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

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

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

ISO 15011-2 was prepared by 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.