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Traceability of rare earths in the supply chain from mine to separated products

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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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, 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 www.iso.org/iso/foreword.html.

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

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The adoption of a traceability system is a strategic decision for an organization that can help provide a sound basis for a sustainable supply chain. A traceability system is a useful tool to assist an organization operating within a rare earth supply chain to achieve defined goals and objectives within their overall management system(s). The choice of how a traceability system is defined is influenced by regulations, product characteristics and end user expectations. The complexity of the traceability system can vary depending on the nature of the product(s) within the supply chain, the sources of inputs and the objectives to be achieved.

The implementation of a traceability system by an organization depends on:

— technical limits inherent to the supply chain organization and products (i.e. nature of the raw materials, size of the lots, collection and transport procedures, processing and packaging methods);

— the cost benefits of applying such a system;

— the characteristics of mining and processing;

— the environmental impact, waste treatment and disposal processing.

The potential benefits of implementing the traceability system defined in this document are:

— the ability to trace rare earth materials and products between mine and separated products;

— reduction and prevention of pollution;

— promotion of environmentally responsible and sustainable production of rare earths throughout the supply chain;

— to align a rare earth supply chain with sustainable development goals;

— to provide better service for users/customers by supplying quality products.

This document can be used by all participants in the rare earth supply chain. However, this document does not specify the need for:

— complete uniformity in the structure of traceability systems for different rare earth supply chains;

— alignment of documentation to the clause structure of this document;

— use of specific terminology within the rare earth supply chain.

In this document, the following verbal forms are used:

— “shall” indicates a requirement;

— “should” indicates a recommendation;

— “may” indicates a permission;

— “can” indicates a possibility or capability.

Information marked as “NOTE” is intended to assist the understanding or use of the document. “Notes to entry” used in Clause 3 provide additional information that supplements the terminological data and can contain provisions relating to the use of a term.

This document describes a traceability system covering the rare earth supply chain between the originating mine and separated rare earth products. This document is intended to give supply chain members the ability to access information relating to rare earth materials or products as they pass through the supply chain. This information will include the identity of each business in the supply chain which has handled the rare earth material or product shipment. This makes it possible for the purchasers and suppliers of separated rare earth products to identify the businesses in the supply

chain that process a given shipment of rare earth material, and the location of that rare earth material as it passes between supply chain nodes.

The following types of businesses in the rare earth supply chain are considered in this document.

a) Mines, in which rare earth-bearing minerals are:

   1) extracted as ore from the ground in solid form by underground, open-pit or dredge mining methods;

   2) extracted as a rare earth-bearing solution from the ground using in situ leaching/recovery methods, or as a solution using heap or vat leaching methods;

   3) extracted from tailings or other wastes that contain rare earths.

b) Recycling operations, in which waste, scrap, tailings or end-of-life materials containing rare earths are reprocessed to produce a rare earth containing material suitable as input to a beneficiation, hydrometallurgical or separation plant.

c) Beneficiation plants, in which solid ore containing rare earth minerals is processed to concentrate the rare earth minerals into one or more mineral concentrates.

d) Hydrometallurgical plants, in which either:

   1) rare earth mineral ore or beneficiation plant product are dissolved, and the solution processed;

   2) an in situ or heap leach or vat leach solution, is processed.

   NOTE In either case, the hydrometallurgical plant produces a relatively pure precipitated solid, salt or concentrated solution, containing mixed rare earths and suitable as feed to a separation plant.

e) Separation plants, in which mixed rare earth products from hydrometallurgical plants are separated into one or more relatively pure products each containing one or more specific rare earths to the substantial exclusion of other rare earths. Separation plant products are further processed into alloys, magnets, catalysts and other materials in downstream operations outside the rare earth supply chain considered in this document.

f) Traders, brokers and wholesalers: entities that handle rare earths, generally the products of hydrometallurgical and separation plants, possibly re-package or blend material, but otherwise do not change the chemical or physical nature of the rare earth-bearing material.

g) Transporters: businesses that move rare earth products between different businesses in the rare earth supply chain.

The connections between the businesses are illustrated in Figure 1.

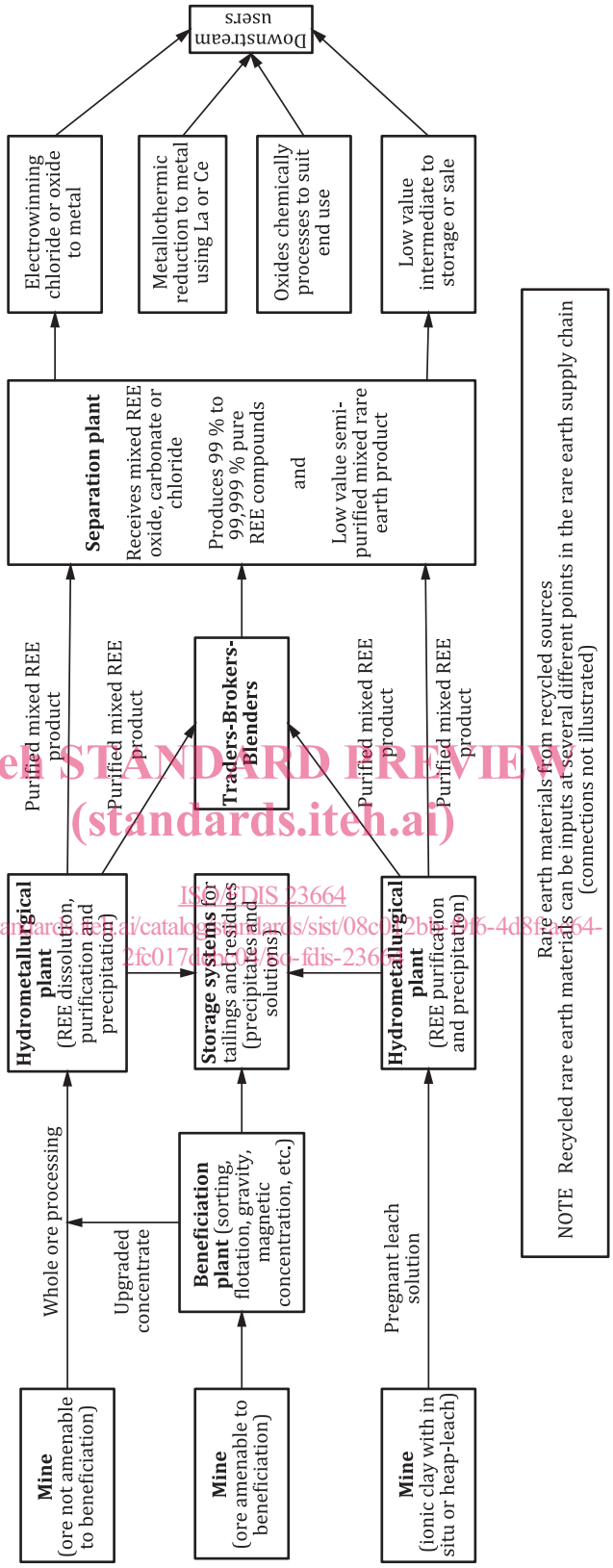

Figure 1 — Overview of rare earth supply chain — Mine to separated products

Some business entities conduct more than one of these activities either at a single site or at two or more sites. For example, it is common for a mine to own and operate a beneficiation plant, so its product is an upgraded concentrate rather than whole ore. It is also common for a mining company to own and operate a hydrometallurgical plant to process its ore or mineral concentrate and then ship a purified

mixed rare earth product to a separation plant or to a trader. Traders can be involved in the supply chain, as indicated, but also in the marketing of mineral concentrates.

Recycled rare earth materials can be inputs at several points in the supply chain model described in Figure 1. Recycling can comprise significant inputs or outputs for some rare earth supply chain nodes. By their nature, it is often difficult to trace the origin of the rare earths in recycled materials, since the recycled material can include end-of-life material from products produced many years earlier. Consequently, it is possible that a percentage of the material in the supply chain will not be traceable back to a source. If recycling is an important input or output for a supply chain, it is the responsibility of the supply chain partners to define and disclose how recycling will be handled to meet the overall objectives of the traceability system (see 4.1).

The scheme specified in this document does not provide guidance on how to account for supply chain mass balance (see 5.3). The methodology for determining mass balance can be unique to each rare earth supply chain. It is anticipated that some of the methodologies being developed by ISO/TC 308, *Chain of custody*, will give insight into how mass balance should be defined and addressed in the context of this traceability standard. However, until such a standard on mass balance is achieved, it will be the responsibility of the rare earth supply chain to provide the framework and justification for their mass balance calculations that would support their traceability claims.

The scheme specified in this document does not demand perfect traceability. There will be occasions where whole chain traceability of rare earth materials and products is neither possible nor commercially practical. Also, some supply chains focus on certain rare earth elements rather than on the full suite of rare earth elements. For example, the focus can be on neodymium-praseodymium oxide (or NdPr oxides) which is a precursor material for NdFeB magnets versus total rare earth oxides (TREOs). Rather than providing full traceability for all the rare earth elements, some supply chains choose to focus on this subset. These limitations and choices should be recognized and should not be taken as a nonconformity of an otherwise conforming rare earth supply chain traceability system.

Traceability may also be viewed as bidirectional. Although the scheme specified in this document focuses on the traceability of rare earths from mine to separated oxides, there can be circumstances in which the backward flow of traceability information from downstream to upstream can be advantageous. Reverse information flows from downstream users to suppliers can include information on the distribution of rare earths in different supply chain channels and downstream use applications. The bidirectional flow of traceability information benefits the downstream users by providing provenance information on the rare earths incorporated into their products, while upstream suppliers benefit through better connections with the downstream users which can allow the supplier to provide better products and services to meet the downstream demand.

Given that rare earth supply chains operate within and between different countries and varying legal requirements, this document cannot stipulate all the requirements for every situation. A measure of flexibility is allowed for supply chain businesses to record further supplementary transaction information in their own non-standardized format but following the same transaction information requirements specified in this document.

The extension of the traceability of rare earths in the supply chain from mine to separated products is expected. This extension beyond the separated products is important in order to provide assurance to consumers that their products contain traceable rare earths and to align the entire rare earth supply chain from mine to finished goods with sustainable development goals. In the immediate future, the most logical extension would be to focus on the traceability of rare earths in the supply chain from separated rare earth products to permanent magnets, such as NdFeB and SmCo. It is possible that other supply chains in which rare earths are an important component, such as catalysts, will also be covered in separate traceability standards. It is anticipated that ISO/TC 298, in tandem with other ISO Technical Committees, will work to draft such traceability standards as a companion to this document.

Traceability of rare earths in the supply chain from mine to separated products

1 Scope

This document specifies requirements for, and gives guidance on, the design and use of a traceability system in a rare earth supply chain. It specifies the information to be recorded by supply chain businesses for rare earth materials or products passing through the supply chain from mine to separated products.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 9000, *Quality management systems — Fundamentals and vocabulary*

ISO 22444-1, *Rare earth — Vocabulary — Part 1: Minerals, oxides and other compounds*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 9000, ISO 22444-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
beneficiation plant
node (3.8) that receives unprocessed ore from mines and produce a *rare earth concentrate* (3.11) using various methods, such as gravity or magnetic concentration, or froth flotation

3.2
confidential information
information related to product *traceability* (3.22) that a company possesses which, although it is possible to share with a *counterparty* (3.3), usually within a non-disclosure agreement, it does not wish to become public

Note 1 to entry: Information can be considered confidential by the possessor because of legal or business reasons.

3.3
counterparty
business or other *entity* (3.6) that either supplies or receives rare earth-bearing materials or products, to or from a given party

Note 1 to entry: It is possible that a party's counterparties will be its *supplier* (3.19) of rare earth-bearing materials or product, or the customer to whom it supplies rare earth-bearing materials or products.

3.4
data matrix code
DM
two-dimensional code that contains encoded data

Note 1 to entry: There are several data matrix systems in use including quick response (QR) code (see ISO 17367), portable data file (PDF417) (see ISO/IEC 15438), and Han Xin code (see ISO/IEC 20830).

3.5
downstream user
customer that buys or uses, or both, *rare earth materials* (3.12) or products, in separated or unseparated forms

3.6
entity
node (3.8) that exists separately from other nodes and has a clear identity of its own

3.7
hydrometallurgical plant
node (3.8) that receives ore from mines or mineral concentrates from *beneficiation plants* (3.1) or solutions from in situ leach operations that extracts rare earths away from other elements by a series of chemical or thermal, or both, processes, and generates a purified mixed *rare earth concentrate* (3.11)

3.8
node
rare earth supply chain business or organization

EXAMPLE Rare earth mine, *beneficiation plant* (3.1), *hydrometallurgical plant* (3.7), *separation plant* (3.17), *trader* (3.25).

Note 1 to entry: Other nodes not identified in this document may also be considered as part of the *traceability system* (3.24) if their contribution to the rare earth supply chain is substantial (e.g. sources of *recycled rare earth materials* (3.14)).

Note 2 to entry: The movement between nodes is generally downstream, although lateral movements are possible (e.g. from one separation plant to another, or upstream movement, such as the reprocessing of recycled material scrap sources of rare earths or off-specification rare earth material). The movement of material through a rare earth supply chain can include substantial holding periods while material is being warehoused or passing through a process with a long residence time.

3.9
primary producer
business or company involved in primary production of *rare earth ores* (3.10) or *rare earth materials* (3.12)

EXAMPLE Rare earth mine, ionic clay processor.

3.10
rare earth ore
naturally occurring solid material containing rare earth minerals that can be commercially exploited

3.11
rare earth concentrate
material containing a preponderance of rare earths, obtained by physical or chemical processes, and in the form of a solid or solution

Note 1 to entry: The concentrate can be obtained from an ionic clay deposit by in situ dissolution followed by solution purification and precipitation of the rare earths, or from an ore or concentrate by leaching followed by solution purification and precipitation of the rare earths.

3.12
rare earth material
inputs to manufacturing processes containing rare earths used to produce products or more complex or refined materials containing rare earths

3.13
rare earth containing material
material in which the rare earth content is not the primary constituent

3.14
recycled rare earth material
recycled magnets, industrial waste or scrap from rare earth permanent magnet manufactures, other rare earth *downstream users* (3.5) and rare earth end-of-life recyclers

Note 1 to entry: This includes end-of-life lamp phosphors, catalysts, *tailings* (3.20), or other waste materials containing rare earths.

3.15
rare earth oxide
compound that contains only rare earths and oxygen

Note 1 to entry: Generally, the formula for a rare earth oxide is RE_xO_y where x is 2 and y is 3.

Note 2 to entry: Three of the rare earth oxides have different formulae, specifically CeO_2, Pr_6O_{11} and Tb_4O_7.

3.16
radio frequency identification
RFID
use of a device applied to or incorporated into a product for the purpose of identification and tracking using radio waves

Note 1 to entry: The device is commonly referred to as an "RFID tag".

3.17
separation plant
plant that receives purified mixed *rare earth concentrate* (3.11) either directly from *hydrometallurgical plants* (3.7) or from *traders* (3.25) and separates the feed material into several purified *rare earth materials* (3.12) that are purchased by *downstream users* (3.5)

Note 1 to entry: The products are purchased to produce metal, alloys, magnets, ceramics, catalysts, etc.

3.18
ship-to-party
person or business that receives goods or materials

3.19
supplier
company that produces and provides *rare earth ores* (3.10), *rare earth concentrates* (3.11), compounds, metals, alloys or solutions for its customer

Note 1 to entry: It includes the mines, *beneficiation plants* (3.1), *hydrometallurgical plants* (3.7) and *traders* (3.25) of *rare earth materials* (3.12).

3.20
tailings
materials left over from various processes, such as mining, beneficiation, hydrometallurgical or solvent extraction