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Rare earth — Terms and definitions —

Part 2:
Metals and their alloys

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Foreword

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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).

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For an explanation on 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 the following URL: www.iso.org/iso/foreword.html.

The committee responsible for this document is Technical Committee *[or Project Committee]* ISO/TC *[or ISO/PC]* 298, *[rare earth]*, Subcommittee SC ##, *[name of subcommittee]*.

This second/third/... edition cancels and replaces the first/second/... edition (ISO 2019#:2019), which has been technically revised.

The main changes compared to the previous edition are as follows:

— xxx xxxxxxx xxx xxxx

A list of all parts in the ISO 2019# series can be found on the ISO website.

Introduction

Rare earth metals and their alloys are key raw materials for developing high-performance rare earth functional materials, such as hydrogen-storage materials, magnetic materials and superconducting materials, and are widely used in fields such as sustainable energy, robotics and electronic information.

Rare earth metals are also important additive elements for aluminium-base, magnesium-base, copper-base, titanium-base and other alloys.

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

Rare earth — Terms and definitions —

Part 2:
Metals and their alloys

1 Scope

This document gives the general terms and definitions to be used for rare earth metals and their alloys, as well as for methods of preparation and purification.

This standard 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

The following ISO standard, in whole or in part, is normatively referenced in this document and indispensable for its application.

ISO 22444-1, *Rare earth – Terms and definitions – Part one: minerals, oxides and other compounds*

3 General Terms and definitions

3.1 Impurity

3.1.1 Rare earth impurity

An undesirable rare earth element presents in a rare earth metal or alloy other than the specified rare or target earth element(s).

3.1.2 Non-rare earth impurity

An undesirable non-rare earth element presents in a rare earth metal or alloy.

3.1.3 Interstitial impurity

An undesirable, non-metallic element such as hydrogen, boron, carbon, nitrogen, or oxygen occupying interstitial positions in the lattice of rare earth metal or alloy.

3.2 Rare earth metal content

Mass fraction of rare earth elements in rare earth metal or alloy provided as a percentage of the metal generally, i.e., %TREM, where TREM stands for the mass of total rare earth metal.

3.3 Average atomic mass of rare earths in mixed rare earth metals or alloys

The average atomic mass of rare earths in a mixed rare earth metal or their alloy is the ratio of total mass of rare earth elements to their total number of moles.

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

where

$\bar{M}$ is average atomic mass of rare earths in the mixed rare earth metal or their alloy, g/mol

m_{total} is total mass of rare earth elements, g

n_{total} is total number of moles of rare earth elements, moles

m_i is mass of rare earth element i, i=1,2,....., N, g

M_i is atomic mass of rare earth element i, i =1, 2, ..., N, g/mol

For example:

Example 1: The average atomic mass of a mixed rare earth metal, which contains 20% mass of praseodymium and 80% of neodymium, is calculated as follows:

m_{Pr}=20 units,m_{Nd}=80 units,M_{Pr}= 140.9077 g/mol,M_{Nd}= 144.24 g/mol

$$\bar{M}=\frac{20+80}{\frac{20}{140.9077}+\frac{80}{144.24}}=143.56\,\text{g/mol}$$

Example 2: The average atomic mass of rare earths in Tb-Dy-Fe magnetostrictive materials, which formula is $Tb_{0.3}Dy_{0.7}Fe_2$, is calculated as follows:

M_{Tb}=158.9254 g/mol, M_{Dy}=162.5 g/mol, M_{Fe}=55.847 g/mol

m_{Tb}=M_{Tb}×0.3/(M_{Tb}×0.3+ M_{Dy}×0.7+ M_{Fe}×2) ×100=17.46 units

m_{Dy}=M_{Dy}×0.7/(M_{Tb}×0.3+ M_{Dy}×0.7+ M_{Fe}×2) ×100=41.65 units

$$\bar{M}=\frac{17.46+41.65}{\frac{17.46}{158.9254}+\frac{41.65}{162.5}}=161.43\,\text{g/mol}$$

3.1 Purity

3.1.1 Rare earth metal purity

The rare earth metal purity is the mass fraction of a specified rare earth element in a metal expressed as a percentage. It is called absolute rare earth metal purity.

3.1.2 Relative rare earth metal purity

The relative rare earth metal purity is the mass fraction of the specified rare earth element out of the rare earth metal content, expressed as a percentage.

4 Rare earth metal

A metallic substance containing one or more rare earth elements.

4.1 Individual rare earth metal

A metallic substance containing only one rare earth element, including La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Sc and Y. The basic information of each rare earth element is given in Annex A-table 1 of part 1 and the basic properties of rare earth metals is given in Annex A of table 1 of this document.

4.2 High purity rare earth metal

Individual rare earth metal with a minimum purity of 99.9%. The main impurities to be controlled typically include rare earth impurities, Si, K, Na, Ca, Mg, Al, Ti, Ni, Co, Mn, Cu, Fe, Pb, Zn, Sn, Cd, Ta, Nb, Cr, W, Mo, C, S, P, Cl, F, N and O.

4.3 Mixed rare earth metal

A metallic substance containing two or more rare earth elements.

4.3.1 Mischmetal

Mixed metal mainly containing Ce and La as major components, with small amounts of Nd, Pr, etc., whose compositional ratio is typically similar to that found in the resource minerals.

4.3.2 Didymium/Pr-Nd metal

A metallic substance containing the rare-earth elements Pr and Nd, and occasionally represented by the abbreviation Di. The content of Pr in Di is generally more than 18%.

4.3.3 La-Ce metal

A metallic substance containing La and Ce.

5 Rare earth alloy

A metallic substance containing one or more rare earth elements and one or more non-rare earth metal(s) or semi-metal element(s). The alloys may be compounds, solid solutions, intermetallics, or mixtures of the components.

5.1 Rare earth master alloy

A rare earth alloy of selected elements that can be added to a charge of molten metal to provide a desired composition or texture or to deoxidize the material.

5.1.1 Rare earth ferroalloy

An alloy containing Fe and one or more rare earth elements. The main rare earth ferroalloys are Dy-Fe, Gd-Fe, Ce-Fe and Ho-Fe alloy.

5.1.2 Rare earth ferrosilicon alloy

A ferroalloy typically containing 35~50% Si by mass with the remainder being Fe and one or more rare earth elements. Other elements such as Mg, Al, Mn and Ca are often also present.