



International
Standard

ISO 11890-1

**Paints and varnishes —
Determination of volatile organic
compounds (VOC) and/or semi
volatile organic compounds (SVOC)
content —**

**Part 1:
Gravimetric method for VOC
determination**

*Peintures et vernis — Détermination de la teneur en composés
organiques volatils (COV) et/ou composés organiques semi-
volatils (COSV) —*

Partie 1: Méthode gravimétrique pour la détermination des COV

**Third edition
2024-05**

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

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

This document was prepared by Technical Committee ISO/TC 35, *Paints and varnishes*, Subcommittee SC 16, *Chemical analysis*.

This third edition cancels and replaces the second edition (ISO 11890-1:2007), which has been technically revised.

The main changes are as follows:

- In the scope, for coating materials identified as case 1, the expected VOC content that can be determined by this document has been lowered from greater than 15 % to greater than 5 %, and matrices that were not previously covered by this document have been added;
- the scope has been expanded to include multi-pack coating materials, described as case 2 and radiation curable coating materials, described as case 3;
- the test method of non-volatile-matter content for multi-pack coating materials and radiation curable coating materials has been added;

A list of all parts in the ISO 11890 series can be found on the website.

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

Introduction

Due to the revision of ISO 11890-2, a revision of ISO 17895 and this document became necessary in order to avoid overlapping scopes. Additionally, ISO/TR 5601 was published as an informative document to help users selecting the appropriate analytical method for their analytical problem.

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Paints and varnishes — Determination of volatile organic compounds (VOC) and/or semi volatile organic compounds (SVOC) content —

Part 1: Gravimetric method for VOC determination

WARNING — The use of this document can involve hazardous materials, operations and equipment. This document does not purport to address all of the safety problems associated with its use. It is the responsibility of users of this document to take appropriate measures to ensure the safety and health of personnel prior to the application of the document, and to determine the applicability of any other restrictions for this purpose.

1 Scope

This document is part of the ISO 11890 series, dealing with the sampling and testing of coating materials and their raw materials.

This document is applicable to the determination of volatile organic compound (VOC) content in the following cases:

- case 1: where there are single-pack coating materials other than case 3, and the expected VOC content is greater than a mass fraction of 5 %, including single-pack coating materials cure not through chemical reactions and single-pack coating materials which cannot be measured by ISO 11890-2 due to chemical cure reactions or gas chromatography temperatures leading to formation of new compounds that would not appear under normal cure conditions and impacts VOC/SVOC calculation.;
- case 2: where there are multi-pack coating materials other than case 3 and the expected VOC content is greater than a mass fraction of 1 %;
- case 3: where there are radiation curable coating materials, and the expected VOC content is greater than a mass fraction of 5 %. Radiation curable coating materials in this document include coating materials that are cured by UV, electron beam, and other radiation methods.

If the system of the first case contains SVOC, but do not cure through chemical reactions, the VOC result can be influenced by SVOC, see [Annex C](#). In this case, ISO 11890-2 is preferred. ISO 11890-1 cannot be used for the determination of the SVOC content. In water-borne coating materials, that do not cure through chemical reactions, if the water content is much greater than VOC content and VOC content is less than a mass fraction of 10 %, ISO 11890-2 is preferred.

For all three cases, the main purpose measured is VOC. However, clarify that this VOC content can also contain SVOC. The real VOC content can be lower than the VOC content measured by ISO 11890-1.

The method specified in this document assumes that the volatile matter is either water or organic. However, it is possible that other volatile inorganic compounds are present which can require another suitable method for quantification, which is thus allowed for in the calculations. The method defined in this document is not applicable for determination of water content.

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 760, *Determination of water — Karl Fischer method (General method)*

ISO 1513, *Paints and varnishes — Examination and preparation of test samples*

ISO 2811-1, *Paints and varnishes — Determination of density — Part 1: Pycnometer method*

ISO 2811-2, *Paints and varnishes — Determination of density — Part 2: Immersed body (plummet) method*

ISO 2811-3, *Paints and varnishes — Determination of density — Part 3: Oscillation method*

ISO 2811-4, *Paints and varnishes — Determination of density — Part 4: Pressure cup method*

ISO 3251, *Paints, varnishes and plastics — Determination of non-volatile-matter content*

ISO 11890-2, *Paints and varnishes — Determination of volatile organic compounds (VOC) and/or semi volatile organic compounds (SVOC) content — Part 2: Gas-chromatographic method*

ISO 15528, *Paints, varnishes and raw materials for paints and varnishes — Sampling*

ISO 23168, *Paints and varnishes — Determination of water content — Gas-chromatographic method*

3 Terms and definitions

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

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

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1

volatile organic compound

VOC

organic liquid and/or solid that evaporates spontaneously at the prevailing temperature and pressure of the atmosphere with which it is in contact

Note 1 to entry: As to current usage of the term VOC in the field of coating materials, see *volatile organic compound content VOC content* (3.3).

Note 2 to entry: Under US government legislation, the term VOC is restricted solely to those compounds that are photochemically active in the atmosphere (see ASTM D3960). Any other compound is then defined as being an exempt compound.

Note 3 to entry: If the term VOC refers to compounds with a defined maximum boiling point, the compounds considered to be part of the VOC content are those with boiling points below and including that limit, and compounds with higher boiling points are considered to be semi-volatile or non-volatile organic compounds.

[SOURCE: ISO 4618:2023, 2.266]

3.2

semi-volatile organic compound

SVOC

organic liquid and/or solid that evaporates spontaneously but slower in comparison to VOC at the prevailing temperature and pressure of the atmosphere with which it is in contact

Note 1 to entry: As to current usage of the term SVOC in the field of coating materials, see *semi-volatile organic compounds content SVOC content* (3.4).

[SOURCE: ISO 4618:2023, 3.227]

3.3

volatile organic compound content

VOC content

VOCC

mass of the *volatile organic compound* (3.1) present in a coating material, as determined under specified conditions

Note 1 to entry: The properties and the amounts of compounds to be taken into account depend on the field of application of the coating material. For each field of application, the limiting values and the methods of determination or calculation are stipulated by regulations or by agreement.

[SOURCE: ISO 4618:2023, 3.267]

3.4

semi-volatile organic compounds content

SVOC content

SVOCC

mass of the *semi-volatile organic compounds* (3.2) present in a coating material, as determined under specified conditions

Note 1 to entry: The properties and the amounts of the compounds to be taken into account will depend on the field of application of the coating material. For each field of application, the limiting values and the methods of determination or calculation are stipulated by regulations or by agreement.

Note 2 to entry: If the term SVOC refers to compounds with a defined maximum boiling point and minimum boiling point, the compounds considered to be part of the SVOC content are those with boiling points below and including the upper and above the lower limit, and compounds with higher boiling points are considered to be non-volatile organic compounds.

Note 3 to entry: If the term VOC refers to compounds with a defined maximum boiling point, the compounds considered to be part of the VOC content are those with boiling points below and including that limit, and compounds with higher boiling points are considered to be semi-volatile or non-volatile organic compounds.

[SOURCE: ISO 4618:2023, 3.228]

3.5

non-volatile organic compound

NVOC

organic liquid and/or solid not classified as *volatile organic compound* (3.1) or *semi-volatile organic compound* (3.2)

[SOURCE: ISO 11890-2:2020, 3.3]

3.6

radiation curable coating material

coating material that is cured by radiation, such as ultra-violet radiation or electron beam

3.7

multi-pack coating

coating material that is supplied in two or more separate components which have to be mixed before use in the proportions specified by the manufacturer

[SOURCE: ISO 4618:2023, 3.159]

3.8

non-volatile matter

NV

residue by mass obtained by evaporation under specified conditions

[SOURCE: ISO 4618:2023, 3.175]

3.9

UV curing

hardening of *coating materials* by exposure to ultra-violet radiation

3.10

exempt compound

organic compound that does not participate in atmospheric photochemical reactions

Note 1 to entry: This expression is only relevant in some countries.

[SOURCE: ISO 11890-2:2020, 3.6]

3.11

ready for use

state of a product when it is mixed in accordance with the manufacturer's instructions in the correct proportions and thinned if required using the correct thinners so that it is ready for application by the approved method

[SOURCE: ISO 11890-2:2020, 3.7]

4 Principle

After preparation of the sample, the non-volatile matter is determined by an appropriate method according to the type of sample. The water content is determined using a titration technique employing a Karl Fischer reagent according to ISO 760 or a gas-chromatographic method according to ISO 23168. If necessary, determine the density of the sample using a suitable method in accordance with the type of sample. The contents of exempt compounds, if applicable, are then determined using the method specified in ISO 11890-2. The VOC content of the sample is then calculated.

5 Required information

For any particular application, the information required should preferably be agreed between the interested parties and may be derived, in part or totally, from an international or national standard or other document related to the product under test. Other items of supplementary information are given in [Annex A](#).

The required information can include the following points:

- a) the organic compound(s) to be determined (if known);
- b) the analytical method(s) to be used to identify these compounds;
- c) the organic compounds in a) which are exempt compounds (see [7.2.5](#));
- d) the method of calculation to be used (see [Clause 8](#)).

6 Apparatus

- 6.1 **Flat-bottomed dish**, as specified in ISO 3251.
- 6.2 **Air oven**, as specified in ISO 3251.
- 6.3 **Analytical balance**, capable of weighing to an accuracy of 0,000 1 g.
- 6.4 **Desiccator**, as specified in ISO 3251.
- 6.5 **Radiation curing equipment**.

Laboratory equipment that can simulate the curing process during the industrial application stage of the radiation curable coating materials.

7 Procedure

7.1 Sampling

Prepare the sample as specified in ISO 1513 for testing in the “ready for use” state.

Take a representative sample of the product to be tested (or of each product in the case of a multi-pack coating), as specified in ISO 15528 and prepare each sample for testing. Carry out the tests in triplicate for radiation curable coating materials and for multi-pack coating materials and in duplicate for all other applications.

7.2 Analysis

7.2.1 General

Determine the parameters required by the calculation (see [8.2](#) to [8.5](#)) as specified in [7.2.2](#) to [7.2.5](#). Some may be determined by difference, depending on the compounds present in the sample.

7.2.2 Density

If required by the calculation (see [8.3](#) to [8.5](#)), determine the density of the sample using the appropriate method specified in ISO 2811-1, ISO 2811-2, ISO 2811-3 or ISO 2811-4, in order to give the best precision for the type of the sample concerned. Determine the density at 23 °C.

7.2.3 Non-volatile-matter content

The non-volatile-matter content is determined according to [Annex B](#).

NOTE The value of non-volatile-matter content determined by this document can be different from that determined by ISO 3251. The methods listed in [Annex B](#) are only intended to be used for the calculation (see [8.2](#) to [8.5](#)) of VOC content in related products.

7.2.4 Water content

Determine the water content, as a percentage by mass, by the method given in ISO 760 or ISO 23168.

NOTE If the product to be tested is well characterized and known not to contain water, it is not necessary to determine the water content, and the water content can be assumed to be zero.

7.2.5 Exempt compounds

If the organic compounds contained in the sample are not known, then determine them qualitatively, e.g. by the method specified in ISO 11890-2.

Determine the contents of the exempt compounds contained in the sample using the method specified in ISO 11890-2.

Determine the densities of the exempt compounds by the method given in [7.2.2](#), or by referring to published reference data.

NOTE This method is not applicable to components that are both reactive ingredients and exempt compounds.

8 Calculation

8.1 General

Calculate the VOC content by the method specified in the referring specification. If no particular method is specified, calculate the VOC content by method 1.

Method 1 is the preferred calculation method because it is the most precise. It does not involve the determination of density, which can introduce additional errors.

8.2 Method 1: VOC content, as a mass fraction in percentage of the product “ready for use”

Apply [Formula \(1\)](#) to calculate VOC_{M1} content:

$$VOC_{M1} = 100 - NV - f_w \quad (1)$$

where

VOC_{M1} is the VOC content, expressed as a mass fraction in percentage, of the product “ready for use”;

NV is the non-volatile-matter content, expressed as a mass fraction in percentage (see [7.2.3](#));

f_w is the mass fraction of water in percent of the test sample (see [7.2.4](#)).

8.3 Method 2: VOC content, in grams per litre, of the product “ready for use”

Apply [Formula \(2\)](#) to calculate VOC_{M2} content:

$$VOC_{M2} = (100 - NV - f_w) \times \rho_s \times 10 \quad (2)$$

where

VOC_{M2} is the VOC content, expressed in grams per litre, of the product “ready for use”;

NV is the non-volatile-matter content, expressed as a mass fraction in percentage (see [7.2.3](#));

f_w is the mass fraction of water in percent of the test sample (see [7.2.4](#));

ρ_s is the density, expressed in grams per millilitre, of the test sample at 23 °C (see [7.2.2](#));

8.4 Method 3: VOC content, in grams per litre, of the product “ready for use” less water

Apply [Formula \(3\)](#) to calculate $VOC_{M3,lw}$ content.

$$VOC_{M3,lw} = \left(\frac{100 - NV - f_w}{100 - \rho_s \times \frac{f_w}{\rho_w}} \right) \times \rho_s \times 1\,000 \quad (3)$$

where

- $VOC_{M3,lw}$ is the VOC content, expressed in grams per litre, of the product “ready for use” less water;
- NV is the non-volatile-matter content, expressed as a mass fraction in percentage (see [7.2.3](#));
- f_w is the mass fraction of water in percent of the test sample (see [7.2.4](#));
- ρ_s is the density, expressed in grams per millilitre, of the test sample at 23 °C (see [7.2.2](#));
- ρ_w is the density, expressed in grams per millilitre, of water at 23 °C (= 0,997 537 g/ ml)
- 1 000 is a conversion factor to convert grams per millilitre to grams per litre.

8.5 Method 4: VOC content, in grams per litre, of the product “ready for use” less water and less exempt compounds

Apply [Formula \(4\)](#) to calculate $VOC_{M4,lwe}$ contents.

$$VOC_{M4,lwe} = \left[\frac{100 - NV - f_w - \sum_{eci=1}^{eci=n} f_{eci}}{100 - \rho_s \times \left(\frac{f_w}{\rho_w} + \sum_{eci=1}^{eci=n} \frac{f_{eci}}{\rho_{eci}} \right)} \right] \times \rho_s \times 1\,000 \quad (4)$$

where

- $VOC_{M4,lwe}$ is the VOC content, expressed in grams per litre, of the product “ready for use” less water and less exempt compounds;
- NV is the non-volatile-matter content, expressed as a mass fraction in percentage (see [7.2.3](#));
- f_w is the mass fraction of water in percent of the test sample (see [7.2.4](#));
- f_{eci} is the mass fraction of exempt compound i in percent of the test sample (see [7.2.5](#));
- ρ_s is the density, expressed in grams per millilitre, of the test sample at 23 °C (see [7.2.2](#));
- ρ_w is the density, expressed in grams per millilitre, of water at 23 °C (= 0,997 537 g/ml);
- ρ_{eci} is the density, expressed in grams per millilitre, of exempt compound i (see [7.2.5](#));
- 1 000 is a conversion factor to convert grams per millilitre to grams per litre.

9 Results

If the results (duplicates or triplicates) differ by more than the maximum value indicated in [10.2](#), repeat the procedure.

Calculate the mean of two (duplicates) or three (triplicates) valid results. For values greater than 1 % (mass fraction), report to the nearest 0,1 %. For values less than or equal to 1 % (mass fraction) and greater than

or equal to 0,1 % (mass fraction), report the result to the nearest 0,01 %. For values less than 0,1 % (mass fraction), report to the nearest 0,001 % (mass fraction).

10 Precision

10.1 General

The precision of the test method was determined by interlaboratory testing in accordance with ISO 5725-1 and ISO 5725-2.

Six different coating materials were tested by five to seven laboratories. Their VOC content was tested for a better comparison with the precision of ISO 11890-2.

10.2 Repeatability limit, r

The repeatability limit, r , is the value below which the absolute difference between two single test results, each the mean of duplicates, obtained on identical material by one operator in one laboratory within a short interval of time using the standardized test method, can be expected to lay. See [Annex D](#).

For materials of case 1:

The repeatability of water borne paint for five repeated determinations made using this test method, expressed as the repeatability coefficient of variation $C_{V,r}$ is 7 %.

The repeatability of cathodic electro-deposition paint for five repeated determinations made using this test method, expressed as the repeatability coefficient of variation $C_{V,r}$ is 13 %.

For materials of case 2:

The repeatability of solvent borne multi-pack epoxy coating for three repeated determinations made using this test method, expressed as the repeatability coefficient of variation $C_{V,r}$ is 5 %.

The repeatability of water borne multi-pack epoxy coating for three repeated determinations made using this test method, expressed as the repeatability coefficient of variation $C_{V,r}$ is 38 %.

The repeatability of solvent-free multi-pack epoxy lacquer for three repeated determinations made using this test method, expressed as the repeatability coefficient of variation $C_{V,r}$ is 8 %.

The repeatability of two-component varnish for five repeated determinations made using this test method, expressed as the repeatability coefficient of variation $C_{V,r}$ is 2 %.

10.3 Reproducibility limit, R

The reproducibility limit, R , is the value below which the absolute difference between two test results, each the mean of duplicates, obtained on identical material by operators in different laboratories using the standardized test method, can be expected to lay. See [Annex D](#).

For materials of case 1:

The reproducibility of cathodic electro-deposition paint for five repeated determinations made using this test method, expressed as the reproducibility coefficient of variation $C_{V,r}$ is 23 %.

For materials of case 2:

The reproducibility of solvent borne multi-pack epoxy coating for three repeated determinations made using this test method, expressed as the reproducibility coefficient of variation $C_{V,r}$ is 13 %.

The reproducibility of water borne multi-pack epoxy coating for three repeated determinations made using this test method, expressed as the reproducibility coefficient of variation $C_{V,r}$ is 38 %.

The reproducibility of solvent-free multi-pack epoxy lacquer for three repeated determinations made using this test method, expressed as the reproducibility coefficient of variation $C_{V,r}$ is 37 %.

The reproducibility of two-component varnish for five repeated determinations made using this test method, expressed as the reproducibility coefficient of variation $C_{V,r}$ is 5 %.

11 Test report

The test report shall contain at least the following information:

- a) a reference to this document, i.e. ISO 11890-1:2024;
- b) all details necessary for complete identification of the product tested (manufacturer, trade name, batch number, etc.);
- c) any requirements specified by the customer, if relevant;
- d) the method used (if the standard includes several);
- e) the product type tested;
- f) the items of supplementary information referred to in [Annex A](#) for radiation curable coating materials;
- g) a reference to the international or national standard, product specification or other document supplying the information referred to in c) above;
- h) the results of the test, as indicated in [Clause 9](#), and the method of calculation used ([8.2](#), [8.3](#), [8.4](#), [8.5](#));
- i) any deviation from the test method specified;
- j) any unusual features (anomalies) observed during the test;
- k) the date of the test.

Annex A
(normative)

Items for supplementary information for radiation curable coating materials

The items of supplementary information listed in this annex shall be supplied as appropriate for coating materials containing reactive volatile ingredients such as radiation curable coating materials, to enable the method to be carried out. This annex is not valid for other coating material types.

The information required should be agreed between the interested parties and may be derived, in part or totally, from an international or national standard or other document related to the product under test.

For radiation curable coating materials, the following information shall be included:

- a) the mass of the test portion;
- b) whether the first heating step is performed;
- c) the test temperature of the second heating;
- d) the period of heating of the second heating;
- e) the curing conditions used.

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Annex B (informative)

Non-volatile-matter content

B.1 For single-pack coating materials other than B.3

Weigh test portions of the appropriate size into dishes specified in ISO 3251, corresponding to a sample loading of $(0,02 \pm 0,003) \text{ g/cm}^2$.

NOTE This normally corresponds to 0,5 to 2 g in dish areas ranging from 25 to 100 cm². Level the sample evenly on the dish area.

Cure the coating materials according to the conditions given by manufacturer. If the manufacturer doesn't specify a certain curing condition, allow the test portions to stand in the dishes for 24 h at $(23 \pm 2) ^\circ\text{C}$ and atmospheric pressure. For single-pack coatings that only have physical drying, the drying time in the dishes can be shortened to 1 h. Then place the dishes in the oven, previously brought to $(80 \pm 2) ^\circ\text{C}$ or agreed higher temperature (Curing temperature is preferred, if it is higher than $(80 \pm 2) ^\circ\text{C}$), for an hour $(60 \pm 5) \text{ min}$ or agreed longer time and proceed in accordance with ISO 3251.

B.2 For multi-pack coating materials

For multi-pack products, thoroughly mix the components in accordance with the manufacturer's instructions. Immediately weigh "ready for use" test portions into dishes.

Weigh test portions of the appropriate size into dishes specified in ISO 3251, corresponding to a sample loading of $(0,02 \pm 0,003) \text{ g/cm}^2$. This normally corresponds to 0,5 to 2 g in dish areas ranging from 25 to 100 cm². Level the sample evenly on the dish area. In precision tests, less than 0,3 g increased the standard deviation.

Cure the coating materials according to the conditions given by manufacturer. If the manufacturer does not specify a certain curing condition, allow the test portions to stand in the dishes for 24 h at $(23 \pm 2) ^\circ\text{C}$ and atmospheric pressure. Then place the dishes in the oven, previously brought to $(80 \pm 2) ^\circ\text{C}$ or an agreed higher temperature [curing temperature is preferred if it is higher than $(80 \pm 2) ^\circ\text{C}$]. Leave the dishes in the oven for an hour $(60 \pm 5) \text{ min}$ or agreed longer period and proceed in accordance with ISO 3251.

If any unusual decomposition or degradation occurs during heating, periods of time and/or temperatures different from those given in ISO 3251 may be used, subject to agreement between the interested parties.

B.3 For radiation curable coating materials

Except for the weighing amount of $(0,2 \pm 0,1) \text{ g}$, the weighing of "ready for use" test portion is carried out according to ISO 3251.

After weighing and adding the solvent, immediately transfer the dish to the oven, previously brought to $(50 \pm 2) ^\circ\text{C}$. Leave the dish in the oven for 30 min. If the content of inert volatiles in the sample is known to be less than 3 %, this step can be omitted and the radiation curing can be directly performed. If it is known that the sample contains a highly volatile reactive diluent (such as styrene, isobornylacrylate, etc.) at $50 ^\circ\text{C}$, this step is not performed regardless of the volatile content and the radiation curing can be directly performed.

NOTE This step is used to simulate the process of removing inert solvents in the industrial application stage. If the sample contains a large amount of inert solvent and is directly cured by radiation, the test result will deviate greatly from the true value.