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

Part 2: Determination of the emission rates of carbon monoxide (CO), carbon dioxide (CO_2), nitrogen monoxide (NO) and nitrogen dioxide (NO_2) during arc welding, cutting and gouging

Hygiène et sécurité en soudage et techniques connexes — Méthode de laboratoire d'échantillonnage des fumées et des gaz —

Partie 2: Détermination des débits d'émission du monoxyde de carbone (CO), du dioxyde de carbone (CO_2), du monoxyde d'azote (NO) et du dioxyde d'azote (NO_2) lors du soudage à l'arc, du coupage et du gougeage

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Foreword

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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 Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 9, *Health and safety*.

This second edition cancels and replaces the first edition (15011-2:2003), which has been technically revised.

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*:

— *Part 1: Determination of fume emission rate during arc welding and collection of fume for analysis*

— *Part 2: Determination of the emission rates of carbon monoxide (CO), carbon dioxide (CO_2), nitrogen monoxide (NO) and nitrogen dioxide (NO_2) during arc welding, cutting and gouging*

— *Part 3: Determination of ozone emission rate during arc welding*

— *Part 4: Fume data sheets*

— *Part 5: Identification of thermal-degradation products generated when welding or cutting through products composed wholly or partly of organic materials*

The following part is under preparation:

— *Part 6: Procedure for quantitative determination of fume and gases from resistance spot welding* [Technical Specification]

Request for an official interpretation of technical aspects of this part of ISO 15011 should be directed to the secretariat of ISO/TC 44/SC 9 via the user's national standardization body; a listing of these bodies can be found at www.iso.org.

Introduction

Welding and allied processes generate fume and gases, which, if inhaled, can be harmful to human health. Knowledge of the composition and the emission rate of the fume and gases can be useful to occupational health professionals in assessing worker exposure and in determining appropriate control measures.

Absolute exposure is dependent upon factors such as welder position with respect to the plume and draughts and cannot be predicted from emission rate data. However, in the same work situation, a higher emission rate is expected to correlate with a higher exposure and a lower emission rate with a lower exposure. Hence, emission rate data can be used to predict relative changes in exposure that might occur in the workplace under different welding conditions and to identify measures for reducing such exposure, but they cannot be used to calculate ventilation requirements.

This part of ISO 15011 specifies a method for measuring the emission rate of carbon monoxide (CO), carbon dioxide (CO_2), nitrogen monoxide (NO) and nitrogen dioxide (NO_2) during arc welding, cutting and gouging using a hood technique. The procedure simply prescribes a methodology, leaving selection of the test parameters to the user, so that the effect of different variables can be evaluated.

It is assumed that the executions of the provisions and the interpretation of the results obtained in this part of ISO 15011 are entrusted to appropriately qualified and experienced people.

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

Part 2: Determination of the emission rates of carbon monoxide (CO), carbon dioxide (CO_2), nitrogen monoxide (NO) and nitrogen dioxide (NO_2) during arc welding, cutting and gouging

1 Scope

This part of ISO 15011 defines laboratory methods for measuring the emission rates of carbon monoxide (CO), carbon dioxide (CO_2), nitrogen monoxide (NO) and nitrogen dioxide (NO_2) generated during arc welding, cutting and gouging, using a hood technique. The methodology is suitable for use with all open arc welding processes, cutting and gouging but different designs of hood are used depending on the process and whether or not it can be conducted automatically.

The method can be used to evaluate the effects of welding wires, welding parameters, processes, shielding gases, test piece composition and test piece surface condition on emission rate.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/TR 25901, *Welding and related processes — Vocabulary*

ISO/IEC Guide 98-3, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/TR 25901 and the following apply.

3.1
bubble flow meter
primary device for measuring gas flow rate, where the time for a bubble of gas, defined by a soap film, to pass through a calibrated volume in a vertical tube is measured

3.2
test chamber
semi-enclosed, continuously extracted chamber used in emission rate tests performed during arc welding, cutting or gouging operations

NOTE Test chambers generally fall into three generic types:

— A test chamber without a floor, widely referred to as a “hood”;

— A test chamber having a floor, widely referred to as a “fume box”;

— A “fume box”, in which the floor of the test chamber is easily removed and replaced, facilitating its ready interconversion to and from a “hood”.

4 Principle

Arc welding, cutting or gouging is performed, inside a semi-enclosed, continuously extracted test chamber of the “hood” type. Gas concentrations (in millilitres per cubic metre) at a sampling position and the air flow rate (in cubic metres per minute) through the hood are measured. Gas emission rates (in millilitres per minute) are calculated by multiplying their concentrations at the sampling position by the air flow rate.

5 Equipment and materials

5.1 Hood, semi-enclosed, continuously extracted chamber of the “hood” type, in which gas emission rate tests are performed during arc welding, cutting and gouging. Examples of possible hood designs are given in Annex A. Hoods with shapes and dimensions similar to those shown in Figure A.1 are appropriate for measuring gas emission rates during arc welding. Hoods similar to those shown in Figure A.2 are appropriate for measuring gas emission rates during cutting and gouging. See B.1 for guidance on the gas sampling position.

5.2 Extraction unit, capable of maintaining an adequate air flow rate through the hood (5.1), such that all gases emitted are contained, but not so high as to compromise the integrity of the process (see B.2). The precise characteristics of the extraction unit are not critical.

5.3 Sampling system, consisting of a sampling line between the sampling point and the equipment, for measuring gas concentration. The sampling line shall be of small internal diameter (10 mm or less) and as short as reasonably practicable. Fume shall be prevented from entering the sampling line using a filter placed as close as is reasonably practicable to the sampling point. See B.3.

5.4 Instrument for measuring carbon monoxide, which is direct reading and which works on one of the following principles:

— dispersive infra-red absorption and non-dispersive infra-red absorption, used with or without filters to reduce interference from carbon dioxide;

— diffusion of 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 by measurement of the current produced;

— gas chromatography.

The instrument shall have a working range that covers the range of CO concentrations to be measured and have a logging capability or be connected to a digital logging system with a logging frequency of 1 s or less. See B.4.

The instrument calibration shall be traceable to national standards.

5.5 Instrument for measuring carbon dioxide, which is direct reading and which works by non-dispersive infra-red absorption.

The instrument shall have a working range that covers the range of CO_2 concentrations to be measured and have a logging capability or be connected to a digital logging system with a logging frequency of 1 s or less. See B.4.

The instrument calibration shall be traceable to national standards.

5.6 Instrument for measuring nitrogen oxide and nitrogen dioxide, which is direct reading and which works using one of the following principles:

— measurement of chemiluminescence produced by reaction between NO and ozone (O_3);

— measurement of the signal generated by electrochemical reaction of NO and NO_2 at catalytically active, potential-controlled, electrodes in aqueous sulphuric acid.

The instrument shall have a working range that covers the range of NO and NO_2 concentrations to be measured and have a logging capability or be connected to a digital logging system with a logging frequency of 1 s or less. See B.4.

The instrument calibration shall be traceable to national standards.

5.7 Equipment for measuring air flow rate, capable of measuring an air flow rate of 2 m^3/min to within ± 5 % or better for the hood shown in Figure A.1, or 20 m^3/min to within ± 5 % or better for the hood shown in Figure A.2.

The following combinations of equipment are suitable (see B.5).

— A calibrated anemometer, together with a calibrated ruler, to measure the diameter (in metres) of the extraction ducting between the hood and the extraction unit. The calibrations of the anemometer and the ruler shall be traceable to national standards. The anemometer shall, itself, have a logging capability or be connected to a logging system with a logging frequency of 1 s or less.

— A flow meter with a calibrated relationship between pressure difference and air flow rate, e.g. an orifice plate, together with a digital manometer with a reading accuracy of at least 0,1 Pa to measure the pressure difference across it. The calibration of the flow meter and the digital manometer shall be traceable to national standards. The digital manometer shall, itself, have a logging capability or be connected to a logging system with a logging frequency of 1 s or less.

— A device for measuring air flow rate with equivalent performance.

The calibration of the equipment shall be traceable to national standards.

5.8 Equipment for measuring welding current, voltage and wire feed speed, capable of measuring the arithmetic mean of the current, voltage and wire feed speed to within ± 5 % or better. Electronic integrating equipment with frequent sampling intervals and a logging capability is recommended. In the absence of such equipment, current may be measured using a Hall effect probe connected to a moving coil meter or a shunt. Voltage may be measured using a moving coil meter. Wire feed speed may be determined by measuring the length of wire exiting the welding torch in a measured time.

The calibration of the equipment shall be traceable to national standards.

5.9 Equipment for measuring shielding and consumable gas flow rates, calibrated for the gas in use, capable of measuring the flow rate to within ± 5 % or better (see B.6).

The calibration of the equipment shall be traceable to national standards.

5.10 Device for setting the contact tip to workpiece distance (CTWD), consisting of a gauge made by machining a metal block to a thickness equivalent to the required CTWD to within ± 5 % or better, or a metal wedge with distance markings at appropriate points.

5.11 Device for setting the electrode tip to workpiece distance (ETWD) for tungsten inert gas (TIG) welding, consisting of a gauge made by machining a metal block to a thickness equivalent to the required ETWD to within ± 5 % or better, or a metal wedge with distance markings at appropriate points.

5.12 Device for automatic arc welding, permitting the emission rate test to be performed under automated conditions, capable of advancing the test piece under a stationary arc welding torch at an appropriate rate (welding speed), whilst positioned over a plane surface (e.g. a table), which extends at least to the extremities of the hood. It shall be possible to secure a test piece to the device, such that it cannot move, bow or flex during testing (see B.7).

5.13 Test pieces, of a material suitable for the process and for welding the consumable used, with dimensions which allow testing to be carried out for a period of at least 60 s (see B.8).

6 Test procedures

6.1 Welding procedure selection

6.1.1 Welding procedure selection for arc welding processes

Perform manual metal arc (MMA) welding tests manually or using automatic welding.

Perform tests with continuous wire processes, e.g. metal inert gas or metal active gas (MIG/MAG) welding with solid wires, metal-cored arc welding (MCAW), gas-shielded flux-cored arc welding (FCAW) and self-shielded flux-cored arc welding (SSFCAW), using automatic welding.

Perform TIG welding manually and autogeneous TIG welding using automatic welding.

NOTE Automatic welding is specified for use with those processes which can be easily performed automatically because it is expected to provide greater reproducibility of gaseous emission rates than manual welding. However, for MMA and TIG welding, this is difficult or impossible to carry out.

Perform manual welding tests and automatic welding set-up using a skilled welder.

Perform welding tests in a hood of similar design to that shown in Figure A.1.

6.1.2 Welding procedure selection for cutting and gouging

Perform cutting and gouging processes, such as oxyfuel gas and plasma cutting and gouging, manually using a hood of similar design to that shown in Figure A.2.

6.2 Setting up the test equipment

Check that all measuring and logging equipment is within its calibration date and is functioning correctly, before carrying out any tests.

Arrange the test equipment appropriate to the arc welding, cutting or gouging process to be evaluated as shown in Annex A.

Adjust the air flow rate through the hood to the required value (see B.2) using either the variable control on the extraction unit or a damper in the extract ducting. Make air flow measurements utilizing either an anemometer or a differential flow meter.

If an anemometer is to be used to measure the velocity of extracted air for use in the calculation of the air flow rate, measure the average velocity of extracted air through the extract ducting with the anemometer, measure the diameter of the extract ducting using a calibrated ruler, calculate the cross-sectional area (in square metres) of the extract ducting and multiply this by the average extracted air velocity (in metres per minute) to obtain the average air flow rate (in cubic metres per minute).

If a pressure differential flow meter is used to measure the air flow rate, measure the average pressure drop across the device and calculate the average air flow rate using the calibration equation provided for the device.

6.3 Blank test

Switch on the extraction device and check that the air flow rate through the hood is at the required value (see 6.2); adjust if necessary.

Switch on the measuring instruments and measure the gases which are the subject of emission rate tests for a suitable time period, e.g. 60 s.

Calculate the mean concentration of each gas and use this for blank correction. See Clause 7.

6.4 Manual metal arc welding

6.4.1 Trial test to set the test current

Set the desired test conditions (see Annex C), performing a trial test to set the test current, as follows, using the same monitoring equipment and materials to be used subsequently to perform the emission rate test proper.

Connect the equipment for measuring current and voltage. See D.1 for further guidance.

Secure a test piece (5.13) inside the hood, centrally, so that it cannot move, bow or flex during welding.

Commence welding and adjust the power source to provide the desired test current.

Stop welding and renew or reposition the test piece so that the next weld is deposited on a cool, unwelded metal surface, securing it so that it cannot move, bow or flex during welding.

Recommence welding, continue for a suitable time period, e.g. 60 s, or until the electrode is consumed and record the average current over the test period.

Verify that the desired test current has been attained and, if not, renew or reposition the test piece, re-adjust the power source and repeat the test.

When the required test conditions have been achieved, proceed to testing (see 6.4.2).

6.4.2 Emission rate test

Renew or reposition the test piece so that the next weld is deposited on a cool, unwelded metal surface, if necessary securing it so that it cannot move, bow or flex during welding. Switch on the extraction unit (5.2) and all measuring instruments (5.4, 5.5 and 5.6) and monitoring equipment (5.7 and 5.8). Check that the air flow rate through the hood is still at the required value (see B.2) and adjust it if necessary. Commence welding, start logging the concentration of the gas(es) emitted, weld for a suitable time period, e.g. 60 s, or until the electrode is consumed, stop logging the gas concentration(s) and then switch off the extraction unit.

Perform three replicate tests and calculate the mean gas emission rate (see Clause 7). If any individual result differs from the mean by more than ± 10 %, carry out two more tests and calculate the mean value of all five results. If any individual result then differs from the new mean by more than ± 10 %, carry out checks to ensure that all equipment is functioning correctly and repeat the entire procedure.

6.5 Continuous wire processes and autogeneous TIG welding

6.5.1 Trial test

Set the desired test conditions (see Annex C), performing a trial test to set the test current and voltage, as follows, using the same monitoring equipment and materials to be used subsequently to perform the emission rate test proper.

Connect the equipment for measuring current, arc voltage, wire feed speed (5.8). See D.1 for further guidance on attaching the leads for measuring voltage and current.

Adjust the shielding gas flow rate to the desired value, if applicable (see C.7).

Secure a test piece inside the hood, so that it cannot move, bow or flex during welding and in such a way that a constant CTWD is maintained throughout the test when carrying out MIG/MAG welding and that a constant ETWD is maintained when carrying out autogeneous TIG welding.

Position the welding torch at the desired angle (see C.3) and secure it.

Set the desired CTWD for continuous wire processes (see C.6.1) following the procedure described in D.2 or, for autogeneous TIG welding, set the desired the ETWD (see C.6.2) following the procedure described in D.3.

Set the required welding speed (see C.4).

Commence welding and adjust the power source to provide the desired test current and voltage.

Stop welding and renew or reposition the test piece so that the next weld is deposited on a cool, unwelded metal surface, if necessary securing it so that it cannot move, bow or flex during welding. Check that the CTWD or ETWD is unchanged and reset if necessary. Recommence welding. Continue for a suitable time period, e.g. 60 s, and record the average current and voltage over the test period.

Verify that the desired current and voltage have been attained and, if not, renew or reposition the test piece, re-adjust the power source and repeat the test.

When the required test conditions have been achieved, proceed to testing (see 6.5.2).

6.5.2 Emission rate tests

Renew or reposition the test piece so that the next weld is deposited on a cool, unwelded metal surface, if necessary securing it so that it cannot move, bow or flex during welding. Check that the CTWD or ETWD is unchanged and reset if necessary. Position the test piece under the torch ready to commence welding. Manoeuvre the hood over the torch so that the torch is positioned centrally and that the bottom edge of the hood is 5 cm above the upper surface of the test piece (see B.7). Switch on the extraction unit (5.2) and all measuring instruments (5.4, 5.5 and 5.6) and monitoring equipment (5.7 and 5.8). Check that the air flow through the hood is still at the required value (see 6.2) and adjust it if necessary. Start the device for automatic welding. Commence welding, start logging the concentration of the gas(es) emitted, weld for a suitable time period, e.g. 60 s, stop logging the gas concentration(s) and then switch off the extraction unit.

Perform three replicate tests and calculate the average gas emission rate (see Clause 7). If any individual result differs from the mean by more than ± 10 %, carry out two more tests and calculate the mean value of all five results. If any individual result then differs from the new mean by more than ± 10 %, carry out checks to ensure that all equipment is functioning correctly and repeat the entire procedure.

6.6 Cutting and gouging

6.6.1 Trial tests (for electrical processes)

Set the desired test conditions (see Annex C), performing a trial test to set the test voltage and/or current, as follows, using the same monitoring equipment and materials to be used subsequently to perform the emission rate test proper.

Connect the equipment for measuring voltage and/or current. See D.1 for further guidance.

Secure a test piece inside the hood so that it cannot move, bow or flex during cutting or gouging.

Commence cutting or gouging and adjust the power source to provide the desired test voltage and/or current.

Stop cutting or gouging and renew or reposition the test piece so that the next cut or gouge is made on a cool metal surface, securing it so that it cannot move, bow or flex during welding.

Recommence cutting or gouging, continue for a suitable time period, e.g. 60 s, and record the average voltage and/or current over the test period.

Verify that the desired voltage and/or current have been attained and, if not, renew or reposition the test piece, re-adjust the power source and repeat the test.

When the required test conditions have been achieved, proceed to testing (see 6.6.3).

6.6.2 Trial test (for non-electrical processes)

Set the desired test conditions (see Annex C), performing a trial test to ensure that all equipment is functioning correctly and then proceed to testing (see 6.6.3).

6.6.3 Emission rate tests

Renew or reposition the test piece so that the next cut or gouge is made on a cool metal surface, if necessary securing it so that it cannot move, bow or flex during cutting or gouging. Switch on the extraction unit (5.2) and all measuring instruments (5.4, 5.5 and 5.6) and monitoring equipment (5.7 and 5.8). Check that the air flow through the hood is still at the required value (see 6.2) and adjust it if necessary. Commence cutting or gouging, start logging the concentration of the gas(es) emitted, cut or gouge for a suitable time period, e.g. 60 s, stop logging the gas concentration(s) and then switch off the extraction unit.

Perform three replicate tests and calculate the average gas emission rate (see Clause 7). If any individual result differs from the mean by more than ± 10 %, carry out two more tests and calculate the mean of all five results. If any individual result then differs from the new mean by more than ± 10 %, carry out checks to ensure that all equipment is functioning correctly and repeat the entire procedure.

7 Calculating and reporting the results

For each replicate test, calculate the average concentration of the gas(es) emitted over the period when the concentration(s) of the gas(es) is(are) “stable” (see Annex E) and subtract the relevant blank concentration (see 6.3) from the average results.

Calculate the average air flow rate and, where applicable, the average current and voltage for each replicate test.

Calculate the emission rate of the gas measured in each replicate test (in millilitres per minute) by multiplying the average stable gas concentration (in millilitres per cubic metre) by the air flow rate (in cubic metres per minute).

NOTE Direct reading instruments measure gas concentrations in parts per million (ppm), which corresponds to millilitres per cubic metre.

Calculate the mean gas emission rate for each set of replicate tests and estimate the uncertainty of the measurements in accordance with ISO/IEC Guide 98-3.

Complete all applicable details in the test report shown in Annex F.

Annex A
(informative)

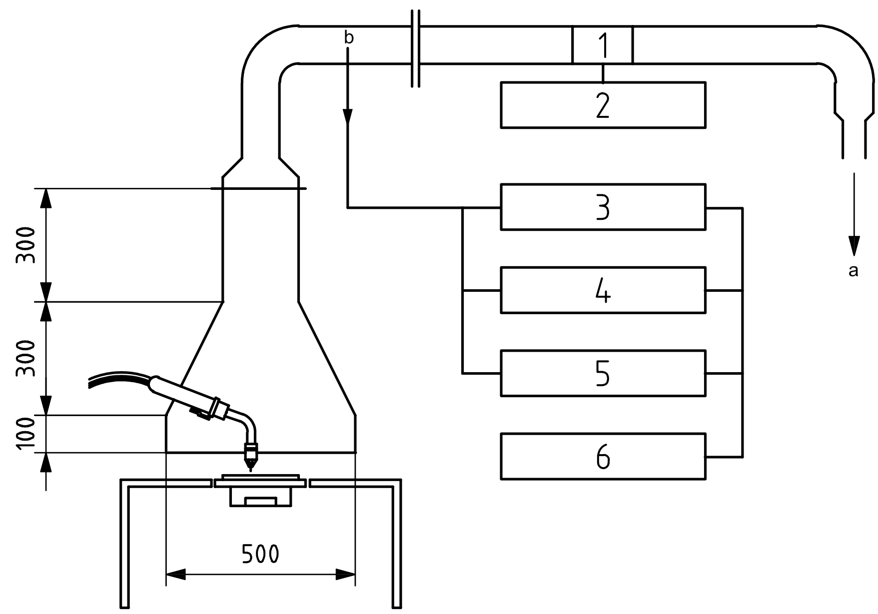
Possible designs of hood

A.1 Design 1

Measurements of the emission rate of carbon monoxide (CO), carbon dioxide (CO_2), nitrogen monoxide (NO) and nitrogen dioxide (NO_2) during arc welding operations may be carried out using a hood of the design shown in Figure A.1. This consists of a pyramidal test chamber, having a base with dimensions of 500 mm × 500 mm, a skirt height of 100 mm and a pyramid height of 300 mm. A 200 mm diameter, 300 mm tall stack is fitted to the top of the chamber, so that the total height from the base to the top of the stack, which is connected to an extraction unit, is approximately 700 mm.

As it is shown in Figure A.1, the hood is only suitable for use in the determination of emission rates during automatic welding. However, with suitable modifications it can also be used for the determination of emission rates of gases during manual welding.

Dimensions in millimetres



Key

1 air flow probe
2 micromanometer
3 CO_2 analyser
4 CO analyser
5 NO-NO_2 analyser
6 logging equipment

a To extraction unit.
b Sampling position.

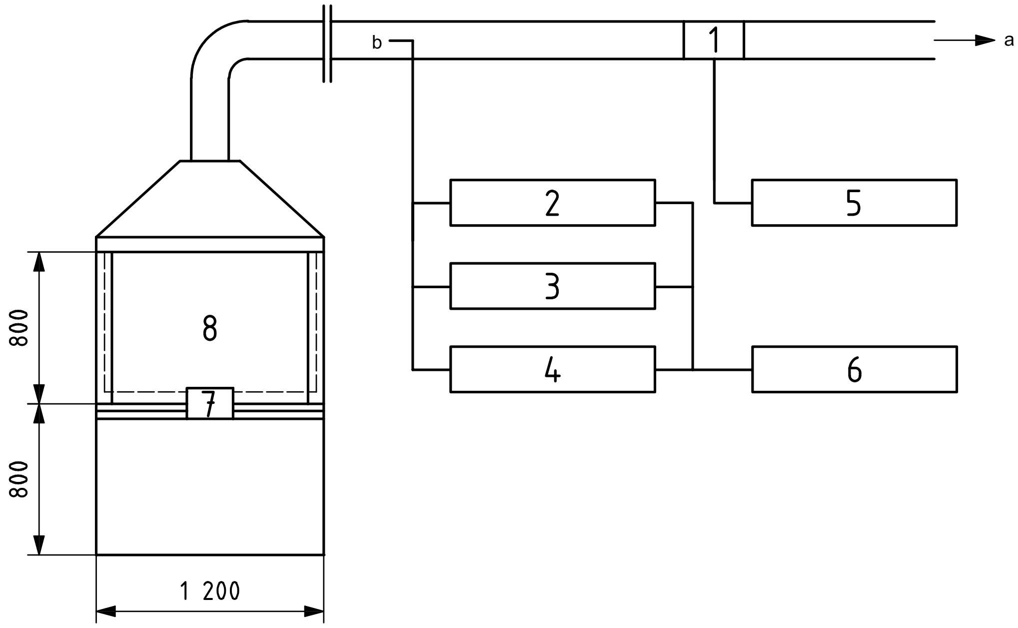
Figure A.1 — Hood for arc welding

A.2 Design 2

Measurements of the emission rate of carbon monoxide (CO), carbon dioxide (CO_2), nitrogen monoxide (NO) and nitrogen dioxide (NO_2) during manual cutting and gouging operations may be carried out using a hood of the design shown in Figure A.2. This is substantially larger than the hood shown for welding in Figure A.1. The overall dimensions of the hood are approximately 1 600 mm high by 1 200 mm wide and 800 mm deep, and the chamber in which the cutting and gouging are performed is approximately 800 mm high, 1 200 mm wide and 800 mm deep. These dimensions permit cutting and gouging processes to be performed without causing significant damage to the hood.

The hood shown in Figure A.2 is only suitable for use in determining of emission rates during manual cutting and gouging.

Dimensions in millimetres



Key

1 air flow probe
2 CO_2 analyser
3 CO analyser
4 NO-NO_2 analyser
5 micromanometer
6 logging equipment
7 position of cutting/gouging torch
8 hood

[a] To extraction unit.
[b] Sampling position.

Figure A.2 — Hood for cutting and gouging

Annex B
(informative)

Equipment notes

B.1 Construction of the hood

The gas sampling position can be in the hood outlet section, or in the extraction ducting, in a position where the gases emitted are mixed uniformly with the extracted air. The minimum distance of the sampling position in the ducting from the outlet of the hood should be approximately five times the diameter of the ducting.

B.2 Extraction unit

For arc welding in hoods of similar dimensions to those shown in Figure A.1, the extraction unit should be capable of providing an air flow rate of approximately 2 m^3/min. Air flow rates below 1,7 m^3/min might not retain the gases emitted within the hood, whilst air flow rates above 3 m^3/min might compromise the integrity of the process. An air flow rate of 2 m^3/min is considered to be suitable.

For cutting and gouging processes in hoods with similar dimensions to those shown in Figure A.2, flow rates between 10 m^3/min and 20 m^3/min are required to retain gaseous emissions.

If the air flow rate is to be controlled using the extraction unit, it should be fitted with a variable control. It is also possible to control the air flow rate using a damper in the extraction ducting.

B.3 Sampling system

B.3.1 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 might 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.

B.3.2 Sampling flow rate

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

B.4 Logging system

Logging systems with a logging interval of at least 1 s permit accurate averaging of gas concentrations over selected time periods.

B.5 Device for measuring air flow rate

Arc welding, cutting and gouging generate particulate fume and consideration should be given to the fact that the measuring device shall operate in fume-laden air.

Use of a digital manometer or anemometer with logging capabilities is desirable because air flow rate can vary somewhat with time and use of such equipment allows an average air flow rate to be calculated.

B.6 Equipment for measuring shielding gas flow rate

Gas flow rates are normally measured using a device, such as a rotameter, turbine, mass flow meter or bubble flow meter. For measurement of shielding gas flow rates in welding, the device should be connected to the gas nozzle of the torch. If the device is connected to a gas supply line, care should be taken to ensure that there are no gas leaks. For some equipment, such as rotameters, the flow rate measurement is dependent on the shielding gas composition.

B.7 Placement of the hood

The hood shall be placed over a plane surface. The small gap between the hood and the surface provides turbulence, causing mixing of the gases generated with the extracted air, providing improved reproducibility. The plane surface can be provided by employing a specially constructed table, clamping metal sheets of appropriate dimensions to the traverse or by placing metal-topped tables of appropriate height and dimensions on either side of the traverse.

B.8 Test pieces

Test pieces made from commercial bar stock, 50 mm wide $\times$ 10 mm thick $\times$ 500 mm long, are generally suitable for linear welding, but materials of other dimensions may be used. Test pieces shall be free of coatings, dirt, grease, oil, paint or rust, unless the purpose of the evaluation is to determine the effect of a surface condition on emission rates. In that case, the condition of the surface shall be as uniform as possible on all test pieces.

Annex C
(informative)

Welding parameters for gas-shielded arc welding

C.1 Starting test conditions

Although this part of ISO 15011 simply defines a method with which to conduct gas emission rate tests, it is considered helpful, nevertheless, to indicate a useful set of starting conditions around which test parameters can be varied. C.2 to C.8 provide suggestions for these starting conditions and indicate possible alternative conditions for evaluation in the testing.

C.2 Welding position

Tests can be carried out by welding bead-on-plate in the PA position (see ISO 6947[2]) or in a horizontal/vertical fillet in the PB position (see ISO 6947[2]).

C.3 Torch angle and travel direction

For MMA welding, the electrode is typically at an angle of 80° to the test piece and a pulling technique would be employed.

For MIG/MAG welding, FCAW, MCAW and SSFCAW, the torch is typically at an angle of 80°, measured between the test piece and the wire axis, i.e. the end of the torch from which the wire exits would be almost vertical. The torch angle, or electrode angle, should be adjusted to produce an acceptable weld bead if a horizontal/vertical fillet weld is deposited. Welding may be carried out using a pushing or pulling technique, but the technique used should be appropriate for use with the consumable tested. For TIG welding, the tungsten electrode would, typically, be at 90° to the test piece, i.e. the torch is vertical. During emission rate testing, it is common practice to weld with a stationary torch whilst the test piece is traversed underneath.

Typically, cutting is performed with the torch in a vertical position, so the travel direction is irrelevant.

Gouging is carried out at an angle of around 20° to the gouged material, using a pushing technique.

C.4 Welding, cutting or gouging speed

The welding, cutting or gouging speed should be set on the device for automatic arc welding, cutting or gouging (see 5.12) by an experienced operator in order to provide a visually satisfactory weld, cut or gouge.

C.5 Polarity

Where relevant, the polarity recommended by the equipment or consumable manufacturer should be used.

C.6 Distances between the process and the test piece

C.6.1 The CTWD

For continuous wire processes, the CTWD suggested by the consumable manufacturer should be used. If this information is not available, the CTWDs shown in Tables C.1 and C.2 can be used.

Table C.1 — Recommended CTWDs for MIG/MAG welding with solid wires using spray transfer

Consumable diameter mm	**CTWD** mm
0,6	8
0,8	10
1,0	15
1,2	18
1,6	22
2,0	26
2,4	28

Table C.2 — Recommended CTWDs for MIG/MAG welding with flux-cored and metal-cored wires

Consumable diameter mm	**CTWD** mm
0,9	15
1,0	18
1,2	20
1,4	22
1,6	25
2,0	28
2,4	30

The manufacturer’s recommended value should be used when welding with flux-cored and metal-cored wires.

The values are based on those recommended in IEC 60974-7[4].

C.6.2 The ETWD

For TIG welding, an ETWD of 3 mm is used.

C.6.3 Flame cone to workpiece distance

For oxyfuel gas cutting, the flame cone(s) should be positioned approximately 1 mm above the test piece surface.

C.7 Gas flow rates

For gas-shielded arc welding, the shielding gas flow rate recommended by the manufacturer should be employed. Similarly, the gas flow rates recommended by the manufacturer should be employed in cutting and gouging.

C.8 Gas nozzles and relative contact or electrode tip positions

For MIG/MAG welding, the gas nozzle should be appropriate for the process and welding conditions. Typically, the internal diameter is between 15 mm and 20 mm.

For MIG/MAG welding with short-circuiting transfer, the contact tip extends 1 mm to 2 mm outside the gas nozzle.

For MIG/MAG welding with spray transfer, the contact tip is 2 mm to 3 mm inside the gas nozzle.

For TIG welding, the electrode usually projects between 3 mm and 6 mm outside the gas nozzle.

Annex D
(normative)

Test procedures

D.1 Attaching the leads for measuring voltage and current

For manual metal arc welding, attach one lead to the electrode holder/torch and the other to the test piece.

For continuous wire welding processes, attach the voltage leads to the wire feed unit and the test piece. For TIG welding, attach the voltage leads across the terminals of the power source.

It is not usual to measure voltage with cutting processes such as plasma cutting, as it would be necessary to connect the leads inside the power source and the voltages can be very high.

NOTE It is recognized that there can be a small voltage drop between the wire feed unit and the torch during continuous wire and TIG welding, but it is very difficult to dismantle the torch and connect a voltage lead. However, as the attachment point for the voltage lead is specified in this part of ISO 15011, measured test voltages are consistent.

If used, the Hall effect probe shall be positioned on the current return lead so that the direction of current flow matches the direction indicated on the probe.

D.2 Setting the CTWD

Remove the gas nozzle from the torch. Fix the test piece in position and place the gauge or metal wedge used for setting the CTWD (see 5.10) on the test piece. Lower the torch until the contact tip touches the gauge and secure the torch.

Drive the traverse until the torch is in a position where the gas nozzle can be re-attached and re-attach it, ensuring that the torch does not move when this is performed.

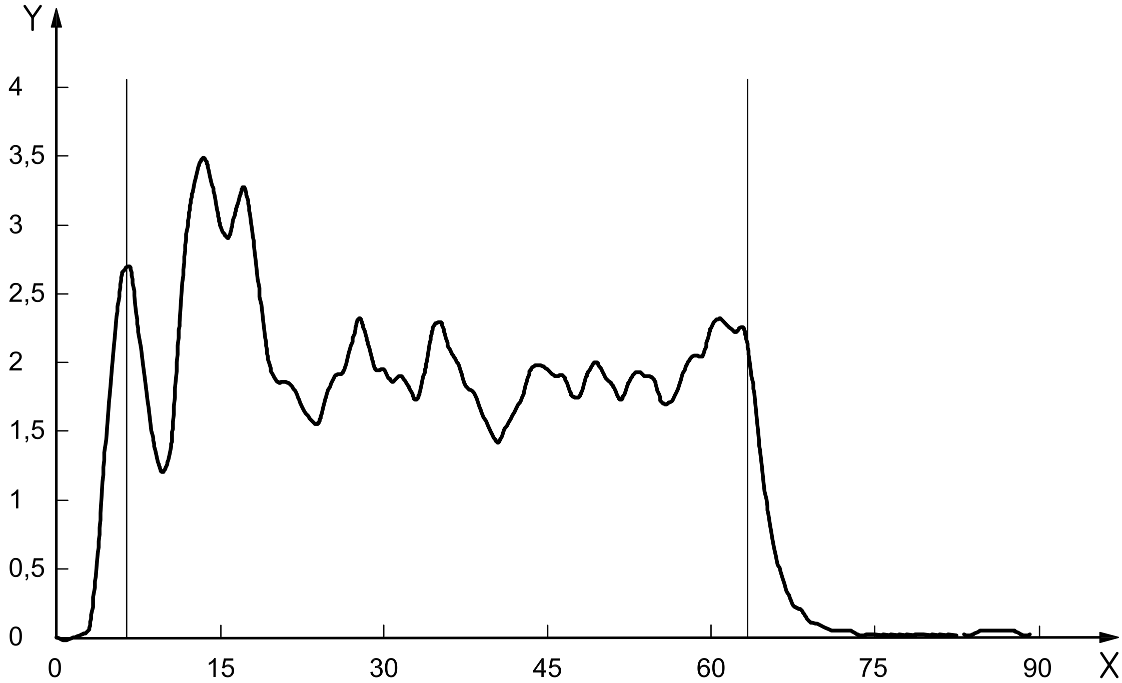
D.3 Setting the ETWD

Fix the test piece in position and place the gauge or metal wedge used for setting the ETWD (5.11) on the test piece. Lower the torch until the contact tip touches the gauge and secure the torch.

Annex E
(normative)

Calculation of the average stable gas concentration

Figure E.1 shows a typical plot of a gas concentration, at the sampling position, against arcing time, for a single replicate test. Arcing commences at time = 0 s and terminates at time = 85 s. Line markers are placed at the extremities of the area selected as providing a stable gas concentration.



X time after arc ignition (s)

Y gas concentration (ml/m^3)

Figure E.1 — Plot of gas concentration against time

Calculate the average stable gas concentration by averaging the gas concentrations measured within the time period selected as providing a stable gas concentration.

Annex F
(normative)

Test report

Date of test						
Laboratory/Operator						
Project No./Test No.						
Welding	Process: Torch angle: Welding speed: Polarity:			Gas nozzle diameter and shape: CTWD: Contact tip position relative to gas nozzle: Pushing or pulling:		
Cutting/Gouging	Process: Gas type: Gas pressures:			Nozzle size: Cutting/gouging speed:		
Welding consumable	Manufacturer/Name/Diameter/Classification/Remarks:					
Test piece	Composition/Dimensions/Surface condition/Remarks:					
Shielding gas	Trade name/Composition/Flow rate/Classification/Remarks:					
Power source	Manufacturer/Type/Model/Set-up/Remarks:					
Air flow measuring equipment	Type/Model:					
Arc monitoring equipment	Make/Model/Reference number/Connections/Remarks:					
Pulse details						
Measurement details	Test 1	Test 2	Test 3	Test 4	Test 5	Mean
Arc current (A)						
Arc voltage (V)						
Wire feed speed (m/min)						
Stable gas concentration (ml/m^3)						
Air velocity or pressure difference						
Air flow (m^3/h)						
Gas emission rate (ml/min)						
Estimated uncertainty in accordance with ISO/IEC Guide 98-3:						
Remarks:						

Bibliography

[1] ISO 5167-1, *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full — Part 1: General principles and requirements*

[2] ISO 6947, *Welds — Working positions — Definitions of angles of slope and rotation*

[3] ISO 9169, *Air quality — Definition and determination of performance characteristics of an automatic measuring system*

[4] IEC 60974-7, *Arc welding equipment — Part 7: Torches*

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