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Steel and iron — Determination of cobalt content — Flame atomic absorption spectrometric method

*Aciers et fontes — Dosage du cobalt — Méthode par spectrométrie
d'absorption atomique dans la flamme*

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ISO 11652:1997(E)**Foreword**

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International Standard ISO 11652 was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 1, *Methods of determination of chemical composition*.

Annex A forms an integral part of this International Standard. Annexes B and C are for information only.

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Steel and iron – Determination of cobalt content – Flame atomic absorption spectrometric method

1 Scope

This International Standard specifies a flame atomic absorption spectrometric method for the determination of the cobalt content in steel and iron.

The method is applicable to cobalt contents between 0,003 % (m/m) and 5,0 % (m/m).

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 385-1:1984, *Laboratory glassware — Burettes — Part 1: General requirements*.

ISO 648:1977, *Laboratory glassware — One-mark pipettes*.

ISO 1042:—1), *Laboratory glassware — One-mark volumetric flasks*.

ISO 3696:1987, *Water for analytical laboratory use — Specification and test methods*.

ISO 5725-1:1994, *Accuracy (trueness and precision) of measurement methods and results — Part 1: General principles and definitions*.

ISO 5725-2:1994, *Accuracy (trueness and precision) of measurement methods and results — Part 2: Basic method for the determination of repeatability and reproducibility of a standard measurement method*.

ISO 5725-3:1994, *Accuracy (trueness and precision) of measurement methods and results — Part 3: Intermediate measures of the precision of a standard measurement method*.

ISO 14284 :1996, *Steel and iron — Sampling and preparation of samples for the determination of chemical composition*.

3 Principle

Dissolution of a test portion in hydrochloric, nitric and perchloric acids.

Spraying of the solution into an air-acetylene flame.

Spectrometric measurement of the atomic absorption of the 240,7 nm spectral line emitted by a cobalt hollow cathode lamp.

1) To be published. (Revision of ISO 1042:1983)

4 Reagents

During the analysis, unless otherwise stated, use only reagents of recognized analytical grade and only grade 2 water as specified in ISO 3696.

4.1 Pure iron, containing less than 0,000 3 % (*m/m*) cobalt.

4.2 Pure nickel, containing less than 0,000 3 % (*m/m*) cobalt.

4.3 Hydrochloric acid, ρ about 1,19 g/ml.

4.4 Nitric acid, ρ about 1,40 g/ml.

4.5 Perchloric acid, ρ about 1,67 g/ml.

4.6 Cobalt, standard solutions.

4.6.1 Standard solution A, corresponding to 1,0 g of Co per litre.

Weigh, to the nearest 0,001 g, 1,000 g of metallic cobalt [purity > 99,9 % (*m/m*) Co]. Transfer to a 250 ml beaker. Add 15 ml of water and 15 ml of nitric acid (4.4). Cover the beaker with a watch-glass, heat gently until complete dissolution has taken place and boil to remove oxides of nitrogen.

Cool to room temperature, transfer the solution quantitatively to a 1 000 ml one-mark volumetric flask, dilute to the mark with water and mix.

1 ml of this standard solution A contains 1,0 mg of Co.

4.6.2 Standard solution B, corresponding to 0,2 g of Co per litre.

Transfer 20,0 ml of the standard solution A (4.6.1) to a 100 ml one-mark volumetric flask, dilute to the mark with water and mix.

1 ml of this standard solution B contains 0,2 mg of Co.

4.6.3 Standard solution C, corresponding to 0,08 g of Co per litre.

Transfer 8,0 ml of the standard solution A (4.6.1) to a 100 ml one-mark volumetric flask, dilute to the mark with water and mix.

Prepare this standard solution C immediately before use.

1 ml of this standard solution C contains 0,08 mg of Co.

5 Apparatus

All volumetric glassware shall be class A, in accordance with ISO 385-1, ISO 648 or ISO 1042 as appropriate.

Ordinary laboratory apparatus, and

5.1 Atomic absorption spectrometer, equipped with a cobalt hollow cathode lamp and supplied with air and acetylene sufficiently pure to give a steady clear fuel-lean flame, free from water and oil, and free from cobalt.

The atomic absorption spectrometer used will be satisfactory if, after optimization according to 7.3.4, the limit of detection and characteristic concentration are in reasonable agreement with the values given by the manufacturer and if it meets the precision criteria given in 5.1.1 to 5.1.3.

It is also desirable that the instrument should conform to the additional performance requirements given in 5.1.4.

5.1.1 Minimum precision (see A.1)

Calculate the standard deviation of 10 measurements of the absorbance of the most concentrated calibration solution. The standard deviation shall not exceed 1,5 % of the mean absorbance.

Calculate the standard deviation of 10 measurements of the absorbance of the least concentrated calibration solution (excluding the zero member). The standard deviation shall not exceed 0,5 % of the mean absorbance of the most concentrated calibration solution.

5.1.2 Limit of detection (see A.2)

This is defined as twice the standard deviation of 10 measurements of the absorbance of a solution containing the appropriate element of a concentration level selected to give an absorbance just above that of the zero member.

The limit of detection of cobalt in a matrix similar to the final test solution shall be better than 0,05 µg of Co per millilitre, for wavelength 240,7 nm.

5.1.3 Graph linearity (see A.3)

The slope of the calibration graph covering the top 20 % of the concentration range (expressed as a change in absorbance) shall not be less than 0,7 times the value of the slope for the bottom 20 % of the concentration range (expressed as a change in absorbance) determined in the same way.

For instruments with automatic calibration using two or more standards, it shall be established prior to the analysis, by obtaining absorbance readings, that the above requirements for graph linearity are fulfilled.

5.1.4 Characteristic concentration (see A.4)

The characteristic concentration of cobalt in a matrix similar to the final test portion solution shall be better than 0,3 µg of Co per millilitre, for wavelength 240,7 nm.

5.2 Ancillary equipment

A strip chart recorder and/or digital readout device is recommended to evaluate the criteria of 5.1.1 to 5.1.3 and for all subsequent measurements.

Scale expansion may be used until the noise observed is greater than the readout error and is always recommended for absorbances below 0,1. If scale expansion has to be used and the instrument does not have the means to read the value of the scale expansion factor, the value can be calculated by measuring the absorbances of a suitable solution with and without scale expansion and simply dividing the signal obtained.

A background corrector equipped with a deuterium hollow cathode lamp is advisable for the analysis of highly alloyed steels, in order to eliminate interference from an FeO molecular absorption band at the cobalt wavelength.

6 Sampling

Carry out sampling in accordance with ISO 14284 or appropriate national standards for steel and iron.

7 Procedure

WARNING — Perchloric acid vapour may cause explosions in the presence of ammonia, nitrous fumes or organic material in general.

7.1 Test portion

Weigh a test portion according to the presumed cobalt content as follows:

- a) for cobalt contents up to 2,0 % (*m/m*), a test portion of about 1,0 g, to the nearest 0,001 g;
- b) for cobalt contents from 2,0 % (*m/m*) to 5,0 % (*m/m*), a test portion of about 0,50 g, to the nearest 0,000 5 g.

7.2 Blank test

In parallel with the determination and following the same procedure, carry out a blank test for each concentration range (see 7.1) using the same quantities of all the reagents, including the pure iron(4.1) but omitting the test portion.

7.3 Determination

7.3.1 Preparation of the test solution

7.3.1.1 Dissolution of the test portion

Transfer the test portion (7.1) to a 250 ml beaker. Add 10 ml of hydrochloric acid (4.3) and 4 ml of nitric acid (4.4) and cover the beaker with a watch-glass. After effervescence ceases, add 10 ml of perchloric acid (4.5) and heat. Heat until dense white fumes of perchloric acid reflux smoothly in the beaker.

Allow to cool, add 30 ml of water and heat gently to dissolve the salts. Cool again and transfer quantitatively to a 100 ml one-mark volumetric flask. Dilute to the mark with water and mix.

Decant the solution through a dry medium-filter paper, to remove any residue or precipitate, for example graphite, silica or tungstic acid, and collect the filtrate in a dry beaker after discarding the first few millilitres.

7.3.1.2 Dilution of the test solution

Depending on the cobalt content expected in the test portion, prepare the test solution in accordance with a), b), c) or d), as follows.

- a) If the expected cobalt content is up to 0,08 % (*m/m*), use the filtrate (see 7.3.1.1) undiluted.
- b) If the expected cobalt content is between 0,08 % (*m/m*) and 0,40 % (*m/m*), dilute the filtrate as follows.

Transfer 20,0 ml of the filtrate to a 100 ml one-mark volumetric flask, dilute to the mark with water and mix (see note 1).

- c) If the expected cobalt content is between 0,40 % (*m/m*) and 2,0 % (*m/m*), dilute the filtrate as follows.

Transfer 10,0 ml of the filtrate to a 250 ml one-mark volumetric flask, dilute to the mark with water and mix (see note 1).

- d) If the expected cobalt content is between 2,0 % (*m/m*) and 5,0 % (*m/m*), dilute the filtrate as follows.

Transfer 5,0 ml of the filtrate to a 250 ml one-mark volumetric flask, dilute to the mark with water and mix (see note 1).

NOTE 1 If the filtrate(see 7.3.1.1) has to be diluted to give the test solution, dilute the blank (see 7.2) in exactly the same way.