भारतीय मानक
Indian Standard

IS 16681 (Part 1) : 2022
ISO 21904-2 : 2020

वेल्डिंग और संबद्ध प्रक्रियाओं मे स्वास्थ्य और सुरक्षा — वेल्डिंग फ्यूम को पकड़ने और अलग करने के लिए उपकरण

भाग 1 पृथक्करण दक्षता के परीक्षण और अंकन के लिए आवश्यकताएँ

(पहला पुनरीक्षण)

Health and Safety in Welding and Allied Processes — Equipment for Capture and Separation of Welding Fume

Part 1 Requirements for Testing and Marking of Separation Efficiency

(First Revision)

ICS 25.160.01

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October 2022 **Price Group 8**

Welding General and its Applications Sectional Committee, MTD 11

NATIONAL FOREWORD

This Indian Standard (Part 1) which is identical to ISO 21904-2 : 2020 'Health and safety in welding and allied processes — Equipment for capture and separation of welding fume — Part 2: Requirements for testing and marking of separation efficiency' issued by the International Organization for Standardization (ISO), was adopted by the Bureau of Indian Standards on the recommendation of the Welding General and its Applications Sectional Committee and approval of the Metallurgical Engineering Division Council.

This standard was originally published in 2018 adopting ISO 15012-1:2013 under dual numbering system. As ISO 15012-1:2013 has been replaced by ISO 21904-2 : 2020, hence, first revision of this standard has been undertaken to align it with the ISO 21904-2 : 2020.

The text of ISO standard has been approved as suitable for publication as an Indian Standard without deviations. Certain terminologies and conventions are, however, not identical with those used in Indian Standard. Attention is especially drawn to the following:

a) Wherever the words `International Standard' appear referring to this standard, it should be read as `Indian Standard'
b) Comma (,) has been used as a decimal marker while in Indian Standards the current Practice is to use a point (.) as the decimal marker.

In this adopted standard, reference appears to certain International Standards for which Indian Standards also exists. The corresponding Indian Standards which are to be substituted in their place are listed below along with their degree of equivalence for the edition indicated:

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
ISO 15011-1 : 2009 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	IS 16278 (Part 1) : 2014/ISO 15011-1 : 2009 Health and safety in welding and allied processes — Laboratory method for sampling fumes and gases: Part 1 Determination of fume emission rate during arc welding and collection of fumes for analysis	Identical

The Technical Committee responsible for the preparation of this standard has reviewed the provisions of following International Standards referred in these adopted standards and has decided that they are acceptable for use in conjunction with this standard.

International Standard	*Title*
ISO 2602 : 1980	Statistical interpretation of test results — Estimation of the mean — Confidence interval
ISO 21904-1 : 2020	Health and safety in welding and allied processes — Equipmentfor capture and separation of welding fume — Part 1: General requirements

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis shall he rounded off in accordance with IS 2 : 2022 'Rules for rounding off numerical values (*second revision*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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Introduction

It is common practice in the fabrication industry to control exposure to welding fume using local exhaust ventilation equipment that, following capture and separation of the fume, returns the extracted air to the workplace or exhausts it to the atmosphere. It is important that such equipment has high separation efficiency so that as little fume as possible is recirculated or exhausted. This document has therefore been developed to specify a test method for determining the efficiency of welding fume separation equipment and the requirements of the test method.

Indian Standard

HEALTH AND SAFETY IN WELDING AND ALLIED PROCESSES — EQUIPMENT FOR CAPTURE AND SEPARATION OF WELDING FUME

PART 2 REQUIREMENTS FOR TESTING AND MARKING OF SEPARATION EFFICIENCY

(First Revision)

1 Scope

This document specifies a method for testing equipment for the separation of welding fume in order to determine whether its separation efficiency meets specified requirements.

The method specified does not apply to testing of filter cartridges independent of the equipment in which they are intended to be used.

This document applies to equipment that is manufactured after its publication.

NOTE General ventilation systems are excluded from the Scope of ISO 21904-1.

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 2602:1980, *Statistical interpretation of test results — Estimation of the mean — Confidence interval*

ISO 15011-1:2009, *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*

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 21904-1 and the following 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
free-standing unit
separation equipment with an integrated fan

3.2
modular system
separation equipment consisting of a scaleable filter system with the same filter elements and conditions normally connected to a single fan

3.3
welding fume source
source generating welding fume by welding process that charges separation equipment to perform separation efficiency tests

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

Note 1 to entry: The emission rate is expressed in milligrams per second.

4 Principle

The method is based on the methods specified in EN 1093-6[10] and EN 1093-7[11]. Under test, the welding fume separation equipment is charged by welding fume generated by a welding process. The welding fume concentrations are measured in the incoming and exhausted air of the separation unit. The welding fume separation equipment under test is operated under defined conditions, according to its intended use.

The emission rate of the welding fume source is measured separately. Therefore, the welding fume generated by the source is sampled on preweighed filters over a period of time.

The air volume flow rate of the welding fume separation equipment and the testing time shall be measured during the separation efficiency test. Emission rate, testing time and air volume flow rate are used subsequently to calculate the concentration of welding fume in the incoming air. Welding parameters should be the same when emission rate and separation efficiency test are performed.

Before separation efficiency measurements are made, all welding fume separation equipment are charged for a period of 30 min using the welding fume source.

For equipment with filters that are not intended to be cleaned, the concentration of welding fume passing through the separation equipment is measured subsequently for a period of 30 min and the measured concentration is used, together with the welding fume concentration calculated from the welding fume emission rate, to determine the separation efficiency.

For equipment with cleanable filters, an additional separation efficiency measurement is performed after a further welding period without measurement and filter cleaning. The average of the two separation efficiencies is calculated.

Two tests are performed and the average, the 95 % one-sided confidence interval and the lower confidence limit value of the separation efficiency are calculated according to ISO 2602. If the resulting lower confidence limit value is less than the required separation efficiency, consideration shall be given to improve the filter unit design.

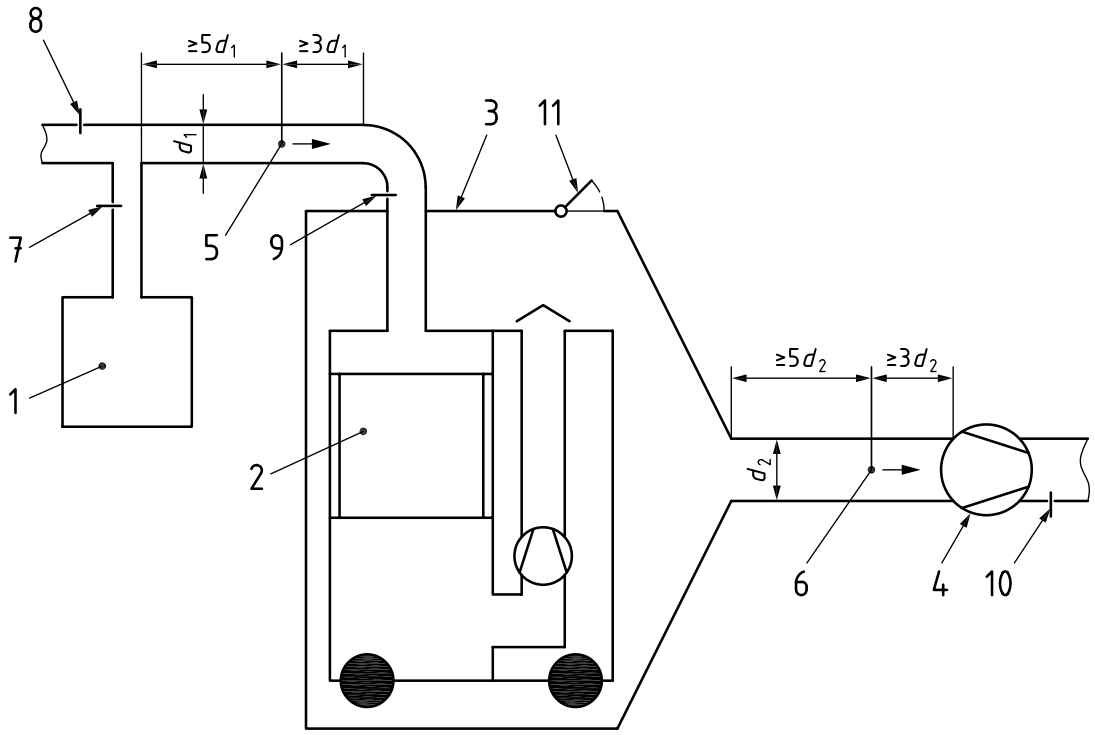
5 Apparatus

5.1 Welding fume source, capable of maintaining an emission rate of 10 mg/s ± 2 mg/s throughout the test period.

The welding fume source shall be fitted with an extraction hood that retains all the welding fume emitted and shall be designed in such a way that it can be connected to the inlet duct of the test cabin, as described in Figure 1, or directly to welding fume separation equipment with a ducted outlet, as described in Figure 2. It shall be possible to determine the welding fume emission rate in situ without disturbing the welding set-up in any way. An example of a suitable welding fume source and parameters required to achieve the required welding fume emission rate are described in Annex B.

5.2 Test cabin, consisting of 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 and an air mover (see Figure 1). The air volume flow rate through the air mover is adjusted to between 95 % and 100 % of the air volume flow rate in the upstream duct, thus ensuring a small positive air pressure in the cabin.



Key

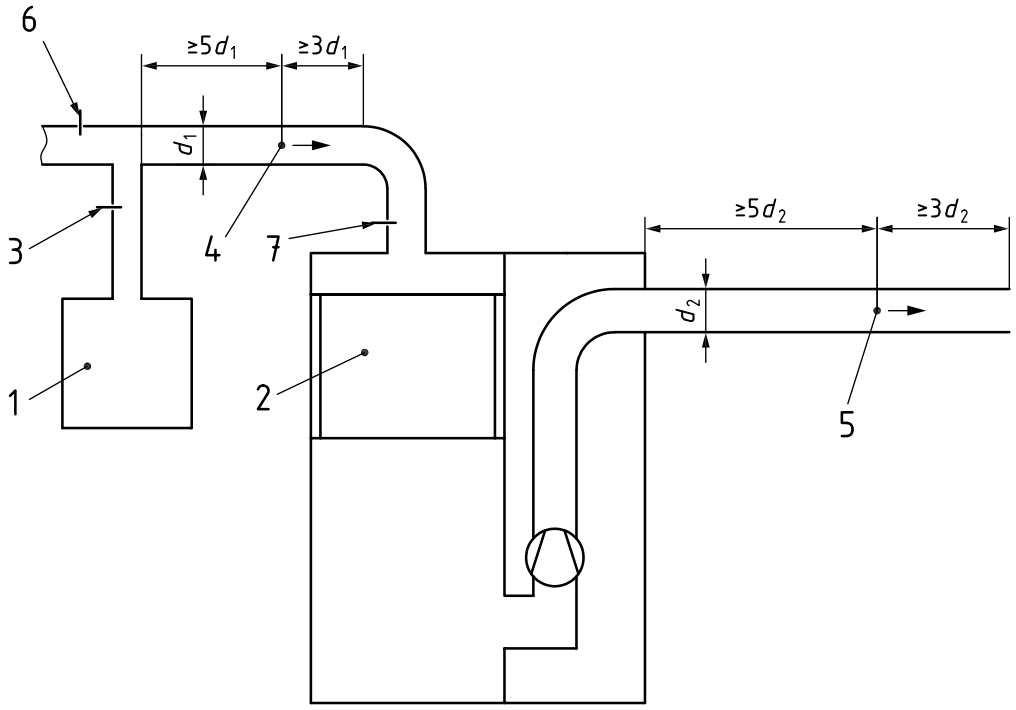
1 welding fume source (see Figure B.1)
2 welding fume separation equipment
3 test cabin
4 air mover
5 position for measuring the air volume flow rate in the upstream duct, $q_{V,1}$
6 positions for measuring the air volume flow rate in the downstream duct, $q_{V,2}$ and isokinetic sampling of welding fume in the downstream duct
7 damper (to control the air volume flow rate passing through the welding fume source in order to avoid shielding gas disturbance)
8 damper (to ensure that all welding fume is captured, even when filter units with a low air volume flow rate are under test)
9 damper (to regulate the total air volume flow rate passing through the separation equipment)
10 damper (to control the air volume flow rate in the downstream duct in order to achieve a slight overpressure in the cabin)
11 gap with a flap (to prevent damage on the cabin in case of high overpressure)
d_1 upstream duct diameter
d_2 downstream duct diameter

Figure 1 — Example of test cabin (schematic layout)

The positions for measuring the air volume flow rate and isokinetic sampling of welding fume in the downstream duct are not the same, but are shown in Figure 1 for convenience. They shall comply with the dimensions marked in Figure 1.

5.3 Test arrangement for welding fume separation equipment with a ducted outlet, consisting of a welding fume source connected to the equipment via an upstream measurement duct.

The outlet of the welding fume separation equipment is directly linked to the downstream measurement duct (see Figure 2).



Key

1 welding fume source
2 welding fume separation equipment
3 damper (to control the air flow passing through the welding fume source in order to avoid shielding gas disturbance)
4 position of equipment for measuring the air volume flow rate in the upstream duct
5 position of equipment for measuring the air volume flow rate and the welding fume concentration in the downstream duct
6 damper (to ensure that all welding fume is captured, even when filter units with low air volume flow rates are under test)
7 damper (to regulate the total air flow passing through the separation equipment)
d_1 upstream duct diameter
d_2 downstream duct diameter

Figure 2 — Test arrangement for welding fume separation equipment with a ducted outlet (schematic layout)

5.4 Air volume flow rate measurement equipment, capable of measuring rates up to 2 000 m^3/h continuously, to within an accuracy of ±10 % or better.

The following combination of equipment is suitable.

A flow meter with a calibrated relationship between pressure difference and air volume flow rate, e.g. an orifice plate, together with a digital manometer to measure the pressure difference across it. The digital manometer shall have a logging capability or be connected to a logging system with a logging frequency of 1 min or less.

A device for measuring air volume flow rate with equivalent performance is also suitable.

National standards shall be taken into consideration for the calibration of all equipment.

6 Test method

6.1 Selection of test arrangement

Use the test cabin illustrated in Figure 1 or the test arrangement shown in Figure 2. Any welding fume separation equipment (including individual modules of a modular system) can be tested using the test cabin depicted in Figure 1, provided it can be fitted into the test cabin. For an example of a test cabin, see Annex A.

Only welding fume separation equipment with a ducted outlet can be tested using the arrangement shown in Figure 2.

6.2 Test conditions

Carry out the test under conditions that are similar to the normal working conditions for the equipment under test.

For modular welding fume separation equipment, if the designed air volume flow rate is greater than 2 000 m^3/h, carry out the test of separation efficiency using a specially made scaled down typical module. If different fans can be used in combination with the welding fume separation equipment, carry out the test of separation efficiency using the minimum and maximum air volume flow rates recommended by the manufacturer.

6.3 Procedure

6.3.1 Source emission rate measurement

Determine the emission rate of the welding fume source using the exact conditions used during testing and the general approach specified in ISO 15011-1. Weld while sampling total welding fume emission on a preweighed filter. Stop welding and sampling and reweigh the filter. Calculate the emission rate by dividing the mass of welding fume collected on the filter by the sampling time.

6.3.2 Equipment without filter cleaning system

Select the test arrangement and set up the test conditions.

— Determine the source emission rate as described in 6.3.1.

— Switch on the welding fume separation equipment, the air volume flow rate measurement systems and the air mover in the downstream measurement duct. Adjust the air volume flow rate in the upstream duct using the dampers to the air volume flow rate stated by the manufacturer.

— Monitor the air volume flow rate throughout the test.

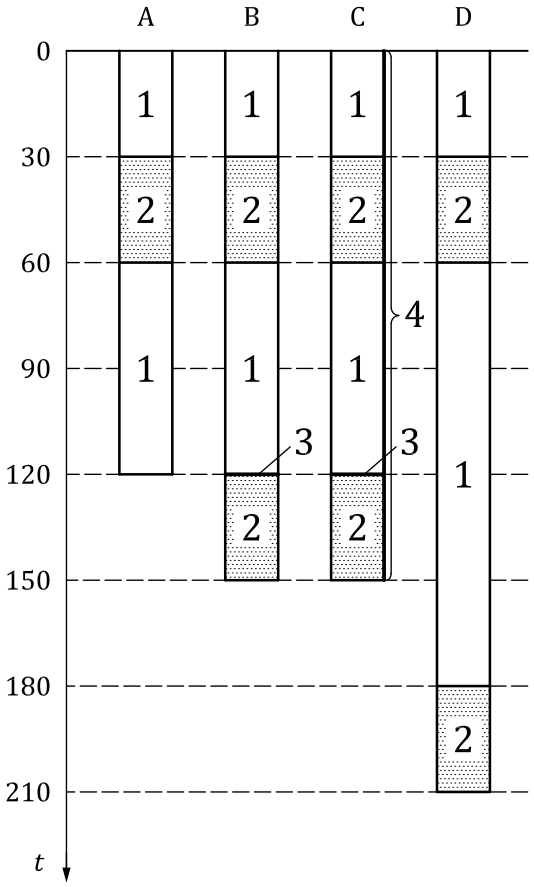
— Generate and separate welding fume for an arcing period of 30 min without measurement in order to precondition the separation equipment. Use precoated filters to test equipment with mechanical separation systems, if the manufacturer intends their use.

— Commence sampling and collect samples of welding fume for an arcing period of 30 min.

— Continue welding for a further arcing period of 60 min without measurement (see Figure 3) and record the air volume flow rate at the end.

— When the test is completed, repeat the determination of the source emission rate and average the results of the first and second emission rate determinations. The average value should be 10 mg/s ± 2 mg/s.

Welding fume separation equipment – Type:



Key

Type:

A welding fume separation equipment without filter cleaning system

B welding fume separation equipment with manually initiated filter cleaning system

C welding fume separation equipment with an automatically initiated filter cleaning system

D welding fume separation equipment with electrostatic precipitator

t arcing time

1 welding without efficiency measurement

2 welding with efficiency measurement

3 manually initiated filter cleaning

4 automatically initiated filter cleaning system is active

NOTE The test is not invalidated if automatically initiated filter cleaning occurs at any point during the test.

Figure 3 — Test procedure

— Repeat the welding fume separation test after fitting a new filter in the welding fume separation equipment.

— Determine the separation efficiency by mass for each test using Formula (1).

— Calculate the average, the 95 % one-sided confidence interval and the lower confidence limit value of the separation efficiency based on the test results and compare to the specified requirements.

NOTE ISO 15767[6] specifies measures to be taken to control and characterize errors in weighing collected aerosols.

6.3.3 Equipment with manually initiated filter cleaning system

Select the test arrangement and set up the test conditions.

— Determine the source emission rate as described in 6.3.1.

— Switch on the welding fume separation equipment, the air volume flow rate measurement systems, and the air mover in the downstream measurement duct. Adjust the air volume flow rate in the upstream duct using the dampers to the air volume flow rate stated by the manufacturer.

— Monitor the air volume flow rate throughout the test.

— Generate and separate welding fume for an arcing period of 30 min without measurement in order to precondition the separation equipment. Use precoated filters to test equipment with mechanical separation systems, if their use is intended by the manufacturer.

— Begin sampling and collect samples of welding fume for an arcing period of 30 min.

— Continue welding for a further arcing period of 60 min without measurement (see Figure 3) provided the air volume flow rate exceeds the minimum value specified by the manufacturer.

— Initiate a filter cleaning and continue welding for a period of 30 min with measurement and with new sampling filters.

— When the test is completed, repeat the determination of the source emission rate and average the results of the first and second emission rate determinations.

— Calculate the separation efficiency for each of the measurement periods and calculate the average. This is the result of the test.

— Repeat the welding fume separation test after fitting a new filter in the welding fume separation equipment.

— Calculate the average, the 95 % one-sided confidence interval and the lower confidence limit value of the separation efficiency based on the test results and compare to the specified requirements defined in ISO 21904-1.

NOTE ISO 15767[6] specifies measures to be taken to control and characterize errors in weighing collected aerosols.

6.3.4 Equipment with automatically initiated filter cleaning system

Select the test arrangement and set up the test conditions.

— Determine the source emission rate as described in 6.3.1.

— Switch on the welding fume separation equipment, the air volume flow rate measurement systems, and the air mover in the downstream measurement duct. Adjust the air volume flow rate in the upstream duct using the dampers to the air volume flow rate stated by the manufacturer.

— Monitor the air volume flow rate throughout the test.

— Generate and separate welding fume for an arcing period of 30 min without measurement in order to precondition the separation equipment. Use precoated filters to test equipment with mechanical separation systems, if their use is intended by the manufacturer.

— Begin sampling and collect samples of welding fume for an arcing period of 30 min.

— Continue welding for a further arcing period of 60 min without measuring (see Figure 3) provided the air volume flow rate exceeds the minimum value specified by the manufacturer.

— Initiate a filter cleaning and continue welding for an arcing period of 30 min with measurement and with new sampling filters.

NOTE 1 Any automatically initiated filter cleaning cycles occurring during the test can be ignored.

— When the test is completed, repeat the determination of the source emission rate and average the results of the first and second emission rate determinations.

— Calculate the separation efficiency for each of the measurement periods and calculate the average. This is the result of the test.

— Repeat the welding fume separation test after fitting a new filter in the welding fume separation equipment.

— Calculate the average, the 95 % one-sided confidence interval and the lower confidence limit value of the separation efficiency based on the test results and compare to the specified requirements.

NOTE 2 ISO 15767[6] specifies measures to be taken to control and characterize errors in weighing collected aerosols.

6.3.5 Equipment with electrostatic precipitators

Select the test arrangement and set up the test conditions.

— Determine the source emission rate as described in 6.3.1.

— Switch on the welding fume separation equipment, the air volume flow rate measurement systems, and the air mover in the downstream measurement duct. Adjust the air volume flow rate in the upstream duct using the dampers to the air volume flow rate stated by the manufacturer.

— Monitor the air volume flow rate throughout the test.

— Generate and separate welding fume for an arcing period of 30 min without measurement in order to precondition the separation equipment.

— Begin sampling and collect samples of welding fume for an arcing period of 30 min.

— Continue welding for a further arcing period of 120 min without measurement (see Figure 3) provided the air volume flow rate exceeds the minimum value specified by the manufacturer.

— Repeat the measurement of the separation efficiency.

— When the test is completed, repeat the determination of the source emission rate and average the results of the first and second emission rate determinations.

— Calculate the separation efficiency for each of the measurement periods and calculate the average. This is the result of the test.

— Repeat the welding fume separation test after fitting a new filter in the welding fume separation equipment.

— Calculate the average, the 95 % one-sided confidence interval and the lower confidence limit value of the separation efficiency based on the test results and compare to the specified requirements.

NOTE ISO 15767[6] specifies measures to be taken to control and characterize errors in weighing collected aerosols.

6.4 Calculation of the separation efficiency

Calculate the separation efficiency by mass, η, using Formula (1):

$$\eta = \left(1 - \frac{\gamma_{out}}{\gamma_{in}}\right) \times 100\,\% \quad (1)$$

where

γ_{in} is the concentration of welding fume entering the separation equipment under test, in mg/m^3, calculated with Formula (2);

γ_{out} is the concentration of welding fume emitted by separation equipment under test in mg/m^3, calculated with Formula (3).

$$\gamma_{in} = \frac{m_{in}}{V_{in}}\ \mathrm{mg/m^3} \quad (2)$$

where

m_{in} is total mass of emitted welding fume from the source calculated from the average emission rate multiplied by the measuring time, in mg;

V_{in} is the total air volume that passes through the separation equipment during the test, in m^3.

$$\gamma_{out} = \frac{m_{s\,out}}{V_{s\,out}}\ \mathrm{mg/m^3} \quad (3)$$

where

$m_{s,out}$ is the mass of the welding fume particles on the sampling filter in the downstream air, in mg;

$V_{s,out}$ is the total air volume that passes through the sampling filter in the downstream air, in m^3;

Use the method described in ISO 2602 for statistical interpretation of the test results.

7 Accuracy of measurement

The measurement error is expected not to exceed 1 %, based on a worst-case scenario.

8 Test report

The test report shall include at least the following:

a) the name or trademark of the manufacturer;

b) the name and model of the separation equipment;

c) the name and address of the party which carries out the test;

d) the dates of test, signature and name of the testing person;

e) a description of the instrumentation, including its specification, calibration;

f) the airflow at the beginning and at the end of the test and the corresponding pressure drop of the filter if applicable;

g) the calculated separation efficiency;

NOTE The results of separation efficiency tests carried out with welding fume are also valid for filter units used for separation of fume generated by allied processes if the particle size expected in these allied processes is equal or bigger.

Annex A
(informative)

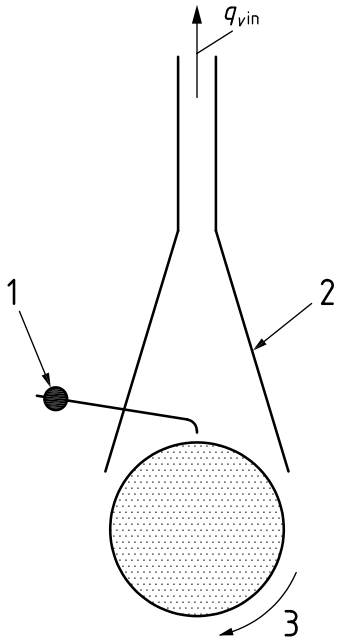
Test cabin

A suitable test cabin for a test arrangement described in Figure 1 is a housing enclosing completely the welding fume separation equipment under test. The cabin shall be provided with openings for connecting the device to the welding fume source and to the measurement duct. The dimensions of the cabin should be matched to the welding fume separation device under test in a suitable manner. For testing of free-standing units with a maximum air volume flow rate, $q_{V,\max}$, approximately 1 500 m^3/h, a test cabin with dimensions of 2,2 m × 1,5 m × 2,2 m (length by width by height) has proven to be suitable.

Annex B
(informative)

Welding fume source

A suitable welding fume source consists of a continuous wire welding torch, connected to a power source operating with pulsed parameters, welding on a rotating steel drum, as shown schematically in Figure B.1. The rig is set up to enable welding to progress continuously for the duration of the test period by fixing the position of the welding torch while automatically shifting the steel drum horizontally along its axis by at least the width of a weld with each rotation of the drum.



Key

1 continuous wire welding torch
2 extraction hood
3 rotating steel drum
$q_{V\text{in}}$ air volume flow rate from the source

Figure B.1 — Welding fume source (schematic layout)

The welding conditions in Table B.1 are suitable for obtaining an emission rate of approximately 10 mg/s.

Table B.1 — Welding conditions

Parameter	Condition
Welding process	Metal active gas (MAG) welding
Material of the welding wire	EN 440 G3 Si1
Diameter of the welding wire	1,2 mm
Wire feed speed	6,3 m/min
Welding voltage	34 V
Peak current	370 A
Basic current	45 A
Peak time	4,2 ms
Peak frequency	200 Hz
Shielding gas	82 % Ar, 18 % CO_2
Shielding gas flow rate	17 l/min
Contact tip to work piece distance	18 mm to 20 mm
Diameter of the drum	600 mm
Welding speed	8 mm/s

Bibliography

[1] ISO 5167 (all parts), *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full*

[2] ISO 5801, *Fans — Performance testing using standardized airways*

[3] ISO 7731, *Ergonomics — Danger signals for public and work areas — Auditory danger signals*

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

[5] ISO 14341, *Welding consumables — Wire electrodes and weld deposits for gas shielded metal arc welding of non alloy and fine grain steels — Classification*

[6] ISO 15767, *Workplace atmospheres — Controlling and characterizing uncertainty in weighing collected aerosols*

[7] EN 842, *Safety of machinery — Visual danger signals — General requirements, design and testing*

[8] EN 1093-1, *Safety of machinery — Evaluation of the emission of airborne hazardous substances — Part 1: Selection of test methods*

[9] EN 1093-3, *Safety of machinery — Evaluation of the emission of airborne hazardous substances — Part 3: Test bench method for the measurement of the emission rate of a given pollutant*

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

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

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Review of Indian Standards

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