SLOVENSKI STANDARD
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Baker in bakrove zlitine - Optična emisijska spektrometrija z induktivno sklopljeno plazmo

Copper and copper alloys - Inductively coupled plasma optical emission spectrometry

Kupfer und Kupferlegierungen - Optische Emissionsspektrometrie mit induktiv gekoppelter Plasmaanregung

Cuivre et alliages de cuivre - Analyse par spectrométrie d'émission optique avec source à plasma induit par haute fréquence

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77.120.30	Baker in bakrove zlitine	Copper and copper alloys

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Copper and copper alloys - Inductively coupled plasma optical emission spectrometry

Cuivre et alliages de cuivre - Analyse par spectrométrie d'émission optique avec source à plasma induit par haute fréquence

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COMITÉ EUROPÉEN DE NORMALISATION
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Foreword

This document (EN 15605:2010) has been prepared by Technical Committee CEN/TC 133 “Copper and copper alloys”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by January 2011, and conflicting national standards shall be withdrawn at the latest by January 2011.

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This document supersedes CEN/TS 15605:2007.

Within its programme of work, Technical Committee CEN/TC 133 requested CEN/TC 133/WG 10 "Methods of Analysis" to revise the following Technical Specification:

CEN/TS 15605, *Copper and copper alloys — Inductively coupled plasma optical emission spectrometry*

In comparison with the first edition of CEN/TS 15605:2007, the following significant technical changes were made:

— Revision from a Technical Specification to a European Standard;

— Method G (specifying the analysis of Copper-tin-lead alloys) is edited under an informative basis (see Annex B), taking into account the mediocrity of the precision criteria related to this method;

— Precision criteria for methods A and E were added;

— Precision criteria for methods B, C, D and F were improved and up-dated.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

1 Scope

This European Standard specifies six inductively coupled plasma emission spectrometry methods (A to F) for the determination of alloying elements and impurities in copper and copper alloys in the form of unwrought, wrought and cast products.

A complementary method, for the analysis of Copper-tin-lead alloys, is described in Annex B (informative). The precision criteria concerning this method do not reach the suitable level, for all the elements specified (zinc and phosphorus, namely).

These methods are applicable to the elements listed in Tables 1 to 6 within the composition ranges shown:

Table 1 — Coppers

Element	Mass fraction %	
	min.	max.
Sn	0,02	0,60
Pb	0,02	0,60
Zn	0,02	0,60
Fe	0,01	0,60
Ni	0,01	0,60
Mn	0,01	0,60
Al	0,02	0,60
P	0,01	0,40
Be	0,01	0,60
Co	0,01	0,60
Cd	0,01	0,60

Table 2 — Copper-zinc alloys

Element	Mass fraction %	
	min.	max.
Sn	0,05	2,00
Pb	0,03	4,00
Zn	10,00	42,00
Fe	0,01	5,00
Ni	0,02	4,00
Mn	0,01	6,00
P	0,01	0,40
Al	0,02	9,00
As	0,01	0,20

Table 3 — Copper-tin alloys

Element	Mass fraction %	
	min.	max.
Sn	3,00	16,00
Pb	0,01	9,00
Zn	0,03	6,00
Fe	0,01	1,00
Ni	0,05	7,00
Mn	0,01	0,40
P	0,01	0,60
Al	0,01	0,50
Sb	0,02	1,60
As	0,02	0,25

Table 4 — Copper-aluminium alloys

Element	Mass fraction %	
	min.	max.
Sn	0,02	0,50
Pb	0,03	0,50
Zn	0,03	1,00
Fe	0,05	7,00
Ni	0,10	8,00
Mn	0,01	5,00
Al	6,00	14,00
Cd	0,01	0,50
Mg	0,002	0,15

Table 5 — Copper-beryllium alloys

Element	Mass fraction %	
	min.	max.
Sn	0,02	0,20
Pb	0,01	0,20
Zn	0,03	0,20
Fe	0,03	0,30
Ni	0,04	2,50
Mn	0,006	0,15
Al	0,03	0,20
Be	0,08	4,00
Co	0,03	4,00

Table 6 — Copper-nickel alloys

Element	Mass fraction %	
	min.	max.
Sn	0,10	0,50
Pb	0,03	0,50
Zn	0,04	2,00
Fe	0,10	4,00
Ni	7,00	35,00
Mn	0,02	3,00
Al	0,02	0,50

NOTE 1 The ranges specified for each method can be extended or adapted, for the determination of lower mass fractions.

NOTE 2 Other elements may be included. However such elements and their mass fractions should be carefully checked, taking into account interference, sensitivity, resolution and linearity criteria for each instrument and each wavelength.

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 1811-1, *Copper and copper alloys — Selection and preparation of samples for chemical analysis — Part 1: Sampling of cast unwrought products*

ISO 1811-2, *Copper and copper alloys — Selection and preparation of samples for chemical analysis — Part 2: Sampling of wrought products and castings*

3 Principle

Dissolution of a test portion with hydrochloric and nitric acids. After suitable dilution and addition of an internal reference element, nebulization of the solution into an inductively coupled plasma emission spectrometer and measurement of the intensity of the emitted light, including that of the internal reference element.

4 Reagents

During the analysis, use only reagents of recognised analytical grade and only distilled water or water of equivalent purity.

The same reagents should be used for the preparation of calibration solutions and of sample solutions.

4.1 Hydrochloric acid, HCl (ρ = 1,19 g/ml)

4.2 Hydrochloric acid, solution 1 + 1

Add 500 ml of hydrochloric acid (4.1) to 500 ml of water.

4.3 Nitric acid, HNO_3 (ρ = 1,40 g/ml)

4.4 Nitric acid, solution 1 + 1

Add 500 ml of nitric acid (4.3) to 500 ml of water.

4.5 Hydrofluoric acid, HF (ρ = 1,13 g/ml)

4.6 Sulphuric acid, H_2SO_4 (4,5 mol/l)

4.7 Electrolytic copper

4.8 Zinc granules of 99,999 % purity

4.9 Aluminium stock solution, 10 g/l Al

Weigh (5 ± 0,001) g of aluminium (Al ≥ 99,99 %) and transfer into a 600 ml beaker. Add 250 ml of hydrochloric acid solution (4.2) and cover with a watch glass. After cooling to room temperature, transfer the solution quantitatively into a 500 ml one-mark volumetric flask, dilute to the mark with water and mix well.

1 ml of this solution contains 10 mg of Al.

4.10 Aluminium stock solution, 1 g/l Al

Weigh (1 ± 0,001) g of aluminium (Al ≥ 99,99 %) and transfer into a 400 ml beaker. Add 50 ml of hydrochloric acid solution (4.2) and cover with a watch glass. After cooling to room temperature, transfer the solution quantitatively into a 1 000 ml one-mark volumetric flask, dilute to the mark with water and mix well.

1 ml of this solution contains 1 mg of Al.

4.11 Antimony stock solution, 1 g/l Sb

Weigh (0,5 ± 0,001) g of antimony (Sb ≥ 99,99 %) and transfer into a 250 ml beaker. Add 50 ml of hydrochloric acid (4.1) and 25 ml of nitric acid solution (4.4) and cover with a watch glass. Heat gently until the metal is dissolved. After cooling to room temperature, transfer the solution quantitatively into a 500 ml one-mark volumetric flask, containing 100 ml of hydrochloric acid (4.1), dilute to the mark with water and mix well.

1 ml of this solution contains 1 mg of Sb.

4.12 Arsenic stock solution, 1 g/l As

Weigh (0,5 ± 0,001) g of arsenic (As ≥ 99,99 %) and transfer into a 250 ml beaker. Add 20 ml of nitric acid solution (4.4) and cover with a watch glass. Heat gently until the metal is dissolved. After cooling to room temperature, transfer the solution quantitatively into a 500 ml one-mark volumetric flask, dilute to the mark with water and mix well.

1 ml of this solution contains 1 mg of As.

4.13 Beryllium stock solution, 5 g/l Be

Weigh (1 ± 0,001) g of beryllium (Be ≥ 99,99 %) and transfer into a 250 ml beaker. Add 40 ml of hydrochloric acid (4.1) and cover with a watch glass. Heat gently until the metal is dissolved. After cooling to room temperature, transfer the solution quantitatively into a 200 ml one-mark volumetric flask, dilute to the mark with water and mix well.

1 ml of this solution contains 5 mg of Be.

4.14 Beryllium stock solution, 1 g/l Be

Weigh (0,5 ± 0,001) g of beryllium (Be ≥ 99,99 %) and transfer into a 250 ml beaker. Add 20 ml of hydrochloric acid (4.1) and cover with a watch glass. Heat gently until the metal is dissolved. After cooling to room temperature, transfer the solution quantitatively into a 500 ml one-mark volumetric flask, dilute to the mark with water and mix well.

1 ml of this solution contains 1 mg of Be.

4.15 Cadmium stock solution, 1 g/l Cd

Weigh (1 ± 0,001) g of cadmium (Cd ≥ 99,99 %) and transfer into a 400 ml beaker. Add 10 ml of nitric acid (4.3) and cover with a watch glass. Heat gently until the metal is dissolved, then boil until nitrous fumes have been expelled. After cooling to room temperature, transfer the solution quantitatively into a 1 000 ml one-mark volumetric flask, dilute to the mark with water and mix well.

1 ml of this solution contains 1 mg of Cd.

4.16 Cobalt stock solution, 5 g/l Co

Weigh (1 ± 0,001) g of cobalt (Co ≥ 99,99 %) and transfer into a 250 ml beaker. Add 10 ml of hydrochloric acid (4.1) and 10 ml of nitric acid (4.3) and cover with a watch glass. Heat gently until the metal is dissolved, then boil until nitrous fumes have been expelled. After cooling to room temperature, transfer the solution quantitatively into a 200 ml one-mark volumetric flask, dilute to the mark with water and mix well.

1 ml of this solution contains 5 mg of Co.

4.17 Cobalt stock solution, 1 g/l Co

Weigh (0,5 ± 0,001) g of cobalt (Co ≥ 99,99 %) and transfer into a 250 ml beaker. Add 5 ml of hydrochloric acid (4.1) and 5 ml of nitric acid (4.3) and cover with a watch glass. Heat gently until the metal is dissolved, then boil until nitrous fumes have been expelled. After cooling to room temperature, transfer the solution quantitatively into a 500 ml one-mark volumetric flask, dilute to the mark with water and mix well.

1 ml of this solution contains 1 mg of Co.

4.18 Iron stock solution, 5 g/l Fe

Weigh (5 ± 0,001) g of iron (Fe ≥ 99,99 %) and transfer into a 400 ml beaker. Add 100 ml of hydrochloric acid (4.1) and 50 ml of nitric acid solution (4.4) and cover with a watch glass. Heat gently until the metal is dissolved, then boil until nitrous fumes have been expelled. After cooling to room temperature, transfer the solution quantitatively into a 1 000 ml one-mark volumetric flask, dilute to the mark with water and mix well.

1 ml of this solution contains 5 mg of Fe.

4.19 Iron stock solution, 1 g/l Fe

Weigh (1 ± 0,001) g of iron (Fe ≥ 99,99 %) and transfer into a 250 ml beaker. Add 20 ml of hydrochloric acid (4.1) and 10 ml of nitric acid solution (4.4) and cover with a watch glass. Heat gently until the metal is dissolved, then boil until nitrous fumes have been expelled. After cooling to room temperature, transfer the solution quantitatively into a 1 000 ml one-mark volumetric flask, dilute to the mark with water and mix well.

1 ml of this solution contains 1 mg of Fe.

4.20 Lead stock solution, 5 g/l Pb

Weigh (2,5 ± 0,001) g of lead (Pb ≥ 99,99 %) and transfer into a 400 ml beaker. Add 50 ml of nitric acid solution (4.4) and cover with a watch glass. Heat gently until the metal is dissolved, then boil until nitrous fumes have been expelled. After cooling to room temperature, transfer the solution quantitatively into a 500 ml one-mark volumetric flask, dilute to the mark with water and mix well.

1 ml of this solution contains 5 mg of Pb.

4.21 Lead stock solution, 1 g/l Pb

Weigh (1 ± 0,001) g of lead (Pb ≥ 99,99 %) and transfer into a 250 ml beaker. Add 20 ml of nitric acid solution (4.4) and cover with a watch glass. Heat gently until the metal is dissolved, then boil until nitrous fumes have been expelled. After cooling to room temperature, transfer the solution quantitatively into a 1 000 ml one-mark volumetric flask, dilute to the mark with water and mix well.

1 ml of this solution contains 1 mg of Pb.

4.22 Magnesium stock solution, 1 g/l Mg

Weigh (1 ± 0,001) g of magnesium (Mg ≥ 99,99 %) and transfer into a 250 ml beaker. Add 50 ml of nitric acid solution (4.4) and cover with a watch glass. Heat gently until the metal is dissolved, then boil until nitrous fumes have been expelled. After cooling to room temperature, transfer the solution quantitatively into a 1 000 ml one-mark volumetric flask, dilute to the mark with water and mix well.

1 ml of this solution contains 1 mg of Mg.

4.23 Manganese stock solution, 5 g/l Mn

The manganese used to prepare the solution is released from superficial oxide possibly present by introducing a few grams of metal in a 250 ml beaker containing 60 ml to 80 ml of sulphuric acid (4.6) and approximately 100 ml of water. Shake and after a few seconds, allow the solution to settle and add water. Repeat the water cleaning several times. Remove the metallic manganese, introduce it into acetone, allow to settle and dry the metal in an oven at 100 °C for 2 min. Cool in a desiccator.

Weigh (5 ± 0,001) g of this purified manganese and transfer into a 400 ml beaker. Add 50 ml of hydrochloric acid (4.1) and 125 ml of nitric acid solution (4.4) and cover with a watch glass. Heat gently until the metal is dissolved. After cooling to room temperature, transfer the solution quantitatively into a 1 000 ml one-mark volumetric flask, dilute to the mark with water and mix well.

1 ml of this solution contains 5 mg of Mn.

4.24 Manganese stock solution, 1 g/l Mn

Weigh (1 ± 0,001) g of manganese, purified as described in 4.23 and transfer into a 250 ml beaker. Add 10 ml of hydrochloric acid (4.1) and 25 ml of nitric acid solution (4.4) and cover with a watch glass. Heat gently until the metal is dissolved. After cooling to room temperature, transfer the solution quantitatively into a 1 000 ml one-mark volumetric flask, dilute to the mark with water and mix well.

1 ml of this solution contains 1 mg of Mn.

4.25 Nickel stock solution, 10 g/l Ni

Weigh (5 ± 0,001) g of nickel (Ni ≥ 99,99 %) and transfer into a 400 ml beaker. Add 125 ml of nitric acid solution (4.4) and cover with a watch glass. Heat gently until the metal is dissolved, then boil until nitrous fumes have been expelled. After cooling to room temperature, transfer the solution quantitatively into a 500 ml one-mark volumetric flask, dilute to the mark with water and mix well.

1 ml of this solution contains 10 mg of Ni.

4.26 Nickel stock solution, 5 g/l Ni

Weigh (5 ± 0,001) g of nickel (Ni ≥ 99,99 %) and transfer into a 400 ml beaker. Add 125 ml of nitric acid solution (4.4) and cover with a watch glass. Heat gently until the metal is dissolved, then boil until nitrous fumes have been expelled. After cooling to room temperature, transfer the solution quantitatively into a 1 000 ml one-mark volumetric flask, dilute to the mark with water and mix well.

1 ml of this solution contains 5 mg of Ni.

4.27 Nickel stock solution, 1 g/l Ni

Weigh (1 ± 0,001) g of nickel (Ni ≥ 99,99 %) and transfer into a 250 ml beaker. Add 25 ml of nitric acid solution (4.4) and cover with a watch glass. Heat gently until the metal is dissolved, then boil until nitrous fumes have been expelled. After cooling to room temperature, transfer the solution quantitatively into a 1 000 ml one-mark volumetric flask, dilute to the mark with water and mix well.

1 ml of this solution contains 1 mg of Ni.

4.28 Phosphorus stock solution, 1 g/l P

Weigh (4,394 ± 0,001) g of dried potassium dihydrogen phosphate into a 1 000 ml one-mark volumetric flask and dissolve it with water. Dilute to the mark with water and mix well.

1 ml of this solution contains 1 mg of P.

4.29 Tin stock solution, 10 g/l Sn

Weigh (5 ± 0,001) g of tin (Sn ≥ 99,99 %) and transfer into a 400 ml beaker. Add 50 ml of hydrochloric acid (4.1) and cover with a watch glass. Heat gently until the metal is dissolved. After cooling to room temperature, transfer the solution quantitatively into a 500 ml one-mark volumetric flask, dilute to the mark with water and mix well.

1 ml of this solution contains 10 mg of Sn.

4.30 Tin stock solution, 5 g/l Sn

Weigh (2,5 ± 0,001) g of tin (Sn ≥ 99,99 %) and transfer into a 400 ml beaker. Add in 50 ml of hydrochloric acid (4.1) and cover with a watch glass. Heat gently until the metal is dissolved. After cooling to room temperature, transfer the solution quantitatively into a 500 ml one-mark volumetric flask, dilute to the mark with water and mix well.

1 ml of this solution contains 5 mg of Sn.

4.31 Tin stock solution, 1 g/l Sn

Weigh (0,5 ± 0,001) g of tin (Sn ≥ 99,99 %) and transfer into a 250 ml beaker. Add 50 ml of hydrochloric acid (4.1) and cover with a watch glass. Heat gently until the metal is dissolved. After cooling to room temperature, transfer the solution quantitatively into a 500 ml one-mark volumetric flask, dilute to the mark with water and mix well.

1 ml of this solution contains 1 mg of Sn.

4.32 Zinc stock solution, 10 g/l Zn

Weigh (5 ± 0,001) g of zinc (Zn ≥ 99,99 %) and transfer into a 400 ml beaker. Add 250 ml of hydrochloric acid solution (4.2) and cover with a watch glass. Heat gently until the metal is dissolved. After cooling to room temperature, transfer the solution quantitatively into a 500 ml one-mark volumetric flask, dilute to the mark with water and mix well.

1 ml of this solution contains 10 mg of Zn.

4.33 Zinc stock solution, 1 g/l Zn

Weigh (1 ± 0,001) g of zinc (Zn ≥ 99,99 %) and transfer into a 400 ml beaker. Add 50 ml of hydrochloric acid solution (4.2) and cover with a watch glass. Heat gently until the metal is dissolved. After cooling to room temperature, transfer the solution quantitatively into a 1 000 ml one-mark volumetric flask, dilute to the mark with water and mix well.

1 ml of this solution contains 1 mg of Zn.

4.34 Internal standard solution, 1g/l Yttrium in 0,5 mol/l nitric acid.

5 Apparatus

Optical emission spectrometer (OES), equipped with inductively coupled plasma (ICP) and nebulization systems.

The instrument used will be considered satisfactory if, after optimizing in accordance with the manufacturer's instructions, it meets the performance criteria given in Annex A.

6 Sampling

Sampling shall be carried out in accordance with ISO 1811-1 or ISO 1811-2 as appropriate.

Test samples shall be in the form of fine chips, drillings or millings, e.g. with a maximum thickness of 0,5 mm.

7 Procedure

7.1 Method A: Coppers

7.1.1 Preparation of the test portion solution

7.1.1.1 Test portion

Weigh (1 ± 0,001) g of the test sample.

7.1.1.2 Test portion solution 5 g/l

Transfer the test portion (7.1.1.1) into a 250 ml beaker.

Add 20 ml of hydrochloric acid solution (4.2) and 5 ml of nitric acid (4.3). Cover with a watch glass and heat gently until the sample is completely dissolved, then heat to boiling. Allow to cool. Rinse the cover and the walls of the beaker with water.

Transfer the dissolved test portion into a 200 ml one-mark volumetric flask containing 10 ml of hydrochloric acid (4.1). Dilute to the mark with water and mix well.

7.1.1.3 Test portion solution 1 g/l

In order to obtain solutions with 1 g/l concentration, pipette exactly 20 ml of the test portion solution (7.1.1.2) into a 100 ml one-mark volumetric flask containing 5 ml of hydrochloric acid (4.1) and 5 ml of yttrium solution (4.34). Dilute to the mark with water and mix well.

7.1.2 Check test

Make a preliminary check of the apparatus by preparing a solution of a copper reference material or a synthetic sample containing known amounts of the elements listed in Table 1 and carrying out the procedure specified in 7.1.4.

7.1.3 Establishment of the calibration curves

7.1.3.1 Preparation of the calibration solutions

7.1.3.1.1 General

In all cases the acidity of the calibration solutions shall be similar to that of the test portion solutions.

If, for measurement purposes, a blank is required, prepare a solution containing only the same amounts of acids as in the test solution.

7.1.3.1.2 Preparation of the 5 g/l calibration solutions, using mono-elemental solutions

Weigh the quantities of copper (4.7) shown in Table 7 and introduce them into each of a series of 250 ml beakers.

Add 20 ml of hydrochloric acid solution (4.2) and 5 ml of nitric acid (4.3) to each beaker. Cover with a watch glass and heat gently in order to dissolve the copper. Rinse the cover and the walls of the beaker with water and heat to boiling. Allow to cool and transfer each copper solution into a 200 ml one-mark volumetric flask containing 10 ml of hydrochloric acid (4.1).

Transfer the volumes of the elemental solutions of Sn, Pb, Zn, Fe, Ni, Mn, P, Al, Be, Co and Cd shown in Table 7 to each volumetric flask. Dilute to the mark with water and mix well.

7.1.3.1.3 Preparation of the 1 g/l calibration solutions

Dilute accurately the 5 g/l calibration solutions (7.1.3.1.2) in order to obtain 1 g/l calibration solutions.

Pipette exactly 20 ml of the 5 g/l calibration solutions (7.1.3.1.2) into 100 ml one-mark volumetric flasks each containing 5 ml of hydrochloric acid (4.1) and 5 ml of yttrium solution (4.34). Dilute to the mark with water and mix well.

Table 7 — Method A — Composition of the 5 g/l calibration solutions

Element	Label			Drift survey solution (see 7.1.3.3)
	P1	P2	P3	
Cu (4.7)	976,3 mg 97,63 %	973,3 mg 97,33 %	979,4 mg 97,94 %	988,0 mg 98,80 %
Sn (4.31)	0,2 mg [a] 0,02 %	0,5mg [b] 0,05 %	6,0 mg 6 ml 0,60 %	1,0 mg 1 ml 0,10 %
Pb (4.21)	6,0 mg 6 ml 0,60 %	0,5mg [c] 0,05 %	0,2mg [d] 0,02 %	1,0 mg 1 ml 0,10 %
Zn (4.33)	0,2mg [e] 0,02 %	0,5 mg [f] 0,05 %	6,0 mg 6 ml 0,60 %	1,0 mg 1 ml 0,10 %
Fe (4.19)	0,5 mg [g] 0,05 %	6,0 mg 6 ml 0,60 %	0,1 mg [h] 0,01 %	1,0 mg 1 ml 0,10 %
Ni (4.27)	0,1 mg [i] 0,01 %	6,0 mg 6 ml 0,60 %	0,5 mg [j] 0,05 %	1,0 mg 1 ml 0,10 %
Mn (4.24)	6,0 mg 6 ml 0,60 %	0,1 mg [k] 0,01 %	0,5 mg [l] 0,05 %	1,0 mg 1 ml 0,10 %
P (4.28)	4,0 mg 4 ml 0,40 %	0,1 mg [m] 0,01 %	0,5 mg [n] 0,05 %	2,0 mg 2 ml 0,20 %
Al (4.10)	6,0 mg 6 ml 0,60 %	0,5 mg [o] 0,05 %	0,2mg [p] 0,02 %	1,0 mg 1 ml 0,10 %
Be (4.14)	0,5 mg [q] 0,05 %	6,0 mg 6 ml 0,60 %	0,1 mg [r] 0,01 %	1,0 mg 1 ml 0,10 %
Co (4.17)	0,1 mg [s] 0,01 %	6,0 mg 6 ml 0,60 %	0,5 mg [t] 0,05 %	1,0 mg 1 ml 0,10 %
Cd (4.15)	0,1 mg [u] 0,01 %	0,5 mg [v] 0,05 %	6,0 mg 6 ml 0,60 %	1,0 mg 1 ml 0,10 %

[a] 2 ml of a 0,1 g/l tin stock solution.
[b] 5 ml of a 0,1 g/l tin stock solution.
[c] 5 ml of a 0,1 g/l lead stock solution.
[d] 2 ml of a 0,1 g/l lead stock solution.
[e] 2 ml of a 0,1 g/l zinc stock solution.
[f] 5 ml of a 0,1 g/l zinc stock solution.
[g] 5 ml of a 0,1 g/l iron stock solution.
[h] 1 ml of a 0,1 g/l iron stock solution.
[i] 1 ml of a 0,1 g/l nickel stock solution.
[j] 5 ml of a 0,1 g/l nickel stock solution.
[k] 1 ml of a 0,1 g/l manganese stock solution.
[l] 5 ml of a 0,1 g/l manganese stock solution.
[m] 1 ml of a 0,1 g/l phosphorus stock solution.
[n] 5 ml of a 0,1 g/l phosphorus stock solution.
[o] 5 ml of a 0,1 g/l aluminium solution.
[p] 2 ml of a 0,1 g/l aluminium stock solution.
[q] 5 ml of a 0,1 g/l beryllium stock solution.
[r] 1 ml of a 0,1 g/l beryllium stock solution.
[s] 1 ml of a 0,1 g/l cobalt stock solution.
[t] 5 ml of a 0,1 g/l cobalt stock solution.
[u] 1 ml of a 0,1 g/l cadmium stock solution.
[v] 5 ml of a 0,1 g/l cadmium stock solution.