BEST
PRACTICE
GUIDELINES

Measuring solvent vapour concentrations in the work environment

European Solvents Industry

Hydrocarbon &
Oxygenated Solvents

ESIG

Introduction

A wide range of techniques and equipment are available for measuring solvent vapour concentrations. They can all help in the process of assessing and controlling exposures to solvent vapours in the workplace, but it is essential that the appropriate equipment is selected, that it is used properly and that the results are interpreted correctly.

This guidance note aims to provide some basic information to assist solvent users design simple but effective monitoring programmes.

Why are measurements necessary?

Measurement of airborne solvent vapour concentrations may be required for a number of reasons, including:

- to help assess possible health risks resulting from work activities,
- to assess the effect of changes in materials, procedures or controls,
- to determine compliance with occupational exposure limits (OELs),
- to determine the need for, and the effectiveness of, exposure controls,
- to determine which work tasks give rise to the most exposure,
- to investigate complaints concerning alleged health effects,
- to reassure workers who may be exposed to solvents,
- to comply with specific legal requirements.

Occupational exposure limits

Solvent OELs are vapour concentrations below which workers may be repeatedly exposed, day after day, without adverse health effects.

- OELs generally refer to 8-hour time-weighted average (TWA) concentrations. Some solvents also have short term exposure limits (STELs) which represent the allowable concentration over 10-15 minute periods.

- Excursions above the 8-hour TWA OEL are permissible as long as the TWA concentration over the work shift is within the limit.

- For substances without STELs, it has been suggested that such excursions should not normally exceed 2-5 times the 8-hour TWA OEL, averaged over a 10-15 minute period.

It should be noted that in some countries there are specific regulatory requirements covering compliance with OELs which need to be taken into account when designing a measurement programme.

What measurements should be made?

As the results of measurements may form the basis of significant decisions on possible health risks, compliance with regulations and investment in control measures, it is important that they are undertaken in a structured and meaningful way. The following aspects should be considered:

What components should be measured?

Solvents often constitute one component of a formulated product. Relevant information on the composition of the solvent and the applicable OELs should be provided on the supplier's safety data sheet (SDS). If not, the supplier should be contacted for further information.

Where should measurements be made?

To demonstrate that exposure does not exceed the OEL, the sample collected should be representative of the air which people breathe. For example, a measurement taken very close to a source of vapour is only representative of 'exposure' if people actually work in that location.

How do vapour levels vary?

Generally, solvent vapour levels associated with a particular work activity vary considerably both with location and time; an example exposure pattern is shown in Figure 1. Measurement programmes need to take account of this variation.

What types of measurements can be made?

There are 3 basic types of measurement:

Short term or 'spot' measurements

- These are measurements taken over a short time period (eg. a few minutes) at a single point in the workplace. They give a rough indication of the concentration at a particular time and location and are indicated on Figure 1 by 'x'.

Measurement of average concentration over a given time period

- These measurements, represented by the TWA line shown in Figure 1, are particularly useful for measuring personal exposure by sampling air from the breathing zone of a worker.

The results can be compared directly with OELs.

Continuous measurement of concentration at a single location

- These provide a continuous measure of the concentration at a particular time and location in the workplace as indicated by the continuous line on Figure 1.

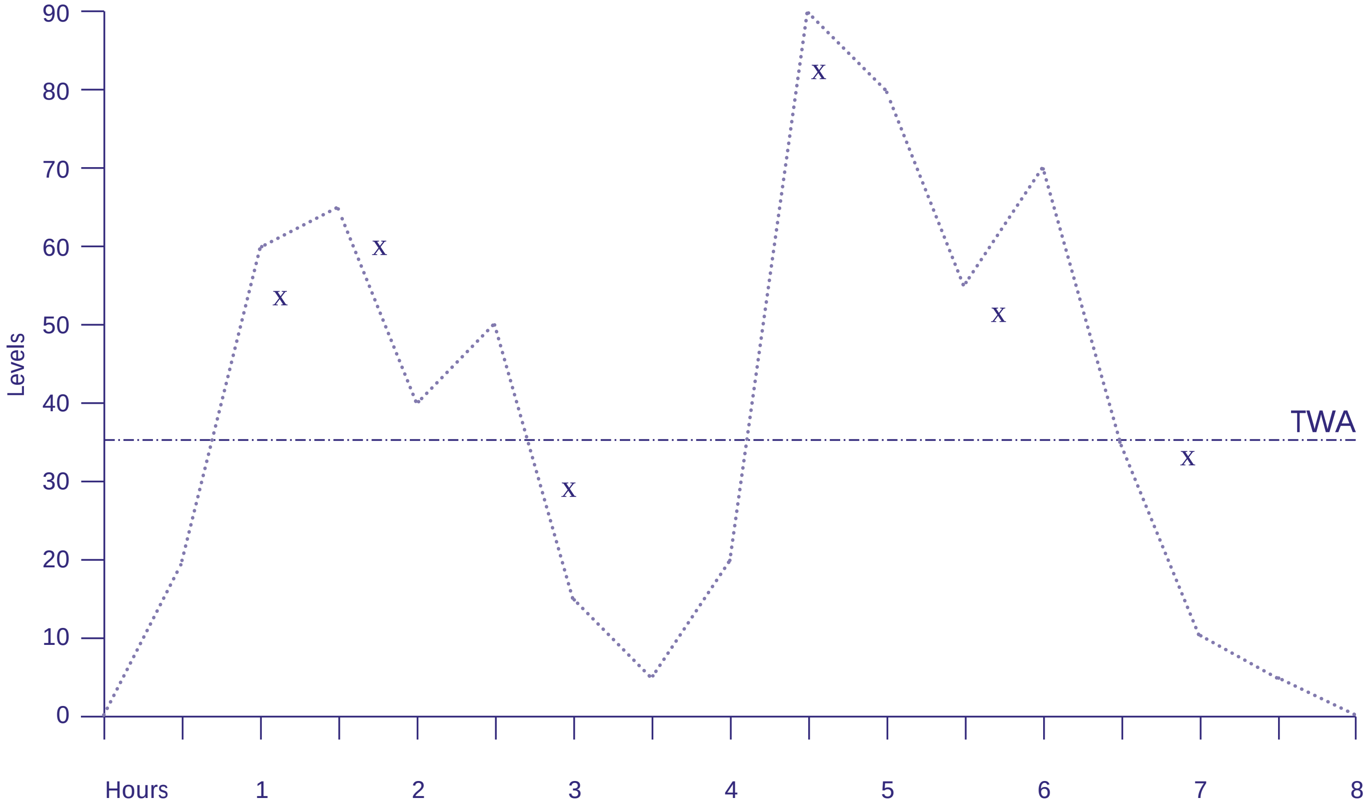
When to measure and how long for?

Measurements for comparison with OELs should be made during the whole period of ‘typical’ work activities during which exposure would be expected to occur. The measurements need to confirm that:

- TWA exposure for the whole work shift is below the OEL,
- exposures during short term tasks are within any short term exposure limits/excursion rules.

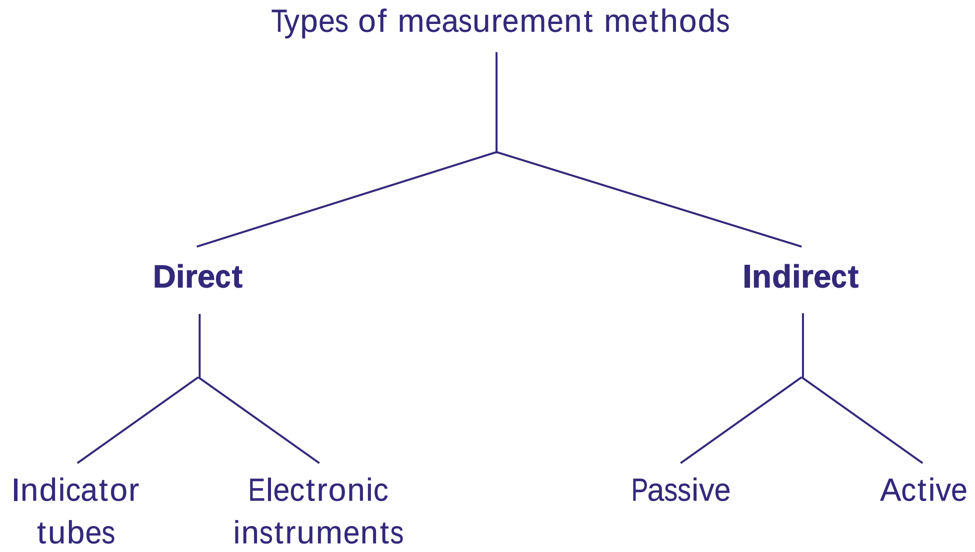
Measurements taken for other reasons, for example to identify vapour emission sources or for confined space entry, are generally taken over much shorter periods using different techniques.

Figure 1



How can measurements be obtained?

Measurement techniques can be broadly subdivided as shown below in Figure 2.



Direct measurements are those which provide the result immediately and range from the relatively simple, for example, chemical indicator tubes, to the more complex, for example, electronic instruments which provide continuous reading of airborne concentrations.

Chemical indicator tubes

These provide a simple, rapid and inexpensive method for evaluating airborne concentrations. A measured volume of air is drawn through the tube using a small hand-held pump. They are available for several specific organic solvents and hydrocarbon mixtures. The length of a coloured stain produced in the tube is related to the concentration of the solvent being measured in the test atmosphere. They are particularly useful for conducting initial screening measurements to determine whether more detailed investigations are required or for periodic checks to confirm that controls remain effective.

Direct reading instruments

A variety of portable, self-contained direct reading instruments are available to measure total solvent vapour concentrations based on techniques such as photo-ionisation detection (PID) or flame ionisation detection (FID). These are useful for tracing sources of emissions and leaks, measuring the solvent vapour levels present, following the movement and dispersal of vapours in air, testing the atmosphere in confined spaces, and so on. They are the method of choice where continuous or repeated measurements are needed and where solvent specificity is not critical. Some of the most recent instruments are not only small enough to fit into a pocket, making them suitable for personal monitoring, but are also specific for individual solvents.

Indirect techniques involve adsorption of the vapour onto a collection media, such as charcoal, and subsequent analysis in the laboratory to provide the average concentration over the sample period.

Active or passive sampling

Such techniques are either ‘active’, in which a small pump is used to draw air through a small tube containing the sorbent, or ‘passive’, in which the sample is collected by natural diffusion. Both are suitable for personal sampling although passive monitoring is particularly convenient as no pump is required. The analysis should be undertaken using validated methods by laboratories meeting appropriate quality control/assurance requirements. These techniques are suitable when initial screening measurements indicate that more detailed/accurate monitoring is required.

Selecting measurement techniques

A number of factors need to be considered prior to selecting an air monitoring technique for any particular application:

- *Specificity* – The ability to uniquely detect one compound in the presence of other contaminants.
- *Accuracy* – Closeness of result to the actual concentration present.
- *Sensitivity* – Quantity of material that must be present to get a response.
- *Cost* – The expense associated with the purchase of equipment or supplies, as well as any associated laboratory analysis costs for indirect methods.
- *Ease of use* – How much training is required to accurately conduct the test and how difficult is it to operate the associated equipment?
- *Calibration* – What checks are required to verify that an electronic instrument is performing acceptably at the concentration(s) of interest?
- *Interferences* – Will the techniques react to substances other than the compound of interest (cause a colour change or give a meter response). Interferents may cause an overestimation or underestimation of the amount of material present in the air.
- *TWA exposure* – The concentration of contaminants can vary significantly from minute to minute over the course of a day; is the average exposure required for comparison with OELs?
- *Size* – Important for personal monitoring where the equipment is attached to the individual.
- *Warning alarms* – For direct reading electronic devices, an audible/visual warning may be desirable to alert personnel that higher than acceptable concentrations are present.

All these techniques have their applications, advantages and disadvantages as described in Figure 3.

Applications advantages and disadvantages of measurement techniques

TECHNIQUE	APPLICATIONS	ADVANTAGES	DISADVANTAGES
DIRECT – INDICATOR TUBES	Confined space entry Initial/screening investigations Identifying high exposure tasks	Easy to use Immediate results Low cost	Colour change sometimes difficult to read Many interferents Low level of accuracy (eg. ± 35%) Do not measure TWA exposure
DIRECT – ELECTRONIC INSTRUMENTS	Confined space entry Identifying emission sources Determining variations in exposures Identifying high exposure tasks	Easy to use Immediate results More accurate than detector tubes Warning alarms available	Many interferents possible Expensive Datalogging facility required for TWA determination Require frequent calibration
INDIRECT – ACTIVE SAMPLING	Detailed monitoring programmes Personal monitoring Area monitoring Characterization of contaminants present	Accurate Able to measure individual components present Can determine 10-15 min and 8-hr TWA exposures Small/lightweight	Results not immediately available Validated method required Laboratory analysis cost per sample Requires pump calibration before and after sampling
INDIRECT – PASSIVE SAMPLING	Detailed monitoring programmes Personal monitoring Area monitoring Characterization of contaminants present	Easy to use Very small/lightweight (no pump required) Accurate Able to measure individual components present Can determine 8-hr TWA exposure	Results not immediately available Validated method required Laboratory analysis cost per sample Cannot determine short term (10-15 min) exposures Limitations on use for mixtures

How should the results be interpreted and used?

All work activities should be subject to periodic risk assessment which aims to identify hazards and confirm that appropriate control measures are in place to ensure that the activity is safe. Where volatile materials such as solvents are involved, measurement of vapour levels may be a necessary part of the risk assessment.

Numerical results should be supported by, and interpreted in light of, other information, such as:
- the presence/performance of ventilation systems,
- observations of work procedures,
- views/experience of those conducting the work,
- good custom and practice within the industry.

Figure 4 outlines an approach to the use of measurement results in support of the health risk assessment process. It suggests that initial screening measurements can be made using relatively unsophisticated techniques, such as chemical indicator tubes. If the results are markedly above or below the OEL, immediate conclusions can usually be drawn. If the results are close to the OEL, more detailed/accurate measurements may be necessary.

Consideration of the results of exposure measurements should lead to answers to the following questions:
- is immediate action necessary to eliminate or reduce exposure?
- is a programme of planned improvements necessary?
- are more detailed measurements required?

Most national health and safety regulations include requirements to keep exposure to hazardous substances within OELs. In some cases, there is also a requirement to reduce exposure ‘as far as is reasonably practicable’, that is to say, where the cost of additional controls is reasonable in relation to the reduction in risk they can achieve.

Exposure control options

A range of possible approaches are available to minimise solvent exposure in the workplace:

- process design – to minimise vapour release, spills and solvent loss,
- workplace arrangement – to segregate areas with higher vapour levels and minimise the number of people exposed,
- local exhaust ventilation – to remove vapour close to its point of release,
- general or dilution ventilation – to adequately dilute released vapours and directed so as to carry vapour away from working areas,
- procedures – to minimise vapour production and release.

Effective control of vapour can have cost-saving benefits such as reducing solvent usage and wastage, reducing waste solvent disposal costs and reducing time spent on cleaning up spills. Exposure to vapour can be reduced by the use of respiratory protective equipment (RPE). This is normally regarded as the least preferable choice and is only acceptable where vapour control systems are unable to provide adequate levels of health protection, or as a temporary measure while control systems are being installed. Respiratory protection is commonly used for maintenance work or emergency situations such as spills.

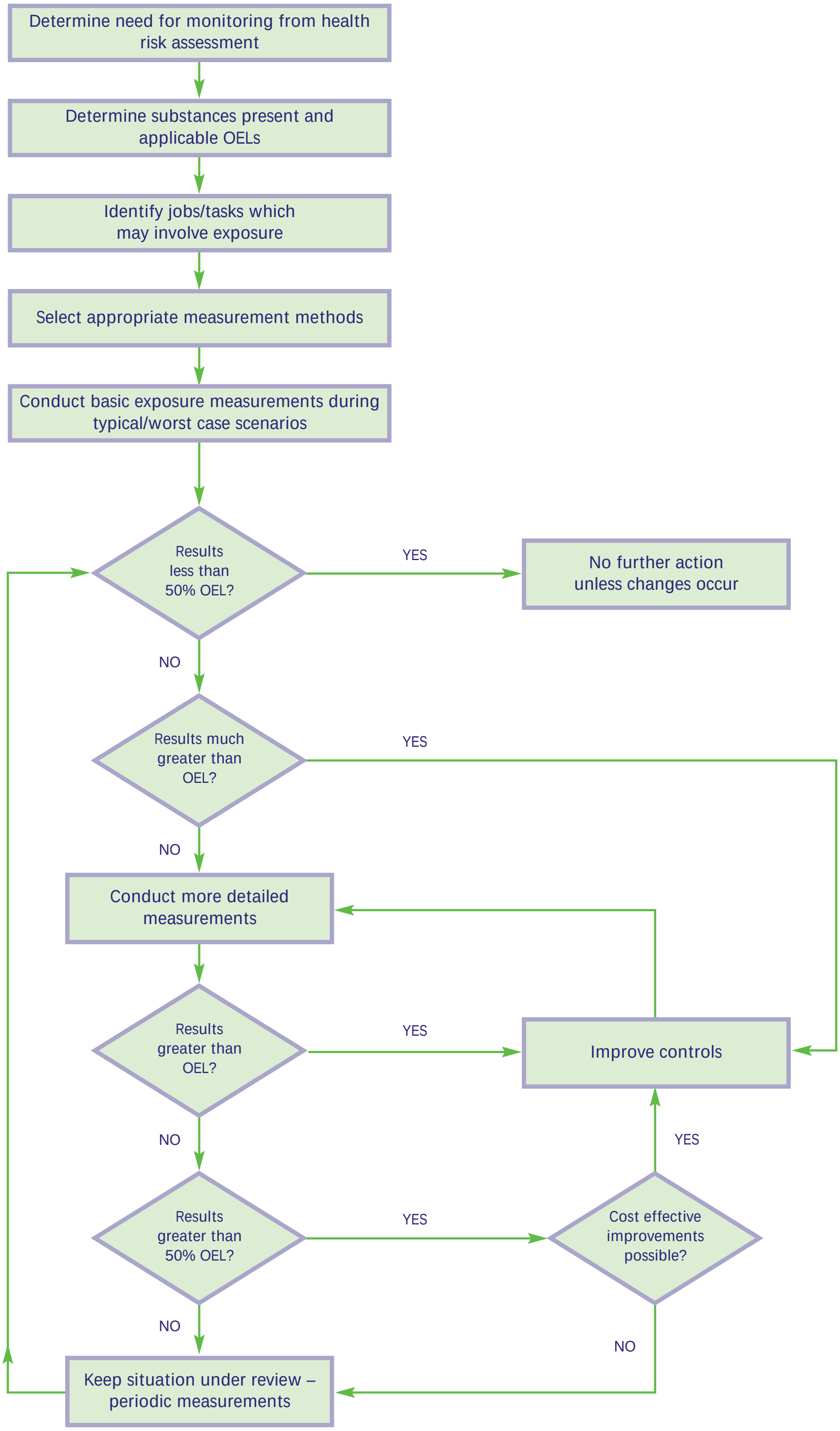
It should be appreciated that RPE may not give completely effective protection, and its use requires a formal programme of equipment selection, training and maintenance.

Absorption of solvents via skin contact can be prevented by impermeable protective clothing such as chemical resistant gloves.

Frequency of sampling

The frequency of periodic measurements depends upon the level of exposure. Typically, low sampling frequencies (for example, once a year) can be applied where exposures are well below OELs, and where workplace conditions are stable and predictable. On the other hand, more frequent sampling (for example, once a month or more) may be desirable where exposures are nearer OEL levels, and where workplace conditions which give rise to exposures are unstable and unpredictable.

Interpretation of measurement results



What are the key messages?

A wide range of techniques and equipment are available for measuring solvent vapour concentrations. They can all help in the process of assessing and controlling exposures to solvent vapours in the workplace, but it is essential that the appropriate equipment is selected, that it is used properly and that the results are interpreted correctly.

Some key DO's and DO NOT's are listed to assist this process:

✓ DO

✓ DO use simple direct reading techniques to determine approximate concentrations of contaminants in work areas and identify priorities for more detailed investigations.

✓ DO ensure that those conducting measurements have received sufficient training to understand the capabilities and limitations of the techniques used.

✓ DO use techniques which provide data representative of personal exposure, for eaxmple, where the air is collected from as near the mouth/nose (breathing zone) as possible, when collecting data to determine compliance with OELs.

✓ DO repeat measurements if significant changes occur to materials, processes or work patterns.

✓ DO seek advice from suppliers or qualified consultants if additional information is needed to make decisions.

✗ DO NOT

✗ DO NOT base exposure control investment decisions on a few direct reading measurements taken very close to the source of the vapour unless the results really reflect the concentrations workers are being exposed to.

✗ DO NOT allow suggestions for "further measurements" to delay the introduction of improved controls, when it is clear that these are necessary.

✗ DO NOT assume that expensive electronic instruments have to be used; simple, inexpensive techniques are often adequate.

✗ DO NOT forget that help and advice is available from solvent suppliers and equipment manufacturers.

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