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Procedures for Rolling Stock Procurement with Environmental Requirements phase II

PROSPER II

Draft 2b 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 discussed and further enhanced within the framework of a wide feedback process and will be submitted for adoption within UIC during autumn 2005. This version is envisaged for circulation among the experts and working groups of rail operators as well as manufacturers and their respective organisations and bodies only. The draft leaflet is not for public use.

Concrete feedback is highly encouraged!

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 has been derived from the UIC project PROSPER ("Procedures for Rolling Stock Procurement with Environmental Requirements").

It is the aim of this leaflet to contribute to a harmonisation of environmental performance in the rail sector on a European and in the long-term global scale. By doing so the process of procurement is to become more efficient and new rolling stock with good environmental performance can be acquired more cost-effectively.

Please note that this leaflet is designed as a guidebook and it is thus not possible to demand for 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 this Leaflet

In the first chapter the scope and overall aim of this leaflet is outlined. In chapter two 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 a scheme is sketched how environmental performance can be incorporated into the procurement process. Chapter 3.5 outlines how the evaluation process of tenders can be set up. As an annex background information on the covered environmental key areas is compiled.

Accompanying this leaflet two background papers have been developed within the PROSPER project. They serve to give additional information on the issues covered in this leaflet. The "Legal Aspects of Eco-Procurement" document specifies in more detail the legal framework. The document "Good Practise in Rail-Eco-Performance" exemplifies the current state of the art of environmental performance for rolling stock.

1.2 Scope and Approach

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

The following key questions in the process of procurement of new environmentally enhanced 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

like the upcoming environmental aspect of electromagnetic fields was included into the leaflet in line with the precautionary principle[1].

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 which process steps are needed and which kinds of experts have to be involved to procure rolling stock and which role they have to play in order to arrive at a clearly defined environmental performance.

Which environmental specifications should be used in invitations to tender?

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

In this respect it has to be pointed out that this leaflet has to be considered a first step towards a list of harmonised environmental standards in rail procurement. Listed are those specifications which can be handled (and verified!) currently. Further needs for harmonisation and ongoing efforts are pointed out in the respective sections.

What approach should be used to evaluate tenders?

An approach for the evaluation of tenders should integrate the 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, as well as engineering and purchasing staff from manufacturers. So, technical and purchasing experts in particular are identified as main user groups, but environmental experts will also find valuable information. The leaflet will help the user:

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

Although the leaflet is mainly aiming at serving operators it is also intended to be useful for manufacturers in the supply chain (system integrators, system manufacturers, sub-suppliers, etc.).

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[1] For a definition of the precautionary principle, see the European Commission's Communication COM(2000) 1.

1.4 Key Environmental Areas for Railways

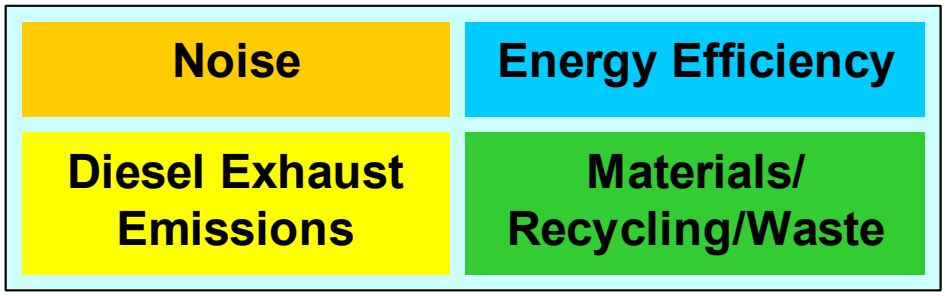

Figure 1: Key Environmental Areas

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 tightening 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 tightening emission limit values are foreseen in these two environmental fields by the legislator.

As for **Energy Efficiency** 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 that, Energy Efficiency has top priority for railways because cutting energy consumption:

- helps to maintain/ to 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 has also become a priority for the rail sector over the last decade due 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 re-integrate materials into the material cycle are high on the agenda. The significance for railways is the need for environmentally sound material and technology selection, to improve the knowledge of forbidden and restricted materials that are used in vehicles to avoid hazardous waste, occupational health impact during manufacture and maintenance and to improve vehicle recyclability and therefore cut resource consumption. Although not generally applicable to rail products, the EU Directives WEEE and RoHS set the scene and reveal 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 interest for railways. The economic effects of concrete measures to improve the environmental performance mainly depend 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.

In order to ensure the competitive advantages of railways in comparison to other modes of transport the improvement of the environmental performance in the non-regulated area has to be done 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 has to 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.

- The improvement of energy efficiency is believed to have clear benefits with respect to LCC. As energy efficiency is also one of the outstanding environmental aspects for railways the priority for the related specifications is very high.
- Reaching lower noise and exhaust emission levels lower than the legally mandatory ones generally leads to increasing LCC, at least under current legislation and applying available technologies. Limiting electromagnetic fields in accordance with present 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 seems often to be a trade-off between higher investment costs and lower end-of-life and sometimes also maintenance costs.

2 Legal Framework of Procurement

2.1 Important Environmental Legislation

The following tables give an overview on international, EU and national legislation concerning the four environmental key areas 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. Covered are aspects of current status and future trend of legislation and other regulations.

Detailed information on the legal framework of each key area can be found in the document "Legal Aspects of Eco-Procurement"[2].

Noise

Legislation	Other Regulations	Trend
• **Harmonisation on EU-level** TSI Noise for HST (EU directive 2002/735/EC) and conventional railways (EU directive 2001/16/EC)	• EU green and white books	• No trend limit values • Noise-level-related route pricing (e.g. Switzerland, The Netherlands) • TSI revision process

Diesel Exhaust Emissions

Legislation	Other Regulations	Trend
• **Harmonisation on EU-level** EU directive 2004/26/EC on non-road mobile machinery	• UIC leaflets 623/ 624 "Exhaust emission tests for diesel traction engines" • EU directive on ambient air quality	• Decreasing limit values • Stage IIIA (2005-2009) of EU directive • Stage IIIB (from 2011 on) subject to revision in 2007

Energy Efficiency

Legislation	Other Regulations	Trend
• No harmonisation on EU-level	• International agreements on climate protection (e.g. Kyoto Protocol) • Indirect measures and incentives: Taxes, Emission Trading	• EU proposal for a directive on energy end-use efficiency and energy services (COM (2003) 739) • 2008-2012: 8-9% EU average reduction for CO_2 emissions

Materials, Recycling and Waste

Legislation	Other Regulations	Trend
Harmonisation on EU-level EU directives on: • Classification of dangerous substances (EU directive 67/548/EEC and its amendments) • Marketing and use of certain dangerous substances (EU directive 76/769/EEC and its amendments) • Dangerous preparations (EU directive 1999/45/EC and its amendments) • European waste catalogue (EWC – EU Commission Decision 2000/532/EC) • EU battery legislation, directive 91/157/EEC	• Prohibited/restricted materials and recycling/recovery rates for electric/electronic equipment (EU directive 2002/96/EC – WEEE[3]) • EU directive 2002/95/EC – RoHS)[4] • Prohibited/restricted materials and recycling/recovery rates for end-of life vehicles (EU directive 2000/53/EC – ELV) • Montreal Protocol on substances that deplete the ozone layer • OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic • Stockholm Convention on persistent organic pollutants (POPs)[5]	• REACH process[6] • More substances will be included • Reduction of target values for harmful substances

Other

Legislation	Other Regulations	Trend
EMF • EU directive 2004/40/EC on exposure of workers to EMF	• European Council recommendation 1999/519/EC on the limitation of exposure of the general public	• Harmonisation efforts on EU level • Low precautionary limits

3 WEEE: **W**aste **E**lectrical and **E**lectronic **E**quipment;

4 RoHS: **R**estriction **o**f the use of certain **H**azardous **S**ubstances in electrical and electronic equipment, WEEE and RoHS are not directly applicable to the rail sector

5 Persistent organic pollutants (POPs) are chemical substances that persist in the environment, bioaccumulate 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 biphenyls, PCBs) and unintentional by-products of industrial processes (such as dioxins and furans).

6 REACH: **R**egistration, **E**valuation and **A**uthorisation of **Ch**emicals

7 International Commission on Non-Ionizing Radiation Protection

• Stringent national legislation (Switzerland, Belgium, Italy, Finland stricter than ICNIRP[7])	to electromagnetic fields (stricter than EU directive 2004/40/EC) • Generally accepted recommendations (ICNIRP values) • National recommendations	• No trend limit values

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

2.2.1 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 Directives” 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

The scope of the procurement process, guided by Council Directive 93/38/EEC (“Utilities Directive”), includes also non-state enterprises operating in the field of transport procurement, which act based on special or exclusive rights in as far as supply or service contracts exceeding a (net) order value of € 400.000,- respectively construction orders exceeding € 5.000.000,- 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 latest January 31st 2006 the EU Member States have to implement the new “Utilities Directive” 2004/17/EC. From an environmental point of view the most important change as compared to the previous one is the explicit statement that the integration of environmental issues in the award procedure is now permissible and desired. Furthermore it clarified that the production process may be taken into consideration for the awarding procedure. Besides this, there where only a few minor modifications except new increased threshold values. These are defined in the Commission Regulation (EC) No 1874/2004 of 28 October 2004 amending the Utilities Directive and sets values for supply and service contracts (473.000,- €) and construction orders (5.923.000,- €).

Essentials of the Awarding Procedure

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

Basically, a comprehensible description of the performance is required, which is guided by the European standards and specifications. The selection of the adequate tenderer (according to the qualification criteria) has to be separated from the evaluation of the offers (according to the awarding criteria). The awarder determines the decisive criteria for the evaluation of the offer. The central principles of the awarding regulations regarding disclosure, transparency, objectivity and equal treatment have to be respected.

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

2.2.2 Options for Integrating Environmental Aspects

Necessity for tight coordination procedures

In order to make use of the existing potentials, a tight coordination of the individual parties involved is required. Firstly, it is necessary to define the performance criteria and standards to be implemented in the performance description. This can be achieved by involving the environmental protection representatives and the legal consultants.

Definite Layout Options

In the awarding procedure environmental aspects can be taken into consideration in various forms: **they can be integrated into the scope of performance** and thus define the tendered performance to be offered by the participants. The possibility to create an environmental procurement process is pointed out in the Commission Staff Working Document "Buying green", see: http://europa.eu.int/comm/internal_market/publicprocurement/key-docs_de.htm .

Environmental aspects can also be taken into consideration **additionally outside the economical evaluation of the offers** if the fulfilment of environmental criteria leads to favouring/preference of the desired environmental behaviour independently from the actual qualification for the tendered scope of performance and also independently from the economic evaluation of the offers.

The favouring/preference can be related either to the participant or to the offer submitted. Besides the possibility of a favouring/preference such an additional criterion can be stipulated as an awarding condition that has to be fulfilled independently from the other qualification and awarding criteria.

The precondition for the consideration of such additional criteria for favouring/preference and as a supplementary awarding criteria is that

- the standardised criteria and exclusion facts of the awarding procedure are not undermined and
- the selected criteria are announced together with the other contract conditions,
- fulfilment of the criteria has to be verifiable and
- they must not leave unrestricted freedom of choice to the public awarder.

The choice, whether environmental performances should be integrated into the scope of performance as compulsory minimum requirements have to be made under careful economic assessments. Minimum requirements are necessary for all specifications where binding legislation exists. Furthermore, important issues could also be integrated into the scope of performance and would consequently lead to a compulsive exclusion of those tenders in which the requirements are not met. In order to reach high environmental performance cost effectively it may be beneficial for the operator to include some specifications as secondary purposes. A high performance in these areas could e.g. be awarded by granting bonus points or notional assessments on the price offered.

It is at the discretion of the public awarder which of these options is given preference. However, the practice of the award procedure should guarantee objectivity and transparency of the awarding decision. Working out a scheme which takes into consideration the individual criteria which shall be essential for the evaluation of the offers can be one measure to ensure objectivity and transparency.

2.3 Integrated Product Policy (IPP)

All products cause environmental degradation in some way, whether resulting from their 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 utilizing 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 people, 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 to be involved there can not be one simple policy measure for everything. Instead there is a whole variety of tools – both voluntary and mandatory – that 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 has the approach to cover one aspect of IPP in the railway sector – the procurement of new rolling stock.

For further information, please visit the EU Commission's web pages on Integrated Product Policy[8].

[8] 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 process of procurement of new rolling stock is characterised by many different requirements that have to be fulfilled and the large number of actors that are involved. For an efficient integration of environmental requirements into the procurement process of railways it is important to clarify and define the roles of the different players in the process and to know the interfaces and what information is needed at which stages in the process.

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. In addition to legal requirements and requirements voluntarily set by the railway operator, there might be additional requirements set by the infrastructure operator or the national authority that puts transport services such as regional rail transport out to tender. These additional requirements have to be taken into account as well in the procurement process.

The following figure suggests a generic procedure for the procurement process (strongly simplified) and proposes how environmental aspects could be integrated into the procurement process, based on this leaflet:

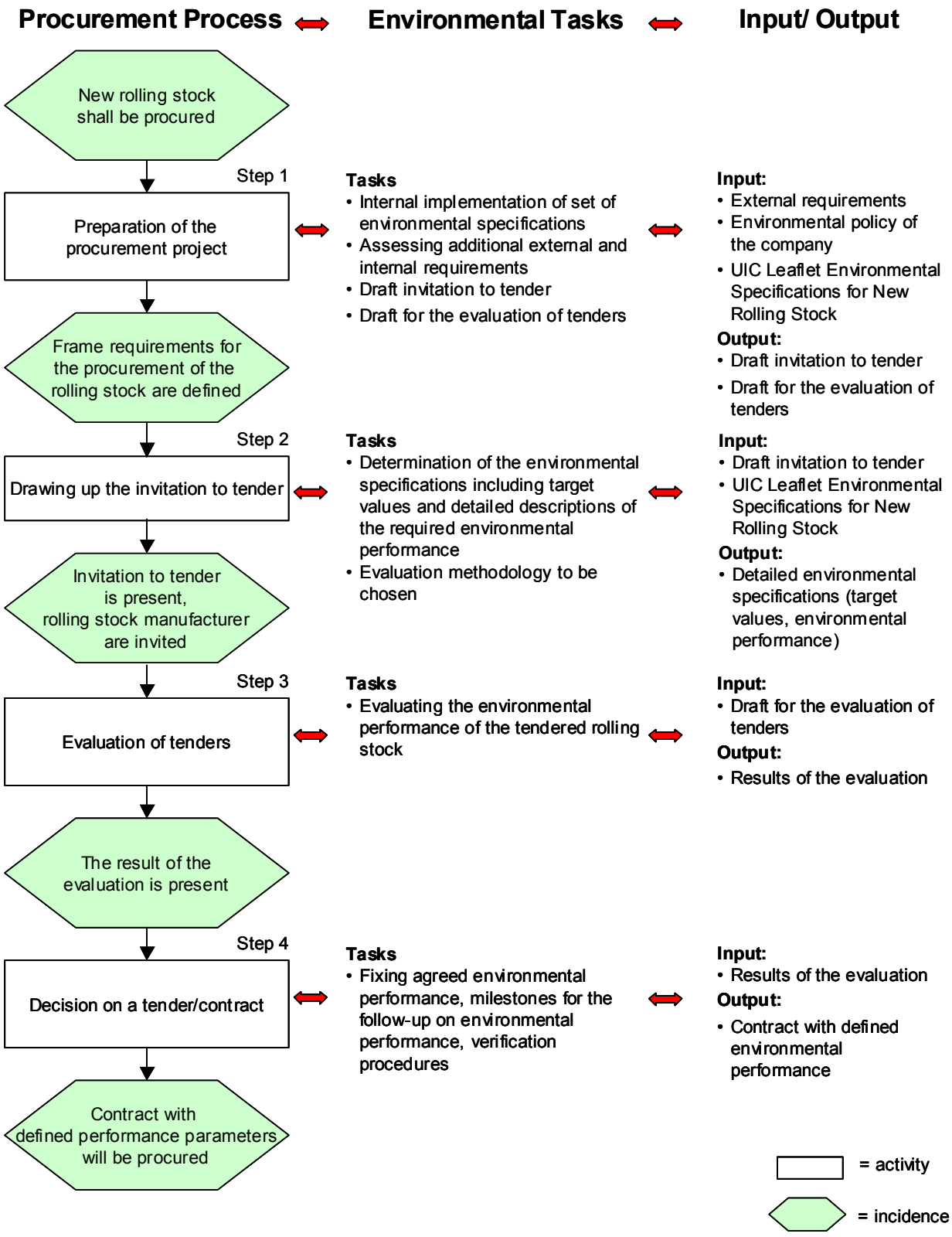

Figure 3: Procedure for the integration of environmental aspects into the procurement process of railways

The above scheme provides 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.

Step 1: Preparation of the procurement project

The preparation of the tendering phase in terms of environmental requirements is a fundamental step to integrate environmental aspects into the procurement process. In this step 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 due to e.g. specific national legislation, special 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. costumers, 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 over 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 co-ordination 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 the negotiations with the manufacturer the defined environmental performance of the offered rolling stock has to be fixed in the contract. In addition, milestones for the follow-up on environmental performance as well as for verification procedures have to be agreed.

3.2 Overview of all Specifications

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

A pie-chart scheme has been developed to structure and prioritise the environmental specifications to be used in the tendering process (see fig. 4).

It differentiates between mandatory (pie-chart 1) and voluntary specifications (pie-charts 2 and 3) and divides the voluntary ones into two priority groups. Target values for the mandatory ones are defined by legislation/regulations and therefore have to be met by any tenderer. However, compliance with applicable legislation is only the minimum requirement and in general a better performance will yield better evaluation results from the environmental point of view.

The approach presented here gives a clear picture of priority assignment and relevance of the different specifications as well as of the respective importance of key areas. It can be used in an operational sense for the actual evaluation of tenders (see chapter 3.5) as well as a in a strategic sense for an assessment of the more general procurement strategy of a railway company or design strategy of a manufacturer.

Without going into detail the following general strategic orientations can be attributed to the different pie-charts:

- For the specifications in the first pie-chart, the environmental performances are legally regulated. An eventually better performance than the legal baseline offers a more future-proof investment into rolling stock because it reduces the risk of future expenses and efforts to meet higher environmental legal standards.
- The second pie-chart contains top priority specifications which are mainly cost relevant and offer high degrees of freedom for the technical solution at the same time as they are not governed by legislation. Thus, there is room for win-win situations. Good or even excellent performance with respect to the specifications in the second pie-chart – if well balanced against higher initial investment costs – can offer economic benefits in a LCC perspective.
- The third pie-chart comprises specifications of secondary priority. Nevertheless, a good or excellent performance in this field can be important for a railway company according to the focus of it's environmental strategy or specific national laws or standards.

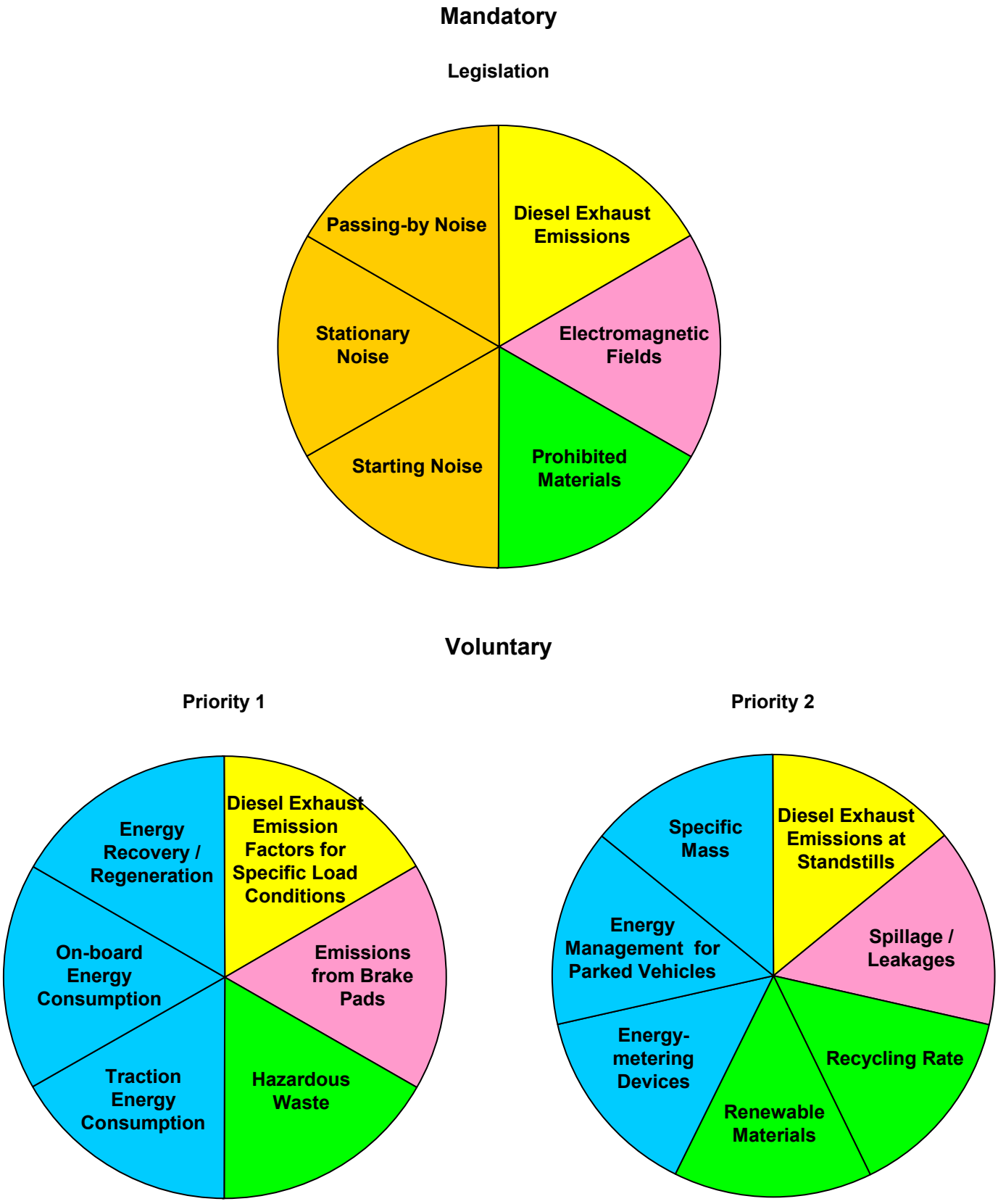

Figure 4: Structured overview over harmonised environmental specifications (pie-chart scheme)

3.3 Types of Environmental Specifications

Environmental specifications can be classified into different types according to the following criteria:

- Openness with respect 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 (defined target values, not yet defined target values, no target values)

The following figure illustrates the resulting classification scheme:

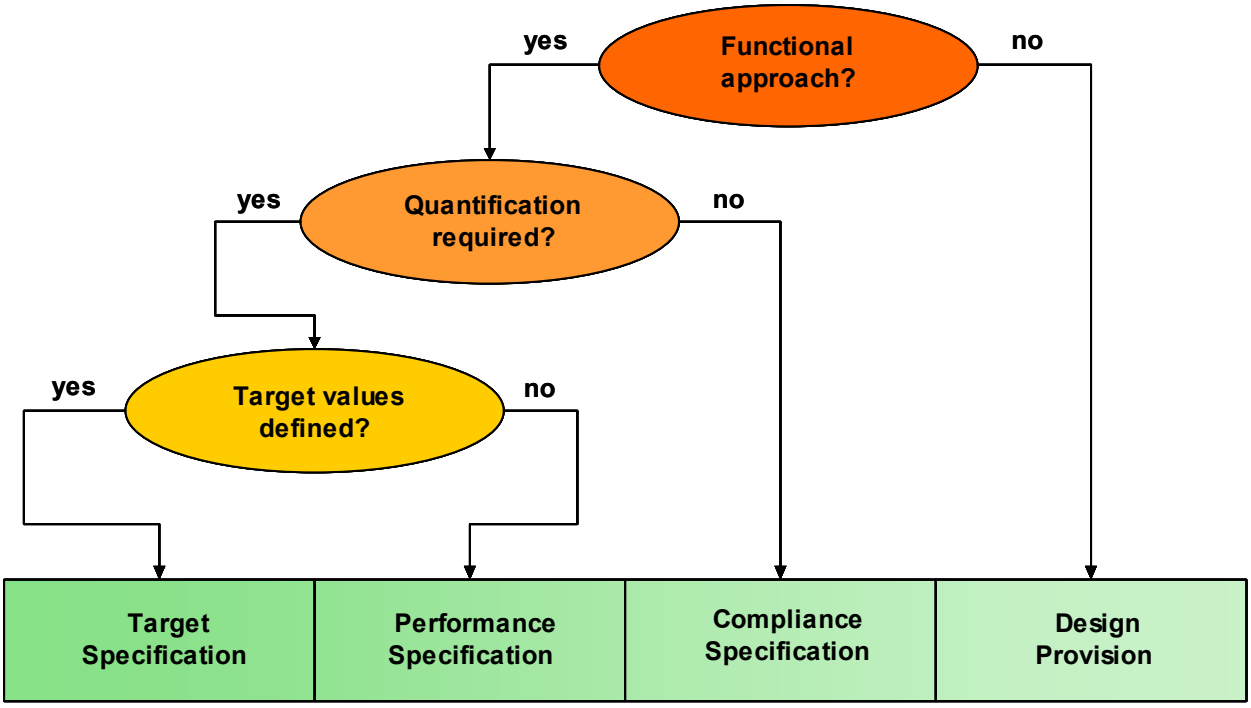

Figure 5: Classification scheme and types of Environmental Specifications

Design Provision (D)

Design Provisions are qualitative environmental specifications which describe a special equipment or component with a certain functionality (e.g. provision of rolling stock with energy meters). The manufacturer should give technical details for the special equipment characterising it's performance.

Compliance Specification (C)

Compliance Specifications are environmental specifications not to be quantified focusing at compliance with existing legislation or standards. The manufacturer has only to state whether or not the rolling stock or certain components meet 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 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 recommendable 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 be gradually improved.
2. For other specifications the interests of manufacturers and operators differ too much to allow the definition of target values at present. In this case target values can be developed by means of a consensus oriented process.
3. Certain specifications strongly depend on framework conditions (e.g. type of operation, comfort class, …) 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.
4. For some environmental specifications too many special cases exist (e.g. according to specific national or operational conditions) so that it is not feasible to set up a target value. By using performance values operators still have the possibility to assess individual cases.

The Performance Specifications for which 1. or 2. applies can be advanced into Target Specifications in the mid- or long term perspective if the necessary information basis has been built up and/or the gap between the interests of operators and manufacturers has been closed. The Specifications characterised by 3. and 4. will keep their status as Performance Specifications also 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).

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 rolling stock can be better.

3.4 Detailed Description of Environmental Specifications

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

No	Priority	Environmental Specification	Type of Env. Spec.	Applicable for
		Energy Efficiency		
1	1	Traction Energy Consumption	P	MUs, locos
2	1	On-board Energy Consumption	P	All
3	1	Energy Recovery / Regeneration	D	All
4	2	Energy Management for Parked Vehicles	D	MUs, pass. coaches
5	2	Energy-metering Devices	D	MUs, locos
6	2	Specific Mass	P	All
		Noise Emissions		
7	Mandatory	Passing-by Noise	T	All
8	Mandatory	Stationary Noise	T	All
9	Mandatory	Starting Noise	T	MUs, locos
		Diesel Exhaust Emissions		
10	Mandatory	Diesel Exhaust Emissions	T	DMUs, D-locos
11	1	Diesel Emission Factors for Specific Load Conditions	P	DMUs, D-locos
12	2	Diesel Exhaust Emissions at Longer Standstills	D	DMUs, D-locos
		Materials/Recycling/Waste		
13	Mandatory	Prohibited Materials	P	All
14	1	Hazardous Waste	P	All
15	2	Recycling Rate	P	All
16	2	Renewable Materials	P	All
		Other		
17	Mandatory	Electromagnetic Fields	C	All
18	1	Emissions from Brake Pads	P	All
19	2	Spillage / Leakages	C	All

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

Abbreviations: C: Compliance Specification; T: Target Specification; P: Performance Specification; D: Design Provision (as introduced in 3.3); MU: Multiple Units; DMU: Diesel Multiple Units

In the following the Environmental Specifications to be used in invitations to tender are 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 annex, but in 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 named
- Target value
  Target values are given for Target Specifications only
- Mandatory value (if applicable)
  For some Target Specifications a legal baseline exists, but it is recommended to ask for stricter values. In this case the mandatory value is stated in addition to the target value.
- Long-term target (if applicable)
  Long-term values are given if they can be either derived from the mid- and long-term perspective stated in the existing legislation or if they can be derived from current good practice in a consensual way.
- Priority
  Mandatory, Priority 1 or Priority 2
- Type of Specification
  The type of the specification is given according to the classification scheme laid out in chapter 3.3 (Compliance Specification, Target Specification, Performance Specification, Design Provision)
- Application
  The range of application is specified (Multiple units, locomotives, passenger coaches, freight wagons)
- Economic Effects
  The economic effects are estimated with regard to impacts on initial investment, operating costs and end-of-life costs. As a reference the estimated image gain is shown.
  The assessment is made under the assumption that a major improvement of the environmental performance described by the respective specification is made as compared to minimal legal requirement or the average level of performance. Possible ratings are:

  ↑ Going strongly up

  ↗ Going up

  → Staying equal

  ↘ Going down

  ↓ Going down strongly

3.4.1 General Precondition

Compliance with Legislation

There is a large variety of environmental regulations. With fulfilling this precondition the manufacturer ensures that the applicable legislation (national/European/international) with respect to the environment has been observed when the vehicle is delivered to the customer.

3.4.2 Energy Efficiency Specifications

1) Traction Energy Consumption

The manufacturer should calculate the energy consumption for the requested operation pattern such that 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 tractive effort				
Environmental performance indicator: Traction energy consumption (kWh) for specific operation pattern				
Long-term Goal: Traction energy consumption for given operation patterns according to standardised methodology (standardised definition of simulation and verification measurements)				
Priority:	1			
Type of specification:	Performance specification			
Application:	Multiple units, locomotives			
Economic effects on:	Initial investment costs	Operating costs	End-of life costs	Image gain
	↑	↓	→	↗

The calculated values have to be verifiable by measurements afterwards. It will be of special relevance to agree on the measurement method to be applied. It is important

to specify framework conditions (including driving pattern, e.g. braking strategy as well as external temperature) in the tender to make different offers comparable. [9]

2) On-board Energy Consumption

Energy consumption for comfort functions amounts to about 20% (or even more) of the total energy consumption in passenger transport in the countries in Central and Northern Europe (heating). With an increased share of air-conditioned vehicles on-board energy consumption will become an issue in Southern Europe also. Energy consumption for comfort functions can be optimised by a set of different "intelligent" technologies.

Definition of environmental specification: Energy consumption for auxiliaries and comfort functions				
Environmental performance indicator: Calculated on-board energy consumption (kWh) for defined conditions				
Priority:	1			
Type of specification:	Performance specification			
Application:	All kinds of rolling stock			
Economic effects on:	Initial investment costs	Operating costs	End-of life costs	Image gain
	↗	🡻	→	↗

The railway has to specify the layout parameters and outside 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 has a very considerable saving potential, especially for:

- electric multiple units and locomotives on AC lines and
- on local and regional 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 be considered as well in future invitations to tender.

[9] 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 joint project of railways and railway industry is foreseen to define an appropriate approach and develop comparable energy consumption standards.

Definition of environmental specification: Equipment of the train with energy recovery / regeneration / storage				
Priority:	1			
Type of specification:	Design Provision			
Application:	All kinds of rolling stock			
Economic effects on:	Initial investment costs	Operating costs	End-of life costs	Image gain
	↗	↓	→	↗

The railway has to specify the detailed functionality of the energy recovery/regeneration/storage system in the invitation to tender. Furthermore for freight wagons and passenger coaches the buffers have to be dimensioned accordingly, to allow for maximal use of the regenerative brakes.

4) Energy Management for Parked Vehicles

Auxiliaries and comfort functions lead to a considerable amount of energy consumption in parked trains if they are e.g. heated / air-conditioned overnight. An automatic control system can considerably reduce the 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 has to 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 fits well with maintenance and service duties and procedures of the railway operator.

Definition of environmental specification: Energy management / control system for comfort functions at longer standstills				
Priority:	2			
Type of specification:	Design Provision			
Application:	Multiple units, passenger coaches			
Economic effects on:	Initial investment costs	Operating costs	End-of life costs	Image gain
	↗	↓	→	→

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 potentials for rolling stock. The energy meter could also be used for the driver to control energy consumption with respect to his driving style.

Definition of environmental specification: Energy-metering devices				
Priority:	2			
Type of specification:	Design Provision			
Application:	Multiple units, locomotives			
Economic effects on:	Initial investment costs	Operating costs	End-of life costs	Image gain
	➔	➘	➔	➔

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 determining parameter for the later energy consumption in operation. Weight losses are more important in operation schemes 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 of energy consumption (see above), it is recommended to use it additionally, because the vehicle mass or specific mass are easy to measure and verify.

Definition of environmental specification: Value for vehicle mass				
Environmental performance indicator: Locomotives: absolute mass MUs and passenger coaches: mass per seat (see below) Freight wagons: mass per pay load				
Priority:	2			
Type of specification:	Performance specification			
Application:	All kinds of rolling stock			
Economic effects on:	Initial investment costs	Operating costs	End-of life costs	Image gain
	➚	➘	➚	➔

For passenger coaches and MU the unit should be mass per (seat + x * square meter), where x is typically 0 for a high speed train, and at least 4 for a metro train.

3.4.3 Noise Emissions Specifications

The general tendency in noise regulation is to set-up common European emission limit values for vehicles in addition to the existing reception limits along certain track. For the EU the Technical Specification for Interoperability (TSI) for High Speed has defined limit values for high-speed trains and is already in force. TSI for conventional train service has been approved by the "Article 21 committee" in November 2004, will be notified by the EC in the first semester of 2005 and will probably become effective end 2005. 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 are running or partly running on the interoperable railway net. This is the major part of the European railway network. However it is highly recommended to use the specifications for all procurement of rolling stock. In many European countries national noise legislations have to be respected too.

7) Passing-by Noise

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

<table>
<tr><td colspan="5">Definition of environmental specification:
Passing-by noise</td></tr>
<tr><td colspan="5">Environmental performance indicator:
$L_{pAeq,Tp}$ in 7,5m distance for conventional trains and TEL in 25m distance for high-speed trains
(Measurement conditions specified by TSI)</td></tr>
<tr><td colspan="5">Target Value:
As defined by TSI</td></tr>
<tr><td colspan="5">Long-term Goal:
to be defined</td></tr>
<tr><td>Priority:</td><td colspan="4">Mandatory</td></tr>
<tr><td>Type of specification:</td><td colspan="4">Target specification</td></tr>
<tr><td>Application:</td><td colspan="4">All kinds of rolling stock</td></tr>
<tr><td rowspan="2">Economic effects on:</td><td>Initial investment costs</td><td>Operating costs</td><td>End-of life costs</td><td>Image gain</td></tr>
<tr><td>↑</td><td>➔</td><td>➔</td><td>↑</td></tr>
</table>

The railway has to require the applicable noise limit. The value has to be fixed in the contract.

8) Stationary Noise

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

Definition of environmental specification: Noise emissions at stand-still with all equipment running				
Environmental performance indicator: $L_{pAeq,Tp}$ in 7,5m distance (Measurement conditions specified by TSI; refer to ISO 3095 and table 1 of TSI provisions for conventional rail system)				
Target Value: As defined by TSI				
Long-term Goal: to be defined				
Priority:	Mandatory			
Type of specification:	Target specification			
Application:	All kinds of rolling stock			
Economic effects on:	Initial investment costs	Operating costs	End-of life costs	Image gain
	↗	→	→	↑

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

9) Starting Noise

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

Definition of environmental specification: Noise emissions during starting process
Environmental performance indicator: L_{pAFmax} in 7,5m distance (Measurement conditions specified by TSI)
Target Value: As defined by TSI
Long-term Goal: to be defined

Priority:	Mandatory			
Type of specification:	Target specification			
Application:	Multiple units, locomotives			
Economic effects on:	Initial investment costs	Operating costs	End-of life costs	Image gain
	↗	➔	➔	↑

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 are one important environmental aspect of rolling stock that is of high public interest mainly because of health concerns.

Exhaust emission limit values for rail diesel engines in Europe are governed by the EU directive 97/68/EC (amended by directive 2004/26/EC) on “non-road mobile machinery”. The limit values for Stage III A for NOx, CO, HC, PM emissions will be binding from 2005/2006 for railcars and from 2006/2007 or 2008/2009 respectively, depending on the power rating for locomotives. As a next step, III B is foreseen for 2011/12, however there will be a review on the feasibility of this values before the end of 2007.

Special attention has to be paid to the fact that the directive not only refers to new vehicles but also to remotorisation. Thus in the procurement of new rolling stock it has to be considered that for a future remotorisation stricter limit values could be

applicable. Consequently it is important to make design provisions which allow for the necessary upgrades (e.g. sufficient space in locomotives for particle filters).

10) Diesel Exhaust Emissions

Although diesel exhaust emissions are governed by the EU directive 97/68/EC it may strategically be advisable to achieve stricter emission values (respectively the values outlined in the directive at an earlier point in time), since DMUs and locomotives with better performances can show a broader range of serviceability if individual local authorities demand stricter limits (e.g.: to comply with the EU directive 1999/30/EC on ambient air quality) or to use low emission vehicles also in tunnels or maintenance facilities.

Definition of environmental specification: Exhaust Emissions for NO_x, 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 through EU directive 2004/26/EC) and their equivalent in national laws				
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)				
Priority:	Mandatory			
Type of specification:	Target specification			
Application:	Diesel multiple units and locomotives			
Economic effects on:	Initial investment costs	Operating costs	End-of life costs	Image gain
	↑	↗	→	↑

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

11) Diesel Emission Factors for Specific Load Conditions[10]

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 the vehicle fleet of a company for communication purposes.

Definition of environmental specification: Exhaust emission of NOx, CO, HC, PM according to the "homologation certificate" (for each load stage of the applied test cycle, e.g. ISO 8178 F or C1)				
Environmental performance indicator: Emission in g/kWh				
Priority:	1			
Type of specification:	Performance specification			
Application:	Diesel multiple units and locomotives			
Economic effects on:	Initial investment costs	Operating costs	End-of life costs	Image gain
	→	→	→	↗

The manufacturer provides a test report with the exact emission factors of the diesel engine. Besides the weighted emission factor according to the applied test cycle (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 needed emission factors have to be measured in the homologation procedure according to 2004/26/EC before the engine is put on the market, no additional measurements are needed.

[10] As the formulation of this specification is still being discussed your feedback is kindly requested.

12) Diesel Exhaust Emissions at Longer Standstills

Diesel engines often have to run at standstills 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 possibilities to prevent exhausts at passenger stations should be considered, such as integration of a separate on-board energy supply or availability of a connection to an external electricity supply for multiple units and passenger coaches of loco-hauled trains.

Definition of environmental specification: Measures to prevent exhaust emissions at longer standstills				
Priority:	2			
Type of specification:	Design provision			
Application:	Diesel multiple units and locomotives			
Economic effects on:	Initial investment costs	Operating costs	End-of life costs	Image gain
	↑	→	→	↑

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

3.4.5 Materials/Recycling/Waste Specifications

13) Prohibited Materials[11]

At national, European and international level there are several substances that are prohibited from or restricted in use, such as PCBs in transformers or CFCs in air conditioners (on EU level regulated by the Council Directive 76/769/EEC and it's amendments). In addition to these legal regulations the operator could exclude or restrict the use of certain other substances voluntarily with regards to the precautionary principle or image gain. To go beyond the legal standard can also be attractive for operators in order to minimise financial risks that is attached to upcoming legislation (material use to be forbidden in the future) or end-of-life costs of vehicles.

In current practise many operators have their own lists of unwanted materials which go beyond the legal standard. Covered are materials which are forbidden in other (similar) products, but not in rail vehicles or materials which will be subject to upcoming legislation. Public sensitivity to certain materials plays an important role for the choice of such exclusions.

[11] As the formulation of this specification is still being discussed your feedback is kindly requested.

Definition of environmental specification: Hazardous materials used in construction.
Environmental performance indicator: Weight rations or absolute amounts of defined hazardous materials
Mandatory performance: Compliance with legislation (exclusion of legally forbidden materials)
Recommended performance: Exclusion of unwanted materials

Priority:	Mandatory			
Type of specification:	Performance Specification			
Application:	All kinds of rolling stock			
Economic effects on:	Initial investment costs	Operating costs	End-of life costs	Image gain
	↗	➔	➔	↗

The minimum performance for this specification is the compliance with legislation (Materials generally forbidden and materials forbidden for certain applications). To ensure a high level of information within this complex field, the operator should explicitly specify the applicable legislation (especially national) in the invitation to tender.

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

A first effort to come to a harmonised list of forbidden and restricted materials has been made within the EU-funded project REPID. The development of a commonly accepted list of restricted materials is still lacking and can be considered as a long-term goal in this field for the rail sector. Outcomes of the REACH process on the classification of hazardous substances have to be taken into consideration.

14) Hazardous Waste

The knowledge of materials which are classified as hazardous waste at the end of the life or during operation and maintenance of a vehicle is not only important for ecological reasons but is also necessary to make life-cycle-cost calculable and keep end-of-life costs low.

Definition of environmental specification: Materials and components which during the lifespan or at the end of 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)				
Priority:	1			
Type of specification:	Performance specification			
Application:	All kinds of rolling stock			
Economic effects on:	Initial investment costs	Operating costs	End-of life costs	Image gain
	↗	➔	↘	↗

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 (and also consumables and spare parts) and other units which are classified as hazardous waste and have to be treated as such. In that sense the declaration of hazardous waste does not depend on a full and detailed material list. Following a much more practical and usable approach the manufacturer should be asked to provide detailed information only about 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 the contract is signed.

15) Recycling Rate

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

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

- Reuse and recovery: 85% by weight
- Reuse and material recycling: 80% by weight.

In the same directive following values has to be met by 2015:

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

Transferred to the rail sector the above-mentioned parameters from the automotive sector would be defined as:

- Material recycling rate after use
- Material that can be incinerated with energy recovery.

Although there are still no regulations in force for the rail sector, rail vehicles should assist the European policy to avoid the generation of waste. Standards in the

automotive industry should be considered a bottom-line benchmark. When a high recycling rate is the result of good materials separation by disassembling, it is believed to have a positive influence on the maintainability of rolling stock as well.

As there are still no standard values for the parameters “material recycling rate” and “material that can be incinerated” for use in invitations to tender, the railway has to co-ordinate closely with the manufacturers about recycling rates of the rail vehicle.

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”).

<table>
<tr><td colspan="5">Definition of environmental specification:
Recyclability</td></tr>
<tr><td colspan="5">Environmental performance indicator:
Defined value for recyclability:
- material recycling rate and/or
- recycling rate including incineration with energy recovery</td></tr>
<tr><td>Priority:</td><td colspan="4">2</td></tr>
<tr><td>Type of specification:</td><td colspan="4">Performance specification</td></tr>
<tr><td>Application:</td><td colspan="4">All kinds of rolling stock</td></tr>
<tr><td rowspan="2">Economic effects on:</td><td>Initial investment costs</td><td>Operating costs</td><td>End-of life costs</td><td>Image gain</td></tr>
<tr><td>↗</td><td>➔</td><td>↘</td><td>➔</td></tr>
</table>

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).

16) 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, the 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, environmental climate conditions, 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.

Definition of environmental specification: Use of renewable materials				
Environmental performance indicator: Weight ratios of renewable materials in vehicle				
Priority:	2			
Type of specification:	Performance specification			
Application:	All kinds of rolling stock			
Economic effects on:	Initial investment costs	Operating costs	End-of life costs	Image gain
	↗	➔	➔	➔

3.4.6 Other

17) 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 “electrosmog” are discussed. Even in the absence of consistent and reliable information about the effects of “electrosmog” caused by railways the railway companies should follow the precautionary principle and ensure low emissions levels where protective measures can be put into practise at reasonable costs.

Existing EU legislation governs the exposure of working staff to electromagnetic fields. The limit values given in the 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 for many national legislations and recommendations. These values are five times stricter than the occupational exposure limit values to account for highly sensitive people (e.g.: children, pregnant women). With respect to the precautionary principle, the limit values should be met at all places where passengers are even briefly present.

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

Definition of environmental specification: EMF exposure at all locations of the vehicle were people are present.				
Mandatory compliance: As defined in 2004/40/EC for all places where staff can be present				
Target compliance: As defined in EU Council Recommendation 1999/519/EC and EN 45502-1, -2-1, -2-2 for all places where passengers can be present.				
Priority:	Mandatory			
Type of specification:	Compliance specification			
Application:	All kinds of rolling stock			
Economic effects on:	Initial investment costs	Operating costs	End-of life costs	Image gain
	↗	➔	➔	↗

The legal baseline is represented by the EU directive 2004/40/EC. Nevertheless, the limit values given in EU Council Recommendation 1999/519/EC should serve (with

respect to the precautionary principle) as objectives. The EN 45502-2-1 covers the EM spectrum from 16 Hz to 3 GHz and assures electromagnetic compatibility active implantable medical devices. Additionally for Switzerland, Belgium, Italy and Finland national legislation may have to be considered.

The manufacturer has to present a protocol of the measurements at the delivery of the vehicles.

18) Emissions from Brake Pads

Presently it can not be assessed to which degree brake pad emissions constitute health risks for staff, passengers or neighbours to railroad lines. However, particulate emissions from brake pads can contain toxic substances or PM10. Little is yet known about the concentrations of these substances emitted into the environment or into rail vehicles (drivers and passenger cabins). However, due to the increasing amount of compound brakes in rail vehicles and a growing public awareness of health risks related to dust emissions the issue should be addressed in the procurement of new rolling stock.

Definition of environmental specification: Emissions from brake pads which are harmful to health or the environment				
Environmental performance indicator: Concentrations of defined hazardous materials in brake pads				
Priority:	1			
Type of specification:	Performance specification			
Application:	All kinds of rolling stock			
Economic effects on:	Initial investment costs	Operating costs	End-of life costs	Image gain
	↗	→	→	↗

So far, no harmonised measurement procedure for brake pad emissions exist. An assessment of the brake pad material can serve as a first step to reduce the risk of hazardous emissions. The operator should demand a materials declaration from the supplier of the brake pads which specifies all concentrations of toxic substances contained in the brake pads (checklist of substances has to be specified by operator, possible references are substances listed in regulations on occupational health e.g. MAK, AFS or COHSS and the upcoming European norm on “Brake Pad Friction Materials”[12]).

In addition, to minimise exposure of staff and passengers design provisions for air intakes for coaches, MU and locomotives should be made to reduce the intake of

[12] European Committee for Standardization CEN, Technical Committee TC256, Work Items WI171 and 173

brake pad emissions into the vehicle. Due to the unpleasant smell of many brake pad emissions this is generally advisable with regard to passenger comfort.

19) Spillage / Leakages

<table>
<tr><td colspan="5">Definition of environmental specification:
The manufacturer verifies that measures to prevent negative environmental impacts due to spilling of oil, leakages, grease, coolant, and other substances have been taken</td></tr>
<tr><td>Priority:</td><td colspan="4">2</td></tr>
<tr><td>Type of specification:</td><td colspan="4">Compliance specification</td></tr>
<tr><td>Application:</td><td colspan="4">All kinds of rolling stock</td></tr>
<tr><td rowspan="2">Economic effects on:</td><td>Initial investment costs</td><td>Operating costs</td><td>End-of life costs</td><td>Image gain</td></tr>
<tr><td>➔</td><td>↘</td><td>➔</td><td>➔</td></tr>
</table>

This specification does not apply for biodegradable lubricants.

3.5 Approach for the Evaluation of Environmental Aspects in Tenders

The pie-chart scheme introduced in chapter 3.2 together with an economic assessment provides a basis for the evaluation of tenders with respect to 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:

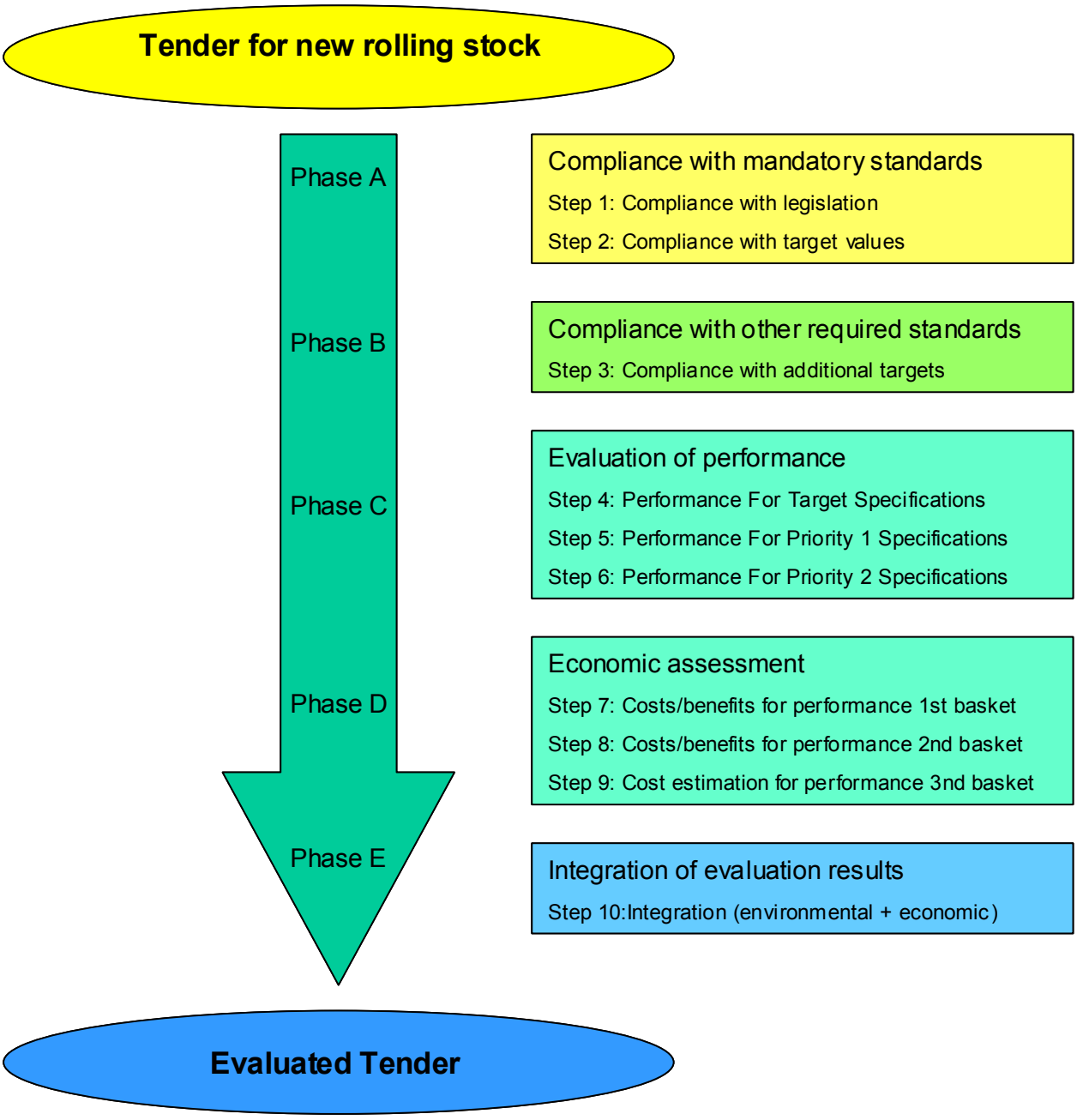

Figure 6: Strategy for the evaluation of environmental aspects in tenders for new rolling stock and refurbishment or upgrading.

Phase A: **Compliance with legal standards**
(mandatory environmental performance)

Input: Compliance statement, Environmental Specifications (1st pie-chart), 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 – not legislation governed but required – environmental standards

Input: Additional targets

Step 3: Compliance with target values set by local authorities, infrastructure operators or other 3rd 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 (1st pie-chart)

Step 5: Environmental performance for the priority 1 specifications (2nd pie-chart)

Step 6: Environmental performance for the priority 2 specifications (3rd pie-chart)

Output: Overall environmental performance, performance with respect to good practice, already defined future standards and upcoming standards/standards under 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 (1st pie-chart)

Step 8: Cost/benefit analysis of environmental performance defined by the priority 1 specifications (2nd pie-chart). The main focus in this step of the economic assessment will be the Energy Efficiency specifications.

Step 9: Estimation of costs and benefits for the environmental performance defined by the priority 2 specifications (3rd pie-chart)

Output: Estimated LCC-effects for the 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: Aggregated result of evaluation

The overall result of the evaluation of a tender regarding environmental aspects is obtained by integrating the results of the evaluation of environmental performance and the respective economic assessment. Due to fact that the 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 for the environmental and economic evaluation for the top priority specifications should be clustered e.g. along strategic aims and then balanced as to adequately reflect the respective importance of these aims.

When comparing different tenders with respect to their environmental performances reasonable trade-offs have to be found e.g. between

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

As for the second trade-off the energy consumption of the rolling stock is clearly one key factor in the decision on which tendered train has the best cost/benefit ratio.

4 Annex: Background Information for Key Areas

4.1 Energy Efficiency

4.1.1 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 is still an outstanding competitive advantage, especially compared to aviation and individual road traffic. A further enhancement of this advantage would improve both the environmental and economic competitiveness of 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

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

[IZT 2003]

There is general agreement about the existence of considerable energy saving potential in railways in the short, mid and long term. The exploitation of this potential is highly plausible due to the positive cost benefits ratio associated with many measures in this field. It should be stressed however that it needs a true Life-Cycle-Cost (LCC) oriented approach to demonstrate the economic advantages of most energy saving measures, e.g. today's focus on initial investment has to be overcome.

In order to find the most promising offers during the procurement process the comparison of different tenders regarding energy efficiency has to become much more transparent. This would also lead to a competition between the different manufacturers towards a more energy efficient design. 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 electrical household appliances) should be developed.

4.1.2 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 needs for passenger comfort (air-conditioning, lighting, etc. in passenger transport).

These three areas cannot be optimised in isolation as there are often trade-offs, e.g. between mass reduction and energy use for comfort functions: a better isolation of the car 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 over application ranges, economic and environmental potentials as well as relevant experiences and projects in this field see the web-based database that has been developed within the framework of the EVENT project. (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 is very important for energy consumption, especially in high-speed and intercity applications. Given the present state of high speed technology, raising the top 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 comprise 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. As for freight transport covering open cars or putting freight wagons of different heights into the aerodynamically optimised 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. Those 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 shown overall saving potentials of over 5% of the total energy use (and up to 20% on certain routes for individual drivers). On a systemic 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 like high temperature super conductors (HTSC) transformers would increase efficiency dramatically, but will they will only be available at reasonable prices in the medium or long term. In a short-term perspective considerable efficiency potential lies in intelligent control algorithms for the individual traction components or their interaction. A better motor management by means of an 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%, e.g. by higher injection pressures and common rail fuel injection technology. But the trade-off between efficiency of the combustion engine and diesel exhaust emissions has to be taken into account. In contrast to electric traction the transmission plays an important role for the energy efficiency of diesel trains. Electric and mechanical transmission have advantages in comparison 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 transmissions as used e.g. in diesel-mechanical multiple units 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 has a very considerable 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 for 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 loco hauled (and especially for heavy) freight trains, unfavourable operation concepts for drivers cabins and limited acceptance by some drivers for the use of regenerative brakes.

Short-term options to overcome the obstacles include driver’s training programmes and improved designs for the driver cabin. Mid- and long-term options are 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 e.g. 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 the entire kinetic energy of a train is transformed only by the locomotive. Many wagon buffers are not dimensioned for the occurring forces and could be damaged/destroyed. For full load dynamic braking it has to be ensured that the 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 countries of Central and Northern Europe. The major share (about 80%) is used for air conditioning, e.g. heating and cooling. Higher efficiency can be reached e.g. 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 the 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. But reliable data on energy consumption help to identify efficiency potentials and allow for an exact monitoring of energy saving measures. They are also an essential condition for fair energy billing, an issue gaining growing importance in liberalised railway markets.

Train concepts

Improvement of energy efficiency cannot only be reached 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 concept for a given operation context in the pre-tendering process. As for passenger transport the energy consumption is determined by two main characteristics of the train concept: the use of space (seats per m²) and flexibility. A high number of seats per m² means low energy consumption per passenger km. This could be achieved e.g. 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.

4.1.3 Measurement Procedures – Test Cycles

So far, in Europe there are only two well established test cycles to measure energy consumption (and exhaust) of rail vehicles: the ISO 8178 F and C1 cycles. Although this mirrors relatively well some major working profiles, there are large deviations possible in practise, 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	10	0
Cycle C1	15%	15%	15%	-	10%	10%	10%	10%	-	-	15%
Cycle F	25%	-	-	-	-	-	-	15%	-	-	60%

Table 4-1: Definition of test cycles ISO 8178 F and C1 – share of working points in %

There are a number of other test cycles or load profiles which are being used by national railway companies or by industrial producers. However, comparability is limited if possible at all. Currently a feasibility-study “Harmonisation of Energy

Consumption Standards for Railways"[13] is carried out. One aim of the study is to assess whether or not test cycles can be an appropriate tool to gain comparable standards for the energy consumption of rolling stock.

4.1.4 References

1) [IZT 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

2) [EEC Paris 2004] Energy Efficiency Conference, Paris (February 2004)

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

4.2 Noise

4.2.1 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 that both noise is indeed perceived as the major negative environmental impact of railways by the public and that there is a growing awareness in politics for this issue which leads to stricter noise regulations. In the past noise has predominantly been governed by setting limit values for noise reception along railway lines, especially hot spots and newly build track lines. The trend of the last decade is that legislation also sets noise emission levels for rolling stock. This trend will gain importance in the context of further harmonisation on EU level (interoperability) and the decoupling of responsibilities for railway infrastructure and operation of rolling stock.

Interior noise for rail vehicles is also governed by the TSI for high-speed trains and in the upcoming TSI for conventional rail. However, the focus in this update report lies on external noise.

Unbundling of responsibilities

The general trend of setting emission values (instead of reception values) falls in line with the trend of liberalisation and harmonisation on EU level. With the unbundling of railway network operators and rolling stock operators, reception levels would lead to undefined responsibilities.

Holistic approach

One has to keep in mind that the overall noise emission is not only dependent on rolling stock but also on the condition of the track. Rough rails can compensate or even overcompensate reductions achieved by low noise rolling stock. Therefore a systemic approach is needed.

[13] Machbarkeitsstudie: "Harmonisierung von Energieverbrauchstandards für Schienenfahrzeugen" Deutsche Bahn AG, contact Mr. Markus Halder, Bahn-Umwelt-Zentrum

Noise barriers vs. low-noise rolling stock

Investment for track-side railway noise barriers makes up about 8% of the total investment for newly build railway lines. In addition, there is a growing public opposition against huge noise barrier walls for aesthetic reasons. For building new lines for high speed trains it could therefore be a cost effective as well as easier acceptable option to invest into low-noise rolling stock rather than being obliged to comply with strict reception levels by installing expensive noise barriers. With the German ICE this rational was one reason behind the noise reduction efforts.

However, current regulation and public funding is not supporting this rational. There are large sums of public funding available for track-side railway noise barriers, which can – so far – not be transferred into noise reduction actions on rolling stock. The reason is that doing so could in fact be interpreted as a subsidy of an individual railway company and could therefore distort competition.

4.2.2 Technical State of the Art

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

Anti noise measures include: damped wheels, disk 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 the noise emissions as a whole and on the measurements carried out to specify the accordance with noise limits.

4.2.3 Measurement Procedures

Standards and Comparability

There are various different acoustic indicators 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 (<190 km/h) and TEL (transition exposure level) at a distance of 25m for high speed trains (>200km/h).

Furthermore for test realisation 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)

Distance from source: 7.5m and 25m

Usually the emitted noise is measured as acoustic pressure at a distance of 7.5 m ($L_{pA\ 7.5}$) or 25 m ($L_{pA\ 25}$). Theoretically $L_{pA\ 7.5}$ should be 20 lg (25/7.5) dB(A) = 10 dB(A) lower than $L_{A\ 25}$. Experimental data show a difference of 6 dB(A) for freight trains and

7 dB(A) for passenger trains, which is usually explained by absorption effects[14]. For conventional trains a 7.5m distance is therefore favoured to achieve more accurate and comparable results.

Condition of Test Tracks

The condition of the tracks has a decisive influence on the noise emissions of passing trains. Grinding of rails can reduce the noise level as much as 7 to 10 dB(A). It is difficult to compare noise limit values with different specifications of the rails condition [O&D 2002]. In order to have a high accuracy when determining the noise emissions of rolling stock, it would be favourable to use test tracks with a very smooth surface. However, this has to two disadvantages:

- Very smooth test tracks with highly specified characteristics are expensive to maintain. Therefore testing would have to be done at special testing site. This would increase costs for manufacturers and railways when rolling stock has to be shipped to those testing sites.
- Using very smooth test tracks would result in very low "theoretical" noise levels. This may either result in strong opposition from producers and railways since those values may sound unrealistic if the measuring procedure is not communicated. On the other hand specifying low "theoretical" values which will not be achieved in practical use may lead to opposition from the public (politicians, NGO, residents near railways, etc.). One point of critique could be: "Why are not all rails in the condition of this test track?" The maintenance needed could become quite costly. However the additional costs for acoustic grinding may be small compared to other anti-noise measures. (Here a need for more research exists).

4.2.4 References

Background papers

1) [EC 2003] Workgroup Railway Noise of the European Commission. Position Paper on the European strategies and priorities for railway noise abatement. Brussels, 2003

2) [UIC Noise 2002] UIC. Noise Creation Limits for Railways – Main Report on the Railway's Position. 2002

3) [UIC 2003] UIC Sub Commission Noise and Vibration. Draft comments on AEIF Draft for Basic Parameters for Conventional Railway TSI. 2003

4) [O&D 2002] Odegaard & Danneskiold-Samsoe A/S. A Study of European Priorities and Strategies for Railway Noise Abatement. Brussels, 2002

5) [Jäcker 2003] Jäcker-Cüppers, Michael. Slide presentation *„Die Aktivitäten der EU zur Reduzierung des Schienenverkehrslärms"*. Berlin, 9/2003

Links

http://www.aeif.org/
European Association on Railway Interoperability
Download of legislation texts

[14] 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).

http://europa.eu.int/comm/transport/rail/index_en.html
Directorate-General for Energy and Transport / Rail transport
Download of legislation and background papers

4.3 Diesel Exhaust Emissions

4.3.1 Relevance of this Key Area

Exhaust emissions from diesel engines is one important environmental aspect of rolling stock that is of high public interest (e.g. health reasons and other).

In a long term perspective exhaust emissions of 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 it needs great common efforts within the whole railway sector to keep the advantages in environmental performance. These efforts should be based on a long term strategy for emission reduction with comparably strict limit values.

4.3.2 Technical State of the Art

Actual and mid-term limit values, as defined in the EU directives mentioned before, should be reachable with existing technologies, although optimisation of engines to reach the NO_x limit values could end up in higher fuel consumption. Limit values of 2011/2012 of the EU directive 97/68/EC will only be reachable by novel technical solutions, e.g. catalytic converters and/or particle filters. At present there are very few applicable systems available, especially in the high power range. Filter technologies are established for applications in cars, trucks, busses and smaller ships. However, due to the different sizes and different load patterns technology transfers for railway use could be limited or could need further research and development input.

4.3.3 Measurement Procedures – Test cycles

Diesel exhaust emissions are measured in g/kWh. In the process of the revision of the EU directive 97/68/EC[15] the 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 4.1.3).

4.3.4 References

Background papers

Diesel Exhaust

1) den Boer, Eelco, Joost Vermeulen, Max Smith, Jos Dings. *Clean on Track – Reducing Emissions from Diesel Locomotives*. Study by CE, Delft, 2003

2) UIC. *Feasibility Study: "UIC Action Plan for Reduction of Diesel Exhaust emissions from Tractive Units".*

3) UIC. *Slide presentation "UIC Action Plan for reduction of diesel exhaust emissions from tractive units".* Utrecht, 2003

[15] Amended through the directive 2004/26/EC from April, 21 2004, published in the European Journal April, 30 2004

4) Kettner, Joachim. Slide presentation *"UIC Action Plan for reduction of diesel exhaust emissions from tractive units"*. Utrecht, 12/2003

5) 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

6) Eisenbahn-Bundesamt. *Informationen zur Abgasemission aus Schienenfahrzeugen.* Bonn, 2003

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

8) The European Association of Internal Combustion Engine Manufacturers *Consideration on Exhaust Emission Optimisation of Diesel Engines for Rail Traction*. Frankfurt, 2000

Links

http://www.dieselnet.com
Good overview of status and process of EU legislation to regulate emissions from non-road (off-road) mobile equipment / directive 97/68/EC and amendments.

4.4 Materials, Recycling, Waste

4.4.1 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 being 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 the recycling approach / technologies be like in 40 years?).
- The comparably low overall waste quantities of rolling stock (low number of trains e.g. in comparison to cars) make dedicated recycling systems difficult to establish and to operate.
- There is great amount of freedom necessary for manufacturers to allow for environmentally optimised design and production processes.

There are basically two different approaches to optimise the environmental performance within this field and both are supported by the REPID methodology and any software tool supporting the methodology

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

→ functional approach: to influence 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 concrete choice of materials for a new train or parts of it and the corresponding

design concept lie mainly within the responsibility of the manufacturer. Therefore the influence of the operator is rather limited in this field (unless the operator has specified certain material or solution).

From an operators 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 communicate certain guiding principles for the choice of materials to the manufacturer which guarantee 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.

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.

Generally it needs to be considered:

- If a certain substance should be excluded from trains, it should very likely be based on an analysis of the risk that this substance creates in a specific component or in a specific use. Indeed, a substance creates a different risk if it is used: (a) as part of an alloy, (b) as a 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 component of the fuel. 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 the whole train does not seem very realistic with a very good confidence level.

4.4.2 Technical State of the Art

Restricted and Forbidden Materials

Focussing on materials and substances relevant for railways, within the framework of **REPID** an easy to handle list for forbidden materials and a “grey list” for restricted materials has been developed.

The manufacturer should be encouraged to use the REPID methodology and software packages supporting the methodology at an early stage of the design process to integrate the use of renewable materials, a careful resource management, prevention of hazardous waste and increase recycling efforts. In this respect two different time scales have to be taken into account: a shorter for major retrofit measures (mainly with respect to interior components) and one for the life-cycle of the vehicle itself.

The results of the REPID project will be developed further under the auspices of the RES board (Rail Eco-procurement Specifications Board) within the AIEF.

Recycling Rate

In the specification on the recycling rate of material after use, the target values for the automotive sector are given (as specified in the 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 ISO22628.

4.4.3 References

Background papers

1) REPID. Development Method of the REPID Material List. 2002
2) REPID. Specification of material properties in the REPID Database. 2003
3) COM(2003) 301 final. COMMUNICATION FROM THE COMMISSION - *Towards a thematic strategy on the prevention and recycling of waste.* Brussels, 27.5.2003
4) Selin, Henrik and Stacy D. VanDeveer. *Hazardous Substances and the Helsinki and Barcelona Conventions: Origins, Results and Future Challenges. 2002*
available from:
http://www.helcom.fi/land/Hazardous/javeapolicypaper.pdf
accessed 5 January 2004

Links

http://europa.eu.int/comm/environment/waste/index.htm
Background papers and general outlook of EU waste strategy

4.5 Other

4.5.1 Electromagnetic Fields

Relevance of this Key Area

There is a very heterogeneous and often non-consistent literature dealing with health influences of high frequency electromagnetic fields. Only very few publications directly address railway specific problems [Grotenhermen 1998] [UIC 2002][16].

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 “electrosmog” are discussed.

Even in the absence of consistent and reliable information about the effects of “electrosmog” caused by railways the railway companies should follow the precautionary principle and ensure low emissions levels where protective measures can be put into practise at reasonable costs.

Long-term and short-term effects

There are basically two approaches to define 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

[16] UIC Scoping Study on Electromagnetic Fields and Environment (“Electrosmog”)

physical impact of electromagnetic fields onto the human body (dosimetric values). Examples are local heating of tissues or increase of corporeal temperature which are measure in laboratory experiments.

- Long-term effects
  Long-term effects have to be identified by statistical means, e.g. higher cancer rates of people who are exposed to higher levels of electromagnetic fields over a longer period of time.

It has to be marked that so far there is no scientific proof of long-term health risks due to electromagnetic fields which do not exceed recommended maximum short-term exposure levels. For this reason the ICNIRP guidelines as well as the 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 which are under suspicion to cause long-term effects are much lower than those which cause short-term effects. For this reason recommendations / legislations which intend to reduce the risk of long-term effects contain limit values which are lower than the ICNIRP / EU directive values by several orders of magnitude[17].

Technical State of the Art

Technical solutions

Electromagnetic fields can be reduced either by design measures or by shielding. In the first case one aims at finding locations for the main sources of high electromagnetic fields (like transformers) which are further away from passenger areas. The second case comprises new interior design 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 railways (low-frequency magnetic fields produced by electrical appliances, transformers, high-current applications, catenaries and overhead lines) there is a growing exposure of passengers and staff to EM radiation by new technologies. Foremost in new vehicle generations produce larger magnetic fields because of the multi-motor technology and much higher currents in the railway vehicles.

4.5.2 Brake Pad Emissions

Relevance of this Key Area

Compound brakes are of high interest and relevance because of lower noise emissions compared to cast-iron brakes. An increasing number of trains with compound brakes are put into operation. This can make emissions from brake pads (wear debris and substances into which the brake pad materials are transformed under higher temperatures) an important issue in the future.

[17] EU Council Recommendation 1999/519/EC on the exposure of the general public to electromagnetic fields

Emissions from brake pads can contain toxic substances. The toxicity is a combination of substance property and exposed concentration. However, little is known yet about the concentrations of these toxic substances emitted into the environment or into rail vehicles (drivers and passenger cabins). Presently it can not be assessed to which degree brake pad emissions constitute health risks for staff, passengers or neighbours to railroads. Further investigation and the establishment of harmonised testing procedures are due necessary. In a Europe-wide survey (carried out by ERRI) several European rail operators expressed further need of information and investigation of this subject.

A distinction has to be made between:

- the **original substances in the break pads**, which are emitted by wearing down the pads (literally grinding them into dust). This is the case when the pads stay relatively cool as is the case for interval breaking or breaking with low power. The main problem is that the suppliers of break pads are very reluctant to provide very detailed information on the content of the pads in order to protect their proprietary knowledge.

- **substances into which the brake pads are transformed at elevated temperatures** (i.e. 400 – 600° C or higher) which is the case for longer breaking activities with high pressure. In this case substances like Volatile Organic Compounds (VOC e.g. Toluene, Ethylbenzene, Xylene, Benzaldehyde, Diphenylmethane), Polycyclic Aromatic Hydrocarbons (PAHs) or Benzo(a)pyrene are being emitted.

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

First testing procedures for the measurement of the brake pad emissions included a series of short interval breaking patterns (low temperature cases), or the so-called Gotthard-breaking which is a continuous break of ~30 minutes (equivalent to the longest possible breaking incident in Europe: keeping a constant speed on a 40 km downhill slope) and which can be considered a worst-case scenario for high temperature breaking.

Furthermore no limit values for emissions exist to date which would allow judgments on whether or not certain emissions can be considered harmless. Three cases have to be distinguished:

- **Brake pad emissions in drivers cabin or in cabins of passenger coaches**. In both cases the concentrations of toxic gases and dusts must be below the respective limit values stated in the occupational health regulations to ensure safety of the staff. However no common test conditions and measurement procedures exist to determine emission concentrations. Furthermore, the concentrations of brake pad emissions inside the train strongly depend on the design of the trains, especially the location of air inlets as well as general conditions (speed of the train, wind conditions, breaking in tunnels etc.).

- So far no toxicity assessments of **brake pad emissions into the environment** are available. However, following the precautionary principle emissions of toxic substances should be reduced to a minimum. This is especially true for highly toxic, carcinogenic and bio accumulative

substances. Toxicity assessments should focus on a first step on likely hot spots for break pad emissions like train stations.

- **Dust** from brake pads can be **accumulated on certain vehicle parts**. During maintenance staff members can get in contact with rather high concentrations of such dust residues. If health risks can not be excluded a priori then the necessary protective measures have to be taken (gloves to avoid skin contact etc.).
  High concentrations of brake pad wear may also be accumulated in vehicle cleaning facilities.

Consequently the European norm (EN) which touches the issue of brake pads for rail vehicle and which is currently being developed (CEN Technical Committee TC256, Work items WI171 and 173) refers explicitly only to certain substances (asbestos, lead, cadmium, hexavalent chrome, ceramic fibre) in the brake pads itself and which are prohibited for use. Referring to the emissions it is only generally 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” has to be avoided.

The development of general testing conditions remains a long-term goal. Such testing procedures should be developed jointly by operators and brake pad suppliers. Then operator could demand a test protocol from the supplier of the brake pads which specifies all emissions of toxic substances emitted under “standard” braking conditions.

Beyond health and environmental aspects, emissions from brake pads cause disturbance of passengers and neighbours to railroads by 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]

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In addition to specification on the brake pads itself, the operator can make design provisions: Air inlets should be placed in such positions on vehicles to minimise break pad emission intake into the driver or passenger cabins. For passenger coaches with air-conditioning and ventilation systems it should be considered to install control devices which allow for an interruption of air intake during longer braking activities.

4.5.3 References

EMF

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

2) [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

Brake Pads

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

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

5 List of Abbreviations

AC/DC	alternating current / direct current
AIEF	Association Européenne pour l'Interopérabilité Ferroviaire – European Association for Railway Interoperability
CFC	chlorofluorocarbons
CO	carbon monoxide
CTR	Technical and research commission of UIC
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 super conductors
ICNIRP	International Commission on Non-Ionizing Radiation Protection
IPP	Integrated product policy
LCC	Life-cycle-cost
MU	Multiple unit
NGO	non-governmental organisation
Nox	nitrogen oxide
PAH	Polycyclic Aromatic Hydrocarbons
PCB	polychlorinated biphenyl
PM	particulate matter
REACH	Registration, Evaluation, and Authorisation of Chemicals
REPID	**R**ail sector framework and tools for standardising and improving usability of **E**nvironmental **P**erformance **I**ndicators and **D**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 the European Railway Industries

VOC	Volatile Organic Compounds
WEEE	EU directive: Waste Electrical and Electronic Equipment