Applications

- Metal Working - Engineering, Construction, Manufacturing, etc
- Foundries/ Metal Heavy Industries
- Dust/Particulates
Face Level Headset and Mini Sampler

- Issues and Needs
- Development and Evaluation
- Criteria and Characteristics
- Applications
  - Welding Fume Metals
  - Other Airborne Hazards

Headset & Mini Sampler

A Practical Solution to Face Level Sampling
BREATHE FREELY
OFFICIAL SPONSOR

Controlling exposures to prevent occupational lung disease in MANUFACTURING

24th October 2017
MWF

Sean Mahar
PhD, CMFOH, CMIOSH, CIH, CSP, PE
Euro Safety and Health

Topics

• Common types of MWF used
• Health effects from exposure to MWF
• An overview of the past and present limits
• An overview of method MDHS 84/2
• Description of MDHS 95/3
• Endotoxins and their monitoring method
• Endotoxin occupational exposure limits
• An overview of HSE RR1044 and RR1043.
Machining

Over 90% of the energy of machining goes into heat production.

Temperatures at the tool–chip interface range between 1000-2000° F (530 to 1093° C).

Fluids
Types

Straight Oils:
not diluted with water

Soluble Oils (emulsifiable oils):
30-85% severely refined petroleum oil

Semi-synthetic fluids:
5-30% severely refined petroleum oil

Synthetic fluids:
No petroleum oils.

Typical Fluid Composition

- Other ingredients
- MBM
- MDEA
- Insoluble hydrocarbons
Machine Mix

- 5-10% Fluid
- 90-95% Water

Health Effects

- Irritation of the skin/dermatitis
- Occupational asthma
- Bronchitis
- Irritation of the upper respiratory tract
- Extrinsic allergic alveolitis (EAA)
Causative Agent/s

- Oil mist?
- Bacteria?
  - Culturable/viable?
- Fungi?
  - Culturable/viable?
- Endotoxins?
- Beta glucans?

UK Analytical Methods

- MDHS 84/2 Gravimetric analysis
- MDHS 95/3 Elemental marker method
  - boron, potassium, sodium
**MDHS 84/2 scope**

Gravimetric procedure for the measurement of time weighted average concentrations of oil mist.

Applicable where viscosities >18 mm²/s at 40 °C.

Lower viscosity oils contain a greater proportion of volatiles that may be unstable and underestimate the airborne aerosol concentration.

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**MDHS 84/2 method**

Inhalable sampling with gravimetric analysis.

If the inhalable particulate concentration > limit, cyclohexane extraction to remove interferences followed by reweighing.
MDHS 95/3 scope

The method is only suitable when the machine sump fluid (liquid circulating in the machine) contains an element which is unlikely to emanate from a source other than the water or metalworking fluid concentrate used to prepare the fluid and this element is present at a high enough concentration to facilitate its use as a marker.

Suitable markers are boron, potassium and sodium.

MDHS 95/3 method

Inhalable sampling and filter desorption with caesium chloride solution.

Marker concentration analysis on the filter and in the sump fluid by AAS or ICP-AES.

Water-mix metalworking sump fluid measured by refractometry comparison with known solutions.

Calculation of the concentration of the metal working fluid concentrate in the air sample.
RR1044 2015

Consultation on monitoring of water-miscible metalworking fluid (MWF) mists

Dr Helena Senior
Dr Gareth Evans
Health and Safety Laboratory

RR1044 objectives

To consult a small group of experts (analysts, British Occupational Health Society (BOHS) members) and relevant trade associations to identify key questions.

To consult with national and international experts about the use of methods to monitor exposure to MWF mist.

To summarise the findings from experts about the guidance and exposure limits for MWFs and about methods to monitor mist.
RR1044 findings

Most exposure guidance MWF relates to mineral oil and not water miscible fluids except for those set by NIOSH and INRS that relate to all.

Historically, average mist levels have not changed over time; most were below 1.0 mg/m\(^3\) with many below 0.5 mg/m\(^3\).

This suggests that as ill health was reported at these low levels of mist, the exposure limits have no relevance to health risk.

Limits

**UK MWF guidance values**

3 mg/m\(^3\) (10hr TWA) for straight oil

1 mg/m\(^3\) (10hr TWA) for water-miscible

- recommended in 2002
- withdrawn in 2005
RR1043 2015

Endotoxin in metal working fluid (MWF) mist
Dr Helena Senior
Dr Christopher Barber
Dr Gareth Evans
Health and Safety Laboratory

RR1043 objectives

Review the evidence used to develop the health based recommended occupational exposure limit (HBROEL) for endotoxin of 90 EU/m$^3$ over 8-hours proposed by the Health Council for the Netherlands; and to assess its relevance as a ‘benchmark’ to assess risks to respiratory health caused by endotoxin in metal working fluid mists.

Assess whether the published evidence on endotoxin concentration in metal working fluids provides sufficient evidence that concentrations in mist are sufficient to cause harm to human health.
RR1043 HBROEL

The DECOS HBROEL 90 EU / m³ was mainly based on the results of a single volunteer human exposure study.

For ethical reasons subjects with pre-existing disease that could have been exacerbated by exposure to endotoxin were excluded and therefore this health based limit may not protect all workers. There is evidence that levels of endotoxin lower than 90 EU/m³ can cause inflammation in the airways of some workers.

RR1043 Air/fluid differences

19 studies pass muster and most measurements were below 1.0 mg/m³.

There was a large discrepancy between endotoxin and viable bacteria levels in mist compared to the concentrations in bulk fluid.

Airborne endotoxin levels were close to or beneath 90 EU/m³, whilst sump levels generally exceeded these by 100 to 1000 fold.

Levels of viable bacteria captured in air were low compared to the levels in the sumps.
Endotoxins

• Major cell wall component of gram-negative bacteria.
• Ubiquitous outdoors and indoors.
• Lipopolysaccharide molecules that contain a lipid region and a long-chain polysaccharide moiety.
• Thought to be causative agent for respiratory effects associated with organic dusts.

Endotoxin Sampling

CSN EN 14031 Workplace atmospheres - Determination of airborne endotoxins
Inhalable sampling with binderfree glass fibre filters

*Limulus* amebocyte lysate assay analysis.

(polycarbonate filters, polytetrafluoroethylene filters and impingers are also used but frowned upon in the standard).
Endotoxin Analysis

*Limulus* amebocyte lysate assay
- gel-clot
- Turbidimetric
- kinetic chromogenic

NIOSH REL

- NMAM 5524 Method
- NIOSH REL
  - 0.4 mg/m³ as thoracic fraction
  - 0.5 mg/m³ as ‘total’ aerosol
NIOSH REL Scope

based on four major considerations:

- the adverse respiratory health effects of MWF exposure;
- the selection of an index for measuring MWF aerosol exposure;
- the universal applicability of the REL to all types of MWFs; and,
- the technological feasibility of the REL.

NMAM 5524

Inhalable sampling with gravimetric analysis.

If the inhalable particulate concentration > limit, ternary solvent (dichloromethane: methanol: toluene (1:1:1)) or binary solvent: methanol: water (1:1) extraction to remove interferences followed by reweighing.
Qualitative Measures

Odor
Dust lamp

Hierarchy of Control

PPE
Administer
Engineer
Substitute
Eliminate
Eliminate Substitute

Good Fluid Management

Engineer Administer

Increase dwell time
LEV
PPE

A slippery slope
Gloves

A tale of 2 factories
A situation worth investigating
Factory A

• A sticky amber film was forming on vertical surfaces
• Most notable on stainless steel fridges and wire grids
• Sample scrapings sent to 2 labs for analysis
• Gas chromatography/mass spectrometry (CG/MS) indicated MDEA
• MDEA, n-methyldiethanolamine

MDEA

• n-methyldiethanolamine
• CAS 105-59-9
• Water soluble
• BP, 760 mm Hg, 247.3 C
• VP, 20 C, <0.01 mm Hg
• R36 Irritating to eyes
Insoluble hydrocarbons

Other ingredients

MBM

Insoluble hydrocarbons
MBM

• n,n’-dimorpholinomethane
• CAS 5625-90-1
• Water soluble
• BP, 760 mm Hg, 266.4 °C
• VP, 20 °C, <0.01 mm Hg
• H314: Causes severe skin burns and eye damage
• H317: May cause an allergic skin reaction
• H350: May cause cancer
• H341: Suspected of causing genetic defects

Factory B

• A worker is suffering from skin rashes
• Works on machines using fluids with MBM
• Could airborne MBM be the cause?
• Previous contact may have allowed sensitization
BIT

- Benzisothiazolinone
- CAS: 220-120-9
- Poorly water soluble, 6.0 g/l (0.60 %) at 30 °C
- BP, 760 mm Hg, 327.6 °C
- VP, 25 °C, <0.01 mm Hg
- H315: Causes skin irritation
- H317: May cause an allergic skin reaction