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Earth-moving machinery — Recyclability and recoverability — Terminology and calculation method

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Earth-moving machinery — Recyclability and recoverability — Terminology and calculation method

Engins de terrassement — Recyclabilité et récupérabilité — Terminologie et méthode de calcul

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ISO 16714 was prepared by Technical Committee ISO/TC 127, *Earth-moving machinery*, Subcommittee SC 3, *Machine characteristics, electrical and electronic systems, operation and maintenance*.

Introduction

End-of-life machines contribute to the total volume of waste to be treated. As part of the machine life cycle, it is essential that recovery issues be taken into consideration during the design phase to ensure environmentally sound treatment.

Today, recycling has to be taken into account in addition to safety, emissions and fuel consumption when designing a machine. Consequently, there is need for an indicator to evaluate the ability and potential of new machines to be recovered/recycled.

The method for calculating recyclability and recoverability rates specified by this International Standard (similar to the one specified in ISO 22628:2002 for road vehicles) is based on four main stages inspired by the treatment of end-of-life machines. Recyclability/recoverability rates depend on the design and material properties of new machines and on the consideration of proven technologies — those technologies which have been successfully tested, at least on a laboratory scale, in this context.

The calculation method of this International Standard cannot in detail reflect the real process that will be applied to the machine at the end of its life.

INTERNATIONAL STANDARD ISO 16714:2008(E)

Earth-moving machinery — Recyclability and recoverability — Terminology and calculation method

1 Scope

This International Standard specifies a method, and defines related terms, for calculating the recyclability rate and the recoverability rate of earth-moving machinery as defined in ISO 6165, each expressed as a percentage by mass (mass fraction in percent) of the machine, which can potentially be

— recycled, reused or both (recyclability rate), or

— recovered, reused or both (recoverability rate).

NOTE Remanufacturing is included in re-use.

The calculation can be performed by the machine manufacturer from the time when a machine is initially put on the market.

2 Normative references

The following referenced documents are indispensable for the application 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 6016, *Earth-moving machinery — Methods of measuring the masses of whole machines, their equipment and components*

ISO 6165, *Earth-moving machinery — Basic types — Identification and terms and definitions*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 6016 and the following apply.

3.1
dismantlability
ability of component parts to be removed from the machine

NOTE Adapted from ISO 22628:2002, definition 3.5.

3.2
end-of-life machine
machine that has completed its useful life and is taken out of service for disposal

3.3
recovery
reprocessing in a production process of the waste materials for the original purpose or for other purposes, together with processing as a means of generating energy

[ISO 22628:2002, definition 3.4]

NOTE See Figure 1.

3.4
recoverability
ability of component parts, materials or both that can be diverted from an end-of-life stream to be recovered

[ISO 22628:2002, definition 3.9]

3.5
recoverability rate
R_{cov}
percentage by mass (mass fraction in percent) of the new machine potentially able to be recovered, reused or both

NOTE 1 Adapted from ISO 22628:2002, definition 3.10.

NOTE 2 See Figure 1.

3.6
recycling
reprocessing in a production process of the waste materials for the original purpose or for other purposes, excluding processing as a means of generating energy

[ISO 22628:2002, definition 3.3]

NOTE See Figure 1.

3.7
recyclability
ability of component parts, materials or both that can be diverted from an end-of-life stream to be recycled

[ISO 22628:2002, definition 3.7]

3.8
recyclability rate
R_{cyc}
percentage by mass (mass fraction in percent) of the new machine potentially able to be recycled, reused or both

NOTE 1 Adapted from ISO 22628:2002, definition 3.8.

NOTE 2 See Figure 1.

3.9
remanufacturing
process by which value is added to component parts of end-of-life machines in order to return them to their original same-as-new condition or better

3.10
reusability
ability of component parts that can be diverted from an end-of-life stream to be reused

[ISO 22628:2002, definition 3.6]

3.11
re-use, noun
any operation by which component parts of end-of-life machines are used for the same purpose for which they were conceived

NOTE 1 Re-use includes **remanufacturing** (3.9).

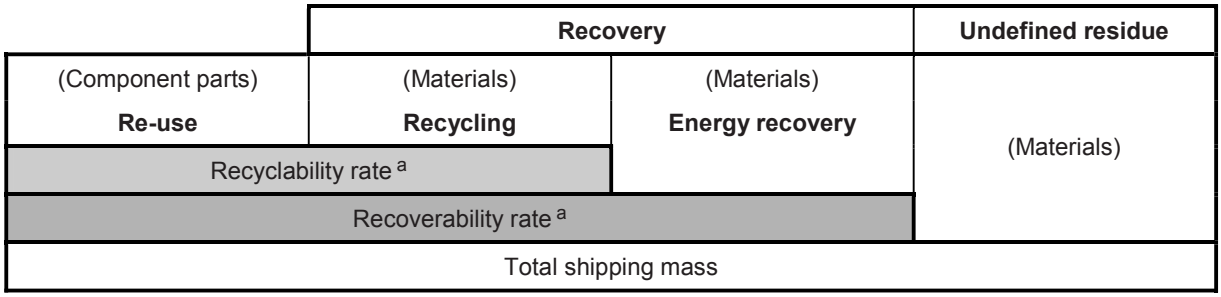
NOTE 2 See Figure 1.

NOTE 3 Adapted from ISO 22628:2002, definition 3.2.

3.12
total shipping mass
m_S
mass of the base machine without an operator, with the fuel level at 10 % of tank capacity or with the minimum fuel level needed for machine shipping purposes as specified by the manufacturer, whichever is higher, with all fluid systems at the levels specified by the manufacturer and with empty sprinkler tank(s), if required, and with equipment, ballast, attachment, cab, canopy, operator-protective structures, wheels and counterweights as specified by the manufacturer and being designated for his production version

NOTE 1 If the manufacturer intends that the machine be partially disassembled for shipping purposes, the masses of the disassembled items are also stated.

NOTE 2 See Figure 1.



[a] As a percentage of machine mass.

Figure 1 — Key terms — Overview

4 Mass variables used in the calculation

Table 1 presents and describes the symbols for the mass variables used in calculating the recyclability and recoverability rates.

Table 1 — Variable masses and their symbols

Symbol	Description
m_P	mass of materials taken into account at the pretreatment step
m_D	mass of materials taken into account at the dismantling step
m_M	mass of metals taken into account at the metals separation step
m_{Tr}	mass of materials taken into account at the non-metallic residue treatment step and which can be considered as recyclable
m_{Te}	mass of materials taken into account at the non-metallic residue treatment step and which can be considered for energy recovery
m_S	total shipping mass
All masses are expressed in kilograms.	

5 Calculation method

5.1 General

The calculation of the recyclability and recoverability rates is carried out through the following four steps on a new machine, for which component parts, materials or both can be taken into account at each step:

a) pretreatment;

b) dismantling;

c) metals separation;

d) non-metallic residue treatment.

A partial mass, m_P, m_D or m_M, is determined, respectively, at each of the first three steps (see 5.3.1 to 5.3.3), while the partial masses m_{Tr} and m_{Te} are determined at the final step (see 5.3.4).

Annexes A and B give data presentation and a schematic representation of the method.

5.2 Materials breakdown

The materials breakdown, including the machine component parts, materials or both, is established by their classification into the following categories:

a) metals;

b) polymers, excluding elastomers;

c) elastomers;

d) glass;

e) fluids;

f) modified organic natural materials (MONM), such as leather, wood, cardboard and cotton fleece;

g) others (components, materials or both, for which a detailed material breakdown cannot be established, e.g. compounds, electronics, electrics).

The total mass of each category can then be determined (see Annex A).

This breakdown may be done at each step of the calculation for each partial mass mentioned in 5.1.

5.3 Determination of m_P, m_D, m_M, m_{Tr} and m_{Te}

5.3.1 Pretreatment — Determination of m_P

At this step, at least the following machine component parts, materials or both shall be taken into account:

— all fluids;

— batteries;

— oil filters;

— tyres;

— tyre wheels;

— roller drum;

— rubber track;

— rubber shoe pads;

— bucket;

— catalytic converters;

— urea tank.

NOTE Fluids include fuel, engine oil, machine hydraulic system oil, transmission/gearbox oil (including differential or transfer box or both), power steering oil, coolant, brake fluid, shock absorber fluid, air conditioning refrigerant, windscreen washer fluid, engine mounting oil and hydraulic suspension fluid.

For the purposes of the calculation, these component parts and materials are considered reusable or recyclable.

Determine the mass, m_P, as the sum of the masses of these component parts and materials.

5.3.2 Dismantling — Determination of m_D

At this step, certain other of the machine's reusable or recyclable component parts may be taken into account, based on the following.

As a general requirement, a component part shall be considered reusable, recyclable or both based on its dismantlability, assessed by

— accessibility,

— fastening technology, and

— proven dismantling technologies.

NOTE Certain component parts can be reusable through the remanufacturing procedure, based on design life as well as proven remanufacturing technologies and processes.

As a specific requirement, a component part shall be considered recyclable based on

— its material composition, and

— proven recycling technologies.

In order to be recyclable, a component part or material shall be linked to a proven recycling technology.

At this step, at least the following machine component parts, materials or both shall also be taken into account:

— engine;

— hydraulic circuit components (hydraulic pump, hydraulic control valve, swing drive motor, travel drive motor, etc.) excepting flexible hoses, filter cartridges and accumulators;

— operator's cab, including window glass, cab door (if disassembling possible) and operator's seat;

— boom;

— arm;

— counterweight;

— suspension system.

The reusability of a component part shall also be subject to considerations of safety and environmental hazards.

Determine the mass, m_D, as the sum of the masses of all parts considered as reusable or recyclable.

5.3.3 Metals separation — Determination of m_M

At this step, all metals, both ferrous and non-ferrous, that have not already been accounted for in the previous steps shall be taken into account. Both ferrous and non-ferrous metals are considered as recyclable.

Determine the mass, m_M, as the sum of the mass of the metal remaining in the machine after the previous steps.

5.3.4 Non-metallic residue treatment — Determination of m_{Tr} and m_{Te}

Other materials remaining (i.e. those not taken into account at the pretreatment, dismantling and metals separation steps) constitute the non-metallic residue.

At this step, the residual non-metallic recyclable materials, or both these and the residual non-metallic recoverable materials, may be taken into account.

Determine m_{Tr}, as the sum of the mass of non-metallic residue considered as recyclable on the basis of proven recycling technologies (see Table A.1);

Determine m_{Te}, as the sum of the remaining masses that can potentially be used for energy recovery after determination of m_P, m_D, m_M and m_{Tr}.

NOTE Technologies for energy recovery of polymers and elastomers are industrialized on a large scale, world-wide. Polymers, elastomers and other modified organic natural materials can potentially be recovered through those technologies.

5.4 Calculation of recyclability/recoverability rate, R_{cyc}/R_{cov}

5.4.1 Recyclability rate

Calculate the recyclability rate, R_{cyc}, of the machine, as a percentage by mass (mass fraction in percent), using the formula:

$$R_{cyc} = \frac{m_P + m_D + m_M + m_{Tr}}{m_S} \times 100$$

5.4.2 Recoverability rate

Calculate the recoverability rate, R_{cov}, of the machine, as a percentage by mass (mass fraction in percent), using the formula:

$$R_{cov} = \frac{m_P + m_D + m_M + m_{Tr} + m_{Te}}{m_S} \times 100$$

Annex A
(normative)

Data presentation

The data for the calculation shall be reported using the following table, either on paper or in electronic form. The materials breakdown section is optional.

Table A.1 — Presentation of data

Model/Type:					**Total shipping mass,** m_S**:**		kg
Materials breakdown	**Metals**	**Polymers** (excluding elastomers)	**Elastomers**	**Glass**	**Fluids**	**MONM**	**Others**
	Mass (kg)						

Pretreatment (m_P)		**Mass** (kg)	
	All fluids	m_{P1}	
	Batteries	m_{P2}	
	Oil filters	m_{P3}	
	Tyres	m_{P4}	
	Tyre wheels	m_{P5}	
	Roller drum	m_{P6}	
	Rubber track	m_{P7}	
	Rubber shoe pads	m_{P8}	
	Bucket	m_{P9}	
	Catalytic converters	m_{P10}	
	Urea tank	m_{P11}	
		m_P total (sum m_{P1} to m_{P11}) =	

Dismantling (m_D)

Part number	**Name**	**Mass** (kg)	**Part number**	**Name**	**Mass** (kg)	**Mass (part 7 to x)** (kg)	
1			4			m_{Dx} [a]	
2			5				
3			6				
m_{D1} total (sum 1 to 3) =			m_{D2} total (sum 4 to 6) =			m_D total ($m_{D1} + m_{D2} + m_{Dx}$) =	

Metals separation (m_M)		**Mass** (kg)	
	Remaining machine metallic content:	m_M =	

Non-metallic residue treatment (m_{Tr} and m_{Te})	**Recyclable materials** (m_{Tr})				
	Technology number	**Name**	**Mass** (kg)		
	1		m_{Tr1}		
	2		m_{Tr2}		
	3 to x [a]		$m_{Tr3\text{-}x}$		
			m_{Tr} total (sum m_{Tr1} to m_{Trx}) =		
	Energy recoverable materials (m_{Te})			**Mass** (kg)	
	Remaining quantity of organic materials (polymers, elastomers, MONM, etc.):			m_{Te} =	

	Recyclability rate	$R_{cyc} = \frac{m_P + m_D + m_M + m_{Tr}}{m_S} \times 100$	%	
	Recoverability rate	$R_{cov} = \frac{m_P + m_D + m_M + m_{Tr} + m_{Te}}{m_S} \times 100$	%	

[a] Please add a separate list for additional parts or technologies.

Annex B
(informative)

Calculation method

Figure B.1 shows the calculation method schematically.

Calculation steps (subclause) ↓	**Machine elements** General character	List	**Assumptions**	**Mass of machine elements** [a] kg Reusable or Recyclable	Energy recoverable	Undefined residue
1 Pretreatment (5.3.1)	Component parts and fluids	All fluids Batteries Oil filters Tyres Tyre wheels Roller drum Rubber track Rubber shoe pads Bucket Catalytic converters Urea tank etc.	Reusable, recyclable or both	m_P		
2 Dismantling (5.3.2)	Component parts	As declared by machine manufacturer	Reusable, recyclable or both	m_D		
3 Metals separation (5.3.3)	Materials	Metals (ferrous and non-ferrous)	Recyclable	m_M		
4 Non-metallic residue treatment (5.3.4)	Materials	Glass	Recyclable	m_{Tr}	m_{Te}	
		Polymers (excluding elastomers)	Recyclable, recoverable or both [a]			
		Elastomers	Recyclable, recoverable or both [a]			
		MONM	Recyclable, recoverable or both [a]			
		Others	[a]			
				Total shipping mass, m_S		
		Recyclability rate, R_{cyc} (%) =		$\frac{m_P + m_D + m_M + m_{Tr}}{m_S} \times 100$		
		Recoverability rate, R_{cov} (%) =		$\frac{m_P + m_D + m_M + m_{Tr} + m_{Te}}{m_S} \times 100$		

[a] In steps 1 to 4, the apportionment among the three treatment possibilities is as declared by the machine manufacturer and commercially traded by the second-hand parts trader network on each country.

Figure B.1 — Calculation method

Bibliography

[1] ISO 22628: 2002, *Road vehicles — Recyclability and recoverability — Calculation method*

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