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Copper, lead and zinc sulfide concentrates — Determination of mass of contained metal in a lot

Concentrés sulfurés de cuivre, de plomb et de zinc — Détermination de la masse de métal contenu dans un lot

Reference number
ISO 13543:1996(E)

Foreword

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International Standard ISO 13543 was prepared by Technical Committee ISO/TC 183, *Copper, lead and zinc ores and concentrates*.

Annex A of this International Standard is for information only.

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Copper, lead and zinc sulfide concentrates — Determination of mass of contained metal in a lot

1 Scope

This International Standard specifies the method for determining the mass of contained metal in a lot, based on the wet mass, moisture content and dry basis metal content of the lot. The procedure for estimating the variance and confidence intervals for the mass of contained metal is also specified.

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 10251:—[1], *Copper, lead and zinc sulfide concentrates — Determination of mass loss of bulk material on drying.*

ISO 12743:—[1], *Copper, lead and zinc sulfide concentrates — Sampling procedures for determination of metal and moisture content.*

ISO 12744:—[1], *Copper, lead and zinc sulfide concentrates — Experimental methods for checking the precision of sampling.*

ISO 12745:—[1], *Copper, lead and zinc sulfide concentrates — Precision and bias of mass measurement techniques.*

3 Definitions

For the purposes of this International Standard the following definitions apply.

3.1 lot: Quantity of concentrate to be sampled.

3.2 wet mass of the lot: Combined mass of concentrate and moisture of the lot at the time of weighing and sampling.

3.3 moisture determination: Quantitative measurement of the mass loss of the moisture test portion under the conditions of drying specified in ISO 10251.

3.4 chemical analysis: Quantitative determination of the required chemical constituents of the analysis test portion.

3.5 precision: Measure of the random variations within a set of measurements.

3.6 dry mass of the lot: Mass of concentrate in the lot after correcting for the mass of moisture in the lot.

4 Determination of mass of contained metal

The mass of contained metal in a lot is determined from measurements of the wet mass, moisture content and dry basis metal content.

4.1 Wet mass of the lot

The wet mass of the lot shall be determined using static scales, belt scales or draft surveys. However, due to their superior precision, static scales are recommended.

4.2 Moisture content of the lot

Samples for moisture determination shall be collected in accordance with ISO 12743. The moisture content of the lot shall be determined according to the procedure specified in ISO 10251.

1) To be published.

4.3 Metal content of the lot

Samples for chemical analysis shall be collected in accordance with ISO 12743 and analysed in accordance with the relevant ISO chemical analysis standards.

4.4 Dry mass of the lot

Calculate the dry mass of the lot using the following equation:

$$m_D = m_W\left(1 - \frac{M}{100}\right) \quad \ldots (1)$$

where

m_D is the dry mass of the lot, in tonnes;

m_W is the wet mass of the lot, in tonnes;

M is the moisture content of the lot, in percent of the wet mass (m/m).

4.5 Mass of contained metal

4.5.1 Major elements

For the major elements copper, lead and zinc, the mass of contained metal in the lot is given by the equation:

$$m_M = \frac{m_D a_L}{100} \quad \ldots (2)$$

where

m_M is the mass of contained metal in the lot, in tonnes;

m_D is the dry mass of lot, in tonnes;

a_L is the metal content of the lot on a dry basis, in percent (m/m).

Alternatively, equation (2) can be rewritten as follows:

$$m_M = \frac{m_W F a_L}{100} \quad \ldots (3)$$

where F is the moisture factor given by:

$$F = 1 - \frac{M}{100} \quad \ldots (4)$$

4.5.2 Precious metals

For the precious metals silver and gold, the mass of contained metal in the lot is given by the equation:

$$m_M = \frac{m_W F a_L}{1000} \quad \ldots (5)$$

where

m_M is the mass of contained metal in the lot, in kilograms;

m_W is the wet mass of lot, in tonnes;

F is the moisture factor;

a_L is the precious metal content of the lot on a dry basis, in grams per tonne (m/m).

5 Determination of variance of mass of contained metal

The variance of the mass of contained metal in the lot can be determined from equation (3) by taking the partial derivatives with respect to the wet mass, the moisture factor and the metal content of the lot as follows:

$$s_M^2 = \left[\frac{\partial m_M}{\partial m_W}\right]^2 s_W^2 + \left[\frac{\partial m_M}{\partial F}\right]^2 s_F^2 + \left[\frac{\partial m_M}{\partial a_L}\right]^2 s_T^2 \quad \ldots (6)$$

where

s_M^2 is the estimated variance of the mass of contained metal in the lot;

s_W^2 is the estimated variance of the wet mass of the lot;

s_F^2 is the estimated total variance of the moisture factor = $(s_H/100)^2$

with s_H being the total precision (1 standard deviation) of moisture determination;

s_T^2 is the estimated total variance of the metal content of the lot.

Note that the estimated total variances of the moisture factor and the metal content include the contributions from primary sampling, sample processing and analysis.

Determining the partial derivatives and substituting them into equation (6) gives:

$$s_M^2 = \left[\frac{F a_L}{100}\right]^2 s_W^2 + \left[\frac{m_W a_L}{100}\right]^2 s_F^2 + \left[\frac{m_W F}{100}\right]^2 s_T^2 \quad \ldots (7)$$

Equation (7) can be simplified as follows:

$$s_M^2 = m_M^2\left[\frac{s_W^2}{m_W^2} + \frac{s_F^2}{F^2} + \frac{s_T^2}{a_L^2}\right] \quad \ldots (8)$$

Equation (8) is applicable to both the major elements and the precious metals.

The variance of the wet mass of the lot shall be determined in accordance with the procedures specified in ISO 12745 for estimating the precision of mass measurement techniques. The variances of the moisture factor and the metal content of the lot shall be determined according to the procedures specified in ISO 12744. The analyses shall be carried out according to the methods prescribed in relevant International Standards.

6 Examples of calculation of contained metal and its variance

6.1 Static scale

Assume a 500 tonne lot containing 30 % copper (*m/m*), 10 g of gold/t (*m/m*) and 8 % moisture (*m/m*) is weighed using a static hopper scale with a capacity of 25 tonne, i.e. 20 hopper loads. The precision (1 standard deviation) of the hopper scale is 0,2 % relative. The lot is divided into 10 sub-lots, and a single moisture determination is carried out on each subsample. A single lot sample is constituted for chemical analysis. The total precisions of the copper, gold and moisture determinations (1 standard deviation) are 0,05 % copper, 0,5 g of gold/t and 0,1 % moisture absolute (*m/m*) respectively.

6.1.1 Mass of contained copper

$m_W = 500$ t

$$s_W^2 = \left(\frac{25 \times 0{,}2}{100}\right)^2 \times 20 = 0{,}05$$

$$F = 1 - \left(\frac{8}{100}\right) = 0{,}92$$

$$s_F^2 = \frac{(0{,}1/100)^2}{10} = 0{,}000\,000\,1$$

$a_L = 30$ % copper

$s_T^2 = (0{,}05)^2 = 0{,}002\,5$

Equations (3) and (8) give:

$$m_M = \frac{500 \times 0{,}92 \times 30}{100} = 138 \text{ t copper}$$

$$s_M^2 = 138^2\left(\frac{0{,}05}{500^2} + \frac{0{,}000\,000\,1}{0{,}92^2} + \frac{0{,}002\,5}{30^2}\right)$$

$= 138^2\,(0{,}000\,000\,2 + 0{,}000\,000\,12 + 0{,}000\,002\,78)$

$= 0{,}003\,8 + 0{,}002\,3 + 0{,}052\,9$

$= 0{,}059$

Calculation of the standard deviation s_M gives:

$s_M = 0{,}24$ t copper

Hence, at the 95 % confidence level (i.e. two standard deviations), the mass of contained copper metal is:

$m_M = 138 \pm 0{,}5$ t copper (i.e. $\pm 0{,}4$ % relative)

The 95 % confidence range is 137,5 t of copper to 138,5 t of copper.

In this case the precision of the measured copper content of the lot is the major contributor to the uncertainty in the mass of contained metal. This can be reduced by carrying out additional analyses on the lot sample, or, in future, by analysing each sub-lot separately.

6.1.2 Mass of contained gold

$m_W = 500$ t

$$s_W^2 = \left(\frac{25 \times 0{,}2}{100}\right)^2 \times 20 = 0{,}05$$

$$F = 1 - \left(\frac{8}{100}\right) = 0{,}92$$

$$s_F^2 = \frac{(0{,}1/100)^2}{10} = 0{,}000\,000\,1$$

$a_L = 10$ g of gold/t

$s_T^2 = (0{,}5)^2 = 0{,}25$

Equations (5) and (8) give:

$$m_M = \frac{500 \times 0{,}92 \times 10}{10^3} = 4{,}6 \text{ kg gold}$$

$$s_M^2 = 4{,}6^2\left(\frac{0{,}05}{500^2} + \frac{0{,}000\,000\,1}{0{,}92^2} + \frac{0{,}25}{10^2}\right)$$

$= 4{,}6^2\,(0{,}000\,000\,2 + 0{,}000\,000\,12 + 0{,}002\,5)$

$= 0{,}000\,004\,2 + 0{,}000\,002\,5 + 0{,}052\,9$

$= 0{,}053$

Calculation of the standard deviation s_M gives:

$s_M = 0{,}23$ kg gold

Hence, at the 95 % confidence level, the mass of contained gold is:

$m_M = 4{,}6 \pm 0{,}5$ kg gold (i.e. ± 11 % relative)

The 95 % confidence range is 4,1 kg of gold to 5,1 kg of gold.

The precision of the measured gold content of the lot is the major contributor to the uncertainty in the mass of contained metal. Again this can be reduced by carrying out additional analyses on the lot sample, or, in future, by analysing each sub-lot separately.

6.2 Draft survey

Assume a lot containing 30 % copper and 8 % moisture (m/m) has a wet mass of 25 000 t. If the wet mass is determined by draft survey with a relative precision (1 standard deviation) of 0,5 % and the copper and moisture content of the lot have been determined with total precisions (1 standard deviation) of 0,05 % copper and 0,1 % moisture absolute (m/m) respectively, then:

$$m_W = 25\,000 \text{ t}$$

$$s_W^2 = \left(\frac{25\,000 \times 0{,}5}{100}\right)^2 = 15\,625$$

$$F = 1 - \left(\frac{8}{100}\right) = 0{,}92$$

$$s_F^2 = \left(\frac{0{,}1}{100}\right)^2 = 0{,}000\,001$$

$$a_L = 30 \text{ \% copper}$$

$$s_T^2 = (0{,}05)^2 = 0{,}002\,5$$

Hence, equations (3) and (8) give:

$$m_M = \frac{25\,000 \times 0{,}92 \times 30}{100} = 6\,900 \text{ t copper}$$

$$s_M^2 = 6\,900^2\left(\frac{15\,625}{25\,000^2} + \frac{0{,}000\,001}{0{,}92^2} + \frac{0{,}002\,5}{30^2}\right)$$

$$= 6\,900^2\,(0{,}000\,025 + 0{,}000\,001\,2 + 0{,}000\,002\,8)$$

$$= 1\,190 + 57 + 133 = 1\,380$$

Calculation of the standard deviation s_M gives:

$$s_M = 37 \text{ t copper}$$

Hence, at the 95 % confidence level, the mass of contained copper metal is:

$$m_M = 6\,900 \pm 74 \text{ t copper (i.e. } \pm 1{,}1 \text{ \% relative)}$$

The 95 % confidence range is 6 826 t of copper to 6 974 t of copper.

Clearly, the poor precision of mass determination is the major contributor to the uncertainty in the mass of contained metal. This is typical when the wet mass of the lot is determined by draft survey.

Annex A
(informative)

Bibliography

[1] ISO 10258:1994, *Copper sulfide concentrates — Determination of copper content — Titrimetric methods.*

[2] ISO 10378:1994, *Copper sulfide concentrates — Determination of gold and silver contents — Fire assay gravimetric and atomic absorption spectrometric method.*

[3] ISO 10469:1994, *Copper sulfide concentrates — Determination of copper content — Electro-gravimetric method.*

[4] ISO 11441:1995, *Lead sulfide concentrates — Determination of lead content — Back titration of EDTA after precipitation of lead sulfate.*

[5] ISO 12739:—2), *Zinc sulfide concentrates — Determination of zinc content — Ion-exchange method.*

[6] ISO 13291:—2), *Zinc sulfide concentrates — Determination of zinc content — Solvent extraction EDTA titrimetric method.*

2) To be published.

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Descriptors: metalliferous minerals, copper ores, lead ores, zinc ores, concentrates, copper inorganic compounds, lead inorganic compounds, zinc inorganic compounds, sulphides, tests, determination, commercial mass, mass measurement, metals.

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