Environmental Guideline
for the Procurement of new Rolling Stock

Berlin, July 2003

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Acknowledgements

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Railion DK
RFF
SBB
SNCB
SNCF
SZ
Trenitalia SpA
ZSR

ISBN 2-7461-0762 - 7
ISBN 2-7461-0760 - 0 (French version)
ISBN 2-7461-0761 - 9 (German version)

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1 Executive Summary

The key environmental areas for railways are noise and exhaust emissions as legislation has come into force or further regulations are being discussed in these two environmental fields. Energy efficiency is an outstanding environmental advantage of railways compared to other modes of transport and has top priority as well. To hold and enhance the environmental advantage of railways is a competitive advantage over our competitors and will be a challenge for the future.

The outcome of the UIC project PROSPER has been set down as an Environmental Guideline, which will help the user to address environmental aspects in rolling stock procurement in an efficient way. The Guideline is proposed as assistance in the procurement of all kinds of rolling stock to enhance the process for both setting up invitations to tender and evaluating tenders in terms of environmental aspects.

The following core questions in the procurement process of new, environmentally enhanced rolling stock will be answered in the Environmental Guideline:

- What are the key environmental areas to be addressed in invitations to tender?
- How should the procurement process be organised to enhance the environmental performance of new rolling stock?
- What are the recommendations as regards environmental specifications to address in invitations to tender?
- Which methodology can be applied to make environmental performance measurable as a prerequisite for evaluating tenders?
- What is the qualitative economic impact of environmental specifications?

In this Environmental Guideline no environmental performance values for rolling stock are defined.

2 Introduction

The environmental performance of transport has been a matter of increasing public discussion in the last two decades. Railway transport is still one of the most environmentally sound modes of transport. With a view to keeping this position and further enhancing environmental performance as a competitive advantage over other modes of transport railways have already done a lot of work and they will pursue this topic in the future.

This “Environmental Guideline for the Procurement of new Rolling Stock” is the outcome of the UIC project PROSPER (“**P**rocedures for **RO**lling **S**tock **P**rocurement with **E**nvironmental **R**equirements”) and addresses all relevant environmental aspects for the rail sector today. The Environmental Guideline can be used in the relevant steps in the procurement process where environmental aspects have to be considered to enhance the environmental performance of new rolling stock.

The Environmental Guideline comprises:

- a description of the environmental priorities for railways (chapter 3)
- an overview of economic aspects related to the environmental performance of rolling stock (chapter 4)
- a recommended procedure for integrating environmental aspects into the “normal” procurement process (chapter 5)
- a list of harmonised and prioritised environmental specifications to be used in invitations to tender, without defining performance values (chapter 6 and ANNEX 1)
- an information about a methodology for evaluating tenders in terms of environmental performance (chapter 7) and
- background information on the most relevant key environmental areas (ANNEXES 2 to 6).

This guideline gives a detailed overview of the environmental priorities for railways and how to handle the issue efficiently.

2.1 Target group

This Environmental Guideline is aimed at user groups within the railways who are involved in the procurement of new rolling stock, but who are not directly concerned with environmental aspects. Technical and purchasing experts in particular are identified as user groups, but environmental experts will also find valuable information in this guideline.

The Environmental Guideline will help the user:

- to prioritise environmental aspects for railways
- to draw up environmental specifications and
- to evaluate tenders in terms of environmental aspects.

2.2 Scope of the Environmental Guideline

The following environmental guideline was drawn up for use in the procurement process of new rolling stock. It is proposed as assistance in the procurement of all kinds of rolling stock to enhance the process for both setting up invitations to tender and evaluating tenders as regards their environmental aspects.

The following core questions in the process of procurement of new environmentally enhanced rolling stock will be answered:

1. **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 and waste are considered. Furthermore the upcoming environmental aspect of electromagnetic fields was integrated into the guideline in keeping with the precautionary principle.
2. **How should the procurement process be organised to enhance the environmental performance of new rolling stock?**
   As the procurement of new rolling stock is carried out by a large number of different players 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 with a clearly defined environmental performance.
3. **Which environmental specifications should be used in invitations to tender**?
   The focus of the work was to co-ordinate a set of qualitative environmental specifications that cover the key aspects that determine the environmental performance of railway operation. In this Environmental Guideline performance values are neither defined nor recommended.
4. **Which methodology can be applied to make environmental performance measurable as a prerequisite for evaluating tenders**?
   The crucial points for all technical specifications in invitations to tender are the functionality, measurability and verifiability of the specifications. The specifications proposed in the guideline follow these principles. The methodology used in this context is the RAVEL/REPID methodology, which uses Environmental Performance Indicators that quantify the environmental performance of rolling stock. This is of course a prerequisite for drawing up functional and measurable environmental specifications and evaluating tenders with regard to environmental aspects.

3 Key Environmental Areas for Railways

The most relevant environmental areas for railways at the moment are Noise and Exhaust Emissions as legislation has come into force (e.g. TSI, national laws) or further regulations are being discussed in these two environmental fields.

In the case of energy consumption railway transport has very clear advantages compared to other modes of transport. Nevertheless competitors are putting a lot of work into reducing energy consumption as well. In view of that, Energy Efficiency also has top priority for railways because cutting energy consumption:

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

The environmental aspect of Materials/Recycling and Waste has also become a priority over the last decade. 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 have appeared on the agenda. The significance for railways is the need to improve especially the knowledge of forbidden and restricted materials that are used in vehicles to avoid hazardous waste and to improve vehicle recyclability and therefore cut resource consumption.

An upcoming environmental aspect that is being intensively discussed in several European countries is Electromagnetic Fields. Even though there is no scientific evidence that electromagnetic fields from railway lines and the rolling stock have an impact on human health, the aspect was integrated into the Environmental Guideline in keeping with the precautionary principle. In 2003 a UIC study was approved to further investigate the impact of electromagnetic fields on human health.

To hold and further enhance the environmental advantages of railways over our competitors the recommendations of this guideline should be followed in the procurement process of new rolling stock.

4 Economic Aspects

The relationship between an enhanced environmental performance from rolling stock and the impact on investment costs and Life Cycle Costs (LCC) is of vital interest for railways. The aim of the efforts to optimise the environmental performance must be to integrate environmental requirements into the procurement process in the most efficient way.

An overview evaluation of the qualitative impact of environmental specifications carried out in the UIC project PROSPER showed that:

- In most cases environmental specifications are believed to have an increasing influence on investment costs;
- Energy-related specifications are 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 these specifications will be very high. Strategies should be developed for

implementing energy specifications in invitations to tenders despite the increasing influence on investment costs;

- Noise and exhaust emission specifications have been assessed as leading to increasing LCC. This can be explained by the negative effects on availability and maintainability that are related to these specifications.
- No significant effect or a slightly positive influence on LCC has been noted for materials/recycling and waste specifications. The construction to recycling aspect could be economically interesting as it is seen by some experts as being connected to better maintainability.
- Electromagnetic field specifications are believed to have no significant influence on LCC but to increase investment costs.

The results of the evaluation only provide an impression of the impact of environmental specifications on the cost aspect as the cost situation of new rolling stock always depends on parameter conditions like competition amongst manufacturers, technological innovations and applied methodologies. Decisions in favour of or against a certain environmental requirement for rolling stock have to take into account competition with other modes of transport and the environmental strategy of the railway company as well.

5 Integration of environmental aspects into 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 players that are involved. For an efficient integration of environmental aspects into the procurement process 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 what 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. Very often only the railway operator requires a certain environmental performance for the rolling stock from the manufacturer (in accordance with legislation of course), but in some cases 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 procedure for the “normal” procurement process (very simplified) and proposes how environmental aspects could be integrated into the procurement process:

- There is a definition of the interfaces to the environmental aspects and of the tasks that have to be done to integrate environmental aspects;
- There is a description of the input needed to carry out the tasks (and also of further sources of information).

In the second part of this chapter the different steps of the process will be explained in detail.

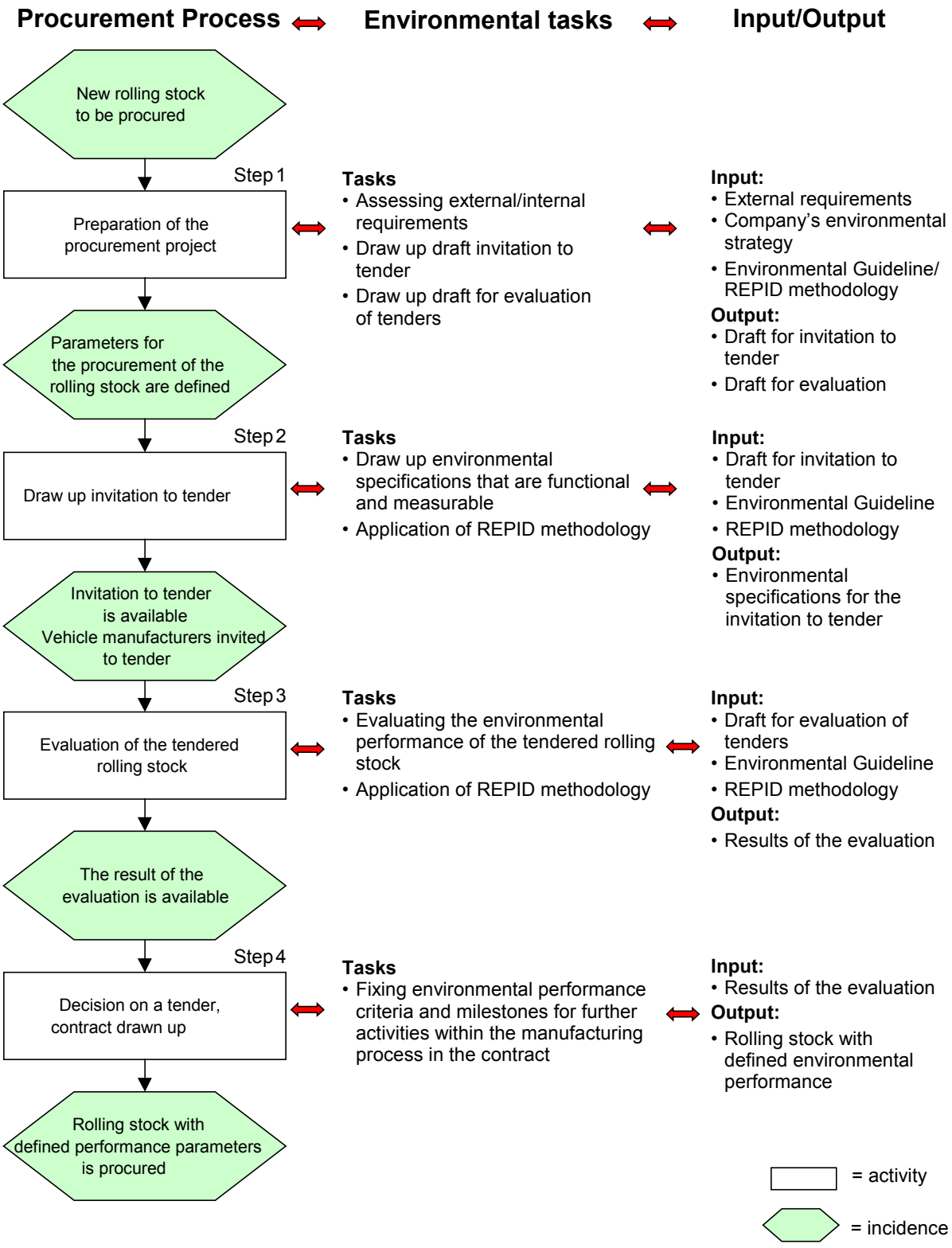

Figure 1: Procedure for the integration of environmental aspects into the procurement process

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 basic requirements (external/internal) should be set down, the drafts for the invitation to tender and the evaluation of tenders should be drawn up, and the responsibilities (who is responsible for carrying out a certain task) should be determined.

External Requirements

Involved: Environmental and technical experts
Input: External requirements, Environmental Guideline (chapter 3)
Output: Overview of the external environmental requirements

In the first step the railway should assess the external requirements for the environmental performance of the kind of rolling stock to be procured. It is important to determine whether there are any outside requirements that the railway company has to take into account in the invitation to tender, e.g. outside requirements from:

- Legislation (TSI)
- Infrastructure operator (e.g. shedding of oils and grease where trains are parked)
- National authorities (e.g. certain environmental requirements when tendering for local transport)
- Other stakeholders (e.g. the public).

Internal Requirements

Involved: Environmental, technical and purchasing experts
Input: Environmental strategy of the company
Output: Overview of the internal environmental requirements

The basic internal requirements should be deduced from the environmental strategy of the company. The priorities of the environmental strategy have to be reflected by the environmental specifications in the invitation to tender. The core targets of the environmental strategy and which strategic fields of action result for the environmental performance of rolling stock should be addressed in accordance with the economic parameter conditions.

Draft invitation to tender

Involved: Technical, environmental and purchasing experts
Input: Outcome of the assessment of external/internal requirements, Environmental Guideline (chapter 6, ANNEX 1), REPID methodology (see chapter 7 and www.railway-procurement.org)
Output: Draft for environmental specifications in invitations to tender

An actual draft document is required as the outcome of the assessment of external and internal requirements for the environmental performance of new rolling stock.

The following items should be determined:

- Environmental aspects that should be addressed in the invitation to tender with top priority and lower priority
- The procedures for drawing up environmental specifications (such as the use of Environmental Performance Indicators (EPIs) according to REPID methodology)

- The requirements that environmental specifications have to fulfil (functionality, measurability, possible to evaluate)
- Responsibilities to take into account the environmental requirements in the invitation to tender.

Draft for the evaluation of tenders

Involved: Technical, environmental and purchasing experts

Input: Outcome of assessment of external/internal requirements (priorities), Environmental Guideline (chapter 7), REPID methodology (see www.railway-procurement.org)

Output: Draft document for the evaluation of tenders

- Procedure for the evaluation of tenders (such as prioritisation of EPIs or economical aspects)
- 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.

The draft for the invitation to tender and the draft document for evaluation of tenders could be drawn up as an “internal environmental guideline”. But as environmental legislation can change quickly the external requirements should be defined for each procurement project separately.

Step 2: Drawing up the invitation to tender

Involved: Technical experts, environmental and purchasing experts

Input: Environmental Guideline (chapter 6, ANNEX 1), REPID methodology, (see www.railway-procurement.org)

Output: Invitation to tender with detailed environmental specifications

The invitation to tender has to be drawn up in detail taking into account the above-mentioned draft document on the procedure for incorporating environmental aspects. Consequently the environmental specifications from the draft document have to be specific and adapted to suit each particular procurement project. The environmental specifications have to:

- be functional
- be measurable
- be verifiable and
- comply with legal aspects and cost-efficiency considerations.

In order to obtain functional and measurable specifications Environmental Performance Indicators should be used in the form of values for the environmental performance. (For further information see chapter 7 and www.railway-procurement.org).

Close co-ordination between technical, environmental and purchasing departments is needed to draw up the invitation to tender.

Step 3: Evaluation of tenders

Involved: Technical, environmental and purchasing experts

Input: Environmental Guideline (chapter 7), REPID methodology (see www.railway-procurement.org)

Output: Results of the evaluation of environmental performance

Before evaluating tenders in terms of environmental performance there must be a specific evaluation methodology that is suited to the procurement project (see also Step 1). The methodology for the evaluation should state:

- how environmental specifications will be prioritised
- how the impact on investment costs and life cycle costs (LCC) will be assessed (methodology) and
- how the result of the evaluation will influence the decision for a certain tender.

The evaluation should again be conducted with close co-ordination between the technical, environmental and purchasing departments (see chapter 7). 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 have to be agreed.

6 Environmental Specifications in invitations to tender

6.1 Requirements for Environmental Specifications

The environmental specifications that are recommended for use in invitations to tender for new rolling stock have to fulfil the requirements of:

1. functionality: no requirement for a certain design
2. measurability: specifications have to be measurable and thus quantifiable
3. verifiability: the railway operator has to be able to verify the specifications.

For each key environmental area the recommended environmental specifications are divided into:

- priority 1 specifications and
- priority 2 specifications.

It is recommended that Priority 1 Specifications be addressed in each invitation to tender if applicable for the rolling stock in question. These specifications address the most relevant aspects that determine the environmental performance of new rolling stock. Priority 2 Specifications could be used in invitations to tender; they specify an enhanced procedure in respect of the environmental performance of rolling stock or specify a certain aspect in more detail.

The order of priority of key environmental areas remains the same (noise emissions, exhaust emissions and energy efficiency will have top priority; materials, recycling and waste, and other emissions will have lower priority).

Section 6.2 gives an overview of the harmonised and prioritised environmental specifications; in ANNEX 1 the environmental specifications and application are explained in detail.

6.2 Overview of the recommended environmental specifications

The following list of recommended environmental specifications gives an overview of the environmental specifications and the priorities for use in invitations to tender. The list comprises altogether 31 environmental specifications that might be used in invitations to tender for the procurement of new rolling stock. 18 of them are priority 1 specifications.

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

No.	Priority	Environmental Specifications
		General requirements
1	1	The manufacturer ensures that at the moment of procurement the applicable legislation (national/European/international) with respect to the environment has been observed
2	2	Provision of an environmental product manual (passenger transport only)
		Energy Efficiency (top priority)
1	1	Defined value for traction unit efficiency at different load factors
2	1	Defined value for vehicle mass
3	1	Energy management/control system for comfort functions at longer standstills
4	1	Defined value for average diesel consumption referring to EN ISO 8178-4, F-cycle (test bench) or another applicable test mode specified in the invitation to tender
5	1	Calculation of on-board energy consumption by manufacturer for defined conditions
6	1	Calculation of traction energy consumption by manufacturer for specified operation pattern
7	2	Energy-metering devices
8	2	Equipment of the train with energy recovery/storage
9	2	Defined value for k-value (standstill/max. speed), specified for different areas of the vehicle
		Noise Emissions (top priority)
1	1	Limit/target value for passing-by noise (according to applicable legislation)
2	1	Limit/target value for stationary noise with all equipment running (e.g. engine, compressors, ventilators)
3	1	Limit/target value for starting noise
4	1	All noise measurements shall be carried out according to prEN ISO 3095 with defined deviations for the reference track
		Exhaust Emissions (top priority)
1	1	Limit values for NOx, CO, HC, PM emissions (according to UIC Leaflets 623-2/624 or to current EU emission legislation for diesel railcars and locomotives respectively (in preparation))
2	2	Measures to reduce the necessity of running engines at standstills
3	2	Diesel engine with the possibility to use alternative fuels (e.g. fuels with low sulphur content, natural gas and options for the use of biological fuels)
4	2	Defined emission factors for NOx, CO, HC, PM for different load conditions (at least referring to EN ISO 8178-4, F-cycle, test bench or another applicable test mode specified in the invitation to tender)
5	2	Requirements for emissions from heating equipment (according to national laws)

No.	Priority	Environmental Specifications
		Materials/Recycling/Waste
1	1	Exclusion of prohibited materials used in construction (black list)
2	1	Defined values (weights/ratios) for restricted materials used in construction (grey list)
3	1	Target value for material recycling rate after use and material that can be incinerated
4	2	Respecting construction to recycling principle
5	2	Waste concept for passenger waste (separation into different component parts)
6	2	Target value for the use of renewable materials
		Other Emissions specifications
1	1	The manufacturer verifies that emissions from brake pads are not harmful to health
2	1	Measures to prevent the shedding of oil, grease, coolant, and other substances
3	1	Electromagnetic compatibility with pacemakers has to be ensured
4	2	The ICNIRP limit values for electromagnetic field emissions have to be respected at all locations where people can be (even briefly) present
5	2	Measurements to prove compliance with the limit values for electromagnetic field emissions should be taken during operation of an accelerated train in the passenger areas near critical radiating elements at floor level up to 1.8 metres above floor level and on walls.

7 Evaluation of environmental aspects in tenders

The evaluation of environmental aspects in tenders is as important as setting certain environmental specifications in invitations to tender. It is necessary to have well defined and agreed indicators as to how to measure the environmental performance of new rolling stock.

For the case of noise emissions, e.g. from passing-by noise, the indicator dB (A) and measuring methods have been defined and they are already available today (the same is true for exhaust emissions). But for materials and recycling in particular there has been no defined methodology for applying indicators and assessing material characteristics. The EU-funded project REPID will provide such a methodology for rolling stock by:

- defining Environmental Performance Indicators (EPIs) for all rail-related environmental aspects that can be used in invitations to tender as environmental specifications (only the value has to be chosen by the railway)
- standardising material lists, which are needed to break down material-related specifications in the construction phase for the manufacturer, and
- developing an IT tool for easy application of this methodology.

If this methodology is applied throughout the entire procurement process (from the invitation to tender onwards) the railway sector will have a consistent and well-defined methodology for optimising the environmental performance of new rolling stock. The REPID methodology will be available by the end of 2003 (see also http://www.railway-procurement.org/.

In principle all environmental specifications that are required by law have to be fulfilled by the manufacturer. These specifications are critical success factors in the evaluation of tenders and should be handled with top priority. All other environmental specifications in the different tenders should be weighted according to the priorities of the railway company (as this is more appropriate than scientific Life Cycle Assessment Studies and because no internationally accepted impact assessment methodology exists).

(See also chapter 5).

Materials, Recycling and Waste

For the environmental aspect of Materials, Recycling and Waste the REPID project defined EPIs that cover (among others) the aspects of:

- forbidden materials
- restricted materials
- recycling rate, and
- renewable materials.

Throughout the entire procurement process the EPIs and methodology proposed by REPID could be used for drawing up specifications as well as for evaluating tenders.(For more information regarding the REPID project please see www.railway-procurement.org).

Noise Emissions

Noise emission values can be set for different train categories according to applicable European and, if in force, national legislation for:

- passing-by noise
- stationary noise, with all equipment running (e.g. diesel engine, compressors, ventilators)
- starting noise.

Noise measurements are taken according to PrEN ISO 3095. This European pre-standard specifies the conditions for obtaining reproducible and comparable measurement results for levels and spectra of noise emitted by all kinds of vehicles operating on rails or other types of defined track. For determination of sound level and measurement methods reference is made to this standard. If a TSI for the vehicle in question exists or if another measurement procedure is prescribed, then it should be used.

The tenderer should be responsible for the execution of the prescribed measurements by an organisation recognised by the Railway Company.

Energy Efficiency

The railways and manufacturers use a large variety of calculation methods to evaluate the energy consumption of tendered rolling stock. The difficulty is that energy consumption not only depends on the train itself but most of all on the operation pattern in service of the train. Indirect indicators for the energy consumption of a train can be such as:

- mass (mass per seat in passenger transport)
- the value for traction unit efficiency at different load factors
- k-value for defined areas of the vehicle, etc.

These required indicators can be determined very easily. The problem is that these indicators cannot be used to predict the energy consumption in operation in detail, as it would often be necessary to make a decision for or against a certain tender. To be able to evaluate tenders as regards energy efficiency the railway should require the manufacturer to calculate energy consumption for a specified route, with specified speeds and stops and a specified calculation method. The energy consumption of the rolling stock should then be calculated with a view to Life Cycle Costs (LCC) as this is one key factor in the decision on which tendered train has the best cost/benefit ratio. Other factors to take into account are the environmental image of railways and competition with other modes of transport.

This approach helps to tackle the problem for an individual case, but it makes it hard to compare energy consumption with other procured trains. A solution could be to develop:

- standard operation cycles, which should represent the most common application cases in railway operation, and
- a standardised calculation method to make calculations transparent.

A UIC feasibility study in progress until the end of 2003 will further investigate the question of whether standardised operation cycles and calculation methods are a much better solution for assessing the energy consumed in the operation of a train.

Exhaust Emissions

UIC Leaflets 623-2 and 624 prescribe values for exhaust emissions from diesel engines for CO, NOx, HC and particles. The emissions have to be measured according to EN ISO 8178 on a test bench and refer to the F-cycle. On the basis of these guidelines it is possible to compare emission values from diesel engines from different providers. It is also important to consider whether the measurement was taken by an approved organisation (e.g. ERRI).
If there is legislation at EU level on exhaust emissions in the future, these values and the prescribed method for measurement must be used.

Electromagnetic Fields

Measurements to prove compliance with the limit values should be taken during full service in an accelerated train in the passenger areas near critical radiating elements at floor level and up to 1.8 metres above floor level and on walls. At the moment there is still no international standard such as an ISO standard.

The tenderer is responsible for the execution of the prescribed measurements by an organisation recognised by the Railway Company.

ANNEX 1: Detailed description of the environmental specifications

This section explains in detail the use and application of environmental specifications in invitations to tender.

Structure of the specifications

No.	➢ Wording of the specification
Priority:	➢ Notification of the priority of the specification (priority 1: top priority; priority 2: lower priority)
Type of specification:	➢ There are four different types of specifications: 1. **Measurable specifications (environmental indicator)**: are specifications that can be measured exactly. The railway must state the performance value (e.g. the limit value for noise emissions from trains that pass by). 2. **Verification specifications**: a certain aspect has to be verified by the manufacturer (e.g. that emissions from brake pads are not harmful to health). 3. **Equipment specifications**: specification of special equipment with a certain functionality (e.g. energy management/control system for comfort functions at longer standstills). The detailed functionality has to be further specified by the railway company. 4. **Information specifications**: these specifications ask the manufacturer for more information about a certain aspect (e.g. provision of an environmental product manual).
Application:	➢ Notification of the kind of rolling stock to which this specification applies.
Explanation:	➢ Short explanation of the specification
Information exchange:	➢ Specifies the further information that the railway company has to provide to the manufacturer or vice versa.

7.1.1 General Specifications

Priority 1 specifications:

No. 1	**The manufacturer ensures that at the moment of procurement the applicable environmental legislation (national/European/international) has been observed**
Priority:	1
Type of specification:	Verification specification
Application:	All kinds of rolling stock
Explanation:	There are a large variety of environmental regulations, especially in Europe. This specification shifts the responsibility for compliance with international and national laws to the manufacturer.
Information exchange:	-

No. 2	Provision of an environmental product manual (passenger transport only)
Priority:	2
Type of specification:	Information specification
Application:	Multiple units (electric/diesel), locomotives (electric/diesel), passenger coaches
Explanation:	The operation of rolling stock can be optimised in terms of the environment. The manufacturer can provide the information needed for optimised operation in an “environmental product manual”. This manual could contain information and recommendations for e.g. energy and waste management, recycling, scrapping, use of restricted materials, etc.
Information exchange:	The railway has to specify the information provided by the environmental product manual in the invitation to tender.

7.1.2 Energy Efficiency Specifications (top priority)

Priority 1 specifications:

No. 1	Defined value for traction unit efficiency at different load factors
Priority:	1
Type of specification:	Measurable specification (environmental indicator)
Application:	Multiple units (electric/diesel), locomotives (electric/diesel)
Explanation:	The minimum performance value for the efficiency of the traction unit has to be specified by the railway to reflect the later application of the multiple unit or locomotive. It is useful to define different load factors that characterise the later operation scheme. The values have to be fixed in the contract.
Information exchange:	The railway has to define different load factors that characterise the later operation scheme to a certain degree.

No. 2	Defined value for vehicle mass
Priority:	1
Type of specification:	Measurable specification (environmental indicator)
Application:	All kinds of rolling stock
Explanation:	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 (e.g. regional transport) than in high-speed applications. The value has to be fixed in the contract.
Information exchange:	The railway has to specify the target mass of the vehicle.

No. 3	**Energy management/control system for comfort functions at longer standstills**
Priority:	1
Type of specification:	Equipment specification
Application:	Multiple units (electric/diesel), passenger coaches
Explanation:	Parked trains are usually heated overnight. This leads to a considerable amount of energy consumption in the countries of Central and Northern Europe. An automatic control system can considerably reduce the energy consumption during parking hours. The saving potential is expected to lie between 3 and 5% (with respect to the total energy consumption).
Information exchange:	The railway has to further specify the functionality of the energy management system in the invitation to tender.

No. 4	**Defined value for average diesel consumption referring to EN ISO 8178-4, F-cycle (test bench) or another applicable test mode specified in the invitation to tender**
Priority:	1
Type of specification:	Measurable specification (environmental indicator)
Application:	Multiple units (diesel), locomotives (diesel)
Explanation:	The F-cycle (test bench) is normally used to determine exhaust emissions from the engine and to determine the average diesel consumption. Nevertheless, if the expected use of the DMU or diesel locomotive is very different from what is simulated by the F-cycle another more specific test mode can be defined (e.g. ESC for diesel mechanical engines). The value has to be fixed in the contract.
Information exchange:	The manufacturer is requested to calculate the average diesel consumption according to the method specified.

No. 5	**Calculation of on-board energy consumption by manufacturer for defined conditions**
Priority:	1
Type of specification:	Measurable specification (environmental indicator)
Application:	Multiple units (electric/diesel) in passenger transport, passenger coaches
Explanation:	Energy consumption for comfort functions amounts to up to 20% of the total energy consumption in passenger transport in the countries in Central and Northern Europe. Energy consumption for comfort functions can be optimised by a set of different “intelligent” technologies. This specification will request the manufacturer to find the most efficient solution.
Information exchange:	The railway has to specify the layout parameters and outside conditions for comfort functions in the invitation to tender.

No. 6	**Calculation of traction energy consumption by manufacturer for specified operation pattern**
Priority:	1
Type of specification:	Measurable specification (environmental indicator)
Application:	Multiple units (electric/diesel), (locomotives)
Explanation:	The efficiency of the traction unit at a certain payload does not say much about the energy consumption in operation. The manufacturer should calculate the energy consumption so that the energy efficiency of the train in service can be enhanced.
Information exchange:	The railway has to specify the operation pattern of the particular train line (e.g. speeds, distance between stops, track gradients, calculation method, etc.) in the invitation to tender.

Priority 2 specifications:

No. 7	**Energy-metering devices**
Priority:	2
Type of specification:	Equipment specification
Application:	Multiple units (electric/diesel), locomotives (electric/diesel)
Explanation:	An energy meter does not minimise energy consumption by itself, but it is a very important prerequisite that provides valuable data to identify energy-saving potential for rolling stock. The energy meter could also be used for the driver to control energy consumption with respect to his driving style.
Information exchange:	The railway has to specify the detailed functionality of the energy-metering devices in the invitation to tender.

No. 8	**Equipment of the train with energy recovery/storage**
Priority:	2
Type of specification:	Equipment specification
Application:	Multiple units (electric/diesel), locomotives (electric/diesel)
Explanation:	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 easy 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.
Information exchange:	The railway has to specify the detailed functionality of the energy recovery/storage system in the invitation to tender.

No. 9	**Defined k-value (standstill/max. speed), specified for different areas of the vehicle**
Priority:	2
Type of specification:	Measurable specification (environmental indicator)
Application:	Multiple units (electric/diesel), passenger coaches
Explanation:	The k-value is a parameter for heat losses through walls, doors, windows and the ceiling of the car body. This is one of the parameters that determine the consumption of on-board energy for comfort functions in passenger vehicles. The value has to be fixed in the contract.
Information exchange:	The railway has to specify the target k-value for different areas of the vehicle and the conditions for which it will be calculated (according to UIC Leaflet 567 or other conditions).

7.1.3 Noise Emissions Specifications (top priority)

Priority 1 specifications:

No. 1	**Limit/target value for passing-by noise (according to applicable legislation)**
Priority:	1
Type of specification:	Measurable specification (environmental indicator)
Application:	All kinds of rolling stock
Explanation:	Limit values for passing-by noise are often regulated by law. In Europe the Technical Specification for Interoperability (TSI) for High Speed has defined limit values for high-speed trains and is already in force. TSIs for conventional train service are being prepared. In many European countries national noise legislation has to be respected too. It is highly recommended that passing-by noise be addressed in each invitation to tender even if there is still no regulation in force other than for high-speed trains.
Information exchange:	The railway has to require the applicable noise limit. The value has to be fixed in the contract.

No. 2	**Limit/target value for stationary noise with all equipment running (e.g. engine, compressors, ventilators)**
Priority:	1
Type of specification:	Measurable specification (environmental indicator)
Application:	Multiple units (electric/diesel), locomotives (electric/diesel), passenger coaches, freight wagons (with cooling units)
Explanation:	For high-speed services there are already limits for stationary noise with all equipment running in Europe. The TSIs for conventional train services are being prepared and will probably define limit values for stationary noise as well. In many European countries national legislation on stationary noise has to be respected too. It is highly recommended that stationary noise be addressed in each invitation to tender even if there is still no regulation in force.
Information exchange:	The railway has to specify the value in the invitation to tender. The value has to be fixed in the contract.

No. 3	**Limit/target value for starting noise**
Priority:	1
Type of specification:	Measurable specification (environmental indicator)
Application:	Multiple units (electric/diesel) and locomotives (electric/diesel)
Explanation:	The starting noise (noise emissions from accelerating from standstill) should be addressed in invitations to tender. The TSIs for conventional train services are being prepared and will probably define limit values for starting noise.
Information exchange:	The railway has to specify the value in the invitation to tender. The value has to be fixed in the contract.

No. 4	**All noise measurements shall be carried out according to prEN ISO 3095 with defined deviations for the reference track**
Priority:	1
Type of specification:	Verification specification
Application:	All kinds of rolling stock
Explanation:	prEN ISO 3095 specifies the conditions and methodology for carrying out noise emission measurements. If specified in the invitation to tender, some deviations have to be taken into account for the reference track and for measuring starting and stationary noise.
Information exchange:	-

7.1.4 Exhaust Emissions Specifications (top priority)

Priority 1 specifications:

No. 1	**Limit values for NOx, CO, HC, PM emissions (according to UIC Leaflets 623-2/624 or according to current EU emission legislation for diesel railcars and locomotives respectively (in preparation))**
Priority:	1
Type of specification:	Verification specification
Application:	Diesel multiple units and locomotives
Explanation:	It should be certified that the diesel engine respects the limit values according to UIC Leaflets 623-2/624 or according to current EU emission legislation for diesel railcars and locomotives respectively (in preparation). The limit values have to be fixed in the contract.
Information exchange:	The railway has to specify the applicable values in the invitation to tender.

Priority 2 specifications:

No. 2	**Measures to reduce the necessity of running engines at standstills**
Priority:	2
Type of specification:	Equipment specification
Application:	Diesel multiple units and locomotives
Explanation:	Diesel engines often have to run at standstills to ensure an electricity supply for comfort functions, e.g. at passenger stations. But exhaust emissions from running diesel engines often disturb passengers, so measures to reduce the necessity of running diesel engines at passenger stations should be considered, such as integration of a separate on-board energy supply or connection to an external electricity supply.
Information exchange:	If the external electricity supply is considered as a possible solution, the railway has to specify the functionality in accordance with the existing infrastructure.

No. 3	**Diesel engine with the possibility to use alternative fuels (e.g. fuels with low sulphur content, natural gas and options for the use of biological fuels)**
Priority:	2
Type of specification:	Verification specification
Application:	Diesel multiple units and locomotives
Explanation:	Presently the EU legislation (directive 98/70/EC) prescribes a reduction of the sulphur content of diesel to 50 ppm by 2005. But there is a proposal to change this directive and to require sulphur-free diesel (10 ppm sulphur) from 2005. Invitations to tender should require an engine that can run on low-sulphur or sulphur-free diesel because there are lower rates of tax on those types of diesel in some European countries. The use of natural gas could be taken into account if the technology is available for the foreseen application and is economically interesting. Use of biological fuels (e.g. rapeseed methyl ester – RME) is seen as partly critical from an environmental point of view, but for special applications, e.g. in water protection areas, it could be significant.
Information exchange:	The manufacturer should give information on the alternative additives that replace the sulphur.

No. 4	**Defined emission factors for NOx, CO, HC, PM for different load conditions (at least referring to EN ISO 8178-4, F-cycle, test bench or another applicable test mode specified in the invitation to tender)**
Priority:	2
Type of specification:	Information specification
Application:	Diesel multiple units and locomotives
Explanation:	This specification is asking the manufacturer for the exact emission factors of the diesel engine (cf. specification 1, where only compliance with the UIC values or the applicable legislation has to be verified). This information can be used to calculate emissions from the vehicle fleet of a company or for communication purposes.
Information exchange:	The manufacturer provides the exact emission factors of the diesel engine.

No. 5	**Requirements for emissions from heating equipment (according to national laws)**
Priority:	2
Type of specification:	Verification specification
Application:	Diesel multiple units and locomotives
Explanation:	In some European countries, e.g. in Germany, there are regulations on the emissions from equipment that is used to pre-heat diesel engines. These regulations are mandatory.
Information exchange:	-

7.1.5 Materials, Recycling and Waste Specifications

Priority 1 specifications:

No. 1	**Exclusion of prohibited materials used in construction (black list)**
Priority:	1
Type of specification:	Verification specification
Application:	All kinds of rolling stock
Explanation:	At international and European level there are several substances that are prohibited from use in rail vehicles, such as PCB in transformers or FCHC in air conditioners (material exclusions). The ongoing REPID project will soon provide (by the end of 2003) a standard material list with prohibited substances (exclusions) that are not allowed in rail vehicles. The excluded substances have to be fixed in the contract.
Information exchange:	In the invitation to tender the railway has to specify the materials/substances that are prohibited in the vehicle. As soon as the standard list of prohibited materials is drawn up in the REPID project the railways can require that the “prohibited substances from the REPID standard list may not be used”. The REPID standard material list will be available by the end of 2003. www.railway-procurement.org

No. 2	**Defined values (weights/ratios) for restricted materials used in construction (grey list)**
Priority:	1
Type of specification:	Measurable specification (environmental indicator)
Application:	All kinds of rolling stock
Explanation:	At international and European level many substances are restricted for use in rail vehicles. The ongoing REPID project will soon provide (by the end of 2003) a standard list with restricted materials for use in rail vehicles. The values have to be fixed in the contract.
Information exchange:	In the invitation to tender the railway has to specify the target weights/ratios of the restricted materials that may be used in construction according to the REPID standard material list. This has to be done in close co-operation with the manufacturer. The REPID standard material list will soon be available on www.railway-procurement.org

No. 3	Target value for material recycling rate after use and material that can be incinerated
Priority:	1
Type of specification:	Measurable specification (environmental indicator)
Application:	All kinds of rolling stock
Explanation:	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% - Reuse and material recycling: 80%. 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.[1] 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. A high recycling rate is believed to have a positive influence on the maintainability of rolling stock as well. The railway could define a target value for “material recycling rate after use” alone or a target value including both “material recycling rate after use” and ”material that can be incinerated”. The values have to be fixed in the contract.
Information exchange:	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 the target value for the most efficient recycling rates of the rail vehicle.

Priority 2 specifications:

No. 4	Respecting construction to recycling principle
Priority:	2
Type of specification:	Verification specification
Application:	All kinds of rolling stock
Explanation:	As construction to recycling and modular construction often serve the same aims, this construction principle could lead to vehicles with a high rate of recycling and modularity at the same time. An international standard is still not available but the guideline of the German Association of Engineers VDI 2243 (Recycling-oriented Product Development) could be made obligatory for the construction of the vehicle.
Information exchange:	-

[1] “Material recycling rate” + “material that can be incinerated” corresponds to the “recovery” value for the automotive sector from Directive 2000/53/EC.

No. 5	**Waste concept for passenger waste (separation into different component parts)**
Priority:	2
Type of specification:	Equipment specification
Application:	Multiple units and passenger coaches
Explanation:	Although the separation of passenger waste in rail vehicles is not regulated by law, several European railways have introduced an on-board waste management system with separation into several component parts to underline their green image. An on-board waste management system could be foreseen in the construction of the vehicle.
Information exchange:	The railway has to specify the detailed requirements for the on-board waste management system in the invitation to tender according to the company's waste concept for passenger trains. This includes especially the number of separate component parts and the volume of the waste boxes.

No. 6	**Target value for the use of renewable materials**
Priority:	2
Type of specification:	Measurable specification (environmental indicator)
Application:	Multiple units (electric/diesel) and passenger coaches
Explanation:	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 passenger rolling stock. But care must be taken to ensure that renewable materials meet the fire prevention requirements and that the weight of renewable materials does not counter efforts to decrease the energy consumption of the train. The relevant values have to be fixed in the contract.
Information exchange:	The railway has to specify the target weight/ratio of the renewable materials in the vehicle in the invitation to tender.

7.1.6 Other Emissions specifications

Priority 1 specifications:

No. 1	**The manufacturer verifies that emissions from brake pads are not harmful to health**
Priority:	1
Type of specification:	Verification specification
Application:	All kinds of rolling stock
Explanation:	-
Information exchange:	-

No. 2	**Measures to prevent the shedding of oil, grease, coolant, and other substances**
Priority:	1
Type of specification:	Verification specification
Application:	Multiple units (electric/diesel), locomotives (electric/diesel), passenger coaches
Explanation:	The manufacturer has to document the measures that prevent the shedding of oil, grease, coolant and other substances.
Information exchange:	-

No. 3	**Electromagnetic compatibility with pacemakers has to be ensured**
Priority:	1
Type of specification:	Verification specification
Application:	Multiple units (electric/diesel) and passenger coaches
Explanation:	Certain spectra of electromagnetic fields can affect the operation of pacemakers. Compatibility with pacemakers has to be ensured by the manufacturer. There is still no international standard but compatibility could be required with the national standard DIN VDE 0848-3-1.
Information exchange:	The railway has to specify how compatibility is to be verified by the manufacturer (see also specification no. 5 below).

Priority 2 specifications:

No. 4	**The ICNIRP limit values for electromagnetic fields have to be respected at all locations where people can be (even briefly) present**
Priority:	2
Type of specification:	Measurable specification (environmental indicator)
Application:	Multiple units (electric/diesel) and passenger coaches
Explanation:	It is suspected that electromagnetic fields in vehicles have an effect on people's health. ICNIRP limit values cover these effects. The values have to be fixed in the contract.
Information exchange:	The railway has to set down the ICNIRP limit values as requirements in the invitation to tender.

No. 5	**Measurements to prove compliance with the limit values for electromagnetic field emissions should be taken during operation of an accelerated train in the passenger areas near critical radiating elements at floor level and up to 1.8 metres above floor level and on walls.**
Priority:	2
Type of specification:	Verification specification
Application:	Multiple units (electric/diesel), passenger coaches
Explanation:	Measurements are needed to verify compatibility with pacemakers (specification no. 3) and the ICNIRP limit values (specification no. 4).
Information exchange:	In the invitation to tender the railway has to specify the exact conditions in which the measurements to verify compliance with the limit values have to be carried out.

ANNEX 2: Background Information on Energy Efficiency

Introduction

Over the last two decades the public has become increasingly interested in the energy consumption of transport, which is responsible for approximately 25% of the world's carbon dioxide emissions (which cause climate change). With the Kyoto Protocol on climate protection the world has agreed to reduce emissions of carbon dioxide. Since then many railways as well as companies from the automotive sector have adopted energy efficiency programmes and carried out projects to reduce the energy consumption of their products and thus reduce the emission of carbon dioxide.

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 over aviation and individual road traffic. This is also a fact that is well known by the public and contributes greatly to the environmentally friendly image of railways.

To hold and further enhance this advantage over our competitors would serve two strategic aims at the same time for railways:

1. Cost efficiency and
2. Energy efficiency.

Reducing energy consumption would contribute to ensuring the competitiveness of railways for the future because energy costs make up a considerable portion of life cycle costs, as is shown in the table below.

Table 2: LCC for rail vehicles

	Locomotive for passenger service*	**Locomotive for freight service***	**High-speed train (ICE 3)****
Investment	22.7%	11.7%	80.8%
Energy	46.2%	73.8%	7.8%
Maintenance	31.0%	14.4%	11.4%

Source: IZT 2003 according to * Trümpi 1998 and ** Ernst 2001

The potential to reduce the energy consumption of railway transport is still large and applies for both rolling stock and train operation. However, this section will cover only aspects at a vehicle level and how the vehicle can be prepared for energy-efficient operation because the scope of the environmental guideline is the procurement of new rolling stock.

Energy consumption of rolling stock

The following section briefly describes the determining factors for energy consumption in railway operation and the strategies for reducing that consumption. Most of the information was extracted from the Final Report of the UIC Project EVENT (Nolte, Würtenberger; 2003).

The energy consumption of rolling stock is determined by the following:

- **Train motion**
  (Overcoming running resistance and inertia as well as grade resistance)
- **Losses in traction equipment**
  (Heat losses from the engine and auxiliaries)
- **Passenger comfort**
  (Air-conditioning, lighting, etc. in passenger transport)
- **(Supply line losses)**
  (Not considered, see above)

Strategies to reduce the energy consumption of rolling stock apply to train motion, losses in traction equipment and passenger comfort. 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 energy consumption. This means that strategies to reduce the energy consumption of rolling stock will only be successful if a system approach is applied that will optimise the whole energy system of the rolling stock. Nevertheless, energy efficiency strategies can be applied for the following aspects:

Mass reduction/reduction of mass per seat

The mass of rolling stock is a decisive indicator for energy consumption in operation. The indicator is more relevant for local and regional transport applications than for high speed. Although lightweight construction is limited particularly by side-wind effects in high--speed service, a lot of work is being done to reduce the mass of new rolling stock, e.g. with new lightweight composite materials. For passenger transport the relevant indicator is mass per seat.

The train concept

The aim of the train concept is to find the most efficient rolling stock for later application in passenger transport. With the train concept two parameters will be determined that are important from the energy perspective – use of space (seats per m²) and flexibility.
A high ratio of seats per m² means low energy consumption per passenger km. This could be achieved by using double-decker vehicles or wide-body vehicles, for example.
High flexibility to react to variable passenger volumes could be attained by such as flexible train sets that are split up at a certain point on the route.

Reducing air resistance and friction

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 energy consumption. Friction could be reduced by reducing curve resistance, e.g. by wheel lubrication.
Air resistance is very important for energy consumption, especially in high-speed and inter-city applications. For example, raising the top speed from 280 km/h to 350 km/h would increase energy costs by about 60%.

Reducing conversion losses (increasing traction efficiency)

As regards conversion losses there is a difference between electric and diesel traction:

- Conversion losses in electric traction derive especially from transformers, inverters and auxiliaries. Gears play a minor role for conversion losses. Efficiency-increasing strategies are directly connected to technological developments like HTSC transformers that would increase efficiency dramatically. But as these technologies will often only be available in the medium term at an economically interesting price, today's strategies to increase efficiency could concentrate on optimising the traction software in terms of energy consumption.
- 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 technology. But the trade-off between efficiency of the combustion engine and diesel exhaust emissions has to be taken into account.
  From the energy consumption perspective the transmission plays an important role. The mechanical power produced by the engine can be transmitted in different ways. Three types of transmission are in general use for rail applications:
  - electric transmission
  - hydro-mechanical transmission (hydraulic transmission)
  - mechanical transmission.

  For most heavy-haul applications diesel-electric locomotives are used. If they are combined with an energy-storage unit, energy efficiency can be increased substantially (see "regenerative braking"). From an energy efficiency point of view electric and mechanical transmission have advantages compared to hydraulic transmission. Modern diesel-mechanical multiple units are very energy-efficient and can be used in a wide range of applications.

Regenerative braking and energy storage

Energy recovery with dynamic brakes 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.

Diesel-electric vehicles can also easily be equipped to use recovered energy for comfort functions in passenger transport.

Energy storage systems, such as the flywheel, are still not in standard application but could be considered as well in the future.

Reducing energy consumption for comfort functions

Energy consumption for comfort functions accounts for up to 20% of the total energy consumption in passenger transport in countries in Central and Northern Europe. About 80% of the energy consumption for comfort functions is used for air conditioning (heating in winter/cooling in summer). Energy consumption for comfort functions can be optimised by:

- demand-controlled regulation of the intake of fresh air (e.g. by CO_2-sensors)
- coach insulation
- smart windows, etc.

Another very important aspect of the energy efficiency of comfort functions is the energy consumption in longer standstills. Parked trains are usually heated overnight, which leads to considerable amounts of energy consumption in the countries of Central and Northern Europe. In some cases the energy demand can account for about 10% of the total energy consumption of a train. An automatic control system can considerably reduce the energy consumption during parking hours. The saving potential is expected to lie between 3 and 5% (of the total energy consumption).

There are many technological options for optimising energy consumption for comfort functions. These options should be considered in a system approach.

Measurement and documentation of energy consumption

An energy meter does not minimise energy consumption by itself, but it is a very important prerequisite to obtain valuable data that identifies potential savings for rolling stock and for the driver to control energy consumption by adapting his driving style.

Energy-efficient driving

Apart from energy-efficient timetabling and increased traffic fluidity at rolling stock level, a driving advice system for permanent information to the driver can be considered. Pilot projects have been carried out at some railway companies, such as NS Reizigers and Deutsche Bahn, and these projects have shown potential for savings of over 5% of the total energy use, but these projects are still not in general application.

(For more information about the most promising energy-efficiency technologies and evaluation of technologies that can be applied to rolling stock as well as for train operation please see www.railway-energy.org).

Energy Efficiency specifications in invitations to tender

When procuring new rolling stock the railways should investigate how the above-mentioned aspects can be addressed in the invitation to tender to reduce the energy consumption during operation in the most efficient way. Priorities and potentials are on the one hand dependent on parameter conditions like infrastructure, voltage and frequency of the energy supply, etc. and on the other hand also on other decisive factors like the RAMS criteria (Reliability, Availability, Maintainability and Safety) and economic aspects.

Apart from the large variety of possible ways to optimise the energy consumption of trains in the design phase of rolling stock, it is of substantial use for the railway to consider the following general aspects in the procurement process:

1. Energy-efficiency specifications should be implemented as standard specifications in invitations to tender.
2. Energy specifications that are requirements in the invitation to tender have to be functional and measurable to allow the manufacturer the freedom to find the optimised, most efficient design solution.
3. From the information given in the tender by the manufacturer the railway should be able to predict the energy consumption in later operation to make a qualified decision in favour of a certain tender.
4. Energy consumption should be integrated into the railway's model of life cycle costs as one decisive factor for a specific design solution, but other decisive factors like competitive advantage over other modes of transport and maintaining and enhancing the green image of railways should be taken into account as well.
5. The precise energy-efficiency specifications have to be fixed in the contract with the manufacturer.

From the above-mentioned energy-reduction strategies and the recommended general aspects the following energy-efficiency specifications for use in invitations to tender have been derived[2]:

Priority 1 Specifications

1. Defined value for traction unit efficiency at different load factors
2. Defined value for vehicle mass
3. Energy management/control system for comfort functions in longer standstills
4. Defined value for average diesel consumption referring to EN ISO 8178-4, F-cycle (test bench) or another applicable test mode specified in the invitation to tender
5. Calculation of on-board energy consumption by manufacturer for defined conditions
6. Calculation of traction energy consumption by manufacturer for specified operation pattern

[2] For details of the specifications see Annex 1.

Priority 2 Specifications

7. Energy-metering devices
8. Equipment of the train with energy recovery/storage
9. Defined k-value (standstill/max. speed), specified for different areas of the vehicle

Outlook

Apart from noise emissions, energy efficiency is one of the most challenging environmental aspects for railways in the future. As energy efficiency can significantly contribute to decreasing operational costs this aspect should be thoroughly taken into account in the procurement process.
The nine proposed specifications will help to further enhance the energy efficiency of new rolling stock. A feasibility study carried out by the UIC in late 2003 will investigate whether it will be possible in the future to cover the whole issue with only a few complete functional specifications, as is possible for noise emissions. That feasibility study will investigate the use of a set of standard driving cycles and a standard calculation method to predict the energy consumption of trains in operation in a way that is comparable to that used in energy consumption standards in the automotive sector.

References

- Nolte, Dr. R., Würtenberger, F.; 2003: EVENT – Evaluation of Energy Efficiency Technologies for Rolling Stock and Train Operation of Railways (Final Report of the project); 2003.
- UIC, UITP, UNIFE, CER 2002: Ticket to Sustainable Transport - Rio to Johannesburg and Beyond, brochure
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ANNEX 3: Background Information on Noise Emissions

Introduction

In the last ten years there has been increasing pressure from residents, environmental lobbyists and legislators to reduce railway noise levels. In Switzerland, Austria and Italy (amongst other countries) legislation has been introduced that sets tight limits on the amount of noise that railways are allowed to create (and inherently on the traffic levels that they can achieve).

The EU's Environment Commission has set up a number of Working Groups to determine the EU's future policy on potential noise legislation. The legal framework for the adoption of noise limit values for conventional trains will be provided by the Directive 2001/16/EC on conventional interoperability. The Directive requires the development of Technical Standards on Interoperability (TSI), including prescriptions related to noise creation. For high-speed trains those TSIs have already been developed on the basis of Directive 1996/48/EC. The first priority now is the development of TSIs for freight wagons.

Measures to reduce noise and vibrations

The emission of noise from railway operation affects the travellers, the railway personnel and the environment, for instance nearby residents.
The main types of railway noise are traction noise, rolling noise and aerodynamic noise. Control of these sources of noise can be applied in new designs or redesigns (retrofits) and has to be safeguarded by maintenance of vehicles and tracks. In the Environmental Guideline we concentrate on specifications for vehicles.

External noise

Measures to reduce airborne or direct noise should be studied and incorporated into rolling stock as early as possible. These measures should preferably focus on the noise sources themselves or nearby components. The primary noise sources are the wheel-rail contact, the brakes and the engines, electric motors, gears, cooling fans and aerodynamics.

Reducing rolling noise

The wheel-rail contact (also called rolling noise) can be divided into noise emitted by the wheel, and noise emitted by the rail. The interaction of roughness of railhead and roughness of the rolling surface of the wheels is essentially the cause of rolling noise. Smooth wheels on smooth rails guarantees low rolling noise. The measures that prevent roughness growth are the first priority for any mitigation at source. The dominant influence for the roughness of the wheel is the braking system, e.g. cast-iron brake blocks cause high roughness of wheels.

Possible mitigation measures are:

- smaller wheels
- wheel-mounted disc brakes
- the vehicle body hangs as low as possible over the wheels whilst still respecting the specified gauge. At wheel level the inside and outside of the body is fitted with acoustic absorbent material.

Reducing traction noise: noise caused by the engines, electric motors, cooling fans

Possible mitigation measures are:

- Acoustic dampeners on the fans on the pulse and extract side;
- During train standstill it must be possible to reduce the fan power to what is needed for cooling.

Especially for diesel traction:

- appropriate exhaust and intake design
- effective engine enclosure and vibration isolation
- selection of quieter components for such as the turbocharger, compressors and fans.

Especially for electric traction:

- elimination or smoothing of obstacles in ducts, intake and outlet
- quieter fan design
- increase in fan efficiency by selecting the best working point.

Reducing aerodynamic noise (only relevant when max. speed > 250 km/h)

Possible measures:

- Elimination of all surface discontinuities/edges on the vehicle body
- Streamlined front of the vehicle
- Streamlining and covering of the pantograph and its recess area
- Streamlined covers for the bogies.

Internal noise

The noise inside the vehicle is mainly an occupational health factor and is specified already in some UIC Leaflets for the driver's cab:

- 660: for high speed, replaced by TSI for high speed
- 642: for conventional speeds, will be adapted by the TSI for conventional traffic.

Vibrations

Vibrations in the ground are the result of an interaction of forces between rolling stock and track, which is difficult to quantify in rolling stock requirements.
However, the level of vibrations depends on the mass of the train and its speed. Less weight, axle load and inelastic mass (wheels, axles, etc.) reduce vibrations in the environment.

Specifications for noise level values for different train categories in invitations to tender

Noise level values in general

European and, if applicable, national noise level values are to be respected.
At national level, noise limits for new rail-bound vehicles are in force in Austria, Finland, Italy and Switzerland; the German Environmental Agency (UBA) has developed proposed limits for possible German legislation that include vehicles that are currently in use.
At European level, noise limits have been set for high-speed trains (TSI for rolling stock); as regards conventional rolling stock, proposals have been formulated by the UIC ("Noise creation limits for railways – main report, 08/2002") and by the AEIF, Noise Experts Group (Scope: Noise; Aspect: Noise Emitted by Freight Wagons, Locomotives, Multiple Units and Coaches; RST-221-nF, 222-n – version of 28.04.2003).

Noise emission values can be set for different train categories according to applicable legislation:

- passing-by noise
- stationary noise, with all equipment running (e.g. diesel engine, compressors, ventilators)
- starting noise.

	Passing-by noise	Stationary noise	Starting noise
High-speed train, Vmax=320	x	x	x
High-speed train, Vmax=300	x	x	x
High-speed train, Vmax=250	x	x	x
Diesel locomotives	x	x	x
Electric locomotives	x	x	x
EMUs	x	x	x
DMUs	x	x	x
Passenger coaches	x	x	-
Freight wagons	x	x	-

Note:
x = applicable; - = not applicable

Values for high-speed trains

The standards in section 4.1.8 of the final version of the TSI for high-speed rolling stock must be followed as regards both stationary noise and noise in high-speed service:

- Noise levels in stations or on stabling tracks shall not exceed 65 dB(A) measured continuously or 70 dB(A) intermittently
- Noise levels generated by a trainset in service shall not exceed a value of 87 dB(A) at a speed of 250 km/h, 91 dB(A) at a speed of 300 km/h and 92 dB(A) at a speed of 320 km/h (linear interpolation for other maximum speeds).

It is permissible for section 4.1.8 of this TSI to be applied with the limit values referred to in the table below for a transitional period of 24 months starting from 09/2002, in the case of:

- options to purchase additional vehicles in contracts already signed at the date of entry into force of the above-mentioned TSI or
- rolling stock being contracted during the transitional period based on existing design platforms.

V (km/h)	Noise level (TEL, dB(A))
250	90
300	93
320	94

Rolling stock already in use and that requires new authorisation to be placed into service or that is already contracted for at the date of entry into force of the above-mentioned TSI shall be allowed to run with the maximum above-mentioned limit values.

AEIF PROPOSAL for noise creation limits for conventional rolling stock (draft version from 04/ 2003)[3]

Noise emitted by freight wagons

Limits for Passing-by Noise

The indicator for passing-by noise is the A-weighted equivalent continuous sound pressure level $L_{pAeq,Tp}$ measured over the passing-by time at a distance of 7.5 m from the centreline of the track, 1.2 ± 0.2 m above the top of the rail. The measurements shall be taken in accordance with prEN ISO 3095:2001 with defined deviations as specified in the call for tenders.

The limiting values $L_{pAeq,Tp}$ for the passing-by noise of freight wagons under these above-mentioned conditions are given in table 3.

[3] Please note that all noise emission values stated in this document are subject of an ongoing revision process. These limit values may only be used for information purposes.

Table 3: Limiting values $L_{pAeq,Tp}$ for the passing-by noise of freight wagons

Wagons	**$L_{pAeq,Tp}$**
Wagons with an average number of axles per length (apl) up to 0.22 m^{-1} at 80 km/h	< = 83 dB(A)
Wagons with an average number of axles per length (apl) greater than 0.22 m^{-1} at 80 km/h	< = 85 dB(A)

Note: “Apl” is the number of axles divided by the length over buffers.

The passing-by noise of a train shall be measured at 80 km/h and at maximum speed, but no higher than 200 km/h. The value to be compared with the limits (see table 5) is the greater of the measured value at 80 km/h and the measured value at maximum speed but referred to 80 km/h by the following equation:

$$L_{pAeq,Tp}(80\ km/h) = L_{pAeq,Tp}(v)-30*\log\ (v/80\ km/h).$$

Limits for Stationary Noise

The sound pressure of stationary noise has to be described by the A-weighted equivalent continuous sound pressure level $L_{pAeq,T}$, according to prEN ISO 3095:2001, section 7.5. The limiting values $L_{pAeq,T}$ for the stationary noise of freight wagons at a distance of 7.5 m from the centreline of the track are given in table 4.

Table 4: Limiting values $L_{pAeq,T}$ for the stationary noise of freight wagons

Wagons	$L_{pAeq,T}$
All freight wagons	< = 65 dB(A)

The sound pressure level of the stationary noise is the energetic mean of all values measured at the measuring points according to prEN ISO 3095:2001.

Noise emitted by locomotives, multiple units and coaches

Limits for Stationary Noise

The limits for stationary noise are defined at a distance of 7.5 m from the centreline of the track, 1.2 m and 3.5 m above the upper surface of the rails. The measuring conditions are defined by the standard pr EN ISO 3095:2001 with defined deviations. The indicator for the sound pressure level is $L_{pAeq,T}$. The limiting values for the noise emission of the vehicles under these above-mentioned conditions are given in table 5.

Table 5: Limiting values $L_{pAeq,T}$ for the stationary noise of electric locomotives, diesel locomotives, EMUs, DMUs and passenger coaches

Vehicles	**$L_{pAeq,T}$**
Electric locomotives	75
Diesel locomotives	75
EMUs	68
DMUs	73
Passenger coaches	65

Limits for Starting Noise

The limits for starting noise are defined at a distance of 7.5 m from the centreline of the track, 1.2 m and 3.5 m above the upper surface of the rails. The measuring conditions are defined by the standard pr EN ISO 3095:2001 with defined deviations. The indicator for the sound pressure level is L_{pAFmax}. The limiting values for the starting noise of the vehicles under these above-mentioned conditions are given in table 6.

Table 6: Limiting values L_{pAFmax} for the starting noise of electric locomotives, diesel locomotives, EMUs and DMUs

Vehicle	L_{pAFmax}
Electric locomotives	82
Diesel locomotives	86
EMUs	82
DMUs	83

Limits for Passing-by Noise

The limits for passing-by noise are defined at a distance of 7.5 m from the centreline of the reference track, 1.2 m or 3.5 m above the upper surface of the rails, for a vehicle speed of 80 km/h. The indicator for the sound pressure level is $L_{pAeq,Tp}$.

The measurements shall be taken in accordance with prEN ISO 3095:2001 with defined deviations for the reference track.

The passing-by noise of a train shall be measured at 80 km/h and at maximum speed, but no higher than 200 km/h. The value to be compared with the limits (see table 7) is the greater of the measured value at 80 km/h and the measured value at maximum speed but referred to 80 km/h by the following equation:

$L_{pAeq,Tp}(80\ km/h) = L_{pAeq,Tp}(v)-30*\log (v/80\ km/h)$.

The limiting values for the noise emission of electric locomotives, diesel locomotives, EMUs, DMUs and passenger coaches under these above-mentioned conditions are given in table 7.

Table 7: Limiting values $L_{pAeq,Tp}$ for the passing-by noise of electric locomotives, diesel locomotives, EMUs, DMUs and passenger coaches

Vehicle	$L_{pAeq,Tp}$ @ 7.5 m
Electric locomotives	85
Diesel locomotives	85
EMUs	81
DMUs	82
Passenger coaches	80

From the above-mentioned information the following noise emission specifications should be addressed in invitations to tender.

Priority 1 Specifications

1. Limit/target value for passing-by noise (according to applicable legislation)
2. Limit/target value for stationary noise with all equipment running (e.g. engine, compressors, ventilators)
3. Limit/target value for starting noise
4. All noise measurements shall be carried out according to prEN ISO 3095

References

- Position Paper on “The European strategies and priorities of railway noise abatement" by the WG Railway Noise of the European Commission (04-10-2002)
- Noise Creation Limits for Railways - Main Report by the UIC, Sub-Commission Noise and Vibrations (27-08-2002)
- Noise Creation Limits for Railways - Background information by the UIC, Sub-Commission Noise and Vibrations (01-10-2002)
- Directive 2001/16/EC of the European Parliament and of the Council of 19 March 2001 on the interoperability of the trans-European conventional rail system
- Commission Decision of 30 May 2002 concerning the Technical Specification for Interoperability relating to the rolling stock subsystem of the trans-European high-speed rail system referred to in Article 6(1) of Directive 96/48/EC (TSI)
- prEN 3095, Railway applications - Acoustics - Measurement of noise emitted by rail-bound vehicles, publication date: 2001-01
- TSI; Subsystem: Conventional Rail Rolling Stock; Scope: Noise; Aspect: Noise Emitted by Freight Wagons, Locomotives, Multiple Units and Coaches; RST-221-nF, 222-n by the AEIF, Noise Expert Group (28.04.2003)

ANNEX 4: Background Information on Exhaust Emissions

Introduction

Legislation

At the moment, there are no statutory emission limits for combustion engines in rolling stock in the EU. The German law on emission control stipulates that avoidable emissions must be prevented and unavoidable emissions must be reduced to a minimum during the operation of rolling stock. The German government is authorised to define emission limits, which has not happened yet. But the EU legislation to keep the air clean and to reduce emissions will develop quickly in the future, and the emission limits for rolling stock will be defined. At the moment it is not clear into which directive the limits will be integrated. Possibilities are directive 97/68/EC on “Measures against the emission of gaseous and particulate pollutants from internal combustion engines to be installed in non-road mobile machinery” or directive 2001/16/EC on the “Interoperability of the trans-European conventional rail system (TSI)”, or a mixture of both depending on the power or the application of the railway engine. The legislation process is still underway.

There are several proposals for the values – one proposal is to take the values from UIC Leaflets 623-2/624. It is not clear at the moment whether the EU will accept test cycle F from EN ISO 8178 for every kind of railway engine. The limit values will apply to new rolling stock, but it is also possible that there will be special regulations for existing vehicles.

In spite of all these uncertainties concerning the future statutory limit values it is clear that there will be limit values in the future, and the railways should be prepared for them.

Environmental competitive advantage of railways

But there are still more reasons why railways should consider emissions from combustion engines when buying new rolling stock. The technology that reduces exhaust emissions from cars and heavy vehicles is developing very quickly and the emission legislation for that sector is very strict, so railway operators must pay attention to keeping their relatively low impact on air pollution and to not losing their competitive advantages in this field. The reputation of an environmentally friendly mode of transport is still one reason why some customers prefer the railways to other modes of transport. Some railways have set targets to reduce emissions.

Emissions from diesel engines – especially the particle emissions - are one environmental aspect of rolling stock that is easily visible for the public. Emissions are often the subject of complaints from people who live near railway tracks or from passengers in railway stations.

Special reasons

In some countries with a large number of tunnels diesel emissions from special applications could also contribute to employees’ occupational health problems.

Emissions from diesel combustion engines

To guarantee that the railways will be able to calculate the emissions from their rolling stock and to advertise the advantages, the emission factors from the procured engines for special load conditions (at least the ISO F-cycle) should be mentioned in the tender.

UIC Leaflets

When the EU has set limit values for combustion engines in rolling stock they naturally have to be incorporated in specifications. By that time compliance with the limit values from UIC Leaflets 623-2 or 624 should be required. These limit values can be seen as a minimum standard for limit values in invitations to tender. The following table gives an overview of the values from the UIC Leaflets and some possible future values ("visions") that were put forward by a UIC ad-hoc group and will be reviewed for some years before they come into force.

Table 8: UIC Leaflets 623-2 "Approval tests for diesel engines of motive power units" and 624 "Exhaust emission tests for diesel traction engines" and visions from the UIC ad-hoc group

Engine power	**CO** in g/kWh	**HC** in g/kWh	**NOx** in g/kWh	**Opacity** Bosch	**PM** in g/kWh	
Engines for multiple units and smaller locomotives						
< 560 kW	3	0.8	12	1.6 – 2.5		Until 31.12.2002
< 560 kW	2.5	0.6	6		0.25	01.01.2003
< 560 kW	2	0.5	4.5		0.15	01.01.2008 vision
Engines for main-line locomotives						
> 560 kW	3	0.8	12	1.6 – 2.5		Until 31.12.2002
> 560 kW	3	0.8	9.5 (9.9)[1)]		0.25 [2)]	01.01.2003
> 560 kW	2	0.5	6		0.20	01.01.2008 vision

[1)] 9.5 g/kWh for > 1000 revolutions per minute, 9.9 g/kWh for < 1000 revolutions per minute

[2)] For engines with a nominal load > 2200 kW/h, particle emissions higher than 0.5 g/kWh will be accepted as an exception, but compliance with the limit value of 0.25 g/kWh is recommended. From 01.01.2005 the limit value of 0.25 g/kWh will be obligatory for all engines.

This is a very good basis for drawing up requirements for diesel emissions because the values were put forward by a group of specialists from railways and industry. A particular challenge for the future will be to respect the limit values for particles and at the same time reduce the NOx emissions.

Other values

In some cases it might be worthwhile to require diesel engines < 560 kW that meet the requirements of 99/96/EC (EURO values). This could be part of an environmental strategy of a railway. These values refer to a test cycle for road vehicles (EN ISO 8178, A–cycle or ESC–cycle) that is normally not considered to represent the driving pattern of railways. Nevertheless, investigations in Denmark showed that the driving pattern of diesel-mechanical rail vehicles in Denmark especially is similar to the A-cycle and the ESC-cycle (EURO III) and that the F-cycle, which is normally used for railway applications, does not fit the Danish operation pattern very well.

It can also be necessary to require especially low emission values. This could be the case if the vehicle is procured for a particular application or if there are special requirements concerning emissions in the call for tenders for the regional transportation where the vehicle will be used. Consideration should also be given to the possibility of procuring rolling stock with combustion engines for natural gas.

At the moment there are almost no applicable systems on the market for reducing the exhaust emissions from rolling stock (catalytic converter to reduce NOx, HC, CO emissions or particle filter). Hopefully there will be improvements in the future. So the market should be watched closely.

Special equipment for sensitive areas

Sometimes there is a clash between reducing emissions and operating rolling stock economically. Adjusting an engine to obtain a low level of NOx emissions can significantly increase fuel consumption. To combine both an economic operating method for uninhabited, non-sensitive areas and environmentally friendly operation (e.g. for sensitive built-up areas), trains could be equipped for both modes of operation.

A special problem in stations is that diesel engines in rolling stock must be running even though the train is at a standstill because the engine provides the energy for auxiliary equipment (e.g. electricity for the lights or the doors) or to keep the engine warm. To avoid the necessity of running engines before or after operation there should be a requirement for an electrical connection to the external power supply system or for separate heating equipment to preheat the engine and to keep it ready for use when the train is at a standstill.

Fuels for combustion engines

To keep operating costs low, the average fuel consumption of the vehicle must be stated and guaranteed in the tender with reference to specific load conditions. Here it makes sense to specify the ISO F-cycle on a test bench or another applicable test mode in the invitation to tender.

The vehicle should also be equipped with a fuel measurement system, like electrical vehicles should be equipped with energy meters.

Sulphur content

The EU legislation (directive 98/70/EC) currently prescribes a reduction in the sulphur content of diesel to 50 ppm by the year 2005. But there is a proposal to change this directive and to make sulphur-free diesel (10 ppm sulphur) available starting from 2005. In Germany higher taxes were introduced in 2003 on diesel with a greater sulphur content than 10 ppm.

As a consequence the market will offer only diesel fuels with this low level of sulphur content. The railways should be able to use the diesel fuel that is normally offered on the market. So the procured diesel engines should be able to combust sulphur-free diesel (10 ppm).

Biological fuels

One subject that is constantly brought up in public discussion is the use of biological fuels (e.g. rapeseed methyl ester – RME, plant oils). They have the advantage of being a renewable energy source. But it has to be stressed that "biological fuels" do not automatically lead to reduced emissions. Even environmental agencies have a critical opinion of the use of biological fuels. Even though biological fuels will not be able to replace diesel fuels completely, they might make sense in special applications (e.g. in water protection areas).

Biological fuels can require the use of special materials in the tank or the engine, so the manufacturer must give detailed information in the procurement process about conditions and the necessary technical changes to use biological fuels. Afterwards it can be difficult to get the desired information or guarantees.

There is a draft EU directive that prescribes the addition of biological fuels to diesel from 2009. This might be interesting if emission trading becomes relevant in traffic.

Other fuels

The development of new fuels (e.g. diesel-water emulsions) should be watched closely in the future.
The use of natural gas could be taken into account if the technology is available for the foreseen application and is economically interesting at the same time.

Heating equipment on rolling stock

However, it is not only the diesel engines in rolling stock that can cause emissions. Some locomotives require a heating system to warm the engine. These heating systems also cause emissions. In Germany there is strict legislation for stationary heaters (e.g. in houses), but there is no legislation for heating systems in rolling stock. This is why in 2001 the German railway administration agency, the environmental agencies and experts from industry and German Railways drew up a guideline that defines the requirements for heating equipment in rolling stock (including as regards emissions). There should be a check to determine whether something similar exists in the country where the procurement takes place.

Other emissions

Materials for brake pads must be chosen such that the dust generated during the braking process does not cause any health problems.

Shedding of oil and grease especially from older multiple units and locomotives is a problem in some European countries for infrastructure operators at train parking places for reasons of water protection. Shedding of oil and grease is no longer a problem for new rolling stock, but

measures to prevent the shedding of oil and grease should be requirements in the invitation to tender.

Exhaust emission specifications in invitations to tender

From the issues mentioned above the following exhaust emission specifications have been derived for use in invitations to tender[4]:

Priority 1 Specifications

1. Limit values for NOx, CO, HC, PM emissions (according to UIC Leaflets 623-2/624 or according to current EU emission legislation for diesel railcars and locomotives respectively (in preparation))

Priority 2 Specifications

2. Measures to reduce the necessity of running engines at standstills
3. Diesel engine with the possibility to use alternative fuels (e.g. fuels with low sulphur content, natural gas and options for the use of biological fuels)
4. Defined emission factors for NOx, CO, HC, and PM for different load conditions (at least referring to EN ISO 8178-4, F-cycle, test bench or another applicable test mode specified in the invitation to tender)
5. Requirements for emissions from heating equipment (according to national laws)

References

- EN ISO 8178: Reciprocating internal combustion engines - Exhaust emission measurement, Publication date: 1996-08
- UIC Leaflet 623-2: “Approval tests for diesel engines of motive power units”, June 1997
- UIC Leaflet 624: “Exhaust emission tests for diesel traction engines”, April 2002
- 2001/16/EC Directive of the European Parliament and of the Council of 19 March 2001 on the interoperability of the trans-European conventional rail system
- 99/96/EC Directive of the European Parliament and of the Council of 13 December 1999 on the approximation of the laws of the Member States relating to measures to be taken against the emission of gaseous and particulate pollutants from compression ignition engines for use in vehicles, and the emission of gaseous pollutants from positive ignition engines fuelled with natural gas or liquefied petroleum gas for use in vehicles and amending Council Directive 88/77/EEC
- 98/70/EC Directive of the European Parliament and of the Council of 13 October 1998 relating to the quality of petrol and diesel fuels and amending Council Directive 93/12/EEC
- 97/68/EC Directive of the European Parliament and of the Council of 16 December 1997 on the approximation of the laws of the Member States relating to measures against the emission of gaseous and particulate pollutants from internal combustion engines to be installed in non-road mobile machinery

[4] For details of the specifications see Annex 1.

ANNEX 5: Background Information on Materials/Recycling/Waste

Introduction

The environmental aspect of Materials/Recycling and Waste has gained increased public and political interest over the last decade. 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 have appeared on the agenda. The EU has focussed especially on the end-of-life treatment of vehicles.

In 2000 the European Commission adopted the Directive 2000/53/EC on “end-of-life vehicles” for the automotive sector. The directive covers cars and light trucks and regulates especially:

- the recycling rate of vehicles and end-of-life vehicles and
- the use of forbidden material, such as lead, mercury and cadmium.

Railway vehicles are not covered by Directive 2000/53/EC, but a good recycling rate can also have a positive influence on the modularity of rail vehicles so it could decrease maintenance and end-of-life costs (see also chapter 4).

Apart from the recycling aspect, the use of forbidden and restricted materials in rail vehicles is implicitly regulated by obligatory international and national regulations.

Materials/Recycling/Waste Aspects of Rolling Stock

Materials

Forbidden materials

At international level and at European level there are several substances that are forbidden for use in rail applications because they are harmful to health and the environment, e.g. PCB in transformers and FCHC in air-conditioning systems. The manufacturer is not allowed to use these forbidden materials in the vehicle, but as there are special regulations for certain substances at national level it is important for the railway to get the information about these forbidden materials and to explicitly state in the invitation to tender that these materials must not be used. Moreover the railway could define certain materials in the invitation to tender that should not be used in the vehicle according to the environmental strategy of the railway although these substances are not forbidden by law.

The ongoing EU-funded REPID project will draw up a standard list of forbidden materials for rail applications by the end of 2003, which can then be used by both railways and manufacturers as an agreed list of forbidden materials for the Rail Sector (for further information on this topic see also www.railway-procurement.org).

Restricted materials

Restricted materials are materials that are subject to certain restrictions as regards use and application. At European level there are a lot of Directives that regulate the application of restricted materials. The environmental impact of restricted materials is less than for forbidden materials, but restricted materials could be used less in vehicles. According to the environmental strategy of the railway certain restricted materials, such as Chromium VI compounds in paints, could be restricted in the invitation to tender. This way of proceeding offers the following advantages for the railway:

- The use of restricted materials is directly related to the generation of hazardous waste in maintenance and at the end of life. Hazardous waste and end-of-life treatment are significant cost items in the life cycle of a vehicle that could be reduced by controlling these parameters.
- The environmental performance of rail vehicles could be significantly improved by reducing the use of restricted materials.

The ongoing EU-funded REPID project will draw up a standard list of restricted materials for rail applications by 2004, which can then be used by both railways and manufacturers as an agreed list of restricted materials for the Rail Sector (for further information on this topic see also www.railway-procurement.org).

Recycling[5]

As regards the consumption of material resources, recycling is less important for rail vehicles than in the automotive industry. In most cases the operational life of rail vehicles exceeds 25 years. This means that rail vehicles consume much less resources in their life cycle than road vehicles, for example.

Intuitively the recycling rate of rail vehicles is quite high because of the large amount of steel and other easy-to-recycle materials that are used in the construction, especially of freight vehicles. However, resource consumption is not the only parameter in this context. An enhanced vehicle-recycling rate could often improve modularity, which would have a positive effect on maintenance costs and end-of-life costs for the railway.

An international standard on construction for recycling is still not available but the railway could make it a requirement to apply the guideline of the German Association of Engineers, VDI 2243 (Recycling-oriented Product Development), in the construction of the vehicle. However, enhancing the recycling rate of rail vehicles must not lead to a significant increase in the weight of the vehicle because that would mean a trade-off in energy efficiency.

Material recycling of products is important both to the public and at political level. The clear objective of European Union policy is to enhance material recycling of products. 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 as follows:

- Reuse and recovery: 85%
- Reuse and material recycling: 80%

[5] 'Recycling' in this context is defined as the reprocessing in a production process of the waste materials for the original purpose or for other purposes but excluding energy recovery (Directive 2000/53/EC).

Transferred to the rail sector the above-mentioned parameters from the automotive sector can be defined as the Environmental Performance Indicators:

- Material recycling rate after use
- Material that can be incinerated[6].

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. A high recycling rate is believed to have a positive influence on the maintainability of rolling stock. The railways could define a target value for “material recycling rate after use” alone or a target value including both “material recycling rate after use” and “material that can be incinerated”.

As the parameters “material recycling rate” and “material that can be incinerated” are still not standard specifications in invitations to tender, the railways have to co-ordinate closely with the manufacturers about the target value for the most efficient recycling rates of rail vehicles.

Passenger Waste

The disposal of passenger waste is a significant item in the maintenance costs of a passenger rail vehicle. The railways should develop a waste concept for trains that is in line with their maintenance and environmental strategy. The cost of disposing of passenger waste can in some cases be reduced if the passenger sorts the waste into different component parts. However, this is only a feasible concept in countries where passengers are used to sorting their waste at home.

Other issues

The issues of forbidden and restricted materials and recycling of rail vehicles are varied and often complex. An environmental product manual would enhance the waste management process during maintenance as well as the process of scrapping the vehicle at the end of its life because the manufacturer has the best knowledge about the product and the materials used in construction. (This approach could also be applied for other environmental issues, such as energy management).

The material composition of freight wagons is very simple in most cases, so a recycling/scrapping manual is of only minor interest for freight applications.

The amount of renewable materials used in vehicle construction could also be interesting for passenger transport applications. For a number of years the automotive industry has been making much use of renewable materials in vehicle construction to enhance the environmental performance of their vehicles and it has publicised the practice. But care must be taken to ensure that renewable materials meet the fire prevention requirements and that the weight of renewable materials does not counter efforts to decrease the energy consumption of trains.

[6] “Material recycling rate” + “material that can be incinerated” corresponds to the “recovery” value for the automotive sector from Directive 2000/53/EC.

Materials/Recycling/Waste specifications in invitations to tender

From the above-mentioned issues the following materials/recycling/waste specifications have been derived for use in invitations to tender[7]:

Priority 1 Specifications

1. Exclusion of prohibited materials from use in construction (black list)
2. Defined values (weights/ratios) for restricted materials used in construction (grey list)
3. Target value for material recycling rate after use and material that can be incinerated

Priority 2 Specifications

4. Respecting construction-to-recycling principle
5. Waste concept for passenger waste (separation into different component parts)
6. Target value for the use of renewable materials

Outlook

The railways often know little about the issues of materials/recycling/waste with regard to their rail vehicles. In terms of recycling the environmental performance of rail vehicles is intuitively quite high. However, it is believed that these issues will be of increasing concern in the future, so railways and manufacturers should gather information on these issues. This would offer railways the possibility of enhancing environmental performance and publicising their efforts to third parties.

[7] For details of the specifications see Annex 1.

References

- Dewulf, W.; Duflou, J.; Ander, A: Integrating Eco-Efficiency in Rail Vehicle Design, Leuven University Press, Leuven (Belgium), 2001.
- Directive 2000/53/EC of the European Parliament and of the Council of 18 September 2000 on end-of-life vehicles.
- Council Directive 76/464/EEC of 4 May 1976 on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community.
- Council Directive 76/769/EEC of 27 July 1976 on the approximation of the laws, regulations and administrative provisions of the Member States relating to restrictions on the marketing and use of certain dangerous substances and preparations.
- Rozycki, Chr. V.; Köser, H., Schwarz, H: Ecology Profile of the German High-Speed Rail Passenger Transport System, ICE, International Journal of Life Cycle Assessment 8 (2) 83 – 91 (2003).
- Guideline VDI 2243: Recycling-oriented product development, Verein Deutscher Ingenieure (The German Association of Engineers), 2002.
- Council Directive 67/548/EEC of 27 June 1967 on the approximation of laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substances
- Council Directive of 15 July 1975 on waste (75/442/EEC)

ANNEX 6: Background Information on Electromagnetic Fields

Introduction

Problems associated with electromagnetic fields concern mostly electromagnetic compatibility (EMC): problems with the interaction between train appliances and signal technology or pacemakers, or screen phenomena such as quivering and flickering. In addition, in the last couple of decades health questions have arisen regarding people who live near to electric installations or people who spend time in vehicles. Symptoms such as nervousness, headache, fatigue, depression and circulatory disorders are claimed. Epidemiological studies in recent years have failed to show that electromagnetic fields cause cancer. However, it is important that unbiased, neutral information is given such as “limit values are respected”, so that an individual who is potentially electro-sensitive has a genuine basis from which to deal with the risk.

Problem of EMF and vehicles

Low-frequency magnetic fields (measured in microtesla, μT) are produced first and foremost by electrical appliances, transformers, high-current applications, catenaries and overhead lines. Magnetic fields, however, only arise when electricity is actually flowing. They penetrate all materials with almost no difficulty. Aside from a few very expensive technical measures (e.g. μ-metals and bucking coils), there are almost no shielding options. In the case of the railways, given that current also flows along other conductors (e.g. rails and return conductors) in the opposite direction to the flow in the catenary, magnetic fields can partially compensate each other at greater distances.

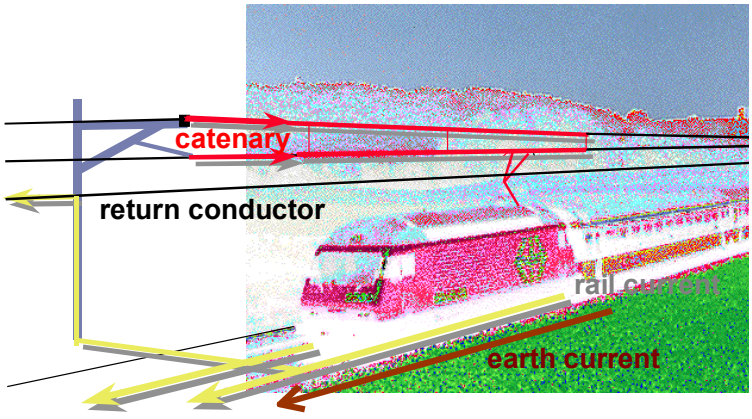

Figure 2: Currents from the railway 16.7 Hz AC-system

New vehicle generations produce larger magnetic fields because of the multi-motor technology and the so much higher currents in the railway vehicles. It is mostly near transformers that there can be very high magnetic fields. Especially high magnetic fields can be produced at floor level and these can approach the ICNIRP limit values.

Status of Legislation in Europe

Basically, the European Commission recommendation published in 1999 about exposure to electromagnetic fields between 0 and 300 GHz refers to the ICNIRP guidelines (limit values: 300 μT for 16.7 Hz, 100 μT for 50 Hz). The Italian and Swiss laws concern these values but propose and impose precautionary limits, some of which are more than 100 times lower.

Already today some railway companies check whether the manufacturer respects the limit values from the ICNIRP guidelines. In Germany there will soon be a new standard (DIN VDE 0848-3-1), which concerns pacemakers. The proposed limit value is equal to the ICNIRP limit value.

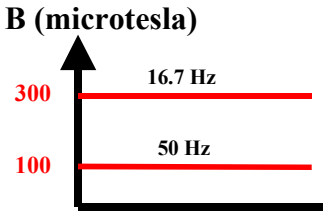

Figure 3: Recommended values from the ICNIRP Guideline for electromagnetic fields for 16.7 and 50 Hz

Technical Solutions

The following technical solutions are possible mitigation measures:

A. Changing the location of transformers or wires

Sometimes it is possible in the construction to find locations for the transformers or wires that are further away from the passenger areas.

B. New design of transformers

A new design of wires inside a transformer can compensate magnetic fields outside.

C. Additional return conductor near the wires

A one-phase system (16.7 Hz) can be shielded by an additional return conductor.

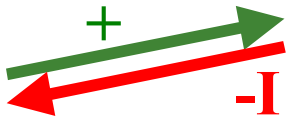

Figure 4: Additional return conductor for a one-phase system (16.7 Hz)

D. Screening of wires

Installation of aluminium-steel shields can be problematic because these shields are heated by induced currents and in contact with the floor and walls (installation of μ-metal shields is difficult because of the breaking properties of the material).

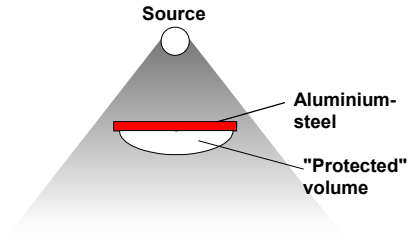

Figure 5: Shielding of wires to reduce electromagnetic fields

Specifications for EMF in invitations to tender[8]

Specifications concerning EMF can mention the following items:

- Limit values of the law in force (at least ICNIRP/Pacemaker Recommendations)
- Measurements in full, accelerated train service near critical elements at floor level, near walls
- Electrical installations should neither interfere with nor be interfered with by other installations
- Respect EN 50121.

As a first result the following moderate set of specifications is proposed as it takes into account the most important laws and verification is well defined. In table 9 a choice has to be made between 2.a and 2.b depending on the applicable specifications or which choice has lower limit values.

Table 9: Specifications regarding electromagnetic fields for invitations to tender

EMC	1. The parts installed have to be constructed so that there is no interference with railway systems or other systems. The parts have to be protected from interference from railway or other systems.
Law	2.a The ICNIRP limit values have to be respected at all locations where people are (even briefly) present.
Pacemakers	2.b Electromagnetic compatibility with pacemakers has to be ensured (e.g. DIN VDE 0848-3-1)
Measurement	3. Measurements to prove compliance with the limit values should be taken in full service in an accelerated train in the passenger areas near critical radiating elements at floor level and up to 1.8 metres above the floor and on the walls.

Outlook

Discussion of intermediary results with suppliers and concerned railways and discussion of consequences of technical solutions and financial aspects could improve the process of invitations to tender.

[8] For details of the specifications see Annex 1.

References

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- EN 50121: Railway applications - Electromagnetic compatibility
  - Part 1: General
  - Part 2: Emission of the whole railway system to the outside world
  - Part 3-1: Rolling stock - Train and complete vehicle
  - Part 3-2: Rolling stock – Apparatus
  - Part 4: Emission and immunity of the signalling and telecommunications apparatus
  - Part 5: Emission and immunity of fixed power supply installations and apparatus

ANNEX 7: Eco-Procurement Glossary

Table 10: Eco-Procurement Glossary

CO	Carbon monoxide (exhaust emission from e.g. diesel engines)
CO_2	Carbon dioxide (exhaust emission from e.g. diesel engines)
dB(A)	Decibel (A), measuring unit of noise, additional conditions need to be applied like max or average value, L_{DEN} (day, evening, night, etc.)
DFE	Design for Environment
DMU	Diesel Multiple Unit
EPI	Environmental Performance Indicator (defined in ISO 14031)
EMU	Electric Multiple Unit
HC	Hydrocarbons (exhaust emission from e.g. diesel engines)
ICNIRP	International Commission on Non-Ionizing Radiation Protection
IPP	Integrated Product Policy
ITT	Invitation To Tender
K-value	Coefficient for thermal transfer of materials, important for the assessment of the insulation of a vehicle
LCA	Life Cycle Assessment, environmental assessment of a product or a system
LCC	Life Cycle Costs
MU	Multiple Unit
NOx,	Nitrogen oxides (exhaust emission from e.g. diesel engines)
PM	Particulate matter (particle emission from e.g. diesel engines)
PROSPER	UIC project acronym for “Procedures for ROlling Stock Procurement with Environmental Requirements”
REPID	EU-funded project acronym for “Rail sector framework and tools for standardising and improving usability of Environmental Performance Indicators and Data formats”
SO_2	Sulphur dioxide (exhaust emission from e.g. diesel engines)
TSI	Technical Specification for Interoperability
VDI	Verein Deutscher Ingenieure (German Association of Engineers)