Best Available Techniques (BAT) in wood preservation with chemicals

Pöyry Finland Oy and Pöyry SwedPower AB

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Content

Abstract

The Nordic Council of Ministers, the BAT Group under the Working Group for sustainable consumption and production, has requested the consultant Pöyry Finland to prepare a report on Best Available Techniques (BAT) in wood preservation with chemicals in the Nordic countries.

The project describes the present status of the used technologies, their emissions and impacts on the environment and technologies that can be considered BAT. The provided information can be utilized by operators, environmental consultants and competent environmental authorities. The report will also be used as an input from the Nordic countries to the EU process under the Industrial Emissions Directive (IED) for preparation of the BAT Reference Document for preservation of wood and wood products with chemicals (WPC BREF) which is foreseen to start in 2014.

The team of consultants that have contributed to the report were:

- Esa Salminen, Pöyry Finland Oy
- Risto Valo, Pöyry Finland Oy
- Maarit Korhonen, Pöyry Finland Oy
- Rikard Jernlås, Pöyry SwedPower AB

The work was supervised by the following Nordic BAT-group members:

- Egil Strøm (Chairman of the group), Norwegian Environment Agency, Norway
- Kaj Forsius, Finnish Environment Institute
- Lena Ziskason, Environment Agency of Faroe Islands
- Jaakko Kuisma, Finnish Ministry of the Environment
- Sigurdur Ingason, Environment Agency of Iceland
- Susanne Särs, Environmental and Health Protection Agency of the Aland Islands
- Birgitte Holm Christensen, Danish Environmental Protection Agency
- Annika Månsson, Swedish Environmental Protection Agency

The BAT project has also been followed and commented on by wood impregnation industry specialists:

- Knut Einar Fjulsrud, Treindustrien, Norway
- Tommi Tähkälä, Kestopuuteollisuus Ry, Demolite Oy, Finland

- Mikael Westin, Svenska Träskyddsföreningen, Sweden
- Bjarne Lund Johansen, Træinformation, Denmark
- Rögnvaldur S. Gislason, Innovation Centre Iceland, Iceland

Summary

The Nordic Council of Ministers, the BAT Group under the Working Group for sustainable consumption and production, has requested the consultant to prepare a report on Best Available Techniques (BAT) in wood preservation with chemicals in the Nordic countries. The project describes the present status of the used technologies, their emissions and impacts on the environment and technologies that can be considered BAT. The provided information can be utilized by operators, environmental consultants and competent environmental authorities. The report will also be used as an input from the Nordic countries to the EU process under the Industrial Emissions Directive (IED) for preparation of the BAT Reference Document for preservation of wood and wood products with chemicals (WPC BREF) which is foreseen to start in 2014.

The Nordic wood preserving industry produces around 2.1 million m^3 of impregnated wood per year, which is about one third of the total supply of pressure-treated wood in Europe. Impregnation usually takes place using water-borne copper salts by different pressure and/or vacuum techniques. Oil-borne creosote, on the other hand, is used in situations where the product is used also underground and in contact with water and in constructions with specific load-carrying demand, for example, in poles and sleepers. There are also other chemicals, processes and techniques in use, such as the flow-coat technology common in Denmark.

The Nordic wood preserving industry relies on the standardized and optimized use of impregnating chemicals specified in the EU and Nordic standards. Important pre-conditions for production are quality control and regular and systematic maintenance of processes, as well as trained and motivated personnel. These pre-conditions are important also in view of the minimization of environmental impacts of the industry.

Since wood impregnating chemicals are classified as dangerous for the aquatic environment, and they are not or only slowly biodegradable, protection of surface waters, soil and groundwater and the minimization of accidental risks is an important environmental aspect in wood impregnation. Replacing hazardous chemicals with less hazardous ones and the minimization of use of chemicals when technically and economically possible are key environmental targets in the wood impregnation industry.

The impregnation process is principally a closed system and therefore, under normal operation conditions, emissions into the environment are limited. Emissions of volatile organic compounds (VOC) into

air, and sometimes odour, are possible from impregnation with oil-borne and organic solvent-based preservatives such as creosote, whereas these emissions are limited in impregnation with water-based impregnating chemicals. Some air emissions can also be produced from finished products storage areas and associated traffic and from ancillary boiler houses.

List of abbreviations

BAT Group	BAT Group is a sub-group of the Working Group for Sustainable Consumption and Production
BAT	Best Available Techniques
BREF document	Best Available Technology Reference Documents; Wood and Wood Products Preservation with Chemicals BREF review will start during 2014
BPR	The Biocidal Product Regulation (EU Regulations No 528/2012 BPR)
CCA	Chromate copper arsenate
CO_x	Carbon oxides
ECHA	European Chemical Agency
PAH	Polyaromatic hydrocarbons
IED directive	The Industrial Emissions Directive (2010/75/EU) lays down rules on the integrated prevention and control of pollution arising from industrial activities; reduce emissions into air, water and land and to prevent the generation of waste in order to achieve a high level of protection of the environment taken as a whole
NO_x	Nitrogen oxides
NTR	Nordiska Träskyddsrådet, Nordic Tree Proctection Association
NTR classes	NTR defines four different wood impregnation classes which indicate the resilience of impregnated wood against degrading environmental factors
NWPC	Nordic Wood Preservation Council
SO_x	Sulphur oxides
VOC	Volatile organic compounds

1. Introduction

1.1 Background and objectives

The Nordic Council of Ministers, the BAT Group under the Working Group for sustainable consumption and production, has requested the consultant to prepare a report on Best Available Techniques (BAT) in wood preservation with chemicals in the Nordic countries. The project aims to provide information for operators, environmental consultants and competent environmental authorities on what is considered BAT within the industrial sector, as defined in the context of the EU's environmental legislation.

The Industrial Emissions Directive (IED, 2010/75/EU), in force since January 2011 defines the term "best available techniques" as "the most effective and advanced stage in the development of activities and their methods of operation which indicates the practical suitability of particular techniques for providing the basis for emission limit values and other permit conditions designed to prevent and, where that is not practicable, to reduce emissions and the impact on the environment as a whole." This definition is further clarified as follows:

- "techniques" includes both the technology used and the way in which the installation is designed, built, maintained, operated and decommissioned.
- "available" techniques are those developed on a scale that allows implementation in the relevant industrial sector, under economically and technically viable conditions, taking into consideration the costs and advantages, whether or not the techniques are used or produced inside the Member State in question, as long as they are reasonably accessible to the operator.
- "best" means most effective in achieving a high general level of protection of the environment as a whole.

BAT shall be the reference for setting new permit conditions for installations as defined in so-called BAT reference documents.

- "BAT reference document" means a document, resulting from the exchange of information organised pursuant to Article 13, drawn up for defined activities and describing, in particular, applied techniques, present emissions and consumption levels, techniques considered for the determination of best available techniques as well as BAT conclusions and any emerging techniques, giving special consideration to the criteria listed in Annex III;

- "BAT conclusions" means a document containing the parts of a BAT reference document laying down the conclusions on best available techniques, their description, information to assess their applicability, the emission levels associated with the best available techniques, associated monitoring, associated consumption levels and, where appropriate, relevant site remediation measures;
- "emission levels associated with the best available techniques" means the range of emission levels obtained under normal operating conditions using the best available technique or a combination of best available techniques, as described in BAT conclusions, expressed as an average over a given period of time, under specified reference conditions;

The IED (2010/75/EU) replaces the Integrated Pollution Prevention and Control (IPPC) Directive (2008/1/EC),

The purpose of this project is to provide timely information for the BAT reference documents preparation process for those wood preservation activities covered by the IED (capacity over 75 m^3/day), but also as a basis for setting permit conditions for smaller installations in the industrial sector.

1.2 Scope and methodology

Scope

This report covers the following areas:

- Chapter 2 provides definitions and wood impregnation classes and an overview of the industry in the Nordic countries.
- Chapter 3 provides a brief description of commonly used wood preservation chemicals, processes and techniques in use in the Nordic countries, including directly associated on-site activities in wood preservation processes and also emerging technologies.
- Chapter 4 describes emissions from wood impregnation, including the emissions of volatile organic compounds, odour and other air emissions, emissions to water, soil protection, noise, wastes and other relevant environmental aspects of commonly used processes, including raw material, water, chemical, and energy use.
- Chapter 5 summarizes the identified best available techniques (BAT) for wood preservation with chemicals covering all of the relevant processes and techniques.

Methodology

Available information on chemical wood impregnation and Nordic installations was reviewed. In the course of the work associations, authorities and operators were contacted and impregnation plants were visited.

Team of consultants

The team of consultants that have contributed to the report were:

- Esa Salminen, Pöyry Finland Oy
- Risto Valo, Pöyry Finland Oy
- Maarit Korhonen, Pöyry Finland Oy
- Rikard Jernlås, Pöyry SwedPower AB

BAT Group

The BAT project has been followed and commented on by the Nordic BAT Group. The members of the BAT Group are:

- Egil Strøm (Chairman of the group), Norwegian Environment Agency, Norway
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Other experts

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- Knut Einar Fjulsrud, Treindustrien, Norway
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2. General information

Wood impregnation protects wood from biological deterioration. Wood impregnant can be defined as "*active ingredient(s) or preparations containing active ingredient(s) in the form in which they are placed on the market, and which are, on the basis of the properties of their active ingredient(s), intended to prevent wood-destroying and/or wood disfiguring organisms (fungi, insects and marine borers) from attacking wood and wood-based products.*"[1]

Wood impregnation takes place in specialized companies or as a production step in sawmills or other wood processing industries, e.g. window and door production. However, this activity, as defined in the BREF context, does not cover the surface coating of timber with paints, varnishes or lacquer. Although, these applications include a protective function, the main purpose of these activities is of a decorative nature.[2]

Wood preservation chemicals can be divided into water-borne, oil-borne and organic solvent-based preservatives. Among the Nordic wood preservation industry, impregnation with water-borne copper salts and oil-borne creosote, usually by different pressure and/or vacuum techniques are the most common, whereas there are also other chemicals, techniques and processes in use, such as the flow-coat technology.

Other wood protection technologies that are not based on chemical treatment, such as thermal treatment, are not discussed in this report.

2.1 Sector overview

The European wood preserving industry produces around 6.5 million m^3 of pressure-treated wood per year. As Figure 1 shows, 44 % of the production is used as garden timber, 21 % as construction timber, 15 % as small roundwood and 6 % as sleepers. 71 % of this wood is treated with water-borne products, 11 % with creosote, mainly poles and sleepers and 18 % with solvent based products, mainly construction timber such as window and door joinery (see Figure 2).[3] Creosote impregnation

[1] Nordic Wood Preservation Council (NWPC), NWPC's conditions for approval of wood preservatives for the production of quality certified treated wood according to NWPC Document No 1:2010

[2] European Commission - DG Environment, Guidance on VOC Substitution and Reduction for Activities Covered by the VOC Solvents Emissions Directive (Directive 1999/13/EC), Guidance 12: Wood impregnation, Contract ENV/C.4/FRA/2007/001; www.enviroportal.sk/.../275pdfsamVOC-doc-210509.p

[3] WEI, Internet pages of WEI, http://www.wei-ieo.org/woodpreservation.html

is somewhat declining because regulations have become tighter and because of new non-wooden products, e.g. the use of concrete sleepers for new railway-lines. In the case of poles, even an increased use of creosote in impregnation has been reported in Europe. However, a significant share of this is exported to countries outside the EU.[4]

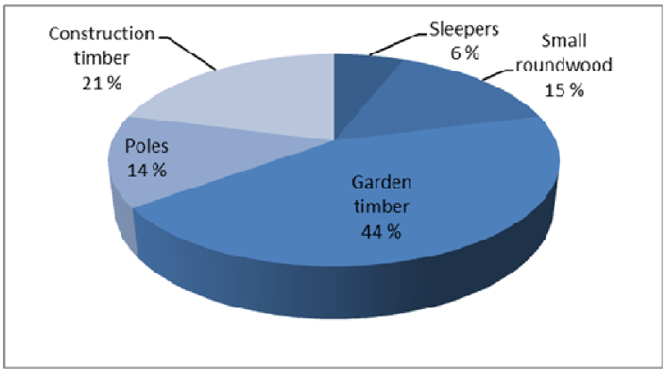

Figure 1 **European wood preserving industry production categorized by types of product.**

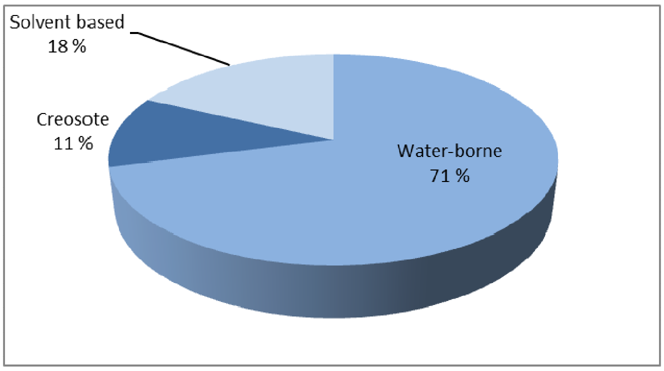

Figure 2 **European wood preserving industry production categorized by impregnant type.**

The Nordic wood preserving industry produced around 2.1 million m^3 of pressure-treated wood in 2012. This amount comprises about one third of the total European supply of pressure-treated wood. The total production of pressure-treated wood in different Nordic countries and number of installations in each country is summarized in Table 1. In the Nordic countries, Sweden is the biggest producer of pressure-treated wood, followed by Norway, Finland and Denmark. In Iceland, there are

[4] European Commission - DG Environment, Guidance on VOC Substitution and Reduction for Activities Covered by the VOC Solvents Emissions Directive (Directive 1999/13/EC), Guidance 12: Wood impregnation, Contract ENV/C.4/FRA/2007/001; www.enviroportal.sk/.../275pdfsamVOC-doc-210509.p

no impregnation plants having large-scale industrial production. Table 1 also summarizes the number of plants in different countries. Roughly half of these plants have a maximum production capacity more than 75 m^3 per day, which is the capacity threshold limit of applicability of the IED. In addition, there are some very small installations not included in these numbers. It is noteworthy that the plants do not operate all year around with the same capacity. The highest season in sales and use is typically from March to August, whereas in the other seasons the plants produce varying amounts to stock and to export.

Table 1 **Nordic wood impregnation plants and their production in 2012.**

Country	**Number of plants**	**Production in 2012 in m^3**
Sweden	63	1,312,000
Finland[a]	18	309,000
Norway	33	436,000
Denmark	3	71,000
Iceland	production only in small scale	N/A
Total	117	About 2.13 million

[a] This includes one installation in Åland producing 2500 - 5000 m^3 of impregnated wood per annum

N/A information not available

Figure 3 shows the Nordic wood preserving industry production categorized by types of the products. In Sweden about 92 %, in Norway about 88 % and in Finland about 76 % of industrially pressure-treated wood is sawn and planed timber, which is significantly more than elsewhere in Europe. Poles comprise about 21 % in Finland, but in Sweden and Norway only about 3 % of industrially impregnated wood. Figure 4 shows the Nordic wood preserving industry categorized by impregnant type. Similarly as elsewhere in Europe, wood is mostly treated with water-borne preservatives also in the Nordic countries. It is noteworthy that a significant part of the production in Sweden is exported. In Denmark, flow-coat spray painting, also using water-borne chemicals, has by far replaced pressure-treated wood in window and door joinery production. Flow-coat production amounts in Denmark were not readily available.

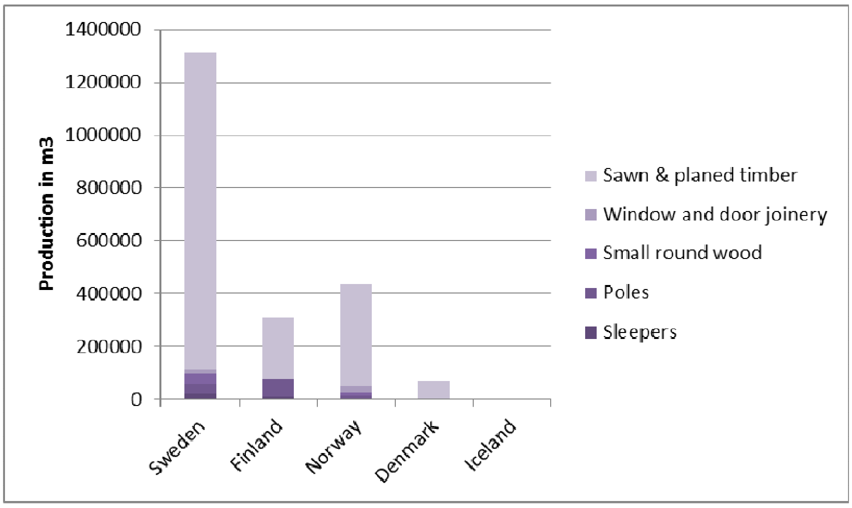

Figure 3 **Nordic wood preserving industry production categorized by types of product in 2012.**[5]

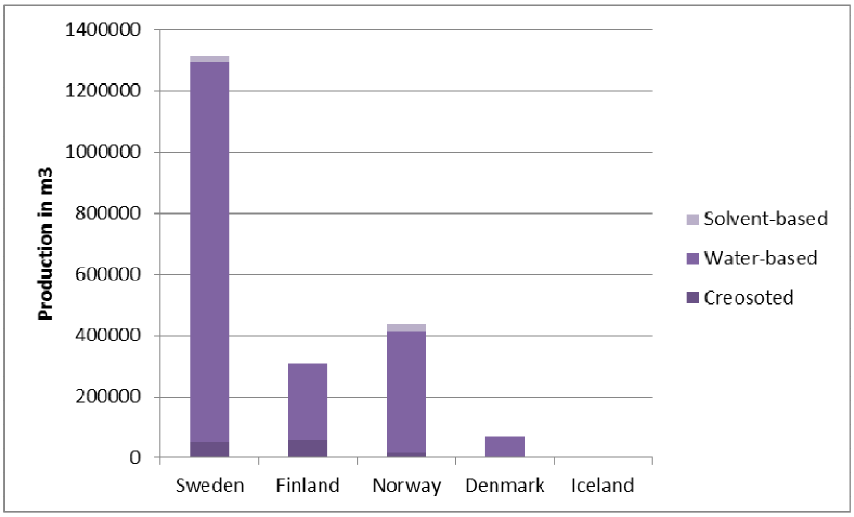

Figure 4 **Nordic wood preserving industry production categorized by impregnant type in 2012.**[5]

[5] WEI statistics from 2012

2.2 Wood impregnation classes

The applicable EU standards (335-1, 351-1 and 599-1)[6] provide guidance on use of impregnating agents for solid timber and wood-based products in defined situations. The standards define five Use Classes that shall be used as the basis for specifying preservative treatments for particular products in order to guarantee the durability of the products in the defined situations:

- Class 1 is to be used in a situation in which the wood or wood-based product is under cover, not exposed to the weather and soaking.
- Class 2 is to be used in a situation in which the wood or wood-based product is under cover and not exposed to the weather but where high environmental humidity can lead to occasional, but not persistent wetting.
- Class 3 is to be used in a situation in which the wood or wood-based product is not under cover and not in contact with the ground. It is either continually exposed to the weather or is protected from the weather but subject to wetting.
- Class 4 is to be used in a situation in which the wood or wood-based product is in contact with the ground or fresh water and thus is permanently exposed to wetting.
- Class 5 is to be used in a situation in which the wood or wood-based product is permanently exposed to salt water.

The Nordic Wood Preservation Council (NWPC) has developed Nordic product quality standards, which consist of three documents: the NWPC Document No 1 for classification of Nordic Use Classes according to EN 335 and 350, Document 2 with the approval system for preservatives and the assesment of retention levels, and Document 3 for internal control and third-party inspections.[7] The Nordicstandards are in line

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[6] EN standard 335-1, Durability of wood and derived materials -Definition of use classes of biological attack - Part 1 General
EN standard 351-1, Durability of wood and wood-based products -Preservative-treated solid wood - Part 1: Classification of preservative penetration and retention
EN standard 599-1 Durability of wood and wood-based products – Performance of preservatives as determined by biological tests Specification according to hazard class

[7] Nordic Wood Preservation Council: Dokument NTR Dokument nr 1:2011, Nordiska träskyddsklasser och produktkrav för impregnerat trä. Del 1: Furu och andra lätt impregnerbara barrträslag; NTR Dokument nr 2:2010, Nordiske regler for godkendelse af midler til industriel træimpregnering. Del 1: Fyr og andre let imprægnerbare nåletræarter; NWPC Document nr 2:2010, Conditions for approval of wood preservatives for industrial wood preservation in the Nordic countries. Part 1: Scots pine and other permeable softwoods;

with the corresponding EU standards, but have some additional features such as the requirement for third-party control and confirmed optimal retention for each use class taking into consideration the efficency of the product and environmental concern. According to the NTR standards, wood impregnation classes are as follows:

- Wood preservation in class NTR B usually takes place by organic oil-based impregnants. Products can be used in commodities, such as external joinery for use in conjunction with paint or other coating or with some other form of protective covering applied prior to exposure in use that protects the preservative from leaching, such as window frames.
- Wood preservation in class NTR AB (corresponding to EN class 3) can take place by either by copper-based impregnants or by metal- free impregnants. Products can be used in commodities used above ground, outdoors in all weathers.
- Wood preservation in class NTR A (corresponding to EN class 4) usually takes place by copper-based impregnants or creosote. Products can also be used underground and in contact with water (salt content not more than 0.7 %) and constructions with load-carrying demands, such as electricity grid poles, railway sleepers, balconies, fences and gate poles.
  Wood preservation in class NTR M (corresponding to EN class 5) takes place by copper-based impregnants or creosote. Products can be used also in contact with seawater and constructions with load-carrying demands, in harbors and construction foundations.

The penetration of wood impregnating chemicals and standardized markings in the different NTR classes are illustrated in Figure 5. Product packages and sometimes each impregnated wood board are marked with a tag showing the impregnation class, used impregnation solution and the manufacturer. Nordic countries also have national standards that are in line with the corresponding Nordic and EU standards.

NTR Dokument nr 3:2011. Tillämpningsområde Sverige. Nordiska regler för kvalitetskontroll av impregnerat trä. Del 1: Furu och andra lätt impregnerbara barrträslag; http://www.ntr-nwpc.com/1.0.1.0/10/1/

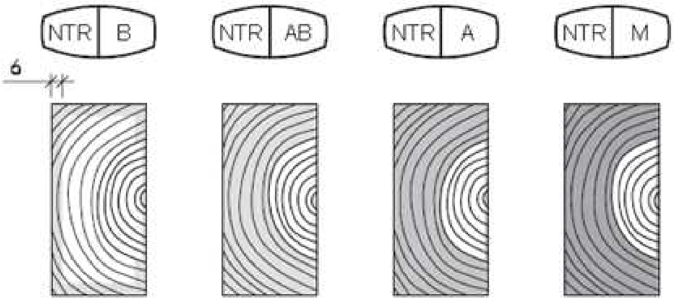

Figure 5 ***The illustrations of penetration of wood impregnating chemicals and markings in different classes.***[8]

Figure 6 ***Impregnated wood storage.***

[8] RT 21-10880 Impregnated wood in Finland

3. Applied chemicals, processes and techniques

3.1 Wood preservation chemicals

Most impregnating chemicals are classified as toxic, dangerous to the environment and they are not or only slowly biodegradable. The preservation solution consists of the preservative itself, but also of anti-mold agents, anti-slime build-up agents and coloring agents. All of these chemicals, except coloring agents, are toxic and dangerous to the environment. Handling of wood impregnating chemicals therefore requires the use of appropriate precautions and also of personal protection measures.

In the EU trade and use of wood preserving biocides require authorization under the Biocidal Regulation 528/2012 (previously Biocidal Directive 98/8/EC). Authorization requires an acceptance procedure where risks to human health and the environment are assessed. Active substances in question shall be approved for an initial period of 10 or 5 years. Annex II of the Regulation sets detailed information and testing requirements for the acceptance of active substances. In principle, compounds containing carcinogens (classes 1A and1B), mutagens (categories 1A and 1B), toxic for reproduction (categories 1A and 1B), having endocrine-disrupting properties or being persistent, bioaccumulative and toxic or very persistent and very bioaccumulative do not get authorization. European Chemical Agency (ECHA) coordinates the registration of biocidal products and provides an EU-wide authoriaation. A national authorisation can also be applied. In this case the application is assessed and the authorisation granted by a competent national authority. Table 2 shows the approved active biocide substances for wood preservation in the EU as dated 25.02.2014.

Replacing hazardous chemicals with less hazardous ones when technically and economically possible is a key target in the wood impregnation industry. In the past, many other impregnation chemicals were also in use, such as chromate copper arsenate (CCA), pentachlorophenol and copper naphthenate, but their use has phased out because of the identified environmental and/or health risks and as less harmful products have been found to replace them. The production of CCA has been prohibited since September 2006 (according to the Directive 98/8/EC), whereas CCA can still be found widely in electricity poles and other applications.

Table 2 *EU approved active biocidic substances for wood preservation (25.02.2014).*

Active substance	CAS number	EC number	Reference
4,5-Dichloro- 2-octyl-2H-isothiazol-3-one (DCOIT)	64359-81-5	264-843-8	Directive 2011/66/EU
Alkyl (C12-16) dimethylbenzyl ammonium chloride - C12-16 ADBAC	68424-85-1	270-325-2	Directive 2013/7/EU
Basic copper carbonate	12069-69-1	235-113-6	Directive 2012/2/EU
Bifenthrin	82657-04-3	Plant protection product	Directive 2011/10/EU
Boric acid	10043-35-3	233-139-2	Directive 2009/94/EC
Boric oxide	1303-86-2	215-125-8	Directive 2009/98/EC
Chlorfenapyr	122453-73-0	Plant protection product	Directive 2013/27/EU
Clothianidin	210880-92-5	433-460-1	Directive 2008/15/EC
Copper (II) oxide	1317-38-0	215-269-1	Directive 2012/2/EU
Copper hydroxide	20427-59-2	243-815-9	Directive 2012/2/EU
Creosote	8001-58-9	232-287-5	Directive 2011/71/EU
Cypermethrin	52315-07-8	257-842-9	Regulation (EU) 945/2013
Dazomet	533-74-4	208-576-7	Directive 2010/50/EU
DDACarbonate	894406-76-9		Directive 2012/22/EU
Dichlofluanid	1085-98-9	214-118-7	Directive 2007/20/EC
Didecyldimethylammonium Chloride (DDAC)	7173-51-5	230-525-2	Directive 2013/4/EU
Disodium octaborate tetrahydrate	12280-03-4	234-541-0	Directive 2009/96/EC
Disodium tetraborate	12267-73-1	215-540-4	Directive 2009/91/EC
Disodium tetraborate	1303-96-4	215-540-4	Directive 2009/91/EC
Disodium tetraborate	1330-43-4	215-540-4	Directive 2009/91/EC
Etofenprox	80844-07-1	407-980-2	Directive 2008/16/EC
Fenoxycarb	72490-01-8	276-696-7	Directive 2011/12/EU
Fenpropimorph	67564-91-4	266-719-9	Directive 2009/86/EC
Flufenoxuron	101463-69-8	417-680-3	Directive 2012/20/EU
Hydrogen cyanide	74-90-8	200-821-6	Directive 2012/42
IPBC	55406-53-6	259-627-5	Directive 2008/79/EC
K-HDO	66603-10-9		Directive 2008/80/EC
Propiconazole	60207-90-1	262-104-4	Directive 2008/78/EC
Sulfuryl fluoride	2699-79-8	220-281-5	Directive 2006/140/EC
Tebuconazole	107534-96-3	403-640-2	Directive 2008/86/EC
Thiabendazole	148-79-8	205-725-8	Directive 2008/85/EC
Thiacloprid	111988-49-9		Directive 2009/88/EC
Thiamethoxam	153719-23-4	428-650-4	Directive 2008/77/EC
Tolylfluanid	731-27-1	211-986-9	Directive 2009/151/EC

Wood preservation chemicals can be divided into water-borne, oil-borne and organic solvent-based preservatives. During the last decade, water-borne preservatives have become more widely used. Today the most commonly used preservatives are copper compounds (typically containing ammoniacal copper quaternary compounds or copper azole, whereas sometimes also other copper compounds). Some of the preservatives also contain chromium, boric acid and/or water-based micro emulsions such as azoles or quaternary ammonium compounds. The advantages of water-borne preservatives include dry and paintable surface of treated wood and no odour.

Creosote is the most widely used oil-borne and tar-based wood impregnant. It is used if conditions are particularly harsh, i.e. products can be used also underground and in contact with water, even seawater, and in constructions with load-carrying demands. Creosote impregnation is commonly used for telephone poles and railroads.

Creosote is an effective preservative having a low solubility in water and therefore a high resistance to leaching. On the other hand, creosote (coal tar) contains polyaromatic hydrocarbons (PAH), including benzo(a)pyrene that is classified by the International Agency for Research on Cancer as a Group 1 carcinogen. Use of creosote is regulated among other wood protection biocides following the rules of the Biocidal Regulation 528/2012. Furthermore, the EU legislation specifies and restricts the use of creosote, but allows its use when no technically or socioeconomically appropriate alternatives are available. For example, replacing all creosote in railroad poles with concrete would be very expensive and replacing just a part of the poles in repair works is not a possible option. The directive limits the use of creosote in products containing less than 0.005 % (by mass) of benzo[a]pyrene and less than 3 % (by mass) water extractable phenols. Those Member States authorizing the use of creosote shall, no later than 31 July 2016, submit a report to the Commission justifying their conclusion that there are no appropriate alternatives and indicating how the development of alternatives is being promoted.[9]

The amount of impregnant in preserved wood is the highest in class NTR M and the lowest in class NTR B. Table 3 shows the list of NTR accepted wood preservatives, their active ingredients and the amount of preservative needed to meet the quality standards of the Swedish Technical Inspection Institute.

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

Table 3 ***NTR list of accepted wood preservatives, their active ingredients and the amount of preservative needed to meet the quality standards of Swedish Technical Inspection Institute.***

Preservation agent (trade name)	Active ingredient	The amount of impregnation agent needed to achieve specific impregnation NTR class kg/m[3]			
		M	A	AB	B
Celcure P50 Fluid	copper, chromium, phosphorus	60.0	30.0		
Impralit CK	copper, chromium	26.0	19.0		
Celcure AC 500	copper, boron, N-alkylbenzyl-dimethylammoniumchloride	-	25.0	12.0	
Celcure AC 800	copper, N-alkylbenzyl-dimethylammoniumchloride	-	36.0	19.0	19.0
Impralit BKD	boron, polymeric betaine	-	-	10.0	-
Impralit KDS 4	copper, polymeric betaine, boron	-	36.0	15.0	-
Kemwood ACQ 1900	copper, N-alkylbenzyl-dimethylammoniumchloride	-	36.0	19.0	-
Kemwood ACQ 2200	copper, boron, N-alkylbenzyl-dimethylammoniumchloride	-	25.0	12.0	-
Sinesto B	N-alkyltrimethylammonium-chloride, boron	-	-	21.0	21.0
Tanalith E-7	copper, boron, tebuconazol, propiconazol	-	16.0	8.0	-
Wolmanit CX-8	copper, copper-HDO, boron	-	22.0	10.0	10.0
Wolmanit CX-8 WB	copper, copper-HDO	-	22.0	10.0	-
Wolmanit CX-10	copper, copper-HDO, boron	-	18.0	9.0	9.0
Wolsit KD-10	propiconazol	-	-	11.0	3.5
Gori 605	propiconazol, tebuconazol, IPBC	-	-	-	0.23[(2]
Protim P-vac 11	propiconazol	-	-	-	0.41[(2]
Vft-Creosote oil M	derived from coal tar[(3]	400	110	80	-
Creosote oil	derived from coal tar [(3]	400	110	80	-
Wood protection Type C	derived from coal tar [(3, (4]	400	100	70	-

2) Absorption is calculated for the sum of active ingredients (propiconazol, etc).

3) Creosote oil shall meet the requirements of EN 13991 type A, B or C.

4) Wood protection agent C consists of 80 % creosote, which is the active ingredient. Absorption is indicated for 100 % creosote oil.

3.2 The most common wood preservation techniques

The most typical wood preservation techniques in use in the Nordic countries are the Bethell process and its modifications used mainly in impregnation with metal oxides and the Rüping process used mainly in creosote impregnation. These techniques are described in more details in the following.

3.2.1 Bethell process and its modifications in wood preservation with metal oxides

Bethell process is the most typical technology for wood preservation with metal oxides. It is a treatment process where an aqueous solution of impregnant is applied using a vacuum and pressure cycle.[10] The process is also called the full-cell method in which the purpose is to fill the wood cells with the impreganation agent in order to receive the highest possible amount of impregnant in the wood. The penetration of the impregnation agent is based on the vacuum created before the process.

The Bethell process begins with a preliminary vacuum, which creates a vacuum inside the wood also. The vacuum is maintained and injection of the impregnation agent begins. When the pressure cylinder is full of the impregnation agent the vacuum is removed and overpressure is created. The overpressure, usually above 1,200 kPa, makes the impregnation agent penetrate the wood. The time of overpressure varies from minutes to hours. After the overpressure period, normal pressure is restored. Finally a short vacuum is created to remove all excess impregnation agents from the wood. This prevents dripping when the wood packages are stored.[11] The process is illustrated in Figure 7.

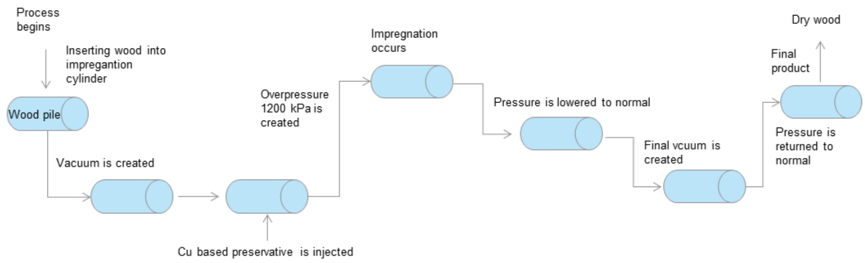

Figure 7 ***Bethell process description.***

[10] Väärä,T. and Boren,H. 2012. Wood modification cluster. Kymenlaakso University of Applied Sciences. Report 84, ISSN: 1239-9094, 70 p.

[11] Vehviläinen, H. 2011. Planning of Automation System for a Modern Wood Impregnation Plant. Kymenlaakso University of Applied Sciences. Mater Thesis, 29 p.

There are also different variations of the Bethell processes, for example:[12, 13]

- In the Lowry process, the preservation solution in injected into wood that has not been dried at low-pressure beforehand. The wood still has some air between the wood cells preventing the preservation solution from penetrating. In the Lowry process, less of the preservation solution is absorbed by the wood compared to the Bethell process.
- In the Royal process, after treatment in the Lowry process, the wood proceeds to a further treatment stage, the actual Royal process, in which it is boiled in a hot Royal bath that contains a fast fixating preservative. By impregnating the wood with linseed-based oil, it is provided with a long lasting water-repellent quality. At the same time, the wood is dried.
- In the oscillating pressure process, the pressure and vacuum phases alternate at short intervals. The process is particularly suitable for wet timber.

3.2.2 Rüping process in impregnating wood with creosote

The Rüping process is the most common method of impregnating wood with creosote under pressure. In the process, there is no initial vacuum such as in the Bethell process. The Rüping process begins by creating a preliminary pressure of 100–700 kPa. During this period, air is compressed into wood cells, after which the pressure cylinder is filled with impregnation agent and the air in the wood cells is compressed. After impregnation, the pressure is returned to normal. In this stage the air left in the wood cells starts to expel the excess impregnation fluid. The process is completed with a vacuum during which all excess impregnation agent is drawn from the wood. This prevents dripping during storage stage. The final product is wood that has the cell walls thoroughly treated. The process is illustrated in Figure 8.

[12] BASF Wolman GmbH internet pages, http://www.wolman.de/en/wood_preservation/vacuum_pressure_impregnation/index.php

[13] Väärä,T. and Boren,H. 2012. Wood modification cluster. Kymenlaakso University of Applied Sciences. Report 84, ISSN: 1239-9094, 70 p.

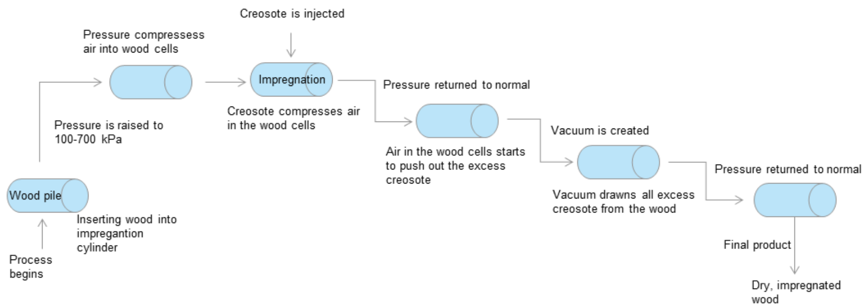

Figure 8 Rüping process description.

3.3 Other techniques and chemicals in use for chemical wood preservation

Several other wood protection techniques and chemicals are also in use in the Nordic countries. Many of them, however, have no NTR approval. The purpose of the products varies. Sometimes only the wood surface is protected and mainly against sapstain fungi and similar microorganisms in order to give a shorter-term protection to wood used as building and construction timber. Some examples of these other techniques and chemicals are given in the following:

- The so-called flow-coat process is a commonly used spraying technique in Denmark for window and door joinery products. In the flow-coat process a spray tunnel enables the preservative to be applied evenly and economically with only little wastage. The flow-coat process uses water-borne chemicals.
- SUPERWOOD™ is a new, Danish developed impregnation method, based on impregnation by means of supercritical CO_2. By using this method, the use of chemicals per m^3 wood can be lower compared to conventional methods. CO_2 and wood preservatives are added to the vessel and the pressure is increased. The so-called "critical" values of pressure and temperature are reached and, under these conditions, CO_2 carries the wood preservatives into the wood (see Figure 9). The wood is impregnated to the core and remains relatively dry for the entire duration of the process. The pressure returns to normal and the process is completed. Excess CO_2 and wood preservatives are collected and recycled. [14]

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[14] Superwood A/S internet pages, http://www.superwood.dk/en/the-superwood-process/

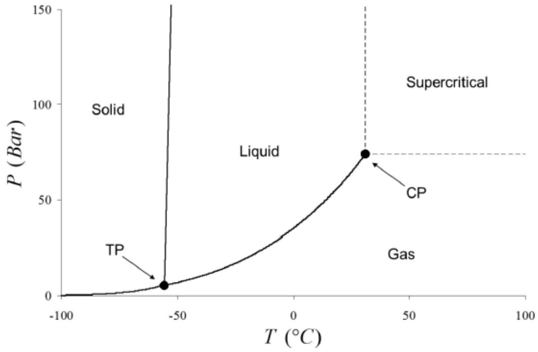

Figure 9 Phase diagram of CO_2. CP: critical point. TP: triple point.[15]

- Stora Enso's patented method is based on pressure impregnated with a wood preservative containing water glass (Sodium silicates). Following the impregnation, water glass will harden in the pores of wood as a result of the evaporation of water and will polymerise when reacting with acid carboxyl groups in the wood cells. Polymerization can be enhanced with thermal treatment, metallic salts and various acids.[16]
- Norwegian Kebony ASA has developed a technology that utilizes a liquid by-product of the sugar industry to treat the wood in a combination of vacuum, pressure and heat treatments.[17]
- Wood acetylation is a process in which the wood is treated with acetic acid that reacts with acetic anhydride. Commercial applications of wood acetylation in the Nordic countries include Accoya and Eastman products.[18, 19]
- Hot-oil impregnation combines an oil treatment with linseed oil with the subsequent drying of impregnated wood. The autoclave with the wood packet is kept under vacuum conditions and filled with hot linseed oil. The wood is dried and the circulating oil is sucked into the wood. The absorption quantity is thus controlled through the vacuum. The linseed oil seals the top surface of the wood and improves dimensional stability through less moisture absorption. The fields of application are, e.g. wooden houses, playground equipment, terrace paneling, exterior panelling, protection against noise and for privacy, balcony panelling, window and door elements and carports.[20, 21]

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15 Danish Technological Insitutue, The performance of supercritical impregnated wood, 2014
16 Google patents, http://www.google.com/patents/WO2009087262A1?hl=fi&cl=en
17 Kebony AS internet pages, http://www.kebony.com/en/index.cfm?c=product&pp=3225
18 Accsys Technologies internet pages, http://www.accoya.com/acetylated-wood/
19 Eastman internet pages, http://www.eastman.com/Company/AcetylatedWood/Pages/Overview.aspx
20 WTT A/S internet pages, http://www.wtt-english.com/Hot_Oil_Treatment.asp
21 Bergs Timber AB internet pages, http://www.bergstimber.se/gb/Timber_Preservation/Products/Bitus_Linax

- Organo-Click (Organowood) is a Swedish technology utilizing silicon-based compounds in the wood treatment.[22]
- Light organic solvent-borne preservatives, usually white spirit or other petroleum-based hydrocarbons are used in the Nordic countries mainly for impregnation of window and door joinery products. The impregnating agent solution does not contain water and, following the impregnation, the solvent is vaporized in the impregnation cylinder and collected for reuse.[23] The preservatives are applied in Bethell or Lowry processes or sometimes in non-pressure techniques, by immersion/dipping or spraying.
- Except for the flow-coat technology the application of wood preservative with non-pressure techniques is only done in special cases. Dipping involves the wood being completely submerged in a tank of preservative solution. Different chemicals are in use, whereas the technology is phasing out. Immersion is a special dipping process in which the wood remains immersed in the preservative solution over a period of one or several days. Due to this long exposure time, immersion also enables the treatment of wood with moisture levels between 30 % and 50 %. Brushing is the simplest form of protective treatment. Commercially, the cost and time involved means this process is only used in special cases, for example, with large construction components and in the treatment of cross cut ends.

3.4 Emerging techniques and chemicals for chemical wood preservation

There are other emerging technologies for wood preservation with chemicals not in commercial production in the Nordic countries. These technologies are at the moment too expensive and/or too inefficient and still at the research stage, including for example[24, 25]:

- Zinc-based systems have been studied since 2004. Zinc has a low cost and can be formulated in a colourless form. It has a long history as a UV stabilizer and preservative component in coatings. However, the low use of this system is due to its lower efficiency

[22] OrganoClick AB, internet pages, http://www.organoclick.com/products/functionalwood/organowood/
[23] Väärä,T. and Boren, H. 2012. Wood modification cluster. Kymenlaakso University of Applied Sciences. Report 84, ISSN: 1239-9094, 70 p.
[24] European Commission - DG Environment, Guidance 12: Wood impregnation, Contract ENV/C.4/FRA/2007/001; www.enviroportal.sk/.../275pdfsamVOC-doc-210509.p
[25] Clausen, C., Green, F. and Kartal, S.N. 2010. Weatherability and Leach Resistance of Wood Impregnated with Nano-Zinc Oxide. Nanoscale Res Lett. 2010; 5(9): 1464–1467.

compared to VOC containing products and the high costs of registering new wood preservatives.

- Aluminum-, iron-, and zirconium-based systems are described in the literature and are patented, but currently there are no known commercial applications.
- Natural protection systems include plant alkaloids extracted from the Neem tree, salicylic acid, and wood vinegar, as well as bacterial metabolites and cysts.

3.5 On-site activities directly associated with the wood preservation processes

In wood preservation plants, wood preservation is typically one activity among others. Often a plant has other wood processing on-site, such as framing, drying, sawing and sorting. Other possible on-site activities include gluing, laminating timber and pellet production.

Industrial wood impregnation often requires heat, which can be produced by an on-site boiler.

Figure 10 ***Wood impregnation plant. Chemical tanks are located on the left side of the picture. The pressure vessel is located on the right side of the picture.***

4. Current consumption and emissions

Since wood impregnating chemicals are classified as dangerous for the aquatic environment and they are not or only slowly biodegradable, the protection of surface waters, soil and groundwater are important environmental aspects in wood impregnation. During the course of history, wood impregnation with chemicals has resulted in soil and/or groundwater contamination. This was due to use of environmentally hazardous substances such as arsenic being handled in a careless manner.

Today, an important pre-condition for consistently good quality production is a well-functioning internal quality control system and regular maintenance of processes. As described in Chapter 2.2., the NWPC has developed Nordic product quality standards for chemical wood impregnation that are in line with the corresponding EU standards, but have some additional features such as the requirement for quality control. The NWPC lists the following points that need to be covered by internal quality controls in its guidelines:

- Inspection of the wood before treatment
- Inspection of the treatment solution before treatment
- Selection of the appropriate treatment process, as well as documentation of the entire course of the process
- Checking the results (penetration and retention of the treatment solution) after the treatment process
- Labeling of the treated wood
- Checking correct fixation and the storage of treated wood
- Treatment protocols. [26]

Quality control, trained and motivated personnel and emergency preparedness and spill prevention are key issues also in the minimization of the environmental impacts of the industry. Third party control shall take place by an NWPC approved institution. Furthermore, third party control of operation by environmental and chemical permit issuing authorities is to assure that the operation complies with national and European legislation, the BAT requirements, and that the environment

[26] Svenska Träskyddsinstitutet, Advice and Guidelines for the Internal Quality Control of Vacuum pressure treatment plants, , 2006

and human health is protected. One important feature of the Nordic standards is confirmed optimal retention for each use-class taking into consideration the efficency of the product and environmental concerns.

The impregnation process itself is rather simple and principally a closed system, thus emissions into the environment are limited. Emissions of volatile organic compounds (VOC) into the air, and sometimes odour, are possible from impregnation with oil-borne and organic solvent-based preservatives such as creosote, whereas these emissions are limited in impregnation with water-based impregnating chemicals. Some air emissions can also be produced from raw materials and finished products' storage areas and associated traffic, and from ancillary boiler houses. Other key environmental aspects within the industry are the resource efficiency to reduce the consumption of water, energy and chemicals, and the target to replace hazardous chemicals in impregnation with less hazardous ones when technically and economically possible.

Important aspects to consider in impregnation are safety measures not deeply covered here, such as the need for approval and regular inspection of pressure vessels.

4.1 Soil protection for commonly used processes

Historically, wood impregnation has resulted in soil and groundwater contamination. Potential soil contamination risks related to wood impregnation are:

- Accidents during the off-loading of impregnation chemicals
- Eruption of an impregnation chemical tank
- Insufficient drying time of wood piles after impregnation may result preservative dripping
- Storing wood piles in a non-roofed area immediately after impregnation may result in rain water rinsing the preservative
- Storing impregnated wood on non-paved surfaces combined with insufficient drying time may result in the preservative leaching and soil contamination
- Some amounts of residuum are created in the impregnation process. The residuum is classified as hazardous waste. The eruption of residuum tanks may result in soil contamination if the tanks are stored in non-paved areas.

Soil protection is a key environmental issue. Today, soil contamination is rare and related to accident situations, spills, releases and fires. Several precautions can be applied and are required from the plants in environmental permits.

In the plants, process and equipment are designed and constructed in a way to prevent any leakages of chemicals into the environment. Roof, walls and floor of the plant are made of water-tight material. The floor in the plant slopes towards a well or a spill storage tank. An embankment has the capacity to retain all preservation fluid in the process in case of leakage or accident.

The mixing of preservation fluid is mainly done in closed systems. High-pressure pipes connected to mixing tanks have pressure-reducing valves. The cylinder is also resistant against mechanical and chemical stress minimizing the risk of destruction by freezing the pressure cylinder or other equipment in the preservation plant. Automatic protection (equipped with an alarm) safeguards against the over-filling of storage tanks, mixing tanks and cylinders.

The filling pipe is installed high enough above the fluid surface level in the storage tanks, dipping and mixing tanks, in order to prevent a siphon effect that allows the preservation fluid backwards.

Old underground storage is lined with impermeable foil and equipped with a leachate warning. The new construction of underground storage tanks for preservation fluid is forbidden. Chemicals and hazardous wastes also need to be kept dry and insulated so that leaching cannot influence the surroundings.

Adequate and regularly inspected and maintained spill kits, fire extinguishers and other emergency provisions and procedures minimize damages in case of an emergency situation.

In dripping and storage areas, impregnated wood is stored in paved and roofed areas minimizing leaching along with storm water. As an alternative, impregnated wood can be stored without a roof, but then all leaching water must be collected. There is also long enough dripping of preserved wood to reach the fixation stage before removal from the preservation site minimizes leaching in the storage area. In creosote impregnation plants un-paved areas may be in use, but then the areas are covered with bark that absorbs the creosote, the bark being removed regularly and utilized in energy production. Appropriate design of a dripping plate has water-tight material and the capacity to store one day's production. It must slope against the rail from the pressure cylinder, be protected from rain by a roof and walls, be protected from surface run-off, the work area must be covered with gratings and, if used at temperatures below 0 C°, the floor must be heated.

When operations are ceased and in some cases also when the environmental permit renewed or when the facilities are expanded, soil and groundwater is sampled and analyzed for the chemicals used in order to show any contamination of the chemicals. The local authority decides if any remedial action is needed.

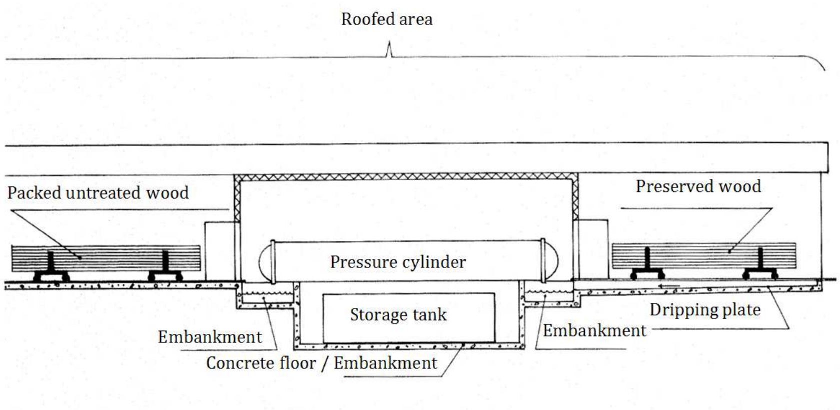

Figure 11 ***Schematic picture of wood impregnation process.***[27]

4.2 Emissions to water from commonly used processes

Most wood preservatives are classified as dangerous for the aquatic environment and they are not (or only slowly) biodegradable. Therefore, any leaks or releases of impregnating agents to surface waters, groundwater and subsoil must be minimized.

The possible release of an impregnating agent to the surface or groundwater can occur when the wood piles are taken out of the impregnation cylinder after the process. The wood piles therefore remain in the cylinder until dry. If the wood piles are taken out of the cylinder before they are completely dry, some leaching can occur. Over time, leaching of impregnation chemicals can be detected in surface and groundwater samples. The dry wood piles are stored on a paved and roofed area so the drying of the wood can continue. If the wood is placed outside in a non-roofed area in wet conditions, some leaching can occur at this stage. Over the course of time, this can result in surface and groundwater contamination.

The impregnation process is closed and therefore does not produce emissions to water. Impregnation chemical residues shall not be discharged as wastewater, but shall be treated as hazardous waste. Systems for cooling water are also closed. If mixing tanks are connected to municipal drinking water systems, the installations have check valves on the pipes and adequate monitoring systems in place.

[27] Viitasaari, S. (1991) Kyllästämöiden ympäristö- ja työturvallisuus, Vesi- ja Ympäristöhallinnon julkaisuja.

Storm water from areas that have a potential for being contaminated by impregnating agents is collected and treated or recycled. Such areas include areas immediately outside the preservation plant and treated wood storages. These areas are paved. It is also possible to use storm water in the preservation process as far as it is technically and economically reasonable and if the quality of water does not impair the quality of the treated wood. The excess storm water that is not used in the process can be directed to surroundings via an oil separator. Oil separators, canals and sumps are inspected, emptied and cleaned regularly. Only clean storm water can be discharged into surrounding ditches as untreated.

Impregnation plants also monitor wastewater emission and the quality of storm water, as well as the quality of groundwater. Waste water discharged into municipal mains is treated beforehand to remove as much of the impurities as possible. The discharged water is monitored by taking control samples. The measurements are performed according to internationally or nationally approved standards. The water quality of surface water bodies in close vicinity of plants is usually monitored by control samples twice a year.

4.3 Emissions of volatile organic compounds, odour and other air emissions from commonly used processes

Emissions of volatile organic compounds (VOC) into the air are possible from impregnation with oil-borne and organic solvent-based preservatives such as creosote, whereas these emissions are not produced in impregnation with water-based impregnating chemicals. This chapter discusses mainly VOC emissions of creosote impregnation, being the main source of VOC emissions within the industry in the Nordic countries, whereas the presented information is largely applicable also to other oil-borne and organic solvent-based preservatives.

Most VOC emissions are emitted from the treatment process during the filling, emptying and opening stages. Air emissions can also be produced from raw materials and the finished products storage areas, particularly in timber drying (VOC), and associated traffic and from ancillary boiler house operation (Carbon, nitrogen and sulphur oxides, CO_x, NO_x, SO_x, and particles). VOC, which remain in the wood after drying, evaporate over longer periods of time.

The EU legislation[28] provides specific limits for VOC emissions from an impregnation plant using more than 25 tons of solvents per year:

- Total emissions shall not exceed 11 kg/m^3 of treated wood
- Fugitive emissions shall not exceed 45 % of added solvents
- Point source emissions shall not exceed 100 mg C/Nm^3 (not applicable to creosote)
- Instead of complying with the above emission limit values, operators may choose to use a specified reduction scheme.

It is noteworthy that the national legislation allows (and there are existing environmental permits) having much stricter emission limit values or additional requirements for VOC emissions.[29]

The VOC Emissions can be reduced by:

- Applying a solvent management plan
- Using alternative VOC reduction can be achieved by substituting solvent-based preservatives with water-based preservatives or other low VOC containing products or non-chemical treatments, when technically and economically possible. For example, the so-called C type creosote contains only < 1 … 2 % of VOC and less than 0.005 % benzo(a)pyrene compared to the currently most typically used B type creosote containing 5-20 % of VOC and 0.005 % of benzo(a)pyrene. The disadvantages of the C type creosote compared to the B type creosote are a higher viscosity and crystallization temperature.[30]
- Containing the process wherever possible so that waste gases can be collected and recycled in the processes or extracted through gas treatment equipment. For example, droplets from the discharge of vacuum pumps and air vents at hatch opening can be diverted to a droplet separator. This can be done by channelling the waste gas through a storage tank. The use of a final vacuum stage to remove excess solvents also reduces VOC emissions.
- The end-of-pipe gas treatment techniques possible are catalytic regenerative combustion of gases and carbon adsorption with solvent recovery on- or off-site. These technologies are usually economically feasible only for the largest plants.

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[28] European Commission, The EU VOC directive (1999/13/EC) has been replaced by Industrial Emissions Directive (IED, 2010/75/EU), in force since January 2011

[29] Regional Environmental Centre of Pirkanmaa, Environmental permit 19.11.2008, 1900Y0291-111

[30] European Commission - DG Environment, Guidance on VOC Substitution and Reduction for Activities Covered by the VOC Solvents Emissions Directive (Directive 1999/13/EC) March, 2009 Final Report, Contract ENV/C.4/FRA/2007/001, http://www.scribd.com/doc/174700624/VOC-Guide; http://www.poles.se/en/environment_quality.php

Different air emissions abatement techniques are described in more detail in the EU Best Available Techniques Reference document on Surface Treatment using Solvents.[31]

Odour can also be of environmental concern and is highly dependent on the type of preservative in use. Some of the VOC compounds, particularly naftalene, have a low odour threshold. Naftalene is a PAH compound. Naftalene content of creosote can be restricted in emission limit values of an installation and as part of the production process of creosote. According to an environmental permit, the naftalene content of creosote shall not exceed 4 %, and in exceptional cases (e.g. if limited in availability) shall not exceed 5 %.[32] Also, minimizing the storage amounts of creosote impregnated products can reduce odour emissions near the installation. In impregnation with water-based impregnating agents ammonia used to cause some odour impacts on the environment, but the development of impregnating chemicals have reduced this impact.

4.4 Sources of waste from commonly used processes

Wood impregnation plant produces a relatively small amount of various non-hazardous and hazardous wastes. Non-hazardous wastes include, for example, untreated wood waste and uncontaminated packaging. Hazardous wastes include, for example, out-of-date and contaminated chemicals, chemical packaging, contaminated wiping, and absorbent, sludge from tanks and process equipment, etc. A publication from the Swedish Environmental Institute[33] provides detailed guidance on the classification of wood impregnation wastes in different cases.

The plant shall primarily minimize waste produced. Secondarily, the source separation of different waste fractions and the reuse, recycling and recovery of wastes shall take place. Industrially impregnated wood can be incinerated only in incineration plants approved and permitted for this purpose.

In the disposal or recycling facility of impregnated waste it can be difficult in practise to determine whether or not the wood is impregnated because of paint or weathering. In case of uncertainty, it should therefore be sorted as impregnated wood/hazardous waste under the precau-

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[31] European Commission, BREF STS, Best Available Techniques Reference document on Surface Treatment using Solvents, August 2007; eippcb.jrc.ec.europa.eu/reference/BREF/sts_bref_0807.pdf

[32] Regional Environmental Centre of Pirkanmaa, Environmental permit 19.11.2008, 1900Y0291-111

[33] IVL Svenska Miljöinstitutet AB, Impregnerat trä i kretsloppet - rekommendationer för restprodukthantering, 2009, http://www.ivl.se/publikationer/importeradebrapporterrorej/impregnerattraikretsloppetrekommendationerforrestprodukthantering.5.7df4c4e812d2da6a416800036642.html

tionary principle. In practice, there is also a mixing of older impregnated wood, since the estimated average life expectancy of treated wood is 30 years. This means that the continued sorting of impregnated wood is important during the demolition of old wooden structures or other projects with uncertain wood composition. Creosote and CCA (Copper, Chromium, Arsenic) impregnated wood waste is classified as hazardous waste, as well as waste wood of unknown composition.[34]

4.5 Noise sources and emissions of commonly used processes

Some noise is produced in impregnation, mainly in the traffic and loading and unloading of wood.

Emission limits correspond to general industrial requirements. Typically, there are different noise limits for daytime (e.g. 55 dB 7:00-22:00) and night-time (e.g. 50 dB 22:00-7:00). Also, the surrounding land use can affect the noise limits set. The legal requirements for industrial noise in particular cases in the Nordic countries are described in detail in the publication of Nordic Council of Ministers from 2013.[35]

[34] Avfall Sverige, Strategier för att hantera tryckimpregnerat virke som bränsle – baserat på flödet av koppar, krom och arsenic - RAPPORT F2012:05 ISSN 1103-4092, http://www.avfallsverige.se/fileadmin/uploads/Rapporter/F%C3%B6rbr%C3%A4nning/F2012-05.pdf

[35] Nordic Council of Ministers, Best Available Technique, Buller från bergtäkter, TemaNord 2013:588, http://www.norden.org/da/publikationer/publikationer/2013-588

5. Best available techniques (BAT)

5.1 General BAT to minimize consumption and accidental spills and releases of chemicals into the environment

- Control and optimized consumption of chemicals for the described end-use
- Implement systematic environmental management tools inc. environmental management system, risk assessments and audits.
- Regularly maintain equipment to keep them in good working order.
- Identify possibilities for energy saving, including the optimization of electrical power supply and consumption, energy efficient equipment, influencing the behaviour of the organization and employees to save energy, etc.
- Recover used solvents from the process.
- Use less harmful chemicals when possible.

5.2 BAT for soil protection

1) Process and equipment:

- Roof, walls and floor of the plant shall be of water-tight material.
- The floor in the plant shall slope towards a well or spill storage tank.
- An embankment shall have the capacity to retain all preservation fluid in the process in case of leakage or accident.
- The mixing of preservation fluid shall mainly be performed in closed systems. High-pressure pipes connected to mixing tanks shall have pressure-reducing valves.
- The cylinder shall be resistant against mechanical and chemical stress, and there shall be no risk of destruction by freezing the pressure cylinder or other equipment in the preservation plant.
- There shall be automatic protection (equipped with an alarm) against over-filling of storage tanks, mixing tanks and cylinders.
- The filling pipe shall end at least 0.5 m above the fluid surface level in the storage tanks, dipping and mixing tanks, in order to

prevent a siphon effect that allows the preservation fluid backwards.

- Old underground storage tanks shall be lined with impermeable foil and equipped with a leachate warning. The new construction of underground storage tanks for preservation fluid is forbidden.
- Chemicals and hazardous wastes shall be kept dry and insulated so that leaching cannot influence the surroundings.
- Spill kits, fire extinguishers and other emergency provisions and procedures shall be adequate and regularly inspected and maintained.

2) Dripping and storage of impregnated wood:

- Impregnated wood shall be stored in paved and roofed areas. As an alternative, it can be stored without a roof, but then all leaching water must be collected. In creosote impregnation plants un-paved areas may be in use, but then the areas must be covered with bark that absorbs the creosote, the bark being removed regularly and utilized in energy production.
- Preserved wood shall reach fixation stage before being removed from the preservation site.
- A dripping plate shall be made of water-tight material and have the capacity to store one day's production. It shall slope against the rail from the pressure cylinder, be protected from rain by a roof and walls, be protected from surface run-off, the work area shall be covered with gratings and, if used at temperatures below 0 C°, the floor shall be heated.

3) Environmental monitoring:

- When operations are ceased and in some cases also when the environmental permit renewed or when the facilities are expanded, soil and groundwater is sampled and analyzed for the chemicals used in order to show any contamination of the chemicals. The local authority decides if any remedial action is needed.

5.3 BAT for control of water emissions

- Collect, treat and recycle, when possible, all wastewater streams as well as storm water from areas that have potential for being contaminated by impregnating agents. Only clean storm water can be discharged into surrounding ditches as untreated.
- Regularly inspect, empty, and clean oil separators, canals and sumps.
- Monitor wastewater and the quality of storm water and groundwater.

5.4 BAT for waste minimization and management

- Minimize waste from process.
- Source separate different waste fractions.
- Reuse, recycle and recover wastes when possible.

5.5 BAT for the control of noise emissions

- Conduct noise measurement and identify significant noise sources and potential sensitive receptors in the vicinity and reduce noise when necessary.

5.6 Additional BAT for creosote impregnation for the control of air emissions

- Apply a solvent management plan.
- Substitute solvent-based preservatives with water-based preservatives or other low VOC containing products (such as Type C creosote) or non-chemical treatments, when possible.
- Contain the process wherever possible so that waste gases can be collected and recycled in the processes or extracted through gas treatment equipment. E.g. droplets discharged from vacuum pumps and air vents at hatch opening can be diverted to a droplet separator. This can be done by channeling the waste gas through a storage tank. Use final vacuum stage in order to remove excess solvents and to reduce VOC emissions.
- The end-of-pipe gas treatment techniques possible are catalytic regenerative combustion of gases and carbon adsorption with solvent recovery on- or off-site. However, these technologies are usually only economically feasible for the largest plants.
- The air outlet from the preservation plant shall be high enough, typically at least 10 m above the ground.
- Restrict the naftalene content of creosote in order to reduce odour, if there are sensitive receptors in the surroundings.
- Reduce the transportation of preservation agents to the surroundings by means of the adhering of particles to vehicle wheels by the regular irrigation of wheels or by using different vehicles for indoor and outdoor operations.

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7. Sammanfattning

Nordiska mininsterrådet, BAT-gruppen under arbetsgruppen för hållbar konsumtion och produktion, har uppdragit åt konsulten att utarbeta en rapport avseende ”bästa tillgängliga teknik” (BAT, Best Available Techniques) för träskydd med kemiska medel i de nordiska länderna. Resultatet av uppdraget redovisar nuvarande status för nyttjade tekniker, deras utsläpp och påverkan på omgivningen, samt vilka teknologier som kan anses utgöra BAT. Den tillhandahållna informationen kan nytjas av verksamhetsutövarna, miljökonsulter och miljömyndigheter.

Den nordiska träskyddsindustrin producerar omkring 2.1 miljoner m3 impregnerat trä per år. Impregneringen utförs vanligen med vattenlösliga kopparsalter tillsammans med tryck- och/eller vakumtekniker. Kreosotolja används i situationer när produkten ska användas i kontakt med mark och vatten och i konstruktioner med särskilda belastningskrav, exempelvis stolpar och slipers. Det finns även andra kemikalier, processer och tekniker i användning, som den i Danmark vanliga ”flowcoat” tekniken.

Den nordiska träskyddsindustrin förlitar sig på standardiserad och optimerad användning av impregneringsmedel specificerade i EU- och Nordiskstandard. Betydelsefulla förutsättningar för produktion är kvalitetskontroll, reguljärt systematiskt underhåll av processer och personal som är tränad och motiverad. Dessa förutsättningar är betydelsefulla även vad gäller minimering av industrins miljöpåverkan.

Eftersom träimpregneringmedel klassificeras som farliga för vattenmiljön och de inte är nedbrytningsbara eller endast kan brytas ned långsamt, är betydelsefulla aspekter av träimpregnering skydd av ytvatten, mark och grundvatten, samt minimering av olycksrisker. Att ersätta farliga kemikalier med mindre farliga och att minimera användningen av kemikalier när tekniskt och ekonomiskt möjligt är viktiga miljömål inom träimpregneringsindustrin.

Impregneringsprocessen är i princip sluten och därför är utsläpp till miljön under normala driftsförhållanden begränsade. Utsläpp av flyktiga organiska lösningsmedel (VOC, Volatile Organic Compounds) och ibland lukt till luft, är möjliga från oljebaserade impregneringsmedel som kreosot då däremot dessa utsläpp är begränsade vid impregnering med vattenbaserade impregneringsmedel. Vissa utsläpp till luft kan också avges från lagrade färdiga produkter och därtill hörrande trafik, samt panncentral.