INTERNATIONAL STANDARD

ISO 15011-1

Second edition
2009-10-15

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

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

Partie 1: Détermination du débit d'émission de fumée lors du soudage à l'arc et collecte des fumées pour analyse

Reference number
ISO 15011-1:2009(E)

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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 15011-1 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 (ISO 15011-1:2002), 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 fume emission rate and for collecting fume for subsequent analysis. The procedure simply prescribes a methodology, leaving selection of the test parameters to the user, so that the effects of different variables can be evaluated.

Emission rates vary considerably depending upon the exact test conditions; therefore, test parameters are prescribed in ISO 15011-4 for the generation of fume emission rate data, which can be used for comparing emission rates of welding consumables.

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

1 Scope

This part of ISO 15011 defines a laboratory method for measuring the emission rate of fume from arc welding. It also defines a method of collecting the fume for subsequent analysis and refers to suitable analytical techniques. The methods described are suitable for use with all open arc welding processes except tungsten inert gas (TIG) welding, which produces little fume.

The emission rate method can be used to evaluate the effects of welding electrodes and wires, welding parameters, processes, shielding gases, test piece composition and test piece surface condition on fume emission rate. Following analysis of the fume collected, the effects of test parameters on fume composition can also be determined.

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 is performed manually or automatically for manual metal arc (MMA) welding or automatically for continuous wire processes, on a test piece inside a semi-enclosed, continuously extracted test chamber. The fume is collected on a pre-weighed filter and the arcing time (in seconds) is recorded. After welding, the filter is re-weighed and the mass of fume collected (in milligrams) is calculated by difference. The fume emission rate (in milligrams per second) is calculated by dividing the mass of fume collected (in milligrams) by the arcing time (in seconds).

The fume generated is removed and retained for subsequent analysis.

5 Equipment and materials

5.1 Test chamber, having a top section in which a filter (5.2) is positioned to capture all fume produced when an emission rate test is carried out, of a construction that minimizes the deposition of fume on the internal surfaces (see B.1), and attached to a suitable extraction unit (5.3). Examples of possible designs are described in Annex A.

5.2 Filters, manufactured from glass or quartz fibre, for emission rate testing. The filters shall be sufficiently robust that they do not tear or perforate during testing (see B.2) and shall not be so friable that fibres can be lost from the filters during handling.

Paper (cellulose) filters, for collection of fume for analysis. Glass and quartz fibre filters are not suitable because the fume cannot be removed from the filter without contaminating it with fibres.

The surface area of the filters shall be large enough to avoid excessive pressure drop during emission rate testing and collection (see B.2).

5.3 Extraction unit, capable of maintaining an adequate air flow rate through the filter (5.2), such that all fume generated is contained within the test chamber (5.1) throughout the arcing period and the test chamber is cleared of fume within 30 s of arc extinction, but not so high as to compromise weld metal integrity (see B.3). The precise characteristics of the extraction unit are not critical.

5.4 Equipment for measuring welding current, arc voltage, wire feed speed and arcing time, capable of measuring the arithmetic mean of the current, voltage and wire feed speed to within ± 5 % or better and the arcing time to 0,1 s 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 shunt or a Hall effect probe connected to a moving coil meter. Voltage may be measured using a moving coil meter. Wire feed speed may be measured by measuring the length of wire exiting the welding torch in a measured time. Arcing time may be measured using a stopwatch with a reading accuracy of 0,1 s or better.

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

5.5 Equipment for measuring the mass of fume collected, consisting of a balance capable of measuring the mass of filters and filters plus fume with an accuracy of ± 1 mg or better.

The balance calibration shall be traceable to national standards.

5.6 Equipment for measuring shielding gas flow rate, calibrated for the shielding gas in use, capable of measuring the flow rate to within ± 5 % or better (see B.4).

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

5.7 Device for setting 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.

5.8 Device for automatic welding, permitting the emission rate test to be performed under automated conditions, capable of advancing the test piece under a stationary 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 the test piece to the device, such that it cannot bow or flex during welding.

5.9 Test pieces, of a material and of dimensions suitable for the process and consumable examined, and which allow a weld of sufficient length to be continuously deposited for an arcing time of at least 60 s (see B.5).

6 Test procedures

6.1 Welding procedure selection

Perform 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.

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 fume emission rates than manual welding. However, for MMA welding, this is difficult or impossible to carry out.

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

6.2 Manual metal arc welding

6.2.1 Setting up the test chamber

Set up the test chamber (5.1) in an interference-free environment (see B.6).

6.2.2 Trial tests

6.2.2.1 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, voltage and time. See D.1 for further guidance.

Secure a test piece (5.9), centrally within the test chamber, so that it cannot move, bow or flex during welding.

Commence welding (see C.2 for information on the welding position) 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 to weld 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 the trial test to establish the test time for emission rate tests (see 6.2.2.2).

6.2.2.2 Trial test to establish the test time for emission rate tests

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. Put a pre-weighed filter (5.2) for measuring fume emission rate in place, start the extraction unit (5.3) and recommence welding.

Weld for 60 s or less if the electrode is completely deposited within this time, e.g. for electrodes less than 4 mm in diameter. Then switch off the extraction unit.

If, visually, fume escapes from the test chamber before the arcing period is complete, note the time at which this first occurs and repeat the trial test using a shorter arcing time than that noted. If fume no longer escapes from the test chamber when using the reduced arcing time, use this arcing time in the emission rate tests. If fume does escape from the test chamber using the reduced arcing time, repeat the process until a suitable arcing time is obtained.

If fume does not escape from the test chamber before the 60 s arcing period is complete, or before the electrode is completely deposited, stop welding and re-weigh the filter. If the mass of fume collected exceeds 100 mg, use the 60 s arcing time in the emission rate tests or deposit a complete electrode. If the mass of fume collected is less than 100 mg, calculate the number of electrodes that need to be deposited to generate at least 100 mg of fume and deposit this number of electrodes in the emission rate tests.

6.2.3 Emission rate tests

Place a pre-weighed filter (5.2) in position in the test chamber.

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 (5.3). Commence welding and, if manual timing is to be performed, start the stopwatch at the same time (5.4). Stop welding after the required arcing time or when the electrode has been completely deposited, as determined in the trial tests (see 6.2.2.2) and, at the same time, stop the stopwatch, if used. Leave the extraction unit on until the fume generated has been cleared from the test chamber (at least 30 s) and then switch off the extraction unit.

If the trial tests indicated the necessity to deposit several electrodes in order to collect sufficient fume, repeat the procedure above, depositing the number of electrodes indicated in the trial tests, whilst collecting the fume on the same filter, and calculate the total arcing time.

Remove the filter and re-weigh.

Perform three replicate tests and calculate the mean fume 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.

6.2.4 Fume collection for analysis

Secure a test piece (5.9) inside the test chamber so that it cannot move, bow or flex during welding.

Place a filter (5.2) in position in the test chamber.

Start the extraction unit and weld until, based upon the result of an emission rate test, sufficient fume for analysis has collected on the filter.

NOTE 1 If an emission rate test is not carried out, estimation of the required arcing time is a matter of trial and error.

NOTE 2 It might be necessary to deposit several electrodes on multiple test pieces to collect sufficient fume for analysis.

Stop welding, turn off the extraction unit and remove the filter from the test chamber.

Immediately brush the fume from the filter with a clean brush and place in a container with an airtight seal for storage to prevent absorption of water.

If it is not possible to remove sufficient fume for analysis from the filter, repeat the process for a longer arcing time, preferably using the same filter.

6.3 Continuous wire processes

6.3.1 Setting up of the test equipment

Set up the test chamber in an interference-free environment (see B.6).

6.3.2 Trial tests

6.3.2.1 Trial test to set the test conditions

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 and time (5.4). 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 (5.9) to the device for automatic welding (5.8) so that it cannot move, bow or flex during welding and such that a constant CTWD is maintained throughout the test.

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

Set the desired CTWD (see D.2) by raising or lowering the torch.

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 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 test 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 the trial test to establish the test time (see 6.3.2.2).

6.3.2.2 Trial test to establish the test time for emission rate tests

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. Put a pre-weighed filter (5.2) for measuring fume emission rate in place, manoeuvre the test chamber over the torch so that the torch is positioned centrally, start the extraction unit (5.3) and recommence welding.

Weld for 60 s and then switch off the extraction unit.

If, visually, fume escapes from the test chamber before the arcing period is complete, note the time at which this first occurs and repeat the trial test using a shorter arcing time than that noted. If fume no longer escapes from the test chamber when using the reduced arcing time, use this arcing time in the emission rate tests. If fume does escape from the test chamber using the reduced arcing time, repeat the process until a suitable arcing time is obtained.

If fume does not escape from the test chamber before the 60 s arcing period is complete, stop welding and re-weigh the filter. If the mass of fume collected exceeds 100 mg, use the 60 s arcing time in the emission rate tests. If the mass of fume collected is less than 100 mg, calculate the arcing time required to generate at least this mass of fume and use this arcing time in the emission rate tests.

NOTE Arcing times exceeding 60 s might necessitate welding on more than one test piece.

6.3.3 Emission rate tests

Place a pre-weighed filter (5.2) in position in the test chamber.

Renew or reposition the test piece (5.9) 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. Position the test piece under the torch ready to commence welding. Manoeuvre the test chamber over the torch so that the torch is positioned centrally. Switch on the extraction unit (5.3) and all monitoring equipment (5.4). Start the device for automatic welding. Commence welding and, if manual timing is to be performed, start the stopwatch at the same time (5.4). Stop welding after the required arcing time, as determined in the trial test (see 6.3.2.2), and, at the same time, stop the stopwatch, if used. Leave the extraction unit on until the fume generated has been cleared from the test chamber (at least 30 s) and then switch off the extraction unit.

If the trial tests indicated that an arcing time of more than 60 s would be required to collect sufficient fume, repeat the procedure above, using new test pieces if necessary, whilst collecting the fume on the same filter, and calculate the total arcing time.

Remove the filter and re-weigh.

Perform three replicate tests and calculate the mean fume 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.

6.3.4 Fume collection for analysis

Secure a test piece (5.9) to the device for automatic welding (5.8) so that it cannot move, bow or flex during welding and such that a constant CTWD is maintained throughout the test.

Place a filter (5.2) in position in the test chamber and then manoeuvre the test chamber over the torch so that the torch is positioned centrally.

Start the extraction unit and weld until, based upon the result of an emission rate test, sufficient fume for analysis has collected on the filter.

NOTE 1 If an emission rate test is not carried out, estimation of the required arcing time is a matter of trial and error.

NOTE 2 It might be necessary to weld on multiple test pieces to collect sufficient fume for analysis.

Stop welding, turn off the extraction unit and remove the filter from the test chamber.

Immediately brush the fume from the filter with a clean brush and place in a container with an airtight seal for storage to prevent absorption of water.

If it is not possible to remove sufficient fume for analysis from the filter, repeat the process for a longer arcing time, preferably using the same filter.

6.4 Analysis of the fume collected

Analyse, as a minimum, the principal components of the welding fume collected, i.e. those components of occupational hygienic significance. For recommended minimum analytical requirements, see ISO 15011-4:2006[2], Annex E. Published methods for the determination of hazardous substances in workplace air may be adapted for the analysis of bulk welding fume (see ISO 15202-2[3], ISO 15202-3[4], ISO 16740[5] and ISO 21438-3[6] for examples of such methods).

7 Calculating and reporting the results

Calculate the mass of fume emitted (in milligrams) for each replicate test.

Calculate the fume emission rate (in milligrams per second) for each replicate test by dividing the mass of fume emitted (in milligrams) by the arcing time (in seconds).

Calculate the mean fume 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 E.

Annex A
(informative)

Possible designs of test chamber

A.1 Test chambers of the “hood” type

A.1.1 Field of use

Test chambers of the “hood” type (see Note in 3.2) are generally suitable for use in automatic arc welding tests, whilst those that incorporate hand-holes are also suitable for use in manual arc welding tests.

A.1.2 Design 1

Emission rate measurements and fume collection may be carried out using a hood of the design shown in Figure A.1. This hood, which is described in detail in AWS F1.2 [7], consists of a conical test chamber, having a base diameter of 600 mm and a height of 600 mm. The chamber has a 300 mm diameter upper section, incorporating, at the top, an extraction unit and, at the bottom, an assembly into which a filter is installed to collect the emitted fume. The chamber is provided with two hand-holes with rubber sealing flaps to prevent fume escaping; it is fitted with a large viewing window, equipped with a protective filter, so that the arc may be viewed and guided during welding and it is mounted on levelling bolts to provide a minimum clearance of 15 mm above the surface on which it stands, to allow for the ingress of air. A filter assembly for collecting the fume, consisting of the filter and its supports, and an extraction device are mounted at the top of the chamber.

Since it incorporates hand-holes and has no floor, the hood shown in Figure A.1 is suitable for both automatic and manual welding tests.

A.1.3 Design 2

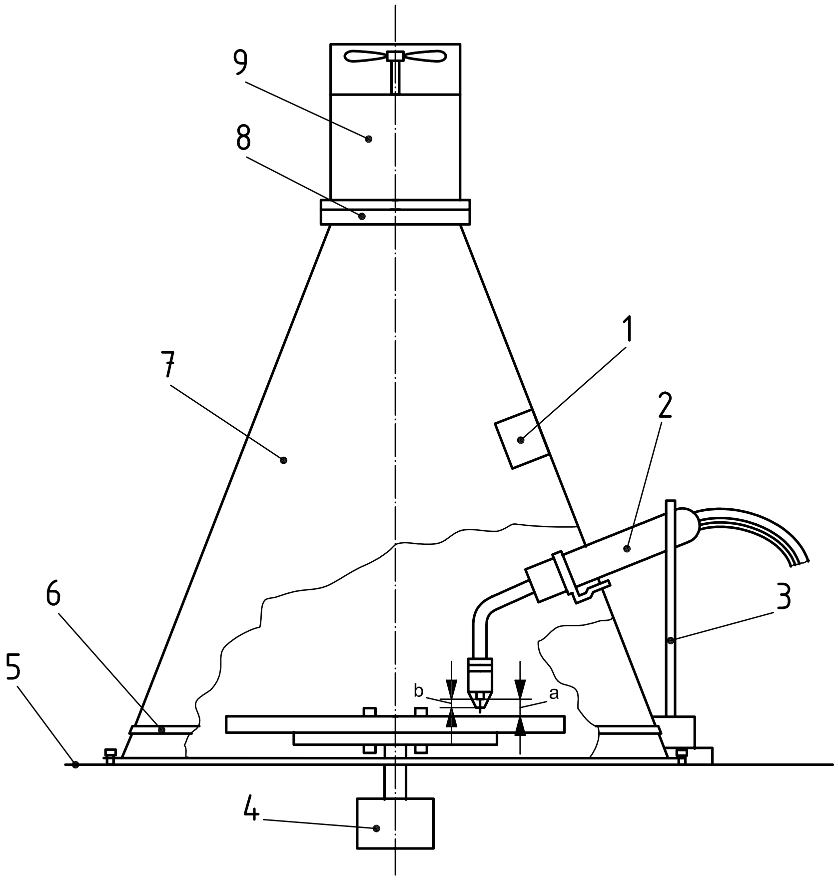
Emission rate measurements and fume collection may be carried out using a hood of the design shown in Figure A.2. This consists of a pyramidal test chamber having a base with dimensions of 500 mm × 500 mm, a skirt height of 100 mm and a pyramid height of 300 mm. A 200 mm diameter, 300 mm tall stack is fitted to the top of the chamber, at the top of which is an assembly into which a filter is installed to collect the emitted fume. The total height from the base to the top of the stack, which is connected to an extraction unit, is approximately 700 mm.

As shown in Figure A.2, the hood is only suitable for use in automatic arc welding tests. However, it could be modified to incorporate hand-holes in which case it could also be used in manual welding tests.

A.2 Test chambers of the “fume box” type

A.2.1 Field of use

Test chambers of the “fume box” type (see Note in 3.2) are suitable for use in manual welding tests only.



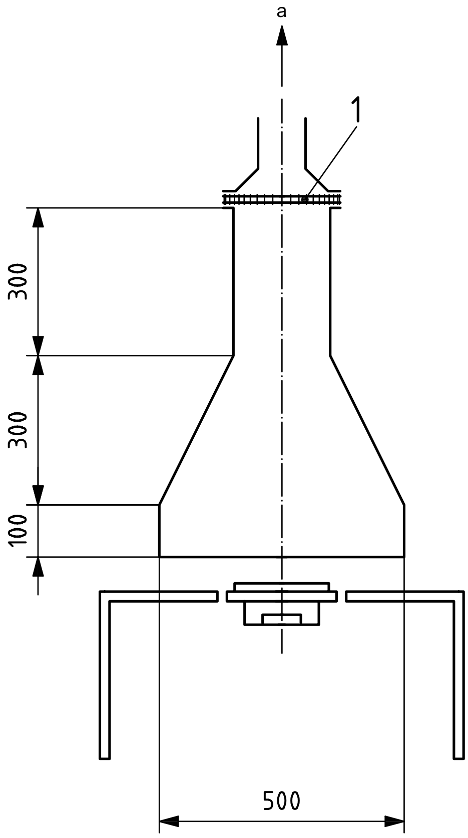
Key

1 viewing window and protective screen
2 welding torch
3 adjustable stand
4 turntable
5 support table
6 stiffener ring
7 test chamber
8 filter and support screen
9 upper part and extraction unit

[a] The CTWD.
[b] Electrode extension.

Figure A.1 — Hood for manual and automatic welding

Dimensions in millimetres



Key

1 filter

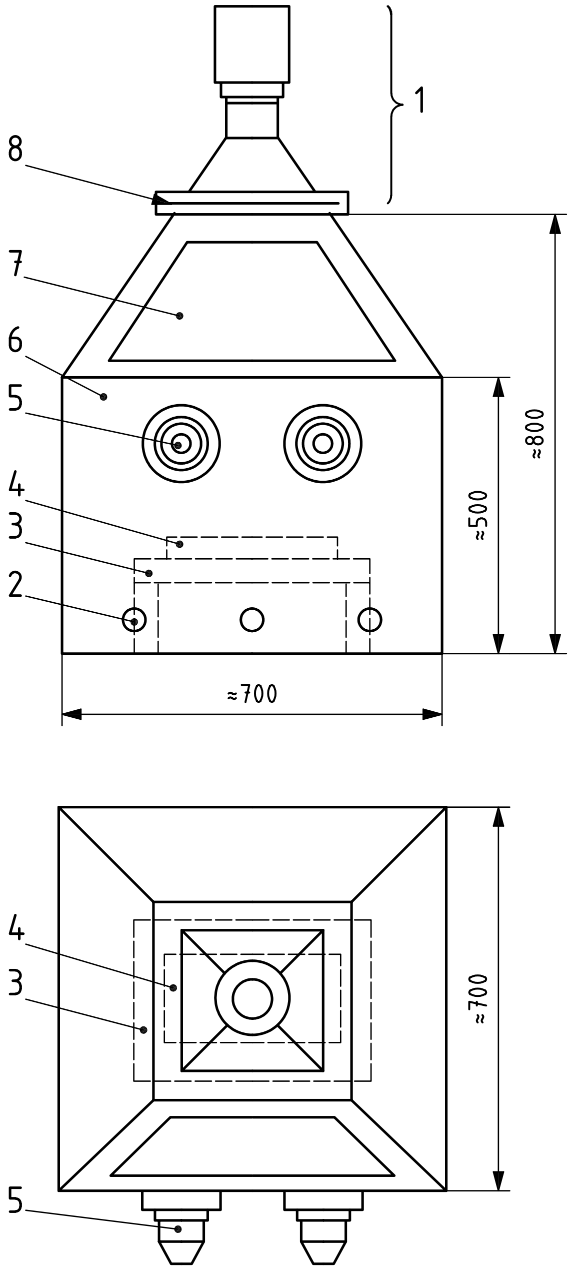
a To extraction unit.

Figure A.2 — Hood for automatic welding

A.2.2 Design 3

The fume box design shown in Figure A.3 originates from Japan and is described in JIS Z 3930 [8]. The test chamber is approximately 700 mm long × 700 mm wide × 500 mm high. The chamber has a 300 mm diameter upper section, at the top of which is an assembly into which a filter is installed to collect the emitted fume. The height from the base to the filter assembly is approximately 800 mm. An extraction unit is attached to the top of the box and ventilation holes are present on each side, near the base, to allow for the ingress of air. There is a viewing window with protective screen and hand-holes on one side to permit manual welding.

Dimensions in millimetres



Key

1 extraction unit
2 ventilation hole
3 welding stand
4 test piece
5 hand-hole
6 chamber
7 viewing window
8 filter

Figure A.3 — Fume box for manual welding

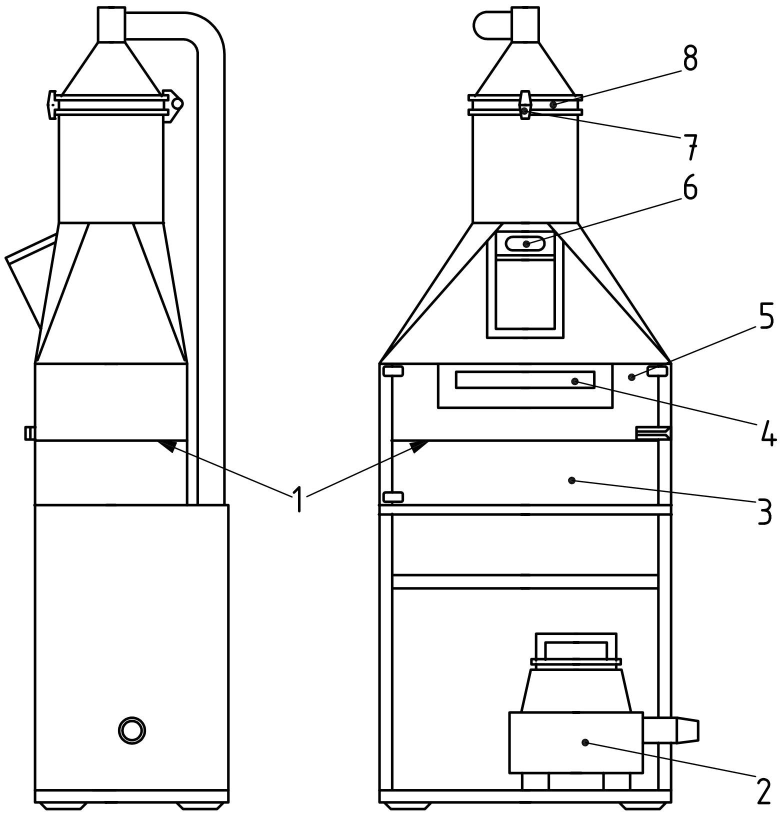
A.3 Interconvertible test chambers

A.3.1 Field of use

Interconvertible test chambers, in which the floor can easily be removed and replaced to facilitate ready interconversion to and from “fume box” type and “hood” type test chambers (see Note in 3.2), are suitable for use in manual and automatic arc welding tests.

A.3.2 Design 4

The interconvertible test chamber, shown in Figures A.4 and A.5, is designed mainly as a fume box for manual welding; however, with slight modification, it can be used as a hood for automatic welding. It consists of a cylindrical upper part on top of a chamber in which welding occurs. In its manual welding form, the front of the chamber has the facility to be opened or detached to allow the introduction of test pieces and cleaning of the inside of the box. The front of the chamber has an aperture to allow insertion of an MMA electrode and the ingress of air. The edges of the aperture should be electrically insulated to prevent inadvertent arcing between the consumable and the box. A copper sheet, at least 2 mm thick, clamped on top of the chamber base, improves electrical contact and enhances spatter removal. The chamber base should be provided with a terminal for electrical connection to the power source. The copper upper shelf in the base on which welding usually takes place should be provided with a means of restraining test pieces during welding. The minimum height of the filter above the base should be 600 mm to prevent spatter reaching the filter and the maximum height should be 1 000 mm. The minimum base area should be 0,1 m^2 and the maximum 0,2 m^2. For automatic welding, that part of the box above the chamber is detached by removing the fixing screws and is replaced with a skirt 500 mm deep, manufactured from mild steel sheet, to produce a hood very similar to that shown in Figure A.2.

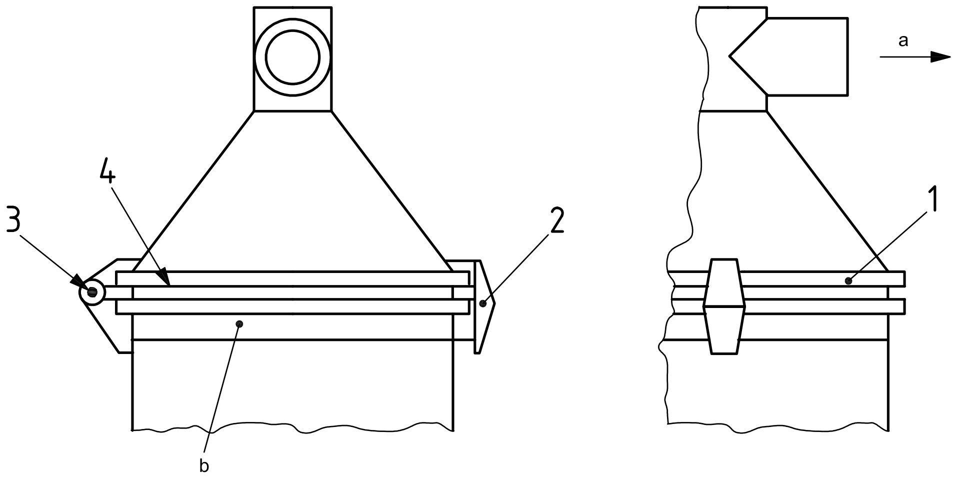


Key

1 copper upper shelf
2 extraction unit
3 welding chamber
4 insulated aperture for manual welding
5 separation level for modification to automatic welding
6 viewing window with protective screen
7 clamp
8 filter assembly

Figure A.4 — Fume box for manual welding that can be readily converted for automatic welding

Dimensions in millimetres



Key

1 flange, recessed to hold O-ring seal

2 clamp

3 hinge

4 wire mesh across top section flange

[a] To extraction unit.

[b] Diameter to match outlet from welding chamber.

Figure A.5 — Detail of filter holding assembly of fume box in Figure A.4

Annex B
(informative)

Equipment notes

B.1 Construction of the test chamber

The inside of the test chamber should be smooth, free of sharp corners and ledges allowing, as far as possible, an unimpaired flow of air through the system. Mild steel sheet that is 1 mm thick is a suitable material for construction of the test chamber.

B.2 Filters

The nominal pore size of the filter is not of great significance as fume covers the filter in the first few seconds after the extraction unit is switched on. The mat of fume, so formed, then acts as an efficient filter for the remaining collection period.

The glass and quartz fibre filters used for fume emission rate testing provide good mass stability with respect to humidity. This ensures that the passage of warm air through them from welding does not result in significant changes in mass.

Paper filters are used to collect fume for analysis because they are not friable and have low analytical blank properties.

Filters with too small a surface area become clogged very quickly when welding consumables with a high fume emission rate are tested. In such cases, test times need to be very short to prevent fume escaping from the test chamber and this can lead to unacceptably high time recording errors. Consequently, the filters used should have a sufficiently large surface area, e.g. 450 cm^2.

B.3 Extraction unit

For test chambers of similar dimensions to those shown in Annex A, the extraction unit should be capable of providing an air flow rate in the range 1 m^3/min to 2 m^3/min. Flow rates higher than this could compromise weld metal integrity, as indicated by visual porosity.

B.4 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 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.5 Test pieces

Test pieces made from commercial bar stock, 50 mm wide × 10 mm thick × 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, paints or rust, unless the purpose of the evaluation is to determine the effect of the surface condition on emission rates. In that case, the condition of the surface shall be as uniform as possible on all test pieces.

B.6 Interference-free environment

An interference-free environment is an environment that does not affect the amount of fume measured. Therefore, it should be free of significant concentrations of particles that could be collected on the filter.

Annex C
(informative)

Welding parameters

C.1 Starting test conditions

Although this part of ISO 15011 simply defines a method by which to conduct fume emission rate tests, it is useful, nevertheless, to indicate some starting conditions around which other parameters might 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[1]) or in a horizontal/vertical fillet in the PB position (see ISO 6947[1]).

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 is employed.

For MIG/MAG, FCAW, MCAW and SSFCAW, the torch is usually 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 shall be almost vertical. Welding can be carried out using either a pushing or a pulling technique. During emission rate testing, it is common practice to weld with a stationary torch whilst the test piece is traversed underneath.

C.4 Welding speed

The welding speed should be set on the device for automatic arc welding (see 5.8) by an experienced welder in order to provide a visually satisfactory weld deposit. Typically, the welding speed is in the range 250 mm/min to 300 mm/min in most cases.

C.5 Polarity

The polarity recommended by the consumable manufacturer should be used.

C.6 The CTWD

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 may be used.

Table C.1 — Recommended CTWDs for MIG/MAG welding

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 FCAW and MCAW

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

C.7 Shielding gas flow rate

The shielding gas flow rate recommended by the manufacturer should be employed.

C.8 Gas nozzle

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

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

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

Annex D
(normative)

Test procedures

D.1 Attaching the leads for measuring voltage and current

For MMA welding, attach one voltage lead to the torch, as close as possible to the electrode, and the other to the test piece, or the base to which the test piece is fixed. For continuous wire processes, attach one voltage lead to the wire feed unit and the other to the test piece.

NOTE It is recognized that there can be a small voltage drop between the wire feed unit and the torch during continuous wire welding, but it is very difficult to dismantle the torch and connect a voltage lead.

If used, a 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

For test chambers that permit adjustment of the CTWD outside the test chamber, use the following procedure.

Remove the gas nozzle from the torch. Fix the test piece in position and place the gauge or wedge on the test piece. Lower the torch until the contact tip touches the gauge or the wedge at the appropriate position 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.

For test chambers that do not allow adjustment of the CTWD outside the test chamber, use a suitable alternative procedure.

Annex E
(normative)

Test report

Date of test						
Laboratory/Operator						
Project No./Test No.						
Welding	Process: Manual or automatic: Torch make and type: Bead-on-plate, other: Torch/electrode angle: Welding speed: Polarity:			Gas nozzle diameter and shape: CTWD: Contact tip position relative to gas nozzle: Pushing or pulling:		
Consumable	Manufacturer/Name/Diameter/Classification/Remarks:					
Test piece	Composition/Dimensions/Surface condition/Remarks:					
Shielding gas	Name/Composition/Flow rate/Classification/Remarks:					
Power source	Manufacturer/Type/Model/Set-up/Remarks:					
Pulse parameters						
Arc monitoring equipment	Make/Model/Reference number/Connections/Remarks:					
Measurement details	Test 1	Test 2	Test 3	Test 4	Test 5	Mean
Arc current (A)						
Arc voltage (V)						
Arcing time (s)						
Wire feed speed (m/min)						
Mass of filter before test (g)						
Mass of filter after test (g)						
Mass of fume (mg)						
Fume emission rate (mg/s)						
Estimated uncertainty in accordance with ISO/IEC Guide 98-3:						
Remarks:						

Bibliography

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

[2] ISO 15011-4:2006, *Health and safety in welding and allied processes — Laboratory method for sampling fume and gases — Part 4: Fume data sheets*

[3] ISO 15202-2, *Workplace air — Determination of metals and metalloids in airborne particulate matter by inductively coupled plasma atomic emission spectrometry — Part 2: Sample preparation*

[4] ISO 15202-3, *Workplace air — Determination of metals and metalloids in airborne particulate matter by inductively coupled plasma spectrometry — Part 3: Analysis*

[5] ISO 16740, *Workplace air — Determination of hexavalent chromium in airborne particulate matter — Method by ion chromatography and spectrophotometric measurement using diphenyl carbazide*

[6] ISO 21438-3, *Workplace air — Determination of inorganic acids by ion chromatography — Part 3: Hydrofluoric acid and particulate fluorides* [1)]

[7] AWS F1.2, *Laboratory method for measuring fume generation rates and total fume emission of welding and allied processes*

[8] JIS Z 3930, *Determination of emission rate of particulate fume in arc welding*

1) Under preparation.

ICS 13.100; 25.160.10
Price based on 20 pages