



Air Sampling Pumps: Equipment Calibration Requirements Technical Paper

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AUSTRALIAN INSTITUTE OF OCCUPATIONAL HYGIENISTS INC (AIOH)

The Australian Institute of Occupational Hygienists Inc. (AIOH) is the association that represents professional occupational hygienists in Australia. Occupational hygiene is the science and art of anticipation, recognition, evaluation and control of hazards in the workplace and the environment. Occupational hygienists specialise in the assessment and control of:

- Chemical hazards (including dusts such as silica, carcinogens such as arsenic, fibrous dusts such as asbestos, gases such as chlorine, irritants such as ammonia and organic vapours such as petroleum hydrocarbons);
- Physical hazards (heat and cold, noise, vibration, ionising radiation, lasers, microwave radiation, radiofrequency radiation, ultra-violet light, visible light); and
- Biological hazards (bacteria, endotoxins, fungi, viruses, zoonoses).

AIOH members are the professionals most likely to be asked to identify hazards associated with airborne contaminants and assess any exposure risks, which often requires the use of air sampling pumps. Therefore, the AIOH has a keen interest in the integrity of air sampling pumps and their use to sample various workplace hazards for airborne contaminants.

The Institute was formed in 1979 and incorporated in 1988. An elected governing Council, comprising the President, President Elect, Secretary, Treasurer and three Councillors, manages the affairs of the Institute. The AIOH is a member of the International Occupational Hygiene Association (IOHA).

The overall objective of the Institute is to help ensure that workplace health hazards are eliminated or controlled. It seeks to achieve this by:

- Promoting the profession of occupational hygiene in industry, government and the general community.
- Improving the practice of occupational hygiene and the knowledge, competence and standing of its practitioners.
- Providing a forum for the exchange of occupational hygiene information and ideas.
- Promoting the application of occupational hygiene principles to improve and maintain a safe and healthy working environment for all.
- Representing the profession nationally and internationally.

More information is available at our website – <http://www.aioh.org.au>.

EXPOSURE STANDARDS COMMITTEE MISSION STATEMENT

The AIOH established the Exposure Standards Committee to provide expert guidance and comment to the exposure standards setting process at a State and National level and internationally where appropriate, through development of AIOH Position Papers, AIOH guidance publications or comment on relevant Standards, Regulations and Codes of Practice. The Committee's remit is to confirm that the revision of exposure standards, and other relevant Standards and Codes of Practice, are valid and based on good occupational hygiene and scientific principles. The Committee is also concerned with the integrity of the exposure assessment process whereby sampling results for airborne contaminants are compared against exposure standards.

STATEMENT OF POSITION REGARDING AIOH TECHNICAL PAPERS

The AIOH is not a standard or method setting body. Through its Technical Papers, the AIOH seeks to provide relevant technical information on equipment and methodologies with regard to ensuring the integrity of the process of evaluating workplace hazards. The information herein is supplementary to published and validated methods for sampling and is provided as a resource where the information is not available elsewhere, such as from Australian Standards (AS) or the National Association of Testing Authorities (NATA), or in methods published by Regulatory organisations (e.g. Safe Work Australia).

NATA is in the process of withdrawing technical documentation regarding procedures and frequency for calibration of field and laboratory equipment used for occupational hygiene assessments and analysis. These documents have been developed by experienced AIOH members as part of their role on the previous NATA Occupational Hygiene Technical Committee and have been subject to public review for more than 20 years. The technical content of the documents along with copyright is being handed over to the AIOH, to be published as Technical Papers.

The information included in this document attempts to provide practical and pertinent information to assist Occupational Hygienists or laboratory personnel to use correct sampling or analytical techniques and equipment for collecting valid samples, which can be used to compare against the relevant workplace exposure standards (WES) where personal sampling has been conducted. Data quality is an important aspect of the exposure assessment process, particularly when it is necessary to demonstrate compliance with a WES.

Consultation with AIOH members

AIOH activities are managed through committees drawn from hygienists nationally. This Technical Paper has been prepared by the Exposure Standards Committee based on NATA documentation, with comments sought from AIOH members with interest and/or expertise in this area. The AIOH acknowledges the following contributors to this Paper: Neil Shepherd from NATA; and AIOH Members Linda Apthorpe, Philip Hibbs, Robert Golec and Ian Firth.

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List of Abbreviations and Acronyms

AIOH	Australian Institute of Occupational Hygienists
AS	Australian Standard
NATA	National Association of Testing Authorities
NIOSH	National Institute of Occupational Safety and Health (America)
NOHSC	National Occupational Health and Safety Commission (Australia)
OSHA	Occupational Health and Safety Administration
SWA	Safe Work Australia
WES	Workplace Exposure Standard
UKHSE	UK Health and Safety Executive

Competent Person

AIOH recommends the following definition of a *Competent Person* for the purposes of this document:

- A person with the relevant experience (at least 5 years) and proven competence in workplace exposure assessment, particularly as related to workplace testing of airborne contaminants; and
- A Full member of the AIOH; and
- Has current professional indemnity insurance for occupational hygiene work (including asbestos if required).

AIOH Technical Paper: Air sampling pumps - equipment and calibration requirements

1. Introduction

This Technical Paper was prepared to give guidance on the equipment and calibration requirements for air sampling pumps. The pumps are primarily used to collect various contaminants to determine airborne concentrations of those contaminants. The portable, battery operated pumps may be placed on a worker (i.e. in the breathing zone) to estimate worker exposure, or in a static (i.e. fixed location) to determine airborne concentrations in strategic locations. The results of the air sampling may be used for risk assessments and determining compliance against the workplace exposure standards (WES).

2. Background

Previously, requirements for air sampling pumps and calibration of pumps was provided by NATA for facilities accredited against ISO/IEC 17025 *General requirements for the competence of testing and calibration laboratories*. However, in accordance with recent changes NATA can no longer provide guidance for how sampling equipment such as air sampling pumps are to be calibrated and maintained. Instead, the focus will be on the facility to provide information on how to calibrate and check their sampling pumps to ensure they are fit for purpose to collect airborne contaminants.

Therefore, AIOH will provide the relevant information for calibration and maintenance of sampling pumps in the form of this Technical Paper. The information contained herein may be used to assist Occupational Hygienists and Laboratory Facilities to ensure their sampling pumps are suitable for workplace airborne monitoring purposes, i.e. to be fit for purpose, for volume measurement purposes.

3. Airborne sampling

The purpose of airborne sampling is to determine the airborne concentration of a substance in a worker's breathing zone (i.e. personal sample) or in an area (i.e. fixed location or static sample). The results of personal sampling can be used to determine compliance to the relevant WES. As the results of personal sampling directly relate to exposure and potential health effects, it is important that the sampling is carried out by persons suitably qualified and experienced. In addition, air sampling for determination of compliance against the WES is a requirement of Work, Health and Safety/Occupational Health and Safety Legislation across all jurisdictions in Australia (Safe Work Australia, 2013; Grantham & Firth, 2014).

Therefore, the AIOH recommends all airborne contaminant sampling be carried out by a competent person using approved and validated methods such as those published by Australian Standards, and National Guidelines as published by NIOSH, OSHA and UKHSE. It is also recommended that analysis of the samples be conducted by laboratory facilities accredited by NATA for the specific test using appropriate validated methods. Based on results obtained from the air sampling, correct interpretation by a competent person of the sampling results is essential to determine compliance with a WES and whether control strategies are required to eliminate or reduce exposures to acceptable levels.

Please refer to the AIOH Technical Paper: *Flow Measuring Equipment: Calibration Requirements* for recommended equipment checks and calibration requirements for air flow measuring equipment.

4. Air sampling pumps

There are a large variety of sampling pumps which can be used for collecting airborne samples and for occupational hygiene sampling. They may be required to collect samples in the breathing zone or at static locations. The pumps are normally battery operated and small enough to be comfortably worn on the person who is being sampled. They can operate at a variety of different flow-rates, with some pumps small enough to fit into a pocket, whilst others are designed to be clipped to the wearer's belt.

There are many features of sampling pumps which make them suitable for workplace sampling. Technical considerations for suitability include:

- Pulsation dampening (to ensure even flow);
- Automatic flow control and flow compensation (for stable flow rate, particularly as the pressure drop increases during sampling);
- Adequate flow range for the particular sampler;
- Intrinsic safety;
- Pump durability (e.g. withstand dropping and placement in harsh conditions); and
- Battery life.

Pumps used for workplace sampling purposes must be suitably calibrated and maintained to ensure optimum performance during use. They must also be able to maintain good operation over long periods of time (e.g. up to 12 hours).

During use, control of the sampling flowrate is important in ensuring the accuracy of the sample volume (and hence calculated airborne concentration of a contaminant) and for ensuring that the correct particle size range is sampled, as in the case of size selective sampling such as for respirable and inhalable dust monitoring.

Modern personal air sampling pumps used for Occupational Hygiene monitoring are fitted with microprocessor controlled electronic circuitry which compensates for changes in vacuum which occurs as the pressure drop increases due to dust loading onto filters. This circuitry maintains the pump flowrate to within a set range (normally $\pm 5\%$) of the set flowrate. These types of pumps are termed automatic flow control or flow compensation pumps.

Pump manufacturers use two methods to achieve this automatic flow control, either by *Indirect* or *Direct* flow control/compensation technology.

Indirect automatic flow control pump circuitry measures the electric load on the pump motor and adjusts the supply voltage to either speed up or slow down the motor to maintain a steady flowrate. Direct automatic flow control pumps circuitry measures the flowrate of air through the pump and/or dynamic pressure and adjusts the voltage to the pump motor to maintain flowrate. Direct flow control pumps are considered to be more reliable than Indirect flow control pumps at maintaining steady pump flowrate, and this is reflected in the differences in the frequency of calibration of the two types of pumps.

5. Airborne contaminants sampled using pumps

The types of airborne contaminants that can be sampled using the pumps include:

- Fibres – e.g. asbestos, man-made vitreous fibres (synthetic mineral fibres), cotton fibres/dust
- Dusts – e.g. respirable dust, respirable crystalline silica, inhalable dust, timber dust, welding fume
- Chemicals - e.g. polyaromatic hydrocarbons, volatile organic chemicals, pesticides etc.
- Mists – e.g. sulphuric acid, hydrochloric acid, alkalis
- Vehicle emissions – e.g. diesel particulate matter

6. Pump calibration

The correct functioning and operation of pumps and associated timers is essential to ensure airborne testing is carried out accurately. Facilities that use the sampling equipment are responsible for establishing an appropriate assurance program for their equipment, and the following information is provided as minimum requirements for such a program.

6.1 Indirect automatic flow-control pumps

Before being placed into service, after six months, and then after a further six months, the following tests must be done on every indirect automatic flow-control pump used by the facility.

- a) Test each pump at each flow rate that is used. For example, if the pump is used at 1.0, 2.0 and 4.0 Litres/minute, then it must be tested at 1.0, 2.0 and 4.0 Litres /minute.
- b) Set the pump flow rate to the chosen flow rate using a flow meter. No other flow resistance should be in the circuit.
- c) By inserting an adjustable or specially chosen flow resistance, select the resistance so that the pressure drop equals or exceeds approximately 2 kPa for each one Litre/minute flow rate. (For example, for 4 Litres/minute, the pressure drop must be 8 kPa or greater). This pressure drop can be determined by using devices such as a simple 'U' tube water manometer or a Magnehelic differential pressure gauge.
- d) Without adjusting the pump, re-measure the flow rate.
- e) If the flow rate changes by more than 5%, the pump's constant flow compensation must be reset.
- f) Repeat steps a) to e) with the pump set to each relevant flow rate.
- g) If the above tests produce results inside the $\pm 5\%$ range for tests on three consecutive occasions (i.e. over 12 months), then future tests need only be done at twelve-monthly intervals.
- h) If any internal components of the pumps have been serviced or changed, the test must be repeated before the pump is placed back into service and must meet the requirements of section g) above before going on to a 12 monthly calibration interval. Pumps that have the circuit board flow compensation potentiometers accessible must not be used until the access is blocked so as to prevent accidental adjustment.

- i) Some manufacturers of indirect automatic flow control pumps specify that flow rates of 1.0 and 2.5 Litres/minute are to be used when electronically adjusting for correct 'constant flow compensation'. This should not be confused with the mandatory requirements stated in paragraph (a) above, where pump testing is to be done at every flow rate used.
- j) For pumps using 13 mm diameter filters, conduct the same tests as for the pumps using 25 mm diameter filters, except to apply a pressure drop criteria of 10 kPa for each 1 Litre/minute of flowrate. This takes into account the fact that a 13 mm diameter filter has an effective filter diameter (i.e. dust deposit area) 5 times smaller than that of the effective filter area of a 25 mm diameter filter and, therefore, a pressure drop 5 times larger.

6.2 Direct automatic flow control pumps

- a) Before any 'direct' automatic flow control pump is placed into service, and after a twelve month period, the tests as described in section 6.1 above (with the exception of paragraphs g) and i)), must be conducted on every direct automatic flow control pump used in the facility.
- b) If any internal components of the pumps have been serviced or changed, the test must be repeated before the pump is placed back into service.
- c) If these tests produce results inside the $\pm 5\%$ range after two consecutive tests (i.e. over one year), then future tests need only be done at three yearly intervals.

6.3 Automatic pump timers

The above mentioned calibration procedures must be adhered to for automatic pump timers.

In addition to these requirements, the following aspects must also be demonstrated to check that automatic pump timers:

- i. reliably deliver the correct flow rate immediately after automatic switch-on:
 - a) set pump at initial 'nominal' flow rate
 - b) program pump to start at least 1 hour later
 - c) measure and record pump flow rate within 5 minutes of auto switch-on
 - d) repeat steps a) to c) for each flow rate used
 - e) repeat steps a) to d) for each pump used
 - f) repeat steps a) to e) on three separate occasions
 - g) accept a pump if any flow rate is within $\pm 5\%$ of initial 'nominal' reading
 - h) reject a pump if any flow rate is more than $\pm 5\%$ of initial 'nominal' reading.
- ii. Reliably deliver the correct flow rate immediately before automatic switch-off over the time cycle chosen:
 - a) set pump at initial 'nominal' flow rate
 - b) program pumps to finish at least 1 hour later
 - c) measure and record 'final' pump flow rate within 5 minutes before auto switch-off
 - d) repeat steps a) to c) for each flow rate used
 - e) repeat steps a) to d) for each pump used
 - f) repeat steps a) to e) on three separate occasions
 - g) accept a pump if any 'final' flow rate is within $\pm 5\%$ of initial 'nominal' reading
 - h) reject a pump if any flow rate is more than $\pm 5\%$ of initial 'nominal' reading.
- iii. Reliably display the sample duration to $\pm 1\%$ or better:
 - a) time in-built pump timer over a typical sampling period and record timer's 'elapsed time'
 - b) repeat step a) for each sampling period likely to be used
 - c) repeat steps a) to b) for each pump used
 - d) repeat steps a) to c) on three separate occasions
 - e) accept a pump if pump timer elapsed time is within $\pm 1\%$ of actual elapsed time.
- iv. reliably switch off automatically in the event of a flow fault such that the final flow rate is within $\pm 10\%$ of the initial flow rate:

- a) set pump at initial 'nominal' flow rate
 - b) progressively restrict pump suction so as to cause 'flow fault' condition
 - c) during step b) measure and record pump flow rate just before auto switch-off
 - d) repeat steps a) to c) for each flow rate used
 - e) repeat steps a) to d) for each pump used
 - f) repeat steps a) to e) on three consecutive occasions
 - g) accept a pump if final flow rate is within $\pm 10\%$ of initial 'nominal' reading
 - h) reject a pump if any final flow rate is more than $\pm 10\%$ of initial 'nominal' reading.
- v. reliably switch off automatically in the event of a low battery such that the final flow rate is within $\pm 10\%$ of the initial flow rate:
- a) set pump at initial 'nominal' flow rate
 - b) progressively reduce voltage supply to pump so as to cause 'low battery' fault
 - c) during step b), measure and record pump flow rate just before auto switch-off
 - d) repeat steps a) to c) for each flow rate used
 - e) repeat steps a) to d) for each pump used
 - f) repeat steps a) to e) on three consecutive occasions
 - g) accept a pump if final flow rate is within $\pm 10\%$ of initial 'nominal' reading
 - h) reject a pump if any final flow rate is more than $\pm 10\%$ of initial 'nominal' reading.

Each pump must be tested and records kept of all of the aspects described above.

If the tests described under 6.3 above have not been done, any sample subject to automatic switch-off due to a flow fault or low battery must be rejected.

7. References and sources of additional information

- Australian Standard 2985-2009. *Method for sampling and gravimetric determination of respirable dust*. Available from <http://infostore.saiglobal.com/store/default.aspx>
- Australian Standard 3640-2009. *Method for sampling and gravimetric determination of inhalable dust*. Available from <http://infostore.saiglobal.com/store/default.aspx>
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- Pickford, G, Davies, B & Apthorpe, L (2013). *Aerosols*, in S Reed *et al* (ed.) *Principles of Occupational Health & Hygiene: An Introduction*. Allen & Unwin, Crows Nest, NSW, Australia.
- Safe Work Australia (2013). *Guidance on the interpretation of workplace exposure standards*. Canberra. April 2013. Available from <https://www.safeworkaustralia.gov.au/doc/guidance-interpretation-workplace-exposure-standards-airborne-contaminants>

SEARCH

- The NATA website (www.nata.com.au) for accredited laboratory facilities who can undertake testing and analysis of workplace airborne contaminants.
- The AIOH website for Occupational Hygiene consultants (www.aioh.org.au).