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

Part 3:
Determination of ozone emission rate during arc welding

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

Partie 3: Détermination du débit d'émission d'ozone lors du soudage à l'arc

Reference number
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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 15011-3 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 (15011-3:2002), 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 rates 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 defines a method for measuring the emission rate of ozone during arc welding using a hood technique. 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. Research [2] has shown that differences in ozone emission rate measured using this technique correlate well with changes in exposure in the workplace.

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 3: Determination of ozone emission rate during arc welding

1 Scope

This part of ISO 15011 defines a laboratory method for measuring the emission rate of ozone during arc welding, using a hood technique. The method is directed primarily at measuring ozone emission rate when using gas-shielded arc welding processes, but it can also be employed with other processes, e.g. self-shielded flux-cored arc welding, provided that welding can be performed automatically under the hood.

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 is performed automatically, on a test piece, inside a continuously extracted test chamber of the "hood" type. The ozone concentration (in millilitres per cubic metre) at a fixed sampling position inside the hood and the air flow rate through the hood (in cubic metres per minute) are measured. The ozone emission rate (in millilitres per minute) is calculated by multiplying the ozone concentration at the fixed measuring point by the air flow rate.

5 Equipment and materials

5.1 Hood, semi-enclosed, continuously extracted chamber of the "hood" type, in which ozone emission rate tests are performed during arc welding. The hood shall be designed in accordance with the dimensions shown in Figure 1. The sampling position shall be 1 000 mm vertically from the base of the hood. The inside of the hood shall be non-reflecting.

NOTE See A.1 for guidance on the construction of the hood.

5.2 Extraction unit, capable of maintaining an air flow rate of 2 m^3/min through the hood (5.1), such that the ozone emitted is contained, but not so high as to compromise weld metal integrity (see A.2). The precise characteristics of the extraction unit are not critical.

5.3 Ozone meter and logging system, consisting of a calibrated ozone meter employing the chemiluminescence principle of measurement. The meter shall be capable of measuring ozone concentrations up to 10 ml/m^3. The ozone meter shall be connected to a digital logging system with a logging frequency of 1 s or less (see A.3). Ozone meters that provide equivalent performance to that obtained with chemiluminescence meters may also be used.

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

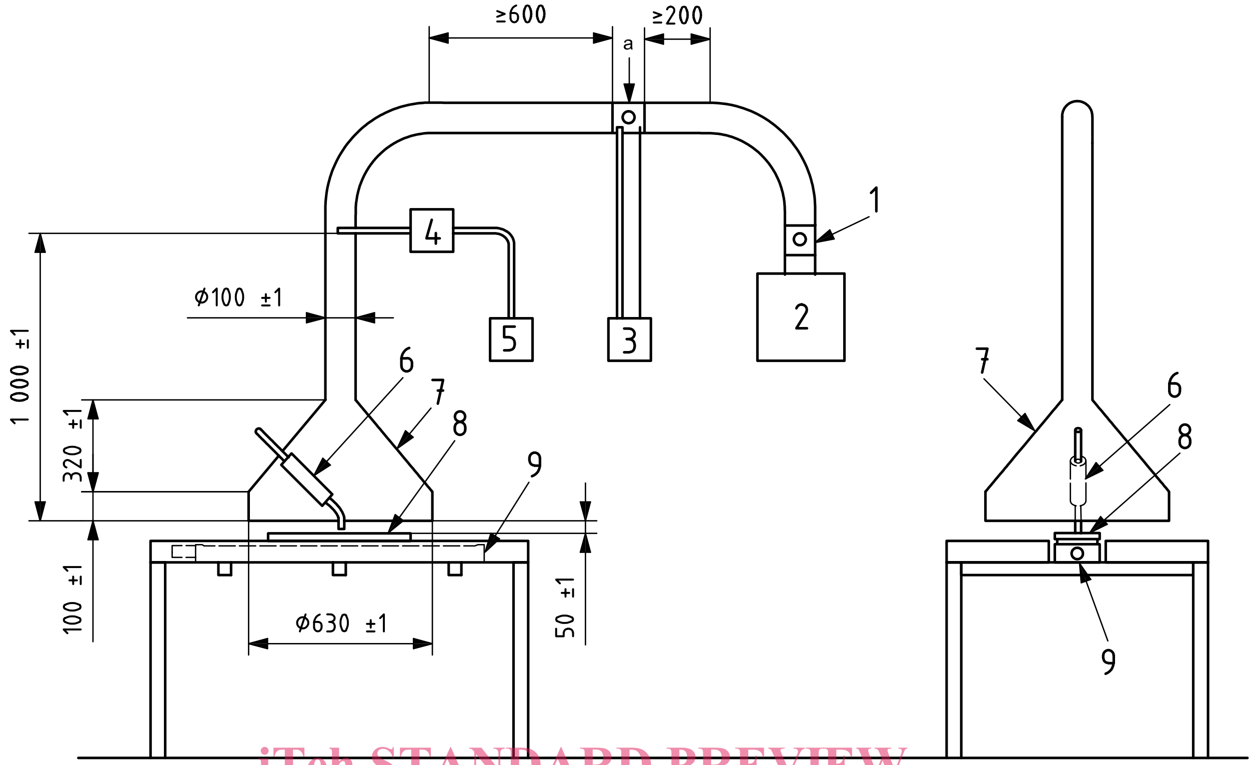
5.4 Sampling system, consisting of a sampling line between the sampling point and the ozone meter, manufactured from polytetrafluoroethylene (PTFE) or stainless steel or a combination of both. The sampling line shall have an internal diameter of 10 mm or less and shall be as short as is reasonably practicable. Fume shall be prevented from entering the sampling line using a PTFE filter. The filter shall be placed as close as is reasonably practicable to the sampling point (see A.4).

5.5 Ozone generator, used to precondition the sampling line and to calibrate the ozone meter.

NOTE Sometimes, ozone meters and generators are incorporated into the same piece of equipment.

If an ozone generator is used to calibrate the ozone meter (5.3), its calibration shall be traceable to national standards.

Dimensions in millimetres



Key

1 damper (if used)
2 extraction unit
3 manometer (if used)
4 polytetrafluoroethylene (PTFE) filter
5 ozone meter connected to sampling point
6 welding torch
7 hood
8 test piece
9 traverse
a Air flow rate measuring point.

Figure 1 — Hood design for ozone emission rate testing

5.6 Equipment for measuring air flow rate, capable of measuring an air flow rate of 2 m^3/min to within ± 5 % or better.

The following combinations of equipment are suitable (see A.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.

5.7 Equipment for measuring welding current, arc 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 can 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.

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

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

5.9 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.

5.10 Device for setting 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.

5.11 Device for automatic 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 the test piece to the device, such that it cannot bow or flex during welding.

5.12 Test pieces, of a material suitable for the process and consumable used, with dimensions that allow continuous welding for an arcing time of at least 60 s (see A.8).

6 Test procedures

6.1 Welding procedure selection

Perform tests using automatic welding.

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 as shown in Figure 1, in an interference-free environment (see A.9).

Adjust the air flow rate through the hood to 2 m^3/min (see A.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 the 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 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 Trial tests

Set the desired test conditions (see Annex B), performing a trial test, which may be outside the hood, 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 (5.7). See C.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 B.6).

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

Position the welding torch at the desired angle (see B.2) and secure it.

Set the desired CTWD for continuous wire processes (see B.5.1) following the procedure described in C.2 or, for autogeneous TIG welding, set the desired ETWD (see B.5.2) following the procedure described in C.3.

Set the required welding speed (see B.3).

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 6.4).

6.4 Emission rate testing

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 the bottom edge of the hood is 5 cm above the upper surface of the test piece (see A.7).

Install a PTFE filter in the sampling line (5.4), handling it with tweezers or wearing nylon gloves. Clean or renew the short length of sampling line between the filter and the sampling point. Connect the sampling system to the ozone meter (5.3) and switch it on. Precondition the sampling system line (5.4) by passing ozone from the ozone generator (5.5) through following the procedure given in C.4. Disconnect the ozone source from the sampling system and secure the inlet of the sampling system at the sampling point in the hood (see Figure 1).

Switch on the extraction unit (5.2) and all monitoring equipment (5.6 and 5.7). 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 ozone concentration, weld for a suitable time period, e.g. 60 s, stop logging the ozone concentration and then switch off the extraction unit.

Perform five replicate tests and calculate the average ozone emission rate (see Clause 7). If any individual result differs from the mean by more than ± 25 %, carry out three further tests and calculate the average value of all eight results. If any results are then unacceptable, checks shall be made to ensure that the equipment is functioning correctly and the entire procedure shall be repeated.