

Workplace Airborne Hazards and Air Sampling

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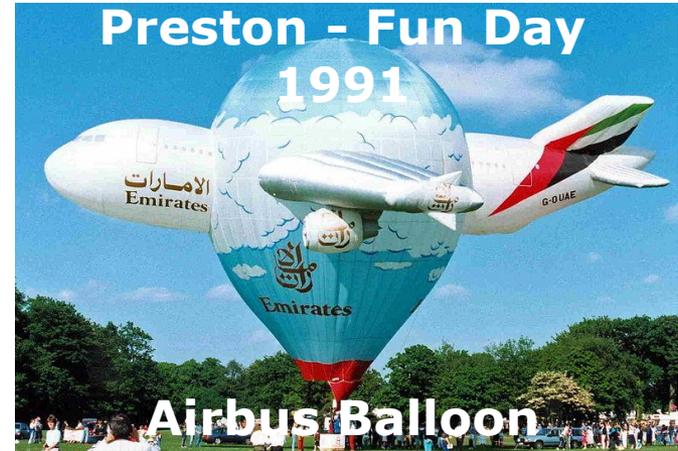
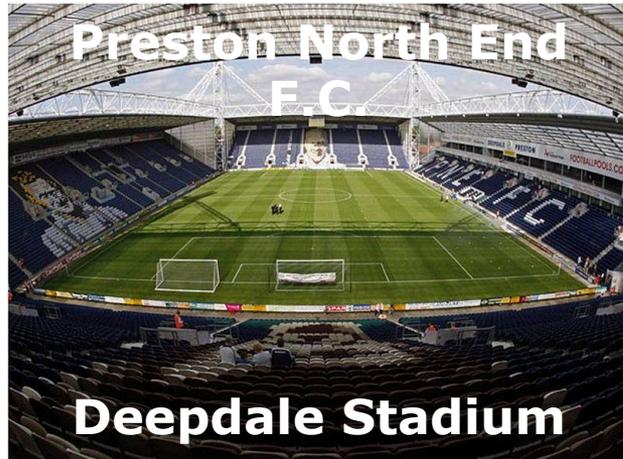
18th February 2020
BAE Systems, Warton



Agenda

- Reasons for Workplace Air Sampling
- Airborne Hazards & Air Sampling - Background
- Workplace Air Sampling Methods
- Active Sampling - Time Based Workplace Exposure
 - Particulates
 - Welding Fumes (Metals)
 - Vapours
- Sampling Options

Size of the Problem?



1 mg/m³

one teaspoon of flour spread over a rugby/football field, to a height of one metre



1 ppm

contents of a party balloon in the volume of **50** three bedroom houses

Size of the Problem?

Safety



147

Health



12,000 - 13,000

Pareto's Principle - 80:20 Rule does not apply

Deaths due to airborne exposure **100:1**

Airborne Hazards (Health)

Cancers
Lung Cancer
Mesothelioma
Leukaemia
Nasal Cancer
etc

Benzene
Butadiene

Chromic Acid Mist
Nickel
Cadmium

Wood Dust
Rubber Dust/Fume

Asbestos
Respirable
Crystalline
Silica

Diseases
COPD
Occupational Asthma
Chronic Bronchitis
Emphysema
Asbestosis
Silicosis
etc.

Isocyanates

Dust
Wood, Flour,
Cotton, etc.

Styrene

Welding
Fume
Particulates

Formaldehyde

Respirable Crystalline Silica

Cancer

RCS – Lung Cancer

Diseases

RCS – Silicosis
COPD



Silicosis

- No cure - irreversible
- Not an old person's disease - seen in people in their 20's
- RCS UK WEL – $0.1\text{mg}/\text{m}^3$ 8 Hour TWA
 - 30% chance of developing Silicosis over 45 years - at WEL

Airborne Hazards (Health)

Industry Examples:

- **Welding, Soldering, Metal Work**
 - 1 in 10 of 30,000 reported breathing/lung problems caused/made worse by work
 - Welding Fumes - 152 Deaths per Annum
- **Bakers**
 - 80 times more likely to develop occupational asthma
- **Construction**
 - 40% of all reported Occupational Cancers



Long Latency Period

e.g. Welding Fumes- can be 18 Years to develop Asthma



H&S Headlines

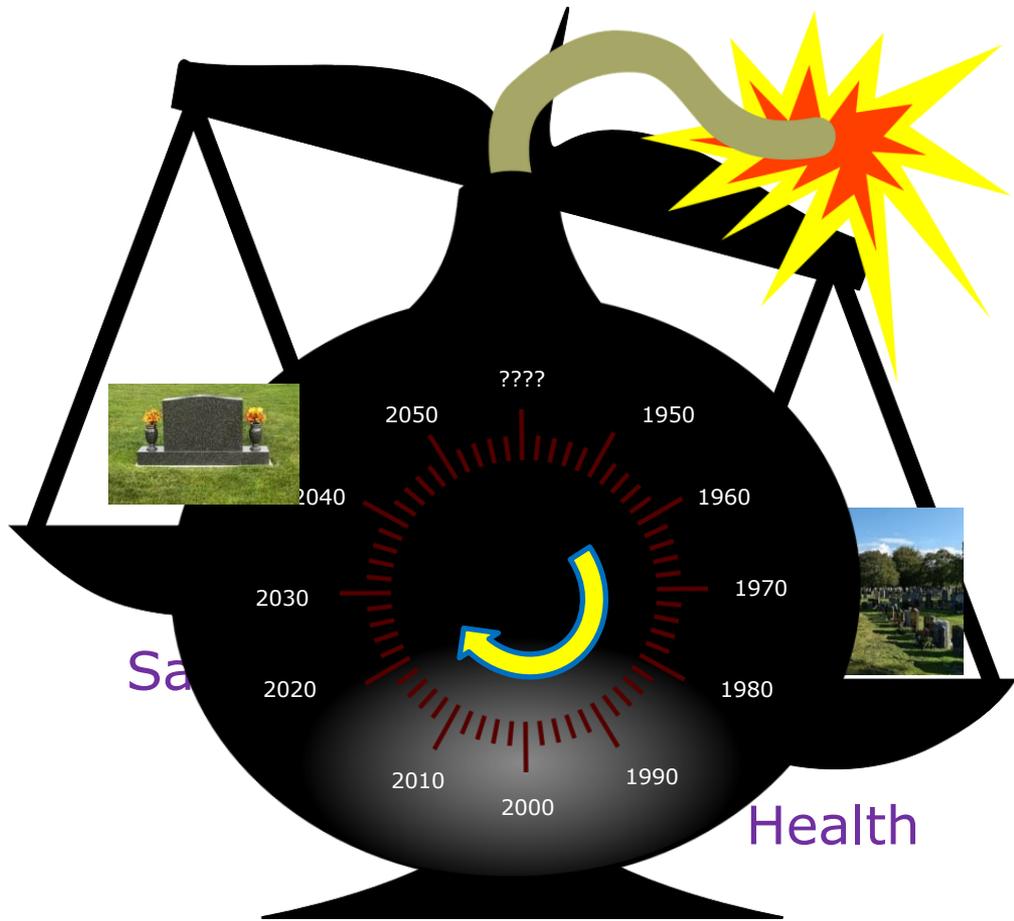
- Scaffold Fall
- Ceiling Collapse Injures Worker
- Chemical Fire
- Worker's Crush Injury
- Severe Electrical Burns
- Forklift Crush Death
- Hit by Steel Girder
- Industrial Saw Injury



Occupational Respiratory Diseases - Headlines?

- Asbestos 
- Others 

Getting the Balance right



History - Time Line

- 1st Century AD PLINY THE ELDER
 - Animal Bladders to protect against Dust & Lead
- 1556 AGRICOLA
 - De Re Metallica - Miners Diseases and Preventive Measures
- 1700 BERNARDINO RAMAZZINI
 - De Morbis Artificum Diatriba (Diseases of Workers)
- 1800's MAD HATTER
 - Mercury Solution - Fur to Felt
- Late 1800's MINERS' CANARIES
 - Audible / Visual Warning (methane / carbon monoxide)
- 1905 BENZO (a) PYRENE
 - Identified as first Chemical Carcinogen
- 1906 WORKMAN'S COMPENSATION ACT
 - 6 Industrial Diseases, e.g. lead, mercury, phosphorous, arsenic poisoning



THE WORKMEN'S
COMPENSATION ACT, 1906

V. R. ARONSON, M.A., B.C.L.

OF THE GREAT BRITAIN AND IRELAND



T. FISHER UNWIN
LONDON & LEIPZIG
SOLE TRADING ESTABLISHMENT IN
1906

Reasons for Workplace Air Sampling

- Health Protection
- Compliance with Government Legislation
 - COSHH: Control of Substances Hazardous to Health
 - EH40: Workplace Exposure Limits
 - CLAW: Control of Lead at Work Regulations
 - CAR: Control of Asbestos Regulations
- Protection from Compensation Claims
- Process Control



Airborne Exposure - Focus?

Less Focus
on



CONTROLS



MEASUREMENT

PURPOSE OF CONTROLS: MINIMISE PERSONAL EXPOSURE

IS EXPOSURE ACTUALLY MEASURED ?

Costs?

CONTROLS



LEV, Suppression, RPE, etc

AIR SAMPLING



Equipment, Analysis (Lab)

What Does it Cost **NOT** to do Air Sampling?

Questions



- How can I be sure my staff are **not overexposed** to Airborne Hazards?
- What **Evidence/Records** do I have of their actual exposure?
- How do I decide the **Need for & Level of Controls** required?
- How can I measure their **Effectiveness**?



EXPOSURE MEASUREMENT - BENEFITS

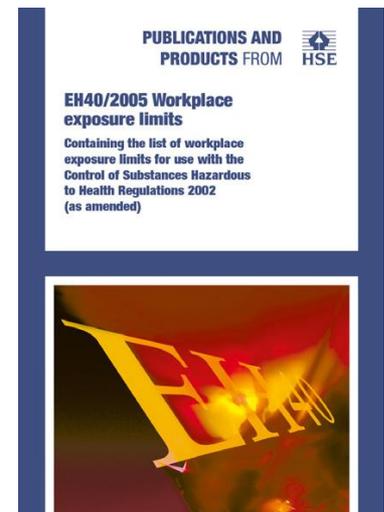
- Records - *Evidence*
- Informed Decisions based on Facts - *not Assumptions*
- Potential Cost Savings
- Protection of Staff and Company



UK Workplace Exposure Limits

- EH40:2002
 - MEL (Maximum Exposure Limit)
 - OES (Occupational Exposure Standard)

- EH40:2005
 - 4th Revision: January 2020
 - WEL (Workplace Exposure Limit)
 - 8 Hour (Time Weighted Average - TWA)
 - 15 Minute (Short Term Exposure Limit - STEL)



Hazardous Substances without Limits

- WEL not specified in EH40?
- This does not mean it is safe!
- Consider Other Published Limits
 - e.g. USA
 - OSHA - *PEL's (Permissible Exposure Limits)*
 - NIOSH - *REL's (Recommended Exposure Limits)*
 - ACGIH - *TLV's (Threshold Limit Values)*
- Take advice

What is Air Sampling?

- Air is passed through a tube, filter or other collecting media
- Hazard Presence / Level detected by

- Colour Change of Media

or

- Laboratory Analysis

or

- Direct Reading



Types of Air Sampling

Passive Sampling

- Diffusion
- Semi-quantitative (*Indicator-Surveys*)
- Immediate results (*Gastec, Dräger*)



Grab Sampling

- Small sample volume
- Semi-quantitative (*Gastec, Dräger*)
- Quantitative (*Bag Sampling*)
- Not time-based exposure

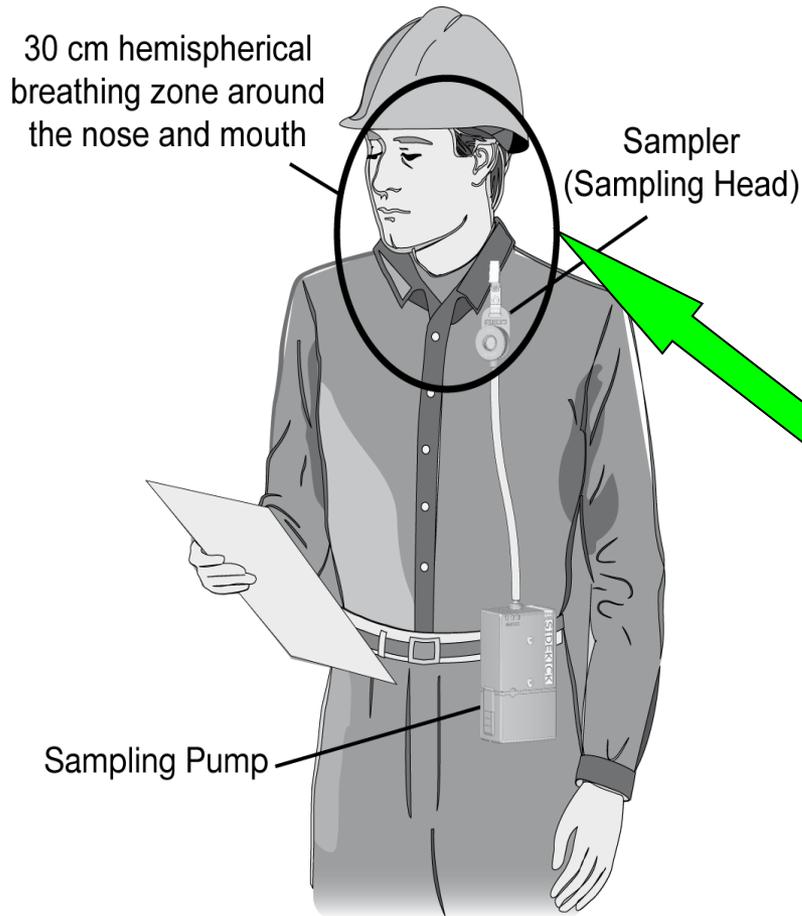


Active Sampling

- Compensating pump
- Quantitative - *known flow rate & time*
- Much larger sample volume



Personal vs Static Sampling

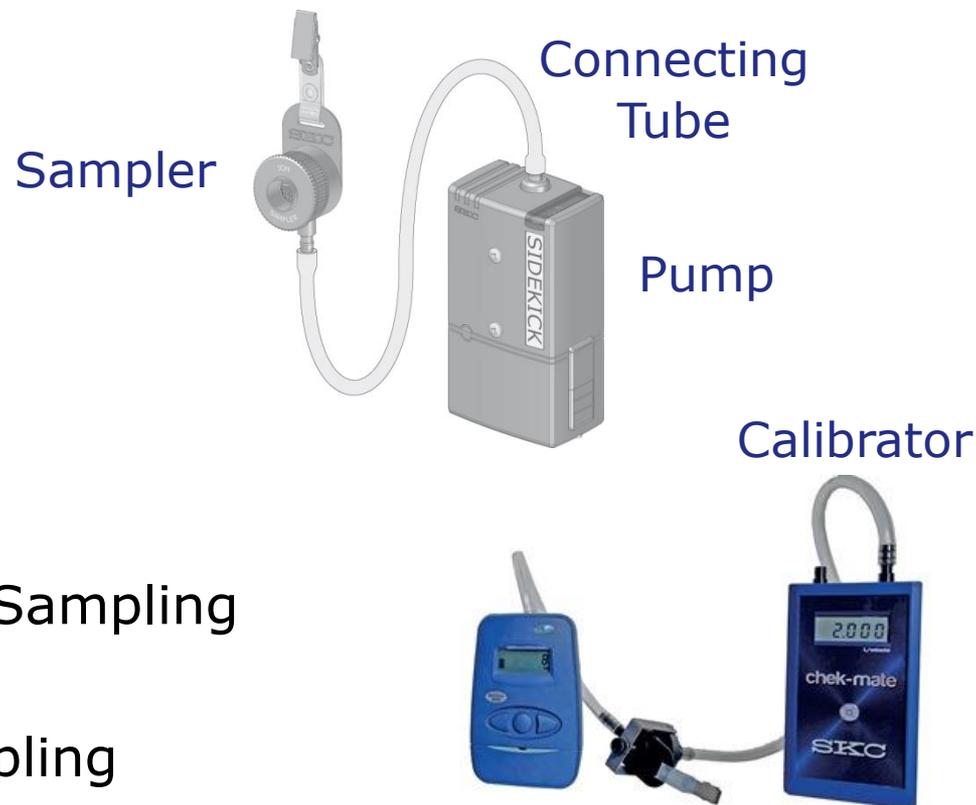


ALL
Workplace Exposure Limits are
based on
**PERSONAL
SAMPLES**

*MUST be taken in the
BREATHING ZONE*

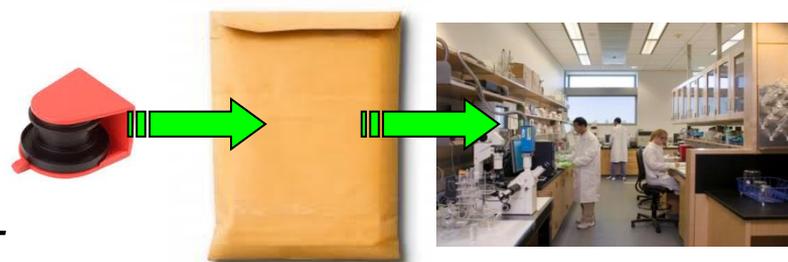
Sampling Train

- Pump
- Connecting tube
- Sampler



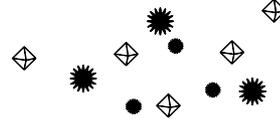
Active Sampling

- Setup Sampling Train
- Calibrate Flow Rate - *Before* Sampling
- Fit Sample Train to Operator
- Check Flow Rate - *After* Sampling
- *Send Sample to Laboratory*
- Review Results
 - *Actual Exposure vs 8 hr WEL*
 - *15 min STEL*

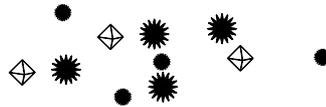


Particulates

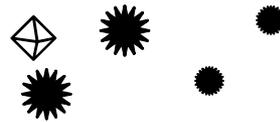
Aerosol



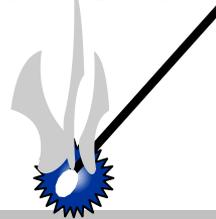
Dust



Fume



Smoke



SOLID

Particulates

- General Dust
- Wood Dust – *Mills, Furniture, Workshops, Paper*
- Fumes - *Welding, Solder, Rubber, etc.*
- Metals - *Electroplating, Grinding, Cutting*
- Fibres - *Asbestos, Mineral, Ceramic, Silica*
- Flour/Grain Dust - *Mills, Bakeries*
- Rubber Process Dust
- Diesel Particulates
- Mining - *Coal, etc.*
- Cotton, Wool Dust



Inhalable Dust

- Size Distribution BS EN 481:1993
- Up to 100 micron AED
- Affects ALL the respiratory system
- Partially visible
- Workplace Exposure Limit (WEL)

- **Dust**

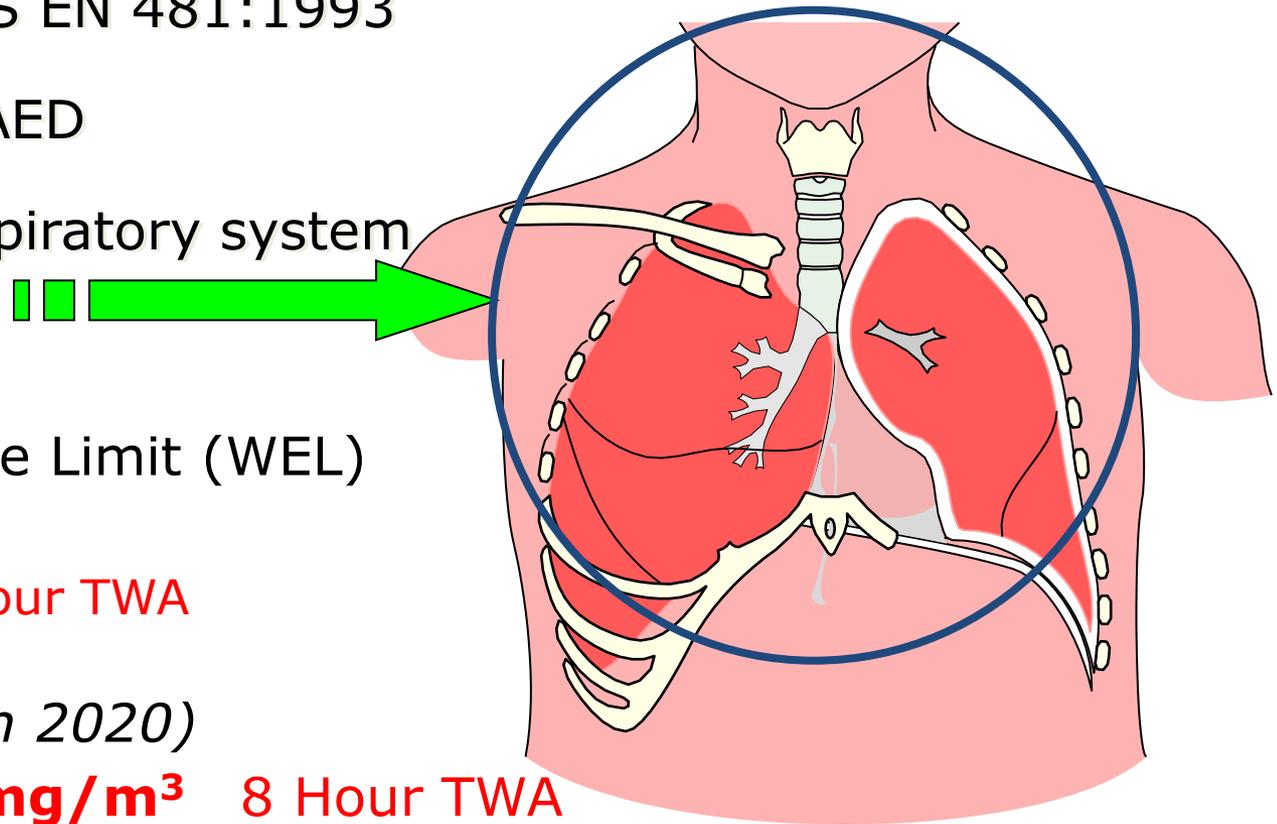
10 mg/m³ 8 Hour TWA

- **Wood Dust** (*Jan 2020*)

Softwood **5 mg/m³** 8 Hour TWA

Hardwood or Mix **3 mg/m³** 8 Hour TWA

(EC- Feb 2019 **2mg/m³** from Jan 2023)



Respirable Dust

- Size Distribution - BS EN 481:1993
- Up to 10 μm AED
- Penetrates deep into the lungs
- Invisible

Workplace Exposure Limits (WELs)

- **Dust**

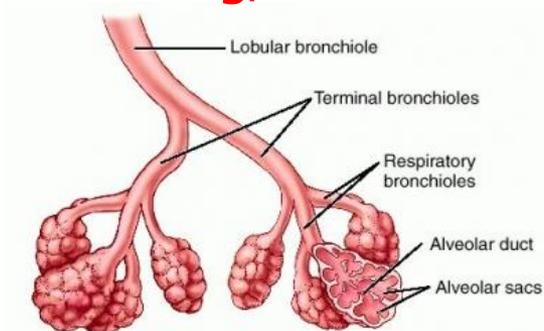
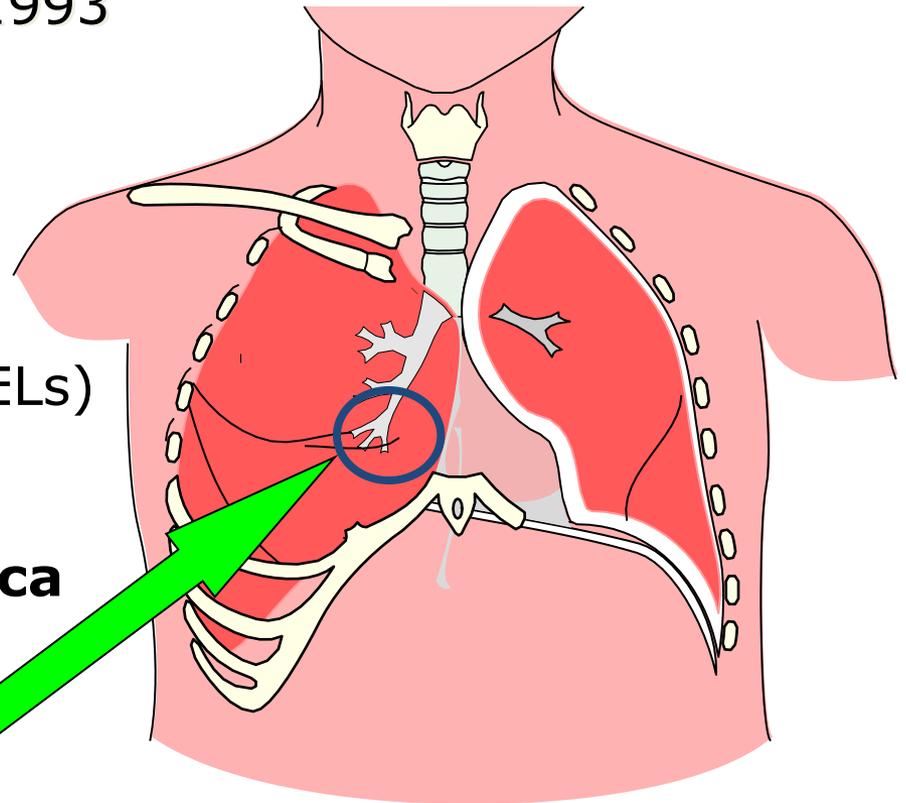
4 mg/m^3

8 Hour TWA

- **Respirable Crystalline Silica**

0.1 mg/m^3

8 Hour TWA



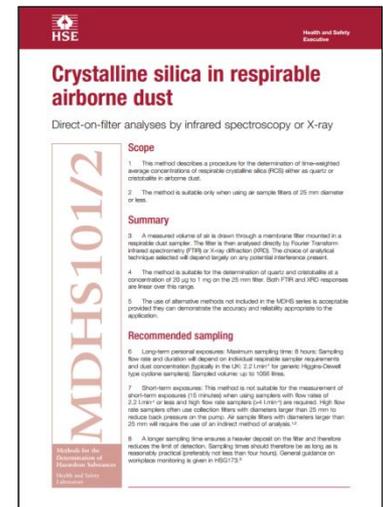
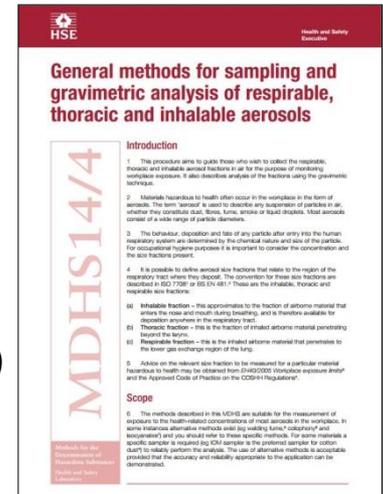
HSE Methods - Particulates

MDHS - Method for the Determination of Hazardous Substances

- MDHS 14/4 – Aerosol Fractions (*Particulates inc. Dust*)

Other Examples

- MDHS 101/2 - Respirable Crystalline Silica



Air Sampling – Particulates

Sampling Heads (containing a Filter)



IOM
Inhalable Dust
Metals



Cyclone
Respirable Dust
Silica

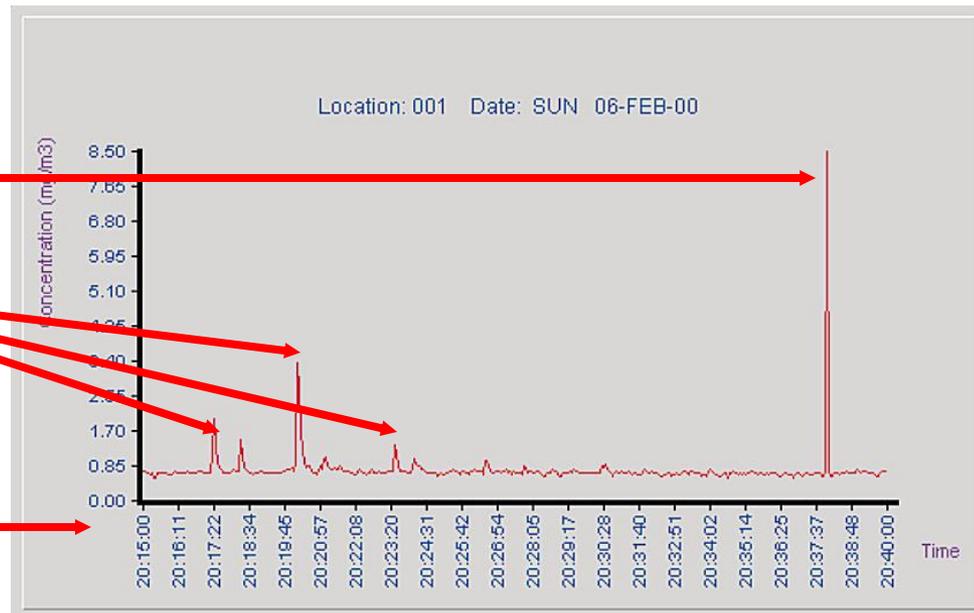


Cowled
Fibres
Asbestos

Survey Methods - Particulates

Direct Reading Dust Monitor - time-based picture of the situation

- Area Mapping
 - Where (*Hotspots*), When, Who
 - Inhalable or Respirable dust



Cleaning

Processes

TIMES!

Welding Fume



- 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

- Exposure Sampling Issue
 - Breathing Zone (*behind mask*)

Welding Fume - HSE Guidelines

- *Feb 2019: Welding Fume – Safety Alert*
 - New scientific evidence: Welding fume inc from mild steel welding - can cause **lung cancer**, and links to possible **kidney cancer**
 - HSE Enforcement Expectations: to **exposure control** including that from mild steel welding
 - Where **engineering controls** are inadequate to control all fume exposure - **adequate/suitable RPE** also required



Welding Fume - HSE Guidelines



- *Nov 2019*: Revised COSHH Guidance Documents

WLO - ADVICE FOR MANAGERS

- *"You may need to undertake an exposure measurement survey, which will involve air sampling and, for some specific hazardous substances, biological monitoring would also be appropriate."*
- Reference to **ISO10882**
"Health and Safety in Welding and Allied Processes – Sampling of airborne particles and gases in the operators' breathing zone Parts 1 and 2."

WL3 – WELDING FUME CONTROL

- Focus on **LEV and RPE** for different Types of Welding
- Reference to: adverse neurological effects from exposure to **Manganese**, *"ubiquitous in mild steels, some stainless steels and welding consumables."*

Exposure Limits EH40: 2005



- Welding Fume – WEL (gravimetric)
- Metals WEL's
 - Manganese, Chromium, Nickel, Cadmium, Iron, etc

PUBLICATIONS AND
PRODUCTS FROM HSE



EH40/2005 Workplace exposure limits

Containing the list of workplace
exposure limits for use with the
Control of Substances Hazardous
to Health Regulations 2002
(as amended)





Aluminium	Lead
Antimony	Manganese
Arsenic	Molybdenum
Beryllium	Nickel
Cadmium	Silver
Chromium	Tin
Cobalt	Titanium
Copper	Vanadium
Iron	Zinc

Carcinogens

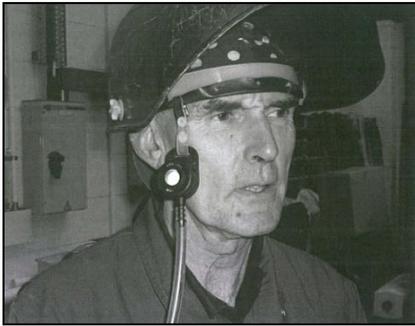
Chromium(VI) **Cr**, Nickel **Ni**, Cadmium **Cd**, Beryllium **Be**

Diseases

Manganism (*Parkinson's*), COPD, Asthma, Metal Fume Fever, Siderosis, Stomach Ulcers, Renal Damage

BS EN ISO 10882-1:2001

- Part 1
 - Sampler Examples



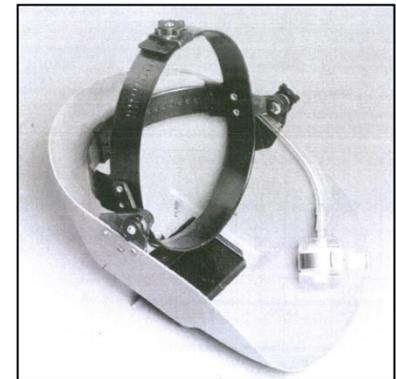
IOM Sampler



Button Sampler



Custom Sampler



Cassette

Welding Fume



BS EN ISO 10882-1:2011

*Health & Safety in Welding and Allied Processes
Sampling of Airborne Particles and Gases
in the Operator's Breathing Zone
Part 1 - Sampling of Airborne Particles*

- Sampling - **Entire Working Period**
- **Ideal Mounting Arrangement** - *12 Ideal Characteristics*
 - Inlet **forward facing** & **within 10 cm** of nose/mouth
 - **Same position** when visor up/down or removed
 - Sampler Position **mechanically stable**
 - Operator can use **own face shield**
- **Comparison** - 8 Mounting Arrangements

Welding Fume

Headset



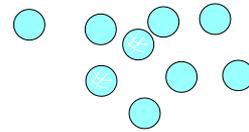
Mini Sampler (flow rate 0.75 L/min)



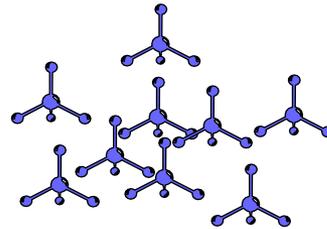
- Mini Sampler and Headset*
 - Validated for Manganese sampling
 - Meets *11 of the 12* Ideal Characteristics
 - ~~Respirable/Inhalable Fractions simultaneously~~
- Other Arrangements
 - Meet *6/7 of the 12* Ideal Characteristics

Vapours

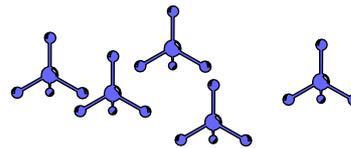
Aerosol



Gas



Vapour



LIQUID

Vapours

- Organic Chemicals – *solvents / VOCs, etc.*
 - Benzene, Toluene, Formaldehyde, Methanol, etc.
- Inorganic Chemicals – *mineral acids*
 - Hydrochloric Acid, Nitric Acid, etc
- Gases
 - Nitrous Oxide, Chlorine, Chloroform, etc.
- Isocyanates



Vapours - Exposure Limits (WELs)

- Parts per Million (ppm)
- Wide range
 - Vapours
 - Limits

Examples	<i>8 Hour TWA</i>	<i>15 Minute STEL</i>
- Formaldehyde	2 ppm	2 ppm
- Xylene	50 ppm	100 ppm
- Dichloromethane	100 ppm	300 ppm
- Propan-2-ol (IPA)	400 ppm	500 ppm

Passive/Grab Sampling - Vapours

Passive Sampling Badges



Colour Change Tubes



Active Sampling - Vapours



Sorbent Tube - with Holder & Cover



Cassette & Holder (containing treated filter)



HSE Methods - Vapours

MDHS - Method for the Determination of Hazardous Substances

Generic (VOCs)

- MDHS 88 *Passive Sampling*
- MDHS 104 *Active Sampling*


Health and Safety Executive

Volatile organic compounds in air

Laboratory method using sorbent tubes, solvent desorption or thermal desorption and gas chromatography

MDHS104

Scope

- 1 Three methods are described for the determination of time-weighted average concentrations of volatile organic compounds (VOCs) using air sampling onto sorbent tubes followed by gas chromatographic analysis. Method 1 uses pumped sampling with sample introduction by thermal desorption, Method 2 uses diffusive sampling also with sample introduction by thermal desorption and Method 3 uses pumped sampling and solvent desorption. All three methods are suitable for personal and static sampling.
- 2 These methods are applicable to a wide range of VOCs. For Methods 1 and 2, two sorbents are recommended for general use for hydrocarbons, halogenated hydrocarbons, esters, glycol ethers, ketones and alcohols. For Method 3 the most common sorbent used is activated coconut shell charcoal although others are available for specific applications.

Summary

- 3 A general guide to which of the three sorbent tube monitoring methods is appropriate for volatile organic compounds dependent upon required sampling time and estimated analyte concentration is given in Table 1.
- 4 The upper limit of the useful range of the three methods is determined by the sorptive capacity of the sorbent used and by the linear dynamic range of the gas chromatograph column and detector. The lower limit of the useful range depends on the noise level of the detector and on blank levels on the sorbent tubes or desorption solvent.
- 5 Method 1 (pumped sampling; thermal desorption) is suitable for sampling times of the order of a few minutes (0.1–100 mg.m⁻³) up to 2 hours (low flow rate, approximate range 0.1–10 mg.m⁻³). A measured volume of air is drawn through a sorbent tube containing appropriate sorbent, specifically selected for the compound or mixture to be sampled. The collected vapour is then thermally desorbed in an inert carrier gas into a gas chromatograph fitted with a suitable capillary column and detector.
- 6 Method 2 (diffusive sampling; thermal desorption) is suitable for samples of greater than 15 minutes up to 8 hours over a concentration range of approximately 1–1000 mg.m⁻³. The sorbent tube, fitted with a diffusion cap, is exposed for a measured period of time, and then thermally desorbed in the same manner as Method 1.
- 7 Method 3 (pumped sampling; solvent desorption) is suitable for samples of a few minutes up to 8 hours over a concentration range of approximately 1–1000 mg.m⁻³. A measured volume of air is drawn through a sorbent tube, which is then desorbed with a solvent, typically carbon disulphide for simple hydrocarbons.

Methods for the Determination of Hazardous Substances
Health and Safety Laboratory

- WHY
- WHAT
- HOW
- **WHO?**

Workplace Air Sampling - Options

- Consultant
- DIY
- Both

DIY Benefits

- Cost Savings
- Flexibility
- Involvement / Ownership
- Additional Skills / Experience

Air Sampling - Exposure Measurement

Don't *just* rely on Controls



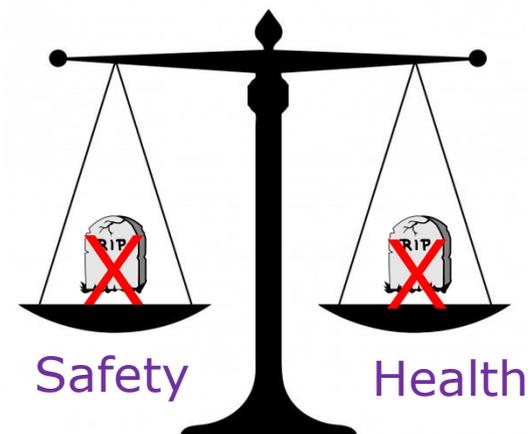
Take the Guesswork Out



Defuse the Exposure Time bombs



Redress the Balance



18th February 2020
BAE Systems, Warton

