



**GUIDELINES ON SAMPLING STRATEGIES
AND
SUBMISSION OF TOXIC SUBSTANCES
MONITORING REPORT**

1. SAMPLING STRATEGIES

1.1 When conducting hygiene monitoring or measurements, the following sampling shall as far as possible be followed:

- (a) The atmosphere of any workplace in which toxic airborne contaminants are given off shall be monitored at sufficient intervals.
- (b) Occupations with the highest expected exposure shall be monitored first. Representative subjects shall be selected for sampling.
- (c) All monitoring shall represent the personal exposure unless otherwise specified. The monitoring device should be attached as close as possible to the worker's breathing zone. Note the periods when exposure may be high due to specific activities or process cycles. Change the sample collection medium when conditions show signs of overloading due to excessive airborne contaminants.
- (d) If area monitoring is conducted, the monitoring device or sampling medium shall be positioned at about 1.2 to 1.8 metre (3 to 4 feet) from the floor. Make sure that the sample collection medium is not in direct contact with, or placed too close to any settled dust or spilled chemical.
- (e) Samples representing a full-shift exposure shall be collected for evaluating or assessing the time-weighted average (TWA) concentration.
- (f) Before conducting the toxic substances monitoring, the toxic substances monitoring service provider shall obtain from the workplace occupier or his representative the information on the work process to be monitored. The information shall be recorded in Part C of the Hygiene Toxic Substances Monitoring Report - Workplace Exposure Assessment.
- (g) A minimum of 6 hours of sampling is required to evaluate exposure over a full 8-hour shift, or 8 hours of sampling for a full 12-hour shift. The minimum sampling hour should not include meal and break time. However, this is only applicable to work process with small concentration variations. Otherwise, a full shift sampling is required.
- (h) If the worker is exposed to contaminants for less than 6 hours, a partial-period sampling could be conducted covering the period of exposure. In this case, the period, which was not sampled, could be assumed to have zero exposure. This information has to be stated in the report clearly.

An example of the calculation of TWA 8hr concentration is in **Appendix A**.

1.2 All sampling and monitoring shall be carried out in accordance with the recommended procedures (e. NIOSH Sampling and Analysis methods). Ensure that all active monitoring devices are calibrated. Before use, check the batteries of the devices for charge and the expiring date of the sampling medium. In addition, make sure that the following are carried out:

- (a) Sample collection medium (membrane filter) for monitoring of total particulate shall be desiccated for at least 24 hours prior to weighing. If a vacuum desiccator is used, desiccation of filter can be reduced to 30 minutes.
 - (b) Sorbent tube used for monitoring of gases or vapours shall be positioned vertically to avoid "channelling" (i.e. the adsorbent shifts and forms a channel within the tube) during the sample collection. After sampling, the sorbent tube shall be capped at both ends and stored at <math><4^{\circ}\text{C}</math> prior in analysis to prevent sample loss.
 - (c) When using passive samplers for static monitoring, measure the air movement around the selected monitoring location to ensure that the environment condition meets the minimum air movement as recommended by supplier/manufacturers for effective air sampling. These air movement readings should also be report in the hygiene toxic substances monitoring report.
- 1.3 All equipment and instruments used for sampling shall be calibrated in accordance with standard calibration methods before and after sampling. The persons carrying out the air monitoring must ensure that the sampling equipment used are reliable and accurately calibrated.
- 1.4 The person carrying out the monitoring shall, as far as possible, remain at the workplace until all the samples are collected. He should ensure that the monitoring devices are not tampered with. He should also check the flowrate of the monitoring devices after the first 15-30 minutes and at intervals of about 2 hours thereafter.
- 1.5 The sample size should be at least 3 to 5 samples per job-classification/group, or from 25% to 50% of those in the group for groups of 10 or more.
- 1.6 The frequency of air monitoring depends on the exposure level:
- | | | |
|--|----------|-------------------------------------|
| less than 10% of the PEL | : | At least once every 3 years |
| $\geq 10\%$ to $< 50\%$ of the PEL | : | At least once every year |
| 50% to 100% of the PEL | : | At least once every 6 months |
| More than 100% of the PEL | : | At least once every 3 months |
- 1.7 If it is not possible to conduct a full-shift sampling, a series of "grab" or "spot" samples can be taken randomly throughout the work shift using detector-tubes or other appropriate instruments. The acceptable number of samples is 4 to 7.
- 1.8 Notes:
- (a) A re-assessment should be carried out if there is any change in the process.
 - (b) Exposure level of 50% is known as the "action level" and shall as far as possible be reduced to less the 50% PEL.
 - (c) Refer to the First Schedule of the Workplace Safety and Health (General Provisions) Regulations for PEL values.

- (d) You may download the softcopy of Hygiene Toxic Substances Monitoring Report from our website at <https://www.mom.gov.sg/workplace-safety-and-health/monitoring-and-surveillance/hygiene-monitoring/toxic-substances-monitoring-report>.

2. PRECAUTIONS IN SAMPLING AND MONITORING

2.1 Follow the recommended sampling protocols

When collecting an air sample, always follow recommended protocols on the preparation, handling and storage of collection media, sampling flow rate, minimum and maximum sample volumes, and analytical techniques.

2.2 Obtain data that are useful for hazard evaluation

The method of sampling must be sensitive enough for quantifying the exposure level of interest. Long-term sampling is required to assess exposure to a substance having a PEL (Long Term). Short-term sampling is needed to evaluate exposure to a substance with a PEL (Short Term). Respirable aerosol samples should be collected for substances having a respirable particulate mass PEL.

2.3 Consider the physical state of the contaminant

If an airborne contaminant can exist simultaneously in particulate and vapour phase, choose the sampling media to collect both phases of the contaminant of interest e.g. a prefilter can be used with a sorbent tube to collect particulate and vapour phases of a contaminant.

2.4 Determine the minimum sample volume

Collect a sample with sufficient volume to obtain a minimum quantity of contaminate that is required for reliable laboratory quantization.

2.5 Clean sampling devices before use

Always wash or clean the sampling devices e.g. cyclone separators before use. The contaminants deposited on the inner surfaces of these devices can affect the results of sampling. If sampling bags are used for sampling, evacuate and purge with clean air or nitrogen before reuse.

2.6 Use EMI or RFI shielded pumps

The flow rate of pumps can be affected by electromagnetic interference (EMI) or radio frequency interference (RFI) from devices such as electric motors and high voltage equipment. EMI or RFI shielded pumps are not affected by this interference.

2.7 Do not use static samples to assess personal exposures

Measurement of contaminant levels from a static or area sample is typically not related to personal exposure, unless the person is stationary at the area sampled. Personal samples should be collected for persons who are not stationary but move around.

2.8 Use constant flow pumps

Constant flow pumps will maintain a constant flow even if the flow resistance increases due to filter loading or pinched sampling tubing. Sampling pumps with this feature will introduce less error in sampling volume estimation.

2.9 Use validated passive samplers

Not all commercially available passive samplers meet the requirements for precision and accuracy. Always ask the supplier of the passive samplers for complete documentation of performance testing.

2.10 Collect enough number of samples

Sufficient numbers of samples are required to provide a true characteristic of exposure levels. Sample size should be at least 3 to 5 samples for each job classification / group or from 25% to 50% of those in the group for groups of 10 or more.

2.11 Do not use grab samples to determine 8-hr exposures

Grab samples are usually used to determine short-term exposure levels. Long-term integrating samples should be taken to assess full-shift exposures.

2.12 Calibrate sampling pumps before and after sampling

Sampling pumps should be calibrated before and after sampling to set and verify the flow rate. Calibration should be performed using a primary standard e.g. a soap bubble meter or an electronic film flow meter. If a secondary standard e.g. a rotameter is used, it must be calibrated to a primary standard at regular intervals.

2.13 Do not use adapter on the inlet of a filter cassette during calibration

Adapters should not be used on the inlet of a filter cassette when calibrating a sampling pump with a filter inline. Since the adapter will not be used for actual sampling, the air flow characteristics during calibration will be different from the actual flow characteristics during sampling.

2.14 Misuse of “self-calibrating” pumps

Sampling pumps with internal flow indicators should be calibrated frequently with a primary standard. Calibration should be performed with the sampling train or collection medium in-line, as this will be used in the field.

2.15 Do not reuse plastic filter cassettes

Plastic filter cassettes are designed for one-time use, not for subsequent reloading. Opening and closing cassettes repeatedly can produce deformities, which can cause incomplete sealing and leaks during sampling.

2.16 Orientation of sorbent tubes in a vertical position during sampling

Airborne contaminants take the least resistance path when sampled through a collection medium. If a sorbent tube is not placed in a vertical position, the collecting medium may fall away from the wall of the tube, forming a small channel through which air flows more readily. This will reduce the collection efficiency.

2.17 Orientation of cyclone in a vertical position during sampling

The performance of a cyclone is affected by orientation. The device should be held in a vertical position during sampling. The 50% cut-point i.e. the size of particulate removed with 50% efficiency, of a 10-mm cyclone is different at different orientations.

2.18 Never invert a cyclone during or after sampling

Cyclones separate non-respirable (larger) particles in the grit pot and collect respirable particulate on the filters. If a cyclone is inverted, larger particles will fall from the grit pot onto the filter, resulting in an erroneous high concentration measurement.

2.19 Sample the design flow rate when using a cyclone

Cyclones are designed to collect the desired respirable particulate at a specific flow rate. A different flow rate will change the 50% cut-point of a cyclone and its collection efficiency.

2.20 Sample at the recommended flow rate and collect the recommended volume

Always follow the recommended sampling flow rate and sampling volume based on the published sampling and analytical methods. Sampling gases and vapours at higher flow rates through sorbent tubes reduces collection efficiency. Sampling too much air can overload a sorbent tube or filter. Check the filters regularly for signs of excessive loading.

2.21 Take notes on work operations or practices during the sampling period

Observe the work conditions and operations, which could affect sampling results. Ensure that the sampling devices are not tampered with. Do not attach or place the sampling devices in the morning and collect them in the afternoon.

2.22 Determine the sampling time accurately

Make an accurate measurement of the sampling time, especially for short-term sampling. The measured concentration depends on the total sampling time.

2.23 Do not use passive samplers under stagnant air conditions

Passive samplers require air movement across the face of the sampler. This condition is met during personal sampling on a mobile worker, but not area sampling in calm air. Use of passive samplers under stagnant air conditions produces an erroneous low measurement of concentration.

2.24 Do not assemble or handle collection materials in contaminate areas

Sampling media and collection materials should be assembled, disassembled, processed and packed in clean or uncontaminated areas, before and after sampling. Assembling or processing collection devices in contaminated areas can produce inexplicably significant amounts of analyte on blanks and erratic high exposure measurements.

2.25 Document chain-of-custody and store samples properly after collection

Sorbent tubes should be stored no longer than 2 to 3 weeks at ambient or refrigerated temp before analysis. Samples collected in sample bags should be analysed within 48 hrs for best results. Samples should not be in the hands of unknown persons. A neat and professional chain-of-custody form should be documented.

2.26 Always supply blanks to the analytical laboratory

Blank samples are analysed to reduce the errors from background contamination on the sampling media. Always supply blanks to the analytical laboratory when sending samples for analysis.

2.27 Use an accredited analytical laboratory

Use of an analytical laboratory with accreditation or an effective quality assurance programme will ensure the credibility of the data.

2.28 Correct the flow rate for changes in temperature and pressure

A mathematical correction of the air volume sampled is necessary if the ambient temperature and pressure at the calibration site is different from those at the sampling site. Some air sampling pumps come with temperature and pressure sensors that automatically correct the flow rate for changes in these environmental conditions.

2.29 Document and report pertinent information

Record all critical sampling parameters such as sampling duration, temperature, barometric pressure, and details concerning location of sampling, subject monitored, and sample identification. Present sampling data and related information in a neat and organised format.

3. TOXIC SUBSTANCES MONITORING AND SAMPLE ANALYSIS REPORT

- 3.1 Analytical results of air samples should be submitted to the customer within 3 weeks from the date of receipt of samples from the customer, if the toxic substances monitoring is not conducted by the same organisation that analyses the samples.
- 3.2 Toxic substances monitoring results should be submitted in the attached hygiene monitoring report form to the customer by the air monitoring device provider within 3 weeks from the date of receipt of analytical results from the laboratory. A copy of the analysis results from the laboratory should be attached with the hygiene monitoring report. (Note: Air samples shall be sent to the analytical laboratory for analysis as early as possible after sampling.)
- 3.3 Toxic substances monitoring results should be submitted in the attached hygiene monitoring report form to the customer within 6 weeks from the date of air monitoring, if both air monitoring and sample analysis are conducted by the same organization.
- 3.4 Toxic substances monitoring results should be submitted by the workplace occupier to the Occupational Safety and Health Division, Ministry of Manpower, within 2 weeks from the date of receipt of the results from the air monitoring service provider or the analytical laboratory.
- 3.5 All analytical laboratories shall use suitable samplers and methods, which are sensitive enough detect or measure the concentration below 10% of the permissible exposure level (PEL) of each chemical being analysed. Report of result "<PEL" is not accepted.
- 3.6 If any air sample is found to have a breakthrough (mass of analyte found in back section of sorbent tube is >10% of the mass of analyte in the front section), it should be reported in the hygiene report. A re-sampling should be conducted for the affected sampling points and results reported in the same hygiene report.
- 3.7 The particulars of the subjects monitored, including their full names, NRIC (for Singaporeans) or FIN numbers (for foreigners) must be recorded in the hygiene monitoring form. DO NOT record the work permit, passport or employee numbers. A sample of the completed form is in **Appendix A**.
- 3.8 A layout indicating the location(s) of sampling point(s) should be attached to the hygiene monitoring report. For personal sampling of a subject who is stationed at a specific location for the whole work shift, the personal sample's location should be indicated in the map. However, if the personal sample is taken from a subject who moves around, the work-area of the subject should as far as possible to be indicated on the map. If the work area is too large to be indicated, the department or section where the subject works should be stated in the "Remarks" column of the hygiene monitoring report form. A sample of a layout plan is in **Appendix B**.
- 3.9 If the TWA concentration exceeds 50% PEL, the air monitoring service provider has to confirm that he has provided appropriate recommendations(s) to the workplace occupier to control or limit the exposure. This information should be given in Part D Findings and Recommendations of the report form. A sample of this is attached in **Appendix A**.

- 3.10 A review of the management of hazardous chemicals programme (MHCP) should be completed by the workplace representative and attached in submission of air monitoring report via MOM e-Service: <https://www.mom.gov.sg/eservices/services/submit-and-manage-toxic-substances-monitoring-reports> . The MHCP checklist can be found in the WSH Management of Hazardous Chemicals Programme Guidelines Annex K on the Workplace Safety and Health Council website: <https://www.tal.sg/wshc> .

Second Revision: 2022

APPENDIX A

HYGIENE TOXIC SUBSTANCES MONITORING REPORT

Part A: AUTHORISED PERSONNEL DETAILS

Authorised Personnel: _____ NRIC/FIN No*: _____

Organisation conducting the assessment: _____

E-Service Account User: _____

Part B: WORKPLACE DETAILS

Company Name: _____

Address: _____

UEN No: _____ SSIC: _____

Workplace No.: _____

Contact No.: _____ Fax No.: _____

Date of Monitoring: _____

Workplace Representative Present During Monitoring: _____

*NRIC/FIN No. of authorised personnel can reflect prefix and last 4 alphanumeric characters in report

SAMPLE REPORT

HYGIENE TOXIC SUBSTANCES MONITORING REPORT

Part A: AUTHORISED PERSONNEL DETAILS

Authorised Personnel: Tan Au Yau NRIC/FIN No: Sxxxx567K

Organisation conducting the assessment: DEF Consultancy Pte Ltd

E-Service Account User: John Lim

Part B: WORKPLACE DETAILS

Company Name: ABC Pte Ltd

Address: 123 Jalan Toa Payoh, Singapore 319900

UEN No: 197100123R SSIC: 30139

Workplace No.: 197100123R0002

Contact No.: 61234567 Fax No.: 61234568

Date of Monitoring: 5 June 2022

Workplace Representative Present During Monitoring: Ms Candy Neo

IMPORTANT NOTES FOR COMPLETING PART C

¹ Total No. of Persons Exposed: Refers to *all* people who are exposed to the chemical over *all* work shifts

² Sampling Method: Direct Reading Instruments, Filter, Filter with cyclone, Impinger, Passive samplers (badges/tubes), Sampling Bag, Sorbent Tubes

³ Process: Choose one process below that best describes the work performed

Abrasive blasting	Forging	Painting (Spray)
Assembly of Parts	Formulation	Palletizing
Blending/Mixing	Foundry Operation	Plastic injection moulding
Blowing	General Housekeeping	Plastic blow moulding
Brazing	Glueing (Brush)	Powder coating
Buffing/Polishing	Glueing (Spray)	Printing (offset)
Car Maintenance	Grinding	Printing (others)
Casting	Heat Treatment	Printing (silk screen)
Chemical Plant	Injection Moulding	Quality Control / Testing
Cleaning	Inspection	Quarrying
Cleaning (acid/alkali)	Laboratory (Specimens dissection)	Sanding
Cleaning (solvents)	Laboratory (testings)	Soldering
Coiling	Lamination	Solvent Cleaning/Drying
Curing of materials	Maintenance	Sorting
Cutting/Sawing	Masking	Sterilisation
Degreasing	Materials transfer/moving	Storage/warehousing
Drilling	Melting/smelting	Surface preparation
Drumming	Metal Injection Moulding	Thermal Spraying
Dry Cleaning	Metal Machining	Washing
Drying of Materials	Metal Stamping	Water Treatment
Electroplating	Others	Weighing
Etching	Packing	Welding
Extrusion/Drawing	Painting (Brush)	Woodworking

⁴ Existing Control Measures: Dilution ventilation, Local exhaust ventilation, No control, Partial enclosure, Personal Protective Equipment, Suppression, Total enclosure

⁵ Concentration measured or TWA_{8hr} concentration: Please provide measured concentration for continuous exposure for a representation period or TWA_{8hr} concentration for intermittent exposure

[For intermittent work processes, if the person monitored is not exposed to the measured chemical for a period of time, a zero-exposure concentration can be assumed for this period]

Calculation of Time-Weighted Average, TWA_{8hr} Concentration

$$TWA = \frac{(C_1T_1 + C_2T_2 + \dots + C_nT_n)}{(T_1 + T_2 + \dots + T_n)}$$

Example:

Duration of intermittent process for an 8 hr shift is 2 hr.

Concentration of Lead $C_1 = 0.01 \text{ mg/m}^3$, $T_1 = 2 \text{ hr}$

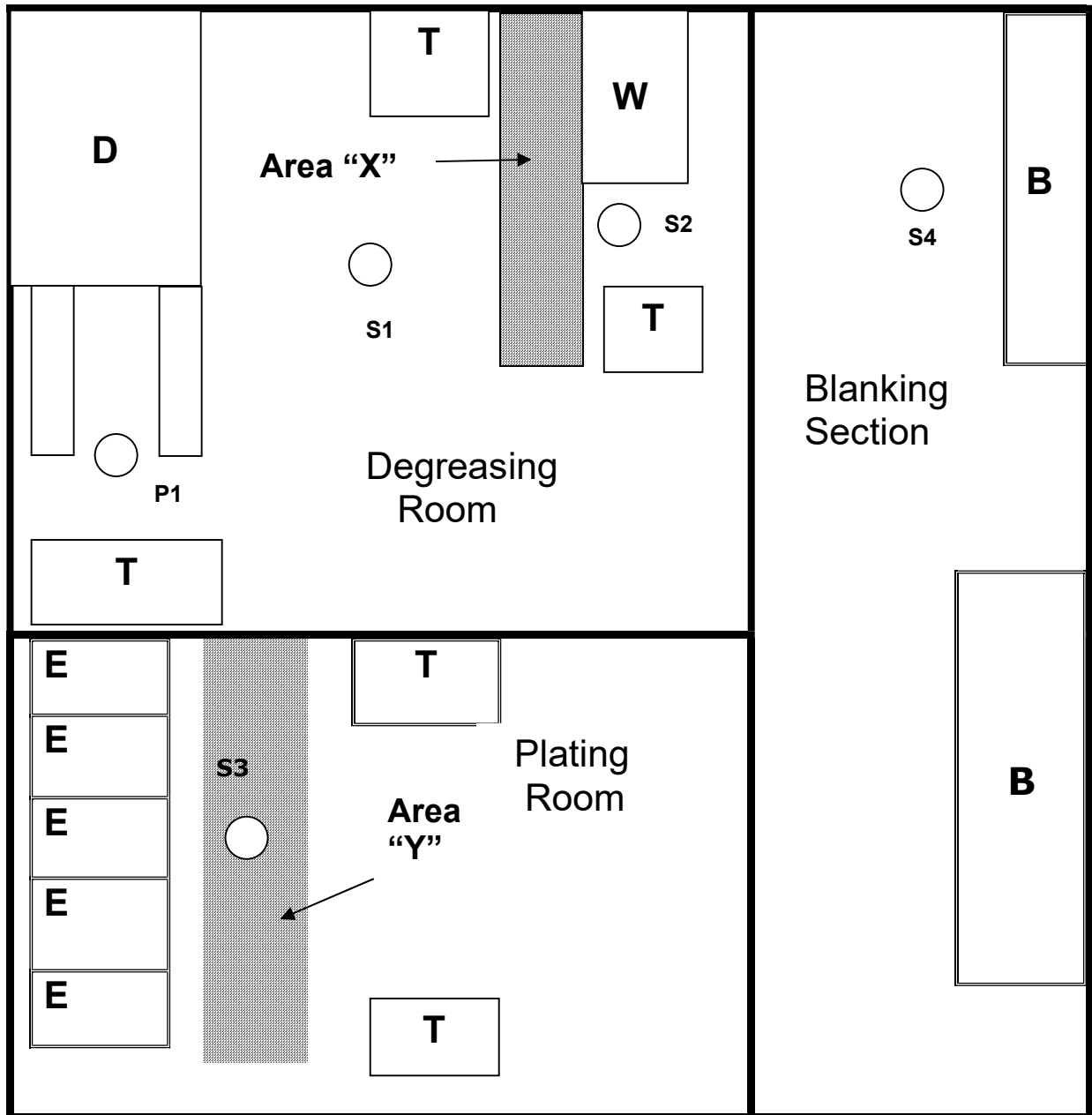
$C_2 = 0 \text{ mg/m}^3$, $T_2 = 6 \text{ hr}$

$$TWA_{8hr} = \frac{(0.01 \times 2 + 0 \times 6)}{(2 + 6)} = 0.0025 \text{ mg/m}^3$$

⁶ Person's ID: Please give the NRIC no. (for Singaporeans only) or FIN no. (for foreigners) of the persons monitored. DO NOT give the work permit, passport, or employee number.

APPENDIX B

ABC PTE LTD WORKPLACE LAYOUT PLAN



Legend:

- Sampling Points (S: Static sample P: Personal sample)
- Work Area of Mobile Worker
- D Conveyorised Degreasing Machine
- W Washing Tank
- W Electroplating Tank
- B Blanking Machine
- T Table