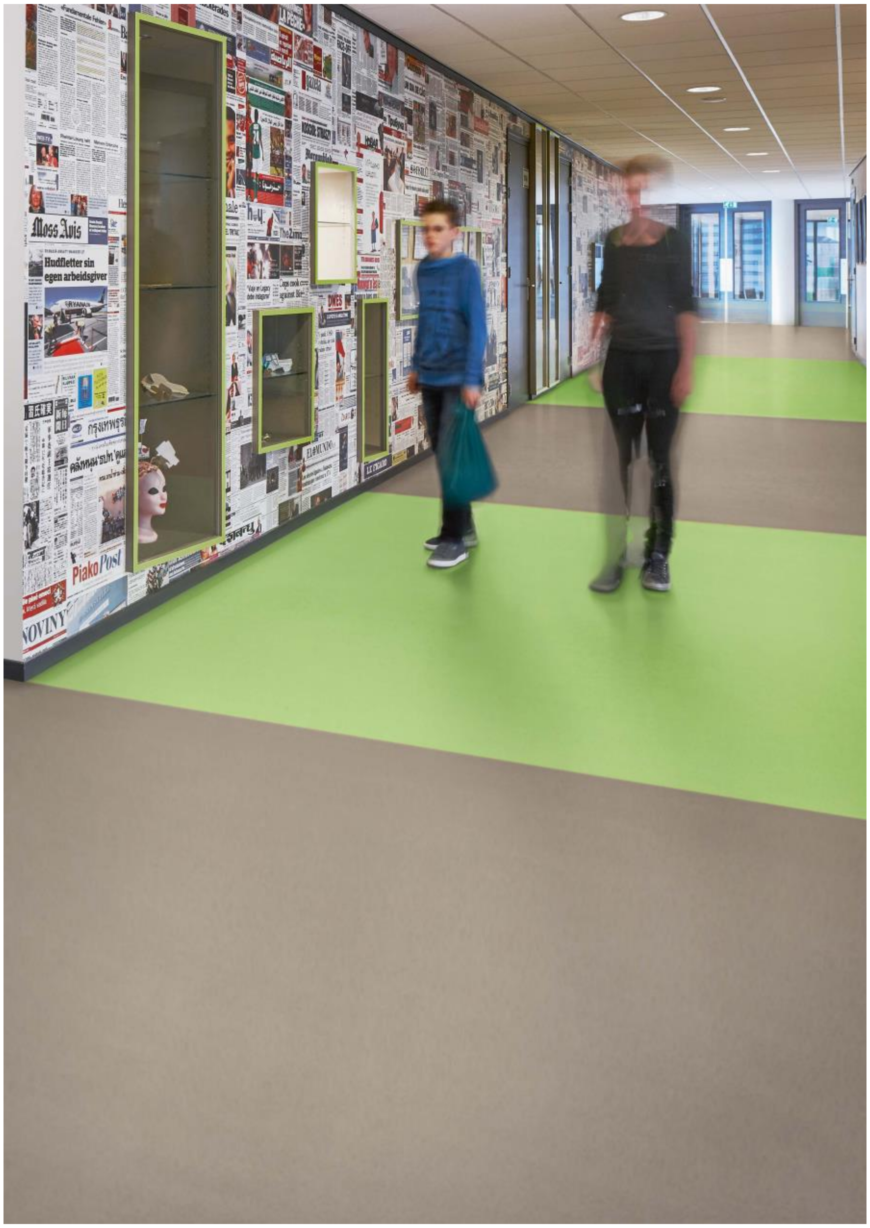
ENVIRONMENTAL PRODUCT DECLARATION

Acoustic Vinyl

FORBO FLOORING SYSTEMS
RESILIENT HETEROGENEOUS VINYL FLOOR COVERING ON FOAM



Sarlon Frequency 433428 Jade / 433424 Taupe

FLOORING SYSTEMS

Achieving lower noise pollution is essential to reducing stress and promoting the well-being, comfort and efficiency of people working or learning. The Forbo acoustic project vinyl collection is the result of more than 30 years of acoustic experience and specific industry knowledge which enables us to deliver the “best in class” acoustic vinyl flooring for every application.

Forbo was the first flooring manufacturer to publish a complete Life Cycle Assessment (LCA) report verified by CML in 2000. In addition, Forbo is now publishing Environmental Product Declarations (EPD) for all products including full LCA reports. This EPD was developed using recognized flooring Product Category Rules and includes additional information to show the impacts on human health and eco-toxicity. By offering the complete story we hope that our stakeholders will be able to use this document as a tool that will translate the environmental performance of acoustic vinyl into true value and benefits for all our customers and stakeholders alike.

For more information visit:
www.forbo-flooring.com

CERTIFIED
ENVIRONMENTAL PRODUCT DECLARATION
UL.COM/EPD

FLOORING SYSTEMS

Acoustic Vinyl
Resilient Floor Covering

According to ISO 14025 & EN 15804

This declaration is an environmental product declaration (EPD) in accordance with ISO 14025. EPDs rely on Life Cycle Assessment (LCA) to provide information on a number of environmental impacts of products over their life cycle. Exclusions: EPDs do not indicate that any environmental or social performance benchmarks are met, and there may be impacts that they do not encompass. LCAs do not typically address the site-specific environmental impacts of raw material extraction, nor are they meant to assess human health toxicity. EPDs can complement but cannot replace tools and certifications that are designed to address these impacts and/or set performance thresholds – e.g. Type 1 certifications, health assessments and declarations, environmental impact assessments, etc. Accuracy of Results: EPDs regularly rely on estimations of impacts, and the level of accuracy in estimation of effect differs for any particular product line and reported impact. Comparability: EPDs are not comparative assertions and are either not comparable or have limited comparability when they cover different life cycle stages, are based on different product category rules or are missing relevant environmental impacts. EPDs from different programs may not be comparable.

PROGRAM OPERATOR	UL Environment 333 Pfingsten Road Northbrook, IL 60611
DECLARATION HOLDER	Forbo Flooring B.V. Industrieweg 12 P.O. Box 13 NL-1560 AA Krommenie
DECLARATION NUMBER	4788294459.104.1
DECLARED PRODUCT	Acoustic Vinyl Resilient Floor Covering
REFERENCE PCR	EN 16810 : Resilient, Textile and Laminate floor coverings – Environmental product declarations – Product category rules
DATE OF ISSUE	June 29, 2018
PERIOD OF VALIDITY	5 Years
CONTENTS OF THE DECLARATION	Product definition and information about building physics Information about basic material and the material's origin Description of the product's manufacture Indication of product processing Information about the in-use conditions Life cycle assessment results Testing results and verifications

The PCR review was conducted by:	PCR Review Panel
This declaration was independently verified in accordance with ISO 14025 by Underwriters Laboratories ☐ INTERNAL ☒ EXTERNAL	Grant R. Martin Grant R. Martin, UL Environment
This life cycle assessment was independently verified in accordance with ISO 14044 and the reference PCR by:	Thomas P. Gloria, Industrial Ecology Consultants

This EPD conforms with EN 15804

Acoustic Vinyl
Resilient Floor Covering

According to ISO 14025 & EN 15804

Product Definition

Product Classification and Description

This declaration covers a broad range of designs and colors. Acoustic vinyl is a resilient floor covering complying with all the requirements of EN 651 / ISO 11638: Resilient floor coverings – Heterogeneous polyvinyl chloride flooring on foam - Specification. The key raw materials include glass fiber, binders (PVC and calcium carbonate), plasticizer and water-based inks.

Acoustic vinyl is produced by Forbo Flooring and is sold worldwide. This declaration refers to Sarlon Acoustic vinyl (sheet or tiles) covering a broad range of designs and colors :

Sparkling, Modul'Up, Modul'Up Compact, Complete Step, Habitat, Habitat Modal, Sarlibase, Compact, Trafic modal.

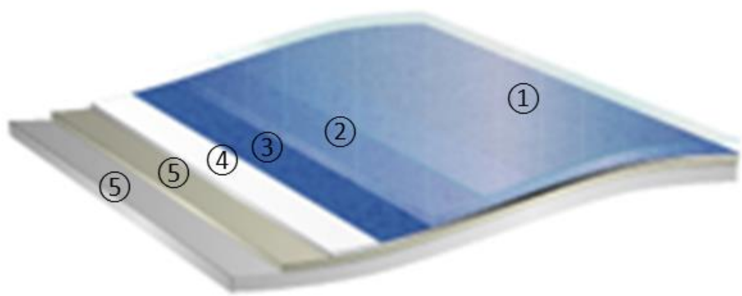


Figure 1 : Schematic build-up of Acoustic Vinyl

Acoustic vinyl is build up in 5 layers :

1. **Lacquer surface:** This layer gives the final protection and stain resistance
2. **Wear layer:** This layer gives a first protection to the printed layer. After finishing the product a factory lacquer surface is applied to protect the surface layer
3. **Printed layer:** Design printed with environmentally friendly water-based inks
4. **Glass fiber:** Support of the floor covering
5. **Under layer**: Foam backing and compact PVC layer achieving an outstanding impact sound reduction and indentation

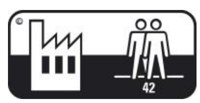
This declaration refers to the declared/functional unit of 1 m2 installed flooring product.

Acoustic Vinyl
Resilient Floor Covering

According to ISO 14025 & EN 15804

Range of application

Acoustic vinyl is classified in accordance with EN 651 / ISO 11638 to be installed in the following use areas defined in EN-ISO 10874:

Area of application	
Domestic	Class 23 
Commercial	Class 34 
Industrial	Class 42 

Product Standards

The products considered in this EPD have the following technical specifications:

- Meets or exceeds all technical requirements in EN 651 / ISO 11638 Resilient floor coverings – Heterogeneous polyvinyl chloride flooring on foam - Specification

Acoustic vinyl meets the requirements of EN 14041

EN 13501-1	Reaction to fire	B_{fl} – s1 / C_{fl} - s1
EN 13893	Slip resistance	DS: ≥ 0,30
EN 1815	Body voltage	< 2 kV
EN ISO10456	Thermal conductivity	0,25 W/mK

Accreditations

- ISO 9001 Quality Management System
- ISO 14001 Environmental Management System
- OHSAS 18001 Occupational Health and Safety Management Systems
- SA 8000 Social Accountability International

ISO 9001 ISO 14001 OHSAS 18001 SA 8000

Delivery Status

Table 1: Specification of delivered product

Characteristics	Nominal Value	Unit
Product thickness	min : 2,55 / max : 4,1	mm
Product Weight	min : 2070 / max : 3880	g/m²
Rolls Width Length Tiles	2.00 (1,01 for complete step) 25 (20 for complete step) min : 4.00 / max : 7.00	Meter m² / box

Material Content

Material Content of the Product

Table 2: Composition of Acoustic Vinyl

Component	Material	Availability	Amount [%]	Origin of raw material
Binder	PVC	Nonrenewable – limited	56.0	Europe
	DOTP	Nonrenewable - limited	26.0	Europe
Filler	Calcium Carbonate	Abundant mineral	13.5	Europe
Stabilizer	Ca/Zn	Nonrenewable - limited	0.5	Europe
Pigment	TiO2	Nonrenewable - limited	0.5	Europe
Substrate	Glass fibers	Nonrenewable - limited	2.5	Europe
Additives	Various chemicals	Nonrenewable - limited	0.5	Europe
Finish	Various chemicals	Nonrenewable - limited	0.5	Europe

Production of Main Materials

PVC: Polyvinyl chloride is obtained by polymerization of the monomer vinyl chloride.

Plasticizer: DOTP, a non-phthalate plasticiser, being the diester of terephthalic acid and the branched-chain 2-ethylhexanol. This colorless viscous liquid used for softening PVC plastics is known for chemical similarity to general purpose phthalates such as DEHP and DINP, but without any negative regulatory pressure.

Stabilizer Ca/Zn: Mixed metal stabilizer made from Calcium and Zinc stearate. It is used to avoid PVC degradation during processing at relative high temperature.

Calcium carbonate: An abundant mineral found in all parts of the world as the chief substance in rocks (i.e., marble and limestone). It can be ground to varying particle sizes and is widely used as filler.

Glass fibre: Glass fibre is used as a substrate for floor coverings and provides better dimensional stability.

Lacquer : acrylate hybrid dispersion

Titanium dioxide : A white pigment produced from the mineral rutile, a naturally occurring form of titanium dioxide. The production of the pigment is a large-scale chemical process.

Production of the Floor Covering

Acoustic vinyl is produced in several stages starting with the impregnation of the glass fiber (consists of filling the glass fiber with a PVC paste) and the rotogravure printing (possibility to deposit different patterns and colors). The next stage is the wear layer gelation with a coating technology (a transparent wear layer on all products). Then the product is put back to deposit a coat of compact reinforcing PVC and a coat of PVC chemical foam. Lacquering is obtained by a UV lacquer (acrylate hybrid dispersion) : it's a long term protection which avoids metallization, reduces costs and facilitates maintenance. Inspection is done and edges are cut (trimmings and rejected product are reused). Finally the floor covering is cut to length into rolls or collected to produce tiles (grinding of the back foam and cutting in tiles). The finished product is sent to the warehouse department.

Health, Safety and Environmental Aspects during Production

- ISO 14001 Environmental Management System
- OHSAS 18001 Occupational Health and Safety Management Systems
- SA 8000 Social Accountability International

Production Waste

Rejected material and the cuttings of the trimming stage are recycled. Packaging materials are collected separately and externally recycled.

Delivery and Installation of the Floor Covering

Delivery

Worldwide distribution by truck and container ship is considered. On average, every square meter of Acoustic Vinyl is transported as follows:

○ Transport distance 40 t truck	694 km
○ Transport distance 7.5t truck (Fine distribution)	254 km
○ Capacity utilization trucks (including empty runs)	85 %
○ Transport distance Ocean ship	0 km
○ Capacity utilization Ocean ship	48%

Since Acoustic Vinyl is mainly sold in Europe on average there is no significant transport distance for the distribution of Acoustic Vinyl by Ocean ship.

Installation

Because of the specific techniques used during the installation of Acoustic vinyl, 6% (PVC sheet) or 4% (PVC tile) of the material is cut off as installation waste. For installation of acoustic vinyl on the floor : 0.25 kg/m² of adhesive is required. For installation of loose lay products, no glue is required. Waste during the installation process may be recycled or landfilled.

Health, Safety and Environmental Aspects during Installation

Forbo flooring recommends using (low) zero emission adhesives for installing Acoustic Vinyl.

Waste

Waste during the installation process may be recycled or landfilled.

Packaging

Cardboard tubes and packaging paper can be collected separately and should be used in a local recycling process.

Use stage

The service lifetime of a floor covering for a certain application on a floor is too widespread to give one common number. For this EPD model the reference service lifetime (RSL) is set to one year. This means that all impacts for the use phase are based on the cleaning and maintenance model for one year. Depending on the area of use, the technical lifetime advised by the manufacturer and the estimated time on the floor by the customer, the service lifetime can be determined. The use phase impacts should be calculated with the foreseen service life to arrive at the total environmental impact.

Cleaning and Maintenance

Level of use	Cleaning Process	Cleaning Frequency	Consumption of energy and resources
Commercial/Residential	Vacuuming	Twice a week	Electricity
	Wet Cleaning	Once a week	Hot water Neutral detergent

For the calculations the following cleaning regime is considered:

- Dry cleaning with a 1.5 kW vacuum cleaner for 0.21 min/m^2, twice a week. This equates to 0.55 kWh/m^2*year.
- Once a week wet cleaning with 0.062 l/m^2 water and 0.0008 kg/m^2 detergent. This result in the use of 3.224 l/m^2*year water and 0.04 kg/m^2*year detergent. The wet cleaning takes place without power machine usage. Waste water treatment of the arising waste water from cleaning is considered (Data sourced from Forbo GABI model).

The cleaning regime that is recommended in practice will be highly dependent on the use of the premises where the floor covering is installed. In high traffic areas more frequent cleaning will be needed compared to areas where there is low traffic. The use of an entrance mat of at least four steps will reduce the cleaning frequency.

The cleaning regime used in the calculations is suitable for high traffic areas.

Prevention of Structural Damage

All newly laid floor covering should be covered and protected with a suitable non-staining protective covering if other building activities are still in progress. Use protective feet on chairs and tables to reduce scratching. Castor wheels should be suitable for resilient floor coverings.

Health Aspects During Usage

Acoustic Vinyl is in compliance with:

- AgBB requirements
- French act Grenelle: A+
- Emission class M1

End of Life

The deconstruction of installed Acoustic Vinyl from the floor is done mechanically and the electrical energy needed for this is estimated to be 0.03 kWh/sqm. This amount of energy is included in the calculations.
For the End of Life stage 100% incineration is taken into account, the average distance to the incineration plant per lorry is set to 200 km.

Life Cycle Assessment

A full Life Cycle Assessment has bee carried out according to ISO 14040 and ISO 14044.

The following Life Cycle Stages are assessed :

- A1-3 : Product Stage (Raw material acquisition, transportation to Manufacturing and Manufacturing)
- A4-5 : Construction stage (Transport Gate to User, Installation flooring)
- B2 : Use Stage (Maintenance of the floor)
- C1-4 : End of Life Stage (Deconstruction, transport, waste processing, disposal)
- D : Benefits and loads beyond the system boundary (Reuse, recovery, recycling potential)

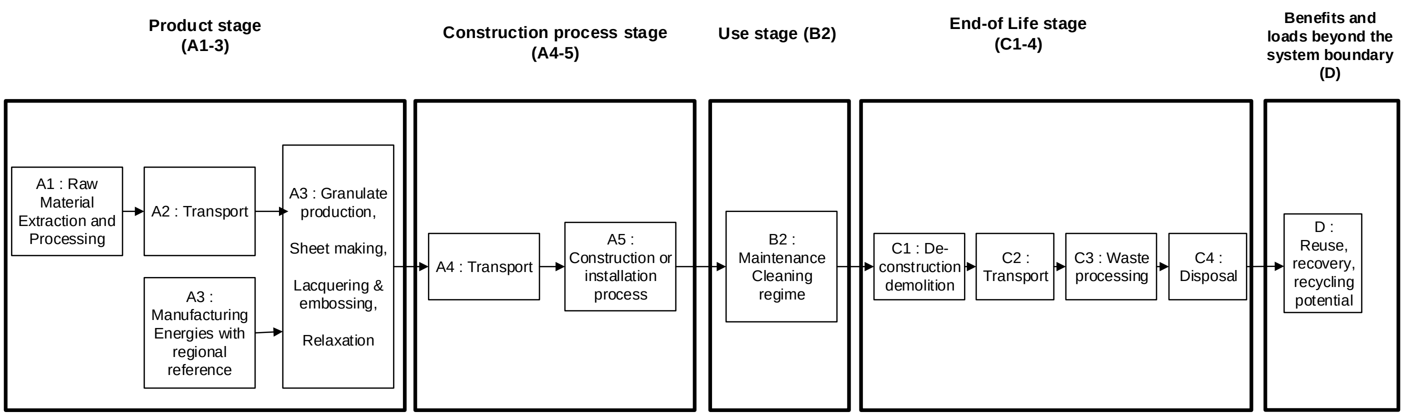


Figure 2: Flow chart of the Life Cycle Assessment

Comparisons of different floor coverings are only allowed, where EN 15804 consistent and/or preverified background data and EN 15804 consistent calculation methods and database versions are used and when the building context is taken into account, i.e. on the basis of the same use-classification (EN ISO 10874), same service life and comparable assumptions for the end of life.

Description of the Declared Functional Unit

The functional unit is one square meter of installed product and the use stage is considered for one year of service life.

Cut off Criteria

The cut-off criteria shall be 1% of renewable and non-renewable primary energy usage and 1% of the total mass of the unit process. The total neglected input flows per module shall be a maximum of 5% of energy usage and mass.

In practice, in this assessment, all data from the production data acquisition are considered, i.e. all raw materials used as per formulation, use of water, electricity and other fuels, the required packaging materials, and all direct production waste. Transport data on all considered inputs and output material are also considered.

Allocations

In the present study some allocations have been made. Detailed explanations can be found in the chapters below.

Co-product allocation

No co-product allocation occurs in the product system.

Allocation of multi-input processes

The Production and End of Life stage include incineration plants. In these processes different products are treated together within a process. The allocation procedures followed in these cases are based on a physical classification of the mass flows or calorific values.

Credits from energy substitution are allocated to the production stage, because the gained energy from energy substitution is lower than the energy input in this stage. The same quality of energy is considered.

Allocation procedure of reuse, recycling and recovery

The installation waste and end of life waste is fed into incineration processes. Incineration processes include cogeneration processes which give thermal and power energy as outputs. It is assumed that this recovered energy offsets that produced by the European average grid mix and thermal energy generation from natural gas.

Description of the allocation processes in the LCA report

The description of allocation rules in of this LCA report meets the requirements of the PCR.

Background Data

As a general rule, specific data derived from specific production processes or average data derived from specific production processes have been used as the first choice as a basis for calculating an EPD.

For life cycle modeling of the considered products, the GaBi 6 Software System for Life Cycle Engineering, developed by THINKSTEP has been used. All relevant LCA datasets are taken from the GaBi 6 software database. The datasets from the database GaBi are documented in the online documentation. To ensure comparability of results in the LCA, the basic data of GaBi database were used for energy, transportation and auxiliary materials.

Data Quality

The requirements for data quality and LCA data correspond to the specifications of the PCR.

Foreground data are based on 1 year averaged data (year 2017). The reference ages of LCA datasets vary but are given in the table in the Appendix. The time period over which inputs to and outputs from the system is accounted for is 100 years from the year for which the data set is deemed representative. The technological LCA of the collected data reflects the physical reality of the declared product. The datasets are complete, conform to the system boundaries and the criteria for the exclusion of inputs and outputs and are geographical representative for the supply chain of Forbo flooring.

For life cycle modeling of the considered products the GaBi 6 Software System for Life Cycle Engineering, developed by THINKSTEP, is used. All relevant LCA datasets are taken from the GaBi 6 software database. The last revision of the used data sets took place within the last 10 years.

System Boundaries

Production Stage includes provision of all materials, products and energy, packaging processing and its transport, as well as waste processing up to the end-of waste state or disposal of final residues during the product stage.

Transport and Installation Stage includes provision of all materials, products and energy, as well as waste processing up to the end-of-waste state or disposal of final residues during the construction stage. These information modules also include all impacts and aspects related to any losses during this construction stage (i.e. production, transport, and waste processing and disposal of the lost products and materials). For the transportation a worldwide distribution is considered.

Use Stage includes provision and transport of all materials, products and related energy and water use, as well as waste processing up to the end-of-waste state or disposal of final residues during this part of the use stage. These information modules also include all impacts and aspects related to the losses during this part of the use stage (i.e. production, transport, and waste processing and disposal of the lost products and materials).

End of Life Stage includes provision and all transports, provision of all materials, products and related energy and water use. It also includes any declared benefits and loads from net flows leaving the product system that have not been allocated as co-products and that have passed the end-of-waste state in the form of reuse, recovery and/or recycling potentials.

Power mix

The selection of LCA data for the electricity generation is in line with the PCR.

The products are manufactured in Reims, France. The GaBi 6 Hydropower dataset has therefore been used (reference year 2017). The energy supplier is providing Forbo with a certificate every year.

CO_2-Certificates

No CO_2-certificates are considered in this study.

Life Cycle Assessment

In table 3 the environmental impacts for one lifecycle are presented for Acoustic Vinyl. In table 4 the environmental impacts are presented for all the lifecycle stages.

Table 3: Results of the LCA – Environmental impacts one lifecycle (one year) – Acoustic Vinyl

Impact Category : CML 2001 – Jan. 2016	Acoustic Vinyl	Unit
Global Warming Potential (GWP 100 years)	1,39E+01	kg CO2-Equiv.
Ozone Layer Depletion Potential (ODP. steady state)	7,06E-08	kg R11-Equiv.
Acidification Potential (AP)	2,77E-02	kg SO2-Equiv.
Eutrophication Potential (EP)	3,17E-03	kg Phosphate-Equiv.
Photochem. Ozone Creation Potential (POCP)	2,24E-03	kg Ethene-Equiv.
Abiotic Depletion Potential Elements (ADPE)	2,68E-05	kg Sb-Equiv.
Abiotic Depletion Potential Fossil (ADPF)	1,79E+02	[MJ]

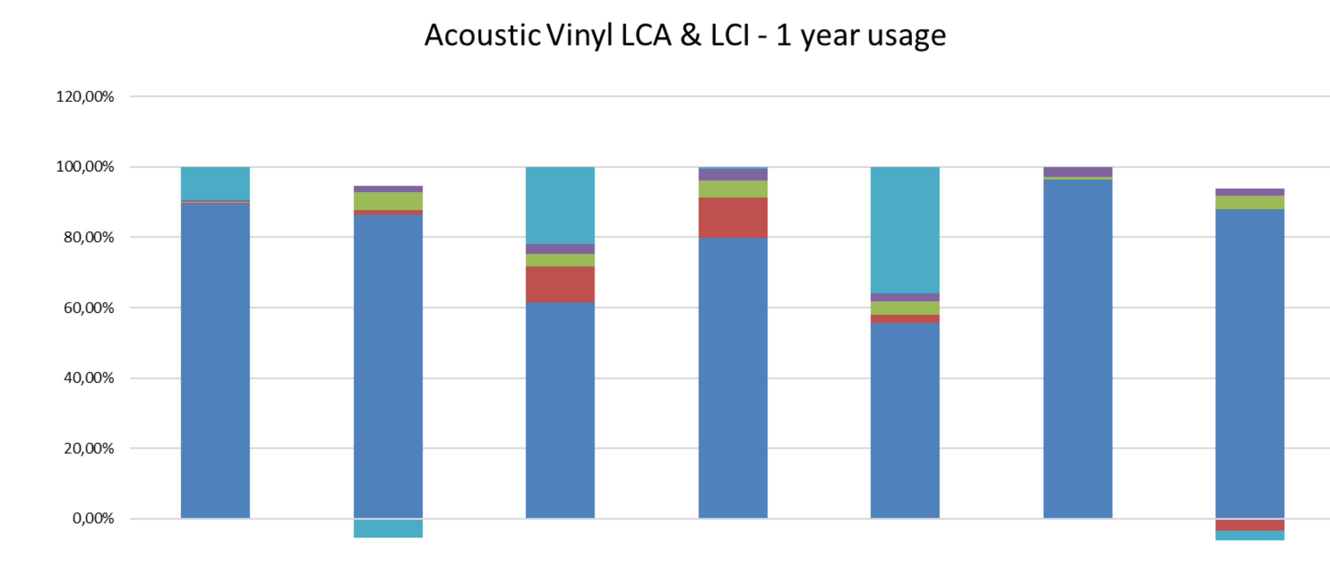
Table 4: Results of the LCA – Environmental impact for Acoustic Vinyl (one year)

Impact Category : CML 2001 – Jan. 2016		Manufacturing	Installation		Use (1yr)	End of Life			Credits
Parameter	**Unit**	**A1-3**	**A4**	**A5**	**B2**	**C1**	**C2**	**C3**	**D**
GWP	[kg CO_2-Eq.]	7,70E+00	3,49E-01	5,20E-01	3,16E-01	5,35E-03	1,79E-02	6,58E+00	-1,63E+00
ODP	[kg CFC11-Eq.]	6,81E-08	5,53E-15	4,03E-10	2,06E-09	2,38E-14	4,89E-16	5,85E-13	-3,55E-12
AP	[kg SO_2-Eq.]	1,70E-02	2,82E-03	9,85E-04	7,82E-04	1,52E-05	4,35E-05	8,77E-03	-2,74E-03
EP	[kg PO_4^{3-}- Eq.]	2,53E-03	3,70E-04	1,47E-04	1,07E-04	1,42E-06	1,10E-05	3,03E-04	-2,97E-04
POCP	[kg Ethen Eq.]	2,24E-03	-8,42E-05	9,50E-05	5,51E-05	9,52E-07	-1,50E-05	1,59E-04	-2,15E-04
ADPE	[kg Sb Eq.]	2,40E-05	1,36E-08	1,07E-07	1,58E-07	2,84E-09	1,47E-09	2,96E-06	-4,62E-07
ADPF	[MJ]	1,74E+02	2,86E+00	9,97E+00	3,53E+00	5,70E-02	2,43E-01	1,12E+01	-2,25E+01

GWP = Global warming potential; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential of land and water; EP = Eutrophication potential; POCP = Formation potential of tropospheric ozone photochemical oxidants; ADPE = Abiotic depletion potential for non-fossil resources; ADPF = Abiotic depletion potential for fossil resources

The relative contribution of each process stage to each impact category for Acoustic Vinyl is shown in figure 3.

Figure 3: relative contribution of each process stage to each impact category for Acoustic Vinyl for a one year usage.



	Abiotic Depletion (Elements)	Abiotic Depletion (Fossil)	Acidification Potential	Eutrophication Potential	Global Warming Potential	Ozone Layer Depletion Potential	Photochem. Ozone Creation Potential
End of Life	9,34%	-5,46%	22,00%	0,58%	35,89%	0,00%	-2,75%
Use	0,59%	1,75%	2,83%	3,37%	2,28%	2,92%	2,17%
Installation	0,40%	4,95%	3,56%	4,63%	3,75%	0,57%	3,73%
Transport	0,05%	1,42%	10,19%	11,66%	2,52%	0,00%	-3,31%
Production	89,62%	86,41%	61,43%	79,75%	55,56%	96,51%	88,04%

Interpretation

The interpretation of the results has been carried out considering the assumptions and limitations declared in the EPD, both methodology- and data-related for a one year usage.

In all of the impact categories the production stage has the main contribution to the overall impact and the raw material supply is the key contributor with a share of 92 – 99%. Main raw materials with a relevant contribution are PVC and the plasticizers.

For the transportation stage a significant contribution comes from the categories AP and EP in which the trucks used for the distribution to the customers are the major contributors.

For ADPF, GWP, AP, EP and POCP the flooring installation has an impact of approximately 4 – 5% of the total, this is mainly caused by the adhesive.

During the use phase all categories have small impacts on the total.

At the End of Life stage the main impact categories are AP, ADPE and GWP, this is mainly due to the incineration of the post-consumer waste.

Resource use

In table 5 the parameters describing resource use are presented for all the lifecycle stages for a one year usage.

Table 5: Results of the LCA – Resource use for Acoustic Vinyl (one year)

		Manufacturing	Installation		Use (1yr)	End of Life			Credits
Parameter	**Unit**	**A1-3**	**A4**	**A5**	**B2**	**C1**	**C2**	**C3**	**D**
PERE	[MJ]	1,54E+01	-	-	-	-	-	-	-
PERM	[MJ]	0,00E+00	-	-	-	-	-	-	-
PERT	[MJ]	1,54E+01	1,10E-01	3,55E-01	1,58E+00	3,67E-02	1,35E-02	2,26E+00	-5,50E+00
PENRE	[MJ]	1,50E+02	-	-	-	-	-	-	-
PENRM	[MJ]	3,63E+01	-	-	-	-	-	-	-
PENRT	[MJ]	1,86E+02	2,87E+00	1,02E+01	5,40E+00	9,78E-02	2,44E-01	1,25E+01	-2,86E+01
SM	[kg]	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
RSF	[MJ]	1,84E-07	1,05E-29	4,41E-21	3,48E-24	0,00E+00	1,32E-30	8,86E-21	0,00E+00
NRSF	[MJ]	2,33E-06	1,59E-28	5,18E-20	4,09E-23	1,45E-31	2,00E-29	1,04E-19	-2,17E-29
FW	[m^3]	3,97E-02	2,03E-04	1,80E-03	2,38E-03	5,01E-05	2,48E-05	1,36E-02	-7,50E-03

PERE = Use of renewable primary energy excluding renewable primary energy resources used as raw materials; PERM = Use of renewable primary energy resources used as raw materials; PERT = Total use of renewable primary energy resources; PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; PENRM = Use of non-renewable primary energy resources used as raw materials; PENRT = Total use of non-renewable primary energy resources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of net fresh water

Waste categories and output flows

In table 6 other environmental information describing different waste categories and output flows are presented for all the lifecycle stages.

Table 6: Results of the LCA – Output flows and Waste categories for Acoustic Vinyl (one year)

		Manufacturing	Transport	Installation	Use (1yr)	End of Life/credits			
Parameter	**Unit**	**A1-3**	**A4**	**A5**	**B2**	**C1**	**C2**	**C3**	**D**
HWD	[kg]	1,91E-03	1,12E-07	3,08E-09	2,17E-09	4,59E-11	1,41E-08	7,92E-08	-1,16E-08
NHWD	[kg]	9,40E-02	1,68E-04	3,54E-03	1,30E-02	6,89E-05	2,05E-05	4,08E+00	-1,22E-02
RWD	[kg]	3,95E-03	3,77E-06	8,86E-05	7,17E-04	1,62E-05	3,34E-07	4,91E-04	-2,42E-03
CRU	[kg]	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
MFR	[kg]	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
MER	[kg]	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
EE Power	[MJ]	0,00E+00	0,00E+00	1,81E-01	0,00E+00	0,00E+00	0,00E+00	6,74E+00	0,00E+00
EE Thermal energy	[MJ]	0,00E+00	0,00E+00	3,25E-01	0,00E+00	0,00E+00	0,00E+00	1,23E+01	0,00E+00

HWD = Hazardous waste disposed; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed; CRU = Components for re-use; MFR = Materials for recycling; MER = Materials for energy recovery; EE = Exported energy per energy carrier

Additional Environmental Information

To be fully transparant Forbo Flooring does not only want to declare the environmental impacts required in the PCR, but also the impacts on human health and eco-toxicity. Furthermore the outcome of the calculations according to the European Standard EN15804 is published in this section.

Toxicity

For this calculations the USEtoxTM model is used as being the globally recommended preferred model for characterization modelling of human and eco-toxic impacts in LCIA by the United Nations Environment Programme SETAC Life Cycle Initiative.

According to the "ILCD Handbook: Recommendations for Life Cycle Impact Assessment in the European context" the recommended characterization models and associated characterization factors are classified according to their quality into three levels:

- Level I (recommended and satisfactory),
- Level II (recommended but in need of some improvements)
- Level III (recommended, but to be applied with caution).

A mixed classification sometimes is related to the application of the classified method to different types of substances.

USEtoxTM is classified as Level II / III, unlike for example the CML impact categories which are classified as Level I.

Table 7: Results of the LCA – Environmental impacts one lifecycle (one year) – Acoustic Vinyl

Impact Category : USEtox	Acoustic Vinyl	Unit
Eco toxicity	8,14E-03	PAF m3.day
Human toxicity, cancer	4,69E-09	Cases
Human toxicity, non-canc.	2,22E-09	Cases

In the following table the impacts are subdivided into the lifecycle stages.

Table 8: Results of the LCA – Environmental impact for Acoustic Vinyl (one year)

Impact Category : USEtox	Unit	Production	Transport	Installation	Use (1yr)	End of Life
Eco toxicity	PAF m3.day	6,05E-03	6,68E-04	1,02E-03	4,43E-04	-4,50E-05
Human toxicity, cancer	cases	4,74E-09	6,32E-13	1,81E-11	1,23E-11	-7,95E-11
Human toxicity, non-canc.	cases	2,15E-09	2,73E-13	6,60E-11	7,13E-13	-1,91E-12

Interpretation

The interpretation of the results has been carried out considering the assumptions and limitations declared in the EPD, both methodology- and data-related for a one year usage.

In all the Toxicity categories the production stage is the main contributor to the total overall impact. The raw material supply has a share of approximately 96-99% of the production stage, therefore the choice of raw materials can highly influence the Toxicity categories.

Transportation only has a significant contribution from Ecotoxicity of 8% of the total, the contribution of the other two categories are neglegible.

For the installation stage the adhesive is the major contributor to the total impact for all three Toxicity categories with a share of 99-100%.

The Use stage has a minor impact of ± 5% for Ecotoxicity, the Humantoxicity impacts in this life cycle stage are very small. Major cause for the impacts is the electricity used for cleaning the floor. The used cleaning regime of vacuuming twice a week is very conservative and will in practice most of the times be lower.

The End of Life stage shows a very minor negative contribution caused by the incineration of the post-consumer waste.

References

GABI 6 2012	THINKSTEP; GaBi 6: Software-System and Database for Life Cycle Engineering. Copyright, TM. Stuttgart, Echterdingen, 1992-2017.
GABI 6 2012D	GaBi 6: Documentation of GaBi 6: Software-System and Database for Life Cycle Engineering. Copyright, TM. Stuttgart, Echterdingen, 1992-2017. http://documentation.gabi-software.com/
UL ENVIRONMENT	UL Environment's Program Operator Rules
PE 2012 ILCD Handbook: General guide for Life Cycle Assessment - Detailed guidance	Description of Selected Impact Categories, Thinkstep, 2012 European Commission-Joint Research Centre - Institute for Environment and Sustainability: International Reference Life Cycle Data System (ILCD) Handbook- Recommendations for Life Cycle Impact Assessment in the European context. First edition November 2011. EUR 24571 EN. Luxemburg. Publications Office of the European Union; 2011
STANDARDS AND LAWS	
DIN EN ISO 14044	Environmental management - Life cycle assessment - Requirements and guidelines (ISO 14044:2006); German and English version EN ISO 14044
ISO 14025 2006	DIN EN ISO 14025: Environmental labels and declarations — Type III environmental declarations — Principles and procedures
ISO 14040 2006	Environmental management - Life cycle assessment - Principles and framework (ISO 14040); German and English version EN ISO 14040
CEN/TR 15941	Sustainability of construction works - Environmental product declarations - Methodology for selection and use of generic data; German version CEN/TR 15941
EN 16810	Resilient, textile and laminate floor coverings - Environmental product declarations - Product category rules
EN 15804	EN 15804: Sustainability of construction works — Environmental Product Declarations — Core rules for the product category of construction products
CPR	REGULATION (EU) No 305/2011 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 9 March 2011 laying down harmonized conditions for the marketing of construction products and repealing Council Directive 89/106/EEC
EN-ISO 10874 EN 651 / ISO 11638	Resilient, textile and laminate floor coverings – Classification Resilient floor coverings – Heterogeneous polyvinyl chloride flooring on foam - Specification

Life Cycle Assessment

Acoustic Vinyl

LCA study conducted by:
Forbo Flooring
Industrieweg 12
1566 JP Assendelft
The Netherlands

June 2018

Environment

Authors:
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Nomenclature

Abbreviation	Explanation
ADPF	Abiotic Depletion Potential Fossil
ADPE	Abiotic Depletion Potential Elements
AP	Acidification Potential
BLBSB	Benefits and Loads Beyond the System Boundary
CRU	Components for re-use
EE	Exported energy per energy carrier
EP	Eutrophication Potential
EPD	Environmental Product Declaration
FCSS	Floor covering standard symbol
FW	Use of net fresh water
GWP	Global Warming Potential
HWD	Hazardous waste disposed
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory analysis
LCIA	Life Cycle Impact Assessment
MER	Materials for energy recovery
MFR	Materials for recycling
NRSF	Use of non-renewable secondary fuels
ODP	Ozone Layer Depletion Potential
PENRE	Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials
PENRM	Use of non-renewable primary energy resources used as raw materials
PENRT	Total use of non-renewable primary energy resources
PERE	Use of renewable primary energy excluding renewable primary energy resources used as raw materials
PERM	Use of renewable primary energy resources used as raw materials
PERT	Total use of renewable primary energy resources
PCR	Product Category Rules
POCP	Photochemical Ozone Creation Potential
RSF	Use of renewable secondary fuels
RSL	Reference Service Life
RWD	Radioactive waste disposed
SM	Use of secondary material

General

The present LCA study of the company Forbo Flooring, a manufacturer of resilient floor coverings, has been performed by Forbo Flooring and has been conducted according to the requirements of the European Standard EN16810 “Resilient, textile and laminate floor coverings – Environmental product declarations – Product category rules”. The LCA report was sent to verification on 06/20/2018

Scope

This document is the LCA report for the “Environmental Product Declaration” (EPD) of "Acoustic Vinyl".
The provision of an LCA report is required for each EPD of the EPD-program holder (UL Environment). This document shows how the calculation rules were applied and describes additional LCA information on the Life Cycle Assessment in accordance with the requirements of ISO 14040 series.

Content, structure and accessibility of the LCA report

The LCA report provides a systematic and comprehensive summary of the project documentation supporting the verification of an EPD.
The report documents the information on which the Life Cycle Assessment is based, while also ensuring the additional information contained within the EPD complies with the requirements of ISO 14040 series.
The LCA report contains all of the data and information of importance for the details published in the EPD. Care is been given to all explanations as to how the data and information declared in the EPD arises from the Life Cycle Assessment.
The verification of the EPD is aligned towards the structure of the rule document based on ISO 14025, EN 15804 and EN16810.

Goal of the study

The reason for performing this LCA study is to publish an EPD based on EN 16810, EN15804 and ISO 14025.
This study contains the calculation and interpretation of the LCA results for Acoustic Vinyl complying with EN-ISO 11638.

Manufactured by
Forbo Sarlino S.A.S.
63, rue Gosset
B.P. 2717
FR-51055 Reims Cedex
France
the following life cycle stages were considered:

- Product stage
- Transport stage
- Installation stage
- Use stage
- End-of-life stage
- Benefits and loads beyond the product system boundary

The main purpose of EPD is for use in business-to-business communication. As all EPD are publicly available on the website of UL Environment and therefore are accessible to the end consumer they can also be used in business-to-consumer communication.
The intended use of the EPD is to communicate environmentally related information and LCA results to support the assessment of the sustainable use of resources and of the impact of construction works on the environment

Scope of the study

Declared / functional unit

The declaration refers to the declared/functional unit of 1m² installed flooring product.

Declaration of construction products classes

The LCA report refers to a manufacturer declaration of type 1a): Declaration of a specific product from a manufacturer's plant.
Sarlon Acoustic Vinyls are also known under the following brand names:

Sparkling, Modul'Up, Modul'Up Compact, Complete Step, Habitat, Habitat Modal, Sarlibase, Compact, Trafic modal

Acoustic Vinyl is produced at the following manufacturing site:
Forbo Sarlino S.A.S.
63, rue Gosset
B.P. 2717
FR-51055 Reims Cedex
France

FLOORING SYSTEMS

Acoustic Vinyl
Resilient Floor Covering

According to ISO 14025 & EN 15804

Product Definition

Product Classification and description

This declaration covers a broad range of designs and colors. Acoustic vinyl is a resilient floor covering complying with all the requirements of EN 651 / ISO 11638 : Resilient floor coverings – Heterogeneous polyvinyl chloride flooring on foam - Specification. The key raw materials include glass fiber, binders (PVC and calcium carbonate), plasticizer and water-based inks.

Acoustic vinyl is produced by Forbo Flooring and is sold worldwide. This declaration refers to Sarlon Acoustic Vinyl (sheet or tiles) covering a broad range of designs and colors :

Sparkling, Modul'Up, Modul'Up Compact, Complete Step, Habitat, Habitat Modal, Sarlibase, Compact, Trafic modal..

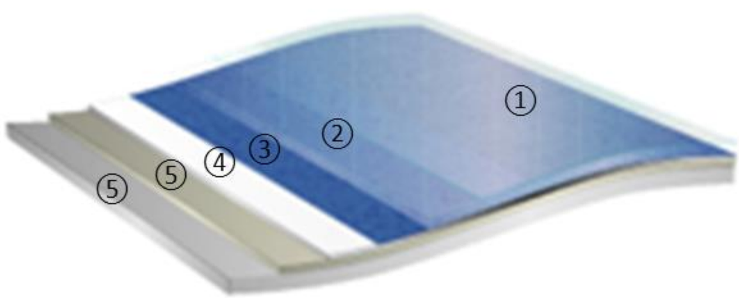


Figure 1 : Schematic build-up of Acoustic Vinyl

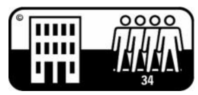
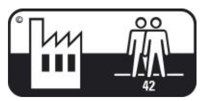
Acoustic vinyl is build up in 5 layers :

1. **Lacquer surface:** This layer gives the final protection and stain resistance
2. **Wear layer :** This layer gives a first protection to the printed layer. After finishing the product a factory lacquer surface is applied to protect the surface layer
3. **Printed layer:** Design printed with environmentally friendly water-based inks
4. **Glass fiber :** Support of the floor covering
5. **Under layer** : Foam backing and compact PVC layer achieving an outstanding impact sound reduction and indentation

This declaration refers to the declared/functional unit of 1 m2 installed flooring product.

Range of application

Acoustic vinyl is classified in accordance with EN 651 / ISO 11638 to be installed in the following use areas defined in EN-ISO 10874:

Area of application	
Domestic	Class 23 
Commercial	Class 34 
Industrial	Class 42 

Product Standard

The products considered in this EPD have the following technical specifications:

- Meets or exceeds all technical requirements in EN 651 / ISO 11638 Resilient floor coverings – Heterogeneous polyvinyl chloride flooring on foam - Specification

Acoustic vinyl meets the requirements of EN 14041

EN 13501-1	Reaction to fire	B_{fl} – s1 / C_{fl} - s1
EN 13893	Slip resistance	DS: ≥ 0,30
EN 1815	Body voltage	< 2 kV
EN ISO10456	Thermal conductivity	0,25 W/mK

Accreditation

- ISO 9001 Quality Management System
- ISO 14001 Environmental Management System
- OHSAS 18001 Occupational Health and Safety Management Systems
- SA 8000 Social Accountability International

FLOORING SYSTEMS

Acoustic Vinyl
Resilient Floor Covering

According to ISO 14025 & EN 15804

Delivery status

Characteristics	Nominal Value	Unit
Product thickness	min : 2,55 / max : 4,1	mm
Product Weight	min : 2070 / max : 3880	g/m^2
Rolls Width Length Tiles	2.00 (1,01 for complete step) 25 (20 for complete step) min : 4.00 / max : 7.00	Meter m² / box

Material Content

Component	Material	Mass %	Availability	Origin of raw material
Binder	PVC	Nonrenewable – limited	56.0	Europe
	DOTP	Nonrenewable - limited	26.0	Europe
Filler	Calcium Carbonate	Abundant mineral	13.5	Europe
Stabilizer	Ca/Zn	Nonrenewable - limited	0.5	Europe
Pigment	TiO2	Nonrenewable - limited	0.5	Europe
Substrate	Glass fibers	Nonrenewable - limited	2.5	Europe
Additives	Various chemicals	Nonrenewable - limited	0.5	Europe
Finish	Various chemicals	Nonrenewable - limited	0.5	Europe

Production of Main Materials

PVC: Polyvinyl chloride is obtained by polymerization of the monomer vinyl chloride.

Plasticizer: DOTP, a non-phthalate plasticiser, being the diester of terephthalic acid and the branched-chain 2-ethylhexanol. This colorless viscous liquid used for softening PVC plastics is known for chemical similarity to general purpose phthalates such as DEHP and DINP, but without any negative regulatory pressure.

Stabilizer Ca/Zn: Mixed metal stabilizer made from Calcium and Zinc stearate. It is used to avoid PVC degradation during processing at relative high temperature.

Calcium carbonate: An abundant mineral found in all parts of the world as the chief substance in rocks (i.e., marble and limestone). It can be ground to varying particle sizes and is widely used as filler.

Glass fibre: Glass fibre is used as a substrate for floor coverings and provides better dimensional stability.

Lacquer : acrylate hybrid dispersion

Titanium dioxide : A white pigment produced from the mineral rutile, a naturally occurring form of titanium dioxide. The production of the pigment is a large-scale chemical process.

Production of the Floor Covering

Acoustic vinyl is produced in several stages starting with the impregnation of the glass fiber (consists of filling the glass fiber with a PVC paste) and the rotogravure printing (possibility to deposit different patterns and colors).
The next stage is the wear layer gelation with a coating technology (a transparent wear layer on all products).
Then the product is put back to deposit a coat of compact reinforcing PVC and a coat of PVC chemical foam.
Lacquering is obtained by a UV lacquer (acrylate hybrid dispersion) : it's a long term protection which avoids metallization, reduces costs and facilitates maintenance.
Inspection is done and edges are cut (trimmings and rejected product are reused).
Finally the floor covering is cut to length into rolls or collected to produce tiles (grinding of the back foam and cutting in tiles). Finished product is send to warehouse department.

Health, Safety and Environmental Aspects during Production

- ISO 14001 Environmental Management System
- OHSAS 18001 Occupational Health and Safety Management Systems
- SA 8000 Social Accountability International

Production Waste

Rejected material and the cuttings of the trimming stage are being recycled.
Packaging materials are being collected separately and externally recycled.

Delivery and Installation of the Floor Covering

Delivery

A worldwide distribution by truck and container ship is considered. On average every square meter of Acoustic Vinyl is transported as follows:

- Transport distance 40 t truck — 694 km
- Transport distance 7.5t truck (Fine distribution) — 257 km
- Capacity utilization trucks (including empty runs) — 85 %
- Transport distance Ocean ship — 0 km
- Capacity utilization Ocean ship — 48%

Since Acoustic Vinyl is mainly sold in Europe on average there is no significant transport distance for the distribution of Acoustic Vinyl by Ocean ship.

Installation

Because of the specific techniques used during the installation of Acoustic vinyl, 6% (PVC sheet) or 4% (PVC tile) of the material is cut off as installation waste. For installation of acoustic vinyl on the floor : 0.25 kg/m2 of adhesive is required. For installation of loose lay products, no glue is required. Waste during the installation process may be recycled or landfilled.

Health, Safety and Environmental Aspects during Installation

Forbo flooring recommends using (low) zero emission adhesives for installing Acoustic Vinyl.

Waste

Waste during the installation process may be recycled or landfilled.

Packaging

Cardboard tubes and packaging paper are being collected separately and are being used in a recycling process.

Use stage

The service lifetime of a floor covering for a certain application on a floor is too widespread to give one common number. For this EPD model the reference service lifetime (RSL) is set to one year. This means that all impacts for the use phase are based on the cleaning and maintenance model for one year. Depending on the area of use, the technical lifetime advised by the manufacturer and the estimated time on the floor by the customer, the service lifetime can be determined. The use phase impacts should be calculated with the foreseen service life to arrive at the total environmental impact.

Cleaning and Maintenance

Level of use	Cleaning Process	Cleaning Frequency	Consumption of energy and resources
Commercial/Residential/Industrial	Vacuuming	Twice a week	Electricity
	Damp mopping	Once a week	Hot water Neutral detergent

For the calculations the following cleaning regime is considered:

- Dry cleaning with a 1.5 kW vacuum cleaner for 0.21 min/m², twice a week. This equates to 0.55 kWh/m²*year.
- Once a week wet cleaning with 0.062 l/m² water and 0.0008 kg/m² detergent. This result in the use of 3.224 l/m²*year water and 0.04 kg/m²*year detergent. The wet cleaning takes place without power machine usage. Waste water treatment of the arising waste water from cleaning is considered.

The cleaning regime that is recommended in practice will be highly dependent on the use of the premises where the floor covering is installed. In high traffic areas more frequent cleaning will be needed compared to areas where there is low traffic. The use of an entrance mat of at least four steps will reduce the cleaning frequency.
The cleaning regime used in the calculations is suitable for high traffic areas and is a worst case scenario.

Prevention of Structural Damage

All newly laid floor covering should be covered and protected with a suitable non-staining protective covering if other building activities are still in progress. Use protective feet on chairs and tables to reduce scratching. Castor wheels should be suitable for resilient floor coverings

Health Aspects during Usage

Acoustic Vinyl is complying with:

- AgBB requirements
- French act Grenelle: A+
- Emission class M1

End of Life

A full Life Cycle Assessment has bee carried out according to ISO 14040 and ISO 14044.

The following Life Cycle Stages are assessed :

- A1-3 : Product Stage (Raw material acquisition, transportation to Manufacturing and Manufacturing)
- A4-5 : Construction stage (Transport Gate to User, Installation flooring)
- B2 : Use Stage (Maintenance of the floor)
- C1-4 : End of Life Stage (Deconstruction, transport, waste processing, disposal)
- D : Benefits and loads beyond the system boundary (Reuse, recovery, recycling potential)

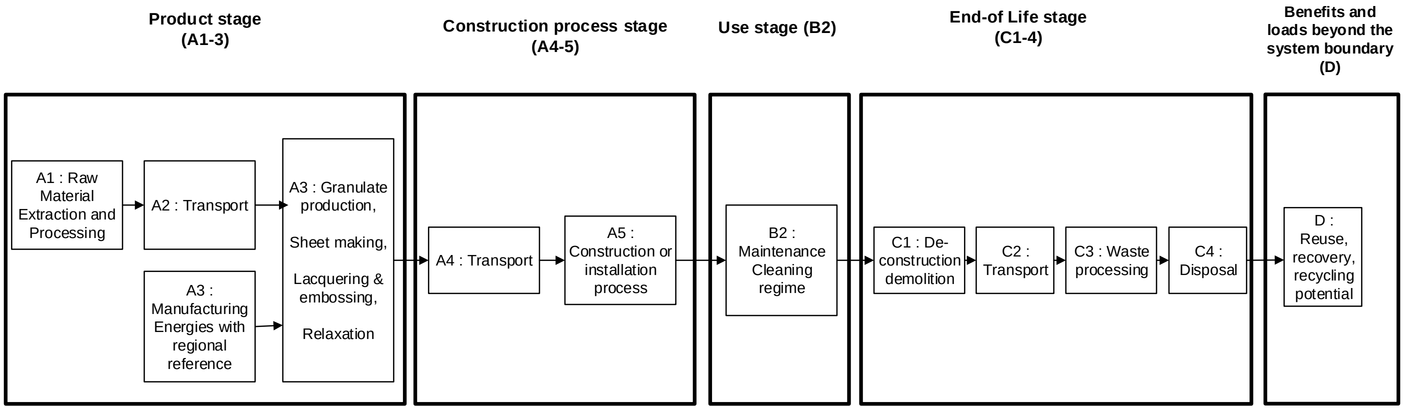


Figure 2: Flow chart of the Life Cycle Assessment

Comparisons of different floor coverings are only allowed, where EN 15804 consistent and/or preverified background data and EN 15804 consistent calculation methods and database versions are used and when the building context is taken into account, i.e. on the basis of the same use-classification (EN ISO 10874), same service life and comparable assumptions for the end of life.

Description of the declared Functional Unit

The functional unit is one square meter of installed product and the use stage is considered for one year of service life.

Cut off Criteria

The cut-off criteria shall be 1% of renewable and non-renewable primary energy usage and 1% of the total mass of the unit process. The total neglected input flows per module shall be a maximum of 5% of energy usage and mass.

In practice, in this assessment, all data from the production data acquisition are considered, i.e. all raw materials used as per formulation, use of water, electricity and other fuels, the required packaging materials, and all direct production waste. Transport data on all considered inputs and output material are also considered.

LCA Data

As a general rule, specific data derived from specific production processes or average data derived from specific production processes have been used as the first choice as a basis for calculating an EPD.

For life cycle modeling of the considered products, the GaBi 6 Software System for Life Cycle Engineering, developed by THINKSTEP, has been used. All relevant LCA datasets are taken from the GaBi 6 software database. The datasets from the database GaBi are documented in the online documentation. To ensure comparability of results in the LCA, the basic data of GaBi database were used for energy, transportation and auxiliary materials.

Data Quality

The requirements for data quality and LCA data correspond to the specifications of the PCR.

Foreground data are based on 1 year averaged data (year 2017). The reference ages of LCA datasets vary but are given in the table in the Appendix. The time period over which inputs to and outputs from the system is accounted for is 100 years from the year for which the data set is deemed representative. The technological LCA of the collected data reflects the physical reality of the declared product. The datasets are complete, conform to the system boundaries and the criteria for the exclusion of inputs and outputs and are geographical representative for the supply chain of Forbo flooring.

For life cycle modeling of the considered products the GaBi 6 Software System for Life Cycle Engineering, developed by THINKSTEP, is used. All relevant LCA datasets are taken from the GaBi 6 software database. The last revision of the used data sets took place within the last 10 years.

Table 1: LCA datasets used in the LCA model

Data set	Region	Reference year
Polyvinyl chloride granulate	Germany	2017
Di-Isononyl Phthalate (DOTP)	Germany	2012
Titanium dioxide	Europe	2012
Benzoates	Europe	2013
Calcium-Zinc Stearate	Europe	2012
Calcium carbonate	Germany	2017
Various chemicals	Europe	2012
PU lacquer	Europe	2012
Glass fibers	Germany	2018
Water (desalinated; deionised)	Germany	2017
Detergent (ammonia based)	Germany	2007
Tap water	Germany	2017
Adhesive for resilient flooring	Germany	2012
Waste incineration of PVC	Europe	2017
Electricity from Hydro power	France	2017
Power grid mix	Europe	2017
Thermal energy from natural gas	France	2017
Thermal energy from natural gas	Europe	2017
Trucks	Global	2017
Municipal waste water treatment (Sludge incineration).	Europe	2017
Container ship	Global	2017
Diesel mix at refinery	Europe	2017
Heavy fuel oil at refinery (1.0wt.% S)	Europe	2017
Polyethylene film	Germany	2017
Corrugated board	Europe	2017
Kraft liner (Paper)	Europe	2017
Wooden pallets	Germany	2006

The documentation of the LCA data sets can be taken from the GaBi documentation.

System Boundaries

Production Stage includes provision of all materials, products and energy, packaging processing and its transport, as well as waste processing up to the end-of waste state or disposal of final residues during the product stage.

Transport and Installation Stage includes provision of all materials, products and energy, as well as waste processing up to the end-of-waste state or disposal of final residues during the construction stage. These information modules also include all impacts and aspects related to any losses during this construction stage (i.e. production, transport, and

waste processing and disposal of the lost products and materials). For the transportation a worldwide distribution is considered.
Use Stage includes provision and transport of all materials, products and related energy and water use, as well as waste processing up to the end-of-waste state or disposal of final residues during this part of the use stage. These information modules also include all impacts and aspects related to the losses during this part of the use stage (i.e. production, transport, and waste processing and disposal of the lost products and materials).

End of Life Stage includes provision and all transports, provision of all materials, products and related energy and water use. It also includes any declared benefits and loads from net flows leaving the product system that have not been allocated as co-products and that have passed the end-of-waste state in the form of reuse, recovery and/or recycling potentials.

Power mix

The selection of LCA data for the electricity generation is in line with the PCR.

The products are manufactured in Reims, France. The GaBi 6 Hydro power datasets has therefore been used (reference year 2017). The energy supplier is providing Forbo with a certificate every year.

CO_2-Certificates

No CO_2-certificates are considered in this study.

Allocations

In the present study some allocations have been made. Detailed explanations can be found in the chapters below.

Co-product allocation

No co-product allocation occurs in the product system.

Allocation of multi-Input processes

The Production and End of Life stage include incineration plants. In these processes different products are treated together within a process. The allocation procedures followed in these cases are based on a physical classification of the mass flows or calorific values.

Credits from energy substitution are allocated to the production stage, because the gained energy from energy substitution is lower than the energy input in this stage. The same quality of energy is considered.

Allocation procedure of reuse, recycling and recovery

The installation waste and end of life waste can be fed into incineration processes. Incineration processes include cogeneration processes which give thermal and power energy as outputs. It is assumed that this recovered energy offsets that produced by the European average grid mix and thermal energy generation from natural gas.

Description of the allocation processes in the LCA report

The description of allocation rules in of this LCA report meets the requirements of the PCR.

Description of the unit processes in the LCA report

The modeling of the unit processes reported for the LCA are documented in a transparent way, respecting the confidentiality of the data present in the LCA report.

In the following tables the type and amount of the different input and output flows are listed for 1m² produced flooring; installed flooring includes the material loss during installation (5%):

Table 2: Composition of Acoustic Vinyl upper top layer

Process data	Unit	Acoustic Vinyl
Polyvinyl chloride granulate (PVC)	kg/m2	0.448
Benzoates	kg/m2	0.027
DOTP	kg/m2	0.161
Calcium-Zinc stearate	kg/m2	0.010

Table 3: Composition of Acoustic Vinyl intermediate layer

Process data	Unit	Acoustic Vinyl
DOTP	kg/m2	0.160
Calcium carbonate	kg/m2	0.125
Polyvinyl Chloride Granulate (PVC)	kg/m2	0.355
Various chemicals	kg/m2	0.014
Titanium dioxide	kg/m2	0.013

Table 4: Composition of Acoustic Vinyl bottom intermediate layer

Process data	Unit	Acoustic Vinyl
Calcium carbonate	kg/m2	0.122
DOTP	kg/m2	0.121
Polyvinyl Chloride Granulate (PVC)	kg/m2	0.303
Various chemicals	kg/m2	0.012

Table 5: Composition of Acoustic Vinyl backing layer

Process data	Unit	Acoustic Vinyl
Calcium carbonate	kg/m2	0.093
DOTP	kg/m2	0.113
Benzoates	kg/m2	0.030
Various chemicals	kg/m2	0.008
Polyvinyl Chloride Granulate (PVC)	kg/m2	0.288

Table 6: Composition of Acoustic Vinyl substrate layer

Process data	Unit	Acoustic Vinyl
Acrylate resin	kg/m2	0.015
Glass fibers	kg/m2	0.045

Table 7: Composition of Acoustic Vinyl Decorating layer

Process data	Unit	Acoustic Vinyl
Acrylic resin	kg/m2	0.001
Water	kg/m2	0.003
Organic pigments	kg/m2	0.001
Polyvinyl Chloride Granulate (PVC)	kg/m2	0.005

Table 8: Composition of Acoustic Vinyl Lacquer layer

Process data	Unit	Acoustic Vinyl
Urethane / acrylic hybride dispersion	kg/m2	0.010

Table 9: Production related inputs/outputs

Process data	Unit	Acoustic Vinyl
INPUTS		
Acoustic Vinyl upper top layer	kg	0.65
Acoustic Vinyl intermediate layer	kg	0.68
Acoustic Vinyl backing layer	kg	0.58
Acoustic Vinyl substrate layer	kg	0.06
Acoustic Vinyl bottom intermediate layer	kg	0.59
Acoustic Vinyl Lacquer layer	kg	0.01
Acoustic Vinyl decorating layer	kg	0.01
Electricity	MJ	3.65
Thermal energy from natural gas	MJ	6.65
OUTPUTS		
Acoustic Vinyl	kg	2.58
Waste	kg	0.26

Table 10: Packaging requirements (per m^2 manufactured product)

Process data	Unit	Acoustic Vinyl
Polyethylene film	kg	0.0002
Corrugated board	kg	0.011
Wrapping paper	kg	0.017
Wooden pallet	kg	0.020

Table 11: Transport distances (same for both products)

Process data	Unit	Road	Truck size	Ship
Calcium carbonate	km	509	14 - 20t gross weight / 11,4t payload capacity	-
PVC granulate (E-PVC)	km	754		-
PVC granulate (S-PVC)	km	803		-
Various chemicals	km	226		-
Benzoates	km	2500		-
Calcium-Zinc stearate	km	795		-
Titanium dioxide	km	478		-
DOTP	km	340		-
Various chemicals	km	795		-
Various chemicals	km	795		
Wooden pallets	km	180		-
Glass fibers	km	2500		-
Lacquer	km	576		-
Acrylic resin	km	305		-
Corrugated board	km	215		-
Wrapping paper	km	2740		-
Polyethylene film	km	250		-
Transport to construction site : -Transport distance 40 t truck -Transport distance 7.5t truck (Fine	km	951 694 257	 34 - 40 t gross weight / 27t payload capacity 7,5 t - 12t gross	-

Process data	Unit	Road	Truck size	Ship
distribution)			weight / 5t payload capacity	
Waste transport Incineration	km	200	7,5 t - 12t gross weight / 5t payload capacity	-

Table 12: Inputs/outputs from Installation

Process data	Unit	Acoustic Vinyl
INPUTS		
Acoustic Vinyl	kg	2.58
Adhesive (30% water content) ○ Water ○ Acrylate co-polymer ○ Styrene Butadiene co-polymer ○ Limestone flour ○ Sand	kg	0.30
OUTPUTS		
Installed Acoustic Vinyl	kg	2.45
Installation Waste	kg	0.13

Table 13: Inputs from use stage (per m^2.year of installed product)

Process data	Unit	Acoustic Vinyl
Detergent	kg/year	0.04
Electricity	kWh/year	0.55
Water	kg/year	3.224

Table 14: Disposal

Process data	Unit	Acoustic Vinyl
Post-consumer Acoustic Vinyl to incineration	%	100

Life Cycle Inventory Analysis

In table 15 the environmental impacts for one lifecycle are presented for Acoustic Vinyl . In the table 16 the environmental impacts are presented for all the lifecycle stages.

Table 15: Results of the LCA – Environmental impacts one lifecycle (one year) – Acoustic Vinyl

Impact Category : CML 2001 – Jan. 2016	Acoustic Vinyl	Unit
Global Warming Potential (GWP 100 years)	1,39E+01	kg CO2-Equiv.
Ozone Layer Depletion Potential (ODP. steady state)	7,06E-08	kg R11-Equiv.
Acidification Potential (AP)	2,77E-02	kg SO2-Equiv.
Eutrophication Potential (EP)	3,17E-03	kg Phosphate-Equiv.
Photochem. Ozone Creation Potential (POCP)	2,24E-03	kg Ethene-Equiv.
Abiotic Depletion Potential Elements (ADPE)	2,68E-05	kg Sb-Equiv.
Abiotic Depletion Potential Fossil (ADPF)	1,79E+02	[MJ]

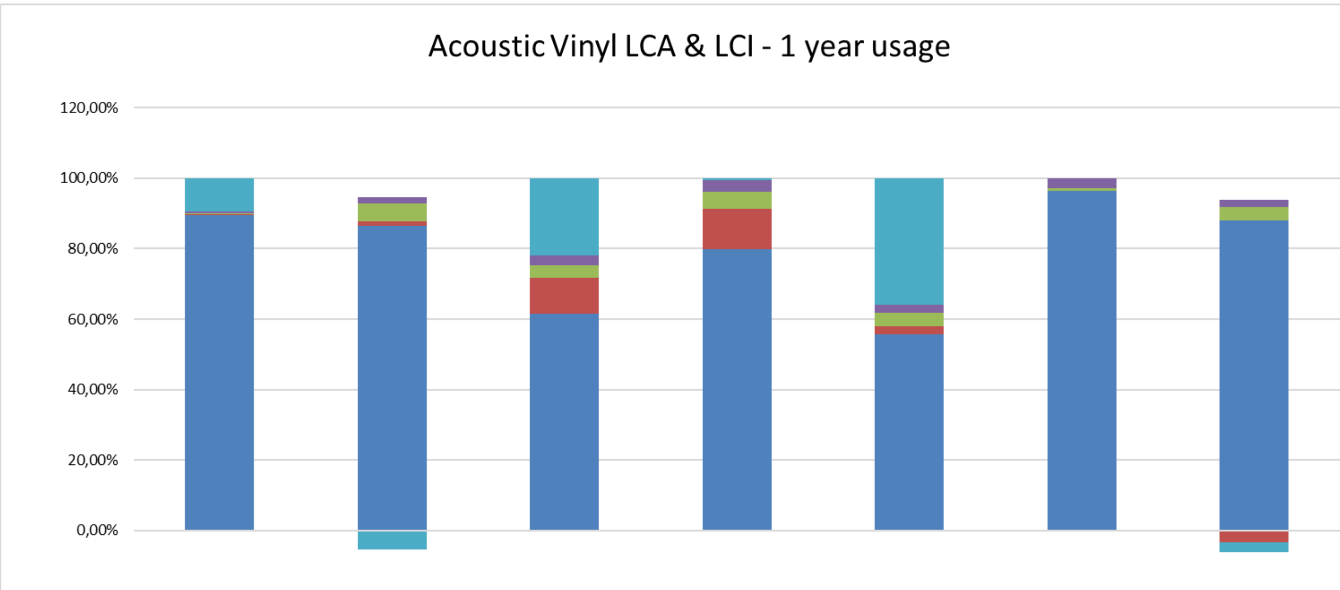
Table 16: Results of the LCA – Environmental impact for Acoustic Vinyl (one year)

		Manufacturing	Installation		Use (1yr)	End of Life			Credits
Parameter	**Unit**	**A1-3**	**A4**	**A5**	**B2**	**C1**	**C2**	**C3**	**D**
GWP	[kg CO_2-Eq.]	7,70E+00	3,49E-01	5,20E-01	3,16E-01	5,35E-03	1,79E-02	6,58E+00	-1,63E+00
ODP	[kg CFC11-Eq.]	6,81E-08	5,53E-15	4,03E-10	2,06E-09	2,38E-14	4,89E-16	5,85E-13	-3,55E-12
AP	[kg SO_2-Eq.]	1,70E-02	2,82E-03	9,85E-04	7,82E-04	1,52E-05	4,35E-05	8,77E-03	-2,74E-03
EP	[kg PO_4^{3-}- Eq.]	2,53E-03	3,70E-04	1,47E-04	1,07E-04	1,42E-06	1,10E-05	3,03E-04	-2,97E-04
POCP	[kg Ethen Eq.]	2,24E-03	-8,42E-05	9,50E-05	5,51E-05	9,52E-07	-1,50E-05	1,59E-04	-2,15E-04
ADPE	[kg Sb Eq.]	2,40E-05	1,36E-08	1,07E-07	1,58E-07	2,84E-09	1,47E-09	2,96E-06	-4,62E-07
ADPF	[MJ]	1,74E+02	2,86E+00	9,97E+00	3,53E+00	5,70E-02	2,43E-01	1,12E+01	-2,25E+01

GWP = Global warming potential; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential of land and water; EP = Eutrophication potential; POCP = Formation potential of tropospheric ozone photochemical oxidants; ADPE = Abiotic depletion potential for non-fossil resources; ADPF = Abiotic depletion potential for fossil resources

The relative contribution of each process stage to each impact category for Acoustic Vinyl is shown in figure 3.

Figure 3: relative contribution of each process stage to each impact category for Acoustic Vinyl for a one year usage.



	Abiotic Depletion (Elements)	Abiotic Depletion (Fossil)	Acidification Potential	Eutrophication Potential	Global Warming Potential	Ozone Layer Depletion Potential	Photochem. Ozone Creation Potential
End of Life	9,34%	-5,46%	22,00%	0,58%	35,89%	0,00%	-2,75%
Use	0,59%	1,75%	2,83%	3,37%	2,28%	2,92%	2,17%
Installation	0,40%	4,95%	3,56%	4,63%	3,75%	0,57%	3,73%
Transport	0,05%	1,42%	10,19%	11,66%	2,52%	0,00%	-3,31%
Production	89,62%	86,41%	61,43%	79,75%	55,56%	96,51%	88,04%

Interpretation

The interpretation of the results has been carried out considering the assumptions and limitations declared in the EPD, both methodology- and data-related for a one year usage.

In all of the impact categories the production stage has the main contribution to the overall impact and the raw material supply is the key contributor with a share of 92 – 99%. Main raw materials with a relevant contribution are PVC and the plasticizers.

For the transportation stage a significant contribution comes from the categories AP and EP in which the trucks used for the distribution to the customers are the major contributors.

For ADPF, GWP, AP, EP and POCP the flooring installation has an impact of approximately 4 – 5% of the total, this is mainly caused by the adhesive.

During the use phase all categories have small impacts on the total.

At the End of Life stage the main impact categories are AP, ADPE and GWP, this is mainly due to the incineration of the post-consumer waste.

Resource use

In table 17 the parameters describing resource use are presented for all the life cycle stages for a one year usage.

Table 17 : Results of the LCA – Resource use for Acoustic Vinyl (one year)

		Manufacturing	Installation		Use (1yr)	End of Life			Credits
Parameter	**Unit**	**A1-3**	**A4**	**A5**	**B2**	**C1**	**C2**	**C3**	**D**
PERE	[MJ]	1,54E+01	-	-	-	-	-	-	-
PERM	[MJ]	0,00E+00	-	-	-	-	-	-	-
PERT	[MJ]	1,54E+01	1,10E-01	3,55E-01	1,58E+00	3,67E-02	1,35E-02	2,26E+00	-5,50E+00
PENRE	[MJ]	1,50E+02	-	-	-	-	-	-	-
PENRM	[MJ]	3,63E+01	-	-	-	-	-	-	-
PENRT	[MJ]	1,86E+02	2,87E+00	1,02E+01	5,40E+00	9,78E-02	2,44E-01	1,25E+01	-2,86E+01
SM	[kg]	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
RSF	[MJ]	1,84E-07	1,05E-29	4,41E-21	3,48E-24	0,00E+00	1,32E-30	8,86E-21	0,00E+00
NRSF	[MJ]	2,33E-06	1,59E-28	5,18E-20	4,09E-23	1,45E-31	2,00E-29	1,04E-19	-2,17E-29
FW	[m^3]	3,97E-02	2,03E-04	1,80E-03	2,38E-03	5,01E-05	2,48E-05	1,36E-02	-7,50E-03

PERE = Use of renewable primary energy excluding renewable primary energy resources used as raw materials; PERM = Use of renewable primary energy resources used as raw materials; PERT = Total use of renewable primary energy resources; PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; PENRM = Use of non-renewable primary energy resources used as raw materials; PENRT = Total use of non-renewable primary energy resources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of net fresh water

Waste categories and output flows

In table 18 other environmental information describing different waste categories and output flows are presented for all the life cycle stages.

Table 18: Results of the LCA – Output flows and Waste categories for Acoustic Vinyl (one year)

		Manufacturing	Transport	Installation	Use (1yr)	End of Life/credits			
Parameter	**Unit**	**A1-3**	**A4**	**A5**	**B2**	**C1**	**C2**	**C3**	**D**
HWD	[kg]	1,91E-03	1,12E-07	3,08E-09	2,17E-09	4,59E-11	1,41E-08	7,92E-08	-1,16E-08
NHWD	[kg]	9,40E-02	1,68E-04	3,54E-03	1,30E-02	6,89E-05	2,05E-05	4,08E+00	-1,22E-02
RWD	[kg]	3,95E-03	3,77E-06	8,86E-05	7,17E-04	1,62E-05	3,34E-07	4,91E-04	-2,42E-03
CRU	[kg]	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
MFR	[kg]	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
MER	[kg]	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
EE Power	[MJ]	0,00E+00	0,00E+00	1,81E-01	0,00E+00	0,00E+00	0,00E+00	6,74E+00	0,00E+00
EE Thermal energy	[MJ]	0,00E+00	0,00E+00	3,25E-01	0,00E+00	0,00E+00	0,00E+00	1,23E+01	0,00E+00

HWD = Hazardous waste disposed; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed; CRU = Components for re-use; MFR = Materials for recycling; MER = Materials for energy recovery; EE = Exported energy per energy carrier

Additional Environmental Information

To be fully transparant Forbo Flooring does not only want to declare the environmental impacts required in the PCR, but also the impacts on human health and eco-toxicity. Furthermore the outcome of the calculations according to the european Standard EN15804 are published in this section.

Toxicity

For this calculations the USEtoxTM model is used as being the globally recommended preferred model for characterization modeling of human and eco-toxic impacts in LCIA by the United Nations Environment Programme SETAC Life Cycle Initiative.

According to the "ILCD Handbook: Recommendations for Life Cycle Impact Assessment in the European context" the recommended characterization models and associated characterization factors are classified according to their quality into three levels:

- Level I (recommended and satisfactory),
- level II (recommended but in need of some improvements)
- level III (recommended, but to be applied with caution).

A mixed classification sometimes is related to the application of the classified method to different types of substances. USEtoxTM is classified as Level II / III, unlike for example the CML impact categories which are classified as Level I.

Table 19: Results of the LCA – Environmental impacts one lifecycle (one year) – Acoustic Vinyl

Impact Category : USEtox	Acoustic Vinyl	Unit
Eco toxicity	8,14E-03	PAF m3.day
Human toxicity, cancer	4,69E-09	Cases
Human toxicity, non-canc.	2,22E-09	Cases

In the following table the impacts are subdivided into the lifecycle stages.

Table 20: Results of the LCA – Environmental impact for Acoustic Vinyl (one year)

Impact Category : USEtox	Unit	Production	Transport	Installation	Use (1yr)	End of Life
Eco toxicity	PAF m3.day	6,05E-03	6,68E-04	1,02E-03	4,43E-04	-4,50E-05
Human toxicity, cancer	cases	4,74E-09	6,32E-13	1,81E-11	1,23E-11	-7,95E-11
Human toxicity, non-canc.	cases	2,15E-09	2,73E-13	6,60E-11	7,13E-13	-1,91E-12

Interpretation

The interpretation of the results has been carried out considering the assumptions and limitations declared in the EPD, both methodology- and data-related for a one year usage.

In all the Toxicity categories the production stage is the main contributor to the total overall impact. The raw material supply has a share of approximately 96-99% of the production stage, therefore the choice of raw materials can highly influence the Toxicity categories.

Transportation only has a significant contribution from Ecotoxicity of 8% of the total, the contribution of the other two categories are neglegible.

For the installation stage the adhesive is the major contributor to the total impact for all three Toxicity categories with a share of 99-100%.

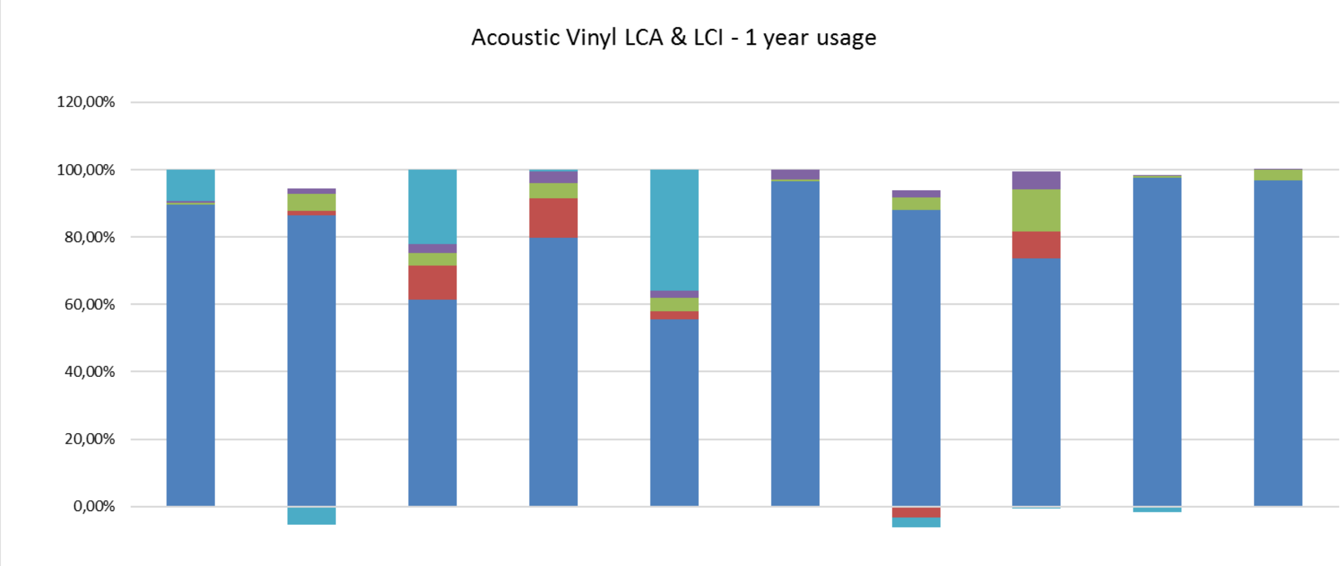
The Use stage has a minor impact of ± 5% for Ecotoxicity, the Humantoxicity impacts in this life cycle stage are very small. Major cause for the impacts is the electricity used for cleaning the floor. The used cleaning regime of vacuuming twice a week is very conservative and will in practice most of the times be lower.

The End of Life stage shows a very minor negative contribution caused by the incineration of the post-consumer waste.

Interpretation main modules and flows

The interpretation of the main modules and flows contributing to the total impact in each category is presented in following figure and table.

Figure 4: relative contribution of each process stage to each impact category for Acoustic Vinyl for a one year usage.



	Abiotic Depletion (Elements)	Abiotic Depletion (Fossil)	Acidification Potential	Eutrophication Potential	Global Warming Potential	Ozone Layer Depletion Potential	Photochem. Ozone Creation Potential	Ecotoxicity	Human toxicity, cancer	Human toxicity, non-canc.
End of Life	9,34%	-5,46%	22,00%	0,58%	35,89%	0,00%	-2,75%	-0,55%	-1,64%	-0,09%
Use	0,59%	1,75%	2,83%	3,37%	2,28%	2,92%	2,17%	5,38%	0,25%	0,03%
Installation	0,40%	4,95%	3,56%	4,63%	3,75%	0,57%	3,73%	12,40%	0,37%	2,97%
Transport	0,05%	1,42%	10,19%	11,66%	2,52%	0,00%	-3,31%	8,12%	0,01%	0,01%
Production	89,62%	86,41%	61,43%	79,75%	55,56%	96,51%	88,04%	73,56%	97,72%	96,90%

Table 21: Main modules and flows contributing to the total impact in each impact category for Acoustic Vinyl for a one year usage

Impact Category	Stage	Module		Main contributor	Main contributing flows
GWP	Production	Raw Material Extraction	7.16 kg CO_2-equiv.	DOTP (2.23 kg CO_2-eq.) PVC (4.39 kg CO_2-eq.)	Production : Inorganic emissions to air, Carbon dioxide
		Transport of Raw materials	0.02 kg CO_2-equiv.	Means of transport (truck, container ship) and their fuels	
		Manufacturing	0.58 kg CO_2-equiv.	100% Thermal energy	
	Transport	Transport Gate to User		Means of transport (truck, container ship) and their fuels	Transport & Installation : Inorganic emissions to air, Carbon dioxide
	Installation	Installation		81% Adhesive	
	Use	Use		72% Electricity 18% Detergent	Use : Inorganic emissions to air, Carbon dioxide
	EOL	EOL		Incineration of post-consumer Acoustic Vinyl	EOL : Inorganic emissions to air, Carbon dioxide

Impact Category	Stage	Module		Main contributor	Main contributing flows
				Energy substitution from incineration	
ODP	Production	Raw Material Extraction	99.5%	87% DOTP	Production : Halogenated organic emissions to air, R11 (trichlorofluoromethane), R114 (Dichlorotetrafluorethane), Halon (1301)
		Transport of Raw materials	< 0.05%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	0.5%	100% Packaging	
	Transport	Transport Gate to User		Means of transport (truck, container ship) and their fuels	Transport & Installation : Halogenated organic emissions to air R114 (Dichlorotetrafluorethane)
	Installation	Installation		100% Adhesive	
	Use	Use		1000% Detergent	Use : Halogenated organic emissions to air, R11 (trichlorofluoromethane), R114 (Dichlorotetrafluorethane)
	EOL	EOL		Incineration of post-consumer Acoustic Vinyl Energy substitution from incineration	EOL: Halogenated organic emissions to air, R22 (chlorodifluoromethane)
AP	Production	Raw Material Extraction	97%	46% PVC 24% DOTP 14% Titanium dioxide	Production : Inorganic emissions to air, NO_x and Sulphur dioxide, Ammonia Production : Inorganic emissions to fresh water, Hydrogen chloride
		Transport of Raw materials	< 0.5%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	2.5%	79% Thermal energy 14% Packaging	
	Transport	Transport Gate to User		Means of transport (truck, container ship) and their fuels	Transport & Installation : Inorganic emissions to air, NO_x and Sulphur dioxide
	Installation	Installation		94% Adhesive	
	Use	Use		83% Electricity 12% Detergent	Use : Inorganic emissions to air, NO_x and Sulphur dioxide
	EOL	EOL		Incineration of post-consumer Acoustic Vinyl Energy substitution from incineration	EOL : Inorganic emissions to air, Hydrogen chloride, NO_x and Sulphur dioxide
EP	Production	Raw Material Extraction	96%	34% Fatty Acid Ester 41% PVC 16% DOTP	Production : Inorganic emissions to air, Ammonia, NO_x Production : Inorganic emissions to fresh water, Nitrate
		Transport of Raw materials	< 0.5%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	3.5%	76% Thermal energy 17% Packaging	
	Transport	Transport Gate to User		Means of transport (truck, container ship) and their fuels	Transport & Installation : Inorganic emissions to air, NO_x Transport & Installation : Inorganic emissions to fresh water, Ammonium / ammonia
	Installation	Installation		91% Adhesive	
	Use	Use		57% Electricity 16% Detergent 27% Waste water treatment	Use : Inorganic emissions to air, NO_x Use : Inorganic emissions to fresh water, Ammonium / ammonia, Nitrate, Phosphorus
	EOL	EOL		Incineration of post-consumer Acoustic Vinyl Energy substitution from incineration	EOL : Inorganic emissions to air, NO_x and Ammonia
POCP	Production	Raw Material Extraction	97%	64% PVC 25% DOTP	Production : Inorganic emissions to air, Carbon monoxide, NO_x , Sulphur dioxide Production : Halogenated organic emissions to air, Butane (n-butane), NMVOC (Unspecified), VOC (Unspecified)
		Transport of Raw materials	1%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	2%	97% Thermal energy	
	Transport	Transport Gate to User		Means of transport (truck, container ship) and their fuels	Transport & Installation : Inorganic emissions to air, Carbon monoxide, NO_x, Sulphur dioxide
	Installation	Installation		97% Adhesive	

Impact Category	Stage	Module		Main contributor	Main contributing flows
					Transport & Installation : Halogenated organic emissions to air, NMVOC (Unspecified),
	Use	Use		74% electricity 22% Detergent	Use : Inorganic emissions to air, Sulphur dioxide, Nitrogen dioxide Use : Halogenated organic emissions to air, NMVOC (Unspecified)
	EOL	EOL		Incineration of post-consumer Acoustic Vinyl Energy substitution from incineration	EOL : Inorganic emissions to air, Carbon monoxide , NO_x, Sulphur dioxide EOL : Organic emissions to air (Group VOC), NMVOC (Unspecified)
ADPe	Production	Raw Material Extraction	99%	64% PVC 20% Glass fiber	Production : Nonrenewable resources, Colemanite ore, Sodium chloride (Rock salt) Production : Nonrenewable elements, Lead
		Transport of Raw materials	<0,01%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	1%	85% Electricity	
	Transport	Transport Gate to User		Means of transport (truck, container ship) and their fuels	Transport & Installation : Nonrenewable resources, Sodium chloride (rock salt) Transport & Installation : Nonrenewable elements, Lead
	Installation	Installation		99% Adhesive	
	Use	Use		76% Electricity 19% Detergent	Use : Nonrenewable resources, Sodium chloride (Rock salt) Use : Nonrenewable elements, Silver, Copper
	EOL	EOL		Incineration of post-consumer Acoustic Vinyl Energy substitution from incineration	EOL : Nonrenewable resources, Magnesium chloride leach (40%)
ADPf	Production	Raw Material Extraction	94%	58% PVC 35% DOTP	Production : Crude oil resource, Crude oil (in MJ) Production : Natural gas (resource), Natural gas (in MJ)
		Transport of Raw materials	<0.3%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	6%	98% Thermal energy	
	Transport	Transport Gate to User		Means of transport (truck, container ship) and their fuels	Transport & Installation : Crude oil (resource) Transport & Installation : Natural gas (resource),
	Installation	Installation		100% Adhesive	
	Use	Use		69% electricity 30% Detergent	Use : Hard coal (resource), Natural gas (resource), Hard coal (resource)
	EOL	EOL		Incineration of post-consumer Acoustic Vinyl Energy substitution from incineration	EOL : Natural gas, Crude oil, Lignite, Hard coal (resource)
Eco toxicity	Production	Raw Material Extraction	96%	67% PVC 14% CaZn-stearate	Production : Hydrocarbons to fresh water, Anthracene, Phenol (hydroxy benzene) Production : Pesticides to fresh water, Alachlor
		Transport of Raw materials	1%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	3%	37% Thermal energy 59% Packaging	
	Transport	Transport Gate to User		Means of transport (truck, container ship) and their fuels	Transport & installation : Hydrocarbons to fresh water, Anthracene, Phenol (hydroxy benzene) Transport & installation : Pesticides to fresh water, Alachlor
	Installation	Installation		100% Adhesive	
	Use	Use		10% Detergent 88% Electricity	Use : Hydrocarbons to fresh water, Anthracene, Phenol (hydroxy benzene) Use : Pesticides to fresh water, Alachlor
	EOL	EOL		Incineration of post-consumer Acoustic Vinyl	EOL : Hydrocarbons to fresh water, Anthracene, Phenol (hydroxy benzene)

Impact Category	Stage	Module		Main contributor	Main contributing flows
				Energy substitution from incineration	EOL : Pesticides to fresh water, Alachlor
Human toxicity, cancer	Production	Raw Material Extraction	99%	97% PVC	Production : Group NMVOC to air, Formaldehyde (Methanal) Production : Halogenated organic emissions to fresh water, Vinyl chloride (VCM; chloroethene) Production : Halogenated organic emissions to air, Vinyl chloride (VCM; chloroethene)
		Transport of Raw materials	< 0.2%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	1%	98% Thermal energy	
	Transport	Transport Gate to User		Means of transport (truck, container ship) and their fuels	Transport & Installation Group NMVOC to air, Formaldehyde (Methanal) Transport & Installation : Halogenated organic emissions to air, Vinyl chloride (VCM; chloroethene)
	Installation	Installation		100% adhesive	
	Use	Use		84% Electricity 15% Detergent	Use : Group NMVOC to air, Formaldehyde (Methanal) Use : Halogenated organic emissions to air, Vinyl chloride (VCM; chloroethene)
	EOL	EOL		Incineration of post-consumer Acoustic Vinyl Energy substitution from incineration	EOL : Group NMVOC to air, Formaldehyde (Methanal) EOL : Halogenated organic emissions to air, Vinyl chloride (VCM; chloroethene)
Human toxicity, non canc.	Production	Raw Material Extraction	100%	99% PVC	Production : Halogenated organic emissions to fresh water, Vinyl chloride (VCM; chloroethene) Production : Halogenated organic emissions to air, Vinyl chloride (VCM; chloroethene)
		Transport of Raw materials	< 0.05%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	< 0.05%	91% Thermal energy	
	Transport	Transport Gate to User		Means of transport (truck, container ship) and their fuels	Transport & Installation Group NMVOC to air, Formaldehyde (Methanal) Transport & Installation : Halogenated organic emissions to air, Vinyl chloride (VCM; chloroethene)
	Installation	Installation		100% adhesive	
	Use	Use		76% electricity 24% Detergent	Use : Group NMVOC to air, Formaldehyde (Methanal) Use : Halogenated organic emissions to air, Vinyl chloride (VCM; chloroethene)
	EOL	EOL		Incineration of post-consumer Acoustic Vinyl Energy substitution from incineration	EOL : Group NMVOC to air, Formaldehyde (Methanal) EOL : Halogenated organic emissions to air, Vinyl chloride (VCM; chloroethene)

Description of Selected Impact Categories

Abiotic Depletion Potential

The abiotic depletion potential covers all natural resources such as metal containing ores, crude oil and mineral raw materials. Abiotic resources include all raw materials from non-living resources that are non-renewable. This impact category describes the reduction of the global amount of non-renewable raw materials. Non-renewable means a time frame of at least 500 years. This impact category covers an evaluation of the availability of natural elements in general, as well as the availability of fossil energy carriers.

ADP (elements) describes the quantity of non-energetic resources directly withdrawn from the geosphere. It reflects the scarcity of the materials in the geosphere and is expressed in Antimony equivalents. The characterization factors are published by the CML, Oers 2010.

Are fossil energy carriers included in the impact category, it is ADP (fossil). Fossil fuels are used similarly to the primary energy consumption; the unit is therefore also MJ. In contrast to the primary fossil energy ADP fossil does not contain uranium, because this does not count as a fossil fuel.

Primary energy consumption

Primary energy demand is often difficult to determine due to the various types of energy source. Primary energy demand is the quantity of energy directly withdrawn from the hydrosphere, atmosphere or geosphere or energy source without any anthropogenic change. For fossil fuels and uranium, this would be the amount of resource withdrawn expressed in its energy equivalent (i.e. the energy content of the raw material). For renewable resources, the energy-characterized amount of biomass consumed would be described. For hydropower, it would be based on the amount of energy that is gained from the change in the potential energy of water (i.e. from the height difference). As aggregated values, the following primary energies are designated:

The total **"Primary energy consumption non-renewable"**, given in MJ, essentially characterizes the gain from the energy sources natural gas, crude oil, lignite, coal and uranium. Natural gas and crude oil will both be used for energy production and as material constituents e.g. in plastics. Coal will primarily be used for energy production. Uranium will only be used for electricity production in nuclear power stations.

The total **"Primary energy consumption renewable"**, given in MJ, is generally accounted separately and comprises hydropower, wind power, solar energy and biomass. It is important that the end energy (e.g. 1 kWh of electricity) and the primary energy used are not miscalculated with each other; otherwise the efficiency for production or supply of the end energy will not be accounted for. The energy content of the manufactured products will be considered as feedstock energy content. It will be characterized by the net calorific value of the product. It represents the still usable energy content.

Waste categories

There are various different qualities of waste. For example, waste can be classed according to German and European waste directives. The modeling principles have changed with the last GaBi4 database update in October 2006. Now all LCA data sets (electricity generation, raw material etc.) already contain the treatment of the waste with very low waste output at the end of the stage. So the amount of waste is predominantly caused by foreground processes during the production phase. This is important for the interpretation of waste amounts.

From a balancing point of view, it makes sense to divide waste into three categories. The categories overburden/tailings, industrial waste for municipal disposal and hazardous waste will be used.

Overburden / tailings in kg: This category consists of the layer which must be removed in order to access raw material extraction, ash and other raw material extraction conditional materials for disposal. Also included in this category are tailings such as inert rock, slag, red mud etc.

Industrial waste for municipal disposal in kg: This term contains the aggregated values of industrial waste for municipal waste according to 3. AbfVwV TA SiedlABf.

Hazardous waste in kg: This category includes materials that will be treated in a hazardous waste incinerator or hazardous waste landfill, such as painting sludge's, galvanic sludge's, filter dusts or other solid or liquid hazardous waste and radioactive waste from the operation of nuclear power plants and fuel rod production.

Global Warming Potential (GWP)

The mechanism of the greenhouse effect can be observed on a small scale, as the name suggests, in a greenhouse. These effects are also occurring on a global scale. The occurring short-wave radiation from the sun comes into contact with the earth's surface and is partly absorbed (leading to direct warming) and partly reflected as infrared radiation. The reflected part is absorbed by so-called greenhouse gases in the troposphere and is re-radiated in all directions, including back to earth. This results in a warming effect on the earth's surface.

In addition to the natural mechanism, the greenhouse effect is enhanced by human activities. Greenhouse gases that are considered to be caused, or increased, anthropogenically are, for example, carbon dioxide, methane and CFCs. *Figure A1* shows the main processes of the anthropogenic greenhouse effect. An analysis of the greenhouse effect should consider the possible long term global effects.

The global warming potential is calculated in carbon dioxide equivalents (CO_2-Eq.). This means that the greenhouse potential of an emission is given in relation to CO_2. Since the residence time of the gases in the atmosphere is incorporated into the calculation, a time range for the assessment must also be specified. A period of 100 years is customary.

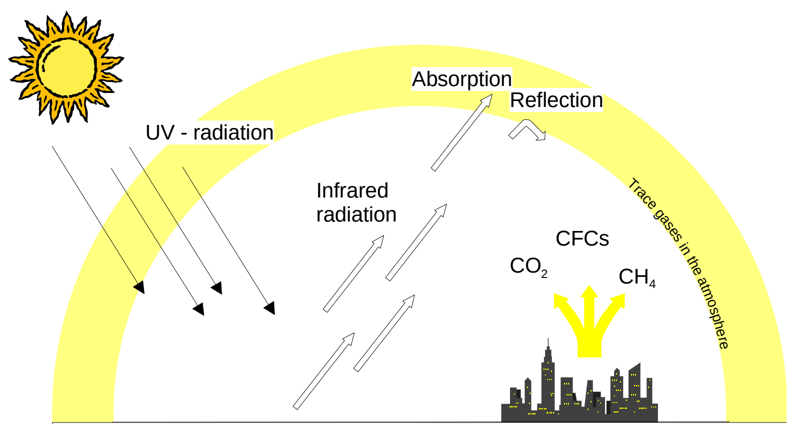


Figure A1: Greenhouse effect (KREISSIG 1999)

Acidification Potential (AP)

The acidification of soils and waters predominantly occurs through the transformation of air pollutants into acids. This leads to a decrease in the pH-value of rainwater and fog from 5.6 to 4 and below. Sulphur dioxide and nitrogen oxide and their respective acids (H_2SO_4 and HNO_3) produce relevant contributions. This damages ecosystems, whereby forest dieback is the most well-known impact.

Acidification has direct and indirect damaging effects (such as nutrients being elutriated from soils or an increased solubility of metals into soils). But even buildings and building materials can be damaged. Examples include metals and natural stones which are corroded or disintegrated at an increased rate.

When analyzing acidification, it should be considered that although it is a global problem, the regional effects of acidification can vary. *Figure A2* displays the primary impact pathways of acidification.

The acidification potential is given in sulphur dioxide equivalents (SO2-Eq.). The acidification potential is described as the ability of certain substances to build and release H+ - ions. Certain emissions can also be considered to have an acidification potential, if the given S-, N- and halogen atoms are set in proportion to the molecular mass of the emission. The reference substance is sulphur dioxide.

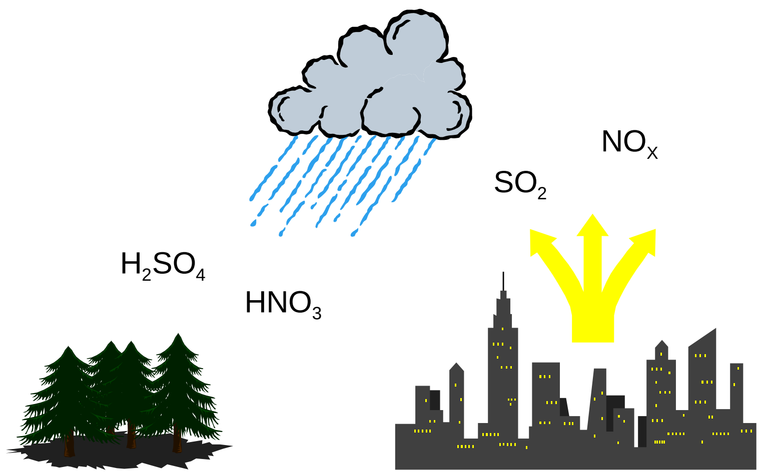


Figure A2: Acidification Potential (KREISSIG 1999)

Eutrophication Potential (EP)

Eutrophication is the enrichment of nutrients in a certain place. Eutrophication can be aquatic or terrestrial. Air pollutants, waste water and fertilization in agriculture all contribute to eutrophication.

The result in water is an accelerated algae growth, which in turn, prevents sunlight from reaching the lower depths. This leads to a decrease in photosynthesis and less oxygen production. In addition, oxygen is needed for the decomposition of dead algae. Both effects cause a decreased oxygen concentration in the water, which can eventually lead to fish dying and to anaerobic decomposition (decomposition without the presence of oxygen). Hydrogen sulphide and methane are thereby produced. This can lead, among others, to the destruction of the eco-system.

On eutrophicated soils, an increased susceptibility of plants to diseases and pests is often observed, as is a degradation of plant stability. If the nutrification level exceeds the amounts of nitrogen necessary for a maximum harvest, it can lead to an enrichment of nitrate. This can cause, by means of leaching, increased nitrate content in groundwater. Nitrate also ends up in drinking water.

Nitrate at low levels is harmless from a toxicological point of view. However, nitrite, a reaction product of nitrate, is toxic to humans. The causes of eutrophication are displayed in Figure A3. The eutrophication potential is calculated in phosphate equivalents (PO4-Eq). As with acidification potential, it's important to remember that the effects of eutrophication potential differ regionally.

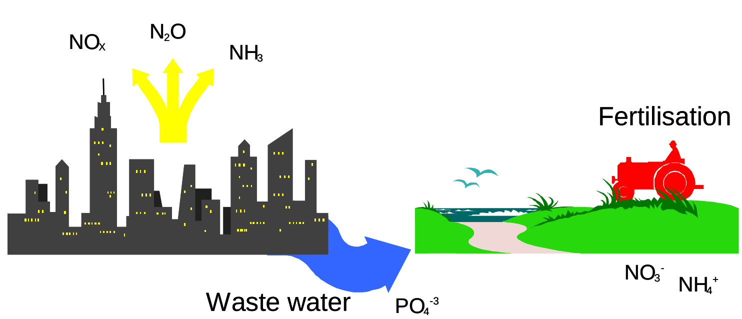


Figure A3: Eutrophication Potential (KREISSIG 1999)

Photochemical Ozone Creation Potential (POCP)

Despite playing a protective role in the stratosphere, at ground-level ozone is classified as a damaging trace gas. Photochemical ozone production in the troposphere, also known as summer smog, is suspected to damage vegetation and material. High concentrations of ozone are toxic to humans.

Radiation from the sun and the presence of nitrogen oxides and hydrocarbons incur complex chemical reactions, producing aggressive reaction products, one of which is ozone. Nitrogen oxides alone do not cause high ozone concentration levels. Hydrocarbon emissions occur from incomplete combustion, in conjunction with petrol (storage, turnover, refueling etc.) or from solvents. High concentrations of ozone arise when the temperature is high, humidity is low, when air is relatively static and when there are high concentrations of hydrocarbons. Today it is assumed that the existence of NO and CO reduces the accumulated ozone to NO_2, CO_2 and O_2. This means, that high concentrations of ozone do not often occur near hydrocarbon emission sources. Higher ozone concentrations more commonly arise in areas of clean air, such as forests, where there is less NO and CO (*Figure A4*).

In Life Cycle Assessments, photochemical ozone creation potential (POCP) is referred to in ethylene-equivalents (C_2H_4-Äq.). When analyzing, it's important to remember that the actual ozone concentration is strongly influenced by the weather and by the characteristics of the local conditions.

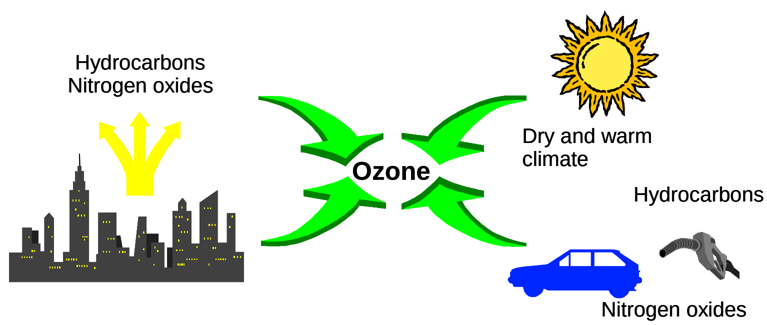


Figure A4: Photochemical Ozone Creation Potential

Ozone Depletion Potential (ODP)

Ozone is created in the stratosphere by the disassociation of oxygen atoms that are exposed to short-wave UV-light. This leads to the formation of the so-called ozone layer in the stratosphere (15 - 50 km high). About 10 % of this ozone reaches the troposphere through mixing processes. In spite of its minimal concentration, the ozone layer is essential for life on earth. Ozone absorbs the short-wave UV-radiation and releases it in longer wavelengths. As a result, only a small part of the UV-radiation reaches the earth.

Anthropogenic emissions deplete ozone. This is well-known from reports on the hole in the ozone layer. The hole is currently confined to the region above Antarctica, however another ozone depletion can be identified, albeit not to the same extent, over the mid-latitudes (e.g. Europe). The substances which have a depleting effect on the ozone can essentially be divided into two groups; the fluorine-chlorine-hydrocarbons (CFCs) and the nitrogen oxides (NOX). *Figure A5* depicts the procedure of ozone depletion.

One effect of ozone depletion is the warming of the earth's surface. The sensitivity of humans, animals and plants to UV-B and UV-A radiation is of particular importance. Possible effects are changes in growth or a decrease in harvest crops (disruption of photosynthesis), indications of tumors (skin cancer and eye diseases) and decrease of sea plankton, which would strongly affect the food chain. In calculating the ozone depletion potential, the anthropogenically released halogenated hydrocarbons, which can destroy many ozone molecules, are recorded first. The so-called

Ozone Depletion Potential (ODP) results from the calculation of the potential of different ozone relevant substances.

This is done by calculating, first of all, a scenario for a fixed quantity of emissions of a CFC reference (CFC 11). This results in an equilibrium state of total ozone reduction. The same scenario is considered for each substance under study whereby CFC 11 is replaced by the quantity of the substance. This leads to the ozone depletion potential for each respective substance, which is given in CFC 11 equivalents. An evaluation of the ozone depletion potential should take the long term, global and partly irreversible effects into consideration.

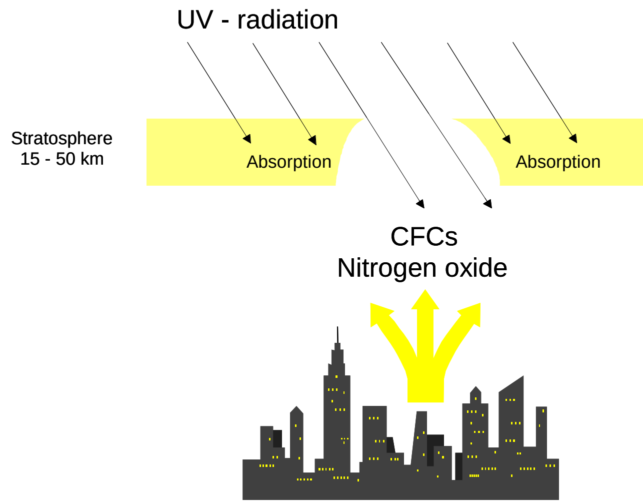


Figure A5: Ozone Depletion Potential (KREISSIG 1999)

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