ANALYT MESSTECHNIK



REFERENCE GUIDE

Air Sampling Step by Step

The basics of workplace air sampling, then step-by-step procedures with SKC sample pumps: inhalable dust with the IOM sampler, respirable dust with the cyclone, gases and vapours with sorbent tubes and impingers, and bag sampling.

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About this guide

This guide introduces workplace air sampling to people who are new to it. Chapters 1 to 3 explain the principles and the equipment; Chapters 4 to 8 run the most common sampling methods step by step, from the empty sampler to the sample on its way to the laboratory; Chapter 9 gives the basic calculations.

The guide describes the equipment, not the sampling strategy. Which method, sampling medium, flow rate and duration you need for a substance comes from the method you work to — for example a method from the HSE series *Methods for the Determination of Hazardous Substances* (MDHS) or an ISO standard — and from the exposure limits that apply where you work.

Which pumps the procedures apply to

The figures show the SKC Sidekick sample pump. Every SKC pump listed under SKC sample pumps (p. 12) can take its place as long as it delivers the flow rate the procedure needs. The one exception is the Pocket Pump TOUCH: it is a low-flow pump for gas and vapour sampling only. Where the procedure differs from pump to pump, the step says so; for the operation of the pump itself, follow its own manual.

How this guide marks information

⚠ CAUTION

A hazardous situation which, if not avoided, could result in minor or moderate injury.

NOTICE

Practices not related to personal injury — damage to the product, the process or the sample.

Note
Information that helps understanding; never a hazard.

Document information

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CHAPTER 1

Air sampling basics

An air sample tells you how much of a contaminant a known volume of air contained. The result is a concentration that can be compared with an exposure limit.

What an air sample measures

To take an air sample, you draw air through a collection medium that captures the contaminant, measure how much was captured, and express that amount as a concentration. Three measurements go into every result:

1. the flow rate of air through the collection medium;
2. the sampling time;
3. the amount of contaminant collected.

The first two give the volume of air sampled; the third, divided by that volume, gives the concentration:

Volume of air sampled	= flow rate × sampling time
Concentration	= amount collected ÷ volume of air sampled

The concentration is given in milligrams per cubic metre (mg/m³) or in parts per million (ppm). Because the result is only as accurate as the air volume, the flow rate is calibrated before and after every sample (see Calibrating the flow rate (p. 11)). Worked examples are in Calculations (p. 33).

Why exposure is monitored

Some substances found in workplaces are harmful to health. Measuring how much of them the workers breathe in shows whether exposure is under control.

In the European Union, the directives on indicative occupational exposure limit values set maximum exposure levels for hazardous substances, and each member state publishes its own list of limits. In the United Kingdom, for example, the limits are the Workplace Exposure Limits (WELs) in the guidance document EH40/2005. Besides the limit values, EH40 notes whether a substance is a skin sensitiser, whether it is carcinogenic and whether biological monitoring guidance applies. Substances with a WEL fall under the UK Control of Substances Hazardous to Health (COSHH) Regulations, which require employers to prevent exposure or keep it under control.

Exposure limits are concentrations averaged over a reference period — a time-weighted average (TWA). Two reference periods are used:

- **Long-term:** 8 hours, a working shift.
- **Short-term:** 15 minutes. Short-term exposure limits (STELs) protect against effects that can appear after only a few minutes of exposure, such as eye irritation.

Types of contaminant

Airborne contaminants fall into three groups by their physical state: **particulates**, **vapours** and **gases**. Particulates are further divided into aerosols, dusts, fumes, smokes, mists and fibres. The sampling method depends on the group.

Table 1. Contaminant definitions

Contaminant	Definition
PARTICULATES	
Aerosol	Solid particles of microscopic size dispersed in air.
Dust	Solid particles that can stay suspended in air for a time. Dust is usually produced when physical force breaks down a larger mass.
Fume	Solid particles that condense from the gas phase. Fume usually forms when a solid — most often a metal — is heated beyond its melting point, as in welding: the heat vaporises part of the solid, and the vapour condenses into fume as it cools.
Smoke	Particles from the incomplete combustion of organic matter, consisting mainly of carbon and carbon oxides.
Mist	Liquid droplets dispersed in air, usually large enough to be seen with the naked eye.
Fibre	Particles of natural or synthetic material that are much longer than they are wide, such as asbestos or glass fibres.
VAPOURS AND GASES	
Vapour	The gas phase of a substance that is normally a liquid or a solid at room temperature and normal pressure.
Gas	A substance that is normally neither a liquid nor a solid at room temperature and normal pressure.

mg/m³ and ppm

Concentrations of solids — dusts, fumes, fibres — are given in milligrams per cubic metre of air (mg/m³). Concentrations of gases and vapours are usually given in parts per million by volume (ppm), but can also be given in mg/m³; the conversion is in Converting ppm to mg/m³ (p. 33).

Both units describe very small amounts. Two rough comparisons help to picture them:

- **1 mg/m³** is about one teaspoon of dust spread through a layer of air 1 metre deep over a whole football pitch.
- **1 ppm** is about the air in one party balloon mixed into the air of 50 three-bedroom houses.

CHAPTER 2

How air sampling is done

Most workplace samples are personal samples: a battery-powered pump worn by the worker draws air through a sampler in the breathing zone, and a laboratory analyses what the sampler collected.

Personal sampling

The pump draws a known volume of air through the sampler. Contaminants in the air are caught on the collection medium inside — normally a filter for solid contaminants and a sorbent for gases and vapours. The sampler then goes to a laboratory, which determines the amount collected so that the concentration can be calculated.

A result can only be compared with an exposure limit if the sample reflects what the worker actually breathes. The sampler is therefore worn in the worker's **breathing zone**: within a zone about 30 cm across around the nose and mouth (Figure 1).

The pump must draw air through the sampler at the required flow rate for the whole sampling time, and hold that flow constant even when the temperature or the back pressure changes. Back pressure is the resistance that the sampler puts up against the air flow.

Recommended methods for substances with an exposure limit are published, for example, by the UK Health and Safety Executive in its series *Methods for the Determination of Hazardous Substances* (MDHS). For some contaminants, such as welding fume, internationally adopted ISO standards are used.

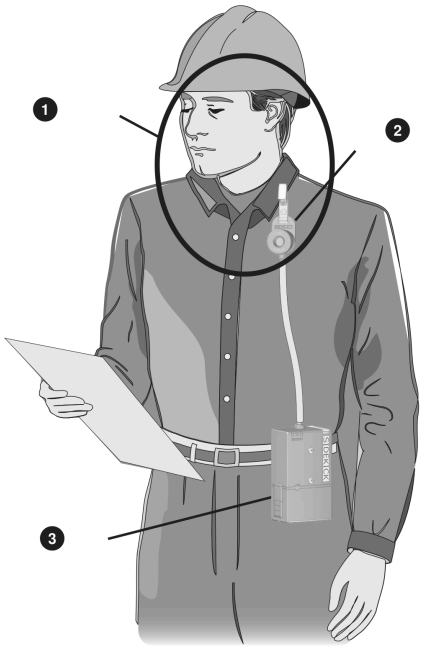


Figure 1. Personal sample.
1 Breathing zone, about 30 cm diameter · **2** Sampler · **3** Sample pump

Dust fractions

How far a dust particle travels into the respiratory tract depends on its size, and so does the harm it can do. Dust (aerosol) is therefore sampled in three size fractions:

- **Inhalable dust** — particles small enough to be carried by the air flow, or to stay airborne, and to be breathed in through the nose and mouth. Particles up to 100 µm.
- **Thoracic dust** — particles that can pass the larynx. Particles up to 30 µm.
- **Respirable dust** — particles small enough to reach deep into the lungs. Particles up to 12 µm.

The fractions are nested: inhalable dust contains the thoracic and the respirable particles, and thoracic dust contains the respirable particles.

Respirable dust has traditionally received the most attention. The finest particles penetrate deepest into the lungs, where breathing out, coughing and the mucus that clears the airways cannot remove

them. They can settle on the lining of the lungs and cause diseases such as silicosis or chronic obstructive pulmonary disease (COPD). Larger particles act on the upper respiratory tract — nose, mouth and throat.

The fractions are defined in the European standard EN 481:1993, *Workplace atmospheres – Size fraction definitions for measurement of airborne particles*. Figure 3 shows its three sampling conventions: for each particle size, the share of all airborne particles that belongs to each fraction.

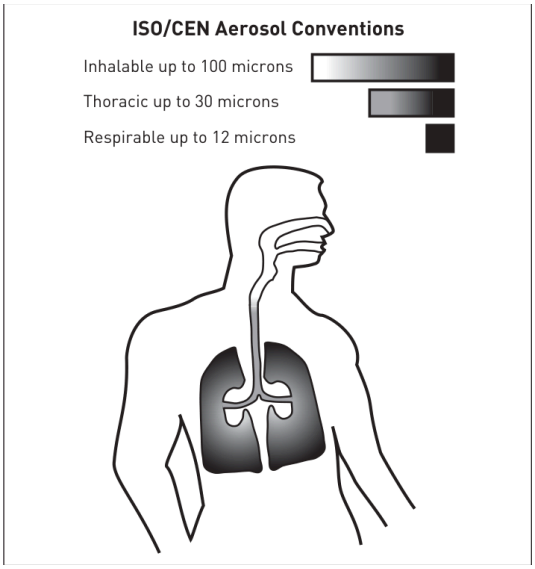


Figure 2. ISO/CEN aerosol conventions: inhalable dust up to 100 µm, thoracic dust up to 30 µm, respirable dust up to 12 µm.

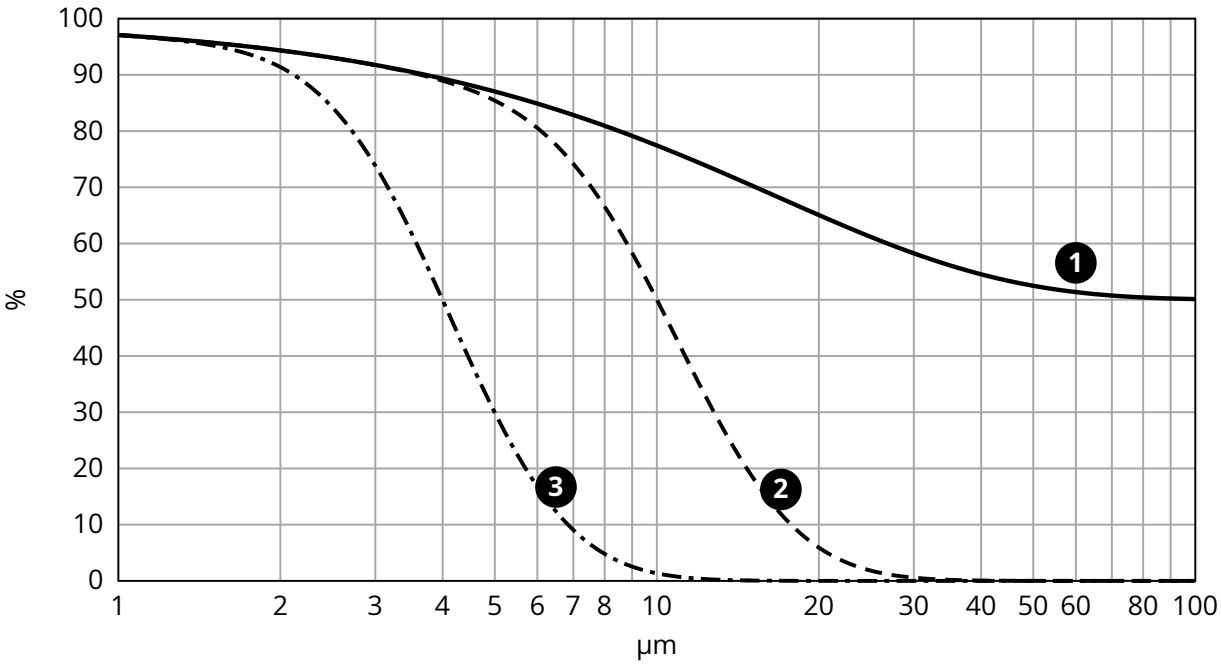


Figure 3. Health-related sampling conventions of EN 481:1993. Horizontal axis: aerodynamic particle diameter in µm (logarithmic). Vertical axis: percentage of all airborne particles included in the fraction.
1 Inhalable convention · **2** Thoracic convention · **3** Respirable convention

Sampling devices

The sampler decides what is collected. Table 2 lists the devices this guide covers; each has its own procedure chapter.

Table 2. Sampling devices

Device	How it works	Procedure
IOM sampler — inhalable dust	The inlet admits only the inhalable fraction. The dust is caught on a filter held in a cassette. The result is usually found by weighing (the weight gain of the filter); the filter can also be analysed for specific substances.	Chapter 4 (p. 14)
IOM sampler with foam plug — respirable dust	A foam plug in the cassette inlet holds back the larger particles; the respirable dust passes through to the filter.	Chapter 4 (p. 14)
Cyclone sampler — respirable dust	A cyclone separates the fine respirable dust, which is caught on a filter in a cassette at the top of the sampler. The larger particles fall into a grit pot at the bottom.	Chapter 5 (p. 19)
Sorbent tube — gases and vapours	A small sealed glass tube filled with a sorbent, such as activated charcoal — one of the most common. The sorbent adsorbs the gas or vapour from the air drawn through it; in the laboratory the contaminant is released again (desorbed) with a solvent or by heat and analysed.	Chapter 6 (p. 23)
Impinger (bubbler) — gases and vapours	The air is forced through a nozzle under a liquid, such as high-purity water. The contaminant dissolves in the liquid, which is then analysed, usually by a colorimetric method.	Chapter 7 (p. 28)
Sample bag — gases and vapours	For grab samples and short-term samples. A pump pushes the air into a special plastic bag, or the bag is filled without the air passing through the pump. The bag, holding a relatively large volume of air, goes to the laboratory.	Chapter 8 (p. 31)



Figure 4. Sampling devices, numbered as in Table 2. **1** IOM sampler · **2** IOM sampler with foam plug · **3** Cyclone sampler · **4** Sorbent tube · **5** Impinger · **6** Sample bag

Other samplers exist for special tasks — for example combined tube and filter samplers, chemically impregnated filters and passive badges. Ask Analyt-MTC which sampler suits your method.

CHAPTER 3

Sampling train, flow calibration and pumps

Every procedure in this guide uses the same building blocks: a sampling train, a calibrated flow rate and a pump that holds it. This chapter describes them once; the procedure chapters refer back to it.

The sampling train

The sample pump, the flexible tubing and the sampling device connected together are called the sampling train. Figure 5 shows two examples: a filter sampler connected straight to the pump, and a sorbent tube holder connected through a constant pressure controller for low flow rates.

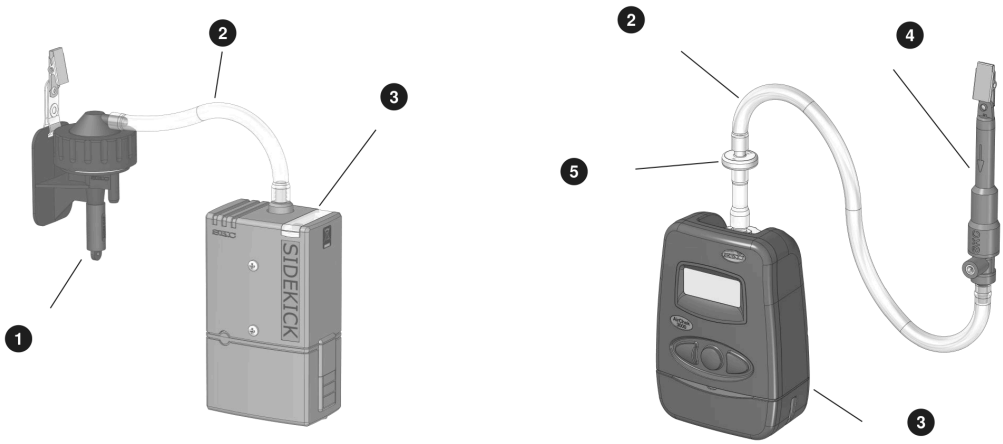


Figure 5. Sampling trains. Left: dust sampler. Right: sorbent tube for low flow.
1 Sampling device · **2** Tubing · **3** Sample pump · **4** Sorbent tube holder · **5** Constant pressure controller (CPC)

Sampling train checklist

- The pump is fully charged.
- The collection media are handled with care.
- The flow is calibrated in a clean area, so that the collection media are not contaminated.
- The flow rate is set to the value the sampling device or the method requires.
- All connections are secure and leak-tight.
- The sampler is mounted in the breathing zone.
- The tubing does not hang loose.
- The start and finish times of the sample are noted.

Fitting the sampling train to the worker

Mount the sampler as close to the breathing zone as is practical and comfortable for the wearer (Figure 1). Clip the pump to the worker's belt or put it in a pouch.

⚠ CAUTION

Tubing left to hang or flap loose is a hazard to the wearer. It can injure the wearer. Secure the tubing so that it cannot hang or flap loose.

Recording the sample

A result is only as good as the sample behind it — and as the record that goes with it. Note the start and stop times as you go, and record together, preferably on a form:

- the sampling medium and its number or code, which links the record to the filter, cassette, tube or impinger;
- the person sampled, the date and the location;
- the start and finish times and the sampling time;
- the flow rates measured before and after sampling;
- for gravimetric samples, the weights before and after sampling;
- anything else relevant to the sample.

Calibrating the flow rate

The air volume — and so the result — depends on the flow rate through the sampling train. Calibrate it before **and** after every sample (see MDHS 14/4), with the sampling device in the sampling train. Most published methods also specify the minimum accuracy of the flowmeter. Three types of flowmeter are common (Figure 6):

Electronic flowmeter (chek-mate). Recommended for its accuracy and ease of use. The chek-mate is an orifice flowmeter: it determines the flow from the pressure drop across an orifice and shows it on its display. It corrects automatically for the ambient temperature and barometric pressure, is accurate over its whole flow range and works in any orientation.

Variable-area flowmeter (rotameter). A simpler, less accurate option. A float rises in a graduated glass tube; its position shows the flow. The scale is valid for one temperature and pressure, for example 20 °C and 1 atm (1013.25 mbar). At other conditions the reading is wrong unless it is corrected, which needs a thermometer and a barometer as well. A rotameter is most accurate at the top of its scale; further down, the accuracy drops considerably.

Bubble film flowmeter. For laboratory use rather than the field. The flow is calculated from the time a bubble takes to travel between two marks on a glass tube, measured with a stopwatch.

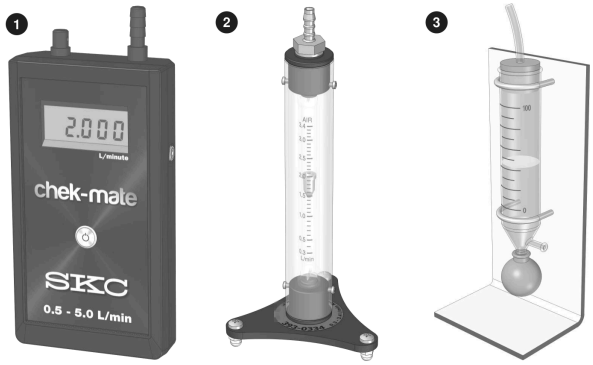


Figure 6. Flowmeters.
1 chek-mate electronic flowmeter · **2** Rotameter · **3** Bubble film flowmeter

> **Note**
> Most dust sampling is done at 1 to 5 L/min, most gas and vapour sampling at 20 to 500 mL/min. Choose flowmeters that cover the flow rates you need.

Adjusting the pump flow rate

The procedures connect the flowmeter to the sampling train, then adjust the pump until the flowmeter shows the required flow. How you adjust depends on the pump; follow the procedure in its manual:

- **Sidekick, Universal, AirLite:** turn the flow adjustment screw with the screwdriver of the pump toolkit.
- **AirChek 3000, AirChek XR5000, AirChek TOUCH:** set the flow with the keypad or on the touch screen.

The flowmeter reading must rise and fall as you adjust. If it does not, look for a leak or a blockage in the sampling train. A common cause of no flow is a separation paper — usually blue — loaded instead of a filter, which is usually white: some filter packs have a separation paper between the filters.

When you read a rotameter:

- stand it on a flat, level surface, so that the float does not touch the tube wall;
- check that the float is steady and spinning in the air flow — then it is clear of the wall, which would falsify the reading;
- read the flow at the top edge of the float.

SKC sample pumps

All SKC pumps in Table 3 can run the procedures in this guide at the flow rates they cover. Analyt-MTC can help you choose the pump that suits your sampling.

Table 3. SKC sample pumps

Pump	Dust	Gas/vapour	Flow setting	Flow range (L/min or mL/min)	Features
Sidekick	Yes	Yes[1]	Adjuster screw	0.75–3 L/min	ATEX-certified models; model with simple timer
Universal	Yes	Yes	Adjuster screw	1–4 L/min	Built-in flow indicator and low flow regulator; exhaust port for bag sampling; programmable model; ATEX-certified
AirChek 3000	Yes	Yes[1]	Keypad, LCD	1–3.25 L/min	Programmable; CalChek automatic flow calibration; DataTrac PC software; ATEX and IECEx certified
AirChek XR5000	Yes	Yes[1]	Keypad, LCD	1–5 L/min	Wide flow range; programmable; up to 40 hours run time
AirChek TOUCH	Yes	Yes[1]	Touch screen	1–5 L/min	Colour touch screen; programmable; CalChek automatic flow calibration; DataTrac Pro PC software
AirChek Connect, AirChek ESSENTIAL+	Yes	Yes[1]	Touch screen	1–5 L/min	ATEX and IECEx certified; Connect only: programmable, Bluetooth, DataTrac Pro PC software
AirLite	Yes	Yes[1]	Adjuster screw	1–3 L/min	Runs on disposable alkaline batteries
Pocket Pump TOUCH	No	Yes	Touch screen	20–500 mL/min	Low-flow pump; touch screen; programmable; Bluetooth; DataTrac Pro PC software; ATEX and IECEx certified

[1] For gas and vapour sampling at 5 to 500 mL/min, these pumps need a constant pressure controller (CPC) or an All-in-One adjustable low flow tube holder (see Chapter 6 (p. 23)).



Figure 7. SKC sample pumps, as listed in Table 3. **1** Sidekick · **2** Universal · **3** AirChek 3000 · **4** AirChek XR5000 · **5** AirChek TOUCH · **6** AirChek Connect, AirChek ESSENTIAL+ · **7** AirLite · **8** Pocket Pump TOUCH

CHAPTER 4

Inhalable dust with the IOM sampler

The IOM sampler collects the inhalable dust fraction on a filter inside a cassette. Flow rate: **2.0 L/min**.

The IOM sampler

The IOM sampler was developed at the Institute of Occupational Medicine (IOM) in Edinburgh and closely follows the definition of inhalable dust in EN 481. It is less affected by air movement around it than other samplers, and it holds the filter in a cassette instead of using a bare filter. With a bare filter, part of the dust settles on the inside walls of the sampler and is lost to the result, so the sample can read too low. In the IOM sampler, that dust lands inside the cassette.

For this reason, weigh the cassette and the filter together as one unit, before and after sampling: the result then includes the dust on the filter and on the inside walls of the cassette.

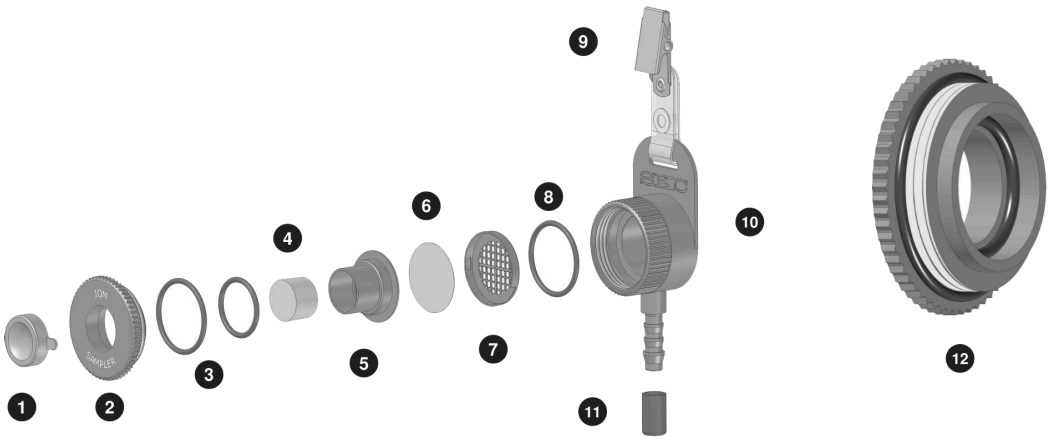


Figure 8. IOM sampler, exploded view.
1 Cassette cap · **2** Front plate · **3** O-rings · **4** Foam plug, for respirable sampling only · **5** Cassette inlet spout · **6** Filter · **7** Cassette support grid · **8** O-ring, not needed on the stainless steel IOM sampler · **9** Spring clip · **10** Sampler body · **11** Sealing cap · **12** Rear of the front plate, showing the O-ring positions

Loading a filter

1. Unscrew the front plate (2).
2. Pull the cassette — inlet spout (5) and support grid (7) — gently forward out of the sampler body.
3. Separate the two halves of the cassette with gentle pressure; they are clipped together.
4. Place a filter in the support grid, then snap the inlet spout back into the grid. Check that it is fully seated.
5. Put the cassette back into the sampler body and screw the front plate on firmly, so that all O-rings are compressed and the sampler does not leak.

Respirable dust with the IOM sampler

With a foam plug (4) pushed into the inlet spout of the cassette, the IOM sampler collects respirable dust: the foam holds back the larger particles of the inhalable fraction, and the respirable particles pass through to the filter. With the foam plug in the IOM cassette, the inhalable and the respirable fraction can both be measured from one sample.

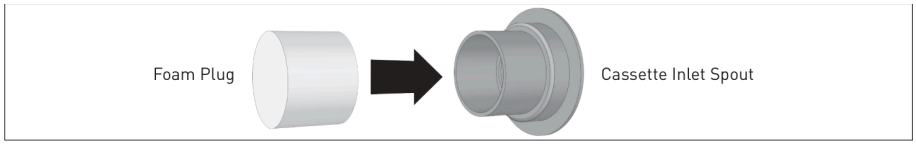


Figure 9. Foam plug in the cassette inlet spout, for respirable dust.

What you need

- Sample pump, fully charged
- IOM sampler with cassette cap and cassette transport clip
- A length of flexible tubing
- Two filters from the same box or batch
- Flowmeter that can measure 2 L/min
- Calidaptor — the calibration adaptor for the IOM sampler
- Pump toolkit, for pumps with manual flow adjustment

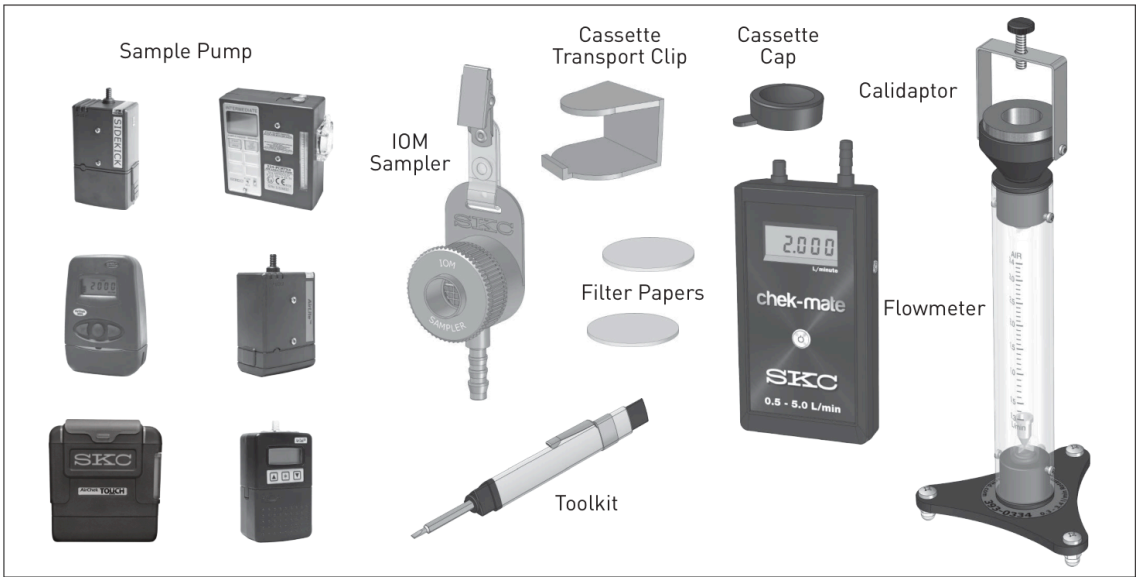


Figure 10. What you need for inhalable dust sampling with the IOM sampler.

Procedure

Setting the flow rate



Figure 11. IOM sampler connected to the sample pump with flexible tubing.

1. Load one of the two filters into the cassette, put the cassette into the sampler body and screw on the front plate (see Loading a filter (p. 14)). This filter is used only to set the flow.
2. Connect the outlet hose nipple of the IOM sampler to the inlet hose nipple of the pump with the tubing.
3. Connect the IOM sampler to the flowmeter through the calidaptor — with a chek-mate as in step 4, with a rotameter as in step 5. Make sure the flowmeter can measure 2 L/min.
4. **With a chek-mate:** set the IOM sampler on the foam sealing pad on top of the calidaptor and secure it with the finger screw, so that the front face of the sampler seals against the pad. Screw the hose nipple fitting supplied with the calidaptor into the hole in the bottom of the calidaptor, and connect it to the outlet hose nipple of the chek-mate with the tubing supplied with the calidaptor (Figure 12). Switch the chek-mate on.

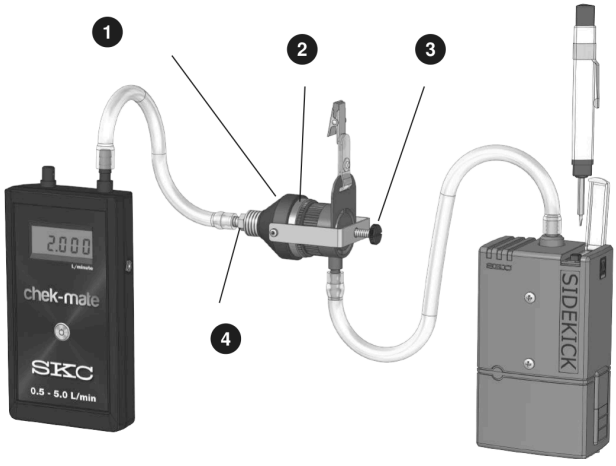


Figure 12. Flow setting with a chek-mate.
1 Calidaptor · **2** Foam pad · **3** Finger screw · **4** Hose nipple fitting

5. **With a rotameter:** the calidaptor screws directly into the outlet at the top of SKC 393 series rotameters. Unscrew the hose nipple fitting from the top of the rotameter and screw the calidaptor tightly into the threaded hole, so that its O-ring seals (Figure 13). With a rotameter of another make, connect the calidaptor through its hose nipple fitting and the tubing supplied with it. Fit the IOM sampler to the calidaptor and secure it with the finger screw.

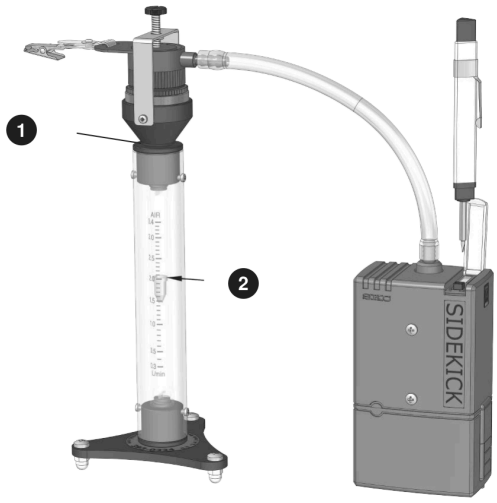


Figure 13. Flow setting with a rotameter.
1 O-ring seal · **2** Read the flow here, at the top edge of the float

6. Switch the pump on and adjust the flow to **2.0 L/min** (see Adjusting the pump flow rate (p. 11)). Then switch the pump off.
7. Take the IOM sampler off the calidaptor and remove the cassette. Take out the filter used for the flow setting and check that the inlet spout and the support grid are clean.
8. Load the second filter, weigh the cassette with the filter, and fit the cassette back into the sampler (Figure 14).

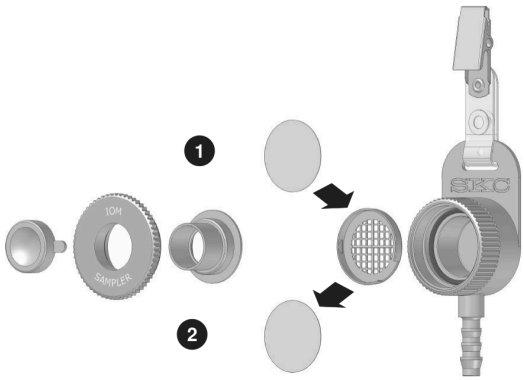


Figure 14. Changing the filter.
1 New filter for the sample · **2** Filter used for the flow setting

9. Check the flow again with the weighed cassette in place and make any final adjustment. Work quickly, so that the filter collects as little as possible before the sample starts.
10. Fit the cassette cap. The sampler is ready to take to the workplace.

Taking the sample

1. Fit the sampling train — pump, tubing and IOM sampler — to the worker who will wear it (see Fitting the sampling train to the worker (p. 10)).

2. Remove the cassette cap (Figure 15, left) and switch the pump on. **Note the start time.**
3. At the end of the sampling time, switch the pump off, refit the cassette cap and **note the finish time**.
4. Take the sampling train off the worker. Away from the sampling location, check the flow rate again (MDHS 14/4). Work quickly, for the same reason as before sampling.
5. Remove the cassette from the sampler and weigh the cassette with the filter.
6. If the sample goes to a laboratory for further analysis, refit the cassette cap and fit a cassette transport clip (Figure 15, right).

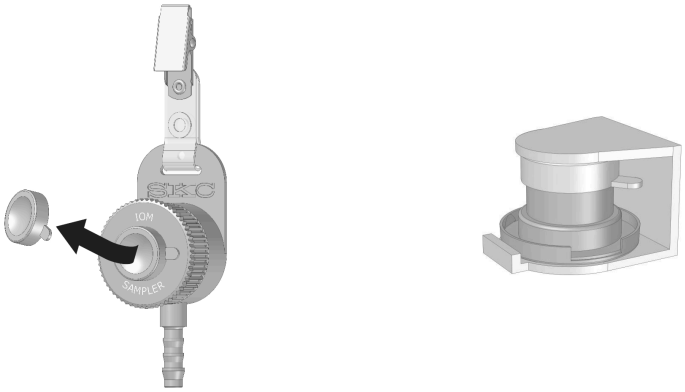


Figure 15. Left: removing the cassette cap before sampling. Right: cassette with cap in a transport clip.

7. Record the sample (see Recording the sample (p. 11)), including the weights before and after sampling, and link the record to the cassette or filter by its number or code.

CHAPTER 5

Respirable dust with the cyclone sampler

The cyclone sampler separates the respirable fraction and collects it on a filter; the coarser dust drops into the grit pot. Flow rate: **3.0 L/min**.

What you need

- Sample pump, fully charged
- Cyclone sampler with filter cassette
- Two lengths of flexible tubing
- Two filters from the same box or batch, one of them weighed
- Flowmeter that can measure 3 L/min
- Pump toolkit, for pumps with manual flow adjustment
- Filter transport cassette

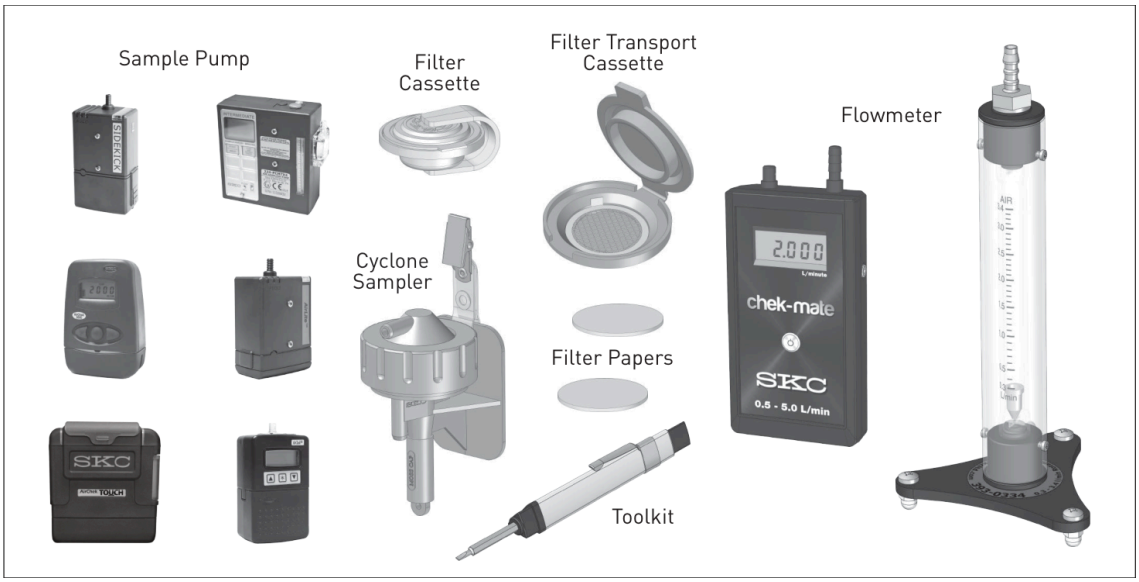


Figure 16. What you need for respirable dust sampling with the cyclone sampler.

Assembling the sampler

1. Load the filter that has **not** been weighed into the filter cassette. This filter is used only to set the flow. The filter stays centred on the support grid if you assemble the cassette this way:
   - Place the cassette top upside down on a flat surface, like a shallow bowl.
   - Lay the support grid in the cassette top and the filter on the grid.
   - Pick up the cassette top with grid and filter and snap the cassette bottom onto it (Figure 17).

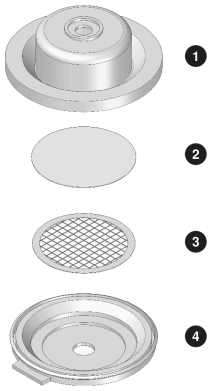


Figure 17. Filter cassette.
1 Cassette bottom · **2** Filter · **3** Filter support grid · **4** Cassette top

2. Put the filter cassette into the sampler body with the embossed text **SKC TOP** facing upwards (Figure 18).



Figure 18. Cyclone sampler, exploded view.
1 Retaining ring · **2** Air outlet · **3** Sampler top · **4** Filter cassette · **5** Sampler body · **6** Air inlet · **7** Grit pot

3. Check that an O-ring sits in the circular groove in the underside of the sampler top. Fit the sampler top over the cassette and tighten the retaining ring firmly, so that the sampler seals.
4. Check that the grit pot is fitted to the bottom of the sampler.

Setting the flow rate

1. Connect the air outlet at the top of the cyclone sampler to the inlet hose nipple of the pump with tubing (Figure 19, left).
2. Connect the air inlet of the cyclone to the flowmeter — a chek-mate as in step 3, a rotameter as in step 4. Make sure the flowmeter can measure 3 L/min.
3. **With a chek-mate:** connect the air inlet of the cyclone to the outlet hose nipple of the chek-mate with tubing (Figure 19, right). Switch the chek-mate on.



Figure 19. Left: cyclone sampler connected to the pump. Right: flow setting with a chek-mate.

4. **With a rotameter:** connect the air inlet of the cyclone to the hose nipple at the top of the rotameter with tubing. If a calidaptor is fitted to the rotameter, screw the threaded hose nipple fitting supplied with the calidaptor into the hole in the bottom of the calidaptor bowl and connect the cyclone air inlet to it (Figure 20).

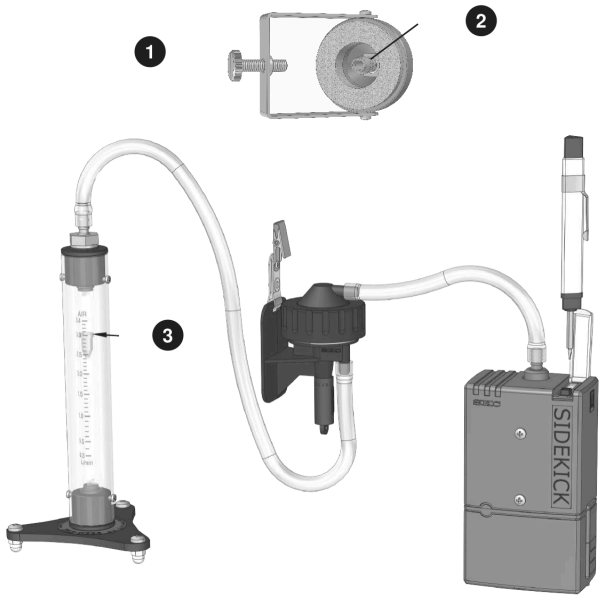


Figure 20. Flow setting with a rotameter.
1 Calidaptor, if fitted to the rotameter · **2** Hose nipple fitting · **3** Read the flow here, at the top edge of the float

5. Switch the pump on and adjust the flow to **3.0 L/min** (see Adjusting the pump flow rate (p. 11)). Then switch the pump off.

6. Remove the filter cassette from the sampler body, replace the filter used for the flow setting with the weighed filter (Figure 21), and fit the cassette back into the sampler.

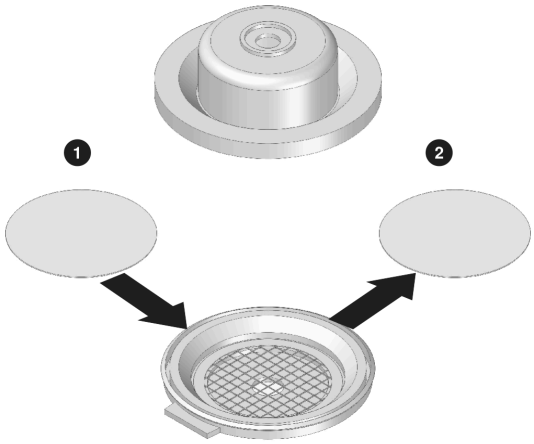


Figure 21. Changing the filter.
1 New filter for the sample · **2** Filter used for the flow setting

7. Check the flow again with the weighed filter in place and make any final adjustment. Work quickly, so that the filter collects as little as possible before the sample starts. The sampler is ready to take to the workplace.

Taking the sample

1. Fit the sampling train — pump, tubing and cyclone sampler — to the worker who will wear it (see Fitting the sampling train to the worker (p. 10)). Switch the pump on. **Note the start time.**
2. At the end of the sampling time, switch the pump off and **note the finish time**.
3. Take the sampling train off the worker. Away from the sampling location, check the flow rate again (MDHS 14/4). Work quickly, for the same reason as before sampling.
4. Remove the filter cassette from the sampler, open it, lift the filter out carefully and weigh it.
5. If the sample goes to a laboratory for further analysis, lay the filter carefully on the support grid of a transport cassette and snap the transport cassette shut (Figure 22).

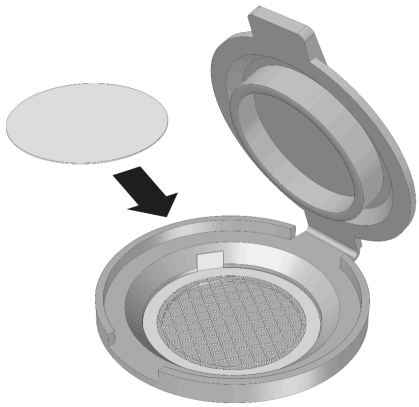


Figure 22. Filter transport cassette.

6. Record the sample (see Recording the sample (p. 11)), including the filter weights before and after sampling, and link the record to the filter by its number or code.

CHAPTER 6

Gases and vapours with sorbent tubes

Sorbent tubes are sampled at low flow rates, typically between 5 and 500 mL/min. Most pumps reach these flows only through a constant pressure controller (CPC) and a low flow tube holder with a throttle valve.

Low flow set-ups

The pump runs at a fixed 1.5 L/min; the CPC keeps the pressure constant, and the throttle valve of the tube holder sets the flow through the tube. Which parts you need depends on the pump:

Table 4. Low flow parts by pump

Pump	Low flow parts
Most SKC pumps (Sidekick, AirChek 3000 and others, see Table 3)	CPC with an adjustable low flow tube holder, *or* an All-in-One low flow single tube holder, which has the CPC built in.
Universal	Adjustable low flow tube holder only: the pump's built-in low flow pressure regulator does the work of the CPC.
Pocket Pump TOUCH	Non-adjustable low flow tube holder only, without a throttle valve: the pump is a low-flow pump and sets the tube flow itself.

What you need

- Sample pump, fully charged
- Low flow parts for your pump (see above)
- Tube cover of the right size for the sorbent tube
- A length of flexible tubing
- Tube adapter for small-diameter sorbent tubes
- Two sorbent tubes from the same box or batch
- Flowmeter for the required flow rate, typically 5 to 500 mL/min
- Pump toolkit, for pumps with manual flow adjustment

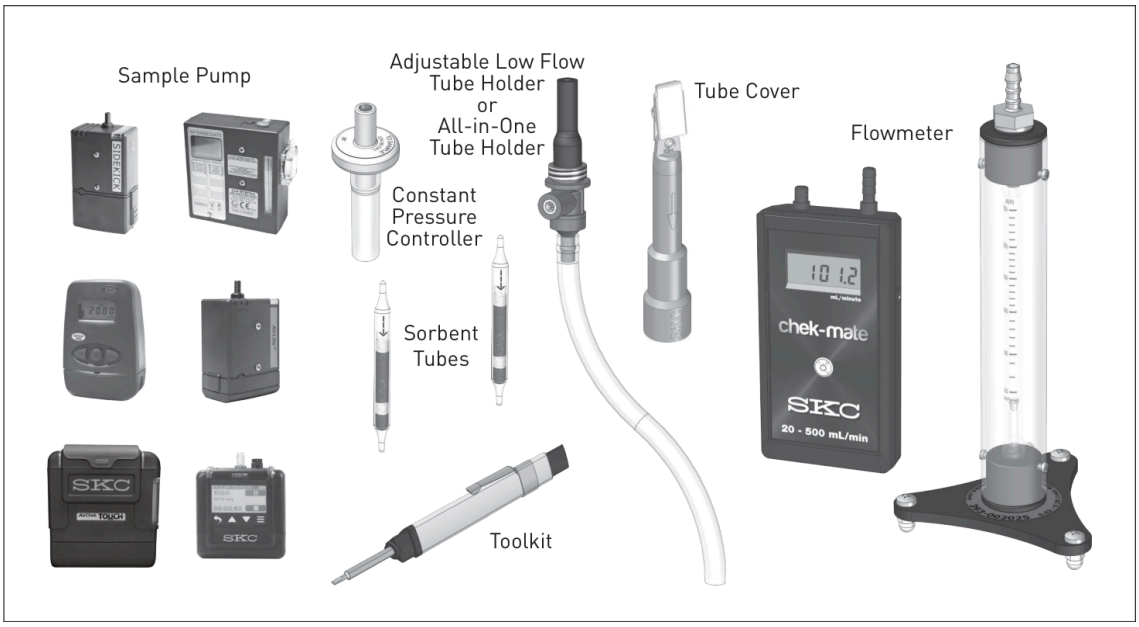


Figure 23. What you need for gas and vapour sampling with sorbent tubes.

Setting up and setting the flow rate



Figure 24. Step 1: the flowmeter connected directly to the pump inlet to set 1.5 L/min.

1. **Set the pump to 1.5 L/min** (not with the Pocket Pump TOUCH). Connect the flowmeter directly to the inlet hose nipple of the pump with tubing, switch the pump on and adjust the flow to 1.5 L/min (see Adjusting the pump flow rate (p. 11)). The CPC, the All-in-One tube holder and the low flow regulator of the Universal pump need this flow to work correctly. Switch the pump off and disconnect the flowmeter.

> **Note**
> From now on, do not change the pump flow. The flow through the tube is set with the throttle valve of the tube holder.

2 **Switch the pump to low flow.**

- With a CPC: connect the short tube attached to the CPC to the inlet hose nipple of the pump (Figure 25). This puts the pump into low flow mode for the adjustable low flow tube holder.
- With an All-in-One tube holder: no separate CPC is needed.
- Universal pump: put the pump into low flow mode as its manual describes — unless you use an All-in-One tube holder.
- Pocket Pump TOUCH: no CPC is needed.

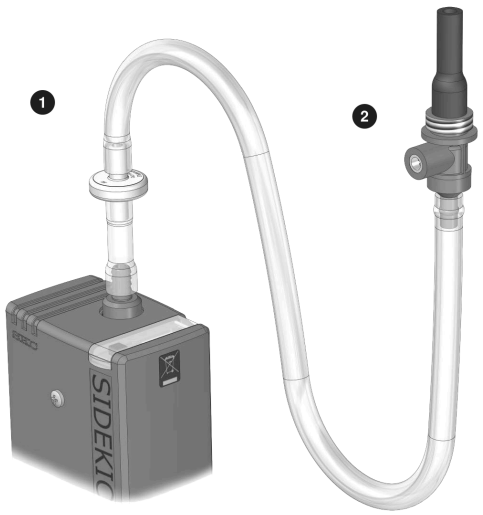


Figure 25. Low flow set-up with a CPC.
1 Constant pressure controller (CPC) · **2** Adjustable low flow tube holder

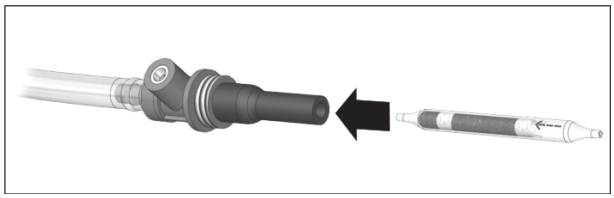


Figure 26. Fitting the sorbent tube into the low flow tube holder.

3 **Connect the tube holder.**

- With a CPC: connect the adjustable low flow tube holder to the free end of the CPC with the long tubing. The labelled side of the CPC faces the tube holder.
- With an All-in-One tube holder: connect the long tubing directly to the inlet hose nipple of the pump.
- Pocket Pump TOUCH: connect the non-adjustable low flow tube holder directly to the inlet hose nipple of the pump.

> ⚠ **CAUTION**
>
> The broken ends of a glass sorbent tube are extremely sharp. They can cut you. Handle opened tubes with care.

4 **Open and fit a sorbent tube.** Break off both ends of one of the two tubes, preferably with a tube breaker made for the purpose. Push the tube into the short black sleeve of the tube holder, the right way round:

- if the tube carries a printed arrow, the arrow shows the direction of air flow and points towards the pump;
- if there is no arrow, the largest air gap or unfilled section faces away from the pump, towards the open air.

⚠ CAUTION

A red cap pushed fully home seals the tube airtight and has to be cut off with a sharp knife. Cutting it off can cut you. Do not push the red cap on all the way.

5 **Set the tube flow.** Connect the free end of the sorbent tube to the outlet hose nipple of the flowmeter; for a small-diameter tube use the tube adapter (Figure 27). Switch on the pump and the flowmeter, and hold the tube vertically while you set the flow. Turn the throttle valve screw in the side of the tube holder with the large flat-blade screwdriver of the pump toolkit until the flowmeter shows the flow your tube type and method require. Then switch the pump off.

With the Pocket Pump TOUCH and a non-adjustable tube holder, set the tube flow on the pump's touch screen instead.

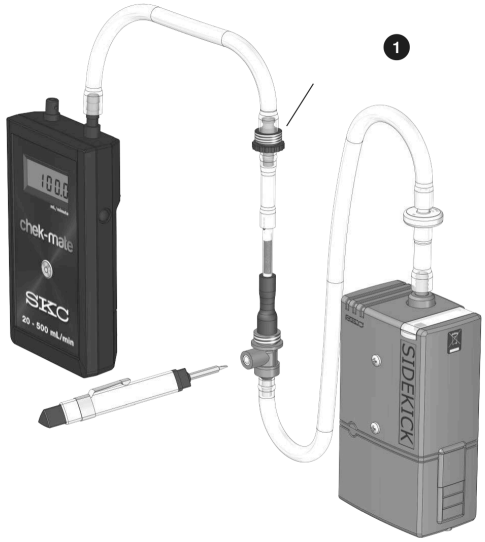


Figure 27. Setting the tube flow with a chek-mate.
1 Tube adapter for small-diameter sorbent tubes

6 **Fit the sampling tube.** Remove the tube used for the flow setting from the tube holder and fit a fresh tube with both ends broken off. Screw the tube cover onto the tube holder to protect the exposed end (Figure 28). Until sampling starts, you can close the open end with one of the red plastic caps supplied.

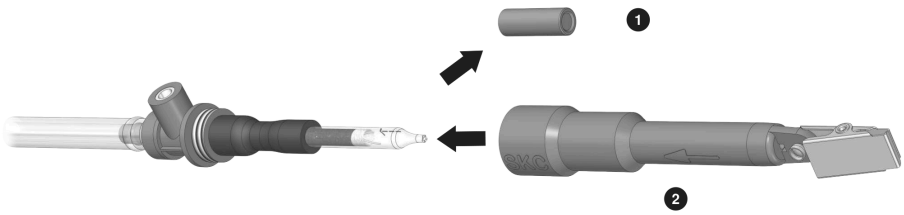


Figure 28. Protecting the tube.
1 Tube cap · **2** Tube cover

Taking the sample

1. Fit the sampling train — pump, tubing, tube holder and tube cover — to the worker who will wear it, with the tube holder vertical (see Fitting the sampling train to the worker (p. 10)). Switch the pump on. **Note the start time.**
2. At the end of the sampling time, switch the pump off and **note the finish time**.
3. Take the sampling train off the worker. Away from the sampling location, check the tube flow again. Work quickly, so that the tube collects as little as possible outside the sampling time.
4. Remove the tube from the tube holder and cap both ends immediately with the red caps (Figure 29).

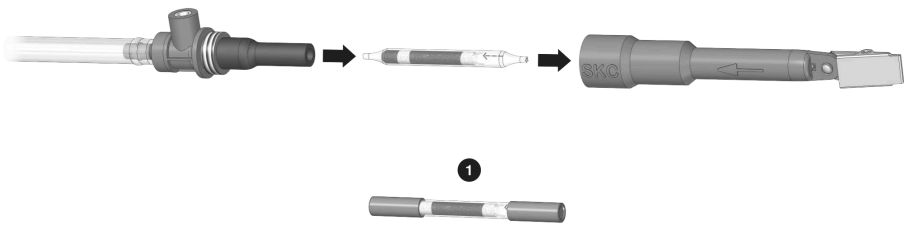


Figure 29. Closing the sampled tube.
1 Tube caps

5. Record the sample (see Recording the sample (p. 11)) and link the record to the tube by its number or code.

Blank tubes

A blank is often skipped, yet it is a required reference for an accurate result. Take a tube from the same batch, open and handle it exactly like the sampling tubes, but do not draw any air through it and cap it again immediately with the red caps. Send it to the laboratory with the sampled tubes. The laboratory analyses the blank and corrects the results of the sampled tubes for whatever it finds on it.

CHAPTER 7

Gases and vapours with impingers

An impinger bubbles the sampled air through a liquid that absorbs the contaminant. It can be used as a static area sample next to the work or as a personal sample worn by the worker.

Static and personal set-ups

- **Static area sample:** the glass impinger stands in an impinger bracket together with a glass trap. The Sidekick, Universal and AirChek TOUCH pumps have mounting points for the bracket.
- **Personal sample:** the glass impinger is carried in an impinger pouch, with an in-line trap.

The trap keeps impinger liquid from being drawn into the pump. Filled with trap sorbent, which is optional, it also adsorbs evaporated impinger liquid before it reaches the pump.

NOTICE

Impinger liquid drawn into the pump mechanism can cause serious damage to the pump. Always sample with a trap between impinger and pump.

⚠ CAUTION

Glassware filled with liquid — in some methods a hazardous liquid — is a hazard to the person wearing it. Broken glassware or spilled liquid can injure the wearer. Personal sampling is recommended, and exposure limits are based on personal exposure. Take this hazard into account when you decide between a personal and a static sample.

Impingers are usually run at 1.0 L/min or less. The method you work to sets the flow rate and the type and amount of liquid. For 500 mL/min and below, use the low flow set-up of the sorbent tube procedure (see Chapter 6 (p. 23)) with the impinger and trap in place of the sorbent tube.

The procedure below describes a static area sample at 1.0 L/min. Where a personal sample differs, the step says so under *Personal sample*.

What you need

- Sample pump, fully charged
- Glass impinger
- Glass impinger trap with trap sorbent (personal sample: in-line trap)
- A length of flexible tubing
- Impinger bracket (personal sample: impinger pouch)
- Flowmeter for the required flow rate
- Pump toolkit, for pumps with manual flow adjustment

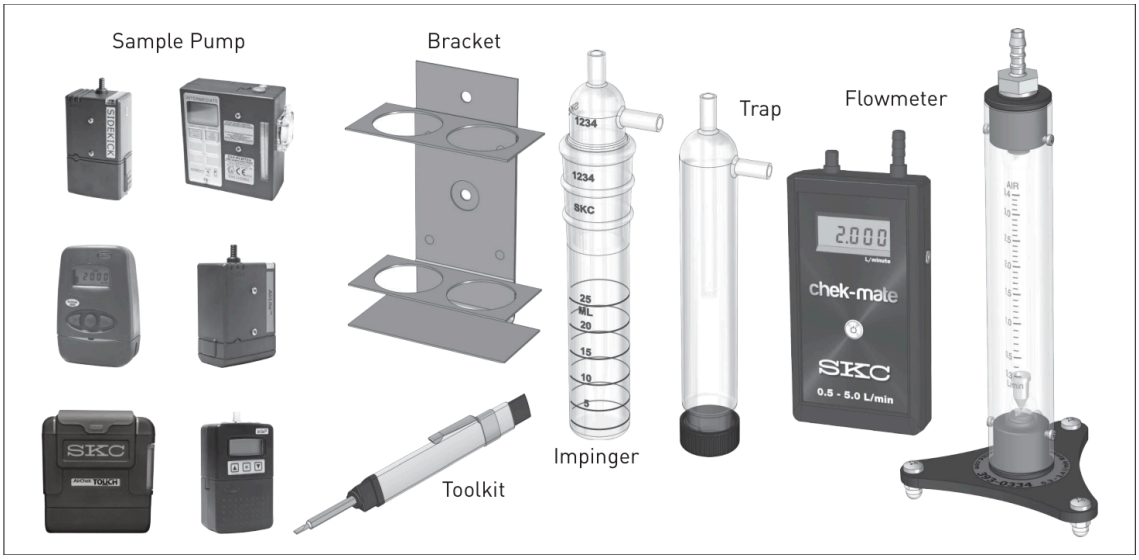


Figure 30. What you need for gas and vapour sampling with impingers.

Procedure

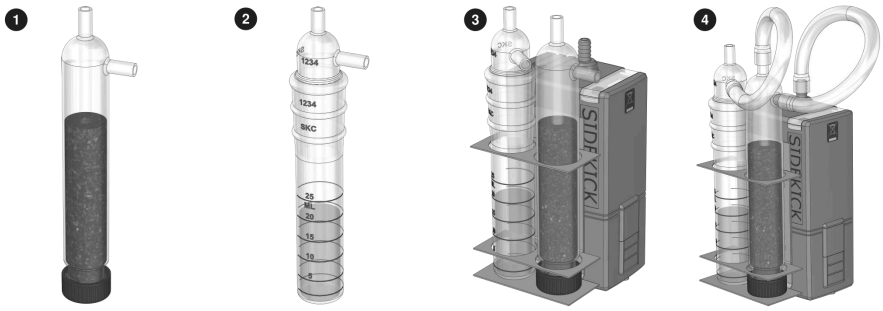


Figure 31. Preparing a static impinger sample; the numbers match steps 1 to 4.

1. Fill the glass trap with trap sorbent until all the holes in its central tube are covered, and screw the plastic cap on securely.

   Personal sample: make sure the in-line trap is full of sorbent.

2. Take the top off the impinger and fill the impinger to the required level with the liquid you will sample with. Press the top back on firmly, so that it seals.

3. Fasten the impinger bracket to the pump — on the Sidekick and Universal to the front of the pump with the two screws supplied with the pump, on the AirChek TOUCH to the belt clip at the back. Place the trap and the impinger in the bracket.

   Personal sample: stand the impinger and the in-line trap on a suitable surface.

4. With two short lengths of tubing, connect the horizontal stub of the impinger to the vertical stub of the trap, and the vertical stub of the trap to the inlet hose nipple of the pump.

   Personal sample: connect the impinger to the in-line trap with tubing. The in-line trap can be connected either way round.

5. Connect the vertical stub of the impinger to the outlet hose nipple of the flowmeter with tubing (Figure 32). Switch the pump on and adjust the flow to **1.0 L/min** (see Adjusting the pump flow rate (p. 11)). Then switch the pump off.



Figure 32. Setting the flow through the impinger with a chek-mate.

6. Replace the liquid in the impinger with fresh liquid, filled to the level your method specifies. Place the unit in the workplace and switch the pump on. **Note the start time.**

   Personal sample: fit the sampling train — pump, tubing, sorbent trap, impinger and pouch — to the worker who will wear it (see Fitting the sampling train to the worker (p. 10)). Run a length of tubing from the impinger inlet to a point as close to the breathing zone as is practical and comfortable. Then switch the pump on and note the start time.

7. The liquid can evaporate quickly. Check the impinger every 30 to 45 minutes and top it up so that the end of the vertical glass tube inside always stays under the liquid.

8. At the end of the sampling time, switch the pump off and **note the finish time**. Check the flow rate again.

9. Record the sample (see Recording the sample (p. 11)) and link the record to the impinger by its number or code.

CHAPTER 8

Bag sampling

A sample bag collects the air itself. It suits gases and vapours whose concentration is above the detection limit of common analytical instruments.

Bag samples are usually taken over a short time and show the peak concentration; a sample of this kind is often called a grab sample. The simplest way to fill a bag is with a pump that has both an inlet (suction) and an outlet (pressure) port: the pump draws in the air and pushes it into the bag. Among SKC pumps, the Pocket Pump TOUCH and the Universal range can be fitted with an outlet port fitting for filling bags.

For a grab sample the flow rate does not matter, but too high a flow can over-fill the bag (Figure 33). If your method specifies a flow rate, calibrate the pump flow before and after sampling as for any other sampling medium, with a chek-mate or a rotameter.

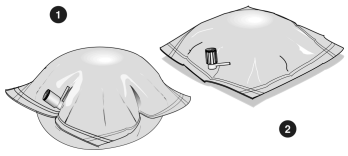


Figure 33. 1 Over-filled bag · **2** Correctly filled bag

What you need

- Sample pump, fully charged
- Outlet (pressure) port fitting for the pump
- Sample bag suitable for the application
- PTFE tubing

Procedure

1. Set up the pump as its manual describes. If your method specifies a flow rate, calibrate the pump to it.
2. Flush the bag with purified air or nitrogen before use.
3. Connect the tubing/valve fitting of the bag to the outlet port of the pump with PTFE tubing (Figure 34).

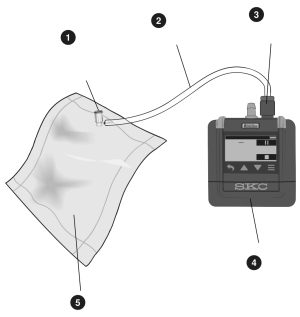


Figure 34. Filling a bag with the pump.
1 Combined tubing connector, valve and syringe port fitting · **2** PTFE tubing · **3** Outlet port fitting · **4** Sample pump · **5** Sample bag

NOTICE

A bag filled beyond 80 % of its maximum volume comes under pressure and can rupture. The sample is then lost. Fill the bag to no more than 80 % of its maximum volume.

4. Open the valve on the bag fitting (see the instructions for the bag), then switch the pump on.
5. When the sample is complete, switch the pump off and close the bag valve securely. Disconnect the bag from the pump and record the sampling details.

NOTICE

In a cargo hold that is not pressurised, a bag sample can burst. The sample is then lost. Do not send bag samples by air freight unless the cargo hold is pressurised.

6. Send the bag to the laboratory for analysis, loosely packed and padded so that it cannot be punctured.

Filling a bag without the pump: Vac-U-Chamber

If the sampled air must not come into contact with the pump, or the atmosphere is aggressive — in stack sampling, for example — fill the bag through an intermediate container such as the SKC Vac-U-Chamber. The Vac-U-Chamber is a rigid box: the pump draws air out of the box, and the negative pressure fills the bag inside it with sample air (Figure 35). Because the sample never passes through the pump, neither the sample nor the pump is contaminated.



Figure 35. Bag sampling with the Vac-U-Chamber.
1 Chamber (Vac-U-Chamber) · **2** Window · **3** Sample bag · **4** Sample inlet · **5** Tubing · **6** Sample pump · **7** Vacuum port · **8** Purge port · **9** Sample inlet port

CHAPTER 9

Calculations

Three formulas cover most everyday calculations: the volume of air sampled, the conversion from ppm to mg/m³, and the 8-hour time-weighted average.

Volume of air sampled

Volume of air sampled = flow rate × sampling time

Example. A sample is taken at 2 L/min for 8 hours.

Sampling time	8 h × 60 = 480 min
Volume of air	2 L/min × 480 min = 960 L
In cubic metres	960 L ÷ 1000 = 0.96 m³

Converting ppm to mg/m³

Concentration in mg/m³ = concentration in ppm × molecular weight ÷ 24

The molecular weight is that of the contaminant in g/mol. If you do not know it, add up the atomic weights of the atoms in its formula from a periodic table. The factor 24 is the volume in litres that one mole of gas takes up at about 20 °C and normal atmospheric pressure.

8-hour time-weighted average (TWA)

To work out the 8-hour TWA from several samples taken within one 24-hour period:

$$\text{TWA} = (C_1 \times T_1 + C_2 \times T_2 + \ldots + C_n \times T_n) \div 8$$

C is the exposure concentration in each period and T the length of that period in hours.

Example. A worker is exposed to 0.12 mg/m³ for 7 hours 20 minutes and to no contaminant (0 mg/m³) for the remaining 40 minutes of the 8 hours. Converted to hours, 7 h 20 min = 7.33 h and 40 min = 0.67 h.

TWA = (0.12 mg/m³ × 7.33 h + 0 mg/m³ × 0.67 h) ÷ 8 = 0.11 mg/m³

CHAPTER 10

Contacts

Help and advice

Analyt-MTC supplies SKC sampling equipment and helps you choose the pump, sampler and accessories for your task. For help with setting up or calibrating your equipment, contact Analyt-MTC.

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Before you contact Analyt-MTC

Have the following at hand so that Analyt-MTC can help you quickly:

- the substance or dust fraction you need to sample, and the method you work to;
- the pump model and the flowmeter you use;
- for a problem with a sample: the flow rates before and after sampling and what you observed.

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