
Health and safety in welding and allied processes — Equipment for capture and separation of welding fume —

**Part 4:
Determination of the minimum air volume flow rate of capture devices**

*Hygiène et sécurité en soudage et techniques connexes —
Équipements de captage et de filtration des fumées —*

*Partie 4: Détermination du débit volumique minimal d'air des
dispositifs de captage*

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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.

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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of 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 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*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Official interpretations of ISO/TC 44 documents, where they exist, are available from this page: <https://committee.iso.org/sites/tc44/home/interpretation.html>.

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

This first edition cancels and replaces ISO 15012-2.

Introduction

Welding and allied processes generate fume and gases, which, if inhaled, can be harmful to human health. Control is often required to maintain exposure at acceptable levels and this can be achieved by capturing the fume and gases using local exhaust ventilation.

For a particular capture device, the air velocity to capture welding fume can only be achieved by applying a minimum air volume flow rate. Consequently, capture devices need to be used with exhaust systems that provide, at least, the minimum air volume flow rate.

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Health and safety in welding and allied processes — Equipment for capture and separation of welding fume —

Part 4:

Determination of the minimum air volume flow rate of capture devices

1 Scope

This document specifies two methods for establishing the minimum air volume flow rate. One method is dedicated for use with captor hoods, nozzles and slot nozzles with a ratio of slot length to hose diameter of 8:1 or less. The other method is dedicated for use with on-gun extraction devices.

These methods are not applicable to down draught tables.

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 12100:2010, *Safety of machinery — General principles for design — Risk assessment and risk reduction*

ISO 21904-1:2020, *Health and safety in welding and allied processes — Equipment for capture and separation of welding fume — Part 1: General requirements*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12100 and ISO 21904-1 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/>

4 Captor hoods, nozzles and slot nozzles

4.1 Principle

Tests are performed to determine the minimum air volume flow rate to provide a suction field of given dimensions and air velocity at a measured distance perpendicular to the entry plane of the hood. The required velocity in the suction field as specified in ISO 21904-1:2020, 5.2, and the required dimensions are at least $1,5 D$ long and at least $1 D$ wide at a distance of $1,5 D$, where D is the internal diameter of the extraction duct. It can be achieved by the measurement described in 4.3 or by numerical simulation (Computational Fluid Dynamics, CFD).

4.2 Apparatus

4.2.1 Anemometer, non-directional, suitable for measuring air velocities in the range 0,2 m/s to 0,5 m/s with a maximum uncertainty of $\pm 0,06$ m/s and having a calibration that is traceable to national standards if available.

4.2.2 Measure, suitable for measuring distances with an uncertainty of ± 1 mm.

4.2.3 Equipment for measuring flow rates in ducts, pressure differential devices such as a venturi nozzle or an orifice plate with an uncertainty of ± 5 % are suitable. This is the most appropriate equipment for measuring flow rates in ducts.

4.2.4 Equipment for generating an adjustable volume flow rate, e.g. a fan with a frequency converter or an in-line valve.

4.3 Test method

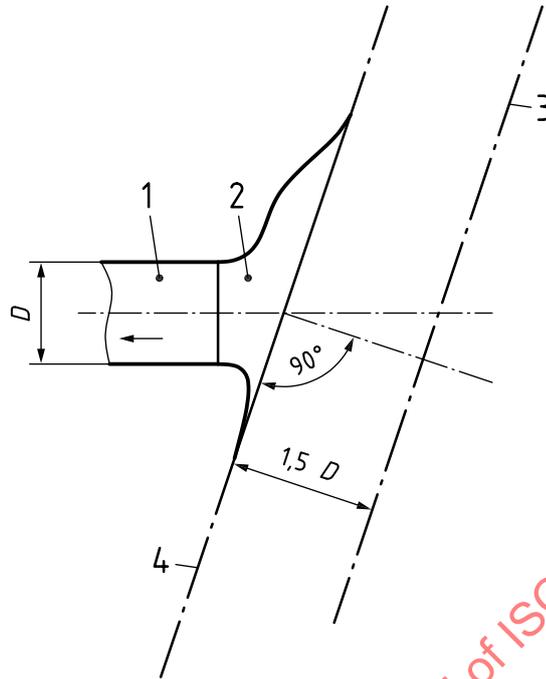
4.3.1 Test setup

Position the hood or nozzle so that it is free standing and sited away from any obstructions. Ensure that any disturbing air draughts in the immediate test area average less than 0,1 m/s in a 5-minute test period.

The anemometer shall be moveable in the measurement plane.

4.3.2 Determination of the position of the entry and the measurement plane

Determine the position of the entry plane according to [Figure 1](#).

**Key**

- 1 duct
- 2 hood
- 3 measurement plane
- 4 entry plane
- D internal diameter of the extraction duct

Figure 1 — Test setup

The measurement plane shall be parallel to and $1,5 D$ distant from the entry plane.

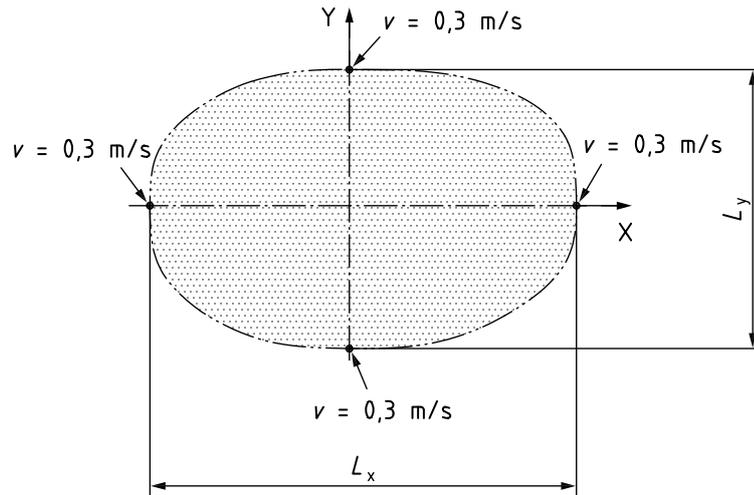
4.3.3 Procedure

Set up the capture device under the test conditions specified in 4.1 and set and record an air volume flow rate. Ensure that the air volume flow rate remains constant throughout the test period.

Place the anemometer on the x-axis in the measurement plane and move it until the required velocity specified in ISO 21904-1 furthest along the x-axis is obtained. If the required velocity cannot be measured, repeat the process using a higher air volume flow rate. If the required velocity can be measured, record the position and then move the anemometer as shown in Figure 2 to establish a similar position on the opposite side of the x-axis and record it. Calculate the distance between the two positions recorded.

Repeat the procedure for the y-axis.

Each air velocity measurement shall be the average over a minimum period of 5 min. The logging interval shall be a maximum of 5 s.



Key

- L_x distance between the measurement points on the x-axis, in cm
- L_y distance between the measurement points on the y-axis, in cm
- assumed shape of the area where $v \geq v_t$ (the required velocity specified in ISO 21904-1)
- v air velocity

Figure 2 — Measurement plane

The distance between the measurement points on either the x- or the y-axis shall be at least $1,5 D$. At the same time, the distance between the measurement points on the other axis shall be at least $1 D$. If these requirements are not met, increase the air volume flow rate and repeat the procedure.

Conversely, if the distance between the measurement points is substantially more than the required distance, reduce the air volume flow rate and repeat the procedure.

4.4 Test report

The test report shall include at least the following information:

- a) a reference to this document, (i.e. ISO 21904-4);
- b) a description of the capture device tested, including details of:
 - the manufacturer;
 - the model number and, if appropriate, the serial number;
 - the design, size, etc.;
- c) details of the test carried out:
 - the distance of the entry plane of the capture device to the measurement plane;
 - the measuring equipment used;
- d) the test results:
 - the determined minimum air volume flow rate;
 - the distances between the points where v equals the required velocity specified in ISO 21904-1 was measured for each direction in centimeters;

- e) any operation not specified in this document, or regarded as optional;
- f) name and address of the party which carries out the test;
- g) the name(s) of person(s) responsible for the test(s);
- h) the date(s) of the test(s); and
- i) any inadvertent deviations, unusual occurrences, or other notable observations.

5 On-torch extraction devices

5.1 Principle

The minimum air volume flow rate at the connector, $Q_{v,c}$, and the associated pressure, Δp_c , able to generate the minimum velocity at the welding fume emission point have to be determined. This induced velocity is the main explanatory variable of the welding fume capture efficiency^[1]. The most robust method for evaluating this velocity is an indirect method of considering the flow extracted at the nozzle, $Q_{v,n}$, and the distance, L , separating the suction from the emission point of the welding fume. Due to the high depression, leakage can occur in the system and mass flow rate at the connector could be significantly different from the mass flow rate at the nozzle. The welding fume emission point is fixed at 20 mm from the end of the contact tube. The distance, L , in metres, is measured from this point to the furthest entry point of the suction.

Assuming a spherical iso-velocities distribution round the air inlet, the volume flow rate, $Q_{v,n}$, to be generated at the nozzle as per [Formula \(1\)](#):

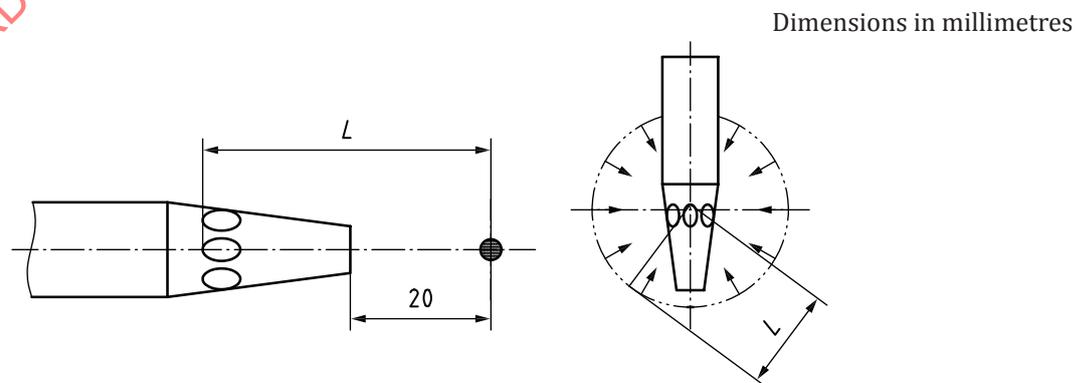
$$Q_{v,n} = v_i \cdot 4\pi L^2 \quad (1)$$

where

L is the distance from the welding fume emission point to the furthest entry point of the suction opening in m (see [Figure 3](#));

$Q_{v,n}$ is the actual air volume flow rate at the nozzle in m³/s;

v_i is the target induced velocity in m/s.



Key

L distance from the welding fume emission point to the furthest entry point of the suction opening in metres

Figure 3 — Nozzle

For information about risk of welding defect due to excessive capture volume flow rate, see [A.1](#) and [A.2](#). For information on how to take into account the geographical altitude during the adjustment of the depression, see [A.3](#).

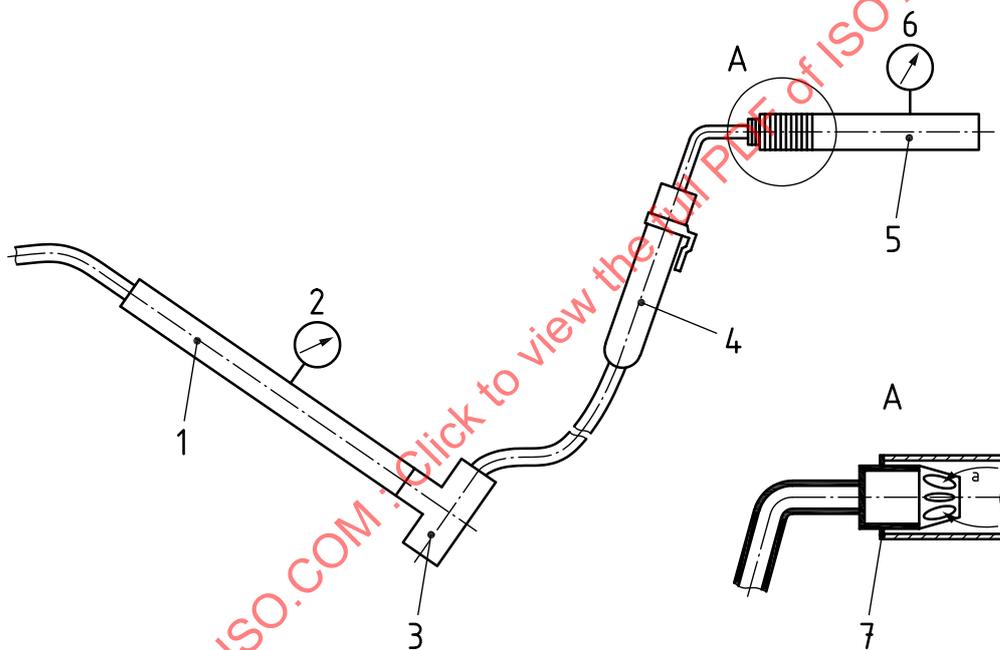
5.2 Apparatus

5.2.1 Device for measuring static pressure, capable of measuring depression in the on-torch extraction line with an uncertainty of measurement not exceeding $\pm 1\%$ of the reading.

5.2.2 Device for measuring flow rate to an accuracy of $\pm 5\%$ or better (e.g. according to ISO 5167). The most appropriate equipment for measuring flow rates in ducts is a pressure differential device such as a venturi nozzle or an orifice plate.

5.3 Test method

5.3.1 Test setup



Key

- 1 measurement point of the flow rate at the connector, $Q_{v,c}$ and the depression, Δp_c
- 2 device to permit flow rate measurement at the connector of the torch
- 3 connector between the torch and the extraction system
- 4 torch
- 5 measurement point of the flow rate at the nozzle, $Q_{v,n}$
- 6 device to permit flow rate measurement at the nozzle
- 7 sealing
- a Airflow.

Figure 4 — Test setup

5.3.2 Procedure

- 1) Measure the distance, L . For torches with a movable suction nozzle first move the nozzle to a position giving the maximum value for the distance, L .

- 2) Calculate the actual volume flow rate, $Q_{v,n}$, based on the target induced velocity $Q_{v,n} = v_i \cdot 4\pi L^2$
- 3) Set the volume flow rate, $Q_{v,n}$, at the nozzle. If the handle of the torch has a bypass valve, it has to be closed during the test procedure.
- 4) Measure the depression at the connector, $\Delta p_{c,meas}$.
- 5) Measure the ambient pressure, p_a (in hPa), and ambient temperature, T_a (in °C), in order to calculate the ambient air density, ρ_a [see [Formula \(2\)](#)]:

$$\rho_a = 1,292 \frac{273,15}{273,15 + T_a} \frac{p_a}{1013,25} \quad (2)$$

- 6) Calculate the depression, Δp_c , that would be required for use the torch at an air density of 1,204 kg/m³ (sea level, 20°C), Δp_c [see [Formula \(3\)](#)]:

$$\Delta p_c = \Delta p_{c,meas} \cdot \frac{1,204}{\rho_a} \quad (3)$$

- 7) If the value of $Q_{v,n}$ cannot be reached without exceeding the maximum value for depression at the connector, Δp_c , given in ISO 21904-1, stop the test. The torch conception needs to be improved.
- 8) Measure the actual volume flow rate at connector, $Q_{v,c}$. If the volume flow rate is measured by way of a mass flow rate, the density of air to convert it in a volume flow rate is as per [Formula \(4\)](#):

$$\rho_c = 1,292 \frac{273,15}{273,15 + T_a} \frac{p_a - p_{c,meas}}{1013,25} \quad (4)$$

NOTE It is assumed that the difference of the temperature at the connector and the ambient temperature, T_a , is negligible.

5.4 Test report

The test report shall include at least the following:

- a) a reference to this document (i.e. ISO 21904-4);
- b) name or trademark of the manufacturer;
- c) make and model of the on-torch extraction torch;
- d) name and address of the party which carries out the test;
- e) dates of test, signature and name of the testing person;
- f) description of the instrumentation, including its specification, calibration;
- g) length of the hose between connector and torch;
- h) the rated maximum amperage of the torch at 100 % of duty cycle;
- i) target induced velocity (see ISO 21904-1);
- j) distance, L , for torches with movable suction nozzles the maximum distance has to be stated;
- k) depression at connector, Δp_c , to obtain $Q_{v,n}$, expressed at an air density of 1,204 kg/m³ (sea level, 20°C);
- l) actual volume flow rate at nozzle, $Q_{v,n}$, to obtain target induced velocity;
- m) actual volume flow rate at connector, $Q_{v,c}$.

Annex A (informative)

Additional information for on-torch extraction

A.1 Excessive capture air volume flow rate

Excessive air volume flow rate may cause shielding gas capture and induce welding defects. The maximal useable value should be indicated by the manufacturer.

In most cases, the air volume flow rate related to an induced velocity of 0,4 m/s may be considered as a limit for no defect risk.

A.2 Acceptable air volume flow rate

As the pressure p and the air volume flow rate, Q , are linked by the relation $p = \alpha Q^2$, one triplet $[\Delta p_c, Q_{v,n}, Q_{v,c}]$ allows to determine the characteristics for other operation points. This information can be communicated as [Table A.1](#). In order to help the end user, the suitable zone, where the air volume flow rate is sufficient to capture welding fume but not too high to induce defect, may be indicated in green. This information is helpful when the user wants to use different models of torches on the same network. An example is proposed below.

Table A.1 — Example of air volume flow rate characteristic

Induced velocity m/s	Air volume flow rate at nozzle m ³ /h	Air volume flow rate at connector m ³ /h	Pressure at connector kPa	Comment
0,20	33	58	3,2	Poor capture
0,25	41	73	5,0	Poor capture (acceptable <200 A)
0,3	49	88	7,2	Poor capture (acceptable <200 A)
0,35	57	102	9,8	OK
0,4	65	117	12,8	OK
0,45	73	131	16,2	Risk of weld defect
0,5	81	146	20,0	Risk of weld defect