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Health and safety in welding and allied processes — Requirements, testing and marking of equipment for air filtration —

Part 3: Determination of the capture efficiency of on-torch welding fume extraction devices

Hygiène et sécurité en soudage et techniques connexes — Exigences, essais et marquage des équipements de filtration d'air —
Partie 3: Détermination de l'efficacité de captage des torches aspirantes

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 9, *Health and safety*.

A list of all parts in the ISO 21904 series can be found on the ISO website.

Requests for official interpretations of any aspect of this document should be directed to the Secretariat of ISO/TC 44/SC 9 via your national standards body. A complete listing of these bodies can be found at www.iso.org.

Introduction

Welding generates fumes and gases which, if inhaled, can be harmful to human health. Therefore, control of the fume and gases needs to be exercised to minimize worker exposure.

The most effective method of welding fume control is local exhaust ventilation (LEV) which captures the fumes at source before they enter the general environment and the breathing zone of workers.

One form of LEV used in welding is on-torch extraction in which the extraction system is either an integral part of the welding torch or is attached to it close to the arc area. Anecdotal evidence within the fabrication industry suggested that it is impossible to capture fume efficiently while maintaining weld metal integrity but research (see Bibliography entry [6]) has shown this not to be the case, certainly as far as weld metal porosity is concerned.

It has been presumed in the drafting of this document that appropriately qualified and experienced people would execute its provisions and interpret the results obtained.

Health and safety in welding and allied processes — Requirements, testing and marking of equipment for air filtration —

Part 3: Determination of the capture efficiency of on-torch welding fume extraction devices

1 Scope

This document defines a laboratory method for measuring the welding fume capture efficiency of on-torch extraction systems. The procedure only prescribes a methodology, leaving selection of the test parameters to the user, so that the effect of different variables can be evaluated.

It is applicable to integrated on-torch systems and to systems where a discrete extraction system is attached to the welding torch close to the arc area. The methodology is suitable for use with all continuous wire welding processes, all material types and all welding parameters.

The method can be used to evaluate the effects of variables such as extraction flow rate, extract nozzle position, shielding gas flow rate, welding geometry, welding torch angle, fume emission rate, etc., on capture efficiency.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 15767, *Workplace atmospheres — Controlling and characterizing uncertainty in weighing collected aerosols*

ISO/IEC Guide 98 (all parts), *Uncertainty of measurement*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
test chamber
semi-enclosed extracted chamber in which welding fume capture efficiency testing is performed

3.2
isokinetic sampler
device for collecting aerosol samples at the same velocity as the air being sampled

3.3
test chamber sampling duct
duct between the test chamber and an extraction fan in which all the fume generated can be collected or sampled isokinetically

3.4
emission rate
mass of the particles emitted by the welding fume source per unit time

Note 1 to entry: The emission rate is expressed in mg/s.

4 Principle

Automatic welding is performed using the on-torch extraction torch under test, on a test piece, inside a continuously extracted test chamber. Testing is carried out using identical welding parameters with and without the on-torch extraction activated. The ratio of measurements in the test chamber sampling duct is used to calculate the capture efficiency of the on-torch extraction torch.

Three methods of measuring the fume can be used. Two methods employ gravimetric measurement. The first method measures the total fume generated while second method employs isokinetic sampling in the test chamber sampling duct. The third method employs a direct reading measuring technique in the test chamber sampling duct.

5 Test equipment and materials

5.1 General requirement

The test setup shall enable containment of the fume generated in the arc area within the test chamber while ensuring the air velocity in the welding area below the torch does not exceed 0,2 m/s without welding and with the on-torch extraction off. See also B.1.

NOTE It is possible that not all of the fume generated by spatter production be contained within the test chamber.

5.2 Test equipment

5.2.1 Test chamber, constructed of materials that withstand close proximity to the heat and spatter generated by the welding or designed so that the materials used are sufficiently distant from the arc to avoid problems arising from heat and spatter generation. See Figures C.1 and C.2.

Compliance with the requirements of 5.1 shall be verified.

5.2.2 Isokinetic samplers.

The sample flow rate shall be such that the velocity through the sample inlet is the same as the surrounding air velocity.

This ensures that:

— the particle size distribution is not affected by the sampling process; and

— the sample represents the particles present in the sampling duct. See also B.2 and B.3.

5.2.3 Total fume and isokinetic filters, manufactured from glass or quartz fibre, with particle retention properties down to approximately 1 µm to 2 µm.

The filters shall not tear or perforate during testing (see A.2) and shall not be so friable that fibres can be lost from the filters during handling.

Filters shall be treated according to the procedures defined in ISO 15767.

5.2.4 Extraction fan, capable of maintaining a constant flow rate (±2 %) in the test chamber sampling duct during testing when using during testing with isokinetic sampling or direct reading equipment.

The air flow generated by the fan shall be capable of retaining the entire fume generated within the test chamber (see A.3).

5.2.5 On-torch extraction unit, capable of maintaining a constant flow rate (±2 %) in the on-torch extraction line during testing.

5.2.6 Equipment for measuring welding current, welding voltage, wire feed speed and arcing time, capable of measuring the current, voltage, wire feed speed and arcing time within ±1 %.

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 determined by measuring the length of wire exiting the welding torch in a measured time.

5.2.7 Equipment for direct-reading of fume concentration, with a reading that is directly proportional to the fume concentration with a maximum linearity error of 5 % over the expected concentration range.

NOTE Equipment suitable for direct-reading of fume concentration is described for example in CEN/TR 16013.

5.2.8 Equipment for measuring the mass of fume collected.

— **Balance** capable of measuring the mass of isokinetic sample filters and isokinetic sample filters plus fume with an accuracy of ±0,01 mg or better.

— **Balance** capable of measuring the mass of total fume collection filters and total fume collection filters plus fume with an accuracy of ±1 mg or better.

5.2.9 Equipment for measuring shielding gas volume flow rate, calibrated for the shielding gas in use, capable of measuring the volume flow rate to within ±5 % or better. See A.4.

5.2.10 Device for automatic welding, permitting the capture efficiency test to be performed under automated conditions, capable of advancing the test piece under a stationary welding torch at an appropriate rate (welding speed).

It shall be possible to secure the test piece to the device, such that it cannot bow during welding.

5.2.11 Device for measuring contact tip to workpiece distance (CTWD).

— **Gauge**, made by machining a metal block to a thickness equivalent to the required CTWD to within ±5 % or better; or

— **Metal wedge** with distance markings at appropriate points.

5.2.12 Device for measuring static pressure, capable of measuring static air pressure in the on-torch extraction line with an uncertainty of measurement not exceeding ±1 % of the reading. See A.6.

5.2.13 Device for measuring the mass flow rate to an accuracy of ±5 % or better (e.g. according to ISO 5167). See A.7.

5.2.14 Test pieces, of a material and dimensions that are suitable for the capture efficiency test to be carried out, that allow a weld of sufficient length to be continuously deposited. See A.5.

The same batch of filler wire and test pieces shall be used for each test series.

6 Test procedure

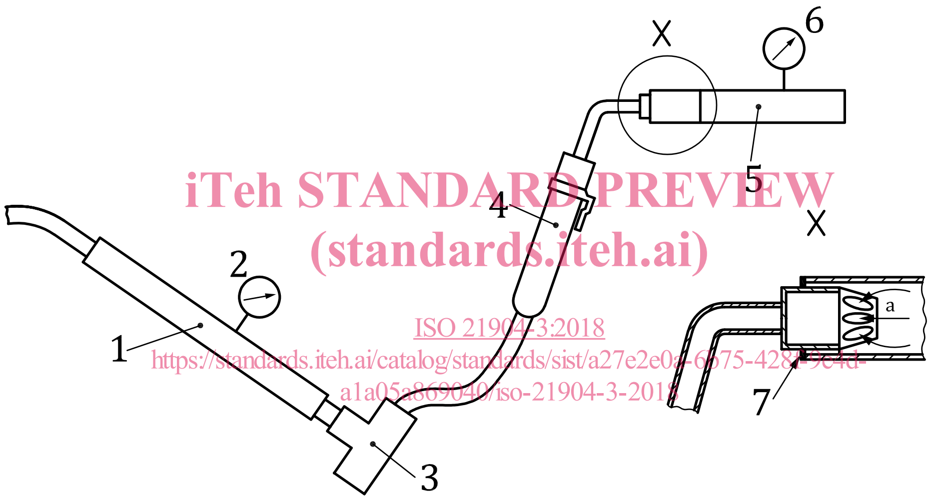
6.1 Preliminary tests

6.1.1 Setting the shielding gas flow rate

Set the shielding gas flow rate using the equipment described in 5.2.9.

6.1.2 Measuring the flow rates and determination of leakage

Measure the mass flow rate at two points shown in Figure 1, without welding, by using appropriate devices and calculate the air volume flow rate. See also A.7 and Annex G.



Key

1 device to permit mass flow rate measurement at extraction inlet on the connector of the torch
2 measurement point of the mass flow rate at the connector $Q_{m,c}$
3 connection between the torch and the extraction system
4 on-torch extraction torch
5 device to permit mass flow rate measurement at extraction inlet on the torch (see A.7)
6 measurement point of the mass flow rate at the nozzle $Q_{m,n}$
7 sealing
a Airflow.

Figure 1 — Points for measuring the flow rate

The leakage ratio is $\dfrac{Q_{m,c} - Q_{m,n}}{Q_{m,c}}$

where

$Q_{m,n}$ is the mass flow rate in the nozzle;

$Q_{m,c}$ is the mass flow rate in the connector.

From $Q_{m,n}$ and $Q_{m,c}$, the volume flow rates ($Q_{v,n}$ and $Q_{v,c}$) are calculated with the theoretical conditions of temperature and pressure of 20 °C and 101 325 Pa (1 013,25 hPa):

$$Q_v = \frac{Q_m}{\rho}$$

where ρ is the air density at 20 °C = 1,204 kg/m^3.

6.1.3 Establishing the arcing time for total fume emission rate test

Follow the procedure stated in B.4.

6.1.4 Setting up the test equipment

Set up the test equipment as shown in Figure 2, in an interference-free environment (see A.8).