

About Nordic Ecolabelled

Floor coverings

Proposal for Floor Coverings criteria version 5

Background for ecolabelling

2010-04-26



Nordic Ecolabelling

Nordic Ecolabelled floor coverings - Background to ecolabelling

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1	Introduction	1
1.	Criteria for floor coverings	1
2.	Differences between version 4 and 5	2
2	What can carry the Nordic Ecolabel?	2
3	Environmental impact of floor coverings	3
3.1	Raw materials	3
3.2	Energy consumption in flooring production.....	4
3.3	Chemicals.....	4
3.4	Use phase	4
3.5	Waste.....	4
4	Bakground to requirements	5
4.1	Requirements on renewable raw materials	5
4.2	Wood raw materials	6
4.3	Textile fibres	8
4.4	Requirements on chemical products	11
4.5	Requirements on raw materials and energy	15
4.6	Requirements on waste management	18
4.7	Requirements on durability	18

Appendix 1 - Flooring production methods

1	WOOD FLOORING	19
2	CARPETS.....	21
3	LINOLEUM	22

1 Introduction

The Nordic Ecolabel (the Swan) is a voluntary, positive ecolabel for products in the Nordic region. Nordic Ecolabelling was established by the Nordic Council of Ministers in 1989. Nordic Ecolabelling has offices in the Nordic countries that have independent boards/committees with representatives on the Nordic Ecolabelling Board.

The ecolabelling criteria for floor coverings have been drawn up based on assessment of the environmental impact of a product's entire life cycle. This background document is initially written for version 4 of the criteria document. The new changes defining the criteria draft proposal for version 5 are included and highlighted.

Nordic Ecolabelling develops its requirements based on LCA screening. A product's environmental impact is considered from a life cycle viewpoint and requirements are set in the areas that have the greatest environmental impact. Nordic Ecolabelling also employs an RPC methodology, where RPC stands for relevance, potential and controllability. Relevance refers to the existence of a relevant environmental problem with the product to be ecolabelled, whether this be in the production, use or waste disposal phase. Potential refers to the existence of alternative products for a certain function or alternative production methods. Controllability refers to ecolabelling being an instrument that can be used to differentiate products and the possibility for ecolabelling bodies to label these products. Controllability also covers market aspects since ecolabelling operates between the producer/seller and the buyer/consumer. Relevance, potential and controllability for the product are evaluated for all environmental criteria. Producers and resellers of floor coverings can apply to ecolabel products. If, following an assessment by the ecolabelling body, the product criteria are fulfilled, the applicant is awarded a license permitting the use of the Nordic Ecolabel on the specific product.

1.1 Criteria for floor coverings

The earlier criteria document version 4 was adopted by the Nordic Ecolabelling Board on 7 December 2007 and was valid until 31 December 2010. The validity of the criteria document was thereafter extended until 31 December 2011. The extended criteria document was called version 4.1.

The changed criteria shall replace "Ecolabelling of Floor Coverings" version 4.1, valid until 31 December 2011.

1.2 Differences between version 4 and 5

The requirements in version 4 of Ecolabelling of Floor Coverings implied following changes from version 3.

- Requirement that the floor covering shall comprise at least 50% renewable raw material. This was not a requirement in version 3 but was specified in the definition of the product group.
- Revision of forestry requirements. The exemption has been removed.
- The requirement on the content of biocides in wool fibres has been tightened.
- Requirements on synthetic fibres (polyester, polyamide and polypropylene).
- Broadening of requirements on auxiliary chemicals used for textile fibres.
- Energy requirements now include more parameters for different flooring types.

The most important changes constituting this draft proposal of the criteria document version 5 are:

- Bamboo flooring are now included into R2 (traceability) and under K21 (energy consumption)
- Antibacterial treatment is not permitted, new requirement R17
- Requirement for nanoparticles, new requirement R18

In recent years the availability of bamboo products has increased in the Nordic market. After several requests requirements for bamboo flooring are now included in this criteria document draft proposal.

Industry is carrying out a continuous development of surface treatment products aimed for floor coverings. Nordic Ecolabelling limits unnecessary use of antibacterial agents and nanoparticles in other criteria documents. It is therefore of interest to evaluate their use also for floor coverings.

2 What can carry the Nordic Ecolabel?

The floor covering must be intended for indoor use and suitable for a concrete, timber joist or similar subfloor. Examples of floor coverings that can be Nordic Ecolabelled include bamboo floors, solid wood, parquet, laminate, linoleum and textile. The floor covering shall not have a supporting function. Nordic Ecolabelling have chosen to limit the criteria to the floor covering alone. Heated floor coverings cannot be Nordic Ecolabelled since the heating system normally lies under the floor covering itself. In cases where the heating system is integrated in the floor covering, Nordic Ecolabelling lacks control over the method of heating and the environmental impact of energy production. Seamless floor coverings that are applied as a curing liquid are not covered by these ecolabelling criteria. Seamless floor coverings comprising a curing chemical product are primarily used in industrial environments and Nordic Ecolabelling has chosen not to include these floor types in the criteria.

The floor covering product group is highly varied. A floor covering can comprise of several types of material and combinations vary considerably. However, there it is an environmental imperative that floors should be made of at least 50% renewable raw material.

Synthetic carpeting, stone and ceramic floor coverings cannot be ecolabelled. Stone and clinker can be ecolabelled according to the EU Ecolabel. Floor coverings applied as a liquid, which often comprise two components that chemically harden, are also excluded from the criteria.

This leaves solid wood flooring, parquet flooring, laminate flooring, linoleum, carpeting (wall-to-wall) and other floor types made of natural fibres as well as bamboo floors. Nordic Ecolabelling has drawn up criteria in the aim to ecolabel the most environmentally suitable floor coverings of these types. Rugs and non-fitted carpets can be ecolabelled according to the Nordic Ecolabel or EU Ecolabel criteria for textiles.

3 Environmental impact of floor coverings

Floor coverings are manufactured from a variety of materials and the production processes used vary greatly. A short presentation of the production processes used for the flooring types that can be awarded the Nordic Ecolabel is provided in Appendix 1 to this background document.

3.1 Raw materials

Solid wood and laminate floorings primarily comprise wood raw materials. Forestry has an impact on the environment and sustainable forestry is a central goal. From a life-cycle viewpoint, forest management is an important aspect of a wood product's environmental impact. Unfortunately, not all forest management today is sustainable, which can lead to negative impacts such as a reduction in biodiversity, soil erosion and the repression of the indigenous population. These problems arise in the boreal forests the northern hemisphere and the rain forests of the southern hemisphere. Tropical forests are currently being felled at a high rate. Each year, roughly 150,000 square kilometres of forest are lost, an area equivalent to one third of the size of Sweden. There is a real danger that by the next generation, the tropical forests will have been lost for all time since these cannot be recreated through planting¹.

Annual crops are often cultivated with the use of pesticides. Flax cultivation, which supplies linseed oil for linoleum floor coverings, involves the use of pesticides, though crops are not generally sprayed each year. Flax cultivation that is pesticide free does exist but flooring manufacturers buy linseed oil on commodity exchanges and it is therefore difficult to trace the origin of the oil. Unlike organic cotton production, there is no system in place to enable this. Linoleum manufacturers cannot at present purchase certified organic or non-sprayed linseed oil.

¹ Source: Website of the Swedish Society for Nature Conservation, www.snf.se

Carpets are made of wool, plant fibres and synthetic fibres such as polyester, polyamide and polypropylene. Wool can contain residues of biocides with which the livestock have been treated to improve fibre quality. The most significant environmental impact from synthetic fibres is that the raw materials used consume finite oil resources. Nordic Ecolabelling limits the scope of using oil-based products by requiring that the floor covering contains at least 50 % renewable raw materials.

3.2 Energy consumption in flooring production

Energy consumption in production varies widely between different types of floor covering. There are even variations between floor coverings of the same type. The choice of fuel impacts on the environment. Nordic Ecolabelling wishes to reduce the amount of energy used per area of floor covering and also the amounts of fossil fuels used.

Wood floor coverings require energy to dry the wood raw material to a suitable level of moisture and for processing. Air-drying can reduce the energy required for drying. Linoleum floor coverings require energy for processing of raw materials and drying /curing the floor covering. In general, the consumption of purchased energy can be reduced by minimising waste in production and using waste materials for on-site energy production.

3.3 Chemicals

The surface treatment of wood floor coverings can involve the use of large quantities of volatile organic compounds (VOC) which have a significant environmental impact, such as the generation of ground ozone. VOCs are also a health hazard.

3.4 Use phase

The environmental impact of the floor covering during the use phase varies depending on the type of covering. Hard and resilient floor coverings require cleaning and carpets require vacuum cleaning. The floor covering's durability determines whether the floor covering is long or short-lived. Nordic Ecolabelling sets durability requirements to ensure that the ecolabelled flooring has a long service life.

3.5 Waste

The reuse of material or a product is prioritised over energy recovery. Energy recovery is an ultimate recycling method that utilises the embodied energy in the material. Sending waste products to a landfill site is the worst possible scenario since the resources in the floor covering's raw materials are not utilised in any way. Products containing chemical substances and compounds that are persistent (long lived) and bioaccumulating (absorbed by living organisms) cause environmental problems in the waste disposal phase. Such products are problematic to reuse and recycle.

4 Background to requirements

4.1 Requirements on renewable raw materials

The size of the global population is expected to increase 50% in the next 50 years. This increase in population is expected to have a significant effect on the environment. The largest population increase will occur in developing countries, which will constitute 85% of the world's population within several decades. The increased population will demand more raw materials and services to satisfy its needs. This trend will influence the use of raw materials and environmental impact on a global scale². The European Commission's "Green Paper on Integrated Product Policy" provides product design guidelines to promote a life cycle perspective within companies. The guidelines encourage more environmentally suitable product design and aim to integrate environmental aspects in product development. Design concepts include "design for use of renewable materials" as a way for products to use resources efficiently and reduce waste, pollutants and the risks associated with the product³. Design for reuse and recycling are also listed as beneficial design concepts.

Nordic Ecolabelling wishes through the ecolabelling of floor coverings to promote the use of renewable raw materials since non-renewable materials are a limited resource and the recycling of such materials is difficult and very uncommon in the Nordic area.

The collection and recycling of synthetic, non-renewable floor coverings is presently very limited and in practice only carried on in small-scale trials. Polyamide recycled from carpets goes primarily to other types of products than new carpets⁴. The recycling of PVC plastic products (including flooring) in Stignæs, Denmark, has been disbanded. The recycling trial was run by RGS 90 with a grant from the European Union. Against this background, Nordic Ecolabelling sets requirements on renewable raw materials. Once the recycling of synthetic floor coverings is well established in the Nordic region, Nordic Ecolabelling can reappraise the requirement.

Nordic Ecolabelling has chosen to require that floor coverings contain at least 50 % renewable resources and not 100 % since linoleum flooring contains mineral materials such as stone dust, and carpeting can contain synthetic fibres to improve durability. Nordic Ecolabelling aims to promote the use of renewable raw materials but for these types of floor covering (which primarily comprise of renewable materials), it is not possible to require the sole use of renewable raw materials.

Renewable raw materials are defined as those materials that are derived from biological materials that are continually reproduced in nature.

² Sustainable use and management of natural resources, European Environment Agency 2005

³ Green Paper on Integrated Product Policy, European Commission, COM (2001) 68.

⁴ http://www.uyseg.org/greener_industry/pages/nylon/8nylonPM3.htm

4.2 Wood raw materials

Origin and traceability

In the new criteria increased attention is focused on the legal felling of wood raw materials and bamboo. According to a report from WWF on illegal timber to the European market 40% on average of the wood-based products imported from South East Asia (including China) has been felled illegally. EU has started a plan of action to combat illegal felling of timber, the so-called FLEGT – action plan (Forest Law Enforcement, Governance and Trade)⁵. They intend to build up a licensing system through bilateral agreements with the largest timber-exporting countries. Several countries in Europe have also adopted EU's green purchasing politics for timber, e.g. Belgium, France, Germany and Great Britain.

The producer shall have control of the wood and bamboo that are not certified by guaranteeing that raw materials are legally felled/harvested and do not originate from forest environments with high bio and/or social protective values. This is a requirement intended to make producers aware of the raw materials that are used in the different products. Nordic Ecolabelling can insist on documentation if they suspect that wood raw materials from these areas are being used. The final consequence can be that the licence will be revoked.

Nordic Ecolabelling now requires that wood or bamboo producers shall account for how they guarantee that the wrong kind of wood is not being used. If a product comes from forestry that is certified according to an approved forestry standard and has been documented previously this requirement does not need to be documented.

Bamboo

Bamboo is a species of grass and is the fastest growing plant in the world. It can be harvested after about 7 years without the plant dying. It is often maintained that it is harder than hardwood and is therefore suitable for flooring, chopsticks, salad bowls, etc. There are more than 1200 species of bamboo growing in Asia, Central America and South America in addition to some species in parts of Africa and Australia. The species have different usage spheres. In animal life bamboo is an important food for the panda; 99 % of what they eat is bamboo. However there is only one species that is used for floor covering (Moso/Phyllostachys pubescens) a species that is not eaten by the panda.

Marketing of bamboo has recently increased considerably which in turn has led to an increased demand for products made of bamboo. Nordic Ecolabelling considers therefore that it is important to guarantee that the raw material is not derived from areas where biodiversity or social protective values are threatened.

Bamboo grows wild like “a weed” and normally does not require fertilizers or spraying with pesticides. Bamboo is also used to prevent soil erosion in exposed areas. When bamboo is harvested new shoots grow out from the remaining stump. This also makes it difficult to get rid of bamboo once it has become established in an

⁵ European Union (EU) Action Plan for Forest Law Enforcement Governance and Trade (FLEGT)
Tilgjengelig fra: (besøkt 5. august 2009)

area. Bamboo is often grown by small farmers, but due to the increased demand for bamboo there is a risk that deforestation and the use of pesticides and fertilizers can lead to damaging of a functioning ecosystem. In the following INBAR (International Network for Bamboo and Rattan) bamboo is counted as a natural resource and is taken from unregulated natural forests in southwest China. In many areas, however, felling is undertaken badly which can both make it difficult for species that are dependent on bamboo (for example red panda [*Ailurus fulgens*] and giant panda) and in the long run can destroy the ecosystem⁶. Bamboo is also grown in many different forms, for example plantations.

Wood from certified forests

Nordic Ecolabelling does not have the prerequisites or resources to develop its own forestry criteria but instead requires the use of existing standards and certification systems. Requirements are placed on the process used to develop the forestry standard. Requirements are also placed on the certification system and certification body that administrate certification in accordance with the forestry standard. The overall requirements regarding standards, certification systems and certification bodies are unaltered from version 3. Nordic Ecolabelling wishes to promote sustainable forestry and rewards producers that use wood raw materials derived from forests that are certified according to a forestry standard that covers economic, environmental and social aspects. Nordic Ecolabelling considers the certification of forests to be a useful tool in the transition of forest management to a more sustainable system.

If the floor covering contains more than 10% by weight of wood raw material, at least 30 % of the annual quantity of purchased wood raw material must come from certified sustainable forests. An exemption is made for Nordic Ecolabelled fibreboards that are part of flooring since these are covered by the criteria for the ecolabelling of building boards. The building board criteria stipulate a limit of 30%. Also, recycled material can be used instead of wood raw material from certified forests.

The availability of certified forest has increased over the last ten years. In 2000 approximately 1.6 % of the world's forests were certified according to forest management standards. In 2005 this figure had risen to approximately 6 %. FN⁷ states that 8.3 % of the world's forest areas were certified between 2007 and 2008, equivalent to 320 million hectares. These figures include the American standard SFI and the Canadian CSA both of which were recognised by PEFC in 2005. The availability of certified wood raw materials varies greatly, however, for different kinds of wood. Large areas of forests in the Nordic and Baltic countries are now certified. The Nordic forests primarily produce pine and spruce. The availability of certified wood raw material of hardwood is low compared to softwood. The majority of the certified forest is currently to be found in Europe and the Nordic countries, but future increases will mainly come from Russia and North America. The requirement of 30 % wood raw materials from certified forests applies to all types of wood despite the variation in supply.

⁶ Från INBARs hemsida om "Bamboo Forest Biodiversity Conservation project", <http://www.inbar.int/Board.asp?BoardID=280>

⁷ UNECE/FAO Forest Products Annual Market Review, 2007-2008. Tilgjengelig fra: <http://timber.unece.org/index.php?id=2> (besøkt juni 2009)

In principle bamboo can be certified when the bamboo forms a natural part of forests which are certified according to a forest management standard. In the new criteria there is no requirement that the bamboo must be certified according to forest management standards or ecological cultivation. The reason for this is that the availability of bamboo from certified areas is currently limited; also this is the first time that bamboo has been included in the criteria for floor coverings. The raw material is guaranteed through the requirement K2 with a declaration of origin and traceability. Nordic Ecolabelling may require additional documentation if there is uncertainty about the origin or if bamboo stems from forest habitats, natural habitats or agricultural areas with high biological and / or social protection levels.

In addition, wood raw material exists as a parameter in the environmental matrix in Chapter 4 of the criteria. Therefore, the floor producer benefits when more than 30% wood derives from certified forests. The energy equation in the new draft proposal has been adapted specifically for bamboo raw material due to prevailing circumstances with limited raw material from certified farms.

4.3 Textile fibres

Requirements on plant fibres – emission of oxygen demanding substances

The production of plant fibres often involves significant emissions into wastewater of oxygen demanding substances. Nordic Ecolabelling therefore requires that the emission of oxygen demanding substances shall be reduced for plant fibres (flax, hemp, coconut and similar) and wool fibres. The content of oxygen demanding substances in wastewater shall be measured in COD or TOC by the flooring manufacturer or raw material supplier. This requirement is unchanged in this revision.

Requirements on wool fibres – biocides

The limit values for biocide residues in the wool fibres have been lowered and harmonised with the German GUT ecolabel value. The aim of harmonisation is to simplify application for carpet producers who already use the GUT label. GUT tests carpets at independent test institutes, which means the label is a third party certificate⁸. This requirement is also fulfilled if the wool fibre fulfils the Nordic Ecolabel or EU Ecolabel requirements.

Requirements on synthetic carpet fibres

This draft includes additional requirements on the recycling of synthetic fibres and requirements regarding polyester, polypropylene and polyamide. The Nordic Ecolabelling criteria only cover floor coverings that comprise at least 50 % renewable raw materials, but since carpets often contain a mixture of synthetic fibres and wool, Nordic Ecolabelling has decided to set requirements for these fibres. The requirements on polyester and polyamide are taken from the EU Ecolabel textile

⁸ Information on GUT is taken from GUT's website (<http://193.201.162.104/index.asp>).

criteria, and the requirement on polypropylene comes from both the Nordic Ecolabel requirements for hygiene products and EU Ecolabel textile criteria.

The synthetic fibre must contain at least 50 % recycled material to increase the recycling of plastics. There are existing plastic collection systems, such as monitored packaging collection, which provides a high-quality, clean recycled raw material. Recycled plastic refers to plastic derived from used products or packaging. Recycling plastics reduces the use of oil and energy in the production of new polymers, and also reduces the quantity of plastic waste produced. The environmental gains depend on the type of plastic, how clean the plastic is and how much washing is required. They also depend on the recycling system used. Energy and chemical recovery remove the plastic from the cycle, while material recycling means that the plastic can be used several times before it is sent for energy recovering or splitting.

Recycled plastics are used in several product areas in the Nordic region. Recycled polyamide is, for example, used in carpeting from Interface. Recycled materials are however uncommon among carpeting manufacturers. Nordic Ecolabelling has chosen to require a level of 50 % to allow the addition of virgin material, which may be necessary for strength and durability.

Some manufacturers that Nordic Ecolabelling has spoken with say that it would be advantageous to relax the quality requirement on recycled plastics to reduce the degree of sorting. An increase in the thickness of plastic products can provide economic and environmental gains due to the physical properties of recycled plastics. According to a report from the Association of Plastics Manufacturers in Europe (APME), 2000 saw a 17 % increase in mechanically recycled used plastic products in Europe. This increase is said to be a result of higher commodity prices and better collection systems. Nordic Ecolabelling does not consider internal production waste to be a source of recycled plastic.

The requirement that the floor covering shall comprise a minimum of 50% renewable raw materials limits the type of carpeting that can currently be ecolabelled. Fitted carpets that primarily comprise renewable raw materials are wool carpets with a small amount of synthetic fibres. These fitted carpets have only a small share of the Nordic market for fitted carpets but are of a high quality.

No requirements are set as to the content of heavy metals or other ecotoxic substances in the recycled plastic. The spread of brominated flame retardants through recycled plastics is a point of discussion in the industry. However, there are no regular analyses of recycled plastics to monitor the content of toxic and ecotoxic substances.

Requirements on polyamide, polyester and polypropylene

Requirements have been added for the three fibre types normally found in fitted carpets. The requirements on polyester and polyamide are taken from the EU Ecolabel textile criteria. The requirements on polypropylene come from EU Ecolabel textile criteria and the Nordic Ecolabel requirements for hygiene products (emission of NO_x and SO₂).

Polyester fibres in ecolabelled floor coverings must be produced with limited amounts of antimony. Antimony is a toxic semimetal that is used as a catalyst. The polyester fibre must contain less than 260 ppm of antimony. Antimony-free polyester fibre exists, but the supply is currently so low that Nordic Ecolabelling cannot demand the use of such polyester.

Nordic Ecolabelling sets requirements limiting the emission of nitrogen dioxide (N₂O) from polyamide production. Nitrogen dioxide is a greenhouse gas that is 270 times more damaging than carbon dioxide. Nitrogen dioxide also depletes the ozone layer. The two greatest industrial sources of N₂O are the production of nitric acid (HNO₃) and adipic acid. Adipic acid is created in a two-stage process where HNO₃ is used in the second stage and is the cause of the N₂O emissions. Adipic acid is primarily used in the production of polyamide. Emissions of N₂O have been reduced in recent years through thermal and catalytic cracking, especially in the production of adipic acid. In the next revision, it will be evaluated whether it is possible to set requirements on caprolactam and other volatile organic compounds used in the production of polyamide.

For polypropylene, Nordic Ecolabelling requires low emission levels of nitrous oxides (NO_x) and sulphur dioxide (SO₂).

Auxiliary chemicals

Alkylphenoxyethoxylates (APEO), alkylbenzen sulfonates (LAS) and ethyl diamine tetracetate (EDTA) are prohibited. The abovementioned substances may not be used in auxiliary chemicals for treatment of textile fibres nor does di(hydrogenated tallow alkyl) dimethyl ammonium chloride (DHTDMAC), distearyldimethyl ammonium chloride (DSDMAC), ditallow dimethyl ammonium chloride (DTDMAC), and diethylene triamine pentaacetate (DTPA) may be used or be an ingredient in any preparation or substance that is used. The requirements have been harmonised with EU Ecolabel criteria. The abovementioned chemicals have environmentally hazardous and toxic properties⁹.

Requirements on foam rubber

Foam rubber may be used as a backing on carpets. There are two common types of backing: foam rubber and woven textile. The majority of fitted carpets sold in the Nordic region have a woven polypropylene or polyester backing. Those carpets with a foam backing have a latex or polyurethane backing. According to carpet manufacturers, latex is most common but there are manufacturers in the USA that use polyurethane. There are environmental issues connected with the production of latex and polyurethane, and it is therefore justified to set environmental requirements, such as in the EU Ecolabel criteria for mattresses. However, a latex backing can make the use of at least 50% renewable fibre (wool) difficult. Subsequently, the requirement on latex is unlikely to have any effect on the product group.

Nordic Ecolabelling requires low emissions of oxygen demanding substances during latex production. The content of 1,3-butadiene in the latex must be low. 1,3-butadiene is a volatile hydrocarbon used as an industrial monomer in the production of latex

⁹ Background Report – April 2002 (<http://ec.europa.eu/environment/ecolabel>).

rubber. 1,3-butadiene is classed as carcinogenic. CFC, HCFC, HFC and methylene chloride must not be used for foaming the polyurethane rubber. These substances are stable organic compounds that intensify the greenhouse effect and deplete the ozone layer. It is also suspected that methylene chloride is carcinogenic (Carc.3 and R40).

4.4 Requirements on chemical products

Chemical products that are classified as carcinogenic, toxic for reproduction or mutagenic must not actively be added to the floor covering. A content of 0.1% is sometimes sufficient for a chemical product to be classified accordingly, but a floor covering is not a chemical product and cannot be classified according to European regulations. The ecolabelling criteria for floor coverings also include limit values for the quantities of substances added to the floor covering that are classified as ecotoxic or allergenic. Alternatively, the chemical producer can certify that the chemical products used in the floor covering are not classified as environmentally hazardous. Nordic Ecolabelling aims to limit the quantities of ecotoxic and toxic substances in the floor covering.

Flame retardants

There are several types of substance that can help prevent the floor from catching fire. According to the Danish Environmental Protection Agency, there are 40 commercial groups of brominated flame retardants, of which 13 are used in Denmark. The most common are tetrabromobisphenol A (TBBPA), polybrominated diphenylether (PBDE), polybrominated biphenyls (PBB) and hexabromocyclododecane (HBCD).

Different brominated flame retardants have varying effects on health and the environment. Some substances are long lived and suspected to cause heritable genetic damage. The Danish Environmental Protection Agency lists PBB and PBDE as the most problematic substances. The European Union prohibited the use of penta-BDE and octo-BDE as of 1 July 2004.

There are alternative flame retardants that are used by several manufacturers. The majority of flame retardants are used in electronic products, but also in textiles, furniture and floor coverings (especially carpets)¹⁰.

No halogenated flame retardant may be added to the floor. Halogenated flame retardants include, for example polybrominated diphenyl ethers (PBDEs).

Chlorinated paraffins are used as flame retardant, but are also used as processing aids in the plastics industry.

Phthalates

In addition to the requirements on substances known to be toxic, requirements are set of substances that are suspected to have harmful effects. The aim of ecolabelling is to impose stricter limits than legislated. Phthalates are suspected to have harmful effects.

¹⁰ Environmental Project 494, 1999, "Brominated Flame Retardants", Danish EPA. Environmental Project 568, 2000, "Brominated flame retardants; Toxicity and Ecotoxicity" Danish EPA and www.mst.dk.

Industrial stakeholders have pointed out that DINP and DIDP should be accepted since these are not classified according to EU regulations.

Heavy metals

Above certain concentrations, heavy metals are toxic to plants, animals and humans. This applies especially to mercury, cadmium and lead. Several of these substances can accumulate in living tissue and remain there for very long periods of time. A basic principle is that ecolabelled floor coverings should not contain heavy metals. However, raw materials may contain impurities. These impurities are not added actively and are hard to avoid¹¹.

Azo dyes

Azo dyes include several types of substances. Some may cause environmental problems, such as substances that degrade forming carcinogenic arylamines and substances that are harmful to the aquatic environment. Azo dyes are primarily used for colouring textiles, but also plastics and leather. Azo pigments are primarily used in the painting/coating industry, graphic production and plastic industry (Source: "Survey of azo-colorants in Denmark", Danish Technological Institute, published by the Danish Environmental Protection Agency, 1999). Subsequently, requirements are only set for azo dyes used for textile fibres.

The use of azo dyes is controlled by EU regulations. Several azo substances are prohibited for products that are in prolonged contact with the skin. The same azo colorants are prohibited by Nordic Ecolabelling from use in floor coverings.

Antibacterial treatment

Society profits by the use of antibacterial biocides. They provide an important function in the control of bacteria flora in different applications. The new proposed criteria however exclude the possibility of treating floor coverings with an antibacterial surface treatment. One of the reasons is that the probability of the development of a resistance in the bacteria flora after a long-term exposure to biocides is considered very likely. According to a newly published report from one of EU's¹² scientific committees there are strong indications that a resistance of bacteria to biocides and antibiotics occurs through the same mechanisms, - cross-resistance. Quantitative data of exposure to biocides, which has impact on gene resistance in bacteria based on different physical conditions, and standard procedures for judging antibacterial resistance to biocides, are missing according to the report to be able to establish the risk with scientific certainty. However researchers agree that the more common exposure to biocides is, e g via several antibacterial surface-treated products in society, the more frequently bacteria are subjected to exposure, which in turn leads to a greater probability that a resistance to the same biocides will arise.^{13, 14}

¹¹ The Swedish Flooring Trade Association in Sweden, 1993

¹² Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR), Assessment of the Antibiotic Resistance Effects of Biocides, European Commission 2009

¹³ Niels Frimodt-Møller, Professor i klinisk mikrobiologi, Statens Serum Institute (SSI) i Danmark

¹⁴ Åsa Melhus, Professor i klinisk bakteriologi, Institutionen för medicinska vetenskaper, Klinisk bakteriologi, Uppsala Universitet i Sverige

Antibacterial biocides are for example nanometals such as nanosilver and nanocopper but also pure silver. These are to be found in many products from stockings and refrigerators to toothpaste for antibacterial purposes.¹⁵ Substances such as nanosilver are counted as biocides by the American Environmental Board (EPA).

There are experiences that show that an excessive use of antibacterial agents with a long-term effect lead to consequences that are hard to grasp. Chlorhexidine and triclosan are two types of disinfectant that have recently been shown to have a marginal effect in combating infection. There are examples from the USA where the bacteria MRSA have shown complete resistance to the disinfectant chlorhexidine and the authorities have recommended the public to limit the use of the disinfectant to reduce the development of increased resistance.¹⁴

Based on the above assumptions Nordic Ecolabelling chooses to follow a precautionary principle with regard to the requirement of antibacterial treatment for floor coverings. Nordic Ecolabelling also aims at a consistency between different criteria documents; the criteria document for hand washing-up liquid version 4.1 and the detergent version 4.5, exclude products that have a disinfecting effect and in this way prevent the growth of microorganisms. For further reading see the background document for hand washing-up liquid and detergents.

There are no requirements regarding biocides that are added to surface-treatment products for preservation purposes. Manufacturers for example of water-based, surface-treatment products for floor coverings may use a small amount of preservative biocides in surface-treatment products that are ready for use. Through the use of preservative biocides the durability of the products is guaranteed and is therefore considered important for the surface-treatment function of the product.

Biocides in the form of active substances and biocidal products must go through an assessment according to the Biocide Directive 98/8/EG and be approved before they are allowed onto the European market. Currently a systematic examination is taking place of the active substances which were on the market before the 14th May 2000. Decree 1451/2007 lists groups of substances that remain to be examined. The examination is being carried out by a number of authorities concerned in different European countries. In Sweden the National Chemicals Inspectorate (KemI) is responsible for the assessment of biocides.

Microorganisms do not grow on wood material that is dry. Wood material also consists of natural antibacterial substances such as resin and fatty acids in varying amounts. Deciduous trees such as aspen do not contain resin but have large amounts of fatty acids as e.g. C12-fatty acid which is a natural antibacterial substance. Bamboo naturally contains an antibacterial substance with the designation Bamboo Kun (antibacterial and bacteriostatic bio-agent called “bamboo Kun”) which is believed to be the reason that bamboo grows without having to be sprayed with pesticides.¹⁶ The new criteria version 5.0 allows ecolabelling of bamboo floor covering.

¹⁵ Swedish Chemical Agency, Usage of nanomaterials in Sweden 2008 – analysis and forecast, 2009

¹⁶ China Bambro Textile Co (2010) http://www.bambrotex.com/second/bc_nab.htm

Nanoparticles

Nanometals, nanominerals, pure nanocarbon compounds or nanofluorine compounds must not actively be added to the floor covering if this does not entail environmental, health problems. Nanoparticles are counted in this case as microscopic particles where at least one of the dimensions is less than 100nm.¹⁷ Nanometals are for example nanosilver, nanogold and nanocopper. Nanometals, such as nanosilver and nanocopper, are particularly urgent as they are to be found in many products, in everything from stockings to refrigerators for antibacterial purposes. Substances such as nanosilver are counted as biocides by the American Environmental Board (EPA) as it is considered to have antibacterial properties.¹⁵ This has been especially worrying as effluents of nanosilver into waste water can eliminate essential bacteria and cause bacterial resistance. A general prohibition of nanoparticles is, however, not dirigible as there is material of less than 100nm in size, which cannot be considered problematic.

In discussions with manufacturers, of linoleum floor coverings for example, we were informed that no in-coming raw materials can be described on a nanoscale. Linoleum floor coverings consist to a certain extent of colour pigment that contains titanium dioxide. This particle is however not on a nanoscale. Nanoparticles regarding floor coverings can to a certain extent occur in surface-treatment products. Surface-treatment products for floor coverings such as certain surface varnishes in the form of chemical products ready for use can contain particles of nano size e g in the category nanominerals. These are used as they have a definite technical advantage with regard to durability, etc. Application and subsequent UV-hardening of these surface varnishes is said to result in a reaction of the nano particles in the matrix of the varnish film. The nanoparticles are thereby prevented from being emitted from the varnish film both during the use of the floor covering and during possible grinding.

Due to lack of knowledge concerning nano particles toxicity and environmental hazardness Nordic Ecolabelling wish through this requirement to make clear that nanoparticles shall not actively be added to Nordic Ecolabelled floor coverings. In those cases where nanoparticles are added this must be motivated as important for functional reasons. Possible use of nanoparticles shall not result in any environmental or health problems. The flooring producer shall confirm this through documentation. This documentation can sometimes consist of a description which shows that the nanoparticles are bound in the final product and thus cannot be liberated to the surroundings or to the consumer when using it and after use.

Due to lack of knowledge concerning nanoparticles health and environmental hazards Nordic Ecolabelling selects to apply the precautionary principle and not allow the use of nanoparticles, unless the producer can justify that the use is important for the functionality of the product, and unless the producer can verify that the use of nanoparticles does not present any health or environmental problems.

Formaldehyde

The emission of formaldehyde from products affects the environment and health and should therefore be avoided or minimised. Adhesives in panels and coatings are the primary sources of formaldehyde in wood products. Products containing

¹⁷ The Research Council of Norway, "National strategy for nanoscience and nanotechnology", 2006

formaldehyde have in the past been used on carpets, but this is no longer the case. There are no satisfactory alternatives to formaldehyde adhesives for fibreboards. A previous alternative has been isocyanate adhesives, but these also have negative health effects. It is however possible to limit the emission of formaldehyde from the fibreboards.

All the Nordic countries require low formaldehyde emissions from fibreboards. The requirement set by Nordic Ecolabelling applies to the entire floor covering.

If the only source of formaldehyde is a fibreboard (e.g. chipboard, plywood or MDF) it is sufficient to document the emissions from the board.

Organic solvent emissions (varnish)

Organic solvents give rise to volatile organic compounds (VOC) which in turn produce ground ozone. Ground ozone is produced by a photochemical reaction between volatile hydrocarbons and nitrous oxides. Ozone is one of several photochemical oxidants. Ground ozone is harmful to vegetation, materials and human health. The American Environmental Protection Agency (EPA) estimates that damage to crops in the USA caused by ground ozone total several billion dollars each year.

The most significant source of VOCs from floor coverings is the emission of solvents from surface treatments (varnish and oil). Solvent-based varnishes contain 70-80 % VOCs, water-based varnishes 0-10 % VOCs and UV-hardened varnishes 0-5 % VOCs. The emission of VOCs can be reduced through the selection of surface treatment product or purification. Nordic Ecolabelling's requirements are flexible. For some producers it may be simplest to declare the content of the surface treatments. A requirement formulated in grams per square meter enables the use of surface treatments containing varying amounts of solvents.

Documentation for chemical products

In most cases, a data sheet detailing the properties of the chemical product is required. The producer or supplier of the chemical product must supply this data sheet. In the European Union, the producer must always supply customers with a material safety data sheet.

This data sheet has different names in the Nordic countries: "16 punkts sikkerhedsdatablad" in Danish, "16 punkters varuinformationsblad" in Swedish and "Material Safety Data Sheet" in English. Nordic Ecolabelling assumes that the material safety data sheet is up to date.

4.5 Requirements on raw materials and energy

Nordic Ecolabelling has the aim of the requirements to set specific requirements on the different types of floor covering and distinguish the best floor coverings from an environmental viewpoint.

In version 3, the energy consumption requirement was specified as a formula containing the weighted consumption of fuel and electricity. Limits were also set for

CO₂ emissions and the sulphur content of fuel to limit the use of fossil fuels. Shown below is the formula used for electricity and fuel consumption:

$$E = \frac{\text{Purchased electricity}}{10 \text{ kWh/m}^2} + \frac{\text{Fuel}}{20 \text{ kWh/m}^2}$$

A matrix or formula provides greater flexibility for the flooring manufacturer. If opportunities to limit electricity consumption are limited, fuel consumption can be reduced instead. Several other parameters have been added into the formula above and additional requirements have been defined for different types of floor covering. Since different floor coverings require different amounts of energy and different raw materials, it is only logical to set different requirements.

Nordic Ecolabelling wishes by this to enable the ecolabelling of the environmentally best floor coverings within each floor covering type: bamboo floors, solid wood, laminate, linoleum and carpeting. In addition to the aforementioned environmental parameters (fuel and electricity), the use of renewable fuels, wood raw material from certified forests and recovered wood raw material in wood and laminate flooring are encouraged.

In the new criteria draft proposal bamboo floor covering has been categorized as a type of flooring under K21. The limit is based on the limited supply of bamboo from certified plantations. For further information see 4.2.

For linoleum and carpeting, the use of renewable fuel and renewable raw materials are encouraged. The use of recycled non-renewable raw materials is also rewarded.

The formula for the new requirement is given below. A point score of 0-4 can be awarded for each environmental parameter. The better the production, the higher the score. An example of the energy consumption of various floor covering types is given at the end of Appendix 1.

Solid wood and laminate floor coverings

$$P = \frac{A}{25} + \frac{B}{25} + \frac{C}{25} + \left(4 - \frac{D}{5}\right) + \left(4 - \frac{E}{12.5}\right)$$

Requirement:

P ≥ 8,5 for bamboo flooring

P ≥ 11.5 for laminate flooring

P ≥ 10.5 for wood flooring

Environmental parameter	Requirement
A = Wood from certified, sustainable forest ¹ (%)	Min. 30%
B = Proportion of recycled wood raw materials ² (%)	
C = Proportion of renewable fuels ³ (%)	
D= Electricity consumption (kWh/m ²)	Max. 20 kWh/m ²
E= Fuel consumption (kWh/m ²)	Max. 50 kWh/m ²

¹ Annual proportion of wood raw material from certified forests

² Recycled wood raw materials = Residual products from other industry and post-consumer materials

³ Renewable fuel = Fuels other than fossil fuels and peat.

Linoleum floor coverings:

$$P = \frac{A}{25} + \frac{B}{25} + \left(4 - \frac{C}{5}\right) + \left(4 - \frac{D}{12.5}\right)$$

Requirement: P ≥ 9.0

Environmental parameter	Requirement
A = Proportion of renewable raw materials and recycled non-renewable raw materials (%)	Min. 50%
B = Proportion of renewable fuels (%)	
C= Electricity consumption (kWh/m ²)	Max. 20 kWh/m ²
D= Fuel consumption (kWh/m ²)	Max. 50 kWh/m ²

Textile floor coverings:

$$P = \frac{A}{25} + \frac{B}{25} + \left(4 - \frac{C}{5}\right) + \left(4 - \frac{D}{12.5}\right)$$

Requirement: P ≥ 9.0

Environmental parameter	Requirement
A = Proportion of renewable raw materials and recycled non-renewable raw materials (%)	Min. 50%
B = Proportion of renewable fuels (%)	
C= Electricity consumption (kWh/m ²)	Max. 20 kWh/m ²
D= Fuel consumption (kWh/m ²)	Max. 50 kWh/m ²

There follows an example of calculations for a solid wood floor.

Example of calculations for a wood floor covering:

Wood from certified, sustainable forest: 55%.

Recycled wood raw materials: 0%.

Proportion of renewable fuels: 95%.

Electricity consumption: 5 kWh/m².

Fuel consumption: 15 kWh/m².

$$P = \frac{55}{25} + \frac{0}{25} + \frac{95}{25} + \left(4 - \frac{5}{5}\right) + \left(4 - \frac{15}{12.5}\right) = 11.8 \text{ The floor covering fulfils the requirement.}$$

4.6 Requirements on waste management

The waste management requirement aims to ensure that waste material from production is recycled as energy if not recycled as raw material. The floor covering must not produce special waste or require special waste handling in any Nordic country. Plasticized PVC is assigned to recycling or disposal in Denmark at the end of its service life. There are recycling systems but these are small and only handle small quantities of waste. The facilities in Stignæs in Denmark, which were to handle and recycle PVC flooring in Denmark have been closed. In Denmark, PVC is considered problematic waste and is not desired for energy recovery. This is supported by the European Commission "Green Paper – Environmental issues of PVC" 2000. The disposal of products containing persistent organic substances that are environmentally hazardous is problematic since these substances can leak from landfill sites and spread into ground water and aquatic ecosystems. The report "Miljø- og sundhedsforhold for plastmaterialer" (Environmental and health aspects of plastic materials) Project no. 1103, 2006, identifies additives in plastics as a risk in landfill sites¹⁸.

4.7 Requirements on durability

The durability of the flooring is of great significance for the use of resources and the service life of the floor covering. Wear resistance should however be suited to the intended area of use of the floor covering. The floor covering should offer good general wear resistance since the use of rooms in houses can change over the flooring's service life. The surface of flooring varies greatly, which is reflected by different test and limits for different types of floor covering.

In the new criteria draft proposal for version 5 reference to the test method for laminate floor coverings has been updated. Other floor coverings, such as bamboo floor covering, are tested according to the test method chosen by an impartial test institute qualified in wear-and-tear tests for floor coverings. If there is no relevant test method that can be applied to bamboo floor coverings these can be tested according to the test methods ANSI/NEMA LD 3-2005, "High-Pressure Decorative Laminates" where the limit is put at 500-600 revolutions. Hardness is measured according to ASTM D1037-99 (hardness test 68-73). Bamboo floor coverings shall be classified at the lowest as corresponding to EN687 definition as class 2.

The above test methods have been adopted from the Canadian EcoLogo environmental label and its criteria document for flooring products, CCD-152.

¹⁸ Miljø- og sundhedsforhold for plastmaterialer, Project 1103, 2006

Appendix 1 Flooring production methods

1 WOOD FLOORING

There follows a short description and simplified flow diagram.

- Wood flooring can vary in its structure:
- Solid wood flooring made of one type of wood and with a varnish or oil surface treatment.
- Several solid wood types glued together and with or without a varnish or oil finish.
- Laminate flooring, of which the top layer is plastic with various fillers and pigments. The structure is made of chipboard or fibreboard, solid wood or a combination.

The production of solid wood flooring is relatively simple (Figure 23). However, trees require planting, growing, thinning and felling, the ground cultivation and replanting or natural regeneration. After felling, the logs are transported to sawmills for barking, sawing and drying (Jonsson *et al*, 1997).

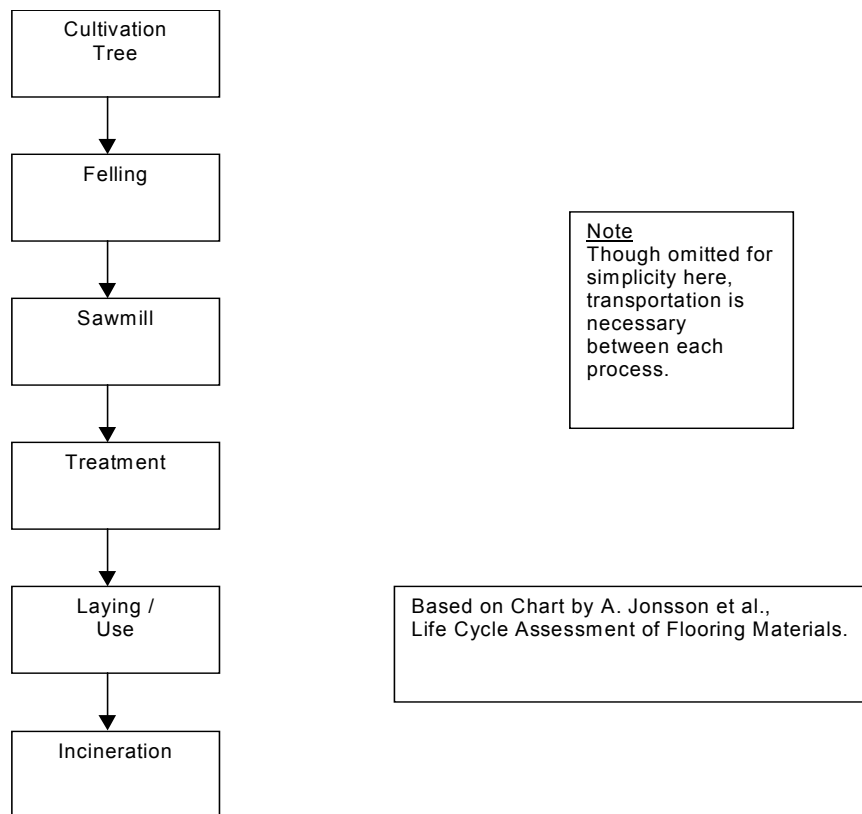
At certain times of the year, felled trees risk attack from pests and fungi. In Danish and other Nordic forests, coniferous trees are attacked by beetles and deciduous trees by fungi (blue-stain). In the past, this has been combated with chemicals and pesticides. This is no longer done, partly since the use of these preparations is now forbidden. Instead, the logs are transported soon after felling (during high-risk periods) to the sawmills and dried. Beetles destroy the wood, while the effect of the blue-stain fungus is only cosmetic. (G. Jensen, 1999)

The energy consumption of forest management for felling and transport is estimated in by A Evald (1993) to 0.213 – 0.380 MJ/kg raw wood (0.059 – 0.106 kWh/kg). A Norwegian evaluation cited by Evald estimates the total energy consumption to be 0.12 GJ/m³ raw wood, which is equivalent to 0,245-0,279 MJ/kg for spruce and pine.

Drying the wood is energy consuming. Air drying is uncommon in the Nordic region but does occur. It is often possible for a sawmill to cover its energy requirement with waste and excess wood. A Norwegian investigation states that drying requires 365 kWh/m³ (1.31 GJ/m³) (Norsk Treteknisk Institut, cited from A Evald 1993). For spruce this figure is 0.849 kWh/kg and for pine 0.745 kWh/kg. This investigation covered wood for construction purposes.

The type of solid wood floor described by Jonsson *et al* (1997) is not treated further, simply transported to the customer and fitted. Several types of wood flooring require an intermediate process step. This may include coating with oil or varnish. (J C. Powell *et al*.)

Figure: Flowchart for solid wood flooring production (excluding surface treatment)



Processing and coating of wood flooring.

Wood flooring may be untreated, luted, varnished or oiled.

The upper surface of the floor covering is sanded. The sawdust from sanding must be extracted to ensure a good working environment. The sawdust can be incinerated and the energy recovered.

The most significant use and emissions of VOCs come from the surface treatment of the flooring (varnishing, oiling). Oxygen-curing varnish and polyurethane (PUR) contain 55-70% VOCs and nitrocellulose varnish 70-80% VOCs. UV-curing varnishes (normally acrylic) generally contain 0-5% VOCs and water-based coatings 0-10%.

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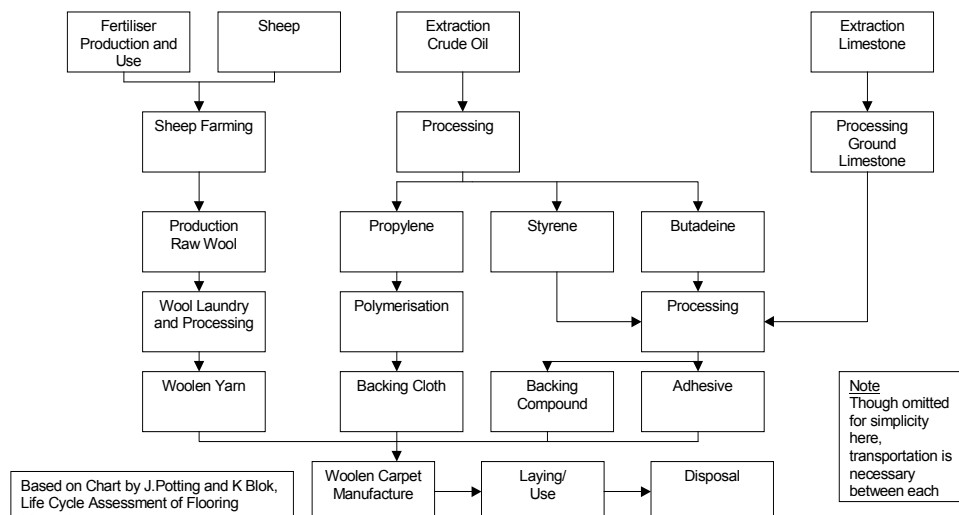
Georg Jensen. Danish Forest and Nature Agency, Danish Ministry of the Environment. February 1999. Personal communication.

2 CARPETS

Roughly 85% of floor carpets are tufted with a polyamide or woollen yarn. Polypropylene is used for the backing weave and styrene butadiene rubber (SBR) mixed with limestone/chalk used as a non-slip foam backing. The production of tufted carpets can be divided into three processes: tufting, dyeing and backing. The tufting process employs a tufting machine with many needles that are used to attach the yarn to the backing weave. The product is then dyed unless the yarn was previously dyed. The backing weave is then coated with adhesive and foam or a secondary backing. Figure 1 and 2 provide a flowchart for the production process. Carpets with a polyamide pile weigh roughly 600 g/m² and wool carpets 950 g/m². (J C. Powell et al.)

Special additives may be added to the carpet. In a test of English carpets, Permethrin (a pesticide against mites) was found in three of eight samples and brominated flame retardants (BDE-209) in one. Two carpets contained organic tin compounds, probably to combat bacteria, mites, mould and suchlike. (Greenpeace, 2000)

Figure: Flowchart of wool carpet production
(J C. Powell et al.)



References

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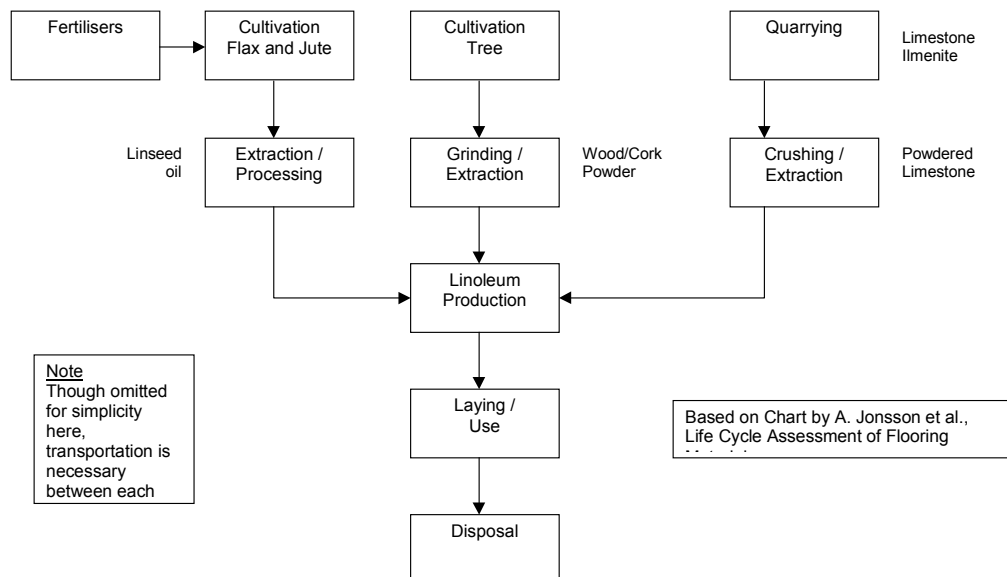
Greenpeace Research Laboratories, University of Exeter, UK. "Poison Underfoot – Hazardous Chemicals in PVC Flooring and Hazardous Chemicals in Carpets"

November 29 2000.

3 LINOLEUM

Linoleum comprises a resilient layer of linoleum compound on a jute backing. Fibreglass backing is used for linoleum tiles to offer better form stability. The compound is a mixture of linseed oil (27%), colophony (resin from coniferous trees) (8%), limestone (10%), wood meal (10%), cork meal (10%) and pigment (5%). Jute weave makes up roughly 10% by weight, depending on the thickness of the flooring. Linseed oil and colophony are oxidised (aerated) and then mixed with the other ingredients (Potting & Blok, 1995). Titanium dioxide is the most commonly used pigment (Jonsson *et al*, 1997). The mixture is pressed with a metal roller onto a woven backing or jute and then dried. Drying is performed in large kilns and takes roughly one hour. After drying, the flooring is finished with an acrylate dispersion (Potting & Blok, 1995). Offcuts are recycled to varying degrees in production. A flowchart of production is provided in Figure 16. Domestic linoleum weighs roughly 2300 g/m².

Figure: Flowchart of linoleum production



References

J C. Powell, I Lorenzoni and O White.

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Energy consumption in flooring production	Ceramic CCHöganås (S)¹⁾ glazed/unglazed	Ceramic CCHöganås (S)¹³⁾	Ceramic Tiles¹⁴⁾ glazed/unglazed	Linoleum Forbo²⁾	Solid wood²⁾ Siljan Trägoly	Parquet Beech¹⁰⁾	Parquet¹²⁾ Beech, solid	Plastic/PVC Tarkett²⁾ (Ronneby)	Carpet⁶⁾ Wool	Carpet⁶⁾ Polyamide
Total energy, kWh/m ² flooring:	81.1/ 80.7	99	17.2 - 44	11.5 ³⁾	13.7 ⁴⁾	42.2 ¹¹⁾	78.8	12.4	23.6 ⁷⁾	46.1 ⁸⁾
- Electricity consumption, kWh/m ² flooring	-	21	-	4.5 ³⁾	2.3	-	17.9	5.1	approx. 0 ⁹⁾	approx. 0 ⁹⁾
Fuel consumption (oil, gas, coke, etc.) kWh/m ² flooring	-	78	-	6.9 ³⁾	11.3	-	66.8	7.36	23.6	46.1
- % biofuel or other renewable energy source	approx. 0	0	approx. 0	72 %	-	-	approx. 100%	0	-	-

Notes:

Data taken from generally available reports and similar:

1) CC Höganäs Byggkeramik AB, Ekeby, Sverige, data sheet, building material declaration. June 1999. Ceramic tiles: Glazed: Raw material extraction: 1.1 kWh/m², Production (moulding and firing): 80 kWh/m².

Unglazed Raw material extraction: 0.7 kWh/m². Production (moulding and firing): 80 kWh/m².

Energy sources: Diesel, oil and electricity - no specification of processes and quantities.

See also note 13.

2) Source: Licentiate report from Chalmers University of Technology: "Life Cycle Assessment of Flooring Materials", Åsa Jönsson, 1995.

3) Total 41.3 MJ/m². Embodied energy: 45.2 MJ/m² (feedstock energy 28.8 MJ/m²)

Raw materials: Linseed oil: 3.87 MJ/kg = 1.1 kWh/kg. Distribution: 0.54 MJ electricity, 0.65 MJ diesel, 2.68 MJ oil.

Production: Natural gas is used for the production of steam in the flooring's production process (13.5 MJ/m²), electricity: 6.5/m². Thickness 2 mm.

4) Total: 49.2 MJ/m². Embodied energy 126 MJ/m² (feedstock energy 113 MJ/m²)

Raw materials: Fossil fuels for felling and transportation: 5.39 kWh/m² = 1.5 kWh/m²

Production: Sawmill: electricity: 8.37 MJ/m² (= 2.3 kWh) and biofuels from the sawmill: 35.4 kWh/m² (= 9.8 kWh/m²)

5) Total: 44.7 MJ/m². Embodied energy: 27.3 MJ (feedstock energy 16 MJ/m²)

Raw materials: Monomer oil and gas: 26.5, PVC polymerisation: 5.46 MJ/m². Production: electricity: 33.3 kWh/m² (= 9.2 kWh/m²)

6) Source: Utrecht University, Department of Science, Technology and Society.

"Life-cycle assessment of four types of floor covering". José Potting and Kornelis Blok. 1994.

7) Embodied energy of 48.4 MJ/m² not included.

8) Embodied energy of 154,3 MJ/m² not included.

9) In the summary inventory, electricity consumption is listed as negative. The article is very brief and the reason is not clearly explained. Possibly since embodied energy that is recovered is included in the calculation. However, feedstock energy is specified separately.

10) Source: www.trae.dk/leksikon/Energiforbrug_i_træs_livscyklus. CowiConsult, Dec. 1998

11) Total energy consumption specified as 6.6 GJ/m³. Assumed that 0.023 m³ is used per m². This includes waste that should be used for other items. No specification as to the distribution of energy sources. No details of the source of production data.

12) "Livscyklusvurdering af gulvmaterialer – bøgemarket og laminatgulv" Special course. Study report. Institute of product development, Technical University of Denmark, T L Hansen and AL Niemann, 1999.

13) CC Höganäs Byggkeramik AB, Ekeby, Sverige. Environmental report. Internal address: www.cchoganas.se. Dec. 1996. Unpublished.

14) ANPA (Italian EPA), 1993. Quoted from ¹ Source:

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Energy given as: 62-158 MJ/m².