

# Procedures for Rolling Stock Procurement with Environmental Requirements phase II

## PROSPER II

### Deliverable

## “Draft 3b (final) of UIC Leaflet Environmental Specifications for New Rolling Stock”

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## **Disclaimer**

This draft leaflet is an intermediate result of the UIC funded PROSPER project and thereby represents in its current form neither the final nor the official position of the UIC. This draft will be submitted to UIC for adoption in autumn 2005.

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# 1 Introduction

The UIC leaflet *Environmental Specifications for New Rolling Stock* addresses all relevant aspects for the integration of environmental aspects into the procurement process. It is designed to enhance the procurement of rolling stock for both setting up invitations to tender and evaluating tenders with regard to their environmental performance. The leaflet is derived from the UIC project PROSPER (“Procedures for Rolling Stock Procurement with Environmental Requirements”).

It is the aim of this leaflet to contribute to harmonisation of the environmental procurement framework in the rail sector at European, and in the long-term global level. By doing so the process of procurement is to become more efficient, enabling new rolling stock with a sound environmental performance to be procured more cost effectively.

Please note that this leaflet is designed as a guidebook and it is thus not possible to demand compliance “clause by clause”. Instead the content of this leaflet will have to be adapted to suit the existing procurement procedures and the economic needs and environmental priorities of each operator. The status of this leaflet is “recommended”.

## 1.1 Structure of the Leaflet

In Chapter 1 the scope and overall aim of the leaflet is outlined. In Chapter 2 the legal framework for procurement is sketched. The core of the leaflet is Chapter 3.4 in which detailed descriptions of environmental performance specifications are given. In Chapter 3.1 an outline is given showing how environmental performance can be incorporated into the procurement process. Chapter 3.5 outlines how the tender evaluation process can be structured. Background information on the key environmental areas covered is given in appendix. A list of abbreviations can be found in Appendix 7.

A background paper accompanying this leaflet entitled “Legal Aspects of Eco-Procurement” was developed within the PROSPER project. It specifies the legal framework in greater detail and gives additional information on the issues covered in this leaflet.<sup>1</sup>

## 1.2 Scope and Approach

This leaflet is intended to provide assistance for the procurement of new rolling stock for passenger as well as freight transport (multiple units, locomotives, wagons and coaches). It addresses all the relevant areas in the context of integrating environmental aspects into the procurement process. The leaflet adopts a functional approach using performance-related and not solution-related environmental specifications.

In general, a life-cycle perspective is favourable when assessing environmental impact. In this respect the recommendations given in this leaflet aim at improving environmental performance focussing on the most crucial issues within the whole life-cycle. In many cases the long life span of rail vehicles shifts the use phase into the centre of attention. On the other hand, operators are best equipped to improve performance during use at the procurement stage.

The following key questions in the process of procurement of rolling stock are addressed:

### **What are the key environmental areas to be addressed in invitations to tender?**

The key areas of energy consumption, noise emissions, exhaust emissions and materials/recycling/waste are considered. Furthermore, other miscellaneous issues such as

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<sup>1</sup> “Legal Aspects of Eco-Procurement” is available in the internet [site will have to be specified](#)

the forthcoming environmental aspect of electromagnetic fields, have been included in the leaflet in line with the precautionary principle<sup>2</sup>.

### **How should the procurement process be organised to enhance the environmental performance of new rolling stock?**

As the procurement of new rolling stock is influenced by a large number of different actors inside and outside the railways, it is crucial to have a clear view of the process steps needed and the categories of experts that must be involved in procurement of rolling stock and the role they must play in order to achieve a clearly defined environmental performance.

### **Which environmental specifications should be used in invitations to tender?**

The focus of this leaflet is to harmonise a set of qualitative environmental specifications that cover the key aspects governing the environmental performance of railway operations. In this leaflet target values are given for those specifications for which they could be derived from the applicable legislation. For all other quantifiable and measurable specifications no values are defined. Instead, operators should set requirements for performance values in order to assess the environmental performance of new rolling stock under specific conditions and at the same time improve the information bases for the respective specification.

In this respect it has to be pointed out that this leaflet is to be considered a first step towards a list of harmonised environmental standards in rail procurement. The specifications which can be handled (and verified!) at present are listed. Further harmonisation requirements and ongoing efforts are pointed out in the respective sections.

### **What approach should be used to evaluate tenders?**

An approach to the evaluation of tenders should integrate assessment of the environmental as well as the economic performance with respect to Life-Cycle-Costs (LCC). A five-phase model for the evaluation process is proposed.

## **1.3 Target Audience for this Leaflet**

This leaflet is aimed at users within the rail business who are involved in the procurement of new rolling stock, but who are not directly concerned with environmental aspects. Technical and purchasing experts in particular are therefore identified as the main user groups, but environmental experts will also find valuable information here. The leaflet will help the user to:

- prioritise environmental aspects for rail vehicles,
- integrate environmental specifications in invitations to tender in a consistent manner and
- evaluate tenders in terms of meeting environmental requirements.

Although the leaflet is primarily geared towards assisting operators, it is also intended to be useful for engineering and purchasing staff of manufacturers in the supply chain (system integrators, system manufacturers, sub-suppliers, etc.).

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<sup>2</sup> For a definition of the precautionary principle, see the European Commission's Communication COM(2000) 1.

## 1.4 Key Environmental Areas for Railways

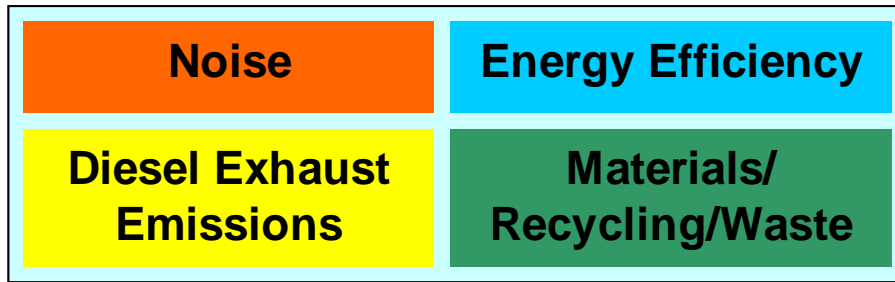


Figure 1: Key Environmental Areas

The most relevant environmental areas for railways at the moment are noise, diesel exhaust emissions and energy efficiency.

**Noise** and **Diesel Exhaust Emissions** are highly relevant for railways because of increasing public pressure in these areas leading to stricter legislation which partly is in force already (Environmental Noise Directive, TSI for High-speed noise, and Non-Road Mobile Machinery Directive) or will enter into force in the near future (TSI Noise for conventional rail). Further steps or stricter emission limit values are foreseen in these two environmental fields by the legislator.

As far as **Energy Efficiency** is concerned, railway transport has very clear advantages compared to other modes of transport. However, competitors are putting a lot of work into reducing their energy consumption. In view of this, energy efficiency is of high priority for the railways because cutting energy consumption:

- helps to maintain/strengthen the competitive position of railways compared with other modes of transport
- helps to cut the Life-Cycle-Costs of railway operation and
- is in line with international agreements on climate protection, such as the Kyoto Protocol.

**Materials/Recycling and Waste** is subject to extensive international legislation. It has increasingly become a priority for the rail sector over the last decade due also to customer requirements. Since the concept of an Integrated Product Policy (IPP) is becoming more and more relevant in the EU, resource consumption and the ability to reintegrate materials into the material cycle are high on the agenda. For the railways this represents the need for environmentally sound selection of materials and technology, improving knowledge of restricted materials used in vehicles to avoid hazardous waste, occupational health impact during manufacture and maintenance and improving vehicle recyclability, thereby cutting resource consumption. Although not generally applicable to rail products, the EU directives WEEE and RoHS<sup>3</sup> set the scene and lay down a strategy from a regulatory point of view.

## 1.5 Economic Effects

The complex interaction between environmental and economic performance of rolling stock is of vital importance for the railways. The economic effects of specific measures to improve environmental performance depend primarily on the framework conditions of the relevant key area (legislation, regulations, policy, standards etc.) as well as the technologies used (technological potential, degree of innovation, maturity, availability, market size) and cover a wide range from being highly cost reducing to highly cost intensive.

<sup>3</sup> WEEE: **W**aste **E**lectrical and **E**lectronic **E**quipment; RoHS: **R**estriction of the use of certain **H**azardous **S**ubstances in electrical and electronic equipment

In order to guarantee the competitive advantages of railways in comparison to other modes of transport, improvement of environmental performance in non-regulated areas must be brought about in a highly cost efficient way. To identify the best solutions a detailed assessment of the environmental and economic effects of the applicable technological options must be carried out.

A qualitative evaluation of the impact of improving environmental performance showed in many cases an increase in investment costs. A thorough analysis of economic effects should not focus on initial investment costs only but be based on a LCC perspective and take into account future developments in the legal, political and technological framework conditions.

- Improving energy efficiency is believed to have clear benefits in terms of LCCs. As energy efficiency is also one of the outstanding environmental aspects for railways, very high priority is accorded to the associated specifications.
- Achieving noise and exhaust emission levels lower than the legally mandatory levels can lead to increasing LCC, at least under the current legislation and using the technologies available. Limiting electromagnetic fields in accordance with current recommendations is believed to have no significant influence on operating costs but to slightly increase investment costs.
- Ambivalent effects on LCC have been noted for improving the environmental performance in the materials/ recycling/ waste area. There often appears to be a compromise between higher investment costs and lower end-of-life and sometimes also maintenance costs. End-of-life costs of rolling stock are quite difficult to assess. The technical standard for dismantling and recycling facilities, as well as the respective legislation, is very difficult to estimate over a thirty year time frame. However, the high costs of asbestos or PCB disposal for example demonstrate the need for a thorough LCC analysis.

## **1.6 Opportunities and Risks**

Sound strategic management should always take into account environmental risks and opportunities as well as the investment perspective (short, medium and/ or long term). This is especially true for the long life-span of rail vehicles, which calls for a long-term risk/ opportunity perspective in the procurement of these vehicles. Changing framework conditions (e.g.: operating conditions, relationships with competitors, legislation, customer requirements) could impose risks but could also create opportunities for railway operators. In line with the overall trend in society, the demand for environmental performance is increasing – a fact which also holds true for the rail sector.

Despite the uncertainties associated with long-term assessments generally, it is a necessity from a prudent business perspective to take such long-term assessments into account and make every effort to minimise future risks. Taking environmental aspects into account in such assessments may not only outweigh investment costs (e.g. by avoiding high retrofitting costs in the life span of vehicles), but may also create advantages towards other modes of transport.

### ***Minimising operational costs***

Sound environmental performance in many fields contributes to minimisation of operational costs. Some issues can quite easily be addressed in LCC assessments (see section 1.5). Most prominent is energy consumption. In view of the mid and long-term increase in energy supply prices, energy efficient vehicles will become a business prerequisite. Furthermore, there are various other minor issues which could contribute to reducing operational costs (for example, reducing the wear of braking material reduces emissions and contributes to lower maintenance costs).

### ***Reducing business risks***

A change in the legal framework in particular could pose severe business risks for railways. Readjustments (modernisation and upgrading) during the life-cycle of rolling stock are normally very costly especially if the respective technical solutions have not been integrated into the design of the vehicle. European and national legislation does not normally focus on the existing fleet but rather on new vehicles and consequently does not cause restrictions in operation in most cases.

However, some very general legislation (such as the EU directive on ambient air quality) may trigger action at national or regional level which could restrict the operability of rolling stock with low environmental performance. In addition, local authorities could demand specific environmental performance in tenders for service contracts. High environmental performance in new rolling stock thus increases the proportion of an operator's fleet able to fulfil a greater variety of demands.

### ***Strategies for the rail sector***

Optimising the environmental performance of rail vehicles in a pro-active way can create opportunities for the whole rail sector. With a view to other modes of transport (road and air), it is important to maintain and extend the environmental advantage of rail transport in order to gain the strong support from politics and the public which is needed to be a successful mode of transport in the future. If the rail sector adopts the strategy of *complying with legal requirements only*, the reputation of the railways could be damaged and a loss of opportunities in intra-modal, as well as in inter-modal, competition could result.

By further developing environmental standards for the rail sector, risks can be minimised and business opportunities enhanced via improved environmental performance with minimised LCCs.

## 2 Legal Framework of Procurement

### 2.1 Key Environmental Legislation

The following tables give an overview of international, EU and national legislation concerning the four environmental key areas of noise, diesel exhaust emissions, energy efficiency and materials/recycling/waste, as well as miscellaneous other issues. The focus of this overview is on legislation which is applicable in Europe. The current status and future trend of legislation and other regulations are covered.

Detailed information on the legal framework of each key area can be found in the background document “Legal Aspects of Eco-Procurement”<sup>4</sup>.

#### Noise

Legislation	Other Regulations	Trend
<ul style="list-style-type: none"> <li>Harmonisation at EU-level TSI Noise for HST (EU Directive 2002/735/EC) and conventional railways (EU Directive 2001/16/EC)</li> </ul>	<ul style="list-style-type: none"> <li>EU Green and White papers</li> </ul>	<ul style="list-style-type: none"> <li>No trend limit values</li> <li>Noise-level-related route pricing (e.g. Switzerland, The Netherlands)</li> <li>TSI revision process</li> </ul>

#### Diesel Exhaust Emissions

Legislation	Other Regulations	Trend
<ul style="list-style-type: none"> <li>Harmonisation at EU level EU directive 97/68/EC on non-road mobile machinery is extended to railway applications by its amendment 2004/26/EC</li> </ul>	<ul style="list-style-type: none"> <li>UIC leaflets 623/ 624 “Exhaust emission tests for diesel traction engines”</li> <li>EU Directive on ambient air quality</li> </ul>	<ul style="list-style-type: none"> <li>Decreasing limit values</li> <li>Stage IIIA (2005-2009) of EU Directive</li> <li>Stage IIIB (from 2011 on) subject to revision in 2007</li> </ul>

#### Energy Efficiency

Legislation	Other Regulations	Trend
<ul style="list-style-type: none"> <li>No harmonisation at EU level</li> </ul>	<ul style="list-style-type: none"> <li>International agreements on climate protection (e.g. Kyoto Protocol)</li> <li>Indirect measures and incentives: taxes, emission trading</li> </ul>	<ul style="list-style-type: none"> <li>EU draft directive on energy end-use efficiency and energy services (COM (2003) 739)</li> <li>EU directive on eco-design requirements for energy-using products (EuP)</li> <li>2008-2012: 8-9% EU average reduction for CO<sub>2</sub> emissions</li> </ul>

<sup>4</sup> This document will not be part of the leaflet, but will serve as background information and will be made available for download on the internet.

**Materials, Recycling and Waste**

Legislation	Other Regulations	Trend
<p><b>Harmonisation at EU level</b> EU directives on:</p> <ul style="list-style-type: none"> <li>▪ Classification of dangerous substances (EU directive 67/548/EEC and its amendments as well as corresponding commission regulation (EC) No 1488/94 on risk assessment of existing and commission directive 93/67/EEC on risk assessment of notified substances)</li> <li>▪ Marketing and use of certain dangerous substances (EU directive 76/769/EEC and its amendments)</li> <li>▪ Dangerous preparations (EU directive 1999/45/EC and its amendments)</li> <li>▪ European waste catalogue (EWC – EU Commission Decision 2000/532/EC)</li> <li>▪ EU battery legislation, directive 91/157/EEC</li> </ul>	<ul style="list-style-type: none"> <li>▪ Restricted materials and recycling/recovery rates for electric/electronic equipment (EU directive 2002/96/EC – WEEE)</li> <li>▪ EU directive 2002/95/EC – RoHS)</li> <li>▪ Restricted materials and recycling/recovery rates for end-of life vehicles (EU directive 2000/53/EC – ELV)</li> <li>▪ Montreal Protocol on substances that deplete the ozone layer</li> <li>▪ OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic</li> <li>▪ Stockholm Convention on persistent organic pollutants (POPs)<sup>5</sup></li> </ul>	<ul style="list-style-type: none"> <li>▪ REACH process<sup>6</sup></li> <li>▪ More substances will be included</li> <li>▪ Reduction of target values for harmful substances</li> </ul>

**Other**

Legislation	Other Regulations	Trend
<p><b>EMF</b></p> <ul style="list-style-type: none"> <li>▪ EU directive 2004/40/EC on exposure of workers to EMF</li> <li>▪ Stringent national legislation (Switzerland, Italy, Finland stricter than ICNIRP<sup>7</sup>)</li> </ul>	<ul style="list-style-type: none"> <li>▪ European Council recommendation 1999/519/EC on the limitation of exposure of the general public to electromagnetic fields (stricter than EU directive 2004/40/EC)</li> <li>▪ Generally accepted recommendations (ICNIRP values)</li> <li>▪ National recommendations</li> </ul>	<ul style="list-style-type: none"> <li>▪ Harmonisation efforts on EU level</li> <li>▪ Low precautionary limits</li> <li>▪ No trend limit values</li> </ul>

<sup>5</sup> Persistent organic pollutants (POPs) are chemical substances that persist in the environment, bio-accumulate through the food web, and pose a risk of causing adverse effects to human health and the environment. This group of priority pollutants consists of pesticides (such as DDT), industrial chemicals (such as polychlorinated biphenyl, PCBs) and unintentional by-products of industrial processes (such as dioxins and furans).

<sup>6</sup> REACH: **R**egistration, **E**valuation and **A**uthorisation of **C**hemicals

<sup>7</sup> International Commission on Non-Ionising Radiation Protection

## **2.2 Legal Framework for the Integration of Environmental Aspects with Respect to EU Public Procurement**

### **Essentials**

EU legislation for procurement in the transport sector explicitly permits and encourages the integration of environmental issues in the award procedure. The so-called “Utilities Directive” covers all state as well as non-state enterprises operating in the field of transportation which act based on special or exclusive rights (e.g. awarding authorities, operators, leasing companies, etc.).

### **Scope of the Utilities Directive**

The scope of the procurement process, guided by Council Directive 93/38/EEC (“Utilities Directive”) and the corresponding Commission Regulation (EC) No 1874/2004 of 28 October 2004, also include non-state enterprises operating in the field of transport procurement, which act based on special or exclusive rights where supply or service contracts exceeding a (net) order value of € 473.000 - or construction orders exceeding € 5.923.000 - are awarded. Thus the procurement of new rolling stock for railways must in most cases comply with the “Utilities Directive”.

### **Modifications by the "new" consolidated regulations for awarding contracts**

By 31 January 2006 at the latest the EU Member States have to implement the new “Utilities Directive” 2004/17/EC. From an environmental point of view, the most significant change compared to the previous version is the explicit statement that the integration of environmental issues into the award procedure is now permissible and desired. Furthermore, it clarifies that the production process may be taken into consideration for the awarding procedure.

### **Essentials of the Awarding Procedure**

The contracting authority is basically free to determine the requested scope of performance. It has procurement autonomy which is subject only to the prohibition of direct and indirect discrimination.

In essence, a comprehensible description of performance is required, which is guided by European standards and specifications. Selection of the appropriate tenderer (according to the qualification criteria) must be separated from the evaluation of the offers (according to the awarding criteria). The awarding party determines the decisive criteria for the evaluation of the tender. The central principles of the awarding regulations regarding disclosure, transparency, objectivity and equal treatment must be respected.

Besides the qualification criteria and the awarding criteria, additional criteria may be taken into consideration when taking the awarding decision. These additional criteria must not be contrary to the exclusion and qualification criteria standardised in the “Utilities Directive”, must not discriminate between participants and must respect further prohibitions and orders of the EU treaty; they have to be announced in parallel to the other contract conditions, must be verifiable in an objective manner and must not leave the awarding party unrestricted freedom of choice.

## **2.3 Integrated Product Policy (IPP)**

All products cause environmental degradation in some way, whether as a result of manufacturing, use or disposal. Integrated Product Policy (IPP) as proposed by the EU seeks to minimise these by looking at all phases of a products' life-cycle and taking action where it is most effective and utilising input from all relevant stakeholders.

The life-cycle of a product is often long and complicated. It covers all the areas from the extraction of natural resources, through design, manufacture, assembly, marketing, distribution, sale and use to eventual disposal as waste. At the same time it also involves many different actors such as designers, industry, marketing experts, retailers and consumers. IPP attempts to stimulate each part of these individual phases to improve their environmental performance.

With so many different products and actors involved, there cannot be one simple policy measure for everything. Instead a whole variety of tools – both voluntary and mandatory – can be used to achieve this objective. These include measures such as economic instruments, substance bans, voluntary agreements, environmental labelling and product design guidelines.

This leaflet supports the EU's IPP approach by defining environmental requirements for rolling stock.

For further information, please visit the EU Commission's web pages on Integrated Product Policy<sup>8</sup>.

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<sup>8</sup> See: <http://europa.eu.int/comm/environment/ipp/>

## **3 Environmental Specifications in Invitations to Tender**

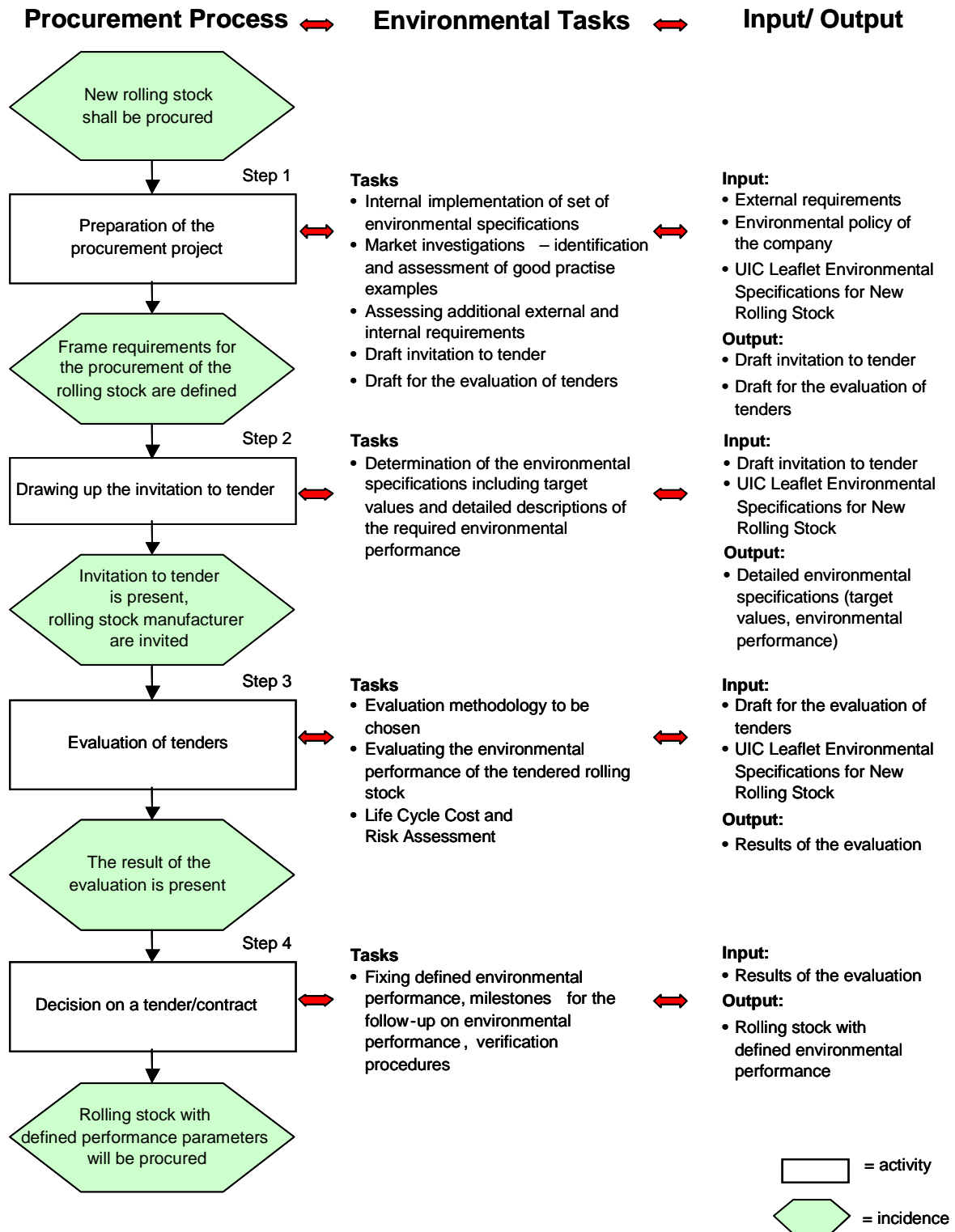
### **3.1 Considering Environmental Aspects in the Procurement Process**

The procurement process for new rolling stock is characterised by a range of different requirements to be fulfilled and a large number of actors involved. For efficient integration of environmental requirements into the railway procurement process, it is important to clarify and define the roles of the different players in the process and be aware of the interfaces involved and information required at the various process stages.

For example, the question of who sets the requirements for the environmental performance of rolling stock is not always easy to answer and differs from country to country and company to company. In addition to legal requirements and requirements voluntarily set by the railway operator, additional requirements may be set by infrastructure operators or national authorities which put transport services out to tender such as regional rail transport. These additional requirements must also be taken into account in the procurement process.

The diagram below proposes a generic procedure for the procurement process (highly simplified) and proposes a method for integrating environmental aspects into the procurement process, based on this leaflet:

The subsequent explanations provide definitions of the interfaces to the environmental aspects and of the tasks that have to be performed to integrate environmental aspects, as well as a description of the input needed to carry out these tasks.



**Figure 3: Procedure for the integration of environmental aspects into the railway procurement process**

### ***Step 1: Preparation of the procurement project***

The preparation of the tendering phase in terms of environmental requirements is a fundamental step towards integrating environmental aspects into the procurement process. Prior to drafting a tender, the operator should perform market investigations to identify the technological state of the art and analyse examples of good practise which could serve as benchmarks.

At this phase, the harmonised set of environmental specifications as defined in this leaflet should be used as a basis for drawing up the invitation to tender (and later for the evaluation of tenders). This first approach should be completed by including additional internal and external requirements resulting from specific national legislation, a particular focus of the operator's environmental strategy, etc. Furthermore, it helps to clearly define responsibilities and interfaces.

#### Harmonised set of Environmental specifications

The internal implementation of the UIC Leaflet "Environmental Specifications for New Rolling Stock" provides the basic set of harmonised environmental specifications to be integrated into the draft invitation to tender.

Involved: Environmental and technical experts  
Input: UIC Leaflet Environmental Specifications for New Rolling Stock  
Output: Internal set of basic environmental specifications

#### Additional external and internal requirements

In the next step the railway should assess additional external and internal requirements for the environmental performance of the kind of rolling stock to be procured not yet or not sufficiently covered by the UIC leaflet. Examples are:

- Specific national or regional legislation and regulations
- Specific requirements from national and/or local authorities or infrastructure operator (if applicable)
- Requirements from other stakeholders (e.g. customers, NGOs, general public).

Involved: Environmental and technical experts  
Input: External requirements, Environmental policy of the company, UIC Leaflet Environmental Specifications for New Rolling Stock  
Output: Overview of additional external environmental requirements

#### Draft invitation to tender

Involved: Technical, environmental and purchasing experts  
Input: UIC Leaflet Environmental Specifications for New Rolling Stock, Outcome of the assessment of external and internal requirements  
Output: Customised set of environmental specifications for the invitation to tender

#### Draft for the evaluation of tenders

Involved: Technical, environmental and purchasing experts  
Input: UIC Leaflet Environmental Specifications for New Rolling Stock, Outcome of assessment of external/internal requirements (priorities)  
Output: Draft document for the evaluation of tenders

- Procedure for the evaluation of tenders
- Procedure for the impact on the decision in favour of a certain tender and implementation of environmental performance criteria in the contract
- Responsibilities for evaluating the environmental performance of the tendered rolling stock.

**Step 2: Drawing up the invitation to tender**

The invitation to tender has to be drawn up in detail taking into account the above-mentioned draft document. Consequently the environmental specifications from the draft document have to be substantiated and adapted to suit the particular procurement project.

Involved: Technical experts, environmental and purchasing experts

Input: UIC Leaflet Environmental Specifications for New Rolling Stock

Output: Invitation to tender with detailed environmental specifications including target values and detailed descriptions of the required environmental performance.

**Step 3: Evaluation of tenders**

Involved: Technical, environmental and purchasing experts

Input: UIC Leaflet “Environmental Specifications for New Rolling Stock”, especially the evaluation strategy laid out in chapter 3.5.

Output: Results of the evaluation of environmental performance

For the evaluation of tenders the proposed evaluation methodology has to be suited to the procurement project. This can be done by assigning priorities according to the results of the assessment described in step 1 and by taking into account the impact on initial investment and Life-Cycle-Costs.

The evaluation should be carried out in close cooperation between the technical, environmental and purchasing departments. The result of the environmental evaluation should be documented and be part of the decision in favour of a certain tender.

**Step 4: Decision on a tender/contract**

Involved: Purchasing, technical and environmental experts

Input: Results of the evaluation of the tenders

Output: Rolling stock with defined environmental performance

In negotiations with the manufacturer, the defined environmental performance of the rolling stock proposed is to be laid down in the contract. In addition, milestones for the follow-up on environmental performance, as well as for verification procedures, must be agreed upon.

## 3.2 Types of Specifications

Environmental specifications are used to assess the environmental performance of new rolling stock. In order to guarantee maximum transparency and comparability as well as a high level of acceptance, the applied set of specifications has undergone a harmonisation process within the railway sector.

A framework has been developed to structure the environmental specifications to be used in the tendering process (see fig. 4). It differentiates between mandatory and voluntary specifications and divides them into two groups (environmental performance mainly dependent on design or dependent on operation). Target values for the mandatory specifications are defined by legislation/regulations and therefore must be met by any tenderer. However, compliance with the applicable legislation is only the minimum requirement and in general a better environmental performance will yield better evaluation results from the environmental point of view.

The following general strategic orientations can be attributed to the different types of specifications:

- **Legally Mandatory Specifications**

For the specifications in the first row, the environmental performances are legally regulated. A potential better performance than the legal baseline could represent a more sound long-term investment in rolling stock because it reduces the risk of future expenses and efforts to meet higher environmental legal standards.

- **Voluntary Specifications**

The second row contains specifications which are not governed by legislation. These specifications can be used in invitations to tender according to the environmental strategy of the company, national requirements and priorities as well as economic assessments.

- **Performance mainly dependent on design**

The first column comprises specifications which have a direct influence on the environmental performance of rolling stock basically independent of the operation of the rolling stock. As examples the rate of renewable materials and the specific mass are fixed by construction and do not change during the lifetime of the vehicle unless design changes are made to the vehicle.<sup>9</sup>

- **Performance mainly dependent on operation**

The environmental performance with respect to issues addressed in the second column depends to a high degree on how the new rolling stock is actually used in operation. The design is certainly a precondition to obtaining a good performance. But whether or not it is reached in practice depends to a large extent on operational patterns and the infrastructure on which the rolling stock is used. Energy meters for example will not yield any reduction in energy consumption by themselves, but are a prerequisite for energy efficient driving campaigns with which energy consumption can be reduced dramatically.

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<sup>9</sup> It must be recognised that for most specifications in this category, environmental performance is not fully defined by design only. Operational patterns may retain a small amount of influence e.g. the rate of leakages can increase due to insufficient maintenance.

	Performance mainly dependent on design		Performance mainly dependent on operation	
	key area	specification	key area	specification
<b>Legally mandatory specifications</b>	Noise	<ul style="list-style-type: none"> <li>▪ Passing-by noise</li> <li>▪ Stationary noise</li> <li>▪ Starting noise</li> </ul>	<i>Not applicable</i>	<i>Not applicable</i>
	Diesel exhaust emissions	<ul style="list-style-type: none"> <li>▪ Diesel exhaust emissions</li> </ul>		
	Materials	<ul style="list-style-type: none"> <li>▪ Legally restricted materials</li> </ul>		
	Others	<ul style="list-style-type: none"> <li>▪ Electromagnetic fields</li> </ul>		
<b>Voluntary specifications</b>	Energy	<ul style="list-style-type: none"> <li>▪ Specific mass</li> </ul>	<i>Energy</i>	<ul style="list-style-type: none"> <li>▪ Traction energy consumption</li> <li>▪ On-board energy consumption</li> <li>▪ Energy recovery/ regeneration</li> <li>▪ Energy management for parked vehicles</li> <li>▪ Energy metering devices</li> </ul>
	Materials	<ul style="list-style-type: none"> <li>▪ Unwanted and controlled materials</li> <li>▪ Hazardous waste</li> <li>▪ Recycling rate</li> <li>▪ Renewable materials</li> </ul>		
	Others	<ul style="list-style-type: none"> <li>▪ Emissions from brake friction material</li> <li>▪ Spillage/ leakages</li> </ul>		<i>Diesel exhaust emissions</i>

**Figure 4: Structured overview of environmental specifications**

The approach can be used in an operational sense for the actual evaluation of tenders (see chapter 3.5) as well as in a strategic sense for an assessment of the more general procurement strategy of a railway company or design strategy of a manufacturer.

For those specifications for which performance largely depends on operations, analysis must be carried out as to how specifications correlate with the existing framework conditions under which the operators work. For example:

- The specification of Energy Management for Parked Vehicles requires certain design options to be specified. These have to be made with respect to operation and maintenance procedures which differ from operator to operator. A consideration here could be whether a remote control (e.g. via GSM) is necessary (and cost effective) or if manual setting of energy management schemes on board trains is preferable.
- Systems for dynamic braking need to be in line with railway infrastructure (electricity grid). The achievable reduction in energy consumption also depends considerably on operational patterns (train density in a certain area).

In return, operators will have to analyse and in the long run adapt their internal processes and technical infrastructure if they want to exploit the full potential for improvement associated with the listed specifications. This holds especially true in the field of energy consumption where a reduction is preferable not only under environmental, but also economic aspects.

### **3.3 Degree of Quantification**

Depending on the extent to which specifications are quantifiable, the following four categories can be assigned to environmental specifications:

#### **Target Specification (T)**

Target Specifications are environmental specifications to be quantified by the manufacturer for which target values are set by the operator.

#### **Performance Specification (P)**

Performance Specifications are environmental specifications to be quantified by the manufacturer for which no target values are set. Instead the manufacturer is asked to specify certain performance value to be calculated or measured under defined conditions.

#### **Compliance Specification (C)**

Compliance Specifications are environmental specifications not to be quantified focusing on compliance with existing legislation or standards.

#### ***Design Provision (D)***

Design Provisions are qualitative environmental specifications which describe a special piece of equipment or component with a certain functionality (e.g. provision of rolling stock with energy meters).

A more detailed description of the classification and the applied quantification scheme can be found in the Appendix.

### 3.4 Detailed Description of Environmental Specifications

In the following the Environmental Specifications recommended for use in invitations to tender are listed by key area and described in more detail according to the following scheme:

- Title of Specification
- Introduction  
The relevance of the Environmental Specification is described.
- Definition  
The General definition of the Environmental Specification is given and specific issues concerning verification or measurement procedures are described. In areas where this is of high importance, detailed measurement procedures are given in the Appendix, but in some cases there will only be a reference made to the document where those procedures are specified.
- Environmental performance indicator  
For all quantifiable specifications (target and performance specifications) the respective indicator is stated
- Target value  
Target values are given for Target Specifications only
- Application  
The range of application is specified (Multiple units, locomotives, passenger coaches, freight wagons)
- Type of specification
  - Mandatory
  - Voluntary - Environmental performance defined by operation and design;  
Environmental performance mainly preconditioned by design
- Degree of quantification:  
The specification is classified according to the quantifiability scheme laid out in chapter 3.3 (Target Specification, Performance Specification, Compliance Specification, Design Provision)

(An overview of all specifications listed by key area is given in the Appendix).

### 3.4.1 General Prerequisites

#### **Compliance with Legislation**

The existing body of environmental regulations is broad and varied. By fulfilling this precondition the manufacturer ensures that the applicable legislation with respect to the environment (national/European/international) has been observed when the vehicle is delivered to the customer.

### 3.4.2 Energy Efficiency Specifications

Energy efficiency of rail vehicles is the area with the least dense legal framework, but is of environmental relevance and has the highest potential to minimise life-cycle costs. Energy costs may even exceed investment costs for some locomotive types.

#### 1) **Traction Energy Consumption**

Traction energy accounts for the largest share of energy consumption by trains. Greater efficiency bears high environmental and economic potential.

The manufacturer should calculate the energy consumption for the requested operation pattern such that the energy-related LCC costs of the train in operation can be taken into account. This operation pattern can either be one (or a set of several) specific route(s) or a standardised pattern (e.g. speeds, distance between stops, track gradients, etc.) which approximate the future service pattern of the vehicle.

Information about the energy efficiency of the engine at different payloads can be requested additionally to get an impression of the performance of the traction unit.

Definition of environmental specification	
Energy consumption of traction unit	
Environmental performance indicator	
Calculated traction energy consumption (kWh or litres of fuel) for specific operation pattern	
<b>Application:</b>	Multiple units, locomotives
<b>Type of specification:</b>	Voluntary Environmental performance defined by operation and design
<b>Degree of quantification:</b>	Performance specification

The calculated values must be verifiable by measurements afterwards. Agreement on the measurement method to be applied, including framework conditions and acceptable tolerances will be of particular relevance.

For the long-term perspective, energy consumption should not be calculated for specific (individual) operational patterns but according to harmonised patterns with a standardised methodology (standardised definition of simulation and verification measurements) in order to allow for an easy to handle comparison of different vehicles.<sup>10</sup>

<sup>10</sup> A feasibility-study "Harmonisation of test cycles for energy consumption of rolling stock" has been approved by the CTR (Technical and Research Commission of the UIC). Based on this study a a

## 2) *On-board Energy Consumption*

Energy consumption for comfort purposes amounts to about 20 to 30% of the total energy consumption in passenger transport in central and northern European countries (heating). With an increased proportion of air-conditioned vehicles, on-board energy consumption is set to become an issue of growing importance in southern European countries too. Energy consumption for comfort functions can be optimised by a set of different “intelligent” technologies, such as CO<sub>2</sub> detectors to optimise interior air quality according to passenger density.

<b>Definition of environmental specification:</b>	
Energy consumption for auxiliaries and comfort functions	
<b>Environmental performance indicator:</b>	
Calculated on-board energy consumption (kWh) for defined conditions	
<b>Application:</b>	All kinds of rolling stock
<b>Type of specification:</b>	Voluntary Environmental performance defined by operation and design
<b>Degree of quantification:</b>	Performance specification

The railway has to specify the layout parameters and external conditions for comfort functions in the invitation to tender and there should be an agreement on the concrete calculation method.

## 3) *Energy Recovery / Regeneration*

Energy recovery with dynamic brakes offers very considerable potential for saving, especially for:

- electric multiple units and locomotives on AC lines and
- on local and regional lines (AC and DC lines) with frequent stops.

It is also possible to equip diesel electric vehicles so that they use recovered energy for comfort functions in passenger transport. Energy storage systems are still not in standard service but might also be considered in future invitations to tender.

<b>Definition of environmental specification:</b>	
Equipment of the train with energy recovery / regeneration / storage	
<b>Application:</b>	Locomotives and Multiple Units
<b>Type of specification:</b>	Voluntary Environmental performance defined by operation and design
<b>Degree of quantification:</b>	Design Provision

joint project between the railways and industry is foreseen to define an appropriate approach and develop comparable energy consumption standards.

The railway must specify the detailed functionality of the energy recovery/ regeneration/ storage system in the invitation to tender.

#### 4) **Energy Management for Parked Vehicles**

Auxiliaries and comfort functions result in a considerable amount of energy consumption in parked trains, for example if they are heated / air-conditioned overnight. An automatic control system can considerably reduce energy consumption during parking hours. The saving potential is expected to be 3 to 5% of total energy consumption (15% – 25% savings for comfort energy consumption).

The railway must further specify the functionality of the energy management system in the invitation to tender. In order to exploit the existing saving potential, it is vital that the automatic control system is compatible with maintenance and service duties and the procedures followed by the railway operator.

<b>Definition of environmental specification:</b>	
Energy management / control system for comfort functions at longer standstills	
<b>Application:</b>	Multiple units, passenger coaches
<b>Type of specification:</b>	Voluntary Environmental performance defined by operation and design
<b>Degree of quantification:</b>	Design Provision

#### 5) **Energy-Metering Devices**

An energy meter does not minimise energy consumption by itself, but it is a very important prerequisite that provides valuable data to identify energy saving potential for rolling stock. The energy meter could also be used for the driver to control energy consumption with respect to his driving style.

<b>Definition of environmental specification:</b>	
Energy metering devices	
<b>Application:</b>	Multiple units, locomotives
<b>Type of specification:</b>	Voluntary Environmental performance defined by operation and design
<b>Degree of quantification:</b>	Design Provision

The railway has to specify the detailed functionality of the energy-metering devices in the invitation to tender.

#### 6) **Specific Mass**

The mass of a vehicle is a decisive parameter for later energy consumption in operation. Weight losses are more significant in operations with frequent stops and a high share of energy consumption for acceleration (e.g. regional transport) than in high speed applications.

Although this specification is redundant with the more general specifications on energy consumption (see above), it is recommended that it be used additionally, because the vehicle mass or specific mass are easy to measure and verify.

<b>Definition of environmental specification:</b>	
Value for vehicle mass	
<b>Environmental performance indicator:</b>	
Locomotives:	absolute mass
MUs and passenger coaches:	mass per seat <sup>11</sup>
Freight wagons:	mass per payload
<b>Application:</b>	All kinds of rolling stock
<b>Type of specification:</b>	Voluntary Environmental performance mainly preconditioned by design
<b>Degree of quantification:</b>	Performance specification

### 3.4.3 Noise Emissions Specifications

The general trend in noise regulation is to set common European emission limit values for vehicles in addition to the existing reception limits along certain tracks. At EU level, the Technical Specification for Interoperability (TSI) for High Speed has defined limit values for high speed trains and is already in force. The TSI for conventional rail was approved by the “Article 21 Committee” in November 2004, will be notified by the EC in the second semester of 2005 and will then come into force six months later. All three specifications listed below - passing-by noise, stationary noise and starting noise - are addressed in the TSI. The TSI for conventional trains refers to vehicles which operate or partly operate on the interoperable railway network - the main section of the European railway network. However, it is highly recommended that the specifications be used for all rolling stock procurement. In many European countries, national noise legislation must also be respected.

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<sup>11</sup> For passenger coaches and MU the unit should be mass per (seat + x \* square meter) to account for passengers standing. X is typically 0 for a high speed train, and at least 4 for a metro train.

## 7) *Passing-by Noise*

It is highly recommended that passing-by noise be addressed in each invitation to tender even if there is no regulation in force for the specific case of the tender.

<b>Definition of environmental specification:</b>	
Passing-by noise	
<b>Environmental performance indicator:</b>	
As specified in TSI ( $L_{pAeq,Tp}$ in 7,5m distance for conventional trains and TEL in 25m distance for high-speed trains <sup>12</sup> ; measurement conditions also specified in the TSI)	
<b>Target Value:</b>	
As defined by TSI	
<b>Long-term Goal:</b>	
To be defined	
<b>Application:</b>	All types of rolling stock
<b>Type of specification:</b>	Mandatory Environmental performance mainly preconditioned by design
<b>Degree of quantification:</b>	Target specification

The railway must stipulate the applicable noise limit. The value must be fixed in the contract.

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<sup>12</sup> In the ongoing high speed TSI revision process, a change to  $L_{pAeq,Tp}$  in 25m distance has been proposed.

### 8) **Stationary Noise**

It is highly recommended that stationary noise be addressed in each invitation to tender even if there is no regulation in force for the specific case of the tender.

<b>Definition of environmental specification:</b>	
Noise emissions at standstill with all equipment running	
<b>Environmental performance indicator:</b>	
As specified in TSI ( $L_{pAeq, Tp}$ in 7,5m distance) (Measurement conditions specified by TSI)	
<b>Target Value:</b>	
As defined by TSI	
<b>Long-term Goal:</b>	
To be defined	
<b>Application:</b>	All kinds of rolling stock
<b>Type of specification:</b>	Mandatory Environmental performance mainly preconditioned by design
<b>Degree of quantification:</b>	Target specification

The railway has to specify the value in the invitation to tender. The value must be fixed in the contract.

### 9) Starting Noise

It is highly recommended that starting noise (noise emissions from accelerating from standstill) be addressed in each invitation to tender even if there is no regulation in force for the specific case of the tender.

<b>Definition of environmental specification:</b>	
Noise emissions during starting process	
<b>Environmental performance indicator:</b>	
As specified in TSI ( $L_{pAFmax}$ in 7.5m distance) (Measurement conditions specified by TSI)	
<b>Target Value:</b>	
As defined by TSI	
<b>Long-term Goal:</b>	
To be defined	
<b>Application:</b>	Multiple units, locomotives
<b>Type of specification:</b>	Mandatory Environmental performance mainly preconditioned by design
<b>Degree of quantification:</b>	Target specification

The railway has to specify the value in the invitation to tender. The value has to be fixed in the contract.

#### 3.4.4 Diesel Exhaust Emissions

Exhaust emissions from diesel engines constitute a key rolling stock-related environmental aspect of high public interest, on account of health concerns primarily.

Exhaust emission limit values for “non-road mobile machinery” in Europe are governed by EU Directive 97/68/EC. The scope of the directive was extended to include rail vehicles in 2004 with amendment 2004/26/EC. The limit values for Stage III A for NO<sub>x</sub>, CO, HC, PM emissions will be binding from 2006 for railcars and from 2007 or 2009 respectively, depending on the power rating for locomotives. As a next step, III B is foreseen for 2012, however there will be a review of the feasibility of these values before the end of 2007.

Special attention must be paid to the fact that the directive not only refers to new vehicles but also to reengining. Thus when procuring new rolling stock, account must be taken of the fact that stricter limit values may be applicable for future reengining. Consequently, it is important to make design provisions allowing for the necessary upgrades (e.g. sufficient space in locomotives for particle filters).

### 10) Diesel Exhaust Emissions

Although diesel exhaust emissions are governed by EU Directive 97/68/EC, amended by EU Directive 2004/26/EC, it may be advisable from a strategic point of view to achieve lower emission values (the values outlined previously in the Directive), since DMUs and locomotives with better performances offer a broader range of serviceability if individual local authorities demand stricter emission requirements (e.g.: to comply with EU Directive 1999/30/EC on ambient air quality), or to use low emission vehicles in tunnels or maintenance facilities as well.

#### Definition of environmental specification:

Exhaust Emissions for NO<sub>x</sub>, CO, HC, and PM

#### Environmental performance indicator:

Emission in g/kWh for standardised load factors (load cycles)

#### Target Value:

As defined by EU directive 97/68/EC amended by EU directive 2004/26/EC and their equivalent in national laws<sup>13</sup>

#### Long-term Goal:

Stage III B values

(only achievable by exhaust gas after-treatment – feasibility subject to technical review of the directive before 31 December 2007)

#### Application:

Diesel multiple units and locomotives

#### Type of specification:

Mandatory  
Environmental performance mainly preconditioned by design

#### Degree of quantification:

Target specification

The railway has to specify the applicable values in the invitation to tender, in line with the directive mentioned above.

### 11) Diesel Exhaust Emissions – Specific Load Conditions

This specification asks the manufacturer for the exact emission factors of the diesel engine. This information can be used e.g. to compare different engines, to design and optimise low emission driving patterns for sensitive areas (“city mode”), or to calculate emissions from a company’s vehicle fleet for communication purposes.

<sup>13</sup> Until EU Directive 97/68/EC, amended by EU Directive 2004/26/EC, enters into force, it is recommended that the UIC Leaflets 623 and 624 be applied in the European Union.

<b>Definition of environmental specification:</b>	
Exhaust emission of NO <sub>x</sub> , CO, HC, PM according to the “approval certificate” (for each load stage of the applied test cycle, e.g. ISO 8178 F or C1)	
<b>Environmental performance indicator:</b>	
Emission in g/kWh	
<b>Application:</b>	Diesel multiple units and locomotives
<b>Type of specification:</b>	Voluntary Environmental performance defined by operation and design
<b>Degree of quantification:</b>	Performance specification

The manufacturer provides a test report with the exact emission factors of the diesel engine. Besides the weighted emission factor according to the test cycle applied (e.g. ISO 8178 F or C1), the emission factors of each measured load stage have to be provided. This would allow the operator to individually weight the load stages. The emission factors required must be measured in the approval procedure in accordance with EU Directive 97/68/EC, amended by EU Directive 2004/26/EC, before the engine is put on the market, signalling that no additional measurements are needed<sup>14</sup>.

## **12) Diesel Exhaust Emissions at Longer Standstills**

Diesel engines often have to run at standstill to ensure an electricity supply for comfort functions, e.g. at passenger stations or during short-term parking. As exhaust emissions (and noise) from running diesel engines often disturb passengers and residents (especially in densely populated areas and close to stations or depots), measures to reduce the necessity of running diesel engines or other ways of avoiding exhaust emissions at passenger stations should be considered, such as integration of a separate on-board energy supply or a connection to an external electricity supply for multiple units and passenger coaches of locomotive-hauled trains.

<b>Definition of environmental specification:</b>	
Measures to prevent exhaust emissions at longer standstills	
<b>Application:</b>	Diesel multiple units and locomotives
<b>Type of specification:</b>	Voluntary Environmental performance defined by operation and design
<b>Degree of quantification:</b>	Design provision

<sup>14</sup> The basis is the approval certificate of the respective engine. If no statement is made with respect to deterioration at the individual load points, it should be assumed that the deterioration factor for the whole engine also applies to each load point.

If an external electricity supply is considered a possible solution, the railway has to specify its operation in accordance with the existing infrastructure.

### 3.4.5 Materials/Recycling/Waste Specifications

#### 13) *Legally Restricted Materials*

At national, European and international level the use of several substances is restricted (i.e. prohibited) in all circumstances or restricted in some circumstances or applications, such as PCB in transformers or CFC in air conditioners (at EU level: regulated by Council Directive 76/769/EEC and its amendments, specific legislation on ozone depleting substances and other miscellaneous legislation). Compliance with such legislation on listed applications/use is mandatory (it must be recognised that very few substances are prohibited in all circumstances, as opposed to the number of substances with specific limitations).

#### Definition of environmental specification:

Legally restricted materials – either for all or for selected uses/applications

#### Mandatory performance:

Compliance with legislation (exclusion of legally forbidden materials)

#### Application:

All kinds of rolling stock

#### Type of specification:

Mandatory  
Environmental performance mainly preconditioned by design

#### Degree of quantification:

Compliance Specification

To ensure a high level of information within this complex field, the operator should inform manufacturers of specific national legislation in the invitation to tender.

#### 14) *Unwanted and Controlled Materials*

##### *Unwanted Materials*

In addition to legally restricted substances, the use of certain other substances should be reduced (in specific applications). The selection of such substances should be based on an exchange of information between operators and manufacturers taking into account risk assessments as well as feasibility and the financial impact of material exclusion. Going beyond the legal standards can be attractive for operators in order to minimise the financial risk associated with the impact of forthcoming legislation (use of a particular material to be prohibited in future) or end-of-life costs of rolling stock. Public sensitivity towards certain materials could also play an important role in the choice of such unwanted materials and uses. In practice, many operators have their own lists of unwanted materials which go beyond the legal standard.

##### *Controlled Materials*

In addition to the aforementioned material exclusions, there may be other reasons for creating a specific information flow on the presence of certain substances/materials in the rail vehicle or some of its components. Train operators need to know what (hazardous) substances/ materials are present in their trains in order to develop the right operation/

maintenance/ dismantling/ recycling policies and procedures. In addition, a detailed inventory of (hazardous) materials supports operators' ability to demonstrate their environmental performance (e.g. environmental report).

<b>Definition of environmental specification:</b>	
Unwanted and/ or controlled materials which are potentially hazardous to health or the environment	
<b>Environmental performance indicator:</b>	
Weight ratios or absolute amounts of defined (hazardous) materials And Inventory degree of controlled materials (Ratio of hazardous substances/uses which actually underwent a full disclosure, relative to all the unwanted and controlled substances/uses which should undergo a full disclosure)	
<b>Recommended Performance:</b>	
a) Exclusion of unwanted materials b) Inventory of (hazardous) materials, primarily for LCA and recycling purposes (controlled materials)	
<b>Application:</b>	All kinds of rolling stock
<b>Type of specification:</b>	Voluntary Environmental performance mainly preconditioned by design
<b>Degree of quantification:</b>	Performance Specification

For any restrictions beyond the legal level, it is advisable to specify in the tender those components in which (hazardous) substances have to be avoided (unwanted materials). A general prohibition of substances is often difficult to verify in practice. Thus the operator should highlight those components in which high concentrations of certain (hazardous) substances could be anticipated and where exposure is potentially high (e.g. potential contact with passengers), but for which substitutions exist.

As with unwanted materials, the operator should specify the controlled materials (substances *and* components) to be evaluated by the manufacturer. The manufacturer should then provide information if the requested substance is present (weight ratio or absolute weight) and state why the specific solution was chosen (e.g. high cost of alternatives). To validate the quality of the information provided, the amount of detail in the inventory should also be assessed.

The number of unwanted/controlled materials and uses must be limited to a feasible number for the sake of manageability by industry. The development of a single agreed and standardised list of unwanted and controlled materials is still lacking and can be considered a medium-term goal in this field for the rail sector. A first attempt to define a harmonised list of unwanted and controlled materials has been made within the EU-funded project REPID. In order to be in line with other activities in this field at EU level, the outcomes of the existing risk assessments and of the upcoming REACH process on the classification of hazardous substances must be taken into consideration.

### 15) **Hazardous Waste**

Knowledge of materials which are classified as hazardous waste at the end of their life-cycle or during operation and maintenance of a vehicle is not only important for ecological reasons but is also necessary in order to be able to calculate life-cycle-costs and keep end-of-life costs low.

#### **Definition of environmental specification:**

Materials and components which during the lifespan and/or at the end of the service life of the vehicle will have to be treated as hazardous waste

#### **Environmental performance indicator:**

Amount (weight) of hazardous waste (according to European waste catalogue)

<b>Application:</b>	All kinds of rolling stock
<b>Type of specification:</b>	Voluntary Environmental performance mainly preconditioned by design
<b>Degree of quantification:</b>	Performance specification

The amount of hazardous waste is not defined by the total amount of hazardous substances but by the total weight of the respective components/parts (including consumables and spare parts) and other units which are classified as hazardous waste and have to be treated as such. In this context, the declaration of hazardous waste does not depend on a full and detailed material list. Adopting a much more practical and usable approach, the manufacturer should only be asked to provide detailed information on those components or parts (including consumables and spare parts) which would have to be treated as hazardous waste according to the European Waste Catalogue if they had to be disposed of at the time at which the contract is signed.

### 16) **Recycling Rate**

Recycling of product materials is an important parameter for the public and at political level. The clear objective of European Union policy is to enhance the recycling of product materials (e.g. with the Integrated Product Policy – IPP).

For the automotive sector Directive 2000/53/EC has defined the values for the recyclability of new road vehicles to be met by 2006<sup>15</sup>:

- Reuse and recovery<sup>16</sup>: 85% by weight
- Reuse and material recycling: 80% by weight.

Under the same directive, the following values are to be met by 2015:

- Reuse and recovery: 95% by weight
- Reuse and material recycling: 85% by weight

<sup>15</sup> The ISO standard 22628 gives a calculation method for the “Recyclability and Recoverability” of road vehicles. It could also serve as a guideline for the rail industry.

<sup>16</sup> Recovery includes material recycling and incineration with energy recovery

Although there are still no regulations in force for the rail sector, rail vehicles should contribute to the European policy of avoiding waste generation. Standards in the automotive industry should be considered a bottom-line benchmark. A high rate of recycling as the result of sound material separation by disassembly is believed to have a positive impact on the maintainability of rolling stock as well.

As there are still no standard values for the parameters entitled “material recycling rate” and “material that can be incinerated” for use in invitations to tender, railways must coordinate closely with manufacturers on recycling rates of rail vehicles.

The railway could define a target value for “material recycling rate after use” alone or a target value for all forms of recycling (including both “material recycling rate after use” and “material that can be incinerated with energy recovery”).

<b>Definition of environmental specification:</b>	
Recyclability	
<b>Environmental performance indicator:</b>	
Defined value for recyclability:	
<ul style="list-style-type: none"> <li>- material recycling rate and/or</li> <li>- recycling rate including incineration with energy recovery</li> </ul>	
<b>Application:</b>	All kinds of rolling stock
<b>Type of specification:</b>	Voluntary Environmental performance mainly preconditioned by design
<b>Degree of quantification:</b>	Performance specification

A recycling rate based on the criterion “recyclability” alone is a rather theoretical indication and gives only an upper limit which can be reached under optimum conditions (high rates of return, use of good technological standards, well organised collecting systems).

### **17) Renewable Materials**

Renewable materials have been used for a number of years in road vehicle construction in particular to enhance environmental performance and this has been publicised by the automotive industry. The railways could also increase the amount of renewable materials in their rolling stock. But care must be taken to ensure that renewable materials are compliant with safety and hygiene specifications, fire prevention requirements and that the weight of renewable materials does not run contrary to efforts to decrease the energy consumption of the train nor crash safety and the overall environmental performance.

The railway company has to specify the target weight/ratio of the renewable materials in the vehicle in the invitation to tender.

<b>Definition of environmental specification:</b>	
Use of renewable materials	
<b>Environmental performance indicator:</b>	
Weight ratios of renewable materials in vehicle	
<b>Application:</b>	Multiple units and passenger coaches
<b>Type of specification:</b>	Voluntary Environmental performance mainly preconditioned by design
<b>Degree of quantification:</b>	Performance specification

### 3.4.6 Other

#### 18) *Electromagnetic Fields*

Problems associated with electromagnetic fields concern mostly electromagnetic compatibility (interaction between train appliances and signal technology or screen phenomena). More recently, potential health problems caused by electromagnetic fields (“electrosmog” or EMF) have been discussed. Even in the absence of consistent and reliable information about the effects of “electrosmog” caused by railway operations, railway companies should apply the precautionary principle and ensure low emission levels where protective measures can be put into practice at reasonable cost.

Existing EU legislation regulates the exposure of staff to electromagnetic fields in the workplace. The limit values given in EU Directive 2004/40/EC correspond to the ICNIRP recommendations on occupational exposure. In addition, the EU Council Recommendation 1999/519/EC provides limit values for the exposure of the general public to electromagnetic fields. They correspond to the ICNIRP recommendations for the general public and are the basis of much national legislation and numerous recommendations. These values are up to five times stricter than the occupational exposure limit values in order to take account of highly sensitive people (e.g.: children, pregnant women). With respect to the precautionary principle, the limit values should be met in all places where passengers are even briefly present.

Certain spectra of electromagnetic fields can affect the operation of life-supporting devices (e.g. pacemakers, insulin pumps). Compatibility with these devices must be ensured by the manufacturer.

<b>Definition of environmental specification:</b>	
EMF exposure in all areas of the vehicle where people are present.	
<b>Mandatory compliance:</b>	
As defined in 2004/40/EC for all areas where staff may be present	
<b>Target compliance:</b>	
As defined in EU Council Recommendation 1999/519/EC for all areas where passengers may be present.	
<b>Application:</b>	All kinds of rolling stock
<b>Type of specification:</b>	Mandatory
<b>Degree of quantification:</b>	Compliance specification

The legal baseline is represented by EU Directive 2004/40/EC. Nevertheless, the limit values given in EU Council Recommendation 1999/519/EC should be regarded (with respect to the precautionary principle) as objectives. In addition, national legislation may have to be considered for Switzerland, Italy and Finland.

The manufacturer must present a protocol of the measurements upon delivery of the vehicles.

### 19) *Emissions from Brake Friction Material*

Particulate emissions from brake pads or disc brakes can contain toxic substances or particulate matter. Railway companies should apply the precautionary principle and ensure low emission levels where measures can be put into practice at reasonable cost.

Due to the increasing number of composite brakes in rail vehicles and growing public awareness of the health risks related to dust emissions, the issue should be addressed as part of the procurement process for new rolling stock.

<b>Definition of environmental specification:</b>	
Emissions from brakes which are harmful to health or the environment	
<b>Environmental performance indicator:</b>	
Concentrations of defined hazardous materials in brake friction material	
<b>Application:</b>	All kinds of rolling stock
<b>Type of specification:</b>	Voluntary Environmental performance mainly preconditioned by design
<b>Degree of quantification:</b>	Performance specification

To date, no harmonised measurement procedure exists for brake friction material emissions. An assessment of the brake friction material can serve as a first step towards reducing the risk of hazardous emissions. The operator should demand a materials declaration from the supplier of the brake friction material specifying all concentrations of toxic substances contained (checklist of substances has to be specified by operator, possible references are substances listed in regulations on occupational health e.g. MAC, AFS or national COHSs<sup>17</sup> and the forthcoming European standard on “Brake Pad Friction Materials”<sup>18</sup>).

In addition, in order to minimise exposure levels for staff and passengers, air intake designs for coaches, MUs and locomotives should seek to reduce the intake of brake friction material emissions into the vehicle. Due to the unpleasant smell of many brake emissions this is generally advisable with regard to passenger comfort. Intensified regenerative braking also helps to minimise dust emissions from brake wear

## 20) *Spillage / Leakages*

### Definition of environmental specification:

The manufacturer verifies that measures to prevent environmental damage due to spilling of oil, leakages, grease, coolant, and other substances have been taken.

<b>Application:</b>	All types of rolling stock
<b>Type of specification:</b>	Voluntary Environmental performance mainly preconditioned by design
<b>Degree of quantification:</b>	Compliance specification

This specification does not apply to biodegradable lubricants.

<sup>17</sup> MAC: maximum allowable concentration; AFS: American Foundry Society; COHS: Centre for Occupational Health & Safety

<sup>18</sup> European Committee for Standardization CEN, Technical Committee TC256, Work Items WI171 and 173

### 3.5 Approach to the Evaluation of Environmental Aspects in Tenders

The descriptions of the specifications introduced in chapter 3.2 together with an economic assessment provide a basis for the evaluation of tenders in terms of environmental issues and their respective costs.

Taking into account the priority settings and strategic orientations laid out in chapter 3.2 and the need to integrate important additional internal and external requirements (see chapters 2.2, 2.3 and 3.1) as well as economic criteria, the following evaluation phases and steps are suggested:

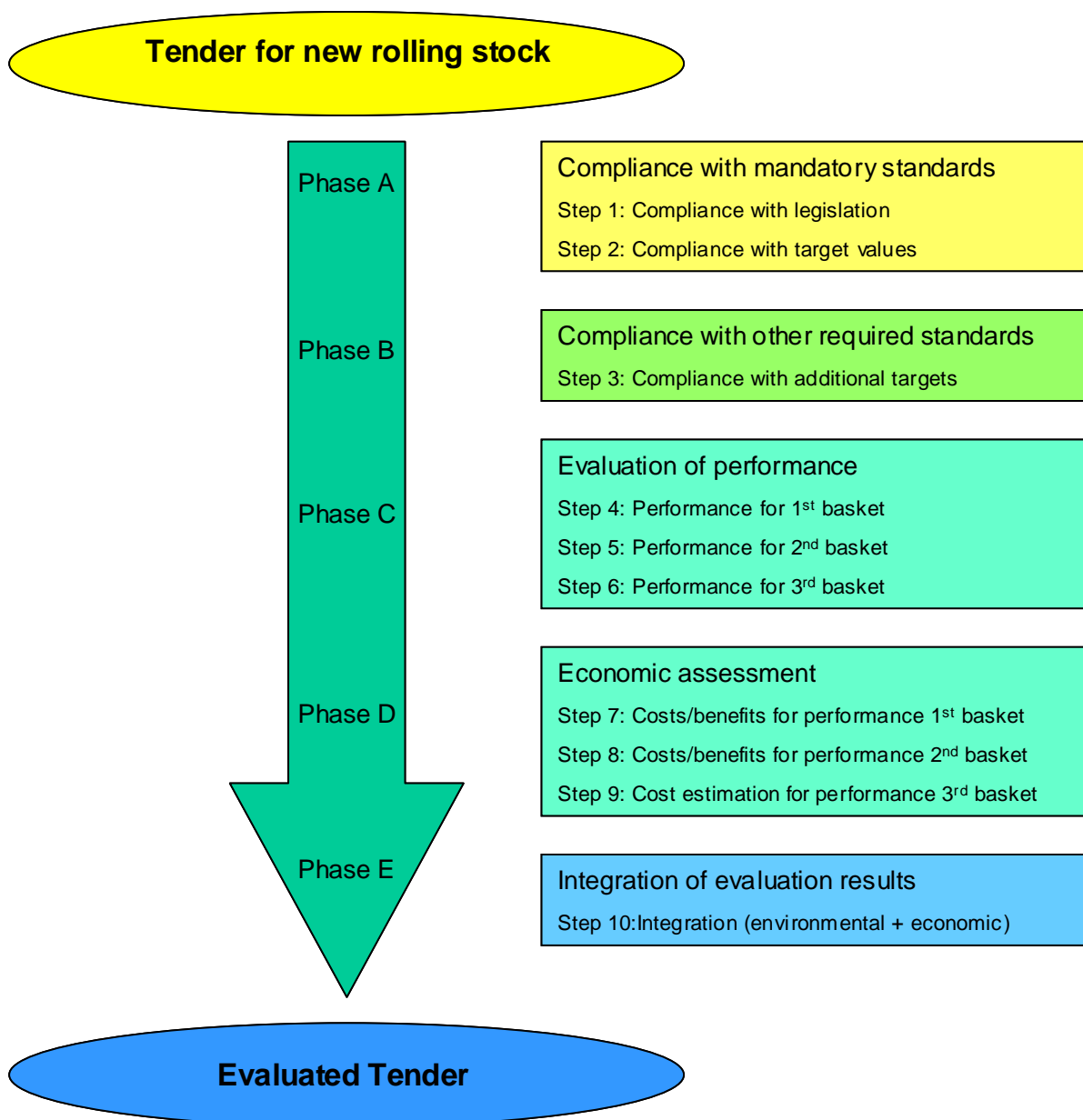


Figure 6: Strategy for the evaluation of environmental aspects in tenders for new rolling stock and refurbishment or upgrading.

**Phase A: Compliance with legal standards**

(mandatory environmental performance)

Input: Compliance statement, Environmental Specifications (mandatory), target values

Step 1: Compliance with applicable legislation (General Precondition)

Step 2: Compliance with defined target values derived from legislation (Specific Precondition)

Output: Compliance/non-compliance

**Phase B: Compliance with other necessary environmental standards not governed by legislation**

Input: Additional targets

Step 3: Compliance with target values set by local authorities, infrastructure operators or other 3<sup>rd</sup> parties

Output: Compliance/non-compliance

**Phase C: Evaluation of environmental performance not governed by legislation/additional requirements or exceeding legal standards**  
(voluntary environmental performance)

Input: Environmental Specifications and their priorities, additional internal and external requirements, knowledge base for current good practice

Step 4: Environmental Performance for target specifications exceeding legal standards (mandatory)

Step 5: Environmental performance for the specifications for which performance is defined by operation and design. Prevailing operational schemes and existing infrastructure have to be considered in the assessment (see also 3.2).

Step 6: Environmental performance for the specifications for which performance is mainly preconditioned by design

Output: Overall environmental performance, performance with respect to good practice, already defined future standards and forthcoming standards/ standards in discussion

**Phase D: Economic assessment of the improved environmental performance**

Input: Environmental Specifications and their priorities, additional internal and external requirements, knowledge base for current good practice

Step 7: Cost/ benefit analysis of environmental performances better than legally required (mandatory)

Step 8: Cost/ benefit analysis of environmental performance defined by operation-dependent specifications. The main focus in this step of the economic assessment will be the Energy Efficiency specifications. Prevailing operational schemes and existing infrastructure have to be considered in the assessment (see also 3.2).

Step 9: Estimation of costs and benefits for environmental performance defined by design-dependent specifications

Output: Estimated LCC effects for improved environmental performance (per key area and per environmental specification)

**Phase E: Integration of evaluation results**

Input: Compliance with additional targets, result of evaluation of environmental performance, results of respective economic assessment, ranking of priorities

Step 10: Integration of the results of the evaluation

Output: Aggregate result of evaluation

The overall result of the evaluation of a tender concerning environmental aspects is obtained by integrating the results of the environmental performance evaluation and the corresponding economic assessment. Due to the fact that environmental performance is determined by quantitative as well as qualitative specifications, the integration procedure is not a straight-forward and fully quantified one. Instead, the results of the environmental and economic evaluation of the top priority specifications should be grouped together e.g. by strategic targets and then weighted so as to adequately reflect the respective importance of these targets.

When comparing different tenders with respect to their environmental performances, a reasonable balance must be struck, for example between:

- Additional initial investment costs and decreased future costs to meet already defined or forthcoming long-term legal standards
- Increased initial investment costs and lower operating costs (including maintenance) or end-of-life costs.

With reference to the second example, rolling stock energy consumption is clearly one key factor in the decision on which proposed train offers the best cost/benefit ratio.

## 4 Appendix I: Quantification of content of specifications

Environmental specifications can be classified according to the following criteria:

- Flexibility with regard to design solutions (functional approach = free choice of design options to achieve the required environmental performance, as compared to a design-oriented approach = restriction of possible design options).
- Required degree of quantification (to be quantified, not to be quantified)
- Existence of target values (target values defined, target values not yet defined, no target values)

The following diagram illustrates the resulting quantification process:

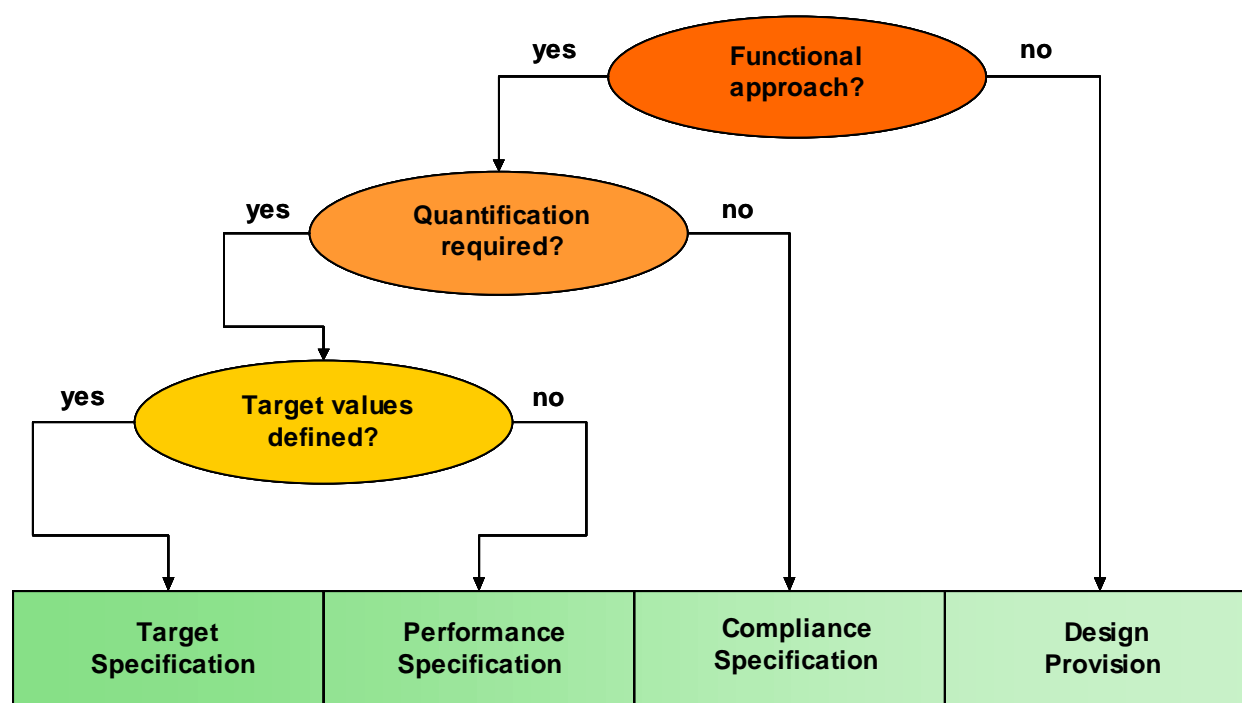


Figure 5: Quantification process for Environmental Specifications

### Design Provision (D)

Design Provisions are qualitative environmental specifications which describe special equipment or component with a specific function (e.g. provision of rolling stock with energy meters). The manufacturer should provide technical information relating to the special equipment detailing its performance (example: energy metering devices).

### Compliance Specification (C)

Compliance Specifications are environmental specifications not to be quantified focusing on compliance with existing legislation or standards. The manufacturer must simply state whether or not the rolling stock or certain components conform with the required legislation/standard (example: electromagnetic fields).

### **Performance Specification (P)**

Performance Specifications are environmental specifications to be quantified by the manufacturer for which no target values are set. Instead the manufacturer is asked to specify a certain performance value to be calculated or measured under defined conditions.

Depending on the environmental specification concerned there can be different reasons why it is not feasible or recommended to define target values despite the fact that the specification is quantifiable and measurable:

1. For certain specifications the comparable information or data basis is too poor to define target values. If the operator asks for performance values the data basis will improve gradually.
2. Certain specifications are highly dependent on framework conditions (e.g. according to specific national or operational conditions) and therefore yield very complex sets of values. In this case it does not make sense to define a target value for every single constellation of framework conditions.
3. For some environmental specifications too many special cases exist (e.g. type of vehicle, comfort class) so that it is not feasible to set up a target value. By using performance values, operators still have the possibility of assessing individual cases.

The Performance Specifications to which scenario 1 applies can be developed into Target Specifications over the mid or long-term if the necessary information basis has been built up and/or the gap between the interests of operators and manufacturers closed. The Specifications characterised by scenarios 2 and 3 will retain their status as Performance Specifications in the foreseeable future.

In the individual tender, however, target values may be given for performance specifications if the operator has sufficient knowledge in this specific field (from previous projects) (example: Traction energy consumption).

### **Target Specification (T)**

Target Specifications are environmental specifications to be quantified by the manufacturer for which target values are set. These are directly taken from the applicable legislation/ regulations/ standards. Alternatively, they can be developed within the framework of a consensus process between operators and manufacturers. The leaflet gives the target values derived from legislation as baseline values any tenderer has to meet. The actual performance of a given item of rolling stock may be better (for example: diesel exhaust emissions).

## 5 Appendix II: Overview of all Specifications

The following table lists the set of environmental specifications shown in figure 4 by key areas. It shows the application of each specification as well as the type and range of quantification.

No	Environmental Specification	Applicable for	Type of specification	Degree of quantification.
<b>Energy Efficiency</b>				
1	Traction Energy Consumption	MUs, locos	O	P
2	On-board Energy Consumption	All	O	P
3	Energy Recovery / Regeneration	MUs, locos	O	D
4	Energy Management for Parked Vehicles	MUs, pass. coaches	O	D
5	Energy-metering Devices	MUs, locos	O	D
6	Specific Mass	All	D	P
<b>Noise Emissions</b>				
7	Passing-by Noise	All	Mandatory	T
8	Stationary Noise	All	Mandatory	T
9	Starting Noise	MUs, locos	Mandatory	T
<b>Diesel Exhaust Emissions</b>				
10	Diesel Exhaust Emissions	DMUs, D-locos	Mandatory	T
11	Diesel Exhaust Emissions – Specific Load Conditions	DMUs, D-locos	O	P
12	Diesel Exhaust Emissions at Longer Standstills	DMUs, D-locos	O	D
<b>Materials/Recycling/Waste</b>				
13	Legally Restricted Materials	All	Mandatory	P
14	Unwanted and Controlled Materials	All	D	P
15	Hazardous Waste	All	D	P
16	Recycling Rate	All	D	P
17	Renewable Materials	MUs, pass. coaches	D	P
<b>Other</b>				
18	Electromagnetic Fields	All	Mandatory	C
19	Emissions from Brake Friction Material	All	D	P
20	Spillage / Leakages	All	D	C

Table 1: Recommended environmental specifications for use in invitations to tender

**Abbreviations:** O: Environmental performance defined by operation and design; D: Environmental performance mainly preconditioned by design (as introduced in 3.2); C: Compliance Specification; T: Target Specification; P: Performance Specification; D: Design Provision (as introduced in 3.3); MU: Multiple Units; DMU: Diesel Multiple Units

## 6 Appendix III: Background Information for Key Areas

### 6.1 Energy Efficiency

#### 6.1.1 Relevance of this Key Area

Energy efficiency is a key challenge for today's railway companies. Due to the advantages of the wheel/track system with its low rolling resistance, the energy efficiency of railways remains an outstanding competitive advantage, especially compared to aviation and individual road traffic. Further enhancement of this advantage would improve both the environmental and economic competitiveness of the railways. Reducing energy consumption could contribute considerably to the improvement of overall cost efficiency because the energy costs make up a substantial portion of life-cycle-costs:

**Table 2: LCC for locomotives**

	<b>Locomotive for passenger service</b>	<b>Locomotive for freight service</b>
<b>Initial investment cost</b>	23 %	12 %
<b>Energy cost</b>	46 %	74 %
<b>Maintenance cost</b>	31 %	14 %

[EVENT 2003]

There is general agreement on the potential for the railways to achieve considerable energy savings over the short, mid and long term. Exploitation of this potential is highly plausible due to the positive cost-benefit ratio associated with many measures in this field. It should be stressed, however, that a Life-Cycle-Cost (LCC) oriented approach is required to demonstrate the economic advantages of most energy saving measures, i.e. today's focus on initial investment must be overcome.

In order to identify the most promising offers during the procurement process, the comparison of different tenders regarding energy efficiency needs to become much more transparent. This would also lead to competition between the different manufacturers to achieve more energy efficient designs. As a long-term objective, generally accepted test cycles or consumption standards (as already established in the automobile sector) and energy efficiency classes (as established e.g. for household electrical appliances) should be developed.

#### 6.1.2 Technical State of the Art

The energy consumption of rolling stock is attributed to three main areas:

- Energy for train motion (Energy for overcoming running resistance and inertia as well as grade resistance)
- Losses in traction equipment (heat losses from the engine and auxiliaries)
- Energy required for passenger comfort (air-conditioning, lighting, etc. in passenger transport).

These three areas cannot be optimised in isolation as different elements often have to be weighed up against each other, for example between mass reduction and energy use for comfort functions: improved insulation of the vehicle body will increase weight and thus increase traction energy consumption. This means that strategies to reduce the energy

consumption of rolling stock will only be successful if a systemic approach is applied that will optimise the whole energy system of a given train or locomotive.

A wide range of existing and forthcoming technologies, concepts and measures addressing the different influencing factors described above can be used to improve energy efficiency. For a well-structured and systematic state-of-the-art overview of application ranges, economic and environmental potential as well as relevant experience and projects in this field, see the web-based database developed as part of the EVENT project. ([www.railway-energy.org](http://www.railway-energy.org)).

### ***Reduction of energy consumption for train motion***

#### **Weight reduction**

The weight of rolling stock is a decisive indicator for energy consumption in operation – especially for local and regional transport applications. Technologies for weight reduction include the use of new lightweight composite materials, lighter traction components and integrated lightweight design.

#### **Reduction of air resistance and friction**

Air resistance plays an important role in energy consumption, especially in high speed and intercity applications. Given the present state of high speed technology, raising the maximum speed from 280 km/h to 350 km/h would increase energy costs by about 60% [IZT 2003]. Technological options for reducing air resistance in high speed transport include covering bogies with smooth fairings, covering the underfloor equipment, streamlining the lateral coach design and reducing resistance from the pantograph, optimising windows, doors and the transition between coaches as well as coating the train surface with an aerodynamically smooth material. With regard to freight transport, covering open wagons or placing different wagons of different heights into the optimum aerodynamic order could cut energy consumption considerably.

Friction and curve resistance are less important for railway applications due to the relatively low wheel/rail interaction. Both effects account for less than 10% of a train's overall energy consumption. Nevertheless, friction could be reduced by lowering curve resistance, e.g. by wheel flange lubrication.

#### **Energy-efficient driving**

Driving assistance systems can be implemented to optimise traction energy consumption. Such systems make use of existing time buffers in the timetable and give permanent feedback to the driver about the most efficient driving style. Pilot projects have been carried out at some railway companies, e.g. at NS Reizigers on a relatively small scale and at Deutsche Bahn on a much larger scale. These projects have revealed overall saving potential of more than 5% of the total energy consumed (and up to 20% on certain routes for individual drivers). At system level, approaches for energy efficient driving include energy-efficient timetabling and the optimisation of traffic fluidity.

### ***Reduction of conversion losses***

#### **Electric traction**

Conversion losses in electric traction derive mainly from transformers, inverters and auxiliaries, whereas gears play only a minor role. New technologies such as high temperature superconductor (HTSC) transformers would increase efficiency dramatically, but they will only be available at reasonable prices in the medium or long-term. In the short-term, intelligent control algorithms for individual traction components or their interaction offer considerable potential for improved efficiency. Improved motor management by means of optimised traction software is often a cost and energy-efficient option.

## **Diesel traction**

Recent developments in diesel technology have improved the efficiency of diesel combustion engines by 15–20%, for example, by using higher injection pressures and common rail fuel injection technology. But the balance between efficiency of the combustion engine and diesel exhaust emissions must be taken into account. In contrast to electric traction, transmission plays an important role in the energy efficiency of diesel trains. Electric and mechanical transmission have certain advantages compared to hydraulic transmission. If electric transmission is combined with an energy storage unit, energy efficiency can be increased substantially (see “reduction of braking losses”). Modern mechanical transmission systems, as used in diesel mechanical multiple units for example; have a very high degree of efficiency and can be used in a wide range of applications.

### ***Reduction of braking losses***

Although energy recovery with dynamic brakes is a standard technology, it still offers a high degree of potential for savings, especially for electric multiple units and locomotives on AC lines and on local and regional lines with frequent stops. The main obstacles to regenerative braking are currently the limited receptivity of the catenary (especially for DC systems), old rolling stock not equipped with dynamic brakes, insufficient braking power of dynamic brakes for locomotive-hauled (and especially for heavy) freight trains, unfavourable operational designs for drivers’ cabs and limited acceptance by some drivers of the use of regenerative brakes.

Short-term options for overcoming these obstacles include driver training programmes and improved driver’s cab designs. Mid and long-term options include upgrading of DC networks, on-board and stationary energy storage systems, and inverter units in substations.

Recovery of braking energy is not restricted to electric traction. Diesel electric vehicles can for example easily be equipped to use recovered energy for comfort functions in passenger transport.

Dynamic/regenerative braking should also be considered when procuring new freight wagons or passenger coaches. Regenerative braking is most effective at full load and without using the wagon’s brakes. Therefore all the kinetic energy of a train is transformed by the locomotive only. Many wagon buffers are not dimensioned for the resulting forces and could be damaged/destroyed. For full load dynamic braking, care must be taken to ensure that wagons are equipped with adequately dimensioned buffers.

### ***Reduction of on-board energy consumption***

Energy consumption for comfort functions accounts for up to 20% of the total energy consumption in passenger transport in central and northern European countries. The majority (about 80%) is used for air conditioning, i.e. heating and cooling. Higher efficiency can be reached for example by demand-controlled regulation of fresh air intake, improved coach insulation, smart windows as well as the use of waste heat from traction components or intelligent control systems for the air-conditioning of parked trains. The saving potential for the latter option is expected to lie between 3 and 5% of total energy consumption. These different options should be considered in a systemic approach.

### ***Measurement and documentation of energy consumption***

Measuring energy consumption by means of energy meters does not save energy by itself. However, reliable data on energy consumption helps to identify potential for improved efficiency and allows for precise monitoring of energy saving measures. It is also an essential condition for fair energy billing, an issue of growing importance in liberalised railway markets.

It is important to note that the requirements of energy meters are more demanding if energy saving potential is to be identified, compared to metering for billing only. While for billing a

sampling rate of 15 minutes is generally sufficient, a rate of 1 to 5 minutes is necessary to identify energy consumption peaks.

The energy meter should be easily accessible by the driver (or better still: visible from the driver's seat during service) to guarantee direct feedback of energy-efficient driving.

### **Train designs**

Improvement of energy efficiency cannot only be achieved by optimising existing or applying new technological solutions (e.g. for traction, comfort functions etc.) but also by choosing the best and most appropriate train design for a given operational context at the pre-tendering stage. As regards passenger transport, energy consumption is determined by two main characteristics of train design: the use of space (seats per m<sup>2</sup>) and flexibility. A high number of seats per m<sup>2</sup> means low energy consumption per passenger km. This could be achieved, for example, by using double-decker vehicles or wide-body vehicles. High flexibility to react to variable passenger volumes can be attained by flexible train sets that are split up at a certain point on the route.

### **6.1.3 Measurement Procedures – Test Cycles**

At present in Europe only two well-established test cycles exist for measuring the energy consumption (and exhaust) of rail vehicles: the ISO 8178 F and C1 cycles. Although these reflect some major working profiles relatively accurately, considerable deviations are possible in practice, especially between shunting and main line conditions.

Speed	Full power (rated speed)					Partial load (intermediate speed)					idle
	Torque, %	100	75	50	25	10	100	75	50	25	
Cycle C1	15%	15%	15%	-	10%	10%	10%	10%	-	-	15%
Cycle F	25%	-	-	-	-	-	-	15%	-	-	60%

Table 6-1: Definition of test cycles ISO 8178 F and C1 – share of working points in %

A number of other test cycles or load profiles are used by national railway companies or industrial producers. However, comparability is limited, if possible at all. A feasibility study entitled "Harmonisation of Energy Consumption Standards for Railways"<sup>19</sup> is currently under way. One aim of the study is to assess whether or not test cycles can be an appropriate tool for obtaining comparable standards for rolling stock energy consumption.

### **6.1.4 References and Further Reading**

[EVENT 2003] Nolte, Dr. Roland and Felix Würtenberger. EVENT – Evaluation of Energy Efficiency Technologies for Rolling Stock and Train Operation of Railways (Final Report of the project). Berlin, 2003.  
<http://www.railway-energy.org>

[Railergy 2004] Vienna University of Technology and psiA-Consult. *RAILERGY – Potentiale für die Steigerung der Energieeffizienz im Eisenbahnwesen. Final report.* Vienna 2004

<sup>19</sup> Feasibility Study : "Harmonisierung von Energieverbrauchstandards für Schienenfahrzeugen" (Harmonisation of Energy Consumption Standards for Railway Vehicles"), Deutsche Bahn AG, contact Mr. Markus Halder, Bahn-Umwelt-Zentrum

## **6.2 Noise**

### **6.2.1 Relevance of this Key Area**

The Green Paper “Future Noise Policy” of November 1996 by the European Commission states that the “public's main criticism of rail transport is the excessive noise level”. This proves both that noise is indeed perceived by the public to be the major negative environmental impact of railways and that there is growing awareness of this issue at political level, resulting in stricter noise regulations. Previously, noise was primarily regulated by setting limit values for noise reception along railway lines, especially at hot spots and on recently constructed lines. The trend over the last decade has been for legislation to set noise emission levels for rolling stock as well. This trend is set to continue in the context of further harmonisation at EU level (interoperability) and the decoupling of responsibilities for railway infrastructure and operation of rolling stock.

#### ***Separation of responsibilities***

The general trend of setting emission values (instead of reception values) is in line with the trend towards liberalisation and harmonisation at EU level. With the separation of railway network operators and rolling stock operators, reception levels result in undefined responsibilities.

#### ***Holistic approach***

It must be borne in mind that overall noise emissions are not only dependent on rolling stock but also on the condition of the track. Rough rails can cancel out reductions achieved by low noise rolling stock, or even result in initial noise levels being exceeded. Therefore a systemic approach is needed.

#### ***Noise barriers vs. low-noise rolling stock***

Investment in trackside railway noise barriers makes up about 8% of the overall investment in new railway lines. In addition, there is growing public opposition to immense noise barrier walls for aesthetic reasons. When constructing new lines for high speed trains it could therefore be a cost effective as well a more readily acceptable option to invest in low-noise rolling stock rather than being obliged to comply with strict reception levels by installing expensive noise barriers. This rationale was adopted for the German ICE trains and was one of the drivers behind the noise reduction efforts.

However, current regulations and public funding do not support this rationale. Large sums of public funding are available for trackside railway noise barriers but cannot – at present – be transferred into noise reduction initiatives for rolling stock. This is because such investment could be interpreted as a subsidy for an individual railway company and therefore as distortion of competition.

### **6.2.2 Technical State of the Art**

The primary sources of noise are engines, electric motors, gears, and cooling fans (predominantly at standstill, starting and low speeds), wheel-rail contact (predominantly at medium speeds), aerodynamics (for speeds >200 km/h), as well as brakes.

Anti-noise measures include: damped wheels, disc brakes, composite brake pads, silent cooling fans and gears, wheel skirts, bogie shrouds.

Rail roughness as well as other preconditions (sleeper type, fastener, rail type) have a major influence on noise emissions as a whole and on measurements carried out to assess compliance with noise limits.

## 6.2.3 Measurement Procedures

### Standards and Comparability

Various acoustic indicators are currently in use. It is quite difficult to compare the noise limit values (proposed or legal) due to the varying measurement procedures and different definitions of acoustic indicators used ( $L_{pAeq,Tp}$ ,  $L_{Amax}$  and TEL). The general tendency (e.g. EU TSI) is to measure  $L_{pAeq,Tp}$  at a distance of 7.5m for conventional trains ( $\leq 190$  km/h) and TEL (transition exposure level)<sup>20</sup> at a distance of 25m for high speed trains ( $>190$  km/h).

Noise emitted is usually measured as acoustic pressure at a distance of 7.5 m ( $L_{pA 7.5}$ ) or 25 m ( $L_{pA 25}$ ). Data of  $L_{pA 7.5}$  is not directly comparable to  $L_{pA 25}$  data since the theoretical difference ( $L_{pA 7.5}$  should be  $20 \lg(25/7.5)$  dB(A) = 10 dB(A) lower than  $L_{pA 25}$ ) is not met in practice. Experimental data shows a difference of about 6 dB(A) for freight trains and 7 dB(A) for passenger trains<sup>21</sup>. For conventional trains a 7.5m distance is becoming the accepted standard in Europe.

Furthermore, when carrying out tests, repeatability is very difficult to obtain. Measured values depend on:

- condition of the test tracks,
- external conditions (weather,...),
- passing conditions of train (e.g.: percentage of traction power applied).

The condition of the tracks has a decisive influence on noise emissions from passing trains. Grinding of rails can reduce the noise level by as much as 7 to 10 dB(A). It is difficult to compare noise limit values with the various specifications on rail condition [O&D 2002]. The latest standards (TSI) demand a test track with specified conditions. For data with different measurement / track conditions, comparability is very limited.

## 6.2.4 References and Further Reading

### Background papers

- [EC 2003] Workgroup Railway Noise of the European Commission. Position Paper on the European strategies and priorities for railway noise abatement. Brussels, 2003
- [UIC Noise 2002] UIC. Noise Creation Limits for Railways – Main Report on the Railway's Position. 2002
- [O&D 2002] Odegaard & Danneskiold-Samsøe A/S. A Study of European Priorities and Strategies for Railway Noise Abatement. Brussels, 2002

### Links

- <http://www.aeif.org/>  
European Association on Railway Interoperability  
Download of legislation texts
- [http://europa.eu.int/comm/transport/rail/index\\_en.html](http://europa.eu.int/comm/transport/rail/index_en.html)  
Directorate-General for Energy and Transport / Rail transport  
Download of legislation and background papers

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<sup>20</sup> In the ongoing revision process of the high-speed TSI, a change to  $L_{pAeq,Tp}$  in 25m distance is being proposed.

<sup>21</sup> The Swiss Federal Office of Transport published limit values for both 25m and 7.5m distance. The difference in noise level is 7 dB(A).

## **6.3 Diesel Exhaust Emissions**

### **6.3.1 Relevance of this Key Area**

Exhaust emissions from diesel engines constitute a key rolling stock-related environmental aspect of high public interest (for health reasons among others).

In the long-term, exhaust emissions from railway diesel engines will have to be compared to those of road vehicles. In view of the relatively strict existing EURO emission levels for road transportation and their further reduction, a considerable concerted effort is required on the part of the whole railway sector to retain its advantages in environmental performance. This effort should be based on a long-term emission reduction strategy with relatively strict limit values.

### **6.3.2 Technical State of the Art**

Actual and mid-term limit values, as defined in the EU directives mentioned above, should be attainable with existing technologies, although optimisation of engines to reach the NO<sub>x</sub> limit values could result in higher fuel consumption. The limit values for 2011/2012 set out in EU Directive 2004/26/EC will only be attainable by implementing innovative technical solutions, e.g. catalytic converters and/or particle filters. At present, very few applicable systems are available, especially in the high power range. Filter technologies have been developed for applications in cars, trucks, buses and smaller ships. However, due to the different sizes and load patterns, the scope for transferring the technology to railway use may prove limited, or further research and development input may be required.

### **6.3.3 Measurement Procedures – Test cycles**

Diesel exhaust emissions are measured in g/kWh. As part of the revision process of EU Directive 97/68/EC<sup>22</sup>, diesel exhaust emissions are to be measured using the ISO 8178 F test cycle for locomotives and the ISO 8178 C1 cycle for multiple units. (For further details and working points of the test cycles refer to section 6.1.3).

### **6.3.4 References and Further Reading**

#### **Background papers**

Diesel Exhaust

[den Boer et al. 2003] den Boer, Eelco, Joost Vermeulen, Max Smith, Jos Dings. Clean on Track – Reducing Emissions from Diesel Locomotives. Study by CE, Delft, 2003

[UIC 2003] UIC. Feasibility Study: “UIC Action Plan for Reduction of Diesel Exhaust emissions from Tractive Units”. Deutsche Bahn AG, Railway Environment Center, Mr. Markus Halder

[UBA online] Umweltbundesamt – German Federal Environmental Agency. „Environment and transport – pollution – locomotives“. Available from: <http://www.umweltbundesamt.de/verkehr/rechtrahm/schadstoffemiss/lokomotiven/jurschiene.htm> accessed 17 November 2003

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<sup>22</sup> Amended by Directive 2004/26/EC of 21 April 2004, published in the European Journal dated 30 April 2004

[EBA 2003] Eisenbahn-Bundesamt. Informationen zur Abgasemission aus Schienenfahrzeugen. Bonn, 2003

[DieselNet online] DieselNet. "Emission Standards: European Union – Non-road Diesel Engines" Available from:  
<http://www.dieselnet.com/standards/eu/offroad.html>  
accessed 21 December 2003

### Links

<http://www.dieselnet.com>

Useful overview of the status and progression of EU legislation to regulate emissions from non-road (off-road) mobile equipment / Directive 97/68/EC and its amendments.

## 6.4 Materials, Recycling, Waste

### 6.4.1 Relevance of this Key Area

The environmental key area materials/recycling/waste constitutes a very heterogeneous and complex field:

- Many different and often complex materials are used in rail vehicles.
- The corresponding legislation is highly specialised and differentiated.
- The very long life-cycles of rolling stock make recycling approaches difficult (What will be the recycling approach / technological state-of-the-art in forty years' time?).
- The relatively low total quantities of rolling stock waste (small number of trains in comparison to cars for example) make dedicated recycling systems difficult to establish and operate.
- A high level of freedom is necessary for manufacturers to allow for environmentally optimised design and production processes.

There are basically two different approaches to optimising environmental performance in this field:

→ direct approach: influencing the rolling stock design process directly and at each single step by means of a sophisticated tool based on environmental specifications and explicit material lists, etc.

→ functional approach: influencing the design and production process of rolling stock indirectly by defining strategic aims and setting priorities (e.g. high resource efficiency, use of renewables, design for environment (DfE), high recycling quota).

The actual choice of materials for a new train or its components and the corresponding design is primarily the responsibility of the manufacturer. Therefore, the operator's influence is rather limited in this field (unless the operator has specified a certain material or solution). From an operator's point of view, the functional approach is much more efficient. It allows the manufacturer to design his product including end-of-life properties and ensures maximum freedom to find solutions with optimum cost/benefit ratios.

Following a functional approach, the operator should provide the manufacturer with certain guiding principles on the choice of materials, guaranteeing high standards of environmental performance:

- the precautionary principle
- the use of best available technology
- the principle of open communication of detailed information and documentation
- the principle of economising and recycling.

Here two different time scales must be taken into account: a shorter one for major retrofit measures (mainly with respect to interior components) and one for the life-cycle of the vehicle itself.

In general, the following must be considered:

- If a given substance is to be excluded from trains, it will most probably be based on an analysis of the risk posed by the substance in a specific component or used for a specific purpose. Indeed, a substance creates a different risk if it is used: (a) as part of an alloy, (b) as an additive in a synthetic structural substance, (c) in a part that is designed to wear over time, (d) as a component of a coating, (e) as a component in a lubricant, (f) as a fuel component. In this respect, coherence with the EU REACH process is advisable for any rail industry standard.
- Controlling the absence of a specific substance in a specific component (or group of components, such as the coatings group) is feasible. Controlling the absence of a substance in an entire train with a high level of reliability does not appear very realistic.

To promote high environmental standards, operators and manufacturers should communicate best/good practice examples and corresponding technologies and encourage the use of components and products with eco labels.

#### **6.4.2 Technical State of the Art**

The EU funded project REPID has sought to define a harmonised methodology for the assessment of the environmental impact of different design solutions, focussing on materials, recycling and waste related issues. [REPID 2003]. In addition, REPID has also produced software packages supporting the methodology.

Manufacturers should be encouraged to use the REPID methodology and supporting software packages at an early stage in the design process in order to integrate the use of renewable materials, careful resource management, to prevent hazardous waste and increase recycling efforts.

##### ***Restricted Materials***

A first attempt to define a harmonised list of voluntarily restricted materials (“grey list”) was made as part of the REPID project [REPID 2002]. However, further harmonisation is required to define clear standards in the rail industry. The results of the REPID project will be developed further under the auspices of the RES board (Rail Eco-procurement Specifications Board) within the AEIF.

##### ***Recycling Rate***

In the specification on the recycling rate of material after use, target values are given for the automotive sector (as specified in Directive 2000/53/EC, which defines the values for the recyclability of new road vehicles to be met by 2006). A calculation method for recyclability and recoverability for road vehicles is outlined in ISO 22628.

#### **6.4.3 References**

##### **Background papers**

[EC 2003a] COM(2003) 301 final. COMMUNICATION FROM THE COMMISSION - *Towards a thematic strategy on the prevention and recycling of waste*. Brussels, 27.5.2003

[REPID 2002] REPID. Development Method of the REPID Material List. 2002

[REPID 2003] REPID. Specification of material properties in the REPID Database. 2003

##### **Links**

<http://europa.eu.int/comm/environment/waste/index.htm>

Background papers and general outlook on EU waste strategy

## **6.5 Other**

### **6.5.1 Electromagnetic Fields**

#### ***Relevance of this Key Area***

A very diverse and often non-consistent range of literature deals with the health impact of high frequency electromagnetic fields. Only very few publications address railway specific problems directly [Grotenhermen 1998] [UIC 2002]<sup>23</sup>.

Problems associated with electromagnetic fields relate primarily to electromagnetic compatibility (interaction between train appliances and signalling technology or screen phenomena). More recently, potential health problems caused by “electrosmog” have been discussed.

Even in the absence of consistent and reliable information on the effects of “electrosmog” caused by railways, railway companies should adopt the precautionary principle and ensure low emission levels where protective measures can be put into practice at reasonable costs.

#### **Long and short-term effects**

There are essentially two approaches to defining limit levels for electromagnetic fields - they can either be based on short-term or long-term health effects:

- Short-term effects  
EM reference levels are defined based on the directly measurable physical impact of electromagnetic fields onto the human body (dosimetric values). Examples are local heating of tissues or increase of corporeal temperature, which are measured in laboratory experiments.
- Long-term effects  
Long-term effects have to be identified by statistical means, e.g. higher cancer rates in people who are exposed to higher levels of electromagnetic fields over a longer period of time.

It must be noted that there is no scientific proof at present of long-term health risks connected to electromagnetic fields where recommended maximum short-term exposure levels are not exceeded. For this reason the ICNIRP guidelines as well as EU Directive 2004/40/EC on exposure of workers to EMF refer to reference levels based on short term exposure.

However, the levels of electromagnetic fields thought to cause long-term effects are much lower than those which cause short-term effects. For this reason, recommendations/legislation seeking to reduce the risk of long-term effects contain limit values which are several orders of magnitude lower than the ICNIRP / EU Directive values<sup>24</sup>.

#### ***Technical State of the Art***

#### **Technical solutions**

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<sup>23</sup> UIC Scoping Study on Electromagnetic Fields and Environment (“Electrosmog”)

<sup>24</sup> EU Council Recommendation 1999/519/EC on the exposure of the general public to electromagnetic fields

Electromagnetic fields can be reduced either by design measures or by shielding. In the first case the aim is to find locations for the main sources of high electromagnetic fields (such as transformers) which are further away from passenger areas. The second case comprises new interior designs for transformers (“self-shielding”), additional return conductors for one-phase systems and shielding of wires by means of aluminium steel shields.

### **New challenges**

In addition to existing electromagnetic fields in the railway system (low-frequency magnetic fields produced by electrical appliances, transformers, high-current applications, catenaries and overhead lines), passengers and staff are increasingly exposed to EM radiation from new technologies. In particular, with new vehicle generations, larger magnetic fields can be produced because of multi-motor technology and much higher currents in railway vehicles.

## **6.5.2 Brake Friction Material Emissions**

### ***Relevance of this Key Area***

Emissions from brake friction material can contain hazardous substances. For health and environmental reasons, such emissions should be minimised. Whereas for cast-iron disc brakes primarily metals are emitted and contribute to metal intake and dust generation, the situation with compound brake pads is more complex and a wider variety of potentially hazardous materials may be emitted. Compound brakes are of high interest and relevance because of lower noise emissions compared to cast-iron brakes. Thus an increasing number of trains – both passenger and freight - with compound brakes or disc brakes are being put into service. This creates emissions from brakes (wear debris and substances into which the brake friction materials are transformed under higher temperatures) which could be a matter of growing importance in future.

However, little is known to date about the concentrations of these hazardous substances emitted into the environment or into rail vehicles (drivers’ cabs and passenger coaches). Since toxicity is a combination of substance property and level of exposure, further investigation and the development of harmonised testing procedures are necessary. In a Europe-wide survey (carried out by ERRI) several European rail operators expressed the need for further information on and investigation of this subject.

A distinction must be made between:

- The **original substances in the brake friction material**, which are emitted by wearing down the friction material (literally grinding them into dust). This is the case when the material stays relatively cool, such as in interval braking or braking with low power. The principle difficulty is that brake pad suppliers are very reluctant to provide very detailed information on the content in order to protect their proprietary knowledge.
- **substances into which the brake friction material is transformed at elevated temperatures** (i.e. 400 – 600° C or higher) which is the case for longer braking activities with high pressure. In this case, compound brake pads in particular may emit substances such as Volatile Organic Compounds (VOC e.g. Toluene, Ethylbenzene, Xylene, Benzaldehyde, Diphenylmethane), Polycyclic Aromatic Hydrocarbons (PAHs) or Benzo(a)pyrene.

One of the major difficulties in the assessment of brake friction material emissions is that **no standard testing conditions** exist.

Initial testing procedures for the measurement of the friction material emissions included a series of short interval braking patterns (low temperature cases), or a continuous braking process (a continuous brake of ~30 minutes which is equivalent to the longest possible braking incident in Europe: maintaining a constant speed on the 40 km Gotthard downhill slope) and which can be considered a worst case scenario for high temperature braking.

Moreover, no limit values for emissions exist to date which would allow judgements on whether or not certain emissions can be considered harmless. Three cases must be distinguished:

- **Brake friction material emissions in drivers' cabs or in passenger coaches.** In both cases, concentrations of hazardous gases and dusts must be below the respective limit values stated in the occupational health regulations to ensure the safety of staff. However, no common test conditions or measurement procedures exist for determining emission concentrations. Furthermore, the concentrations of these emissions inside the train are highly dependent on the design of the trains, especially the location of air inlets as well as general conditions (train speed, wind conditions, braking in tunnels, etc.).
- No assessments are available at present of the toxicity of **brake friction material released into the environment.** However, in accordance with the precautionary principle, emissions of hazardous substances should be reduced to a minimum. This is especially true for highly toxic, carcinogenic and bioaccumulative substances. Toxicity assessments should focus in a first phase on likely hot spots for friction material emissions such as train stations.
- **Dust** from brake friction material can **accumulate on certain vehicle parts.** Members of staff may come into contact with quite high concentrations of such dust residue during maintenance operations. If health risks can not be excluded outright, appropriate protective measures must be taken (gloves to avoid skin contact, etc.). High concentrations of brake friction material dust may also accumulate in vehicle cleaning facilities.

Consequently, the European standard (EN) dealing with the issue of brake friction material for railway vehicles which is currently being drafted (CEN Technical Committee TC256, Work items W1171 and 173) only refers explicitly to certain substances (asbestos, lead, cadmium, hexavalent chrome, ceramic fibre) in the brake friction material itself, the use of which is prohibited. With reference to emissions, it is simply stated that "any other material that may produce dust or fumes that could be hazardous to the health of maintenance personnel, operating staff or passengers" must be avoided.

The development of general testing conditions remains a long-term goal. Such testing procedures should be developed jointly by operators and brake friction material suppliers. The operator could then demand from the supplier a test protocol of the brake friction material specifying all hazardous substances emitted under "standard" braking conditions.

Beyond health and environmental aspects, emissions from brake friction material inconvenience people living near railway lines in the form of smell nuisance. Since the smell of burnt rubber is generally connected to health risks (whether this is true or not), smell nuisances should be avoided for passenger comfort and image reasons. [SBB 2004] [ERRI 2003]

### ***Technical State of the Art***

In addition to specifications on the brake friction material itself, the operator can make design provisions: air inlets should be placed in such positions on vehicles as to minimise brake friction material emission intake into the driver's or passenger coaches. For passenger coaches with air-conditioning and ventilation systems, installation of control devices allowing for an interruption of air intake during longer braking activities should be considered.

### **6.5.3 References**

EMF

[Grotenhermen 1998] Grotenhermen, Franjo and Michael Karus. „Magnetfelder der Bahn und Krebs – Magnetic fields from railway and cancer“, *Elektrosmog-Report* 1 (1998), [e-journal] [http://www.datadiwan.de/netzwerk/index.htm?esmog/es\\_001d .htm](http://www.datadiwan.de/netzwerk/index.htm?esmog/es_001d.htm)

[UIC 2002] Müller, Roger, Raimondo Orsini, Luigi Contestabile. *UIC Scoping Study on Electromagnetic Fields and Environment („Electrosmog“) Report*. Paris, 2002

Brake Pads

[ERRI 2003] ERRI. Güterwagen – Einfluß des Zerfalls von Verbundstoffsohlen auf die Luftqualität. Utrecht, November 2003

[SBB 2004] SBB CFF FFS. *Emissionen von Verbundstoff-Bremsklotzsohlen*. Internal report of a trainee at the Swiss BahnUmwelt-Center. Bern, March 2004

## 7 Appendix IV: List of Abbreviations

AC/DC	alternating current / direct current
AEIF	Association Européenne pour l'Interopérabilité Ferroviaire – European Association for Railway Interoperability
CFC	chlorofluorocarbons
CO	carbon monoxide
CTR	UIC Technical and Research Commission
DMU	Diesel Multiple Unit
EC	European Commission
EEC	European Economic Community
ELV	end-of life vehicle
EMF	electro-magnetic field
EMU	Electric Multiple Unit
ERRI	European Rail Research Institute
EU	European Union
EWC	European waste catalogue
HC	hydrocarbon
HTSC	high temperature superconductors
ICNIRP	International Commission on Non-Ionizing Radiation Protection
IPP	Integrated product policy
LCC	life-cycle-cost
MU	Multiple Unit
NGO	Non-governmental Organisation
NO <sub>x</sub>	nitrogen oxide
PAH	Polycyclic Aromatic Hydrocarbons
PCB	polychlorinated biphenyl
PM	particulate matter
REACH	Registration, Evaluation, and Authorisation of Chemicals
REPID	<b>R</b> ail sector framework and tools for standardising and improving usability of <b>E</b> nvironmental <b>P</b> erformance Indicators and <b>D</b> ata formats
RoHS	EU Directive: Restriction of the use of certain Hazardous Substances in electrical and electronic equipment
UIC	Union Internationale des Chemins de fer - International Union of Railways
UNIFE	The Union of European Railway Industries
VOC	Volatile Organic Compounds
WEEE	EU directive: Waste Electrical and Electronic Equipment