Eco-profiles and Environmental Product Declarations of the European Plastics Manufacturers

Vinyl chloride (VCM) and Polyvinyl chloride (PVC)

PlasticsEurope /
The European Council of Vinyl Manufacturers (ECVM)

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Environmental Product Declaration

Introduction

This Environmental Product Declaration (EPD) is based upon life cycle inventory (LCI) data from PlasticsEurope's Eco-profile programme. It has been prepared according to **PlasticsEurope's Eco-profiles and Environmental Declarations – LCI Methodology and PCR for Uncompounded Polymer Resins and Reactive Polymer Precursors** (PCR version 2.0, April 2011). EPDs provide environmental performance data, but no information on the economic and social aspects which would be necessary for a complete sustainability assessment. Further, they do not imply a value judgment between environmental criteria.

This EPD describes the production of the vinyl chloride monomer and the polyvinyl chloride polymer from cradle to gate (from crude oil extraction to granules or resin at plant). **Please keep in mind that comparisons cannot be made on the level of the monomer or polymer material alone**: it is necessary to consider the full life cycle of an application in order to compare the performance of different materials and the effects of relevant life cycle parameters. This EPD is intended to be used by member companies, to support product-orientated environmental management; by users of plastics, as a building block of life cycle assessment (LCA) studies of individual products; and by other interested parties, as a source of life cycle information.

Meta Data

Data Owner	PlasticsEurope, ECVM
LCA Practitioner	IFEU Heidelberg GmbH, Germany
Programme Owner	PlasticsEurope, ECVM
Programme Manager, Reviewer	DEKRA Assurance Services GmbH
Number of plants included in data collection	38
Representativeness	VCM 71% S-PVC 60% - E-PVC 83%
Reference year	2013
Year of data collection and calculation	2014
Expected temporal validity	2018
Cut-offs	none
Data Quality	good
Allocation method	physical and economic

Description of the Product and the Production Process

This Eco-profile and EPD represents the average industrial production of both vinyl chloride monomer (VCM) and polyvinyl chloride (PVC) from cradle to gate. The Eco-profile treats the two main production processes for PVC separately: S-PVC from suspension polymerisation and E-PVC from emulsion polymerisation.

Production Process

Polyvinyl chloride (PVC) is manufactured by polymerisation of vinyl chloride monomer (VCM), which in Europe is produced by the thermal cracking of ethylene dichloride (EDC).

In Europe (EU27+NO+CH), most ethylene used in the manufacture of EDC is produced by steam cracking of naphtha. Chlorine is produced by electrolysis of sodium chloride (NaCl).

The model of this Eco-profile comprises extraction and refinery of crude oil for the ethylene production, salt recovery and chlorine electrolysis as well as production of EDC and the final polymerisation of VCM into PVC. The model of the polymer production process represents the major commercial PVC production technologies, which are suspension process (S-PVC) and emulsion process (E-PVC).

Impacts related to abnormal process conditions (e.g. accidents) are not considered in this study.

Data Sources and Allocation

Ethylene production is modelled based on the Eco-profile and EPD for ethylene [PLASTICSEUROPE 2012A] and chlorine production is based on the Eco-profile and EPD for chlorine [EUROCHLOR 2013].

For the production of those raw materials all upstream processes until raw material extraction were considered.

The production of the precursor ethylene dichloride (EDC), of the monomer vinyl chloride (VCM) and the polymer production processes themselves are based on confidential process and emission data collected from participating production sites (primary data).

Country-specific electricity mixes are used for grid electricity supply. On-site production of electricity and steam is partially modelled using primary data from the polymer producers; data gaps in on-site energy production are closed using European average data of power plants and steam boilers.
Representative literature data is used to fill gaps wherever primary data is unavailable, and in order to cross-check primary data. Allocation within the foreground system is intended to be avoided; where necessary, processes are allocated by physical properties, such as mass, exergy or enthalpy. Products with different economic values are allocated using the known relative prices (see Eco-profile for details).

Use Phase and End-of-Life Management

The use phase and end-of-life processes of the investigated polymer are outside the system boundaries of this cradle-to-gate system: since the objects of this study are VCM and PVC, which is widely applied, even a qualitative discussion of these aspects was deemed inappropriate. However, the disposal of waste from production processes is considered within the system boundaries of this Eco-profile.

Environmental Performance

The tables below show the environmental performance indicators associated with the production of 1 kg of VCM and of each considered PVC type.

Input Parameters

Indicator	Unit	Vinyl chloride (VCM)	Suspension PVC (S-PVC)	Emulsion PVC (E-PVC)
Non-renewable energy resources[1)]	MJ	51.1	56.9	66.1
• Fuel energy	MJ	30.4	36.2	45.4
• Feedstock energy	MJ	20.7	20.7	20.7
Renewable energy resources (biomass)[1)]	MJ	3.6	3.7	4.7
• Fuel energy	MJ	3.6	3.7	4.7
• Feedstock energy	MJ	0.0	0.0	0.0
Abiotic Depletion Potential				
• Elements	kg Sb eq	1.3×10^{-5}	1.3×10^{-5}	1.4×10^{-5}
• Fossil fuels	MJ	42.8	47.2	54.2
Water use	kg	162.0	197.7	280.9
• for process	kg	41.4	44.2	48.2
• for cooling	kg	120.6	153.5	232.7

[1)] Calculated as upper heating value (UHV)

Output Parameters

Indicator	Unit	Vinyl chloride (VCM)	Suspension PVC (S-PVC)	Emulsion PVC (E-PVC)
Global Warming Potential (GWP)	kg CO2 eq	1.71	1.99	2.56
Ozone Depletion Potential (ODP)	g CFC-11 eq	1.9×10^{-3}	2.2×10^{-3}	2.4×10^{-3}
Acidification Potential (AP)	g SO2 eq	4.50	5.05	6.93
Photochemical Ozone Creation Potential (POCP) [2)]	g Ethene eq	0.50	0.56	0.54
Eutrophication Potential (EP)	g PO4 eq	0.81	0.94	1.25
Dust/particulate matter • 10 µm [3)] (PM10)	g PM10	3.36	3.84	5.05
Total particulate matter [2)]	g	3.63	4.18	5.60
Waste	g	17.86	21.41	27.33
• Non-hazardous	g	14.64	12.47	16.20
• Hazardous	g	1.28	1.83	1.08
• Unspecified	g	1.94	7.11	10.04

[2)] Including NMVOC (0.15 / 0.16 / 0.19 g Ethene eq./kg VCM/S-PVC/E-PVC)
[3)] Including secondary PM10 (particulate matter formed from precursors, see Chapter "Life Cycle Assessment" for details)

Additional Environmental and Health Information – PVC

Like many other materials, the manufacture of PVC involves the use of some hazardous chemicals. Such manufacturing processes are very tightly regulated and the risks are adequately controlled. Regulations are completed since the 1990s by voluntary commitments (ECVM Charters). PVC is probably the world's most researched plastic/polymer.

A substantial volume of research and over 50 years of experience support the fact that PVC can be safely used even in the most sensitive of applications (such as medical devices).

PVC is one of the most recyclable of polymers but can be disposed of, if required, quite safely.

Building upon the achievements of the Vinyl 2010 commitments, the European PVC industry launched VinylPlus in 2011, the new ten-year voluntary commitment of the European PVC industry. It addresses five key sustainable development challenges, including controlled loop management of PVC and sustainable use of additives. (More information can be found under: [VINYLPLUSA]). Recycling and more generally end-of-life treatment of PVC is described in the "PVC recycling technologies brochure available for download from [VINYLPLUSB]. Due to the low thermal stability of PVC, heat stabilisers have to be added. Furthermore, plasticisers are necessary to ensure the flexibility required by some applications. To meet the product requirements various further substances are added to the PVC resin. More information can be found on [PVC].

The current Eco-profile includes only those additives which are used and added within the declared boundaries of the model system. Further additives that may be applied during later processing are thus not considered within the current study.

Additional Technical Information – PVC

The chemistry of PVC has been understood since the end of the last century. PVC was first commercially produced in Europe in the 1930s and has since then undergone continuous development and improvement. PVC's adaptability comes from its molecular structure. This makes possible many different blends of ingredients providing a range of properties, enabling the PVC industry to respond to the commercial and technical needs of many market sectors.

PVC can be found in an extremely wide range of applications whether transparent or pigmented, such as construction products like window frames, pipes and facade elements, or as products for mechanical or electrical engineering like cable insulation. PVC also has applications in food packaging or consumer goods.

PVC products are characterised by low natural flammability and high chemical and biological inertness.

Additional Economic Information

Together with polyolefins, PVC is one of the economically most prominent thermoplastics. The PVC production in Europe sums up to about 5 million tons/year.

The production volumes of PVC have been slightly decreasing within Europe in recent years due to a depression of the construction sector; from a global point of view, however, demand and production of PVC are still growing.

Information

Data Owners

The European Council of Vinyl Manufacturers (ECVM); PVC sector group of PlasticsEurope
Avenue E van Nieuwenhuyse 4, Box 4
B-1160 Brussels, Belgium
Tel.: +32 (2) 676 74 45, Fax: +32 (2) 676 74 47
E-mail: info@plasticseurope.org.

Programme Manager & Reviewer
DEKRA Assurance Services GmbH
This Environmental Product Declaration has been reviewed by DEKRA Assurance Services GmbH. It was approved according to the Product Category Rules PCR version 2.0 (2011-04) and ISO 14025:2006.
Registration number: PlasticsEurope 2015-005, validation expires on 30 June 2018 (date of next revalidation review).

Programme Owners

PlasticsEurope
Avenue E van Nieuwenhuyse 4, Box 3
B-1160 Brussels, Belgium
Tel.: +32 (2) 675 32 97, Fax: +32 (2) 675 39 35
E-mail: info@plasticseurope.org.
For copies of this EPD, for the underlying LCI data (Eco-profile); and for additional information, please refer to http://www.plasticseurope.org/.

References

- PlasticsEurope 2011: Eco-profiles and environmental declarations – LCI methodology and PCR for uncompounded polymer resins and reactive polymer precursor (version 2.0, April 2011).
- PlasticsEurope 2012: Eco-profiles and Environmental Product Declarations of the European Plastics Manufacturers - Ethylene, Propylene, Butadiene, Pyrolysis Gasoline, Ethylene Oxide (EO), Ethylene Glycols (MEG, DEG, TEG), November 2012.
- EuroChlor 2013: Eco-profiles and Environmental Product Declarations of the European Chlor Manufacturers - Chlorine (The chlor-alkali process). November 2013.