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

Part 1:

**Testing of the separation efficiency for
welding fume**

*Hygiène et sécurité en soudage et techniques connexes — Exigences,
essais et marquage des équipements de filtration d'air —*

Partie 1: Essai de l'efficacité de la séparation des fumées de soudage



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Foreword

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ISO 15012-1 was prepared by the European Committee for Standardization (CEN) in collaboration with Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 9, *Health and safety*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

Throughout the text of this document, read “...this European Standard...” to mean “...this International Standard...”.

ISO 15012 consists of the following parts, under the general title *Health and safety in welding and allied processes — Requirements testing and marking of equipment for air filtration*:

- *Part 1: Testing of the separation efficiency for welding fume*
- *Part 2: Testing of the capture zone of welding fume extraction devices*

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Foreword

This document (EN ISO 15012-1:2004) has been prepared by Technical Committee CEN/TC 121 "Welding", the secretariat of which is held by DIN, in collaboration with Technical Committee ISO/TC 44 "Welding and allied processes".

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2005, and conflicting national standards shall be withdrawn at the latest by June 2005.

This document includes a Bibliography.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

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1 Scope

This document deals with the significant hazards caused by the emission of welding fume particles from welding fume separation equipment operated according to its intended use and under the conditions foreseen by the manufacturer.

This document specifies safety requirements concerning the separation of welding fumes and describes a method for determining the particle separation efficiency of welding fume separation equipment.

This document does not deal with:

- the hazards caused by gases emitted by welding, cutting and allied processes or by the welding fume separation equipment itself;
- the hazards caused by the noise and vibrations of the welding fume separation equipment or
- other fundamental aspects of safety technology, such as electrical, mechanical and pneumatical safety, maintenance, etc.

This document applies to equipment that is manufactured after the issue of this document.

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.

EN 842, *Safety of machinery - Visual danger signals - General requirements, design and testing.*

EN 1070:1998, *Safety of machinery – Terminology.*

EN 1093-6, *Safety of machinery - Evaluation of the emission of airborne hazardous substances - Part 6: Separation efficiency by mass, unducted outlet.*

EN 1093-7, *Safety of machinery - Evaluation of the emission of airborne hazardous substances - Part 7: Separation efficiency by mass, ducted outlet.*

EN ISO 12100-2:2003, *Safety of machinery - Basic concepts, general principles for design - Part 2: Technical principles (ISO 12100-2:2003)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 1070:1998 and the following apply.

3.1

welding fume separation equipment

air filtration equipment, the purpose of which is to separate particles generated by welding and allied processes from workplace air

3.2

filter cleaning system

system designed to clean the filter of welding fume separation equipment in order to restore the air flow rate through the filter when it is reduced by an accumulation of welding fume particles

3.3

on-line filter cleaning system

filter cleaning system that operates while welding fume separation equipment is working

- 3.4 off-line filter cleaning system**
filter cleaning system that is operated after the fan of the filtration equipment is switched off
- 3.5 separation efficiency by mass**
ratio of the mass of particles retained by welding fume separation equipment to the mass of particles entering the equipment during a given period (see also EN 1093-6 and EN 1093-7)
- 3.6 emission rate**
mass of the particles emitted by the welding fume source per unit of time, in mg/s (see Annexes C and D).
- 3.7 preseparatorators**
capture devices with built-in closed-meshed sieves or spark arrestors

4 List of significant hazards

This clause contains the significant hazards dealt with in this document.

Table 1 — List of hazards, risk assessment, measures for reduction

Hazard	Hazardous situation	Measure	Clause	Verification
Welding fume emission	welding fume emission with separated air	separation of welding fumes	6.2	testing of the separation efficiency

5 Safety requirements and/or measures

5.1 Preseparator

The welding fume separation equipment or the exhaust system shall be designed to protect the separation unit and shall prevent damage to the filter caused by the impact of large, hot and/or abrasive particles.

5.2 Emission of particles from welding fume separation equipment

5.2.1 Welding fume separation efficiency

Welding fume separation equipment shall have a separation efficiency of at least 95 % and shall be assigned to a welding fume separation class using the classification system given in Table 2. The welding fume classes differ in the requirements for the separation efficiency based on the state of the art.

Table 2 — Welding fume classes

Welding fume class	Separation efficiency (%)	Recommended for the separation of particles generated by welding of:
W 1	≥ 95	unalloyed and low-alloy steel, i.e. steel with a very low nickel and chromium content
W 2	≥ 98	as above and alloyed steel, i.e. steel with a nickel and chromium content ≤ 30 %
W 3	≥ 99	as above and high-alloy steel

NOTE The welding fume classes are only intended to provide guidance on the suitability of a given unit when considered in combination with:

- the welding location (e.g., a confined space or open workshop);
- the fume emission rate;
- the toxic elements present in the fume;
- current legal requirements; and
- the capture efficiency.

5.2.2 Marking of welding fume separation equipment

The manufacturer shall mark the welding fume separation equipment to indicate the welding fume class to which it has been assigned using labels conforming to the specifications given in Annex A. The marking shall be permanent and remain legible throughout the expected lifetime of the equipment.

5.3 Emission of particles during change of separation elements

Welding fume separation equipment shall be designed to minimise the emission of the collected welding fume particles during the changing of the separation elements.

5.4 System for waste management

5.4.1 Particles collected by the welding fume separation equipment shall be removed from the separation elements and disposed of in a manner that minimises their emission.

5.4.2 If the collected welding fume particles are disposed of in containers or bags, these shall be able to withstand the stresses of transportation, even when filled to their maximum capacity, and they shall be tightly sealed in a manner that will ensure that there is no possibility of emission of the collected particles.

5.5 Filter cleaning system

5.5.1 For welding fume separation equipment with a filter cleaning system, the filter cleaning system shall maintain the performance of the equipment so that it continues to meet the separation efficiency requirement for the welding fume class into which it is placed (see 5.2).

5.5.2 Cleaning of the separation elements shall not result in emission of welding fume particles.

5.6 Control units/indicators

5.6.1 General

Welding fume separation equipment shall be fitted with control units or indicators that warn of or prevent abnormal operation conditions, as described in 5.6.2 to 5.6.5.

Acoustic warning signals shall work within an audio-frequency between 500 Hz and 3000 Hz and have a pulse time between 0,5 s and 5 s. The A-weighted sound pressure level shall be between 15 dB and 30 dB higher than the 1 m-surface sound pressure level of the welding fume separation equipment (see EN 457).

Visual warning signals shall work with a pulse time between 0,5 s and 5 s, emitting yellow or yellow-orange light. The warning signals shall comply with the requirements of EN 842.

5.6.2 Direction of rotation of the fan

Mobile welding fume separation equipment operated with three-phase electrical motors shall be marked to indicate the correct direction of rotation of the fan.

5.6.3 Prevention of reversed air flow

If the consequence of a "wrong" direction of rotation is a reversed air flow, mobile welding fume separation equipment shall be fitted with equipment (e.g. a check valve or a damper) that prevents the reversal of air flow and an emission of collected welding fume particles.

5.6.4 Electrostatic separation systems

Separation equipment with an electrostatic separation system shall be fitted with a device that indicates if abnormal electrical properties occur.

5.6.5 Mechanical separation systems

Separation equipment with a mechanical separation system - even a system that services several work stations - shall be fitted with a device that indicates if a high pressure drop, exceeding the manufacturer's recommendation, occurs.

5.7 Exhaust and cooling air

Mobile welding fume separation equipment shall be positioned so that the exhaust and the cooling air of the motor do not blow in the direction of any persons working in the vicinity of the equipment. They also shall not unduly disturb dust settled on the floor and/or on walls. The velocities of the exhaust and of the cooling air shall not exceed 1 m/s at a distance of 1,5 m around the welding fume separator, between a lower measurement plane at a height of 50 mm above the floor level and an upper measurement plane at a height of 2 m above the floor level (see Figure 4).

6 Verification of safety requirements and/or measures

6.1 Testing of the preseparator

Check compliance with the requirements of 5.1 by inspection.

6.2 Testing of the separation efficiency

6.2.1 Principle

The method is based on the methods described in EN 1093-6 and EN 1093-7. The welding fume separation equipment under test is operated under defined conditions, according to its intended use, and the mass flow rates of welding fume in the upstream and downstream air are measured and used to determine the separation efficiency of the equipment.

6.2.2 Welding fume source

For testing of welding fume separation equipment intended for single work stations, use a welding fume source with an emission rate of 10 mg/s (suitable welding fume sources are described in Annex C or D).

For testing of welding fume separation equipment used to filter air from a number of work stations, use a welding fume source with an emission rate equal to 10 mg/s multiplied by the number of work stations that are operated at the same time (see Annex D).

6.2.3 Test rig or test arrangement

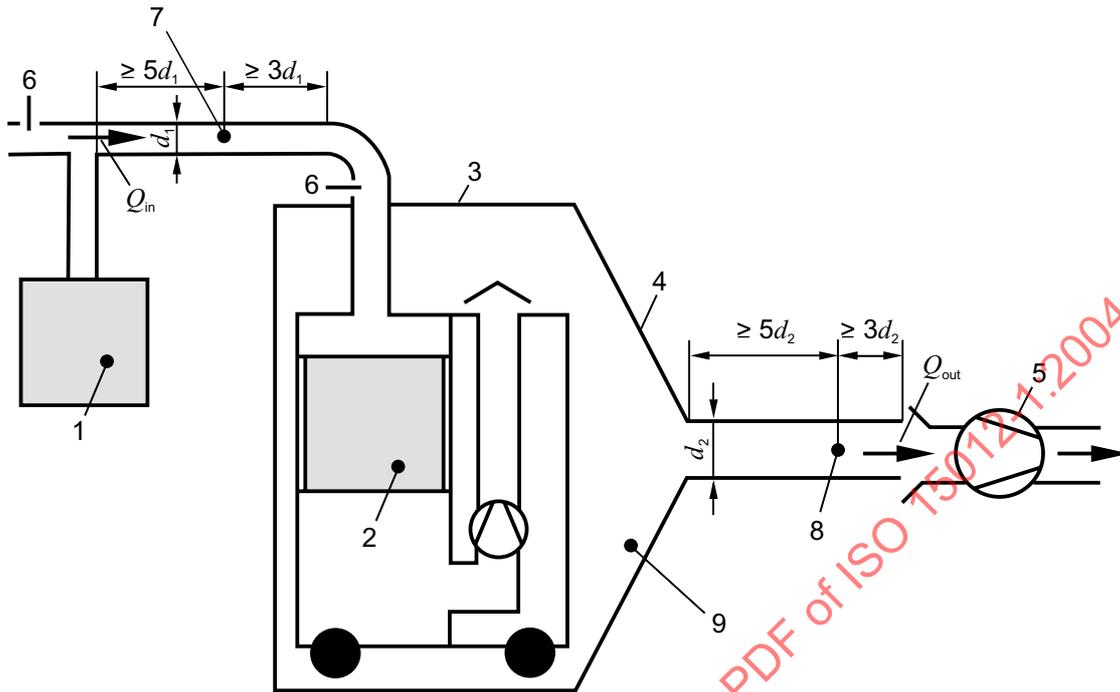
6.2.3.1 Selection of test rig or test arrangement

For welding fume separation equipment with unducted outlet, carry out the test of separation efficiency using a test rig as described in Figure 1.

For welding fume separation equipment with a ducted outlet, carry out the test of separation efficiency using a test rig as described in Figure 1 or using a test arrangement as described in Figure 2. However, if the filter is working with internal overpressure, leak test the welding fume separation equipment before testing it or test it using a test rig as described in Figure 1.

6.2.3.2 Test rig for determination for welding fume separation equipment with an unducted outlet

The test rig consists of a closed test cabin as an enclosure for the welding fume separation equipment under test, connected to the welding fume source via an upstream measurement duct. The cabin is connected to a downstream measurement duct, followed up by an optional air mover to keep a small overpressure within the cabin to prevent the measurements from being influenced by leakages (see Figure 1). The outlet air flow rate in the downstream measurement duct shall be at least 95 % and shall not exceed 100 % of the inlet air flow rate. If compressed air is used as the motive power this air flow rate shall be taken into consideration when determining the outlet air flow rate.



Key

- 1 Welding fume source
- 2 Welding fume separation equipment
- 3 Cabin
- 4 Funnel
- 5 Air mover
- 6 Damper
- 7 Upstream measurement plane (concentration and air flow rate measurement)
- 8 Downstream measurement plane
- 9 Measurement point (air pressure)

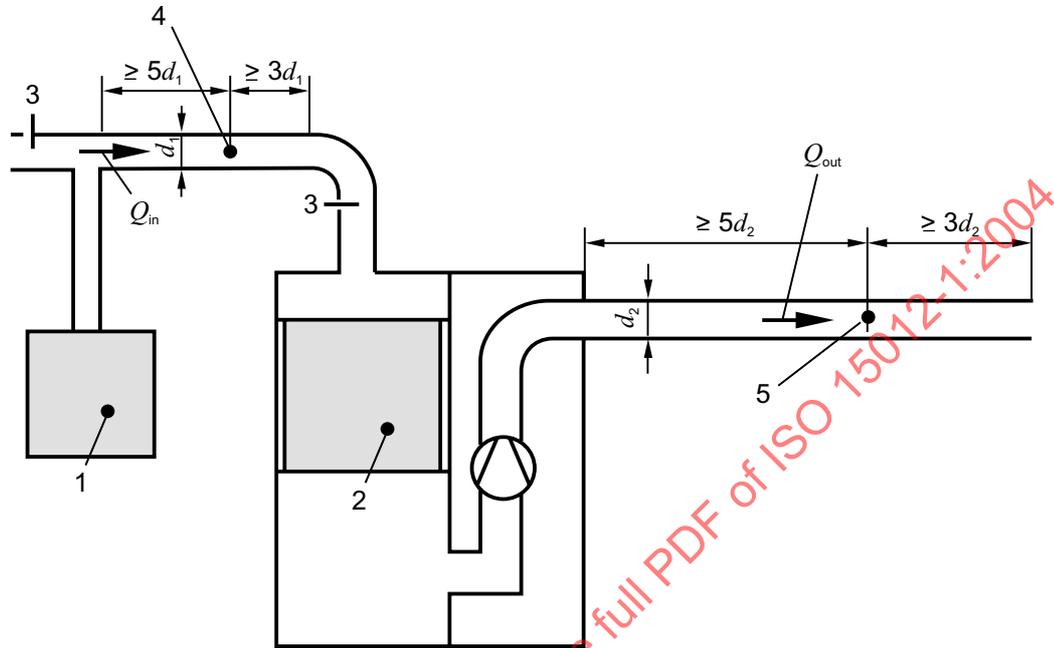
Figure 1 - Test rig for determination of the separation efficiency of welding fume separation equipment with an unducted outlet (schematic layout)

To maximise the transport of emitted particles from the welding fume separation equipment to the downstream measuring point, position the equipment in the cabin in such a way that the exhaust air is emitted along the longitudinal axis of the downstream measurement duct.

Ensure that the aerodynamic conditions in the cabin and the duct do not lead to significant deposition of emitted particles between the welding fume separation equipment and the downstream measurement point.

6.2.3.3 Test arrangement for welding fume separation equipment with a ducted outlet

The test arrangement for welding fume separation equipment with a ducted outlet also consists of a welding fume source connected to the equipment via an upstream measurement duct. However, unlike the test rig for welding fume separation equipment with an unducted outlet, in this instance the outlet of the welding fume separation equipment is directly linked with a downstream measurement duct (see Figure 2).



Key

- 1 Welding fume source
- 2 Welding fume separation equipment
- 3 Damper
- 4 Upstream measurement plane (concentration and air flow rate measurement)
- 5 Downstream measurement plane

Figure 2 - Test arrangement for determination of the separation efficiency of welding fume separation equipment with a ducted outlet (schematic layout)

The welding fume produced by the welding fume source is transported to the welding fume separation equipment under test via the upstream measurement duct. Within the separation equipment the particles are separated and the cleaned air is discharged. For separators with a ducted outlet the exhaust air flows directly into the downstream measurement duct.

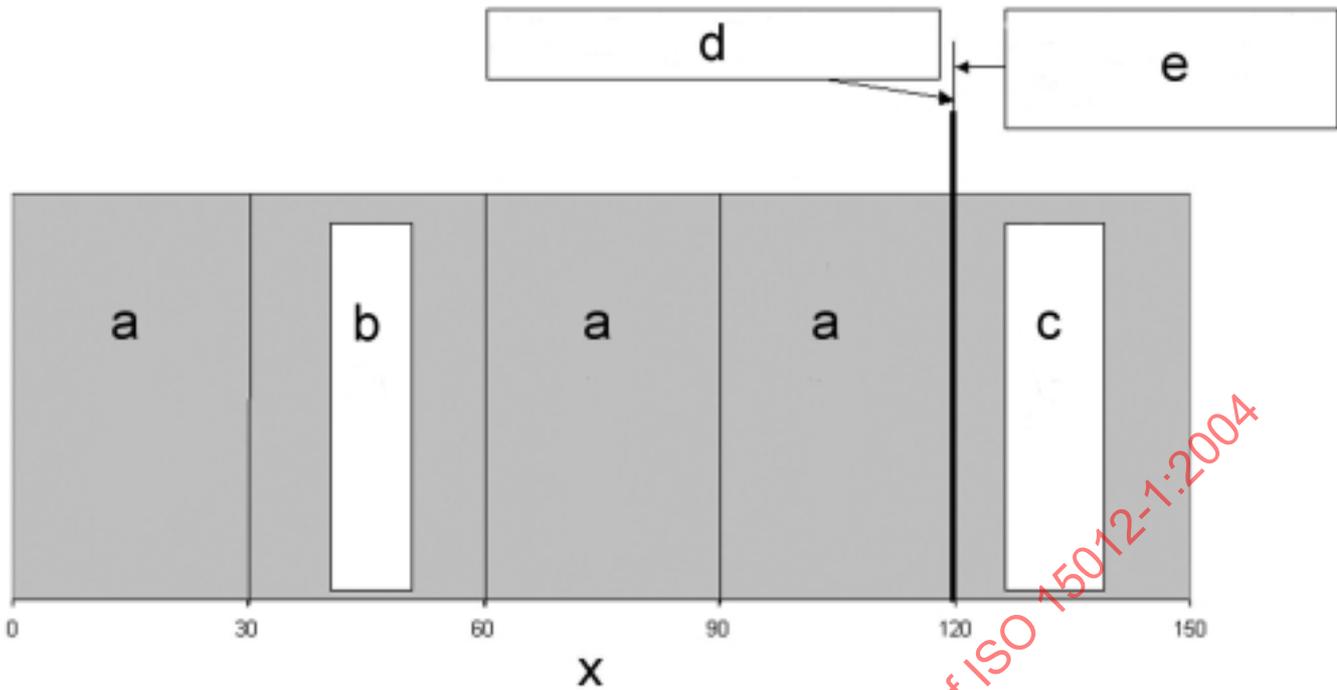
6.2.4 Test conditions

For modular welding fume separation equipment, carry out the test of separation efficiency using a typical modular configuration.

If different fans can be used in combination with the welding fume separation equipment, carry out the test of separation efficiency using the maximum air volume flow rate recommended by the manufacturer.

6.2.5 Test procedure

Collect samples of welding fume in the upstream and downstream measurement ducts by sampling the air flow at each of the measurement planes (see Figure 1 or Figure 2) using an isokinetic sampling device and diverting it to a pre-weighed sampling filter. Re-weigh each of the sampling filters to determine the mass of welding fume particles collected. Make two measurements of 30 min duration (see Figure 3). Determine the separation efficiency by mass for each measurement using the equation given in 6.2.6 and then calculate the arithmetic average of the results.



Key

- a) Welding without measuring
- b) Welding while making 1st measurement
- c) Welding while making 2nd measurement
- d) For separation equipment without filter cleaning system: end of the first trial
- e) For separation equipment with filter cleaning system: cleaning of the filter just before making 2nd measurement
- x) Test time (min)

Figure 3 — Test period

For welding fume separation equipment with a manual built-in filter cleaning system, clean the separation units once, after 120 min of the test period, following the manufacturer's instructions. If pressurised air is used for cleaning, use the maximum pressure recommended by the manufacturer.

In case of automatically started on-line filter cleaning, if no filter cleaning occurs automatically within the first 120 min of the test period, carry out the cleaning process before the second measuring period by manually starting it.

Check that the separator air volume flow rate after 120 min of the test period is greater than the minimum air volume flow rate indicated by the manufacturer.

Repeat the test procedure at least once.

For separation equipment with mechanical separation systems, test conditions comparable to normal working conditions can be realised by precoating the filter with limestone dust (particle size distribution 75 % < 5 µm, 22 % < 2 µm, 10 % < 1 µm). Up to 50 g of the limestone dust per m² of filter area is introduced into the upstream measurement duct using a dust feeder. After this precoating a cleaning cycle is performed.

6.2.6 Calculation of the separation efficiency

Calculate the separation efficiency by mass, η , using the following equation:

$$\eta = (1 - (\dot{m}_{out} / \dot{m}_{in})) \times 100 \% \tag{1}$$

where

\dot{m}_{in} is the average mass flow rate in the upstream air during the sampling time [mg/s]

\dot{m}_{out} is the average mass flow rate in the downstream air during the sampling time [mg/s]

The mass flow rates are determined according to the following equations:

$$\dot{m}_{in} \text{ is the } Q_{in} \times (m_{\text{sample in}}/V_{\text{sample in}}) \quad [\text{mg/s}] \quad (2)$$

$$\dot{m}_{out} \text{ is the } Q_{out} \times (m_{\text{sample out}}/V_{\text{sample out}}) \quad [\text{mg/s}] \quad (3)$$

where

Q_{in} is the average air flow rate in the upstream measurement duct during the sampling time [Nm^3/s]

Q_{out} is the average air flow rate in the downstream measurement duct during the sampling time [Nm^3/s]

$m_{\text{sample in}}$ is the mass of the welding fume particles on the sampling filter in the upstream air [mg]

$m_{\text{sample out}}$ is the mass of the welding fume particles on the sampling filter in the downstream air [mg]

$V_{\text{sample in}}$ is the air volume through the sampling filter in the upstream air [Nm^3]

$V_{\text{sample out}}$ is the air volume through the sampling filter in the downstream air [Nm^3]

NOTE If a welding fume source with a constant and known emission rate is used for the test this emission rate can be used for \dot{m}_{in} in equation (1).

Calculate the mass concentrations of the particles, C , using the equations:

$$C_{in} = m_{\text{sample in}}/V_{\text{sample in}} \quad [\text{mg}/\text{Nm}^3] \quad (4)$$

$$C_{out} = m_{\text{sample out}}/V_{\text{sample out}} \quad [\text{mg}/\text{Nm}^3] \quad (5)$$

Use the method described in Annex B for statistical interpretation of the test results.

6.3 Testing for emission of particles during change of separation elements

Check compliance with the requirements of 5.3 by inspection and by changing the separation elements according to the manufacturer's instructions. Verify that there is no visible emission of collected particles during this operation.

6.4 Testing of the system for waste management

Check compliance with the requirements of 5.4 by inspection. Verify that there is no visible emission of collected particles when the separation element is cleaned according to the manufacturer's instructions or when lifting a container or bag that is filled to its maximum capacity.

6.5 Testing of the filter cleaning system

Check compliance with the requirements of 5.5.1 by measuring the air volume flow rate before and after cleaning the filter according to the manufacturer's instructions and verifying that the equipment continues to meet the required separation efficiency for the welding fume class into which it has been placed (see 5.2).

Check compliance with the requirements of 5.5.2 by inspecting the equipment to verify that there is no emission of welding fume particles during cleaning of the filter.

6.6 Examination of the control units/indicators

6.6.1 General

Check compliance of acoustic warning signals with the requirements of 5.6.1 by measuring the sound pressure level and the audio frequency.

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Check compliance of visual warning signals with the requirements of 5.6.1 by inspection and by measuring the pulse frequency.

6.6.2 Direction of rotation of the fan

Check compliance with the requirements of 5.6.2 by inspection.

6.6.3 Prevention of reversed air flow

Check compliance with the requirements of 5.6.3 by changing the direction of rotation. Verify that there is no reverse air flow.

6.6.4 Electrostatic separation systems

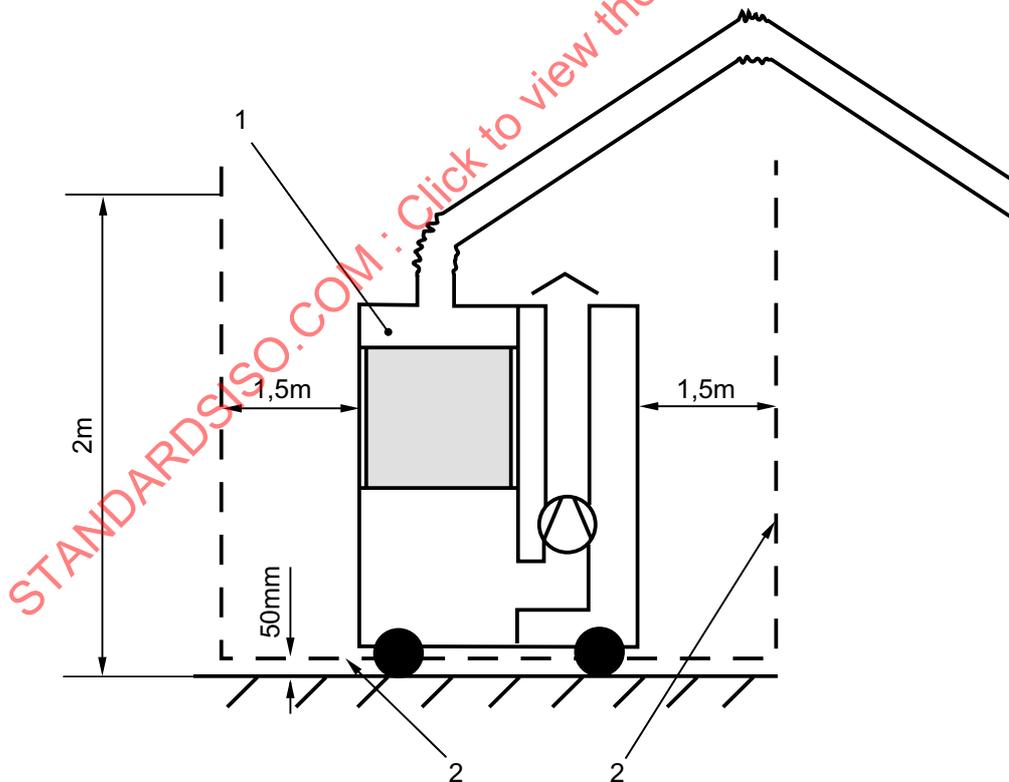
Check compliance with the requirements of 5.6.4 by a simulation of a failure of the electrostatic system, for example by lowering the ionizing current and/or the collector voltage in conjunction with the manufacturer.

6.6.5 Mechanical separation systems

Check compliance with the requirements of 5.6.5 by simulating a high pressure drop.

6.7 Testing of the air velocities of the exhaust and cooling air

Check compliance with the requirements of 5.7 by scanning the maximum velocity within a distance of 1,5 m around the separation unit at heights between 50 mm and 2 m above the floor level (see Figure 4). During the test position the appliance at least 2 m from any wall or vertical surface.



Key

- 1 Welding fume separation equipment
- 2 Vertical and horizontal measuring planes around the separation unit

Figure 4 —Measuring planes for determination of the maximum air velocity (schematic layout)

7 Information for use

7.1 General

The information for use is a compulsory part of welding fume separation equipment. The information shall fulfil the requirements of EN ISO 12100-2:2003, Clause 6.

7.2 Accompanying documents (in particular: Instruction handbook)

An instruction handbook shall be supplied with all welding fume separation equipment, written in the language of the country in which it is sold. The instruction handbook shall include at least the following information:

- name and address of the manufacturer;
- designation of the type or series;
- date of edition of the instruction handbook;
- technical specifications (e.g. filter area, maximum air flow rate, alarm signals, emission of noise, electrical and/or pneumatical specifications);
- description of alarm signals;
- welding fume class of the equipment;
- the intended use of the welding fume separation equipment and, if applicable, any limitations for use;
- for electrostatic systems, any special warning about the risk of a drop in separation efficiency;
- designations of spare parts relating to safety, such as filters, and information about where they can be obtained;

The instruction handbook shall also advise the user to refer to applicable safety regulations appropriate to the materials being handled. It shall include the substance of the following information:

- a) before use, operators shall be provided with information, instruction and training on the use of the appliance and the substances for which it is to be used, including the safe method of removal and disposal of the collected pollutant;
- b) for user servicing, the appliance shall be dismantled, cleaned and serviced, as far as is reasonably practicable, without causing risk to maintenance staff and others. Suitable precautions include decontamination before dismantling, provision for local filtered exhaust ventilation where the appliance is dismantled, cleaning of the maintenance area and suitable personal protection.

8 Marking

The air welding fume separation equipment shall be classified into one of the three welding fume classes prescribed in Table 2 and marked with a corresponding label (see Annex A).

9 Test report

The test report shall include at least the following information (see EN 1093-6 and EN 1093-7):

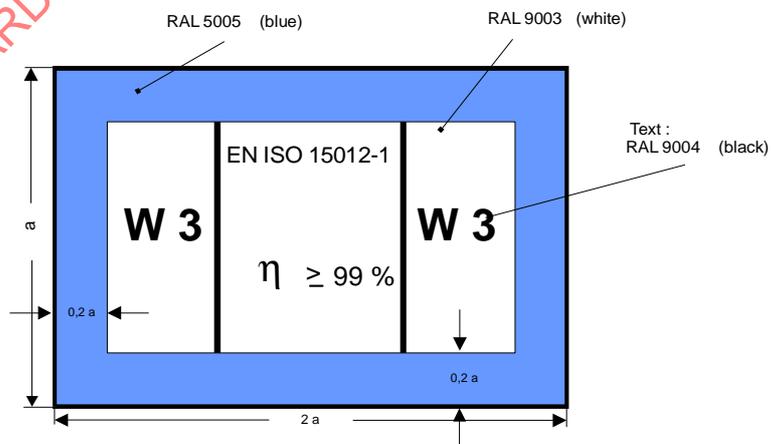
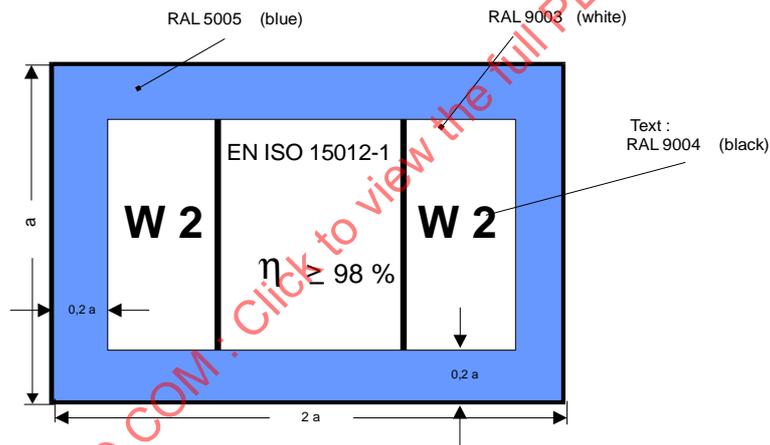
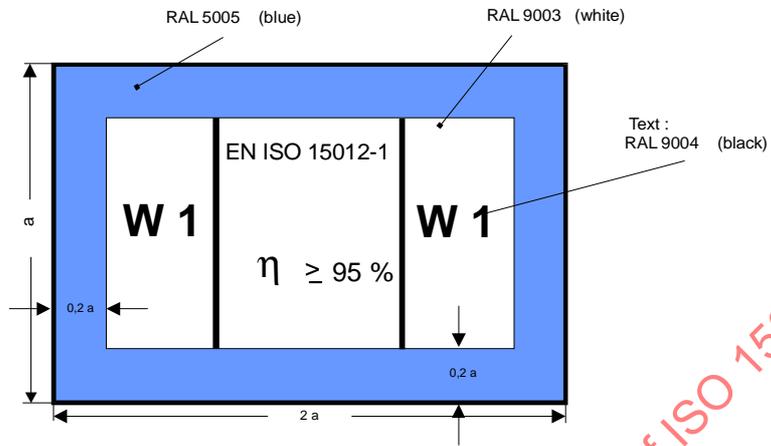
- a) reference to this document, EN ISO 15012-1;
- b) description of the tested machine, which shall at least include the name of the manufacturer, the type, the identification number of the machine, the size, the design and for mechanical filtration units the filter surface and precoating if used;

- c) input data (e. g. $\Delta p/Q$ - curve including Q_{start} , Q_{end} , Q_{min} ; ~~the~~ pollutant);
- d) operational data during test (e. g. welding process, material, welding rod, rod feed rate, welding voltage, welding current, type of shield gas, shield gas flow, contact tube clearance);
- e) test substance [welding fumes according to the conditions under c), emission rate];
- f) description of measurement procedures;
- g) measuring instruments and most recent calibration date;
- h) environmental data (temperature, humidity, pressure);
- i) test results (separation efficiency including statistical interpretation, concentration of pollutant in the cleaned air, welding fume class);
- j) test laboratory;
- k) name of the test person responsible;
- l) date(s) of testing;
- m) comments on deviations from relevant standards;
- n) additional comments (if necessary).

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Annex A (normative)

Labels for welding fume separation equipment



$a = 50 \text{ mm or } 100 \text{ mm}$

Annex B (informative)

Statistical interpretation of the test results - Estimation of the mean - Confidence interval (according to ISO 2602:1980)

B.1 Estimation of the mean (Case of ungrouped results)

After the discarding of any doubtful results, the series comprises n measurements x_i (where $i = 1, 2, 3, \dots, n$), some of which may have the same value.

The mean m of the underlying normal distribution is estimated by the arithmetic mean \bar{x} of the n results:

$$\bar{x} = \frac{1}{n} \times \sum_{i=1}^n x_i \quad (\text{B.1})$$

B.2 Confidence interval for the mean

B.2.1 General

The confidence interval for the population mean is calculated from the estimates of the mean and of the standard deviation.

B.2.2 Estimation of the standard deviation (Case of ungrouped results)

$$S = \sqrt{\frac{1}{n-1} \sum_{i=1}^n (x_i - \bar{x})^2} \quad (\text{B.2})$$

where

x_i is the value of the i^{th} measurement ($i = 1, 2, 3, \dots, n$)

n is the total number of measurements

\bar{x} is the arithmetic mean of the n measurements, calculated as in B.1

For ease of calculation, the use of the following formula is recommended:

$$S = \sqrt{\frac{1}{n-1} \left[\sum_{i=1}^n x_i^2 - \frac{1}{n} \left(\sum_{i=1}^n x_i \right)^2 \right]} \quad (\text{B.3})$$

B.2.3 Confidence interval for the mean (One-sided confidence interval)

The one-sided confidence interval for the population mean is defined by the following inequality (at the confidence level 95 %):

$$m < \bar{x} - \frac{t_{0,95}}{\sqrt{n}} S \quad (\text{B.4})$$

Table B.1 — Values of $t_{0,95}$

Confidence level One - sided case 95 %	
n	$t_{0,95}$
2	6,314
3	2,920
4	2,353
5	2,132

m: = lower confidence limit

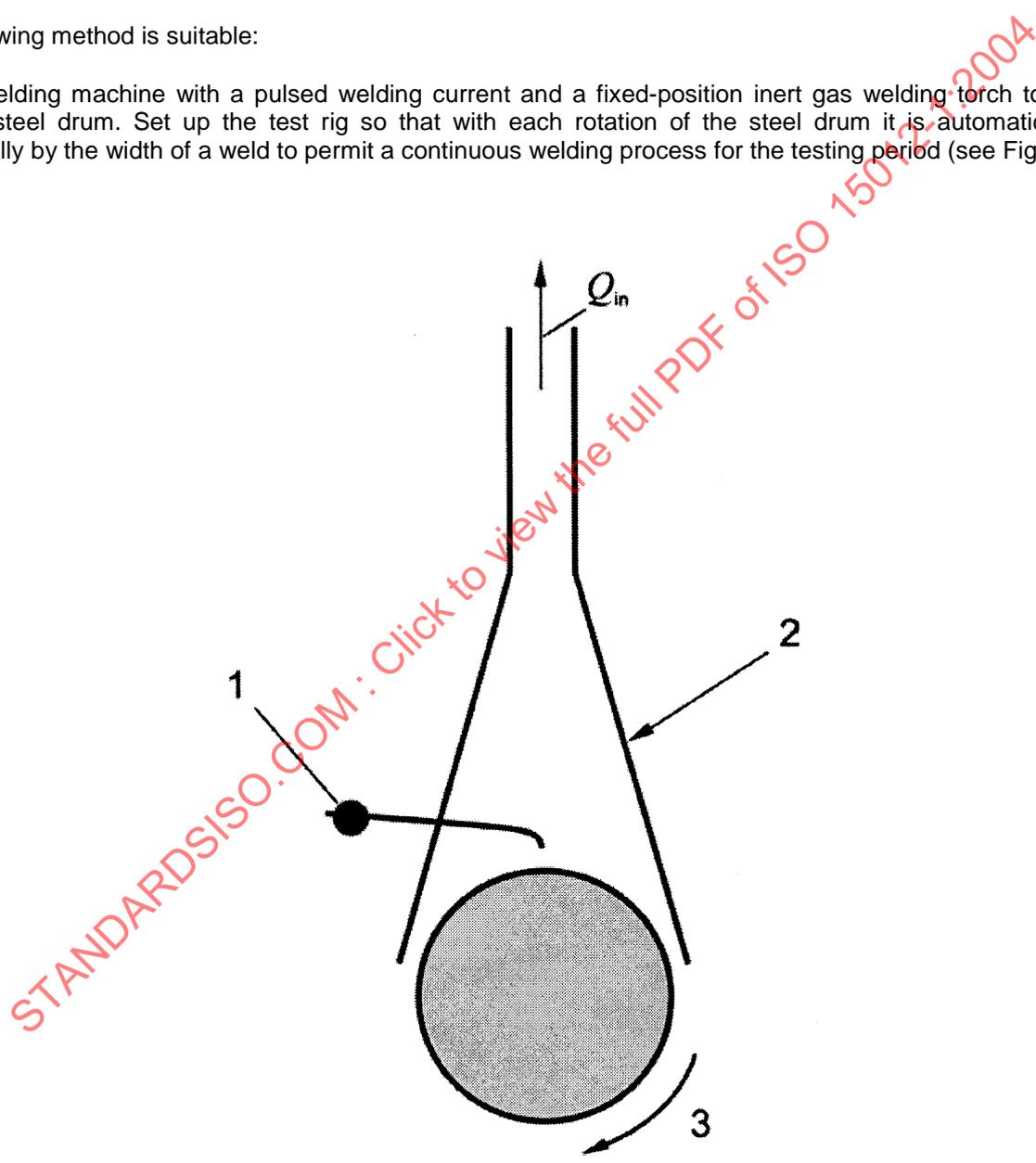
Annex C
(informative)

Welding fume source for single work stations

The welding fume source should have an emission rate of approximately 10 mg/s, which can be achieved by using an active gas metal-arc welding process.

The following method is suitable:

Use a welding machine with a pulsed welding current and a fixed-position inert gas welding torch to weld on a rotating steel drum. Set up the test rig so that with each rotation of the steel drum it is automatically shifted horizontally by the width of a weld to permit a continuous welding process for the testing period (see Figure C.1).



Key

- 1 MAG welding gun
- 2 Fume box
- 3 Rotating cylinder

Figure C.1 - Welding fume source for single work stations (schematic layout)

The emitted welding fumes should be captured completely using a fume hood and drawn into the separator under test via the upstream measurement duct.

The following parameters for the metal-arc welding process have proven suitable for attaining an emission rate of 10 mg/s (see Table C.1):

Table C.1 – Parameters for an emission rate of 10 mg/s

Parameters	Emission rate: 10 mg/s:
Material of the welding wire	EN 440 G3 Si1 $\varnothing = 1,2 \text{ mm}$
Wire feed speed:	6,3 m/min
Welding voltage:	34 V
Welding current:	280 A
Shielding gas:	82 % Ar, 18 % CO ₂ ; 17 l/min
Contact tube distance:	18 mm to 20 mm
Diameter of the drum:	600 mm
Welding speed:	8 mm/s

Annex D
(informative)

Welding fume source for single and/or several work stations

The separation efficiency of welding fume separation equipment suitable for the separation of welding fumes from one or from several work stations should be tested using the same procedure as described in this document. However, instead of using the welding fume source described in Annex C, another welding fume source with high emission should be used. This welding fume source generates welding fumes by a process based on active metal-arc welding and works like thermal spraying. Instead of welding on a base material, two welding guns are positioned towards each other. The arc is produced between the two welding wires connected to the plus and the minus pole of the welding machine. The melted metal falls down into a sand box (see Figure D.1).

By placing the guns in an enclosure, i.e. a ventilation duct, the fume can be captured completely. To prevent spatters entering the unit a spatter trap is installed above the guns. The schematic layout of the unit is shown in Figures D.1, D.2 and D.3.

By using a welding machine with a pulsed welding current the emission rate can be varied over a wide range.

The following parameters for the metal-arc-welding process have proven to be suitable:

Table D.1 – Arrangement for the metal-arc welding process

Material of the welding wire	EN 440 G3 Si1 Plus pole: Ø = 1,2 mm Minus pole: Ø. = 0,8 mm
Shielding gas	80 % Ar, 20 % CO ₂ ; 2 x 15 l/min
Contact tube distance	14 mm

Table D.2 – Parameters for different emission rates

Emission rate [mg/s]	Arc - voltage [V]	Wire feed speed		Pulse characteristics		Peak time [ms]	Frequency [Hz]
		Plus pole [m/min]	Minus pole [m/min]	Peak current [A]	Background current [A]		
5	35,5	3,8	2,5	296	24	1,7	54
10	35,5	4,3	2,8	296	24	1,7	100
15	35,5	4,9	3,3	296	32	1,7	185
30	35,5	7,0	3,5	296	60	1,7	202
60	35,5	10,7	5,5	356	256	1,7	312