
**Determination of total sulfur in
fertilizers by high temperature
combustion**

*Dosage du soufre total dans les engrais par combustion à haute
température*

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Foreword

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

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

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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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 134, *Fertilizers, soil conditioners and beneficial substances*.

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

This document was created out of a need for newer and faster laboratory techniques to determine the total sulfur in fertilizer materials. There are numerous documented and validated methods available for determining total sulfur, but they are time-consuming and, in some cases, require the use of hazardous chemicals (e.g. bromine, perchloric acid). These methods also rely on the competency of the chemist/analyst and the laboratory technique is a critical component for producing accurate and reproducible results.

Combustion as an analytical tool has made great strides in recent years and, in some laboratories, this is a commonly used technique. Various detectors have been coupled to a furnace (combustion chamber) and the ensuing gases are measured for the analyte in question.

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Determination of total sulfur in fertilizers by high temperature combustion

1 Scope

This document specifies a method to measure the total sulfur content in fertilizer and soil conditioner materials.

This method is applicable for measuring total sulfur concentration in solid and liquid fertilizers and its raw inputs in the range of 0,1 % to 97 %.

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 8157, *Fertilizers and soil conditioners — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 8157 apply.

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

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

4 Principle

This procedure involves conversion of sulfur (S) species from fertilizers and chemical standards into SO₂ through combustion at a temperature > 1 100 °C followed by measurement with thermal conductivity detection (TCD) or infrared (IR) detection reported as mass fraction percentage (w/w %). In the case of thermal conductivity detection and where simultaneous measurements of additional elements, such as carbon (C), hydrogen (H), or nitrogen (N), are performed, an intermediate SO₂ separation by thermal adsorption/desorption is necessary.

5 Apparatus, material and reagents

5.1 General

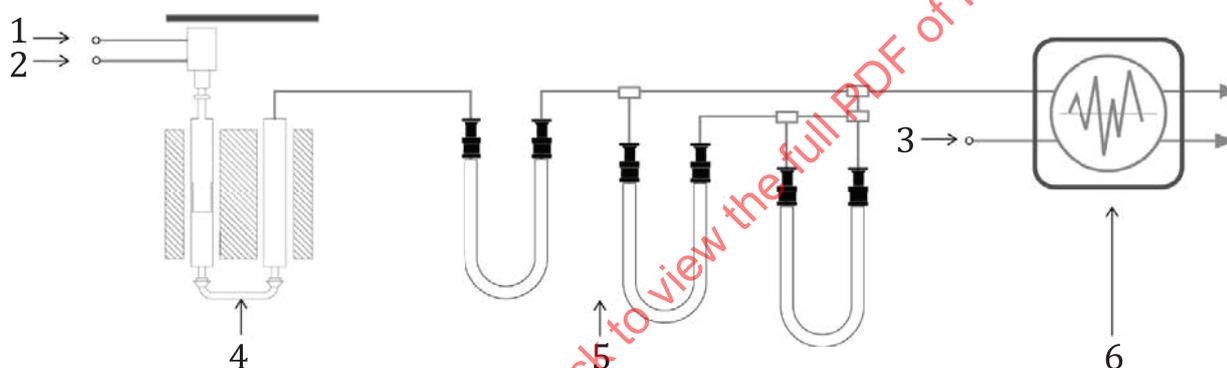
CAUTION — Incorrect handling during the elemental analysis using combustion can lead to the risk of burns as certain instrument components are heated during the method. Even after switching off the instrument, some components stay hot for long periods of time. Serious burns can occur if working carelessly with the instrument. Follow the manufacturer's specific operating instructions to ensure safe handling of equipment.

Total sulfur measurements can be performed via variable apparatus types depending on detection method of choice.

5.2 Apparatus

5.2.1 Apparatus A: Combustion followed by thermal conductivity detection

For Apparatus A type instruments, shown in [Figure 1](#), sulfur as SO_2 is determined by TCD with helium or argon carrier gas allowing for multi-element analysis. With this setup, the test portion should be introduced into the combustion zone in a way such that atmospheric contamination is removed. Oxygen is added over the test portion at a temperature $> 1\ 100\ ^\circ\text{C}$ converting all elements to their fully oxidized gaseous specie. A catalyst, such as tungsten (VI) oxide (WO_3), inside the combustion tube is used to aid oxidation. Following combustion, gases pass through a reducing environment and halogen scrubber in order that NO_x species be converted to N_2 and removal of halogen contaminants, respectively. Other resulting combustion gas components CO_2 , H_2O , and SO_2 are scrubbed or adsorbed on analyte-specific thermal adsorption/desorption columns. N_2 is not adsorbed and flows directly to the thermal conductivity detector. Each CO_2 , H_2O , and SO_2 are desorbed sequentially following the previous elements complete measurement by the TCD allowing for clear separation of the analyte species. Scrubbing materials, such as chemical or physical absorbers, may be placed between the furnace and detector to remove CO_2 and/or H_2O if determination of either C and/or H is undesired. With the help of a calibration curve, software processing converts the SO_2 peak signal into a mass fraction percentage of S in the sample.



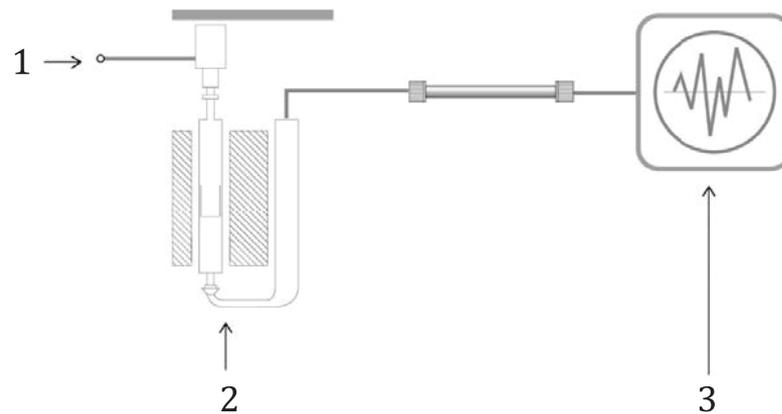
Key

- 1 He/Ar carrier gas
- 2 oxygen inlet
- 3 He/Ar reference gas
- 4 combustion and reduction
- 5 gas separation
- 6 detection (TCD)

Figure 1 — Typical multi-element measuring combustion system using adsorption/desorption separations and TCD

5.2.2 Apparatus B: Combustion followed by single-range infrared detection

For Apparatus B type instruments, shown in [Figure 2](#), sulfur as SO_2 is determined by a sulfur-specific IR detector with oxygen carrier gas. The test portion is introduced into the combustion zone where oxygen in combination with a temperature $> 1\ 100\ ^\circ\text{C}$ converts S to SO_2 . A catalyst, such as tungsten (VI) oxide (WO_3), inside the combustion tube is used to aid oxidation. The gas stream is dried before entering the detector. With the help of a calibration curve, software processing converts the SO_2 peak signal into a w/w percentage of S in the sample. For best results using this apparatus type, follow special instructions in [Clause 6](#).



Key

- 1 oxygen carrier gas
- 2 combustion
- 3 detection (IR)

Figure 2 — Typical sulfur only measuring combustion analyser using SO₂-specific IR detection

5.3 Materials, reagents and consumables

5.3.1 Materials

- a) Analytical balance, resolution to at least 0,1 mg;
- b) Test portions containers, typically tin foil or ceramic crucible;
- c) Hand pellet press, for pelletizing powder materials;
- d) Capsule sealing press, for making a gas-tight cold seal on tin capsule holding liquid materials.

5.3.2 Reagents

5.3.2.1 Helium or argon, minimum 99,995 % purity.

5.3.2.2 Oxygen, minimum 99,5 % purity.

5.3.2.3 Tungsten (VI) oxide (WO₃) granulate, grain size approximately 0,5 mm to 2 mm, minimum 99,7 % purity — supplied by the instrument manufacturer.

5.3.2.4 Tungsten (VI) oxide (WO₃) powder as sample additive, minimum 99,7 % purity — supplied by the instrument manufacturer.

5.3.2.5 Copper wires, approximately 0,5 mm length — supplied by the instrument manufacturer.

5.3.2.6 Copper oxide wires, approximately 0,5 mm length — supplied by the instrument manufacturer.

5.3.2.7 Pt catalyst, 5 % on Al₂O₃, pelletized — supplied by the instrument manufacturer.

5.3.2.8 Corundum balls (inert), 3 mm to 5 mm diameter — supplied by the instrument manufacturer.

5.3.2.9 Quartz wool (inert), fibre thickness of approximately 9 µm — supplied by the instrument manufacturer.

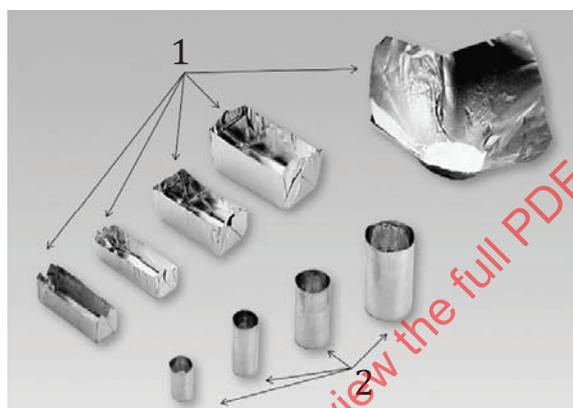
5.3.2.10 Silver wool, wire thickness of approximately 0,04 mm — supplied by the instrument manufacturer.

5.3.2.11 Desiccant, for example phosphorus pentoxide — supplied by the instrument manufacturer.

5.3.3 Consumables

See [Figure 3](#).

- a) Tin foil.
- b) Tin capsules.



Key

- 1 tin foils
- 2 tin capsules

Figure 3 — Selection of tin foils and tin capsules used for sampling

6 Calibration curve and daily factor

Check calibration on the instrument, ([5.2.1](#), [5.2.2](#)), daily and perform as needed according to the manufacturer's recommendation. It is recommended that a non-hygroscopic pure chemical standard or set of standards be used for calibrating the instrument, such as sulfanilamide ($\geq 99\%$), ammonium or sodium sulfate ($\geq 99\%$), or sublimed sulfur ($\geq 99\%$). Use a minimum of five calibration points to generate the calibration curve and cover the absolute sulfur range encompassing that of the expected S concentration of unknowns. For apparatus A and B type instruments ([5.2.1](#), [5.2.2](#)), a single higher order calibration is sufficient. Any drift in the calibration curve can be observed and corrected for by daily use of an alternative non-hygroscopic pure chemical standard of known S concentration. Follow manufacturer's instructions for setting up and calculating drift corrections. If the drift correction or daily factor exceeds 0,9 or 1,1, perform the necessary maintenance and ensure reagents in the combustion or reduction tubes are not depleted.

7 Preparation of test samples (analytical samples)

7.1 Liquid fertilizers

Accurately weigh test portions containing a sulfur amount within the calibration range (typically 20 mg to 100 mg) into a tared tin capsule or ceramic crucible already containing tungsten (VI) oxide powder

to be used as combustion aid. For tin capsules, cold weld with a capsule sealing press, and accurately weigh the test portion to at least the nearest 0,1 mg. Do not include the WO_3 powder in the final mass. Insert mass into the operating software. Optionally, the test portion can be weighed into a tin foil containing WO_3 . The WO_3 powder will absorb the liquid fertilizer sample and the foil can be pelletized to be run as a solid. If the WO_3 powder does not absorb the liquid sufficiently, it can be dried at 60 °C for 2 h before the foil can be pelletized to be run as a solid.

7.2 Solid fertilizers

Prepare an analytical sample of sufficiently small particle size to ensure sufficient representation at the expected test portion mass. Accurately weigh test portions containing a sulfur amount within the calibration range (typically 20 mg to 100 mg) into a tared tin foil cup or ceramic crucible, to at least the nearest 0,1 mg. Additionally, add WO_3 powder creating an approximate 10:1 ratio of combustion aid to test portion. If using tin foil, pelletize the foil cup using an appropriate pressing device.

8 Determination

- a) Ensure that the instrument is powered on, leak free and the parameters are set according to the manufacturer's instructions. This includes furnace temperatures, flows and pressures.
- b) Ensure that reagents are not spent and still of functional use. For apparatus A type instruments, this includes [5.3.2.1](#), [5.3.2.2](#), [5.3.2.3](#), [5.3.2.5](#), [5.3.2.6](#), [5.3.2.7](#), [5.3.2.10](#) and [5.3.2.11](#). For apparatus B type instruments, this includes [5.3.2.2](#), [5.3.2.3](#) and [5.3.2.11](#). Run blanks and check the calibration according to [Clause 6](#). Use the daily factor or recalibrate if necessary.
- c) Prepare and weigh the test portion according to [Clause 7](#).
- d) Load the test portions onto the instrument and run the apparatus according to manufacturer's instructions.
- e) Samples yielding results outside of the calibrated range should be reanalysed with an adjusted sample mass according to [Clause 7](#).

9 Calculations and quality control

9.1 Calculations

Element concentration (content, mass fraction %) is given by the instrument software. Absolute element content can be computed according to the following formula if needed:

$$A = \frac{m \times C}{100}$$

where

A is the absolute element content, in mg;

m is the sample mass, in mg;

C is the element concentration, in %.

To determine an appropriate sample size for analysis (m), use the same formula as mentioned above. For A , use the target absolute element content in mg and for C , use the element concentration in %. If the element concentration is not known, then use an estimated concentration and a target mass in the middle of the calibrated range.

9.2 Quality control

- a) Perform blank determination before daily operation and any time a reagent or carrier gas tank is replaced.
- b) Perform drift correction using a suitable standard before each day's analyses.
- c) Include at least one reference material with each batch of 30 test portions. Results should be within limits specified for reference material.
- d) Perform two to three replicates of each sample. Replicate results of samples with sulfur concentrations $\leq 25\%$ and $> 25\%$ should have a standard deviation of less than 0,8 and 1,6, respectively.

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