Environmental Product Declaration

In accordance with ISO 14025:2006 and EN 15804:2012+A2:2019/AC:2021 for:

MULTI-STRAND POST-TENSIONING SYSTEM
PT-PLUS DUCT SYSTEM

From ***VSL International, Ltd.***

A member of Bouygues Construction

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General information

Programme information

Programme:	The International EPD® System
Address:	EPD International AB Box 210 60 SE-100 31 Stockholm Sweden
Website:	www.environdec.com
E-mail:	info@environdec.com

CEN standard EN 15804 serves as the Core Product Category Rules (PCR)
Product category rules (PCR): PCR 2019:14 Construction products (EN 15804:A2) Version 1.2.5
PCR review was conducted by: PCR review was conducted by: The Technical Committee of the International EPD®System. See www.environdec.com/TCfor a list of members. Review chair: Claudia A. Peña, University of Concepción, Chile. The review panel may be contacted via the Secretariat www.environdec.com/contact.
Independent third-party verification of the declaration and data, according to ISO 14025:2006: ☒ External ☐ Internal Covering ☐ EPD process certification ☒ EPD verification
Third party verifier: Elisabet Amat, GREENIZE Accredited by: The International EPD© System
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EPDs within the same product category but registered in different EPD programmes, or not compliant with EN 15804, may not be comparable. For two EPDs to be comparable, they must be based on the same PCR (including the same version number) or be based on fully-aligned PCRs or versions of PCRs; cover products with identical functions, technical performances and use (e.g. identical declared/functional units); have equivalent system boundaries and descriptions of data; apply equivalent data quality requirements, methods of data collection, and allocation methods; apply identical cut-off rules and impact assessment methods (including the same version of characterisation factors); have equivalent content declarations; and be valid at the time of comparison. For further information about comparability, see EN 15804 and ISO 14025.

Company information

Owner of the EPD: **VSL International, Ltd.**

Description of the organisation:

VSL is one of the two civil works subsidiaries of Bouygues Construction, a French global player in construction with a presence in more than 60 countries and 32.400 employees worldwide. VSL is expert in four domains. In civil works, to help their clients to the design, construction of engineered structures. In ground engineering and foundations, they get involved in all the geotechnical processes of a construction Project including ground investigation and analysis. In asset preservation, structural repairs and upgrade, they offer tailored services to suit any structure´s life cycle and in post-tensioning, stay-cable and other structural systems and technologies.

Multi-strand post-tensioning systems for the prestressing of concrete were developed by specialists, such as VSL in Switzerland in the early fifties. Even though post-tensioning is a mature technology, it is still a fantastic tool for the design engineer as it enables the active definition of the internal load path in concrete structures by superposing a favourable state for the internal stresses. This enables deformations to be minimized, helps reduce the thickness of members, reduces reinforcement congestion, facilitates segmental construction without the need for wet joints and allows the use of high-strength steel.

VSL designs, manufactures, and installs durable multi-strand post-tensioning systems that comply with international standards and approval guidelines for both new and existing structures.
VSL post-tensioning technology includes several systems that are specifically designed for different applications and requirements. The choice of a suitable system can be made by considering three key criteria:

- Unit of structural element: slab tendons with flat ducts are generally used for thin structural elements (slabs) whereas multistrand tendons can be used for any other application.
- Structural design: post-tensioning can be introduced using internal or external tendons, or a combination of both. In addition, slab post-tensioning tendons can be either bonded or unbonded depending on the application.
- Corrosion: the extent of protection needed to safeguard the tendon against corrosion. The tendon encapsulation is chosen depending on the required protection level.

In line with Bouygues Construction´s objectives, VSL is strongly motivated and committed to reducing its greenhouse gas emissions by 2030. Every year since 2019, VSL has calculated its carbon footprint on the basis of scopes 1, 2 and 3A, and has refined its scorecard at the end of 2020 with more complete and accurate data. In order to continue reducing their own carbon footprint, their plan is to evaluate their products with the Environmental Product Declaration (EPD). Depending on the EPDs, VSL Will adjust its strategy for the technologies and supply chain.

VSL Thailand has been certified in ISO 9001, ISO 14001 and ISO 45001.

Figure 1.ISO 9001, ISO 14001, ISO 45001 *Certifications*

Name and location of production site(s):
VSL SYSTEMS MANUFACTURER
20230, Laem Chabang, Thailand.

Contact:
Guillermo RAMÍREZ
Email: guillermo.ramirez@vsl.com
More information: https://vsl.com

Product information

Product name: Multi-strand post-tensioning system, PT-PLUS duct-system, of the following range types: 76, 85, 100, 115, and 130

Product description: This EPD covers the life-cycle analysis of the PT-PLUS duct-system. The VSL post-tensioning systems feature the VSL PT-PLUS duct system, which provides a leak-tight encapsulation of the tendon and increased fatigue resistance. The VSL PT-PLUS duct segmental coupler is used for internal prestressing in match-cast precast segmental structures to
optimize the encapsulation at segment joints. It consists of a face seal ring that is compressed during the joining of segments against well-defined bearing surfaces on both segments. The VSL PT-PLUS duct segmental coupler has the following design features:

- complete encapsulation of the post-tensioning tendons
- across segment joints
- enables implementation of electrically isolated tendons in precast segmental structures
- compact
- can be used when tendons cross the segment joint at an angle

Figure 2. *VSL post-tensioning system (left) and PT-PLUS duct-system (right).*

The technical characteristics of the products of the PT-PLUS duct-system family are the following ones:

Table 1: *Dimensions of the PT-PLUS duct-system family products.*

Type	Tendon	Round duct					Coupler			Protection shell		
	Unit	ØA	ØB	ØC	D	E	F	G	H	K	L	M
	0.6"	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
76	6-12	76	81	91	2.5	52.5	101	116	125	48.5	100	40
85	6-15	85	91	101	3	52.5	109	118	133	53.5	100	50
100	6-19/22	100	106	116	3.0	60	124	126	148	61	119	50
115	6-27	115	121	131	3.0	60	139	127	163	68.5	119	60
130	6-31/37	130	136	146	3.0	52.5	154	134	179	76	110	65

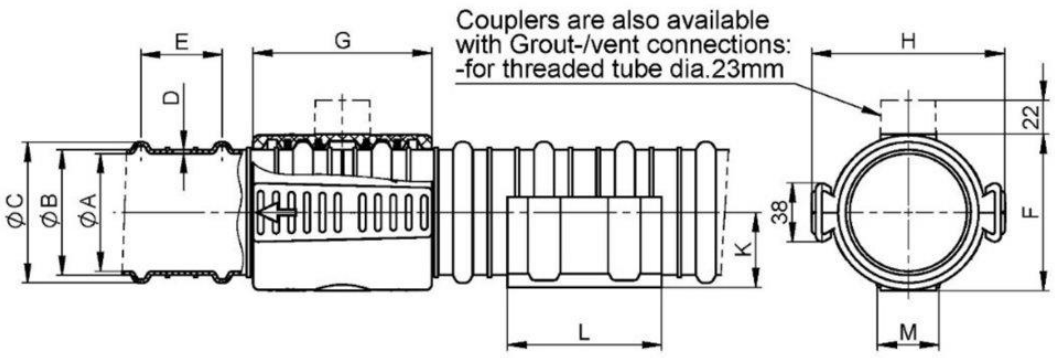


Figure 1. Structure of the PT-PLUS

UN CPC code: I4219 - Other structures (except prefabricated buildings) and parts of structures, of iron, steel or aluminium; plates, rods, angles, shapes, sections, profiles, tubes and the like, prepared for use in structures, of iron, steel or aluminium; props and similar equipment for scaffolding, shuttering or pit propping.

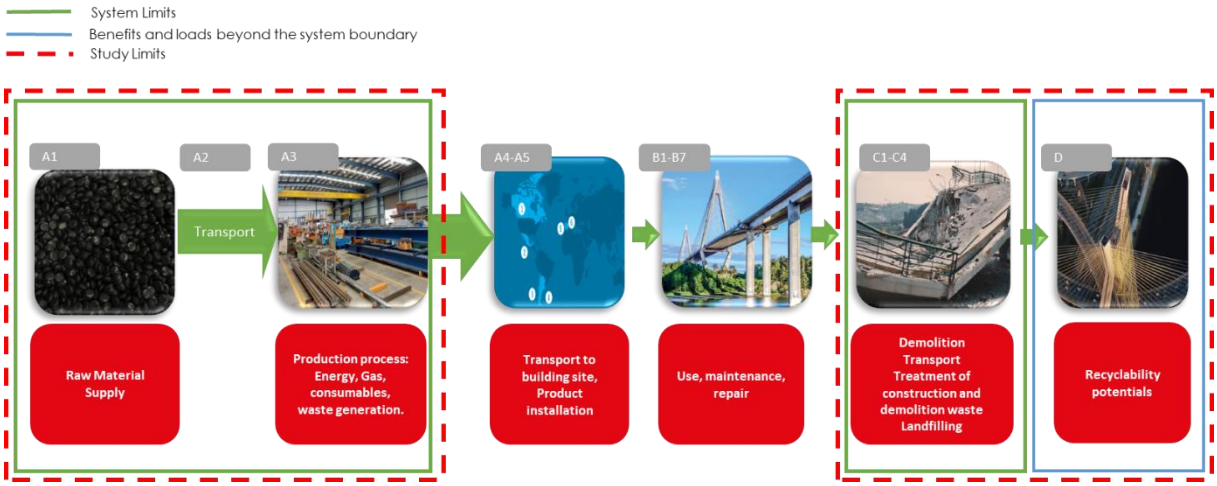
LCA information

Declared unit: The declared unit is the baseline reference for which all information is collected. In this study, the declared unit is **"1 kg of multi-strand post-tensioning system (PT-PLUS duct system)".**
Reference service life: Not relevant for this EPD.
Geographical scope: The geographical scope of this EPD is global.
Time representativeness: The data collection from factory (primary data) and electricity mixes are from 2022. In this study, no datasets older than 10 years were used.
Database(s) and LCA software used: All the data used to model the process and obtain the Life Cycle Inventory are specific data and have been obtained by measurements made during the period from 2022. They are representative of the different processes implemented during the manufacturing process. The data has been measured directly at the company's own premises. In addition, the most complete and highest quality European life cycle inventory database, Ecoinvent 3.8, has been used, as this database contains the most extensive and updated information and its scope coincides with the geographical, technological and temporal area of the project. The LCA was modelled with Simapro 9.3.0.3.

Description of system boundaries: According to the standard UNE-EN 15804_2012+A2_2020 (MARCH 2020) and PCR 2019:14 CONSTRUCTION PRODUCTS (version 1.24) the system boundary is cradle

to gate with modules C1–C4 and module D (A1–A3 + C + D). The life cycle stages A4-A5, B1-B7 were excluded from the LCA study.

System diagram:



Manufacturing process:

The manufacture of the PT-PLUS duct system begins with the reception of the material. The ducts are subjected several times to the process of extrusion and shaped to the desired precision in successive individual extrusion steps. The different parts are classified depending on the unit of anchorage requested.

Author of the Life Cycle Assessment:

IK ingeniería
Av. Cervantes 51,Edif. 10, panta 5, dpto.
48970 Basauri, Bizkaia (Spain)

Data quality

The environmental impact of the PT-PLUS duct system has been calculated. It is based on the international standards established for the development of environmental product declarations, such as ISO 14025 for the preparation of the environmental product declaration, ISO 14040 and ISO 14044 for the preparation of the life cycle analysis, UNE-EN 15804:2012+A2:2020 (MARCH 2020) and the Product Category Rules PCR - "2019:14 Construction products " (Version 1.2.5).

Data has been collected from 2022 and is representative of that year. Data for raw material supply, transport to fabrication plant and production (A1-A3) is based on specific consumption data for the factory at Laem Chabang. Generic background datasets were used for the downstream processes. SimaPro v9.3.0.3. software was used to prepare the life cycle analysis together with the Ecoinvent 3.8 database. Characterization factors from EN15804: 2012 + A2:2019. The geographical coverage is global. Technological coverage is typical or average.

Assumptions

The modularity principle, as well as the polluter-payer principle have been followed. The following assumptions have been made in this EPD:

- ✓ It does not include the manufacturing processes of the capital goods or spare parts and/or maintenance with a life of more than three years.

- ✓ The environmental impact of infrastructure for general management, office, and headquarters operations is not included.
- ✓ The impact caused by people (common activities, travel for work...) will not be considered.
- ✓ It does not include the consumption of natural gas for sanitary hot water from showers and heating system for the comfort of people.
- ✓ The processes associated with fuel production are intrinsically included in the indicators in ECOINVENT's database used in carrying out the LCA.
- ✓ The environmental impact of external transport has been calculated using lorries from the ECOINVENT 3.8 database, EURO 5. These lorries have been selected to reflect the most realistic scenario possible.

Cut-off rules
The standard ISO 14025 and the PCR -"2019:14 CONSTRUCTION PRODUCTS" indicate that the life cycle inventory data should include a minimum of 95% of the total inputs (materials and energy) for each stage. This cut-off rule does not apply for hazardous materials and substances. No such cut-off criteria have been taken into account in this study.

Allocation.
Where necessary, such us waste generation and energy consumption, an allocation based in mass has been used.

Greenhous gas emission from the use of electricity in the manufacturing phase
Medium voltage (direct emissions and losses in grid) electricity are considered for the manufacturing process.

Electricity mix	Amount	Units
Specific electricity mix (supplier 1)	6,53E-01	Kg CO2-eqv/kWh

LCA Scenarios and additional technical information

Dismantling/demolition (module C1):
It is considered not relevant

Transport (module C2):
With a collection rate of 100%, the transports are carried out by lorry (EURO 5) over 50 km.

Waste processing (modules C3 and C4):
The entire product is treated as landfill (C4) because after installation on the construction site, it is not possible to separate and recycle it, so it would go with the rest of the waste construction to landfill.

Recyclability potentials (module D):
It is considered not relevant

LCA Scenarios for end of life

Processes	Per Declared unit	
Collection process specified by unit	0,00E+00	Kg collected separatelly
	1,00E+00	Kg collected with mixed construction waste
Recovery system specified by unit	0,00E+00	Kg for reuse
	0,00E+00	Kg for recycling
	0,00E+00	Kg for energy recovery
Disposal specified by unit	1,00E+00	Kg for final disposal
Assumptions for scenario transportation	Lorry 16-32 metric ton, EURO5 Consumption: 0,03kg/km Distance:50 km	

Modules declared, geographical scope, share of specific data (in GWP-GHG indicator) and data variation:

	Product stage			Construction process stage		Use stage							End of life stage				Resource recovery stage
	Raw material supply	Transport	Manufacturing	Transport	Construction installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction demolition	Transport	Waste processing	Disposal	Reuse-Recovery-Recycling-potential
Module	**A1**	**A2**	**A3**	**A4**	**A5**	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**C1**	**C2**	**C3**	**C4**	**D**
Modules declared	X	X	X	ND	ND	ND	ND	ND	ND	ND	ND	ND	X	X	X	X	X
Geography	TH	TH	TH	ND	ND	ND	ND	ND	ND	ND	ND	ND	GLO	GLO	GLO	GLO	GLO
Specific data	>90%			-	-	-	-	-	-	-	-	-	-	-	-	-	-
Variation – products	1,33%			-	-	-	-	-	-	-	-	-	-	-	-	-	-
Variation – sites	0%			-	-	-	-	-	-	-	-	-	-	-	-	-	-

ND: Not declared

Content information

The result of the most representative product involves the following product: **multi-strand post-tensioning system PT-PLUS duct system unit 100.**

Product components	Per 1 kg		
	Weight, kg	Post-consumer material, weight-%	Renewable material, weight-%
Plastic components	>0,75	0,00%	0,00%
Others	<0,25	0,00%	0,00%
TOTAL	1,00	0,00%	0,00%
Packaging materials	**Weight, kg**	**Weight-% (versus the product)**	
Wood	2,65E-02	2,65%	
Pallet	3,04E-04	0,03%	
Plastic	1,97E-04	0,03%	
cardboard	1,70E-03	0,17%	
TOTAL	2,85E-02	2,85%	

Packaging: The product is transported to the construction site packed with plastic film and cardboard, in pallets.

No substances included in the Candidate List of Substances of Very High Concern for authorization under REACH Regulations are present in the analyzed PT-PLUS duct systems manufactured by VSL, either above the threshold for registration with the European Chemicals Agency or above 0,1% (wt/wt).

Environmental Information

Potential environmental impact – mandatory indicators according to EN 15804:

Results per declared unit							
Indicator	**Unit**	**A1-A3**	**C1**	**C2**	**C3**	**C4**	**D**
GWP-fossil	kg CO_2 eq.	3,07E+00	0,00E+00	4,54E-03	0,00E+00	1,17E-01	0,00E+00
GWP-biogenic	kg CO_2 eq.	6,67E-03	0,00E+00	1,81E-06	0,00E+00	1,20E-05	0,00E+00
GWP-luluc	kg CO_2 eq.	1,68E-03	0,00E+00	1,63E-06	0,00E+00	1,20E-05	0,00E+00
GWP-total	kg CO_2 eq.	3,08E+00	0,00E+00	4,54E-03	0,00E+00	1,17E-01	0,00E+00
ODP	kg CFC 11 eq.	7,69E-08	0,00E+00	1,08E-09	0,00E+00	3,22E-09	0,00E+00
AP	mol H^+ eq.	1,14E-02	0,00E+00	1,89E-05	0,00E+00	9,59E-05	0,00E+00
EP-freshwater	kg PO_4^{3-} eq.	2,36E-04	0,00E+00	9,52E-08	0,00E+00	6,01E-07	0,00E+00
EP-freshwater	kg P eq.	7,68E-05	0,00E+00	3,10E-08	0,00E+00	1,96E-07	0,00E+00
EP-marine	kg N eq.	2,02E-03	0,00E+00	5,72E-06	0,00E+00	1,50E-04	0,00E+00
EP-terrestrial	mol N eq.	2,25E-02	0,00E+00	6,32E-05	0,00E+00	3,47E-04	0,00E+00
POCP	kg NMVOC eq.	8,67E-03	0,00E+00	2,03E-05	0,00E+00	1,24E-04	0,00E+00
ADP-minerals&metals*	kg Sb eq.	2,15E-05	0,00E+00	1,04E-08	0,00E+00	3,72E-08	0,00E+00
ADP-fossil*	MJ	8,19E+01	0,00E+00	7,07E-02	0,00E+00	2,55E-01	0,00E+00
WDP	m^3 deprive	2,12E+00	0,00E+00	2,43E-04	0,00E+00	1,09E-02	0,00E+00
Acronyms	GWP-fossil = Global Warming Potential fossil fuels; GWP-biogenic = Global Warming Potential biogenic; GWP-luluc = Global Warming Potential land use and land use change; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential, Accumulated Exceedance; EP-freshwater = Eutrophication potential, fraction of nutrients reaching freshwater end compartment; EP-marine = Eutrophication potential, fraction of nutrients reaching marine end compartment; EP-terrestrial = Eutrophication potential, Accumulated Exceedance; POCP = Formation potential of tropospheric ozone; ADP-minerals&metals = Abiotic depletion potential for non-fossil resources; ADP-fossil = Abiotic depletion for fossil resources potential; WDP = Water (user) deprivation potential, deprivation-weighted water consumption						

** Disclaimer: The results of this environmental impact indicator shall be used with care as the uncertainties of these results are high or as there is limited experience with the indicator.*

Potential environmental impact – additional mandatory and voluntary indicators

Results per declared unit						
Indicator	**A1-A3**	**C1**	**C2**	**C3**	**C4**	**D**
GWP-GHG[1]	3,08E+00	0,00E+00	4,54E-03	0,00E+00	1,17E-01	0,00E+00

Use of resources

Results per declared unit							
Indicator	**Unit**	**A1-A3**	**C1**	**C2**	**C3**	**C4**	**D**
PERE	MJ	2,32E+00	0,00E+00	9,00E-04	0,00E+00	5,24E-03	0,00E+00
PERM	MJ	5,03E-01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PERT	MJ	2,82E+00	0,00E+00	9,00E-04	0,00E+00	5,24E-03	0,00E+00
PENRE	MJ	3,60E+01	0,00E+00	7,07E-02	0,00E+00	2,55E-01	0,00E+00
PENRM	MJ.	4,59E+01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PENRT	MJ	8,19E+01	0,00E+00	7,07E-02	0,00E+00	2,55E-01	0,00E+00
SM	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
RSF	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
NRSF	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
FW	m^3	5,10E-02	0,00E+00	8,41E-06	0,00E+00	2,66E-04	0,00E+00
Acronyms	PERE = Use of renewable primary energy excluding renewable primary energy resources used as raw materials; PERM = Use of renewable primary energy resources used as raw materials; PERT = Total use of renewable primary energy resources; PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; PENRM = Use of non-renewable primary energy resources used as raw						

[1] The indicator includes all greenhouse gases included in GWP-total but excludes biogenic carbon dioxide uptake and emissions and biogenic carbon stored in the product. This indicator is thus equal to the GWP indicator originally defined in EN 15804:2012+A1:2013.

	materials; PENRT = Total use of non-renewable primary energy re-sources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of net fresh water

Waste production

Results per functional or declared unit							
Indicator	**Unit**	**A1-A3**	**C1**	**C2**	**C3**	**C4**	**D**
Hazardous waste disposed	kg	1,82E-05	0,00E+00	1,71E-07	0,00E+00	3,86E-07	0,00E+00
Non-hazardous waste disposed	kg	3,09E-01	0,00E+00	6,62E-03	0,00E+00	1,00E+00	0,00E+00
Radioactive waste disposed	kg	2,77E-05	0,00E+00	4,79E-07	0,00E+00	1,50E-06	0,00E+00

Output flows

Results per functional or declared unit							
Indicator	**Unit**	**A1-A3**	**C1**	**C2**	**C3**	**C4**	**D**
Components for re-use	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Material for recycling	kg	4,05E-01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Materials for energy recovery	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Exported energy, electricity	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Exported energy, thermal	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00

Information on biogenic carbon content

Results per declared unit		
BIOGENIC CARBON CONTENT	**Unit**	**QUANTITY**
Biogenic carbon content in product	kg C	0,00E+00
Biogenic carbon content in packaging	kg C	0,00E+00

The packaging of the reference product corresponds to <5% of the total weight of the reference product.
Note: 1 kg biogenic carbon is equivalent to 44/12 kg CO_2.

Additional information

More information can be found in the following webpage:
https://vsl.com

Information related to Sector EPD

This is an individual EPD®

Differences versus previous versions

This is the first version of the EPD®.

References

- General Programme Instruction of the International EPD®System. Version 4.0.
- ISO 14020:2000 Environmental labels and declarations-General principles.
- ISO 14025:2010 Environmental labels and declarations-Unit III Environmental Declarations-Principles and procedures.
- ISO 14040:2006 Environmental Management-Life Cycle Assessment-Principles and framework.
- ISO 14044:2006 Environmental Management-Life Cycle Assessment-Requirements and guidelines.
- PCR 2019:14 Construction products (EN 15804: A2) version 1.25
- EN 15804:2012+A2:2019 Sustainability of construction works-Environmental Product Declarations-Core rules for the product category of construction products

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