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Rare earth — Recyclable neodymiumNeodymium iron boron (NdFeB) resources — Classification, general requirements and acceptance conditions

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This document was prepared by Technical Committee ISO/TC 298, *Rare earth*.

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Introduction

Rare earth elements (REEs) are an important ingredient in products such as magnets, luminous devices and catalysts. Among these, magnets, especially neodymium iron boron ($Nd_2Fe_{14}B$ or NdFeB in shortened form), consume more than a mass fraction of 30 % of rare earths. The process of exploring and producing rare earths is causing pressure on the environment due to the use of different kinds of chemical agents as well as the resulting emissions of waste water, slag, dust and gas. In addition, there are limited primary rare earth resources available for economically viable production across the world. The recovery of rare earth from industrial products (including scraps and sludge) and end-of-life (EOL) products will help address these problems, particularly from a long-term perspective.

The NdFeB magnet is the permanent magnet of choice in many products, including in the motors of electronic vehicles and hard discs in computers, and is a key component of air conditioners. The use of both sintered and bonded NdFeB products has grown steadily during the last several decades at an average annual growth rate of around 9 % and 6,2 %, respectively~~[1].~~[1] The steady growth of NdFeB production has led to an increase in recyclable resources, especially sintered NdFeB scrap. These recyclable NdFeB resources contain not only about 30 % of REEs, but also other valuable elements such as Co, Ni, Ga, etc., which shows there is significant potential in recycling these resources to effectively supplement rare earth resources.

In addition, when the products containing NdFeB magnets come to the end of their lives, there will be an increase in EOL products. Therefore, recycling rare earth from recyclable NdFeB resources can meet a substantial part of the demand for global light (Nd and Pr) REEs and heavy (Dy and Tb) REEs.

However, a challenge for recycling rare earth is that the recyclable NdFeB resources from different sources and processes can vary significantly in form, shape, chemical composition, phase structure, etc., leading to quite complex and diverse recycling methods. ~~Figure 1~~Figure 1 provides an example of sintered NdFeB (S-NdFeB), which accounts for about 90 % of the total market~~[2].~~[2] to illustrate some of the typical recyclable resources from EOL products and industrial processes, and the recycled products that can be created using a highly efficient and low polluting recovery method as follows:

— ~~—~~For some large sintered NdFeB magnets from EOL products, after removing the coating, the cleaned magnet can be used as raw materials and can be further manufactured into sintered NdFeB magnets.

— ~~—~~NdFeB sludge from industrial products in the machining stage is usually recycled into NdFeB powders or magnets by using a combination of calcium thermal reduction and sintering, or into REE compounds by using hydrometallurgy or thermometallurgy, depending on the oxidation and main phase structure of the sludge.

— ~~—~~Scraps including unqualified bulk, residual powder and other recyclable resources from different processing stages can be applied in different steps of the sintering process and regenerated into recycled NdFeB magnets according to the phase, and the degree of contamination and oxidation.