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Railway applications — Recyclability and recoverability calculation method for rolling stock

Applications ferroviaires — Méthode de calcul de recyclabilité et valorisabilité pour matériel roulant

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Foreword

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This document was prepared by Technical Committee ISO/TC 269, *Railway applications*, Subcommittee SC 2, *Rolling stock*.

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

Rolling stock products are generally designed for operational safety, availability and reliability with the consideration to minimize any impact on society and environment. The treatment and environmentally sound disposal of end-of-life products are the desirable environmental priority of railway industry. This needs a common method to describe the end-of-life treatment of rolling stock products.

In order to benchmark the theoretical recyclability and recoverability of rolling stock, common calculation rules have been introduced in this document, which has been developed considering the work of UNIFE Life Cycle Assessment topical group between 2009 and 2011[5].

The calculation approach is based on common recycling practice. Throughout a life cycle perspective, the method adopts railway specific requirements for necessary material information.

End-of-life treatment processes are divided into three stages; pre-treatment, dismantling and shredding. Pre-treatment and dismantling calculations consider recycling and recoverability properties of the materials specific to these stages. At each stage, individual material flows are split into materials for recycling and materials for recoverability, depending on the availability of appropriate technology for recycling and/or recoverability. Therefore, knowledge of materials and dismantling of rolling stock or equipment is essential. The entire supply chain needs to be involved because material information is crucial when using this calculation method. This harmonized calculation method for recyclability and recoverability for rolling stock is intended to prevent misleading data gaps and contradictions.

The primary aim of this calculation method is for the rolling stock domain and other related interfaces with other subsystems.

The calculation method introduced by this document considers different end-of-life paths such as reuse, recycling and recoverability as well as treatment efficiencies at each stage. This means that this method is developed in order to take into account the efficiencies of recycling and recoverability technologies with regard to each material at the different end-of-life treatment stages. The recyclability and recoverability rates of rolling stock are each expressed as a percentage by mass (mass fraction in percent) after applying efficiency factors for each material of the rolling stock, which can potentially be reused, recycled or recovered.

Railway applications — Recyclability and recoverability calculation method for rolling stock

1 Scope

This document specifies a calculation method of recyclability and recoverability rates for rolling stock.

The method defined in this document applies to the design of new rolling stock. However, it can be applied to other existing rolling stock depending on available information. If calculation of recyclability or recoverability is applied to separate parts and/or products used in rolling stock and a specific calculation standard or method exists for the part and/or product, such standard or method can be applied, if relevant.

This calculation method is applicable regardless of any geographical concern.

This calculation method is applicable to any stage of life cycle of rolling stock. The calculated recyclability and recoverability rates are valid at the point of delivering the rolling stock products or equipment. Future recycling technologies or predicted trends with respect to the recycling industry are excluded from any consideration for this calculation method.

This calculation method considers the four main treatment processes, which are reuse, recycling, energy recovery and disposal (Figure 1). Process losses of recycling are treated in the disposal stage. The residue substances of the energy recovery stage (mostly ash and slag) and the residue of the incineration process of the disposal stage are most likely landfilled.

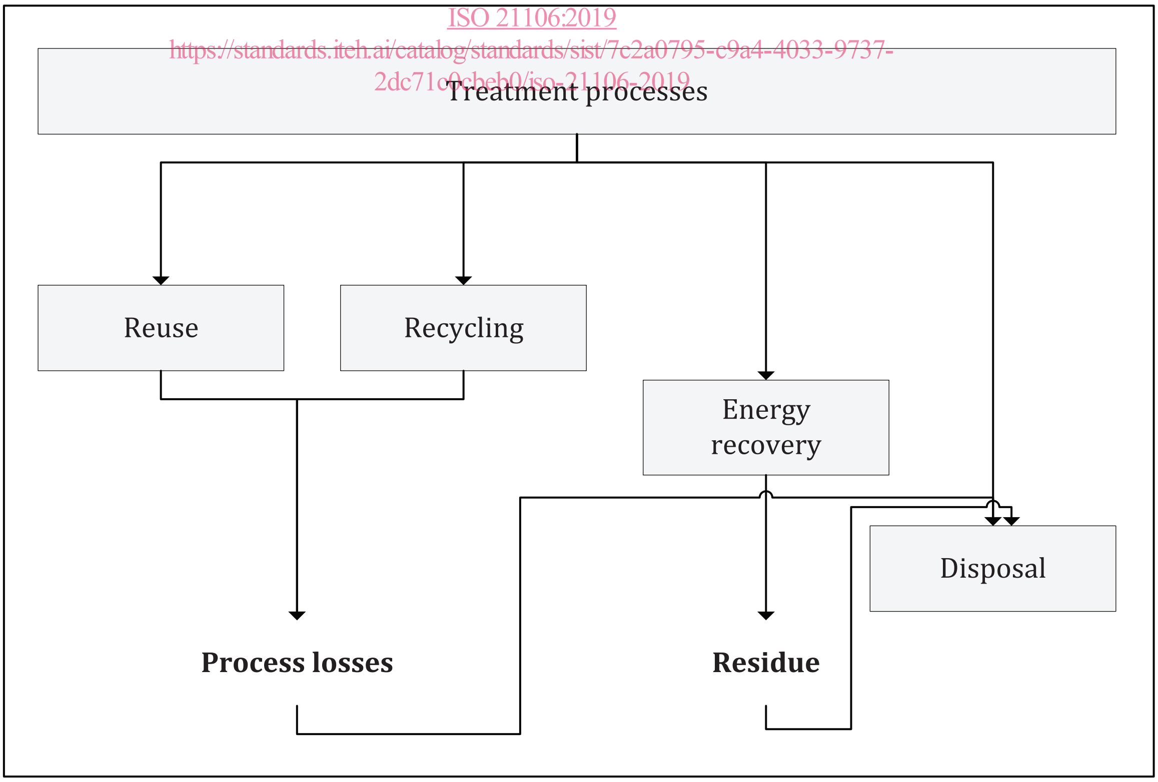

Figure 1 — End-of-life treatment

The application of this calculation method considers the rolling stock or equipment as delivered. Spare parts and/or maintenance parts necessary to keep the rolling stock in service over the entire life cycle, e.g. brake pads, are not taken into account. Also, infrastructure systems like stations, electrification, signal and control units, etc. are excluded from the calculation (Figure 2).

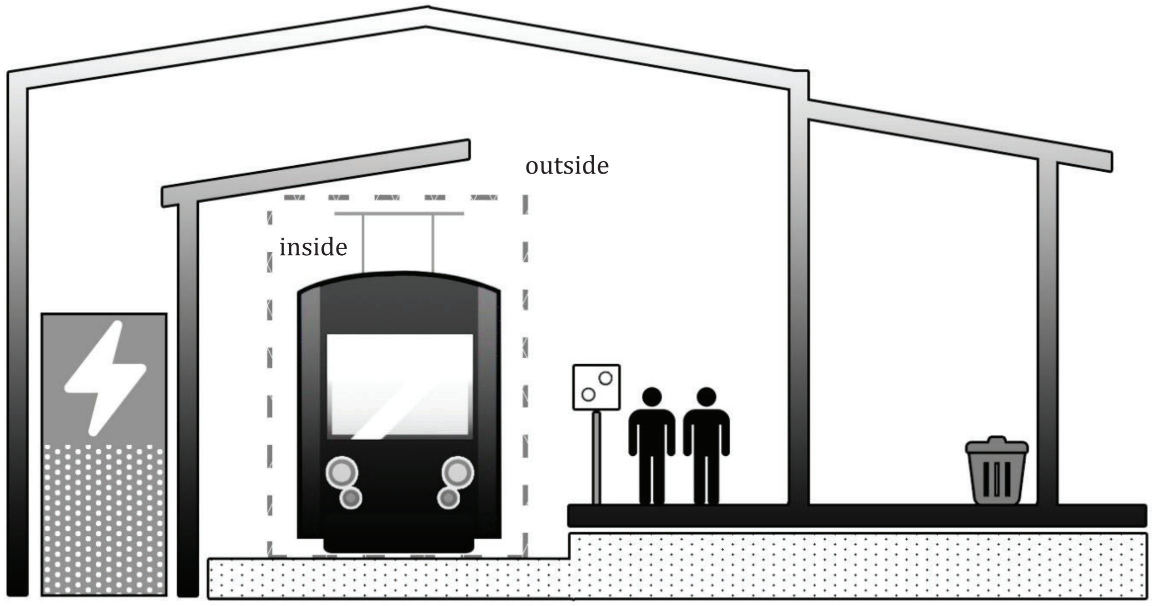

Figure 2 — Scope of the calculation

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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
design mass of rolling stock in working order
m_V
state of the complete mass of rolling stock equipped with all the consumables (e.g., fuel, oil, water, etc.) and without staff, passengers, and payload

[SOURCE: EN 15663:2017, 2.1.2.1, modified — The symbol has been amended and the mass of the staff is not included in the definition.]

3.2
reuse
use components of end-of-life rolling stock for the same purpose as that for which they were designed

Note 1 to entry: See ISO 22628.

3.3
recycle
process the waste materials for the original purpose or for other purposes, excluding processing as a means of generating energy

3.4
recover
process the waste materials for the original purpose or for other purposes, including processing as a means of generating energy

Note 1 to entry: "energy recovery" differs from recovery in that it does only include processing the waste materials with the aim to generate energy.

3.5
reusable
<of a component> suitable to be diverted from an end-of-life treatment to be *reused* (3.2)

3.6
recyclability
suitability of components, materials or both to be diverted from an end-of-life treatment to be *recycled* (3.3)

Note 1 to entry: See ISO 22628.

3.7
recyclability rate
R_{cyc}
percentage by design mass (mass fraction in percent) of the rolling stock potentially able to be *recycled* (3.3), *reused* (3.2) or both

Note 1 to entry: See ISO 22628.

3.8
recoverability
suitability of components or materials to be diverted from an end-of-life treatment to be *recovered* (3.4)

Note 1 to entry: See ISO 22628.

3.9
recoverability rate
R_{cov}
percentage by design mass (mass fraction in percent) of the rolling stock potentially able to be *recovered* (3.4), *reused* (3.2) or both

Note 1 to entry: See ISO 22628.

3.10
residue
mixture of materials remaining from the end-of-life treatment that is not *reused* (3.2), *recycled* (3.3) or *recovered* (3.4)

3.11
shredding loss factor
F_{SL}
shredder process efficiency indicating material mass losses during the process

3.12
shredder heavy fraction
metal fraction from the shredding process that can be further divided into ferrous metal fraction or ferrous fraction composed of pure ferrous materials like steel and iron and its alloys and a non-ferrous metal fraction or non-ferrous fraction containing different metals like aluminium, copper, brass, etc.

3.13
shredder light fraction
non-metallic *residue* (3.10) from the shredding process composed of plastics, rubber, foam, residual metal pieces, paper, fabric, glass, sand, etc.

3.14
material recycling factor
MRF
F_{MR}
suitability of material to be *recycled* (3.3) as materials for secondary products depending on the availability of recycling processes

3.15
energy recovery factor
ERF
F_{ER}
efficiency of process based on material weight to be recovered as usable energy

Note 1 to entry: Energy recovery from material is the conversion of materials into usable heat, electricity, or fuel through a variety of processes, including combustion, gasification, pyrolysis, anaerobic digestion and landfill gas recovery.

Note 2 to entry: As shown in Table 1, the *recyclability rate* (3.7) embraces the percentage by design mass of the rolling stock that can potentially be reused and recycled, while the *recoverability rate* (3.9) includes the percentage by design mass of the rolling stock that can potentially be reused, recycled and recovered as energy.

Table 1 — Overview of key terms

<table>
<tr><th></th><th colspan="2">Recovery</th><th>Residue</th></tr>
<tr><td>(Components)
Reuse</td><td>(Materials)
Recycling</td><td rowspan="2">(Materials)
Energy recovery</td><td rowspan="3">(Materials)
Disposal</td></tr>
<tr><td colspan="2">Recyclability rate[a]</td></tr>
<tr><td colspan="3">Recoverability rate[a]</td></tr>
<tr><td colspan="4">Design mass of rolling stock</td></tr>
<tr><td colspan="4">[a] As a percentage of rolling stock mass.</td></tr>
</table>

4 Symbols and abbreviated terms

Table 2 describes the symbols of the mass variables used in calculating the recyclability and recoverability rates.

Table 2 — Symbols and definitions for masses

Symbol	Description
$m_{AE,i}$	mass of material category *i* available for energy recovery
$m_{AR,i}$	mass of material category *i* available for recycling
$m_{D,E}$	sum of masses of materials considered as energy recoverable at the dismantling stage considering F_{ER} for material category *i*, $\sum m_{D,iE}$
$m_{D,R}$	sum of masses of materials considered as recyclable at the dismantling stage considering F_{MR} for material category *i*, $\sum m_{D,iR}$
$m_{D,Reuse}$	sum of masses of materials which can be considered as reusable at the dismantling stage for material category *i*, $\sum m_{D,iReuse}$
$m_{E,i}$	mass of material category *i* recovered as energy
$m_{P,E}$	sum of masses of materials considered as energy recoverable at the pre-treatment stage considering F_{ER} for material category *i*, $\sum m_{P,iE}$
$m_{P,R}$	sum of masses of materials considered as recyclable at the pre-treatment stage considering F_{MR} for material category *i*, $\sum m_{P,iR}$
$m_{P,Reuse}$	sum of masses of materials which can be considered as reusable at the pre-treatment stage for material category *i*, $\sum m_{P,iReuse}$
$m_{R,i}$	mass of material category *i* recycled
$m_{S,E}$	sum of masses of materials considered as energy recoverable at the shredding stage considering F_{ER} for material category *i*, $\sum m_{S,iE}$
$m_{S,iS}$	mass of material category *i* after applying shredding loss factor at the shredding stage for material category *i*, $m_{S,iS} = m_{S,i} \times (1 - F_{SL})$
$m_{S,R}$	sum of masses of materials considered as recyclable at the shredding stage considering F_{MR} for material category *i*, $\sum m_{S,iR}$
$m_{S,S}$	sum of masses of materials available for the next process after shredding stage considering F_{SL}, $\Sigma m_{S,iS}$
m_V	design mass of rolling stock in working order
m_W	sum of masses of materials considered as residue for material category *i*, $\sum m_{iw}$
$m_{Y,i}$	mass of material category *i* [a] before treatment process Y
$m_{Y,iE}$	mass of material category *i* after applying energy recovery efficiency values of material category *i* at treatment process Y, $m_{Y,iE} = m_{Y,i} \times F_{ER,i}$ [c]
$m_{Y,iR}$	mass of material category *i* after applying material recycling efficiency values of material category *i* at treatment process Y, $m_{Y,iR} = m_{Y,i} \times F_{MR,i}$ [b]

NOTE All masses are expressed in kilograms.

[a] Material category is defined as a group of materials having similar chemical properties, classified in 5.4.

[b] $F_{MR,i}$ is defined as the output of the recycling process divided by the input; it gives an indication of the proportion of the materials actually recycled, which thus provides a more adequate indicator for recycling performance. $F_{MR,i} = \frac{m_{R,i}}{m_{AR,i}}$.

[c] $F_{ER,i}$ for specific material can be obtained from the amount of material actually recovered divided by the total amount of the material available for energy recovery. $F_{ER,i} = \frac{m_{E,i}}{m_{AE,i}}$.

