13th UIC Sustainability Conference

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Standardization in progress for the recyclability of rollingstock

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12, 13, 14 October 2016

Do we consider sustainability for rolling stock?

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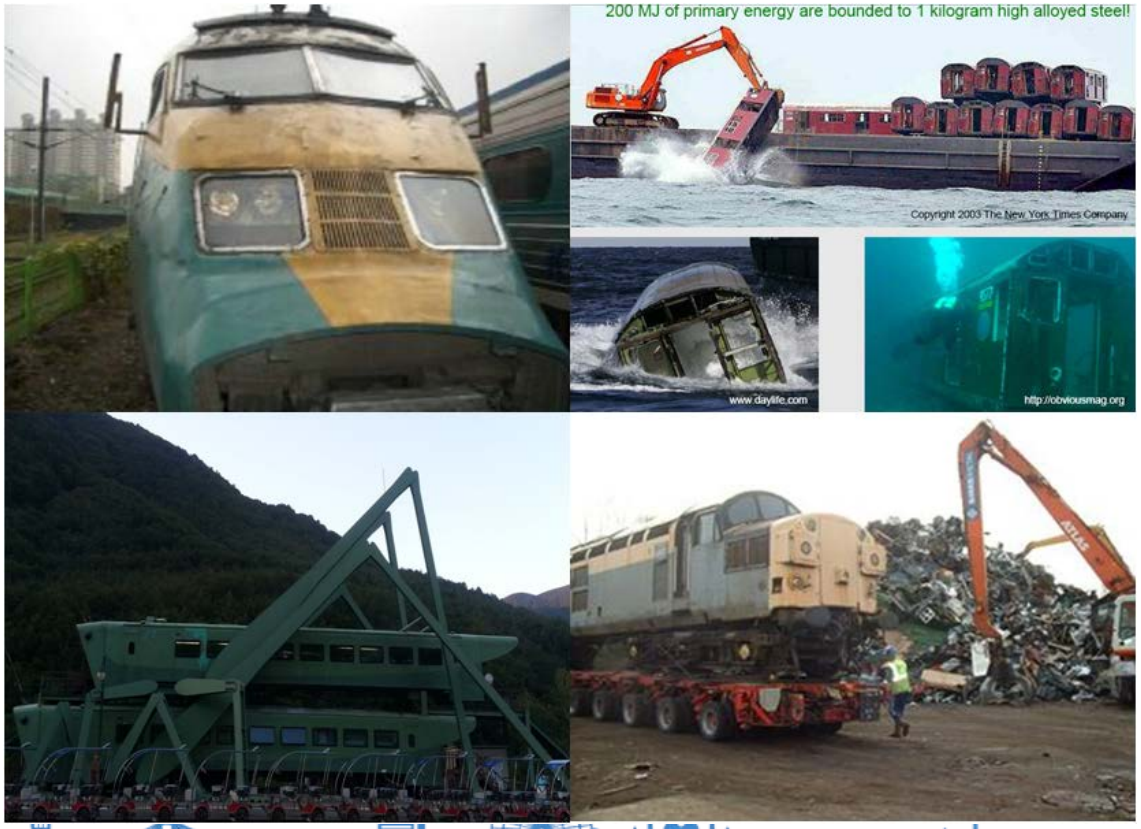
Dismantling?

Train Cafeteria?

Dump in the Sea?

Reuse?



Why don’t we consider dedicated recycling system?

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ELV directives
(Directive 2000/53/EC)

ISO 22628
(Road vehicles – Recyclability and recoverability – Calculation method)

Recycling Facility

Pretreatment

Dismantling

Pressing for Shredder

Automobile industry increasing material recycling

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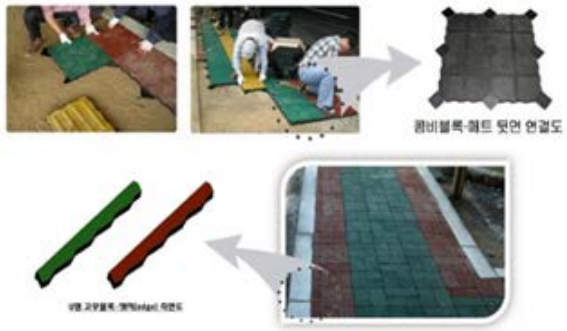
95% RECYCABILITY
(RECOVERABILITY)

IS NOT EASY TO
MAKE REALIZE

Glass Recycling

Plastic Recycling

Battery Recycling



Rubber Recycling

Current International Standard re. Recycling

- Based on ISO 22628, modified considering product's characteristics

  - ISO 16714 : Earth-moving machinery — Recyclability and recoverability — Terminology and Calculation method
  - ISO 13714 : Manually portable forest machinery — Recyclability and recoverability — Calculation method

- In the case of ship, consists of recycling system and management

Ship recycling management systems -

- ISO 30000 : Specifications for management systems for safe and environmentally sound ship recycling facilities
- ISO 30002 : Guidelines for selection of ship recyclers (and pro forma contract)
- ISO 30003 : Requirements for bodies providing audit and certification of ship recycling management
- ISO 30004 : Guidelines for the implementation of ISO 30000
- ISO 30005 : Information control for hazardous materials in the manufacturing chain of shipbuilding and ship operations
- ISO 30006 : Diagrams to show the location of hazardous materials onboard ships
- ISO 30007 : Measures to prevent asbestos emission and exposure during ship recycling

Railway industry HAS BEEN under consideration!

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UIC CODE **3 4 5**

1st edition, June 2006
Original

R

Environmental specifications for new rolling stock

Spécifications environnementales pour le matériel roulant neuf
Umweltspezifikationen für neue Schienenfahrzeuge

Noise	**Energy Efficiency**
Diesel Exhaust Emissions	**Materials/ Recycling/Waste**

(Key Environmental Area)

UNION INTERNATIONALE DES CHEMINS DE FER
INTERNATIONALER EISENBAHNVERBAND
INTERNATIONAL UNION OF RAILWAYS

UNIFE Sustainable Transport Committee
Topical Group: Life Cycle Assessment

Recyclability and Recoverability Calculation Method Railway Rolling Stock

Date: 01.03.2013

Version: 00

Life Cycle Environmental Performance

is being important factor in railway industry

VERSION 1.1 - 2010 04 23

EPD®

PRODUCT CATEGORY RULES (PCR)

for preparing an environmental product declaration (EPD) for

rail vehicles

UNCPC CODE: 495
PCR 2009: 05

International EPD Consortium, IEC
Version 1.1
Guaranteed validity until 2014-12-01

This PCR document is in compliance with PROGRAMME REQUIREMENTS EPD® an international EPD system for environmental product declarations, published by the "Body managing the EPD system" as a part of the EPD® system.

Further information is available on: www.environdec.com

Examples : EPD certificate of BOMBARDIER and KOREA TRAIN

Current Recyclability of ISO 22628

applied for the EPD considers only weight without efficiency

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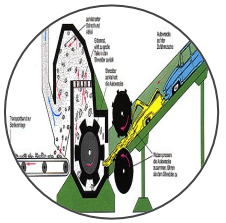
- Recycling Process

1.Pretreatment

2.Dismantling

3.Metal separation



4.Non-metallic residue treatment

- Recyclability Calculation method (Weight basis)

> Recyclability rate

$$Rcyc = \frac{m_P + m_D + m_M + m_{Tr}}{m_V} \times 100$$

> Recoverability rate

$$Rcov = \frac{m_P + m_D + m_M + m_{Tr} + m_{Te}}{m_V} \times 100$$

m_P : mass of materials taken into account at the pre-treatment step
m_D : mass of materials taken into account at the dismantling step
m_M : mass of metals taken into account at the metal 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_V ; Vehicle mass

UNIFE considered efficient factor

for recycling and recovery of each materials and components

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- Recyclability Rate

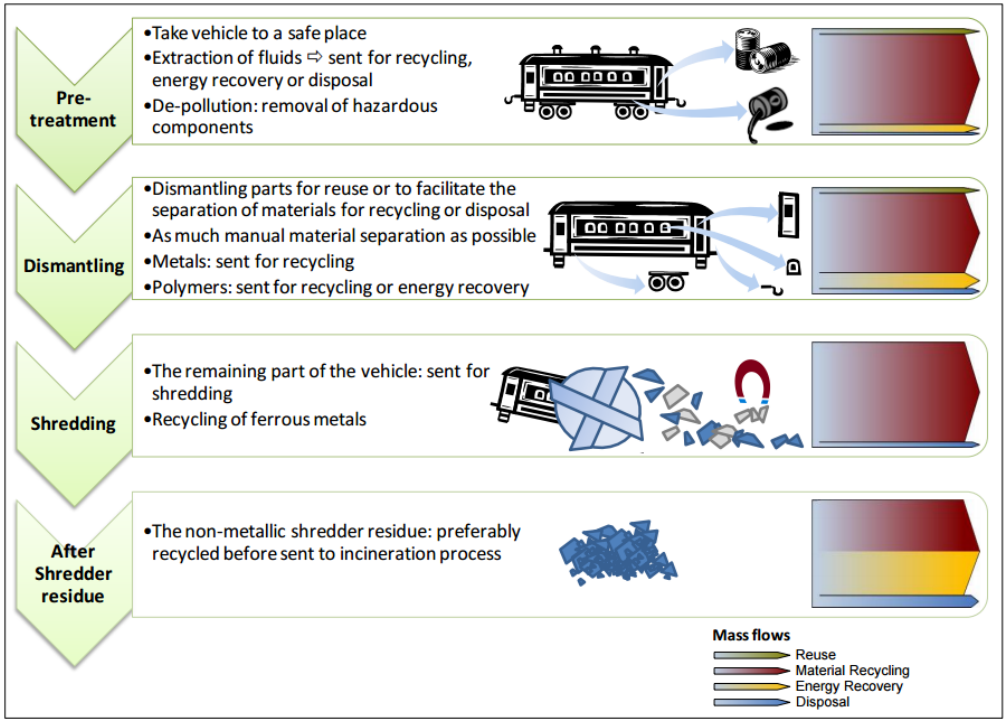
$$m_{i(cyc)} = m_{i(treat)} \times MRF_i$$

i : material type
m : mass
mi(treat) : mass of material type to be treated
Mi(cyc) : result of recycling process

- Recoverability Rate

$$m_{i(cov)} = m_{i(treat)} \times ERF_i$$

i : material type
m : mass
mi(treat) : mass of material type to be treated
Mi(cov) : result of energy recovery process



Source : UNIFE_Recyclability and Recoverability Calculation Method Railway Rolling Stock

UNIFE categorized 16 materials of rolling stock

for the efficiency factor of each material

Index	Material categories considered in rolling stock calculation method
1	FE metals
2	Non-FE metals
3	Elastomers (unfilled)
4	Thermoplastics (unfilled)
5	Thermoplastics (glass filled)
6	Thermosets (unfilled)
7	Thermosets (glass filled)
8	Carbon or natural fiber reinforced polymers
9	Glass
10	Safety Glass (shatterproof glass)
11	Oil, grease or similar
12	Acids and Cooling agents or similar
13	MONM (leather, wood, cotton fleece …)
14	Electric /
15	Ceramics
16	Mineral wool

Source : UNIFE_Recyclability and Recoverability Calculation Method Railway Rolling Stock

MRF and ERF suggested by UNIFE

of each materials at each process

Index	11	12	14
Material category	Oil, grease or similar	Acids and Cooling agents or similar[7]	Electric / Electronic[8]
MRF	0%	83%	79%
ERF	100%	0%	19%
Residue	0,0%	17%	2%

1.Pretreatment

Index	1	2	3	4	5	6	7
Material category	FE metals[9]	Non-FE metals [10]	[11]	Thermoplastics (unfilled) [2]	Thermoplastics (glass filled)[12]	Thermosets (unfilled) [2]	Thermosets (glass filled)[12]
MRF	98%	98%	80%	100%	66,7%	100%	66,7%
ERF	0%	0%	20%	0%	33,3%	0%	33,3%
Waste	2%	2%	0%	0%	0%	0%	0%
Index	8	9	10	13	14	15	16
Material category	Carbon or natural fibre reinforced polymers[12]	Glass[13]	Safety Glass (shatterproof glass)[14]	MONM (leather, wood, cotton fleece ...) [2]	Electric / Electronic[8]	Ceramics[7]	Mineral wool[15]
MRF	66,7%	100%	94%	95%	79%	43%	97%
ERF	33,3%	0%	0%	5%	19%	0%	0%
Residue	0%	0%	6%	0%	2%	57%	3%

2.Dismantling

3.Shredding

Index	1	2	-
Material category	FE metals[9]	Non-FE metals [10]	Mixed materials [16]
MRF	98%	98%	14%
ERF	0%	0%	19%
Residue	2%	2%	67%

Source : UNIFE_Recyclability and Recoverability Calculation Method Railway Rolling Stock

Test Results (Korea case)

KRRI experimented for the recyclability

with old rolling stocks

❖ **Transportation of ELRV (Mugungwha coach / G-7 high speed train coach)**

❖ **Settle down and fixing**

KRRI experimented for the recyclability

considering ISO 22628 & UNIFE guideline

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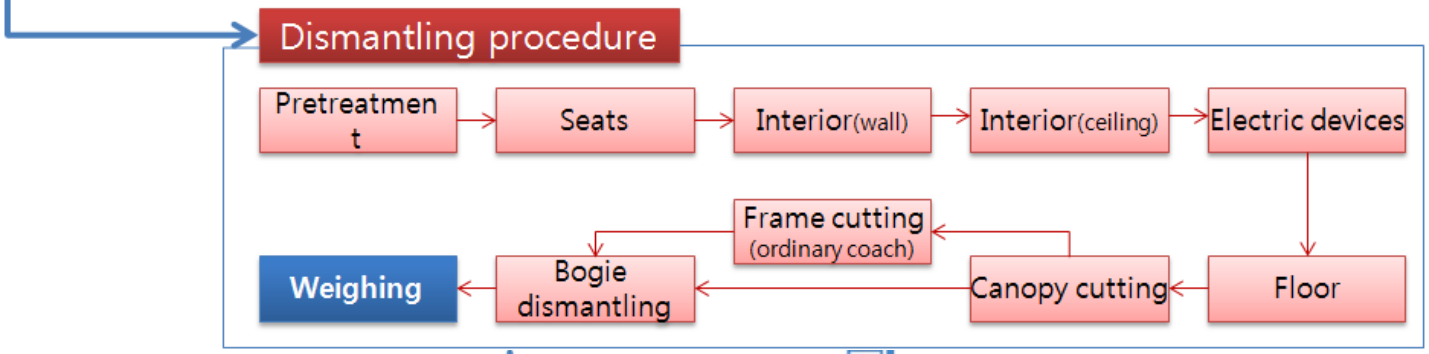
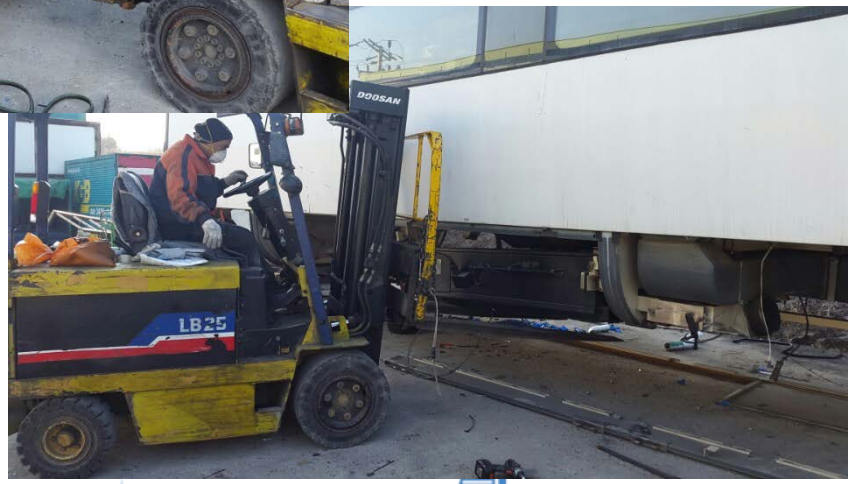
Transportation	Loading, transportation and unloading of vehicle
Dismantling	Dismantling of vehicle by sections
Sorting of materials	Detail dismantling and sorting by kind of material
Weighing	Determination of weight by kind of material
Report	Result / Report



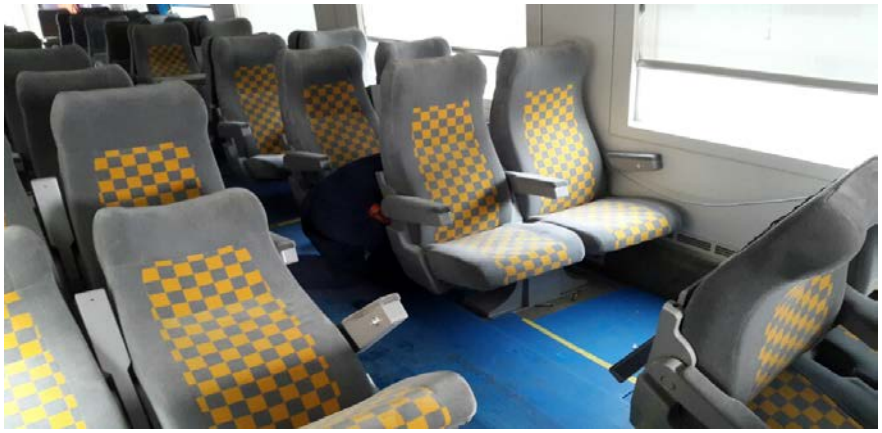
KRRI experimented for the recyclability

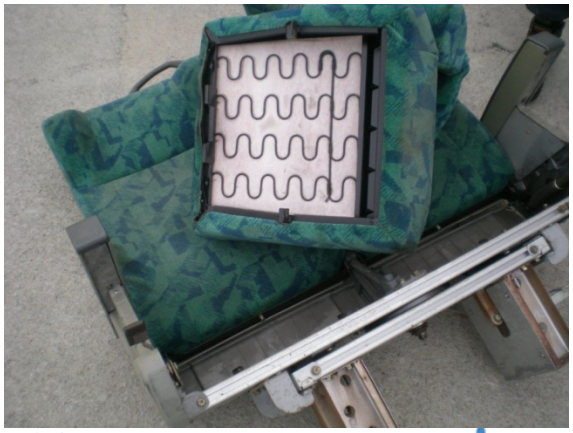
At pretreatment, (potentially) hazardous material were removed



KRRI experimented for the recyclability

At dismantling process, all components inside were removed (Seats)





KRRI experimented for the recyclability

At dismantling process, all components inside were removed (Windows)

KRRI experimented for the recyclability

At dismantling process, all components inside were removed (Insulator, Ceiling and Floor)

KRRI experimented for the recyclability

For metal seperation, car body was divided into 2 pieces due to its big size

KRRI experimented for the recyclability

All seperated materials and components were measured their weight for the calculation









KRRI experimented for the recyclability

Recyclability 84.9 %, Recoverability 95.4 % with efficiency of each materials and components

Contents		Sum	Portion	mP	mM	mDr	mDe	mDw
Metal	Iron	24,329.10	79.2%	-	23,842.5		340.6	146.0
	Stainless steel	502.2	1.6%	-	477.1		17.6	7.5
	Aluminum	435.6	1.4%	-	413.8		15.2	6.5
	Copper wire	83.6	0.3%	-				83.0
Plastics	Solid plastics	210.7	0.7%	-		105.4		105.4
	PU foam	292.4	1.0%	-		292.4		
	FRP	54.4	0.2%	-			38.1	27.2
	Rubber	137	0.4%	-			137.0	
	PVB film	8.5	0.0%	-			8.5	
Wood	Plywood ets	2305.8	7.5%	-			2,305.8	
Fiber	Fabric, fiber	122	0.4%	-			122.0	
Inorganic/	Silicon	30	0.1%	-				30.0
Non-metal	Glass	602.8	2.0%	-		542.5		60.3
	Glass wool	97.3	0.3%	-				97.3
Electric/	Motors	100	0.3%	-	100.0			
Electronic	Illuminations	30	0.1%	-	9.0			21.0
devices	Air-conditioner*	280	0.9%	-	252.0			28.0
	Control panel	65	0.2%	-	52.0			13.0
	Monitors	20.2	0.1%	-	4.0		8.1	8.1
Paint	Paint/under coat	542.8	1.8%	-				542.8
Others	Others	469.6	1.5%	-			234.8	234.8
Grand sum		**30,719.00**	100%	0.00	25,150.5	940.3	3,227.7	1,410.8
				0.0%	**81.9%**	**3.1%**	**10.5%**	4.6%
						84.9%	**95.4%**	100.0%

Standardization

Standardization for recyclability of rolling stock

Experts from Austria, France, Japan, Germany, Sweden, China, UK, South Africa, Russia, Korea

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1. NWIP Suggested ISO/TC269 3rd meeting 04/12/2014

   - Adhoc group approved

2. Call for experts AG 6 ISO/TC269 01/04/2015

   - 9 countries replied in 17 countries

3. 1st meeting in Seoul ISO/TC269/AHG06 15~16/04/2015

   - Experts from 7 countries attend and NWIP agreed

4. NWIP Balloting 16/12/2015

5. Working Draft from WG 4 of TC269

Standardization for recyclability of rolling stock

TC 269
(Railway application)

Chairman : Nishie **(Japan)**
Secretary : Wendt **(Germany)**

CAG
(Chairman Advisory Group)

WG 3 : Rail project planning **(JP)**

AG 1 : CAG
AG 9 : Cooperation agreement development **(JP)**
AG 15 : Railway quality management system **(FR)**

SC #1 (Infrastructure)	SC #2 (Rolling stock)	SC #3 (Operations&services)
Chair : Francisco PARENTE **(PT)** Secretary **(FR)**, co-secretary **(CN)**	Chair : Jean-Marie BODSON **(FR)**, Vice-Chair : HUO Baoshi **(CN)**	Chair : Federico ULIVI **(IT)** Secretary **(JP)**
WG 5 : Plastic sleepers **(FR)** WG 6 : Concrete sleepers and bearers **(FR)** WG 7 : Fastening systems **(UK)**	WG 1 : Railway braking WG 2 : HVAC systems WG 4 : Recyclability and recoverability of rolling stock **(KR)**	- - -
AG 12 : Track quality measurement methods **(CN)**	AG 11 : Rubber suspension components **(CN)** AG 13 : Body side windows **(CN)**	AG 10 : Driving simulator **(JP)**

Recyclability and Recoverability calculation

is on the table and door is open to all interested

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ISO TC269/WG4

Secretariat: Ruediger Wendt

Recyclability and recoverability calculation method of rolling stock

(Draft Ver.4.0)

Warning for WDs and CDs

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Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

To help you, this guide on writing standards was produced by the ISO/TMB and is available at http://www.iso.org/iso/how-to-write-standards.pdf

Issues under discussion

At DESIGN stage,

Recycling Process

MUST items to remove at each steps

Material Categories of Rolling Stock

Recycling and Recovery Efficiencies of each items

`

Recycling Process

Metal separation step is unnecessary process when consider recyclability of rolling stock at design stage

ISO 22628

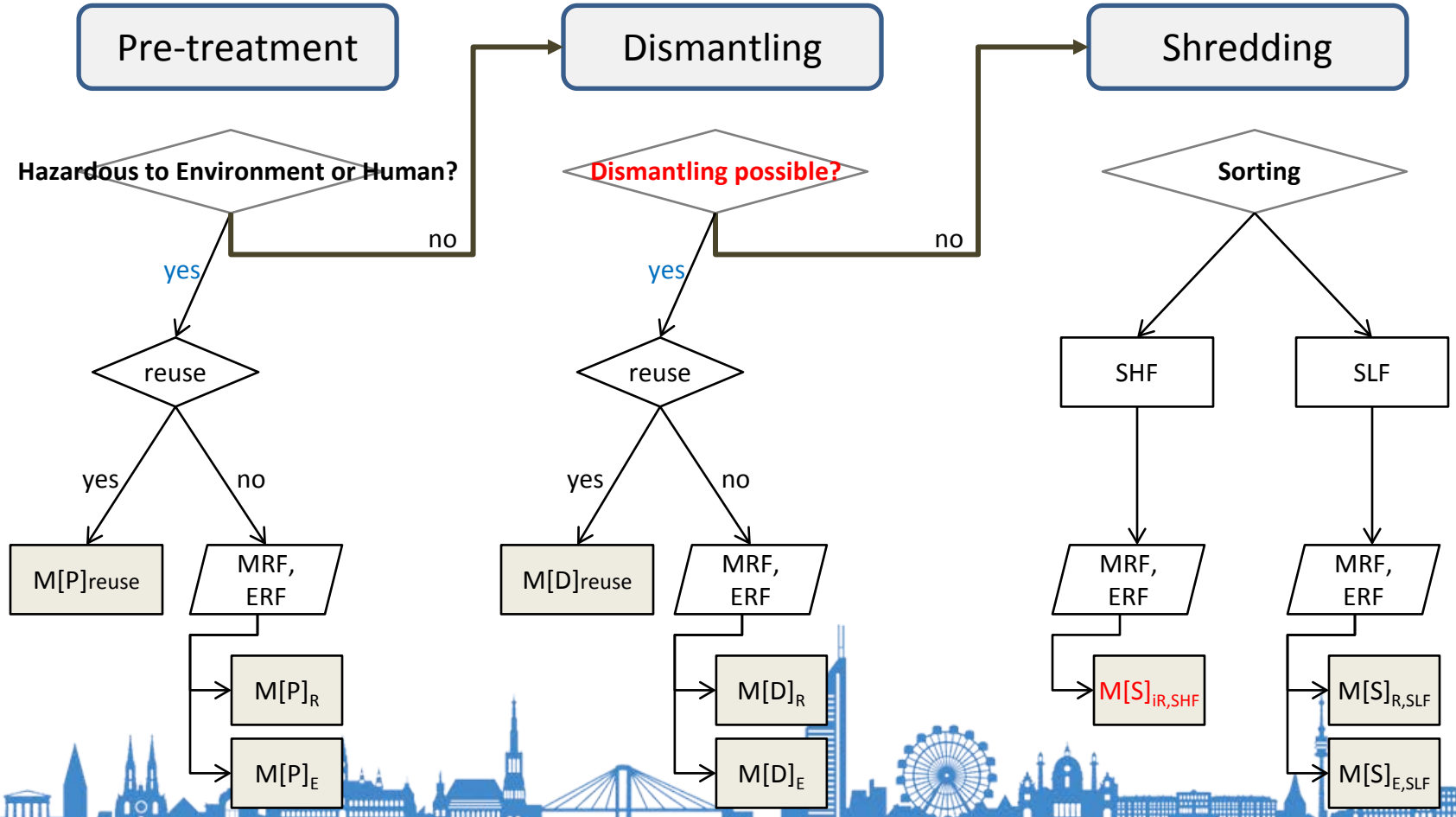
Pre treatment	Fluids Battery LPG tanks Tyres …	m_{p1} m_{p2} m_{p3} M_{p4} …
Dismantling	Part No. 1 Part No. 2 Part No. 3 …	m_{D1} m_{D2} m_{D3} …
Shredding: Metal separation	Metallic content	m_M
Shredding: Non-metallic residue treatment	Recyclables Recoverables	m_{Tr} m_{Te}

Railway vehicle (NWIP)

Pre treatment	Fluids Battery Sewage Tanks Coolants …	m_{p1} m_{p2} m_{p3} m_{p4} …
Dismantling	Part No. 1 Part No. 2 Part No. 3 …	m_{D1} m_{D2} m_{D3} …
Dismantling	Material No. 1 Material No. 2 Material No. 3 …	$m_{D,r}$ $m_{D,e}$ …
Metal Cutting	Metallic content	m_M

Recycling Process

Considering factors at each steps for the environment as well as human



Material Categories

Materials are divided by main and sub groups for management purpose

#	Main category	Sub category	Examples
1	Metal	Fe metal	Fe and Fe alloys
		Non Fe metal	Cu or Cu alloy
			Al or Al alloy
			Others (Mg alloy etc.)
2	Polymer	Elastomers (unfilled)	
		Elastomers (filled)	Gangway
		Thermoplastics (unfilled)	PP, PE
		Thermoplastics (filled)	Glass or Carbon fibre reinforced
		Thermosets (unfilled)	Epoxy
		Thermosets (filled)	Glass or Carbon fiber reinforced
		Others	Paint
3	Electric	Electric parts	
		Batteries	
		Cables	
4	Electronics	Electronics	Exterior and interior display
5	Glass	Glass	
		Safety Glass	Shatterproof glass
6	Fluids	Oil and greases	
		Cooling agents	Refrigerant
		Acids and similar non-organic solutions	
7	Ceramic	Porcelain	
8	MONM	Wood	
		Textile	Cotton
		Leather	

Recyclability and recoverability calculation

	Recyclability	Recoverability
Rolling Stock (draft)	$Rcyc = \frac{m[P]_{reuse} + m[P]_R + m[D]_{reuse} + m[D]_R + m[S]_R}{m[V]} \times 100\%$	$Rcov = Rcyc + \frac{m[P]_E + m[D]_E + m[S]_E}{M[V]} \times 100\%$
ISO 22629 : 2002	$Rcyc = \frac{m_P + m_D + m_M + m_{Tr}}{m_V} \times 100$	$Rcov = \frac{m_P + m_D + m_M + m_{Tr} + m_{Te}}{m_V} \times 100$

$m[Y]iR = m[Y]i \times MRF[Y]i$

$\mathbf{m[Y]\ R = \sum m[Y]iR}$

i = material type
m = mass
m[Y]i = mass of material type i before treatment process Y
m[Y]iR = mass of material type i MRF of material i after applying at treatment process Y

Management sheet for recycling of rolling stock

Main category	Sub category	Weight (kg)	MRF (%)	ERF (%)	1) Pre-treatment				2) Dismantling				3) Shredding		
					m[p]reuse	m[p]R	m[p]E	Reside	m[D]re-use	m[D]R	m[D]E	Reside	m[S]R	m[S]E	Reside
			ⓐ	ⓑ	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪
Fluids	Acids, similar non-organic														
	Oil and greases														
Electric	Batteries														
	Electric parts														
	Cables														
Electronics	Electronics														
Glass	Glass														
	Safety Glass														
Ceramic	Porcelain														
Polymer	Elastomers (unfilled)														
	Elastomers (filled)														
	Thermoplastics (unfilled)														
	Thermoplastics (filled)														
	Thermosets (unfilled)														
	Thermosets (filled)														
	Others														
Metal	Fe metal														
	Non Fe metal														
MONM	Wood														
	Textile														
	Leather														
Total															
Rcyc = $\sum[①+⑤+(ⓐ*(②+⑥+⑨))]/mv * 100\%$															
Rcov= Rcyc+$\sum$ⓑ*(③+⑦+⑩)/mv * 100%															

Benefits expected from 20% more recycling

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- Cost : 120 Mil. Euro
- CO2 : 1.3 MtonCO_2

(10,000 coach / year)

▪Recycling rate : 75 % (26 ton/35ton)
▪Profit : 9 kEuro / coach
▪CO2 emission : 327 tCO_2

▪Recycling rate : 95 % (33t/35t)
▪Profit : 21 kEuro/coach
▪CO2 emission : 460 tCO_2

Current (unit:t,kWon)

		Weight	Unit cost	Amount
①	Ferrous	25.0	450	11,200
②	Non-Ferrous	1.6	2,100	7,300
	Others	8.5	–	–
	Total	35.1		18,500

Profit = current + Impro.
18,500 + 7,400 = 25,900

Improvement

③ Non-metal	2.0	2,100	4,200
Electric	1.5	1,100	1,700
Plastic	1.0	350	350
Glasses	2.0	100	200
Seats	1.0	500	1,000
Landfill	1.0	–	–
Total	35.1		7,400

① : Profit of Korail (after sale)
② : Profit of recycler
①+ ②+ ③ : Improvement effect

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THANK YOU