

## ROAD MARKING SYSTEMS

PRODUCT GROUP CLASSIFICATION: UN CPC 53211, 53222

C-PCR-XXX (TO PCR 2019:14) **TO BE ADDED UPON PUBLICATION**  
VERSION: 20XX-YY-ZZ **FOR OPEN CONSULTATION, DO NOT USE OR CITE**



**DRAFT FOR OPEN  
CONSULTATION**

ROAD MARKING SYSTEMS

PRODUCT GROUP CLASSIFICATION: UN CPC 53211, 53222

## INTRODUCTION TO OPEN CONSULTATION

This draft PCR document is available for open consultation from 2024-11-06 until 2025-01-06. Feel free to forward the draft to any other stakeholder you might think is relevant, including colleagues and other organisations.

We are interested in comments from stakeholders on:

- General
  - Alignment with PCRs available in other programmes for type III environmental declarations, industry-specific LCA guidelines or similar.
- Scope of PCR
  - Product category definition and description
  - Classification of product category using CPC codes
- Goal and scope, life cycle inventory and life cycle impact assessment
  - Functional unit/declared unit
  - System boundary
  - Allocation rules
  - Data quality requirements
  - Recommended databases for generic data
  - Impact categories and impact assessment methodology
- Additional information

Comments shall be sent directly to the PCR Moderator (contact details available in Section 1). There is a template for comments on [www.environdec.com](http://www.environdec.com) that may be used.

For questions about the PCR, please contact the PCR moderator. For general questions about the International EPD System, EPD or PCR development, please contact the Secretariat via [pcr@environdec.com](mailto:pcr@environdec.com).

ROAD MARKING SYSTEMS  
PRODUCT GROUP CLASSIFICATION: UN CPC 53211, 53222

## TABLE OF CONTENTS

1	Introduction .....	4
	1.1 General .....	4
	1.2 Role of this document .....	4
2	General information .....	6
	2.1 Administrative information .....	6
	2.2 Scope .....	7
3	PCR review and background information .....	9
	3.1 Open consultation .....	9
	3.2 PCR review .....	9
	3.3 Existing PCRs for the product category .....	9
	3.4 Reasoning for development of c-PCR .....	9
	3.5 Underlying studies used for c-PCR development .....	10
4	Goal and scope, life cycle inventory and life cycle impact assessment .....	11
	4.1 Declared/functional unit .....	11
	4.2 TECHNICAL SPECIFICATION, LIFESPAN AND REFERENCE SERVICE LIFE (RSL) .....	11
	4.3 system boundaries .....	17
	4.4 System diagram .....	21
	4.5 Cut-off rules .....	21
	4.6 Allocation rules .....	21
	4.7 Data quality requirements .....	21
	4.8 Environmental performance indicators .....	21
	4.9 Including multiple products in the same EPD .....	21
5	Content and format of EPD .....	22
	5.1 EPD language .....	22
	5.2 Unit and quantities .....	22
	5.3 Use of images in EPD .....	22
	5.4 EPD reporting format .....	22
6	List of abbreviations .....	24
7	References .....	25
8	Version history of c-PCR .....	26

ROAD MARKING SYSTEMS

PRODUCT GROUP CLASSIFICATION: UN CPC 53211, 53222

# 1 INTRODUCTION

## 1.1 GENERAL

This document constitutes complementary Product Category Rules (c-PCR) developed in the framework of the International EPD® System: a programme for type III environmental declarations<sup>1</sup> according to ISO 14025:2006, ISO 14040:2006, ISO 14044:2006, and product-specific standards such as EN 15804 and ISO 21930 for construction products. Environmental Product Declarations (EPD) are voluntary documents for a company or organisation to present transparent, consistent and verifiable information about environmental performance of their product (goods or services).

The rules for the overall administration and operation of the programme are the General Programme Instructions (GPI), publicly available at [www.environdec.com](http://www.environdec.com). PCRs and c-PCRs complement the GPI and the normative standards by providing specific rules, requirements and guidelines for developing an EPD for one or more specific product categories (see Figure 1). A PCR/c-PCR should enable different practitioners using the PCR/c-PCR to generate consistent results when assessing products of the same product category.

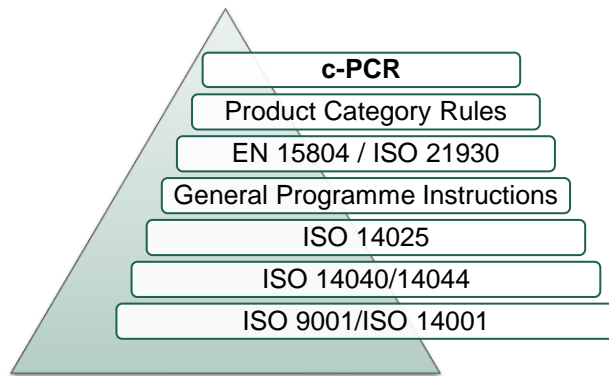


Figure 1 This c-PCR in relation to the hierarchy of standards and other documents.

Within the present c-PCR, the following terminology is adopted:

- The term “shall” is used to indicate what is obligatory, i.e. a requirement.
- The term “should” is used to indicate a recommendation, rather than a requirement. Any deviation from a “should” requirement shall be justified in the PCR development process.
- The terms “may” or “can” is used to indicate an option that is permissible.

For definitions of further terms used in the document, see the normative standards.

A PCR and its c-PCRs are valid for a pre-determined period of time to ensure that it is updated at regular intervals. The latest version of the PCR and its c-PCRs are available at [www.environdec.com](http://www.environdec.com). Stakeholder feedback on PCRs and c-PCRs is very much encouraged. Any comments on this c-PCR may be sent directly to the PCR Moderator and/or the Secretariat during its development or during its period of validity.

Any references to this document shall include the PCR registration number, name and version.

The programme operator maintains the copyright of the document to ensure that it is possible to publish, update, and make it available to all organisations to develop and register EPDs. Stakeholders participating in c-PCR development should be acknowledged in the final document and on the website.

## 1.2 ROLE OF THIS DOCUMENT

This document provides complementary product category rules (c-PCR) to PCR 2019:14 Construction products available at [www.environdec.com](http://www.environdec.com). This document cannot be used by itself but shall be used together with PCR 2019:14 and the European standard EN 15804:2012+A2:2019 (called EN 15804 in short). If a c-PCR is available for a product category, it shall be used.

See Figure 2 for an illustration on how PCR 2019:14 and this c-PCR relate to each other and the EPDs that may be based on them.

<sup>1</sup> Type III environmental declarations in the International EPD® System are referred to as EPD, Environmental Product Declarations.

ROAD MARKING SYSTEMS

PRODUCT GROUP CLASSIFICATION: UN CPC 53211, 53222

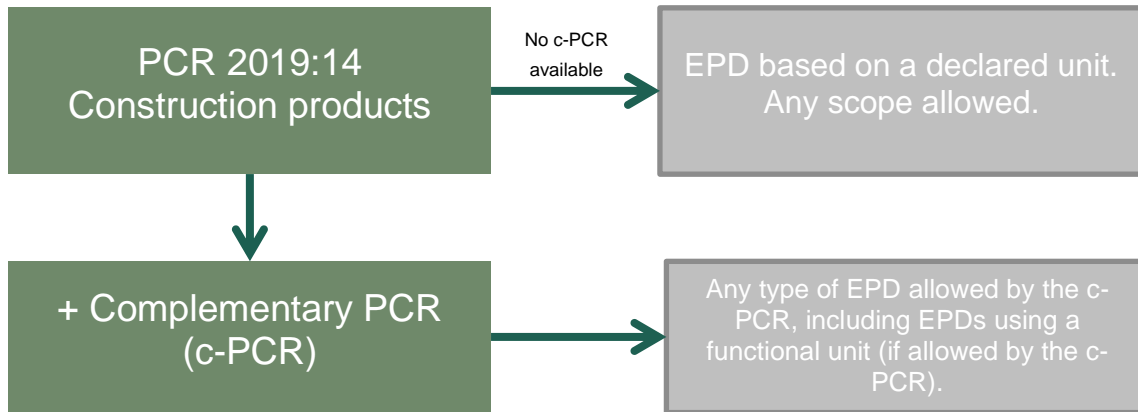



Figure 2 Overview of using PCR 2019:14 directly to develop an EPD, or how to use it together with a c-PCR.

ROAD MARKING SYSTEMS  
PRODUCT GROUP CLASSIFICATION: UN CPC 53211, 53222

## 2 GENERAL INFORMATION

### 2.1 ADMINISTRATIVE INFORMATION

Name:	Road marking systems	
Registration number and version:	<i>To be added by the Secretariat</i>	
Programme:	 THE INTERNATIONAL EPD® SYSTEM  The International EPD System	
Programme operator:	EPD International AB, Box 210 60, SE-100 31 Stockholm, Sweden.  Website: <a href="http://www.environdec.com">www.environdec.com</a> E-mail: <a href="mailto:info@environdec.com">info@environdec.com</a>	
PCR Moderator:	Áron Mári, Geveko Markings ApS, moderator on behalf of SVMF (Skandinaviska Vägmarkeringsföreningen)	
PCR Committee:	Alexander Klein	Röhm GmbH / Deutsche Studiengesellschaft für Straßenmarkierungen e.V. [DSGS]
	Claudia Drewes	Deutsche Studiengesellschaft für Straßenmarkierungen e. V. [DSGS]
	Friedrich Wiesinger	SWARCO Road Marking Systems
	Hanna Fager	Statens väg- och transportforskningsinstitut [VTI]
	Hans Olsen	Geveko Markings ApS
	Jon Kjær Jørgensen	Vejdirektoratet [Danish Road Directorate]
	Kenneth Lind	Trafikverket [Swedish Transport Administration]
	Martin Gunnarsson	Svevia AB
	Morten Carlsen	Mediator ApS
	Tine Damkjær	Vejdirektoratet [Danish Road Directorate]
	Toni Ogemark	Skandinaviska Vägmarkeringsföreningen [SVMF]
	Michaux Gauthier	SPW mobilité & infrastructures
	Louis Ducassou	Société d'Application Routière
	David Broere	Kraton Chemicals BV
Date of publication and last revision:	<i>To be added by the Secretariat</i>	
Valid until:	<i>To be added by the Secretariat</i>	
Schedule for renewal:	This document will be revised together with the PCR for Construction products. In case a c-PCR is developed by a CEN Product TC, the standard will replace this c-PCR, with a transition period of at least 90 days under which both are valid.	

ROAD MARKING SYSTEMS

PRODUCT GROUP CLASSIFICATION: UN CPC 53211, 53222

Standards conformance:	<ul style="list-style-type: none"> <li>▪ General Programme Instructions (GPI) of the International EPD System, version 4.0, based on ISO 14025:2006, ISO 14040:2006 and ISO 14044:2006</li> <li>▪ EN 15804:2012+A2:2019</li> <li>▪ ISO 21930:2017. This standard is used in selected sections, such as allocation, when it provides additional but not contradictory rules to EN 15804. EPDs may comply with this standard if additional requirements are met, see PCR 2019:14 for further information.</li> </ul> <p>All EPDs based on this PCR are compliant with EN 15804:2012+A2:2019/AC:2021. If additional requirements in PCR 2019:14 are followed, this PCR may also be used to develop EPDs compliant with ISO 21930:2017.</p>
PCR language(s):	This PCR was developed and is available in English. In case of translated versions, the English version takes precedence in case of any discrepancies.

## 2.2 SCOPE

### 2.2.1 PRODUCT CATEGORY DEFINITION AND DESCRIPTION

This document provides a complementary Product Category Rules (c-PCR) for the assessment of the environmental performance of Road marking systems and the declaration of this performance by an EPD. The product category corresponds to subset of UN CPC 53211 - Highways (except elevated highways), streets and roads and UN CPC 53222 – Tunnels.

#### 2.2.1.1 Road marking:

Road markings are used to enforce traffic rules and guide drivers, pedestrians, cyclists, and other road users to their destinations in a safe and timely manner. Road markings are a crucial element in urban environments, guiding vehicle traffic and creating dedicated spaces for micromobility like bikes and scooters. These markings also play a vital role in Advanced Driver-Assistance Systems (ADAS) by providing visual cues for automated vehicle functions.

Road markings are typically systems composed of a pigmented material and a surface component consisting of reflective objects (glass beads) to provide nighttime visibility and/or anti skid aggregates or and/or anti-skid properties of the road marking surface.

Road marking materials are a mixture of binders, pigments, fillers (incl. premix beads and anti-skid aggregates) and various additives (including polymers). Based on their composition and usage, these materials can be categorised as:

- Hot-applied thermoplastics;
- Preformed thermoplastics;
- Waterborne paints;
- Solvent-borne paints;
- Reactive, plural component systems;
- Preformed cold plastics, and
- Tapes.

The definition of each of these materials is described in the European EN1871 and EN1790 standards.

Raised pavement markers, while providing similar function to road marking systems, are excluded from the standard due to their specific technical properties.

In conclusion, [1] road markings are a speciality, heavy-duty industrial maintenance coating, [2] two-layer system always comprised of the road marking material and the drop-on glass beads and/or anti-skid materials, [3] only the combination of the two layers creates a functional road marking system, [4] the same materials used as drop-on material can be premixed with the road marking material.

#### 2.2.1.2 Definition of premix and drop-on glass beads and other aggregates:

An essential part of road marking systems are premix and drop-on glass beads as well as antiskid aggregates. The glass beads (premix and drop-on) provide retroreflection, the aggregates skid resistance and all of them provide protection for road marking systems. Premix glass beads are additionally used as filler material to modify the rheology of the road marking material. According to the EN 1423 and EN 1424 standards, the definition of these products is the following:

- **Glass beads** - transparent spherical glass particles, used to provide night visibility for the road markings by retroreflecting the incident headlight beams of a vehicle towards the driver. Crystalline particles with refractive indices >1.9 are not

## ROAD MARKING SYSTEMS

PRODUCT GROUP CLASSIFICATION: UN CPC 53211, 53222

necessarily glassy but in road markings play the same role, so they must be considered equally. In order to enhance friction, drop-on material typically is a mixture of glass beads and anti-skid aggregates.

- **Antiskid aggregates** - hard grains of natural or artificial origin, used to provide anti-skid qualities for road markings. They can be grouped into transparent anti-skid aggregates and non-transparent anti-skid aggregates.

### 2.2.1.3 UN CPC classification hierarchy:

Section: 5 - Constructions and Construction Services

Division: 53 - Constructions

Group: 532 - Civil engineering works

Class: 5321 - Highways (except elevated highways), streets, roads, railways and airfield runways

SubClass: 53211 - Highways (except elevated highways), streets and roads

SubClass: 53222 – Tunnels

For additional information, please visit <https://unstats.un.org/unsd/classifications/Econ/Detail/EN/1074/53211>.

## 2.2.2 TYPE OF EPD AND INFORMATION MODULES INCLUDED

This c-PCR is primarily developed to be used by road infrastructure developers that want to develop an EPD to evaluate the environmental impact of an infrastructure project (see Section 2.2.1 Product category definition and description), either in the planning/design phase or for a completed project (as built). For a planning/design EPD it is strongly recommended to update it to as built when the construction project has been finalized. This includes updating to specific data for LCA calculations, see Section 4.7.

The purpose and preconditions for the EPD, including if EPD is valid for planning/design or as built, shall be declared, see Section 5.4.1.

Following the requirements in Section 2.2.2 of PCR 2019:14, an EPD based on this c-PCR shall be of type:

- Cradle to grave and module D (A + B + C + D);
- Cradle to gate with modules C1–C4 and module D (A1-A3 + C + D);
- Cradle to gate with options, modules C1-C4, module D and with optional modules (A1-A3 + C+ D and additional modules)

## 2.2.3 GEOGRAPHICAL SCOPE

This c-PCR may be used globally.

## 2.2.4 EPD VALIDITY

See PCR 2019:14.



ROAD MARKING SYSTEMS  
PRODUCT GROUP CLASSIFICATION: UN CPC 53211, 53222

### 3 PCR REVIEW AND BACKGROUND INFORMATION

This c-PCR was developed in accordance with the PCR development process described in the GPI of the International EPD® System, including open consultation and review.

#### 3.1 OPEN CONSULTATION

##### 3.1.1 VERSION 20XX-YY-ZZ

This c-PCR was available for open consultation from 2024-11-05 until 2025-01-05, during which any stakeholder was able to provide comments by contacting the PCR Moderator and/or the Secretariat.

**Web based meetings:** There are no meetings planned during the open consultation.

Stakeholders were invited via e-mail or other means to take part in the open consultation and were encouraged to forward the invitation to other relevant stakeholders. The following stakeholders provided comments during the open consultation and agreed to be listed as contributors in the c-PCR and at [www.environdec.com](http://www.environdec.com).

- *List of stakeholder names and affiliation – to be added after open consultation*

#### 3.2 PCR REVIEW

##### 3.2.1 VERSION 20XX-YY-ZZ

PCR review panel:	The Technical Committee of the International EPD® System. A full list of members is available at <a href="http://www.environdec.com">www.environdec.com</a> . The review panel may be contacted via <a href="mailto:info@environdec.com">info@environdec.com</a> .  Members of the Technical Committee were requested to state any potential conflict of interest with the PCR Committee, and if there were conflicts of interest they were excused from the review.
Chair of the PCR review:	<i>To be added by the Secretariat</i>
Review dates:	<i>To be added by the Secretariat</i>

#### 3.3 EXISTING PCRS FOR THE PRODUCT CATEGORY

As part of the development of this c-PCR, existing PCRs/c-PCRs and other internationally standardised methods that could potentially act as c-PCRs were considered to avoid unnecessary overlaps in scope and to ensure harmonisation with established methods of relevance for the product category. The existence of such documents was checked among the following EPD programmes and international standardisation bodies:

- International EPD® System. [www.environdec.com](http://www.environdec.com).

Table 1 lists the identified PCRs and other standardised methods.

*Table 1: Existing PCRs/c-PCRs and other internationally standardized methods that were considered to avoid overlap in scope and to ensure harmonisation with established methods.*

NAME OF PCR/c-PCR/STANDARD	PROGRAMME/STANDARDISATION BODY	REGISTRATION NUMBER, VERSION NUMBER/DATE OF PUBLICATION	SCOPE
N/A	N/A	N/A	N/A

#### 3.4 REASONING FOR DEVELOPMENT OF C-PCR

This c-PCR was developed to provide requirements and guidelines additional to those in PCR 2019:14 and EN 15804, for developing EPDs for the product category. The c-PCR thereby enables different practitioners to generate consistent results when assessing the environmental impact of products of the same product category, and thereby it supports comparability of products within a product category.

ROAD MARKING SYSTEMS

PRODUCT GROUP CLASSIFICATION: UN CPC 53211, 53222

### 3.5 UNDERLYING STUDIES USED FOR C-PCR DEVELOPMENT

The methodological choices made during the development of this c-PCR (declared/functional unit, system boundary, allocation methods, impact categories, data quality rules, etc.) were primarily based on the following underlying studies:

- Deutsche Studiengesellschaft für Straßenmarkierungen e. V., “Environmental Impacts from Road Markings in Germany” 2024, [Environmental Impacts from Road Markings in Germany \(dsgs.de\)](https://www.dsgs.de)
- Burghardt TE, Pashkevich A (2020) Materials selection for structured horizontal road markings: financial and environmental case studies, *European Transport Research Review*, 12, 11 doi: 10.1186/s12544-020-0397-x
- Cruz M, Klein A, Steiner V (2016) Sustainability assessment of road marking systems, *Transportation Research Procedia*, 14, 869-875. doi: 10.1016/j.trpro.2016.05.035
- Burghardt TE, Babić D, Pashkevich A (2022) Sustainability of thin layer road markings based on their service life. *Transportation Research Part D: Transport and Environment*, 109, 103339; doi: 10.1016/j.trd.2022.103339.
- Burghardt TE, Pashkevich A (2021) Green Public Procurement criteria for road marking materials from insiders’ perspective. *Journal of Cleaner Production*, 298, 126521; doi: 10.1016/j.jclepro.2021.126521.
- Burghardt TE, Pashkevich A, Żakowska L (2016) Influence of volatile organic compounds emissions from road marking paints on ground-level ozone formation. case study of Kraków, Poland. *Transportation Research Procedia*, 14, 714–723; doi: 10.1016/j.trpro.2016.05.338.

## 4 GOAL AND SCOPE, LIFE CYCLE INVENTORY AND LIFE CYCLE IMPACT ASSESSMENT

This section provides specific rules, requirements and guidelines for developing an EPD for the product category as defined in Section 2.2.1.

### 4.1 DECLARED/FUNCTIONAL UNIT

EPDs based on this c-PCR shall use a declared or functional unit. The declared or functional unit for road marking systems can be defined in the following ways:

- The **declared unit** is the specific unit for which the environmental impact of a product is assessed throughout its life cycle. Essentially it provides a base for comparison between different products within the same category.
  - The recommended declared units for road marking systems are the following:
    - Mass: [kg, t, lbs...]
    - Area: [m<sup>2</sup>, ft<sup>2</sup>...]
  - In every case a **conversion unit** shall be provided in the technical details section in the EPD, to facilitate comparison between EPDs using different declared units. [e.g. Product Consumption: 0.428 kg/m<sup>2</sup>, 4.56 kg/m<sup>2</sup>, 11.03 lbs/ft<sup>2</sup>]
- The **functional unit** refers to a quantified description of a product system's performance. It serves as a reference unit within an LCA study and provides a basis for comparing different products that fulfill the same function.
  - The functional unit shall be used if the road marking system's durability, performance and other services are also included in the environmental assessment.
  - The use of a functional unit might restrict the comparability of the EPD to the materials that provide the same performance. To facilitate the comparison the product properties and details of the road marking system certification may be included in the EPD.
  - The functional unit must account for all variables that defines the durability of the road marking system during use phase, i.e.: [1] geographic region of the use phase, [2] the location of the road marking system in the traffic (if and which type of special area is applied on [i.e: curves, recessed road marking system, etc.]), [3] the width of the traffic lane, [4] number/type of heavy vehicles, [5] winter maintenance requirements, and [6] the presence and absence of studded tyres.
  - **Example** of functional units:
    - *"Guiding traffic and providing retroreflection on 1 m<sup>2</sup> of road surface with thermoplastic road marking system in Germany in a high traffic area with 150 mcd/m<sup>2</sup>/lx (R3), 130 mcd/m<sup>2</sup>/lx (Q3) with 50 (S2) SRT over 8 years of functional life time."*
    - **Remark:** If the scope of the EPD is **Cradle to Grave (A+B+C+D)** or any other scope that includes the **use phase** the functional unit shall be selected, otherwise the declared unit is recommended to simplify the comparison between road marking systems.

### 4.2 TECHNICAL SPECIFICATION, LIFESPAN AND REFERENCE SERVICE LIFE (RSL)

#### 4.2.1 INFLUENCING FACTORS FOR THE REFERENCE SERVICE LIFE (RSL)

The definition of the reference service life (RSL) of road markings is not straightforward. The performance of the road marking is directly connected to the durability of the road markings. The durability not only depends on the type of road marking but also highly depends on environmental conditions, traffic load and type, surface texture, and proficiency of the application. The **type of road marking system** is defined by the formulation and the chemical properties of the products. Some road marking systems are inherently more durable than others. **Environmental conditions** such as climate (warm – cold), temperature fluctuations (high – low), precipitation (rain, snow, other), and UV radiation can hamper the performance and thus the durability of the road marking. Indirect effects of environmental conditions in cold climates, such as the negative effect of winter road maintenance and the use of studded tyres, which significantly reduce the reference service life of the road marking systems. Depending on where the road marking systems are applied on the road surface, they can be exposed to various **traffic loads** which can be high, moderate or low. Generally, the areas with high traffic load can be areas where there is a significant amount of transversal traffic can be observed (lane markings, centre lines, stop lines, or zebra crossings). The composition of the traffic load can further erode the durability of the road marking systems, with more heavy vehicles resulting in lower reference service life. Furthermore, tyres of turning vehicles express torque that exacerbates the damage to road markings disproportionately to the actual traffic load. The quality and conditions of **application** can also largely influence the durability of the products. Usually, better conditions during application and excellent workmanship result in higher durability.

## ROAD MARKING SYSTEMS

PRODUCT GROUP CLASSIFICATION: UN CPC 53211, 53222

To better understand the reference service life and the durability of road marking systems we need to introduce two concepts. The **functional service life** and **physical service life** of road marking systems are two crucial aspects in understanding their performance and longevity. Here's a detailed definition of each:

### 4.2.1.1 Functional Service Life

Functional service life refers to the period during which road markings effectively fulfill their intended purpose of guiding and informing road users. This encompasses several factors:

- **Visibility:** Road markings must be clearly visible both day and night, and under various weather conditions. **Retroreflectivity** [RI] and **diffuse illumination** [Qd] is the ability of the road markings to reflect light from vehicle headlights back to the driver during night time, it is achieved due to the glass beads
- **Color:** The markings must retain their color on the road surface. For instance, white and yellow markings should remain distinct and not fade to the extent that they are hard to distinguish.
- **Skid Resistance:** Especially for areas like pedestrian crossings, the markings must maintain a certain level of skid resistance to ensure safety.
- **Durability Against Wear:** The markings must withstand traffic wear, such as abrasion from tires and mechanical wear from snow plows.
- **Compliance with Standards:** The markings should continue to meet regulatory standards set by relevant authorities.

### 4.2.1.2 Physical Service Life

Physical service life refers to the total lifespan of the road marking systems before they physically degrade to the point of non-existence. This period is influenced by:

- **Material Properties:** Different materials have varying levels of durability.
- **Environmental Exposure:** Factors like UV radiation, temperature variations, or winter maintenance can accelerate the degradation of marking materials.
- **Traffic Volume:** High traffic volumes, especially of heavy and turning vehicles, can wear down markings more quickly.

**In summary, the functional service life is generally a shorter period during which the road markings remain effective in terms of visibility and color, while the physical service life is the total lifespan of the materials used in the markings before they degrade to the point of needing reapplication. One must note that road markings can be effective also during their physical service life period, even though they do not meet the requirements. Proper selection of materials and maintenance practices can optimize both functional and physical service life, ensuring road markings remain effective and safe for as long as possible.**

### 4.2.1.3 Testing of Road marking systems

There are two standards available to define the **functional service life** of the road markings. EN 13197+A1:2014 is the relevant standard describing wear simulator or turntable testing, while EN 1824:2020 is the relevant standard describing field testing.

#### EN 13197+A1:2014

This standard defines an accelerated durability testing method for road marking systems using a wear simulator, also known as a turntable. It specifies the conditions under which the performance of road markings is assessed, based on a controlled number of wheel passages to simulate wear and tear. The test aims to classify the road markings into functional classes according to their durability under specific conditions. While some environmental factors, like humidity, can be replicated in the test, others such as temperature and UV exposure cannot be simulated. The results from the test provide an indication of the performance class of the road markings, but they may not fully represent the real-life functional service life of the markings under varying environmental conditions.

#### EN 1824:2020

This standard outlines the methodology for evaluating the durability of road marking systems in real-world conditions through road trials. It defines the parameters for testing the road markings' functional class based on their ability to withstand a set number of wheel passages over an extended period. The trials are carried out over a minimum of one year, and in some cases, depending on the class of material (e.g., in Austria), up to four years of testing may be required. The outcomes help define the roll-over class of the road marking system, reflecting its durability in actual traffic and environmental conditions.

#### Regional standards

There are no global consensus about the testing methods of the road marking systems. Therefore it is advised to use the local standards to best define the durability and the reference service life. If there are no available knowledge on the local systems, it is recommended to consult with industry experts during the EPD development process. Additional local authorities may help the LCA practitioners interpret the most commonly used certifications within the region.

ROAD MARKING SYSTEMS

PRODUCT GROUP CLASSIFICATION: UN CPC 53211, 53222

4.2.1.4 Notes on durability

Due to the fact that there is no single method to accurately define the reference service life of the road marking systems, since it depends in many variable. The durability of road markings in practice needs to be assessed based on empirical observation across the regional or national road network. The LCA practitioner shall include all necessary information that might be helpful to use the EPD, and include in sustainable road infrastructure planning.

Furthermore it is advised that a model based on empirical data is developed for each type of road marking systems. The purpose of the model shall be to define an annual wear factor, that later can be used to define a scheduled maintenance for the road marking systems. The scheduled maintenance would allow the definition of how many times the road marking systems must be reapplied over the analysed time period, or reapplication factor. The reapplication factor could give the correct estimate on the amount of material used during the reference service life, or the analysed time period.

4.2.1.5 Examples of common practice in the road marking industry

Working together with the local representative of the road marking industry apart from the already mentioned, a more hands on approach have been added to estimate the functional service life of the road marking systems.

4.2.1.5.1 France

In France, road markings aim to enhance road safety, manage traffic flow, and convey important information to drivers. The regulatory framework includes the Highway Code, the Vienna Convention, and the Interministerial Instruction on Road Signs and Signals (IISR), particularly Part 7, which mandates certification for white and yellow road markings. Since 1992, the certification process has been managed by ASCQUER, following standards like NF-EN 1824 and NF-EN 1436. Certified road marking systems, comprising marking products and glass beads or aggregates, are granted the NF 058 Road Equipment mark.

To be used on French roads, products must have a technical sheet and an annual Right of Use from ASCQUER. Certification classes vary: for example, Type I markings for permanent white require P1 Q2 R3 S1, while Type II markings for temporary yellow require P1 Q1 R4 RW2 RR2 S1. Certified products include various paints, hot coatings, cold plastics, and prefabricated tapes, with durability ranging from 1 to 10 years depending on the product type.

The IDRRIM 2019 (Table 2) guide provides average durability estimates for these products and recommendations for their compatibility. Additionally, an optional NF 331 Environment certification, issued by AFNOR, ensures lower environmental impact and includes criteria such as reduced hazardous substances, minimal VOC content, and controlled production waste.

Table 2: Guideline to estimate the durability of road marking systems in France.

Road marking system	Estimated functional service life time
Solvent-based paints	1 year
Water-based paints	2 years
Reactive paints	2 years
Thermo extruded	4 years
Thermo ribbon	5 years
Thermo spray	3 years
Cold plastics	6 years
Thermo prefa tapes	5 years
Glued prefa tapes	9 years
<i>No product specifications by class of roads</i>	

ROAD MARKING SYSTEMS

PRODUCT GROUP CLASSIFICATION: UN CPC 53211, 53222

4.2.1.5.2 Germany

In Germany, road markings are regulated under the Straßenverkehrsordnung (StVO), requiring certification from the Bundesanstalt für Straßenwesen (BASt - Federal Highway Research Institute) before use on public roads. Certification is based on rigorous testing according to standards such as DIN EN 1423, DIN EN 1436, and others, as detailed in the TP M 2024 document. Road marking manufacturers must ensure compliance with the TL M 23 technical delivery conditions, with certificates issued for both permanent white and temporary yellow markings. These certificates specify essential parameters like material composition, thickness, and retro-reflectivity.

The ZTV M 13 standard outlines performance requirements, including the coefficient of retroreflected luminance (R<sub>L</sub>) and luminance coefficient under diffuse illumination (Q<sub>d</sub>). Applicators must submit a BASt test certificate when tendering and adhere to specifications during application, providing a warranty under VOB regulations. Durability is measured by the period during which retro-reflectivity remains above the required thresholds, with renewal recommended if values fall below 80% of the minimum standards.

Environmental impact assessments of these systems consider their functional durability, with data provided by the Deutsche Studiengesellschaft für Straßenmarkierungen e.V. (DSGS). This data, outlined in the 2024 DSGS study, forms the basis for calculating environmental impacts and should be referenced in future evaluations. Please refer to Table 3.

Table 3: Typical application scenarios as recommended by German guidelines ZTV M 13 for various road marking system technologies and functional durability @80% of the corresponding technology based on empirical data from roads in Germany\*.

Wear of the marking	Type	System	Functional durability@80% of minimum retro-reflectivity in use-phase required by ZTV M 13 [years]
Very High	Type II	Tape	10
		Thermoplastic Agglomerates	8
		Thermoplastic Flat	8
		Preformed Thermoplastic	8
		Cold Plastic Agglomerates**	9
		Cold Plastic Flat	8
Medium to High	Type II	Thermoplastic Agglomerates	9
		Thermoplastic Flat	9
		Preformed Thermoplastic	9
		Cold Plastic Agglomerates**	10
		Cold Plastic Flat	9
		Cold Spray Plastic	5
		Thermoplastic Spray	5
		Water-based Paint	2
		Solvent-based Paint	2
Low	Type I	Thermoplastic Flat	15
		Preformed Thermoplastic	N/A
		Cold Plastic Flat	15
		Cold Spray Plastic	8
		Water-borne Paint***	4
		Solvent-borne Paint***	4

4.2.1.5.3 Sweden

Swedish road markings are governed by the Traffic Regulation (SFS 1998:1276), the Swedish Transport Agency's Regulations (TSFS 2010:171), and the Road Sign Regulation (SFS 2007:90). The Swedish Transport Administration (Trafikverket) mandates that road marking systems on state roads must be certified by NordicCert, following standards like EN 1824, EN 1423, EN 1424, and EN 1436. Certification includes specific requirements for material thickness, ranging from 0.6 mm for waterborne paint to 4 mm for thermoplastic extrusion, with performance assessed in road trials. Maintenance is guided by AMA Anläggning and specific contract documents, where the choice of marking materials varies based on road classification and traffic volume. In performance contracts, any material can be used if functional parameters are maintained throughout the contract period. Road marking classes (1-5) are determined by traffic volume, with higher classes receiving more frequent maintenance (Table 4). Thermoplastic extrusion is preferred for high-traffic roads, while waterborne paint is used for lower-traffic areas and maintenance. Solvent-based paints are prohibited, and cold plastics are rarely requested. The functional lifetime of road markings varies, with thermoplastic extrusion lasting up to 9 years on low-traffic roads.

ROAD MARKING SYSTEMS

PRODUCT GROUP CLASSIFICATION: UN CPC 53211, 53222

Table 4: Functional lifetime of the corresponding technology based on experience from roads in Sweden for the different road marking classes.

Road marking Class	System	Thickness (mm)	Functional lifetime (years)
Class 1	Thermoplastic Extrusion	4	5
	Thermoplastic Extrusion	3	4
	Thermoplastic Extrusion*	2	2
	Thermoplastic Spray*	1.5	2
	Water-based paint*	0.6	1
Class 2	Thermoplastic Extrusion	4	6
	Thermoplastic Extrusion	3	5
	Thermoplastic Extrusion*	2	4
	Thermoplastic spray*	1.5	2
	Water-based paint*	0.6	1
Class 3	Thermoplastic Extrusion	4	7
	Thermoplastic Extrusion	3	6
	Thermoplastic Extrusion*	2	4
	Thermoplastic spray*	1.5	3
	Water-based paint*	0.6	2
Class 4	Thermoplastic Extrusion**	4	8
	Thermoplastic Extrusion**	3	7
	Thermoplastic Extrusion*	2	5
	Thermoplastic spray*	1.5	4
	Water-based paint*	0.6	2
Class 5	Thermoplastic Extrusion**	4	9
	Thermoplastic Extrusion**	3	8
	Thermoplastic Extrusion*	2	6
	Thermoplastic Spray*	1.5	5
	Water-based Paint*	0.6	4

4.2.1.5.4 Other regions

As the c-PCR has a global scope more regional estimation will be added for the next revision of the document.

ROAD MARKING SYSTEMS

PRODUCT GROUP CLASSIFICATION: UN CPC 53211, 53222

## 4.2.2 CONSIDERATION ON USE PHASE

Road marking materials and glass beads with standardized formulations are manufactured for various national markets, with application technology based on material rather than local specifics. The system composition and traffic class depend on national certifications, as each country has its standards stating local traffic wear and climate conditions. While numerous national certifications exist, including the use phase in Environmental Product Declarations (EPDs) makes them too specific, creating a significant financial burden and additional workload for producers to obtain third-party verification for every system. Therefore, verifying each system is impractical. However, producers can still provide third-party verified EPDs for their materials and glass beads (+anti-skid aggregates) with manageable effort, while the application can be standardized to meet national requirements. Whether the **use phase is included or not** the following principles should be considered when developing or using the EPD, to ensure a comprehensive analysis.

After careful consideration, it was decided by the PCR committee that to best represent the road marking systems should be evaluated over a **13-17 year observation period**, accounting for the expected performance under real-world traffic and environmental conditions. The system must accommodate a mix of materials over time, especially in situations where the road surface will not be renewed within the observation period (renewal of road markings).

Road marking systems are typically a composite product, with two main categories:

- Road marking material
- Drop-on blends<sup>2</sup>

The environmental impact calculated for these components shall be reported separately to facilitate the assessment of the individual components. The total environmental impacts should be calculated by summing the contribution of all materials used in the system. The total environmental impacts will be summed up from the values of EPD of each system component, calculated based on its percentage contribution to the total system consumption:

$X\% \text{ of } 1. \text{ Road marking material} + Y\% \text{ of } 2. \text{ Drop on blends} = \text{total environmental impacts}^3/\text{m}^2$

If certain materials fail to meet the given observation period, additional materials intended for use over that period shall be included in the calculation to ensure comparability (renewal of road markings). For instance, if a cold plastic structured marking has a projected functional durability (lifetime) of X years under heavy traffic wear, and it requires three maintenance cycles with cold spray plastics (functional durability of X years), the emissions for all materials used over that time shall be combined.

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<sup>2</sup> Drop-on blends: mixture of drop on beads and anti-skid material. Manufacturer of drop on blends delivers the calculated emissions (e.g. eCO<sub>2</sub>/m<sup>2</sup>) depending on the mixture/percentage of used drop on beads and anti-skid material, together with the required EPDs (for drop on beads and for anti-skid material).

<sup>3</sup> i.e: Total Global Warming Potential [kg CO<sub>2</sub> eq.]



ROAD MARKING SYSTEMS

PRODUCT GROUP CLASSIFICATION: UN CPC 53211, 53222

### 4.3 SYSTEM BOUNDARIES

EPDs that are developed based on this c-PCR shall cover product stage (A1-A3), construction process stage (A4-A5), use stage (B1-B7), end-of-life stage (C1-C4) as well as benefits and loads beyond the system boundary (D). The scope allowed by this c-PCR, and requirements for excluding information modules, must be aligned with PCR 2019:14 and EN 15804.

In case of conflicts between PCR for subsystems of the infrastructure (infrastructure components, e.g asphalt pavement) and this c-PCR, system boundaries specified in this c-PCR shall be used.

The following subsections describe examples of processes included in the covered information modules, as guidance to the EPD developer. For detailed information on each module, see EN 15804 (Section 6.3.5).

#### 4.3.1 PRODUCT STAGE: MODULES A1-A3

See PCR 2019:14 and Section 6.3.5.2 of EN 15804.

Guiding examples of processes to include in A1 – A3:

- Manufacturing of products (Table 5),
- Manufacturing of co-products that provide further functionality for the products (
- 
- Table 6),
- The tables below should be used as a guiding example, its content is not limited to the listed technologies and raw materials.

Table 5: Examples on product types and their chemical compositions (Non-comprehensive list)

Type	Raw material Groups	Raw Materials
▪ Waterborne paints	<ul style="list-style-type: none"> <li>▪ Filler</li> <li>▪ Binder</li> <li>▪ Pigment</li> <li>▪ Additive</li> <li>▪ Solvent</li> </ul>	<ul style="list-style-type: none"> <li>▪ Calcium carbonate, talc, nepheline syenite...</li> <li>▪ Acrylates, hydrocarbons, other polymers...</li> <li>▪ Titanium dioxide and other inorganic pigments, organic pigments,</li> <li>▪ Platicizers, coalescent, other chemicals...</li> <li>▪ Water, organic solvents...</li> </ul>
▪ Solventborne paints	<ul style="list-style-type: none"> <li>▪ Filler</li> <li>▪ Binder</li> <li>▪ Pigment</li> <li>▪ Additive</li> <li>▪ Solvent</li> </ul>	<ul style="list-style-type: none"> <li>▪ Calcium Carbonate, Sand...</li> <li>▪ Acrylates, styrenic, other polymers...</li> <li>▪ Titanium dioxide, Organic pigments, Inorganic Pigments..</li> <li>▪ Platicizers, other chemicals...</li> <li>▪ Organic solvents (e.g. Acetone)...</li> </ul>
▪ Reactive, plural component systems	<ul style="list-style-type: none"> <li>▪ Filler</li> <li>▪ Binder</li> <li>▪ Pigment</li> <li>▪ Additive</li> </ul>	<ul style="list-style-type: none"> <li>▪ Calcium Carbonate, Sand, glass beads...</li> <li>▪ MMA, other acrylates; epoxy...</li> <li>▪ Titanium dioxide, Organic pigments, Inorganic Pigments..</li> <li>▪ Platicizers, other chemicals...</li> </ul>
▪ Thermoplastics	<ul style="list-style-type: none"> <li>▪ Premix Glass beads</li> <li>▪ Filler</li> <li>▪ Binder</li> <li>▪ Pigment</li> <li>▪ Additive</li> </ul>	<ul style="list-style-type: none"> <li>▪ Product specific information required</li> <li>▪ Calcium Carbonate, Sand...</li> <li>▪ Rosin esters, Maleated rosin, EVA, SIS polymers, SBS polymers, polyamides, C5 resin, C9 resin and their mixtures...</li> <li>▪ Titanium dioxide, Organic pigments, Inorganic Pigments..</li> <li>▪ Plasticizers, other chemicals...</li> </ul>
▪ Tape	<ul style="list-style-type: none"> <li>▪ Adhesive</li> <li>▪ Elastic rubber layer</li> <li>▪ Polyurethane topcoat</li> <li>▪ Surface materials</li> <li>▪ Pigments</li> <li>▪ Fillers</li> <li>▪ Additives</li> </ul>	<ul style="list-style-type: none"> <li>▪ Organic chemicals</li> <li>▪ Rubber</li> <li>▪ Polyurethane</li> <li>▪ Calcium Carbonate, Sand, Ground ceramic particles (embedded ceramic elements, ceramic or non-ceramis anti-skid aggregates, and/or glass beads</li> <li>▪ Titanium dioxide, Organic pigments, Inorganic Pigments..</li> <li>▪ Plasticizers, other chemicals...</li> </ul>
▪ Preformed materials (other than preformed tapes)	<ul style="list-style-type: none"> <li>▪ Raw materials groups are the same depending on the type of the material. The production process is different.</li> </ul>	

ROAD MARKING SYSTEMS

PRODUCT GROUP CLASSIFICATION: UN CPC 53211, 53222

Table 6: Examples on co-products and their chemical compositions (Non-comprehensive list)

Function provided	Product Groups	Raw Materials
<ul style="list-style-type: none"> <li>Retroreflection</li> </ul>	<ul style="list-style-type: none"> <li>Glass beads</li> <li>Ceramic elements</li> </ul>	<ul style="list-style-type: none"> <li>Sand, Lime, Dolomite, Soda...</li> <li>Recycled materials (Cullets)</li> </ul>
<ul style="list-style-type: none"> <li>Friction</li> </ul>	<ul style="list-style-type: none"> <li>Glass granulates</li> <li>Other friction materials</li> </ul>	<ul style="list-style-type: none"> <li>Sand, Lime, Dolomite, Soda, Sulfate...</li> <li>Corundum, Crystobalite, crystalline silica, ceramic aggregates...</li> </ul>
<ul style="list-style-type: none"> <li>Adhesion</li> </ul>	<ul style="list-style-type: none"> <li>Primers</li> <li>Glues</li> </ul>	<ul style="list-style-type: none"> <li>Resins, Rosin esters, Organic chemicals (plasticisers, solvents...), Pigments...</li> <li>Resins, Organic chemicals...</li> </ul>
<ul style="list-style-type: none"> <li>Rheology and viscosity Modifiers</li> </ul>	<ul style="list-style-type: none"> <li>Thinners</li> </ul>	<ul style="list-style-type: none"> <li>Organic Solvents (Ethyl acetate, MEK, Acetone, Toluene), Additives...</li> </ul>
<ul style="list-style-type: none"> <li>Initiators</li> </ul>	<ul style="list-style-type: none"> <li>Liquid peroxides</li> <li>Solid peroxides</li> <li>Others</li> </ul>	<ul style="list-style-type: none"> <li>Organic oxidisers (dibenzoyl peroxide...), Additives...</li> <li>Organic oxidisers (dibenzoyl peroxide...), Fillers (Calcium Carbonate, Sand...), Additives</li> </ul>
<ul style="list-style-type: none"> <li>Retarders</li> </ul>	<ul style="list-style-type: none"> <li>Composition differs in road markings types</li> </ul>	<ul style="list-style-type: none"> <li>Glycols, waxes and plasticizers, organic acids...</li> </ul>
<ul style="list-style-type: none"> <li>Accelerators</li> </ul>	<ul style="list-style-type: none"> <li>Composition differs in road markings types</li> </ul>	<ul style="list-style-type: none"> <li>Organic peroxides, ammonium chloride, amine accelerators (DMPT)...</li> </ul>

### 4.3.2 CONSTRUCTION PROCESS STAGE: MODULES A4-A5

See PCR 2019:14 and Section 6.3.5.3 of EN 15804.

Guiding examples of processes to include in A4 – A5:

- Transportation of product to the application sites (project or market specific distances)
  - Example transport scenario based on Klein and Cruz (2015):

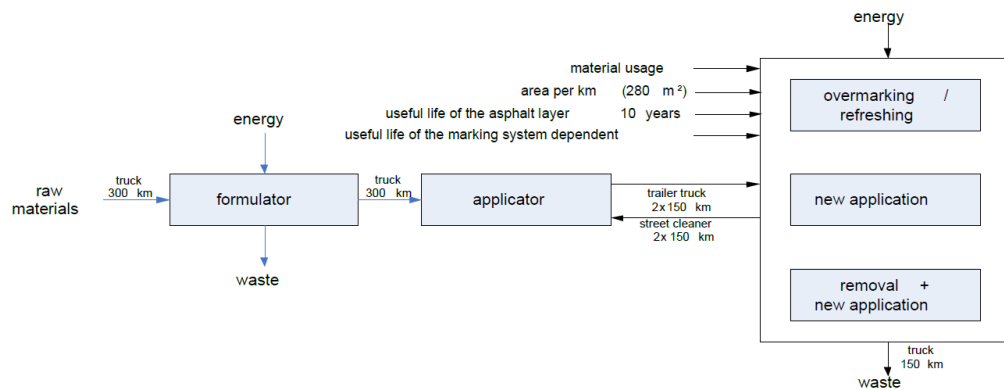


Figure 3: Transport routes of precursors and marking systems from cradle to grave (Klein and Cruz, 2016)

- Application of road marking systems with various techniques:
  - The application processes shall include adequate estimation of the energy consumption and material losses during the application.

ROAD MARKING SYSTEMS

PRODUCT GROUP CLASSIFICATION: UN CPC 53211, 53222

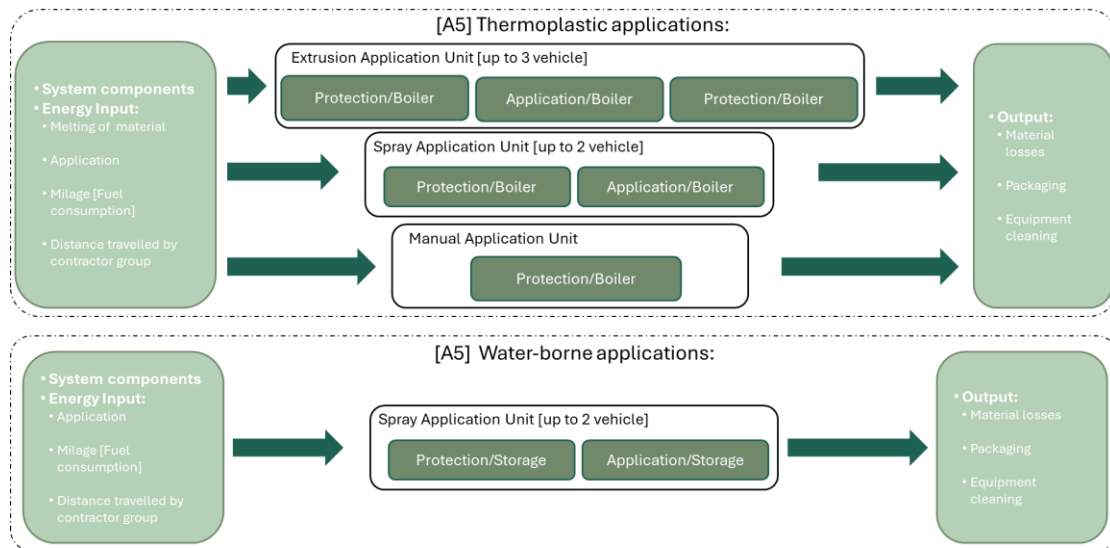


Figure 4: Example application scenarios in Norway:

- Preparation of the surface (cleaning).
- Transportation and handling of waste from the packaging materials.

Table 7: Examples on application methods [Non-comprehensive list]

Application	Description	Material Type
<ul style="list-style-type: none"> <li>▪ Manual</li> </ul>	<ul style="list-style-type: none"> <li>▪ Roller, brush, Screed-box</li> <li>▪ Cleaning of the equipment (materials used in the process)</li> <li>▪ Additional output flows to air, soil or water (solvents, VOCs, etc.)</li> <li>▪ Tape: <ul style="list-style-type: none"> <li>▪ Automatic tape applicator, Manual tape applicator, Stamping process – manual tamping or driving on tape with heavy vehicle</li> </ul> </li> <li>▪ Preformed materials: <ul style="list-style-type: none"> <li>▪ The application depends on the type of the preformed material. (Thermoplastic – Blowtorch, PU materials – manual gluing, ect.)</li> <li>▪ The selected application method, and the used inputs shall be defined.</li> </ul> </li> <li>▪ Consider other inputs and outputs</li> </ul>	<ul style="list-style-type: none"> <li>▪ Primer</li> <li>▪ Tape</li> <li>▪ Water borne paints</li> <li>▪ Solvent-borne paints</li> <li>▪ Reactive, plural component systems [Cold plastics, two component systems, etc.]</li> <li>▪ Thermoplastics</li> <li>▪ Preformed materials</li> </ul>
<ul style="list-style-type: none"> <li>▪ Spray</li> </ul>	<ul style="list-style-type: none"> <li>▪ Various types of spray machinery. Collaboration with the local contractors is suggested to sufficiently estimate the input flows of the application process (fuel consumption during application, material loss...)</li> <li>▪ Cleaning of the equipment (materials used in the process)</li> <li>▪ Other output flows, such as fumes and pollutants has to be described if there are available data...</li> </ul>	<ul style="list-style-type: none"> <li>▪ Primer</li> <li>▪ Water borne paints</li> <li>▪ Solvent-borne paints</li> <li>▪ Reactive, plural component systems [Cold plastics, two component systems, etc.]</li> <li>▪ Thermoplastics</li> </ul>
<ul style="list-style-type: none"> <li>▪ Extrusion</li> </ul>	<ul style="list-style-type: none"> <li>▪ Various types of extrusion machinery. Collaboration with the local contractors is suggested to sufficiently estimate the input flows of the application process (fuel consumption during application, material loss...)</li> <li>▪ Cleaning of the equipment (materials used in the process)...</li> <li>▪ Other output flows, such as fumes and pollutants has to be described if there are available data...</li> <li>▪ Thermoplastics:</li> </ul>	<ul style="list-style-type: none"> <li>▪ Reactive, plural component systems [Cold plastics, two component systems, etc.]</li> <li>▪ Thermoplastics</li> </ul>

ROAD MARKING SYSTEMS

PRODUCT GROUP CLASSIFICATION: UN CPC 53211, 53222

	<ul style="list-style-type: none"><li>▪ The heating of the thermoplastic material must be included in the application process (heat capacity of the material, type of energy used for heating...)</li></ul>	
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ROAD MARKING SYSTEMS

PRODUCT GROUP CLASSIFICATION: UN CPC 53211, 53222

### 4.3.3 USE STAGE: MODULES B1-B7

See PCR 2019:14 and Section 6.3.5.4 of EN 15804.

Guiding examples of processes to include in B1 – B7:

- B1 – Use: This stage should include all the expected emissions<sup>4</sup> to the environment that is anticipated during the use of the road marking system.
- B2 – Maintenance: In case of scheduled maintenance (or renewal) that might occur during the lifetime of the product shall be included here. (The right application method has to be selected based on the application methods described in Table 7)
- B3 – Repair: In case of scheduled repair (cleaning or mild abrasion to restore retroreflectivity) that might occur during the lifetime of the product shall be included here.
- B4 – Replacement: In case of scheduled replacement that might occur during the lifetime of the product shall be included here.
- B5 – Refurbishment: Not applicable.
- B6 – Operational Energy Use: All road marking systems are providing their function passively, thus this life cycle stage is not applicable.
- B7 – Operational Water Use: All road marking systems are providing their function passively, thus this life cycle stage is not applicable.

### 4.3.4 GUIDING EXAMPLES OF PROCESSES TO INCLUDE IN END-OF-LIFE (EOL) STAGE: MODULES C1-C4

See PCR 2019:14 and Section 6.3.5.5 of EN 15804. The choice of the road infrastructure's end-of-life scenario shall be described in the EPD. The EPD developer should consider national standards and policies while creating the scenario.

- Typical end-of-life scenarios for road marking systems:
  - Worst case scenario and in most cases the road marking system is worn off completely at the end of the physical life.
  - Removal of the asphalt surface with cold planing/cold milling and landfilling of the materials
  - Removal of the asphalt surface, remelting it to a new asphalt surface together with the road marking system
  - Removal of road marking system with water jet/dry ice/cold planing etc.,
    - Removed material disposal or recycling or down-cycling in form of filler material for new road construction
- Define the fate of residual and lost material during the application and the use phase – i.e. dust pollution

### 4.3.5 BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARY: MODULE D

See PCR 2019:14 and Section 6.4.3.3 of EN 15804. The choice of scenario for benefits and loads beyond the system boundary shall be described in the EPD. The EPD developer should consider national standards and policies while creating the scenario.

### 4.3.6 OTHER BOUNDARY SETTING

See PCR 2019:14 and EN 15804.

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<sup>4</sup> These emissions could be expected substances (i.e. high boiling film forming agents in paints or plasticizers that contribute to VOCs, POCP or other toxicity emissions). Furthermore, particles from wear of the road marking system (i.e. microplastic particles), whose during small maintenance work such as washing and winter maintenance.

ROAD MARKING SYSTEMS  
 PRODUCT GROUP CLASSIFICATION: UN CPC 53211, 53222

## 4.4 SYSTEM DIAGRAM

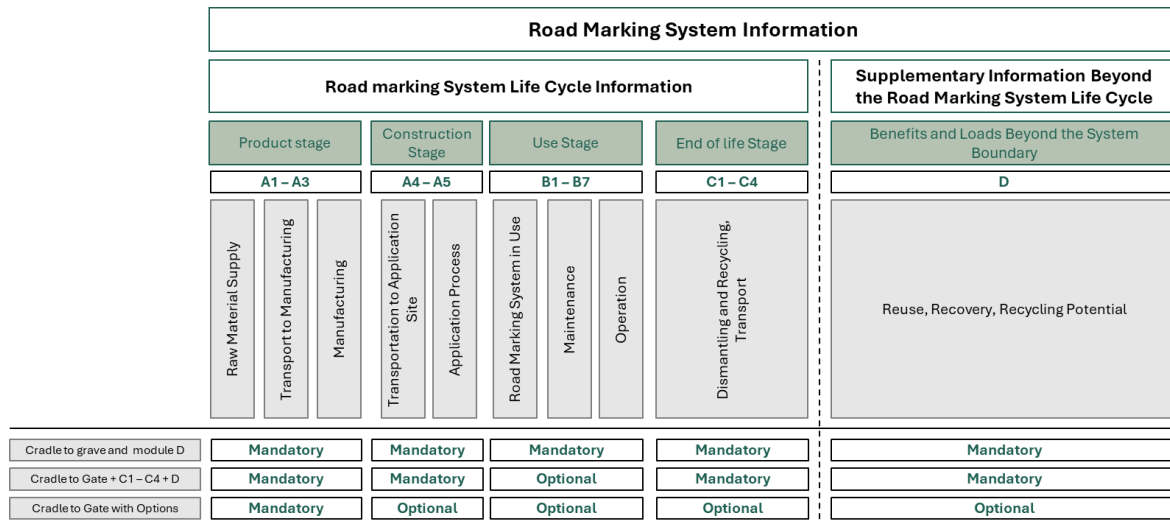


Figure 5 System diagram illustrating the processes that are included in the product system, divided into life-cycle stages and information modules.

## 4.5 CUT-OFF RULES

See PCR 2019:14 and EN 15804.

## 4.6 ALLOCATION RULES

See PCR 2019:14 and EN 15804.

## 4.7 DATA QUALITY REQUIREMENTS

See PCR 2019:14 and EN 15804.

When designing and creating the EPD, the LCA practitioner/EPD creator shall describe the requirements for data quality, and how these requirements are met. If the correct description is done, it is allowed to use available inventory data for comparable technologies with existing background datasets (e.g. data from suppliers, competitors or other manufacturers), but shall be qualified as specific data (for further information please see The International EPD System GPI, 2024, Chapter A.5)

## 4.8 ENVIRONMENTAL PERFORMANCE INDICATORS

See PCR 2019:14 and EN 15804.

## 4.9 INCLUDING MULTIPLE PRODUCTS IN THE SAME EPD

See PCR 2019:14.

ROAD MARKING SYSTEMS  
 PRODUCT GROUP CLASSIFICATION: UN CPC 53211, 53222

## 5 CONTENT AND FORMAT OF EPD

See PCR 2019:14.

### 5.1 EPD LANGUAGE

See PCR 2019:14.

### 5.2 UNIT AND QUANTITIES

See PCR 2019:14.

### 5.3 USE OF IMAGES IN EPD

See PCR 2019:14.

### 5.4 EPD REPORTING FORMAT

See PCR 2019:14.

#### 5.4.1 PRODUCT INFORMATION

Mandatory and recommended information.

##### 5.4.1.1 EPD Owner information

Mandatory information	The owner of the EPD may be the <b>producer</b> of the road marking material/system, glass beads and other aggregates or <b>applicator/contractor</b> . An environmental management system may be cited.
	Short description of the organisation, including all relevant information on products- or management system-related certifications (e.g. ECOLabels [Type I], ISO 9001 and 14001 certificates, etc.) and other sustainability work that the organization wants to communicate (e.g. social responsibility, supply-chain management, etc.)
	Name and contact information of the organisation carrying out the underlying LCA study.
Recommended information	In case other partners are involved in the EPD development process, their role and contribution may be described.

##### 5.4.1.2 Product specific information

Mandatory information	The name, location of manufacturing and the product design shall be described. A descriptive image of the product must be included.
	Description of the intended usage.
	Relevances to any websites for more information or explanatory materials.
	Unambiguous identification of the product according to the UN CPC scheme system, standards, concessions or other means.
	Declared/Functional Unit

ROAD MARKING SYSTEMS

PRODUCT GROUP CLASSIFICATION: UN CPC 53211, 53222

	<p>All assumptions made while defining the functional and physical service life. In addition the following information shall be shared:</p> <ul style="list-style-type: none"> <li>▪ Estimated dosage [kg/m<sup>2</sup>]</li> <li>▪ Recommended thickness (note whether it is dry or wet) [mm]</li> <li>▪ Drop-on amount [kg/m<sup>2</sup>]</li> <li>▪ Additional products used for application [primer, initiator, etc.]</li> <li>▪ Reapplication frequency based on the regional estimates with reference. (The renewal could be also done with different type of product. In this case this should be accounted for in the LCA as well.)</li> </ul>
	<p>Process flow diagram/system diagram, divided into the life cycle stages and information modules defined according to the EN 15804 standard. See Table 3 in PCR 2019:14, v.1.2 for an example.</p>
	<p>Description of geographical scope.</p>
	<p>Declaration of the year(s) representative for the inventory used for the A and B modules.</p>
	<p>Reference to the main database(s) for generic data and LCA software used, if relevant.</p>
	<p>If the purchased electricity used in the manufacturing process of module A3 accounts for more than 30% of the GWP-GHG results of modules A1-A3, the energy sources of this electricity use and its climate impact (in kg CO<sub>2</sub> eq./kWh using the GWP GHG indicator) shall be declared in the EPD.</p>
	<p>Data and information from the technical datasheet of the product.</p>
Recommended	<p>If the functional unit has been selected to include the performance of the road marking, it is recommended to include the documents of the certification.</p>

### 5.4.2 CONTENT DECLARATION

The EPD shall include a content declaration of the construction products covering relevant materials and substances included in the infrastructure itself. Resources which contribute 1% or more of the different resource use categories, shall be listed and detailed. Content of regulated substances within the geographical regions for which the EPD is valid shall be declared as well as the geographical validity of the EPD.

If there is more than 5% (post-consumer) recycled or biogenic content in the product, this shall be declared (if below 5%, this may be declared). If there is more than 5% biogenic content in the packaging material, this shall be declared (if below 5%, this may be declared)<sup>22</sup>. Also (post-consumer) recycled content of the packaging material may be declared.

The content declaration shall also include information on the environmental and hazardous properties of substances contained in products, for substances in the Candidate List of Substances of Very High Concern (SVHC) which exceeds the limits for registration with the European Chemicals Agency (i.e., if the substance constitute more than 0.1% of the weight of the product). The Candidate List of SVHC is available via the European Chemicals Agency.

### 5.4.3 ADDITIONAL ENVIRONMENTAL INFORMATION

If available additional information shall be included in the EPD. These information can be the following:

- Environmental information of the packaging materials (bio-content, recycled polymers...).
- Recommended handling of packaging waste during the application.



ROAD MARKING SYSTEMS  
PRODUCT GROUP CLASSIFICATION: UN CPC 53211, 53222

## 6 LIST OF ABBREVIATIONS

In addition to abbreviations listed in PCR 2019:14, Section 6:

ROAD MARKING SYSTEMS

PRODUCT GROUP CLASSIFICATION: UN CPC 53211, 53222

## 7 REFERENCES

CEN (2019) EN 15804:2012+A2:2019, Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products.

EPD International (2023) PCR 2019:14 Construction products, version 1.3.1.

EPD International (2024) General Programme Instructions of the International EPD® System. Version 5.0.0, dated 2024-06-19. [www.environdec.com](http://www.environdec.com).

ISO (2006a) ISO 14025:2006, Environmental labels and declarations – Type III environmental declarations – Principles and procedures.

ISO (2006b) ISO 14040:2006, Environmental management – Life cycle assessment – Principles and framework.

ISO (2006c) ISO 14044: 2006, Environmental management – Life cycle assessment – Requirements and guidelines.

ISO (2017) ISO 21930:2017, Sustainability in buildings and civil engineering works -- Core rules for environmental product declarations of construction products and services.

CEN (2018) EN 1436:2018 Road marking materials. Road marking performance for road users and test methods.

CEN (2020) EN 1871:2020 Road marking materials. Paint, thermoplastic and cold plastic materials. Physical properties.

CEN (2014) EN 13197+A1:2014 Road marking materials. Wear simulator Turntable.

CEN (2011) EN 1824:2020 Road marking materials. Road trials.

CEN (2012) EN 1423:2012 Road marking materials. Drop on materials - Glass beads, antiskid aggregates and mixtures of the two.

CEN (2013) EN 1790:2013 Road marking materials. Preformed road markings.

CEN (2014) EN 13197+A1:2014 Road marking materials. Wear simulator Turntable.

Cruz M, Klein A, Steiner V (2016) Sustainability assessment of road marking systems, *Transportation Research Procedia*, 14, 869-875. doi: 10.1016/j.trpro.2016.05.035

ROAD MARKING SYSTEMS  
PRODUCT GROUP CLASSIFICATION: UN CPC 53211, 53222

## 8 VERSION HISTORY OF C-PCR

### VERSION 20XX-YY-ZZ

Original version of the c-PCR

## 9 APPENDIX

### 9.1 ANNEX A – German Road Marking Practice

Roadmarkings in Germany subject to principle German guideline for regulation of public traffic StVO (Straßenverkehrsordnung). In Germany road marking systems to be applied on public roads must have a certificate issued by the German Bundesanstalt für Straßenwesen (BASt - Federal Highway Research Institute). The test procedure of the qualifying examination is performed in a wear simulator and is based on DIN EN 1423, DIN EN 1424, DIN EN 1436, DIN EN 1790, DIN EN 1871, DIN EN 12802 and DIN EN13197. It is described in detail in the national document TP M 2024 (Technische Prüfbedingungen für Markierungssysteme, Ausgabe 2024 - Technical test conditions for marking systems, edition 2024). Road marking material producers apply for the certification. In addition, road marking material producers must ensure that the delivered marking materials comply with the national document TL M 23 (Technische Lieferbedingungen für Markierungsmaterialien, Ausgabe 2023 - Technical delivery conditions for marking materials, edition 2023). Certificates are issued for permanent white markings and temporary yellow marking systems used in Germany.

These certificates define, for instance, both the marking material and the broadcasted glass bead aggregate mixture along with the thickness of the marking material or the amount of marking material per square meter (in case of agglomerates) and the proper specific consumption per square meter of the drop-on material that must be applied in practice on the road. The national standard ZTV M 13 (Zusätzliche Technische Vertragsbedingungen und Richtlinien für Markierungen auf Straßen, Ausgabe 2013 - Additional technical contract conditions and guidelines for road markings, edition 2013) specifies minimum thickness and performance figures, such as coefficient of retro-reflected luminance ( $R_L$ ) of the road marking, for example. Safety markings with high wet night-time visibility - so-called Type II markings - are characterized by a coefficient  $R_L$  measured at a wet condition of at least  $25 \text{ mcd} \cdot \text{m}^{-2} \cdot \text{x}^{-1}$ , for instance. There are also requirements for example for the luminance coefficient under diffuse illumination  $Q_d$ , chromaticity in daylight, skid resistance and the area of road marking remaining after wear. There are requirements in new and in used condition, respectively. A certificate is only issued by BASt if the minimum requirements according to ZTV M 13 are met at each measuring cycle during the wear test. The test certificate includes the achieved traffic class according to DIN EN 13197.

The road authorities in Germany award contracts for markings in Germany. The selection of marking systems within the framework of the tenders is defined in ZTV M 13. Typical phrases for tenders are provided in the standard service catalogue STLK (Standardleistungskatalog). Among other things traffic classes are specified in the tenders. Applicators must submit a BASt test certificate when submitting their offer and, once the contract has been awarded, apply the marking system as described therein. The applicator is giving a warranty according to German regulations VOB (Vergabe- und Vertragsordnung für Bauleistungen) for the system he applied on the road over a certain period of time defined in ZTV M 13. The service life, respectively the in-use durability of such road markings is given by the time during which retroreflection remains above this threshold under traffic load. ZTV M 13 recommends renewing the permanent white marking if the minimum value for the classes Q3, R2 or RW1 are undercut by 20 % or S1 is undercut.

Given this regulatory background (ZTV M 13 in particular) and German road marking practice typical application scenarios for the various road marking material technologies in representative system composition are compiled in table D1. The wear scenario is not only depending on the average daily traffic volume (ADTV) per lane, but on the actual number of wheel passages over the marking due to the position on the road and / or other modes of wear such as winter maintenance (snow plow).

For instance, road marking paint systems are typically applied as Type I systems only on secondary roads with rather low ADTV of less than 5000 per lane (low wear scenario), while thermoplastic or cold plastic or tape is applied as Type II markings on highly trafficked roads with more than 15.000 vehicles per day and per lane on average (very high wear scenario). Spray applied Type II systems are typically in medium to high traffic wear situations with 5000 to 15000 ADTV.

Environmental impacts considering the use phase can be assessed individually for each system depending on the functional durability@80% of each system type when retro-reflectivity falls below 80% of the minimum requirement and renewal of the marking is advised by the ZTV M 13. Data on typical functional durability@80% as well as on the typical erosion level for the individual systems in the representative application scenario with the corresponding traffic load based on practical experience on roads in Germany has been published by the German road marking association DSGS (Deutsche Studiengesellschaft für Straßenmarkierungen e. V., "Environmental Impacts from Road Markings in Germany" 2024, [Environmental Impacts from Road Markings in Germany \(dsgs.de\)](https://www.dsgs.de)). Table D1 provides this data together with additional relevant road marking systems in corresponding application scenarios. Calculation of environmental impacts from road markings in Germany shall be based on this consolidated industry study, respectively on future revisions of the same.

ROAD MARKING SYSTEMS

PRODUCT GROUP CLASSIFICATION: UN CPC 53211, 53222

Table 8: Typical application scenarios as recommended by German guidelines ZTV M 13 for various road marking system technologies and functional durability @80% of the corresponding technology based on empirical data from roads in Germany\*.

Wear of the marking	Type	System	Functional durability@80% of minimum retro-reflectivity in use-phase required by ZTV M 13 [years]
Very High	Type II	Tape	10
		Thermoplastic Agglomerates	8
		Thermoplastic Flat	8
		Preformed Thermoplastic	8
		Cold Plastic Agglomerates**	9
		Cold Plastic Flat	8
Medium to High	Type II	Thermoplastic Agglomerates	9
		Thermoplastic Flat	9
		Preformed Thermoplastic	9
		Cold Plastic Agglomerates**	10
		Cold Plastic Flat	9
		Cold Spray Plastic	5
		Thermoplastic Spray	5
		Water-based Paint	2
Solvent-based Paint	2		
Low	Type I	Thermoplastic Flat	15
		Preformed Thermoplastic	Missing
		Cold Plastic Flat	15
		Cold Spray Plastic	8
		Water-borne Paint***	4
		Solvent-borne Paint***	4

\* In case of novel or experimental road marking system technologies 3<sup>rd</sup> party verified data from practical qualification on the road according to ZTV M 13 (Praxisbewährung) shall be used to temporarily assign a functional durability@80% at the respective wear scenario given at that road until more practical experience is available.

\*\* :Used Cold Plastic Agglomerates may be refreshed with cold spray plastic Type I to restore Type II characteristics of the marking. Functional durability@80% of the refreshed cold plastic agglomerates Type II is 4 years.

\*\*\*:High solid 1 component and 2 component water-borne/solvent-borne paints.

ROAD MARKING SYSTEMS

PRODUCT GROUP CLASSIFICATION: UN CPC 53211, 53222

**Table 9: Recommendations for assessment of CRADLE-TO-GRAVE environmental impact from road markings in Germany**

<p><b>Description</b></p>	<ul style="list-style-type: none"> <li>• Only road marking systems are to be used according to the traffic class specified in the tender.</li> <li>• Life cycle calculation shall be based on the system composition and material and drop on glass bead amount per square meter as specified by the approval test certificate issued by the Bundesanstalt für Straßenwesen (BASt).</li> <li>• A generic sample EPD within a given material technology (e. g. waterborne paint, solvent-borne paint, cold plastic, thermoplastic or tape) shall be constructed for the worst-case scenario of the system compositions.</li> <li>• Scope of the impact evaluation has to be cradle-to grave to allow the comparison of different road marking system technologies (material technologies) and system compositions.</li> <li>• Cradle-to-gate emissions of materials and drop-on beads and application are not sufficient to assess environmental impacts of a road marking system over the whole life cycle.</li> <li>• Cradle-to-grave emissions of the various material technologies shall be evaluated in relevant traffic scenarios as established in table D1.</li> <li>• Cradle-to-grave emissions for a given material technology shall be calculated based on the representative in-use-durability, namely the functional durability@80% as specified in Table 8</li> </ul>
<p><b>Functional unit:</b></p>	<ul style="list-style-type: none"> <li>• Environmental impacts per square meter marked area.</li> </ul>
<p><b>Evaluation Range/Temporal Scope:</b></p>	<ul style="list-style-type: none"> <li>• Typical pavement life before renewal is required is 15 years for primary roads, respectively 25 years for secondary roads [„Chancen und Risiken der Lebenszyklusbewertung in Straßenbau und -erhaltung“ K. Mollenhauer, 19. Januar 2022 Asphaltstraßentag VSVI Hessen]. <b>Thus Cradle-to-grave impacts shall be evaluated over 15 years.</b></li> </ul>
<p><b>Remarks on Life Cycle Stages:</b></p>	<ul style="list-style-type: none"> <li>• <b>A4 – Transportation to Application site:</b> This stage effects only marginally effects the cradle-to-grave life cycle. Average data is recommended, but the stage can be neglected as well.</li> <li>• <b>A5 – Application:</b> This stage needs to be considered to the highest detail possible (e.g. heating systems for hot applied thermoplastic systems, or thin layer refreshment technologies for agglomerates etc.)</li> <li>• <b>B1-7 – Use:</b> Use phase and in use-durability of the system is decisive for the overall environmental impact of the road marking system.</li> <li>• <b>C1-C5 – Disposal:</b> Most of the road markings does not have a direct end-of-life stage as they are degraded</li> </ul>

ROAD MARKING SYSTEMS

PRODUCT GROUP CLASSIFICATION: UN CPC 53211, 53222

## 9.2 ANNEX B – FRENCH ROAD MARKING PRACTICE

In France, the purpose of road markings is to make road traffic safer, to facilitate road traffic, to indicate or remind people of certain specific police requirements and to provide information on the use of the road. Road markings refer to all the signalling equipment that can be read by road users and that can be installed on the road property.

The regulatory framework is as follows:

- The Highway Code, which governs the relationship between the driver, the vehicle and the road in its use
- The Highway Code, which governs the rights and duties of an owner of public or private road property
- The Vienna Convention, which establishes the principle of international standardization of road signs, symbols and markings to facilitate international road traffic and to increase road safety.
- The Interministerial Instruction on Road Signs and Signals (IISR) and more particularly Part 7.
- The Decree of 10 May 2000 relating to the certification of conformity of pavement marking products.

In accordance with IISR Part 7, only white and yellow road markings are regulatory and must be subject to a certification process.

The certification process has been defined and controlled by ASCQUER (Association for the Certification and Quality of Road Equipment) since 1992.

The durability test method is defined by the NF-EN 1824 road test standard, following the values defined by the NF-EN 1436 standard

It is also based on standards: NF-EN 1790 / NF-EN 1871 / NF-EN 12802 / NF-EN 1423 / NF-EN 1424 / NF-EN 13212 / NF-EN 13459 among others.

This certification allows the issuance of the NF 058 Road Equipment mark (so-called NF2 certification)

This certification applies to a road marking system: road marking product pair + Glass beads or aggregates

A marking product certified in this way has:

- A technical sheet showing the values measured during the road test, the dosages of marking product per m2, glass beads per m2 as well as the climatic conditions of the test and the certification number obtained.
- An annual Right of Use issued by the ASCQUER

Only road marking products with these two documents in force can be used on the roads of France.

Type I markings:

- The minimum certification class for a white product: P1 Q2 R3 S1 with an exception for urban markings in areas with permanent public lighting: P1 Q3 S1
- The minimum certification class for a permanent yellow marking: P1 Q1 S1
- The minimum certification class for a temporary yellow marking: T1 Q1 R4 S1

Type II markings:

- Minimum certification class for a white product: P1 Q2 R3 RW2 RR2 S1
- The minimum certification class for a temporary yellow product: P1 Q1 R4 RW2 RR2 S1
- The minimum certification class for a SAR (Audible Warning Device): P1

Certified products:

- Paints: solvent, water-based or reactive
- Hot coatings: extruded, ribbon or sprayed
- Cold plastics: two components or water-based coatings
- Prefabricated heat-bonded or cold-bonded tapes

The choice of product is the sole responsibility of the road manager

*Table 10: The 2019 IDRRIM (Institute of Roads, Streets and Road Infrastructure) horizontal signage guide gives elements of average durability of road marking systems*

Road Marking product	Durability
Solvent-based paints	1 year
Water-based paints	2 years
Reactive paints	2 years
Thermo extruded	4 years
Thermo ribbon	5 years
Thermo spray	3 years
Cold plastics	6 years
Thermo prefa tapes	5 years
Glued prefa tapes	9 years
No product specifications by class of roads	

ROAD MARKING SYSTEMS

PRODUCT GROUP CLASSIFICATION: UN CPC 53211, 53222

This guide also gives recommendations for the compatibility of the different marking products with each other.

The environmental impacts are enhanced by an additional but not mandatory voluntary certification: NF 331 Environment, which certifies that the product has a lower impact on the environment and a satisfactory quality of use compared to other marking products.

- Freedom from hazardous substances
- No hazard label
- Reduction of production losses: minimum threshold
- Processing of manufacturing waste
- Maximum white pigment content (TiO<sub>2</sub>)
- Maximum VOC content < 80g/Kg
- Maximum hydrocarbon content < 0.5%

This certification is issued by AFNOR (French Agency for Maritime Transport)



ROAD MARKING SYSTEMS

PRODUCT GROUP CLASSIFICATION: UN CPC 53211, 53222

### 9.3 ANNEX C – SWEDISH ROAD MARKING PRACTICE

Road markings in Sweden are regulated in *the Traffic Regulation* (Trafikförordningen, SFS 1998:1276) and specified in *The Swedish Transport Agency's Regulations on Road Markings* (Transportstyrelsens föreskrifter om vägmarkeringar TSFS 2010:171) and *the Road Sign Regulation* (Vägmärkesförordningen SFS 2007:90).

The Swedish Transport Administration (Trafikverket) is responsible for the regulations regarding the design of roads and streets (*Krav – VGU, Vägars och gators utformning*, Trafikverket 2022). The regulations include both requirements and guidelines and must be followed when planning for new roads and infrastructure on state roads and include requirements on road markings. The regulations are not intended for maintenance measures.

For the operation and maintenance of road markings, AMA Anläggning, is used together with contract documents. These documents are unique to each tender and the requirements may vary in different contracts.

For most roads governed by The Swedish Transport Administration, the applied road marking system must have a certificate issued by NordicCert. The certification procedure is based on road trials according to EN 1824, EN 1423, EN 1424, EN 1436, EN 1790, EN 12802, and EN 13212. The certification system is described in detail in *Nordic certification system for road marking materials - Version 10:2024* (Fors, Johansen, and Fager 2024). Road marking material producers participate in the road trials and can apply for certification if their materials fulfill the performance requirements. The requirements are based on EN 1436 and include  $R_L$  dry [ $\text{mcd}/\text{m}^2/\text{lx}$ ],  $Q_d$  [ $\text{mcd}/\text{m}^2/\text{lx}$ ], friction, and chromaticity coordinates. For structured/profiled type II markings there are additional requirements for  $R_L$  wet [ $\text{mcd}/\text{m}^2/\text{lx}$ ].

The NordicCert certification system applies in so-called state road *unit contracts*, but there are some regions where *performance contracts* are used instead. In those contracts, no specific material requirements are set, and the road marking contractor can choose any road marking material system as long as the functional parameters are met during the entire contract period.

It's worthwhile to notice that the functional requirements in the performance contracts are the same as in unit contracts, regardless on the age of the markings. The warranty in unit contracts is only valid during a certain period and the Swedish transport administration determine when new markings must be applied. The ambition would be to have a certain intervention level in respect of functional performance, especially in dark and wet conditions, but decisions about maintenance operations are still based on visual evaluation of markings during daytime and are balanced against available funds.

Public roads owned by cities or municipalities have their own contracts and are normally not using the exact same rules and contract conditions as The Swedish Transport Administration. Some cities have adopted the NordicCert system, but most are still not requiring certified road marking systems.

The certificates issued by NordicCert define both the marking material and the drop on-material along with the thickness of the marking and the specific amount of drop on-material in grams per square meter that must be applied to fulfil the requirements. Materials can be applied in five thicknesses; 0.4 or 0.6 mm wet (paint), 1.5 mm (thermoplastic spray), 3.0 mm (thermoplastic extrusion), and 5.0 mm (only allowed for structured/profiled type II markings and antiskid materials). In reality, The Swedish Transport Administration order thicknesses of 0.6 mm for waterborne paint, 1.5 mm for thermoplastic spray and 2 mm, 3 mm or 4 mm for extruded thermoplastics. According to AMA Anläggning, the maximum allowed thickness is 4 mm even for structured/profiled type II markings. Edge lines are normally required to be structured/profiled with the "trappflex" pattern, and The Swedish Transport Administration allow for materials with certification as type I materials to be used for profiled/structured type II road markings.

The road marking materials are certified by NordicCert for certain roll-over class. The expected roll-over classes for permanent road markings range from P0 to P4 after one year and P5 after two years at the Icelandic-Norwegian-Swedish test site in Norway. Requested roll-over classes for longitudinal markings are minimum P4 for thermoplastic extrusion and minimum P3 for thermoplastic spray. For transverse and other road markings at least P2 is requested. The requirements are continuously updated in new tenders. Cold plastic materials are normally not requested. Solvent-based paints are prohibited.

The Swedish Transport Administration classifies the roads into five different road marking classes (class 1-5) which is governed by an appendix in the individual road marking contracts under the AMA code DEE. The road marking classes are sorted after average daily traffic volume (ADTV) going from class 1 (high ADTV) to class 5 (low ADTV). The roads are also prioritized from class 1 *most important* to class 5 *least important*. Road markings in class 1 are generally well maintained and maintenance is carried out when the function falls below the functional requirements. Class 2 and 3 are generally well maintained but class 4 and 5 are normally not maintained often enough to fulfil the functional requirements due to lack of funding.

The total road length of the different road marking classes as well as the share of the traffic volume is found in Table 11.

*Table 11 Road marking class, ADTV, road length and respective share of traffic volume.*

Road marking class	ADTV	Road length	Share of traffic volume
1	>16000	2000 km	22 %
2	8 000 – 15 999	3300 km	17 %
3	1 500 – 7 999	19 300 km	41 %
4	500 – 1 499	22 400 km	13 %
5	<500	51 500 km	7 %

ROAD MARKING SYSTEMS

PRODUCT GROUP CLASSIFICATION: UN CPC 53211, 53222

Based on the regulatory background and Swedish road marking practice, typical application scenarios for various road marking material technologies in representative systems are compiled in Table 12. All wear scenarios are not possible to include due to the complexity, and the user must be aware that wear scenarios depend not only on the average daily traffic volume (ADTV) but also on the actual number of wheel passages over the marking due to the position on the road (e.g., compare a lane line to a left side edge lane) and other modes of wear such as use of studded winter tires and winter maintenance (snow plows).

Thermoplastic extrusion is typically used on all new pavements applied in either 3 mm or 4 mm thickness. Renewal of road markings can be made in different ways for different road marking classes and line positions. For instance, road marking paint systems can be applied for maintenance purposes both on class 1 roads (for example on the left edge line where the traffic load is very low) or in any line position on class 4 or class 5 roads, which have rather low traffic loads. For road marking classes 1-3, thermoplastic extrusion markings are normally applied with thicknesses 2-4 mm, depending on the choice by the road authority. Thermoplastic spray with thickness 1.5 mm is used for renewal on roads where type I road markings are allowed.

Table 12: Functional lifetime of the corresponding technology based on experience from roads in Sweden for the different road marking classes.

Road marking Class	System	Thickness (mm)	Functional lifetime (years)
Class 1	Thermoplastic Extrusion	4	5
	Thermoplastic Extrusion	3	4
	Thermoplastic Extrusion*	2	2
	Thermoplastic Spray*	1.5	2
	Water-based paint*	0.6	1
Class 2	Thermoplastic Extrusion	4	6
	Thermoplastic Extrusion	3	5
	Thermoplastic Extrusion*	2	4
	Thermoplastic spray*	1.5	2
	Water-based paint*	0.6	1
Class 3	Thermoplastic Extrusion	4	7
	Thermoplastic Extrusion	3	6
	Thermoplastic Extrusion*	2	4
	Thermoplastic spray*	1.5	3
	Water-based paint*	0.6	2
Class 4	Thermoplastic Extrusion**	4	8
	Thermoplastic Extrusion**	3	7
	Thermoplastic Extrusion*	2	5
	Thermoplastic spray*	1.5	4
	Water-based paint*	0.6	2
Class 5	Thermoplastic Extrusion**	4	9
	Thermoplastic Extrusion**	3	8
	Thermoplastic Extrusion*	2	6
	Thermoplastic Spray*	1.5	5
	Water-based Paint*	0.6	4

\*Only used for maintenance where the material is applied on top of the old road marking

\*\*Normally not used

Evaluation range: Typical pavement life in Sweden before maintenance depends on the pavement type but varies from 8 years for very high traffic load to up to 25 years for very low traffic loads with a median of 13 years for all pavement types and traffic volumes (Lang and Svensson 2012). Thus cradle-to-grave impacts shall be evaluated over maximum 8 years (worst-case).

ROAD MARKING SYSTEMS  
PRODUCT GROUP CLASSIFICATION: UN CPC 53211, 53222

ROAD MARKING SYSTEMS  
PRODUCT GROUP CLASSIFICATION: UN CPC 53211, 53222

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