INTERNATIONAL STANDARD

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Health and safety in welding and allied processes — Sampling of airborne particles and gases in the operator's breathing zone —

Part 1: Sampling of airborne particles

Hygiène et sécurité en soudage et techniques connexes — Échantillonnage de particules en suspension et gaz dans la zone respiratoire des opérateurs —

Partie 1: Échantillonnage des particules en suspension

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Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this part of ISO 10882 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 10882-1 was prepared by the European Committee for Standardization (CEN) in collaboration with ISO Technical Committee TC 44, *Welding and allied processes*, Subcommittee SC 9, *Health and security*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

Throughout the text of this standard, read "...this European Standard..." to mean "...this International Standard...".

ISO 10882 consists of the following parts, under the general title *Health and safety in welding and allied processes — Sampling of airborne particles and gases in the operator's breathing zone*:

— *Part 1: Sampling of airborne particles*

— *Part 2: Sampling of gases*

Annexes A to E of this part of ISO 10882 are for information only.

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Foreword

The text of EN ISO 10882-1:2001 has been prepared by Technical Committee CEN/TC 121 "Welding", the secretariat of which is held by DS**,** in collaboration with Technical Committee ISO/TC 44 "Welding and allied processes".

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by July 2001, and conflicting national standards shall be withdrawn at the latest by July 2001**.**

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

This part of EN ISO 10882 gives details of relevant European Standards which specify required characteristics, performance requirements and test methods; augments guidance provided in EN 689 on assessment strategy and measurement strategy; specifies a procedure for gravimetric determination of personal exposure to welding fume; and provides information about the use of chemical analysis to determine personal exposure to specific chemical agents in welding fume.

A person who performs welding and allied processes (the operator) can be exposed to welding fume and to other airborne particles generated by welding related operations, e.g. grinding. In some instances exposure to other airborne particles can be higher than exposure to welding fume. It is therefore necessary to carefully consider this possibility when using the method described in this standard.

Welding fume consists of airborne particles generated by welding and allied processes. In general, these particles are less than 1 µm in diameter, and respirable. However, most countries currently have exposure limits for welding fume, and for specific chemical agents present in welding fume, that apply to the inhalable fraction of airborne particles. This part of EN ISO 10882 therefore specifies a procedure for sampling the inhalable fraction, but the respirable fraction should be sampled in cases where exposure limits apply to that fraction.

It has been assumed in the drafting of this standard that the execution of its provisions, and the interpretation of the results obtained, is entrusted to appropriately qualified and experienced people.

1 Scope

This part of EN ISO 10882 specifies a procedure for personal sampling of airborne particles in welding and allied processes.

The procedure describes determination of personal exposure to welding fume and other airborne particles generated by welding related operations.

The general background level of airborne particles in the workplace atmosphere influences personal exposure, and therefore the role of fixed point sampling is also considered.

Guidance is given on the use of chemical analysis to determine personal exposure to specific chemical agents present in welding fume, but analytical methods are not described.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 175, *Personal protection — Equipment for eye and face protection during welding and allied processes*

EN 481:1993, *Workplace atmospheres — Size fraction definitions for measurement of airborne particles*

EN 482, *Workplace atmospheres — General requirements for the performance of procedures for the measurement of chemical agents*

EN 689, *Workplace atmospheres — Guidance for the assessment of exposure by inhalation to chemical agents for comparison with limit values and measurement strategy*

EN 1232, *Workplace atmospheres — Pumps for personal sampling of chemical agents — Requirements and test methods*

EN 1540, *Workplace atmospheres — Terminology*

EN ISO 4063, *Welding and allied processes — Nomenclature of processes and reference numbers*

prEN 13205:1998, *Workplace atmospheres - Assessment of performance of instruments for measurement of airborne particle concentrations*

ISO 3534-1, *Statistics — Vocabulary and symbols — Part 1: Probability and general statistical terms*

ISO 6879, *Air quality — Performance characteristics and related concepts for air quality measuring methods*

3 Terms and definitions

For the purposes of this standard, the following terms and definitions apply:

3.1
air sampling
a process consisting of the collection, withdrawal or isolation of a fractional part of a larger volume of air. It can include the simultaneous isolation of selected components. (EN 1540)

3.2
bias
consistent deviation of the measured value from the value of the air quality characteristic itself or the accepted reference value. (ISO 6879)

3.3
breathing zone
the space around the worker's face from where he takes his breath. For technical purposes a more precise definition is as follows: hemisphere (generally accepted to be 0,3 m in radius) extending in front of the human face, centered on a mid point of a line joining the ears; the base of the hemisphere is a plane through this line, the top of the head and the larynx. The definition is not applicable when respiratory protective equipment is used. (EN 1540)

NOTE This definition is not strictly applicable when a welder's face shield is used. In such circumstances the breathing zone should be considered to extend only behind the welder's face shield.

3.4
chemical agent
any chemical, pure or mixed, produced by welding and allied processes or welding related operations.

3.5
exposure (by inhalation)
a situation in which a chemical or biological agent is present in air which is inhaled by a person. (EN 1540)

3.6
filler material
consumables added during the welding process to form the weld, i.e. welding rods, wire, stick electrodes etc.

3.7
harness
an assembly that provides a means of maintaining a welder's face shield in position on the head. (EN 175)

3.8
headband
that part of the harness to which the welder's face shield is fixed and which surrounds the head, or that part of the welder's goggles or welder's spectacles which secures the goggles or spectacles onto the head. (EN 175)

3.9
inhalable fraction
the mass fraction of total airborne particles which is inhaled through the nose and mouth. (EN 481)

NOTE The inhalable fraction depends on the speed and direction of the air movement, on breathing rate and other factors.

3.10
limit value
reference figure for concentration of a chemical or biological agent in air. (EN 1540)

3.11
operator
a person who performs welding and allied processes.

3.12
overall uncertainty (of a measuring procedure or of an instrument)
quantity used to characterise as a whole the uncertainty of a result given by an apparatus or measuring procedure. It is expressed, as percentage, by a combination of bias and precision, usually according to the formula:

$$\frac{\left|\bar{x} - x_{ref}\right| + 2s}{x_{ref}} \times 100$$

where:

$\bar{x}$ is the mean value of results of a number (n) of repeated measurements;

x_{ref} is the true or accepted reference value of concentration;

S is the standard deviation of measurements. (EN 482)

3.13
personal sampler
a device attached to a person that samples air in the breathing zone. (EN 689)

3.14
personal sampling
the process of air sampling carried out using a personal sampler. (EN 1540)

3.15
precision
the closeness of agreement between independent test results obtained under stipulated conditions. (ISO 6879)

3.16
reference period
the specified period of time stated for the limit value of a specific chemical or biological agent. (EN 1540)

3.17
respirable fraction
the mass fraction of inhalable particles penetrating to the unciliated airways. (EN 481)

3.18
sampler
a device for air sampling.

3.19
screening measurements of time-weighted average concentration
measurements performed to obtain relatively crude information on the exposure level in order to decide whether an exposure problem exists at all and if so to appraise its possible seriousness. They can also be used to determine if the exposure is well below or well above the limit value.

3.20
screening measurements of variation of concentration in time/and or space
measurements performed to provide information on the likely pattern of concentration of chemical agents. They can be used to identify locations and periods of elevated exposure and to set the duration and frequency of sampling for measurements for comparison with limit values. Emission sources can be located and the effectiveness of ventilation or other technical measures can be estimated.

3.21
suspended matter
particles that remain airborne long enough to be detected by any physical means. (EN 1540)

3.22
time-weighted average (TWA) concentration
the concentration of a chemical agent in the atmosphere, averaged over the reference period.

3.23
total airborne particles
all particles surrounded by air in a given volume of air. (EN 481)

3.24
true value
the value which characterises a quantity perfectly defined in the conditions which exist at the moment when that quantity is considered. (ISO 3534-1)

NOTE The true value of a quantity is a theoretical concept and, in general, cannot be known exactly. (EN 1540)

3.25
welder's face shield
a welder's shield worn on the head and in front of the face, usually secured in position by a harness to give protection to the eyes and face when fitted with the appropriate filter(s). (EN 175)

3.26
welder's goggles
a device, held in position usually by a headband, enclosing the orbital cavity, into which radiation arising from welding and allied processes can penetrate only through filter(s) and, where provided, filter cover(s). (EN 175)

3.27
welder's hand shield
a welder's shield held in the hand to give protection to the eyes and face when fitted with the appropriate filter(s). (EN 175)

3.28
welder's spectacles
a frame, with lateral protection, holding suitable filters in front of the eyes, to give them protection.

NOTE It may be held in position with sidearms or a headband fitting. (EN 175)

3.29
welding (and allied processes)
thermal processes used to join, cut, surface or remove metals, but excluding low temperature processes such as soldering.

3.30
welding episode
a period during which the operator carries out welding and allied processes. For practical purposes this may include welding related operations, except when these generate a significant quantity of airborne particles e.g. during lengthy periods of grinding.

3.31
welding fume
airborne particles generated during welding episodes.

3.32
welding protector
a device which provides protection to the wearer against harmful optical radiation and other specific hazards generated by welding and allied processes.

NOTE: It may be a welder's shield, welder's goggles or welder's spectacles. (EN 175)

3.33
welding related operations
operations other than welding and allied processes carried out by the operator.

3.34
work pattern
the sequence of activities carried out by the worker during the period under consideration. (EN 1540)

3.35
workplace
the defined area or areas in which the work activities are carried out. (EN 689)

3.36
worst case measurements
screening measurements of time-weighted average concentration made to identify work activity during which highest exposure occurs.

4 Principle

Welding fume is collected by drawing a known volume of air through a preweighed filter or filter cassette, mounted in a sampler designed to collect the inhalable fraction of airborne particles (or the respirable fraction of airborne particles, if appropriate - see the introduction). For personal sampling, the sampler is positioned in the operator's breathing zone, which is inside the welder's face shield, when one is worn. It will be necessary for the operator to wear special apparatus that enables the sampler to be maintained in position in the breathing zone throughout the sampling period without impeding normal work activity.

At the end of the sampling period, the mass of welding fume collected is determined by reweighing the filter or filter cassette. The mass concentration of welding fume in air is calculated by dividing this by the volume of air sampled.

Exposure to specific chemical agents in welding fume may be determined by chemical analysis of the sample. Alternatively, it may be estimated from the mass concentration of welding fume in air using fume analysis data for filler materials, e.g. from fume analysis data sheets.

5 Requirement

Procedures used for assessment of personal exposure to welding fume and other airborne particles generated by welding related operations shall comply with the provisions of EN 482.

6 Equipment

6.1 Sampling equipment

6.1.1 Samplers

The samplers used shall collect the inhalable fraction of airborne particles, as defined in EN 481. They shall comply with the provisions of prEN 13205:1998 and shall be compatible with the filters (6.1.2) and the sampling pumps (6.1.3) used.

If chemical analysis of welding fume is to be carried out (see 10.1) the samplers used shall not be constructed from material which could influence the analytical result.

NOTE 1 If measurements are made for comparison with an exposure limit which applies to the respirable fraction of airborne particles, as defined in EN 481, a sampler that collects that fraction should be used.

NOTE 2 A number of different terms are used to describe samplers designed for collection of the inhalable fraction of airborne particles e.g. sampling heads, filter holders, filter cassettes and air monitoring cassettes.

NOTE 3 In general, the collection characteristics of aerosol samplers are such that particulate matter collected on the filter constitutes the sample, and any particulate matter deposited on the internal surfaces of the sampler is not of interest. The filter is removed from such samplers for weighing. However, some samplers are designed such that airborne particles which pass through the entry orifice(s) constitute the sample, in which case this includes particulate matter deposited on the internal surfaces of the sampler. In most cases, such samplers incorporate an internal filter cassette or cartridge which is removed from the sampler for weighing.

NOTE 4 Samplers manufactured in non-conducting material have electrostatic properties which can influence representative sampling. Electrostatic influences should be reduced, where possible, by using samplers manufactured from conducting material.

NOTE 5 In general, personal samplers for collection of the inhalable fraction of airborne particles do not exhibit the same size selective characteristics if used for fixed point sampling.

NOTE 6 Personal samplers that separately determine the respirable and inhalable fractions of airborne particles could be useful to distinguish between exposure to submicron particles generated by welding and allied processes and larger particles generated by welding related operations. If such samplers become available their use would be an alternative to collection of separate samples to discriminate between welding fume and other airborne particles, as advocated in 8.4.3.2.

6.1.2 Filters

The filters used shall be of a diameter suitable for use in the selected sampler (6.1.1), and shall meet the following requirements:

a) The filters shall have a retentivity not less than 99,5 % for particles with a 0,3 µm diffusion diameter (see note to 2.2 of EN 481:1993);

b) The filters shall be suitable for use in the gravimetric method described. In particular, they shall be sufficiently resistant to moisture retention and shall not be excessively friable;

c) If chemical analysis of the sample is to be carried out, the filters shall not be of a type that can react with the chemical agents to be determined and shall be compatible with the analytical method.

6.1.3 Sampling pumps

The sampling pumps used shall comply with the provisions of EN 1232. They shall have an adjustable flow rate, incorporate a flowmeter or a flow fault indicator, and be capable of maintaining the required flow rate to within ± 5 % of the nominal value throughout the sampling period. For personal sampling the pumps shall be capable of being worn without impeding the operator's normal work activity. The pumps shall give a pulsation-free flow (if necessary a pulsation damper shall be incorporated between the sampler and the pump, as near to the pump as possible).

NOTE Flow-stabilised sampling pumps might be required to maintain the flow rate within the limits specified in 6.1.3.

6.1.4 Flowmeter

The flowmeter used shall be portable, capable of measuring the flow rate (see 9.2.3) to within ± 5 %, and calibrated against a primary standard i.e. a flowmeter whose accuracy is traceable to national standards.

NOTE 1 The flowmeter incorporated in the sampling pump should not be used unless it has been shown to have adequate sensitivity, has been calibrated against a primary standard with a loaded sampler in line, and is read whilst in a vertical orientation if it is of the supported float type. If such a flowmeter is used, it is particularly important to ensure that there are no leaks in the sampling train between the sampler and the flowmeter, since in this event a flowmeter in the sampling pump or elsewhere in line will give an erroneous flow rate.

NOTE 2 A soap bubble flowmeter may be used as a primary standard, provided its accuracy is traceable to national standards.

NOTE 3 If appropriate (see 9.2.4.2), the atmospheric temperature and pressure at which the flowmeter was calibrated should be recorded.

6.1.5 Ancillary equipment

A variety of ancillary equipment is required including

— flexible tubing, which shall be of a diameter suitable for making a leakproof connection from the samplers (6.1.1) to the sampling pumps (6.1.3);

— belts, to which the sampling pumps can conveniently be attached, unless they are small enough to fit in the operator's pockets;

— flat-tipped tweezers for loading and unloading filters into samplers; and

— filter transport cassettes or other suitable containers, to hold filters or filter cassettes while filters are conditioned (see 9.1.2) and for transport of samples to the weighing room.

6.1.6 Thermometer

A thermometer is required for measurement of atmospheric temperature (see 9.2.4).

It shall be capable of reading from 0 ^{o}C to 50 ^{o}C and shall be graduated in divisions of 1^{o}C or better.

6.1.7 Barometer

A barometer is required for measurement of atmospheric pressure (see 9.2.4).

6.2 Weighing apparatus

6.2.1 Analytical balance

The analytical balance shall be capable of weighing to ± 0,01 mg, able to accommodate the diameter of filter used, and calibrated with weights traceable to national standards. The balance shall be set up and operated according to the manufacturer's instructions, and its calibration shall be checked before use by means of a test weight.

6.2.2 Electrostatic charge neutraliser

An electrostatic charge neutralising device is required to dissipate electrostatic charge on the filters during weighing. If a radioactive source is used, its recommended useful life shall be observed, and national legislation dealing with maintenance, monitoring and disposal of the source shall be complied with.

7 Assessment strategy

EN 689 gives guidance for the assessment of exposure by inhalation to chemical agents in workplace atmospheres. The generalised assessment strategy it describes shall be observed. This could involve (i) an initial appraisal of the likelihood of exposure to welding fume and the chemical agents present in it, e.g. by using known information about the process and workplace factors; (ii) a basic survey to provide quantitative information about likely exposure, e.g. by using existing exposure data from comparable processes; and (iii) a more detailed survey involving workplace measurements.

8 Measurement strategy

8.1 General

EN 689 shall be referred to for generalised guidance on measurement strategy.

It highlights the need to take an approach which makes the most efficient use of resources by making full use of screening measurements and worst case measurements when it is suspected that exposure levels are well below or above the limit values. The following guidance, specific for measurement of personal exposure to welding fume and other airborne particles generated by welding related operations, is given to supplement that given in EN 689.

8.2 Personal exposure measurement

Personal sampling shall take place behind welders face shields, if used.

NOTE 1 The highest concentration of welding fume usually occurs in the immediate vicinity of the operator and it is therefore essential that personal exposure measurement is performed in the operator's breathing zone.

Welders' face shields can provide some degree of protection from exposure by physically deflecting the welding plume away from the breathing zone.

NOTE 2 It will usually be necessary for the operator to wear special apparatus that enables the sampler to be maintained in position in the breathing zone throughout the sampling period without impeding normal work activity.

8.3 Fixed point measurements

Fixed point measurements may be carried out, if appropriate.

NOTE Fixed point measurements can be used to characterise the background level of airborne particles in the workplace. They can also be useful for assessment of the exposure to welding fume of persons in adjacent locations or in overhead cranes, and they can give an indication of the efficiency of ventilation.

8.4 Selection of measurement conditions and measurement pattern

8.4.1 General

The sampling procedure shall be devised to cause the least possible interference with the operator and the normal performance of his job and to provide samples that are representative of his normal working conditions and that are compatible with subsequent methods of analysis.

The pattern of measurement shall take into consideration practical issues, such as the frequency and duration of welding episodes, and the nature of the measurement task.

NOTE Personal exposure to welding fume is very variable over a single work period. The pattern of exposure depends on the nature of the job and its location, the use of hygiene controls, the work technique of the operator and the work pattern. Many of these variables are subject to the control of the operator and sampling strategies designed to assess the exposure of one individual operator as representative of a group carrying out similar work are not appropriate. Every operator should therefore be the subject of a separate assessment, which does not necessarily imply a separate measurement.

8.4.2 Screening measurements of time-weighted average concentration and worst case measurements

Screening measurements of time-weighted average concentration may be carried out during representative welding episodes in the initial stages of a survey to obtain clear information about the level and pattern of exposure.

Worst case measurements may also be carried out. If the results of such measurements show that the concentration of welding fume is significantly below the exposure limit value, this indicates that there is adequate control and measurements of time-weighted average concentration for comparison with limit values are not necessary.

If results indicate that the concentration of welding fume is significantly above the exposure limit value, control measures are inadequate. In such instances, control measures in place shall be reviewed and measurements shall be repeated after improvements have been made.

NOTE: The margins above and below the exposure limit value which are acceptable will depend upon relevant national regulatory requirements and/or practice.

8.4.3 Measurements for comparison with limit values and periodic measurements

8.4.3.1 Short term measurements

When appropriate, measurements for comparison with short term limit values and associated periodic measurements shall be made over a sampling period equal to the reference period, which is normally 15 min or less (see Annex E for minimum sampling time).

NOTE No short term limit values have been set for welding fume, but short term limit values for chemical agents present in welding fume can be applicable.

8.4.3.2 Measurements of time-weighted average concentration

Measurements shall be made during a number of representative welding episodes throughout the work period (see Annex E for minimum sampling time). Sampling shall be discontinued during episodes when there is a potential for significant exposure to other airborne particles, but in most cases a complete shift can be regarded as a single welding episode. A single filter shall be used to collect the sample when measurements are made for more than

one welding episode, but at least one filter shall be used per day. However, multiple samples shall be taken if the concentration of welding fume appears to be so high that there is a risk of overloading the filter.

NOTE 1: The best estimates of time-weighted average concentrations are obtained by taking breathing zone samples over the entire working period. However, personal exposure to welding fume is intermittent, and it is sometimes possible to separately identify work episodes in which an operator is exposed to welding fume and work episodes in which exposure is predominantly to other airborne particles e.g. dust generated in prolonged grinding operations. In such circumstances it is desirable to discontinue sampling between welding episodes, in order that exposure to welding fume can be discriminated from exposure to other airborne particles. This is essential if fume analysis data for filler materials is to be used to estimate the concentration of specific chemical agents (see 10.2).

NOTE 2: Additional samples may be collected between welding episodes if during such periods the operator is exposed to other airborne particles which contain specific chemical agents of occupational hygienic significance.

9 Procedure

9.1 Handling and conditioning of filters

9.1.1 Handling of filters

Handle the filters only in a clean environment. Use flat-tipped tweezers to reduce the possibility of perforation.

9.1.2 Conditioning of filters

Before weighing filters or loaded filter cassettes, allow the moisture content of the filters to equilibrate with the air in the weighing room by conditioning for a suitable period, e.g. overnight (see Annex E). Expose the filters in such a manner that contamination of the filter is avoided, e.g. place filters in individual, clean, labelled filter transport cassettes (see 6.1.5) with the lids ajar.

9.1.3 Dissipation of electrostatic charge

If the filters used are susceptible to the accumulation of electrostatic charge, e.g. membrane filters, use an electrostatic charge neutraliser to dissipate the charge on the filters before each weighing.

9.1.4 Handling of internal filter cassettes

Do not use bare hands to handle filter cassettes that will be weighed.

9.2 Preparation for sampling

9.2.1 Cleaning of samplers

Unless disposable filter cassettes are used, clean the samplers (6.1.1) before use. Disassemble the samplers, soak in detergent solution, rinse thoroughly with water, wipe with absorptive tissue and allow to dry before reassembly. Alternatively, use a laboratory washing machine.

9.2.2 Preweighing

9.2.2.1 Filters

For samplers that collect the inhalable fraction of airborne particles on the filter (see 6.1.1 note 2) and samplers of the disposable cassette type, weigh the required number of filters following the instructions given in 9.1 on handling and conditioning. Record the weight, and load the preweighed filters into clean, labelled samplers. Seal each sampler with its protective cover or plug to prevent contamination during transport. Retain the labelled filter transport cassettes in which the filters were conditioned (see 9.1.2) for use after sampling (see 9.5.1). If extra filters are required for collection of additional samples, preweigh these and place in separate, labelled, filter transport cassettes (6.1.5) to protect them from damage in transit.

9.2.2.2 Filter cassettes

For samplers that incorporate an internal filter cassette or cartridge designed to be removed for weighing (see 6.1.1 note 2), load the required number of filters (6.1.2) into labelled filter cassettes and weigh each loaded cassette following the instructions given in 9.1 on handling and conditioning.

Record the weight, and install the preweighed and loaded filter cassette in a sampler. Label each sampler with the same identification as the filter cassette installed in it. Seal each sampler with its protective cover or plug to prevent contamination during transport. If spare filter cassettes are required for collection of additional samples, preweigh these and fasten with the transport clips supplied by the manufacturer.

9.2.2.3 Blanks

Retain, as blanks, one unused preweighed filter or loaded filter cassette from each batch of ten weighed, subject to a minimum of three. Treat these in the same manner as those used for sampling in respect of storage and transport from and to the weighing room, but draw no air through the filters.

9.2.3 Selection of flow rate

Use the samplers (6.1.1) at the design flow rate, so that they collect the inhalable fraction of airborne particles, as defined in EN 481.

9.2.4 Consideration of temperature and pressure effects

9.2.4.1 Consider whether it is necessary to recalculate the concentration of welding fume or specific chemical agents in air to reference conditions. If so, measure and record the atmospheric temperature and pressure throughout the sampling period (see 9.4.1, 9.4.2 and 9.4.4) and use the equation given in 9.6.5 to apply the necessary correction.

NOTE The concentration of welding fume or specific chemical agents in air is generally stated for the actual environmental conditions (temperature, pressure) at the workplace.

9.2.4.2 Refer to the manufacturer's literature to determine if the indicated flow rate of the flowmeter used is dependent upon temperature and pressure. Consider whether the difference between the atmospheric temperature and pressure at the time of calibration of the flowmeter and during sampling is likely to be great enough to justify making a correction to take this into account e.g. if the error could be greater than ± 5 %. If a correction is necessary, measure and record the atmospheric temperature and pressure at which the flowmeter (6.1.4) was calibrated and measure and record the atmospheric temperature and pressure throughout the sampling period (see 9.4.1, 9.4.2 and 9.4.4).

NOTE An example of temperature and pressure correction for the indicated flow rate is given in 9.6.4, for a constant pressure drop, variable area, flowmeter.

9.2.5 Setting of flow rate

Perform the following in a clean area, where the concentration of airborne particles is low:

Connect each loaded sampler (see 9.2.2) to a sampling pump (6.1.3) using flexible tubing (6.1.5), ensuring that no leaks can occur.

Remove the protective cover or plug from each sampler, switch on the sampling pump, attach the calibrated flowmeter (6.1.4) to the sampler so that it measures the flow through the sampler inlet orifice(s), and set the flow rate (see 9.2.3) with an accuracy of ± 5 %. Switch off the sampling pump and seal the sampler with its protective cover or plug to prevent contamination during transport to the sampling position.

9.3 Sampling position

9.3.1 Personal sampling position

9.3.1.1 If a welder's face shield is used, position the sampler in the operator's breathing zone, preferably adjacent to the operator's nose and mouth, at mouth level, a maximum distance of 50 mm to the right or left of the mouth, and in a horizontal orientation with the sampler inlet facing forwards. See Annex A for examples of arrangements for mounting a sampler behind a welder's face shield.

NOTE Sampling inside an air-fed welder's face shield can be useful to confirm that it is functioning correctly.

9.3.1.2 If an alternative welding protector is used, e.g. a welder's hand shield, position the sampler in the breathing zone, as close as possible to the operator's nose and mouth. An example of an arrangement for mounting the sampler in such a position is given in figure A.3.2.

NOTE For some processes it is not necessary to make special arrangements to mount the sampler as close as possible to the operator's nose and mouth, i.e. the sampler may be placed on the lapel (see Annex B).

9.3.1.3 Place the sampling pump in a convenient pocket or attach it to the operator in a manner that causes minimum inconvenience e.g. to a belt around the waist (6.1.5).

9.3.2 Fixed point sampling position

If fixed point sampling to determine the general background level of welding fume in the workplace atmosphere is to be carried out (see 8.3), select a suitable sampling position that is sufficiently remote from welding and allied processes, such that results are not directly affected by sources of welding fume or other airborne particles. Take into consideration all workplace parameters, e.g. ventilation, local circumstances, etc.

9.4 Sampling

9.4.1 Record the time at the start of the sampling period, and if the sampling pump has an elapsed time indicator, set this to zero.

If appropriate (see 9.2.4), measure the atmospheric temperature and pressure at the start of the sampling period using the thermometer (6.1.6) and barometer (6.1.7). Record the measured values.

9.4.2 Monitor the performance of the sampler frequently, a minimum of once per hour. Check that the tubes connecting the sampling pump to the sampler are still in place and measure the flow rate with an accuracy of ± 5 % using the calibrated flowmeter (6.1.4). If appropriate (see 9.2.4), measure the atmospheric temperature and pressure using the thermometer (6.1.6) and barometer (6.1.7). Record the measured values.

NOTE Regular observation of the flow fault indicator is an acceptable means of ensuring that the flow rate of a flow-stabilised sampling pump is maintained satisfactorily, provided that the flow fault indicator indicates malfunction when the flow rate is outside ± 5 % of the nominal value.

9.4.3 Terminate sampling if the flow rate is not maintained to within ± 5 % of the nominal value. Consider the sample to be invalid if the maximum error possible in the calculated volume of air sampled (see 9.4.6) is greater than ± 5 %.

9.4.4 At the end of the sampling period (see 8.4.3), measure the flow rate with an accuracy of ± 5 % using the calibrated flowmeter (6.1.4). Record the flow rate and the time, and calculate the duration of the sampling period. Observe the reading on the elapsed time indicator, if fitted, and consider the sample to be invalid if this and the calculated sampling duration do not agree to within ± 5 %, since this suggests that the sampling pump has not been operating throughout the sampling period. If appropriate (see 9.2.4), measure the atmospheric temperature and pressure at the end of the sampling period using the thermometer (6.1.6) and barometer (6.1.7) and record the measured values.

9.4.5 If the same filter is to be used during subsequent welding episodes (see 8.4.3.2), repeat the procedures described in 9.4.1 through 9.4.4, otherwise disconnect the sampler from the sampling pump.

9.4.6 Carefully record the sample identity and all relevant sampling data (see Annex C). Calculate the time-weighted average flow rate from the flow rate measurements taken throughout the sampling period and, if appropriate (see 9.2.4), calculate the mean atmospheric temperature and pressure. Calculate the volume of air sampled, in litres, at atmospheric temperature and pressure, by multiplying the time-weighted average flow rate in litres per minute by the duration of the sampling period in minutes.

9.5 Transportation

9.5.1 For samplers which have an internal filter cassette (see 6.1.1), remove the filter cassette from each sampler and fasten with its lid or transport clip.

9.5.2 For samplers of the disposable cassette type, transport samples to the laboratory in the samplers in which they were collected.

9.5.3 For samplers which collect airborne particles on the filter (see 6.1.1), remove the filter from each sampler, place in its labelled filter transport cassette (see 9.2.2.1) and close with a lid. Take particular care to prevent fume from becoming dislodged from heavily loaded filters.

9.5.4 Transport the samples (9.5.1 through 9.5.3) to the weighing room in a container which has been designed to prevent damage to the samples in transit and which has been labelled to assure proper handling.

9.6 Determination of welding fume concentration

9.6.1 Reweighing of samples

9.6.1.1 Filters

After sampling, remove each blank and sample filter from its sampler (see 9.5.2) or filter transport cassette (see 9.5.3), and reweigh each filter following the procedure described in 9.1.

Then calculate the weight of welding fume collected, using the mean weight change of the blank filters to correct the weight change measured for each sample filter.

If exposure to specific chemical agents in the welding fume is to be determined (see 10.2), transport the blank and sample filters to the laboratory for chemical analysis: either replace each filter in its filter transport cassette, or, if the filters were transported to the weighing room in samplers, place each filter in a new labelled filter transport cassette (6.1.5).

9.6.1.2 Filter cassettes

After sampling, reweigh each blank and sample filter cassette (see 9.5.1). Then calculate the weight of welding fume collected, using the mean weight change of the blank filter cassettes to correct the weight change measured for each sample filter cassette. If exposure to specific chemical agents in the welding fume is to be determined (see 10.2), transport the blank and sample filter cassettes to the laboratory for chemical analysis.

9.6.2 Calculation of welding fume concentration

The amount of welding fume collected is equal to the increase in weight of the filter over the sampling period.

Calculate the concentration of welding fume in the air sample, c, in milligrams per cubic metre, using the following equation:

$$c = \frac{1000 \times m}{V}$$

where

m is the weight of welding fume collected on the filter, in milligrams corrected for the mean weight change of the blanks (see 9.6.1);

V is the volume of air sampled, in litres, (see 9.4.6).

9.6.3 Calculation of the time-weighted average concentration of welding fume

Calculate the time-weighted average concentration of welding fume over the reference period from the results of the measurements made during the representative welding episodes (9.6.2).

9.6.4 Temperature and pressure correction for the indicated sampling flow rate

In some instances it is necessary to apply a temperature and pressure correction for the indicated sampling flow rate (see 9.2.4.2). A typical example of when such a correction is necessary is when a constant pressure drop, variable area, flowmeter was calibrated (6.1.4) and used to measure the flow rate in 9.4.1, 9.4.2 and 9.4.4.

In this instance the corrected volume of air sampled, V_{corr}, in litres, is given by:

$$V_{corr} = q_v \times t \times \sqrt{\frac{p_1 \times T_2}{p_2 \times T_1}}$$

where

q_v is the mean flow rate, in litres per minute;

t is the duration of the sampling period, in minutes;

p_1 is the atmospheric pressure, in kilopascals, during calibration of the sampling pump flowmeter;

p_2 is the mean atmospheric pressure, in kilopascals, during the sampling period;

T_1 is the temperature, in kelvin, during calibration of the sampling pump flowmeter;

T_2 is the mean temperature, in kelvin, during the sampling period.

Other flowmeters can also require correction for variation in temperature and pressure. Follow the manufacturer's directions for such corrections.

9.6.5 Calculation of the concentration of welding fume at reference temperature and pressure

If appropriate (see 9.2.4.1), calculate the concentration of welding fume, C_{corr}, in the air sample at reference temperature and pressure, using the following equation:

$$c_{corr} = c \times \frac{p_1 \times T_2}{p_2 \times T_1}$$

where

c is the concentration of welding fume in the air sample, in milligrams per cubic metre, at ambient conditions, as calculated in 9.6.3;

T_2 is the mean temperature, in kelvin, during the sampling period;

p_2 is the mean atmospheric pressure, in kilopascals, during the sampling period;

T_1 is the reference temperature, in kelvin (usually 273 K);

p_1 is the reference atmospheric pressure, in kilopascals (usually 101,3 kPa).

10 Determination of exposure to specific chemical agents in welding fume

10.1 Chemical analysis of samples

If chemical analysis of the welding fume is to be carried out, each welding fume sample shall be the subject of an appropriate analytical investigation. This shall include determination of the chemical agent or agents of occupational hygienic significance. The analytical techniques used shall be selected to enable several chemical agents to be determined simultaneously or sequentially on a single sample. See Annex D for examples of techniques suitable for chemical analysis.

NOTE The chemical analysis required will depend on the composition of the filler material and the possible presence of contaminants.

10.2 Use of fume analysis data sheets

Manufacturers sometimes provide a fume analysis data sheet for each type of filler material they supply, giving full details of the chemical composition of airborne particles generated in use.

These data may be used in conjunction with the determined concentration of welding fume to obtain an approximate value for the concentration of specific chemical agents.

NOTE 1 Use of fume analysis data to estimate the concentration of specific chemical agents can lead to erroneous results if the welding fume sample contains a significant quantity of airborne particles generated by welding related operations.

NOTE 2 Fume analysis data should not be used to estimate the concentration of specific chemical agents if the workpiece has been treated with paint, primer, sealer or other surface coating, in which case chemical analysis of the welding fume sample is necessary.

11 Recording of sampling data and presentation of results

To obtain the full benefit of measurements made in the manner described in clauses 9 and 10, record as much information as possible about the process itself, the materials used and the particular circumstances of each measurement. Such information is essential for the correct interpretation of results.

NOTE An example of the type of information that should be recorded in the report is given in Annex C. Basic data related to the investigation are recorded in C.1, process specific data are recorded in C.2, and sampling data and results are recorded in C.3. If chemical analysis of welding fume samples is carried out then results for specific chemical agents should also be reported in C.3, together with calculated 8-hour time-weighted average concentrations.

Annex A
(informative)

Examples of arrangements for mounting samplers behind the welder's face shield

A.1 Introduction

Welder's face shields and welder's hand shields can provide some degree of protection from exposure to welding fume by physically deflecting the plume away from the breathing zone. For personal sampling of welding fume it is therefore essential to locate the sampler behind the welder's shield, if used. An ideal arrangement maintains the sampler in a fixed position relative to the operator's mouth and nose for the duration of the sampling period without influencing the operator's equipment, performance or comfort. Examples of practical mounting arrangements are given in A.2 to A.4.

A.2 Sampler attached to the welder's face shield by means of a removable clip

A specially designed, removable clip may be used to attach the sampler inside the welder's face shield. See figures A.1.1, A.1.2 and A.1.3.

Advantages:

The sampler is easy to mount.

The operator can use his or her personal welder's face shield.

The operator should experience no discomfort when using a welder's face shield that has dimensions which comply with the provisions of EN 175.

The sampler can be attached to different types of welder's face shield.

Disadvantages:

The position of the sampler changes, relative to the nose and mouth, when the operator raises his or her welder's face shield.

If the clip is not of an appropriate design the sampler will not face forwards (see 9.3.1).

In order to maintain the sampler in the operator's breathing zone, it is necessary to reposition it on the lapel if the welder's face shield is removed.

A.3 Sampler attached to the headband of the welder's face shield harness

A specially designed mounting may be used to attach the sampler to the headband of the welder's face shield harness. See figure A.2.

Advantages:

The sampler is easy to mount.

The sampler is retained in position when the operator raises his or her welder's face shield.

The operator can use his or her personal welder's face shield.

Disadvantages:

The operator can experience discomfort in use.

In order to maintain the sampler in the operator's breathing zone, it is necessary to reposition it on the lapel if the welder's face shield is removed.

A.4 Sampler attached to a separate headband

A specially designed mounting may be used to attach the sampler to a separate headband that is worn in addition to the headband of the welder's face shield harness e.g. a sports person's headband (sweatband). See figures A.3.1, A.3.2 and A.3.3.

Advantages:

The sampler is easy to mount.

The sampler is retained in position when the operator raises his or her welder's face shield.

The arrangement can be used with different types of welder's face shield and with other welding protectors.

The operator can use his or her personal welder's face shield.

Disadvantages:

The operator can experience discomfort in use.

A personal headband is required or laundering is necessary.

Figure A.1.1 — Welder's face shield with a sampler attached by means of a removable clip (see figure A.1.3)

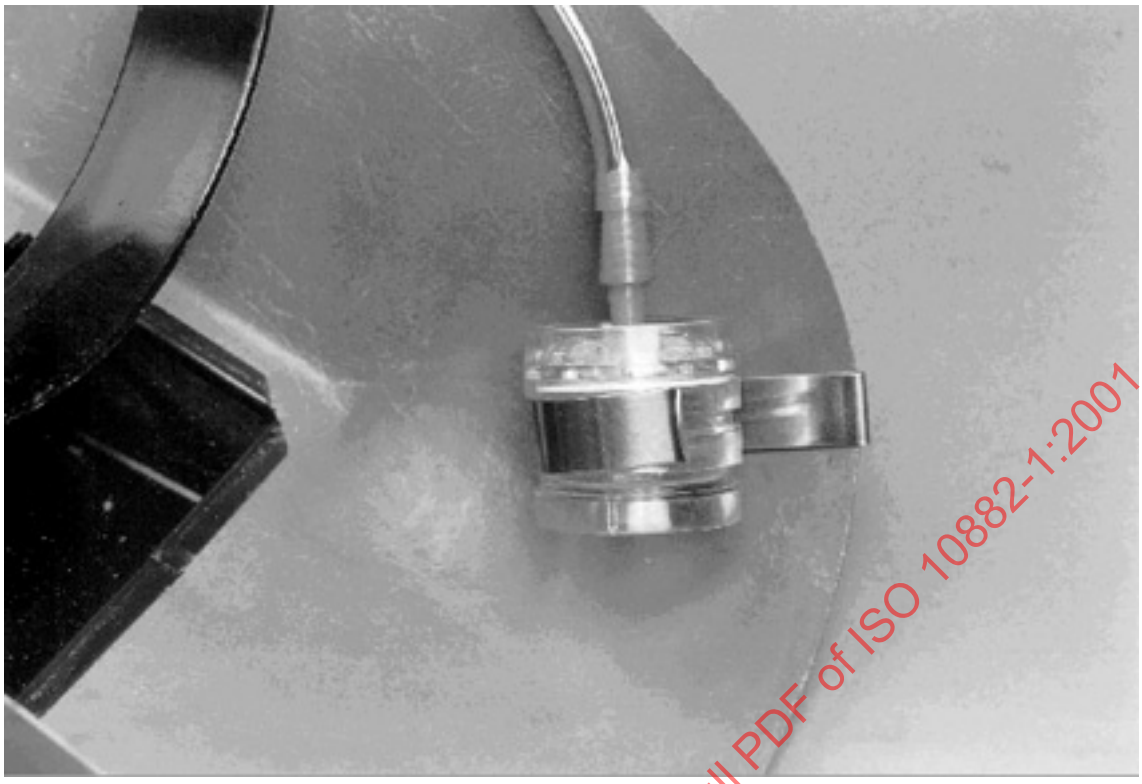
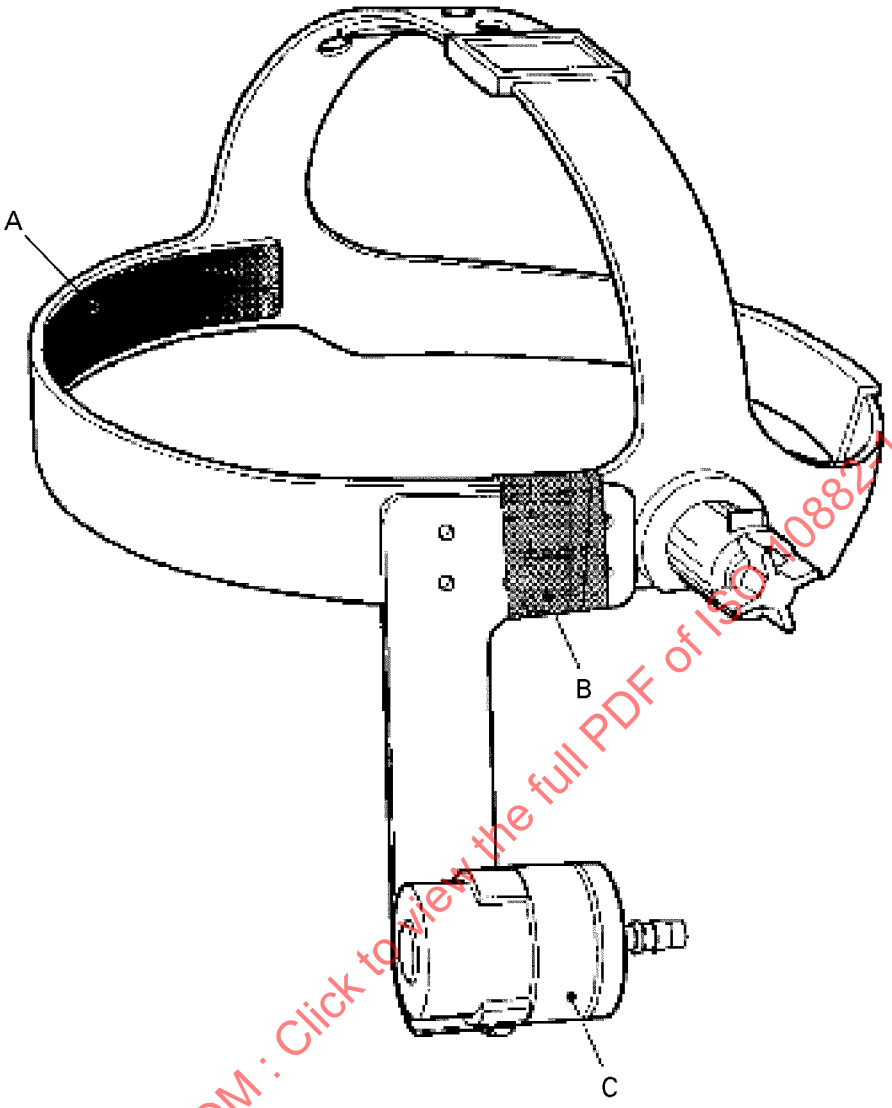


Figure A.1.2 — Detail of a welder's face shield with a sampler attached by means of a removable clip (see figure A.1.3)

Figure A.1.3 — Removable clip used to attach a sampler to the welder's face shield



Key:

A Headband inside welder's headshield

B Bind together with adhesive tape

C Sampling head

Figure A.2 - Welder's face shield with a sampler mounted using a bracket taped to the headband

Figure A.3.1 — Sampler attached to a sportsperson's headband (sweatband)

Figure A.3.2 — Operator wearing a sampler attached to a sportsperson's headband (see figure A.3.1)

Figure A.3.3 — Operator wearing a sampler attached to a sportsperson's headband (see figure A.3.1) and a welder's face shield