



Eco-profile of moulded PU foam

EURO-MOULDERERS

September 2021



European Association of Manufacturers of Moulded
Polyurethane Parts for the Automotive Industry

1 Summary

This Eco-profile has been prepared according to **Eco-profiles program and methodology –PlasticsEurope – V3.0 (2019)**.

It provides environmental performance data representative of the average European production of moulded Polyurethane foam (PU) for the reference year 2019. The declared unit is 1 kg of moulded PU foam from cradle-to-gate (from crude oil extraction to moulded PU foam production).

Please keep in mind that comparisons cannot be made on the level of the 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. It 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	Euro-Moulders aisbl
LCA Practitioner	Sphera Solutions GmbH
Programme Owner	PlasticsEurope AISBL
Reviewer	Angela Schindler, Umweltberatung, Salem
Number of plants included in data collection	5
Representativeness	>50% coverage in terms of production volumes for the automotive sector in Europe
Reference year	2019
Year of data collection and calculation	2020
Expected temporal validity	2026
Cut-offs	No significant cut-offs
Data Quality	Good
Allocation method	No allocations in foreground system

Description of the Product and the Production Process

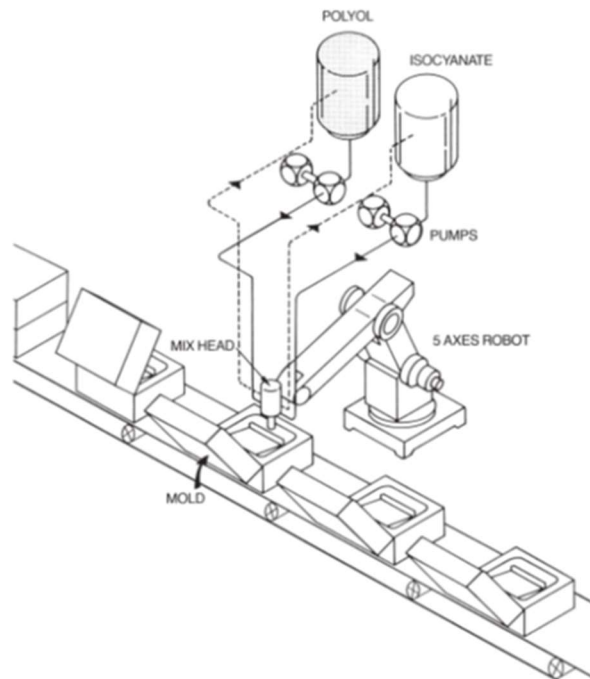
Moulded PU foam is a cellular, thermosetting plastic (flexible foam) which is a widely used material in vehicles. It is by far the preferred cushioning material for automotive seating. Industry data for the production of moulded PU foam has been collected for this Eco-profile from the following 5 companies:

- Adient
- Faurecia
- Fehrer
- Proseat
- Toscana Gomma

Production Process

The production of moulded flexible polyurethane foam is a discontinuous process. Moulded foam articles are made one at a time by injecting the foam mixture (isocyanates (MDI and TDI), polyether polyols, catalysts

Moulding is the preferred process for the production of PU foam parts with complex shapes. It also allows for placing inserts into the moulds for further easier assembly. This is why moulded foam technology is widely used in the automotive industry for producing e.g. seat cushions, seat backs, armrests, headrests, and knee cushions.



Gel-Reaction (Polymer Formation):

$\text{OCN}-\text{[Red Box]}-\text{NCO} + \text{HO}-\text{[Green Wavy Line]}-\text{OH}$
Isocyanate *Polyol*

\longrightarrow

$\text{OCN}-\text{[Red Box]}-\text{N}-\text{C}(=\text{O})-\text{O}-\text{[Green Wavy Line]}-\text{OH}$
Urethane

Gas-Reaction (Cell Gas) and Formation of Urea:

$\text{OCN}-\text{[Red Box]}-\text{NCO} + \text{H}-\text{O}-\text{H} + \text{OCN}-\text{[Red Box]}-\text{NCO}$
Isocyanate *Water* *Isocyanate*

\longrightarrow

$\text{CO}_2 \uparrow$
Carbon Dioxide

\longrightarrow

$\text{OCN}-\text{[Red Box]}-\text{N}-\text{C}(=\text{O})-\text{N}-\text{[Red Box]}-\text{NCO}$
Urea

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Polyurethane is a polymer in which the basic chemical structural element is called “Urethane”. The urethane link is formed through the reaction of an isocyanate with an alcohol. This reaction is called the ‘gelling’ reaction since it contributes to forming the polymer network, or gel. The ‘blowing’ reaction comes from the reaction of isocyanate with water which results in a urea link and also liberates CO₂ gas which expands to ‘blow’ the foam.

The reference flow, to which all data given in this Eco-Profile refer, is 1 kg of flexible moulded PU foam “at gate”. Other technologies like flexible PU slabstock foams or rigid PU foams are not subject of this Eco-profile.

Data Sources and Allocation

The main data source is a primary data collection from European producers of moulded PU foam, providing site-specific gate-to-gate production data for processes under the operational control of the participating companies: 5 producers manufacturing in 26 plants in 13 different European countries. Data has been collected generally from one or two representative site(s) for each company. For the other sites (twin plants), the production is very similar - same recipes and consumption amounts - and therefore mainly the energy sources (country grid mixes; energy source for thermal energy) have been adjusted to represent the geography according to the production volumes, as applicable. This means, a weighted vertical average has been done with data of the plants from the same company and subsequently also for creating the average of the five companies.

This covers more than 50 % of the total estimated production volume in Europe of just above 250,000 tonnes of the European moulded PU foam production for the automotive sector in 2019.

In the foreground system, no allocations were needed (no co-products). All relevant background data for the upstream supply chain until the precursors as well as energy and auxiliary materials are taken from the database version GaBi 2021 (<https://gabi.sphera.com/support/gabi>) of the software system GaBi 10 [SPHERA 2021].

Use Phase and End-of-Life Management

Use-phase

Due to the stringent tests on mechanical and physical properties that the foam has to pass to be in conformity with OEM specifications, the seat stays in the car for the lifetime of the car usually unless there is a major damage.

End-of-Life phase

Moulded foams from EoL vehicles are typically sent to waste-to-energy plants or to pyrolysis plants. There are two reasons for that: i) the cost of dismantling vs resources would be quite high compared to other more "profitable" sources of polyurethane for recycling such as mattresses or furniture; ii) seats are not removed from cars before the EoL vehicles go to a shredder, the foams thus get contaminated with oils and other fluids that remained in the car, which means the best way of treatment is waste-to-energy / pyrolysis for the time being.

Environmental Performance

The tables below show the environmental performance indicators associated with the production of 1 kg of moulded PU foam (cradle-to-gate).

Input Parameters

Indicator	Unit	Value	Impact method ref.
Non-renewable energy resources ¹⁾			
• Fuel energy	MJ	71	Gross calorific value
• Feedstock energy ²⁾	MJ	27	Gross calorific value
Renewable energy resources (biomass) ¹⁾			
• Fuel energy	MJ	7.4	Gross calorific value
• Feedstock energy	MJ	0	Gross calorific value
Abiotic Depletion Potential			
• Elements	kg Sb eq	9.07E-06	CML (Jan.2016)
• Fossil fuels	MJ	84.8	CML (Jan.2016)
Renewable materials (biomass)	kg	4.98E-12	n.a.
Water			
• Use	kg	3214	Blue water use
• Consumption	kg	20	Blue water consumption
1) Calculated as gross calorific value (upper heating value, UHV).			
2) Since this value cannot be retrieved directly from the LCA model, it was assumed to be equal to the gross calorific value, being 27 MJ/kg.			

Output Parameters

Indicator	Unit	Value	Impact method ref.
GWP	kg CO ₂ eq.	3.66	CML 2016
ODP	g CFC-11 eq.	1.93E-07	CML 2016
AP	g SO ₂ eq.	5.32	CML 2016
POCP	g Ethene eq.	1.60	CML 2016
EP	g PO ₄ ³⁻ eq.	1.02	CML 2016
Dust/particulate matter ³⁾	g PM10	0.194	n.a.
Total particulate matter ³⁾	g	0.298	n.a.
Waste			
• Non-hazardous	kg	5.68	n.a.
• Hazardous	kg	0.0022	n.a.
³⁾ Including secondary PM10			

Additional Environmental and Health Information

This part has been written under the only responsibility of the Data owner and is not part of the LCA practitioner and reviewer work.

PU foam is an article under the REACH regulation and not a mixture of substances. The diisocyanate reagents used for flexible PU foam production have a highly reactive NCO group. This ensures that they are fully consumed during the chemical reaction with polyols yielding the polyurethane foam. Hence, they cannot be

released into the air from the foam. That is why there cannot be any exposure of consumers to diisocyanates resulting from PU foam [SCOTT 2012].

Additional Technical Information

This part has been written under the only responsibility of the Data owner and is not part of the LCA practitioner and reviewer work. No additional information declared here.

Additional Economic Information

This part has been written under the only responsibility of the Data owner and is not part of the LCA practitioner and reviewer work. No additional information declared here.

Programme Owner

PlasticsEurope

Rue Belliard 40 Box 16
B-1040 Brussels, Belgium
Tel.: +32 (0)2 792 30 99

E-mail: info@plasticseurope.org.

For copies of this Eco-profile, for the underlying LCI data (Eco-profile); and for additional information, please refer to www.euromoulders.org or to <http://www.plasticseurope.org/>.

Data Owner

Euro-Moulders aisbl

Avenue de Cortenbergh 71
1000 Brussels, Belgium
Tel.: +32 2 741 81/83

www.euromoulders.org

LCA practitioner

Sphera Solutions GmbH

Hauptstr. 111-113
70771 Leinfelden-Echterdingen, Germany
Tel.: +49 711 3431870

www.sphera.com

Reviewer

Angela Schindler, Umweltberatung

Tüfing Str. 12
88682 Salem, Germany
Email: angela@schindler-umwelt.de

References

PlasticsEurope - Eco-profiles program and methodology (version 3.0, October 2019).