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Rare earth — Terms and definitions —

Part 1:
Minerals, oxides and other compounds

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Foreword

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The committee responsible for this document is Technical Committee ISO/TC *298*, *rare earth*,.

A list of all parts in the ISO 22444 series can be found on the ISO website.

Introduction

Rare earth elements are widely used. Different business and industry sectors have various descriptions for rare earth elements and their compounds and alloys. Therefore, it is of vital importance to unify the terminology used in the rare earth element industry.

About 250 minerals contain significant amounts of rare earth elements although there are only a few that are economically exploited at this time. Various rare earth oxides and other compounds are obtained from these rare earth minerals as they are processed through to intermediate products and on to final products.

This part of ISO 22444 is intended as a guide to terminology for use by producers, consumers and traders in the field of rare earth minerals, oxides and other compounds. This international standard will serve as a reference that will help to reduce discrepancies or trade disputes caused by inconsistencies in terminology used when dealing with rare earth minerals, oxides and other compounds.

Rare earth — Terms and definitions —

Part 1:
Minerals, oxides and other compounds

1 Scope

The document gives the general terms and definitions to be used for rare earth minerals, oxides and other compounds as well as the relative production process.

This standard/document can be used as a reference to unify technical terms in rare earth production, application, inspection, circulation, trading, scientific research and education.

2 Normative references

There are no normative references in this document.

3 General terms and definitions

3.1 Rare earth element

The International Union for Pure and Applied Chemistry (IUPAC) approved the term “rare earth metals” as a collective name for scandium, yttrium, and the lanthanoids (La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu) in its 2005 Nomenclature of Inorganic Chemistry Recommendations (ISBN 0-85404-438-8). The seventeen rare earth metals are further defined in Annex 1.

Certain terms and corresponding abbreviations are common such as rare earth elements (REE or RE) and rare earth oxide (REO). The rare earth elements are frequently referred to as being either light rare earths (LREE), medium rare earths (MREE) or heavy rare earths (HREE) with the LREE including the elements between La and Nd, the MREE including the elements between Sm and Gd and the HREE including the elements from Tb to Lu as well as Sc and Y.

Didymium, which is commonly used to express a mixture of the elements Pr and Nd.

3.2 Rare earth mineral

A rare earth mineral is a mineral containing one or more rare earth elements. The rare earths might be present as a simple compound, incorporated in the lattice of another mineral, or sorbed to another mineral, such as bastnaesite, monazite, or montmorillonite as in the ionic clay deposits.

3.3 Rare earth ore

Rare earth mineralization is found in nature in various types of ore deposit. Those deposit types that are now, or have previously been, commercially exploited include Baiyun Obo ore, ion-adsorption rare earth ores, carbonatite/alkali pipes, weathered carbonatites and beach sands.

3.4 Rare earth deposit

A rare earth deposit is an area or volume of the earth’s crust where there is an accumulation of rare earth minerals, with or without other valuable minerals, such that the deposit is of economic interest.

3.5 Rare earth grade

The rare earth grade is the mass fraction of rare earth oxide (REO) in the deposit/concentrate or tailings. The grade can be presented as a percentage or as either kg/t or g/t. Statements of grade must clearly state if the data are given on a REE, RE or REO basis.

When a rare earth metal mass is converted to oxide mass, all REE should be taken as trivalent except for the following oxide forms: ceric oxide– CeO_2, praseodymium oxide- Pr_6O_{11} and terbium oxide - Tb_4O_7.

3.6 Rare earth mineral resource and mineral reserve

Resources of ore or minerals containing rare earths, which can be mined legally and profitably under existing conditions. The indicated reserve is the estimate of ore computed from boreholes, outcrops, and developmental data, and projected for a reasonable distance on geologic evidence.

3.7 Rare earth content

The rare earth content of a material is the mass fraction of rare earths in the material. For rare earth oxides and other compounds, the fraction is generally provided as a percentage of the oxide, i.e, % REO. For metals and alloys, the content is generally provided as a percentage of the metal, i.e., % RE. For products containing a mixture of rare earths, the total rare earth content can be stated.

3.8 Rare earth distribution

The rare earth distribution in a material containing a mixture of rare earths is the mass fraction of each individual rare earths in the material to the total rare earth content of the material. The distribution is normally expressed as the percentage of RE for metals and alloys and percentage of REO for compounds and other materials.

3.9 Average molar mass of mixed rare earth compounds

The average molar mass of rare earths in the mixed rare earth compounds is the ratio of total mass of all rare earth compounds to their total number of moles.

$$\bar{M} = \frac{m_{total}}{n_{total}} = \frac{\sum_{i=1}^{N} m_i}{\sum_{i=1}^{N} \frac{m_i}{M_i}} = \frac{m_1 + m_2 + \ldots + m_N}{\frac{m_1}{M_1} + \frac{m_2}{M_2} + \ldots + \frac{m_N}{M_N}} .$$

where

$\bar{M}$ is the average molar mass of mixed rare earths, g/mol

m_{total} is the total mass of mixed rare earths, g

n_{total} is the total number of moles of mixed rare earths, moles

m_i is the mass of rare earth compound i, i=1,2,……,N , g

M_i is the molar mass of rare earth compound i, i=1,2,……,N. The basic unit of calculation is $1/x(RE_xB_y)$, g/mol.

For example:

Example 1: The average molar mass of a mixed rare earth oxide, which contains 40% mass of lanthanum oxide and 60% of yttrium oxide, is calculated as follows:

m_{La2O3}=40 units,m_{Y2O3}=60 units,M_{La}=325.81/2 = 162.90 g/mol,M_Y= 225.81/2 = 112.90 g/mol

$$\bar{M}=\frac{40+60}{\frac{40}{162.9}+\frac{60}{112.9}}=128.7\,g/mol$$

Example 2: The average molar mass of the mixed rare earth oxide, which contains 25% of praseodymium oxide and 75% of neodymium oxide, is calculated as follows:

m_{Pr6O11}=25 units,m_{Nd2O3}=75 units,M_{Pr}=1021.44/6 = 170.24 g/mol,M_{Nd}=336.48/2 = 168.24 g/mol

$$\bar{M}=\frac{25+75}{\frac{25}{170.2}+\frac{75}{168.2}}=168.7\,g/mol$$

Example 3: The average molar mass of the mixed rare earth chloride, which contains 40% of lanthanum chloride and 40% of cerium chloride, is calculated as follows:

m_{LaCl3}=40 units, m_{CeCl3}=60 units, M_{LaCl3}= 245.26 g/mol, M_{CeCl3}=246.48 g/mol

$$\bar{M}=\frac{40+60}{\frac{40}{245.26}+\frac{60}{246.48}}=246.0\,g/mol\ .$$

3.10 purity

3.10.1 Rare earth impurity

An undesirable rare earth element apart from the target rare earth components in a rare earth product.

3.10.2 Non-rare earth impurity

An undesirable non-rare earth component in a rare earth product. such as Fe, Al, Ca, SO_4^{2-}, sand, etc.

3.11 Purity

3.11.1 Rare earth purity

The rare earth purity is the mass fraction of a specified rare earth element or oxide in a rare earth product expressed as a percentage and with the basis (REE or REO) stated. It is also called absolute rare earth purity.

Note The content of target element in the oxide, metal or compound is expressed by purity when the content is higher than 90%.

3.11.2 Relative rare earth purity

The relative rare earth purity is the mass fraction of the specified rare earth element or oxide out of the total rare earth content, expressed as a percentage. and with the basis (REE or REO) stated.

4 Rare earth minerals and ore

4.1 Rare earth minerals

4.1.1 Bastnaesite

The formula of bastnaesite is (Ce,La,Nd,Pr) CO_3F. The colour is yellow, reddish brown, light green or brown. The total rare earth oxide content is usually with the range of 65 to 75% REO. The Mohs hardness