SUWOS

Sustainable Wooden railway Sleepers

INTERNATIONAL UNION
OF RAILWAYS

ISBN 978-2-7461-2164-5

Contents

Introduction and purpose

The use of concrete sleepers has rapidly grown in Europe during the past years; however, wooden sleepers are still widely used principally for technical, but also for economical, reasons. To be prepared for a possible ban of creosote in Europe and to reduce its negative external effects in wooden sleepers, infrastructure managers (IM) have recently been actively looking for viable alternatives to creosote sleepers.

Research has already been done on potential substitutes to creosote and on alternatives to wooden sleepers. Some of the alternatives and substitutes have been analysed, tested and put into use in some national networks such as using other wood species without any preservative, “more ecological” preservatives (e.g. wood polymer), the use of composite and steel sleepers.

At the end of 2010, UIC members approved the project “Sustainable Wooden railway Sleepers” (SUWOS) in order to obtain an overview of all alternative wood preservation technologies and to evaluate the technological, mechanical and environmental features of each one.

The concept:

Assessment of the environmental impact of alternative (i.e. without creosote) preservation technologies of wooden railway sleepers and a feasibility study of common pilot/test projects.

Deliverable: a document describing:

- the legal framework for creosote and other preservatives;
- an update on the use of creosoted wooden sleepers in Europe;
- the environmental, economical, social and technical aspects of creosoted wooden sleepers and the alternatives;
- an inventory of all existing experiments and ongoing projects regarding research on potential substitutes to creosote.

The technical and mechanical assessment of acceptable alternative treatment methods has been performed in collaboration with the UIC Rail System Department and Forum and the wood preservation industry.

The present document

The present document is based on the results of the UIC inquiry made in 2011, a meeting with external parties (wood federations and wood preservative industry) in August 2011 and a meeting with IM representatives in December 2011 and June 2012.

The questionnaire's goal was to update the survey of 2007 with more structured information on:

- the use of wood in comparison to concrete and the evolution of the market;
- the technical, environmental and economical reasons for using wood and the conditions for a good alternative;
- the alternatives to creosote;
- end-of-life cycle of creosoted sleepers;
- safety and health issues.

1 Policy and legislation

1.1 Background to European regulations on the use of creosote

The placing on the market and use of creosote or creosote-treated timber has been strictly limited. These restrictions were first defined in European legislation by Directive 94/60/EC of 20 December 1994 and Directive 2001/90/EC of 26 October 2001.

1.1.1 Commission Directive 2001/90/EC of 26 October 2001 adapting to technical progress for the seventh time Annex I to Council Directive 76/769/EEC 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 (creosote)

In 1999, following research on the effects of creosote on health, the Commission entered into discussions with the Member States with a view to revise the provisions of Directive 76/769/EEC with regard to creosote.

On 26 October 2001, the Commission adopted Directive 2001/90/EC. The introductory clauses referred to findings that creosote had a greater potential to cause cancer than previously thought.

Directive 2001/90/EC replaced point 32 of the Annex to Directive 76/769/EEC, introducing new restrictions on the sale and use of creosote for treating timber and of creosote-treated timber. Under point 32, creosote cannot be used to treat wood, and wood treated in this way cannot be sold.

However, by way of derogation:

- Use is still authorised in industrial installations or by professionals for retreatment *in situ* only if the product contains:
    - a) benzo[a]pyrene at a concentration of less than 0.005 % by mass;
    - b) water-extractable phenols at a concentration of less than 3 % by mass.
- Creosoted timber (in compliance with the above conditions) placed on the market for the first time, or retreated *in situ*, is permitted for professional and industrial

use only, e.g. on railways. This means that it can in no circumstances be sold to consumers and can only be placed on the market in packaging of a capacity equal to or greater than 20 litres. The packaging must be marked "*For use in industrial installations or professional treatment only".*

- Timber treated in this way which is sold for the first time, or retreated *in situ*, cannot be used: inside buildings, in playgrounds, in parks, gardens and outdoor recreational and leisure facilities where there is a risk of frequent skin contact, in the manufacture of garden furniture, or where it may come into contact with products intended for human or animal consumption.

1.1.2 Commission Directive 2011/71/EU of 26 July 2011 amending Directive 98/8/EC of the European Parliament and of the Council to include creosote as an active substance in Annex I thereto

1. Directive 98/8/EC (Biocides Directive) - Introduction

The term "biocidal products" is used to describe products designed to combat, destroy or repel harmful organisms or render them harmless or inactive by chemical or biological means. Biocides are by definition active products that may have harmful effects on humans, animals, or the environment.

These products are classified in four major groups, consisting of 23 different types of product. Protective products (e.g. those protecting wood against insects and fungi, products for protection of leather, and fluids used in the processing of metals) fall within these four groups.

Community Directive 98/8/EC regarding the sale of biocidal products has the effect of harmonising the regulations of the European Union Member States, which until that time had differed greatly, and of ensuring unity of the market. But, the main aim of this regulation is to ensure a high degree of protection for humans, animals and the environment by restricting the sale of only those effective biocidal products presenting acceptable risks and encouraging the sale of active substances presenting increasingly lower risks for humans and the environment. The measures are designed in particular to prevent long-term effects, i.e. carcinogenic or toxic to reproduction capabilities and effects of toxic substances that are persistent or which can be bio-accumulated.

Regulatory implementation requires dual authorisation for biocidal products:

- firstly, the active substances must be registered on the European list of authorised active substances (i.e. Annex I, IA or IB of the Biocides Directive), and this authorisation must not be general, but only valid for specific uses;
- secondly, the biocidal products in which the active substances are incorporated must themselves be authorised at national level, with common requirements at European level. A procedure for recognition of authorisations issued by other Member States is also planned.

2. Procedure for inclusion of creosote in Annex I to Directive 98/8/EC (Biocides Directive)

Active substances are registered in an Annex to the Biocides Directive on request. A request of this nature was notified in March 2004 by the Creosote Council Europe (CCE, representing all European creosote manufacturers) for creosote to be included in Annex I or IA of Biocides Directive 98/8/EC for the following application: “treatment of wood (products 8vii of the Biocides Directive) by professionals”.

This application was then evaluated by a Rapporteur Member State, Sweden, for creosote.

In October 2007, the Rapporteur presented its report. Its conclusion was that the listing of creosote as an active substance in wood preservation products in Annex I to the Biocides Directive could not be recommended.

This conclusion was based on the fact that most of the data available at the time identified serious risks for certain uses in direct contact with the ground or water.

Nevertheless, given the risks identified, the European Commission wished to obtain further information and held a consultation with third parties in June 2008 regarding the benefits and risks of keeping creosote on the wood treatment market. The results of this European consultation highlighted the absence of other wood products which are comparable effective and durable for the same applications while being less toxic.

In 2009, on this basis, Sweden revised its recommendation against listing and ruled that the level of risk could be reduced to acceptable levels by applying protective measures, such as rigorous monitoring of the protective measures adopted, frequent changing of personal protective equipment, the wearing of respiratory equipment during operations presenting a risk of exposure by inhalation and the use of mechanical or automated processes to prevent any physical handling of the wood treated.

The European Commission then proposed that listing should be authorised subject to several conditions:

- listing of the active substance to be restricted to five years;
- prior evaluation in the event of an application for re-listing, in order to investigate the market and the development of substitutes;
- the issue of national authorisation for creosote-based biocide products for only those uses where no appropriate alternative exists;
- the obligation for Member States granting the use of creosote to submit a report to the European Commission by 31 July 2016, proving that no appropriate alternative exists within their territory and explaining how the development of alternatives is being encouraged;
- finally, strict conditions on the use of products incorporating creosote, i.e.
    - the requirements of the REACH Regulations (Annex XVII), in particular not placing these substances on the market except in packages of 20 litres or more, and the impossibility of using the treated timber for certain purposes[1];
    - the implementation of measures to manage the risk in such a way as to protect operators, including subsequent users, from exposure during the treatment of wood and the handling of treated wood in compliance with REACH, as well as Directive 2004/37/EC on the protection of workers from the risks related to exposure to carcinogens or mutagens at work;
    - appropriate measures designed to attenuate risks and protect the environment and water, in particular by means of labels and/or safety data sheets for products authorised for industrial use; these labels or sheets must state in particular that treated timber must be stored after treatment under shelter and/or on impermeable hard standing and that any losses must be collected for reuse or disposal.

1. REACH
The case of creosote has been partly dealt with in the REACH Regulations.
The substance is listed under Appendix XVII Article 17 governing the restrictions on the use of dangerous substances or preparations. The possible areas of use of creosote have thus been reduced.
It cannot be used to treat wood to be used inside buildings, in toys, in the equipment of public play areas, in outdoor recreation areas open to the public, or in the manufacture of garden furniture.

In terms of procedure, the Council (representing the Member States) could have opposed this decision if it had been able to attain a qualified majority, but it was unable to do so. Denmark, the Netherlands and Belgium opposed the motion. Germany, Italy, Romania, Hungary, Austria and Slovakia abstained. The other Member States supported it.

Given this position, at its meeting of 12 April 2011, the Commission took note of the future adoption of the proposed Community Legislation on the basis of the information before it.

The proposal was formally approved on 26 July 2011.

3. Directive 2011/71/EU - Content

The registration period is five years and runs from 1/05/2013 to 30/04/2018. Creosote-based biocides can only be authorised for the applications for which the Member State granting the authorisation considers that there is no adequate alternative (the types of use should therefore be identified separately). Member States authorising these products should submit a report to the Commission by 31 July 2016 at the latest, stating the reasons why no adequate alternative had been found and the way in which the development of alternatives is being promoted. These reports will be published by the Commission.

The Member States are responsible for ensuring that all authorisations meet the conditions defined above, i.e.

- the conditions laid down by the REACH Regulation must be met;
- adequate measures must be taken to protect workers, including end users, against exposure during treatment and during the handling of the treated wood;
- adequate measures must be taken to contain risks, in order to protect the ground and aquatic life.

It is important that creosote continues to undergo comparative evaluation. Under Article 10, this means that the mention of an active substance in one of the annexes may be omitted when another active substance is used for the same type of product which has markedly lower risks in the light of scientific and technical knowledge. This clause is, however, accompanied by an evaluation of the alternative active substance to show that it can be used without any major practical or economic problems for the users and without increased risk for public health or the environment, while having the same effect on the target organism. It is also for this reason that the alternatives to creosote are being intensively studied at the moment.

1.1.3 Summary of European Regulations

At present, European regulations provide for strict control of the uses of creosote.

The current situation (since 2003) is as laid down in Directive 2001/90 – a ban on the use of creosote by the general public, with very strict restrictions on authorised industrial use, which includes railway sleepers (industrial installations, professional uses, characteristics of creosote, subsequent use).

As of 1 May 2013, more stringent restrictions will come into force, as the principle will then be a total ban on creosote, even for industrial use and thus for the railways.

However, all Member States still retain the option of authorising the use of creosote for an initial five years (until 30 April 2018). Any Member State wishing to do so, must submit a report no later than 31 July 2016 justifying its conclusion that there are no appropriate alternatives and indicating how the development of alternatives is promoted.

This means that railway companies wishing to be able to continue using creosote at least until 2018 must sound out the intentions of the competent national authorities on this matter and try to persuade them to opt for this time extension (before 1 May 2013). In this case, they should provide the necessary information when drawing up their reports. This is precisely the purpose of the SUWOS project regarding progress on possible alternatives to creosote for use by the railways.

1.2 Country specific information

The participants to the working group reported the following:

Finland:

Creosote will be allowed as long as the EU allows it, for now till 30.04.2018. An application has to be submitted before 01.05.2013. If this product application is approved, creosote may be used until 2018.

Norway:

The Norwegian authority on this matter, called Klif, states that a manufacturer who wishes to use creosote for wood impregnation, must write an application before 1 May 2013 to Klif. The application must state that there are no alternatives available, regarding technical and economical features, or else it will not be approved. If Klif finds it necessary to approve the application, the manufacturer may use creosote until 2018. However, only businesses that use creosote as an impregnation method must apply, and not businesses that use products that are creosote impregnated. For example, importers of *already impregnated products*, such as our sleepers, are, according to Klif, not required to apply. This means that Jernbaneverket, which imports all of their wooden sleepers from Germany, (for the moment) is not obliged to apply, and are not affected by a possible ban in Norway either.

Hungary

Creosote may be used till 30.04.2018.

Austria

Austria has since 2011 no impregnation plant for creosote and imports all creosoted sleepers. Creosote may be used till 30.04.2018.

Sweden

According to The Swedish Chemical Agency (KEMI), a product application from the companies wishing to put creosote on the market has to be submitted to the authorities before 1 May 2013. If this product application is approved, creosote may be used for impregnation until 2018. **That is as long as there are no reasonable alternatives available**. If creosote is approved, the authority has to send a report to EU COM before 31 July 2016 with an analysis of how alternatives have been evaluated.

Spain

The Spanish Authority of Health and Environment has accepted the point of view of the European Union that includes creosote in the Annex 1 of the Directive 98/8/EC for five years. Additionally, the Spanish Authority has been studying this issue, and for that reason, they asked the Spanish wood industry to undergo some studies.

The Spanish wood industry is very important for rural areas. In 2006, this industry generates directly about 1,600 jobs and indirectly 840 more, in impregnation plants, the chemical industry, sawmills exclusively dedicated to making pieces of wood/products to be treated with creosote like posts, sleepers, etc., in forest exploitations and in transport.

The aggregate net total amount of the turnover in 2006 for the creosote wood treatment industry was € 64 millions and € 78 millions in 2007. This 21,2 % increase was due to the augmentation of exportations and to the increase of the wood cost.

Belgium

A decision of the Belgian Authority will be taken when a well motivated demand for the further use of creosote is submitted either by the wood preservative industry or by the rail Infrastructure manager Infrabel.

France

A report has to be submitted to the authorities before 1 May 2013. For SNCF, creosote is the only product on the market that fits the application. SNCF has its own impregnation plants.

Germany

DB also has its own impregnation plant. So far there is no official feedback from the authorities, but the same strategy will be followed, a report will has to be submitted before 1 May 2013 by the producer of creosote.

2 Analysis of the results from the survey and meetings

As part of this study, a survey and two meetings were performed analysing:

- the purchase of wooden and concrete sleepers;
- the ratio in use between wooden and concrete sleepers;
- the use of creosote;
- the existing alternatives.

The questionnaire was sent to all European UIC members. Figure 1 illustrates the coverage of the online survey and the interviews performed. The following sections present the main findings from all the feedback received. This covers about 70 % of the European tracks (in km).

Figure 1: Overview of feedback from survey and meetings

2.1 Purchase of sleepers

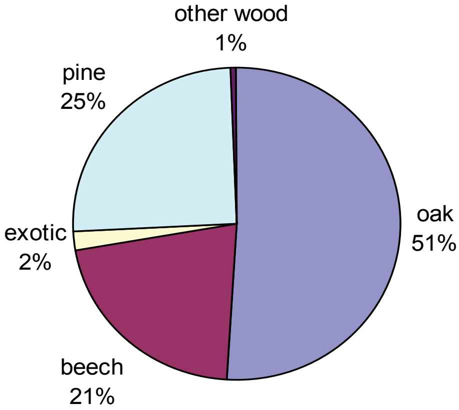
Before exploring the alternatives to creosote, it is important to have knowledge of the quantity and species of wooden sleepers currently in use.

Information was asked about the purchase of sleepers for the past 3 years and planns for the coming 3 years. For 2010, the amount of wood purchased totalled 160.030 m³ (for approximately 70 % coverage of European rail infrastructure).

According to information on the WEI website, European wood industries supply each year around 390.000 m³ of wooden sleepers, part of which is exported out of Europe.

This figure gives an idea of the different species of wood purchased in Europe, in 2010.

- Mainly only 3 timber species are used: oak, pine and beech, the different level of impregnated creosote guaranties more or less the same lifespan.



- 94 % of pine is used in Finland, Sweden and Poland.
- 95 % of beech wood is used in Switzerland, Germany, Norway and Austria, but their IM also uses important quantities of oak.
- Beech is less expensive than oak but needs more creosote.
- Azobe gets sometimes a surface treatment with creosote.
- 95 % of the sleepers are treated with creosote.

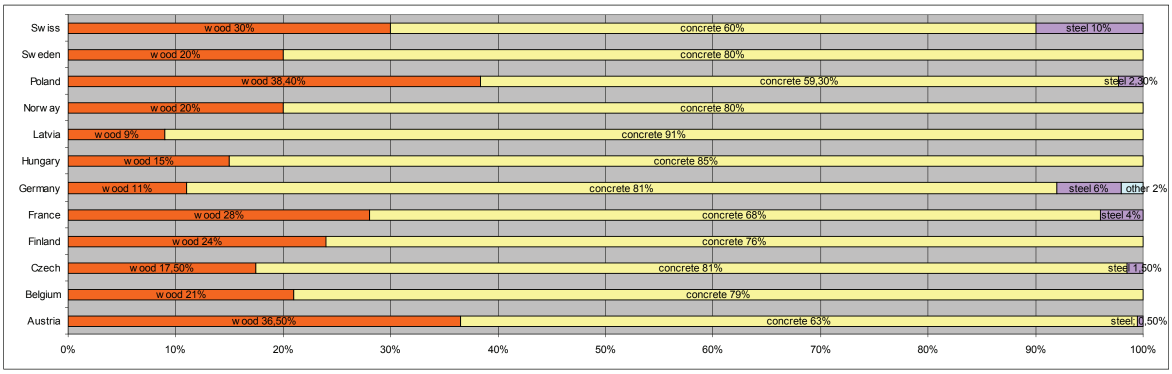
Origin of the wood:

IM (by country)	Wood origin (by country)
Austria	Poland, Germany, Croatia, Czech Republic, France
Belgium	France
Czech Republic	Czech Republic
Finland	Finland (For switches from Germany and Czech Republic)
France	France
Germany	Poland, Czech Republic, France, Austria, The Netherlands, Hungary, Slovenia, Switserland
Hungary	Czech Republic, Austria, Romania, Slovakia, France
Norway	Germany
Poland	Poland, Ukraine, Germany, France, The Netherlands
Spain	Spain
Sweden	Sweden, Germany

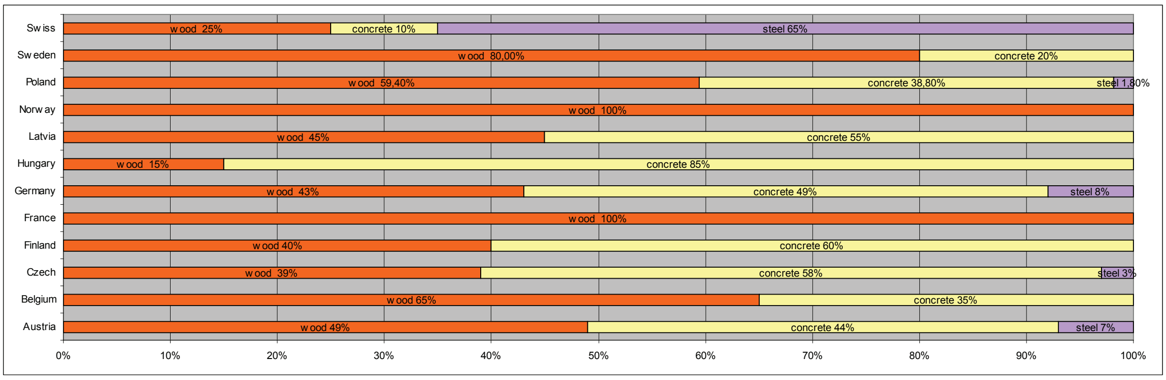
2.2 Actual Ratio between concrete and wooden sleepers

The figures below give an overview of the actual presence (figures for 2010) of the different kinds of sleepers (wood = red, concrete = yellow, steel = lila, other = blue) used in railway infrastructure.

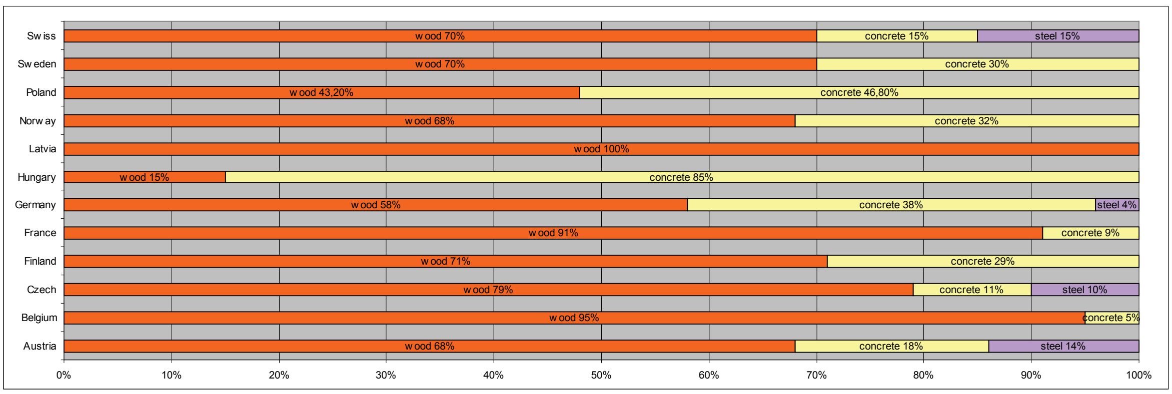
Main tracks



Side tracks



Switches



Level crossings

In Finland, there are over 3000 level crossings, mainly built in wood. The oldest (≈2000) were impregnated with creosote, the new ones with copper-chrome.

In France, there are almost 17,000 level crossings, all built with creosoted wood.

Private railways

Beside States or IM owned tracks, there are also private railways owned by different owners. Some of these sidings interoperate with the public network. Others exist solely for internal use in industrial areas, as logistic nodes or tourist attractions.

Traffic on these private sidings varies hugely: from occasional train visits to millions of tons of cargo transported annually.

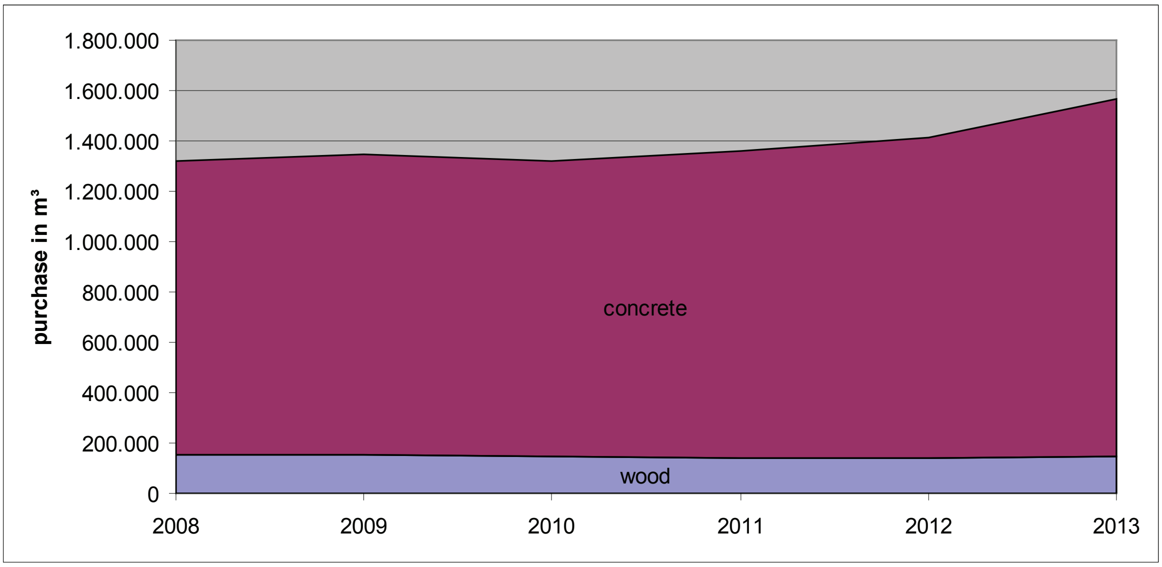
- *Finland*:
  In Finland, over 1,000 km of tracks are private sidings. Approximately 95 % of those private railways are equipped with wooden creosoted sleepers.

2.3 Choice of type of sleeper for new or overhauled railway lines

Concrete sleepers are now the most common type used for *new or overhauled railway lines*.

Even if the use of concrete sleepers has rapidly grown (and is still growing) during the last years, *wooden sleepers* are still widely used in Europe for both technical and economical reasons.

For the evolution of the concrete-wood ratio, there is a certain stagnation in the use of wood.



Among European countries, there are important differences regarding the use of wooden, concrete or steel sleepers. There is a geographical and historical explanation for this:

- countries with vast woodlands have nearby wood suppliers (in the northern and eastern countries, there is more pine wood);
- in Switzerland, there are a lot of mountains with narrow curves that need light track, one of the reasons there are more than 50 % of steel sleepers in use for main tracks.

2.4 Main reasons for using wood

Based on the answers to the questionnaire, the **mentioned** reasons for using wood can be summarized as follows:

Technical reasons

- Allows the use of custom-made sleepers in some localized areas (e.g. tunnels, bridges).

- In stations, yards and industrial lines, the use of wooden sleepers is recommended because of their mechanical behavior.
- In old tunnels, the necessary height to install concrete sleepers is not always available.
- Wooden sleepers are more suitable in situations with extreme shocks and excessive forces.
- Low sensitivity to fluctuations in temperature.
- Use of wooden sleepers in small radius curves.
- To maintain equal profile in tracks that have already wooden sleepers and there is no technical need to replace all sleepers of this line.
- Specific supports on metal bridges with direct fastenings, other specific cases.

Economical reasons

- **A switch from wood to concrete means a change from an ordinary maintenance to a fully-mechanized renewal operation, which poses an economic problem for:**
  - secondary tracks and low traffic lines for which a renewal is not planned in the short or medium term;
  - substructures of bridges, tunnels and other specific structures have to be replaced or modified;
  - disposal of large quantities of sleepers.
- In the case of new tunnels, the use of wooden sleepers allows a smaller diameter so that both the economical and environmental costs of the earth excavation are reduced;
- Less damage in case of derailment (switches, curves);
- Employment in saw mills and impregnation plants.

Environmental reasons

- Only certified wood is used, e.g. FSC – Forest Stewardship Council.
- Replacing pine or beech with exotic wood (that does not necessarily require any chemical treatment) is more questionable as tropical wood entails: long transports, deforestation and unreliable production conditions.
- Although a significant difference between wooden and concrete sleepers cannot be measured in terms of noise emission, concrete sleepers have been experienced as noisier than wooden ones in some cases.
- CO_2 balance over the lifetime of a sleeper is more beneficial for wood.

2.5 Preservation methods

Creosote is the best known and most used preservative for wooden sleepers (95 % of the wooden sleepers treated in 2010). The use of creosote increases the life of the sleeper for 10 to 30 years; the sleeper is more resistant and compared to concrete weighs less.

All railways are nevertheless following the ongoing scientific debate on the possible negative health effects of creosote and are generally willing to investigate all potential environmental impacts.

2.5.1 Creosote as a preservation method

Types of Creosote

Creosote is the name used for a variety of products including wood-tar creosote and coal-tar creosote. Wood-tar is obtained by high temperature (900-1200°C) treatment of wood (pine, oak, beech) and is then distilled between 180C° and 400C° to produce wood-tar creosote. Creosote consists of polycyclic aromatic hydrocarbons (PAH's). Some of these substances – especially benzo[a]pyrene – have been classified as carcinogenic.

- The WEI type C creosote is the most common type (lower amounts of light polycyclic hydrocarbons than types A and B).
- WEI type C causes less smell and exudation of the impregnated timber.
- In the northern countries, the use of WEI type C is not suitable during wintertime because of low viscosity.

- As a precautionary measure, some railways have further limited the use of creosoted sleepers to areas where there is absolutely no risk of contact with groundwater/ surface water.

Life-cycle assessment (LCA) of wooden creosoted sleepers

Creosote has been evaluated within the review programme for biocides under the Biocidal Products Directive 98/8/EC, for which Sweden is the Rapporteur Member State (RMS). The Swedish Chemicals Agency (KEMI) was the authorized body for the evaluation of creosote and its possible inclusion in Annex I of the above mentioned Directive.

As a possible contribution to the work of KEMI, a LCA on creosoted poles was performed in October 2009 by the Swedish Environmental Research Institute and sponsored by Swedenergy (Svensk energi), Skanova (branch of TeliaSonera AB), Swedish Wood Preservation Institute, Naturvårdsverket (Swedish Environmental Protection Agency) and Formas (Swedish Research Council)

In the same period, another LCA was performed by Umwelt & Entwicklung to contribute to the stakeholders' consultation. This study was ordered by Studiengesellschaft Holzschwellenoberbau in November 2008.

Both LCA evaluate the environmental impact of creosoted wood products (poles and sleepers) and compare these to their concrete and steel alternatives.

Recently an LCA was performed by Studio Crona AB on behalf of the Swedish Transport Administration focusing on an alternative concrete sleeper (TCS-sleeper), a pine sleeper impregnated with linseed oil and a creosote impregnated pine sleeper as a reference alternative.

1. Erlandsson M. & Almemark M. (2009). Background data and assumptions made for an LCA on creosote **poles** – Working report (B 1865). Swedish Environmental Research Institute, 40 pages.

Conclusions of the LCA:

"The result of the LCA illustrates that poles made of steel or concrete have a higher impact on climate change than creosote poles. The significant aspect of creosote poles is human toxicity. Even so, steel poles have a higher impact than creosote poles on ecotoxicity as well as on human toxicity. An overall assessment will favor the creosote poles as the ecologically most sustainable alternative in respect to the environmental quality objectives used for normalisation.

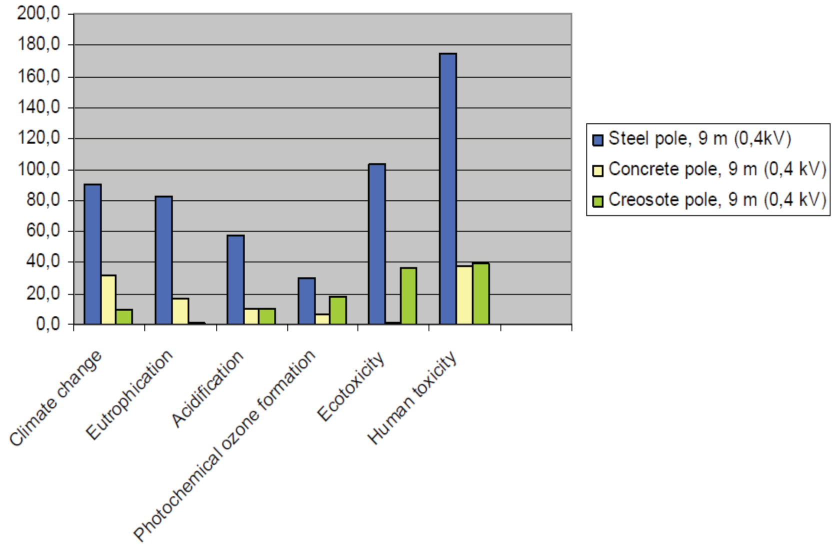


Figure 8 The relative importance of different impact categories included in the LCA study and normalised according to the EQO normalisation approach. The LCA covers the life cycle from raw material production to the use phase, where the emission significantly contributes to the performance of the steel and wood poles.

The results presented in Figure 8 probably underestimate the impacts of steel and concrete poles on ecotoxicity and human toxicity, since the contribution of hexavalent chromium is possibly underestimated."

2. Werner F. (2008). Life Cycle assessment (LCA) of railway **sleepers.** Comparison of railway sleepers made from concrete, steel, beech wood and oak wood. Study by *Umwelt & Entwicklung* for SGH. 7 pages.

This study concentrates more specifically on sleepers. It also takes into consideration the respective share of track bed construction and maintenance since it varies from one wood type to the next. This might explain some differences in the outcome of the two LCA's

"Some important conclusions of this study:

- *Wooden creosote sleepers have (sometimes very significantly) the lowest impacts in all categories (except in eutrophication).*
- *Switching to the use of creosote grade C has led to a very significant decrease of the environmental impacts of wooden railway sleepers.*
- *Incineration with heat recuperation is a favorable environmental characteristics of wooden sleepers."*

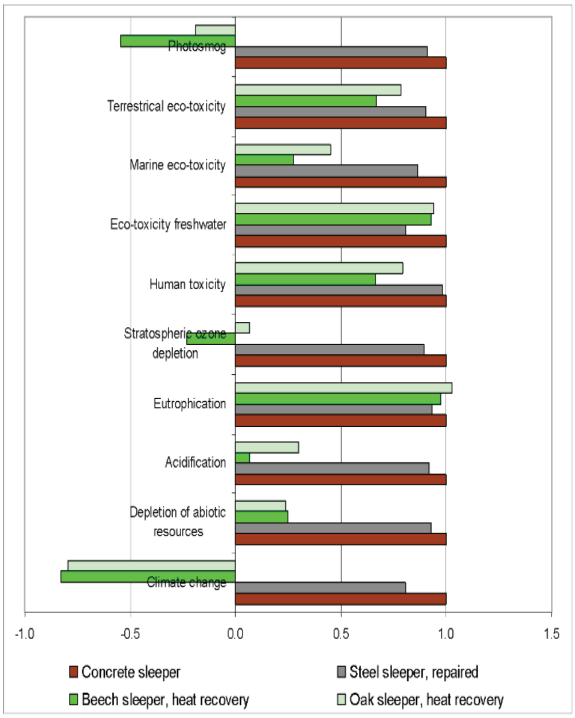


Figure 2.1: **Comparison of the environmental impacts of railway sleepers relative to the impacts of the sleeper made from concrete; heat recovery fort he wooden railway sleepers (without the sleeper newly made from steel)**

3. Jan Schmidtbauer Crona & Stefan Bydén (2012). LCA av alterniv betongsliper och linolkeimregnerad träsliper – som alternativ till Kreosotsliper. Study by studio CRONA AB. (53 pages)

The LCA was carried out according to the steps of ISO 14040, goal and scope definition, inventory analysis, impact assessment and interpretation and compares 3 kind of sleepers: TCS concrete, linseed impregnated and creosote impregnated.

The LCA gives no coherent picture of which of the 3 kind of sleepers has the least negative impact on the Swedish Environmental Objectives. But it is clearly showed that the linseed oil sleeper in general has the most negative impact.

The study also states that a TCS-sleeper with standard steel reinforcement could be a good alternative in case of a ban on creosote.

Occupational Safety

At first, KEMI (the Swedish Chemical Agency) proposed in October 2007 not to include creosote in Annex I of the Biocidal Products Directive. The main reason for this negative conclusion was the fact that creosote has been classified as carcinogenic and that no safe use was possible. Dermal absorption and exposure were especially considered. In 2008, new studies showed that skin uptake is much lower than anticipated and that penetration through the human skin is minimal.

According to KEMI, the safe use of creosote in industrial applications is possible provided collective and individual protection measures are taken.

According to the inquiry, the following precautions are taken:

- All companies have health & safety guidelines in place
- Treatment is carried out in closed system and the process is automated
- Use of individual protection measures like:
  - systematic shower and change of dungarees/underwear at the end of shift,
  - systematic use of “creosote proof” gloves,
  - wearing long-sleeved clothes,

- systematic use of air-purifying respirators by workers exposed to creosote vapors (in impregnation plants) and/or to creosoted wood dust,
- use of UV-screen creams for outdoor tasks.

- Regular medical check-up like:
  - skin examination,
  - biomonitoring: measurement of 1-hydroxypyrene in urine to check the effectiveness of individual protection measures,
  - blood samples.

SNCF performed several risk assessments in impregnation and manufacturing plants. As creosote is a complex mixture consisting of several hundreds of different compounds, mainly PAH (Poly Aromatic Hydrocarbons), exposure cannot be evaluated using a single indicator. US-EPA suggested that exposure to PAH mixtures could be evaluated measuring simultaneously 16 different compounds, namely: naphthalene, fluorene, acenaphtene, acenaphtylene, phenanthrene, antracene, fluoranthene, pyrene, chrysene, benzo(a) anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, dibenzo(ah) anthracene, indeno(1,2,3-cd)pyrene, benzo(g,h,i)perylene. Accordingly, atmospheric concentrations of these 16 PAH were measured in samples obtained next to the respiratory tract of creosote-exposed workers. Simultaneously, urine samples were obtained from the same workers for biomonitoring. Biomonotoring indicators were:

- urine 1-hydroxypyrene (pyrene metabolite): pyrene is present in high concentrations in creosote but is a light, non carcinogenic PAH;
- 3-hydroxybenzo(a)pyrene (benzo(a)pyrene metabolite): benzo(a)pyrene is present in low concentrations but is a heavy, carcinogenic PAH.

The main results were the following:

- Atmospheric concentrations of naphthalene and benzo(a)pyrene were very far below their respective threshold limit values (French TLVs for naphthalene and benzo(a)pyrene are 50 mg/m3 and 150 ng/m3, respectively). For the other 14 PAH, it is quite difficult to interpret the atmospheric measurement results because there are no corresponding limit values; nevertheless, only atmospheric concentrations of light (non carcinogenic) PAH where high, while those of heavy carcinogenic PAH where very low (as observed for benzo(a)pyrene which is conventionally used as the indicator of exposure to carcinogenic PAH).

- Urine 3-hydroxybenzo(a)pyrene measurements did not show any significant benzo(a)pyrene contamination. On the contrary, urine 1-hydroxypyrene monitoring demonstrated significant exposure to pyrene (and probably to other light PAHs).
- 1-hydroxypyrene elimination kinetics clearly showed that workers exposure mainly occurred through the dermal route.

Environment

In terms of its effects on the environment, the SCA report states that the effects of the most toxic creosote components rapidly vanish in the atmosphere. The risk is therefore not so much related to creosote-impregnated wood already in use but rather to the impregnating activity and industry.

Production

In Europe, impregnation facilities need to use the best available technology in order to prevent new soil pollution and air/water-emissions, besides, this is one of the conditions to respect in order to obtain an environmental permit delivered by the regional or federal competent authority.

The impregnation plants are closed systems and mostly computerized so the process is easy to control. At high temperature and under vacuum pressure, the wood is impregnated with creosote oil. The high temperature is necessary to increase the depth of impregnation and obtain a better fixation of the oil in the wood fiber. The wood stays approximate 2.5 hours in the autoclave. The surplus of creosote oil flows back to the storage tank. The impregnated wood is transported to a drying tunnel for several hours. During the cooling-off process, the oil crystallizes at a temperature of 50°C. So, the end product will be dry/cold and the creosote will be optimally-fixed. The risk of rinsing out is suppressed in this way.

After the drying process, the wood is stored for several days under a roof, on a concrete floor.

Gases are captured and evacuated through filters. The contaminated water (from rainfall) is treated through an active coal filter.

In Belgium, Germany and Finland, sleepers are creosoted in ISO 9001/14001 certified plants.

On-site storage of recently-treated sleepers before assembling in the tracks

- no direct contact with the ground, stored on non-treated timber or on a concrete layer;
- always covered, in order to reduce additionally the risk of rinsing out.

Laying in the tracks

Wooden sleepers are always laid on ballast, so they never are in direct contact with the soil. Several IM regularly sample the ballast before renewal or maintenance.

In Norway, values normally range between 0.01-1 mg/kg benzo(a)pyrene in the test samples; lower numbers represent the random sample test of the ballast whereas the higher numbers are found in the ballast waste.

In Belgium, ballast has been continuously investigated since 2005 to determine different disposal possibilities such as, for instance, direct reuse as a construction material or reuse after treatment in a "wash facility". Different fractions are analysed depending on the kind of maintenance work that is carried out.

Benzo(a)pyrene **in Ballast residue 0-25mm**	# samples	Average (mg/kg)	% of	Min (mg/kg)	Max (mg/kg)	SD (mg/kg)
Yards	52	0,51	6	0	1,5	0,4535
Stations	15	0,63	7,5	0	3	1,1172
Switches	28	0,19	2,2	0	1	0,2796
Main track	53	0,048	0,6	0	0,95	0,1437

Benzo(a)pyrene **in Ballast residue 0-50mm**	# samples	Average (mg/kg)	% of	Min (mg/kg)	Max (mg/kg)	SD (mg/kg)
Yards	68	0,18	2,1	0	1,6	0,2527
Stations	65	0,22	2,6	0	3,6	0,641
Switches	142	0,23	2,7	0	1,9	0,4107
Main track	172	0,19	2,3	0	4,6	0,505

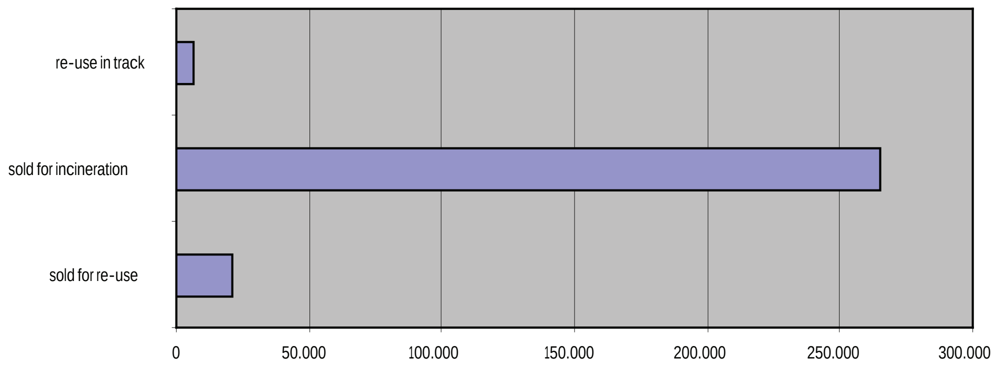
Benzo(a)pyrene **in Ballast 25-50mm**	# samples	Average (mg/kg)	% of	Min (mg/kg)	Max (mg/kg)	SD (mg/kg)
Yards	7	0,13	1,5	0,056	0,23	0,0639

The higher values for benzo(a)pyrene can not always be assigned to the use of creosoted sleepers. Other sources can also be the cause such as oil and grease from rolling stock or the lubrication of switches.

Disposal of creosted sleepers and the end of life

The European directive stipulates that private use of creosoted wood is not allowed anymore. In some cases, creosoted wooden sleepers can be sold to professional partners for re-use as fences or in other constructions. This practise is fading out.

Almost all creosoted wooden sleepers are burned in specialised incineration plants with heat recuperation.



Quantities (in tons) of disposed creosoted sleepers in 2010 in Europe (covers 60 % of European track)

2.5.2 Conditions for a good alternative preservation method

From the 2007 survey, it is clear that other preservation methods like pine oil and metal salts were already being tested by infrastructure managers; but, at that time, they did not have enough experience to determine if similar results to those obtained with creosote could be expected.

A good alternative to creosote-impregnated wooden sleepers should have the following features:

- Good toxic profile
- Life-cycle of over 30 years
- Fulfillment of technical characteristics
- A class 4 quality of treatment (EN 335-2, see hereunder)
- Economically viable. For example, in Sweden, the maintenance budget for low traffic lines concerned by this issue is very limited. An important aspect of the economical issue is of course the product life span (if it is short, it will automatically increase maintenance costs).
- Not conductive for electricity
- No (or less) chemical residues in the ballast
- Waste management issue: it should be demonstrated that the impact of the alternative preservation methods do not cause more problems than creosote. For example does not contain to high concentrations of metal salts because some incineration plants have limit values for metals as Cu, Cr, As.
- Market-ready within 5 years

The following standards should be met:

- **EN 252:** To evaluate the effectiveness of new wood preservatives intended for treated-wood in ground use. The test shall run for five years before any interpretation of the results can be made.
- **EN 335:** Hazard classes of wood and wood-based products against biological attack.

- **EN 350:** Durability of wood and wood-based products. Natural durability of solid wood. Guide to the principles of testing and classification of wood's natural durability.
- **EN 351:** Standard for preservative-treated wood.
- **EN 460:** It combines the results of EN 350-2 and EN 335 in a "Guide to the durability requirements for wood to be used in hazard classes".
- **EN 599:** Durability of wood and wood-based products. Efficacy of preventive wood preservatives as determined by biological tests.
- **EN 13145:** This European Standard defines wood species, quality requirements, origin, manufacturing conditions, forms, dimensions and tolerances, as well as the durability and preservation of wood sleepers and bearers for use in railway tracks.

2.5.3 Alternatives to creosoted wooden sleepers

Several studies giving an overview of possible alternatives have been carried out:

- A 2010 Swedish study: "Alternativ till kreosotimpregnerade sliprar" by Melica-consultants;
- A 2012 Austrian study: "Potentialabschätzung von Alternativen zur Kreosot-Imprägnierung von Bahnschwellen aus Holz" by Holz Forschung Austria;
- Studies by Woodprotect and THP on different preservation methods.

Some alternatives have already been in use for several years, others are still in test phase. The possible alternatives can be divided as follow:

1) Chemical wood preservatives: These alternatives can be applied in the same pressure-vacuum plants that are in use for the impregnation with creosote
    a. Wood preservatives with chromium
    b. Wood preservatives without chromium
    c. Oil-based wood preservatives
2) Wood modification
3) Wood alternatives:
    a. Alternative materials
    b. Non-treated alternative wood

OVERVIEW OF AVAILABLE METHODS

Potential:

"-" : no

"+" : yes

"?" : need for further investigations

Chemical wood preservatives

Method	In use	Test phase	Potential	Comment
Wood preservatives with chromium			-	Copper salts and chromic acid, with addition of boron: → lifetime for beech: more than 20 years, good fixing through chromium → chromium is carcinogenic, possible ban within a few years (same problem as for creosote) → boron might also cause health issues: mutagenic, danger for genetic material
Wood preservatives without chromium				Copper and a co-biocide (Impralit KDS(-B), Wolmantit CX10, Tanalith E,…): → lifetime for beech: more than 20 years → biological efficiency is known because of existing documentation → use of many co-biocides → boron might also cause health issues: mutagenic, danger for genetic material → already on the market for some years → possible corrosion caused by copper ions → moist wood with free copper ions can increase conductivity
Tanalith	LDZ: 2010		+	Cost for treatment: ~ 17,5 Euro/sleeper

Method	In use	Test phase	Potential	Comment
Impralit KDS		Infrabel: 2012	+	
Wolmanit CX	RFI: 2007		+	RFI: fulfilment to EN standards EN335, EN599, EN350, EN351. The wood is treated with Wolmanit CX10 and subsequently with paraffin, no problems with electric conductivity. Cost for treatment: ~ 200 Euro/m³
Oil-based wood preservatives				
Sleeper protect		DB/JBV/ OBB/ Infrabel: 2011-2012	+	Sleeper protect is a water-free wood preservative on the basis of natural oils. It contains copper compounds and organic biocides to assure the biocidal efficiency. Aims at reducing conductivity and increasing the flexibility of treated sleepers: → lifetime of more than 20 years → no organic solvents → natural oil → Cu-additives
Linseed oil			?	100 % organic origin. The main uncertainty regards the lifespan of the sleepers. Negative effects cfr Swedish LCA.
Vegetable oil (oleobois)			-	Oleobois (France) – Research CNRS/ CIRAD (France) Immersion in heated oil without pressure Strong hydrophobicity, dimensional stability (constant volume?) not compatible for UC3 or UC4 (EN335)

Method	In use	Test phase	Potential	Comment
Asabo			-	Research of Ensiacet (France) Impregnation of vegetable oil with pressure (like creosote impregnation) Experiment made with a Swiss producer of wooden sleepers Apparently a problem with oil stability – Needs further research Effectiveness for UC3 or UC4 is uncertain
Creosote sleeper with paraffine surface			-	The sleeper offers some environmental advantages but creosote impregnation remains necessary.
Oil-treated pine sleepers with inlays of compressed wood			?	A study of pine sleepers with inlays of compressed wood has been carried out in Sweden. No results available yet

Wood Modification

Method	In use	Test phase	Potential	Comment
Acetylating (Accoya, Nl)			-	Requires acetic anhydride – difficult procedure Advantages: higher durability, dimension stability (constant volume?) Disadvantages: corrosion/smell, only one industrial plant, high price
Furfurylating (Kebony,N)			-	Pressure vacuum treatment with furfuryl-alcohol followed by drying and hardening Advantages: higher durability, dimension stability (id) Disadvantages: loss of mechanical characteristics

Method	In use	Test phase	Potential	Comment
Heat treatment (Thermowood, CH) (Platowood, Nl) (Retiwood, F)			-	High temperature without oxygen to prevent combustion – Full treatment: to the core of the wood Advantages: higher durability, dimensional stability (id) Disadvantages: → Ok for small thickness but hardly possible for big sections of wood like sleepers → Loss of wood flexibility: problematic for railway applications → Only possible for dry wood (12 % humidity hardly possible for big sections) → Aggressive surface causing corrosion of the baseplates and screws
Heat treatment with CO_2			-	BIO3D Replace H2O with CO_2: anhydride wood Full treatment: to the core of the wood – High temperature: ± 130°C Disadvantages: Collapses, loss of mechanical characteristics
DMDHEU-treatment (Belmadur, D)			-	Pressure vacuum treatment through drying interlacing Advantages: higher durability, dimension stability, hardness, pressure resistance Disadvantages: loss of mechanical characteristics, no industrial plant (2011)

Non-treated alternative wood

Method	In use	Test phase	Potential	Comment
Siberian larch	Vrtrack		-	Life span is questionable.
Austrian larch	OBB		-	Bridge sleepers, life span of only 10 years, since then only oak sleepers
Karri	Infrabel		-	Lifespan is questionable.
Azobe	Several IM		-	Sometimes, a light surface treatment with creosote is given to extend the life span.
Pine			-	Unimpregnated pine is suitable but its life span is too short.
Oak	Prorail/DSB		-	Unimpregnated oak has good qualities in track but its life span is too short.

Wood Alternatives – other materials

Sleepers	In use	Test phase	Potential	Comment
Concrete USP	Several IM		+	15 % more expensive than basic concrete sleeper
Steel	Several IM SBB		+	According to a life-cycle analysis, not a good alternative but has been in use for many years at SBB → for low traffic tracks (lifetime of 100 years) → possible reuse → lighter than wood
Aluminium			-	Uncertainties exist regarding function, environment and cost

Sleepers	In use	Test phase	Potential	Comment
TCS-concrete with wood characteristics		Sweden	+	The conclusion of the Swedish Study is that the TCS-concrete sleeper is a suitable alternative to creosoted wooden sleepers. Production of this kind of sleeper is not fully-automatic yet, so the cost per sleeper is very high: 150 EUR/sleeper including fastening system. In large scale production the cost would be about 50-60 EUR/sleeper Trafikverket has 120 TCS-sleepers in use since August 2010 (main track – low traffic) and is planning to install about 1500-3000 TCS-sleepers in 2013 (main track).
Poly wood composite			-	A sleeper mainly made up of recycled plastics (uncertain life span).
FFU sleeper	DB: 2011 OBB: 2010 (bridge)		+	Corrosion-resistant structural material made from **f**iber-reinforced **f**oamed **u**rethane. ⇢ FFU is a strong structural material, but it is as light as lumber and has excellent working properties. ⇢ Since FFU is a plastic material, it also has excellent durability and water resistance. ⇢ Technical experiences are good but the price is at the moment 9 to 10 times more than for a treated concrete sleeper (DB). Price of Poly urethane is quite high.
TieTek-composite			-	TieTek – composite material mainly made up of used car tires. Tested in America, Highly Aromatics oils can cause a problem

Sleepers	In use	Test phase	Potential	Comment
Primix Corporation composite			-	A heterogeneous “engineered” sleeper, not yet tested in track. Non-renewable materials are used.
Plas Ties – wood with plastic cover			-	A wooden core is impregnated, in this case with borate, and then concealed with plastic. The environmental effects depend on which plastic is used
WoodPlastic composite sleeper			-	The wood-plastic composite sleeper does not function with spikes. Swedish experiences suggest a quite long life span.

3 Conclusions and next steps

All IM and wood producers will try to identify a suitable alternative to creosoted wooden sleepers with better environmental performance (life-cycle perspective) and that fulfils the required technical and functional properties.

This alternative sleeper could for example be a wooden sleeper with a new impregnating agent without negative impact on health and environment. It could also be a completely different material with the same characteristics as wood. As mentioned above, a lot of alternatives are already in use or being tested…but, sometimes not long enough to collect all the necessary data to perform a life-cycle assessment.

In 2012 there are some alternatives available but they do not fulfil all the necessary economical, environmental and technical conditions.

In the absence of satisfactory substitutes to wood or to creosote, the European railways are still relying on creosote impregnated sleepers for its activities at least until 2018 as it has been allowed by the European Commission.

In order to be able to formulate a clear answer for the European Commission (and national governments as well), it is necessary that IM exchange information so that the following deliverables be met by 2018:

1. close follow-up of the tests being carried out with different impregnation and wood alternatives:
    - environmental impact (lixiviation tests, emissions' monitoring at incineration plants),
    - human toxicology,
    - technical and functional properties,
    - costs,
    - disposal possibilities,
    - time needed to be able to market / industrialize.

2. LCA on wooden sleepers with different impregnation alternatives.

References:

- CER: “A ban on the use of creosote, possible consequences for the railway sector, 2008
- Answers from the different IM on the SUWOS-questionnaire, 2011
- THP, “Sleeper Protect / SP-Sleepers: The consequent improvement of the professional railway sleeper treatment”,
- IVL Swedish Environmental Research Institute, “Background data and assumptions made for an LCA on creosote poles”, October 2009;
- Umwelt & Entwicklung, “Life cycle assessment (LCA) of railway sleepers: comparison of railway sleepers made from concrete, steel, beech wood and oak wood”, November 2009;
- Melica, “Alternativ till kreosotimpregnerade sliprar”, 2010;
- Holz Forschung Austria, “Potentialabschätzung von Alternativen zur Kreosot-Imprägnierung von Bahnschwellen aus Holz” 2012;
- Studio CRONA AB, Jan Schmidtbauer Crona & Stefan Bydén LCA av alterniv betongsliper och linolkeimregnerad träsliper – som alternativ till Kreosotsliper, 2012

Text editing

Name	Company	Email
Willy Bontinck	SNCB-Holding, Direction Stratégie et coordination ; H-SE.03 Coordination centrale Environnement	Willy.bontinck@b-holding.be
Leen Wittevrongel	SNCB-Holding, Direction Stratégie et coordination ; H-SE.03 Coordination centrale Environnement	Leen.wittevrongel@b-holding.be
Thibaut De Gyns	INFRABEL, Corporate & Public Affairs	Thibaut.degyns@infrabel.be

IM – co-operation to questionnaire and/or working group from December 2011 to June 2012

Name	Company	Email
Pascal Fodiman	SNCF Infra	Pascal.fodiman@sncf.fr
Jean-Louis Cazillac	SNCF Infra – Pôle Développement prospective, Développement durable	Jean-louis.cazillac@sncf.fr
Anne-Laure Genty	RFF – Unité Performance et Développement Durable	Anne-Laure.genty@rff.fr
Nicolas Milesi	RFF	Nicolas.milesi@rff.fr
Christian Suhren	DB Netze – Werk Oberbaustoffen Witte	christian.suhren@deutschebahn.com
Anders Hammar	Trafikverket – Operations Division Infrastructure, Track & Civil Engineering	anders.hammar@trafikverket.se
Malin Kotake	Trafikverket – Nationell samordnare Material och Kemiska produkter	Malin.Kotake@trafikverket.se
Anu Asikainen	VR Track – Quality and Environment	anu.asikainen@vr.fi
Pekka Rautanen	VR Track – Materials	Pekka.rautanen@vr.fi
Susanna Koivujärvi	Finnish Transport Agency – Environmental Specialist	susanna.koivujarvi@fta.fi
Julie M Amlie	Jernbaneverket – Environmental Advisor	julie.mathilde.amlie@jbv.no
Stein Olav Lundgreen	Jernbaneverket – Technology Department	Stein.olav.lundgreen@jbv.no
Aleksandra Grabowska	PKP – Biuro Ochrony Srodowiska	al.grabowska@plk-sa.pl
Urszula Michajlow	PKP	u.michajlow@plk-sa.pl
Iwona Zubiliwicz	PKP	i.zubilewicz@plk-sa.pl
Leslaw Czaczka	PKP	l.czaczka@plk-sa.pl
Bruno Müller	SBB Infrastruktur – Anlagen und Technologie	Bruno.mb.mueller@sbb.ch
Coen Valkenburg	ProRail - Systeemspecialist Spoor	Coen.Valkenburg@Prorail.nl
László Daczi	MAV - Vezérigaztóság	daczil@mav.hu
Gonzalo Martin de Miguel	ADIF – Tecnico de Via	gmartindemiguel@adif.es
Maris Poikans	LDZ – Environmental Manager	Maris.poikans@ldz.lv
Jan Panchartek	SZDC – Department of railway infrastructure management	panchartek@szdc.cz
Rafael Peerlinck	INFRABEL	Rafael.peerlinck@infrabel.be
Helmut Reitbauer	OBB – Infrastruktur AG	Helmut.reitbauer@oebb.at
Harold Resida	NS – Coördinator milieu- en privacybeleid	Harold.resida@NS.nl
Mario Testa	RFI – Direzione Tecnica	M.Testa@rfi.it

ETF
Editions Techniques Ferroviaires
Railway Technical Publications
Eisenbahntechnische Publikationen

16 rue Jean Rey - F 75015 Paris
Email: ETFpubli@uic.org
www.uic.org/etf

Published by
International Union of Railways (UIC) - Railway Technical Publications (ETF)
16, rue Jean Rey 75015 Paris - France
Cover and layout: Coralie Filippini / © ETF Publication
January 2013

ISBN 978-2-7461-2164-5