INTERNATIONAL STANDARD

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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

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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 15011-1 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.