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Health and safety in welding and allied processes — Laboratory method for sampling fume and gases generated by arc welding —

Part 2: Determination of emission rates of gases, except ozone

Hygiène et sécurité en soudage et techniques connexes — Méthode de laboratoire d'échantillonnage des fumées et des gaz émis par le soudage à l'arc —

Partie 2: Détermination du taux d'émission des gaz, à l'exception de l'ozone

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Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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 the member bodies casting a vote.

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

ISO 15011-2 was prepared by the European Committee for Standardization (CEN) in collaboration with Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 9, *Health and safety*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

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

ISO 15011 consists of the following parts, under the general title *Health and safety in welding and allied processes — Laboratory method for sampling fume and gases generated by arc welding*:

— *Part 1: Determination of emission rate and sampling for analysis of particulate fume*

— *Part 2: Determination of emission rates of gases, except ozone*

— *Part 3: Determination of ozone concentration using fixed point measurements*

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Foreword

The text of EN ISO 15011-2:2003 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 November 2003, and conflicting national standards shall be withdrawn at the latest by November 2003.

This standard consists of the following parts:

- Part 1: Determination of emission rate and sampling for analysis of particulate fume;
- Part 2: Determination of emission rates of gases and vapours, except ozone;
- Part 3: Determination of ozone concentration using fixed point measurements.

The annexes A, B and C are informative.

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, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom.

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Introduction

Welding and allied processes produce airborne particles and gaseous by-products, which can be harmful to human health. Knowledge of the quantity and composition of the airborne particles and gases emitted can be useful for occupational hygienists in assessing workplace atmospheres and in determining appropriate control measures. Emission rates cannot be used directly to assess the welder's exposure, but it is expected that processes, consumables and welding parameters giving low emission rates will result in lower welder exposures than processes with high emission rates used in the same working situation.

The laboratory procedure described in this standard can be used to determine the emission rate of gases generated by arc welding and provides a method of sampling the gases for chemical analysis. The gases generated and their emission rates depend upon the welding process, welding parameters, work piece surface, coatings, etc.

In the context of this standard emission rate means the total amount of a substance per unit time that is produced under defined process conditions, by different reactions in the system defined in this standard.

Gases encountered in arc welding are so numerous that it would be impracticable to cover them all in this standard. The scope of this standard has therefore been limited to those gases, which are commonly generated during arc welding.

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

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1 Scope

This European Standard provides guidance on the determination of emission rates of gases generated by arc welding using a fume box technique. It describes the test principle, gives a possible fume box arrangement and considers methods for sampling and analysis.

The following gases that can be produced during arc welding are covered:

- Carbon monoxide (CO);
- Carbon dioxide (CO_2);
- Nitrogen oxide (NO);
- Nitrogen dioxide (NO_2).

The fume box described in this standard can also be used for the determination of organic gases produced in the arc welding of coated metals, e.g. primed, painted or plastic coated material (see annex A for further information).

Ozone is considered in EN ISO 15011-3.

2 Normative references

This European Standard incorporates by dated or undated references, 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 (including amendments).

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

EN 1076, *Workplace atmospheres - Pumped sorbent tubes for the determination of gases and vapours - Requirements and test methods.*

EN 1540, *Workplace atmospheres – Terminology.*

EN 45544-1, *Workplace atmospheres - Electrical apparatus used for the direct detection and direct concentration measurement of toxic gases and vapours – Part 1: General requirements and test methods.*

EN ISO 4063, *Welding and allied processes — Nomenclature of processes and reference numbers (ISO 4063:1998).*

EN ISO 10882–2, *Health and safety in welding and allied processes — Sampling of airborne particles and gases in the operator's breathing zone — Part 2: Sampling of gases (ISO 10882-2:2000).*

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

ISO 5167–1, *Measurements of fluid flow by means of pressure differential devices - Part 1: Orifice plates, nozzles and Venturi tubes inserted in circular cross sections conduits running full.*

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

ISO 8756, *Air quality - Handling of temperature, pressure and humidity data.*

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3 Terms and definitions

For the purposes of this European Standard, the terms and definitions given in EN 1540, ISO 6879, EN ISO 10882–2, EN 482, EN 1076, ISO 3534–1, EN ISO 4063 and the following apply.

3.1
fume box
closed or semi-closed ventilated chamber used for sampling and determination (emission rate and composition) of fume and gases in welding and allied processes

4 Principle

Arc welding is performed in a fume box suitable for the process. During testing the gases produced are captured and continuously extracted from the fume box using a ventilator or pump. The emission rates of gases are calculated by multiplication of the gas concentration in the outlet air and the air flow rate.

5 Measurement methods

5.1 Gases

5.1.1 General

A complex mixture of particulates and gases is produced by most arc welding processes, and, whatever method of sampling and analysis is selected, it is necessary to confirm that techniques, which have been used successfully for other applications, are suitable for use with emission rate measurements. Particular attention shall be paid to the possibility of interference with the determination of one gas by the presence of another.

For fume box testing of arc welding processes, the concentrations of gases can be determined using either direct or indirect methods.

Direct reading electrical apparatus is generally most appropriate for the measurement of gases. Indirect methods, which involve laboratory analysis of samples collected using a suitable solid or liquid sorbent, are most appropriate for the determination of organic gases, which can be produced in the arc welding of metals having paint or other coatings.

5.1.2 Direct methods

Direct reading instruments, that can be accurately calibrated, are available for the measurement of gases covered by this standard.

Analysis is usually performed on an air sample drawn through the instrument using a pump. Measurements that involve the use of spectrometry or an electrochemical sensor, can be made directly or indirectly following reaction of the sample with solids, liquids or gases.

Both pumped and diffusive detector tubes provide a direct method of gas analysis but they are not sufficiently accurate for measurements involving fume box testing.

5.1.3 Indirect methods

Indirect methods have separate sampling and analysis stages and involve the use of sorbent tubes and liquid sorbent methods. They are widely applicable to the measurement of organic gases, such as those emitted in the welding of coated metals. Generally they exhibit low relative overall uncertainty and good selectivity but are seldom appropriate to measurement of other gases covered in this standard.

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Sorbent tubes are available for some of the gases and for most of the organic gases produced when welding metals having paint or other coatings. The associated analytical technique used varies according to which gases and organic gases are to be determined.

In liquid sorbent methods the sample is drawn through a liquid contained in a bubbler and the resultant solution analysed.

5.2 Fume box air flow rate

It is important to measure accurately the flow rate (see ISO 5167-1).

The airflow rate through the fume box can be measured directly using a flow meter or indirectly as the product of the air velocity and the area of the ventilation tube.

6 Equipment

6.1 Fume box

The fume box should consist of a process chamber, a ventilation outlet section containing probes for gas sampling and, if appropriate, an air inlet section.

Examples of possible fume box arrangements for sampling and determining the emission rate of gases in arc welding are given in annex B.

NOTE 1 The process chamber should be suitable for the process, i.e. it should enclose the process and be large enough to allow complete capture of the gases emitted.

NOTE 2 The ventilation airflow through the process chamber should reinforce the thermal air movement, i.e. the ventilation outlet section should be positioned above the process and the air inlet beneath.

6.2 Ventilator or pump

The airflow capacity of the pump or ventilator shall be sufficient to ensure complete capture of the emitted gases inside the fume box, but should not affect the integrity of the process.

7 Sampling

7.1 Sampling position

Sampling of gases shall be performed in the fume box outlet section or in the ventilation line in a position where gases are uniformly mixed with the air. The sampling distance, from the outlet of the fume box, should be approximately 5 times the diameter of this outlet.

7.2 Sampling equipment

7.2.1 Direct reading electrical apparatus

Direct reading electrical apparatus for fume box measurements of gases in arc welding should comply with the provisions of EN 45544-1.

7.2.2 Sorbent tubes

Sorbent tube methods used for fume box measurements of gases should comply with the provisions of EN 1076.

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7.2.3 Sampling materials

Probes, sampling lines, filters, filter holders, connectors, etc. should be made of inert materials to prevent absorption of or reaction with the gases being sampled. Tubing manufactured from PVC is suitable. The use of heat resistant materials in sampling lines and gas cooling devices is normally not necessary.

7.3 Sample filtration

Particulate matter in the sampled air should be removed by filtration before the air is introduced into the sampling or measuring system. This may not be necessary for direct reading electrical apparatus incorporating an internal filter.

Where possible, filtration should be performed at the point of sampling but when this is not possible, a filter should be inserted into the sampling line between the sampling position and the analytical equipment. In the last case, regular cleaning of the sampling line/s and/or checking and calibration of the instrument should be carried out.

7.4 Multiple sampling

When the emission rate of more than one gas is to be determined, successive samples may be taken through a single sample line, or it may be possible to make successive measurements on a single sample. Where simultaneous sampling is required, either multiple sample lines should be used or branch sampling lines should be taken from a single sampling line.

7.5 Volume of sampling line

The length and internal volume of the sampling line, and of filter holders if used, should be kept to a minimum and the residence time of the air in them should not exceed a few seconds. If a discrete volume of air is sampled, the volume of sampling line plus filter holder should not exceed 5 % of the volume of the discrete sample.

7.6 Sampling flow rate

Direct reading electrical apparatus usually incorporates an integral air sampling pump. This should be used in accordance with the manufacturer's instructions.

For other methods, the sampling flow rate should be compatible with the sampler used.

Refer to the manufacturer's instructions. The flow rate should be measured with an uncertainty of 5 % using a calibrated integrating gas meter or, if the flow is pulsation free, a calibrated flow meter.

A flow meter integrated in the sampling pump may be used providing it has adequate sensitivity and has been calibrated against a primary standard with the sampler in line.

7.7 Fume box ventilation air flow rate

It is important to use the appropriate flow rate, see 5.2 and 6.2.

7.8 Handling of temperature, pressure and humidity data

ISO 8756 gives procedures for adjusting air quality measurements for changes in temperature, pressure and humidity during the sampling periods and states the reference conditions of temperature, pressure and humidity to be used in reporting the results. The requirements of ISO 8756 should be taken into consideration when using the measurements methods referred to in this standard.

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8 Measurement of individual gases

8.1 General

This section gives specific guidance on measurement methods available for the gases covered in this standard.

8.2 Carbon monoxide

Direct reading electrical apparatus used most commonly for the measurement of carbon monoxide works on one of the following principles:

a) dispersive infra-red absorption and non-dispersive infra-red absorption used with or without filters to reduce interference by carbon dioxide. Interfering compounds include acetylene, nitrogen oxide, olefins, carbon dioxide and water vapour. However, carbon dioxide is unlikely to interfere with dispersive methods or non-dispersive methods used with a suitable filter at concentrations of carbon dioxide less than 3 %;

b) diffusion of the carbon monoxide through a semi-permeable membrane, at a rate proportional to the concentration, followed by electrochemical oxidation of the gas at a potential-controlled electrode and measurement of the current produced;

c) gas chromatography: The apparatus should be calibrated with certified gas mixtures of known carbon monoxide concentration. (Suitable concentrations of carbon monoxide in air and carbon monoxide in nitrogen are available).

8.3 Carbon dioxide

Direct reading electrical apparatus used most commonly for measurements of carbon dioxide works by non-dispersive infra-red absorption. It should be calibrated using standard gas mixtures of known carbon dioxide concentration.

8.4 Nitrogen oxide and nitrogen dioxide

8.4.1 General

Nitrogen oxide and nitrogen dioxide are considered together since they generally occur together in arc welding. They may be determined separately or together, as oxides of nitrogen, using related methods.

8.4.2 Direct reading electrical apparatus

Direct reading electrical apparatus used most commonly for measurement of nitrogen oxide and nitrogen dioxide works on one of the following principles:

a) measurement of chemical luminescence produced by reaction between nitrogen oxide and ozone. Nitrogen dioxide present in the sample may be determined by the difference between the nitrogen oxide concentration before and after conversion of nitrogen dioxide to nitrogen oxide in a thermal or catalyst-assisted thermal converter;

b) measurement of the signal generated by electrochemical reaction of nitrogen oxide and nitrogen dioxide at catalytically-active, potential-controlled electrodes in aqueous sulphuric acid. By using two sensing electrodes at appropriate potentials, each gas may be determined in the presence of the other.

The apparatus should be calibrated with certified gas mixtures of known concentration (suitable concentrations of nitrogen oxide and nitrogen dioxide in nitrogen are available).

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9 Test report

Test data and presentation of results shall be recorded. An example of a suitable test report is given in annex C.

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Annex A
(informative)

Organic gases

A.1 General

A complex mixture of organic gases and particulate can be produced by arc welding metals having paint or other surface coatings. The fume composition will be dependent upon the nature of the coating but more than 100 organic decomposition products have been identified. However, relatively few of the organic gases emitted are likely to be present in sufficient quantities to produce significant work place exposures.

Those that can be determined, include the following:

Acids	e.g. formic acid, acetic acid, aliphatic acids, benzoic acid, phthalic anhydride
Alcohols	e.g. aliphatic alcohols
Phenols	e.g. phenol, alkyl phenols, bisphenol-A
Aldehydes	e.g. formaldehyde, acetaldehyde, acrolein, butyraldehyde, aliphatic aldehydes
Esters	e.g. methyl methacrylate, butyimethaerylate
Hydrocarbons	e.g. aliphatic and aromatic hydrocarbons, alkylbenzenes, polyaromatic hydrocarbons
Ketones	e.g. aliphatic and aromatic ketones

These are too numerous for detailed consideration in this standard, but some general guidance on sampling and analysis are given in A.2 and A.3.

A.2 Direct reading electrical apparatus

Direct reading electrical apparatus is available for many of the organic gases mentioned in A.1. However, because of its poor specificity and the complex mixture of chemical agents involved, such apparatus is not generally useful in emission rate measurements of organic gases in arc welding.

A.3 Indirect methods involving laboratory analysis

Indirect methods provide the most useful techniques for determining varying concentrations of organic gases. In fume box sampling, organic gases are typically sampled using pumped sorbent tubes or liquid sorbent methods.

Particulate organics and volatile organics absorbed on airborne particles are collected on filters. Analysis is generally performed by high performance liquid chromatography or gas chromatography following solvent desorption.

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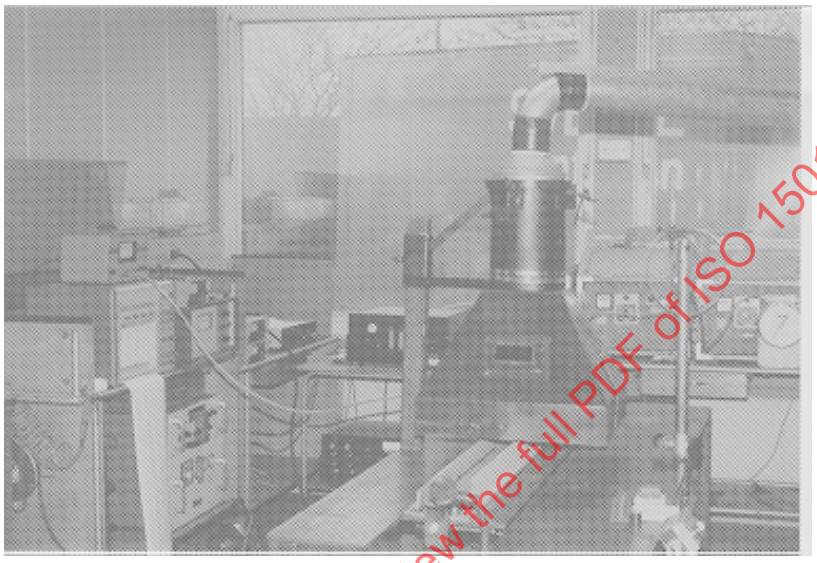
Annex B
(informative)

Examples of fume box arrangements for determination of emission rates of gases in arc welding, except ozone

Figures B.1 and B.2 are possible fume box designs.



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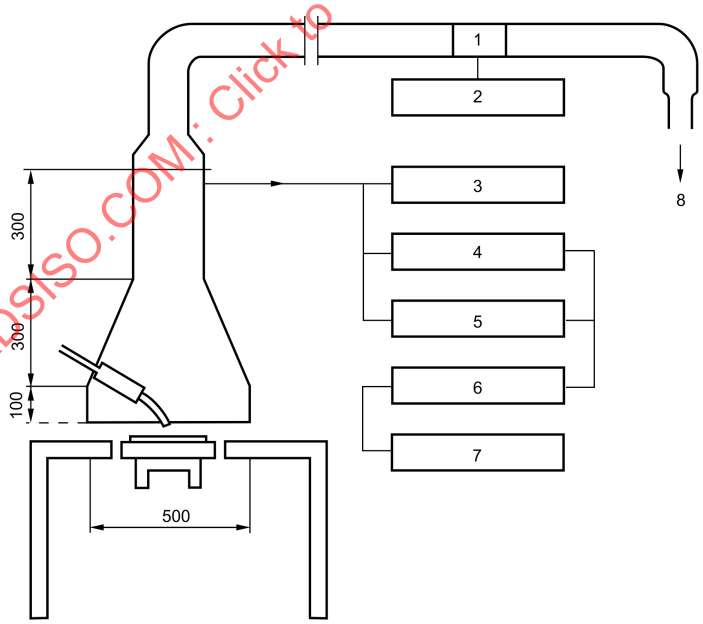

Key

1 Air flow probe
2 Micromanometer
3 Sampling tubes
4 CO analyser
5 $NO-NO_2$ analyser
6 Signal averager
7 Recorder
8 Extraction

Figure B.1 — Example of fume box designs for sampling of gases generated by arc welding

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