WORKING FOR A HEALTHY FUTURE

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Guidance for the collection of inhalable and respirable airborne manganese dust

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WORLD HEALTH ORGANISATION
COLLABORATING CENTRE
FOR OCCUPATIONAL HEALTH

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ABBREVIATIONS

AAS	Atomic Absorption Spectrometry
AES	Atomic Emission Spectrometry
ACGIH	American Conference of Governmental Industrial Hygienists
CEN	Comité européen de normalisation (European committee for standarization)
BMRC	British Medical Research Council
GC/MS	Gas Chromatography / Mass spectrometry
GM	Geometric Mean
GSD	Geometric Standard Deviation
GSP	Gesamtstaubprobenahme an der Person
HD	Higgins Dewell
HSE	Health and Safety Executive (UK)
ICP/MS	Ionization Couple Plasma / Mass Spectrometry
IEH	Institute for Environment and Health
INERIS	Institut National de l'Environnement Industriel et des risques
IOM	Institute of Occupational Medicine
ISO	International Standard Organization
LOD	Limit of Detection
Mn	Manganese
NIOSH	National Institute for Occupational Safety and Health (US)
OEL	Occupational Exposure Limit
OSHA	Occupational Safety and Health Administration (US)
PIDS	Personal Inhalable dust Spectrometer
PUF	Polyurethane Foam
RSD	Relative Standard Deviation
SD	Standard Deviation
WASP	Workplace Analysis Scheme for Proficiency

1 INTRODUCTION

1.1 BACKGROUND TO PROJECT

In 2004, occupational exposure limits (OELs) for manganese (Mn) were proposed according to the health related size fractions of inhalable and respirable dust (IEH/IOM, 2004). The sampling devices for measuring occupational Mn exposure currently in use by member companies of the International Manganese Institute (IMnI) and their sites vary considerably. Unfortunately, the sampling performance of the different devices will also vary which means that exposure levels reported between sites and companies cannot be directly compared.

IMnI therefore contracted the Institute of Occupational Medicine (IOM) (Edinburgh, UK) to review current sampling devices and propose a standard method for measuring inhalable and respirable Mn exposure in the workplace. A standard method would ensure that there is a level playing field between companies and sites when comparing exposure levels to international occupational exposure standards. However, during the project it became clear that introducing standard methods may not be feasible as companies and sites will also have to conform to national requirements. Therefore, it was decided to propose reference samplers for measuring inhalable and respirable Mn exposure and a simple guidance for the appropriate collection of inhalable and respirable airborne manganese dust for those producers with national requirements. Section 1.2 describes briefly the procedure that lead to the selection of the reference samplers. The full final project report (Sánchez Jiménez et al, 2010) can be obtained from the IOM website URL: http://www.iom-world.org/.

1.2 SELECTION OF REFERENCE SAMPLERS

An examination of the dust samplers available for personal exposure was performed to select suitable candidate samplers for respirable and inhalable Mn dust. This involved a literature review on the performance of the different samplers and a questionnaire survey to the Mn industry to collect information on the current samplers used. The results were presented and discussed with IMnI representatives, which led to the selection of three candidate samplers:

- the IOM head for the inhalable fraction,
- the Higgins Dewell (HD) cyclone for the respirable fraction,
- the Conical Inhalable Sampler (CIS) for the simultaneous collection of both fractions.

The selection was based on the following requirements:

- the samplers should follow the recognised scientific criteria for collection of inhalable and respirable airborne particles,
- the sampling medium should not impede the chemical analyses of Mn,
- the samplers should be readily commercially available worldwide,
- the cost of the samplers.

The performance of these three sampling devices was compared at four separate Mn production facilities. The sampling strategy aimed to collect samples at processes covering a range of Mn concentrations and included both personal and static measurements.

The results of these measurements showed that the CIS sampler consistently overestimated the inhalable and respirable dust concentrations compared with the IOM head and cyclone, respectively. In addition, the polyurethane foams (PUF) used in the CIS sampler for separation of the inhalable and respirable fraction had a high Mn content compared to the glass fibre filters

used in the cyclone and the IOM sampling head, which results in higher limits of detection (LODs) for the CIS sampler compared to the IOM and cyclone. In addition, the foams used with the CIS sampler have higher gravimetric instability, which also results in a higher gravimetric LOD compared to that of the glass fibre filters used with the IOM head and the cyclone. These results mean that the cyclone and IOM head are more sensitive to sample low dust and Mn concentrations than the CIS sampler.

Based on the results from the sampling campaigns, the IOM head and HD cyclone are proposed as the reference samplers for collection of the inhalable and respirable Mn exposure concentrations, respectively.

With regard to the chemical analysis of Mn, there are several standard methods suitable for Mn extraction: (e.g. OSHA ID 121 OSHA (2002), OSHA ID 125-G OSHA (1991), NIOSH 7301 (NIOSH, 2003a); NIOSH 7303 (NIOSH, 2003b). These methods used Atomic Absorption Spectrometry (AAS) or Ionization Inductive Coupled Plasma Atomic Emission Spectrometry (ICP-AES) to quantify Mn. Both techniques are equally suitable for quantification of Mn.

1.3 WHY YOU SHOULD USE THESE REFERENCE SAMPLERS

The use of these reference methods for sampling and Mn analysis will allow comparison of the Mn concentrations across all Mn production sites. The IOM head and the HD cyclone are already used at many IMnI manufacturing sites. Therefore, for most of the sites there would not be any additional cost associated to the implementation of these reference samplers. For those sites where other samplers are used for regulatory compliance it is still recommended that their sampling strategy includes the reference samplers to aid comparison throughout the industry and for any future epidemiological studies. It is recommended that measurements collected with the sites local and reference samplers are undertaken side-by-side. This would allow estimation of a conversion factor between the local and proposed methods, so all measurements can be converted to the corresponding reference method and therefore be compared across all sites.

Differences in sampling strategy can be as important as the use of differences samplers. Therefore, to get comparable data, sites should use similar sampling strategies (such as that detailed in this document) along with the reference samplers. Samples should be representative of typical exposure concentrations. Consequently, an agreement should be taken on the selection of employees, the sampling areas and the sampling period. Information on the sampling survey, including variations in the pump flow rate, exposure controls, exposure pattern, description of the workplace and tasks carried out, and observations on factors could influence exposure should be properly recorded.

The IOM has developed a database “Manganex” to store information on Mn concentrations. The database includes different entry fields to allow retrospective and prospective data gathering. Data can be exported for statistical analysis. It also allows automatic generation of summary reports. The database would be available from the IMnI website.

1.4 CONTENT OF GUIDANCE DOCUMENT

This guidance document describes how to operate the selected sampling devices, based on information provided by the main manufacturers and the UK HSE guidance on dust sampling (HSE, 2000). We strongly recommend reading the manufacturer operating manual before using the samplers.

It is recommended that samples are collected by suitably qualified personnel experienced with good occupational hygiene practices and samples should be analysed in accredited analytical

laboratories, ideally involved in proficiency schemes such as Workplace Analysis Scheme for Proficiency (WASP).

2 SAMPLER DEVICES

2.1 INTRODUCTION

Two reference samplers are recommended, these being the IOM sampling head for sampling the inhalable aerosol fraction and the HD cyclone sampler for assessing the respirable fraction. Information on these two samples and how these should be cleaned and operated is provided in the following sections.

A list with the IOM and HD cyclone's manufactures is shown in Appendix 2.

2.2 SAMPLERS DESCRIPTION

2.2.1 IOM sampling head

The IOM sampling head is designed to collect inhalable particles (particles with an aerodynamic diameter below 100 µm collected with 50% efficiency) for optimal agreement with the CEN/ISO/ACGIH convention, when operated at 2.0 l/min (HSE, 2000). The IOM head comprises a cylindrical body, with a reusable cassette and front plate. The cassette incorporates a 25-mm filter. The sampler has a 15-mm circular inlet with a lip that protrudes 1.5-mm outwards (Figure 1).

Figure 1 IOM conductive plastic (left) and stainless steel (right) sampler (source: http://www.skcinc.com/instructions/37372.pdf)

The purpose of the lip is to minimize particles deposited on the outer surfaces of the inlet to be carried into the sampler.

There are two versions of the head and cassette, one made of conductive plastic and another of stainless steel. For personal sampling, the plastic head version is preferred as this is lighter

however the stainless steel cassettes are less prone to weight changes due to moisture uptake than the plastic cassettes.

Ideally, the cassette with the filter inside are weighed together before and after sampling so any particles deposited on the internal surfaces of the cassette are included in the measurement (note that as cassettes are weighed with the filters cassettes should also be conditioned in the weighing room along with the filters). Glass fibre filters (25-mm grade A) are suitable for sampling and analysis of total Mn. It is important to include any dust deposited on the inside of the cassette, especially when high levels of dust are expected It is recommended to weigh both the filter and filter and cassette together, so as to check whether dust have been deposited on the cassette. If there are dust deposits on the cassette, brush the loose dust using a lint-free brush and added it to the beaker containing the filter prior to digestion

2.2.2 Higgins Dewell Cyclone

The HD cyclone is designed to collect respirable particles (particles with an aerodynamic diameter smaller than 4 µm collected with 50% efficiency) for optimal agreement with the CEN/ISO/ACGIH convention, when operated at 2.2 l/min (HSE, 2000). The rapid circulation of air separates particles according to their aerodynamic diameter. Particles larger than 4 µm are forced to the periphery of the air stream, falling into a grit pot and are discarded (Figure 2). Particles of a diameter below 4 µm remain in the centre of the air stream and are drawn onto the pre-weighed filter. The size fraction sampled is very sensitive to variations in the flow rate and deviations from the sampler's ideal flow-rate may result in significant sampling errors. Therefore it is recommended that flow-rates are checked during the sampling period.

The cyclone is available in conductive plastic and metal (Figure 2). For personal sampling the plastic version is preferred as this is lighter than the metal cyclone. However, the stainless steel cassettes are less prone to weight changes due to moisture uptake than the plastic cassettes.

The cassette with the filter included should be weighed together before and after sampling. By weighing the cassette and filter together any dust deposit on the inside of the cassette wall will be included in the measurement. This is especially important when high levels of dust are expected. As mentioned earlier, it is recommended to weigh both the filter and filter and cassette together, so as to check whether dust have been deposited on the cassette. If there are dust deposits on the cassette, brush the loose dust using a lint-free brush and added it to the beaker containing the filter prior to digestion.

Glass fibre filters (37-mm grade A) are suitable for sampling and analysis of total Mn. If other type of filters are used the Mn content in the blank filter should be lower than 0.1 µg per filter (ISO, 2004).

Figure 2 SKC (left) and Cassella Measurement (right) Higgins Dewell cyclone

2.3 HOW TO CLEAN THE SAMPLERS

All samplers' components should be cleaned prior to any sampling survey. Dismount the sampler parts. Cleaning can be done by soaking all the sampler's parts in a mild soap solution, rinsing thoroughly and air drying. An ultrasonic cleaner is recommended but not essential. Sampler components may also be cleaned with a solvent such as isopropyl alcohol. Note that O-rings should be cleaned separately using water only. When using solvents, suitable protective glasses should be worn to protect against splashes to the eye. Be aware of the danger of vapor inhalation, and vapor ignition.

The plastic IOM may be autoclaved at a temperature setting of 90 to 100 ºC. Do not heat the plastic IOM beyond 100 ºC. If the samplers are used repeatedly on the same survey, after each sampling period the samplers should be cleaned with a lint-free cloth to eliminate any rest of dust.

The grit pot of the cyclone should be cleaned between surveys using a lint-free cloth or brush.

2.4 SAMPLER OPERATION

Always, wear gloves when handling cassettes and use previously washed tweezers to handle filters to prevent transferring moisture or dust particles to the cassettes or filters.

2.4.1 IOM sampler

Before using the sampler it is important to ensure that the various parts are in place (Figure 3).

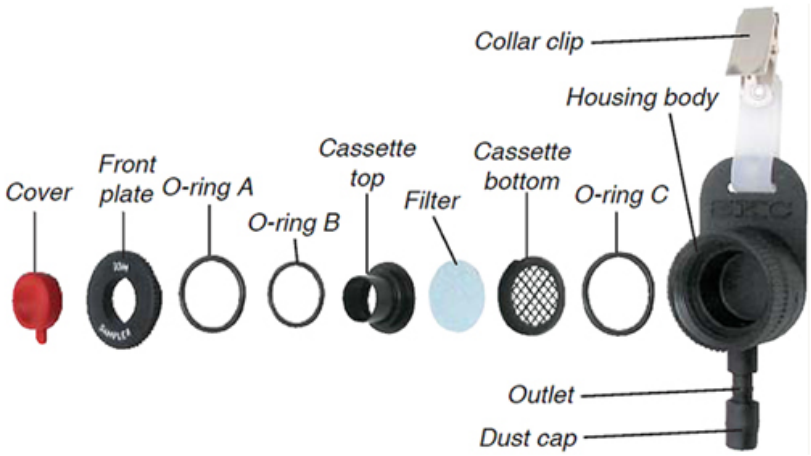


Figure 3 Conductive plastic IOM sampling head and cassette
(source: http://www.skcinc.com/prod/225-70.asp)

Before operating the sampler, the filter and the cassette have to be weighed. Wear gloves when handling cassettes and use forceps when handling filters

Place the filter on the cassette bottom (onto the grid, Figure 4, step 1) and snap the cassette top, ensuring a tight fit (Figure 4, step 2). It is recommended that cassettes are weighed together with the loaded filter as a single unit as well as weighing the filter separately beforehand. By doing this is possible to check whether any dust have been deposited on the internal wall of the cassettes.

Once the filter and cassette have been weighed, put the IOM protective cover on the cassette to prevent dust from entering the sampler when transporting the cassettes and put the cassette in the transport clip (Figure 3, step 3). Each cassette should be properly labelled with a unique sample identification code. Labels can be put on the neck of the cassette or on the transport clip.

Step 1

Step 2

Step 3

Figure 4 Loading of filter in the IOM cassette

The filter and cassette, once weighed can be loaded in the IOM sampler.

Step 1: Assemble the sampler starting with the O-ring C. Place the O-ring in the rig of the sampler body. Make sure it is properly placed in the IOM body as any leak would result in a measurement error.

Step 2: Remove the clip protective red cover from the IOM cassette and place the cassette in the IOM body.

Step 3: Insert the O-ring A into the outer rig of the front plate and the O-ring B into the inner recess of the front plate (Figure 5). Note that the sampler when bought has all the O-rings in place. It is recommended purchasing extra O-rings in case they are misplaced.

Figure 5 Placement of the O-ring B inside the inner recess of the front plate of the IOM sampler

Step 4: Insert the IOM cassette in the bottom of the IOM sampler and screw on the front plate (Figure 6).

Figure 6 Loading of the IOM cassette in the IOM body

Step 4: Put back the protective red cap on the sampler's cassette to prevent dust from entering the sampler.

Step 5: Label the IOM sampling head with the same unique identification code present on the cassette label.

Step 6: Adjust the pump flow rate. The flow rate should be set to (2.0 ± 0.01 $l.min^{-1}$) using a calibrated rotameter or bubble meter. An IOM calibration adapter is also required (Figure 7, IOM calibration adapter are commercially available from the manufacturer). The flow meter in the pump should not be used to adjust the flow rate. It is recommended that the pumps should be warmed up at least during 10 minutes prior to measuring the flow rate so the flow rate is stable.

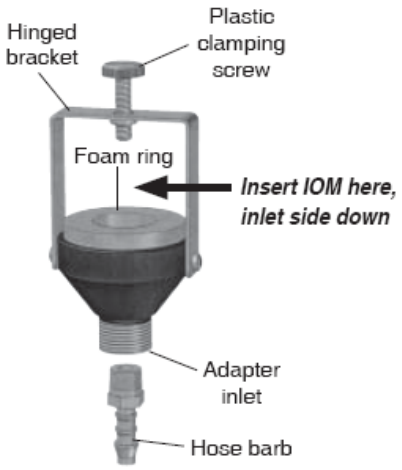


Figure 7 IOM calibration adapter
(source:http://www.skcinc.com/instructions/37372.pdf)

- Place the IOM sampler in the IOM calibration adapter:

    1. Remove the protective red cover and place the IOM inlet (with the loaded cassette) in the center against the foam ring.
    2. Clamp the IOM sampler in place with the plastic clamping and screw until the foam ring compresses by 1 mm.
    3. Ensure the IOM inlet is centered.
    4. Screw the hose barb into threaded hole in the calibration adapter inlet.

- Use a length of flexible tubing to connect the hose barb to the outlet of the rotameter or calibration device being used.
- Use flexible conductive tubing to connect the IOM outlet to the personal pump.
- First, measure the length of the tubing needed for the sampling purposes (personal or static). Connect the tubing to the IOM outlet and to the outlet of a personal pump able to reach up to 2.5 l/min.
- Adjust the flow rate in the pump to 2.0 ± 0.01 $l.min^{-1}$. Note that any variation in the flow rate means the sampler is not sampling according to the ISO/CEN/ACGHI inhalable convention.
- Remove the IOM sampler from the calibration adapter, switch off the pump and replace the red protective cover until the sampler is required for use.

The sampler is now ready to take measurements. The procedure for taking personal and static measurements is shown in section 3.

To unload the cassette after use, unscrew the front plate, take the cassette out and put the red protective cover. Insert the cassette in the transport clip (if you labelled the transport clip, make sure you put the transport clip that matches that sample).

2.4.2 Higgins Dewell cyclone

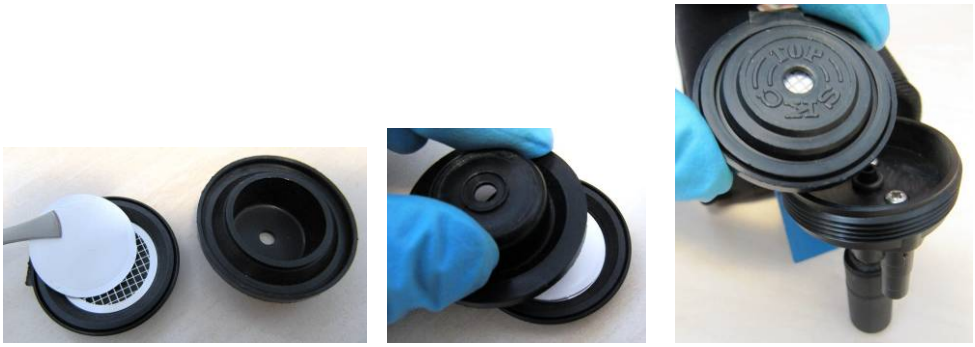
There are two main HD cyclone manufacturers (SKC Ltd. and Cassella Measurement); each offers a slightly different design. The SKC cyclone has the outlet at the top of the cyclone, whereas the Cassella cyclone has the outlet on one side (Figure 8).

Figure 8 SKC Higgins Dewell (HD) cyclone (left) and Casella Measurement HD cyclone (right)

Before operating the sampler, ensure you have all the sampler's parts with you (Figure 9). The filter and the cassette have to be weighed as a single unit. Note that as the filter and cassette are weighed together the cassettes have to be conditioned in the same way as the filters.

Figure 9 SKC plastic cyclone components (left) and Casella Measurement plastic cyclone components (right)

Step 1: Load the cassette. Insert the metal grid on the top of the cassette and place the filter over the grid. Snap the top of the cassette onto the bottom and make sure it is tight (Figure 10, steps 1 and 2).



Step 1 **Step 2** **Step 3**

Figure 10 SKC Higgins Dewell respirable cyclone filter assembly

Step 2: Insert the cassette (with the filter inside) into the bottom part of cyclone body (Figure 10, step 3). The grid faces up, since the air inlet is facing down. Assemble the upper part of the cyclone body. Make sure the grit pot is attached.

Step 3: Label the HD cyclone with the same unique identification code present on the cassette label.

Step 4: Adjust the pump flow rate. The flow rate should be set to (2.2 ± 0.01 l.min^{-1}) using a calibrated rotameter or bubble meter. The flow meter in the pump should not be used to adjust the flow rate. The pumps should be warmed up at least during 10 minutes prior to measuring the flow rate so the flow rate is stable.

- Use a length of conductive tubing to attach the cyclone outlet to the pump‘s outlet. Make sure the length of the tubing is appropriate for the sampling purposes (personal or static). Attach a length of tubing to the cyclone inlet and connect the other end to the rotameter or bubble meter (Figure 11).
- Adjust the flow rate in the pump to 2.2 ± 0.01 l.min^{-1}. Note that any variation in the flow rate means the sampler is not sampling according to the ISO/CEN/ACGHI inhalable convention.

Figure 11 Calibration of the HD SKC cyclone using a rotameter

The sampler is now ready to take measurements. After sampling, remove the filter cassette from the holder and cap the inlet and outlet of the cassette with the plugs provided.

3 GENERAL SAMPLING PROCEDURE

Any measurement survey should be properly designed in order to ensure that appropriate data are collected for the purpose of the survey. This should involve consideration of the sampling reasons, the number of measurements, when to take the measurements etc. It is recommended that samples are collected by suitably qualified personnel experienced with good occupational hygiene practices and that appropriate contextual information is collected during the sampling survey to allow for a proper interpretation of the results.

Samples should be collected, stored, transferred and analysed in a controlled and systematic manner. The key general sampling procedure points to note are as follows.

- Samplers must be attached to personal pumps capable to maintain a constant flow rate (± 10% of the indicated flow rate) during the length of the sampling period.
- The flow rates should be assessed at regular intervals (every 2-3 hours) until the conclusion of the sampling period and at the end of the sampling period. Should the routine checks during sampling indicate that the flow rate has deviated by <10% the flow rate can be adjusted. If the flow rate has changed by >10% the sample should be rejected. The final flow-rate is calculated by averaging the flow at the start, during and at the end of the sampling period.
- The loading of sampling media into the various sampling heads should at all times be conducted in a clean environment to avoid contamination. Always, wear gloves when handling, loading and unloading the samplers. The protective cover should be removed right before the pump is switched on and it should be put back once the sampling period is finished and the sampler is still in the field, to avoid any contamination.
- Pumps should be fully charged before use (see pump operators manual).
- The sampler should be connected to the pump using conductive plastic tubing (e.g. Tygon®) to prevent particle losses.
- Core data relevant to the sample should be recorded. This includes:

    - sample ID
    - sample start and end time. The duration of the sampling period should be recorded to the nearest minute (use 24 hour). It is recommended that the timer on the sampling pump should not be used.
    - pump start and end flow rates, and any flow-rate collected during the sampling period
    - wearer's name and job title (personal samples),
    - details of the wearers work (personal samples),
    - location and activities in the area where the samplers were located (static, area samples),

    An example of a suitable recording form, which was developed to inform the Manganex database, is shown in Appendix 1.

- At the end of the sampling period, if possible, immediately measure the flow in the field before switching off the pumps and replacing the protective caps.
- If it is not possible immediately to measure the flow rate, at the end of the sampling period switch off the pump and put back the protective cap. Take the pumps to a clean area and measure the flow rate.
- Notes taken during the sampling campaign should be recorded in a designated hard backed book. Supplementary notes to be recorded include details (and any deviations)

of production on the day of sampling, use of control measures, spills/leakages/downtimes and details of any other events which may influence the exposures results. .

Details of the recommended procedures for the collection of the personal and static samples are provided in sections 3.1 and 3.2, respectively.

3.1 PERSONAL SAMPLING PROCEDURES

Employees to be sampled should be selected carefully. Usually, employees are grouped according to job and location, so that all workers within the group are similarly exposed (however it should be noted that exposures between workers will differ due to differences in working practices). It should also be realised that exposure levels will be different from one day to the next or from one shift to the next, and this should be taken into account when designing a sampling programme.
Prior to sampling, the employees being sampled should be provided with an explanation of the survey objectives and the sampling equipment should be briefly explained and demonstrated. The employees should be asked to avoid touching or covering the samplers and to refrain from deliberate attempts to influence the outcome of the sampling exercise, e.g. by carrying out actions that expose the samples to unusually high or low airborne concentrations.
The procedure for attaching the pumped sampling equipment onto the subject is as follows:

1. Subject should be given a belt / harness to put on.
2. The sampling heads should be placed as close to the breathing zone as possible (within 200 mm of the nose and mouth), normally on the lapel of the workers overalls/clothes. The samplers should be placed on the dominant workers side (e.g. if the worker is right handed, place the samplers on the right lapel). Take care clothes do not cover the samplers' inlet. Also advise workers that if they have to wear any additional garments the sampling heads must not be covered.
3. The two samplers (if simultaneous sampling of both fractions is required) should be collocated on the same side of the lapel (Figure 12). Sampling simultaneously with the IOM and the cyclone requires wearing two pumps. Employees should be informed of this and the occupational hygienist must ensure the burden of the two pumps does not interfere with the employees working tasks.
4. The pumps should be secured to the belts or harness. Care should be taken to ensure that neither the pump, nor the tubing interferes with workers range of movement.
5. Once the pump and sampling head has been attached satisfactorily, the protective cover for the sampling heads will be removed and the pump switched on.
6. Where sampling is to be carried out over a representative period of the workers full-shift it is recommended that the minimum sampling duration for an 8 hour shift is 6 hours.
7. The sampling equipment should be checked within the first hour of sampling. If the sampling duration extends over a number of hours, the flow rate should be checked every 2-3 hours and adjusted if it is <10% of the set up flow-rate.

Figure 12 Simultaneous sampling with the HD cyclone and IOM head. Wrong collocation with jacket covering one of the samplers (top) and right collocation (bottom)

3.2 STATIC SAMPLING PROCEDURES

Sampling location should be identified carefully to ensure that the results are relevant for the purpose of the study, without interfering with the process. The samplers must be positioned at approximately head height, away from obstructions and air drafts. Care should be taken to ensure that samplers are not placed in areas where they may interfere with the work being carried out. It is also recommended that employees working in the area are advised of the presence of the samplers and the purpose of the sampling campaign and that they should avoid touching the samplers.

3.3 FIELD BLANKS

For quality assurance purposes, field blanks must be obtained with each sampling survey. Field blanks are filters/cassettes handled in an identical manner to the exposed samples with the exception that no air is drawn through them. The number of filter blanks should be at least 10% of the number of samples collected. Filter blanks should be collected separately for inhalable and respirable samples.

3.4 STORAGE AND TRANSPORTATION

Sampling filters should be weighed and loaded into cassettes at the laboratory, and subsequently transported in the cassettes to the site. After measurements, cassettes should be capped appropriately and transported back to the laboratory for weighing. Filters should not be taken out of the cassettes until weighing at the laboratory.

4 SAMPLE ANALYSIS

Each collected sample should be analysed both gravimetrically and for total Mn.

Gravimetric analysis should be undertaken in accordance with a standard gravimetric method (e.g. MDHS 14/3 (HSE, 2000); NIOSH 0600 (NIOSH, 1998). It is recommended that cassettes are weighed together with the filter inside as well as the filter separately, especially when high dust levels of dust are expected. This is important as dust may have been deposited on the inside walls of the cassette. The cassettes with the filters should be conditioned prior to weighing.

There are well established analytical methods to support the routine monitoring of workplace air for Mn to meet current regulatory exposure standards. Analytical laboratories should ideally be accredited to ISO 17025 (for metal analysis) (ISO, 2005). This ensures the use of traceable analytical standards, calibrated glassware, analytical grade acids, internal method validation and determination of detection limits and re-analysis of an appropriate number of replicate samples.

The extraction of Mn involved heating the collected filter in concentrated acid, followed by dilution. There are several standard methods suitable for Mn extraction: (e.g. OSHA ID 121 OSHA (2002), OSHA ID 125-G OSHA (1991), NIOSH 7301 (NIOSH, 2003a); NIOSH 7303 (NIOSH, 2003b). These methods used Atomic Absorption Spectrometry (AAS) or Ionization Couple Plasma- Atomic Emission Spectrometry (ICP-AES) to quantify Mn. Both techniques are equally suitable for quantification of Mn. ICP- Mass Spectrometry (MS) is also suitable although it is a more expensive technique.

It is important that implementation of reference method for measuring Mn in air amongst member companies of IMnI, is supported by a quality control scheme, for example by joining existing proficiency schemes such as Workplace Analysis Scheme for Proficiency (WASP).This allows to assess properly differences in the concentration measured at different sites since, although samples are collected and analysed using the same methods, laboratory inter-variability can lead to different results.

5 CONCLUDING REMARKS

The use of these reference samplers and recommended analytical methods for Mn analysis will allow comparison of Mn exposure data across all Mn production sites. However, to guarantee data is comparable it is important to follow the same sampling strategy as well as the recommendations given in this document. Ensure you follow this guidance and take note of any deviation of the procedure.

In addition, laboratory inter-variability can also lead to different results. Therefore, it is recommended that the analytical laboratories are involved in quality control schemes.

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APPENDIX 1 MANGANEX DATABASE

Manganese Exposure Database System – [KEY FIELDS ON PAGE 1WILL BE FILLED WITH ALREADY DEFINED SURVEY PLANNING DATA]

General survey planning details Survey ID/Ref no

Full survey name: Start date: End date:

Commissioned by: Survey manager Reason:

Sampling Strategy: If random, applies to: Day Worker

Sample types included Personal: Static/Fixed:

Sample durations: Whole/Part shift: Short term: Task specific

Service providers (if used): Surveyor: Analyst:

Sampling and analytical methods

Dust Fraction	Sampling Device	Sampling Medium	Analyte	Analytical method & technique	LOD (Units)	Note

Processes covered by survey

Process name	Process type	Batch Frequency	Duration	N Operators	Primary Controls	Note

Workplaces covered by survey

Workplace name	Workplace type	Size category	Ventilation type	Note

Individual Static Sample Details **Static Samples**

Sample ID: Sampling device: Sampling media:

Static sample source proximity Near (< 1m) Far (> 1m)

Sample date:

Start time	End time	Break duration (min)	Break sampled Y/N	Sample duration	Start flow rate	End flow rate	Mean flow rate	Note
:	:							

Tasks undertaken

Task	Duration (min)	Controls type	Note

Workplaces visited

Workplace	Duration (min)	N Workers	Note

Process undertaken

Process	Duration (min)	N Workers	Note

General exposure pattern:

Exposure conditions:

Analytical results

Substance	Fraction	Analytical method	LOD	Result	Result units	Sample vol	Concentration	Note

Individual Personal Sample Details **Personal Samples**

Sample ID: Sampling device: Sampling media:

Sample Date

Start time	End time	Break duration (min)	Break sampled Y/N	Sample duration	Start flow rate	End flow rate	Mean flow rate	Note
:	:							

For personal samples – Employee information

Staff ID	Forename	Surname	Job Title	Shift start time	Shift finish time	Note

Tasks undertaken

Task	Duration (min)	Controls in use	RPE used	Protn factor	PPE Gloves	PPE Clothing	Note

Workplaces visited

Workplace	Duration (min)	Number of Workers	Note

Process undertaken

Workplace	Duration (min)	Number of Workers	Note

General exposure pattern:

Exposure conditions:

Personal workrate:

Analytical results

Substance	Fraction	Analytical method	LOD	Result	Result units	Sample vol	Concentration	Note

APPENDIX 2 IOM HEAD AND CYCLONE'S SUPPLIERS

Sampler	Supplier		
	Casella Measurement	SKC Ltd.	JS Holdings
IOM head	✓	✓	
Higgins Dewell cyclone	✓	✓	✓
Web page	http://www.casellameasurement.com/	http://www.skcinc.com/index.asp	http://www.jsholdings.co.uk/index.asp
E-mail	info@casellameasurement.	skcinc@skcinc.com	info@JSHoldings.co.uk
Offices	UK, US, Spain & China	US, UK, South Africa	UK