TECHNICAL SPECIFICATION

ISO/TS 15011-6

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

Part 6:
Procedure for quantitative determination of fume and gases from resistance spot welding

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

Partie 6: Procédure pour la détermination quantitative des fumées et des gaz générés par le soudage par résistance par points

Reference number
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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

In other circumstances, particularly when there is an urgent market requirement for such documents, a technical committee may decide to publish other types of document:

— an ISO Publicly Available Specification (ISO/PAS) represents an agreement between technical experts in an ISO working group and is accepted for publication if it is approved by more than 50 % of the members of the parent committee casting a vote;

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An ISO/PAS or ISO/TS is reviewed after three years in order to decide whether it will be confirmed for a further three years, revised to become an International Standard, or withdrawn. If the ISO/PAS or ISO/TS is confirmed, it is reviewed again after a further three years, at which time it must either be transformed into an International Standard or be withdrawn.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO/TS 15011-6 was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 9, *Health and safety*.

ISO 15011 consists of the following parts, under the general title *Health and safety in welding and allied processes — Laboratory method for sampling fume and gases*:

— *Part 1: Determination of fume emission rate during arc welding and collection of fume for analysis*

— *Part 2: Determination of the emission rates of carbon monoxide (CO), carbon dioxide (CO_2), nitrogen monoxide (NO) and nitrogen dioxide (NO_2) during arc welding, cutting and gouging*

— *Part 3: Determination of ozone emission rate during arc welding*

— *Part 4: Fume data sheets*

— *Part 5: Identification of thermal-degradation products generated when welding or cutting through products composed wholly or partly of organic materials using pyrolysis-gas chromatography-mass spectrometry*

— *Part 6: Procedure for quantitative determination of fume and gases from resistance spot welding* (Technical Specification)

Requests for official interpretations of any aspect of this Technical Specification 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 and cutting activities generate fume and gases which can be harmful to health and should be controlled within the limits laid down by regulations.

Determination of the particle size distribution and the qualitative analysis (metallic and organic fraction and, if possible, speciation) of the dust collected are part of the current practices in human health risk assessment.

In addition, determination of the emission rate of fume and gases is essential for a proper hazard characterization (qualitative and quantitative analysis).

Emission rates cannot be used directly to assess the welder's exposure, but it is expected that materials giving low emission rates will result in lower welder exposures than materials with high emission rates used in the same working situation.

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

Part 6: Procedure for quantitative determination of fume and gases from resistance spot welding

1 Scope

This part of ISO 15011 provides guidance on determination of emission rates of fume and gases generated by spot welding of uncoated and coated steel sheets, expressed as the quantity of pollutants per spot weld. It describes the test principle and considers methods for sampling and analysis.

This part of ISO 15011 can be used for determining the influence of the type of material, the coating system, and the material thickness on the possible generation of fume and gases when using a fixed combination of electrodes, welding equipment, and testing conditions.

The data generated can be used by product manufacturers to provide information for inclusion in safety data sheets and by occupational hygienists to evaluate the significant substances emitted by spot welding in the performance of risk assessments and/or workplace exposure measurements.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 7708, *Air quality — Particle size fraction definitions for health-related sampling*

ISO 15011-5, *Health and safety in welding and allied processes — Laboratory method for sampling fume and gases — Part 5: Identification of thermal-degradation products generated when welding or cutting through products composed wholly or partly of organic materials using pyrolysis-gas chromatography-mass spectrometry*

ISO 15609-5, *Specification and qualification of welding procedures for metallic materials — Welding procedure specification — Part 5: Resistance welding*

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

ISO 18278-2:2004, *Resistance welding — Weldability — Part 2: Alternative procedures for the assessment of sheet steels for spot welding*

CEN/TR 14599, *Terms and definitions for welding purposes in relation with EN 1792*

CEN/TR 15230, *Workplace atmospheres — Guidance for sampling of inhalable, thoracic and respirable aerosol fractions*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in CEN/TR 14599 and the following apply.

3.1
gas
thermal degradation substance generated when welding and sampled in the gas phase

3.2
welding spatter
exit of molten metal from the overlapping area between the sheets and characterized by flying sparks and/or by plumes in the overlapping area emanating from the solidified weld nugget

NOTE The solidified weld nugget can be examined for signs of weld spatter by destructive testing.

3.3
surface spatter
exit of molten metal occurring in resistance spot welding at the contact area between electrode and sheet surface

NOTE Surface spatter is visible to the eye and can often be recognized after welding by means of a remaining dark trace of residues on, and/or light formation of plumes at, the sheet surface.

4 Principle

Fume and gases generated by resistance spot welding are extracted into a sampling chamber in order to determine the amount of dust generated. According to the principle of sedimentation, coarse particles are separated and the airborne particles are collected on a preweighed filter, which is then reweighed. The fume can then be chemically analysed, if required.

In order to determine the gaseous components, the emissions are collected in a fume box, then sampled and quantified in an appropriate manner. Identification of any thermal degradation products of occupational hygiene significance are undertaken in accordance with ISO 15011-5 prior to the welding test.

5 Apparatus

5.1 Resistance spot welding equipment. Refer to ISO 15609-5 for information and guidance on appropriate resistance spot welding equipment and resistance spot welding conditions.

5.2 Equipment for determination of fume emission rate.

5.2.1 Welding chamber for determination of fume emission rate. See Annex A.

5.2.2 Sampler.

5.2.2.1 Inhalable sampler, designed to collect the inhalable fraction of airborne particles, as defined in ISO 7708, with a high enough design flow rate to extract all the fume generated without loss on to the walls of the welding chamber.

5.2.2.2 Respirable sampler, designated to collect the respirable fraction of airborne particles, as defined in ISO 7708, with a high enough design flow rate to extract all the fume generated without loss on to the walls of the welding chamber.

5.2.3 Filters, with a suitable pore size, e.g. 8 µm, and of a diameter that is compatible with the sampler (5.2.2). Refer to ISO 15767 for guidance on selection of filters when carrying out gravimetric measurements.

5.2.4 Adaptor, for connecting the welding chamber to the sampler, having an airtight fit in order to prevent outside air being entrained into the chamber.

5.2.5 Balance, accurate to ±0,01 mg, for preweighing and reweighing test filters.

5.3 Equipment for determination emission rates of gases.

5.3.1 Welding chamber for determination emission rates of gases shall be large enough to contain the emitted gases during welding and shall not be constructed using materials which could emit organic gases on heating. The chamber shall be equipped with a number of suitable ports through which the emitted gases can be sampled.

An example of a welding chamber for determination emission rates of gases is given in Annex B.

5.3.2 Sampling lines, consisting of tubing connecting the sampling points and the pumps or equipment for measuring gas concentration.

The sampling lines shall have a diameter ≤10 mm, be as short as practicable, and shall incorporate a dust filter, mounted in a suitable filter holder, placed as close as possible to the sampling point in order to prevent dust from entering the sampling line.

5.3.3 Direct-reading apparatus for measuring carbon monoxide (CO) is based on one of the following principles:

— dispersive infra-red absorption and non-dispersive infra-red absorption, used with or without filters to reduce interference from carbon dioxide;

— diffusion of CO through a semi-permeable membrane at a rate proportional to the concentration, followed by electrochemical oxidation of the gas at a potential-controlled electrode and measurement of the current produced.

5.3.4 Equipment for sampling volatile organic compounds (VOCs), e.g. Tenax[1)] tubes.

5.3.5 Equipment for sampling aldehydes and other carbonyl compounds, e.g. 2,4-dinitrophenylhydrazine (DNPH) tube.

5.3.6 Equipment for sampling polycyclic aromatic hydrocarbons (PAHs), e.g. XAD-2[1)] tube.

5.3.7 Equipment for sampling phenols, e.g. XAD-7[1)] tube.

5.3.8 Equipment for sampling isocyanates, e.g. glass-fibre filters impregnated with 1-(2-pyridyl)piperazine.

6 Procedure

6.1 Preparation of test pieces

Prepare strips of the material to be tested, having a width of 50 mm and a length which is sufficient to ensure a minimum of 100 spot welds can be performed at a welding frequency of 20 spots/min with a spot weld distance of 30 mm. If necessary, join two or more strips to produce a test piece of sufficient length.

1) Example of a suitable product available commercially. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of the product named.

6.2 Set up of welding equipment

Set up the resistance spot welding equipment (5.1) to weld together two test pieces (see 6.1) within the welding chamber, with the spot welds centrally placed at a spot weld distance of 30 mm. Use the welding chamber described in Annex A for determination of fume emission rate or as described in Annex B for determination of emission rates and gases.

In order to ensure good contact between the electrode and the test piece, condition the welding electrodes by performing 20 welds. Carry out this conditioning of the electrodes using sheets of soft, deep-drawing steel without layer or coating, having the same thickness as the material under test.

6.3 Selection of welding parameters

Set the welding parameters for emission measurements as given in Annex C.

Set the welding current so the spot diameter, in millimetres, is approximately $4{,}5\sqrt{t}$, where t is the thickness of the material under test, in millimetres. If spatter occurs, set the welding current 500 A below this value.

NOTE 1 Setting the current to produce a test spot diameter of approximately $4{,}5\sqrt{t}$ avoids most spatter, which is necessary for reproducible emission rate measurements.

NOTE 2 Guidelines on the measurement of spot weld diameters for peel and shear fracture are contained in ISO 14329[2].

Ensure that the welding time is sufficiently long to overcome electrode bounce effects and setting inertia, in order that the pressure on the electrodes reaches a minimum of 95 % of the nominal value before the current is flowing.

6.4 Fume emission rate

6.4.1 Selection and use of sampler

Use either inhalable samplers (5.2.2.1) or respirable samplers (5.2.2.2), according to which size fraction is applicable to the limit values of interest, e.g. for manganese.

Use the samplers at their design flow rate, in accordance with the specifications given by the manufacturer, in order that they collect the intended fraction of the airborne particles.

Refer to CEN/TR 15230 for guidance on suitable samplers.

6.4.2 Connection of sampler to the welding chamber

Connect the sampler (5.2.2) to the welding chamber (see Annex A) using the sampling line (5.3.2) and the adaptor (5.2.4).

6.4.3 Sampling

Before sampling, mark, condition, and preweigh the filter to be used for sampling (see 6.4.5.1).

Subject the material under test to a minimum of nine series of 100 spot welds, cleaning the welding chamber after each test and replacing the electrode caps after every 300 spot welds. Remove, condition, reweigh, and replace the test filter after completing each series (see 6.4.5.1). If there is shut-down of the pump or clogging of the filter, terminate sampling with fewer than 100 spot welds completed.

If welding spatter occurs during sampling (material discharge), the test is invalid, so reject the filter.

NOTE The generation of welding spatter increases fume emission.

If surface spatter occurs, document its occurrence, but do not reject the filter, as the test is still considered valid.

If necessary, perform additional tests to obtain at least six valid measurements, which is the minimum necessary for satisfactory counting statistics.

6.4.4 Blank test

Collect a sample blank by performing a test similar to that described in 6.4.3, but without making welds. Draw air through the filter for a time which corresponds to that taken to carry out a series of 100 spot welds.

6.4.5 Analysis

6.4.5.1 Gravimetry

Determine the mass of fume collected on each filter from the difference in mass before and after sampling and divide by the number of spot welds made to express the result in milligrams per spot weld.

Refer to ISO 15767 for controlling and characterizing errors in weighing collected aerosols.

Before each weighing, condition the filter for 48 h with a temperature maintained constant to within ±2 °C and the relative humidity to within ±5 %.

In order to compensate for possible environmental variations during weighing or conditioning of filters, weigh a suitable number of reference filters, which are not being used for the measurement, during each series of weighing. Apply a correction to all test results to account for the average difference in mass of the reference filters between the initial and final weighings.

Subtract the result of the sample blank test from the result of the emission measurements to correct for any cross-contamination from the welding chamber.

6.4.5.2 Determination of the metal in the fume

If information about the composition of the fume is required, especially with respect to the presence and concentration of hazardous metals, analyse the fume using an appropriate technique.

Refer to ISO 15202-2[3] for sampling dissolution, ISO 15202-3[4] for analysis by inductively coupled plasma – atomic emission spectrometry and ISO 30011[6] or analysis by inductively coupled plasma-mass spectrometry.

6.5 Emission rate of gases

6.5.1 Preparation for sampling

Ensure that the welding chamber is clean before use. Wipe the internal surfaces of the welding chamber with a cloth wetted with a suitable solvent, e.g. acetone, and ensure that all traces of the solvent have dissipated before welding.

Fit the welding chamber with appropriate sampling systems, according to the type of analyses to be performed. Select the specific sorbent tubes or filters to be used (5.3.3 to 5.3.8) using the results of pyrolysis performed on the coating present on the test piece surface using the method specified in ISO 15011-5.

NOTE Examples of gases that can be generated by resistance welding of organic coated materials are:

- volatile organic compounds (VOCs), including 1,3-butadiene, some aldehydes and carbonyl compounds;
- polycyclic aromatic hydrocarbons (PAHs);
- phenols;
- isocyanates.

In all cases, connect the chamber to direct reading apparatus for measuring CO, as CO concentration is monitored throughout sampling to correct the measured concentration of gases for leakage from the welding chamber.

6.5.2 Sampling

Carry out 50 to 100 spot welds and then close the entrance and exit slits in the front and back panels of the welding chamber with their lids. Collect samples of the gases to be measured for 30 min. Measure the concentration of CO during the first 2 min of sampling and then again between 13 min and 15 min and finally between 28 min and 30 min of sampling.

Repeat the test three times, flushing the welding chamber with compressed air between each test.

6.5.3 Blank test

Collect blank samples for each gas by performing a test similar to 6.5.2, but without making welds. Draw air through the sorbent tubes/filters for a time corresponding with the time needed to carry out a series of 100 welding points.

6.5.4 Analysis

Analyse the components according to published recommended analytical methods for the determination of hazardous substances in workplace air.

7 Calculation method

7.1 Emission rate of dust

For each of the three tests carried out, calculate the amount of dust per spot weld, in micrograms, using the following equations.

$$m_{\mathrm{F}} = m_{\mathrm{F1}} - m_{\mathrm{F0}} \frac{\sum m_{\mathrm{ref1}}}{\sum m_{\mathrm{ref0}}}$$

$$m_{\mathrm{B}} = m_{\mathrm{B1}} - m_{\mathrm{B0}} \frac{\sum m_{\mathrm{ref1}}}{\sum m_{\mathrm{ref0}}}$$

$$m_{\mathrm{E}} = m_{\mathrm{F}} - m_{\mathrm{B}}$$

$$m_{\mathrm{SP}} = \frac{m_{\mathrm{E}}}{a_{\mathrm{SP}}} \, 1\,000$$

where

a_{SP} is the number of spot welds;

m_{B} is the mass of dust on the blank filter, expressed in milligrams;

m_{B0} is the mass of blank filter before the test, expressed in milligrams;

m_{B1} is the mass of the blank filter + mass of dust from the blank test, expressed in milligrams;

m_{E} is the mass of dust emitted during welding, expressed in milligrams;

m_F is the mass of dust on the measurement filter, expressed in milligrams;

m_{F0} is the mass of the measurement filter before the test, expressed in milligrams;

m_{F1} is the mass of the measurement filter + mass of dust after the test, expressed in milligrams;

$\sum m_{ref0}$ is the sum of the reference filter masses before the test, expressed in milligrams;

$\sum m_{ref1}$ is the sum of the reference filter masses after the test, expressed in milligrams;

m_{SP} is the amount of dust per spot weld, expressed in micrograms per spot weld.

Calculate and report the average of the three test results.

7.2 Emission rate of gases

For each of the three tests carried out, calculate the concentration of gas per spot weld, in micrograms, using the following equations.

The mass of gaseous compound on the sorbent tube or filter emitted during welding, m, in micrograms, is given by:

$$m = m_g - m_b$$

where

m_b is the mass of gaseous compound on the blank value sorbent tube or filter, in micrograms;

m_g is the mass of gaseous compound on the measurement sorbent tube or filter, in micrograms.

The mass of gaseous compound on the sorbent tube or filter taking the monitored CO concentration into account, m_{recalc}, in micrograms, is then given by:

$$m_{recalc} = m \frac{\varphi_{CO,0}}{\varphi_{CO,av}}$$

where

$\varphi_{CO,av}$ is the average concentration of CO monitored over the entire sampling period, in microlitres per litre (ppm by volume);

$\varphi_{CO,0}$ is the initial concentration of CO monitored in the first 2 min of sampling, in microlitres per litre (ppm by volume).

The concentration of gaseous compound adjusted for the measured CO concentration, ρ_{recalc}, in micrograms per cubic metre, is then given by:

$$\rho_{recalc} = \frac{m_{recalc}}{V_{air}}$$

where V_{air} is the volume of air sampled after welding during 30 min, in litres.

The concentration of gaseous compound per spot weld, ρ_{SP}, in micrograms per cubic metre per spot weld, is then given by:

$$\rho_{SP} = \frac{\rho_{recalc}}{b_{SP}}$$

where b_{SP} is the number of spot welds.

Finally, the mass of the gaseous compound per spot weld, m_{SP}, in micrograms per spot weld, is given by:

$$m_{SP} = \frac{\rho_{SP} V}{1\,000}$$

where V is the volume of the welding chamber in litres.

Calculate and report the average of the three test results.

8 Documentation

The documentation shall contain at least the following information:

a) material:

- all essential information for the identification of the material under test such as identification number, marks of quality, sheet thickness, type of surface and thickness, type identification of the surface or composition of the coating system including associated charge numbers, type and amount of oil or of the surface after treatment, if applicable,
- cleaning methods for the material, if applicable;

b) details of the welding chamber;

c) data on welding equipment and welding parameters:

- type of machine,
- type of current (a.c./d.c.),
- current polarity, if applicable,
- height of r.m.s. current for obtaining the test spot diameter ($4,5\sqrt{t}$),
- control mode (phase control/constant current mode),
- electrode force,
- squeeze time,
- welding time,
- hold time,
- interval time, if applicable;

NOTE Sample documentation of welding parameters is given in Annex C.

d) dust sampling:

— details of the filters,

— consecutive numbering of the filters,

— number of spot welds per filter,

— number of occurrences of surface spatter per filter,

— number of occurrences of weld spatter (having caused rejection of filters), if applicable,

— dust emission per spot weld for each filter,

— mass per spot weld for each element measured, if applicable;

NOTE An example of the sampling test report is given in Annex D.

e) gas sampling — emission per spot weld for each gaseous compound measured.

9 Test report

The test report shall contain at least the following information:

a) a reference to this part of ISO 15011 (ISO/TS 15011-6:2012);

b) the name and address of the product manufacturer or supplier;

c) the type of product and/or the trade name of the product tested;

d) the test results, as documented in Clause 8, to the extent required by the customer.

Annex A
(informative)

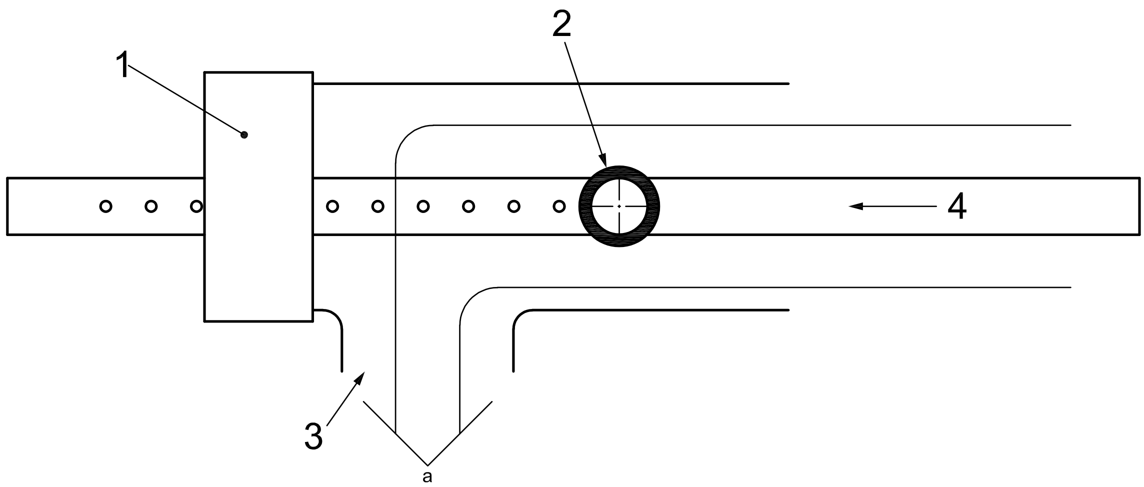
Examples of designs of fume box

A.1 Use a welding chamber as shown in Figures A.1 to A.4. The opening of the tube where the strip is introduced may be closed by a polymer cap as well, to facilitate the guiding of the strip. In that case, the opening in this cap should be significantly bigger, as shown in Figure A.4, to maintain the proper air flow direction.

A.2 The welding chamber is a cylindrical glass tube with an internal diameter of (70 ± 1) mm. During the test, the metal strips to be welded are guided through this tube. The chamber encloses the welding electrodes and has side arms top and bottom with threaded-rubber or PTFE joints which seal against the electrode shanks. On one side of the tube is an opening for connecting the sampler.

A.3 The flow through the welding chamber is such that air enters by the tube end nearest to the electrodes, passes the welding point, and exits through the side opening to the sampler (see Figure A.1).

A.4 The end through which the test strip leaves the tube is closed, to the extent possible, by a cap to reduce air ingress; in its centre, the cap contains a horizontal slot through which the test strip is guided.



Key

1 polymer cap with sealing

2 electrodes

3 opening for attachment of sampler

4 welding direction

a Air flow.

Figure A.1 — Schematic diagram of the welding chamber for determination of fume emission rate

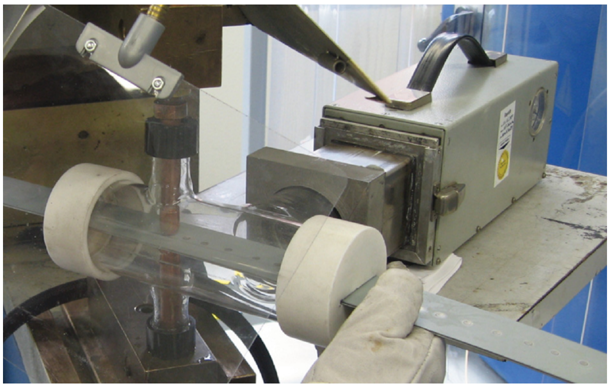
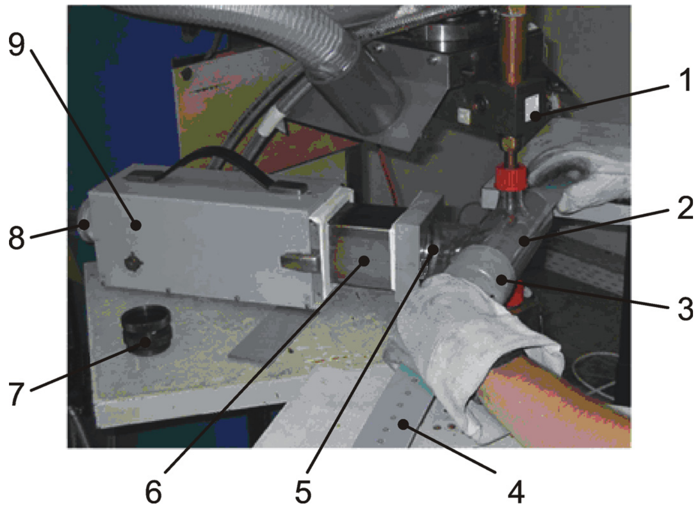


Figure A.2 — Illustration of the welding chamber for determination of fume emission rate using a respirable sampler



Key

1 welding machine
2 welding chamber
3 lead-through of metal sheet
4 metal sheet
5 connecting piece inlet
6 adaptor
7 filter support
8 sampling head with filter support and connection of pump
9 MPG

Figure A.3 — Illustration of a test set-up for determination of fume emission rate using a respirable sampler

Dimensions in millimetres

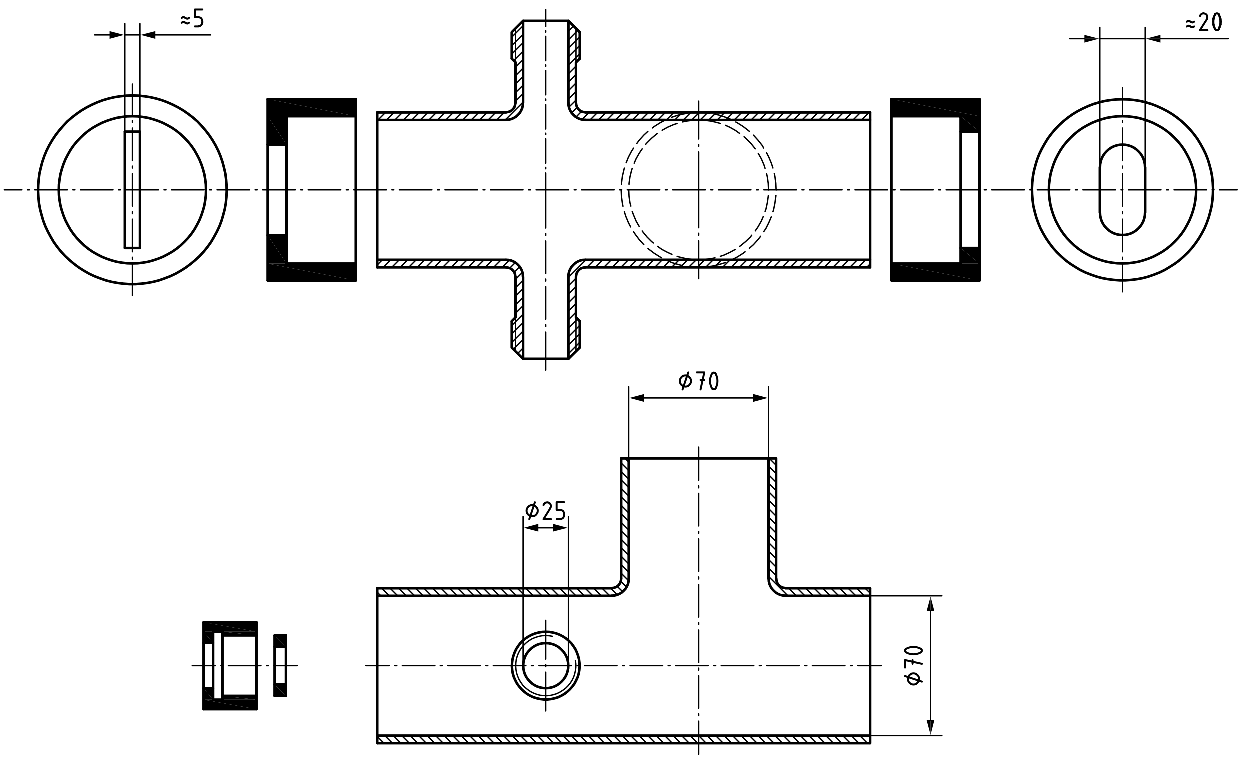


Figure A.4 — Design specification for the welding chamber for determination of fume rate

Annex B
(informative)

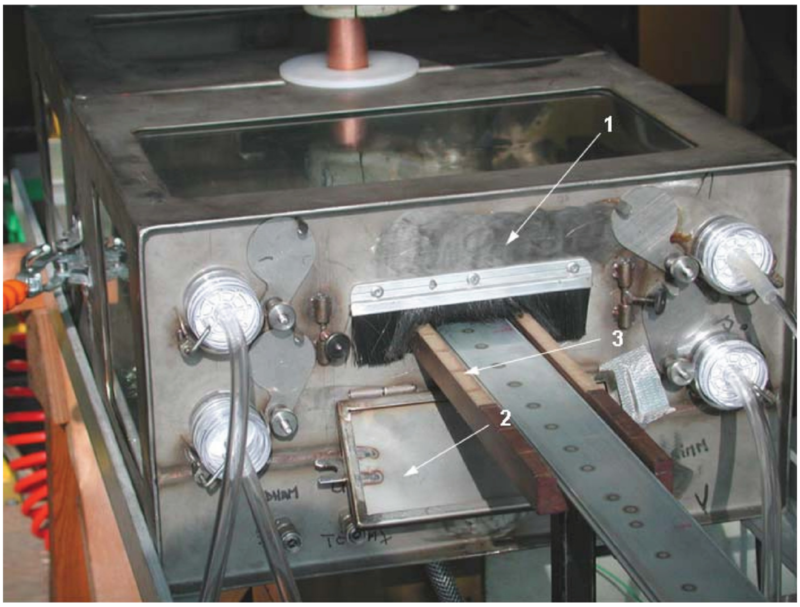
Example of a welding chamber for determination of the emission rate of gases

This annex gives an example of a welding chamber having been used successfully for determination of the emission rate of gases from resistance spot welding. This welding chamber has a width of 230 mm, a length of 400 mm, a depth of 650 mm, a volume of approximately 60 l, and is made of stainless steel with glass (or polycarbonate) windows.

The welding chamber is constructed with slits in the front and the back, through which the test piece is fed [see Figure B.1 b)]. The height and the width of these slits are large enough to enable welding of test pieces of different thicknesses and widths. The test piece, in the form of a strip, is manually moved through the slits on a guide, and for this reason, the maximum feasible length of a test piece is 1,2 m.

The gap between the top and the bottom of the slits and the test piece is minimized during welding by means of brushes [see Figure B.1 b)], both at the front (entrance of the test piece) and the back (exit of the test piece). The entrance and exit slits in the front and back panels of the welding chamber are closed after welding by means of lids attached to the welding chamber. The holes through which the electrodes pass into the welding chamber are sealed in such a way that leakage of emitted gases from the chamber is minimized.

There are four positions at the back of the welding chamber for connection of 37 mm filter cassettes. The diameter of the sampling positions are a little smaller (30 mm) in order to prevent any leakage of gases during and after welding.



Key

1 brush

2 lid (in open position)

3 test piece guide

a) During welding

Key

1 dust filter

2 feeding slit (closed with lid)

3 sampling line

4 electrodes

b) During sampling (after welding)

Figure B.1 — Examples of a welding chamber for gas analysis

Dimensions in millimetres

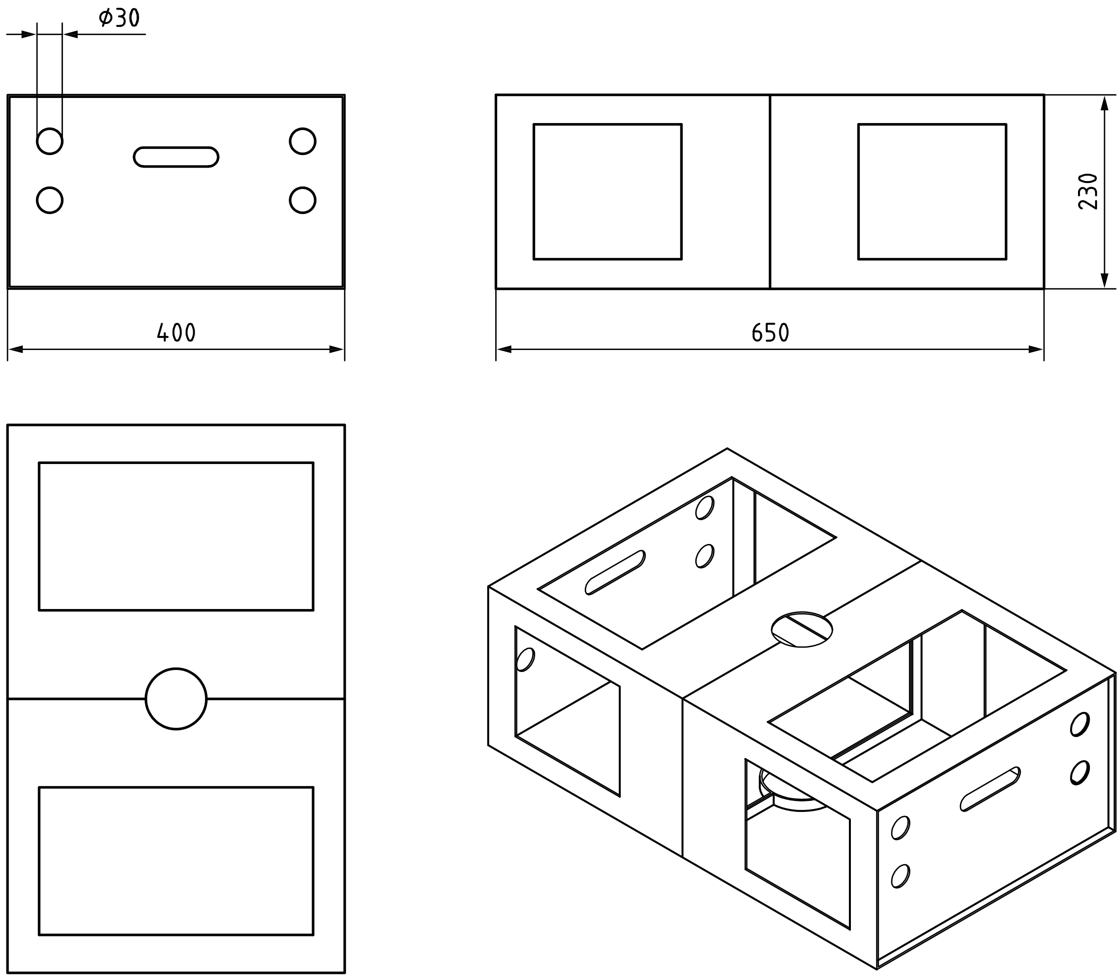


Figure B.2 — Schematic diagram of a welding chamber for determination of emission rate of gases

Annex C
(normative)

Welding parameters

For intermediate thicknesses (thicknesses between the given values in Table C.1), the parameters for the lower thicknesses *x*,*x*0 to *x*,*x*4 and the parameters for higher thicknesses *x*,*x*5 to *x*,*x*9 shall be used.

EXAMPLE From 0,80 mm to 0,84 mm, the parameters for 0,80 mm are used and from 0,85 mm to 0,90 mm the parameters for 0,90 mm are used.

Table C.1 — Welding parameters

Sheet thickness, t mm	Electrode diameter mm F16 × 5,5 F20 × 8,0	Electrode force N R_m < 380 MPa	Electrode force N $R_m \geq$ 380 MPa	Number of pulses	Weld time ms R_m < 380 MPa	Weld time ms $R_m \geq$ 380 MPa	Pause time ms	Hold time ms Uncoated steel sheet	Hold time ms Coated steel sheet
0,5	5,5	170	210	1	100 + X[a]	120 + X[a]	—	120	120
0,6	5,5	190	230	1	120 + X[a]	140 + X[a]	—	120	120
0,7	5,5	210	260	1	140 + X[a]	160 + X[a]	—	120	120
0,8	5,5	230	300	1	160 + X[a]	180 + X[a]	—	120	120
0,9	5,5	250	350	1	180 + X[a]	200 + X[a]	—	120	120
1,0	5,5	270	350	1	200 + X[a]	220 + X[a]	—	120	120
1,2	5,5	300	400	1	240 + X[a]	280 + X[a]	—	200	200
1,5	5,5	400	450	1	300 + X[a]	340 + X[a]	—	250	300
1,8	8	450	500	3	140 + X[a]	160 + X[a]	40	300	300
2,0	8	450	500	4	120 + X[a]	140 + X[a]	40	300	300
2,5	8	500	600	5	120 + X[a]	140 + X[a]	40	400	400
3,0	8	500	650	5	140 + X[a]	160 + X[a]	40	500	500

[a] For X values, see ISO 18278-2:2004, Table 5, coating at the faying surface.

Table C.2 — X value (for Table C.1) depending on coating thickness and number of coated faces at the faying interface

Number of coated faces at the faying interface	1	2
thickness ≤10 µm	X = 20	X = 40
thickness >10 µm	X = 40	X = 80

Annex D
(informative)

Example of test report

Table D.1 — Example of a control and documentation sheet for welding parameters

Parameter	Value	Unit	Remarks
Material		—	Standard designation (similar composition)
Sheet thickness		mm	
Metallic coating		µm	One-sided/double-sided
Organic coating		µm	One-sided/double-sided
Anticorrosive primer		—	Supplier
Location of coating in composition		—	For one-sided coating A: coatings on electrode side B: coatings on composition level C: coatings towards electrode surface (for DCMF + pole at upper surface) D: special case
Sample width for measurement	50	mm	
Spot weld distance	30	mm	
Squeeze time		ms	
Welding time		ms	
Post-weld hold time		ms	
Hold-open time		ms	
Sequence of cycles		spots/ minute	
Electrode force		kN	
Start-up	20	spots	On uncoated steel sheet at welding current for spot diameter $4{,}5\sqrt{t}$
Welding current (I_{eff})		kA	To be selected for test series so that spot diameter occurs without spatter with welding current for spot diameter $4{,}5\sqrt{t}$
Welding unit		—	Manufacturer and designation of type
		—	Type of construction (pedestal, C-tongs, …)
		kVA	Nominal power
		Hz	Kind of current (50 Hz, 1 000 Hz)
		—	Control mode (phase control, constant current mode)
Electrode caps		—	Material (standard designation)
		—	Geometry (standard designation)
		l/min	Inlet, optional
Cooling water temperature		°C	Outlet, optional
Execution of the test			
Place			
Date			
Person responsible	**Name**		**Signature**
Performer			
Welding supervisor			

Table D.2 — Example of a sampling report

Parameter	Value	Unit	Remarks
Test number/test		—	
Material		—	
Coating		—	
Surface condition (e.g. oiled)		—	
Sampling device		—	
Device number		—	
Air volume flow		m^3/h	
External temperature		°C	
Air pressure		hPa	
Filter		—	
Type of filter		—	
Filter No.			
Filter before measurement		mg	
Filter after measurement		mg	
Number of spot welds per filter		—	
Number of occurrences of surface spatter		—	
Occurrence of spatter having caused rejection of filters			
Beginning of sampling		—	
End of sampling		—	
Duration of sampling		min	
Execution of the test			
Place			
Date			
Person responsible	**Name**		**Signature**
Performer			

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