EPD - ENVIRONMENTAL PRODUCT DECLARATION

as per ISO 14025 and EN 15804+A2

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PROGRAMME OPERATOR	Bau EPD GmbH, A-1070 Wien, Seidengasse 13/3, www.bau-epd.at
HOLDER OF THE DECLARATION	Tiroler Rohre GmbH
DECLARATION NUMBER	Bau EPD-TRM-2025-1-ECOINVENT-VRS-T-DN80
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ENERGY MIX APPROACH	MARKET BASED APPROACH

VRS®-T ductile cast iron pipe system – DN 80
Tiroler Rohre GmbH

Content of the EPD

1 General information

Product name
VRS®-T ductile cast iron pipe system DN 80

Declaration number
Bau EPD-TRM-2025-1-ECOINVENT-VRS-T-DN80

Declaration data
☒ Specific data
☐ Average data

Declared Product / Declared Unit
1 m ductile cast iron pipe of the VRS®-T system DN 80 with Portland composite cement lining and zinc coating with PUR long-life coating with the nominal dimensions:

Table 1: Nominal dimensions

Nominal diameter [mm]	Longitudinally related mass [kg/m]
80	16,3

Declaration based on
MS-HB Version 6.0.0 dated 06.11.2024
Name of PCR: Cast iron products
PCR-Code 2.16.8, Version 12.0 dated 10.10.2024
(PCR tested and approved by the independent expert committee = PKR-Gremium)
Version of EPD-Format-Template M-Dok 14A2 dated 11.06.2024

The owner of the declaration is liable for the underlying information and evidence; Bau EPD GmbH is not liable with respect to manufacturer information, life cycle assessment data and evidence.

Number of datasets in EPD Document: 1

Range of validity
The EPD applies to the nominal diameter DN 80 of the VRS®-T ductile cast iron pipe system with the above-mentioned lining and duplex outer coating (zinc coating with PUR long-life coating) from the Hall in Tyrol plant of Tiroler Rohre GmbH (TRM).
The EPD and the production technologies assessed are representative for the production of pipes with a nominal diameter DN 80 at the Hall in Tyrol plant of Tiroler Rohre GmbH (TRM).

Type of Declaration as per EN 15804
From cradle to grave with module D (modules A+B+C+D)
LCA method: Cut-off by classification

Database, Software, Version
Ecoinvent 3.10, SimaPro 9.6.0.1
Version Characterisation Factors: Joint Research Center, EF 3.1

Author of the Life Cycle Assessment
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The CEN standard EN 15804:2012+A2:2019+AC:2021 serves as the core-PCR.
Independent verification of the declaration according to ISO 14025:2010
☐ internally ☒ externally

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Note: EPDs from similar product groups from different programme operators might not be comparable.

2 Product

2.1 2.1 General product description

The declared product is a ductile cast iron pipe of the VRS®-T system (restrained locking system) with cement mortar lining (CML) and zinc coating with PUR long-life coating with a nominal diameter DN 80 from Tiroler Rohre GmbH (TRM).

The TRM VRS®-T system consists of ductile, centrifugally cast pipes with a spigot end with a welding ring and a socket, which are joined together to form any length of pipe. The VRS®-T joint, consisting of a VRS®-T socket, VRS®-T sealing ring, spigot end with a welding ring and locking elements, is a highly resilient, flexible and restrained locking system. It is quick and easy to install and can be bent up to 5°. No welding and no weld-seam testing is necessary. The joint can be dismantled at any time.

The ductile cast iron pipes are manufactured in lengths of 5 m with nominal diameters from DN 80 to DN 600 and different wall thicknesses. The nominal dimensions of the declared ductile cast iron pipes with a nominal diameter DN 80 as well as the corresponding wall thickness classes, (normative) minimum wall thicknesses and masses per metre of pipe are shown in Table 2. To further illustrate the declared product, Figure 1 and Figure 2 show excerpts from the Tiroler Rohre GmbH product catalogue with technical and geometric specifications and corresponding mass data.

Table 2: VRS®-T ductile cast iron pipes DN 80 – nominal diameter, Wall thickness class, minimum wall thickness, mass per Meter

DN	Wall thickness class (K class)	Minimum wall thickness [mm]	Mass per m of pipe [kg/m]
80	K 10	4,7	16,3

DN	PFA [a] [bar]	Maße [mm]		zul. Zugkraft [kN]	Max. Abwinkelung [°]	Anzahl der Riegel	Gewicht Rohr 5m [kg] [b]
		s_1 Guss	s_2 ZMA				
80	100	4,7	4	115	5	2	81,6
100	75	4,7	4	150	5	2	100,0
125	63	4,8	4	225	5	2	128,2
150	63	4,7	4	240	5	2	157,3
200	40	4,8	4	350	4	2	204,5
250	40	5,2	4	375	4	2	268,9
300	40	5,6	4	380	4	4	339,5
400	30	6,4	5	650	3	4	519,9
500	25/30	7,2/8,2	5	860	3	4	711,8
600	35	8,0	5	1.525	2	9	909,5

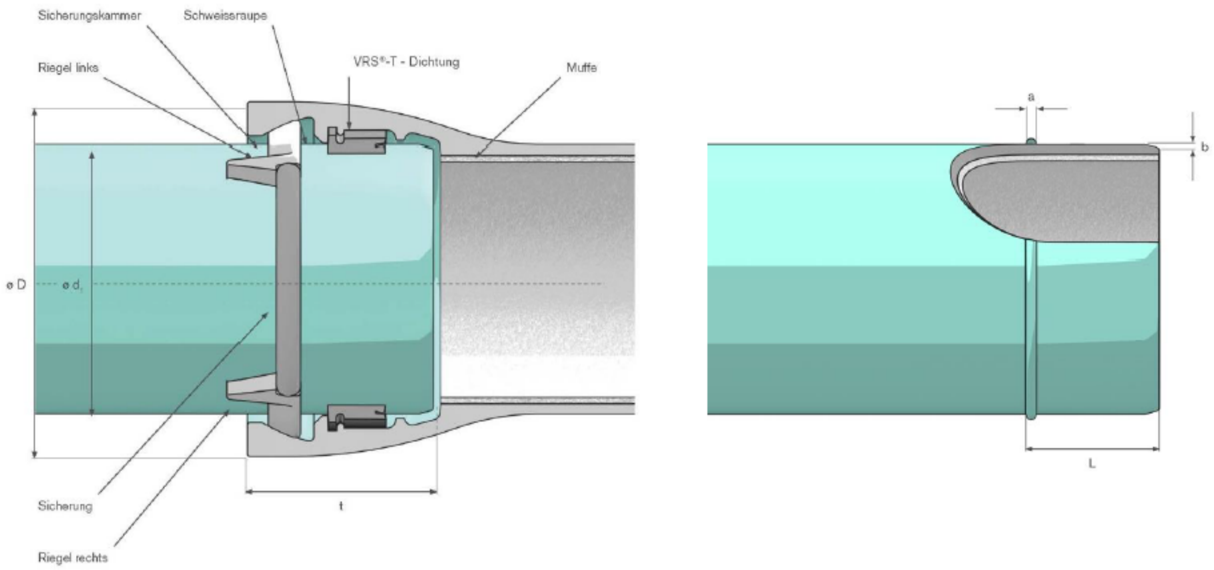
[a] PFA: zulässiger Bauteilbetriebsdruck | PMA = 1,2 x PFA | PEA = 1,2 x PFA + 5 | höhere PFA auf Anfrage | siehe Hinweise zum Einsatz von Klemmringen

[b] theoretische Masse pro Rohr für K9/10, inkl. ZMA, Zink, Deckbeschichtung

[1] Mindestmaß - Toleranzen beachten [2] Nennmaß - Toleranzen beachten

Figure 1: VRS®-T pipes – technical and geometric specifications

VRS®-T Verbindung DN 80 bis DN 600



DN	Maße [mm] a						
	Durchmesser Spitzende	Abweichungen	Durchmesser Muffe	Einstecktiefe	Schweißraupe		
	d1		D	t	L	a	b
80	98	+1,0 | -2,7	156	127	86 ±4	8 ±2	5 +0,5 | -1
100	118	+1,0 | -2,8	177	135	91 ±4	8 ±2	5 +0,5 | -1
125	144	+1,0 | -2,8	206	143	96 ±4	8 ±2	5 +0,5 | -1
150	170	+1,0 | -2,9	232	150	101 ±4	8 ±2	5 +0,5 | -1
200	222	+1,0 | -3,0	292	160	106 ±4	9 ±2	5,5 +0,5 | -1
250	274	+1,0 | -3,1	352	165	106 ±4	9 ±2	5,5 +0,5 | -1
300	326	+1,0 | -3,3	410	170	106 ±4	9 ±2	5,5 +0,5 | -1
400	429	+1,0 | -3,5	521	190	115 ±5	10 ±2	6 +0,5 | -1
500	532	+1,0 | -3,8	630	200	120 ±5	10 ±2	5 +0,5 | -1
600	635	+1,0 | -4,0	732	175	160 +0 | -2	9 ±1	5 +0,5 | -1

a Toleranzen sind möglich

Figure 2: Schematic illustration of a VRS®-T ductile cast iron pipe

The density of ductile cast iron is 7,050 kg/m³.

2.2 Application field

The VRS®-T cast iron pipe system with Portland composite cement lining is mainly used for drinking water supply and for fire extinguishing pipes, snow-making systems and turbine pipes. The cast iron pipe can be installed using various methods, such as:

- Conventional installation (trench)
- Trenchless installation
- Bridge pipes
- Interim pipes

- Floating

The usual installation method is conventional laying with the excavation of a trench, the creation of a bedding for the pipe and backfilling with suitable material.

2.3 Standards, guidelines and regulations relevant for the product

Table 3: Product specific standards

Regulation	Title
OENORM EN 545	Ductile iron pipes, fittings, accessories and their joints for water pipelines - Requirements and test methods
OENORM B 2599-1	Ductile iron pipes and fittings — Part 1: Use for water pipelines
OENORM B 2597	Ductile cast iron pipes and fittings for water, sewage and gas pipe lines - Restrained push-in-joints - Requirements and tests
OENORM B 2555	Coating of cast iron pipes - Thermal zinc spraying
OENORM B 2560	Ductile iron pipes - Finishing coating of polyurethane, epoxy or acrylic materials - Requirements and test methods
OENORM B 2562	Ductile cast iron pipes - Factory made lining with cement mortar - Requirements and test methods
OENORM EN 681-1	Elastomeric seals - Material requirements for pipe joint seals used in water and drainage applications - Part 1: Vulcanized rubber

2.4 Technical data

Mechanical properties are verified according to OENORM EN 545:2011, sections 6.3 and 6.4.

Table 4: Material parameters for ductile cast iron pipes of the VRS®-T system

Name	Value	Unit
Iron density	7050	kg/m^3
Minimum tensile strength	≥ 420	MPa
Proportional limit, 0.2% yield strength ($R_{p0.2}$)	≥ 300	MPa
Minimum elongation at fracture	≥ 10	%
Maximum Brinell hardness	≤ 230	HB
Pipe length	5000	mm
Mean coefficient of linear thermal expansion	$10*10^{-6}$	m/m*K
Thermal conductivity	0,42	W/cm*K

Table 5: VRS®-T pipes DN 80 – nominal dimension-dependent technical data

DN	Wall thickness class K class	Minimum wall thickness [mm]	Mass per metre of pipe [kg/m]	Allowable operating pressure PFA [bar]	Permissible tensile force [kN]
80	K 10	4,7	16,3	100	115

2.5 Basic/auxiliary materials

Table 6: VRS®-T pipes DN 80 – basic materials in mass %

DN	Casting	Zinc	Cement stone	PUR
80	79,2%	0,8%	19,2%	0,8%

Table 7: Basic materials – casting in mass %

Ingredients:	**Mass %**
Iron 1)	ca. 94 %
Carbon 2)	ca. 3,5 %
Silicon 3)	ca. 2 %
Ferric by-elements 4)	ca.0,5 %

1) Iron consisting mainly of steel scrap and a very small proportion of pig iron and return iron from the casting process

2) Foundry coke carbon. The coke in the cupola furnace serves both as an energy supplier for the scrap melting and the adjusting of the desired carbon content

3) Silicon is added in the form of SiC pellets and/or ferro-silicon

4) Ferric by-elements are found in the steel scrap in different minor quantities (<<1%)

2.6 Production stage

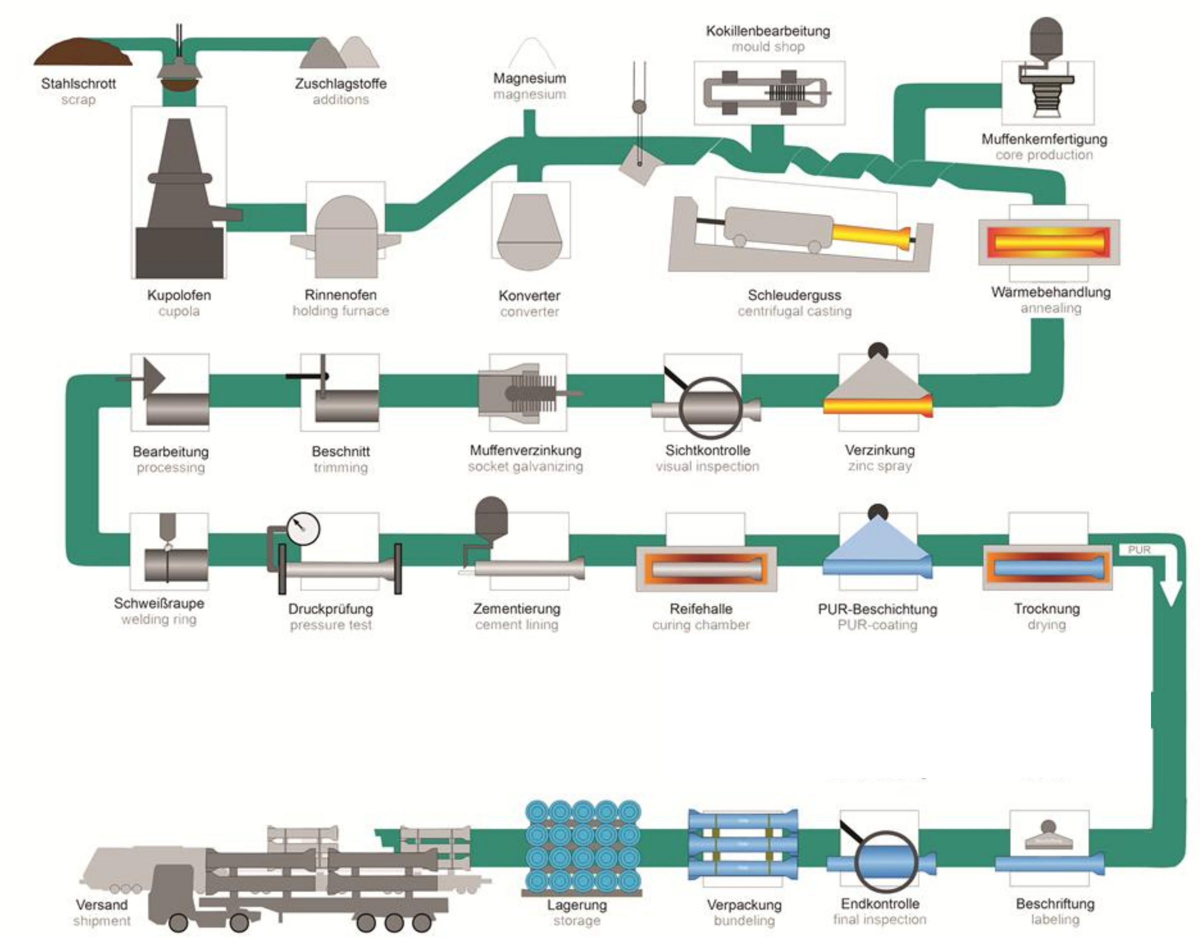


Figure 3: Flow chart of production process

For casting production, steel scrap and recycled material are smelted in the cupola furnace with the help of coke as a reaction and reduction agent. Silicon carbide is added as an alloying element. Added aggregates enhance slagging. The chemical composition of the smelted basic iron is then constantly monitored through spectral analysis. The smelted basic iron is kept warm in the holding furnace, a storage medium, and then treated with magnesium in the Georg Fischer converter, in order to reach the appropriate ductility. The liquid iron is then cast in a centrifuge machine with the De Lavaud procedure. In order to produce a specific pipe diameter, this machine is equipped with the corresponding mould (metal form that the liquid iron is poured into). The socket core made of quartz sand seals the inlet of the machine and forms the pipe socket. The glowing pipe is pulled out of the cast unit and placed in a furnace with the help of an automatic transport system. Here it undergoes annealing in order to achieve the desired mechanical properties.

The pipe is then galvanised using the electric arc spraying process and then cooled. The pipe is visually inspected in the pipe line. The spigot end and socket are machined if necessary. In the area of the welding ring, the zinc and annealing skin (tinder) are ground off and finally the welding ring is applied.

During the pressure test, each pipe is hydrostatically pressurised with a certain internal pressure and checked for leaks. The pipe is then lined with cement mortar using the centrifugal rotation process. The weld seam is galvanised and the pipes are visually inspected again. The cement stone hardens in the curing chamber. Finally, a solvent-free two-component polyurethane top coat is applied. All pipes are labelled according to the specifications, bundled and brought to the warehouse.

2.7 Packaging

The TRM pipes are sealed with protective caps and bundled using squared timber and spacer rings as stacking aid and PET tapes. All packaging materials can be used for thermal recycling.

2.8 Conditions of delivery

The ductile cast iron pipes are bundled for transport and storage with the help of squared lumber and spacer rings as stacking aid as well as PET binding tapes.

2.9 Transport to site

The cast pipes are transported to their destination within Europe by lorry and, in rare cases, overseas by ship.

2.10 Construction product stage

The installation of pressure pipes made of ductile cast iron must comply with OENORM EN 805 (Water supply - Requirements for systems and components outside buildings) and OENORM B 2538 (Additional specifications concerning OENORM EN 805). When constructing the pipe trench, sufficient working space must be provided for the installation of the pipeline, depending on the trench depth and the outer diameter of the pipe. The Ordinance on Protection of Construction Workers (Bauarbeiterschutzverordnung) and other provisions as well as relevant standards and regulations must be complied with accordingly.

As this is a push-in joint, no additional work such as welding is required. The pipe trench must be constructed and excavated in such a way that all pipe sections are at frost-free depths. The trench must be excavated deep enough so that the final cover height is at least 1.50 m. In the case of ductile iron pipes, the existing soil is generally suitable for bedding the pipeline. This means there is no need for a lower bedding layer and the bottom of the trench becomes the lower bedding.

The pipeline must be embedded and the pipe trench refilled in such a way that the pipeline is securely fixed in its intended position and that damage to the pipeline is prevented and settlement can only occur to the permissible extent. Suitable material that does not damage the pipe components and the coating must be used for embedding the pipeline. The backfill material should be installed in layers and sufficiently compacted.

2.11 Use stage

If installed and designed professionally and if the phase of utilisation is not disturbed, no modification of the material composition of construction products made of ductile cast iron occur.

2.12 Reference service life (RSL)

Table 8: Reference service life (RSL)

Name	Value	Unit
Ductile cast iron pipes	50	Years

In practice, it has been shown that a service life of 100 years, based on the DVGW damage statistics (German Technical and Scientific Association for Gas and Water – https://www.dvgw.de/themen/sicherheit/gas-und-wasserstatistik/), is achieved.

2.13 End of life stage

In inner-city areas, the main area of application for the pipe systems, the installed pipes are currently almost entirely removed. These pipes can then be recycled accordingly. These pipes can then be sent to recycling. The removal and recycling rate was therefore set correspondingly high in the scenarios considered (see 4.4 - C1-C4 disposal phase). However, it should be noted that the 100% removal rate is a manufacturer's scenario, which must be checked and adjusted accordingly in each individual use case.

The pipes are disposed of in very rare cases. The EAK waste code number for iron and steel from construction and demolition is 170405.

2.14 Further information

For further information about the TRM pipe system and its possible applications, see the website http://trm.at/rohr.

3 LCA: Calculation rules

3.1 Declared unit/ Functional unit

The functional unit is 1 metre [m] of pipe. For conversion into kg, Table 9 can be used.

Table 9: Conversion factor to mass

Nominal diameter [mm]	Longitudinally related mass [kg/m]	Multiplication factor
80	16,3	0,0613

3.2 System boundary

The entire product life cycle and module D is declared. This is a "from cradle to grave with module D"-EPD (modules A+B+C+D).

Table 10: Declared life cycle stages

PRODUCT STAGE			CON-STRUCTION PROCESS STAGE		USE STAGE							END-OF-LIFE STAGE				BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARIES
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
Raw material supply	Transport	Manufacturing	Transport from the gate to the site	Construction, installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction, demolition	Transport	Waste processing	Disposal	Reuse- Recovery- Recycling- potential
x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

X = included in LCA; ND = Not declared

3.2.1 A1-A3 Product Stage:

The cast iron pipes (semi-finished parts) are almost exclusively made of the secondary material steel scrap and a very small proportion of pig iron and return iron from the casting process. The system boundary for the steel scrap is set when the processed steel scrap leaves the recycling plants, because the end of the waste properties of the steel scrap is reached here. This system is blamed for the transportation of the scrap to the TRM plant. The product stage includes the production steps in the plant along with the energy supply (including the upstream chains), the production of raw materials, auxiliary materials and packaging (including transport to the plant), the infrastructure and the disposal of the waste occurring during production. Module A1-A3 also includes the manufacture of the locks and gaskets required for assembling the pipe.

3.2.2 A4-A5 Construction stage:

The cast iron pipe can be installed in various ways. This EPD considers the standard case for installation, i.e. the conventional laying of the pipe:

- Excavation of trench
- Bedding of the pipe
- Backfilling with suitable material

The protective caps, squared lumber and binding tapes needed for transport are thermally recycled.

3.2.3 B1-B7 Use stage:

Generally, construction products made of ductile cast iron show no impact on the LCA during the use stage.

3.2.4 C1-C4 End-of-life stage:

In inner-city areas, the main area of application for the pipe systems, the installed pipes are currently almost entirely removed. For this reason, a 100% removal rate is applied as a scenario.

The removed pipes are sent to a recycling process and are considered until the end-of-waste state according to EN 15804 in the current product system. The system boundary is therefore set when the processed steel scrap leaves the recycling plants.

As a recycling scenario, due to the robustness of the pipe systems, it is assumed that 97% of the removed pipes are suitable for the recycling process and 3% have to be sent to landfill due to breakage, etc. The recycling scenario applied is a manufacturer's scenario based on the experience of Tiroler Rohre GmbH, which must be checked and adapted accordingly in each individual use case.

3.2.5 D Benefits and loads:

Due to the recycling of the removed pipes, there is a corresponding output of secondary raw materials in C3. The output flows are compared with the scrap share in the production of the cast iron pipes in accordance with the net flow rule according to EN 15804 and the net output flow is determined. The recycling and net flow scenario applied is a manufacturer's scenario based on the experience of Tiroler Rohre GmbH, which must be checked and adapted accordingly in each individual use case.

3.3 Flow chart of processes/stages in the life cycle

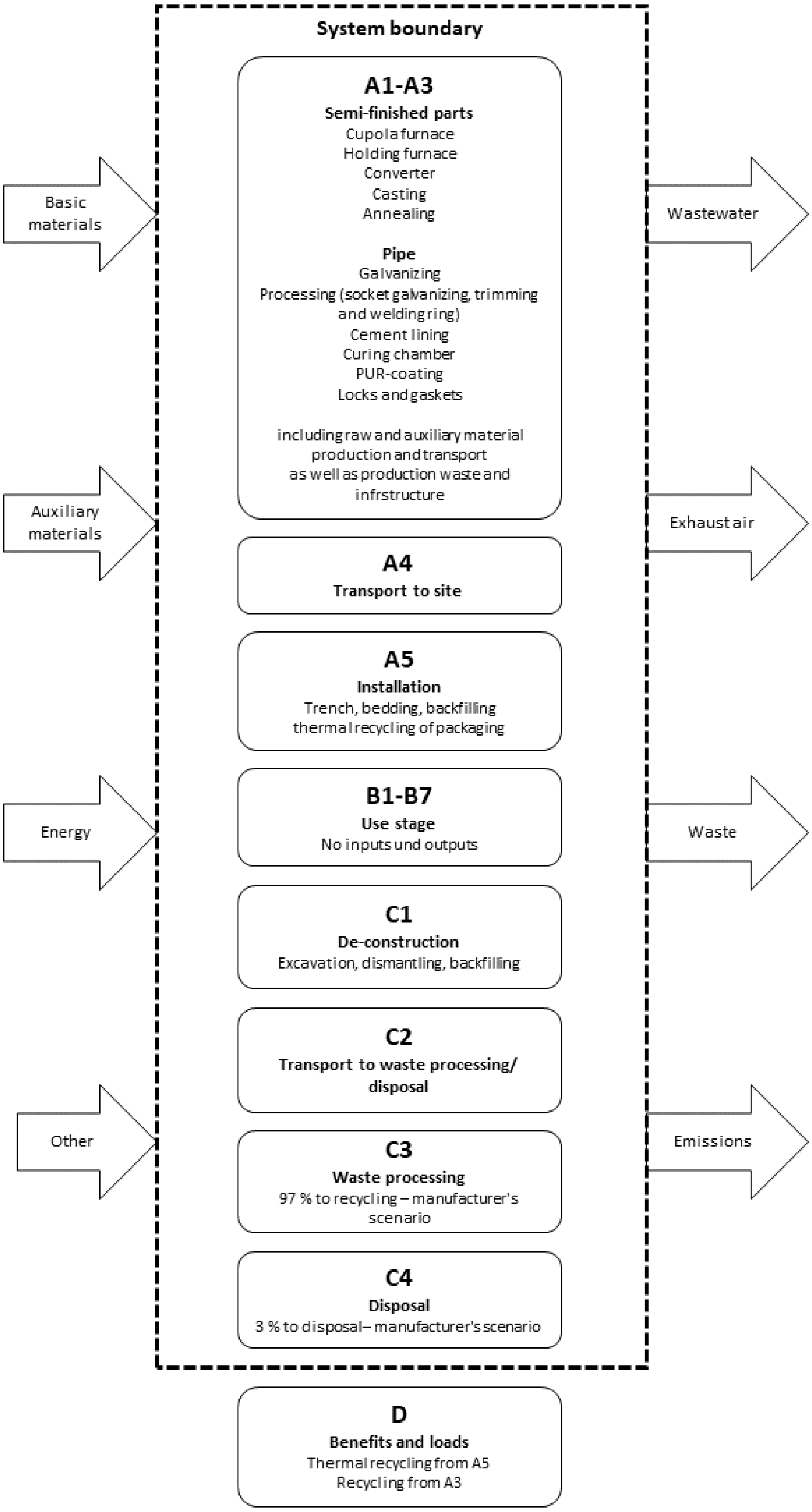


Figure 4: Life cycle flow chart

3.4 Estimations and assumptions

The SiC pellets used in casting production consist of various silicon components, Portland cement and water. In ecoinvent 3.10 there is only one data set for silicon carbide, which is typical of wafer production and has a very high SiC purity compared to the SiC component mixture used in casting production and therefore also a high energy intensity (information from the manufacturer of the pellets). According to the manufacturer of the SiC pellets, the energy required to produce the SiC components or silicon carbide is reflected in the respective prices per tonne. This allows an adjustment of the SiC purity (correction factor) of the data set available in ecoinvent based on an economic comparison (i.e. in the style of an economic allocation).

Cast steel is a special steel with no available data set. As the input is below 1 kg per t of ductile cast iron, the ecoinvent data set for chrome steel was applied.

For magnesium, which mainly comes from China, the global data set for magnesium was used ("market"-data set).

Since the infrastructure only makes a very small contribution to environmental impact, the machinery was modelled with its main components steel and casting.

For the use stage, it was assumed that no LCA-relevant material and energy flows occur.

All transport distances, with the exception of magnesium, were collected by the customer and taken into account in the LCA. For magnesium, the average transports are taken into account by the application of the global "market"-data set (which includes transport processes for the market under consideration).

3.5 Cut-off criteria

The producer calculated and submitted the amount of all applied materials, energy needed, the packaging material, the arising waste material and the way of disposal and the necessary infrastructure (buildings and machinery for the production). The measurement values for emissions according to the casting regulations were specified.

Auxiliary materials whose material flow is less than 1% were ignored as insignificant. Internal transport was negligible due to the short transport distances. It can be assumed that the total of insignificant processes is less than 5% of the impact categories.

During the production of the ductile pipes, slag (from cupola furnace) and coke dust are produced as by-products. Part of the waste heat is sold as district heating. However, these by-products contribute less than 1% to the operational income and can therefore be ignored according to the Management-System-Handbook (MS-HB) of the Bau EPD GmbH (MS-HB Version 6.0.0 dated 06.11.2024). The system limit for these two recyclable materials is set when they are collected from the plant by the future user.

The materials resulting from the production of semi-finished parts – foundry debris, fly-ash, filter cake from cupola furnace dust extraction and converter slag – are taken to a recycling plant for processing, whereby the system limit is set when the substances arrive at this plant, because no detailed information is available on the further treatment processes and the influence on the results of the impact categories is classified as negligible.

In C3, the recycling of the pipes (97%), i.e. the processing of the removed pipes in a recycling plant into a secondary raw material that can be used in cast iron and steel production, is taken into account. For this purpose, it is assumed that the pipe (including CML, etc.) is sent as a whole to the recycling plant, where any materials that cannot be used for cast iron and steel production are separated out. The treatment of these separated materials is excluded due to the expected minor influence.

3.6 Allocation

The system boundary for the steel scrap is set when the processed steel scrap leaves the recycling plants, because the end of the waste staus of the steel scrap is reached here. This system is blamed for the transportation of the scrap to the TRM plant.

In the liquid iron sector, an allocation by mass based on stock additions was carried out between the pipes considered in this EPD and the products not considered. The same applies to waste.

During the production of the ductile pipes, slag and coke dust are produced as by-products. Part of the waste heat is sold as district heating. However, these by-products contribute less than 1% to the operational income and can therefore be ignored according to the “Management-System-Handbook (MS-HB) of the Bau EPD GmbH (MS-HB Version 6.0.0 dated 06.11.2024).

For the annealing, the energy used was allocated according to the dwell times in the furnace.

Due to the recycling of the removed pipes, there is a corresponding output of secondary raw materials in C3. The output flows are compared with the scrap share in the production of the cast iron pipes in accordance with the net flow rule according to EN 15804 and the net output flow is determined.

3.7 Comparability

In principle, a comparison or evaluation of EPD data is only possible if all data sets to be compared have been created in accordance with EN 15804, the same programme-specific PCR/any additional rules and the same background database have been used, and the building context/product-specific performance characteristics are also taken into account.

4 LCA: Scenarios and additional technical information

4.1 A1-A3 Product stage

According to OENORM EN 15804, no technical scenario details are required for A1-A3 as the producer is responsible for the accounting of these modules, and this must not be changed by the user of the LCA.

Data collection for the product stage was carried out according to ISO 14044 Section 4.3.2. In accordance with the target definition, all relevant input and output flows that occur in connection with the product under consideration were identified and quantified in the life cycle inventory analysis.

Electricity generation is modelled according to the electricity mix supplied by Tiroler Wasserkraft AG (TIWAG) to Tiroler Rohre GmbH. In 2020, Tiroler Rohre GmbH purchased the TIWAG 2020 supplier mix (Versorgermix) from Tiroler Wasserkraft AG TIWAG (electricity mix contractually secured).

A part of the electricity consumption in the semi-finished parts production takes place at medium voltage level. The remaining electricity consumption takes place at low voltage level, with 5.75% coming from the in-house photovoltaic system.

Since photovoltaic electricity is generally fed into the grid and consumed at low voltage, and Tiroler Rohre GmbH purchases its electricity at medium voltage, the photovoltaic share is deducted when modelling the medium-voltage electricity supplied by TIWAG (see Table 11).

Table 11: Electricity mix

Source	**TIWAG Supplier mix general**	**Medium voltage without photovoltaics**
Hydro power	84,90%	86,32%
Norway	*20,23%*	*20,57%*
Tyrol	*64,67%*	*65,75%*
Wind power	10,37%	10,54%
Solid or liquid biomass	2,02%	2,05%
Photovoltaics	1,64%	0,00%
Biogas	1,05%	1,07%
Other eco-energy	0,02%	0,02%
Sum	**100,00%**	**100,00%**

The GWP total- result for the TIWAG electricity mix used is 57.3 g CO_2 eq/kWh at high voltage level, 60.5 g CO_2 eq/kWh at medium voltage level and 61.6 g CO_2 eq/kWh at low voltage level. The GWP total-result for low-voltage electricity from the photovoltaic system at the TRM plant is 104 g CO_2 eq/kWh.

4.2 A4-A5 Construction process stage

The pipes are transported to their destination by truck. The client provided relevant information on the transports, and based on this, an average transport distance of approximately 470 km was determined.

Table 12 shows the general parameters for describing transportation to the building site.

Table 12: Description of the scenario „Transport to building site (A4)“

Parameters to describe the transport to the building site (A4)	Value	Unit
Average transport distance	471	km
Vehicle type, Commission Directive 2007/37/EC (European Emission Standard)	Euro 6	-
Average fuel consumption, fuel type: Diesel or heavy fuel oil	25,3	l/100 km
Average transport mass	5,79	t
Average capacity utilisation (including empty returns)	85	%
Average gross density of transported products	16,3	kg/m
Volume capacity utilisation factor (factor: =1 or <1 or ≥ 1 for compressed or nested packaged products)	<1	-

Conventional laying was chosen as the installation method for the EPD, i.e. excavating a trench, bedding the pipe and backfilling with suitable material. A hydraulic excavator with an engine power of 80 kW, a scoop capacity of 0,87 m3 and a weight of 17 t was used for the excavation and backfilling of the pipe trench (including bedding).

Most of the excavation material is temporarily stored and reused for backfilling. However, a certain proportion of the excavation material (varying for the specific nominal diameters depending on the proportion of bedding) must be disposed of at a landfill 20 km away. The additional backfill material required for this is transported from a gravel pit 20 km away.

The spacer rings (PP), protective caps (PE), stacked wood and binding tape (PET) are thermally recycled in a waste incinerator 100 km away.

Table 13: Description of the scenario „Installation of the product in the building (A5)“

Parameters to describe the installation of the product in the building (A5)	Value	Unit
Ancillary materials for installation (specified by material);	Backfill material 113	kg/m
Ancillary materials for installation (specified by type)	Hydraulic excavator	-
Water use	0	m^3/m
Other resource use	0	kg/m
Electricity demand	0	kWh/m
Other energy carrier(s): Diesel	8	MJ/m
Wastage of materials on the building site before waste processing, generated by the product’s installation (specified by type)	0	kg/m
Output materials (specified by type) as result of waste processing at the building site e.g. of collection for recycling, for energy recovery, disposal (specified by route)	Disposal Excavation: 113 Waste incineration Wood: 0,0886 PET: 0,0009 PE: 0,009 PP: 0,010	kg/m
Direct emissions to ambient air (such as dust, VOC), soil and water	-	kg/m

4.3 B1-B7 Use stage

In the use stage, no material and energy flows relevant for the life cycle assessment take place for the VRS®-T pipe systems, wherefor no activities were taken into account.

4.4 C1-C4 End-of-Life stage

In inner-city areas, the main area of application for the pipe systems, the installed pipes are currently almost entirely removed. For this reason, a 100% removal rate is used as a scenario. The removed pipes are sent to a recycling process, being considered until the end-of-waste state in the current product system. The system limit is set when the processed steel scrap leaves the recycling plants. From this point on, the pipe is part of a new product system. As a recycling scenario it is assumed that 97% of the pipes are suitable for the recycling process and 3% have to be sent to disposal.

The pipes are removed with the same excavator that was used for the installation. The excavation volume for the removal corresponds to volume for the installation. The existing excavation material is reinstalled, but must be supplemented with additional backfill material (different for the specific DN). The distance to the gravel pit is estimated at 20 km.

Table 14: Description of the scenario "Dismantling (C1)"

Parameters to describe the dismantling (C1)	Value	Unit
Auxiliary materials for the dismantling	Backfill material 16,7	kg/m
Aids for the demolition	Hydraulic excavator	-
Water consumption	0	m^3/m
Other resource use	0	kg/m
Electricity consumption	0	kWh/m
Other energy carrier: Diesel	8	MJ/m
Material loss on the construction site before waste treatment, caused by the installation of the product	0	kg/m
Output materials due to waste treatment on the construction site, e.g. collection for recycling, for energy recovery or for disposal	0	kg/m
Direct emissions to ambient air (e.g. dust, VOC), soil and water	-	kg/m

The transport distance to the nearest recycling company (97% of the pipes) as well as to the nearest inert material landfill (3% of the pipes) or waste incineration plant (gaskets) was assumed to be 100 km.

Table 15: Description of the scenario "Transport for disposal (C2)"

Parameters to describe the transport for disposal (C2)	Value	Unit
Average transport distance	100	km
vehicle type, Commission Directive 2007/37/EC (European Emission Standard)	Euro 6	-
Average fuel consumption, fuel type: Diesel or heavy fuel oil	25,3	l/100 km
Average transport mass	5,79	t
Average capacity utilisation (including empty returns)	85	%
Average gross density of transported products	16,3	kg/m
Volume capacity utilisation factor (factor: =1 or <1 or ≥ 1 for compressed or nested packaged products)	<1	-

In C3, the recycling of the pipes (97%), i.e. the processing of the removed pipes in a recycling plant into a secondary raw material that can be used in cast iron and steel production, is taken into account. For this purpose, it is assumed that the pipe (including CML, etc.) is sent as a whole to the recycling plant, where any materials that cannot be used for cast iron and steel production are separated out. The treatment of these separated out materials is excluded due to the expected minor influence. A new product system begins with the transport of the processed scrap from the recycling plant to the production plant.

In C4, the disposal of 3% of the pipe mass in an inert material landfill and the disposal of the EPDM gasket material in a waste incinerator are considered. A 100% recycling rate is applied for the removed bolts, which are made of pure cast material.

Table 16: Disposal processes (C3 and C4) per m of pipe

DN	Mass per metre of pipe	Total pipe mass for recycling (97%)	Total pipe mass for disposal (3%)	Lock mass for recycling (100%)	Total mass (pipe and Lock) for recycling	Gasket mass for waste incineration
[mm]	*[kg/m]*	*[kg/m]*	*[kg/m]*	*[kg/m]*	*[kg/m]*	*[kg/m]*
80	16,30	15,811	0,489	0,078	15,889	0,0374

Table 17: Description of the scenario „Disposal of the product (C1 to C4)"

Parameters for end-of-life stage (C1-C4)	Value	Unit
Collection process, separately	see Table 16	kg collected separately
Recycling	see Table 16	kg for recycling
Disposal, inert material landfill	see Table 16	kg material for final deposition

4.5 D Potential of reuse and recycling

Due to the recycling of the removed pipes (97%), there is a corresponding output of secondary raw materials (D from C3). Due to the net flow rule according to EN 15804 and the high proportion of scrap in the production of cast iron pipes (988 kg per tonne of cast semi-finished part), there is a slightly negative net output flow here.

Table 18: Description of the scenario „re-use, recovery and recycling potential (module D)“

Parameters for module D	Value	Unit
Materials for reuse, recovery or recycling from A4-A5	-	%
Energy recovery or secondary fuels from A4-A5	Waste incineration Wood: 0,0886 PP: 0,0009 PE: 0,009 PET: 0,010	kg/m
Materials for reuse, recovery or recycling from B2-B5	-	%
Energy recovery or secondary fuels from B2-B5	-	kg/m
Materials for reuse, recovery or recycling from C1-C4	97	%
Energy recovery or secondary fuels from C1-C4	Waste incineration Gasket: 0,0374	kg/m

Due to the multi-recycling potential of the pipes, they could again replace primary raw materials in the next product system. In this EPD, the multi-recycling potential is not shown as a life cycle assessment result (in the results tables) but as additional information (Appendix 1), because this value does not comply with the rules and specifications of EN 15804 (net flow rule). The additional information on multi-recycling potential is based on a manufacturer scenario based on the experience of Tiroler Rohre GmbH.

5 Information on data quality and data selection in accordance with EN 15941

5.1 Principles for the description of data quality

The following information on data quality is provided in accordance with the requirements of EN 15941 (EN 15941, section 7.3.4).

The data fulfils the following quality requirements:

The data is representative for the production year 2020 (annual average). The production year 2020 is considered based on the existing data for ductile cast iron production (semi-finished part production) of the EPD for ductile piles from Tiroler Rohre GmbH (published 2022).

For the data collection, generic data and the cut-off of material and energy flows the criteria of the Bau EPD GmbH were considered.

The manufacturer provided all essential data such as energy and raw material consumption, transport distances and vehicles as well as packaging within the system boundaries.

The applied background database ecoinvent 3.10 was published in 2024, but contains individual data sets whose collection or reference year dates back more than 10 years (requirement EN 15804 or Bau EPD GmbH). These data sets remained in the various ecoinvent database versions through the years, taking necessary adjustments for database updates into account. Nevertheless, these data sets are subject to a corresponding potential for fluctuation because some of the (technological) developments of recent years are not reflected.

The data is plausible, i.e. the deviations from comparable results are within a plausible range.

5.2 Description of the temporal, geographical and technological representativeness of the product data

Temporal representativeness:

- The data collection period corresponds to the year 2020. All specific data are from this year.
- There is no deviation from the reporting year 2020 in the collection of specific data.
- The applied background database ecoinvent 3.10 was published in 2024, but contains individual data sets whose collection or reference year dates back more than 10 years (requirement EN 15804 or Bau EPD GmbH).

Geographical representativeness:

- VRS®-T pipe systems are manufactured exclusively at the plant in Hall in Tirol. In the production year 2020, almost 50% of the products were delivered within Austria and a total of approx. 90% within Europe (with a focus on Germany and Italy in addition to Austria).
- The pipe systems are disposed of in an area close to where they were used.

Technological representativeness:

- The production technology at the plant in Hall in Tyrol is state-of-the-art. The facilities are regularly maintained and modernised.
- In addition to cast iron pipe systems, other products such as ductile piles (pure cast iron product corresponds to semi-finished parts) are also manufactured at the analysed plant.

Geographical and technological representativeness for EPDs covering an industry:

- Not relevant for this EPD.

5.3 Explanation of the averaging process

Not relevant for this EPD, as specific products from the plant in Hall in Tyrol of the Tiroler Rohre GmbH are considered.

5.4 Assessment of the data quality of the Life Cycle Inventory data

The validity (database/source, country/region, reference year, publication/update) and the geographical, technical and temporal representativeness (according to ÖNORM EN 15804 Annex E - Table E.1) of all data sets used are assessed in the project report for this EPD.

The manufacturer provided all essential data such as energy and raw material consumption, transport distances and vehicles, and packaging within the system boundaries (quality management system and SAP system).

6 LCA: results

Table 19: Parameters to describe the environmental impact per metre [m] VRS®-T DN 80

Parameters	Unit	A1-A3	A4	A5	B1-B7	C1	C2	C3	C4	C1-C4	A-C	D
GWP total	kg CO_2 eq	1,72E+01	1,48E+00	3,72E+00	0,00E+00	1,04E+00	3,12E-01	4,10E-01	1,21E-01	1,88E+00	2,43E+01	3,26E-01
GWP fossil fuels	kg CO_2 eq	1,73E+01	1,48E+00	3,59E+00	0,00E+00	1,04E+00	3,12E-01	4,15E-01	1,21E-01	1,88E+00	2,42E+01	3,27E-01
GWP biogenic	kg CO_2 eq	-7,75E-02	1,02E-03	1,33E-01	0,00E+00	4,92E-04	2,16E-04	-5,39E-03	1,48E-05	-4,66E-03	5,18E-02	-1,54E-03
GWP luluc	kg CO_2 eq	1,19E-02	4,91E-04	1,79E-03	0,00E+00	2,48E-04	1,04E-04	5,86E-04	2,08E-06	9,40E-04	1,52E-02	3,12E-05
ODP	kg CFC-11 eq	2,65E-07	2,94E-08	5,93E-08	0,00E+00	1,49E-08	6,20E-09	5,72E-09	1,24E-10	2,70E-08	3,81E-07	2,88E-10
AP	mol H^+ eq	4,42E-02	3,08E-03	2,11E-02	0,00E+00	8,41E-03	6,50E-04	4,57E-03	3,80E-05	1,37E-02	8,21E-02	1,20E-03
EP freshwater	kg P eq	5,83E-03	1,00E-04	5,10E-04	0,00E+00	8,23E-05	2,11E-05	2,37E-04	5,61E-07	3,41E-04	6,78E-03	1,42E-04
EP marine	kg N eq	1,14E-02	7,40E-04	7,37E-03	0,00E+00	3,63E-03	1,56E-04	1,06E-03	1,48E-05	4,86E-03	2,44E-02	2,88E-04
EP terrestrial	mol N eq	1,18E-01	7,98E-03	8,24E-02	0,00E+00	4,00E-02	1,68E-03	1,19E-02	1,61E-04	5,38E-02	2,62E-01	3,12E-03
POCP	kg NMVOC eq	4,01E-02	5,12E-03	2,70E-02	0,00E+00	1,20E-02	1,08E-03	3,57E-03	5,07E-05	1,67E-02	8,89E-02	1,04E-03
ADPE	kg Sb eq	3,32E-04	4,81E-06	1,02E-05	0,00E+00	1,38E-06	1,02E-06	2,56E-05	9,44E-09	2,80E-05	3,75E-04	1,57E-07
ADPF	MJ H_u	1,08E+02	1,73E+00	1,03E+01	0,00E+00	1,65E+00	3,65E-01	1,80E+00	8,02E-03	3,81E+00	1,24E+02	3,23E+00
WDP	m3 World eq	4,55E+00	8,64E-02	2,50E+00	0,00E+00	2,73E-01	1,82E-02	6,95E-02	2,94E-03	3,64E-01	7,50E+00	1,85E-02
Legend		GWP = Global warming potential; luluc = land use and land use change; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential, Accumulated Exceedance; EP = Eutrophication potential; POCP = Formation potential of tropospheric ozone photochemical oxidants; ADPE = Abiotic depletion potential for non-fossil resources; ADPF = Abiotic depletion potential for fossil resources WDP = Water (user) deprivation potential, deprivation-weighted water consumption										

Table 20: Additional environmental impact indicators per metre [m] VRS®-T DN 80

Parameters	Unit	A1-A3	A4	A5	B1-B7	C1	C2	C3	C4	C1-C4	A-C	D
PM	Occurrence of diseases	1,86E-06	1,09E-07	4,89E-07	0,00E+00	2,26E-07	2,30E-08	6,39E-08	5,76E-10	3,13E-07	2,77E-06	2,60E-08
IRP	kBq U235 eq	8,12E-01	2,70E-02	1,44E-01	0,00E+00	2,25E-02	5,69E-03	4,19E-02	1,14E-04	7,02E-02	1,05E+00	-4,83E-05
ETP-fw	CTUe	2,09E+02	5,66E+00	1,35E+01	0,00E+00	2,66E+00	1,19E+00	4,03E+00	2,08E-01	8,10E+00	2,36E+02	3,46E+01
HTP-c	CTUh	1,78E-07	1,05E-08	2,29E-08	0,00E+00	5,13E-09	2,21E-09	3,60E-09	2,58E-11	1,10E-08	2,23E-07	1,31E-07
HTP-nc	CTUh	1,83E-07	1,31E-08	2,12E-08	0,00E+00	3,20E-09	2,76E-09	2,22E-08	4,65E-11	2,82E-08	2,45E-07	1,13E-09
SQP	dimensionless	5,98E+01	1,26E+01	5,50E+01	0,00E+00	3,17E+00	2,65E+00	9,97E+00	1,53E-01	1,59E+01	1,43E+02	7,13E-01
Legend		PM = Potential incidence of disease due to Particulate Matter emissions; IRP = Potential Human exposure efficiency relative to U235; ETP-fw = Potential Comparative Toxic Unit for ecosystems; HTP-c = Potential Comparative Toxic Unit for humans – cancer effect; HTP-nc = Potential Comparative Toxic Unit for humans – non-cancer effect; SQP = Potential soil quality index										

Table 21: Parameters to describe the use of resources per metre [m] VRS®-T DN 80

Parameters	Unit	A1-A3	A4	A5	B1-B7	C1	C2	C3	C4	C1-C4	A-C	D
PERE	MJ H_u	2,82E+01	3,57E-01	2,90E+00	0,00E+00	2,83E-01	7,53E-02	9,10E-01	1,67E-03	1,27E+00	3,28E+01	3,26E-02
PERM	MJ H_u	1,09E+00	0,00E+00	-1,09E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PERT	MJ H_u	2,93E+01	3,57E-01	1,81E+00	0,00E+00	2,83E-01	7,53E-02	9,10E-01	1,67E-03	1,27E+00	3,28E+01	3,26E-02
PENRE	MJ H_u	1,08E+02	1,73E+00	1,10E+01	0,00E+00	1,65E+00	3,65E-01	1,80E+00	8,03E-03	3,82E+00	1,24E+02	3,23E+00
PENRM	MJ H_u	7,59E-01	0,00E+00	-7,59E-01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PENRT	MJ H_u	1,08E+02	1,73E+00	1,03E+01	0,00E+00	1,65E+00	3,65E-01	1,80E+00	8,03E-03	3,82E+00	1,24E+02	3,23E+00
SM	kg	1,28E+01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,28E+01	-2,31E-01
RSF	MJ H_u	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
NRSF	MJ H_u	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
FW	m^3	1,74E-01	2,88E-03	6,15E-02	0,00E+00	6,93E-03	6,08E-04	2,74E-03	1,92E-04	1,05E-02	2,49E-01	4,74E-04
Legend		PERE = Renewable primary energy as energy carrier; PERM = Renewable primary energy resources as material utilization; PERT = Total use of renewable primary energy resources; PENRE = Non-renewable primary energy as energy carrier; PENRM = Non-renewable primary energy as material utilization; PENRT = Total use of non-renewable primary energy resources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of fresh water										

Table 22: Parameters describing LCA-output flows and waste categories per metre [m] VRS®-T DN 80

Parameters	Unit	A1-A3	A4	A5	B1-B7	C1	C2	C3	C4	C1-C4	A-C	D
HWD	kg	2,78E-03	1,40E-04	3,21E-04	0,00E+00	8,70E-05	2,96E-05	3,42E-05	7,90E-07	1,52E-04	3,40E-03	4,12E-05
NHWD	kg	1,36E+00	1,00E+00	1,14E+02	0,00E+00	7,71E-02	2,12E-01	1,46E-01	4,91E-01	9,26E-01	1,17E+02	8,38E-03
RWD	kg	3,76E-04	1,22E-05	6,35E-05	0,00E+00	9,89E-06	2,57E-06	1,95E-05	5,27E-08	3,20E-05	4,84E-04	4,23E-08
CRU	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
MFR	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,26E+01	0,00E+00	1,26E+01	1,26E+01	0,00E+00
MER	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
EEE	MJ	0,00E+00	0,00E+00	1,15E-01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,15E-01	0,00E+00
EET	MJ	0,00E+00	0,00E+00	1,02E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,02E+00	0,00E+00
Legend		HWD = Hazardous waste disposed; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed; CRU = Components for re-use; MFR = Materials for recycling; MER = Materials for energy recovery; EEE = Exported electric energy; EET = Exported thermal energy										

Table 23: Information describing the biogenic carbon content at the factory gate per metre [m] VRS®-T DN 80

Biogenic carbon content	Unit	A1-A3
Biogenic carbon content in product	kg C	0,00E+00
Biogenic carbon content in accompanying packaging	kg C	3,65E-02
NOTE: 1 kg biogenic carbon is equivalent to 44/12 kg of CO_2		

Table 24 presents disclaimers which shall be declared in the project report and in the EPD with regard to the declaration of relevant core and additional environmental impact indicators according to the following classification. That can be declared in a footnote in the EPD.

Table 24: Classification of disclaimers to the declaration of core and additional environmental impact indicators

ILCD-classification	Indicator	disclaimer
ILCD-Type 1	Global warming potential (GWP)	none
	Depletion potential of the stratospheric ozone layer (ODP)	none
	Potential incidence of disease due to PM emissions (PM)	none
ILCD-Type 2	Acidification potential, Accumulated Exceedance (AP)	none
	Eutrophication potential, Fraction of nutrients reaching freshwater end compartment (EP-freshwater)	none
	Eutrophication potential, Fraction of nutrients reaching marine end compartment (EP-marine)	none
	Eutrophication potential, Accumulated Exceedance (EP-terrestrial)	none
	Formation potential of tropospheric ozone (POCP)	none
	Potential Human exposure efficiency relative to U235 (IRP)	1
ILCD-Type 3	Abiotic depletion potential for non-fossil resources (ADP-minerals&metals)	2
	Abiotic depletion potential for fossil resources (ADP-fossil)	2
	Water (user) deprivation potential, deprivation-weighted water consumption (WDP)	2
	Potential Comparative Toxic Unit for ecosystems (ETP-fw)	2
	Potential Comparative Toxic Unit for humans (HTP-c)	2
	Potential Comparative Toxic Unit for humans (HTP-nc)	2
	Potential Soil quality index (SQP)	2
Disclaimer 1 – This impact category deals mainly with the eventual impact of low dose ionizing radiation on human health of the nuclear fuel cycle. It does not consider effects due to possible nuclear accidents, occupational exposure nor due to radioactive waste disposal in underground facilities. Potential ionizing radiation from the soil, from radon and from some construction materials is also not measured by this indicator.		
Disclaimer 2 – The results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experienced with the indicator.		

7 LCA: Interpretation

It should be noted that the impact assessment results are only relative statements that do not include any statements about "end-points" of the impact categories, exceeding of thresholds or risks.

Since the definition of basic materials (those substances that remain in the product) and auxiliary materials (those substances that do not remain in the product) are not applicable for this product, because small percentages of the energy source coke and the input materials ferrosilicon and silicon carbide remain in the product, a breakdown into A1-A3 was not carried out.

Figure 5 shows a dominance analysis of the percentage shares of modules A1-A3 (production), A4 (transport to construction site), A5 (installation), C1 (removal), C2 (transport) and C4 (waste treatment). The pipe production is the main contributor to all impact categories (except NHWD). The next largest impacts are the installation (A5) and the removal (C1) of the pipes and the transport to the construction site (A4).

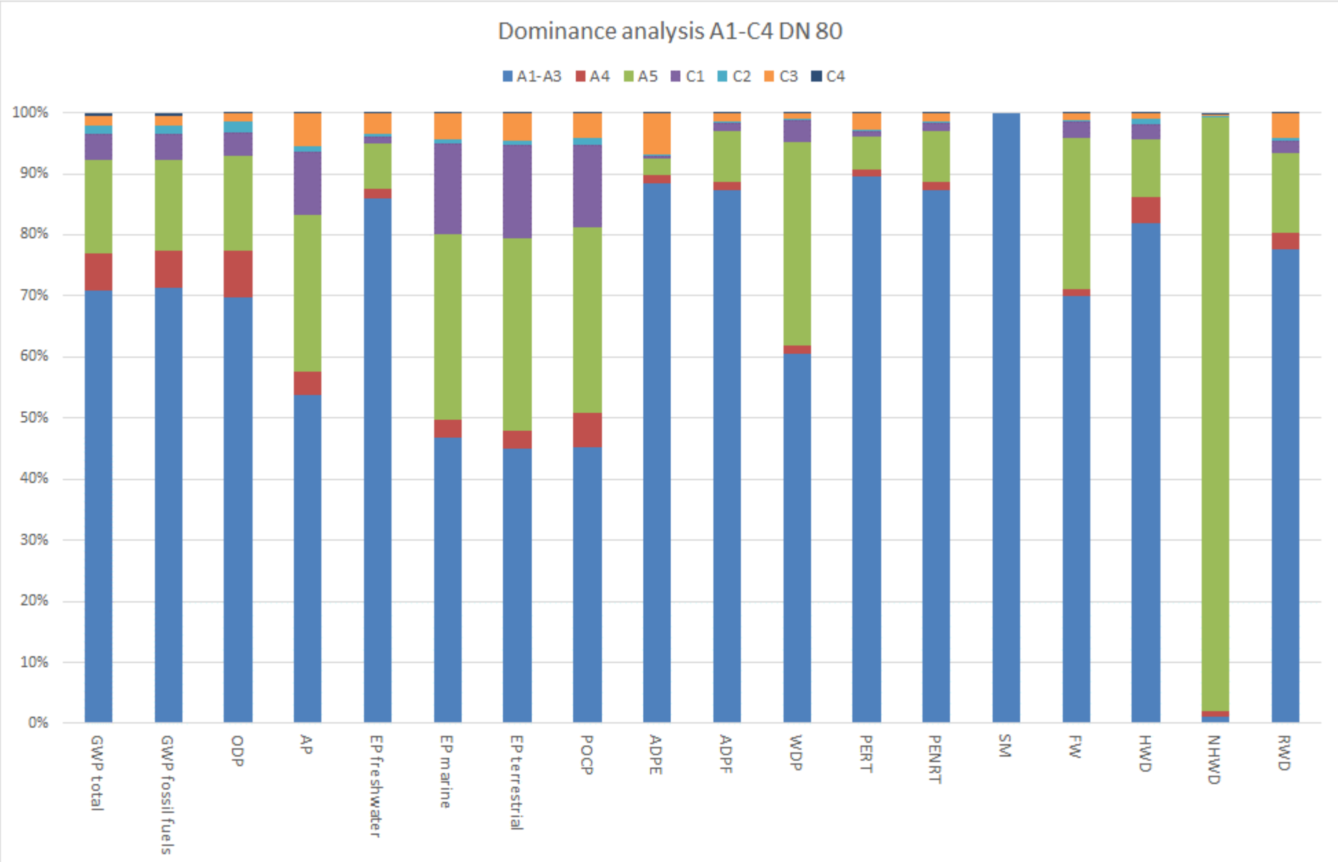


Figure 5: Dominance analysis DN 80

In the production phase (A1-A3), cast iron production has the greatest impact in terms of core indicators, with some impacts exceeding 80%. For individual indicators, galvanising has a high impact (e.g. ADPE >80%).

For the cast iron production, the cupola furnace, the annealing process and the converter have the greatest impact on the core indicators (together >90% in some cases). In the cupola furnace, CO_2 emissions from fuel use, SiC pellets and foundry coke have the greatest impact. The impact of the annealing process is determined by the natural gas used. In the converter, the magnesium and ferrosilicon applied have the greatest impact on the core indicators (in some cases >95%).

Pipe galvanisation is mainly dominated by the zinc applied (in some cases >99%).

The installation of the pipes (A5) is determined by the bedding material, the transport of the bedding material and the diesel consumption of the hydraulic excavator.

In C3, the upstream chain (wood input in the production of the scrap processing plant) of the data set used for recycling, "Iron scrap, sorted, pressed {RER}| sorting and pressing of iron scrap | Cut-off, U", causes a slightly negative value for GWP biogenic.

8 Literature

ÖNORM EN ISO 14025: 2010 Environmental labels and declarations — Type III environmental declarations — Principles and procedures

ÖNORM EN ISO 14040: 2021 Environmental management — Life cycle assessment — Principles and framework

ÖNORM EN ISO 14044: 2021 Environmental management — Life cycle assessment — Requirements and guidelines

ÖNORM 15804:2012+A2:2019+AC:2021 Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products

Bau EPD GmbH: Product category rules for building related products and services - Requirements on the EPD for cast iron products, PCR-Code 2.16.8, Version 12.0, dated 10.10.2024. Bau EPD Österreich, Vienna, 2024

Bau EPD GmbH: Management system handbook (EPD-MS-HB) of the EPD program, Version 6.0.0, dated 06.11.2024. Bau EPD Österreich, Vienna, 2024

9 Directory and Glossary

9.1 List of figures

9.2 List of tables

9.3 Abbreviations

9.3.1 Abbreviations as per EN 15804

EPD environmental product declaration
PCR product category rules
LCA life cycle assessment
LCI life cycle inventory analysis
LCIA life cycle impact assessment
RSL reference service life
ESL estimated service life
EPBD Energy Performance of Buildings Directive
GWP global warming potential
ODP depletion potential of the stratospheric ozone layer
AP acidification potential of soil and water
EP eutrophication potential
POCP formation potential of tropospheric ozone
ADP abiotic depletion potential

9.3.2 Abbreviations as per corresponding PCR

CE-mark french: Communauté Européenne or Conformité Européenne = EC certificate of conformity
REACH Registration, Evaluation, Authorisation and Restriction of Chemicals

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EPD - ENVIRONMENTAL PRODUCT DECLARATION

as per ISO 14025 and EN 15804+A2

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DECLARATION NUMBER	Bau EPD-TRM-2025-2-ECOINVENT-VRS-T-DN100
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ENERGY MIX APPROACH	MARKET BASED APPROACH

VRS®-T ductile cast iron pipe system – DN 100
Tiroler Rohre GmbH

Content of the EPD

1 General information

Product name VRS®-T ductile cast iron pipe system DN 100 **Declaration number** **Bau EPD-TRM-2025-2-ECOINVENT-VRS-T-DN100** **Declaration data** ☒ Specific data ☐ Average data	**Declared Product / Declared Unit** 1 m ductile cast iron pipe of the VRS®-T system DN 100 with Portland composite cement lining and zinc coating with PUR long-life coating with the nominal dimensions: **Table 1: Nominal dimensions** Nominal diameter [mm]: 100 — Longitudinally related mass [kg/m]: 20,0
Declaration based on MS-HB Version 6.0.0 dated 06.11.2024 Name of PCR: Cast iron products PCR-Code 2.16.8, Version 12.0 dated 10.10.2024 (PCR tested and approved by the independent expert committee = PKR-Gremium) Version of EPD-Format-Template M-Dok 14A2 dated 11.06.2024 The owner of the declaration is liable for the underlying information and evidence; Bau EPD GmbH is not liable with respect to manufacturer information, life cycle assessment data and evidence.	**Number of datasets in EPD Document: 1** **Range of validity** The EPD applies to the nominal diameter DN 100 of the VRS®-T ductile cast iron pipe system with the above-mentioned lining and duplex outer coating (zinc coating with PUR long-life coating) from the Hall in Tyrol plant of Tiroler Rohre GmbH (TRM). The EPD and the production technologies assessed are representative for the production of pipes with a nominal diameter DN 100 at the Hall in Tyrol plant of Tiroler Rohre GmbH (TRM).
Type of Declaration as per EN 15804 From cradle to grave with module D (modules A+B+C+D) LCA method: Cut-off by classification	**Database, Software, Version** Ecoinvent 3.10, SimaPro 9.6.0.1 **Version Characterisation Factors:** Joint Research Center, EF 3.1
Author of the Life Cycle Assessment floGeco GmbH Hinteranger 61d 6161 Natters Austria	**The CEN standard EN 15804:2012+A2:2019+AC:2021 serves as the core-PCR.** **Independent verification of the declaration according to ISO 14025:2010** ☐ internally ☒ externally **Verifier 1:** Dipl.-Ing. Therese Daxner M.sc. **Verifier 2:** Dipl.-Ing. Roman Smutny
Holder of the Declaration Tiroler Rohre GmbH Innsbruckerstraße 51 6060 Hall in Tyrol Austria	**Owner, Publisher and Programme Operator** Bau EPD GmbH Seidengasse 13/3 1070 Wien Austria

Table 1: Nominal dimensions

Nominal diameter [mm]	Longitudinally related mass [kg/m]
100	20,0

DI (FH) DI DI Sarah Richter
Head of Conformity Assessment Body

Dipl.-Ing. Therese Daxner, M.Sc.
Verifier

Dipl.-Ing. Roman Smutny
Verifier

Note: EPDs from similar product groups from different programme operators might not be comparable.

2 Product

2.1 General product description

The declared product is a ductile cast iron pipe of the VRS®-T system (restrained locking system) with cement mortar lining (CML) and zinc coating with PUR long-life coating with a nominal diameter DN 100 from Tiroler Rohre GmbH (TRM).

The TRM VRS®-T system consists of ductile, centrifugally cast pipes with a spigot end with a welding ring and a socket, which are joined together to form any length of pipe. The VRS®-T joint, consisting of a VRS®-T socket, VRS®-T sealing ring, spigot end with a welding ring and locking elements, is a highly resilient, flexible and restrained locking system. It is quick and easy to install and can be bent up to 5°. No welding and no weld-seam testing is necessary. The joint can be dismantled at any time.

The ductile cast iron pipes are manufactured in lengths of 5 m with nominal diameters from DN 80 to DN 600 and different wall thicknesses. The nominal dimensions of the declared ductile cast iron pipes with a nominal diameter DN 100 as well as the corresponding wall thickness classes, (normative) minimum wall thicknesses and masses per metre of pipe are shown in Table 2. To further illustrate the declared product, Figure 1 and Figure 2 show excerpts from the Tiroler Rohre GmbH product catalogue with technical and geometric specifications and corresponding mass data.

Table 2: VRS®-T ductile cast iron pipes DN 100 – nominal diameter, Wall thickness class, minimum wall thickness, mass per Meter

DN	Wall thickness class (K class)	Minimum wall thickness [mm]	Mass per m of pipe [kg/m]
100	K 10	4,7	20,0

DN	PFA [a] [bar]	Maße [mm]		zul. Zugkraft [kN]	Max. Abwinkelung [°]	Anzahl der Riegel	Gewicht Rohr 5m [kg] [b]
		s_1 Guss	s_2 ZMA				
80	100	4,7	4	115	5	2	81,6
100	75	4,7	4	150	5	2	100,0
125	63	4,8	4	225	5	2	128,2
150	63	4,7	4	240	5	2	157,3
200	40	4,8	4	350	4	2	204,5
250	40	5,2	4	375	4	2	268,9
300	40	5,6	4	380	4	4	339,5
400	30	6,4	5	650	3	4	519,9
500	25/30	7,2/8,2	5	860	3	4	711,8
600	35	8,0	5	1.525	2	9	909,5

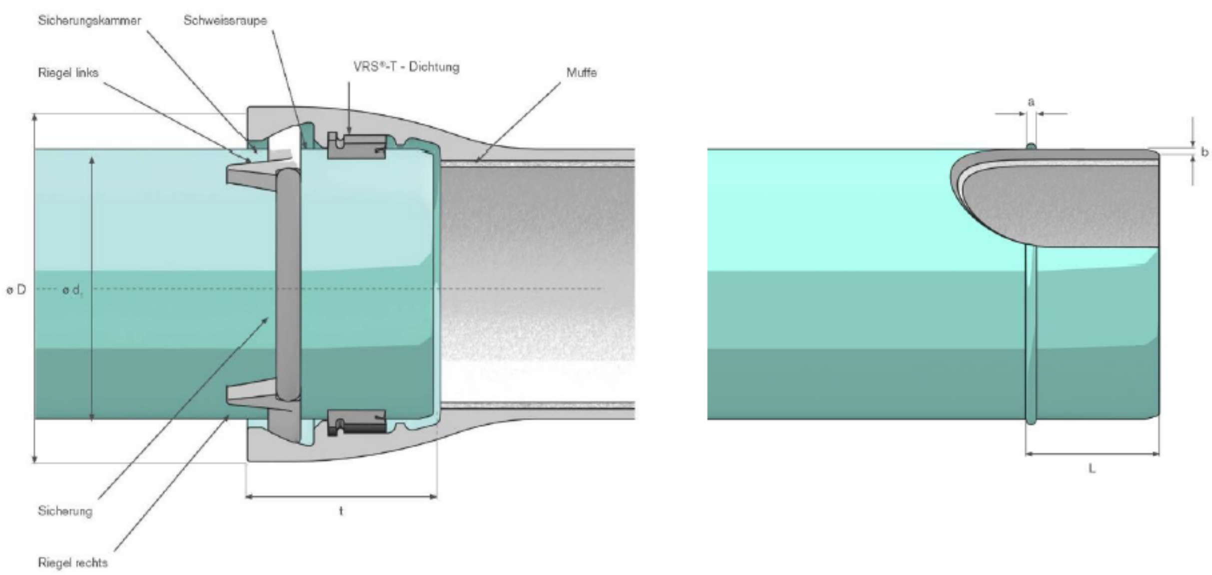
[a] PFA: zulässiger Bauteilbetriebsdruck | PMA = 1,2 x PFA | PEA = 1,2 x PFA + 5 | höhere PFA auf Anfrage | siehe Hinweise zum Einsatz von Klemmringen

[b] theoretische Masse pro Rohr für K9/10, inkl. ZMA, Zink, Deckbeschichtung

[1] Mindestmaß - Toleranzen beachten | [2] Nennmaß - Toleranzen beachten

Figure 1: VRS®-T pipes – technical and geometric specifications

VRS®-T Verbindung DN 80 bis DN 600



DN	Maße [mm] a							
	Durchmesser Spitzende	Abweichungen	Durchmesser Muffe	Einstecktiefe	Schweißraupe		
	d1		D	t	L	a	b
80	98	+1,0 | -2,7	156	127	86 ±4	8 ±2	5 +0,5 | -1
100	118	+1,0 | -2,8	177	135	91 ±4	8 ±2	5 +0,5 | -1
125	144	+1,0 | -2,8	206	143	96 ±4	8 ±2	5 +0,5 | -1
150	170	+1,0 | -2,9	232	150	101 ±4	8 ±2	5 +0,5 | -1
200	222	+1,0 | -3,0	292	160	106 ±4	9 ±2	5,5 +0,5 | -1
250	274	+1,0 | -3,1	352	165	106 ±4	9 ±2	5,5 +0,5 | -1
300	326	+1,0 | -3,3	410	170	106 ±4	9 ±2	5,5 +0,5 | -1
400	429	+1,0 | -3,5	521	190	115 ±5	10 ±2	6 +0,5 | -1
500	532	+1,0 | -3,8	630	200	120 ±5	10 ±2	5 +0,5 | -1
600	635	+1,0 | -4,0	732	175	160 +0 | -2	9 ±1	5 +0,5 | -1

a Toleranzen sind möglich

Figure 2: Schematic illustration of a VRS®-T ductile cast iron pipe

The density of ductile cast iron is 7,050 kg/m³.

2.2 Application field

The VRS®-T cast iron pipe system with Portland composite cement lining is mainly used for drinking water supply and for fire extinguishing pipes, snow-making systems and turbine pipes. The cast iron pipe can be installed using various methods, such as:

- Conventional installation (trench)
- Trenchless installation
- Bridge pipes
- Interim pipes

- Floating

The usual installation method is conventional laying with the excavation of a trench, the creation of a bedding for the pipe and backfilling with suitable material.

2.3 Standards, guidelines and regulations relevant for the product

Table 3: Product specific standards

Regulation	Title
OENORM EN 545	Ductile iron pipes, fittings, accessories and their joints for water pipelines - Requirements and test methods
OENORM B 2599-1	Ductile iron pipes and fittings — Part 1: Use for water pipelines
OENORM B 2597	Ductile cast iron pipes and fittings for water, sewage and gas pipe lines - Restrained push-in-joints - Requirements and tests
OENORM B 2555	Coating of cast iron pipes - Thermal zinc spraying
OENORM B 2560	Ductile iron pipes - Finishing coating of polyurethane, epoxy or acrylic materials - Requirements and test methods
OENORM B 2562	Ductile cast iron pipes - Factory made lining with cement mortar - Requirements and test methods
OENORM EN 681-1	Elastomeric seals - Material requirements for pipe joint seals used in water and drainage applications - Part 1: Vulcanized rubber

2.4 Technical data

Mechanical properties are verified according to OENORM EN 545:2011, sections 6.3 and 6.4.

Table 4: Material parameters for ductile cast iron pipes of the VRS®-T system

Name	Value	Unit
Iron density	7050	kg/m^3
Minimum tensile strength	≥ 420	MPa
Proportional limit, 0.2% yield strength ($R_{p0.2}$)	≥ 300	MPa
Minimum elongation at fracture	≥ 10	%
Maximum Brinell hardness	≤ 230	HB
Pipe length	5000	mm
Mean coefficient of linear thermal expansion	$10*10^{-6}$	m/m*K
Thermal conductivity	0,42	W/cm*K

Table 5: VRS®-T pipes DN 100 – nominal dimension-dependent technical data

DN	Wall thickness class K class	Minimum wall thickness [mm]	Mass per metre of pipe [kg/m]	Allowable operating pressure PFA [bar]	Permissible tensile force [kN]
100	K 10	4,7	20,0	75	150

2.5 Basic/auxiliary materials

Table 6: VRS®-T pipes DN 100 – basic materials in mass %

DN	Casting	Zinc	Cement stone	PUR
100	79,3%	0,7%	19,3%	0,8%

Table 7: Basic materials – casting in mass %

Ingredients:	**Mass %**
Iron [1)]	ca. 94 %
Carbon [2)]	ca. 3,5 %
Silicon [3)]	ca. 2 %
Ferric by-elements [4)]	ca.0,5 %

[1)] Iron consisting mainly of steel scrap and a very small proportion of pig iron and return iron from the casting process

[2)] Foundry coke carbon. The coke in the cupola furnace serves both as an energy supplier for the scrap melting and the adjusting of the desired carbon content

[3)] Silicon is added in the form of SiC pellets and/or ferro-silicon

[4)] Ferric by-elements are found in the steel scrap in different minor quantities (<<1%)

2.6 Production stage

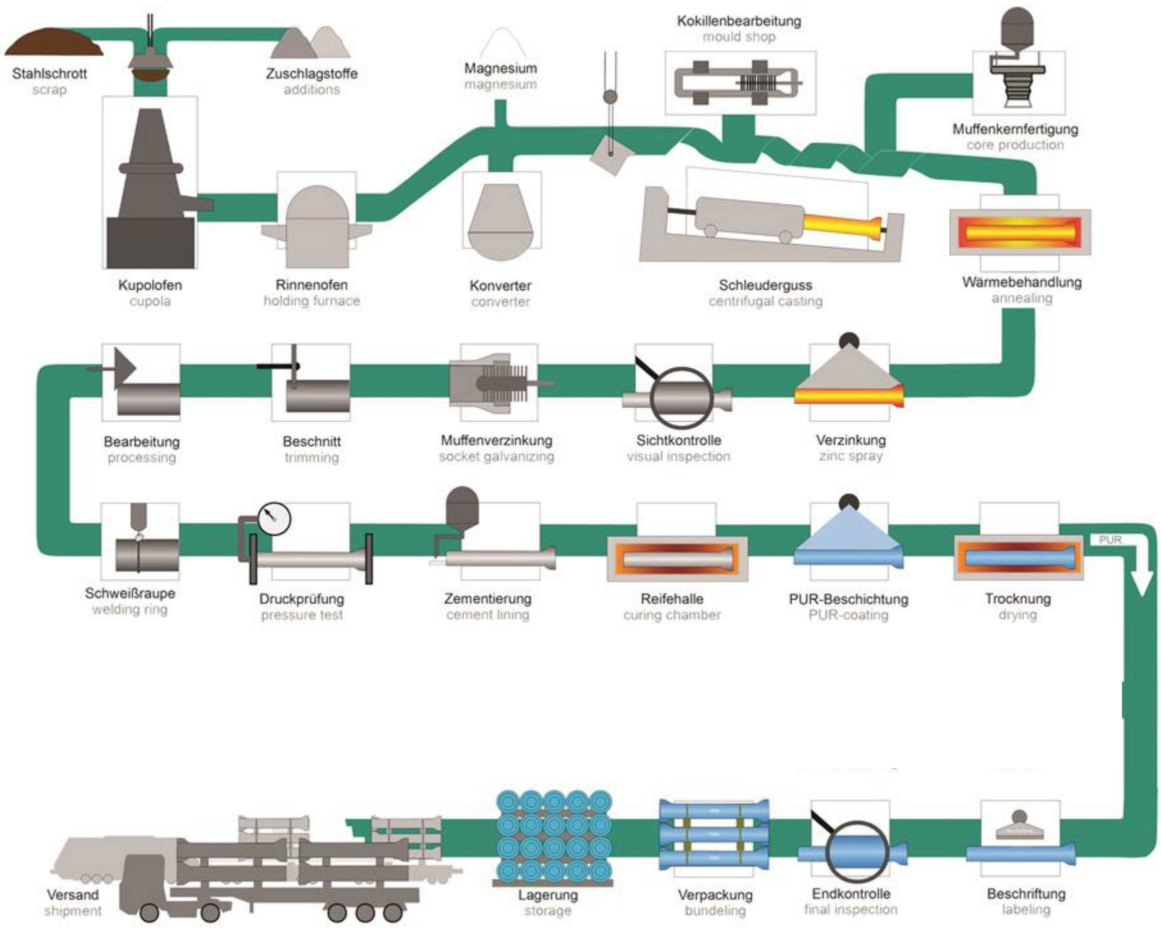


Figure 3: Flow chart of production process

For casting production, steel scrap and recycled material are smelted in the cupola furnace with the help of coke as a reaction and reduction agent. Silicon carbide is added as an alloying element. Added aggregates enhance slagging. The chemical composition of the smelted basic iron is then constantly monitored through spectral analysis. The smelted basic iron is kept warm in the holding furnace, a storage medium, and then treated with magnesium in the Georg Fischer converter, in order to reach the appropriate ductility. The liquid iron is then cast in a centrifuge machine with the De Lavaud procedure. In order to produce a specific pipe diameter, this machine is equipped with the corresponding mould (metal form that the liquid iron is poured into). The socket core made of quartz sand seals the inlet of the machine and forms the pipe socket. The glowing pipe is pulled out of the cast unit and placed in a furnace with the help of an automatic transport system. Here it undergoes annealing in order to achieve the desired mechanical properties.

The pipe is then galvanised using the electric arc spraying process and then cooled. The pipe is visually inspected in the pipe line. The spigot end and socket are machined if necessary. In the area of the welding ring, the zinc and annealing skin (tinder) are ground off and finally the welding ring is applied.

During the pressure test, each pipe is hydrostatically pressurised with a certain internal pressure and checked for leaks. The pipe is then lined with cement mortar using the centrifugal rotation process. The weld seam is galvanised and the pipes are visually inspected again. The cement stone hardens in the curing chamber. Finally, a solvent-free two-component polyurethane top coat is applied. All pipes are labelled according to the specifications, bundled and brought to the warehouse.

2.7 Packaging

The TRM pipes are sealed with protective caps and bundled using squared timber and spacer rings as stacking aid and PET tapes. All packaging materials can be used for thermal recycling.

2.8 Conditions of delivery

The ductile cast iron pipes are bundled for transport and storage with the help of squared lumber and spacer rings as stacking aid as well as PET binding tapes.

2.9 Transport to site

The cast pipes are transported to their destination within Europe by lorry and, in rare cases, overseas by ship.

2.10 Construction product stage

The installation of pressure pipes made of ductile cast iron must comply with OENORM EN 805 (Water supply - Requirements for systems and components outside buildings) and OENORM B 2538 (Additional specifications concerning OENORM EN 805). When constructing the pipe trench, sufficient working space must be provided for the installation of the pipeline, depending on the trench depth and the outer diameter of the pipe. The Ordinance on Protection of Construction Workers (Bauarbeiterschutzverordnung) and other provisions as well as relevant standards and regulations must be complied with accordingly.

As this is a push-in joint, no additional work such as welding is required. The pipe trench must be constructed and excavated in such a way that all pipe sections are at frost-free depths. The trench must be excavated deep enough so that the final cover height is at least 1.50 m. In the case of ductile iron pipes, the existing soil is generally suitable for bedding the pipeline. This means there is no need for a lower bedding layer and the bottom of the trench becomes the lower bedding.

The pipeline must be embedded and the pipe trench refilled in such a way that the pipeline is securely fixed in its intended position and that damage to the pipeline is prevented and settlement can only occur to the permissible extent. Suitable material that does not damage the pipe components and the coating must be used for embedding the pipeline. The backfill material should be installed in layers and sufficiently compacted.

2.11 Use stage

If installed and designed professionally and if the phase of utilisation is not disturbed, no modification of the material composition of construction products made of ductile cast iron occur.

2.12 Reference service life (RSL)

Table 8: Reference service life (RSL)

Name	Value	Unit
Ductile cast iron pipes	50	Years

In practice, it has been shown that a service life of 100 years, based on the DVGW damage statistics (German Technical and Scientific Association for Gas and Water – https://www.dvgw.de/themen/sicherheit/gas-und-wasserstatistik/), is achieved.

2.13 End of life stage

In inner-city areas, the main area of application for the pipe systems, the installed pipes are currently almost entirely removed. These pipes can then be recycled accordingly. These pipes can then be sent to recycling. The removal and recycling rate was therefore set correspondingly high in the scenarios considered (see 4.4 - C1-C4 disposal phase). However, it should be noted that the 100% removal rate is a manufacturer's scenario, which must be checked and adjusted accordingly in each individual use case.

The pipes are disposed of in very rare cases. The EAK waste code number for iron and steel from construction and demolition is 170405.

2.14 Further information

For further information about the TRM pipe system and its possible applications, see the website http://trm.at/rohr.

3 LCA: Calculation rules

3.1 Declared unit/ Functional unit

The functional unit is 1 metre [m] of pipe. For conversion into kg, Table 9 can be used.

Table 9: Conversion factor to mass

Nominal diameter [mm]	Longitudinally related mass [kg/m]	Multiplication factor
100	20,0	0,0500

3.2 System boundary

The entire product life cycle and module D is declared. This is a "from cradle to grave with module D"-EPD (modules A+B+C+D).

Table 10: Declared life cycle stages

PRODUCT STAGE			CON-STRUCTION PROCESS STAGE		USE STAGE							END-OF-LIFE STAGE				BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARIES
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
Raw material supply	Transport	Manufacturing	Transport from the gate to the site	Construction, installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction, demolition	Transport	Waste processing	Disposal	Reuse- Recovery- Recycling- potential
x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

X = included in LCA; ND = Not declared

3.2.1 A1-A3 Product Stage:

The cast iron pipes (semi-finished parts) are almost exclusively made of the secondary material steel scrap and a very small proportion of pig iron and return iron from the casting process. The system boundary for the steel scrap is set when the processed steel scrap leaves the recycling plants, because the end of the waste properties of the steel scrap is reached here. This system is blamed for the transportation of the scrap to the TRM plant. The product stage includes the production steps in the plant along with the energy supply (including the upstream chains), the production of raw materials, auxiliary materials and packaging (including transport to the plant), the infrastructure and the disposal of the waste occurring during production. Module A1-A3 also includes the manufacture of the locks and gaskets required for assembling the pipe.

3.2.2 A4-A5 Construction stage:

The cast iron pipe can be installed in various ways. This EPD considers the standard case for installation, i.e. the conventional laying of the pipe:

- Excavation of trench
- Bedding of the pipe
- Backfilling with suitable material

The protective caps, squared lumber and binding tapes needed for transport are thermally recycled.

3.2.3 B1-B7 Use stage:

Generally, construction products made of ductile cast iron show no impact on the LCA during the use stage.

3.2.4 C1-C4 End-of-life stage:

In inner-city areas, the main area of application for the pipe systems, the installed pipes are currently almost entirely removed. For this reason, a 100% removal rate is applied as a scenario.

The removed pipes are sent to a recycling process and are considered until the end-of-waste state according to EN 15804 in the current product system. The system boundary is therefore set when the processed steel scrap leaves the recycling plants.

As a recycling scenario, due to the robustness of the pipe systems, it is assumed that 97% of the removed pipes are suitable for the recycling process and 3% have to be sent to landfill due to breakage, etc. The recycling scenario applied is a manufacturer's scenario based on the experience of Tiroler Rohre GmbH, which must be checked and adapted accordingly in each individual use case.

3.2.5 D Benefits and loads:

Due to the recycling of the removed pipes, there is a corresponding output of secondary raw materials in C3. The output flows are compared with the scrap share in the production of the cast iron pipes in accordance with the net flow rule according to EN 15804 and the net output flow is determined. The recycling and net flow scenario applied is a manufacturer's scenario based on the experience of Tiroler Rohre GmbH, which must be checked and adapted accordingly in each individual use case.

3.3 Flow chart of processes/stages in the life cycle

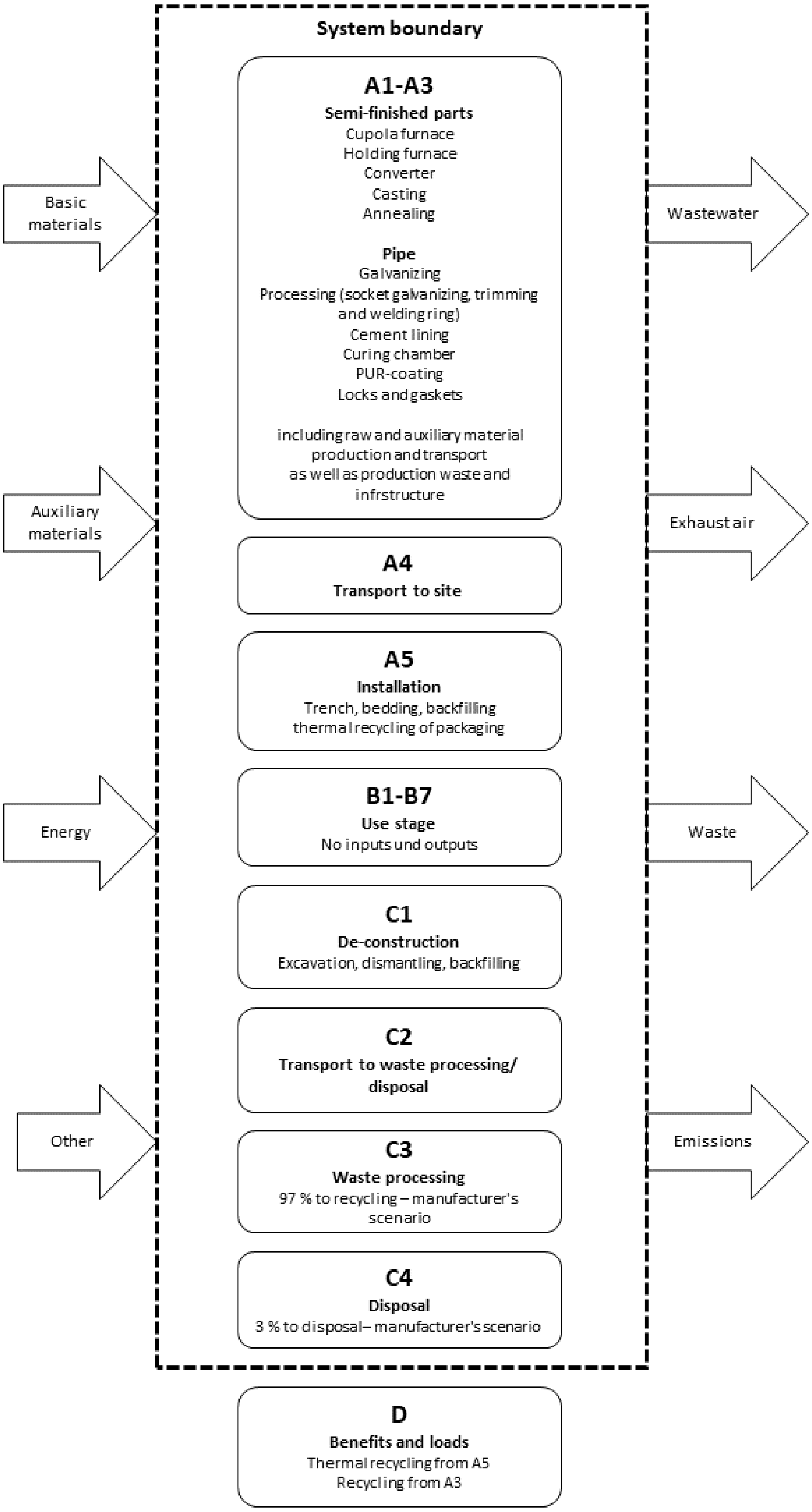


Figure 4: Life cycle flow chart

3.4 Estimations and assumptions

The SiC pellets used in casting production consist of various silicon components, Portland cement and water. In ecoinvent 3.10 there is only one data set for silicon carbide, which is typical of wafer production and has a very high SiC purity compared to the SiC component mixture used in casting production and therefore also a high energy intensity (information from the manufacturer of the pellets). According to the manufacturer of the SiC pellets, the energy required to produce the SiC components or silicon carbide is reflected in the respective prices per tonne. This allows an adjustment of the SiC purity (correction factor) of the data set available in ecoinvent based on an economic comparison (i.e. in the style of an economic allocation).

Cast steel is a special steel with no available data set. As the input is below 1 kg per t of ductile cast iron, the ecoinvent data set for chrome steel was applied.

For magnesium, which mainly comes from China, the global data set for magnesium was used ("market"-data set).

Since the infrastructure only makes a very small contribution to environmental impact, the machinery was modelled with its main components steel and casting.

For the use stage, it was assumed that no LCA-relevant material and energy flows occur.

All transport distances, with the exception of magnesium, were collected by the customer and taken into account in the LCA. For magnesium, the average transports are taken into account by the application of the global "market"-data set (which includes transport processes for the market under consideration).

3.5 Cut-off criteria

The producer calculated and submitted the amount of all applied materials, energy needed, the packaging material, the arising waste material and the way of disposal and the necessary infrastructure (buildings and machinery for the production). The measurement values for emissions according to the casting regulations were specified.

Auxiliary materials whose material flow is less than 1% were ignored as insignificant. Internal transport was negligible due to the short transport distances. It can be assumed that the total of insignificant processes is less than 5% of the impact categories.

During the production of the ductile pipes, slag (from cupola furnace) and coke dust are produced as by-products. Part of the waste heat is sold as district heating. However, these by-products contribute less than 1% to the operational income and can therefore be ignored according to the Management-System-Handbook (MS-HB) of the Bau EPD GmbH (MS-HB Version 6.0.0 dated 06.11.2024). The system limit for these two recyclable materials is set when they are collected from the plant by the future user.

The materials resulting from the production of semi-finished parts – foundry debris, fly-ash, filter cake from cupola furnace dust extraction and converter slag – are taken to a recycling plant for processing, whereby the system limit is set when the substances arrive at this plant, because no detailed information is available on the further treatment processes and the influence on the results of the impact categories is classified as negligible.

In C3, the recycling of the pipes (97%), i.e. the processing of the removed pipes in a recycling plant into a secondary raw material that can be used in cast iron and steel production, is taken into account. For this purpose, it is assumed that the pipe (including CML, etc.) is sent as a whole to the recycling plant, where any materials that cannot be used for cast iron and steel production are separated out. The treatment of these separated materials is excluded due to the expected minor influence.

3.6 Allocation

The system boundary for the steel scrap is set when the processed steel scrap leaves the recycling plants, because the end of the waste staus of the steel scrap is reached here. This system is blamed for the transportation of the scrap to the TRM plant.

In the liquid iron sector, an allocation by mass based on stock additions was carried out between the pipes considered in this EPD and the products not considered. The same applies to waste.

During the production of the ductile pipes, slag and coke dust are produced as by-products. Part of the waste heat is sold as district heating. However, these by-products contribute less than 1% to the operational income and can therefore be ignored according to the "Management-System-Handbook (MS-HB) of the Bau EPD GmbH (MS-HB Version 6.0.0 dated 06.11.2024).

For the annealing, the energy used was allocated according to the dwell times in the furnace.

Due to the recycling of the removed pipes, there is a corresponding output of secondary raw materials in C3. The output flows are compared with the scrap share in the production of the cast iron pipes in accordance with the net flow rule according to EN 15804 and the net output flow is determined.

3.7 Comparability

In principle, a comparison or evaluation of EPD data is only possible if all data sets to be compared have been created in accordance with EN 15804, the same programme-specific PCR/any additional rules and the same background database have been used, and the building context/product-specific performance characteristics are also taken into account.

4 LCA: Scenarios and additional technical information

4.1 A1-A3 Product stage

According to OENORM EN 15804, no technical scenario details are required for A1-A3 as the producer is responsible for the accounting of these modules, and this must not be changed by the user of the LCA.

Data collection for the product stage was carried out according to ISO 14044 Section 4.3.2. In accordance with the target definition, all relevant input and output flows that occur in connection with the product under consideration were identified and quantified in the life cycle inventory analysis.

Electricity generation is modelled according to the electricity mix supplied by Tiroler Wasserkraft AG (TIWAG) to Tiroler Rohre GmbH. In 2020, Tiroler Rohre GmbH purchased the TIWAG 2020 supplier mix (Versorgermix) from Tiroler Wasserkraft AG TIWAG (electricity mix contractually secured).

A part of the electricity consumption in the semi-finished parts production takes place at medium voltage level. The remaining electricity consumption takes place at low voltage level, with 5.75% coming from the in-house photovoltaic system.

Since photovoltaic electricity is generally fed into the grid and consumed at low voltage, and Tiroler Rohre GmbH purchases its electricity at medium voltage, the photovoltaic share is deducted when modelling the medium-voltage electricity supplied by TIWAG (see Table 11).

Table 11: Electricity mix

Source	**TIWAG Supplier mix general**	**Medium voltage without photovoltaics**
Hydro power	84,90%	86,32%
Norway	*20,23%*	*20,57%*
Tyrol	*64,67%*	*65,75%*
Wind power	10,37%	10,54%
Solid or liquid biomass	2,02%	2,05%
Photovoltaics	1,64%	0,00%
Biogas	1,05%	1,07%
Other eco-energy	0,02%	0,02%
Sum	**100,00%**	**100,00%**

The GWP total- result for the TIWAG electricity mix used is 57.3 g CO_2 eq/kWh at high voltage level, 60.5 g CO_2 eq/kWh at medium voltage level and 61.6 g CO_2 eq/kWh at low voltage level. The GWP total-result for low-voltage electricity from the photovoltaic system at the TRM plant is 104 g CO_2 eq/kWh.

4.2 A4-A5 Construction process stage

The pipes are transported to their destination by truck. The client provided relevant information on the transports, and based on this, an average transport distance of approximately 470 km was determined.

Table 12 shows the general parameters for describing transportation to the building site.

Table 12: Description of the scenario „Transport to building site (A4)“

Parameters to describe the transport to the building site (A4)	Value	Unit
Average transport distance	471	km
Vehicle type, Commission Directive 2007/37/EC (European Emission Standard)	Euro 6	-
Average fuel consumption, fuel type: Diesel or heavy fuel oil	25,3	l/100 km
Average transport mass	5,79	t
Average capacity utilisation (including empty returns)	85	%
Average gross density of transported products	20,0	kg/m
Volume capacity utilisation factor (factor: =1 or <1 or ≥ 1 for compressed or nested packaged products)	<1	-

Conventional laying was chosen as the installation method for the EPD, i.e. excavating a trench, bedding the pipe and backfilling with suitable material. A hydraulic excavator with an engine power of 80 kW, a scoop capacity of 0,87 m3 and a weight of 17 t was used for the excavation and backfilling of the pipe trench (including bedding).

Most of the excavation material is temporarily stored and reused for backfilling. However, a certain proportion of the excavation material (varying for the specific nominal diameters depending on the proportion of bedding) must be disposed of at a landfill 20 km away. The additional backfill material required for this is transported from a gravel pit 20 km away.

The spacer rings (PP), protective caps (PE), stacked wood and binding tape (PET) are thermally recycled in a waste incinerator 100 km away.

Table 13: Description of the scenario „Installation of the product in the building (A5)“

Parameters to describe the installation of the product in the building (A5)	Value	Unit
Ancillary materials for installation (specified by material);	Backfill material 132	kg/m
Ancillary materials for installation (specified by type)	Hydraulic excavator	-
Water use	0	m^3/m
Other resource use	0	kg/m
Electricity demand	0	kWh/m
Other energy carrier(s): Diesel	8,1	MJ/m
Wastage of materials on the building site before waste processing, generated by the product's installation (specified by type)	0	kg/m
Output materials (specified by type) as result of waste processing at the building site e.g. of collection for recycling, for energy recovery, disposal (specified by route)	Disposal Excavation: 132 Waste incineration Wood: 0,098 PET: 0,001 PE: 0,014 PP: 0,013	kg/m
Direct emissions to ambient air (such as dust, VOC), soil and water	-	kg/m

4.3 B1-B7 Use stage

In the use stage, no material and energy flows relevant for the life cycle assessment take place for the VRS®-T pipe systems, wherefor no activities were taken into account.

4.4 C1-C4 End-of-Life stage

In inner-city areas, the main area of application for the pipe systems, the installed pipes are currently almost entirely removed. For this reason, a 100% removal rate is used as a scenario. The removed pipes are sent to a recycling process, being considered until the end-of-waste state in the current product system. The system limit is set when the processed steel scrap leaves the recycling plants. From this point on, the pipe is part of a new product system. As a recycling scenario it is assumed that 97% of the pipes are suitable for the recycling process and 3% have to be sent to disposal.

The pipes are removed with the same excavator that was used for the installation. The excavation volume for the removal corresponds to volume for the installation. The existing excavation material is reinstalled, but must be supplemented with additional backfill material (different for the specific DN). The distance to the gravel pit is estimated at 20 km.

Table 14: Description of the scenario "Dismantling (C1)"

Parameters to describe the dismantling (C1)	Value	Unit
Auxiliary materials for the dismantling	Backfill material 24,2	kg/m
Aids for the demolition	Hydraulic excavator	-
Water consumption	0	m^3/m
Other resource use	0	kg/m
Electricity consumption	0	kWh/m
Other energy carrier: Diesel	8,1	MJ/m
Material loss on the construction site before waste treatment, caused by the installation of the product	0	kg/m
Output materials due to waste treatment on the construction site, e.g. collection for recycling, for energy recovery or for disposal	0	kg/m
Direct emissions to ambient air (e.g. dust, VOC), soil and water	-	kg/m

The transport distance to the nearest recycling company (97% of the pipes) as well as to the nearest inert material landfill (3% of the pipes) or waste incineration plant (gaskets) was assumed to be 100 km.

Table 15: Description of the scenario "Transport for disposal (C2)"

Parameters to describe the transport for disposal (C2)	Value	Unit
Average transport distance	100	km
vehicle type, Commission Directive 2007/37/EC (European Emission Standard)	Euro 6	-
Average fuel consumption, fuel type: Diesel or heavy fuel oil	25,3	l/100 km
Average transport mass	5,79	t
Average capacity utilisation (including empty returns)	85	%
Average gross density of transported products	20,0	kg/m
Volume capacity utilisation factor (factor: =1 or <1 or ≥ 1 for compressed or nested package products)	<1	-

In C3, the recycling of the pipes (97%), i.e. the processing of the removed pipes in a recycling plant into a secondary raw material that can be used in cast iron and steel production, is taken into account. For this purpose, it is assumed that the pipe (including CML, etc.) is sent as a whole to the recycling plant, where any materials that cannot be used for cast iron and steel production are separated out. The treatment of these separated out materials is excluded due to the expected minor influence. A new product system begins with the transport of the processed scrap from the recycling plant to the production plant.

In C4, the disposal of 3% of the pipe mass in an inert material landfill and the disposal of the EPDM gasket material in a waste incinerator are considered. A 100% recycling rate is applied for the removed bolts, which are made of pure cast material.

Table 16: Disposal processes (C3 and C4) per m of pipe

DN	Mass per metre of pipe	Total pipe mass for recycling (97%)	Total pipe mass for disposal (3%)	Lock mass for recycling (100%)	Total mass (pipe and Lock) for recycling	Gasket mass for waste incineration
[mm]	*[kg/m]*	*[kg/m]*	*[kg/m]*	*[kg/m]*	*[kg/m]*	*[kg/m]*
100	20,00	19,400	0,600	0,092	19,492	0,0426

Table 17: Description of the scenario „Disposal of the product (C1 to C4)"

Parameters for end-of-life stage (C1-C4)	Value	Unit
Collection process, separately	see Table 16	kg collected separately
Recycling	see Table 16	kg for recycling
Disposal, inert material landfill	see Table 16	kg material for final deposition

4.5 D Potential of reuse and recycling

Due to the recycling of the removed pipes (97%), there is a corresponding output of secondary raw materials (D from C3). Due to the net flow rule according to EN 15804 and the high proportion of scrap in the production of cast iron pipes (988 kg per tonne of cast semi-finished part), there is a slightly negative net output flow here.

Table 18: Description of the scenario „re-use, recovery and recycling potential (module D)"

Parameters for module D	Value	Unit
Materials for reuse, recovery or recycling from A4-A5	-	%
Energy recovery or secondary fuels from A4-A5	Waste incineration Wood: 0,098 PP: 0,001 PE: 0,014 PET: 0,013	kg/m
Materials for reuse, recovery or recycling from B2-B5	-	%
Energy recovery or secondary fuels from B2-B5	-	kg/m
Materials for reuse, recovery or recycling from C1-C4	97	%
Energy recovery or secondary fuels from C1-C4	Waste incineration Gasket: 0,0426	kg/m

Due to the multi-recycling potential of the pipes, they could again replace primary raw materials in the next product system. In this EPD, the multi-recycling potential is not shown as a life cycle assessment result (in the results tables) but as additional information (Appendix 1), because this value does not comply with the rules and specifications of EN 15804 (net flow rule). The additional information on multi-recycling potential is based on a manufacturer scenario based on the experience of Tiroler Rohre GmbH.

5 Information on data quality and data selection in accordance with EN 15941

5.1 Principles for the description of data quality

The following information on data quality is provided in accordance with the requirements of EN 15941 (EN 15941, section 7.3.4).

The data fulfils the following quality requirements:

The data is representative for the production year 2020 (annual average). The production year 2020 is considered based on the existing data for ductile cast iron production (semi-finished part production) of the EPD for ductile piles from Tiroler Rohre GmbH (published 2022).

For the data collection, generic data and the cut-off of material and energy flows the criteria of the Bau EPD GmbH were considered.

The manufacturer provided all essential data such as energy and raw material consumption, transport distances and vehicles as well as packaging within the system boundaries.

The applied background database ecoinvent 3.10 was published in 2024, but contains individual data sets whose collection or reference year dates back more than 10 years (requirement EN 15804 or Bau EPD GmbH). These data sets remained in the various ecoinvent database versions through the years, taking necessary adjustments for database updates into account. Nevertheless, these data sets are subject to a corresponding potential for fluctuation because some of the (technological) developments of recent years are not reflected.

The data is plausible, i.e. the deviations from comparable results are within a plausible range.

5.2 Description of the temporal, geographical and technological representativeness of the product data

Temporal representativeness:

- The data collection period corresponds to the year 2020. All specific data are from this year.
- There is no deviation from the reporting year 2020 in the collection of specific data.
- The applied background database ecoinvent 3.10 was published in 2024, but contains individual data sets whose collection or reference year dates back more than 10 years (requirement EN 15804 or Bau EPD GmbH).

Geographical representativeness:

- VRS®-T pipe systems are manufactured exclusively at the plant in Hall in Tirol. In the production year 2020, almost 50% of the products were delivered within Austria and a total of approx. 90% within Europe (with a focus on Germany and Italy in addition to Austria).
- The pipe systems are disposed of in an area close to where they were used.

Technological representativeness:

- The production technology at the plant in Hall in Tyrol is state-of-the-art. The facilities are regularly maintained and modernised.
- In addition to cast iron pipe systems, other products such as ductile piles (pure cast iron product corresponds to semi-finished parts) are also manufactured at the analysed plant.

Geographical and technological representativeness for EPDs covering an industry:

- Not relevant for this EPD.

5.3 Explanation of the averaging process

Not relevant for this EPD, as specific products from the plant in Hall in Tyrol of the Tiroler Rohre GmbH are considered.

5.4 Assessment of the data quality of the Life Cycle Inventory data

The validity (database/source, country/region, reference year, publication/update) and the geographical, technical and temporal representativeness (according to ÖNORM EN 15804 Annex E - Table E.1) of all data sets used are assessed in the project report for this EPD.

The manufacturer provided all essential data such as energy and raw material consumption, transport distances and vehicles, and packaging within the system boundaries (quality management system and SAP system).

6 LCA: results

Table 19: Parameters to describe the environmental impact per metre [m] VRS®-T DN 100

Parameters	Unit	A1-A3	A4	A5	B1-B7	C1	C2	C3	C4	C1-C4	A-C	D
GWP total	kg CO_2 eq	1,97E+01	1,82E+00	4,23E+00	0,00E+00	1,15E+00	3,83E-01	5,03E-01	1,38E-01	2,18E+00	2,79E+01	4,03E-01
GWP fossil fuels	kg CO_2 eq	1,98E+01	1,81E+00	4,08E+00	0,00E+00	1,15E+00	3,82E-01	5,09E-01	1,38E-01	2,18E+00	2,79E+01	4,05E-01
GWP biogenic	kg CO_2 eq	-8,67E-02	1,26E-03	1,47E-01	0,00E+00	6,75E-04	2,65E-04	-6,61E-03	1,69E-05	-5,65E-03	5,60E-02	-1,89E-03
GWP luluc	kg CO_2 eq	1,37E-02	6,02E-04	2,08E-03	0,00E+00	3,30E-04	1,27E-04	7,19E-04	2,51E-06	1,18E-03	1,76E-02	4,00E-05
ODP	kg CFC-11 eq	2,85E-07	3,61E-08	6,73E-08	0,00E+00	1,63E-08	7,61E-09	7,01E-09	1,49E-10	3,10E-08	4,19E-07	4,00E-10
AP	mol H^+ eq	5,10E-02	3,78E-03	2,35E-02	0,00E+00	9,03E-03	7,97E-04	5,60E-03	4,52E-05	1,55E-02	9,38E-02	1,48E-03
EP freshwater	kg P eq	6,77E-03	1,23E-04	5,92E-04	0,00E+00	1,09E-04	2,59E-05	2,91E-04	6,61E-07	4,26E-04	7,91E-03	1,75E-04
EP marine	kg N eq	1,31E-02	9,07E-04	8,09E-03	0,00E+00	3,80E-03	1,91E-04	1,30E-03	1,76E-05	5,31E-03	2,74E-02	3,56E-04
EP terrestrial	mol N eq	1,35E-01	9,79E-03	9,05E-02	0,00E+00	4,20E-02	2,06E-03	1,46E-02	1,91E-04	5,89E-02	2,94E-01	3,86E-03
POCP	kg NMVOC eq	4,58E-02	6,28E-03	2,98E-02	0,00E+00	1,26E-02	1,32E-03	4,38E-03	6,05E-05	1,84E-02	1,00E-01	1,28E-03
ADPE	kg Sb eq	3,33E-04	5,90E-06	1,19E-05	0,00E+00	1,88E-06	1,24E-06	3,14E-05	1,12E-08	3,45E-05	3,85E-04	1,95E-07
ADPF	MJ H_u	1,27E+02	2,12E+00	1,19E+01	0,00E+00	2,20E+00	4,47E-01	2,20E+00	9,54E-03	4,86E+00	1,46E+02	3,98E+00
WDP	m3 World eq	5,28E+00	1,06E-01	2,92E+00	0,00E+00	3,86E-01	2,23E-02	8,53E-02	3,64E-03	4,97E-01	8,80E+00	2,30E-02
Legend		GWP = Global warming potential; luluc = land use and land use change; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential, Accumulated Exceedance; EP = Eutrophication potential; POCP = Formation potential of tropospheric ozone photochemical oxidants; ADPE = Abiotic depletion potential for non-fossil resources; ADPF = Abiotic depletion potential for fossil resources WDP = Water (user) deprivation potential, deprivation-weighted water consumption										

Table 20: Additional environmental impact indicators per metre [m] VRS®-T DN 100

Parameters	Unit	A1-A3	A4	A5	B1-B7	C1	C2	C3	C4	C1-C4	A-C	D
PM	Occurrence of diseases	2,20E-06	1,34E-07	5,39E-07	0,00E+00	2,37E-07	2,82E-08	7,83E-08	6,99E-10	3,45E-07	3,21E-06	3,20E-08
IRP	kBq U235 eq	9,32E-01	3,31E-02	1,68E-01	0,00E+00	3,06E-02	6,98E-03	5,14E-02	1,34E-04	8,91E-02	1,22E+00	1,08E-04
ETP-fw	CTUe	2,31E+02	6,94E+00	1,55E+01	0,00E+00	3,21E+00	1,46E+00	4,95E+00	2,38E-01	9,86E+00	2,63E+02	4,25E+01
HTP-c	CTUh	2,09E-07	1,29E-08	2,63E-08	0,00E+00	6,06E-09	2,71E-09	4,41E-09	3,06E-11	1,32E-08	2,62E-07	1,62E-07
HTP-nc	CTUh	2,04E-07	1,60E-08	2,45E-08	0,00E+00	4,07E-09	3,38E-09	2,72E-08	5,40E-11	3,48E-08	2,79E-07	1,40E-09
SQP	dimensionless	6,91E+01	1,54E+01	6,41E+01	0,00E+00	4,27E+00	3,25E+00	1,22E+01	1,87E-01	1,99E+01	1,69E+02	8,80E-01
Legend		PM = Potential incidence of disease due to Particulate Matter emissions; IRP = Potential Human exposure efficiency relative to U235; ETP-fw = Potential Comparative Toxic Unit for ecosystems; HTP-c = Potential Comparative Toxic Unit for humans – cancer effect; HTP-nc = Potential Comparative Toxic Unit for humans – non-cancer effect; SQP = Potential soil quality index										

Table 21: Parameters to describe the use of resources per metre [m] VRS®-T DN 100

Parameters	Unit	A1-A3	A4	A5	B1-B7	C1	C2	C3	C4	C1-C4	A-C	D
PERE	MJ H_u	3,31E+01	4,38E-01	3,30E+00	0,00E+00	3,82E-01	9,24E-02	1,12E+00	1,96E-03	1,59E+00	3,85E+01	4,20E-02
PERM	MJ H_u	1,20E+00	0,00E+00	-1,20E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PERT	MJ H_u	3,43E+01	4,38E-01	2,11E+00	0,00E+00	3,82E-01	9,24E-02	1,12E+00	1,96E-03	1,59E+00	3,85E+01	4,20E-02
PENRE	MJ H_u	1,26E+02	2,12E+00	1,30E+01	0,00E+00	2,20E+00	4,47E-01	2,21E+00	9,55E-03	4,86E+00	1,46E+02	3,98E+00
PENRM	MJ H_u	1,06E+00	0,00E+00	-1,06E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PENRT	MJ H_u	1,27E+02	2,12E+00	1,19E+01	0,00E+00	2,20E+00	4,47E-01	2,21E+00	9,55E-03	4,86E+00	1,46E+02	3,98E+00
SM	kg	1,58E+01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,58E+01	-2,84E-01
RSF	MJ H_u	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
NRSF	MJ H_u	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
FW	m^3	2,03E-01	3,53E-03	7,17E-02	0,00E+00	9,72E-03	7,45E-04	3,36E-03	2,25E-04	1,40E-02	2,92E-01	5,93E-04
Legend	PERE = Renewable primary energy as energy carrier; PERM = Renewable primary energy resources as material utilization; PERT = Total use of renewable primary energy resources; PENRE = Non-renewable primary energy as energy carrier; PENRM = Non-renewable primary energy as material utilization; PENRT = Total use of non-renewable primary energy resources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of fresh water											

Table 22: Parameters describing LCA-output flows and waste categories per metre [m] VRS®-T DN 100

Parameters	Unit	A1-A3	A4	A5	B1-B7	C1	C2	C3	C4	C1-C4	A-C	D
HWD	kg	2,90E-03	1,72E-04	3,64E-04	0,00E+00	9,44E-05	3,62E-05	4,20E-05	9,41E-07	1,74E-04	3,61E-03	5,08E-05
NHWD	kg	1,61E+00	1,23E+00	1,33E+02	0,00E+00	1,09E-01	2,60E-01	1,79E-01	6,03E-01	1,15E+00	1,37E+02	1,03E-02
RWD	kg	4,32E-04	1,50E-05	7,38E-05	0,00E+00	1,34E-05	3,15E-06	2,40E-05	6,18E-08	4,06E-05	5,61E-04	1,25E-07
CRU	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
MFR	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,55E+01	0,00E+00	1,55E+01	1,55E+01	0,00E+00
MER	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
EEE	MJ	0,00E+00	0,00E+00	1,41E-01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,41E-01	0,00E+00
EET	MJ	0,00E+00	0,00E+00	1,24E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,24E+00	0,00E+00
Legend	HWD = Hazardous waste disposed; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed; CRU = Components for re-use; MFR = Materials for recycling; MER = Materials for energy recovery; EEE = Exported electric energy; EET = Exported thermal energy											

Table 23: Information describing the biogenic carbon content at the factory gate per metre [m] VRS®-T DN 100

Biogenic carbon content	Unit	A1-A3
Biogenic carbon content in product	kg C	0,00E+00
Biogenic carbon content in accompanying packaging	kg C	4,02E-02
NOTE: 1 kg biogenic carbon is equivalent to 44/12 kg of CO_2		

Table 24 presents disclaimers which shall be declared in the project report and in the EPD with regard to the declaration of relevant core and additional environmental impact indicators according to the following classification. That can be declared in a footnote in the EPD.

Table 24: Classification of disclaimers to the declaration of core and additional environmental impact indicators

ILCD-classification	Indicator	disclaimer
ILCD-Type 1	Global warming potential (GWP)	none
	Depletion potential of the stratospheric ozone layer (ODP)	none
	Potential incidence of disease due to PM emissions (PM)	none
ILCD-Type 2	Acidification potential, Accumulated Exceedance (AP)	none
	Eutrophication potential, Fraction of nutrients reaching freshwater end compartment (EP-freshwater)	none
	Eutrophication potential, Fraction of nutrients reaching marine end compartment (EP-marine)	none
	Eutrophication potential, Accumulated Exceedance (EP-terrestrial)	none
	Formation potential of tropospheric ozone (POCP)	none
	Potential Human exposure efficiency relative to U235 (IRP)	1
ILCD-Type 3	Abiotic depletion potential for non-fossil resources (ADP-minerals&metals)	2
	Abiotic depletion potential for fossil resources (ADP-fossil)	2
	Water (user) deprivation potential, deprivation-weighted water consumption (WDP)	2
	Potential Comparative Toxic Unit for ecosystems (ETP-fw)	2
	Potential Comparative Toxic Unit for humans (HTP-c)	2
	Potential Comparative Toxic Unit for humans (HTP-nc)	2
	Potential Soil quality index (SQP)	2
Disclaimer 1 – This impact category deals mainly with the eventual impact of low dose ionizing radiation on human health of the nuclear fuel cycle. It does not consider effects due to possible nuclear accidents, occupational exposure nor due to radioactive waste disposal in underground facilities. Potential ionizing radiation from the soil, from radon and from some construction materials is also not measured by this indicator.		
Disclaimer 2 – The results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experienced with the indicator.		

7 LCA: Interpretation

It should be noted that the impact assessment results are only relative statements that do not include any statements about "end-points" of the impact categories, exceeding of thresholds or risks.

Since the definition of basic materials (those substances that remain in the product) and auxiliary materials (those substances that do not remain in the product) are not applicable for this product, because small percentages of the energy source coke and the input materials ferrosilicon and silicon carbide remain in the product, a breakdown into A1-A3 was not carried out.

Figure 5 shows a dominance analysis of the percentage shares of modules A1-A3 (production), A4 (transport to construction site), A5 (installation), C1 (removal), C2 (transport) and C4 (waste treatment). The pipe production is the main contributor to all impact categories (except NHWD). The next largest impacts are the installation (A5) and the removal (C1) of the pipes and the transport to the construction site (A4).

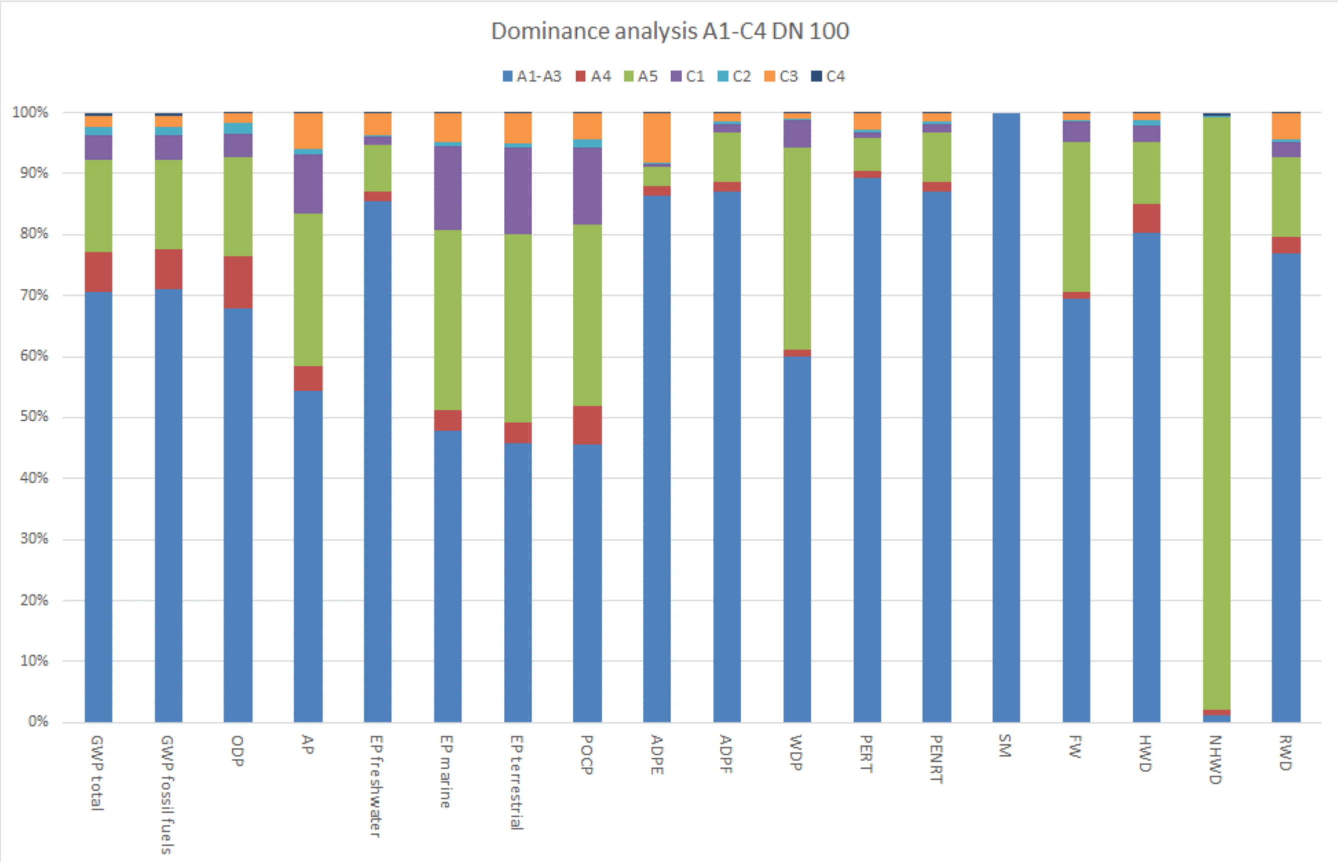


Figure 5: Dominance analysis DN 100

In the production phase (A1-A3), cast iron production has the greatest impact in terms of core indicators, with some impacts exceeding 80%. For individual indicators, galvanising has a high impact (e.g. ADPE >80%).

For the cast iron production, the cupola furnace, the annealing process and the converter have the greatest impact on the core indicators (together >90% in some cases). In the cupola furnace, CO_2 emissions from fuel use, SiC pellets and foundry coke have the greatest impact. The impact of the annealing process is determined by the natural gas used. In the converter, the magnesium and ferrosilicon applied have the greatest impact on the core indicators (in some cases >95%).

Pipe galvanisation is mainly dominated by the zinc applied (in some cases >99%).

The installation of the pipes (A5) is determined by the bedding material, the transport of the bedding material and the diesel consumption of the hydraulic excavator.

In C3, the upstream chain (wood input in the production of the scrap processing plant) of the data set used for recycling, "Iron scrap, sorted, pressed {RER}| sorting and pressing of iron scrap | Cut-off, U", causes a slightly negative value for GWP biogenic.

8 Literature

ÖNORM EN ISO 14025: 2010 Environmental labels and declarations — Type III environmental declarations — Principles and procedures

ÖNORM EN ISO 14040: 2021 Environmental management — Life cycle assessment — Principles and framework

ÖNORM EN ISO 14044: 2021 Environmental management — Life cycle assessment — Requirements and guidelines

ÖNORM 15804:2012+A2:2019+AC:2021 Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products

Bau EPD GmbH: Product category rules for building related products and services - Requirements on the EPD for cast iron products, PCR-Code 2.16.8, Version 12.0, dated 10.10.2024. Bau EPD Österreich, Vienna, 2024

Bau EPD GmbH: Management system handbook (EPD-MS-HB) of the EPD program, Version 6.0.0, dated 06.11.2024. Bau EPD Österreich, Vienna, 2024

9 Directory and Glossary

9.1 List of figures

9.2 List of tables

9.3 Abbreviations

9.3.1 Abbreviations as per EN 15804

EPD	environmental product declaration
PCR	product category rules
LCA	life cycle assessment
LCI	life cycle inventory analysis
LCIA	life cycle impact assessment
RSL	reference service life
ESL	estimated service life
EPBD	Energy Performance of Buildings Directive
GWP	global warming potential
ODP	depletion potential of the stratospheric ozone layer
AP	acidification potential of soil and water
EP	eutrophication potential
POCP	formation potential of tropospheric ozone
ADP	abiotic depletion potential

9.3.2 Abbreviations as per corresponding PCR

CE-mark	french: Communauté Européenne or Conformité Européenne = EC certificate of conformity
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals

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EPD - ENVIRONMENTAL PRODUCT DECLARATION

as per ISO 14025 and EN 15804+A2

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HOLDER OF THE DECLARATION	Tiroler Rohre GmbH
DECLARATION NUMBER	Bau EPD-TRM-2025-3-ECOINVENT-VRS-T-DN125
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VALID TO	10.08.2030
NUMBER OF DATASETS	1
ENERGY MIX APPROACH	MARKET BASED APPROACH

VRS®-T ductile cast iron pipe system – DN 125
Tiroler Rohre GmbH

Content of the EPD

1 General information

Product name
VRS®-T ductile cast iron pipe system DN 125

Declaration number
Bau EPD-TRM-2025-3-ECOINVENT-VRS-T-DN125

Declaration data
☒ Specific data
☐ Average data

Declaration based on
MS-HB Version 6.0.0 dated 06.11.2024
Name of PCR: Cast iron products
PCR-Code 2.16.8, Version 12.0 dated 10.10.2024
(PCR tested and approved by the independent expert committee = PKR-Gremium)
Version of EPD-Format-Template M-Dok 14A2 dated 11.06.2024

The owner of the declaration is liable for the underlying information and evidence; Bau EPD GmbH is not liable with respect to manufacturer information, life cycle assessment data and evidence.

Declared Product / Declared Unit
1 m ductile cast iron pipe of the VRS®-T system DN 125 with Portland composite cement lining and zinc coating with PUR long-life coating with the nominal dimensions:

Table 1: Nominal dimensions

Nominal diameter [mm]	Longitudinally related mass [kg/m]
125	25,6

Number of datasets in EPD Document: 1

Range of validity
The EPD applies to the nominal diameter DN 125 of the VRS®-T ductile cast iron pipe system with the above-mentioned lining and duplex outer coating (zinc coating with PUR long-life coating) from the Hall in Tyrol plant of Tiroler Rohre GmbH (TRM).
The EPD and the production technologies assessed are representative for the production of pipes with a nominal diameter DN 125 at the Hall in Tyrol plant of Tiroler Rohre GmbH (TRM).

Type of Declaration as per EN 15804
From cradle to grave with module D (modules A+B+C+D)
LCA method: Cut-off by classification

Database, Software, Version
Ecoinvent 3.10, SimaPro 9.6.0.1
Version Characterisation Factors: Joint Research Center, EF 3.1

Author of the Life Cycle Assessment
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The CEN standard EN 15804:2012+A2:2019+AC:2021 serves as the core-PCR.
Independent verification of the declaration according to ISO 14025:2010
☐ internally ☒ externally
Verifier 1: Dipl.-Ing. Therese Daxner M.sc.
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Note: EPDs from similar product groups from different programme operators might not be comparable.

2 Product

2.1 2.1 General product description

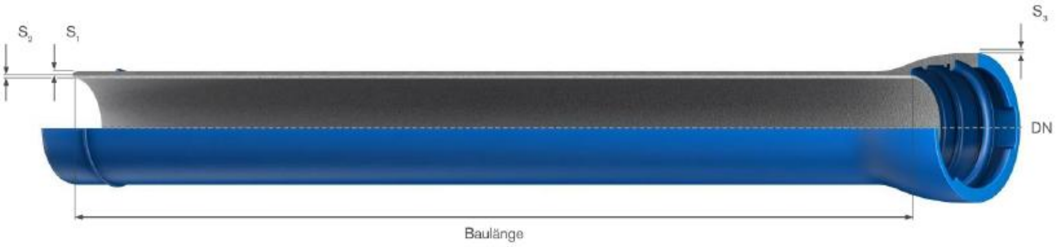
The declared product is a ductile cast iron pipe of the VRS®-T system (restrained locking system) with cement mortar lining (CML) and zinc coating with PUR long-life coating with a nominal diameter DN 125 from Tiroler Rohre GmbH (TRM).

The TRM VRS®-T system consists of ductile, centrifugally cast pipes with a spigot end with a welding ring and a socket, which are joined together to form any length of pipe. The VRS®-T joint, consisting of a VRS®-T socket, VRS®-T sealing ring, spigot end with a welding ring and locking elements, is a highly resilient, flexible and restrained locking system. It is quick and easy to install and can be bent up to 5°. No welding and no weld-seam testing is necessary. The joint can be dismantled at any time.

The ductile cast iron pipes are manufactured in lengths of 5 m with nominal diameters from DN 80 to DN 600 and different wall thicknesses. The nominal dimensions of the declared ductile cast iron pipes with a nominal diameter DN 125 as well as the corresponding wall thickness classes, (normative) minimum wall thicknesses and masses per metre of pipe are shown in Table 2. To further illustrate the declared product, Figure 1 and Figure 2 show excerpts from the Tiroler Rohre GmbH product catalogue with technical and geometric specifications and corresponding mass data.

Table 2: VRS®-T ductile cast iron pipes DN 125 – nominal diameter, Wall thickness class, minimum wall thickness, mass per Meter

DN	Wall thickness class (K class)	Minimum wall thickness [mm]	Mass per m of pipe [kg/m]
125	K 10	4,8	25,6



DN	PFA [a] [bar]	Maße [mm]		zul. Zugkraft [kN]	Max. Abwinkelung [°]	Anzahl der Riegel	Gewicht Rohr 5m [kg] [b]
		s_1 Guss	s_2 ZMA				
80	100	4,7	4	115	5	2	81,6
100	75	4,7	4	150	5	2	100,0
125	63	4,8	4	225	5	2	128,2
150	63	4,7	4	240	5	2	157,3
200	40	4,8	4	350	4	2	204,5
250	40	5,2	4	375	4	2	268,9
300	40	5,6	4	380	4	4	339,5
400	30	6,4	5	650	3	4	519,9
500	25/30	7,2/8,2	5	860	3	4	711,8
600	35	8,0	5	1.525	2	9	909,5

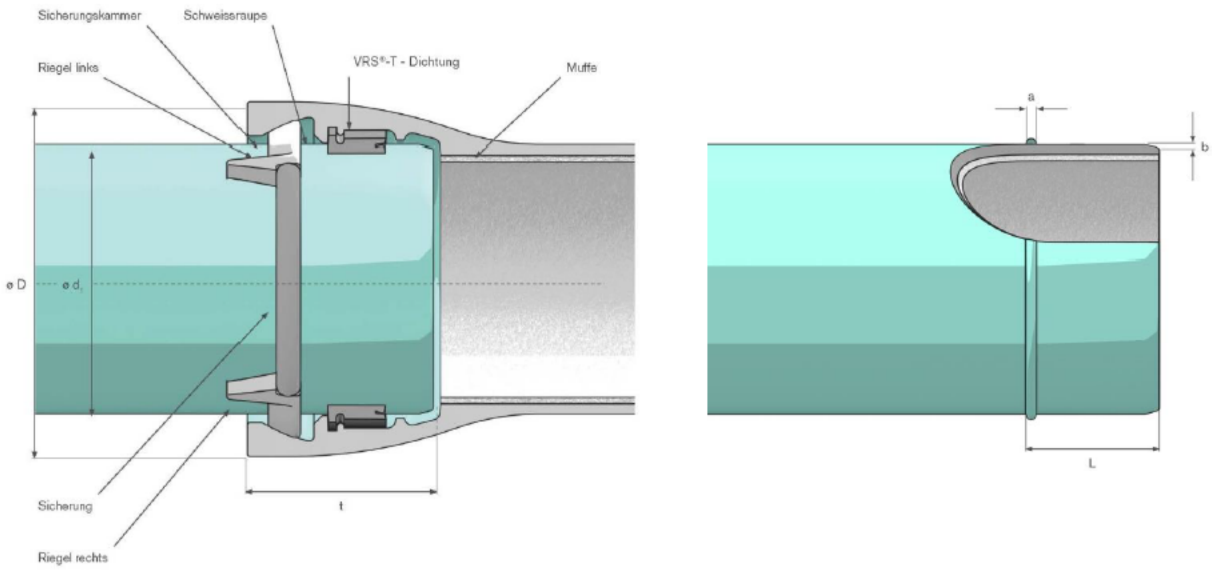
[a] PFA: zulässiger Bauteilbetriebsdruck | PMA = 1,2 x PFA | PEA = 1,2 x PFA + 5 | höhere PFA auf Anfrage | siehe Hinweise zum Einsatz von Klemmringen

[b] theoretische Masse pro Rohr für K9/10, inkl. ZMA, Zink, Deckbeschichtung

[1] Mindestmaß - Toleranzen beachten | [2] Nennmaß - Toleranzen beachten

Figure 1: VRS®-T pipes – technical and geometric specifications

VRS®-T Verbindung DN 80 bis DN 600



DN	Maße [mm] a							
	Durchmesser Spitzende	Abweichungen	Durchmesser Muffe	Einstecktiefe	Schweißraupe		
	d1		D	t	L	a	b
80	98	+1,0 | -2,7	156	127	86 ±4	8 ±2	5 +0,5 | -1
100	118	+1,0 | -2,8	177	135	91 ±4	8 ±2	5 +0,5 | -1
125	144	+1,0 | -2,8	206	143	96 ±4	8 ±2	5 +0,5 | -1
150	170	+1,0 | -2,9	232	150	101 ±4	8 ±2	5 +0,5 | -1
200	222	+1,0 | -3,0	292	160	106 ±4	9 ±2	5,5 +0,5 | -1
250	274	+1,0 | -3,1	352	165	106 ±4	9 ±2	5,5 +0,5 | -1
300	326	+1,0 | -3,3	410	170	106 ±4	9 ±2	5,5 +0,5 | -1
400	429	+1,0 | -3,5	521	190	115 ±5	10 ±2	6 +0,5 | -1
500	532	+1,0 | -3,8	630	200	120 ±5	10 ±2	5 +0,5 | -1
600	635	+1,0 | -4,0	732	175	160 +0 | -2	9 ±1	5 +0,5 | -1

a Toleranzen sind möglich

Figure 2: Schematic illustration of a VRS®-T ductile cast iron pipe

The density of ductile cast iron is 7,050 kg/m³.

2.2 Application field

The VRS®-T cast iron pipe system with Portland composite cement lining is mainly used for drinking water supply and for fire extinguishing pipes, snow-making systems and turbine pipes. The cast iron pipe can be installed using various methods, such as:

- Conventional installation (trench)
- Trenchless installation
- Bridge pipes
- Interim pipes

- Floating

The usual installation method is conventional laying with the excavation of a trench, the creation of a bedding for the pipe and backfilling with suitable material.

2.3 Standards, guidelines and regulations relevant for the product

Table 3: Product specific standards

Regulation	Title
OENORM EN 545	Ductile iron pipes, fittings, accessories and their joints for water pipelines - Requirements and test methods
OENORM B 2599-1	Ductile iron pipes and fittings — Part 1: Use for water pipelines
OENORM B 2597	Ductile cast iron pipes and fittings for water, sewage and gas pipe lines - Restrained push-in-joints - Requirements and tests
OENORM B 2555	Coating of cast iron pipes - Thermal zinc spraying
OENORM B 2560	Ductile iron pipes - Finishing coating of polyurethane, epoxy or acrylic materials - Requirements and test methods
OENORM B 2562	Ductile cast iron pipes - Factory made lining with cement mortar - Requirements and test methods
OENORM EN 681-1	Elastomeric seals - Material requirements for pipe joint seals used in water and drainage applications - Part 1: Vulcanized rubber

2.4 Technical data

Mechanical properties are verified according to OENORM EN 545:2011, sections 6.3 and 6.4.

Table 4: Material parameters for ductile cast iron pipes of the VRS®-T system

Name	Value	Unit
Iron density	7050	kg/m^3
Minimum tensile strength	≥ 420	MPa
Proportional limit, 0.2% yield strength ($R_{p0.2}$)	≥ 300	MPa
Minimum elongation at fracture	≥ 10	%
Maximum Brinell hardness	≤ 230	HB
Pipe length	5000	mm
Mean coefficient of linear thermal expansion	$10*10^{-6}$	m/m*K
Thermal conductivity	0,42	W/cm*K

Table 5: VRS®-T pipes DN 125 – nominal dimension-dependent technical data

DN	Wall thickness class K class	Minimum wall thickness [mm]	Mass per metre of pipe [kg/m]	Allowable operating pressure PFA [bar]	Permissible tensile force [kN]
125	K 10	4,8	25,6	63	225

2.5 Basic/auxiliary materials

Table 6: VRS®-T pipes DN 125 – basic materials in mass %

DN	Casting	Zinc	Cement stone	PUR
125	80,3%	0,7%	18,3%	0,7%

Table 7: Basic materials – casting in mass %

Ingredients:	**Mass %**
Iron [1)]	ca. 94 %
Carbon [2)]	ca. 3,5 %
Silicon [3)]	ca. 2 %
Ferric by-elements [4)]	ca.0,5 %

[1)] Iron consisting mainly of steel scrap and a very small proportion of pig iron and return iron from the casting process

[2)] Foundry coke carbon. The coke in the cupola furnace serves both as an energy supplier for the scrap melting and the adjusting of the desired carbon content

[3)] Silicon is added in the form of SiC pellets and/or ferro-silicon

[4)] Ferric by-elements are found in the steel scrap in different minor quantities (<<1%)

2.6 Production stage

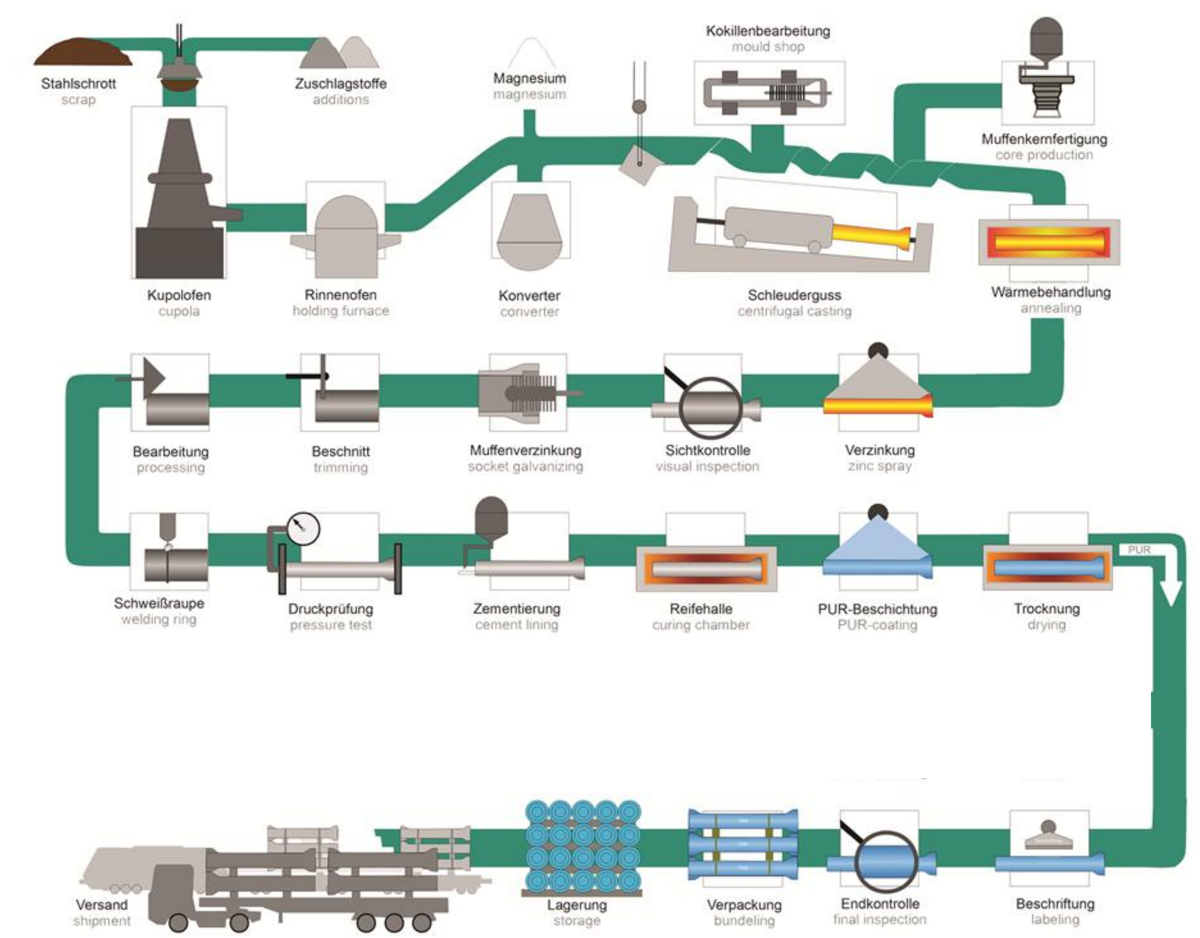


Figure 3: Flow chart of production process

For casting production, steel scrap and recycled material are smelted in the cupola furnace with the help of coke as a reaction and reduction agent. Silicon carbide is added as an alloying element. Added aggregates enhance slagging. The chemical composition of the smelted basic iron is then constantly monitored through spectral analysis. The smelted basic iron is kept warm in the holding furnace, a storage medium, and then treated with magnesium in the Georg Fischer converter, in order to reach the appropriate ductility. The liquid iron is then cast in a centrifuge machine with the De Lavaud procedure. In order to produce a specific pipe diameter, this machine is equipped with the corresponding mould (metal form that the liquid iron is poured into). The socket core made of quartz sand seals the inlet of the machine and forms the pipe socket. The glowing pipe is pulled out of the cast unit and placed in a furnace with the help of an automatic transport system. Here it undergoes annealing in order to achieve the desired mechanical properties.

The pipe is then galvanised using the electric arc spraying process and then cooled. The pipe is visually inspected in the pipe line. The spigot end and socket are machined if necessary. In the area of the welding ring, the zinc and annealing skin (tinder) are ground off and finally the welding ring is applied.

During the pressure test, each pipe is hydrostatically pressurised with a certain internal pressure and checked for leaks. The pipe is then lined with cement mortar using the centrifugal rotation process. The weld seam is galvanised and the pipes are visually inspected again. The cement stone hardens in the curing chamber. Finally, a solvent-free two-component polyurethane top coat is applied. All pipes are labelled according to the specifications, bundled and brought to the warehouse.

2.7 Packaging

The TRM pipes are sealed with protective caps and bundled using squared timber and spacer rings as stacking aid and PET tapes. All packaging materials can be used for thermal recycling.

2.8 Conditions of delivery

The ductile cast iron pipes are bundled for transport and storage with the help of squared lumber and spacer rings as stacking aid as well as PET binding tapes.

2.9 Transport to site

The cast pipes are transported to their destination within Europe by lorry and, in rare cases, overseas by ship.

2.10 Construction product stage

The installation of pressure pipes made of ductile cast iron must comply with OENORM EN 805 (Water supply - Requirements for systems and components outside buildings) and OENORM B 2538 (Additional specifications concerning OENORM EN 805). When constructing the pipe trench, sufficient working space must be provided for the installation of the pipeline, depending on the trench depth and the outer diameter of the pipe. The Ordinance on Protection of Construction Workers (Bauarbeiterschutzverordnung) and other provisions as well as relevant standards and regulations must be complied with accordingly.

As this is a push-in joint, no additional work such as welding is required. The pipe trench must be constructed and excavated in such a way that all pipe sections are at frost-free depths. The trench must be excavated deep enough so that the final cover height is at least 1.50 m. In the case of ductile iron pipes, the existing soil is generally suitable for bedding the pipeline. This means there is no need for a lower bedding layer and the bottom of the trench becomes the lower bedding.

The pipeline must be embedded and the pipe trench refilled in such a way that the pipeline is securely fixed in its intended position and that damage to the pipeline is prevented and settlement can only occur to the permissible extent. Suitable material that does not damage the pipe components and the coating must be used for embedding the pipeline. The backfill material should be installed in layers and sufficiently compacted.

2.11 Use stage

If installed and designed professionally and if the phase of utilisation is not disturbed, no modification of the material composition of construction products made of ductile cast iron occur.

2.12 Reference service life (RSL)

Table 8: Reference service life (RSL)

Name	Value	Unit
Ductile cast iron pipes	50	Years

In practice, it has been shown that a service life of 100 years, based on the DVGW damage statistics (German Technical and Scientific Association for Gas and Water – https://www.dvgw.de/themen/sicherheit/gas-und-wasserstatistik/), is achieved.

2.13 End of life stage

In inner-city areas, the main area of application for the pipe systems, the installed pipes are currently almost entirely removed. These pipes can then be recycled accordingly. These pipes can then be sent to recycling. The removal and recycling rate was therefore set correspondingly high in the scenarios considered (see 4.4 - C1-C4 disposal phase). However, it should be noted that the 100% removal rate is a manufacturer's scenario, which must be checked and adjusted accordingly in each individual use case.

The pipes are disposed of in very rare cases. The EAK waste code number for iron and steel from construction and demolition is 170405.

2.14 Further information

For further information about the TRM pipe system and its possible applications, see the website http://trm.at/rohr.

3 LCA: Calculation rules

3.1 Declared unit/ Functional unit

The functional unit is 1 metre [m] of pipe. For conversion into kg, Table 9 can be used.

Table 9: Conversion factor to mass

Nominal diameter [mm]	Longitudinally related mass [kg/m]	Multiplication factor
125	25,6	0,0391

3.2 System boundary

The entire product life cycle and module D is declared. This is a "from cradle to grave with module D"-EPD (modules A+B+C+D).

Table 10: Declared life cycle stages

PRODUCT STAGE			CON-STRUCTION PROCESS STAGE		USE STAGE							END-OF-LIFE STAGE				BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARIES
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
Raw material supply	Transport	Manufacturing	Transport from the gate to the site	Construction, installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction, demolition	Transport	Waste processing	Disposal	Reuse- Recovery- Recycling- potential
x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

X = included in LCA; ND = Not declared

3.2.1 A1-A3 Product Stage:

The cast iron pipes (semi-finished parts) are almost exclusively made of the secondary material steel scrap and a very small proportion of pig iron and return iron from the casting process. The system boundary for the steel scrap is set when the processed steel scrap leaves the recycling plants, because the end of the waste properties of the steel scrap is reached here. This system is blamed for the transportation of the scrap to the TRM plant. The product stage includes the production steps in the plant along with the energy supply (including the upstream chains), the production of raw materials, auxiliary materials and packaging (including transport to the plant), the infrastructure and the disposal of the waste occurring during production. Module A1-A3 also includes the manufacture of the locks and gaskets required for assembling the pipe.

3.2.2 A4-A5 Construction stage:

The cast iron pipe can be installed in various ways. This EPD considers the standard case for installation, i.e. the conventional laying of the pipe:

- Excavation of trench
- Bedding of the pipe
- Backfilling with suitable material

The protective caps, squared lumber and binding tapes needed for transport are thermally recycled.

3.2.3 B1-B7 Use stage:

Generally, construction products made of ductile cast iron show no impact on the LCA during the use stage.

3.2.4 C1-C4 End-of-life stage:

In inner-city areas, the main area of application for the pipe systems, the installed pipes are currently almost entirely removed. For this reason, a 100% removal rate is applied as a scenario.

The removed pipes are sent to a recycling process and are considered until the end-of-waste state according to EN 15804 in the current product system. The system boundary is therefore set when the processed steel scrap leaves the recycling plants.

As a recycling scenario, due to the robustness of the pipe systems, it is assumed that 97% of the removed pipes are suitable for the recycling process and 3% have to be sent to landfill due to breakage, etc. The recycling scenario applied is a manufacturer's scenario based on the experience of Tiroler Rohre GmbH, which must be checked and adapted accordingly in each individual use case.

3.2.5 D Benefits and loads:

Due to the recycling of the removed pipes, there is a corresponding output of secondary raw materials in C3. The output flows are compared with the scrap share in the production of the cast iron pipes in accordance with the net flow rule according to EN 15804 and the net output flow is determined. The recycling and net flow scenario applied is a manufacturer's scenario based on the experience of Tiroler Rohre GmbH, which must be checked and adapted accordingly in each individual use case.

3.3 Flow chart of processes/stages in the life cycle

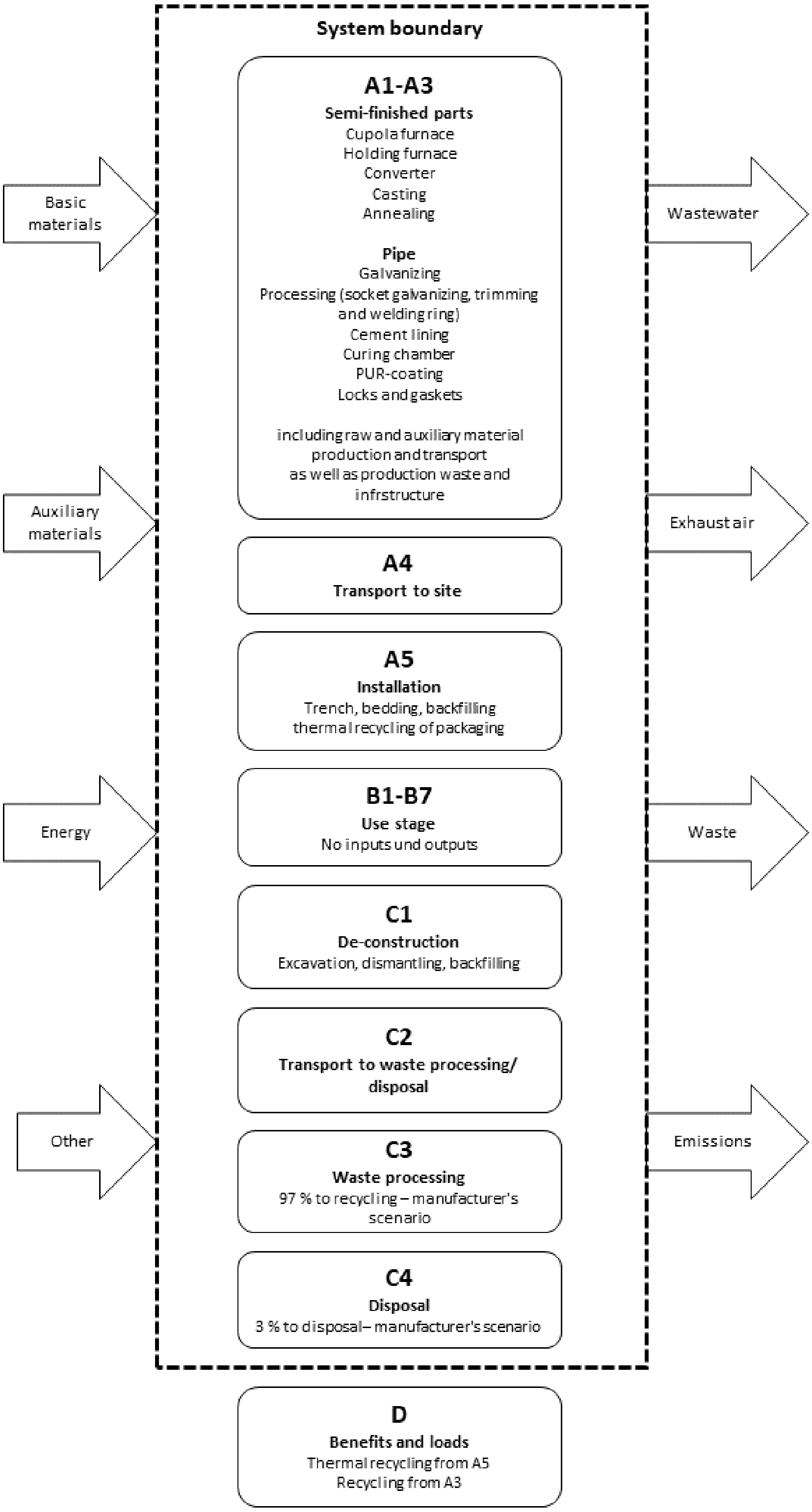


Figure 4: Life cycle flow chart

3.4 Estimations and assumptions

The SiC pellets used in casting production consist of various silicon components, Portland cement and water. In ecoinvent 3.10 there is only one data set for silicon carbide, which is typical of wafer production and has a very high SiC purity compared to the SiC component mixture used in casting production and therefore also a high energy intensity (information from the manufacturer of the pellets). According to the manufacturer of the SiC pellets, the energy required to produce the SiC components or silicon carbide is reflected in the respective prices per tonne. This allows an adjustment of the SiC purity (correction factor) of the data set available in ecoinvent based on an economic comparison (i.e. in the style of an economic allocation).

Cast steel is a special steel with no available data set. As the input is below 1 kg per t of ductile cast iron, the ecoinvent data set for chrome steel was applied.

For magnesium, which mainly comes from China, the global data set for magnesium was used ("market"-data set).

Since the infrastructure only makes a very small contribution to environmental impact, the machinery was modelled with its main components steel and casting.

For the use stage, it was assumed that no LCA-relevant material and energy flows occur.

All transport distances, with the exception of magnesium, were collected by the customer and taken into account in the LCA. For magnesium, the average transports are taken into account by the application of the global "market"-data set (which includes transport processes for the market under consideration).

3.5 Cut-off criteria

The producer calculated and submitted the amount of all applied materials, energy needed, the packaging material, the arising waste material and the way of disposal and the necessary infrastructure (buildings and machinery for the production). The measurement values for emissions according to the casting regulations were specified.

Auxiliary materials whose material flow is less than 1% were ignored as insignificant. Internal transport was negligible due to the short transport distances. It can be assumed that the total of insignificant processes is less than 5% of the impact categories.

During the production of the ductile pipes, slag (from cupola furnace) and coke dust are produced as by-products. Part of the waste heat is sold as district heating. However, these by-products contribute less than 1% to the operational income and can therefore be ignored according to the Management-System-Handbook (MS-HB) of the Bau EPD GmbH (MS-HB Version 6.0.0 dated 06.11.2024). The system limit for these two recyclable materials is set when they are collected from the plant by the future user.

The materials resulting from the production of semi-finished parts – foundry debris, fly-ash, filter cake from cupola furnace dust extraction and converter slag – are taken to a recycling plant for processing, whereby the system limit is set when the substances arrive at this plant, because no detailed information is available on the further treatment processes and the influence on the results of the impact categories is classified as negligible.

In C3, the recycling of the pipes (97%), i.e. the processing of the removed pipes in a recycling plant into a secondary raw material that can be used in cast iron and steel production, is taken into account. For this purpose, it is assumed that the pipe (including CML, etc.) is sent as a whole to the recycling plant, where any materials that cannot be used for cast iron and steel production are separated out. The treatment of these separated materials is excluded due to the expected minor influence.

3.6 Allocation

The system boundary for the steel scrap is set when the processed steel scrap leaves the recycling plants, because the end of the waste staus of the steel scrap is reached here. This system is blamed for the transportation of the scrap to the TRM plant.

In the liquid iron sector, an allocation by mass based on stock additions was carried out between the pipes considered in this EPD and the products not considered. The same applies to waste.

During the production of the ductile pipes, slag and coke dust are produced as by-products. Part of the waste heat is sold as district heating. However, these by-products contribute less than 1% to the operational income and can therefore be ignored according to the "Management-System-Handbook (MS-HB) of the Bau EPD GmbH (MS-HB Version 6.0.0 dated 06.11.2024).

For the annealing, the energy used was allocated according to the dwell times in the furnace.

Due to the recycling of the removed pipes, there is a corresponding output of secondary raw materials in C3. The output flows are compared with the scrap share in the production of the cast iron pipes in accordance with the net flow rule according to EN 15804 and the net output flow is determined.

3.7 Comparability

In principle, a comparison or evaluation of EPD data is only possible if all data sets to be compared have been created in accordance with EN 15804, the same programme-specific PCR/any additional rules and the same background database have been used, and the building context/product-specific performance characteristics are also taken into account.

4 LCA: Scenarios and additional technical information

4.1 A1-A3 Product stage

According to OENORM EN 15804, no technical scenario details are required for A1-A3 as the producer is responsible for the accounting of these modules, and this must not be changed by the user of the LCA.

Data collection for the product stage was carried out according to ISO 14044 Section 4.3.2. In accordance with the target definition, all relevant input and output flows that occur in connection with the product under consideration were identified and quantified in the life cycle inventory analysis.

Electricity generation is modelled according to the electricity mix supplied by Tiroler Wasserkraft AG (TIWAG) to Tiroler Rohre GmbH. In 2020, Tiroler Rohre GmbH purchased the TIWAG 2020 supplier mix (Versorgermix) from Tiroler Wasserkraft AG TIWAG (electricity mix contractually secured).

A part of the electricity consumption in the semi-finished parts production takes place at medium voltage level. The remaining electricity consumption takes place at low voltage level, with 5.75% coming from the in-house photovoltaic system.

Since photovoltaic electricity is generally fed into the grid and consumed at low voltage, and Tiroler Rohre GmbH purchases its electricity at medium voltage, the photovoltaic share is deducted when modelling the medium-voltage electricity supplied by TIWAG (see Table 11).

Table 11: Electricity mix

Source	**TIWAG Supplier mix general**	**Medium voltage without photovoltaics**
Hydro power	84,90%	86,32%
Norway	*20,23%*	*20,57%*
Tyrol	*64,67%*	*65,75%*
Wind power	10,37%	10,54%
Solid or liquid biomass	2,02%	2,05%
Photovoltaics	1,64%	0,00%
Biogas	1,05%	1,07%
Other eco-energy	0,02%	0,02%
Sum	**100,00%**	**100,00%**

The GWP total- result for the TIWAG electricity mix used is 57.3 g CO_2 eq/kWh at high voltage level, 60.5 g CO_2 eq/kWh at medium voltage level and 61.6 g CO_2 eq/kWh at low voltage level. The GWP total-result for low-voltage electricity from the photovoltaic system at the TRM plant is 104 g CO_2 eq/kWh.

4.2 A4-A5 Construction process stage

The pipes are transported to their destination by truck. The client provided relevant information on the transports, and based on this, an average transport distance of approximately 470 km was determined.

Table 12 shows the general parameters for describing transportation to the building site.

Table 12: Description of the scenario „Transport to building site (A4)"

Parameters to describe the transport to the building site (A4)	Value	Unit
Average transport distance	471	km
Vehicle type, Commission Directive 2007/37/EC (European Emission Standard)	Euro 6	-
Average fuel consumption, fuel type: Diesel or heavy fuel oil	25,3	l/100 km
Average transport mass	5,79	t
Average capacity utilisation (including empty returns)	85	%
Average gross density of transported products	25,6	kg/m
Volume capacity utilisation factor (factor: =1 or <1 or ≥ 1 for compressed or nested packaged products)	<1	-

Conventional laying was chosen as the installation method for the EPD, i.e. excavating a trench, bedding the pipe and backfilling with suitable material. A hydraulic excavator with an engine power of 80 kW, a scoop capacity of 0,87 m3 and a weight of 17 t was used for the excavation and backfilling of the pipe trench (including bedding).

Most of the excavation material is temporarily stored and reused for backfilling. However, a certain proportion of the excavation material (varying for the specific nominal diameters depending on the proportion of bedding) must be disposed of at a landfill 20 km away. The additional backfill material required for this is transported from a gravel pit 20 km away.

The spacer rings (PP), protective caps (PE), stacked wood and binding tape (PET) are thermally recycled in a waste incinerator 100 km away.

Table 13: Description of the scenario „Installation of the product in the building (A5)"

Parameters to describe the installation of the product in the building (A5)	Value	Unit
Ancillary materials for installation (specified by material);	Backfill material 155	kg/m
Ancillary materials for installation (specified by type)	Hydraulic excavator	-
Water use	0	m^3/m
Other resource use	0	kg/m
Electricity demand	0	kWh/m
Other energy carrier(s): Diesel	8,2	MJ/m
Wastage of materials on the building site before waste processing, generated by the product's installation (specified by type)	0	kg/m
Output materials (specified by type) as result of waste processing at the building site e.g. of collection for recycling, for energy recovery, disposal (specified by route)	Disposal Excavation: 155 Waste incineration Wood: 0,101 PET: 0,001 PE: 0,019 PP: 0,015	kg/m
Direct emissions to ambient air (such as dust, VOC), soil and water	-	kg/m

4.3 B1-B7 Use stage

In the use stage, no material and energy flows relevant for the life cycle assessment take place for the VRS®-T pipe systems, wherefor no activities were taken into account.

4.4 C1-C4 End-of-Life stage

In inner-city areas, the main area of application for the pipe systems, the installed pipes are currently almost entirely removed. For this reason, a 100% removal rate is used as a scenario. The removed pipes are sent to a recycling process, being considered until the end-of-waste state in the current product system. The system limit is set when the processed steel scrap leaves the recycling plants. From this point on, the pipe is part of a new product system. As a recycling scenario it is assumed that 97% of the pipes are suitable for the recycling process and 3% have to be sent to disposal.

The pipes are removed with the same excavator that was used for the installation. The excavation volume for the removal corresponds to volume for the installation. The existing excavation material is reinstalled, but must be supplemented with additional backfill material (different for the specific DN). The distance to the gravel pit is estimated at 20 km.

Table 14: Description of the scenario "Dismantling (C1)"

Parameters to describe the dismantling (C1)	Value	Unit
Auxiliary materials for the dismantling	Backfill material 36	kg/m
Aids for the demolition	Hydraulic excavator	-
Water consumption	0	m^3/m
Other resource use	0	kg/m
Electricity consumption	0	kWh/m
Other energy carrier: Diesel	8,2	MJ/m
Material loss on the construction site before waste treatment, caused by the installation of the product	0	kg/m
Output materials due to waste treatment on the construction site, e.g. collection for recycling, for energy recovery or for disposal	0	kg/m
Direct emissions to ambient air (e.g. dust, VOC), soil and water	-	kg/m

The transport distance to the nearest recycling company (97% of the pipes) as well as to the nearest inert material landfill (3% of the pipes) or waste incineration plant (gaskets) was assumed to be 100 km.

Table 15: Description of the scenario "Transport for disposal (C2)"

Parameters to describe the transport for disposal (C2)	Value	Unit
Average transport distance	100	km
vehicle type, Commission Directive 2007/37/EC (European Emission Standard)	Euro 6	-
Average fuel consumption, fuel type: Diesel or heavy fuel oil	25,3	l/100 km
Average transport mass	5,79	t
Average capacity utilisation (including empty returns)	85	%
Average gross density of transported products	25,6	kg/m
Volume capacity utilisation factor (factor: =1 or <1 or ≥ 1 for compressed or nested packaged products)	<1	-

In C3, the recycling of the pipes (97%), i.e. the processing of the removed pipes in a recycling plant into a secondary raw material that can be used in cast iron and steel production, is taken into account. For this purpose, it is assumed that the pipe (including CML, etc.) is sent as a whole to the recycling plant, where any materials that cannot be used for cast iron and steel production are separated out. The treatment of these separated out materials is excluded due to the expected minor influence. A new product system begins with the transport of the processed scrap from the recycling plant to the production plant.

In C4, the disposal of 3% of the pipe mass in an inert material landfill and the disposal of the EPDM gasket material in a waste incinerator are considered. A 100% recycling rate is applied for the removed bolts, which are made of pure cast material.

Table 16: Disposal processes (C3 and C4) per m of pipe

DN	Mass per metre of pipe	Total pipe mass for recycling (97%)	Total pipe mass for disposal (3%)	Lock mass for recycling (100%)	Total mass (pipe and Lock) for recycling	Gasket mass for waste incineration
[mm]	*[kg/m]*	*[kg/m]*	*[kg/m]*	*[kg/m]*	*[kg/m]*	*[kg/m]*
125	25,60	24,832	0,768	0,126	24,958	0,0520

Table 17: Description of the scenario „Disposal of the product (C1 to C4)"

Parameters for end-of-life stage (C1-C4)	Value	Unit
Collection process, separately	see Table 16	kg collected separately
Recycling	see Table 16	kg for recycling
Disposal, inert material landfill	see Table 16	kg material for final deposition

4.5 D Potential of reuse and recycling

Due to the recycling of the removed pipes (97%), there is a corresponding output of secondary raw materials (D from C3). Due to the net flow rule according to EN 15804 and the high proportion of scrap in the production of cast iron pipes (988 kg per tonne of cast semi-finished part), there is a slightly negative net output flow here.

Table 18: Description of the scenario „re-use, recovery and recycling potential (module D)“

Parameters for module D	Value	Unit
Materials for reuse, recovery or recycling from A4-A5	-	%
Energy recovery or secondary fuels from A4-A5	Waste incineration Wood: 0,101 PP: 0,001 PE: 0,019 PET: 0,015	kg/m
Materials for reuse, recovery or recycling from B2-B5	-	%
Energy recovery or secondary fuels from B2-B5	-	kg/m
Materials for reuse, recovery or recycling from C1-C4	97	%
Energy recovery or secondary fuels from C1-C4	Waste incineration Gasket: 0,0520	kg/m

Due to the multi-recycling potential of the pipes, they could again replace primary raw materials in the next product system. In this EPD, the multi-recycling potential is not shown as a life cycle assessment result (in the results tables) but as additional information (Appendix 1), because this value does not comply with the rules and specifications of EN 15804 (net flow rule). The additional information on multi-recycling potential is based on a manufacturer scenario based on the experience of Tiroler Rohre GmbH.

5 Information on data quality and data selection in accordance with EN 15941

5.1 Principles for the description of data quality

The following information on data quality is provided in accordance with the requirements of EN 15941 (EN 15941, section 7.3.4).

The data fulfils the following quality requirements:

The data is representative for the production year 2020 (annual average). The production year 2020 is considered based on the existing data for ductile cast iron production (semi-finished part production) of the EPD for ductile piles from Tiroler Rohre GmbH (published 2022).

For the data collection, generic data and the cut-off of material and energy flows the criteria of the Bau EPD GmbH were considered.

The manufacturer provided all essential data such as energy and raw material consumption, transport distances and vehicles as well as packaging within the system boundaries.

The applied background database ecoinvent 3.10 was published in 2024, but contains individual data sets whose collection or reference year dates back more than 10 years (requirement EN 15804 or Bau EPD GmbH). These data sets remained in the various ecoinvent database versions through the years, taking necessary adjustments for database updates into account. Nevertheless, these data sets are subject to a corresponding potential for fluctuation because some of the (technological) developments of recent years are not reflected.

The data is plausible, i.e. the deviations from comparable results are within a plausible range.

5.2 Description of the temporal, geographical and technological representativeness of the product data

Temporal representativeness:

- The data collection period corresponds to the year 2020. All specific data are from this year.
- There is no deviation from the reporting year 2020 in the collection of specific data.
- The applied background database ecoinvent 3.10 was published in 2024, but contains individual data sets whose collection or reference year dates back more than 10 years (requirement EN 15804 or Bau EPD GmbH).

Geographical representativeness:

- VRS®-T pipe systems are manufactured exclusively at the plant in Hall in Tirol. In the production year 2020, almost 50% of the products were delivered within Austria and a total of approx. 90% within Europe (with a focus on Germany and Italy in addition to Austria).
- The pipe systems are disposed of in an area close to where they were used.

Technological representativeness:

- The production technology at the plant in Hall in Tyrol is state-of-the-art. The facilities are regularly maintained and modernised.
- In addition to cast iron pipe systems, other products such as ductile piles (pure cast iron product corresponds to semi-finished parts) are also manufactured at the analysed plant.

Geographical and technological representativeness for EPDs covering an industry:

- Not relevant for this EPD.

5.3 Explanation of the averaging process

Not relevant for this EPD, as specific products from the plant in Hall in Tyrol of the Tiroler Rohre GmbH are considered.

5.4 Assessment of the data quality of the Life Cycle Inventory data

The validity (database/source, country/region, reference year, publication/update) and the geographical, technical and temporal representativeness (according to ÖNORM EN 15804 Annex E - Table E.1) of all data sets used are assessed in the project report for this EPD.

The manufacturer provided all essential data such as energy and raw material consumption, transport distances and vehicles, and packaging within the system boundaries (quality management system and SAP system).

6 LCA: results

Table 19: Parameters to describe the environmental impact per metre [m] VRS®-T DN 125

Parameters	Unit	A1-A3	A4	A5	B1-B7	C1	C2	C3	C4	C1-C4	A-C	D
GWP total	kg CO_2 eq	2,41E+01	2,32E+00	4,82E+00	0,00E+00	1,33E+00	4,90E-01	6,44E-01	1,69E-01	2,63E+00	3,39E+01	5,37E-01
GWP fossil fuels	kg CO_2 eq	2,42E+01	2,32E+00	4,66E+00	0,00E+00	1,33E+00	4,90E-01	6,52E-01	1,69E-01	2,64E+00	3,38E+01	5,40E-01
GWP biogenic	kg CO_2 eq	-7,09E-02	1,61E-03	1,52E-01	0,00E+00	9,61E-04	3,39E-04	-8,46E-03	2,07E-05	-7,14E-03	7,57E-02	-2,44E-03
GWP luluc	kg CO_2 eq	1,67E-02	7,70E-04	2,43E-03	0,00E+00	4,57E-04	1,63E-04	9,21E-04	3,18E-06	1,54E-03	2,14E-02	6,02E-05
ODP	kg CFC-11 eq	3,24E-07	4,61E-08	7,70E-08	0,00E+00	1,83E-08	9,74E-09	8,98E-09	1,88E-10	3,72E-08	4,84E-07	7,48E-10
AP	mol H^+ eq	6,36E-02	4,83E-03	2,64E-02	0,00E+00	9,95E-03	1,02E-03	7,17E-03	5,68E-05	1,82E-02	1,13E-01	1,96E-03
EP freshwater	kg P eq	8,55E-03	1,57E-04	6,91E-04	0,00E+00	1,51E-04	3,32E-05	3,72E-04	8,25E-07	5,57E-04	9,96E-03	2,30E-04
EP marine	kg N eq	1,63E-02	1,16E-03	8,94E-03	0,00E+00	4,04E-03	2,45E-04	1,66E-03	2,20E-05	5,97E-03	3,24E-02	4,70E-04
EP terrestrial	mol N eq	1,68E-01	1,25E-02	1,00E-01	0,00E+00	4,48E-02	2,64E-03	1,87E-02	2,40E-04	6,64E-02	3,47E-01	5,09E-03
POCP	kg NMVOC eq	5,61E-02	8,03E-03	3,32E-02	0,00E+00	1,35E-02	1,70E-03	5,61E-03	7,63E-05	2,09E-02	1,18E-01	1,70E-03
ADPE	kg Sb eq	4,20E-04	7,55E-06	1,39E-05	0,00E+00	2,66E-06	1,59E-06	4,02E-05	1,40E-08	4,44E-05	4,86E-04	2,61E-07
ADPF	MJ H_u	1,61E+02	2,71E+00	1,39E+01	0,00E+00	3,07E+00	5,73E-01	2,82E+00	1,20E-02	6,47E+00	1,84E+02	5,23E+00
WDP	m3 World eq	6,64E+00	1,36E-01	3,42E+00	0,00E+00	5,63E-01	2,86E-02	1,09E-01	4,68E-03	7,06E-01	1,09E+01	3,11E-02
Legend		GWP = Global warming potential; luluc = land use and land use change; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential, Accumulated Exceedance; EP = Eutrophication potential; POCP = Formation potential of tropospheric ozone photochemical oxidants; ADPE = Abiotic depletion potential for non-fossil resources; ADPF = Abiotic depletion potential for fossil resources WDP = Water (user) deprivation potential, deprivation-weighted water consumption										

Table 20: Additional environmental impact indicators per metre [m] VRS®-T DN 125

Parameters	Unit	A1-A3	A4	A5	B1-B7	C1	C2	C3	C4	C1-C4	A-C	D
PM	Occurrence of diseases	2,79E-06	1,71E-07	5,99E-07	0,00E+00	2,54E-07	3,61E-08	1,00E-07	8,90E-10	3,92E-07	3,95E-06	4,19E-08
IRP	kBq U235 eq	1,16E+00	4,23E-02	1,96E-01	0,00E+00	4,33E-02	8,94E-03	6,58E-02	1,67E-04	1,18E-01	1,52E+00	9,44E-04
ETP-fw	CTUe	2,86E+02	8,88E+00	1,80E+01	0,00E+00	4,06E+00	1,87E+00	6,33E+00	2,91E-01	1,26E+01	3,26E+02	5,52E+01
HTP-c	CTUh	2,64E-07	1,65E-08	3,04E-08	0,00E+00	7,52E-09	3,48E-09	5,65E-09	3,84E-11	1,67E-08	3,28E-07	2,10E-07
HTP-nc	CTUh	2,56E-07	2,05E-08	2,86E-08	0,00E+00	5,44E-09	4,33E-09	3,49E-08	6,69E-11	4,47E-08	3,49E-07	1,86E-09
SQP	dimensionless	8,35E+01	1,97E+01	7,52E+01	0,00E+00	6,01E+00	4,16E+00	1,57E+01	2,40E-01	2,61E+01	2,04E+02	1,16E+00
Legend		PM = Potential incidence of disease due to Particulate Matter emissions; IRP = Potential Human exposure efficiency relative to U235; ETP-fw = Potential Comparative Toxic Unit for ecosystems; HTP-c = Potential Comparative Toxic Unit for humans – cancer effect; HTP-nc = Potential Comparative Toxic Unit for humans – non-cancer effect; SQP = Potential soil quality index										

Table 21: Parameters to describe the use of resources per metre [m] VRS®-T DN 125

Parameters	Unit	A1-A3	A4	A5	B1-B7	C1	C2	C3	C4	C1-C4	A-C	D
PERE	MJ H_u	4,14E+01	5,60E-01	3,70E+00	0,00E+00	5,38E-01	1,18E-01	1,43E+00	2,44E-03	2,09E+00	4,77E+01	6,38E-02
PERM	MJ H_u	1,24E+00	0,00E+00	-1,24E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PERT	MJ H_u	4,26E+01	5,60E-01	2,46E+00	0,00E+00	5,38E-01	1,18E-01	1,43E+00	2,44E-03	2,09E+00	4,77E+01	6,38E-02
PENRE	MJ H_u	1,60E+02	2,71E+00	1,53E+01	0,00E+00	3,07E+00	5,73E-01	2,82E+00	1,20E-02	6,48E+00	1,84E+02	5,23E+00
PENRM	MJ H_u	1,37E+00	0,00E+00	-1,37E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PENRT	MJ H_u	1,61E+02	2,71E+00	1,39E+01	0,00E+00	3,07E+00	5,73E-01	2,82E+00	1,20E-02	6,48E+00	1,84E+02	5,23E+00
SM	kg	2,04E+01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,04E+01	-3,69E-01
RSF	MJ H_u	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
NRSF	MJ H_u	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
FW	m^3	2,56E-01	4,52E-03	8,41E-02	0,00E+00	1,41E-02	9,54E-04	4,30E-03	2,81E-04	1,96E-02	3,64E-01	8,21E-04
Legend		PERE = Renewable primary energy as energy carrier; PERM = Renewable primary energy resources as material utilization; PERT = Total use of renewable primary energy resources; PENRE = Non-renewable primary energy as energy carrier; PENRM = Non-renewable primary energy as material utilization; PENRT = Total use of non-renewable primary energy resources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of fresh water										

Table 22: Parameters describing LCA-output flows and waste categories per metre [m] VRS®-T DN 125

Parameters	Unit	A1-A3	A4	A5	B1-B7	C1	C2	C3	C4	C1-C4	A-C	D
HWD	kg	3,57E-03	2,20E-04	4,15E-04	0,00E+00	1,06E-04	4,64E-05	5,38E-05	1,18E-06	2,07E-04	4,41E-03	6,67E-05
NHWD	kg	2,01E+00	1,58E+00	1,56E+02	0,00E+00	1,59E-01	3,33E-01	2,29E-01	7,71E-01	1,49E+00	1,61E+02	1,36E-02
RWD	kg	5,37E-04	1,91E-05	8,63E-05	0,00E+00	1,90E-05	4,04E-06	3,07E-05	7,70E-08	5,38E-05	6,96E-04	5,14E-07
CRU	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
MFR	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,01E+01	0,00E+00	2,01E+01	2,01E+01	0,00E+00
MER	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
EEE	MJ	0,00E+00	0,00E+00	1,59E-01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,59E-01	0,00E+00
EET	MJ	0,00E+00	0,00E+00	1,40E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,40E+00	0,00E+00
Legend		HWD = Hazardous waste disposed; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed; CRU = Components for re-use; MFR = Materials for recycling; MER = Materials for energy recovery; EEE = Exported electric energy; EET = Exported thermal energy										

Table 23: Information describing the biogenic carbon content at the factory gate per metre [m] VRS®-T DN 125

Biogenic carbon content	Unit	A1-A3
Biogenic carbon content in product	kg C	0,00E+00
Biogenic carbon content in accompanying packaging	kg C	4,16E-02
NOTE: 1 kg biogenic carbon is equivalent to 44/12 kg of CO_2		

Table 24 presents disclaimers which shall be declared in the project report and in the EPD with regard to the declaration of relevant core and additional environmental impact indicators according to the following classification. That can be declared in a footnote in the EPD.

Table 24: Classification of disclaimers to the declaration of core and additional environmental impact indicators

ILCD-classification	Indicator	disclaimer
ILCD-Type 1	Global warming potential (GWP)	none
	Depletion potential of the stratospheric ozone layer (ODP)	none
	Potential incidence of disease due to PM emissions (PM)	none
ILCD-Type 2	Acidification potential, Accumulated Exceedance (AP)	none
	Eutrophication potential, Fraction of nutrients reaching freshwater end compartment (EP-freshwater)	none
	Eutrophication potential, Fraction of nutrients reaching marine end compartment (EP-marine)	none
	Eutrophication potential, Accumulated Exceedance (EP-terrestrial)	none
	Formation potential of tropospheric ozone (POCP)	none
	Potential Human exposure efficiency relative to U235 (IRP)	1
ILCD-Type 3	Abiotic depletion potential for non-fossil resources (ADP-minerals&metals)	2
	Abiotic depletion potential for fossil resources (ADP-fossil)	2
	Water (user) deprivation potential, deprivation-weighted water consumption (WDP)	2
	Potential Comparative Toxic Unit for ecosystems (ETP-fw)	2
	Potential Comparative Toxic Unit for humans (HTP-c)	2
	Potential Comparative Toxic Unit for humans (HTP-nc)	2
	Potential Soil quality index (SQP)	2
Disclaimer 1 – This impact category deals mainly with the eventual impact of low dose ionizing radiation on human health of the nuclear fuel cycle. It does not consider effects due to possible nuclear accidents, occupational exposure nor due to radioactive waste disposal in underground facilities. Potential ionizing radiation from the soil, from radon and from some construction materials is also not measured by this indicator.		
Disclaimer 2 – The results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experienced with the indicator.		

7 LCA: Interpretation

It should be noted that the impact assessment results are only relative statements that do not include any statements about "end-points" of the impact categories, exceeding of thresholds or risks.

Since the definition of basic materials (those substances that remain in the product) and auxiliary materials (those substances that do not remain in the product) are not applicable for this product, because small percentages of the energy source coke and the input materials ferrosilicon and silicon carbide remain in the product, a breakdown into A1-A3 was not carried out.

Figure 5 shows a dominance analysis of the percentage shares of modules A1-A3 (production), A4 (transport to construction site), A5 (installation), C1 (removal), C2 (transport) and C4 (waste treatment). The pipe production is the main contributor to all impact categories (except NHWD). The next largest impacts are the installation (A5) and the removal (C1) of the pipes and the transport to the construction site (A4).

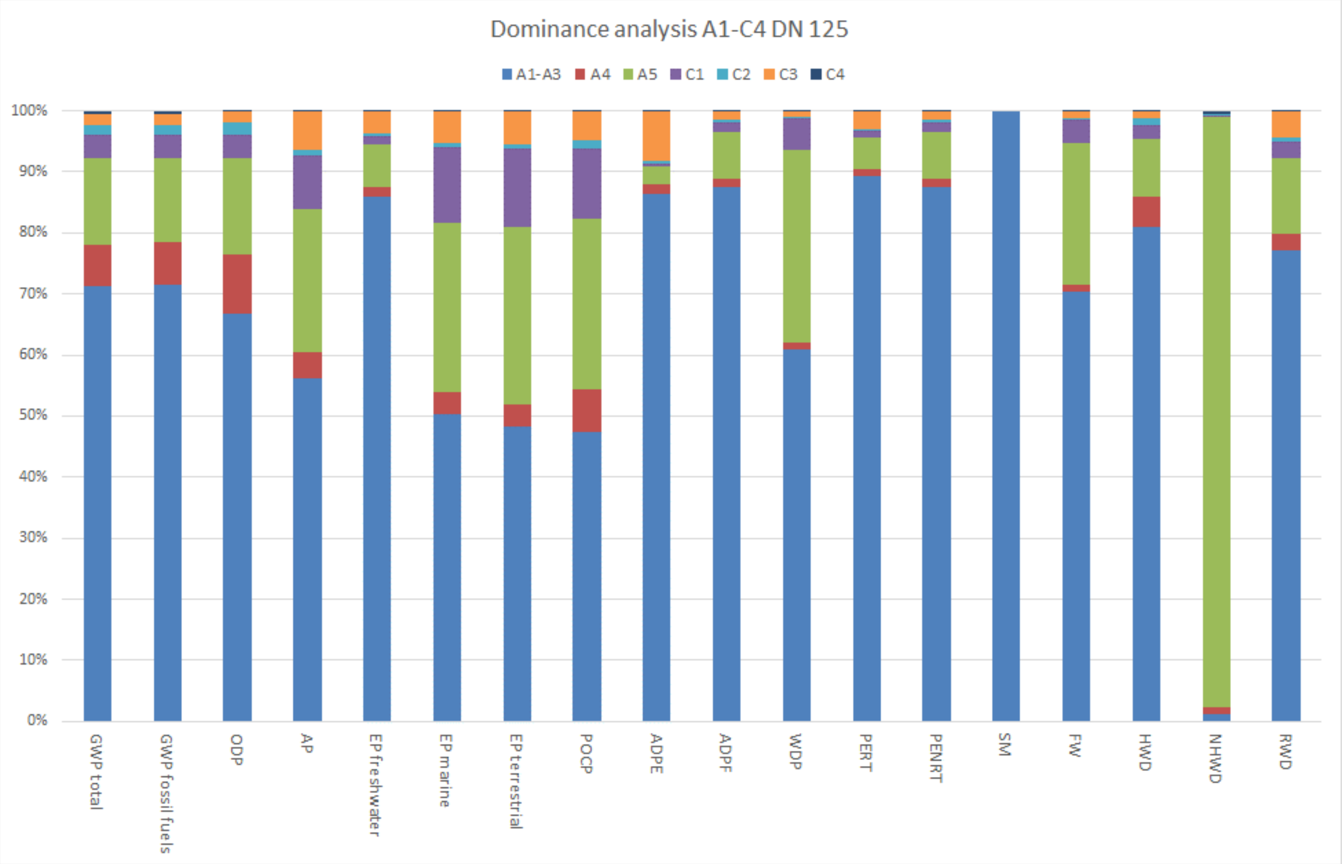


Figure 5: Dominance analysis DN 125

In the production phase (A1-A3), cast iron production has the greatest impact in terms of core indicators, with some impacts exceeding 80%. For individual indicators, galvanising has a high impact (e.g. ADPE >80%).

For the cast iron production, the cupola furnace, the annealing process and the converter have the greatest impact on the core indicators (together >90% in some cases). In the cupola furnace, CO_2 emissions from fuel use, SiC pellets and foundry coke have the greatest impact. The impact of the annealing process is determined by the natural gas used. In the converter, the magnesium and ferrosilicon applied have the greatest impact on the core indicators (in some cases >95%).

Pipe galvanisation is mainly dominated by the zinc applied (in some cases >99%).

The installation of the pipes (A5) is determined by the bedding material, the transport of the bedding material and the diesel consumption of the hydraulic excavator.

In C3, the upstream chain (wood input in the production of the scrap processing plant) of the data set used for recycling, "Iron scrap, sorted, pressed {RER}| sorting and pressing of iron scrap | Cut-off, U", causes a slightly negative value for GWP biogenic.

8 Literature

ÖNORM EN ISO 14025: 2010 Environmental labels and declarations — Type III environmental declarations — Principles and procedures

ÖNORM EN ISO 14040: 2021 Environmental management — Life cycle assessment — Principles and framework

ÖNORM EN ISO 14044: 2021 Environmental management — Life cycle assessment — Requirements and guidelines

ÖNORM 15804:2012+A2:2019+AC:2021 Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products

Bau EPD GmbH: Product category rules for building related products and services - Requirements on the EPD for cast iron products, PCR-Code 2.16.8, Version 12.0, dated 10.10.2024. Bau EPD Österreich, Vienna, 2024

Bau EPD GmbH: Management system handbook (EPD-MS-HB) of the EPD program, Version 6.0.0, dated 06.11.2024. Bau EPD Österreich, Vienna, 2024

9 Directory and Glossary

9.1 List of figures

9.2 List of tables

9.3 Abbreviations

9.3.1 Abbreviations as per EN 15804

EPD environmental product declaration
PCR product category rules
LCA life cycle assessment
LCI life cycle inventory analysis
LCIA life cycle impact assessment
RSL reference service life
ESL estimated service life
EPBD Energy Performance of Buildings Directive
GWP global warming potential
ODP depletion potential of the stratospheric ozone layer
AP acidification potential of soil and water
EP eutrophication potential
POCP formation potential of tropospheric ozone
ADP abiotic depletion potential

9.3.2 Abbreviations as per corresponding PCR

CE-mark french: Communauté Européenne or Conformité Européenne = EC certificate of conformity
REACH Registration, Evaluation, Authorisation and Restriction of Chemicals

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EPD - ENVIRONMENTAL PRODUCT DECLARATION

as per ISO 14025 and EN 15804+A2

OWNER AND PUBLISHER	Bau EPD GmbH, A-1070 Wien, Seidengasse 13/3, www.bau-epd.at
PROGRAMME OPERATOR	Bau EPD GmbH, A-1070 Wien, Seidengasse 13/3, www.bau-epd.at
HOLDER OF THE DECLARATION	Tiroler Rohre GmbH
DECLARATION NUMBER	Bau EPD-TRM-2025-4-ECOINVENT-VRS-T-DN150
ISSUE DATE	10.08.2025
VALID TO	10.08.2030
NUMBER OF DATASETS	1
ENERGY MIX APPROACH	MARKET BASED APPROACH

VRS®-T ductile cast iron pipe system – DN 150
Tiroler Rohre GmbH

Content of the EPD

1 General information

Product name
VRS®-T ductile cast iron pipe system DN 150

Declaration number
Bau EPD-TRM-2025-4-ECOINVENT-VRS-T-DN150

Declaration data
☒ Specific data
☐ Average data

Declared Product / Declared Unit
1 m ductile cast iron pipe of the VRS®-T system DN 150 with Portland composite cement lining and zinc coating with PUR long-life coating with the nominal dimensions:

Table 1: Nominal dimensions

Nominal diameter [mm]	Longitudinally related mass [kg/m]
150	31,5

Declaration based on
MS-HB Version 6.0.0 dated 06.11.2024
Name of PCR: Cast iron products
PCR-Code 2.16.8, Version 12.0 dated 10.10.2024
(PCR tested and approved by the independent expert committee = PKR-Gremium)
Version of EPD-Format-Template M-Dok 14A2 dated 11.06.2024

The owner of the declaration is liable for the underlying information and evidence; Bau EPD GmbH is not liable with respect to manufacturer information, life cycle assessment data and evidence.

Number of datasets in EPD Document: 1

Range of validity
The EPD applies to the nominal diameter DN 150 of the VRS®-T ductile cast iron pipe system with the above-mentioned lining and duplex outer coating (zinc coating with PUR long-life coating) from the Hall in Tyrol plant of Tiroler Rohre GmbH (TRM).
The EPD and the production technologies assessed are representative for the production of pipes with a nominal diameter DN 150 at the Hall in Tyrol plant of Tiroler Rohre GmbH (TRM).

Type of Declaration as per EN 15804
From cradle to grave with module D (modules A+B+C+D)
LCA method: Cut-off by classification

Database, Software, Version
Ecoinvent 3.10, SimaPro 9.6.0.1
Version Characterisation Factors: Joint Research Center, EF 3.1

Author of the Life Cycle Assessment
floGeco GmbH
Hinteranger 61d
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The CEN standard EN 15804:2012+A2:2019+AC:2021 serves as the core-PCR.
Independent verification of the declaration according to ISO 14025:2010
☐ internally ☒ externally
Verifier 1: Dipl.-Ing. Therese Daxner M.sc.
Verifier 2: Dipl.-Ing. Roman Smutny

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Note: EPDs from similar product groups from different programme operators might not be comparable.

2 Product

2.1 2.1 General product description

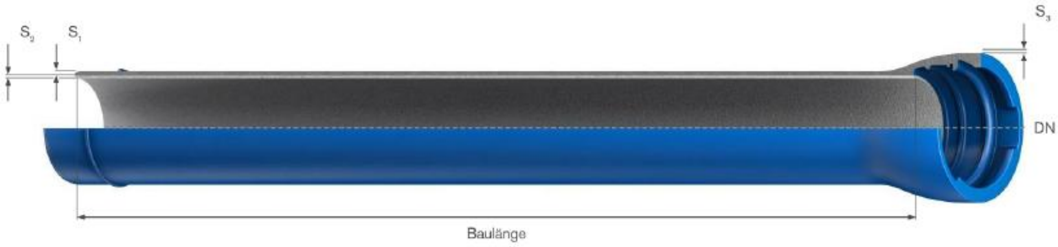
The declared product is a ductile cast iron pipe of the VRS®-T system (restrained locking system) with cement mortar lining (CML) and zinc coating with PUR long-life coating with a nominal diameter DN 150 from Tiroler Rohre GmbH (TRM).

The TRM VRS®-T system consists of ductile, centrifugally cast pipes with a spigot end with a welding ring and a socket, which are joined together to form any length of pipe. The VRS®-T joint, consisting of a VRS®-T socket, VRS®-T sealing ring, spigot end with a welding ring and locking elements, is a highly resilient, flexible and restrained locking system. It is quick and easy to install and can be bent up to 5°. No welding and no weld-seam testing is necessary. The joint can be dismantled at any time.

The ductile cast iron pipes are manufactured in lengths of 5 m with nominal diameters from DN 80 to DN 600 and different wall thicknesses. The nominal dimensions of the declared ductile cast iron pipes with a nominal diameter DN 150 as well as the corresponding wall thickness classes, (normative) minimum wall thicknesses and masses per metre of pipe are shown in Table 2. To further illustrate the declared product, Figure 1 and Figure 2 show excerpts from the Tiroler Rohre GmbH product catalogue with technical and geometric specifications and corresponding mass data.

Table 2: VRS®-T ductile cast iron pipes DN 150 – nominal diameter, Wall thickness class, minimum wall thickness, mass per Meter

DN	Wall thickness class (K class)	Minimum wall thickness [mm]	Mass per m of pipe [kg/m]
150	K 9	4,7	31,5



DN	PFA a [bar]	Maße [mm]		zul. Zugkraft [kN]	Max. Abwinkelung [°]	Anzahl der Riegel	Gewicht Rohr 5m [kg] b
		s1 Guss	s2 ZMA				
80	100	4,7	4	115	5	2	81,6
100	75	4,7	4	150	5	2	100,0
125	63	4,8	4	225	5	2	128,2
150	63	4,7	4	240	5	2	157,3
200	40	4,8	4	350	4	2	204,5
250	40	5,2	4	375	4	2	268,9
300	40	5,6	4	380	4	4	339,5
400	30	6,4	5	650	3	4	519,9
500	25/30	7,2/8,2	5	860	3	4	711,8
600	35	8,0	5	1.525	2	9	909,5

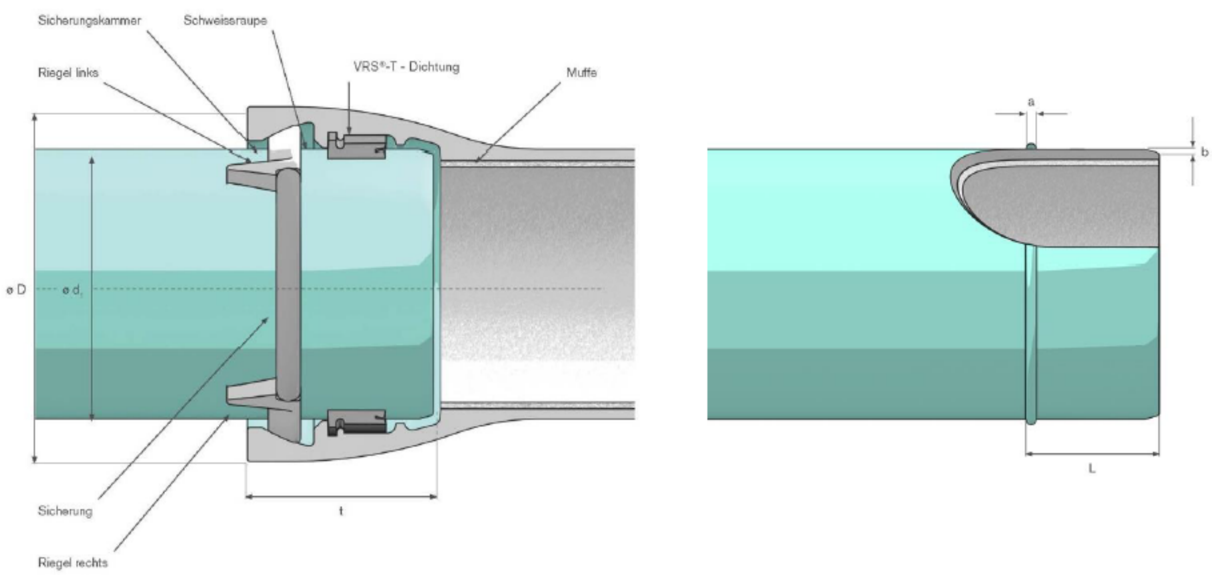
a PFA: zulässiger Bauteilbetriebsdruck | PMA = 1,2 x PFA | PEA = 1,2 x PFA + 5 | höhere PFA auf Anfrage | siehe Hinweise zum Einsatz von Klemmringen

b theoretische Masse pro Rohr für K9/10, inkl. ZMA, Zink, Deckbeschichtung

1 Mindestmaß - Toleranzen beachten | 2 Nennmaß - Toleranzen beachten

Figure 1: VRS®-T pipes – technical and geometric specifications

VRS®-T Verbindung DN 80 bis DN 600



DN	Maße [mm] a							
	Durchmesser Spitzende	Abweichungen	Durchmesser Muffe	Einstecktiefe	Schweißraupe		
	d1		D	t	L	a	b
80	98	+1,0 | -2,7	156	127	86 ±4	8 ±2	5 +0,5 | -1
100	118	+1,0 | -2,8	177	135	91 ±4	8 ±2	5 +0,5 | -1
125	144	+1,0 | -2,8	206	143	96 ±4	8 ±2	5 +0,5 | -1
150	170	+1,0 | -2,9	232	150	101 ±4	8 ±2	5 +0,5 | -1
200	222	+1,0 | -3,0	292	160	106 ±4	9 ±2	5,5 +0,5 | -1
250	274	+1,0 | -3,1	352	165	106 ±4	9 ±2	5,5 +0,5 | -1
300	326	+1,0 | -3,3	410	170	106 ±4	9 ±2	5,5 +0,5 | -1
400	429	+1,0 | -3,5	521	190	115 ±5	10 ±2	6 +0,5 | -1
500	532	+1,0 | -3,8	630	200	120 ±5	10 ±2	5 +0,5 | -1
600	635	+1,0 | -4,0	732	175	160 +0 | -2	9 ±1	5 +0,5 | -1

a Toleranzen sind möglich

Figure 2: Schematic illustration of a VRS®-T ductile cast iron pipe

The density of ductile cast iron is 7,050 kg/m³.

2.2 Application field

The VRS®-T cast iron pipe system with Portland composite cement lining is mainly used for drinking water supply and for fire extinguishing pipes, snow-making systems and turbine pipes. The cast iron pipe can be installed using various methods, such as:

- Conventional installation (trench)
- Trenchless installation
- Bridge pipes
- Interim pipes

- Floating

The usual installation method is conventional laying with the excavation of a trench, the creation of a bedding for the pipe and backfilling with suitable material.

2.3 Standards, guidelines and regulations relevant for the product

Table 3: Product specific standards

Regulation	Title
OENORM EN 545	Ductile iron pipes, fittings, accessories and their joints for water pipelines - Requirements and test methods
OENORM B 2599-1	Ductile iron pipes and fittings — Part 1: Use for water pipelines
OENORM B 2597	Ductile cast iron pipes and fittings for water, sewage and gas pipe lines - Restrained push-in-joints - Requirements and tests
OENORM B 2555	Coating of cast iron pipes - Thermal zinc spraying
OENORM B 2560	Ductile iron pipes - Finishing coating of polyurethane, epoxy or acrylic materials - Requirements and test methods
OENORM B 2562	Ductile cast iron pipes - Factory made lining with cement mortar - Requirements and test methods
OENORM EN 681-1	Elastomeric seals - Material requirements for pipe joint seals used in water and drainage applications - Part 1: Vulcanized rubber

2.4 Technical data

Mechanical properties are verified according to OENORM EN 545:2011, sections 6.3 and 6.4.

Table 4: Material parameters for ductile cast iron pipes of the VRS®-T system

Name	Value	Unit
Iron density	7050	kg/m^3
Minimum tensile strength	≥ 420	MPa
Proportional limit, 0.2% yield strength ($R_{p0.2}$)	≥ 300	MPa
Minimum elongation at fracture	≥ 10	%
Maximum Brinell hardness	≤ 230	HB
Pipe length	5000	mm
Mean coefficient of linear thermal expansion	$10*10^{-6}$	m/m*K
Thermal conductivity	0,42	W/cm*K

Table 5: VRS®-T pipes DN 150 – nominal dimension-dependent technical data

DN	Wall thickness class K class	Minimum wall thickness [mm]	Mass per metre of pipe [kg/m]	Allowable operating pressure PFA [bar]	Permissible tensile force [kN]
150	K 9	4,7	31,5	63	240

2.5 Basic/auxiliary materials

Table 6: VRS®-T pipes DN 150 – basic materials in mass %

DN	Casting	Zinc	Cement stone	PUR
150	80,4%	0,6%	18,3%	0,7%

Table 7: Basic materials – casting in mass %

Ingredients:	**Mass %**
Iron 1)	ca. 94 %
Carbon 2)	ca. 3,5 %
Silicon 3)	ca. 2 %
Ferric by-elements 4)	ca.0,5 %

1) Iron consisting mainly of steel scrap and a very small proportion of pig iron and return iron from the casting process

2) Foundry coke carbon. The coke in the cupola furnace serves both as an energy supplier for the scrap melting and the adjusting of the desired carbon content

3) Silicon is added in the form of SiC pellets and/or ferro-silicon

4) Ferric by-elements are found in the steel scrap in different minor quantities (<<1%)

2.6 Production stage

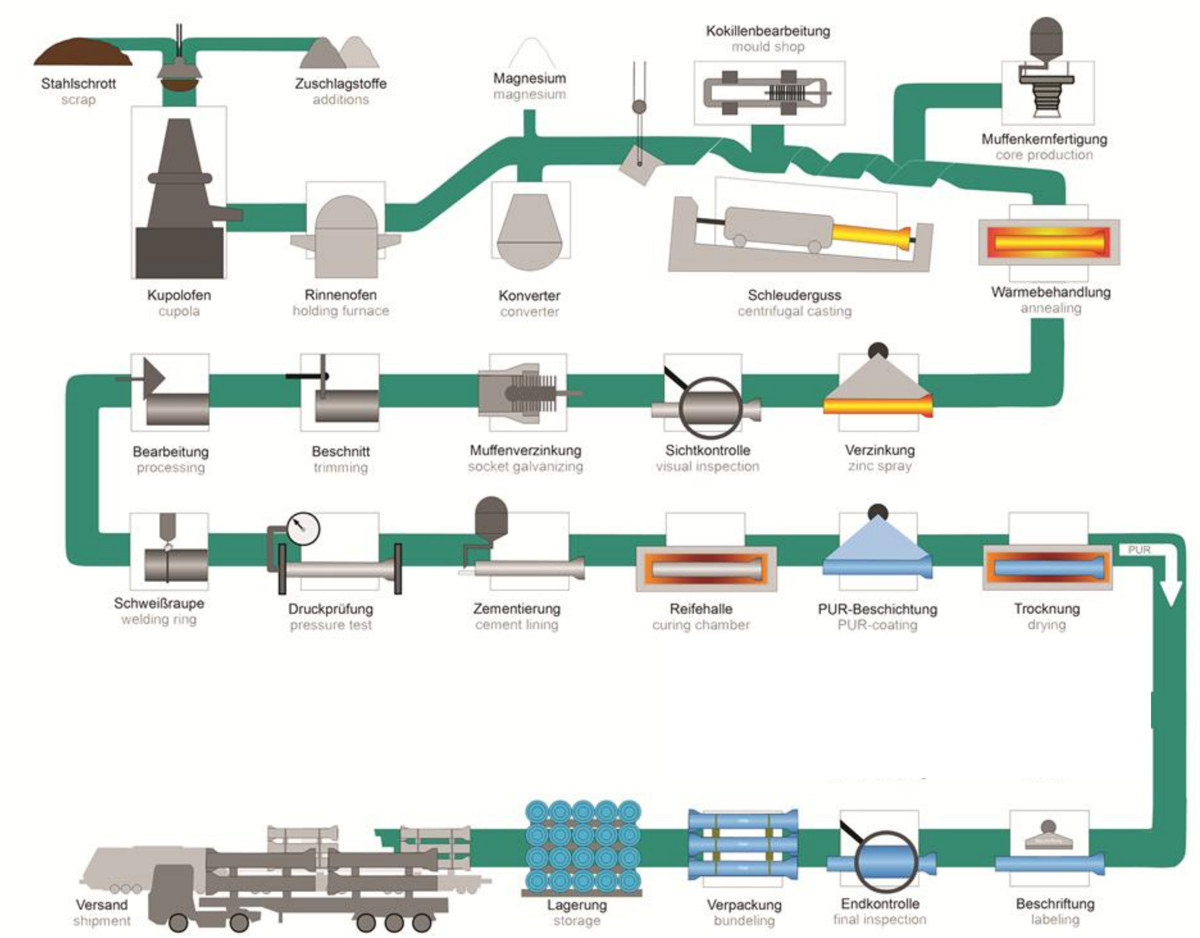


Figure 3: Flow chart of production process

For casting production, steel scrap and recycled material are smelted in the cupola furnace with the help of coke as a reaction and reduction agent. Silicon carbide is added as an alloying element. Added aggregates enhance slagging. The chemical composition of the smelted basic iron is then constantly monitored through spectral analysis. The smelted basic iron is kept warm in the holding furnace, a storage medium, and then treated with magnesium in the Georg Fischer converter, in order to reach the appropriate ductility. The liquid iron is then cast in a centrifuge machine with the De Lavaud procedure. In order to produce a specific pipe diameter, this machine is equipped with the corresponding mould (metal form that the liquid iron is poured into). The socket core made of quartz sand seals the inlet of the machine and forms the pipe socket. The glowing pipe is pulled out of the cast unit and placed in a furnace with the help of an automatic transport system. Here it undergoes annealing in order to achieve the desired mechanical properties.

The pipe is then galvanised using the electric arc spraying process and then cooled. The pipe is visually inspected in the pipe line. The spigot end and socket are machined if necessary. In the area of the welding ring, the zinc and annealing skin (tinder) are ground off and finally the welding ring is applied.

During the pressure test, each pipe is hydrostatically pressurised with a certain internal pressure and checked for leaks. The pipe is then lined with cement mortar using the centrifugal rotation process. The weld seam is galvanised and the pipes are visually inspected again. The cement stone hardens in the curing chamber. Finally, a solvent-free two-component polyurethane top coat is applied. All pipes are labelled according to the specifications, bundled and brought to the warehouse.

2.7 Packaging

The TRM pipes are sealed with protective caps and bundled using squared timber and spacer rings as stacking aid and PET tapes. All packaging materials can be used for thermal recycling.

2.8 Conditions of delivery

The ductile cast iron pipes are bundled for transport and storage with the help of squared lumber and spacer rings as stacking aid as well as PET binding tapes.

2.9 Transport to site

The cast pipes are transported to their destination within Europe by lorry and, in rare cases, overseas by ship.

2.10 Construction product stage

The installation of pressure pipes made of ductile cast iron must comply with OENORM EN 805 (Water supply - Requirements for systems and components outside buildings) and OENORM B 2538 (Additional specifications concerning OENORM EN 805). When constructing the pipe trench, sufficient working space must be provided for the installation of the pipeline, depending on the trench depth and the outer diameter of the pipe. The Ordinance on Protection of Construction Workers (Bauarbeiterschutzverordnung) and other provisions as well as relevant standards and regulations must be complied with accordingly.

As this is a push-in joint, no additional work such as welding is required. The pipe trench must be constructed and excavated in such a way that all pipe sections are at frost-free depths. The trench must be excavated deep enough so that the final cover height is at least 1.50 m. In the case of ductile iron pipes, the existing soil is generally suitable for bedding the pipeline. This means there is no need for a lower bedding layer and the bottom of the trench becomes the lower bedding.

The pipeline must be embedded and the pipe trench refilled in such a way that the pipeline is securely fixed in its intended position and that damage to the pipeline is prevented and settlement can only occur to the permissible extent. Suitable material that does not damage the pipe components and the coating must be used for embedding the pipeline. The backfill material should be installed in layers and sufficiently compacted.

2.11 Use stage

If installed and designed professionally and if the phase of utilisation is not disturbed, no modification of the material composition of construction products made of ductile cast iron occur.

2.12 Reference service life (RSL)

Table 8: Reference service life (RSL)

Name	Value	Unit
Ductile cast iron pipes	50	Years

In practice, it has been shown that a service life of 100 years, based on the DVGW damage statistics (German Technical and Scientific Association for Gas and Water – https://www.dvgw.de/themen/sicherheit/gas-und-wasserstatistik/), is achieved.

2.13 End of life stage

In inner-city areas, the main area of application for the pipe systems, the installed pipes are currently almost entirely removed. These pipes can then be recycled accordingly. These pipes can then be sent to recycling. The removal and recycling rate was therefore set correspondingly high in the scenarios considered (see 4.4 - C1-C4 disposal phase). However, it should be noted that the 100% removal rate is a manufacturer's scenario, which must be checked and adjusted accordingly in each individual use case.

The pipes are disposed of in very rare cases. The EAK waste code number for iron and steel from construction and demolition is 170405.

2.14 Further information

For further information about the TRM pipe system and its possible applications, see the website http://trm.at/rohr.

3 LCA: Calculation rules

3.1 Declared unit/ Functional unit

The functional unit is 1 metre [m] of pipe. For conversion into kg, Table 9 can be used.

Table 9: Conversion factor to mass

Nominal diameter [mm]	Longitudinally related mass [kg/m]	Multiplication factor
150	31,5	0,0317

3.2 System boundary

The entire product life cycle and module D is declared. This is a "from cradle to grave with module D"-EPD (modules A+B+C+D).

Table 10: Declared life cycle stages

PRODUCT STAGE			CON-STRUCTION PROCESS STAGE		USE STAGE							END-OF-LIFE STAGE				BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARIES
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
Raw material supply	Transport	Manufacturing	Transport from the gate to the site	Construction, installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction, demolition	Transport	Waste processing	Disposal	Reuse- Recovery- Recycling- potential
x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

X = included in LCA; ND = Not declared

3.2.1 A1-A3 Product Stage:

The cast iron pipes (semi-finished parts) are almost exclusively made of the secondary material steel scrap and a very small proportion of pig iron and return iron from the casting process. The system boundary for the steel scrap is set when the processed steel scrap leaves the recycling plants, because the end of the waste properties of the steel scrap is reached here. This system is blamed for the transportation of the scrap to the TRM plant. The product stage includes the production steps in the plant along with the energy supply (including the upstream chains), the production of raw materials, auxiliary materials and packaging (including transport to the plant), the infrastructure and the disposal of the waste occurring during production. Module A1-A3 also includes the manufacture of the locks and gaskets required for assembling the pipe.

3.2.2 A4-A5 Construction stage:

The cast iron pipe can be installed in various ways. This EPD considers the standard case for installation, i.e. the conventional laying of the pipe:

- Excavation of trench
- Bedding of the pipe
- Backfilling with suitable material

The protective caps, squared lumber and binding tapes needed for transport are thermally recycled.

3.2.3 B1-B7 Use stage:

Generally, construction products made of ductile cast iron show no impact on the LCA during the use stage.

3.2.4 C1-C4 End-of-life stage:

In inner-city areas, the main area of application for the pipe systems, the installed pipes are currently almost entirely removed. For this reason, a 100% removal rate is applied as a scenario.

The removed pipes are sent to a recycling process and are considered until the end-of-waste state according to EN 15804 in the current product system. The system boundary is therefore set when the processed steel scrap leaves the recycling plants.

As a recycling scenario, due to the robustness of the pipe systems, it is assumed that 97% of the removed pipes are suitable for the recycling process and 3% have to be sent to landfill due to breakage, etc. The recycling scenario applied is a manufacturer's scenario based on the experience of Tiroler Rohre GmbH, which must be checked and adapted accordingly in each individual use case.

3.2.5 D Benefits and loads:

Due to the recycling of the removed pipes, there is a corresponding output of secondary raw materials in C3. The output flows are compared with the scrap share in the production of the cast iron pipes in accordance with the net flow rule according to EN 15804 and the net output flow is determined. The recycling and net flow scenario applied is a manufacturer's scenario based on the experience of Tiroler Rohre GmbH, which must be checked and adapted accordingly in each individual use case.

3.3 Flow chart of processes/stages in the life cycle

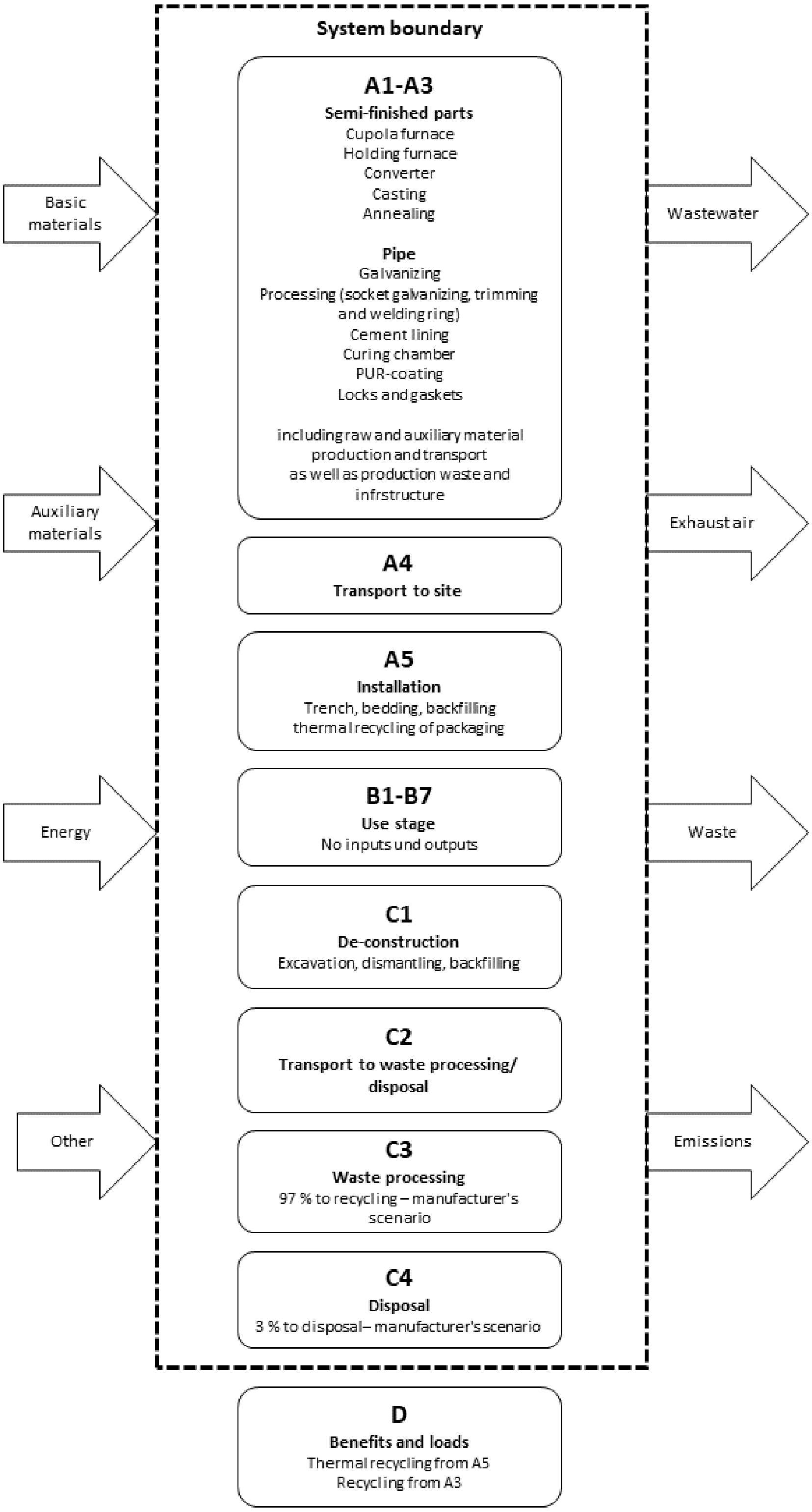


Figure 4: Life cycle flow chart

3.4 Estimations and assumptions

The SiC pellets used in casting production consist of various silicon components, Portland cement and water. In ecoinvent 3.10 there is only one data set for silicon carbide, which is typical of wafer production and has a very high SiC purity compared to the SiC component mixture used in casting production and therefore also a high energy intensity (information from the manufacturer of the pellets). According to the manufacturer of the SiC pellets, the energy required to produce the SiC components or silicon carbide is reflected in the respective prices per tonne. This allows an adjustment of the SiC purity (correction factor) of the data set available in ecoinvent based on an economic comparison (i.e. in the style of an economic allocation).

Cast steel is a special steel with no available data set. As the input is below 1 kg per t of ductile cast iron, the ecoinvent data set for chrome steel was applied.

For magnesium, which mainly comes from China, the global data set for magnesium was used ("market"-data set).

Since the infrastructure only makes a very small contribution to environmental impact, the machinery was modelled with its main components steel and casting.

For the use stage, it was assumed that no LCA-relevant material and energy flows occur.

All transport distances, with the exception of magnesium, were collected by the customer and taken into account in the LCA. For magnesium, the average transports are taken into account by the application of the global "market"-data set (which includes transport processes for the market under consideration).

3.5 Cut-off criteria

The producer calculated and submitted the amount of all applied materials, energy needed, the packaging material, the arising waste material and the way of disposal and the necessary infrastructure (buildings and machinery for the production). The measurement values for emissions according to the casting regulations were specified.

Auxiliary materials whose material flow is less than 1% were ignored as insignificant. Internal transport was negligible due to the short transport distances. It can be assumed that the total of insignificant processes is less than 5% of the impact categories.

During the production of the ductile pipes, slag (from cupola furnace) and coke dust are produced as by-products. Part of the waste heat is sold as district heating. However, these by-products contribute less than 1% to the operational income and can therefore be ignored according to the Management-System-Handbook (MS-HB) of the Bau EPD GmbH (MS-HB Version 6.0.0 dated 06.11.2024). The system limit for these two recyclable materials is set when they are collected from the plant by the future user.

The materials resulting from the production of semi-finished parts – foundry debris, fly-ash, filter cake from cupola furnace dust extraction and converter slag – are taken to a recycling plant for processing, whereby the system limit is set when the substances arrive at this plant, because no detailed information is available on the further treatment processes and the influence on the results of the impact categories is classified as negligible.

In C3, the recycling of the pipes (97%), i.e. the processing of the removed pipes in a recycling plant into a secondary raw material that can be used in cast iron and steel production, is taken into account. For this purpose, it is assumed that the pipe (including CML, etc.) is sent as a whole to the recycling plant, where any materials that cannot be used for cast iron and steel production are separated out. The treatment of these separated materials is excluded due to the expected minor influence.

3.6 Allocation

The system boundary for the steel scrap is set when the processed steel scrap leaves the recycling plants, because the end of the waste staus of the steel scrap is reached here. This system is blamed for the transportation of the scrap to the TRM plant.

In the liquid iron sector, an allocation by mass based on stock additions was carried out between the pipes considered in this EPD and the products not considered. The same applies to waste.

During the production of the ductile pipes, slag and coke dust are produced as by-products. Part of the waste heat is sold as district heating. However, these by-products contribute less than 1% to the operational income and can therefore be ignored according to the "Management-System-Handbook (MS-HB) of the Bau EPD GmbH (MS-HB Version 6.0.0 dated 06.11.2024).

For the annealing, the energy used was allocated according to the dwell times in the furnace.

Due to the recycling of the removed pipes, there is a corresponding output of secondary raw materials in C3. The output flows are compared with the scrap share in the production of the cast iron pipes in accordance with the net flow rule according to EN 15804 and the net output flow is determined.

3.7 Comparability

In principle, a comparison or evaluation of EPD data is only possible if all data sets to be compared have been created in accordance with EN 15804, the same programme-specific PCR/any additional rules and the same background database have been used, and the building context/product-specific performance characteristics are also taken into account.

4 LCA: Scenarios and additional technical information

4.1 A1-A3 Product stage

According to OENORM EN 15804, no technical scenario details are required for A1-A3 as the producer is responsible for the accounting of these modules, and this must not be changed by the user of the LCA.

Data collection for the product stage was carried out according to ISO 14044 Section 4.3.2. In accordance with the target definition, all relevant input and output flows that occur in connection with the product under consideration were identified and quantified in the life cycle inventory analysis.

Electricity generation is modelled according to the electricity mix supplied by Tiroler Wasserkraft AG (TIWAG) to Tiroler Rohre GmbH. In 2020, Tiroler Rohre GmbH purchased the TIWAG 2020 supplier mix (Versorgermix) from Tiroler Wasserkraft AG TIWAG (electricity mix contractually secured).

A part of the electricity consumption in the semi-finished parts production takes place at medium voltage level. The remaining electricity consumption takes place at low voltage level, with 5.75% coming from the in-house photovoltaic system.

Since photovoltaic electricity is generally fed into the grid and consumed at low voltage, and Tiroler Rohre GmbH purchases its electricity at medium voltage, the photovoltaic share is deducted when modelling the medium-voltage electricity supplied by TIWAG (see Table 11).

Table 11: Electricity mix

Source	**TIWAG Supplier mix general**	**Medium voltage without photovoltaics**
Hydro power	84,90%	86,32%
Norway	*20,23%*	*20,57%*
Tyrol	*64,67%*	*65,75%*
Wind power	10,37%	10,54%
Solid or liquid biomass	2,02%	2,05%
Photovoltaics	1,64%	0,00%
Biogas	1,05%	1,07%
Other eco-energy	0,02%	0,02%
Sum	**100,00%**	**100,00%**

The GWP total- result for the TIWAG electricity mix used is 57.3 g CO_2 eq/kWh at high voltage level, 60.5 g CO_2 eq/kWh at medium voltage level and 61.6 g CO_2 eq/kWh at low voltage level. The GWP total-result for low-voltage electricity from the photovoltaic system at the TRM plant is 104 g CO_2 eq/kWh.

4.2 A4-A5 Construction process stage

The pipes are transported to their destination by truck. The client provided relevant information on the transports, and based on this, an average transport distance of approximately 470 km was determined.

Table 12 shows the general parameters for describing transportation to the building site.

Table 12: Description of the scenario „Transport to building site (A4)“

Parameters to describe the transport to the building site (A4)	Value	Unit
Average transport distance	471	km
Vehicle type, Commission Directive 2007/37/EC (European Emission Standard)	Euro 6	-
Average fuel consumption, fuel type: Diesel or heavy fuel oil	25,3	l/100 km
Average transport mass	5,79	t
Average capacity utilisation (including empty returns)	85	%
Average gross density of transported products	31,5	kg/m
Volume capacity utilisation factor (factor: =1 or <1 or ≥ 1 for compressed or nested packaged products)	<1	-

Conventional laying was chosen as the installation method for the EPD, i.e. excavating a trench, bedding the pipe and backfilling with suitable material. A hydraulic excavator with an engine power of 80 kW, a scoop capacity of 0,87 m3 and a weight of 17 t was used for the excavation and backfilling of the pipe trench (including bedding).

Most of the excavation material is temporarily stored and reused for backfilling. However, a certain proportion of the excavation material (varying for the specific nominal diameters depending on the proportion of bedding) must be disposed of at a landfill 20 km away. The additional backfill material required for this is transported from a gravel pit 20 km away.

The spacer rings (PP), protective caps (PE), stacked wood and binding tape (PET) are thermally recycled in a waste incinerator 100 km away.

Table 13: Description of the scenario „Installation of the product in the building (A5)“

Parameters to describe the installation of the product in the building (A5)	Value	Unit
Ancillary materials for installation (specified by material);	Backfill material 175	kg/m
Ancillary materials for installation (specified by type)	Hydraulic excavator	-
Water use	0	m^3/m
Other resource use	0	kg/m
Electricity demand	0	kWh/m
Other energy carrier(s): Diesel	8,3	MJ/m
Wastage of materials on the building site before waste processing, generated by the product's installation (specified by type)	0	kg/m
Output materials (specified by type) as result of waste processing at the building site e.g. of collection for recycling, for energy recovery, disposal (specified by route)	Disposal Excavation: 175 Waste incineration Wood: 0,105 PET: 0,002 PE: 0,024 PP: 0,018	kg/m
Direct emissions to ambient air (such as dust, VOC), soil and water	-	kg/m

4.3 B1-B7 Use stage

In the use stage, no material and energy flows relevant for the life cycle assessment take place for the VRS®-T pipe systems, wherefor no activities were taken into account.

4.4 C1-C4 End-of-Life stage

In inner-city areas, the main area of application for the pipe systems, the installed pipes are currently almost entirely removed. For this reason, a 100% removal rate is used as a scenario. The removed pipes are sent to a recycling process, being considered until the end-of-waste state in the current product system. The system limit is set when the processed steel scrap leaves the recycling plants. From this point on, the pipe is part of a new product system. As a recycling scenario it is assumed that 97% of the pipes are suitable for the recycling process and 3% have to be sent to disposal.

The pipes are removed with the same excavator that was used for the installation. The excavation volume for the removal corresponds to volume for the installation. The existing excavation material is reinstalled, but must be supplemented with additional backfill material (different for the specific DN). The distance to the gravel pit is estimated at 20 km.

Table 14: Description of the scenario "Dismantling (C1)"

Parameters to describe the dismantling (C1)	Value	Unit
Auxiliary materials for the dismantling	Backfill material 50,2	kg/m
Aids for the demolition	Hydraulic excavator	-
Water consumption	0	m³/m
Other resource use	0	kg/m
Electricity consumption	0	kWh/m
Other energy carrier: Diesel	8,3	MJ/m
Material loss on the construction site before waste treatment, caused by the installation of the product	0	kg/m
Output materials due to waste treatment on the construction site, e.g. collection for recycling, for energy recovery or for disposal	0	kg/m
Direct emissions to ambient air (e.g. dust, VOC), soil and water	-	kg/m

The transport distance to the nearest recycling company (97% of the pipes) as well as to the nearest inert material landfill (3% of the pipes) or waste incineration plant (gaskets) was assumed to be 100 km.

Table 15: Description of the scenario "Transport for disposal (C2)"

Parameters to describe the transport for disposal (C2)	Value	Unit
Average transport distance	100	km
vehicle type, Commission Directive 2007/37/EC (European Emission Standard)	Euro 6	-
Average fuel consumption, fuel type: Diesel or heavy fuel oil	25,3	l/100 km
Average transport mass	5,79	t
Average capacity utilisation (including empty returns)	85	%
Average gross density of transported products	31,5	kg/m
Volume capacity utilisation factor (factor: =1 or <1 or ≥ 1 for compressed or nested package products)	<1	-

In C3, the recycling of the pipes (97%), i.e. the processing of the removed pipes in a recycling plant into a secondary raw material that can be used in cast iron and steel production, is taken into account. For this purpose, it is assumed that the pipe (including CML, etc.) is sent as a whole to the recycling plant, where any materials that cannot be used for cast iron and steel production are separated out. The treatment of these separated out materials is excluded due to the expected minor influence. A new product system begins with the transport of the processed scrap from the recycling plant to the production plant.

In C4, the disposal of 3% of the pipe mass in an inert material landfill and the disposal of the EPDM gasket material in a waste incinerator are considered. A 100% recycling rate is applied for the removed bolts, which are made of pure cast material.

Table 16: Disposal processes (C3 and C4) per m of pipe

DN	Mass per metre of pipe	Total pipe mass for recycling (97%)	Total pipe mass for disposal (3%)	Lock mass for recycling (100%)	Total mass (pipe and Lock) for recycling	Gasket mass for waste incineration
[mm]	*[kg/m]*	*[kg/m]*	*[kg/m]*	*[kg/m]*	*[kg/m]*	*[kg/m]*
150	31,50	30,555	0,945	0,152	30,707	0,0704

Table 17: Description of the scenario „Disposal of the product (C1 to C4)"

Parameters for end-of-life stage (C1-C4)	Value	Unit
Collection process, separately	see Table 16	kg collected separately
Recycling	see Table 16	kg for recycling
Disposal, inert material landfill	see Table 16	kg material for final deposition

4.5 D Potential of reuse and recycling

Due to the recycling of the removed pipes (97%), there is a corresponding output of secondary raw materials (D from C3). Due to the net flow rule according to EN 15804 and the high proportion of scrap in the production of cast iron pipes (988 kg per tonne of cast semi-finished part), there is a slightly negative net output flow here.

Table 18: Description of the scenario „re-use, recovery and recycling potential (module D)“

Parameters for module D	Value	Unit
Materials for reuse, recovery or recycling from A4-A5	-	%
Energy recovery or secondary fuels from A4-A5	Waste incineration Wood: 0,105 PP: 0,002 PE: 0,024 PET: 0,018	kg/m
Materials for reuse, recovery or recycling from B2-B5	-	%
Energy recovery or secondary fuels from B2-B5	-	kg/m
Materials for reuse, recovery or recycling from C1-C4	97	%
Energy recovery or secondary fuels from C1-C4	Waste incineration Gasket: 0,0704	kg/m

Due to the multi-recycling potential of the pipes, they could again replace primary raw materials in the next product system. In this EPD, the multi-recycling potential is not shown as a life cycle assessment result (in the results tables) but as additional information (Appendix 1), because this value does not comply with the rules and specifications of EN 15804 (net flow rule). The additional information on multi-recycling potential is based on a manufacturer scenario based on the experience of Tiroler Rohre GmbH.

5 Information on data quality and data selection in accordance with EN 15941

5.1 Principles for the description of data quality

The following information on data quality is provided in accordance with the requirements of EN 15941 (EN 15941, section 7.3.4).

The data fulfils the following quality requirements:

The data is representative for the production year 2020 (annual average). The production year 2020 is considered based on the existing data for ductile cast iron production (semi-finished part production) of the EPD for ductile piles from Tiroler Rohre GmbH (published 2022).

For the data collection, generic data and the cut-off of material and energy flows the criteria of the Bau EPD GmbH were considered.

The manufacturer provided all essential data such as energy and raw material consumption, transport distances and vehicles as well as packaging within the system boundaries.

The applied background database ecoinvent 3.10 was published in 2024, but contains individual data sets whose collection or reference year dates back more than 10 years (requirement EN 15804 or Bau EPD GmbH). These data sets remained in the various ecoinvent database versions through the years, taking necessary adjustments for database updates into account. Nevertheless, these data sets are subject to a corresponding potential for fluctuation because some of the (technological) developments of recent years are not reflected.

The data is plausible, i.e. the deviations from comparable results are within a plausible range.

5.2 Description of the temporal, geographical and technological representativeness of the product data

Temporal representativeness:

- The data collection period corresponds to the year 2020. All specific data are from this year.
- There is no deviation from the reporting year 2020 in the collection of specific data.
- The applied background database ecoinvent 3.10 was published in 2024, but contains individual data sets whose collection or reference year dates back more than 10 years (requirement EN 15804 or Bau EPD GmbH).

Geographical representativeness:

- VRS®-T pipe systems are manufactured exclusively at the plant in Hall in Tirol. In the production year 2020, almost 50% of the products were delivered within Austria and a total of approx. 90% within Europe (with a focus on Germany and Italy in addition to Austria).
- The pipe systems are disposed of in an area close to where they were used.

Technological representativeness:

- The production technology at the plant in Hall in Tyrol is state-of-the-art. The facilities are regularly maintained and modernised.
- In addition to cast iron pipe systems, other products such as ductile piles (pure cast iron product corresponds to semi-finished parts) are also manufactured at the analysed plant.

Geographical and technological representativeness for EPDs covering an industry:

- Not relevant for this EPD.

5.3 Explanation of the averaging process

Not relevant for this EPD, as specific products from the plant in Hall in Tyrol of the Tiroler Rohre GmbH are considered.

5.4 Assessment of the data quality of the Life Cycle Inventory data

The validity (database/source, country/region, reference year, publication/update) and the geographical, technical and temporal representativeness (according to ÖNORM EN 15804 Annex E - Table E.1) of all data sets used are assessed in the project report for this EPD.

The manufacturer provided all essential data such as energy and raw material consumption, transport distances and vehicles, and packaging within the system boundaries (quality management system and SAP system).

6 LCA: results

Table 19: Parameters to describe the environmental impact per metre [m] VRS®-T DN 150

Parameters	Unit	A1-A3	A4	A5	B1-B7	C1	C2	C3	C4	C1-C4	A-C	D
GWP total	kg CO_2 eq	3,02E+01	2,86E+00	5,35E+00	0,00E+00	1,54E+00	6,03E-01	7,93E-01	2,28E-01	3,16E+00	4,16E+01	6,63E-01
GWP fossil fuels	kg CO_2 eq	3,02E+01	2,85E+00	5,18E+00	0,00E+00	1,54E+00	6,03E-01	8,02E-01	2,28E-01	3,17E+00	4,15E+01	6,66E-01
GWP biogenic	kg CO_2 eq	-6,01E-02	1,98E-03	1,59E-01	0,00E+00	1,31E-03	4,18E-04	-1,04E-02	2,79E-05	-8,66E-03	9,18E-02	-3,00E-03
GWP luluc	kg CO_2 eq	2,02E-02	9,47E-04	2,73E-03	0,00E+00	6,10E-04	2,00E-04	1,13E-03	4,00E-06	1,95E-03	2,59E-02	7,53E-05
ODP	kg CFC-11 eq	4,17E-07	5,67E-08	8,55E-08	0,00E+00	2,07E-08	1,20E-08	1,10E-08	2,38E-10	4,40E-08	6,03E-07	9,51E-10
AP	mol H^+ eq	7,83E-02	5,94E-03	2,90E-02	0,00E+00	1,10E-02	1,26E-03	8,82E-03	7,27E-05	2,12E-02	1,34E-01	2,41E-03
EP freshwater	kg P eq	1,05E-02	1,93E-04	7,78E-04	0,00E+00	2,01E-04	4,08E-05	4,58E-04	1,07E-06	7,01E-04	1,22E-02	2,84E-04
EP marine	kg N eq	2,01E-02	1,43E-03	9,70E-03	0,00E+00	4,31E-03	3,02E-04	2,05E-03	2,82E-05	6,69E-03	3,79E-02	5,80E-04
EP terrestrial	mol N eq	2,07E-01	1,54E-02	1,09E-01	0,00E+00	4,80E-02	3,25E-03	2,30E-02	3,07E-04	7,46E-02	4,06E-01	6,28E-03
POCP	kg NMVOC eq	6,97E-02	9,87E-03	3,62E-02	0,00E+00	1,45E-02	2,09E-03	6,90E-03	9,70E-05	2,36E-02	1,39E-01	2,10E-03
ADPE	kg Sb eq	4,73E-04	9,28E-06	1,57E-05	0,00E+00	3,60E-06	1,96E-06	4,94E-05	1,80E-08	5,50E-05	5,53E-04	3,22E-07
ADPF	MJ H_u	2,00E+02	3,34E+00	1,57E+01	0,00E+00	4,11E+00	7,05E-01	3,47E+00	1,53E-02	8,30E+00	2,27E+02	6,44E+00
WDP	m3 World eq	8,17E+00	1,67E-01	3,86E+00	0,00E+00	7,77E-01	3,52E-02	1,34E-01	5,70E-03	9,52E-01	1,31E+01	3,84E-02
Legend		GWP = Global warming potential; luluc = land use and land use change; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential, Accumulated Exceedance; EP = Eutrophication potential; POCP = Formation potential of tropospheric ozone photochemical oxidants; ADPE = Abiotic depletion potential for non-fossil resources; ADPF = Abiotic depletion potential for fossil resources WDP = Water (user) deprivation potential, deprivation-weighted water consumption										

Table 20: Additional environmental impact indicators per metre [m] VRS®-T DN 150

Parameters	Unit	A1-A3	A4	A5	B1-B7	C1	C2	C3	C4	C1-C4	A-C	D
PM	Occurrence of diseases	3,46E-06	2,10E-07	6,52E-07	0,00E+00	2,74E-07	4,44E-08	1,23E-07	1,11E-09	4,43E-07	4,76E-06	5,16E-08
IRP	kBq U235 eq	1,42E+00	5,21E-02	2,21E-01	0,00E+00	5,85E-02	1,10E-02	8,09E-02	2,17E-04	1,51E-01	1,85E+00	1,28E-03
ETP-fw	CTUe	3,41E+02	1,09E+01	2,02E+01	0,00E+00	5,08E+00	2,31E+00	7,79E+00	3,93E-01	1,56E+01	3,88E+02	6,79E+01
HTP-c	CTUh	3,28E-07	2,02E-08	3,39E-08	0,00E+00	9,25E-09	4,28E-09	6,95E-09	4,93E-11	2,05E-08	4,03E-07	2,58E-07
HTP-nc	CTUh	3,07E-07	2,52E-08	3,21E-08	0,00E+00	7,08E-09	5,32E-09	4,29E-08	8,81E-11	5,54E-08	4,20E-07	2,30E-09
SQP	dimensionless	1,00E+02	2,42E+01	8,48E+01	0,00E+00	8,08E+00	5,12E+00	1,93E+01	2,96E-01	3,28E+01	2,42E+02	1,42E+00
Legend		PM = Potential incidence of disease due to Particulate Matter emissions; IRP = Potential Human exposure efficiency relative to U235; ETP-fw = Potential Comparative Toxic Unit for ecosystems; HTP-c = Potential Comparative Toxic Unit for humans – cancer effect; HTP-nc = Potential Comparative Toxic Unit for humans – non-cancer effect; SQP = Potential soil quality index										

Table 21: Parameters to describe the use of resources per metre [m] VRS®-T DN 150

Parameters	Unit	A1-A3	A4	A5	B1-B7	C1	C2	C3	C4	C1-C4	A-C	D
PERE	MJ H_u	5,09E+01	6,89E-01	4,06E+00	0,00E+00	7,25E-01	1,46E-01	1,76E+00	3,17E-03	2,63E+00	5,82E+01	7,98E-02
PERM	MJ H_u	1,28E+00	0,00E+00	-1,28E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PERT	MJ H_u	5,21E+01	6,89E-01	2,77E+00	0,00E+00	7,25E-01	1,46E-01	1,76E+00	3,17E-03	2,63E+00	5,82E+01	7,98E-02
PENRE	MJ H_u	1,98E+02	3,34E+00	1,74E+01	0,00E+00	4,11E+00	7,05E-01	3,47E+00	1,53E-02	8,30E+00	2,27E+02	6,44E+00
PENRM	MJ H_u	1,69E+00	0,00E+00	-1,69E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PENRT	MJ H_u	2,00E+02	3,34E+00	1,57E+01	0,00E+00	4,11E+00	7,05E-01	3,47E+00	1,53E-02	8,30E+00	2,27E+02	6,44E+00
SM	kg	2,52E+01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,52E+01	-4,54E-01
RSF	MJ H_u	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
NRSF	MJ H_u	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
FW	m^3	3,15E-01	5,56E-03	9,49E-02	0,00E+00	1,94E-02	1,17E-03	5,29E-03	3,65E-04	2,62E-02	4,42E-01	1,02E-03
Legend		PERE = Renewable primary energy as energy carrier; PERM = Renewable primary energy resources as material utilization; PERT = Total use of renewable primary energy resources; PENRE = Non-renewable primary energy as energy carrier; PENRM = Non-renewable primary energy as material utilization; PENRT = Total use of non-renewable primary energy resources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of fresh water										

Table 22: Parameters describing LCA-output flows and waste categories per metre [m] VRS®-T DN 150

Parameters	Unit	A1-A3	A4	A5	B1-B7	C1	C2	C3	C4	C1-C4	A-C	D
HWD	kg	4,15E-03	2,70E-04	4,60E-04	0,00E+00	1,19E-04	5,71E-05	6,61E-05	1,51E-06	2,44E-04	5,12E-03	8,21E-05
NHWD	kg	2,49E+00	1,94E+00	1,76E+02	0,00E+00	2,19E-01	4,09E-01	2,82E-01	9,49E-01	1,86E+00	1,82E+02	1,68E-02
RWD	kg	6,60E-04	2,35E-05	9,72E-05	0,00E+00	2,57E-05	4,97E-06	3,77E-05	1,00E-07	6,85E-05	8,49E-04	6,83E-07
CRU	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
MFR	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,47E+01	0,00E+00	2,47E+01	2,47E+01	0,00E+00
MER	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
EEE	MJ	0,00E+00	0,00E+00	1,81E-01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,81E-01	0,00E+00
EET	MJ	0,00E+00	0,00E+00	1,60E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,60E+00	0,00E+00
Legend		HWD = Hazardous waste disposed; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed; CRU = Components for re-use; MFR = Materials for recycling; MER = Materials for energy recovery; EEE = Exported electric energy; EET = Exported thermal energy										

Table 23: Information describing the biogenic carbon content at the factory gate per metre [m] VRS®-T DN 150

Biogenic carbon content	Unit	A1-A3
Biogenic carbon content in product	kg C	0,00E+00
Biogenic carbon content in accompanying packaging	kg C	4,31E-02
NOTE: 1 kg biogenic carbon is equivalent to 44/12 kg of CO_2		

Table 24 presents disclaimers which shall be declared in the project report and in the EPD with regard to the declaration of relevant core and additional environmental impact indicators according to the following classification. That can be declared in a footnote in the EPD.

Table 24: Classification of disclaimers to the declaration of core and additional environmental impact indicators

<table>
<tr><th>ILCD-classification</th><th>Indicator</th><th>disclaimer</th></tr>
<tr><td rowspan="3">ILCD-Type 1</td><td>Global warming potential (GWP)</td><td>none</td></tr>
<tr><td>Depletion potential of the stratospheric ozone layer (ODP)</td><td>none</td></tr>
<tr><td>Potential incidence of disease due to PM emissions (PM)</td><td>none</td></tr>
<tr><td rowspan="6">ILCD-Type 2</td><td>Acidification potential, Accumulated Exceedance (AP)</td><td>none</td></tr>
<tr><td>Eutrophication potential, Fraction of nutrients reaching freshwater end compartment (EP-freshwater)</td><td>none</td></tr>
<tr><td>Eutrophication potential, Fraction of nutrients reaching marine end compartment (EP-marine)</td><td>none</td></tr>
<tr><td>Eutrophication potential, Accumulated Exceedance (EP-terrestrial)</td><td>none</td></tr>
<tr><td>Formation potential of tropospheric ozone (POCP)</td><td>none</td></tr>
<tr><td>Potential Human exposure efficiency relative to U235 (IRP)</td><td>1</td></tr>
<tr><td rowspan="7">ILCD-Type 3</td><td>Abiotic depletion potential for non-fossil resources (ADP-minerals&metals)</td><td>2</td></tr>
<tr><td>Abiotic depletion potential for fossil resources (ADP-fossil)</td><td>2</td></tr>
<tr><td>Water (user) deprivation potential, deprivation-weighted water consumption (WDP)</td><td>2</td></tr>
<tr><td>Potential Comparative Toxic Unit for ecosystems (ETP-fw)</td><td>2</td></tr>
<tr><td>Potential Comparative Toxic Unit for humans (HTP-c)</td><td>2</td></tr>
<tr><td>Potential Comparative Toxic Unit for humans (HTP-nc)</td><td>2</td></tr>
<tr><td>Potential Soil quality index (SQP)</td><td>2</td></tr>
<tr><td colspan="3">Disclaimer 1 – This impact category deals mainly with the eventual impact of low dose ionizing radiation on human health of the nuclear fuel cycle. It does not consider effects due to possible nuclear accidents, occupational exposure nor due to radioactive waste disposal in underground facilities. Potential ionizing radiation from the soil, from radon and from some construction materials is also not measured by this indicator.</td></tr>
<tr><td colspan="3">Disclaimer 2 – The results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experienced with the indicator.</td></tr>
</table>

7 LCA: Interpretation

It should be noted that the impact assessment results are only relative statements that do not include any statements about "end-points" of the impact categories, exceeding of thresholds or risks.

Since the definition of basic materials (those substances that remain in the product) and auxiliary materials (those substances that do not remain in the product) are not applicable for this product, because small percentages of the energy source coke and the input materials ferrosilicon and silicon carbide remain in the product, a breakdown into A1-A3 was not carried out.

Figure 5 shows a dominance analysis of the percentage shares of modules A1-A3 (production), A4 (transport to construction site), A5 (installation), C1 (removal), C2 (transport) and C4 (waste treatment). The pipe production is the main contributor to all impact categories (except NHWD). The next largest impacts are the installation (A5) and the removal (C1) of the pipes and the transport to the construction site (A4).

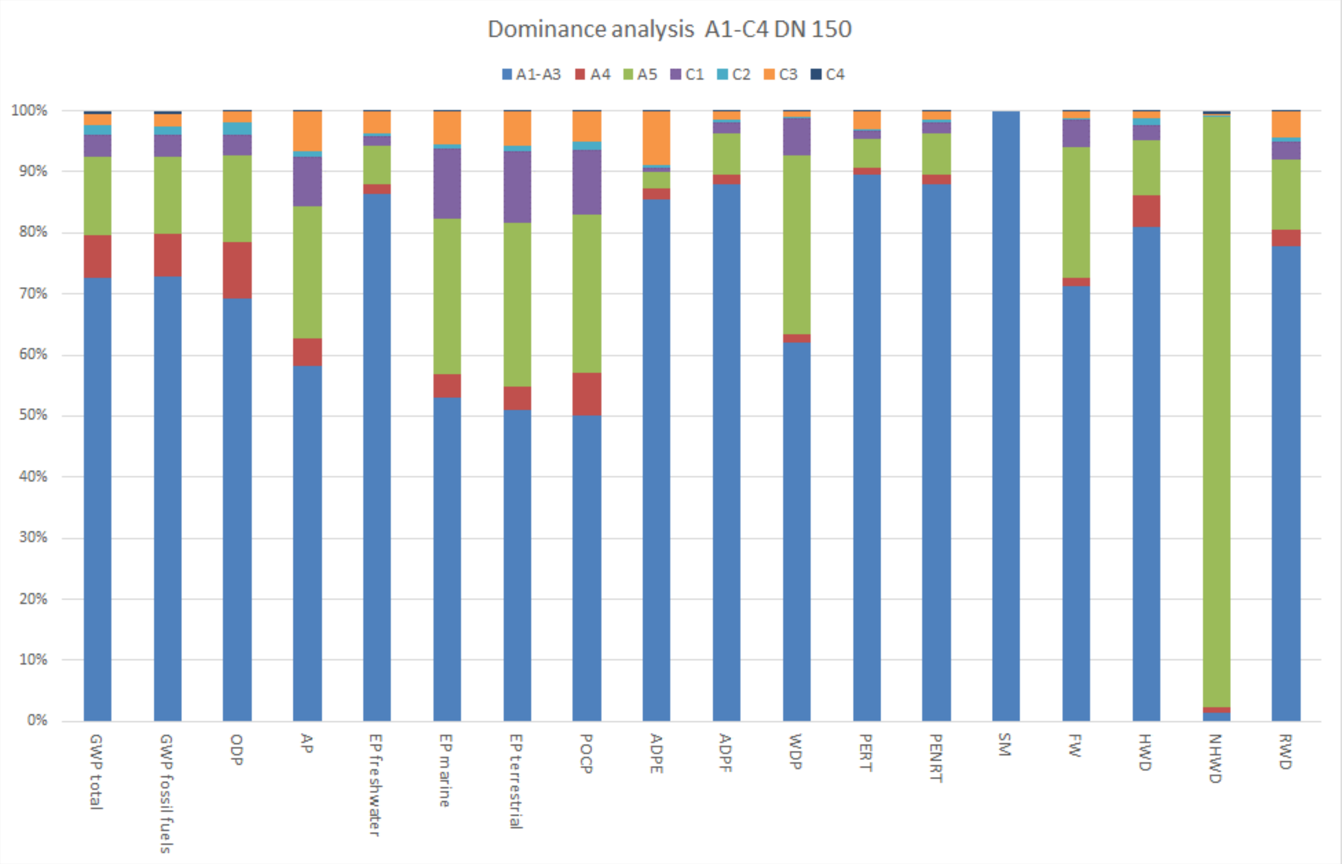


Figure 5: Dominance analysis DN 150

In the production phase (A1-A3), cast iron production has the greatest impact in terms of core indicators, with some impacts exceeding 80%. For individual indicators, galvanising has a high impact (e.g. ADPE >80%).

For the cast iron production, the cupola furnace, the annealing process and the converter have the greatest impact on the core indicators (together >90% in some cases). In the cupola furnace, CO_2 emissions from fuel use, SiC pellets and foundry coke have the greatest impact. The impact of the annealing process is determined by the natural gas used. In the converter, the magnesium and ferrosilicon applied have the greatest impact on the core indicators (in some cases >95%).

Pipe galvanisation is mainly dominated by the zinc applied (in some cases >99%).

The installation of the pipes (A5) is determined by the bedding material, the transport of the bedding material and the diesel consumption of the hydraulic excavator.

In C3, the upstream chain (wood input in the production of the scrap processing plant) of the data set used for recycling, "Iron scrap, sorted, pressed {RER}| sorting and pressing of iron scrap | Cut-off, U", causes a slightly negative value for GWP biogenic.

8 Literature

ÖNORM EN ISO 14025: 2010 Environmental labels and declarations — Type III environmental declarations — Principles and procedures

ÖNORM EN ISO 14040: 2021 Environmental management — Life cycle assessment — Principles and framework

ÖNORM EN ISO 14044: 2021 Environmental management — Life cycle assessment — Requirements and guidelines

ÖNORM 15804:2012+A2:2019+AC:2021 Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products

Bau EPD GmbH: Product category rules for building related products and services - Requirements on the EPD for cast iron products, PCR-Code 2.16.8, Version 12.0, dated 10.10.2024. Bau EPD Österreich, Vienna, 2024

Bau EPD GmbH: Management system handbook (EPD-MS-HB) of the EPD program, Version 6.0.0, dated 06.11.2024. Bau EPD Österreich, Vienna, 2024

9 Directory and Glossary

9.1 List of figures

9.2 List of tables

9.3 Abbreviations

9.3.1 Abbreviations as per EN 15804

EPD	environmental product declaration
PCR	product category rules
LCA	life cycle assessment
LCI	life cycle inventory analysis
LCIA	life cycle impact assessment
RSL	reference service life
ESL	estimated service life
EPBD	Energy Performance of Buildings Directive
GWP	global warming potential
ODP	depletion potential of the stratospheric ozone layer
AP	acidification potential of soil and water
EP	eutrophication potential
POCP	formation potential of tropospheric ozone
ADP	abiotic depletion potential

9.3.2 Abbreviations as per corresponding PCR

CE-mark	french: Communauté Européenne or Conformité Européenne = EC certificate of conformity
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals

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EPD - ENVIRONMENTAL PRODUCT DECLARATION

as per ISO 14025 and EN 15804+A2

OWNER AND PUBLISHER	Bau EPD GmbH, A-1070 Wien, Seidengasse 13/3, www.bau-epd.at
PROGRAMME OPERATOR	Bau EPD GmbH, A-1070 Wien, Seidengasse 13/3, www.bau-epd.at
HOLDER OF THE DECLARATION	Tiroler Rohre GmbH
DECLARATION NUMBER	Bau EPD-TRM-2025-5-ECOINVENT-VRS-T-DN200
ISSUE DATE	10.08.2025
VALID TO	10.08.2030
NUMBER OF DATASETS	1
ENERGY MIX APPROACH	MARKET BASED APPROACH

VRS®-T ductile cast iron pipe system – DN 200
Tiroler Rohre GmbH

Content of the EPD

1 General information

Product name VRS®-T ductile cast iron pipe system DN 200	**Declared Product / Declared Unit** 1 m ductile cast iron pipe of the VRS®-T system DN 200 with Portland composite cement lining and zinc coating with PUR long-life coating with the nominal dimensions:
Declaration number **Bau EPD-TRM-2025-5-ECOINVENT-VRS-T-DN200**	
Declaration data ☒ Specific data ☐ Average data	
Declaration based on MS-HB Version 6.0.0 dated 06.11.2024 Name of PCR: Cast iron products PCR-Code 2.16.8, Version 12.0 dated 10.10.2024 (PCR tested and approved by the independent expert committee = PKR-Gremium) Version of EPD-Format-Template M-Dok 14A2 dated 11.06.2024 The owner of the declaration is liable for the underlying information and evidence; Bau EPD GmbH is not liable with respect to manufacturer information, life cycle assessment data and evidence.	**Number of datasets in EPD Document: 1** **Range of validity** The EPD applies to the nominal diameter DN 200 of the VRS®-T ductile cast iron pipe system with the above-mentioned lining and duplex outer coating (zinc coating with PUR long-life coating) from the Hall in Tyrol plant of Tiroler Rohre GmbH (TRM). The EPD and the production technologies assessed are representative for the production of pipes with a nominal diameter DN 200 at the Hall in Tyrol plant of Tiroler Rohre GmbH (TRM).
Type of Declaration as per EN 15804 From cradle to grave with module D (modules A+B+C+D) LCA method: Cut-off by classification	**Database, Software, Version** Ecoinvent 3.10, SimaPro 9.6.0.1 **Version Characterisation Factors:** Joint Research Center, EF 3.1
Author of the Life Cycle Assessment floGeco GmbH Hinteranger 61d 6161 Natters Austria	**The CEN standard EN 15804:2012+A2:2019+AC:2021 serves as the core-PCR.** **Independent verification of the declaration according to ISO 14025:2010** ☐ internally ☒ externally **Verifier 1:** Dipl.-Ing. Therese Daxner M.sc. **Verifier 2:** Dipl.-Ing. Roman Smutny
Holder of the Declaration Tiroler Rohre GmbH Innsbruckerstraße 51 6060 Hall in Tyrol Austria	**Owner, Publisher and Programme Operator** Bau EPD GmbH Seidengasse 13/3 1070 Wien Austria

Table 1: Nominal dimensions

Nominal diameter [mm]	Longitudinally related mass [kg/m]
200	40,9

DI (FH) DI DI Sarah Richter
Head of Conformity Assessment Body

Dipl.-Ing. Therese Daxner, M.Sc.
Verifier

Dipl.-Ing. Roman Smutny
Verifier

Note: EPDs from similar product groups from different programme operators might not be comparable.

2 Product

2.1 2.1 General product description

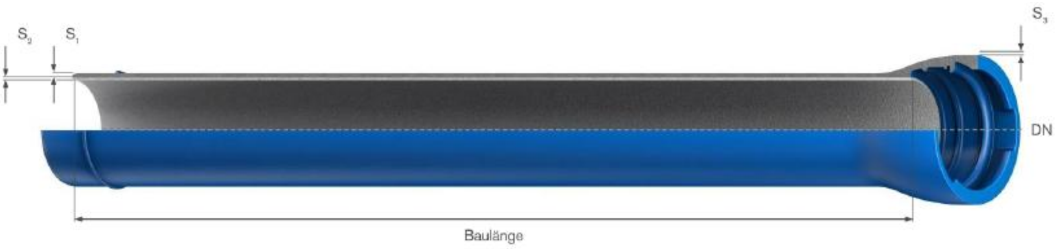
The declared product is a ductile cast iron pipe of the VRS®-T system (restrained locking system) with cement mortar lining (CML) and zinc coating with PUR long-life coating with a nominal diameter DN 200 from Tiroler Rohre GmbH (TRM).

The TRM VRS®-T system consists of ductile, centrifugally cast pipes with a spigot end with a welding ring and a socket, which are joined together to form any length of pipe. The VRS®-T joint, consisting of a VRS®-T socket, VRS®-T sealing ring, spigot end with a welding ring and locking elements, is a highly resilient, flexible and restrained locking system. It is quick and easy to install and can be bent up to 5°. No welding and no weld-seam testing is necessary. The joint can be dismantled at any time.

The ductile cast iron pipes are manufactured in lengths of 5 m with nominal diameters from DN 80 to DN 600 and different wall thicknesses. The nominal dimensions of the declared ductile cast iron pipes with a nominal diameter DN 200 as well as the corresponding wall thickness classes, (normative) minimum wall thicknesses and masses per metre of pipe are shown in Table 2. To further illustrate the declared product, Figure 1 and Figure 2 show excerpts from the Tiroler Rohre GmbH product catalogue with technical and geometric specifications and corresponding mass data.

Table 2: VRS®-T ductile cast iron pipes DN 200 – nominal diameter, Wall thickness class, minimum wall thickness, mass per Meter

DN	Wall thickness class (K class)	Minimum wall thickness [mm]	Mass per m of pipe [kg/m]
200	K 9	4,8	40,9



DN	PFA [a] [bar]	Maße [mm]		zul. Zugkraft [kN]	Max. Abwinkelung [°]	Anzahl der Riegel	Gewicht Rohr 5m [kg] [b]
		s_1 Guss	s_2 ZMA				
80	100	4,7	4	115	5	2	81,6
100	75	4,7	4	150	5	2	100,0
125	63	4,8	4	225	5	2	128,2
150	63	4,7	4	240	5	2	157,3
200	40	4,8	4	350	4	2	204,5
250	40	5,2	4	375	4	2	268,9
300	40	5,6	4	380	4	4	339,5
400	30	6,4	5	650	3	4	519,9
500	25/30	7,2/8,2	5	860	3	4	711,8
600	35	8,0	5	1.525	2	9	909,5

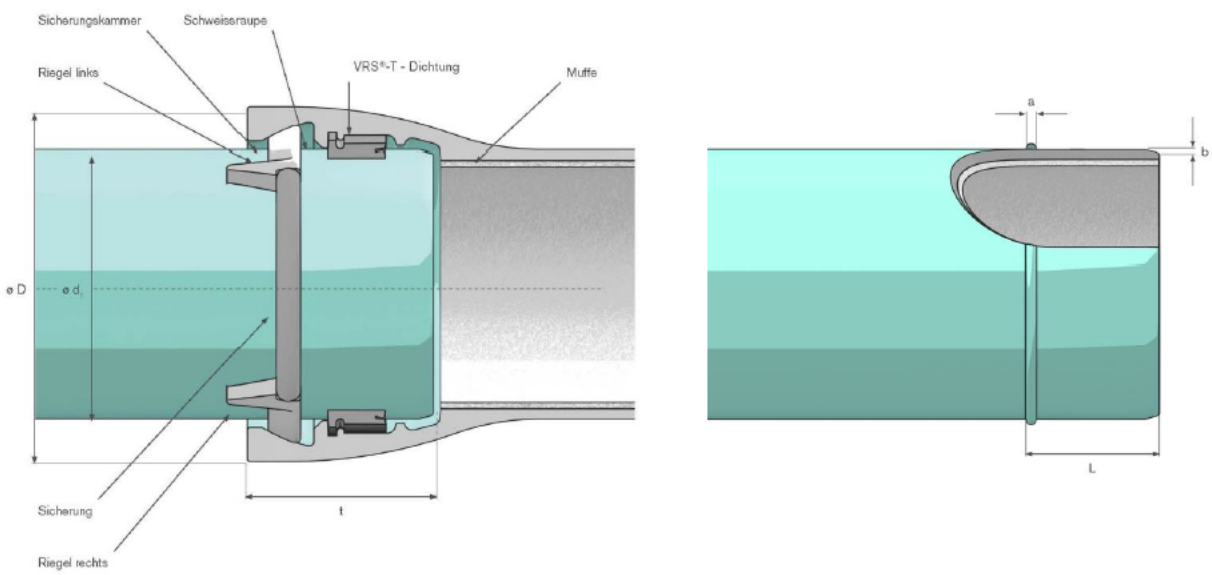
[a] PFA: zulässiger Bauteilbetriebsdruck | PMA = 1,2 x PFA | PEA = 1,2 x PFA + 5 | höhere PFA auf Anfrage | siehe Hinweise zum Einsatz von Klemmringen

[b] theoretische Masse pro Rohr für K9/10, inkl. ZMA, Zink, Deckbeschichtung

[1] Mindestmaß - Toleranzen beachten [2] Nennmaß - Toleranzen beachten

Figure 1: VRS®-T pipes – technical and geometric specifications

VRS®-T Verbindung DN 80 bis DN 600



DN	Maße [mm] ᵃ						
	Durchmesser Spitzende	Abweichungen	Durchmesser Muffe	Einstecktiefe	Schweißraupe		
	d1		D	t	L	a	b
80	98	+1,0 | -2,7	156	127	86 ±4	8 ±2	5 +0,5 | -1
100	118	+1,0 | -2,8	177	135	91 ±4	8 ±2	5 +0,5 | -1
125	144	+1,0 | -2,8	206	143	96 ±4	8 ±2	5 +0,5 | -1
150	170	+1,0 | -2,9	232	150	101 ±4	8 ±2	5 +0,5 | -1
200	222	+1,0 | -3,0	292	160	106 ±4	9 ±2	5,5 +0,5 | -1
250	274	+1,0 | -3,1	352	165	106 ±4	9 ±2	5,5 +0,5 | -1
300	326	+1,0 | -3,3	410	170	106 ±4	9 ±2	5,5 +0,5 | -1
400	429	+1,0 | -3,5	521	190	115 ±5	10 ±2	6 +0,5 | -1
500	532	+1,0 | -3,8	630	200	120 ±5	10 ±2	5 +0,5 | -1
600	635	+1,0 | -4,0	732	175	160 +0 | -2	9 ±1	5 +0,5 | -1

ᵃ Toleranzen sind möglich

Figure 2: Schematic illustration of a VRS®-T ductile cast iron pipe

The density of ductile cast iron is 7,050 kg/m³.

2.2 Application field

The VRS®-T cast iron pipe system with Portland composite cement lining is mainly used for drinking water supply and for fire extinguishing pipes, snow-making systems and turbine pipes. The cast iron pipe can be installed using various methods, such as:

- Conventional installation (trench)
- Trenchless installation
- Bridge pipes
- Interim pipes

- Floating

The usual installation method is conventional laying with the excavation of a trench, the creation of a bedding for the pipe and backfilling with suitable material.

2.3 Standards, guidelines and regulations relevant for the product

Table 3: Product specific standards

Regulation	Title
OENORM EN 545	Ductile iron pipes, fittings, accessories and their joints for water pipelines - Requirements and test methods
OENORM B 2599-1	Ductile iron pipes and fittings — Part 1: Use for water pipelines
OENORM B 2597	Ductile cast iron pipes and fittings for water, sewage and gas pipe lines - Restrained push-in-joints - Requirements and tests
OENORM B 2555	Coating of cast iron pipes - Thermal zinc spraying
OENORM B 2560	Ductile iron pipes - Finishing coating of polyurethane, epoxy or acrylic materials - Requirements and test methods
OENORM B 2562	Ductile cast iron pipes - Factory made lining with cement mortar - Requirements and test methods
OENORM EN 681-1	Elastomeric seals - Material requirements for pipe joint seals used in water and drainage applications - Part 1: Vulcanized rubber

2.4 Technical data

Mechanical properties are verified according to OENORM EN 545:2011, sections 6.3 and 6.4.

Table 4: Material parameters for ductile cast iron pipes of the VRS®-T system

Name	Value	Unit
Iron density	7050	kg/m^3
Minimum tensile strength	≥ 420	MPa
Proportional limit, 0.2% yield strength ($R_{p0.2}$)	≥ 300	MPa
Minimum elongation at fracture	≥ 10	%
Maximum Brinell hardness	≤ 230	HB
Pipe length	5000	mm
Mean coefficient of linear thermal expansion	$10*10^{-6}$	m/m*K
Thermal conductivity	0,42	W/cm*K

Table 5: VRS®-T pipes DN 200 – nominal dimension-dependent technical data

DN	Wall thickness class K class	Minimum wall thickness [mm]	Mass per metre of pipe [kg/m]	Allowable operating pressure PFA [bar]	Permissible tensile force [kN]
200	K 9	4,8	40,9	40	350

2.5 Basic/auxiliary materials

Table 6: VRS®-T pipes DN 200 – basic materials in mass %

DN	Casting	Zinc	Cement stone	PUR
200	79,9%	0,6%	18,8%	0,7%

Table 7: Basic materials – casting in mass %

Ingredients:	**Mass %**
Iron [1)]	ca. 94 %
Carbon [2)]	ca. 3,5 %
Silicon [3)]	ca. 2 %
Ferric by-elements [4)]	ca.0,5 %

[1)] Iron consisting mainly of steel scrap and a very small proportion of pig iron and return iron from the casting process

[2)] Foundry coke carbon. The coke in the cupola furnace serves both as an energy supplier for the scrap melting and the adjusting of the desired carbon content

[3)] Silicon is added in the form of SiC pellets and/or ferro-silicon

[4)] Ferric by-elements are found in the steel scrap in different minor quantities (<<1%)

2.6 Production stage

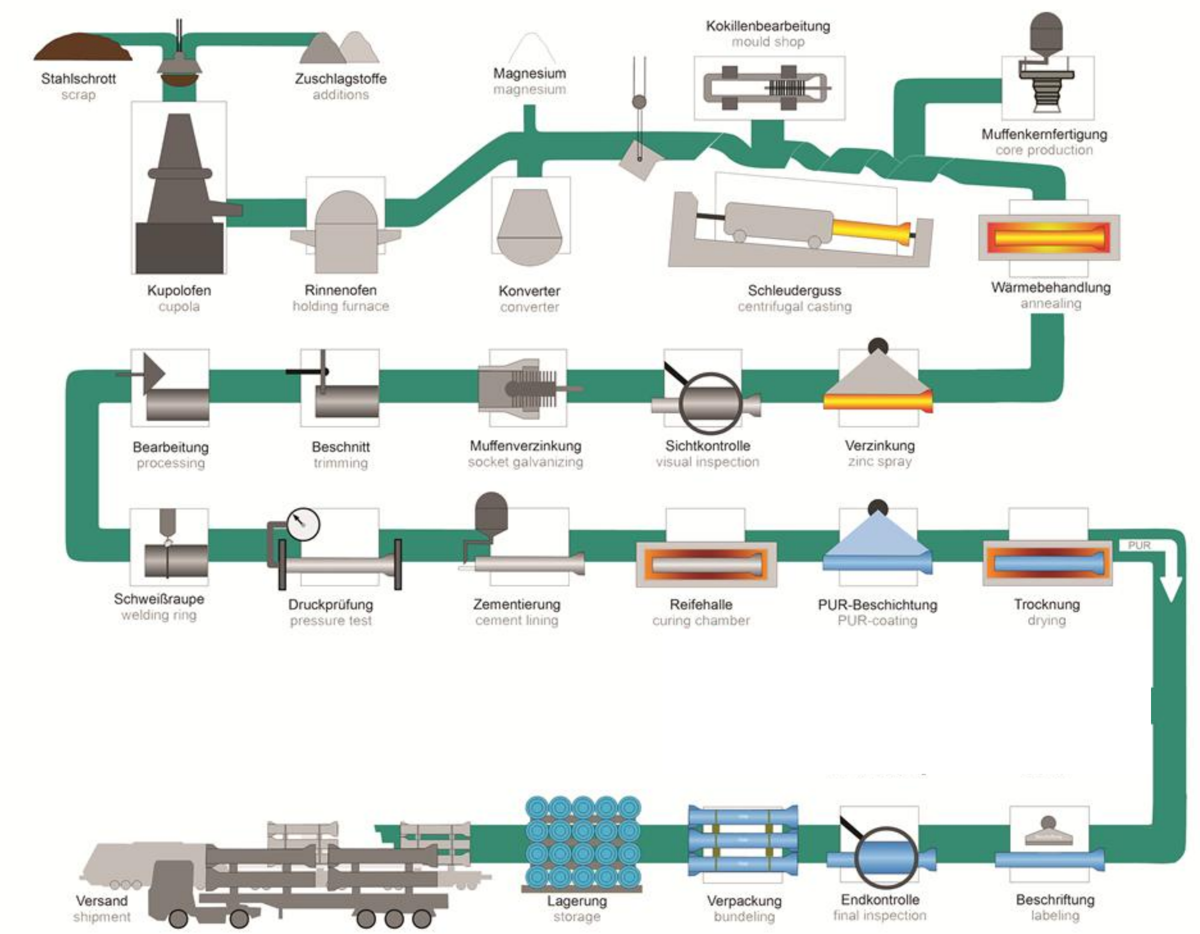


Figure 3: Flow chart of production process

For casting production, steel scrap and recycled material are smelted in the cupola furnace with the help of coke as a reaction and reduction agent. Silicon carbide is added as an alloying element. Added aggregates enhance slagging. The chemical composition of the smelted basic iron is then constantly monitored through spectral analysis. The smelted basic iron is kept warm in the holding furnace, a storage medium, and then treated with magnesium in the Georg Fischer converter, in order to reach the appropriate ductility. The liquid iron is then cast in a centrifuge machine with the De Lavaud procedure. In order to produce a specific pipe diameter, this machine is equipped with the corresponding mould (metal form that the liquid iron is poured into). The socket core made of quartz sand seals the inlet of the machine and forms the pipe socket. The glowing pipe is pulled out of the cast unit and placed in a furnace with the help of an automatic transport system. Here it undergoes annealing in order to achieve the desired mechanical properties.

The pipe is then galvanised using the electric arc spraying process and then cooled. The pipe is visually inspected in the pipe line. The spigot end and socket are machined if necessary. In the area of the welding ring, the zinc and annealing skin (tinder) are ground off and finally the welding ring is applied.

During the pressure test, each pipe is hydrostatically pressurised with a certain internal pressure and checked for leaks. The pipe is then lined with cement mortar using the centrifugal rotation process. The weld seam is galvanised and the pipes are visually inspected again. The cement stone hardens in the curing chamber. Finally, a solvent-free two-component polyurethane top coat is applied. All pipes are labelled according to the specifications, bundled and brought to the warehouse.

2.7 Packaging

The TRM pipes are sealed with protective caps and bundled using squared timber and spacer rings as stacking aid and PET tapes. All packaging materials can be used for thermal recycling.

2.8 Conditions of delivery

The ductile cast iron pipes are bundled for transport and storage with the help of squared lumber and spacer rings as stacking aid as well as PET binding tapes.

2.9 Transport to site

The cast pipes are transported to their destination within Europe by lorry and, in rare cases, overseas by ship.

2.10 Construction product stage

The installation of pressure pipes made of ductile cast iron must comply with OENORM EN 805 (Water supply - Requirements for systems and components outside buildings) and OENORM B 2538 (Additional specifications concerning OENORM EN 805). When constructing the pipe trench, sufficient working space must be provided for the installation of the pipeline, depending on the trench depth and the outer diameter of the pipe. The Ordinance on Protection of Construction Workers (Bauarbeiterschutzverordnung) and other provisions as well as relevant standards and regulations must be complied with accordingly.

As this is a push-in joint, no additional work such as welding is required. The pipe trench must be constructed and excavated in such a way that all pipe sections are at frost-free depths. The trench must be excavated deep enough so that the final cover height is at least 1.50 m. In the case of ductile iron pipes, the existing soil is generally suitable for bedding the pipeline. This means there is no need for a lower bedding layer and the bottom of the trench becomes the lower bedding.

The pipeline must be embedded and the pipe trench refilled in such a way that the pipeline is securely fixed in its intended position and that damage to the pipeline is prevented and settlement can only occur to the permissible extent. Suitable material that does not damage the pipe components and the coating must be used for embedding the pipeline. The backfill material should be installed in layers and sufficiently compacted.

2.11 Use stage

If installed and designed professionally and if the phase of utilisation is not disturbed, no modification of the material composition of construction products made of ductile cast iron occur.

2.12 Reference service life (RSL)

Table 8: Reference service life (RSL)

Name	Value	Unit
Ductile cast iron pipes	50	Years

In practice, it has been shown that a service life of 100 years, based on the DVGW damage statistics (German Technical and Scientific Association for Gas and Water – https://www.dvgw.de/themen/sicherheit/gas-und-wasserstatistik/), is achieved.

2.13 End of life stage

In inner-city areas, the main area of application for the pipe systems, the installed pipes are currently almost entirely removed. These pipes can then be recycled accordingly. These pipes can then be sent to recycling. The removal and recycling rate was therefore set correspondingly high in the scenarios considered (see 4.4 - C1-C4 disposal phase). However, it should be noted that the 100% removal rate is a manufacturer's scenario, which must be checked and adjusted accordingly in each individual use case.

The pipes are disposed of in very rare cases. The EAK waste code number for iron and steel from construction and demolition is 170405.

2.14 Further information

For further information about the TRM pipe system and its possible applications, see the website http://trm.at/rohr.

3 LCA: Calculation rules

3.1 Declared unit/ Functional unit

The functional unit is 1 metre [m] of pipe. For conversion into kg, Table 9 can be used.

Table 9: Conversion factor to mass

Nominal diameter [mm]	Longitudinally related mass [kg/m]	Multiplication factor
200	40,9	0,0244

3.2 System boundary

The entire product life cycle and module D is declared. This is a “from cradle to grave with module D”-EPD (modules A+B+C+D).

Table 10: Declared life cycle stages

PRODUCT STAGE			CON-STRUCTION PROCESS STAGE		USE STAGE							END-OF-LIFE STAGE				BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARIES
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
Raw material supply	Transport	Manufacturing	Transport from the gate to the site	Construction, installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction, demolition	Transport	Waste processing	Disposal	Reuse- Recovery- Recycling- potential
x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

X = included in LCA; ND = Not declared

3.2.1 A1-A3 Product Stage:

The cast iron pipes (semi-finished parts) are almost exclusively made of the secondary material steel scrap and a very small proportion of pig iron and return iron from the casting process. The system boundary for the steel scrap is set when the processed steel scrap leaves the recycling plants, because the end of the waste properties of the steel scrap is reached here. This system is blamed for the transportation of the scrap to the TRM plant. The product stage includes the production steps in the plant along with the energy supply (including the upstream chains), the production of raw materials, auxiliary materials and packaging (including transport to the plant), the infrastructure and the disposal of the waste occurring during production. Module A1-A3 also includes the manufacture of the locks and gaskets required for assembling the pipe.

3.2.2 A4-A5 Construction stage:

The cast iron pipe can be installed in various ways. This EPD considers the standard case for installation, i.e. the conventional laying of the pipe:

- Excavation of trench
- Bedding of the pipe
- Backfilling with suitable material

The protective caps, squared lumber and binding tapes needed for transport are thermally recycled.

3.2.3 B1-B7 Use stage:

Generally, construction products made of ductile cast iron show no impact on the LCA during the use stage.

3.2.4 C1-C4 End-of-life stage:

In inner-city areas, the main area of application for the pipe systems, the installed pipes are currently almost entirely removed. For this reason, a 100% removal rate is applied as a scenario.

The removed pipes are sent to a recycling process and are considered until the end-of-waste state according to EN 15804 in the current product system. The system boundary is therefore set when the processed steel scrap leaves the recycling plants.

As a recycling scenario, due to the robustness of the pipe systems, it is assumed that 97% of the removed pipes are suitable for the recycling process and 3% have to be sent to landfill due to breakage, etc. The recycling scenario applied is a manufacturer's scenario based on the experience of Tiroler Rohre GmbH, which must be checked and adapted accordingly in each individual use case.

3.2.5 D Benefits and loads:

Due to the recycling of the removed pipes, there is a corresponding output of secondary raw materials in C3. The output flows are compared with the scrap share in the production of the cast iron pipes in accordance with the net flow rule according to EN 15804 and the net output flow is determined. The recycling and net flow scenario applied is a manufacturer's scenario based on the experience of Tiroler Rohre GmbH, which must be checked and adapted accordingly in each individual use case.

3.3 Flow chart of processes/stages in the life cycle

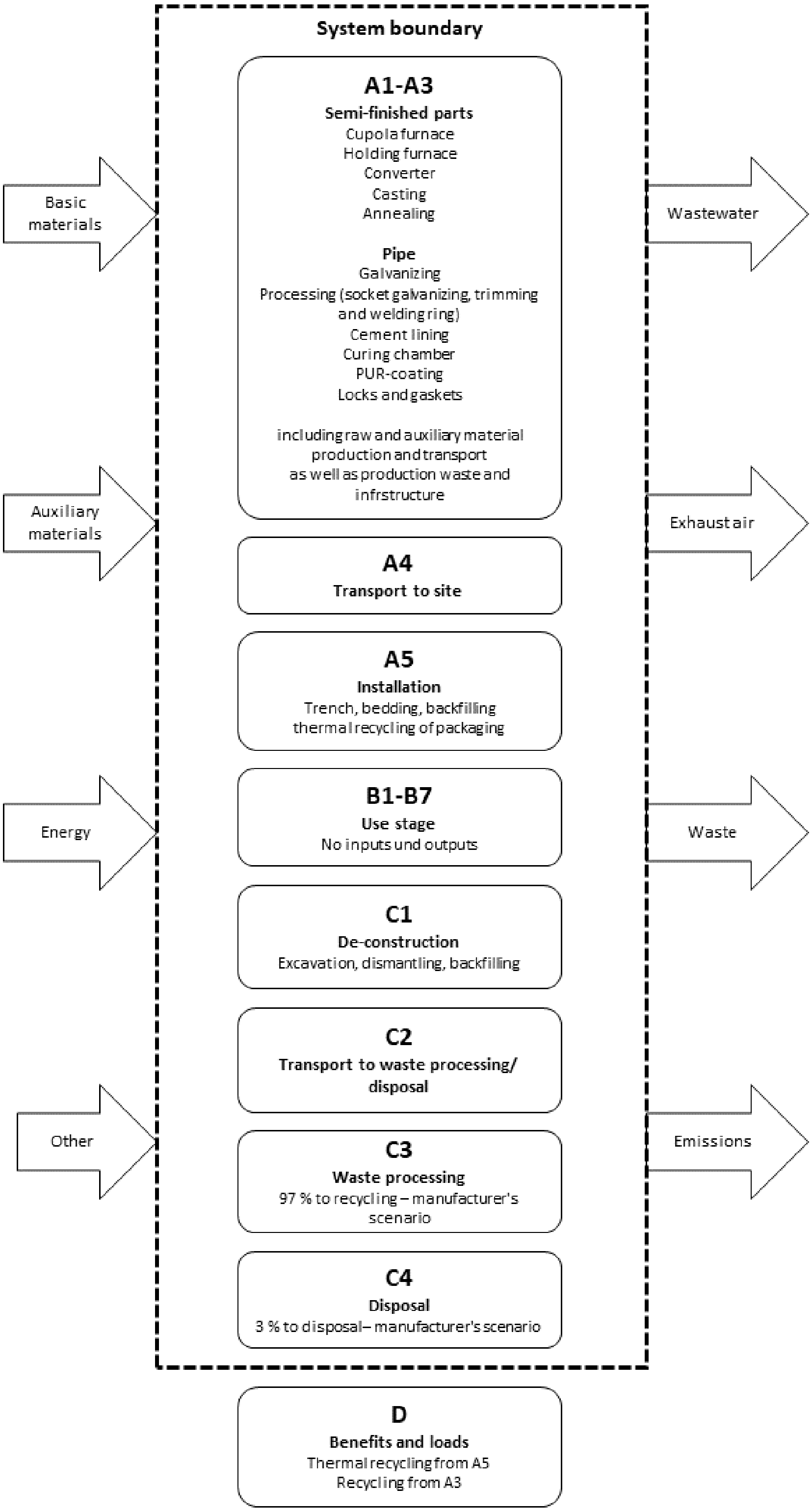


Figure 4: Life cycle flow chart

3.4 Estimations and assumptions

The SiC pellets used in casting production consist of various silicon components, Portland cement and water. In ecoinvent 3.10 there is only one data set for silicon carbide, which is typical of wafer production and has a very high SiC purity compared to the SiC component mixture used in casting production and therefore also a high energy intensity (information from the manufacturer of the pellets). According to the manufacturer of the SiC pellets, the energy required to produce the SiC components or silicon carbide is reflected in the respective prices per tonne. This allows an adjustment of the SiC purity (correction factor) of the data set available in ecoinvent based on an economic comparison (i.e. in the style of an economic allocation).

Cast steel is a special steel with no available data set. As the input is below 1 kg per t of ductile cast iron, the ecoinvent data set for chrome steel was applied.

For magnesium, which mainly comes from China, the global data set for magnesium was used ("market"-data set).

Since the infrastructure only makes a very small contribution to environmental impact, the machinery was modelled with its main components steel and casting.

For the use stage, it was assumed that no LCA-relevant material and energy flows occur.

All transport distances, with the exception of magnesium, were collected by the customer and taken into account in the LCA. For magnesium, the average transports are taken into account by the application of the global "market"-data set (which includes transport processes for the market under consideration).

3.5 Cut-off criteria

The producer calculated and submitted the amount of all applied materials, energy needed, the packaging material, the arising waste material and the way of disposal and the necessary infrastructure (buildings and machinery for the production). The measurement values for emissions according to the casting regulations were specified.

Auxiliary materials whose material flow is less than 1% were ignored as insignificant. Internal transport was negligible due to the short transport distances. It can be assumed that the total of insignificant processes is less than 5% of the impact categories.

During the production of the ductile pipes, slag (from cupola furnace) and coke dust are produced as by-products. Part of the waste heat is sold as district heating. However, these by-products contribute less than 1% to the operational income and can therefore be ignored according to the Management-System-Handbook (MS-HB) of the Bau EPD GmbH (MS-HB Version 6.0.0 dated 06.11.2024). The system limit for these two recyclable materials is set when they are collected from the plant by the future user.

The materials resulting from the production of semi-finished parts – foundry debris, fly-ash, filter cake from cupola furnace dust extraction and converter slag – are taken to a recycling plant for processing, whereby the system limit is set when the substances arrive at this plant, because no detailed information is available on the further treatment processes and the influence on the results of the impact categories is classified as negligible.

In C3, the recycling of the pipes (97%), i.e. the processing of the removed pipes in a recycling plant into a secondary raw material that can be used in cast iron and steel production, is taken into account. For this purpose, it is assumed that the pipe (including CML, etc.) is sent as a whole to the recycling plant, where any materials that cannot be used for cast iron and steel production are separated out. The treatment of these separated materials is excluded due to the expected minor influence.

3.6 Allocation

The system boundary for the steel scrap is set when the processed steel scrap leaves the recycling plants, because the end of the waste staus of the steel scrap is reached here. This system is blamed for the transportation of the scrap to the TRM plant.

In the liquid iron sector, an allocation by mass based on stock additions was carried out between the pipes considered in this EPD and the products not considered. The same applies to waste.

During the production of the ductile pipes, slag and coke dust are produced as by-products. Part of the waste heat is sold as district heating. However, these by-products contribute less than 1% to the operational income and can therefore be ignored according to the "Management-System-Handbook (MS-HB) of the Bau EPD GmbH (MS-HB Version 6.0.0 dated 06.11.2024).

For the annealing, the energy used was allocated according to the dwell times in the furnace.

Due to the recycling of the removed pipes, there is a corresponding output of secondary raw materials in C3. The output flows are compared with the scrap share in the production of the cast iron pipes in accordance with the net flow rule according to EN 15804 and the net output flow is determined.

3.7 Comparability

In principle, a comparison or evaluation of EPD data is only possible if all data sets to be compared have been created in accordance with EN 15804, the same programme-specific PCR/any additional rules and the same background database have been used, and the building context/product-specific performance characteristics are also taken into account.

4 LCA: Scenarios and additional technical information

4.1 A1-A3 Product stage

According to OENORM EN 15804, no technical scenario details are required for A1-A3 as the producer is responsible for the accounting of these modules, and this must not be changed by the user of the LCA.

Data collection for the product stage was carried out according to ISO 14044 Section 4.3.2. In accordance with the target definition, all relevant input and output flows that occur in connection with the product under consideration were identified and quantified in the life cycle inventory analysis.

Electricity generation is modelled according to the electricity mix supplied by Tiroler Wasserkraft AG (TIWAG) to Tiroler Rohre GmbH. In 2020, Tiroler Rohre GmbH purchased the TIWAG 2020 supplier mix (Versorgermix) from Tiroler Wasserkraft AG TIWAG (electricity mix contractually secured).

A part of the electricity consumption in the semi-finished parts production takes place at medium voltage level. The remaining electricity consumption takes place at low voltage level, with 5.75% coming from the in-house photovoltaic system.

Since photovoltaic electricity is generally fed into the grid and consumed at low voltage, and Tiroler Rohre GmbH purchases its electricity at medium voltage, the photovoltaic share is deducted when modelling the medium-voltage electricity supplied by TIWAG (see Table 11).

Table 11: Electricity mix

Source	**TIWAG Supplier mix general**	**Medium voltage without photovoltaics**
Hydro power	84,90%	86,32%
Norway	*20,23%*	*20,57%*
Tyrol	*64,67%*	*65,75%*
Wind power	10,37%	10,54%
Solid or liquid biomass	2,02%	2,05%
Photovoltaics	1,64%	0,00%
Biogas	1,05%	1,07%
Other eco-energy	0,02%	0,02%
Sum	**100,00%**	**100,00%**

The GWP total- result for the TIWAG electricity mix used is 57.3 g CO_2 eq/kWh at high voltage level, 60.5 g CO_2 eq/kWh at medium voltage level and 61.6 g CO_2 eq/kWh at low voltage level. The GWP total-result for low-voltage electricity from the photovoltaic system at the TRM plant is 104 g CO_2 eq/kWh.

4.2 A4-A5 Construction process stage

The pipes are transported to their destination by truck. The client provided relevant information on the transports, and based on this, an average transport distance of approximately 470 km was determined.

Table 12 shows the general parameters for describing transportation to the building site.

Table 12: Description of the scenario „Transport to building site (A4)“

Parameters to describe the transport to the building site (A4)	Value	Unit
Average transport distance	471	km
Vehicle type, Commission Directive 2007/37/EC (European Emission Standard)	Euro 6	-
Average fuel consumption, fuel type: Diesel or heavy fuel oil	25,3	l/100 km
Average transport mass	5,79	t
Average capacity utilisation (including empty returns)	85	%
Average gross density of transported products	40,9	kg/m
Volume capacity utilisation factor (factor: =1 or <1 or ≥ 1 for compressed or nested packaged products)	<1	-

Conventional laying was chosen as the installation method for the EPD, i.e. excavating a trench, bedding the pipe and backfilling with suitable material. A hydraulic excavator with an engine power of 80 kW, a scoop capacity of 0,87 m3 and a weight of 17 t was used for the excavation and backfilling of the pipe trench (including bedding).

Most of the excavation material is temporarily stored and reused for backfilling. However, a certain proportion of the excavation material (varying for the specific nominal diameters depending on the proportion of bedding) must be disposed of at a landfill 20 km away. The additional backfill material required for this is transported from a gravel pit 20 km away.

The spacer rings (PP), protective caps (PE), stacked wood and binding tape (PET) are thermally recycled in a waste incinerator 100 km away.

Table 13: Description of the scenario „Installation of the product in the building (A5)“

Parameters to describe the installation of the product in the building (A5)	Value	Unit
Ancillary materials for installation (specified by material);	Backfill material 220	kg/m
Ancillary materials for installation (specified by type)	Hydraulic excavator	-
Water use	0	m^3/m
Other resource use	0	kg/m
Electricity demand	0	kWh/m
Other energy carrier(s): Diesel	8,9	MJ/m
Wastage of materials on the building site before waste processing, generated by the product’s installation (specified by type)	0	kg/m
Output materials (specified by type) as result of waste processing at the building site e.g. of collection for recycling, for energy recovery, disposal (specified by route)	Disposal Excavation: 220 Waste incineration Wood: 0,132 PET: 0,003 PE: 0,063 PP: 0,030	kg/m
Direct emissions to ambient air (such as dust, VOC), soil and water	-	kg/m

4.3 B1-B7 Use stage

In the use stage, no material and energy flows relevant for the life cycle assessment take place for the VRS®-T pipe systems, wherefor no activities were taken into account.

4.4 C1-C4 End-of-Life stage

In inner-city areas, the main area of application for the pipe systems, the installed pipes are currently almost entirely removed. For this reason, a 100% removal rate is used as a scenario. The removed pipes are sent to a recycling process, being considered until the end-of-waste state in the current product system. The system limit is set when the processed steel scrap leaves the recycling plants. From this point on, the pipe is part of a new product system. As a recycling scenario it is assumed that 97% of the pipes are suitable for the recycling process and 3% have to be sent to disposal.

The pipes are removed with the same excavator that was used for the installation. The excavation volume for the removal corresponds to volume for the installation. The existing excavation material is reinstalled, but must be supplemented with additional backfill material (different for the specific DN). The distance to the gravel pit is estimated at 20 km.

Table 14: Description of the scenario "Dismantling (C1)"

Parameters to describe the dismantling (C1)	Value	Unit
Auxiliary materials for the dismantling	Backfill material 85,5	kg/m
Aids for the demolition	Hydraulic excavator	-
Water consumption	0	m^3/m
Other resource use	0	kg/m
Electricity consumption	0	kWh/m
Other energy carrier: Diesel	8,9	MJ/m
Material loss on the construction site before waste treatment, caused by the installation of the product	0	kg/m
Output materials due to waste treatment on the construction site, e.g. collection for recycling, for energy recovery or for disposal	0	kg/m
Direct emissions to ambient air (e.g. dust, VOC), soil and water	-	kg/m

The transport distance to the nearest recycling company (97% of the pipes) as well as to the nearest inert material landfill (3% of the pipes) or waste incineration plant (gaskets) was assumed to be 100 km.

Table 15: Description of the scenario "Transport for disposal (C2)"

Parameters to describe the transport for disposal (C2)	Value	Unit
Average transport distance	100	km
vehicle type, Commission Directive 2007/37/EC (European Emission Standard)	Euro 6	-
Average fuel consumption, fuel type: Diesel or heavy fuel oil	25,3	l/100 km
Average transport mass	5,79	t
Average capacity utilisation (including empty returns)	85	%
Average gross density of transported products	40,9	kg/m
Volume capacity utilisation factor (factor: =1 or <1 or ≥ 1 for compressed or nested package products)	<1	-

In C3, the recycling of the pipes (97%), i.e. the processing of the removed pipes in a recycling plant into a secondary raw material that can be used in cast iron and steel production, is taken into account. For this purpose, it is assumed that the pipe (including CML, etc.) is sent as a whole to the recycling plant, where any materials that cannot be used for cast iron and steel production are separated out. The treatment of these separated out materials is excluded due to the expected minor influence. A new product system begins with the transport of the processed scrap from the recycling plant to the production plant.

In C4, the disposal of 3% of the pipe mass in an inert material landfill and the disposal of the EPDM gasket material in a waste incinerator are considered. A 100% recycling rate is applied for the removed bolts, which are made of pure cast material.

Table 16: Disposal processes (C3 and C4) per m of pipe

DN	Mass per metre of pipe	Total pipe mass for recycling (97%)	Total pipe mass for disposal (3%)	Lock mass for recycling (100%)	Total mass (pipe and Lock) for recycling	Gasket mass for waste incineration
[mm]	*[kg/m]*	*[kg/m]*	*[kg/m]*	*[kg/m]*	*[kg/m]*	*[kg/m]*
200	40,90	39,673	1,227	0,272	39,945	0,1080

Table 17: Description of the scenario „Disposal of the product (C1 to C4)"

Parameters for end-of-life stage (C1-C4)	Value	Unit
Collection process, separately	see Table 16	kg collected separately
Recycling	see Table 16	kg for recycling
Disposal, inert material landfill	see Table 16	kg material for final deposition

4.5 D Potential of reuse and recycling

Due to the recycling of the removed pipes (97%), there is a corresponding output of secondary raw materials (D from C3). Due to the net flow rule according to EN 15804 and the high proportion of scrap in the production of cast iron pipes (988 kg per tonne of cast semi-finished part), there is a slightly negative net output flow here.

Table 18: Description of the scenario „re-use, recovery and recycling potential (module D)“

Parameters for module D	Value	Unit
Materials for reuse, recovery or recycling from A4-A5	-	%
Energy recovery or secondary fuels from A4-A5	Waste incineration Wood: 0,132 PP: 0,003 PE: 0,063 PET: 0,030	kg/m
Materials for reuse, recovery or recycling from B2-B5	-	%
Energy recovery or secondary fuels from B2-B5	-	kg/m
Materials for reuse, recovery or recycling from C1-C4	97	%
Energy recovery or secondary fuels from C1-C4	Waste incineration Gasket: 0,1080	kg/m

Due to the multi-recycling potential of the pipes, they could again replace primary raw materials in the next product system. In this EPD, the multi-recycling potential is not shown as a life cycle assessment result (in the results tables) but as additional information (Appendix 1), because this value does not comply with the rules and specifications of EN 15804 (net flow rule). The additional information on multi-recycling potential is based on a manufacturer scenario based on the experience of Tiroler Rohre GmbH.

5 Information on data quality and data selection in accordance with EN 15941

5.1 Principles for the description of data quality

The following information on data quality is provided in accordance with the requirements of EN 15941 (EN 15941, section 7.3.4).

The data fulfils the following quality requirements:

The data is representative for the production year 2020 (annual average). The production year 2020 is considered based on the existing data for ductile cast iron production (semi-finished part production) of the EPD for ductile piles from Tiroler Rohre GmbH (published 2022).

For the data collection, generic data and the cut-off of material and energy flows the criteria of the Bau EPD GmbH were considered.

The manufacturer provided all essential data such as energy and raw material consumption, transport distances and vehicles as well as packaging within the system boundaries.

The applied background database ecoinvent 3.10 was published in 2024, but contains individual data sets whose collection or reference year dates back more than 10 years (requirement EN 15804 or Bau EPD GmbH). These data sets remained in the various ecoinvent database versions through the years, taking necessary adjustments for database updates into account. Nevertheless, these data sets are subject to a corresponding potential for fluctuation because some of the (technological) developments of recent years are not reflected.

The data is plausible, i.e. the deviations from comparable results are within a plausible range.

5.2 Description of the temporal, geographical and technological representativeness of the product data

Temporal representativeness:

- The data collection period corresponds to the year 2020. All specific data are from this year.
- There is no deviation from the reporting year 2020 in the collection of specific data.
- The applied background database ecoinvent 3.10 was published in 2024, but contains individual data sets whose collection or reference year dates back more than 10 years (requirement EN 15804 or Bau EPD GmbH).

Geographical representativeness:

- VRS®-T pipe systems are manufactured exclusively at the plant in Hall in Tirol. In the production year 2020, almost 50% of the products were delivered within Austria and a total of approx. 90% within Europe (with a focus on Germany and Italy in addition to Austria).
- The pipe systems are disposed of in an area close to where they were used.

Technological representativeness:

- The production technology at the plant in Hall in Tyrol is state-of-the-art. The facilities are regularly maintained and modernised.
- In addition to cast iron pipe systems, other products such as ductile piles (pure cast iron product corresponds to semi-finished parts) are also manufactured at the analysed plant.

Geographical and technological representativeness for EPDs covering an industry:

- Not relevant for this EPD.

5.3 Explanation of the averaging process

Not relevant for this EPD, as specific products from the plant in Hall in Tyrol of the Tiroler Rohre GmbH are considered.

5.4 Assessment of the data quality of the Life Cycle Inventory data

The validity (database/source, country/region, reference year, publication/update) and the geographical, technical and temporal representativeness (according to ÖNORM EN 15804 Annex E - Table E.1) of all data sets used are assessed in the project report for this EPD.

The manufacturer provided all essential data such as energy and raw material consumption, transport distances and vehicles, and packaging within the system boundaries (quality management system and SAP system).

6 LCA: results

Table 19: Parameters to describe the environmental impact per metre [m] VRS®-T DN 200

Parameters	Unit	A1-A3	A4	A5	B1-B7	C1	C2	C3	C4	C1-C4	A-C	D
GWP total	kg CO_2 eq	4,13E+01	3,72E+00	6,68E+00	0,00E+00	2,10E+00	7,85E-01	1,03E+00	3,49E-01	4,26E+00	5,60E+01	8,00E-01
GWP fossil fuels	kg CO_2 eq	4,13E+01	3,71E+00	6,48E+00	0,00E+00	2,09E+00	7,84E-01	1,04E+00	3,49E-01	4,27E+00	5,58E+01	8,04E-01
GWP biogenic	kg CO_2 eq	-6,63E-02	2,57E-03	1,99E-01	0,00E+00	2,17E-03	5,43E-04	-1,35E-02	4,26E-05	-1,08E-02	1,25E-01	-3,91E-03
GWP luluc	kg CO_2 eq	2,67E-02	1,23E-03	3,42E-03	0,00E+00	9,93E-04	2,60E-04	1,47E-03	5,41E-06	2,73E-03	3,41E-02	6,42E-05
ODP	kg CFC-11 eq	5,92E-07	7,39E-08	1,05E-07	0,00E+00	2,72E-08	1,56E-08	1,44E-08	3,25E-10	5,75E-08	8,28E-07	2,97E-10
AP	mol H^+ eq	1,06E-01	7,74E-03	3,51E-02	0,00E+00	1,41E-02	1,63E-03	1,15E-02	1,02E-04	2,73E-02	1,76E-01	2,97E-03
EP freshwater	kg P eq	1,41E-02	2,52E-04	9,73E-04	0,00E+00	3,27E-04	5,31E-05	5,96E-04	1,52E-06	9,78E-04	1,63E-02	3,55E-04
EP marine	kg N eq	2,71E-02	1,86E-03	1,16E-02	0,00E+00	5,15E-03	3,92E-04	2,66E-03	3,96E-05	8,25E-03	4,88E-02	7,16E-04
EP terrestrial	mol N eq	2,79E-01	2,01E-02	1,30E-01	0,00E+00	5,78E-02	4,23E-03	2,99E-02	4,30E-04	9,24E-02	5,22E-01	7,76E-03
POCP	kg NMVOC eq	9,50E-02	1,29E-02	4,34E-02	0,00E+00	1,75E-02	2,71E-03	8,97E-03	1,34E-04	2,93E-02	1,81E-01	2,57E-03
ADPE	kg Sb eq	5,94E-04	1,21E-05	1,97E-05	0,00E+00	5,95E-06	2,55E-06	6,43E-05	2,54E-08	7,28E-05	6,98E-04	3,85E-07
ADPF	MJ H_u	2,69E+02	4,34E+00	1,96E+01	0,00E+00	6,72E+00	9,17E-01	4,52E+00	2,14E-02	1,22E+01	3,05E+02	8,09E+00
WDP	m3 World eq	1,10E+01	2,17E-01	4,85E+00	0,00E+00	1,31E+00	4,58E-02	1,75E-01	7,25E-03	1,54E+00	1,76E+01	4,46E-02
Legend		GWP = Global warming potential; luluc = land use and land use change; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential, Accumulated Exceedance; EP = Eutrophication potential; POCP = Formation potential of tropospheric ozone photochemical oxidants; ADPE = Abiotic depletion potential for non-fossil resources; ADPF = Abiotic depletion potential for fossil resources WDP = Water (user) deprivation potential, deprivation-weighted water consumption										

Table 20: Additional environmental impact indicators per metre [m] VRS®-T DN 200

Parameters	Unit	A1-A3	A4	A5	B1-B7	C1	C2	C3	C4	C1-C4	A-C	D
PM	Occurrence of diseases	4,65E-06	2,74E-07	7,80E-07	0,00E+00	3,33E-07	5,78E-08	1,61E-07	1,48E-09	5,52E-07	6,26E-06	6,53E-08
IRP	kBq U235 eq	1,92E+00	6,78E-02	2,77E-01	0,00E+00	9,66E-02	1,43E-02	1,05E-01	3,11E-04	2,16E-01	2,48E+00	-1,56E-03
ETP-fw	CTUe	4,44E+02	1,42E+01	2,51E+01	0,00E+00	7,68E+00	3,00E+00	1,01E+01	5,98E-01	2,14E+01	5,05E+02	8,75E+01
HTP-c	CTUh	4,42E-07	2,64E-08	4,20E-08	0,00E+00	1,37E-08	5,57E-09	9,04E-09	6,93E-11	2,84E-08	5,39E-07	3,33E-07
HTP-nc	CTUh	4,05E-07	3,28E-08	4,02E-08	0,00E+00	1,12E-08	6,93E-09	5,58E-08	1,29E-10	7,41E-08	5,53E-07	2,80E-09
SQP	dimensionless	1,33E+02	3,16E+01	1,06E+02	0,00E+00	1,33E+01	6,66E+00	2,51E+01	3,87E-01	4,54E+01	3,17E+02	1,78E+00
Legend		PM = Potential incidence of disease due to Particulate Matter emissions; IRP = Potential Human exposure efficiency relative to U235; ETP-fw = Potential Comparative Toxic Unit for ecosystems; HTP-c = Potential Comparative Toxic Unit for humans – cancer effect; HTP-nc = Potential Comparative Toxic Unit for humans – non-cancer effect; SQP = Potential soil quality index										

Table 21: Parameters to describe the use of resources per metre [m] VRS®-T DN 200

Parameters	Unit	A1-A3	A4	A5	B1-B7	C1	C2	C3	C4	C1-C4	A-C	D
PERE	MJ H_u	6,80E+01	8,97E-01	5,10E+00	0,00E+00	1,19E+00	1,89E-01	2,29E+00	4,55E-03	3,67E+00	7,77E+01	6,59E-02
PERM	MJ H_u	1,62E+00	0,00E+00	-1,62E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PERT	MJ H_u	6,96E+01	8,97E-01	3,47E+00	0,00E+00	1,19E+00	1,89E-01	2,29E+00	4,55E-03	3,67E+00	7,77E+01	6,59E-02
PENRE	MJ H_u	2,65E+02	4,35E+00	2,34E+01	0,00E+00	6,72E+00	9,18E-01	4,52E+00	2,14E-02	1,22E+01	3,05E+02	8,09E+00
PENRM	MJ H_u	3,72E+00	0,00E+00	-3,72E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PENRT	MJ H_u	2,69E+02	4,35E+00	1,96E+01	0,00E+00	6,72E+00	9,18E-01	4,52E+00	2,14E-02	1,22E+01	3,05E+02	8,09E+00
SM	kg	3,26E+01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,26E+01	-5,85E-01
RSF	MJ H_u	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
NRSF	MJ H_u	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
FW	m^3	4,22E-01	7,24E-03	1,19E-01	0,00E+00	3,25E-02	1,53E-03	6,88E-03	5,24E-04	4,14E-02	5,90E-01	1,11E-03
Legend		PERE = Renewable primary energy as energy carrier; PERM = Renewable primary energy resources as material utilization; PERT = Total use of renewable primary energy resources; PENRE = Non-renewable primary energy as energy carrier; PENRM = Non-renewable primary energy as material utilization; PENRT = Total use of non-renewable primary energy resources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of fresh water										

Table 22: Parameters describing LCA-output flows and waste categories per metre [m] VRS®-T DN 200

Parameters	Unit	A1-A3	A4	A5	B1-B7	C1	C2	C3	C4	C1-C4	A-C	D
HWD	kg	5,39E-03	3,52E-04	5,64E-04	0,00E+00	1,55E-04	7,43E-05	8,60E-05	2,10E-06	3,17E-04	6,63E-03	1,03E-04
NHWD	kg	3,34E+00	2,52E+00	2,21E+02	0,00E+00	3,70E-01	5,33E-01	3,67E-01	1,23E+00	2,50E+00	2,30E+02	2,08E-02
RWD	kg	8,91E-04	3,06E-05	1,22E-04	0,00E+00	4,24E-05	6,47E-06	4,91E-05	1,44E-07	9,81E-05	1,14E-03	-5,23E-07
CRU	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
MFR	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,20E+01	0,00E+00	3,20E+01	3,20E+01	0,00E+00
MER	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
EEE	MJ	0,00E+00	0,00E+00	3,21E-01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,21E-01	0,00E+00
EET	MJ	0,00E+00	0,00E+00	2,84E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,84E+00	0,00E+00
Legend		HWD = Hazardous waste disposed; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed; CRU = Components for re-use; MFR = Materials for recycling; MER = Materials for energy recovery; EEE = Exported electric energy; EET = Exported thermal energy										

Table 23: Information describing the biogenic carbon content at the factory gate per metre [m] VRS®-T DN 200

Biogenic carbon content	Unit	A1-A3
Biogenic carbon content in product	kg C	0,00E+00
Biogenic carbon content in accompanying packaging	kg C	5,45E-02
NOTE: 1 kg biogenic carbon is equivalent to 44/12 kg of CO_2		

Table 24 presents disclaimers which shall be declared in the project report and in the EPD with regard to the declaration of relevant core and additional environmental impact indicators according to the following classification. That can be declared in a footnote in the EPD.

Table 24: Classification of disclaimers to the declaration of core and additional environmental impact indicators

ILCD-classification	Indicator	disclaimer
ILCD-Type 1	Global warming potential (GWP)	none
	Depletion potential of the stratospheric ozone layer (ODP)	none
	Potential incidence of disease due to PM emissions (PM)	none
ILCD-Type 2	Acidification potential, Accumulated Exceedance (AP)	none
	Eutrophication potential, Fraction of nutrients reaching freshwater end compartment (EP-freshwater)	none
	Eutrophication potential, Fraction of nutrients reaching marine end compartment (EP-marine)	none
	Eutrophication potential, Accumulated Exceedance (EP-terrestrial)	none
	Formation potential of tropospheric ozone (POCP)	none
	Potential Human exposure efficiency relative to U235 (IRP)	1
ILCD-Type 3	Abiotic depletion potential for non-fossil resources (ADP-minerals&metals)	2
	Abiotic depletion potential for fossil resources (ADP-fossil)	2
	Water (user) deprivation potential, deprivation-weighted water consumption (WDP)	2
	Potential Comparative Toxic Unit for ecosystems (ETP-fw)	2
	Potential Comparative Toxic Unit for humans (HTP-c)	2
	Potential Comparative Toxic Unit for humans (HTP-nc)	2
	Potential Soil quality index (SQP)	2
Disclaimer 1 – This impact category deals mainly with the eventual impact of low dose ionizing radiation on human health of the nuclear fuel cycle. It does not consider effects due to possible nuclear accidents, occupational exposure nor due to radioactive waste disposal in underground facilities. Potential ionizing radiation from the soil, from radon and from some construction materials is also not measured by this indicator.		
Disclaimer 2 – The results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experienced with the indicator.		

7 LCA: Interpretation

It should be noted that the impact assessment results are only relative statements that do not include any statements about “end-points“ of the impact categories, exceeding of thresholds or risks.

Since the definition of basic materials (those substances that remain in the product) and auxiliary materials (those substances that do not remain in the product) are not applicable for this product, because small percentages of the energy source coke and the input materials ferrosilicon and silicon carbide remain in the product, a breakdown into A1-A3 was not carried out.

Figure 5 shows a dominance analysis of the percentage shares of modules A1-A3 (production), A4 (transport to construction site), A5 (installation), C1 (removal), C2 (transport) and C4 (waste treatment). The pipe production is the main contributor to all impact categories (except NHWD). The next largest impacts are the installation (A5) and the removal (C1) of the pipes and the transport to the construction site (A4).

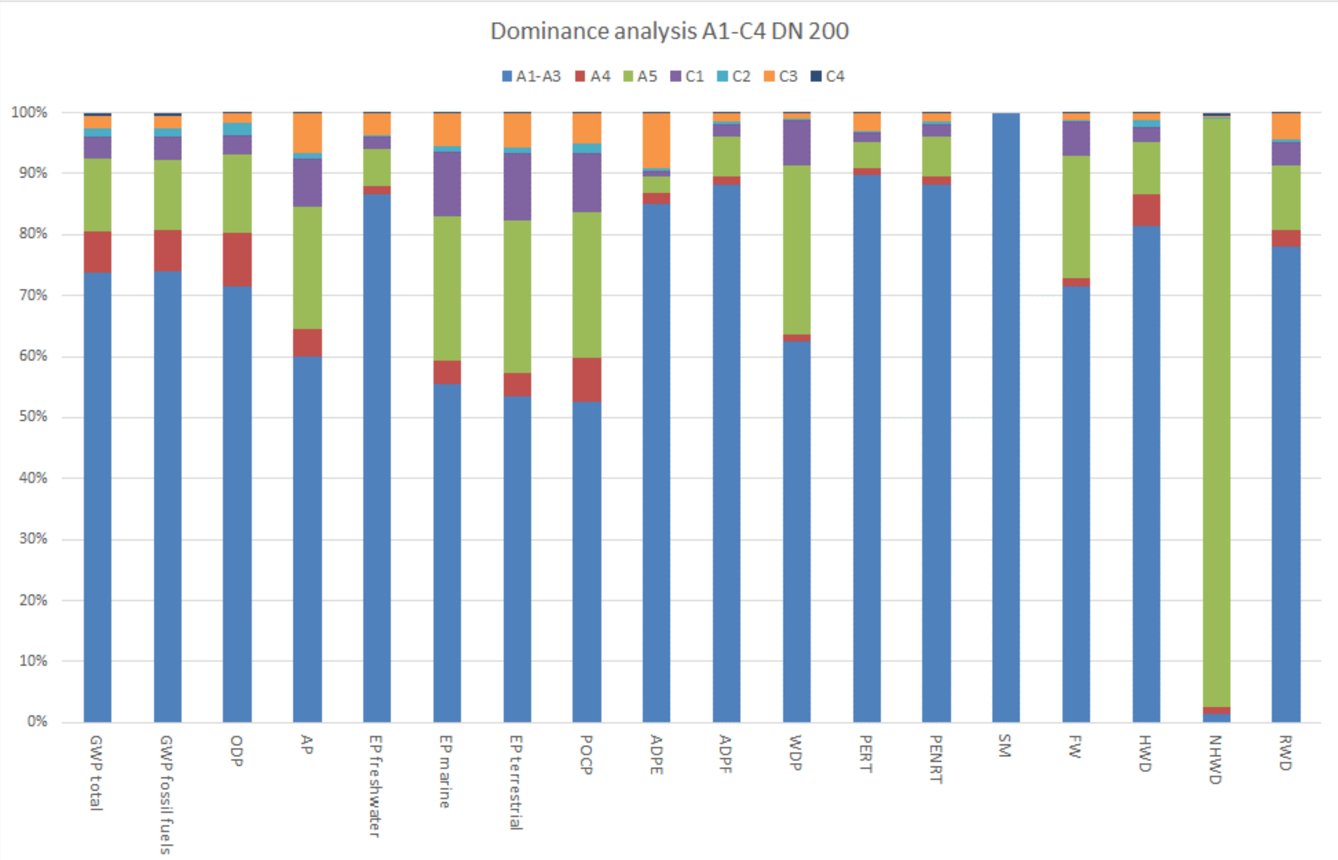


Figure 5: Dominance analysis DN 200

In the production phase (A1-A3), cast iron production has the greatest impact in terms of core indicators, with some impacts exceeding 80%. For individual indicators, galvanising has a high impact (e.g. ADPE >80%).

For the cast iron production, the cupola furnace, the annealing process and the converter have the greatest impact on the core indicators (together >90% in some cases). In the cupola furnace, CO_2 emissions from fuel use, SiC pellets and foundry coke have the greatest impact. The impact of the annealing process is determined by the natural gas used. In the converter, the magnesium and ferrosilicon applied have the greatest impact on the core indicators (in some cases >95%).

Pipe galvanisation is mainly dominated by the zinc applied (in some cases >99%).

The installation of the pipes (A5) is determined by the bedding material, the transport of the bedding material and the diesel consumption of the hydraulic excavator.

In C3, the upstream chain (wood input in the production of the scrap processing plant) of the data set used for recycling, “Iron scrap, sorted, pressed {RER}| sorting and pressing of iron scrap | Cut-off, U”, causes a slightly negative value for GWP biogenic.

8 Literature

ÖNORM EN ISO 14025: 2010 Environmental labels and declarations — Type III environmental declarations — Principles and procedures

ÖNORM EN ISO 14040: 2021 Environmental management — Life cycle assessment — Principles and framework

ÖNORM EN ISO 14044: 2021 Environmental management — Life cycle assessment — Requirements and guidelines

ÖNORM 15804:2012+A2:2019+AC:2021 Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products

Bau EPD GmbH: Product category rules for building related products and services - Requirements on the EPD for cast iron products, PCR-Code 2.16.8, Version 12.0, dated 10.10.2024. Bau EPD Österreich, Vienna, 2024

Bau EPD GmbH: Management system handbook (EPD-MS-HB) of the EPD program, Version 6.0.0, dated 06.11.2024. Bau EPD Österreich, Vienna, 2024

9 Directory and Glossary

9.1 List of figures

9.2 List of tables

9.3 Abbreviations

9.3.1 Abbreviations as per EN 15804

EPD	environmental product declaration
PCR	product category rules
LCA	life cycle assessment
LCI	life cycle inventory analysis
LCIA	life cycle impact assessment
RSL	reference service life
ESL	estimated service life
EPBD	Energy Performance of Buildings Directive
GWP	global warming potential
ODP	depletion potential of the stratospheric ozone layer
AP	acidification potential of soil and water
EP	eutrophication potential
POCP	formation potential of tropospheric ozone
ADP	abiotic depletion potential

9.3.2 Abbreviations as per corresponding PCR

CE-mark	french: Communauté Européenne or Conformité Européenne = EC certificate of conformity
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals

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EPD - ENVIRONMENTAL PRODUCT DECLARATION

as per ISO 14025 and EN 15804+A2

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PROGRAMME OPERATOR	Bau EPD GmbH, A-1070 Wien, Seidengasse 13/3, www.bau-epd.at
HOLDER OF THE DECLARATION	Tiroler Rohre GmbH
DECLARATION NUMBER	Bau EPD-TRM-2025-6-ECOINVENT-VRS-T-DN250
ISSUE DATE	10.08.2025
VALID TO	10.08.2030
NUMBER OF DATASETS	1
ENERGY MIX APPROACH	MARKET BASED APPROACH

VRS®-T ductile cast iron pipe system – DN 250
Tiroler Rohre GmbH

Content of the EPD

1 General information

Product name
VRS®-T ductile cast iron pipe system DN 250

Declaration number
Bau EPD-TRM-2025-6-ECOINVENT-VRS-T-DN250

Declaration data
☒ Specific data
☐ Average data

Declaration based on
MS-HB Version 6.0.0 dated 06.11.2024
Name of PCR: Cast iron products
PCR-Code 2.16.8, Version 12.0 dated 10.10.2024
(PCR tested and approved by the independent expert committee = PKR-Gremium)
Version of EPD-Format-Template M-Dok 14A2 dated 11.06.2024

The owner of the declaration is liable for the underlying information and evidence; Bau EPD GmbH is not liable with respect to manufacturer information, life cycle assessment data and evidence.

Declared Product / Declared Unit
1 m ductile cast iron pipe of the VRS®-T system DN 250 with Portland composite cement lining and zinc coating with PUR long-life coating with the nominal dimensions:

Table 1: Nominal dimensions

Nominal diameter [mm]	Longitudinally related mass [kg/m]
250	53,8

Number of datasets in EPD Document: 1

Range of validity
The EPD applies to the nominal diameter DN 250 of the VRS®-T ductile cast iron pipe system with the above-mentioned lining and duplex outer coating (zinc coating with PUR long-life coating) from the Hall in Tyrol plant of Tiroler Rohre GmbH (TRM).
The EPD and the production technologies assessed are representative for the production of pipes with a nominal diameter DN 250 at the Hall in Tyrol plant of Tiroler Rohre GmbH (TRM).

Type of Declaration as per EN 15804
From cradle to grave with module D (modules A+B+C+D)
LCA method: Cut-off by classification

Database, Software, Version
Ecoinvent 3.10, SimaPro 9.6.0.1
Version Characterisation Factors: Joint Research Center, EF 3.1

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The CEN standard EN 15804:2012+A2:2019+AC:2021 serves as the core-PCR.
Independent verification of the declaration according to ISO 14025:2010
☐ internally ☒ externally
Verifier 1: Dipl.-Ing. Therese Daxner M.sc.
Verifier 2: Dipl.-Ing. Roman Smutny

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Note: EPDs from similar product groups from different programme operators might not be comparable.

2 Product

2.1 2.1 General product description

The declared product is a ductile cast iron pipe of the VRS®-T system (restrained locking system) with cement mortar lining (CML) and zinc coating with PUR long-life coating with a nominal diameter DN 250 from Tiroler Rohre GmbH (TRM).

The TRM VRS®-T system consists of ductile, centrifugally cast pipes with a spigot end with a welding ring and a socket, which are joined together to form any length of pipe. The VRS®-T joint, consisting of a VRS®-T socket, VRS®-T sealing ring, spigot end with a welding ring and locking elements, is a highly resilient, flexible and restrained locking system. It is quick and easy to install and can be bent up to 5°. No welding and no weld-seam testing is necessary. The joint can be dismantled at any time.

The ductile cast iron pipes are manufactured in lengths of 5 m with nominal diameters from DN 80 to DN 600 and different wall thicknesses. The nominal dimensions of the declared ductile cast iron pipes with a nominal diameter DN 250 as well as the corresponding wall thickness classes, (normative) minimum wall thicknesses and masses per metre of pipe are shown in Table 2. To further illustrate the declared product, Figure 1 and Figure 2 show excerpts from the Tiroler Rohre GmbH product catalogue with technical and geometric specifications and corresponding mass data.

Table 2: VRS®-T ductile cast iron pipes DN 250 – nominal diameter, Wall thickness class, minimum wall thickness, mass per Meter

DN	Wall thickness class (K class)	Minimum wall thickness [mm]	Mass per m of pipe [kg/m]
250	K 9	5,2	53,8

DN	PFA a [bar]	Maße [mm]		zul. Zugkraft [kN]	Max. Abwinkelung [°]	Anzahl der Riegel	Gewicht Rohr 5m [kg] b
		s1 Guss	s2 ZMA				
80	100	4,7	4	115	5	2	81,6
100	75	4,7	4	150	5	2	100,0
125	63	4,8	4	225	5	2	128,2
150	63	4,7	4	240	5	2	157,3
200	40	4,8	4	350	4	2	204,5
250	40	5,2	4	375	4	2	268,9
300	40	5,6	4	380	4	4	339,5
400	30	6,4	5	650	3	4	519,9
500	25/30	7,2/8,2	5	860	3	4	711,8
600	35	8,0	5	1.525	2	9	909,5

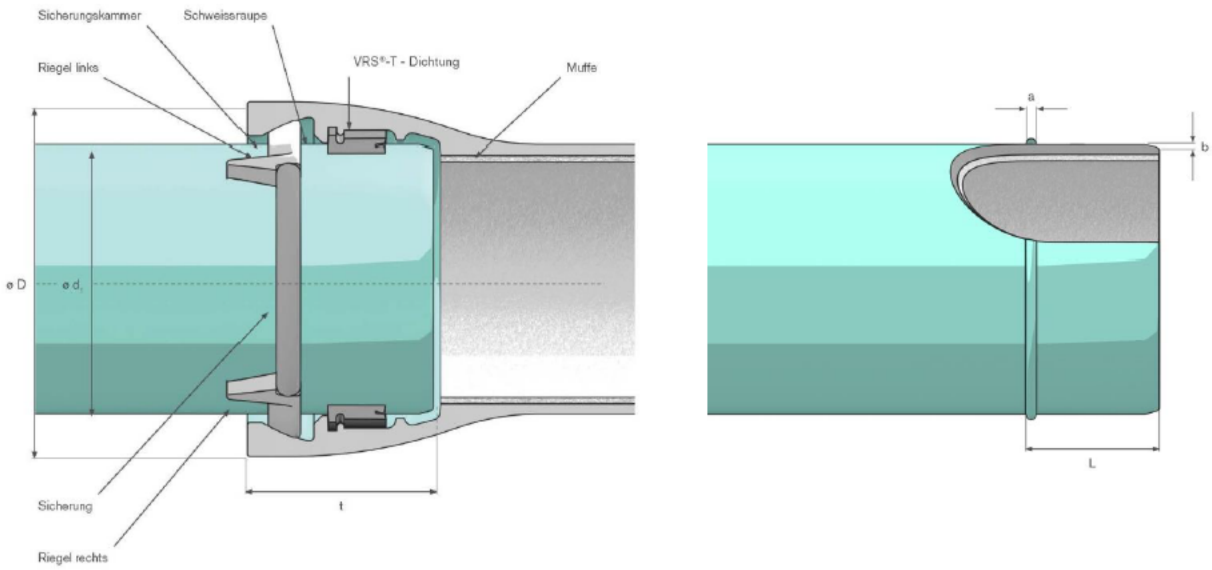
a PFA: zulässiger Bauteilbetriebsdruck | PMA = 1,2 x PFA | PEA = 1,2 x PFA + 5 | höhere PFA auf Anfrage | siehe Hinweise zum Einsatz von Klemmringen

b theoretische Masse pro Rohr für K9/10, inkl. ZMA, Zink, Deckbeschichtung

1 Mindestmaß - Toleranzen beachten | 2 Nennmaß - Toleranzen beachten

Figure 1: VRS®-T pipes – technical and geometric specifications

VRS®-T Verbindung DN 80 bis DN 600



<table>
<tr><th rowspan="3">DN</th><th colspan="7">Maße [mm] a</th></tr>
<tr><th>Durchmesser Spitzende</th><th>Abweichungen</th><th>Durchmesser Muffe</th><th>Einstecktiefe</th><th colspan="3">Schweißraupe</th></tr>
<tr><th colspan="2">d1</th><th>D</th><th>t</th><th>L</th><th>a</th><th>b</th></tr>
<tr><td>80</td><td>98</td><td>+1,0 | -2,7</td><td>156</td><td>127</td><td>86 ±4</td><td>8 ±2</td><td>5 +0,5 | -1</td></tr>
<tr><td>100</td><td>118</td><td>+1,0 | -2,8</td><td>177</td><td>135</td><td>91 ±4</td><td>8 ±2</td><td>5 +0,5 | -1</td></tr>
<tr><td>125</td><td>144</td><td>+1,0 | -2,8</td><td>206</td><td>143</td><td>96 ±4</td><td>8 ±2</td><td>5 +0,5 | -1</td></tr>
<tr><td>150</td><td>170</td><td>+1,0 | -2,9</td><td>232</td><td>150</td><td>101 ±4</td><td>8 ±2</td><td>5 +0,5 | -1</td></tr>
<tr><td>200</td><td>222</td><td>+1,0 | -3,0</td><td>292</td><td>160</td><td>106 ±4</td><td>9 ±2</td><td>5,5 +0,5 | -1</td></tr>
<tr><td>250</td><td>274</td><td>+1,0 | -3,1</td><td>352</td><td>165</td><td>106 ±4</td><td>9 ±2</td><td>5,5 +0,5 | -1</td></tr>
<tr><td>300</td><td>326</td><td>+1,0 | -3,3</td><td>410</td><td>170</td><td>106 ±4</td><td>9 ±2</td><td>5,5 +0,5 | -1</td></tr>
<tr><td>400</td><td>429</td><td>+1,0 | -3,5</td><td>521</td><td>190</td><td>115 ±5</td><td>10 ±2</td><td>6 +0,5 | -1</td></tr>
<tr><td>500</td><td>532</td><td>+1,0 | -3,8</td><td>630</td><td>200</td><td>120 ±5</td><td>10 ±2</td><td>5 +0,5 | -1</td></tr>
<tr><td>600</td><td>635</td><td>+1,0 | -4,0</td><td>732</td><td>175</td><td>160 +0 | -2</td><td>9 ±1</td><td>5 +0,5 | -1</td></tr>
<tr><td colspan="8">a Toleranzen sind möglich</td></tr>
</table>

Figure 2: Schematic illustration of a VRS®-T ductile cast iron pipe

The density of ductile cast iron is 7,050 kg/m³.

2.2 Application field

The VRS®-T cast iron pipe system with Portland composite cement lining is mainly used for drinking water supply and for fire extinguishing pipes, snow-making systems and turbine pipes. The cast iron pipe can be installed using various methods, such as:

- Conventional installation (trench)
- Trenchless installation
- Bridge pipes
- Interim pipes

- Floating

The usual installation method is conventional laying with the excavation of a trench, the creation of a bedding for the pipe and backfilling with suitable material.

2.3 Standards, guidelines and regulations relevant for the product

Table 3: Product specific standards

Regulation	Title
OENORM EN 545	Ductile iron pipes, fittings, accessories and their joints for water pipelines - Requirements and test methods
OENORM B 2599-1	Ductile iron pipes and fittings — Part 1: Use for water pipelines
OENORM B 2597	Ductile cast iron pipes and fittings for water, sewage and gas pipe lines - Restrained push-in-joints - Requirements and tests
OENORM B 2555	Coating of cast iron pipes - Thermal zinc spraying
OENORM B 2560	Ductile iron pipes - Finishing coating of polyurethane, epoxy or acrylic materials - Requirements and test methods
OENORM B 2562	Ductile cast iron pipes - Factory made lining with cement mortar - Requirements and test methods
OENORM EN 681-1	Elastomeric seals - Material requirements for pipe joint seals used in water and drainage applications - Part 1: Vulcanized rubber

2.4 Technical data

Mechanical properties are verified according to OENORM EN 545:2011, sections 6.3 and 6.4.

Table 4: Material parameters for ductile cast iron pipes of the VRS®-T system

Name	Value	Unit
Iron density	7050	kg/m^3
Minimum tensile strength	≥ 420	MPa
Proportional limit, 0.2% yield strength ($R_{p0.2}$)	≥ 300	MPa
Minimum elongation at fracture	≥ 10	%
Maximum Brinell hardness	≤ 230	HB
Pipe length	5000	mm
Mean coefficient of linear thermal expansion	$10*10^{-6}$	m/m*K
Thermal conductivity	0,42	W/cm*K

Table 5: VRS®-T pipes DN 250 – nominal dimension-dependent technical data

DN	Wall thickness class K class	Minimum wall thickness [mm]	Mass per metre of pipe [kg/m]	Allowable operating pressure PFA [bar]	Permissible tensile force [kN]
250	K 9	5,2	53,8	40	375

2.5 Basic/auxiliary materials

Table 6: VRS®-T pipes DN 250 – basic materials in mass %

DN	Casting	Zinc	Cement stone	PUR
250	81,2%	0,5%	17,6%	0,7%

Table 7: Basic materials – casting in mass %

Ingredients:	**Mass %**
Iron 1)	ca. 94 %
Carbon 2)	ca. 3,5 %
Silicon 3)	ca. 2 %
Ferric by-elements 4)	ca.0,5 %

1) Iron consisting mainly of steel scrap and a very small proportion of pig iron and return iron from the casting process

2) Foundry coke carbon. The coke in the cupola furnace serves both as an energy supplier for the scrap melting and the adjusting of the desired carbon content

3) Silicon is added in the form of SiC pellets and/or ferro-silicon

4) Ferric by-elements are found in the steel scrap in different minor quantities (<<1%)

2.6 Production stage

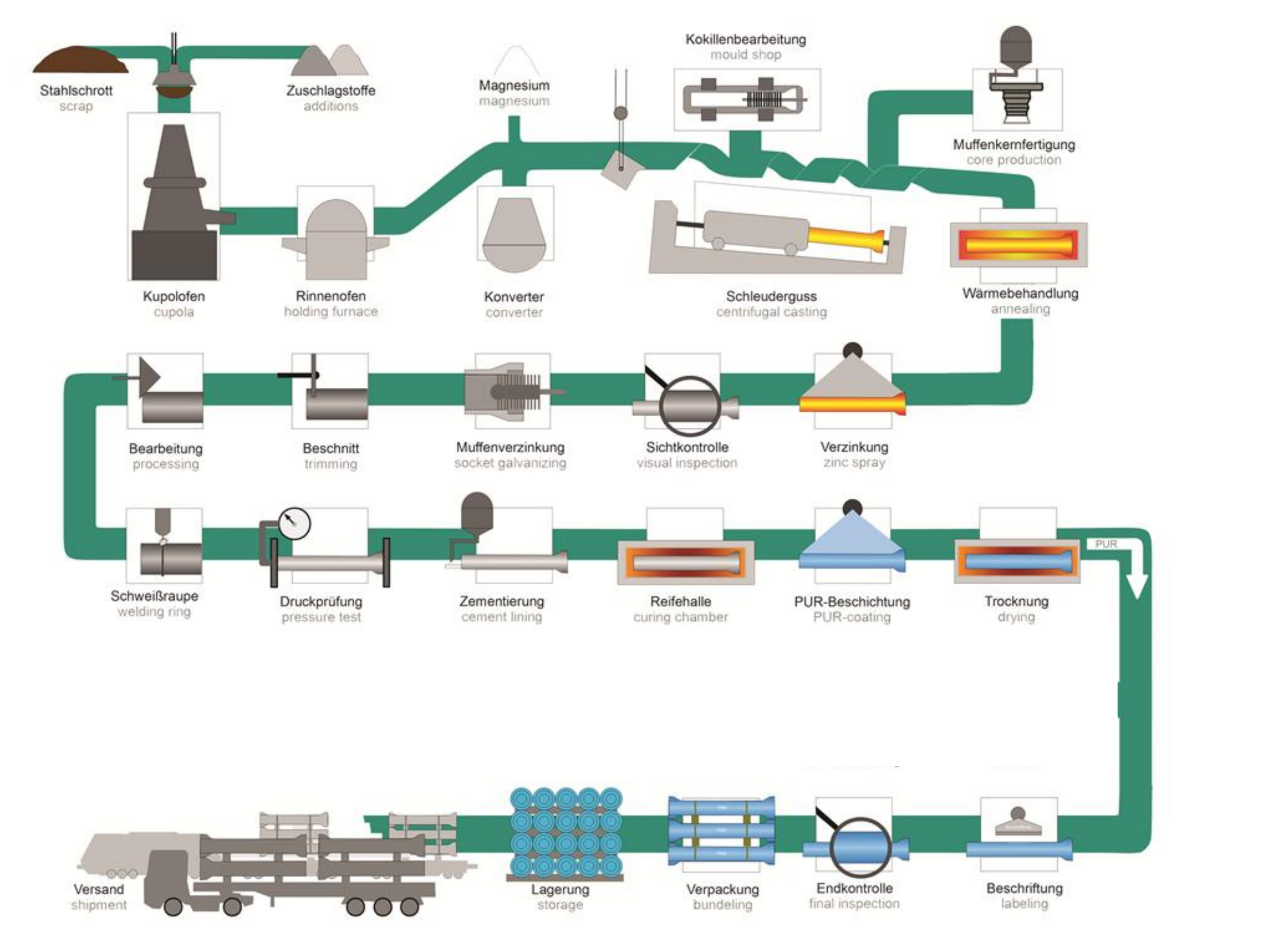


Figure 3: Flow chart of production process

For casting production, steel scrap and recycled material are smelted in the cupola furnace with the help of coke as a reaction and reduction agent. Silicon carbide is added as an alloying element. Added aggregates enhance slagging. The chemical composition of the smelted basic iron is then constantly monitored through spectral analysis. The smelted basic iron is kept warm in the holding furnace, a storage medium, and then treated with magnesium in the Georg Fischer converter, in order to reach the appropriate ductility. The liquid iron is then cast in a centrifuge machine with the De Lavaud procedure. In order to produce a specific pipe diameter, this machine is equipped with the corresponding mould (metal form that the liquid iron is poured into). The socket core made of quartz sand seals the inlet of the machine and forms the pipe socket. The glowing pipe is pulled out of the cast unit and placed in a furnace with the help of an automatic transport system. Here it undergoes annealing in order to achieve the desired mechanical properties.

The pipe is then galvanised using the electric arc spraying process and then cooled. The pipe is visually inspected in the pipe line. The spigot end and socket are machined if necessary. In the area of the welding ring, the zinc and annealing skin (tinder) are ground off and finally the welding ring is applied.

During the pressure test, each pipe is hydrostatically pressurised with a certain internal pressure and checked for leaks. The pipe is then lined with cement mortar using the centrifugal rotation process. The weld seam is galvanised and the pipes are visually inspected again. The cement stone hardens in the curing chamber. Finally, a solvent-free two-component polyurethane top coat is applied. All pipes are labelled according to the specifications, bundled and brought to the warehouse.

2.7 Packaging

The TRM pipes are sealed with protective caps and bundled using squared timber and spacer rings as stacking aid and PET tapes. All packaging materials can be used for thermal recycling.

2.8 Conditions of delivery

The ductile cast iron pipes are bundled for transport and storage with the help of squared lumber and spacer rings as stacking aid as well as PET binding tapes.

2.9 Transport to site

The cast pipes are transported to their destination within Europe by lorry and, in rare cases, overseas by ship.

2.10 Construction product stage

The installation of pressure pipes made of ductile cast iron must comply with OENORM EN 805 (Water supply - Requirements for systems and components outside buildings) and OENORM B 2538 (Additional specifications concerning OENORM EN 805). When constructing the pipe trench, sufficient working space must be provided for the installation of the pipeline, depending on the trench depth and the outer diameter of the pipe. The Ordinance on Protection of Construction Workers (Bauarbeiterschutzverordnung) and other provisions as well as relevant standards and regulations must be complied with accordingly.

As this is a push-in joint, no additional work such as welding is required. The pipe trench must be constructed and excavated in such a way that all pipe sections are at frost-free depths. The trench must be excavated deep enough so that the final cover height is at least 1.50 m. In the case of ductile iron pipes, the existing soil is generally suitable for bedding the pipeline. This means there is no need for a lower bedding layer and the bottom of the trench becomes the lower bedding.

The pipeline must be embedded and the pipe trench refilled in such a way that the pipeline is securely fixed in its intended position and that damage to the pipeline is prevented and settlement can only occur to the permissible extent. Suitable material that does not damage the pipe components and the coating must be used for embedding the pipeline. The backfill material should be installed in layers and sufficiently compacted.

2.11 Use stage

If installed and designed professionally and if the phase of utilisation is not disturbed, no modification of the material composition of construction products made of ductile cast iron occur.

2.12 Reference service life (RSL)

Table 8: Reference service life (RSL)

Name	Value	Unit
Ductile cast iron pipes	50	Years

In practice, it has been shown that a service life of 100 years, based on the DVGW damage statistics (German Technical and Scientific Association for Gas and Water – https://www.dvgw.de/themen/sicherheit/gas-und-wasserstatistik/), is achieved.

2.13 End of life stage

In inner-city areas, the main area of application for the pipe systems, the installed pipes are currently almost entirely removed. These pipes can then be recycled accordingly. These pipes can then be sent to recycling. The removal and recycling rate was therefore set correspondingly high in the scenarios considered (see 4.4 - C1-C4 disposal phase). However, it should be noted that the 100% removal rate is a manufacturer's scenario, which must be checked and adjusted accordingly in each individual use case.

The pipes are disposed of in very rare cases. The EAK waste code number for iron and steel from construction and demolition is 170405.

2.14 Further information

For further information about the TRM pipe system and its possible applications, see the website http://trm.at/rohr.

3 LCA: Calculation rules

3.1 Declared unit/ Functional unit

The functional unit is 1 metre [m] of pipe. For conversion into kg, Table 9 can be used.

Table 9: Conversion factor to mass

Nominal diameter [mm]	Longitudinally related mass [kg/m]	Multiplication factor
250	53,8	0,0186

3.2 System boundary

The entire product life cycle and module D is declared. This is a "from cradle to grave with module D"-EPD (modules A+B+C+D).

Table 10: Declared life cycle stages

PRODUCT STAGE			CON-STRUCTION PROCESS STAGE		USE STAGE							END-OF-LIFE STAGE				BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARIES
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
Raw material supply	Transport	Manufacturing	Transport from the gate to the site	Construction, installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction, demolition	Transport	Waste processing	Disposal	Reuse- Recovery- Recycling- potential
x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

X = included in LCA; ND = Not declared

3.2.1 A1-A3 Product Stage:

The cast iron pipes (semi-finished parts) are almost exclusively made of the secondary material steel scrap and a very small proportion of pig iron and return iron from the casting process. The system boundary for the steel scrap is set when the processed steel scrap leaves the recycling plants, because the end of the waste properties of the steel scrap is reached here. This system is blamed for the transportation of the scrap to the TRM plant. The product stage includes the production steps in the plant along with the energy supply (including the upstream chains), the production of raw materials, auxiliary materials and packaging (including transport to the plant), the infrastructure and the disposal of the waste occurring during production. Module A1-A3 also includes the manufacture of the locks and gaskets required for assembling the pipe.

3.2.2 A4-A5 Construction stage:

The cast iron pipe can be installed in various ways. This EPD considers the standard case for installation, i.e. the conventional laying of the pipe:

- Excavation of trench
- Bedding of the pipe
- Backfilling with suitable material

The protective caps, squared lumber and binding tapes needed for transport are thermally recycled.

3.2.3 B1-B7 Use stage:

Generally, construction products made of ductile cast iron show no impact on the LCA during the use stage.

3.2.4 C1-C4 End-of-life stage:

In inner-city areas, the main area of application for the pipe systems, the installed pipes are currently almost entirely removed. For this reason, a 100% removal rate is applied as a scenario.

The removed pipes are sent to a recycling process and are considered until the end-of-waste state according to EN 15804 in the current product system. The system boundary is therefore set when the processed steel scrap leaves the recycling plants.

As a recycling scenario, due to the robustness of the pipe systems, it is assumed that 97% of the removed pipes are suitable for the recycling process and 3% have to be sent to landfill due to breakage, etc. The recycling scenario applied is a manufacturer's scenario based on the experience of Tiroler Rohre GmbH, which must be checked and adapted accordingly in each individual use case.

3.2.5 D Benefits and loads:

Due to the recycling of the removed pipes, there is a corresponding output of secondary raw materials in C3. The output flows are compared with the scrap share in the production of the cast iron pipes in accordance with the net flow rule according to EN 15804 and the net output flow is determined. The recycling and net flow scenario applied is a manufacturer's scenario based on the experience of Tiroler Rohre GmbH, which must be checked and adapted accordingly in each individual use case.

3.3 Flow chart of processes/stages in the life cycle

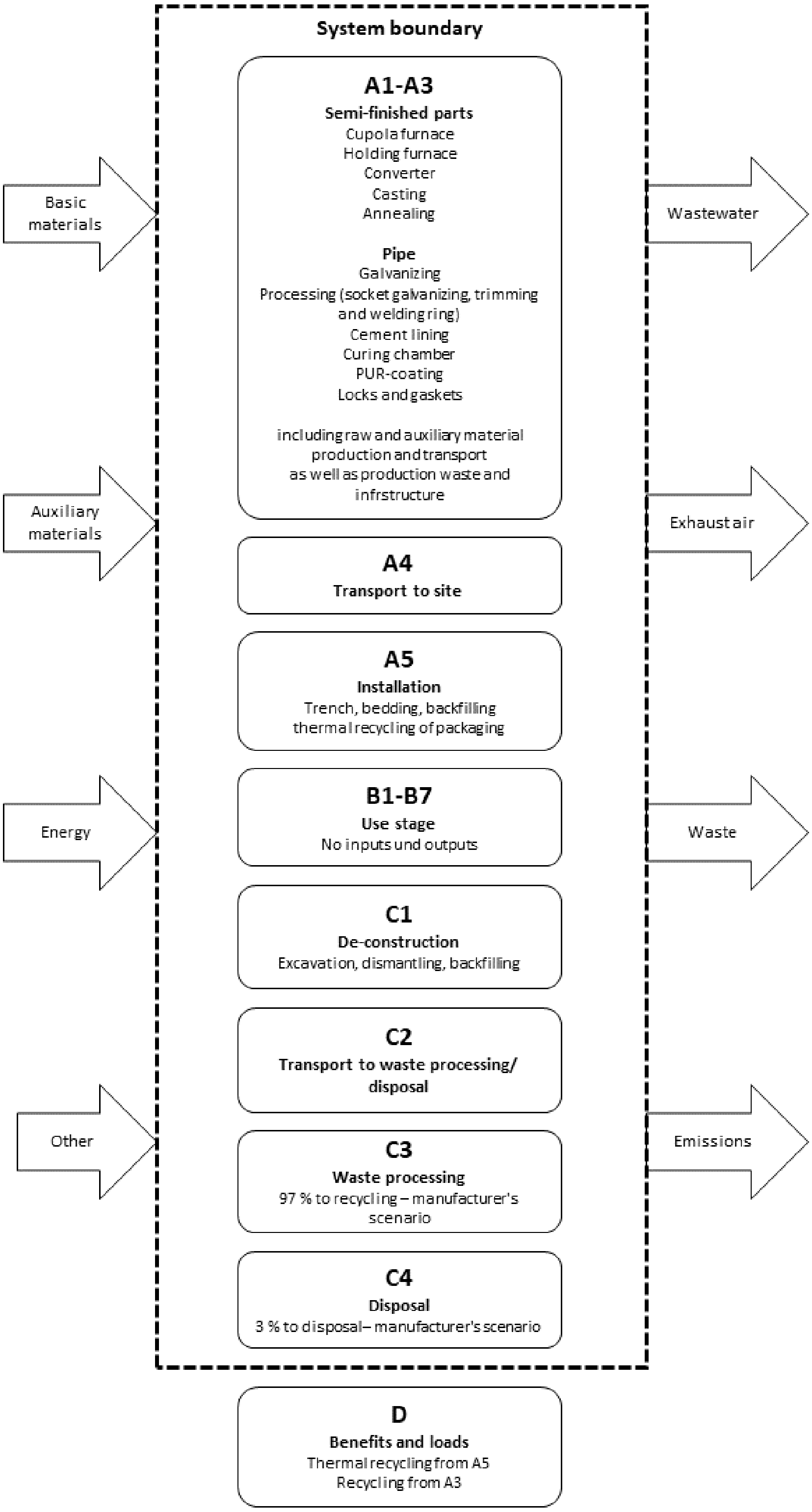


Figure 4: Life cycle flow chart

3.4 Estimations and assumptions

The SiC pellets used in casting production consist of various silicon components, Portland cement and water. In ecoinvent 3.10 there is only one data set for silicon carbide, which is typical of wafer production and has a very high SiC purity compared to the SiC component mixture used in casting production and therefore also a high energy intensity (information from the manufacturer of the pellets). According to the manufacturer of the SiC pellets, the energy required to produce the SiC components or silicon carbide is reflected in the respective prices per tonne. This allows an adjustment of the SiC purity (correction factor) of the data set available in ecoinvent based on an economic comparison (i.e. in the style of an economic allocation).

Cast steel is a special steel with no available data set. As the input is below 1 kg per t of ductile cast iron, the ecoinvent data set for chrome steel was applied.

For magnesium, which mainly comes from China, the global data set for magnesium was used ("market"-data set).

Since the infrastructure only makes a very small contribution to environmental impact, the machinery was modelled with its main components steel and casting.

For the use stage, it was assumed that no LCA-relevant material and energy flows occur.

All transport distances, with the exception of magnesium, were collected by the customer and taken into account in the LCA. For magnesium, the average transports are taken into account by the application of the global "market"-data set (which includes transport processes for the market under consideration).

3.5 Cut-off criteria

The producer calculated and submitted the amount of all applied materials, energy needed, the packaging material, the arising waste material and the way of disposal and the necessary infrastructure (buildings and machinery for the production). The measurement values for emissions according to the casting regulations were specified.

Auxiliary materials whose material flow is less than 1% were ignored as insignificant. Internal transport was negligible due to the short transport distances. It can be assumed that the total of insignificant processes is less than 5% of the impact categories.

During the production of the ductile pipes, slag (from cupola furnace) and coke dust are produced as by-products. Part of the waste heat is sold as district heating. However, these by-products contribute less than 1% to the operational income and can therefore be ignored according to the Management-System-Handbook (MS-HB) of the Bau EPD GmbH (MS-HB Version 6.0.0 dated 06.11.2024). The system limit for these two recyclable materials is set when they are collected from the plant by the future user.

The materials resulting from the production of semi-finished parts – foundry debris, fly-ash, filter cake from cupola furnace dust extraction and converter slag – are taken to a recycling plant for processing, whereby the system limit is set when the substances arrive at this plant, because no detailed information is available on the further treatment processes and the influence on the results of the impact categories is classified as negligible.

In C3, the recycling of the pipes (97%), i.e. the processing of the removed pipes in a recycling plant into a secondary raw material that can be used in cast iron and steel production, is taken into account. For this purpose, it is assumed that the pipe (including CML, etc.) is sent as a whole to the recycling plant, where any materials that cannot be used for cast iron and steel production are separated out. The treatment of these separated materials is excluded due to the expected minor influence.

3.6 Allocation

The system boundary for the steel scrap is set when the processed steel scrap leaves the recycling plants, because the end of the waste staus of the steel scrap is reached here. This system is blamed for the transportation of the scrap to the TRM plant.

In the liquid iron sector, an allocation by mass based on stock additions was carried out between the pipes considered in this EPD and the products not considered. The same applies to waste.

During the production of the ductile pipes, slag and coke dust are produced as by-products. Part of the waste heat is sold as district heating. However, these by-products contribute less than 1% to the operational income and can therefore be ignored according to the "Management-System-Handbook (MS-HB) of the Bau EPD GmbH (MS-HB Version 6.0.0 dated 06.11.2024).

For the annealing, the energy used was allocated according to the dwell times in the furnace.

Due to the recycling of the removed pipes, there is a corresponding output of secondary raw materials in C3. The output flows are compared with the scrap share in the production of the cast iron pipes in accordance with the net flow rule according to EN 15804 and the net output flow is determined.

3.7 Comparability

In principle, a comparison or evaluation of EPD data is only possible if all data sets to be compared have been created in accordance with EN 15804, the same programme-specific PCR/any additional rules and the same background database have been used, and the building context/product-specific performance characteristics are also taken into account.

4 LCA: Scenarios and additional technical information

4.1 A1-A3 Product stage

According to OENORM EN 15804, no technical scenario details are required for A1-A3 as the producer is responsible for the accounting of these modules, and this must not be changed by the user of the LCA.

Data collection for the product stage was carried out according to ISO 14044 Section 4.3.2. In accordance with the target definition, all relevant input and output flows that occur in connection with the product under consideration were identified and quantified in the life cycle inventory analysis.

Electricity generation is modelled according to the electricity mix supplied by Tiroler Wasserkraft AG (TIWAG) to Tiroler Rohre GmbH. In 2020, Tiroler Rohre GmbH purchased the TIWAG 2020 supplier mix (Versorgermix) from Tiroler Wasserkraft AG TIWAG (electricity mix contractually secured).

A part of the electricity consumption in the semi-finished parts production takes place at medium voltage level. The remaining electricity consumption takes place at low voltage level, with 5.75% coming from the in-house photovoltaic system.

Since photovoltaic electricity is generally fed into the grid and consumed at low voltage, and Tiroler Rohre GmbH purchases its electricity at medium voltage, the photovoltaic share is deducted when modelling the medium-voltage electricity supplied by TIWAG (see Table 11).

Table 11: Electricity mix

Source	**TIWAG Supplier mix general**	**Medium voltage without photovoltaics**
Hydro power	84,90%	86,32%
Norway	*20,23%*	*20,57%*
Tyrol	*64,67%*	*65,75%*
Wind power	10,37%	10,54%
Solid or liquid biomass	2,02%	2,05%
Photovoltaics	1,64%	0,00%
Biogas	1,05%	1,07%
Other eco-energy	0,02%	0,02%
Sum	**100,00%**	**100,00%**

The GWP total- result for the TIWAG electricity mix used is 57.3 g CO_2 eq/kWh at high voltage level, 60.5 g CO_2 eq/kWh at medium voltage level and 61.6 g CO_2 eq/kWh at low voltage level. The GWP total-result for low-voltage electricity from the photovoltaic system at the TRM plant is 104 g CO_2 eq/kWh.

4.2 A4-A5 Construction process stage

The pipes are transported to their destination by truck. The client provided relevant information on the transports, and based on this, an average transport distance of approximately 470 km was determined.

Table 12 shows the general parameters for describing transportation to the building site.

Table 12: Description of the scenario „Transport to building site (A4)"

Parameters to describe the transport to the building site (A4)	Value	Unit
Average transport distance	471	km
Vehicle type, Commission Directive 2007/37/EC (European Emission Standard)	Euro 6	-
Average fuel consumption, fuel type: Diesel or heavy fuel oil	25,3	l/100 km
Average transport mass	5,79	t
Average capacity utilisation (including empty returns)	85	%
Average gross density of transported products	53,8	kg/m
Volume capacity utilisation factor (factor: =1 or <1 or ≥ 1 for compressed or nested packaged products)	<1	-

Conventional laying was chosen as the installation method for the EPD, i.e. excavating a trench, bedding the pipe and backfilling with suitable material. A hydraulic excavator with an engine power of 80 kW, a scoop capacity of 0,87 m3 and a weight of 17 t was used for the excavation and backfilling of the pipe trench (including bedding).

Most of the excavation material is temporarily stored and reused for backfilling. However, a certain proportion of the excavation material (varying for the specific nominal diameters depending on the proportion of bedding) must be disposed of at a landfill 20 km away. The additional backfill material required for this is transported from a gravel pit 20 km away.

The spacer rings (PP), protective caps (PE), stacked wood and binding tape (PET) are thermally recycled in a waste incinerator 100 km away.

Table 13: Description of the scenario „Installation of the product in the building (A5)"

Parameters to describe the installation of the product in the building (A5)	Value	Unit
Ancillary materials for installation (specified by material);	Backfill material 278	kg/m
Ancillary materials for installation (specified by type)	Hydraulic excavator	-
Water use	0	m^3/m
Other resource use	0	kg/m
Electricity demand	0	kWh/m
Other energy carrier(s): Diesel	10	MJ/m
Wastage of materials on the building site before waste processing, generated by the product's installation (specified by type)	0	kg/m
Output materials (specified by type) as result of waste processing at the building site e.g. of collection for recycling, for energy recovery, disposal (specified by route)	Disposal Excavation: 278 Waste incineration Wood: 0,185 PET: 0,004 PE: 0,071 PP: 0,028	kg/m
Direct emissions to ambient air (such as dust, VOC), soil and water	-	kg/m

4.3 B1-B7 Use stage

In the use stage, no material and energy flows relevant for the life cycle assessment take place for the VRS®-T pipe systems, wherefor no activities were taken into account.

4.4 C1-C4 End-of-Life stage

In inner-city areas, the main area of application for the pipe systems, the installed pipes are currently almost entirely removed. For this reason, a 100% removal rate is used as a scenario. The removed pipes are sent to a recycling process, being considered until the end-of-waste state in the current product system. The system limit is set when the processed steel scrap leaves the recycling plants. From this point on, the pipe is part of a new product system. As a recycling scenario it is assumed that 97% of the pipes are suitable for the recycling process and 3% have to be sent to disposal.

The pipes are removed with the same excavator that was used for the installation. The excavation volume for the removal corresponds to volume for the installation. The existing excavation material is reinstalled, but must be supplemented with additional backfill material (different for the specific DN). The distance to the gravel pit is estimated at 20 km.

Table 14: Description of the scenario "Dismantling (C1)"

Parameters to describe the dismantling (C1)	Value	Unit
Auxiliary materials for the dismantling	Backfill material 130,3	kg/m
Aids for the demolition	Hydraulic excavator	-
Water consumption	0	m^3/m
Other resource use	0	kg/m
Electricity consumption	0	kWh/m
Other energy carrier: Diesel	10	MJ/m
Material loss on the construction site before waste treatment, caused by the installation of the product	0	kg/m
Output materials due to waste treatment on the construction site, e.g. collection for recycling, for energy recovery or for disposal	0	kg/m
Direct emissions to ambient air (e.g. dust, VOC), soil and water	-	kg/m

The transport distance to the nearest recycling company (97% of the pipes) as well as to the nearest inert material landfill (3% of the pipes) or waste incineration plant (gaskets) was assumed to be 100 km.

Table 15: Description of the scenario "Transport for disposal (C2)"

Parameters to describe the transport for disposal (C2)	Value	Unit
Average transport distance	100	km
vehicle type, Commission Directive 2007/37/EC (European Emission Standard)	Euro 6	-
Average fuel consumption, fuel type: Diesel or heavy fuel oil	25,3	l/100 km
Average transport mass	5,79	t
Average capacity utilisation (including empty returns)	85	%
Average gross density of transported products	53,8	kg/m
Volume capacity utilisation factor (factor: =1 or <1 or ≥ 1 for compressed or nested package products)	<1	-

In C3, the recycling of the pipes (97%), i.e. the processing of the removed pipes in a recycling plant into a secondary raw material that can be used in cast iron and steel production, is taken into account. For this purpose, it is assumed that the pipe (including CML, etc.) is sent as a whole to the recycling plant, where any materials that cannot be used for cast iron and steel production are separated out. The treatment of these separated out materials is excluded due to the expected minor influence. A new product system begins with the transport of the processed scrap from the recycling plant to the production plant.

In C4, the disposal of 3% of the pipe mass in an inert material landfill and the disposal of the EPDM gasket material in a waste incinerator are considered. A 100% recycling rate is applied for the removed bolts, which are made of pure cast material.

Table 16: Disposal processes (C3 and C4) per m of pipe

DN	Mass per metre of pipe	Total pipe mass for recycling (97%)	Total pipe mass for disposal (3%)	Lock mass for recycling (100%)	Total mass (pipe and Lock) for recycling	Gasket mass for waste incineration
[mm]	*[kg/m]*	*[kg/m]*	*[kg/m]*	*[kg/m]*	*[kg/m]*	*[kg/m]*
250	53,80	52,186	1,614	0,300	52,486	0,1160

Table 17: Description of the scenario „Disposal of the product (C1 to C4)"

Parameters for end-of-life stage (C1-C4)	Value	Unit
Collection process, separately	see Table 16	kg collected separately
Recycling	see Table 16	kg for recycling
Disposal, inert material landfill	see Table 16	kg material for final deposition

4.5 D Potential of reuse and recycling

Due to the recycling of the removed pipes (97%), there is a corresponding output of secondary raw materials (D from C3). Due to the net flow rule according to EN 15804 and the high proportion of scrap in the production of cast iron pipes (988 kg per tonne of cast semi-finished part), there is a slightly negative net output flow here.

Table 18: Description of the scenario „re-use, recovery and recycling potential (module D)“

Parameters for module D	Value	Unit
Materials for reuse, recovery or recycling from A4-A5	-	%
Energy recovery or secondary fuels from A4-A5	Waste incineration Wood: 0,185 PP: 0,004 PE: 0,071 PET: 0,028	kg/m
Materials for reuse, recovery or recycling from B2-B5	-	%
Energy recovery or secondary fuels from B2-B5	-	kg/m
Materials for reuse, recovery or recycling from C1-C4	97	%
Energy recovery or secondary fuels from C1-C4	Waste incineration Gasket: 0,1160	kg/m

Due to the multi-recycling potential of the pipes, they could again replace primary raw materials in the next product system. In this EPD, the multi-recycling potential is not shown as a life cycle assessment result (in the results tables) but as additional information (Appendix 1), because this value does not comply with the rules and specifications of EN 15804 (net flow rule). The additional information on multi-recycling potential is based on a manufacturer scenario based on the experience of Tiroler Rohre GmbH.

5 Information on data quality and data selection in accordance with EN 15941

5.1 Principles for the description of data quality

The following information on data quality is provided in accordance with the requirements of EN 15941 (EN 15941, section 7.3.4).

The data fulfils the following quality requirements:

The data is representative for the production year 2020 (annual average). The production year 2020 is considered based on the existing data for ductile cast iron production (semi-finished part production) of the EPD for ductile piles from Tiroler Rohre GmbH (published 2022).

For the data collection, generic data and the cut-off of material and energy flows the criteria of the Bau EPD GmbH were considered.

The manufacturer provided all essential data such as energy and raw material consumption, transport distances and vehicles as well as packaging within the system boundaries.

The applied background database ecoinvent 3.10 was published in 2024, but contains individual data sets whose collection or reference year dates back more than 10 years (requirement EN 15804 or Bau EPD GmbH). These data sets remained in the various ecoinvent database versions through the years, taking necessary adjustments for database updates into account. Nevertheless, these data sets are subject to a corresponding potential for fluctuation because some of the (technological) developments of recent years are not reflected.

The data is plausible, i.e. the deviations from comparable results are within a plausible range.

5.2 Description of the temporal, geographical and technological representativeness of the product data

Temporal representativeness:

- The data collection period corresponds to the year 2020. All specific data are from this year.
- There is no deviation from the reporting year 2020 in the collection of specific data.
- The applied background database ecoinvent 3.10 was published in 2024, but contains individual data sets whose collection or reference year dates back more than 10 years (requirement EN 15804 or Bau EPD GmbH).

Geographical representativeness:

- VRS®-T pipe systems are manufactured exclusively at the plant in Hall in Tirol. In the production year 2020, almost 50% of the products were delivered within Austria and a total of approx. 90% within Europe (with a focus on Germany and Italy in addition to Austria).
- The pipe systems are disposed of in an area close to where they were used.

Technological representativeness:

- The production technology at the plant in Hall in Tyrol is state-of-the-art. The facilities are regularly maintained and modernised.
- In addition to cast iron pipe systems, other products such as ductile piles (pure cast iron product corresponds to semi-finished parts) are also manufactured at the analysed plant.

Geographical and technological representativeness for EPDs covering an industry:

- Not relevant for this EPD.

5.3 Explanation of the averaging process

Not relevant for this EPD, as specific products from the plant in Hall in Tyrol of the Tiroler Rohre GmbH are considered.

5.4 Assessment of the data quality of the Life Cycle Inventory data

The validity (database/source, country/region, reference year, publication/update) and the geographical, technical and temporal representativeness (according to ÖNORM EN 15804 Annex E - Table E.1) of all data sets used are assessed in the project report for this EPD.

The manufacturer provided all essential data such as energy and raw material consumption, transport distances and vehicles, and packaging within the system boundaries (quality management system and SAP system).

6 LCA: results

Table 19: Parameters to describe the environmental impact per metre [m] VRS®-T DN 250

Parameters	Unit	A1-A3	A4	A5	B1-B7	C1	C2	C3	C4	C1-C4	A-C	D
GWP total	kg CO_2 eq	5,20E+01	4,88E+00	8,30E+00	0,00E+00	2,84E+00	1,03E+00	1,36E+00	3,76E-01	5,60E+00	7,08E+01	1,11E+00
GWP fossil fuels	kg CO_2 eq	5,21E+01	4,88E+00	8,01E+00	0,00E+00	2,83E+00	1,03E+00	1,37E+00	3,76E-01	5,61E+00	7,06E+01	1,12E+00
GWP biogenic	kg CO_2 eq	-9,80E-02	3,38E-03	2,79E-01	0,00E+00	3,26E-03	7,14E-04	-1,78E-02	4,61E-05	-1,38E-02	1,70E-01	-5,20E-03
GWP luluc	kg CO_2 eq	3,31E-02	1,62E-03	4,31E-03	0,00E+00	1,48E-03	3,42E-04	1,94E-03	6,77E-06	3,77E-03	4,28E-02	1,12E-04
ODP	kg CFC-11 eq	7,14E-07	9,70E-08	1,31E-07	0,00E+00	3,60E-08	2,05E-08	1,89E-08	4,02E-10	7,58E-08	1,02E-06	1,14E-09
AP	mol H^+ eq	1,34E-01	1,02E-02	4,32E-02	0,00E+00	1,82E-02	2,15E-03	1,51E-02	1,22E-04	3,56E-02	2,23E-01	4,09E-03
EP freshwater	kg P eq	1,81E-02	3,30E-04	1,23E-03	0,00E+00	4,88E-04	6,98E-05	7,82E-04	1,79E-06	1,34E-03	2,10E-02	4,83E-04
EP marine	kg N eq	3,44E-02	2,44E-03	1,41E-02	0,00E+00	6,36E-03	5,15E-04	3,50E-03	4,75E-05	1,04E-02	6,13E-02	9,83E-04
EP terrestrial	mol N eq	3,54E-01	2,63E-02	1,58E-01	0,00E+00	7,17E-02	5,56E-03	3,94E-02	5,17E-04	1,17E-01	6,56E-01	1,06E-02
POCP	kg NMVOC eq	1,19E-01	1,69E-02	5,31E-02	0,00E+00	2,18E-02	3,57E-03	1,18E-02	1,64E-04	3,73E-02	2,26E-01	3,55E-03
ADPE	kg Sb eq	7,17E-04	1,59E-05	2,48E-05	0,00E+00	8,93E-06	3,35E-06	8,44E-05	3,02E-08	9,68E-05	8,54E-04	5,39E-07
ADPF	MJ H_u	3,47E+02	5,71E+00	2,47E+01	0,00E+00	1,01E+01	1,20E+00	5,94E+00	2,58E-02	1,72E+01	3,95E+02	1,10E+01
WDP	m3 World eq	1,40E+01	2,85E-01	6,13E+00	0,00E+00	1,98E+00	6,02E-02	2,30E-01	9,77E-03	2,28E+00	2,27E+01	6,36E-02
Legend		GWP = Global warming potential; luluc = land use and land use change; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential, Accumulated Exceedance; EP = Eutrophication potential; POCP = Formation potential of tropospheric ozone photochemical oxidants; ADPE = Abiotic depletion potential for non-fossil resources; ADPF = Abiotic depletion potential for fossil resources WDP = Water (user) deprivation potential, deprivation-weighted water consumption										

Table 20: Additional environmental impact indicators per metre [m] VRS®-T DN 250

Parameters	Unit	A1-A3	A4	A5	B1-B7	C1	C2	C3	C4	C1-C4	A-C	D
PM	Occurrence of diseases	6,03E-06	3,59E-07	9,53E-07	0,00E+00	4,15E-07	7,59E-08	2,11E-07	1,88E-09	7,04E-07	8,05E-06	8,83E-08
IRP	kBq U235 eq	2,42E+00	8,90E-02	3,49E-01	0,00E+00	1,45E-01	1,88E-02	1,38E-01	3,63E-04	3,03E-01	3,16E+00	4,57E-04
ETP-fw	CTUe	5,52E+02	1,87E+01	3,14E+01	0,00E+00	1,10E+01	3,94E+00	1,33E+01	6,48E-01	2,90E+01	6,31E+02	1,17E+02
HTP-c	CTUh	5,71E-07	3,46E-08	5,26E-08	0,00E+00	1,95E-08	7,31E-09	1,19E-08	8,28E-11	3,88E-08	6,97E-07	4,46E-07
HTP-nc	CTUh	5,10E-07	4,31E-08	5,06E-08	0,00E+00	1,65E-08	9,10E-09	7,34E-08	1,47E-10	9,91E-08	7,03E-07	3,88E-09
SQP	dimensionless	1,72E+02	4,15E+01	1,34E+02	0,00E+00	1,99E+01	8,75E+00	3,29E+01	5,05E-01	6,21E+01	4,10E+02	2,43E+00
Legend		PM = Potential incidence of disease due to Particulate Matter emissions; IRP = Potential Human exposure efficiency relative to U235; ETP-fw = Potential Comparative Toxic Unit for ecosystems; HTP-c = Potential Comparative Toxic Unit for humans – cancer effect; HTP-nc = Potential Comparative Toxic Unit for humans – non-cancer effect; SQP = Potential soil quality index										

Table 21: Parameters to describe the use of resources per metre [m] VRS®-T DN 250

Parameters	Unit	A1-A3	A4	A5	B1-B7	C1	C2	C3	C4	C1-C4	A-C	D
PERE	MJ H_u	8,78E+01	1,18E+00	6,65E+00	0,00E+00	1,79E+00	2,49E-01	3,01E+00	5,31E-03	5,05E+00	1,01E+02	1,18E-01
PERM	MJ H_u	2,27E+00	0,00E+00	-2,27E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PERT	MJ H_u	9,00E+01	1,18E+00	4,38E+00	0,00E+00	1,79E+00	2,49E-01	3,01E+00	5,31E-03	5,05E+00	1,01E+02	1,18E-01
PENRE	MJ H_u	3,43E+02	5,71E+00	2,88E+01	0,00E+00	1,01E+01	1,21E+00	5,94E+00	2,58E-02	1,72E+01	3,95E+02	1,10E+01
PENRM	MJ H_u	4,02E+00	0,00E+00	-4,02E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PENRT	MJ H_u	3,47E+02	5,71E+00	2,47E+01	0,00E+00	1,01E+01	1,21E+00	5,94E+00	2,58E-02	1,72E+01	3,95E+02	1,10E+01
SM	kg	4,35E+01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	4,35E+01	-7,83E-01
RSF	MJ H_u	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
NRSF	MJ H_u	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
FW	m^3	5,41E-01	9,51E-03	1,50E-01	0,00E+00	4,92E-02	2,01E-03	9,04E-03	6,10E-04	6,09E-02	7,62E-01	1,64E-03
Legend		PERE = Renewable primary energy as energy carrier; PERM = Renewable primary energy resources as material utilization; PERT = Total use of renewable primary energy resources; PENRE = Non-renewable primary energy as energy carrier; PENRM = Non-renewable primary energy as material utilization; PENRT = Total use of non-renewable primary energy resources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of fresh water										

Table 22: Parameters describing LCA-output flows and waste categories per metre [m] VRS®-T DN 250

Parameters	Unit	A1-A3	A4	A5	B1-B7	C1	C2	C3	C4	C1-C4	A-C	D
HWD	kg	6,48E-03	4,62E-04	7,02E-04	0,00E+00	2,04E-04	9,76E-05	1,13E-04	2,54E-06	4,17E-04	8,07E-03	1,40E-04
NHWD	kg	4,27E+00	3,31E+00	2,80E+02	0,00E+00	5,60E-01	7,00E-01	4,83E-01	1,62E+00	3,36E+00	2,91E+02	2,85E-02
RWD	kg	1,12E-03	4,02E-05	1,54E-04	0,00E+00	6,37E-05	8,49E-06	6,45E-05	1,68E-07	1,37E-04	1,45E-03	4,15E-07
CRU	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
MFR	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	4,27E+01	0,00E+00	4,27E+01	4,27E+01	0,00E+00
MER	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
EEE	MJ	0,00E+00	0,00E+00	3,82E-01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,82E-01	0,00E+00
EET	MJ	0,00E+00	0,00E+00	3,37E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,37E+00	0,00E+00
Legend		HWD = Hazardous waste disposed; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed; CRU = Components for re-use; MFR = Materials for recycling; MER = Materials for energy recovery; EEE = Exported electric energy; EET = Exported thermal energy										

Table 23: Information describing the biogenic carbon content at the factory gate per metre [m] VRS®-T DN 250

Biogenic carbon content	Unit	A1-A3
Biogenic carbon content in product	kg C	0,00E+00
Biogenic carbon content in accompanying packaging	kg C	7,62E-02
NOTE: 1 kg biogenic carbon is equivalent to 44/12 kg of CO_2		

Table 24 presents disclaimers which shall be declared in the project report and in the EPD with regard to the declaration of relevant core and additional environmental impact indicators according to the following classification. That can be declared in a footnote in the EPD.

Table 24: Classification of disclaimers to the declaration of core and additional environmental impact indicators

ILCD-classification	Indicator	disclaimer
ILCD-Type 1	Global warming potential (GWP)	none
	Depletion potential of the stratospheric ozone layer (ODP)	none
	Potential incidence of disease due to PM emissions (PM)	none
ILCD-Type 2	Acidification potential, Accumulated Exceedance (AP)	none
	Eutrophication potential, Fraction of nutrients reaching freshwater end compartment (EP-freshwater)	none
	Eutrophication potential, Fraction of nutrients reaching marine end compartment (EP-marine)	none
	Eutrophication potential, Accumulated Exceedance (EP-terrestrial)	none
	Formation potential of tropospheric ozone (POCP)	none
	Potential Human exposure efficiency relative to U235 (IRP)	1
ILCD-Type 3	Abiotic depletion potential for non-fossil resources (ADP-minerals&metals)	2
	Abiotic depletion potential for fossil resources (ADP-fossil)	2
	Water (user) deprivation potential, deprivation-weighted water consumption (WDP)	2
	Potential Comparative Toxic Unit for ecosystems (ETP-fw)	2
	Potential Comparative Toxic Unit for humans (HTP-c)	2
	Potential Comparative Toxic Unit for humans (HTP-nc)	2
	Potential Soil quality index (SQP)	2
Disclaimer 1 – This impact category deals mainly with the eventual impact of low dose ionizing radiation on human health of the nuclear fuel cycle. It does not consider effects due to possible nuclear accidents, occupational exposure nor due to radioactive waste disposal in underground facilities. Potential ionizing radiation from the soil, from radon and from some construction materials is also not measured by this indicator.		
Disclaimer 2 – The results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experienced with the indicator.		

7 LCA: Interpretation

It should be noted that the impact assessment results are only relative statements that do not include any statements about “end-points“ of the impact categories, exceeding of thresholds or risks.

Since the definition of basic materials (those substances that remain in the product) and auxiliary materials (those substances that do not remain in the product) are not applicable for this product, because small percentages of the energy source coke and the input materials ferrosilicon and silicon carbide remain in the product, a breakdown into A1-A3 was not carried out.

Figure 5 shows a dominance analysis of the percentage shares of modules A1-A3 (production), A4 (transport to construction site), A5 (installation), C1 (removal), C2 (transport) and C4 (waste treatment). The pipe production is the main contributor to all impact categories (except NHWD). The next largest impacts are the installation (A5) and the removal (C1) of the pipes and the transport to the construction site (A4).

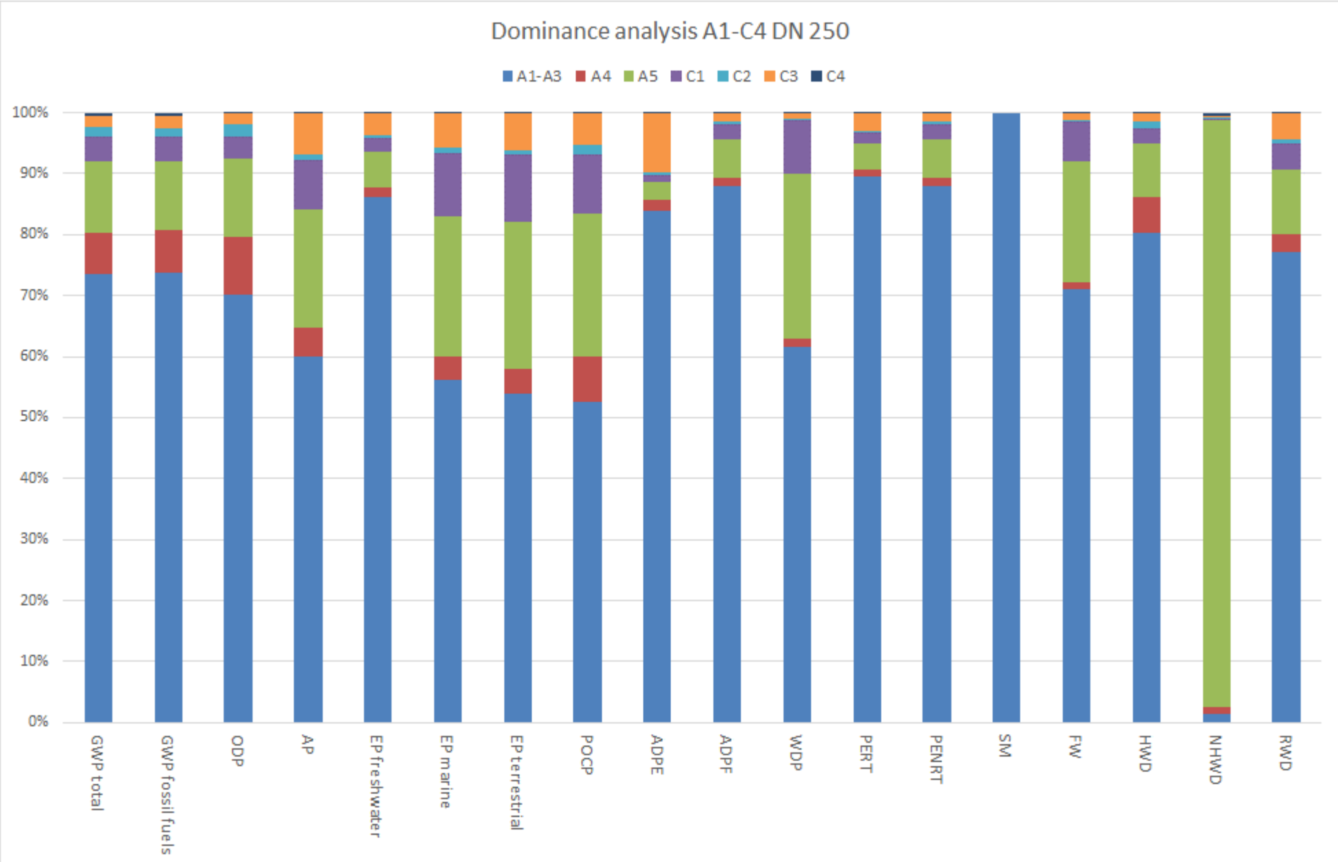


Figure 5: Dominance analysis DN 250

In the production phase (A1-A3), cast iron production has the greatest impact in terms of core indicators, with some impacts exceeding 80%. For individual indicators, galvanising has a high impact (e.g. ADPE >80%).

For the cast iron production, the cupola furnace, the annealing process and the converter have the greatest impact on the core indicators (together >90% in some cases). In the cupola furnace, CO_2 emissions from fuel use, SiC pellets and foundry coke have the greatest impact. The impact of the annealing process is determined by the natural gas used. In the converter, the magnesium and ferrosilicon applied have the greatest impact on the core indicators (in some cases >95%).

Pipe galvanisation is mainly dominated by the zinc applied (in some cases >99%).

The installation of the pipes (A5) is determined by the bedding material, the transport of the bedding material and the diesel consumption of the hydraulic excavator.

In C3, the upstream chain (wood input in the production of the scrap processing plant) of the data set used for recycling, “Iron scrap, sorted, pressed {RER}| sorting and pressing of iron scrap | Cut-off, U”, causes a slightly negative value for GWP biogenic.

8 Literature

ÖNORM EN ISO 14025: 2010 Environmental labels and declarations — Type III environmental declarations — Principles and procedures

ÖNORM EN ISO 14040: 2021 Environmental management — Life cycle assessment — Principles and framework

ÖNORM EN ISO 14044: 2021 Environmental management — Life cycle assessment — Requirements and guidelines

ÖNORM 15804:2012+A2:2019+AC:2021 Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products

Bau EPD GmbH: Product category rules for building related products and services - Requirements on the EPD for cast iron products, PCR-Code 2.16.8, Version 12.0, dated 10.10.2024. Bau EPD Österreich, Vienna, 2024

Bau EPD GmbH: Management system handbook (EPD-MS-HB) of the EPD program, Version 6.0.0, dated 06.11.2024. Bau EPD Österreich, Vienna, 2024

9 Directory and Glossary

9.1 List of figures

9.2 List of tables

9.3 Abbreviations

9.3.1 Abbreviations as per EN 15804

EPD environmental product declaration
PCR product category rules
LCA life cycle assessment
LCI life cycle inventory analysis
LCIA life cycle impact assessment
RSL reference service life
ESL estimated service life
EPBD Energy Performance of Buildings Directive
GWP global warming potential
ODP depletion potential of the stratospheric ozone layer
AP acidification potential of soil and water
EP eutrophication potential
POCP formation potential of tropospheric ozone
ADP abiotic depletion potential

9.3.2 Abbreviations as per corresponding PCR

CE-mark french: Communauté Européenne or Conformité Européenne = EC certificate of conformity
REACH Registration, Evaluation, Authorisation and Restriction of Chemicals

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EPD - ENVIRONMENTAL PRODUCT DECLARATION

as per ISO 14025 and EN 15804+A2

OWNER AND PUBLISHER	Bau EPD GmbH, A-1070 Wien, Seidengasse 13/3, www.bau-epd.at
PROGRAMME OPERATOR	Bau EPD GmbH, A-1070 Wien, Seidengasse 13/3, www.bau-epd.at
HOLDER OF THE DECLARATION	Tiroler Rohre GmbH
DECLARATION NUMBER	Bau EPD-TRM-2025-7-ECOINVENT-VRS-T-DN300
ISSUE DATE	10.08.2025
VALID TO	10.08.2030
NUMBER OF DATASETS	1
ENERGY MIX APPROACH	MARKET BASED APPROACH

VRS®-T ductile cast iron pipe system – DN 300
Tiroler Rohre GmbH

Content of the EPD

1 General information

Product name VRS®-T ductile cast iron pipe system DN 300	**Declared Product / Declared Unit** 1 m ductile cast iron pipe of the VRS®-T system DN 300 with Portland composite cement lining and zinc coating with PUR long-life coating with the nominal dimensions:
Declaration number **Bau EPD-TRM-2025-7-ECOINVENT-VRS-T-DN300**	
Declaration data ☒ Specific data ☐ Average data	
Declaration based on MS-HB Version 6.0.0 dated 06.11.2024 Name of PCR: Cast iron products PCR-Code 2.16.8, Version 12.0 dated 10.10.2024 (PCR tested and approved by the independent expert committee = PKR-Gremium) Version of EPD-Format-Template M-Dok 14A2 dated 11.06.2024 The owner of the declaration is liable for the underlying information and evidence; Bau EPD GmbH is not liable with respect to manufacturer information, life cycle assessment data and evidence.	**Number of datasets in EPD Document: 1** **Range of validity** The EPD applies to the nominal diameter DN 300 of the VRS®-T ductile cast iron pipe system with the above-mentioned lining and duplex outer coating (zinc coating with PUR long-life coating) from the Hall in Tyrol plant of Tiroler Rohre GmbH (TRM). The EPD and the production technologies assessed are representative for the production of pipes with a nominal diameter DN 300 at the Hall in Tyrol plant of Tiroler Rohre GmbH (TRM).
Type of Declaration as per EN 15804 From cradle to grave with module D (modules A+B+C+D) LCA method: Cut-off by classification	**Database, Software, Version** Ecoinvent 3.10, SimaPro 9.6.0.1 **Version Characterisation Factors:** Joint Research Center, EF 3.1
Author of the Life Cycle Assessment floGeco GmbH Hinteranger 61d 6161 Natters Austria	**The CEN standard EN 15804:2012+A2:2019+AC:2021 serves as the core-PCR.** **Independent verification of the declaration according to ISO 14025:2010** ☐ internally ☒ externally **Verifier 1:** Dipl.-Ing. Therese Daxner M.sc. **Verifier 2:** Dipl.-Ing. Roman Smutny
Holder of the Declaration Tiroler Rohre GmbH Innsbruckerstraße 51 6060 Hall in Tyrol Austria	**Owner, Publisher and Programme Operator** Bau EPD GmbH Seidengasse 13/3 1070 Wien Austria

Table 1: Nominal dimensions

Nominal diameter [mm]	Longitudinally related mass [kg/m]
300	67,9

DI (FH) DI DI Sarah Richter
Head of Conformity Assessment Body

Dipl.-Ing. Therese Daxner, M.Sc.
Verifier

Dipl.-Ing. Roman Smutny
Verifier

Note: EPDs from similar product groups from different programme operators might not be comparable.

2 Product

2.1 2.1 General product description

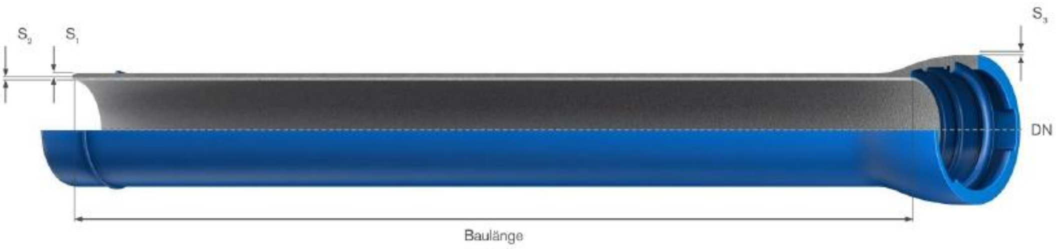
The declared product is a ductile cast iron pipe of the VRS®-T system (restrained locking system) with cement mortar lining (CML) and zinc coating with PUR long-life coating with a nominal diameter DN 300 from Tiroler Rohre GmbH (TRM).

The TRM VRS®-T system consists of ductile, centrifugally cast pipes with a spigot end with a welding ring and a socket, which are joined together to form any length of pipe. The VRS®-T joint, consisting of a VRS®-T socket, VRS®-T sealing ring, spigot end with a welding ring and locking elements, is a highly resilient, flexible and restrained locking system. It is quick and easy to install and can be bent up to 5°. No welding and no weld-seam testing is necessary. The joint can be dismantled at any time.

The ductile cast iron pipes are manufactured in lengths of 5 m with nominal diameters from DN 80 to DN 600 and different wall thicknesses. The nominal dimensions of the declared ductile cast iron pipes with a nominal diameter DN 300 as well as the corresponding wall thickness classes, (normative) minimum wall thicknesses and masses per metre of pipe are shown in Table 2. To further illustrate the declared product, Figure 1 and Figure 2 show excerpts from the Tiroler Rohre GmbH product catalogue with technical and geometric specifications and corresponding mass data.

Table 2: VRS®-T ductile cast iron pipes DN 300 – nominal diameter, Wall thickness class, minimum wall thickness, mass per Meter

DN	Wall thickness class (K class)	Minimum wall thickness [mm]	Mass per m of pipe [kg/m]
300	K 9	5,6	67,9



DN	PFA a [bar]	Maße [mm]		zul. Zugkraft [kN]	Max. Abwinkelung [°]	Anzahl der Riegel	Gewicht Rohr 5m [kg] b
		s1 Guss	s2 ZMA				
80	100	4,7	4	115	5	2	81,6
100	75	4,7	4	150	5	2	100,0
125	63	4,8	4	225	5	2	128,2
150	63	4,7	4	240	5	2	157,3
200	40	4,8	4	350	4	2	204,5
250	40	5,2	4	375	4	2	268,9
300	40	5,6	4	380	4	4	339,5
400	30	6,4	5	650	3	4	519,9
500	25/30	7,2/8,2	5	860	3	4	711,8
600	35	8,0	5	1.525	2	9	909,5

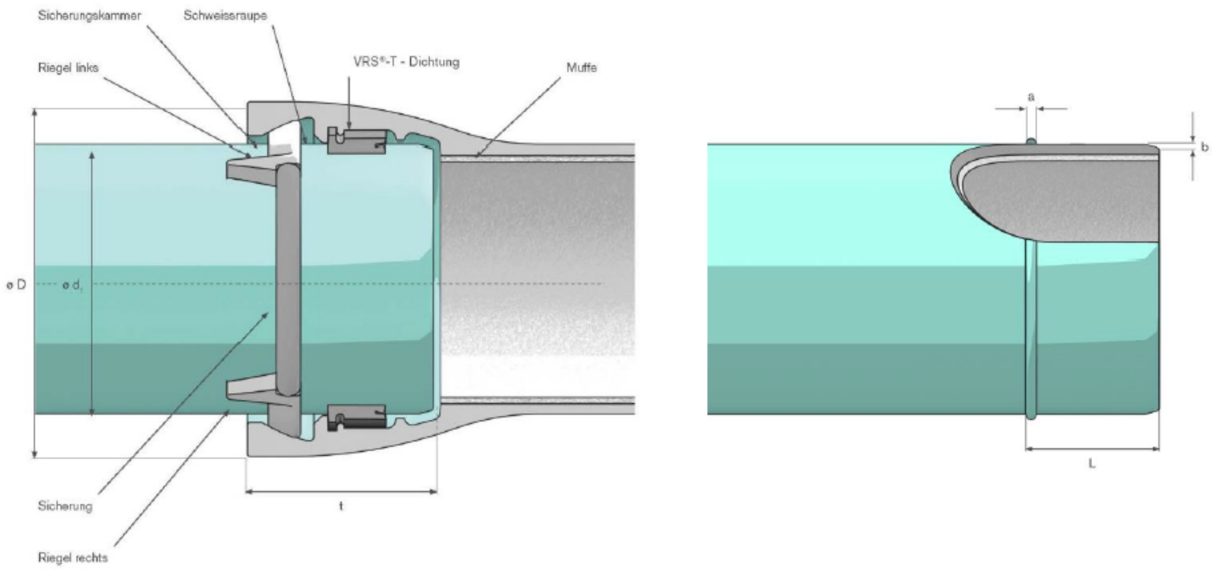
a PFA: zulässiger Bauteilbetriebsdruck | PMA = 1,2 x PFA | PEA = 1,2 x PFA + 5 | höhere PFA auf Anfrage | siehe Hinweise zum Einsatz von Klemmringen

b theoretische Masse pro Rohr für K9/10, inkl. ZMA, Zink, Deckbeschichtung

1 Mindestmaß - Toleranzen beachten | 2 Nennmaß - Toleranzen beachten

Figure 1: VRS®-T pipes – technical and geometric specifications

VRS®-T Verbindung DN 80 bis DN 600



<table>
<tr><th rowspan="3">DN</th><th colspan="7">Maße [mm] a</th></tr>
<tr><th>Durchmesser Spitzende</th><th>Abweichungen</th><th>Durchmesser Muffe</th><th>Einstecktiefe</th><th colspan="3">Schweißraupe</th></tr>
<tr><th colspan="2">d1</th><th>D</th><th>t</th><th>L</th><th>a</th><th>b</th></tr>
<tr><td>80</td><td>98</td><td>+1,0 | -2,7</td><td>156</td><td>127</td><td>86 ±4</td><td>8 ±2</td><td>5 +0,5 | -1</td></tr>
<tr><td>100</td><td>118</td><td>+1,0 | -2,8</td><td>177</td><td>135</td><td>91 ±4</td><td>8 ±2</td><td>5 +0,5 | -1</td></tr>
<tr><td>125</td><td>144</td><td>+1,0 | -2,8</td><td>206</td><td>143</td><td>96 ±4</td><td>8 ±2</td><td>5 +0,5 | -1</td></tr>
<tr><td>150</td><td>170</td><td>+1,0 | -2,9</td><td>232</td><td>150</td><td>101 ±4</td><td>8 ±2</td><td>5 +0,5 | -1</td></tr>
<tr><td>200</td><td>222</td><td>+1,0 | -3,0</td><td>292</td><td>160</td><td>106 ±4</td><td>9 ±2</td><td>5,5 +0,5 | -1</td></tr>
<tr><td>250</td><td>274</td><td>+1,0 | -3,1</td><td>352</td><td>165</td><td>106 ±4</td><td>9 ±2</td><td>5,5 +0,5 | -1</td></tr>
<tr><td>300</td><td>326</td><td>+1,0 | -3,3</td><td>410</td><td>170</td><td>106 ±4</td><td>9 ±2</td><td>5,5 +0,5 | -1</td></tr>
<tr><td>400</td><td>429</td><td>+1,0 | -3,5</td><td>521</td><td>190</td><td>115 ±5</td><td>10 ±2</td><td>6 +0,5 | -1</td></tr>
<tr><td>500</td><td>532</td><td>+1,0 | -3,8</td><td>630</td><td>200</td><td>120 ±5</td><td>10 ±2</td><td>5 +0,5 | -1</td></tr>
<tr><td>600</td><td>635</td><td>+1,0 | -4,0</td><td>732</td><td>175</td><td>160 +0 | -2</td><td>9 ±1</td><td>5 +0,5 | -1</td></tr>
<tr><td colspan="8">a Toleranzen sind möglich</td></tr>
</table>

Figure 2: Schematic illustration of a VRS®-T ductile cast iron pipe

The density of ductile cast iron is 7,050 kg/m³.

2.2 Application field

The VRS®-T cast iron pipe system with Portland composite cement lining is mainly used for drinking water supply and for fire extinguishing pipes, snow-making systems and turbine pipes. The cast iron pipe can be installed using various methods, such as:

- Conventional installation (trench)
- Trenchless installation
- Bridge pipes
- Interim pipes

- Floating

The usual installation method is conventional laying with the excavation of a trench, the creation of a bedding for the pipe and backfilling with suitable material.

2.3 Standards, guidelines and regulations relevant for the product

Table 3: Product specific standards

Regulation	Title
OENORM EN 545	Ductile iron pipes, fittings, accessories and their joints for water pipelines - Requirements and test methods
OENORM B 2599-1	Ductile iron pipes and fittings — Part 1: Use for water pipelines
OENORM B 2597	Ductile cast iron pipes and fittings for water, sewage and gas pipe lines - Restrained push-in-joints - Requirements and tests
OENORM B 2555	Coating of cast iron pipes - Thermal zinc spraying
OENORM B 2560	Ductile iron pipes - Finishing coating of polyurethane, epoxy or acrylic materials - Requirements and test methods
OENORM B 2562	Ductile cast iron pipes - Factory made lining with cement mortar - Requirements and test methods
OENORM EN 681-1	Elastomeric seals - Material requirements for pipe joint seals used in water and drainage applications - Part 1: Vulcanized rubber

2.4 Technical data

Mechanical properties are verified according to OENORM EN 545:2011, sections 6.3 and 6.4.

Table 4: Material parameters for ductile cast iron pipes of the VRS®-T system

Name	Value	Unit
Iron density	7050	kg/m^3
Minimum tensile strength	≥ 420	MPa
Proportional limit, 0.2% yield strength ($R_{p0.2}$)	≥ 300	MPa
Minimum elongation at fracture	≥ 10	%
Maximum Brinell hardness	≤ 230	HB
Pipe length	5000	mm
Mean coefficient of linear thermal expansion	$10*10^{-6}$	m/m*K
Thermal conductivity	0,42	W/cm*K

Table 5: VRS®-T pipes DN 300 – nominal dimension-dependent technical data

DN	Wall thickness class K class	Minimum wall thickness [mm]	Mass per metre of pipe [kg/m]	Allowable operating pressure PFA [bar]	Permissible tensile force [kN]
300	K 9	5,6	67,9	40	380

2.5 Basic/auxiliary materials

Table 6: VRS®-T pipes DN 300 – basic materials in mass %

DN	Casting	Zinc	Cement stone	PUR
300	82,0%	0,5%	16,8%	0,6%

Table 7: Basic materials – casting in mass %

Ingredients:	**Mass %**
Iron 1)	ca. 94 %
Carbon 2)	ca. 3,5 %
Silicon 3)	ca. 2 %
Ferric by-elements 4)	ca.0,5 %

1) Iron consisting mainly of steel scrap and a very small proportion of pig iron and return iron from the casting process

2) Foundry coke carbon. The coke in the cupola furnace serves both as an energy supplier for the scrap melting and the adjusting of the desired carbon content

3) Silicon is added in the form of SiC pellets and/or ferro-silicon

4) Ferric by-elements are found in the steel scrap in different minor quantities (<<1%)

2.6 Production stage

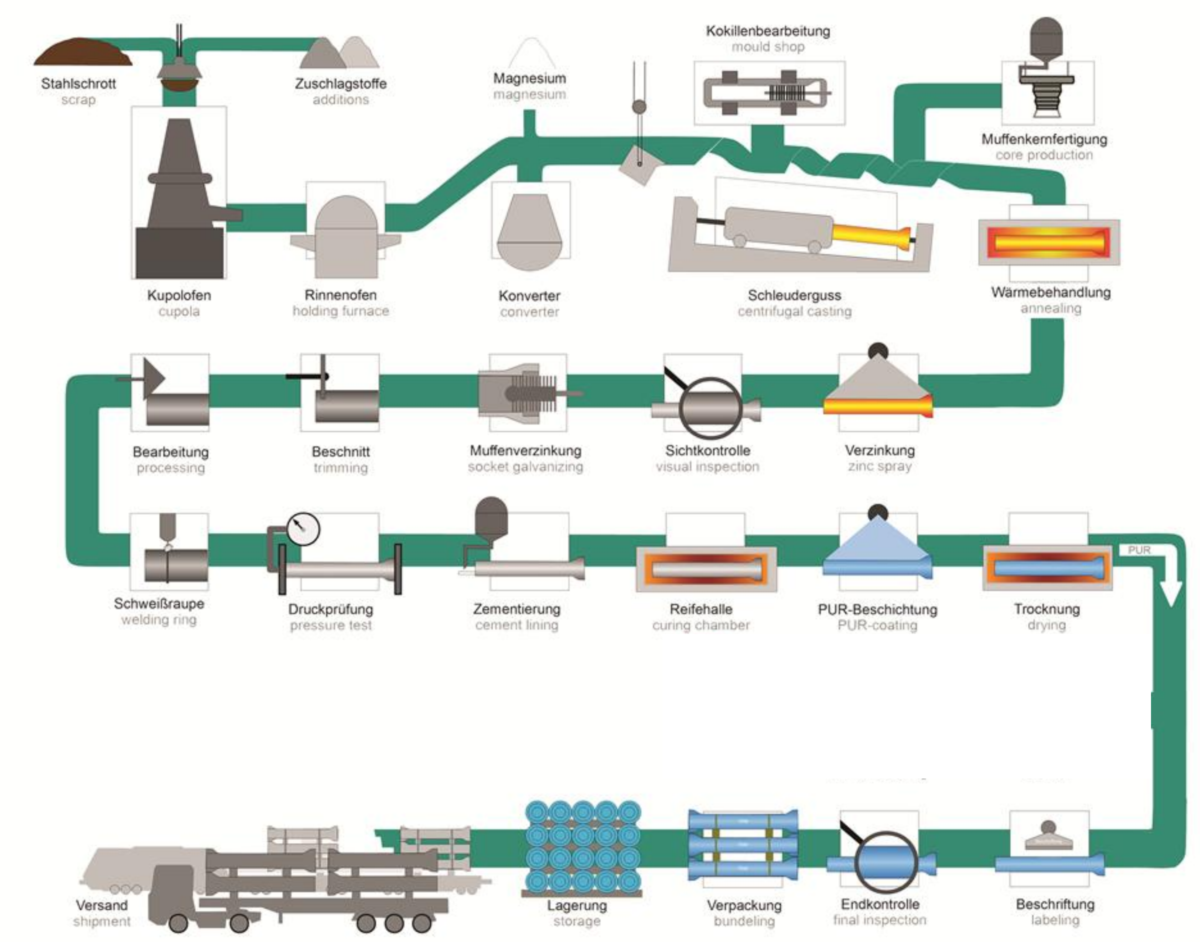


Figure 3: Flow chart of production process

For casting production, steel scrap and recycled material are smelted in the cupola furnace with the help of coke as a reaction and reduction agent. Silicon carbide is added as an alloying element. Added aggregates enhance slagging. The chemical composition of the smelted basic iron is then constantly monitored through spectral analysis. The smelted basic iron is kept warm in the holding furnace, a storage medium, and then treated with magnesium in the Georg Fischer converter, in order to reach the appropriate ductility. The liquid iron is then cast in a centrifuge machine with the De Lavaud procedure. In order to produce a specific pipe diameter, this machine is equipped with the corresponding mould (metal form that the liquid iron is poured into). The socket core made of quartz sand seals the inlet of the machine and forms the pipe socket. The glowing pipe is pulled out of the cast unit and placed in a furnace with the help of an automatic transport system. Here it undergoes annealing in order to achieve the desired mechanical properties.

The pipe is then galvanised using the electric arc spraying process and then cooled. The pipe is visually inspected in the pipe line. The spigot end and socket are machined if necessary. In the area of the welding ring, the zinc and annealing skin (tinder) are ground off and finally the welding ring is applied.

During the pressure test, each pipe is hydrostatically pressurised with a certain internal pressure and checked for leaks. The pipe is then lined with cement mortar using the centrifugal rotation process. The weld seam is galvanised and the pipes are visually inspected again. The cement stone hardens in the curing chamber. Finally, a solvent-free two-component polyurethane top coat is applied. All pipes are labelled according to the specifications, bundled and brought to the warehouse.

2.7 Packaging

The TRM pipes are sealed with protective caps and bundled using squared timber and spacer rings as stacking aid and PET tapes. All packaging materials can be used for thermal recycling.

2.8 Conditions of delivery

The ductile cast iron pipes are bundled for transport and storage with the help of squared lumber and spacer rings as stacking aid as well as PET binding tapes.

2.9 Transport to site

The cast pipes are transported to their destination within Europe by lorry and, in rare cases, overseas by ship.

2.10 Construction product stage

The installation of pressure pipes made of ductile cast iron must comply with OENORM EN 805 (Water supply - Requirements for systems and components outside buildings) and OENORM B 2538 (Additional specifications concerning OENORM EN 805). When constructing the pipe trench, sufficient working space must be provided for the installation of the pipeline, depending on the trench depth and the outer diameter of the pipe. The Ordinance on Protection of Construction Workers (Bauarbeiterschutzverordnung) and other provisions as well as relevant standards and regulations must be complied with accordingly.

As this is a push-in joint, no additional work such as welding is required. The pipe trench must be constructed and excavated in such a way that all pipe sections are at frost-free depths. The trench must be excavated deep enough so that the final cover height is at least 1.50 m. In the case of ductile iron pipes, the existing soil is generally suitable for bedding the pipeline. This means there is no need for a lower bedding layer and the bottom of the trench becomes the lower bedding.

The pipeline must be embedded and the pipe trench refilled in such a way that the pipeline is securely fixed in its intended position and that damage to the pipeline is prevented and settlement can only occur to the permissible extent. Suitable material that does not damage the pipe components and the coating must be used for embedding the pipeline. The backfill material should be installed in layers and sufficiently compacted.

2.11 Use stage

If installed and designed professionally and if the phase of utilisation is not disturbed, no modification of the material composition of construction products made of ductile cast iron occur.

2.12 Reference service life (RSL)

Table 8: Reference service life (RSL)

Name	Value	Unit
Ductile cast iron pipes	50	Years

In practice, it has been shown that a service life of 100 years, based on the DVGW damage statistics (German Technical and Scientific Association for Gas and Water – https://www.dvgw.de/themen/sicherheit/gas-und-wasserstatistik/), is achieved.

2.13 End of life stage

In inner-city areas, the main area of application for the pipe systems, the installed pipes are currently almost entirely removed. These pipes can then be recycled accordingly. These pipes can then be sent to recycling. The removal and recycling rate was therefore set correspondingly high in the scenarios considered (see 4.4 - C1-C4 disposal phase). However, it should be noted that the 100% removal rate is a manufacturer's scenario, which must be checked and adjusted accordingly in each individual use case.

The pipes are disposed of in very rare cases. The EAK waste code number for iron and steel from construction and demolition is 170405.

2.14 Further information

For further information about the TRM pipe system and its possible applications, see the website http://trm.at/rohr.

3 LCA: Calculation rules

3.1 Declared unit/ Functional unit

The functional unit is 1 metre [m] of pipe. For conversion into kg, Table 9 can be used.

Table 9: Conversion factor to mass

Nominal diameter [mm]	Longitudinally related mass [kg/m]	Multiplication factor
300	67,9	0,0143

3.2 System boundary

The entire product life cycle and module D is declared. This is a "from cradle to grave with module D"-EPD (modules A+B+C+D).

Table 10: Declared life cycle stages

PRODUCT STAGE			CON-STRUCTION PROCESS STAGE		USE STAGE							END-OF-LIFE STAGE				BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARIES
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
Raw material supply	Transport	Manufacturing	Transport from the gate to the site	Construction, installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction, demolition	Transport	Waste processing	Disposal	Reuse- Recovery- Recycling- potential
x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

X = included in LCA; ND = Not declared

3.2.1 A1-A3 Product Stage:

The cast iron pipes (semi-finished parts) are almost exclusively made of the secondary material steel scrap and a very small proportion of pig iron and return iron from the casting process. The system boundary for the steel scrap is set when the processed steel scrap leaves the recycling plants, because the end of the waste properties of the steel scrap is reached here. This system is blamed for the transportation of the scrap to the TRM plant. The product stage includes the production steps in the plant along with the energy supply (including the upstream chains), the production of raw materials, auxiliary materials and packaging (including transport to the plant), the infrastructure and the disposal of the waste occurring during production. Module A1-A3 also includes the manufacture of the locks and gaskets required for assembling the pipe.

3.2.2 A4-A5 Construction stage:

The cast iron pipe can be installed in various ways. This EPD considers the standard case for installation, i.e. the conventional laying of the pipe:

- Excavation of trench
- Bedding of the pipe
- Backfilling with suitable material

The protective caps, squared lumber and binding tapes needed for transport are thermally recycled.

3.2.3 B1-B7 Use stage:

Generally, construction products made of ductile cast iron show no impact on the LCA during the use stage.

3.2.4 C1-C4 End-of-life stage:

In inner-city areas, the main area of application for the pipe systems, the installed pipes are currently almost entirely removed. For this reason, a 100% removal rate is applied as a scenario.

The removed pipes are sent to a recycling process and are considered until the end-of-waste state according to EN 15804 in the current product system. The system boundary is therefore set when the processed steel scrap leaves the recycling plants.

As a recycling scenario, due to the robustness of the pipe systems, it is assumed that 97% of the removed pipes are suitable for the recycling process and 3% have to be sent to landfill due to breakage, etc. The recycling scenario applied is a manufacturer's scenario based on the experience of Tiroler Rohre GmbH, which must be checked and adapted accordingly in each individual use case.

3.2.5 D Benefits and loads:

Due to the recycling of the removed pipes, there is a corresponding output of secondary raw materials in C3. The output flows are compared with the scrap share in the production of the cast iron pipes in accordance with the net flow rule according to EN 15804 and the net output flow is determined. The recycling and net flow scenario applied is a manufacturer's scenario based on the experience of Tiroler Rohre GmbH, which must be checked and adapted accordingly in each individual use case.

3.3 Flow chart of processes/stages in the life cycle

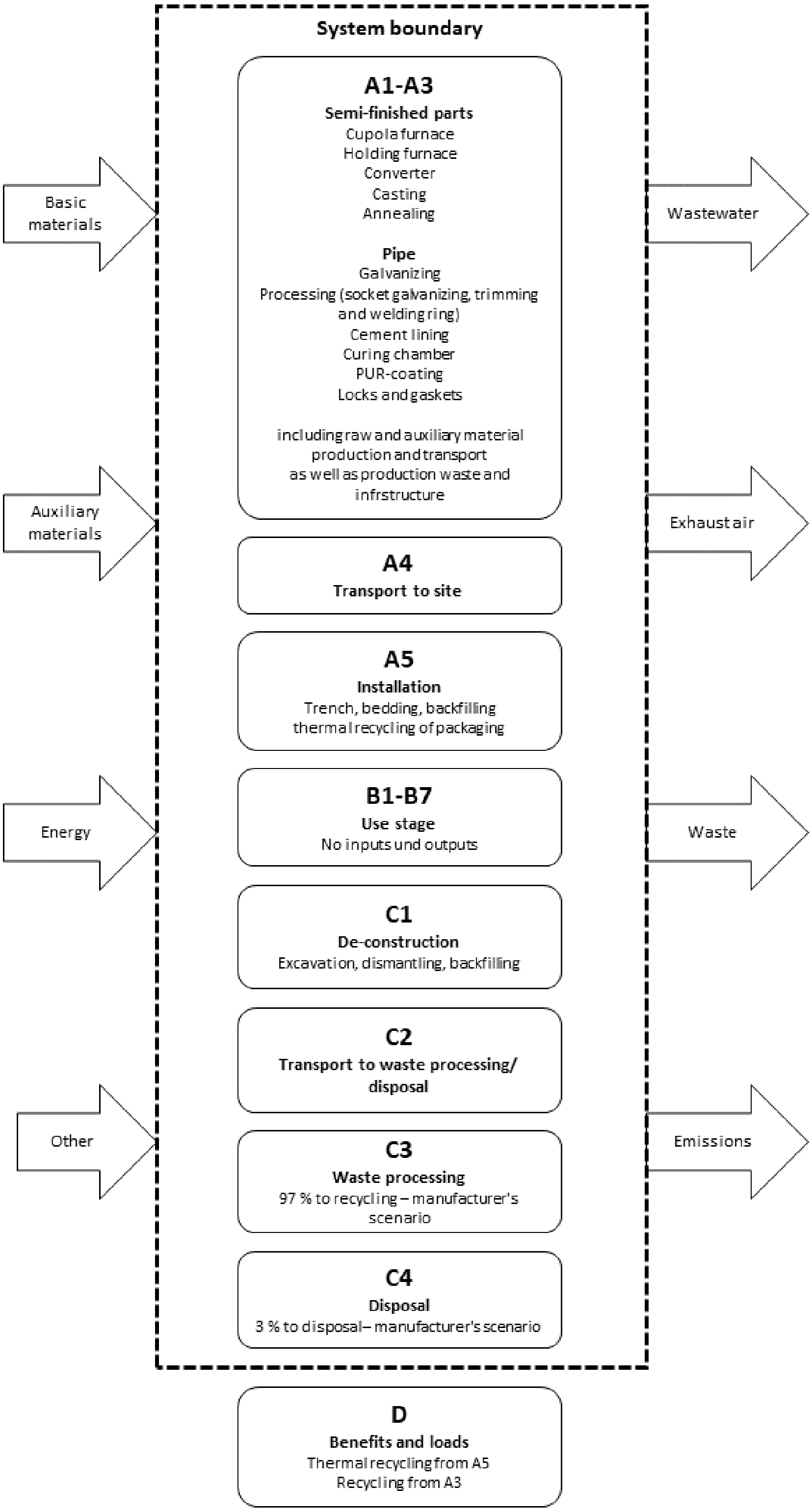


Figure 4: Life cycle flow chart

3.4 Estimations and assumptions

The SiC pellets used in casting production consist of various silicon components, Portland cement and water. In ecoinvent 3.10 there is only one data set for silicon carbide, which is typical of wafer production and has a very high SiC purity compared to the SiC component mixture used in casting production and therefore also a high energy intensity (information from the manufacturer of the pellets). According to the manufacturer of the SiC pellets, the energy required to produce the SiC components or silicon carbide is reflected in the respective prices per tonne. This allows an adjustment of the SiC purity (correction factor) of the data set available in ecoinvent based on an economic comparison (i.e. in the style of an economic allocation).

Cast steel is a special steel with no available data set. As the input is below 1 kg per t of ductile cast iron, the ecoinvent data set for chrome steel was applied.

For magnesium, which mainly comes from China, the global data set for magnesium was used ("market"-data set).

Since the infrastructure only makes a very small contribution to environmental impact, the machinery was modelled with its main components steel and casting.

For the use stage, it was assumed that no LCA-relevant material and energy flows occur.

All transport distances, with the exception of magnesium, were collected by the customer and taken into account in the LCA. For magnesium, the average transports are taken into account by the application of the global "market"-data set (which includes transport processes for the market under consideration).

3.5 Cut-off criteria

The producer calculated and submitted the amount of all applied materials, energy needed, the packaging material, the arising waste material and the way of disposal and the necessary infrastructure (buildings and machinery for the production). The measurement values for emissions according to the casting regulations were specified.

Auxiliary materials whose material flow is less than 1% were ignored as insignificant. Internal transport was negligible due to the short transport distances. It can be assumed that the total of insignificant processes is less than 5% of the impact categories.

During the production of the ductile pipes, slag (from cupola furnace) and coke dust are produced as by-products. Part of the waste heat is sold as district heating. However, these by-products contribute less than 1% to the operational income and can therefore be ignored according to the Management-System-Handbook (MS-HB) of the Bau EPD GmbH (MS-HB Version 6.0.0 dated 06.11.2024). The system limit for these two recyclable materials is set when they are collected from the plant by the future user.

The materials resulting from the production of semi-finished parts – foundry debris, fly-ash, filter cake from cupola furnace dust extraction and converter slag – are taken to a recycling plant for processing, whereby the system limit is set when the substances arrive at this plant, because no detailed information is available on the further treatment processes and the influence on the results of the impact categories is classified as negligible.

In C3, the recycling of the pipes (97%), i.e. the processing of the removed pipes in a recycling plant into a secondary raw material that can be used in cast iron and steel production, is taken into account. For this purpose, it is assumed that the pipe (including CML, etc.) is sent as a whole to the recycling plant, where any materials that cannot be used for cast iron and steel production are separated out. The treatment of these separated materials is excluded due to the expected minor influence.

3.6 Allocation

The system boundary for the steel scrap is set when the processed steel scrap leaves the recycling plants, because the end of the waste staus of the steel scrap is reached here. This system is blamed for the transportation of the scrap to the TRM plant.

In the liquid iron sector, an allocation by mass based on stock additions was carried out between the pipes considered in this EPD and the products not considered. The same applies to waste.

During the production of the ductile pipes, slag and coke dust are produced as by-products. Part of the waste heat is sold as district heating. However, these by-products contribute less than 1% to the operational income and can therefore be ignored according to the "Management-System-Handbook (MS-HB) of the Bau EPD GmbH (MS-HB Version 6.0.0 dated 06.11.2024).

For the annealing, the energy used was allocated according to the dwell times in the furnace.

Due to the recycling of the removed pipes, there is a corresponding output of secondary raw materials in C3. The output flows are compared with the scrap share in the production of the cast iron pipes in accordance with the net flow rule according to EN 15804 and the net output flow is determined.

3.7 Comparability

In principle, a comparison or evaluation of EPD data is only possible if all data sets to be compared have been created in accordance with EN 15804, the same programme-specific PCR/any additional rules and the same background database have been used, and the building context/product-specific performance characteristics are also taken into account.

4 LCA: Scenarios and additional technical information

4.1 A1-A3 Product stage

According to OENORM EN 15804, no technical scenario details are required for A1-A3 as the producer is responsible for the accounting of these modules, and this must not be changed by the user of the LCA.

Data collection for the product stage was carried out according to ISO 14044 Section 4.3.2. In accordance with the target definition, all relevant input and output flows that occur in connection with the product under consideration were identified and quantified in the life cycle inventory analysis.

Electricity generation is modelled according to the electricity mix supplied by Tiroler Wasserkraft AG (TIWAG) to Tiroler Rohre GmbH. In 2020, Tiroler Rohre GmbH purchased the TIWAG 2020 supplier mix (Versorgermix) from Tiroler Wasserkraft AG TIWAG (electricity mix contractually secured).

A part of the electricity consumption in the semi-finished parts production takes place at medium voltage level. The remaining electricity consumption takes place at low voltage level, with 5.75% coming from the in-house photovoltaic system.

Since photovoltaic electricity is generally fed into the grid and consumed at low voltage, and Tiroler Rohre GmbH purchases its electricity at medium voltage, the photovoltaic share is deducted when modelling the medium-voltage electricity supplied by TIWAG (see Table 11).

Table 11: Electricity mix

Source	**TIWAG Supplier mix general**	**Medium voltage without photovoltaics**
Hydro power	84,90%	86,32%
Norway	*20,23%*	*20,57%*
Tyrol	*64,67%*	*65,75%*
Wind power	10,37%	10,54%
Solid or liquid biomass	2,02%	2,05%
Photovoltaics	1,64%	0,00%
Biogas	1,05%	1,07%
Other eco-energy	0,02%	0,02%
Sum	**100,00%**	**100,00%**

The GWP total- result for the TIWAG electricity mix used is 57.3 g CO_2 eq/kWh at high voltage level, 60.5 g CO_2 eq/kWh at medium voltage level and 61.6 g CO_2 eq/kWh at low voltage level. The GWP total-result for low-voltage electricity from the photovoltaic system at the TRM plant is 104 g CO_2 eq/kWh.

4.2 A4-A5 Construction process stage

The pipes are transported to their destination by truck. The client provided relevant information on the transports, and based on this, an average transport distance of approximately 470 km was determined.

Table 12 shows the general parameters for describing transportation to the building site.

Table 12: Description of the scenario „Transport to building site (A4)“

Parameters to describe the transport to the building site (A4)	Value	Unit
Average transport distance	471	km
Vehicle type, Commission Directive 2007/37/EC (European Emission Standard)	Euro 6	-
Average fuel consumption, fuel type: Diesel or heavy fuel oil	25,3	l/100 km
Average transport mass	5,79	t
Average capacity utilisation (including empty returns)	85	%
Average gross density of transported products	67,9	kg/m
Volume capacity utilisation factor (factor: =1 or <1 or ≥ 1 for compressed or nested packaged products)	<1	-

Conventional laying was chosen as the installation method for the EPD, i.e. excavating a trench, bedding the pipe and backfilling with suitable material. A hydraulic excavator with an engine power of 80 kW, a scoop capacity of 0,87 m3 and a weight of 17 t was used for the excavation and backfilling of the pipe trench (including bedding).

Most of the excavation material is temporarily stored and reused for backfilling. However, a certain proportion of the excavation material (varying for the specific nominal diameters depending on the proportion of bedding) must be disposed of at a landfill 20 km away. The additional backfill material required for this is transported from a gravel pit 20 km away.

The spacer rings (PP), protective caps (PE), stacked wood and binding tape (PET) are thermally recycled in a waste incinerator 100 km away.

Table 13: Description of the scenario „Installation of the product in the building (A5)“

Parameters to describe the installation of the product in the building (A5)	Value	Unit
Ancillary materials for installation (specified by material);	Backfill material 339	kg/m
Ancillary materials for installation (specified by type)	Hydraulic excavator	-
Water use	0	m^3/m
Other resource use	0	kg/m
Electricity demand	0	kWh/m
Other energy carrier(s): Diesel	11	MJ/m
Wastage of materials on the building site before waste processing, generated by the product’s installation (specified by type)	0	kg/m
Output materials (specified by type) as result of waste processing at the building site e.g. of collection for recycling, for energy recovery, disposal (specified by route)	Disposal Excavation: 339 Waste incineration Wood: 0,206 PET: 0,005 PE: 0,101 PP: 0,031	kg/m
Direct emissions to ambient air (such as dust, VOC), soil and water	-	kg/m

4.3 B1-B7 Use stage

In the use stage, no material and energy flows relevant for the life cycle assessment take place for the VRS®-T pipe systems, wherefor no activities were taken into account.

4.4 C1-C4 End-of-Life stage

In inner-city areas, the main area of application for the pipe systems, the installed pipes are currently almost entirely removed. For this reason, a 100% removal rate is used as a scenario. The removed pipes are sent to a recycling process, being considered until the end-of-waste state in the current product system. The system limit is set when the processed steel scrap leaves the recycling plants. From this point on, the pipe is part of a new product system. As a recycling scenario it is assumed that 97% of the pipes are suitable for the recycling process and 3% have to be sent to disposal.

The pipes are removed with the same excavator that was used for the installation. The excavation volume for the removal corresponds to volume for the installation. The existing excavation material is reinstalled, but must be supplemented with additional backfill material (different for the specific DN). The distance to the gravel pit is estimated at 20 km.

Table 14: Description of the scenario "Dismantling (C1)"

Parameters to describe the dismantling (C1)	Value	Unit
Auxiliary materials for the dismantling	Backfill material 184,5	kg/m
Aids for the demolition	Hydraulic excavator	-
Water consumption	0	m^3/m
Other resource use	0	kg/m
Electricity consumption	0	kWh/m
Other energy carrier: Diesel	11	MJ/m
Material loss on the construction site before waste treatment, caused by the installation of the product	0	kg/m
Output materials due to waste treatment on the construction site, e.g. collection for recycling, for energy recovery or for disposal	0	kg/m
Direct emissions to ambient air (e.g. dust, VOC), soil and water	-	kg/m

The transport distance to the nearest recycling company (97% of the pipes) as well as to the nearest inert material landfill (3% of the pipes) or waste incineration plant (gaskets) was assumed to be 100 km.

Table 15: Description of the scenario "Transport for disposal (C2)"

Parameters to describe the transport for disposal (C2)	Value	Unit
Average transport distance	100	km
vehicle type, Commission Directive 2007/37/EC (European Emission Standard)	Euro 6	-
Average fuel consumption, fuel type: Diesel or heavy fuel oil	25,3	l/100 km
Average transport mass	5,79	t
Average capacity utilisation (including empty returns)	85	%
Average gross density of transported products	67,9	kg/m
Volume capacity utilisation factor (factor: =1 or <1 or ≥ 1 for compressed or nested package products)	<1	-

In C3, the recycling of the pipes (97%), i.e. the processing of the removed pipes in a recycling plant into a secondary raw material that can be used in cast iron and steel production, is taken into account. For this purpose, it is assumed that the pipe (including CML, etc.) is sent as a whole to the recycling plant, where any materials that cannot be used for cast iron and steel production are separated out. The treatment of these separated out materials is excluded due to the expected minor influence. A new product system begins with the transport of the processed scrap from the recycling plant to the production plant.

In C4, the disposal of 3% of the pipe mass in an inert material landfill and the disposal of the EPDM gasket material in a waste incinerator are considered. A 100% recycling rate is applied for the removed bolts, which are made of pure cast material.

Table 16: Disposal processes (C3 and C4) per m of pipe

DN	Mass per metre of pipe	Total pipe mass for recycling (97%)	Total pipe mass for disposal (3%)	Lock mass for recycling (100%)	Total mass (pipe and Lock) for recycling	Gasket mass for waste incineration
[mm]	*[kg/m]*	*[kg/m]*	*[kg/m]*	*[kg/m]*	*[kg/m]*	*[kg/m]*
300	67,90	65,863	2,037	0,540	66,403	0,1620

Table 17: Description of the scenario „Disposal of the product (C1 to C4)"

Parameters for end-of-life stage (C1-C4)	Value	Unit
Collection process, separately	see Table 16	kg collected separately
Recycling	see Table 16	kg for recycling
Disposal, inert material landfill	see Table 16	kg material for final deposition

4.5 D Potential of reuse and recycling

Due to the recycling of the removed pipes (97%), there is a corresponding output of secondary raw materials (D from C3). Due to the net flow rule according to EN 15804 and the high proportion of scrap in the production of cast iron pipes (988 kg per tonne of cast semi-finished part), there is a slightly negative net output flow here.

Table 18: Description of the scenario „re-use, recovery and recycling potential (module D)“

Parameters for module D	Value	Unit
Materials for reuse, recovery or recycling from A4-A5	-	%
Energy recovery or secondary fuels from A4-A5	Waste incineration Wood: 0,206 PP: 0,005 PE: 0,101 PET: 0,031	kg/m
Materials for reuse, recovery or recycling from B2-B5	-	%
Energy recovery or secondary fuels from B2-B5	-	kg/m
Materials for reuse, recovery or recycling from C1-C4	97	%
Energy recovery or secondary fuels from C1-C4	Waste incineration Gasket: 0,1620	kg/m

Due to the multi-recycling potential of the pipes, they could again replace primary raw materials in the next product system. In this EPD, the multi-recycling potential is not shown as a life cycle assessment result (in the results tables) but as additional information (Appendix 1), because this value does not comply with the rules and specifications of EN 15804 (net flow rule). The additional information on multi-recycling potential is based on a manufacturer scenario based on the experience of Tiroler Rohre GmbH.

5 Information on data quality and data selection in accordance with EN 15941

5.1 Principles for the description of data quality

The following information on data quality is provided in accordance with the requirements of EN 15941 (EN 15941, section 7.3.4).

The data fulfils the following quality requirements:

The data is representative for the production year 2020 (annual average). The production year 2020 is considered based on the existing data for ductile cast iron production (semi-finished part production) of the EPD for ductile piles from Tiroler Rohre GmbH (published 2022).

For the data collection, generic data and the cut-off of material and energy flows the criteria of the Bau EPD GmbH were considered.

The manufacturer provided all essential data such as energy and raw material consumption, transport distances and vehicles as well as packaging within the system boundaries.

The applied background database ecoinvent 3.10 was published in 2024, but contains individual data sets whose collection or reference year dates back more than 10 years (requirement EN 15804 or Bau EPD GmbH). These data sets remained in the various ecoinvent database versions through the years, taking necessary adjustments for database updates into account. Nevertheless, these data sets are subject to a corresponding potential for fluctuation because some of the (technological) developments of recent years are not reflected.

The data is plausible, i.e. the deviations from comparable results are within a plausible range.

5.2 Description of the temporal, geographical and technological representativeness of the product data

Temporal representativeness:

- The data collection period corresponds to the year 2020. All specific data are from this year.
- There is no deviation from the reporting year 2020 in the collection of specific data.
- The applied background database ecoinvent 3.10 was published in 2024, but contains individual data sets whose collection or reference year dates back more than 10 years (requirement EN 15804 or Bau EPD GmbH).

Geographical representativeness:

- VRS®-T pipe systems are manufactured exclusively at the plant in Hall in Tirol. In the production year 2020, almost 50% of the products were delivered within Austria and a total of approx. 90% within Europe (with a focus on Germany and Italy in addition to Austria).
- The pipe systems are disposed of in an area close to where they were used.

Technological representativeness:

- The production technology at the plant in Hall in Tyrol is state-of-the-art. The facilities are regularly maintained and modernised.
- In addition to cast iron pipe systems, other products such as ductile piles (pure cast iron product corresponds to semi-finished parts) are also manufactured at the analysed plant.

Geographical and technological representativeness for EPDs covering an industry:

- Not relevant for this EPD.

5.3 Explanation of the averaging process

Not relevant for this EPD, as specific products from the plant in Hall in Tyrol of the Tiroler Rohre GmbH are considered.

5.4 Assessment of the data quality of the Life Cycle Inventory data

The validity (database/source, country/region, reference year, publication/update) and the geographical, technical and temporal representativeness (according to ÖNORM EN 15804 Annex E - Table E.1) of all data sets used are assessed in the project report for this EPD.

The manufacturer provided all essential data such as energy and raw material consumption, transport distances and vehicles, and packaging within the system boundaries (quality management system and SAP system).

6 LCA: results

Table 19: Parameters to describe the environmental impact per metre [m] VRS®-T DN 300

Parameters	Unit	A1-A3	A4	A5	B1-B7	C1	C2	C3	C4	C1-C4	A-C	D
GWP total	kg CO_2 eq	6,44E+01	6,18E+00	1,00E+01	0,00E+00	3,70E+00	1,30E+00	1,71E+00	5,24E-01	7,25E+00	8,78E+01	1,41E+00
GWP fossil fuels	kg CO_2 eq	6,44E+01	6,17E+00	9,69E+00	0,00E+00	3,70E+00	1,30E+00	1,73E+00	5,24E-01	7,26E+00	8,75E+01	1,42E+00
GWP biogenic	kg CO_2 eq	-8,20E-02	4,27E-03	3,11E-01	0,00E+00	4,59E-03	9,03E-04	-2,25E-02	6,41E-05	-1,70E-02	2,16E-01	-6,62E-03
GWP luluc	kg CO_2 eq	4,02E-02	2,05E-03	5,25E-03	0,00E+00	2,07E-03	4,33E-04	2,45E-03	8,75E-06	4,96E-03	5,25E-02	1,38E-04
ODP	kg CFC-11 eq	8,65E-07	1,23E-07	1,58E-07	0,00E+00	4,61E-08	2,59E-08	2,39E-08	5,22E-10	9,65E-08	1,24E-06	1,32E-09
AP	mol H^+ eq	1,66E-01	1,29E-02	5,16E-02	0,00E+00	2,29E-02	2,71E-03	1,91E-02	1,61E-04	4,49E-02	2,75E-01	5,18E-03
EP freshwater	kg P eq	2,26E-02	4,18E-04	1,49E-03	0,00E+00	6,82E-04	8,83E-05	9,90E-04	2,39E-06	1,76E-03	2,62E-02	6,13E-04
EP marine	kg N eq	4,26E-02	3,09E-03	1,67E-02	0,00E+00	7,68E-03	6,52E-04	4,43E-03	6,27E-05	1,28E-02	7,51E-02	1,25E-03
EP terrestrial	mol N eq	4,38E-01	3,33E-02	1,88E-01	0,00E+00	8,70E-02	7,04E-03	4,98E-02	6,82E-04	1,45E-01	8,04E-01	1,35E-02
POCP	kg NMVOC eq	1,47E-01	2,14E-02	6,32E-02	0,00E+00	2,66E-02	4,51E-03	1,49E-02	2,14E-04	4,62E-02	2,78E-01	4,49E-03
ADPE	kg Sb eq	8,59E-04	2,01E-05	3,02E-05	0,00E+00	1,25E-05	4,24E-06	1,07E-04	4,01E-08	1,24E-04	1,03E-03	6,82E-07
ADPF	MJ H_u	4,33E+02	7,22E+00	3,01E+01	0,00E+00	1,41E+01	1,52E+00	7,51E+00	3,40E-02	2,31E+01	4,93E+02	1,40E+01
WDP	m3 World eq	1,74E+01	3,61E-01	7,47E+00	0,00E+00	2,80E+00	7,62E-02	2,91E-01	1,22E-02	3,18E+00	2,84E+01	8,03E-02
Legend		GWP = Global warming potential; luluc = land use and land use change; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential, Accumulated Exceedance; EP = Eutrophication potential; POCP = Formation potential of tropospheric ozone photochemical oxidants; ADPE = Abiotic depletion potential for non-fossil resources; ADPF = Abiotic depletion potential for fossil resources WDP = Water (user) deprivation potential, deprivation-weighted water consumption										

Table 20: Additional environmental impact indicators per metre [m] VRS®-T DN 300

Parameters	Unit	A1-A3	A4	A5	B1-B7	C1	C2	C3	C4	C1-C4	A-C	D
PM	Occurrence of diseases	7,53E-06	4,54E-07	1,13E-06	0,00E+00	5,07E-07	9,60E-08	2,67E-07	2,41E-09	8,72E-07	9,99E-06	1,12E-07
IRP	kBq U235 eq	2,99E+00	1,13E-01	4,25E-01	0,00E+00	2,04E-01	2,38E-02	1,75E-01	4,86E-04	4,03E-01	3,93E+00	1,53E-04
ETP-fw	CTUe	6,73E+02	2,36E+01	3,81E+01	0,00E+00	1,50E+01	4,99E+00	1,69E+01	9,01E-01	3,78E+01	7,73E+02	1,49E+02
HTP-c	CTUh	7,12E-07	4,38E-08	6,37E-08	0,00E+00	2,64E-08	9,25E-09	1,50E-08	1,10E-10	5,08E-08	8,70E-07	5,67E-07
HTP-nc	CTUh	6,28E-07	5,45E-08	6,15E-08	0,00E+00	2,28E-08	1,15E-08	9,28E-08	1,99E-10	1,27E-07	8,72E-07	4,91E-09
SQP	dimensionless	2,10E+02	5,24E+01	1,64E+02	0,00E+00	2,79E+01	1,11E+01	4,17E+01	6,39E-01	8,13E+01	5,08E+02	3,08E+00
Legend		PM = Potential incidence of disease due to Particulate Matter emissions; IRP = Potential Human exposure efficiency relative to U235; ETP-fw = Potential Comparative Toxic Unit for ecosystems; HTP-c = Potential Comparative Toxic Unit for humans – cancer effect; HTP-nc = Potential Comparative Toxic Unit for humans – non-cancer effect; SQP = Potential soil quality index										

Table 21: Parameters to describe the use of resources per metre [m] VRS®-T DN 300

Parameters	Unit	A1-A3	A4	A5	B1-B7	C1	C2	C3	C4	C1-C4	A-C	D
PERE	MJ H_u	1,09E+02	1,49E+00	7,86E+00	0,00E+00	2,51E+00	3,15E-01	3,80E+00	7,11E-03	6,63E+00	1,25E+02	1,45E-01
PERM	MJ H_u	2,53E+00	0,00E+00	-2,53E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PERT	MJ H_u	1,12E+02	1,49E+00	5,33E+00	0,00E+00	2,51E+00	3,15E-01	3,80E+00	7,11E-03	6,63E+00	1,25E+02	1,45E-01
PENRE	MJ H_u	4,27E+02	7,22E+00	3,58E+01	0,00E+00	1,41E+01	1,52E+00	7,51E+00	3,40E-02	2,31E+01	4,93E+02	1,40E+01
PENRM	MJ H_u	5,65E+00	0,00E+00	-5,65E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PENRT	MJ H_u	4,33E+02	7,22E+00	3,01E+01	0,00E+00	1,41E+01	1,52E+00	7,51E+00	3,40E-02	2,31E+01	4,93E+02	1,40E+01
SM	kg	5,55E+01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	5,55E+01	-9,96E-01
RSF	MJ H_u	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
NRSF	MJ H_u	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
FW	m^3	6,73E-01	1,20E-02	1,83E-01	0,00E+00	6,94E-02	2,54E-03	1,14E-02	8,17E-04	8,42E-02	9,53E-01	2,07E-03
Legend		PERE = Renewable primary energy as energy carrier; PERM = Renewable primary energy resources as material utilization; PERT = Total use of renewable primary energy resources; PENRE = Non-renewable primary energy as energy carrier; PENRM = Non-renewable primary energy as material utilization; PENRT = Total use of non-renewable primary energy resources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of fresh water										

Table 22: Parameters describing LCA-output flows and waste categories per metre [m] VRS®-T DN 300

Parameters	Unit	A1-A3	A4	A5	B1-B7	C1	C2	C3	C4	C1-C4	A-C	D
HWD	kg	7,82E-03	5,85E-04	8,45E-04	0,00E+00	2,60E-04	1,23E-04	1,43E-04	3,34E-06	5,29E-04	9,78E-03	1,78E-04
NHWD	kg	5,31E+00	4,19E+00	3,41E+02	0,00E+00	7,91E-01	8,85E-01	6,11E-01	2,05E+00	4,33E+00	3,55E+02	3,62E-02
RWD	kg	1,39E-03	5,09E-05	1,87E-04	0,00E+00	8,94E-05	1,07E-05	8,16E-05	2,25E-07	1,82E-04	1,81E-03	3,40E-07
CRU	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
MFR	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	5,45E+01	0,00E+00	5,45E+01	5,45E+01	0,00E+00
MER	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
EEE	MJ	0,00E+00	0,00E+00	4,79E-01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	4,79E-01	0,00E+00
EET	MJ	0,00E+00	0,00E+00	4,23E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	4,23E+00	0,00E+00
Legend		HWD = Hazardous waste disposed; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed; CRU = Components for re-use; MFR = Materials for recycling; MER = Materials for energy recovery; EEE = Exported electric energy; EET = Exported thermal energy										

Table 23: Information describing the biogenic carbon content at the factory gate per metre [m] VRS®-T DN 300

Biogenic carbon content	Unit	A1-A3
Biogenic carbon content in product	kg C	0,00E+00
Biogenic carbon content in accompanying packaging	kg C	8,50E-02
NOTE: 1 kg biogenic carbon is equivalent to 44/12 kg of CO_2		

Table 24 presents disclaimers which shall be declared in the project report and in the EPD with regard to the declaration of relevant core and additional environmental impact indicators according to the following classification. That can be declared in a footnote in the EPD.

Table 24: Classification of disclaimers to the declaration of core and additional environmental impact indicators

<table>
<tr><th>ILCD-classification</th><th>Indicator</th><th>disclaimer</th></tr>
<tr><td rowspan="3">ILCD-Type 1</td><td>Global warming potential (GWP)</td><td>none</td></tr>
<tr><td>Depletion potential of the stratospheric ozone layer (ODP)</td><td>none</td></tr>
<tr><td>Potential incidence of disease due to PM emissions (PM)</td><td>none</td></tr>
<tr><td rowspan="6">ILCD-Type 2</td><td>Acidification potential, Accumulated Exceedance (AP)</td><td>none</td></tr>
<tr><td>Eutrophication potential, Fraction of nutrients reaching freshwater end compartment (EP-freshwater)</td><td>none</td></tr>
<tr><td>Eutrophication potential, Fraction of nutrients reaching marine end compartment (EP-marine)</td><td>none</td></tr>
<tr><td>Eutrophication potential, Accumulated Exceedance (EP-terrestrial)</td><td>none</td></tr>
<tr><td>Formation potential of tropospheric ozone (POCP)</td><td>none</td></tr>
<tr><td>Potential Human exposure efficiency relative to U235 (IRP)</td><td>1</td></tr>
<tr><td rowspan="7">ILCD-Type 3</td><td>Abiotic depletion potential for non-fossil resources (ADP-minerals&metals)</td><td>2</td></tr>
<tr><td>Abiotic depletion potential for fossil resources (ADP-fossil)</td><td>2</td></tr>
<tr><td>Water (user) deprivation potential, deprivation-weighted water consumption (WDP)</td><td>2</td></tr>
<tr><td>Potential Comparative Toxic Unit for ecosystems (ETP-fw)</td><td>2</td></tr>
<tr><td>Potential Comparative Toxic Unit for humans (HTP-c)</td><td>2</td></tr>
<tr><td>Potential Comparative Toxic Unit for humans (HTP-nc)</td><td>2</td></tr>
<tr><td>Potential Soil quality index (SQP)</td><td>2</td></tr>
<tr><td colspan="3">Disclaimer 1 – This impact category deals mainly with the eventual impact of low dose ionizing radiation on human health of the nuclear fuel cycle. It does not consider effects due to possible nuclear accidents, occupational exposure nor due to radioactive waste disposal in underground facilities. Potential ionizing radiation from the soil, from radon and from some construction materials is also not measured by this indicator.</td></tr>
<tr><td colspan="3">Disclaimer 2 – The results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experienced with the indicator.</td></tr>
</table>

7 LCA: Interpretation

It should be noted that the impact assessment results are only relative statements that do not include any statements about "end-points" of the impact categories, exceeding of thresholds or risks.

Since the definition of basic materials (those substances that remain in the product) and auxiliary materials (those substances that do not remain in the product) are not applicable for this product, because small percentages of the energy source coke and the input materials ferrosilicon and silicon carbide remain in the product, a breakdown into A1-A3 was not carried out.

Figure 5 shows a dominance analysis of the percentage shares of modules A1-A3 (production), A4 (transport to construction site), A5 (installation), C1 (removal), C2 (transport) and C4 (waste treatment). The pipe production is the main contributor to all impact categories (except NHWD). The next largest impacts are the installation (A5) and the removal (C1) of the pipes and the transport to the construction site (A4).

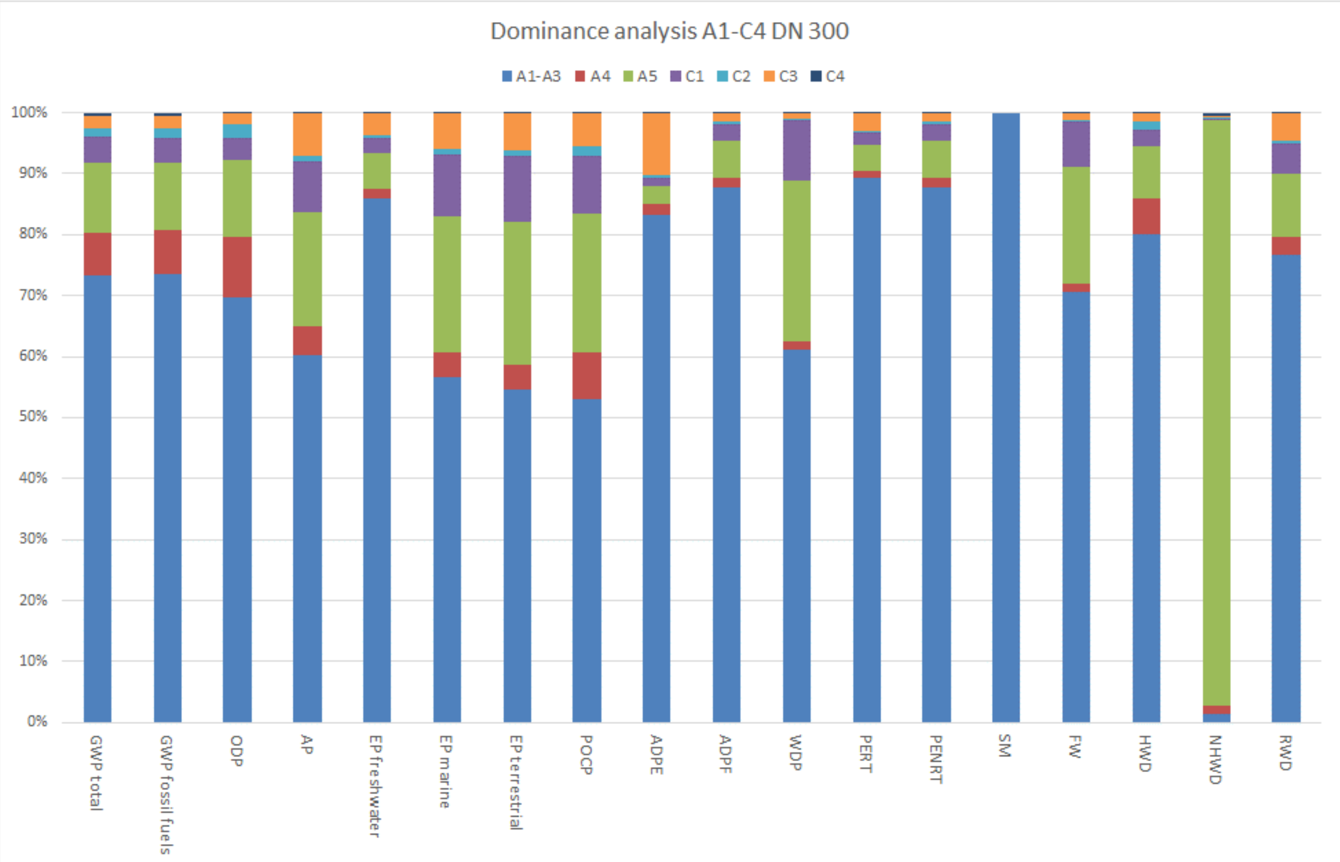


Figure 5: Dominance analysis DN 300

In the production phase (A1-A3), cast iron production has the greatest impact in terms of core indicators, with some impacts exceeding 80%. For individual indicators, galvanising has a high impact (e.g. ADPE >80%).

For the cast iron production, the cupola furnace, the annealing process and the converter have the greatest impact on the core indicators (together >90% in some cases). In the cupola furnace, CO_2 emissions from fuel use, SiC pellets and foundry coke have the greatest impact. The impact of the annealing process is determined by the natural gas used. In the converter, the magnesium and ferrosilicon applied have the greatest impact on the core indicators (in some cases >95%).

Pipe galvanisation is mainly dominated by the zinc applied (in some cases >99%).

The installation of the pipes (A5) is determined by the bedding material, the transport of the bedding material and the diesel consumption of the hydraulic excavator.

In C3, the upstream chain (wood input in the production of the scrap processing plant) of the data set used for recycling, "Iron scrap, sorted, pressed {RER}| sorting and pressing of iron scrap | Cut-off, U", causes a slightly negative value for GWP biogenic.

8 Literature

ÖNORM EN ISO 14025: 2010 Environmental labels and declarations — Type III environmental declarations — Principles and procedures

ÖNORM EN ISO 14040: 2021 Environmental management — Life cycle assessment — Principles and framework

ÖNORM EN ISO 14044: 2021 Environmental management — Life cycle assessment — Requirements and guidelines

ÖNORM 15804:2012+A2:2019+AC:2021 Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products

Bau EPD GmbH: Product category rules for building related products and services - Requirements on the EPD for cast iron products, PCR-Code 2.16.8, Version 12.0, dated 10.10.2024. Bau EPD Österreich, Vienna, 2024

Bau EPD GmbH: Management system handbook (EPD-MS-HB) of the EPD program, Version 6.0.0, dated 06.11.2024. Bau EPD Österreich, Vienna, 2024

9 Directory and Glossary

9.1 List of figures

9.2 List of tables

9.3 Abbreviations

9.3.1 Abbreviations as per EN 15804

EPD environmental product declaration
PCR product category rules
LCA life cycle assessment
LCI life cycle inventory analysis
LCIA life cycle impact assessment
RSL reference service life
ESL estimated service life
EPBD Energy Performance of Buildings Directive
GWP global warming potential
ODP depletion potential of the stratospheric ozone layer
AP acidification potential of soil and water
EP eutrophication potential
POCP formation potential of tropospheric ozone
ADP abiotic depletion potential

9.3.2 Abbreviations as per corresponding PCR

CE-mark french: Communauté Européenne or Conformité Européenne = EC certificate of conformity
REACH Registration, Evaluation, Authorisation and Restriction of Chemicals

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EPD - ENVIRONMENTAL PRODUCT DECLARATION

as per ISO 14025 and EN 15804+A2

OWNER AND PUBLISHER	Bau EPD GmbH, A-1070 Wien, Seidengasse 13/3, www.bau-epd.at
PROGRAMME OPERATOR	Bau EPD GmbH, A-1070 Wien, Seidengasse 13/3, www.bau-epd.at
HOLDER OF THE DECLARATION	Tiroler Rohre GmbH
DECLARATION NUMBER	Bau EPD-TRM-2025-8-ECOINVENT-VRS-T-DN400
ISSUE DATE	10.08.2025
VALID TO	10.08.2030
NUMBER OF DATASETS	1
ENERGY MIX APPROACH	MARKET BASED APPROACH

VRS®-T ductile cast iron pipe system – DN 400
Tiroler Rohre GmbH

Content of the EPD

1 General information

Product name
VRS®-T ductile cast iron pipe system DN 400

Declaration number
Bau EPD-TRM-2025-8-ECOINVENT-VRS-T-DN400

Declaration data
☒ Specific data
☐ Average data

Declared Product / Declared Unit
1 m ductile cast iron pipe of the VRS®-T system DN 400 with Portland composite cement lining and zinc coating with PUR long-life coating with the nominal dimensions:

Table 1: Nominal dimensions

Nominal diameter [mm]	Longitudinally related mass [kg/m]
400	104,0

Declaration based on
MS-HB Version 6.0.0 dated 06.11.2024
Name of PCR: Cast iron products
PCR-Code 2.16.8, Version 12.0 dated 10.10.2024
(PCR tested and approved by the independent expert committee = PKR-Gremium)
Version of EPD-Format-Template M-Dok 14A2 dated 11.06.2024

The owner of the declaration is liable for the underlying information and evidence; Bau EPD GmbH is not liable with respect to manufacturer information, life cycle assessment data and evidence.

Number of datasets in EPD Document: 1

Range of validity
The EPD applies to the nominal diameter DN 400 of the VRS®-T ductile cast iron pipe system with the above-mentioned lining and duplex outer coating (zinc coating with PUR long-life coating) from the Hall in Tyrol plant of Tiroler Rohre GmbH (TRM).
The EPD and the production technologies assessed are representative for the production of pipes with a nominal diameter DN 400 at the Hall in Tyrol plant of Tiroler Rohre GmbH (TRM).

Type of Declaration as per EN 15804
From cradle to grave with module D (modules A+B+C+D)
LCA method: Cut-off by classification

Database, Software, Version
Ecoinvent 3.10, SimaPro 9.6.0.1
Version Characterisation Factors: Joint Research Center, EF 3.1

Author of the Life Cycle Assessment
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The CEN standard EN 15804:2012+A2:2019+AC:2021 serves as the core-PCR.
Independent verification of the declaration according to ISO 14025:2010
☐ internally ☒ externally
Verifier 1: Dipl.-Ing. Therese Daxner M.sc.
Verifier 2: Dipl.-Ing. Roman Smutny

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Verifier

Note: EPDs from similar product groups from different programme operators might not be comparable.

2 Product

2.1 2.1 General product description

The declared product is a ductile cast iron pipe of the VRS®-T system (restrained locking system) with cement mortar lining (CML) and zinc coating with PUR long-life coating with a nominal diameter DN 400 from Tiroler Rohre GmbH (TRM).

The TRM VRS®-T system consists of ductile, centrifugally cast pipes with a spigot end with a welding ring and a socket, which are joined together to form any length of pipe. The VRS®-T joint, consisting of a VRS®-T socket, VRS®-T sealing ring, spigot end with a welding ring and locking elements, is a highly resilient, flexible and restrained locking system. It is quick and easy to install and can be bent up to 5°. No welding and no weld-seam testing is necessary. The joint can be dismantled at any time.

The ductile cast iron pipes are manufactured in lengths of 5 m with nominal diameters from DN 80 to DN 600 and different wall thicknesses. The nominal dimensions of the declared ductile cast iron pipes with a nominal diameter DN 400 as well as the corresponding wall thickness classes, (normative) minimum wall thicknesses and masses per metre of pipe are shown in Table 2. To further illustrate the declared product, Figure 1 and Figure 2 show excerpts from the Tiroler Rohre GmbH product catalogue with technical and geometric specifications and corresponding mass data.

Table 2: VRS®-T ductile cast iron pipes DN 400 – nominal diameter, Wall thickness class, minimum wall thickness, mass per Meter

DN	Wall thickness class (K class)	Minimum wall thickness [mm]	Mass per m of pipe [kg/m]
400	K 9	6,4	104,0

DN	PFA a [bar]	Maße [mm]		zul. Zugkraft [kN]	Max. Abwinkelung [°]	Anzahl der Riegel	Gewicht Rohr 5m [kg] b
		s_1 Guss	s_2 ZMA				
80	100	4,7	4	115	5	2	81,6
100	75	4,7	4	150	5	2	100,0
125	63	4,8	4	225	5	2	128,2
150	63	4,7	4	240	5	2	157,3
200	40	4,8	4	350	4	2	204,5
250	40	5,2	4	375	4	2	268,9
300	40	5,6	4	380	4	4	339,5
400	30	6,4	5	650	3	4	519,9
500	25/30	7,2/8,2	5	860	3	4	711,8
600	35	8,0	5	1.525	2	9	909,5

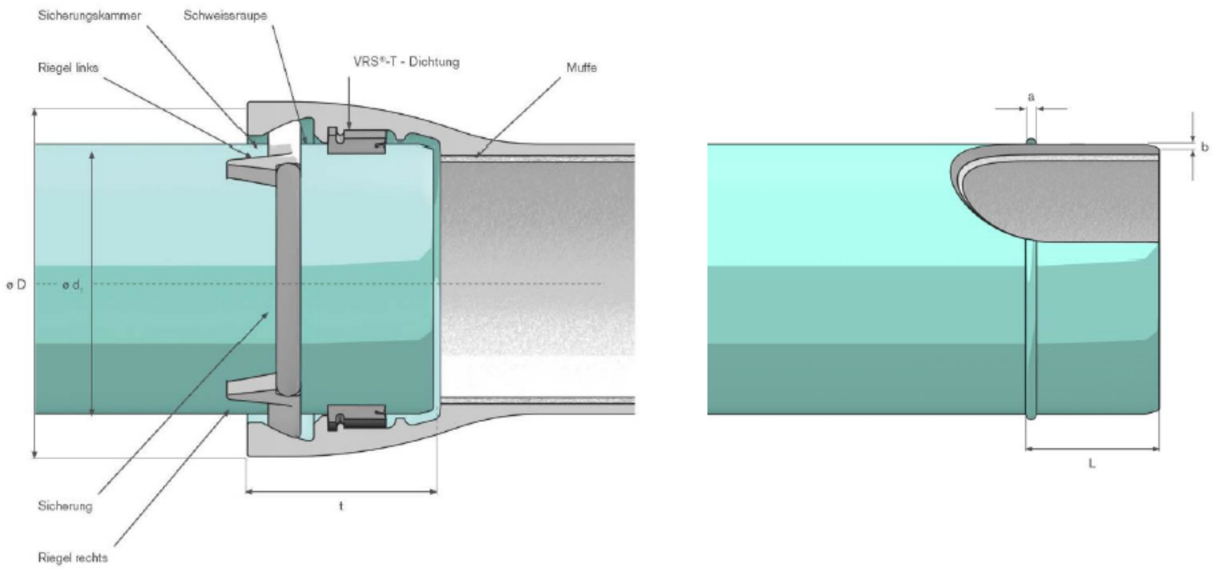
a PFA: zulässiger Bauteilbetriebsdruck | PMA = 1,2 x PFA | PEA = 1,2 x PFA + 5 | höhere PFA auf Anfrage | siehe Hinweise zum Einsatz von Klemmringen

b theoretische Masse pro Rohr für K9/10, inkl. ZMA, Zink, Deckbeschichtung

1 Mindestmaß - Toleranzen beachten | 2 Nennmaß - Toleranzen beachten

Figure 1: VRS®-T pipes – technical and geometric specifications

VRS®-T Verbindung DN 80 bis DN 600



DN	Maße [mm] a						
	Durchmesser Spitzende	Abweichungen	Durchmesser Muffe	Einstecktiefe	Schweißraupe		
	d1		D	t	L	a	b
80	98	+1,0 | -2,7	156	127	86 ±4	8 ±2	5 +0,5 | -1
100	118	+1,0 | -2,8	177	135	91 ±4	8 ±2	5 +0,5 | -1
125	144	+1,0 | -2,8	206	143	96 ±4	8 ±2	5 +0,5 | -1
150	170	+1,0 | -2,9	232	150	101 ±4	8 ±2	5 +0,5 | -1
200	222	+1,0 | -3,0	292	160	106 ±4	9 ±2	5,5 +0,5 | -1
250	274	+1,0 | -3,1	352	165	106 ±4	9 ±2	5,5 +0,5 | -1
300	326	+1,0 | -3,3	410	170	106 ±4	9 ±2	5,5 +0,5 | -1
400	429	+1,0 | -3,5	521	190	115 ±5	10 ±2	6 +0,5 | -1
500	532	+1,0 | -3,8	630	200	120 ±5	10 ±2	5 +0,5 | -1
600	635	+1,0 | -4,0	732	175	160 +0 | -2	9 ±1	5 +0,5 | -1

a Toleranzen sind möglich

Figure 2: Schematic illustration of a VRS®-T ductile cast iron pipe

The density of ductile cast iron is 7,050 kg/m³.

2.2 Application field

The VRS®-T cast iron pipe system with Portland composite cement lining is mainly used for drinking water supply and for fire extinguishing pipes, snow-making systems and turbine pipes. The cast iron pipe can be installed using various methods, such as:

- Conventional installation (trench)
- Trenchless installation
- Bridge pipes
- Interim pipes

- Floating

The usual installation method is conventional laying with the excavation of a trench, the creation of a bedding for the pipe and backfilling with suitable material.

2.3 Standards, guidelines and regulations relevant for the product

Table 3: Product specific standards

Regulation	Title
OENORM EN 545	Ductile iron pipes, fittings, accessories and their joints for water pipelines - Requirements and test methods
OENORM B 2599-1	Ductile iron pipes and fittings — Part 1: Use for water pipelines
OENORM B 2597	Ductile cast iron pipes and fittings for water, sewage and gas pipe lines - Restrained push-in-joints - Requirements and tests
OENORM B 2555	Coating of cast iron pipes - Thermal zinc spraying
OENORM B 2560	Ductile iron pipes - Finishing coating of polyurethane, epoxy or acrylic materials - Requirements and test methods
OENORM B 2562	Ductile cast iron pipes - Factory made lining with cement mortar - Requirements and test methods
OENORM EN 681-1	Elastomeric seals - Material requirements for pipe joint seals used in water and drainage applications - Part 1: Vulcanized rubber

2.4 Technical data

Mechanical properties are verified according to OENORM EN 545:2011, sections 6.3 and 6.4.

Table 4: Material parameters for ductile cast iron pipes of the VRS®-T system

Name	Value	Unit
Iron density	7050	kg/m^3
Minimum tensile strength	≥ 420	MPa
Proportional limit, 0.2% yield strength ($R_{p0.2}$)	≥ 300	MPa
Minimum elongation at fracture	≥ 10	%
Maximum Brinell hardness	≤ 230	HB
Pipe length	5000	mm
Mean coefficient of linear thermal expansion	$10*10^{-6}$	m/m*K
Thermal conductivity	0,42	W/cm*K

Table 5: VRS®-T pipes DN 400 – nominal dimension-dependent technical data

DN	Wall thickness class K class	Minimum wall thickness [mm]	Mass per metre of pipe [kg/m]	Allowable operating pressure PFA [bar]	Permissible tensile force [kN]
400	K 9	6,4	104,0	30	650

2.5 Basic/auxiliary materials

Table 6: VRS®-T pipes DN 400 – basic materials in mass %

DN	Casting	Zinc	Cement stone	PUR
400	80,9%	0,4%	18,1%	0,5%

Table 7: Basic materials – casting in mass %

Ingredients:	**Mass %**
Iron [1)]	ca. 94 %
Carbon [2)]	ca. 3,5 %
Silicon [3)]	ca. 2 %
Ferric by-elements [4)]	ca.0,5 %

[1)] Iron consisting mainly of steel scrap and a very small proportion of pig iron and return iron from the casting process

[2)] Foundry coke carbon. The coke in the cupola furnace serves both as an energy supplier for the scrap melting and the adjusting of the desired carbon content

[3)] Silicon is added in the form of SiC pellets and/or ferro-silicon

[4)] Ferric by-elements are found in the steel scrap in different minor quantities (<<1%)

2.6 Production stage

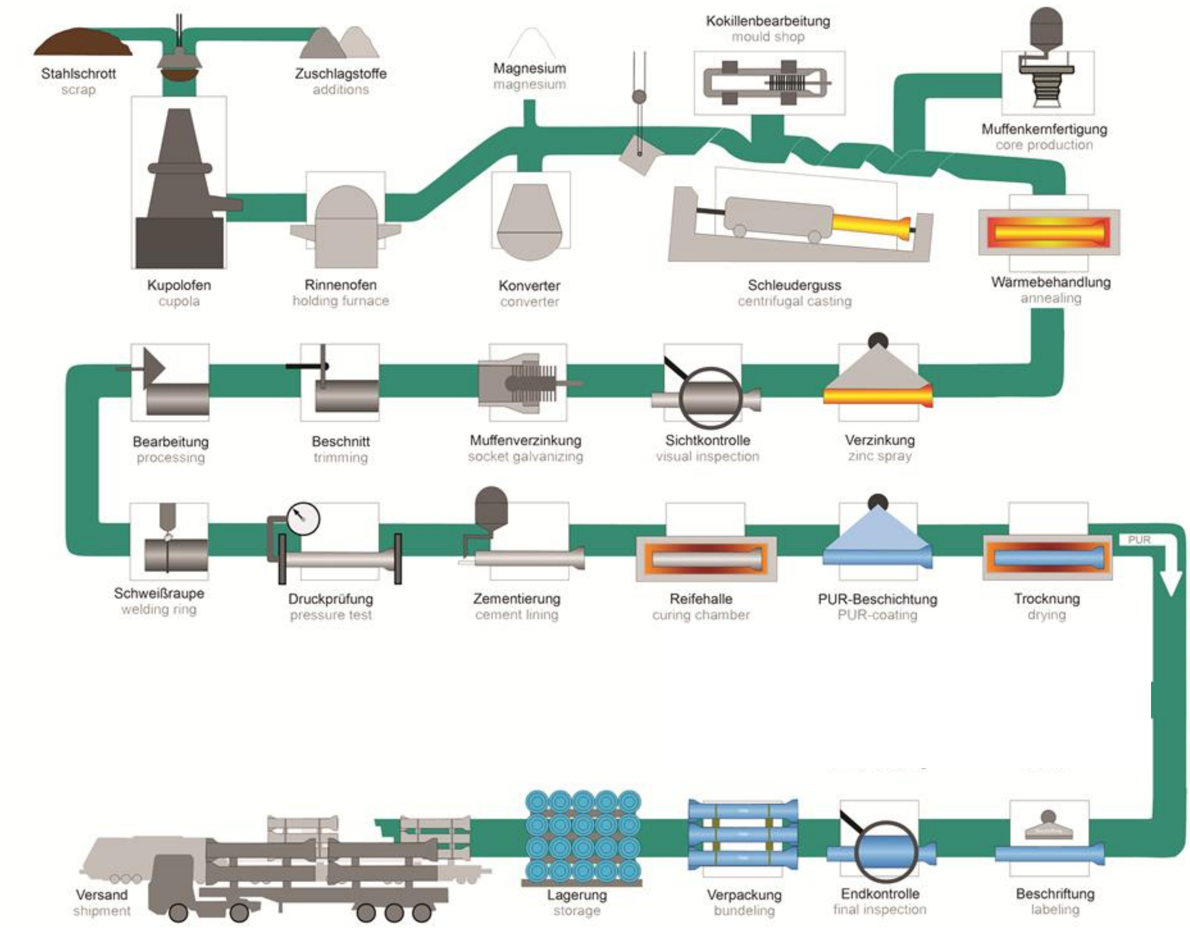


Figure 3: Flow chart of production process

For casting production, steel scrap and recycled material are smelted in the cupola furnace with the help of coke as a reaction and reduction agent. Silicon carbide is added as an alloying element. Added aggregates enhance slagging. The chemical composition of the smelted basic iron is then constantly monitored through spectral analysis. The smelted basic iron is kept warm in the holding furnace, a storage medium, and then treated with magnesium in the Georg Fischer converter, in order to reach the appropriate ductility. The liquid iron is then cast in a centrifuge machine with the De Lavaud procedure. In order to produce a specific pipe diameter, this machine is equipped with the corresponding mould (metal form that the liquid iron is poured into). The socket core made of quartz sand seals the inlet of the machine and forms the pipe socket. The glowing pipe is pulled out of the cast unit and placed in a furnace with the help of an automatic transport system. Here it undergoes annealing in order to achieve the desired mechanical properties.

The pipe is then galvanised using the electric arc spraying process and then cooled. The pipe is visually inspected in the pipe line. The spigot end and socket are machined if necessary. In the area of the welding ring, the zinc and annealing skin (tinder) are ground off and finally the welding ring is applied.

During the pressure test, each pipe is hydrostatically pressurised with a certain internal pressure and checked for leaks. The pipe is then lined with cement mortar using the centrifugal rotation process. The weld seam is galvanised and the pipes are visually inspected again. The cement stone hardens in the curing chamber. Finally, a solvent-free two-component polyurethane top coat is applied. All pipes are labelled according to the specifications, bundled and brought to the warehouse.

2.7 Packaging

The TRM pipes are sealed with protective caps and bundled using spacer rings as stacking aid and PET tapes. All packaging materials can be used for thermal recycling.

2.8 Conditions of delivery

The ductile cast iron pipes are bundled for transport and storage with the help of spacer rings as stacking aid as well as PET binding tapes.

2.9 Transport to site

The cast pipes are transported to their destination within Europe by lorry and, in rare cases, overseas by ship.

2.10 Construction product stage

The installation of pressure pipes made of ductile cast iron must comply with OENORM EN 805 (Water supply - Requirements for systems and components outside buildings) and OENORM B 2538 (Additional specifications concerning OENORM EN 805). When constructing the pipe trench, sufficient working space must be provided for the installation of the pipeline, depending on the trench depth and the outer diameter of the pipe. The Ordinance on Protection of Construction Workers (Bauarbeiterschutzverordnung) and other provisions as well as relevant standards and regulations must be complied with accordingly.

As this is a push-in joint, no additional work such as welding is required. The pipe trench must be constructed and excavated in such a way that all pipe sections are at frost-free depths. The trench must be excavated deep enough so that the final cover height is at least 1.50 m. In the case of ductile iron pipes, the existing soil is generally suitable for bedding the pipeline. This means there is no need for a lower bedding layer and the bottom of the trench becomes the lower bedding.

The pipeline must be embedded and the pipe trench refilled in such a way that the pipeline is securely fixed in its intended position and that damage to the pipeline is prevented and settlement can only occur to the permissible extent. Suitable material that does not damage the pipe components and the coating must be used for embedding the pipeline. The backfill material should be installed in layers and sufficiently compacted.

2.11 Use stage

If installed and designed professionally and if the phase of utilisation is not disturbed, no modification of the material composition of construction products made of ductile cast iron occur.

2.12 Reference service life (RSL)

Table 8: Reference service life (RSL)

Name	Value	Unit
Ductile cast iron pipes	50	Years

In practice, it has been shown that a service life of 100 years, based on the DVGW damage statistics (German Technical and Scientific Association for Gas and Water – https://www.dvgw.de/themen/sicherheit/gas-und-wasserstatistik/), is achieved.

2.13 End of life stage

In inner-city areas, the main area of application for the pipe systems, the installed pipes are currently almost entirely removed. These pipes can then be recycled accordingly. These pipes can then be sent to recycling. The removal and recycling rate was therefore set correspondingly high in the scenarios considered (see 4.4 - C1-C4 disposal phase). However, it should be noted that the 100% removal rate is a manufacturer's scenario, which must be checked and adjusted accordingly in each individual use case.

The pipes are disposed of in very rare cases. The EAK waste code number for iron and steel from construction and demolition is 170405.

2.14 Further information

For further information about the TRM pipe system and its possible applications, see the website http://trm.at/rohr.

3 LCA: Calculation rules

3.1 Declared unit/ Functional unit

The functional unit is 1 metre [m] of pipe. For conversion into kg, Table 9 can be used.

Table 9: Conversion factor to mass

Nominal diameter [mm]	Longitudinally related mass [kg/m]	Multiplication factor
400	104,0	0,00962

3.2 System boundary

The entire product life cycle and module D is declared. This is a “from cradle to grave with module D”-EPD (modules A+B+C+D).

Table 10: Declared life cycle stages

PRODUCT STAGE			CON-STRUCTION PROCESS STAGE		USE STAGE							END-OF-LIFE STAGE				BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARIES
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
Raw material supply	Transport	Manufacturing	Transport from the gate to the site	Construction, installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction, demolition	Transport	Waste processing	Disposal	Reuse- Recovery- Recycling- potential
x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

X = included in LCA; ND = Not declared

3.2.1 A1-A3 Product Stage:

The cast iron pipes (semi-finished parts) are almost exclusively made of the secondary material steel scrap and a very small proportion of pig iron and return iron from the casting process. The system boundary for the steel scrap is set when the processed steel scrap leaves the recycling plants, because the end of the waste properties of the steel scrap is reached here. This system is blamed for the transportation of the scrap to the TRM plant. The product stage includes the production steps in the plant along with the energy supply (including the upstream chains), the production of raw materials, auxiliary materials and packaging (including transport to the plant), the infrastructure and the disposal of the waste occurring during production. Module A1-A3 also includes the manufacture of the locks and gaskets required for assembling the pipe.

3.2.2 A4-A5 Construction stage:

The cast iron pipe can be installed in various ways. This EPD considers the standard case for installation, i.e. the conventional laying of the pipe:

- Excavation of trench
- Bedding of the pipe
- Backfilling with suitable material

The protective caps, squared lumber and binding tapes needed for transport are thermally recycled.

3.2.3 B1-B7 Use stage:

Generally, construction products made of ductile cast iron show no impact on the LCA during the use stage.

3.2.4 C1-C4 End-of-life stage:

In inner-city areas, the main area of application for the pipe systems, the installed pipes are currently almost entirely removed. For this reason, a 100% removal rate is applied as a scenario.

The removed pipes are sent to a recycling process and are considered until the end-of-waste state according to EN 15804 in the current product system. The system boundary is therefore set when the processed steel scrap leaves the recycling plants.

As a recycling scenario, due to the robustness of the pipe systems, it is assumed that 97% of the removed pipes are suitable for the recycling process and 3% have to be sent to landfill due to breakage, etc. The recycling scenario applied is a manufacturer's scenario based on the experience of Tiroler Rohre GmbH, which must be checked and adapted accordingly in each individual use case.

3.2.5 D Benefits and loads:

Due to the recycling of the removed pipes, there is a corresponding output of secondary raw materials in C3. The output flows are compared with the scrap share in the production of the cast iron pipes in accordance with the net flow rule according to EN 15804 and the net output flow is determined. The recycling and net flow scenario applied is a manufacturer's scenario based on the experience of Tiroler Rohre GmbH, which must be checked and adapted accordingly in each individual use case.

3.3 Flow chart of processes/stages in the life cycle

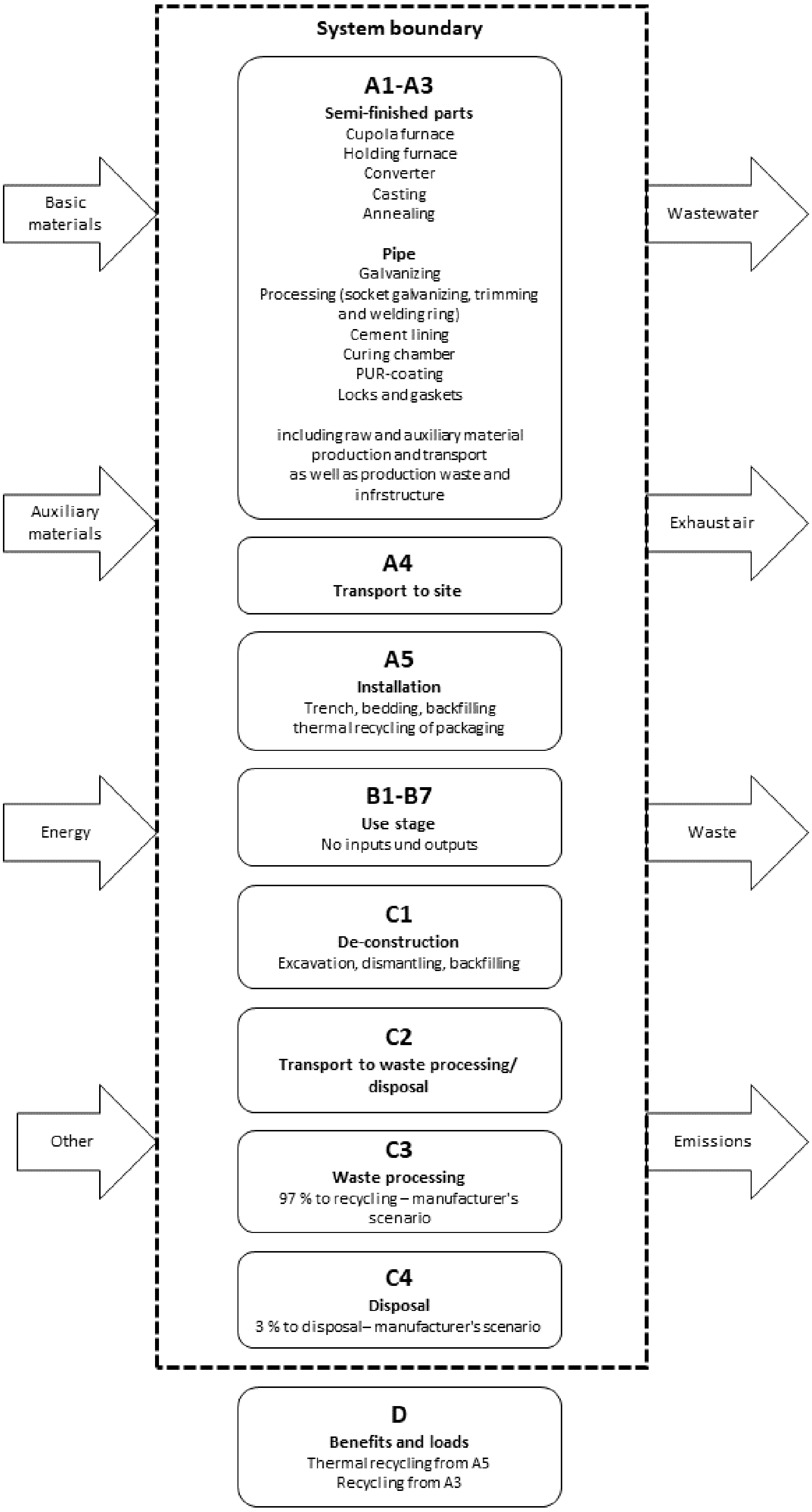


Figure 4: Life cycle flow chart

3.4 Estimations and assumptions

The SiC pellets used in casting production consist of various silicon components, Portland cement and water. In ecoinvent 3.10 there is only one data set for silicon carbide, which is typical of wafer production and has a very high SiC purity compared to the SiC component mixture used in casting production and therefore also a high energy intensity (information from the manufacturer of the pellets). According to the manufacturer of the SiC pellets, the energy required to produce the SiC components or silicon carbide is reflected in the respective prices per tonne. This allows an adjustment of the SiC purity (correction factor) of the data set available in ecoinvent based on an economic comparison (i.e. in the style of an economic allocation).

Cast steel is a special steel with no available data set. As the input is below 1 kg per t of ductile cast iron, the ecoinvent data set for chrome steel was applied.

For magnesium, which mainly comes from China, the global data set for magnesium was used ("market"-data set).

Since the infrastructure only makes a very small contribution to environmental impact, the machinery was modelled with its main components steel and casting.

For the use stage, it was assumed that no LCA-relevant material and energy flows occur.

All transport distances, with the exception of magnesium, were collected by the customer and taken into account in the LCA. For magnesium, the average transports are taken into account by the application of the global "market"-data set (which includes transport processes for the market under consideration).

3.5 Cut-off criteria

The producer calculated and submitted the amount of all applied materials, energy needed, the packaging material, the arising waste material and the way of disposal and the necessary infrastructure (buildings and machinery for the production). The measurement values for emissions according to the casting regulations were specified.

Auxiliary materials whose material flow is less than 1% were ignored as insignificant. Internal transport was negligible due to the short transport distances. It can be assumed that the total of insignificant processes is less than 5% of the impact categories.

During the production of the ductile pipes, slag (from cupola furnace) and coke dust are produced as by-products. Part of the waste heat is sold as district heating. However, these by-products contribute less than 1% to the operational income and can therefore be ignored according to the Management-System-Handbook (MS-HB) of the Bau EPD GmbH (MS-HB Version 6.0.0 dated 06.11.2024). The system limit for these two recyclable materials is set when they are collected from the plant by the future user.

The materials resulting from the production of semi-finished parts – foundry debris, fly-ash, filter cake from cupola furnace dust extraction and converter slag – are taken to a recycling plant for processing, whereby the system limit is set when the substances arrive at this plant, because no detailed information is available on the further treatment processes and the influence on the results of the impact categories is classified as negligible.

In C3, the recycling of the pipes (97%), i.e. the processing of the removed pipes in a recycling plant into a secondary raw material that can be used in cast iron and steel production, is taken into account. For this purpose, it is assumed that the pipe (including CML, etc.) is sent as a whole to the recycling plant, where any materials that cannot be used for cast iron and steel production are separated out. The treatment of these separated materials is excluded due to the expected minor influence.

3.6 Allocation

The system boundary for the steel scrap is set when the processed steel scrap leaves the recycling plants, because the end of the waste staus of the steel scrap is reached here. This system is blamed for the transportation of the scrap to the TRM plant.

In the liquid iron sector, an allocation by mass based on stock additions was carried out between the pipes considered in this EPD and the products not considered. The same applies to waste.

During the production of the ductile pipes, slag and coke dust are produced as by-products. Part of the waste heat is sold as district heating. However, these by-products contribute less than 1% to the operational income and can therefore be ignored according to the “Management-System-Handbook (MS-HB) of the Bau EPD GmbH (MS-HB Version 6.0.0 dated 06.11.2024).

For the annealing, the energy used was allocated according to the dwell times in the furnace.

Due to the recycling of the removed pipes, there is a corresponding output of secondary raw materials in C3. The output flows are compared with the scrap share in the production of the cast iron pipes in accordance with the net flow rule according to EN 15804 and the net output flow is determined.

3.7 Comparability

In principle, a comparison or evaluation of EPD data is only possible if all data sets to be compared have been created in accordance with EN 15804, the same programme-specific PCR/any additional rules and the same background database have been used, and the building context/product-specific performance characteristics are also taken into account.

4 LCA: Scenarios and additional technical information

4.1 A1-A3 Product stage

According to OENORM EN 15804, no technical scenario details are required for A1-A3 as the producer is responsible for the accounting of these modules, and this must not be changed by the user of the LCA.

Data collection for the product stage was carried out according to ISO 14044 Section 4.3.2. In accordance with the target definition, all relevant input and output flows that occur in connection with the product under consideration were identified and quantified in the life cycle inventory analysis.

Electricity generation is modelled according to the electricity mix supplied by Tiroler Wasserkraft AG (TIWAG) to Tiroler Rohre GmbH. In 2020, Tiroler Rohre GmbH purchased the TIWAG 2020 supplier mix (Versorgermix) from Tiroler Wasserkraft AG TIWAG (electricity mix contractually secured).

A part of the electricity consumption in the semi-finished parts production takes place at medium voltage level. The remaining electricity consumption takes place at low voltage level, with 5.75% coming from the in-house photovoltaic system.

Since photovoltaic electricity is generally fed into the grid and consumed at low voltage, and Tiroler Rohre GmbH purchases its electricity at medium voltage, the photovoltaic share is deducted when modelling the medium-voltage electricity supplied by TIWAG (see Table 11).

Table 11: Electricity mix

Source	**TIWAG Supplier mix general**	**Medium voltage without photovoltaics**
Hydro power	84,90%	86,32%
Norway	*20,23%*	*20,57%*
Tyrol	*64,67%*	*65,75%*
Wind power	10,37%	10,54%
Solid or liquid biomass	2,02%	2,05%
Photovoltaics	1,64%	0,00%
Biogas	1,05%	1,07%
Other eco-energy	0,02%	0,02%
Sum	**100,00%**	**100,00%**

The GWP total- result for the TIWAG electricity mix used is 57.3 g CO_2 eq/kWh at high voltage level, 60.5 g CO_2 eq/kWh at medium voltage level and 61.6 g CO_2 eq/kWh at low voltage level. The GWP total-result for low-voltage electricity from the photovoltaic system at the TRM plant is 104 g CO_2 eq/kWh.

4.2 A4-A5 Construction process stage

The pipes are transported to their destination by truck. The client provided relevant information on the transports, and based on this, an average transport distance of approximately 470 km was determined.

Table 12 shows the general parameters for describing transportation to the building site.

Table 12: Description of the scenario „Transport to building site (A4)“

Parameters to describe the transport to the building site (A4)	Value	Unit
Average transport distance	471	km
Vehicle type, Commission Directive 2007/37/EC (European Emission Standard)	Euro 6	-
Average fuel consumption, fuel type: Diesel or heavy fuel oil	25,3	l/100 km
Average transport mass	5,79	t
Average capacity utilisation (including empty returns)	85	%
Average gross density of transported products	104,0	kg/m
Volume capacity utilisation factor (factor: =1 or <1 or ≥ 1 for compressed or nested packaged products)	<1	-

Conventional laying was chosen as the installation method for the EPD, i.e. excavating a trench, bedding the pipe and backfilling with suitable material. A hydraulic excavator with an engine power of 150 kW, a scoop capacity of 2,2 m3 and a weight of 35 t was used for the excavation and backfilling of the pipe trench (including bedding).

Most of the excavation material is temporarily stored and reused for backfilling. However, a certain proportion of the excavation material (varying for the specific nominal diameters depending on the proportion of bedding) must be disposed of at a landfill 20 km away. The additional backfill material required for this is transported from a gravel pit 20 km away.

The spacer rings (PP), protective caps (PE), stacked wood and binding tape (PET) are thermally recycled in a waste incinerator 100 km away.

Table 13: Description of the scenario „Installation of the product in the building (A5)“

Parameters to describe the installation of the product in the building (A5)	Value	Unit
Ancillary materials for installation (specified by material);	Backfill material 561	kg/m
Ancillary materials for installation (specified by type)	Hydraulic excavator	-
Water use	0	m^3/m
Other resource use	0	kg/m
Electricity demand	0	kWh/m
Other energy carrier(s): Diesel	11,2	MJ/m
Wastage of materials on the building site before waste processing, generated by the product's installation (specified by type)	0	kg/m
Output materials (specified by type) as result of waste processing at the building site e.g. of collection for recycling, for energy recovery, disposal (specified by route)	Disposal Excavation: 561 Waste incineration PE: 0,163 PP: 0,050	kg/m
Direct emissions to ambient air (such as dust, VOC), soil and water	-	kg/m

4.3 B1-B7 Use stage

In the use stage, no material and energy flows relevant for the life cycle assessment take place for the VRS®-T pipe systems, wherefor no activities were taken into account.

4.4 C1-C4 End-of-Life stage

In inner-city areas, the main area of application for the pipe systems, the installed pipes are currently almost entirely removed. For this reason, a 100% removal rate is used as a scenario. The removed pipes are sent to a recycling process, being considered until the end-of-waste state in the current product system. The system limit is set when the processed steel scrap leaves the recycling plants. From this point on, the pipe is part of a new product system. As a recycling scenario it is assumed that 97% of the pipes are suitable for the recycling process and 3% have to be sent to disposal.

The pipes are removed with the same excavator that was used for the installation. The excavation volume for the removal corresponds to volume for the installation. The existing excavation material is reinstalled, but must be supplemented with additional backfill material (different for the specific DN). The distance to the gravel pit is estimated at 20 km.

Table 14: Description of the scenario "Dismantling (C1)"

Parameters to describe the dismantling (C1)	Value	Unit
Auxiliary materials for the dismantling	Backfill material 319,4	kg/m
Aids for the demolition	Hydraulic excavator	-
Water consumption	0	m^3/m
Other resource use	0	kg/m
Electricity consumption	0	kWh/m
Other energy carrier: Diesel	11,2	MJ/m
Material loss on the construction site before waste treatment, caused by the installation of the product	0	kg/m
Output materials due to waste treatment on the construction site, e.g. collection for recycling, for energy recovery or for disposal	0	kg/m
Direct emissions to ambient air (e.g. dust, VOC), soil and water	-	kg/m

The transport distance to the nearest recycling company (97% of the pipes) as well as to the nearest inert material landfill (3% of the pipes) or waste incineration plant (gaskets) was assumed to be 100 km.

Table 15: Description of the scenario "Transport for disposal (C2)"

Parameters to describe the transport for disposal (C2)	Value	Unit
Average transport distance	100	km
vehicle type, Commission Directive 2007/37/EC (European Emission Standard)	Euro 6	-
Average fuel consumption, fuel type: Diesel or heavy fuel oil	25,3	l/100 km
Average transport mass	5,79	t
Average capacity utilisation (including empty returns)	85	%
Average gross density of transported products	104,0	kg/m
Volume capacity utilisation factor (factor: =1 or <1 or ≥ 1 for compressed or nested package products)	<1	-

In C3, the recycling of the pipes (97%), i.e. the processing of the removed pipes in a recycling plant into a secondary raw material that can be used in cast iron and steel production, is taken into account. For this purpose, it is assumed that the pipe (including CML, etc.) is sent as a whole to the recycling plant, where any materials that cannot be used for cast iron and steel production are separated out. The treatment of these separated out materials is excluded due to the expected minor influence. A new product system begins with the transport of the processed scrap from the recycling plant to the production plant.

In C4, the disposal of 3% of the pipe mass in an inert material landfill and the disposal of the EPDM gasket material in a waste incinerator are considered. A 100% recycling rate is applied for the removed bolts, which are made of pure cast material.

Table 16: Disposal processes (C3 and C4) per m of pipe

DN	Mass per metre of pipe	Total pipe mass for recycling (97%)	Total pipe mass for disposal (3%)	Lock mass for recycling (100%)	Total mass (pipe and Lock) for recycling	Gasket mass for waste incineration
[mm]	*[kg/m]*	*[kg/m]*	*[kg/m]*	*[kg/m]*	*[kg/m]*	*[kg/m]*
400	104,00	100,880	3,120	0,880	101,760	0,1860

Table 17: Description of the scenario „Disposal of the product (C1 to C4)"

Parameters for end-of-life stage (C1-C4)	Value	Unit
Collection process, separately	see Table 16	kg collected separately
Recycling	see Table 16	kg for recycling
Disposal, inert material landfill	see Table 16	kg material for final deposition

4.5 D Potential of reuse and recycling

Due to the recycling of the removed pipes (97%), there is a corresponding output of secondary raw materials (D from C3). Due to the net flow rule according to EN 15804 and the high proportion of scrap in the production of cast iron pipes (988 kg per tonne of cast semi-finished part), there is a slightly negative net output flow here.

Table 18: Description of the scenario „re-use, recovery and recycling potential (module D)“

Parameters for module D	Value	Unit
Materials for reuse, recovery or recycling from A4-A5	-	%
Energy recovery or secondary fuels from A4-A5	Waste incineration PP: 0,050 PE: 0,163	kg/m
Materials for reuse, recovery or recycling from B2-B5	-	%
Energy recovery or secondary fuels from B2-B5	-	kg/m
Materials for reuse, recovery or recycling from C1-C4	97	%
Energy recovery or secondary fuels from C1-C4	Waste incineration Gasket: 0,1860	kg/m

Due to the multi-recycling potential of the pipes, they could again replace primary raw materials in the next product system. In this EPD, the multi-recycling potential is not shown as a life cycle assessment result (in the results tables) but as additional information (Appendix 1), because this value does not comply with the rules and specifications of EN 15804 (net flow rule). The additional information on multi-recycling potential is based on a manufacturer scenario based on the experience of Tiroler Rohre GmbH.

5 Information on data quality and data selection in accordance with EN 15941

5.1 Principles for the description of data quality

The following information on data quality is provided in accordance with the requirements of EN 15941 (EN 15941, section 7.3.4).

The data fulfils the following quality requirements:

The data is representative for the production year 2020 (annual average). The production year 2020 is considered based on the existing data for ductile cast iron production (semi-finished part production) of the EPD for ductile piles from Tiroler Rohre GmbH (published 2022).

For the data collection, generic data and the cut-off of material and energy flows the criteria of the Bau EPD GmbH were considered.

The manufacturer provided all essential data such as energy and raw material consumption, transport distances and vehicles as well as packaging within the system boundaries.

The applied background database ecoinvent 3.10 was published in 2024, but contains individual data sets whose collection or reference year dates back more than 10 years (requirement EN 15804 or Bau EPD GmbH). These data sets remained in the various ecoinvent database versions through the years, taking necessary adjustments for database updates into account. Nevertheless, these data sets are subject to a corresponding potential for fluctuation because some of the (technological) developments of recent years are not reflected.

The data is plausible, i.e. the deviations from comparable results are within a plausible range.

5.2 Description of the temporal, geographical and technological representativeness of the product data

Temporal representativeness:

- The data collection period corresponds to the year 2020. All specific data are from this year.
- There is no deviation from the reporting year 2020 in the collection of specific data.
- The applied background database ecoinvent 3.10 was published in 2024, but contains individual data sets whose collection or reference year dates back more than 10 years (requirement EN 15804 or Bau EPD GmbH).

Geographical representativeness:

- VRS®-T pipe systems are manufactured exclusively at the plant in Hall in Tirol. In the production year 2020, almost 50% of the products were delivered within Austria and a total of approx. 90% within Europe (with a focus on Germany and Italy in addition to Austria).
- The pipe systems are disposed of in an area close to where they were used.

Technological representativeness:

- The production technology at the plant in Hall in Tyrol is state-of-the-art. The facilities are regularly maintained and modernised.
- In addition to cast iron pipe systems, other products such as ductile piles (pure cast iron product corresponds to semi-finished parts) are also manufactured at the analysed plant.

Geographical and technological representativeness for EPDs covering an industry:

- Not relevant for this EPD.

5.3 Explanation of the averaging process

Not relevant for this EPD, as specific products from the plant in Hall in Tyrol of the Tiroler Rohre GmbH are considered.

5.4 Assessment of the data quality of the Life Cycle Inventory data

The validity (database/source, country/region, reference year, publication/update) and the geographical, technical and temporal representativeness (according to ÖNORM EN 15804 Annex E - Table E.1) of all data sets used are assessed in the project report for this EPD.

The manufacturer provided all essential data such as energy and raw material consumption, transport distances and vehicles, and packaging within the system boundaries (quality management system and SAP system).

6 LCA: results

Table 19: Parameters to describe the environmental impact per metre [m] VRS®-T DN 400

Parameters	Unit	A1-A3	A4	A5	B1-B7	C1	C2	C3	C4	C1-C4	A-C	D
GWP total	kg CO_2 eq	9,91E+01	9,43E+00	1,53E+01	0,00E+00	5,63E+00	2,00E+00	2,63E+00	6,07E-01	1,09E+01	1,35E+02	2,28E+00
GWP fossil fuels	kg CO_2 eq	9,86E+01	9,42E+00	1,53E+01	0,00E+00	5,61E+00	2,00E+00	2,66E+00	6,07E-01	1,09E+01	1,34E+02	2,29E+00
GWP biogenic	kg CO_2 eq	3,64E-01	6,53E-03	1,57E-02	0,00E+00	7,86E-03	1,38E-03	-3,45E-02	7,43E-05	-2,52E-02	3,61E-01	-9,90E-03
GWP luluc	kg CO_2 eq	5,59E-02	3,13E-03	8,62E-03	0,00E+00	3,52E-03	6,63E-04	3,76E-03	1,26E-05	7,95E-03	7,56E-02	2,98E-04
ODP	kg CFC-11 eq	1,23E-06	1,87E-07	2,50E-07	0,00E+00	6,78E-08	3,97E-08	3,66E-08	7,41E-10	1,45E-07	1,81E-06	4,56E-09
AP	mol H^+ eq	2,48E-01	1,96E-02	7,90E-02	0,00E+00	3,26E-02	4,16E-03	2,92E-02	2,20E-04	6,62E-02	4,13E-01	8,20E-03
EP freshwater	kg P eq	3,38E-02	6,38E-04	2,45E-03	0,00E+00	1,16E-03	1,35E-04	1,52E-03	3,14E-06	2,81E-03	3,97E-02	9,55E-04
EP marine	kg N eq	6,39E-02	4,71E-03	2,46E-02	0,00E+00	1,00E-02	9,99E-04	6,79E-03	8,51E-05	1,79E-02	1,11E-01	1,97E-03
EP terrestrial	mol N eq	6,59E-01	5,09E-02	2,78E-01	0,00E+00	1,15E-01	1,08E-02	7,63E-02	9,27E-04	2,03E-01	1,19E+00	2,13E-02
POCP	kg NMVOC eq	2,22E-01	3,26E-02	9,49E-02	0,00E+00	3,53E-02	6,91E-03	2,29E-02	2,97E-04	6,53E-02	4,15E-01	7,17E-03
ADPE	kg Sb eq	1,09E-03	3,07E-05	4,98E-05	0,00E+00	2,14E-05	6,50E-06	1,64E-04	5,37E-08	1,92E-04	1,36E-03	1,11E-06
ADPF	MJ H_u	6,56E+02	1,10E+01	4,94E+01	0,00E+00	2,39E+01	2,33E+00	1,15E+01	4,64E-02	3,78E+01	7,54E+02	2,16E+01
WDP	m3 World eq	2,59E+01	5,51E-01	1,23E+01	0,00E+00	4,82E+00	1,17E-01	4,45E-01	1,92E-02	5,41E+00	4,42E+01	1,35E-01
Legend		GWP = Global warming potential; luluc = land use and land use change; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential, Accumulated Exceedance; EP = Eutrophication potential; POCP = Formation potential of tropospheric ozone photochemical oxidants; ADPE = Abiotic depletion potential for non-fossil resources; ADPF = Abiotic depletion potential for fossil resources WDP = Water (user) deprivation potential, deprivation-weighted water consumption										

Table 20: Additional environmental impact indicators per metre [m] VRS®-T DN 400

Parameters	Unit	A1-A3	A4	A5	B1-B7	C1	C2	C3	C4	C1-C4	A-C	D
PM	Occurrence of diseases	1,14E-05	6,94E-07	1,69E-06	0,00E+00	6,76E-07	1,47E-07	4,09E-07	3,56E-09	1,24E-06	1,51E-05	1,72E-07
IRP	kBq U235 eq	4,42E+00	1,72E-01	7,00E-01	0,00E+00	3,48E-01	3,64E-02	2,68E-01	6,34E-04	6,53E-01	5,94E+00	9,05E-03
ETP-fw	CTUe	9,36E+02	3,61E+01	6,17E+01	0,00E+00	2,46E+01	7,64E+00	2,58E+01	1,05E+00	5,91E+01	1,09E+03	2,25E+02
HTP-c	CTUh	1,08E-06	6,69E-08	1,03E-07	0,00E+00	4,26E-08	1,42E-08	2,30E-08	1,48E-10	7,99E-08	1,33E-06	8,56E-07
HTP-nc	CTUh	9,09E-07	8,32E-08	1,00E-07	0,00E+00	3,83E-08	1,76E-08	1,42E-07	2,49E-10	1,98E-07	1,29E-06	7,87E-09
SQP	dimensionless	2,72E+02	8,01E+01	2,70E+02	0,00E+00	4,76E+01	1,70E+01	6,39E+01	9,69E-01	1,29E+02	7,52E+02	4,79E+00
Legend		PM = Potential incidence of disease due to Particulate Matter emissions; IRP = Potential Human exposure efficiency relative to U235; ETP-fw = Potential Comparative Toxic Unit for ecosystems; HTP-c = Potential Comparative Toxic Unit for humans – cancer effect; HTP-nc = Potential Comparative Toxic Unit for humans – non-cancer effect; SQP = Potential soil quality index										

Table 21: Parameters to describe the use of resources per metre [m] VRS®-T DN 400

Parameters	Unit	A1-A3	A4	A5	B1-B7	C1	C2	C3	C4	C1-C4	A-C	D
PERE	MJ H_u	1,59E+02	2,28E+00	8,76E+00	0,00E+00	4,28E+00	4,82E-01	5,83E+00	9,27E-03	1,06E+01	1,81E+02	3,20E-01
PERM	MJ H_u	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PERT	MJ H_u	1,59E+02	2,28E+00	8,76E+00	0,00E+00	4,28E+00	4,82E-01	5,83E+00	9,27E-03	1,06E+01	1,81E+02	3,20E-01
PENRE	MJ H_u	6,47E+02	1,10E+01	5,80E+01	0,00E+00	2,39E+01	2,34E+00	1,15E+01	4,65E-02	3,78E+01	7,54E+02	2,16E+01
PENRM	MJ H_u	8,53E+00	0,00E+00	-8,53E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PENRT	MJ H_u	6,56E+02	1,10E+01	4,94E+01	0,00E+00	2,39E+01	2,34E+00	1,15E+01	4,65E-02	3,78E+01	7,54E+02	2,16E+01
SM	kg	8,40E+01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	8,40E+01	-1,50E+00
RSF	MJ H_u	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
NRSF	MJ H_u	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
FW	m^3	1,01E+00	1,84E-02	3,03E-01	0,00E+00	1,19E-01	3,89E-03	1,75E-02	1,06E-03	1,42E-01	1,47E+00	3,67E-03
Legend		PERE = Renewable primary energy as energy carrier; PERM = Renewable primary energy resources as material utilization; PERT = Total use of renewable primary energy resources; PENRE = Non-renewable primary energy as energy carrier; PENRM = Non-renewable primary energy as material utilization; PENRT = Total use of non-renewable primary energy resources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of fresh water										

Table 22: Parameters describing LCA-output flows and waste categories per metre [m] VRS®-T DN 400

Parameters	Unit	A1-A3	A4	A5	B1-B7	C1	C2	C3	C4	C1-C4	A-C	D
HWD	kg	1,04E-02	8,93E-04	1,33E-03	0,00E+00	3,78E-04	1,89E-04	2,19E-04	4,60E-06	7,91E-04	1,34E-02	2,77E-04
NHWD	kg	8,10E+00	6,40E+00	5,65E+02	0,00E+00	1,36E+00	1,36E+00	9,36E-01	3,13E+00	6,79E+00	5,86E+02	5,68E-02
RWD	kg	2,05E-03	7,77E-05	3,08E-04	0,00E+00	1,53E-04	1,65E-05	1,25E-04	2,91E-07	2,94E-04	2,73E-03	4,37E-06
CRU	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
MFR	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	8,25E+01	0,00E+00	8,25E+01	8,25E+01	0,00E+00
MER	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
EEE	MJ	0,00E+00	0,00E+00	4,85E-01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	4,85E-01	0,00E+00
EET	MJ	0,00E+00	0,00E+00	4,28E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	4,28E+00	0,00E+00
Legend		HWD = Hazardous waste disposed; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed; CRU = Components for re-use; MFR = Materials for recycling; MER = Materials for energy recovery; EEE = Exported electric energy; EET = Exported thermal energy										

Table 23: Information describing the biogenic carbon content at the factory gate per metre [m] VRS®-T DN 400

Biogenic carbon content	Unit	A1-A3
Biogenic carbon content in product	kg C	0,00E+00
Biogenic carbon content in accompanying packaging	kg C	0,00E+00
NOTE: 1 kg biogenic carbon is equivalent to 44/12 kg of CO_2		

Table 24 presents disclaimers which shall be declared in the project report and in the EPD with regard to the declaration of relevant core and additional environmental impact indicators according to the following classification. That can be declared in a footnote in the EPD.

Table 24: Classification of disclaimers to the declaration of core and additional environmental impact indicators

<table>
<tr><th>ILCD-classification</th><th>Indicator</th><th>disclaimer</th></tr>
<tr><td rowspan="3">ILCD-Type 1</td><td>Global warming potential (GWP)</td><td>none</td></tr>
<tr><td>Depletion potential of the stratospheric ozone layer (ODP)</td><td>none</td></tr>
<tr><td>Potential incidence of disease due to PM emissions (PM)</td><td>none</td></tr>
<tr><td rowspan="6">ILCD-Type 2</td><td>Acidification potential, Accumulated Exceedance (AP)</td><td>none</td></tr>
<tr><td>Eutrophication potential, Fraction of nutrients reaching freshwater end compartment (EP-freshwater)</td><td>none</td></tr>
<tr><td>Eutrophication potential, Fraction of nutrients reaching marine end compartment (EP-marine)</td><td>none</td></tr>
<tr><td>Eutrophication potential, Accumulated Exceedance (EP-terrestrial)</td><td>none</td></tr>
<tr><td>Formation potential of tropospheric ozone (POCP)</td><td>none</td></tr>
<tr><td>Potential Human exposure efficiency relative to U235 (IRP)</td><td>1</td></tr>
<tr><td rowspan="7">ILCD-Type 3</td><td>Abiotic depletion potential for non-fossil resources (ADP-minerals&metals)</td><td>2</td></tr>
<tr><td>Abiotic depletion potential for fossil resources (ADP-fossil)</td><td>2</td></tr>
<tr><td>Water (user) deprivation potential, deprivation-weighted water consumption (WDP)</td><td>2</td></tr>
<tr><td>Potential Comparative Toxic Unit for ecosystems (ETP-fw)</td><td>2</td></tr>
<tr><td>Potential Comparative Toxic Unit for humans (HTP-c)</td><td>2</td></tr>
<tr><td>Potential Comparative Toxic Unit for humans (HTP-nc)</td><td>2</td></tr>
<tr><td>Potential Soil quality index (SQP)</td><td>2</td></tr>
<tr><td colspan="3">Disclaimer 1 – This impact category deals mainly with the eventual impact of low dose ionizing radiation on human health of the nuclear fuel cycle. It does not consider effects due to possible nuclear accidents, occupational exposure nor due to radioactive waste disposal in underground facilities. Potential ionizing radiation from the soil, from radon and from some construction materials is also not measured by this indicator.</td></tr>
<tr><td colspan="3">Disclaimer 2 – The results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experienced with the indicator.</td></tr>
</table>

7 LCA: Interpretation

It should be noted that the impact assessment results are only relative statements that do not include any statements about "end-points" of the impact categories, exceeding of thresholds or risks.

Since the definition of basic materials (those substances that remain in the product) and auxiliary materials (those substances that do not remain in the product) are not applicable for this product, because small percentages of the energy source coke and the input materials ferrosilicon and silicon carbide remain in the product, a breakdown into A1-A3 was not carried out.

Figure 5 shows a dominance analysis of the percentage shares of modules A1-A3 (production), A4 (transport to construction site), A5 (installation), C1 (removal), C2 (transport) and C4 (waste treatment). The pipe production is the main contributor to all impact categories (except NHWD). The next largest impacts are the installation (A5) and the removal (C1) of the pipes and the transport to the construction site (A4).

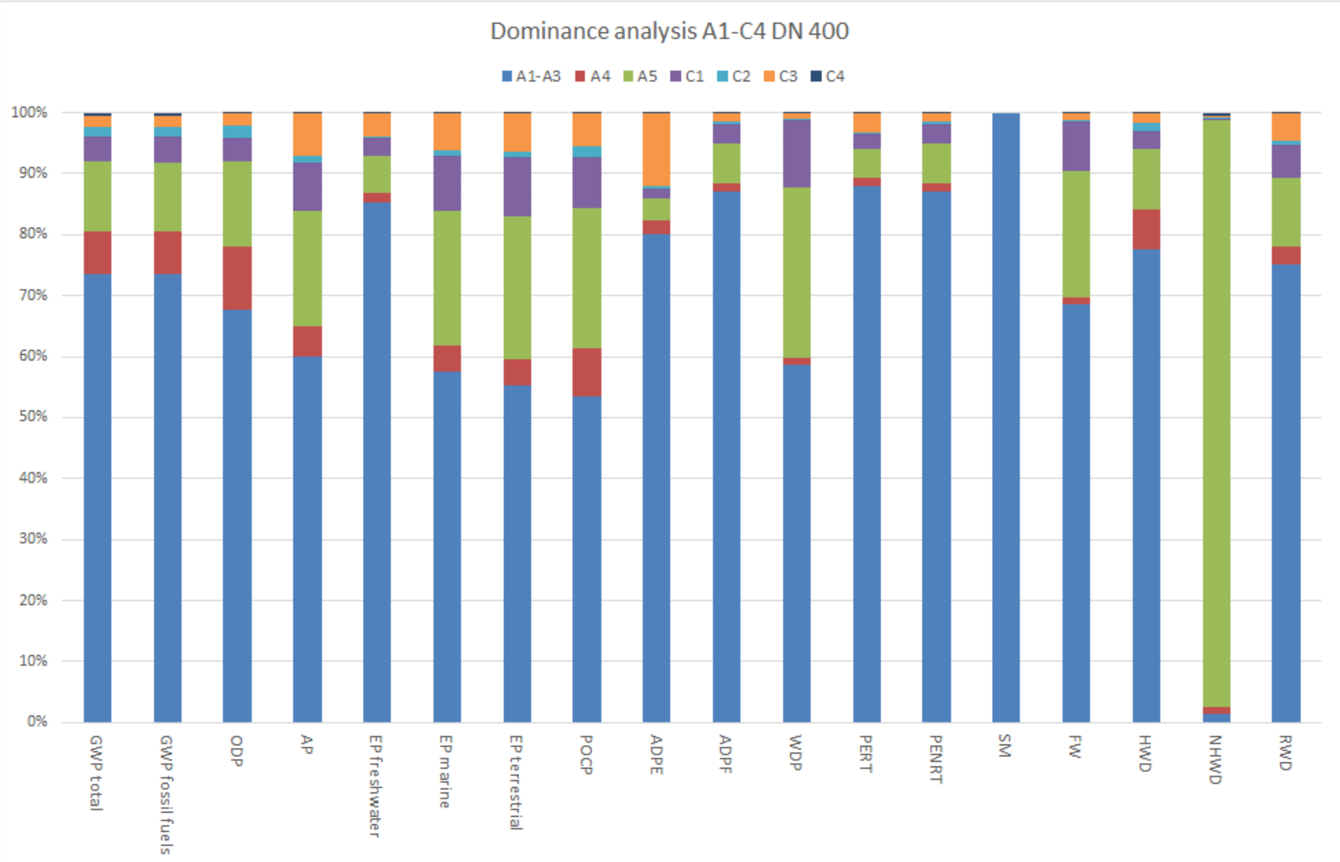


Figure 5: Dominance analysis DN 400

In the production phase (A1-A3), cast iron production has the greatest impact in terms of core indicators, with some impacts exceeding 80%. For individual indicators, galvanising has a high impact (e.g. ADPE >80%).

For the cast iron production, the cupola furnace, the annealing process and the converter have the greatest impact on the core indicators (together >90% in some cases). In the cupola furnace, CO_2 emissions from fuel use, SiC pellets and foundry coke have the greatest impact. The impact of the annealing process is determined by the natural gas used. In the converter, the magnesium and ferrosilicon applied have the greatest impact on the core indicators (in some cases >95%).

Pipe galvanisation is mainly dominated by the zinc applied (in some cases >99%).

The installation of the pipes (A5) is determined by the bedding material, the transport of the bedding material and the diesel consumption of the hydraulic excavator.

In C3, the upstream chain (wood input in the production of the scrap processing plant) of the data set used for recycling, "Iron scrap, sorted, pressed {RER}| sorting and pressing of iron scrap | Cut-off, U", causes a slightly negative value for GWP biogenic.

8 Literature

ÖNORM EN ISO 14025: 2010 Environmental labels and declarations — Type III environmental declarations — Principles and procedures

ÖNORM EN ISO 14040: 2021 Environmental management — Life cycle assessment — Principles and framework

ÖNORM EN ISO 14044: 2021 Environmental management — Life cycle assessment — Requirements and guidelines

ÖNORM 15804:2012+A2:2019+AC:2021 Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products

Bau EPD GmbH: Product category rules for building related products and services - Requirements on the EPD for cast iron products, PCR-Code 2.16.8, Version 12.0, dated 10.10.2024. Bau EPD Österreich, Vienna, 2024

Bau EPD GmbH: Management system handbook (EPD-MS-HB) of the EPD program, Version 6.0.0, dated 06.11.2024. Bau EPD Österreich, Vienna, 2024

9 Directory and Glossary

9.1 List of figures

9.2 List of tables

9.3 Abbreviations

9.3.1 Abbreviations as per EN 15804

EPD	environmental product declaration
PCR	product category rules
LCA	life cycle assessment
LCI	life cycle inventory analysis
LCIA	life cycle impact assessment
RSL	reference service life
ESL	estimated service life
EPBD	Energy Performance of Buildings Directive
GWP	global warming potential
ODP	depletion potential of the stratospheric ozone layer
AP	acidification potential of soil and water
EP	eutrophication potential
POCP	formation potential of tropospheric ozone
ADP	abiotic depletion potential

9.3.2 Abbreviations as per corresponding PCR

CE-mark	french: Communauté Européenne or Conformité Européenne = EC certificate of conformity
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals

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EPD - ENVIRONMENTAL PRODUCT DECLARATION

as per ISO 14025 and EN 15804+A2

OWNER AND PUBLISHER	Bau EPD GmbH, A-1070 Wien, Seidengasse 13/3, www.bau-epd.at
PROGRAMME OPERATOR	Bau EPD GmbH, A-1070 Wien, Seidengasse 13/3, www.bau-epd.at
HOLDER OF THE DECLARATION	Tiroler Rohre GmbH
DECLARATION NUMBER	Bau EPD-TRM-2025-9-ECOINVENT-VRS-T-DN500
ISSUE DATE	10.08.2025
VALID TO	10.08.2030
NUMBER OF DATASETS	1
ENERGY MIX APPROACH	MARKET BASED APPROACH

VRS®-T ductile cast iron pipe system – DN 500
Tiroler Rohre GmbH

Content of the EPD

1 General information

Product name
VRS®-T ductile cast iron pipe system DN 500

Declaration number
Bau EPD-TRM-2025-9-ECOINVENT-VRS-T-DN500

Declaration data
☒ Specific data
☐ Average data

Declared Product / Declared Unit
1 m ductile cast iron pipe of the VRS®-T system DN 500 with Portland composite cement lining and zinc coating with PUR long-life coating with the nominal dimensions:

Table 1: Nominal dimensions

Nominal diameter [mm]	Longitudinally related mass [kg/m]
500	142,4

Declaration based on
MS-HB Version 6.0.0 dated 06.11.2024
Name of PCR: Cast iron products
PCR-Code 2.16.8, Version 12.0 dated 10.10.2024
(PCR tested and approved by the independent expert committee = PKR-Gremium)
Version of EPD-Format-Template M-Dok 14A2 dated 11.06.2024

The owner of the declaration is liable for the underlying information and evidence; Bau EPD GmbH is not liable with respect to manufacturer information, life cycle assessment data and evidence.

Number of datasets in EPD Document: 1

Range of validity
The EPD applies to the nominal diameter DN 500 of the VRS®-T ductile cast iron pipe system with the above-mentioned lining and duplex outer coating (zinc coating with PUR long-life coating) from the Hall in Tyrol plant of Tiroler Rohre GmbH (TRM).
The EPD and the production technologies assessed are representative for the production of pipes with a nominal diameter DN 500 at the Hall in Tyrol plant of Tiroler Rohre GmbH (TRM).

Type of Declaration as per EN 15804
From cradle to grave with module D (modules A+B+C+D)
LCA method: Cut-off by classification

Database, Software, Version
Ecoinvent 3.10, SimaPro 9.6.0.1
Version Characterisation Factors: Joint Research Center, EF 3.1

Author of the Life Cycle Assessment
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The CEN standard EN 15804:2012+A2:2019+AC:2021 serves as the core-PCR.
Independent verification of the declaration according to ISO 14025:2010
☐ internally ☒ externally
Verifier 1: Dipl.-Ing. Therese Daxner M.sc.
Verifier 2: Dipl.-Ing. Roman Smutny

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Verifier

Dipl.-Ing. Roman Smutny
Verifier

Note: EPDs from similar product groups from different programme operators might not be comparable.

2 Product

2.1 2.1 General product description

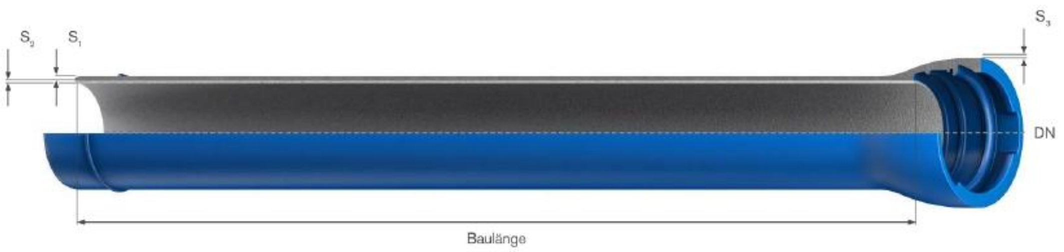
The declared product is a ductile cast iron pipe of the VRS®-T system (restrained locking system) with cement mortar lining (CML) and zinc coating with PUR long-life coating with a nominal diameter DN 500 from Tiroler Rohre GmbH (TRM).

The TRM VRS®-T system consists of ductile, centrifugally cast pipes with a spigot end with a welding ring and a socket, which are joined together to form any length of pipe. The VRS®-T joint, consisting of a VRS®-T socket, VRS®-T sealing ring, spigot end with a welding ring and locking elements, is a highly resilient, flexible and restrained locking system. It is quick and easy to install and can be bent up to 5°. No welding and no weld-seam testing is necessary. The joint can be dismantled at any time.

The ductile cast iron pipes are manufactured in lengths of 5 m with nominal diameters from DN 80 to DN 600 and different wall thicknesses. The nominal dimensions of the declared ductile cast iron pipes with a nominal diameter DN 500 as well as the corresponding wall thickness classes, (normative) minimum wall thicknesses and masses per metre of pipe are shown in Table 2. To further illustrate the declared product, Figure 1 and Figure 2 show excerpts from the Tiroler Rohre GmbH product catalogue with technical and geometric specifications and corresponding mass data.

Table 2: VRS®-T ductile cast iron pipes DN 500 – nominal diameter, Wall thickness class, minimum wall thickness, mass per Meter

DN	Wall thickness class (K class)	Minimum wall thickness [mm]	Mass per m of pipe [kg/m]
500	K 9	7,2	142,4



DN	PFA a [bar]	Maße [mm]		zul. Zugkraft [kN]	Max. Abwinkelung [°]	Anzahl der Riegel	Gewicht Rohr 5m [kg] b
		s_1 Guss	s_2 ZMA				
80	100	4,7	4	115	5	2	81,6
100	75	4,7	4	150	5	2	100,0
125	63	4,8	4	225	5	2	128,2
150	63	4,7	4	240	5	2	157,3
200	40	4,8	4	350	4	2	204,5
250	40	5,2	4	375	4	2	268,9
300	40	5,6	4	380	4	4	339,5
400	30	6,4	5	650	3	4	519,9
500	25/30	7,2/8,2	5	860	3	4	711,8
600	35	8,0	5	1.525	2	9	909,5

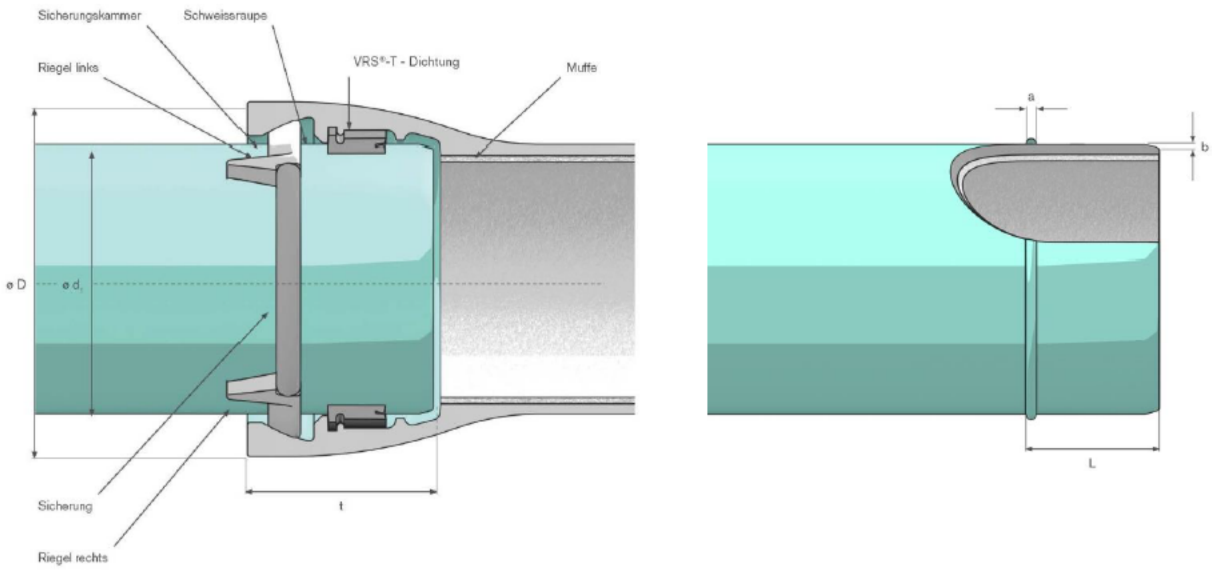
a PFA: zulässiger Bauteilbetriebsdruck | PMA = 1,2 x PFA | PEA = 1,2 x PFA + 5 | höhere PFA auf Anfrage | siehe Hinweise zum Einsatz von Klemmringen

b theoretische Masse pro Rohr für K9/10, inkl. ZMA, Zink, Deckbeschichtung

1 Mindestmaß - Toleranzen beachten | 2 Nennmaß - Toleranzen beachten

Figure 1: VRS®-T pipes – technical and geometric specifications

VRS®-T Verbindung DN 80 bis DN 600



DN	Maße [mm] a						
	Durchmesser Spitzende	Abweichungen	Durchmesser Muffe	Einstecktiefe	Schweißraupe		
	d1		D	t	L	a	b
80	98	+1,0 | -2,7	156	127	86 ±4	8 ±2	5 +0,5 | -1
100	118	+1,0 | -2,8	177	135	91 ±4	8 ±2	5 +0,5 | -1
125	144	+1,0 | -2,8	206	143	96 ±4	8 ±2	5 +0,5 | -1
150	170	+1,0 | -2,9	232	150	101 ±4	8 ±2	5 +0,5 | -1
200	222	+1,0 | -3,0	292	160	106 ±4	9 ±2	5,5 +0,5 | -1
250	274	+1,0 | -3,1	352	165	106 ±4	9 ±2	5,5 +0,5 | -1
300	326	+1,0 | -3,3	410	170	106 ±4	9 ±2	5,5 +0,5 | -1
400	429	+1,0 | -3,5	521	190	115 ±5	10 ±2	6 +0,5 | -1
500	532	+1,0 | -3,8	630	200	120 ±5	10 ±2	5 +0,5 | -1
600	635	+1,0 | -4,0	732	175	160 +0 | -2	9 ±1	5 +0,5 | -1

a Toleranzen sind möglich

Figure 2: Schematic illustration of a VRS®-T ductile cast iron pipe

The density of ductile cast iron is 7,050 kg/m³.

2.2 Application field

The VRS®-T cast iron pipe system with Portland composite cement lining is mainly used for drinking water supply and for fire extinguishing pipes, snow-making systems and turbine pipes. The cast iron pipe can be installed using various methods, such as:

- Conventional installation (trench)
- Trenchless installation
- Bridge pipes
- Interim pipes

- Floating

The usual installation method is conventional laying with the excavation of a trench, the creation of a bedding for the pipe and backfilling with suitable material.

2.3 Standards, guidelines and regulations relevant for the product

Table 3: Product specific standards

Regulation	Title
OENORM EN 545	Ductile iron pipes, fittings, accessories and their joints for water pipelines - Requirements and test methods
OENORM B 2599-1	Ductile iron pipes and fittings — Part 1: Use for water pipelines
OENORM B 2597	Ductile cast iron pipes and fittings for water, sewage and gas pipe lines - Restrained push-in-joints - Requirements and tests
OENORM B 2555	Coating of cast iron pipes - Thermal zinc spraying
OENORM B 2560	Ductile iron pipes - Finishing coating of polyurethane, epoxy or acrylic materials - Requirements and test methods
OENORM B 2562	Ductile cast iron pipes - Factory made lining with cement mortar - Requirements and test methods
OENORM EN 681-1	Elastomeric seals - Material requirements for pipe joint seals used in water and drainage applications - Part 1: Vulcanized rubber

2.4 Technical data

Mechanical properties are verified according to OENORM EN 545:2011, sections 6.3 and 6.4.

Table 4: Material parameters for ductile cast iron pipes of the VRS®-T system

Name	Value	Unit
Iron density	7050	kg/m^3
Minimum tensile strength	≥ 420	MPa
Proportional limit, 0.2% yield strength ($R_{p0.2}$)	≥ 300	MPa
Minimum elongation at fracture	≥ 10	%
Maximum Brinell hardness	≤ 230	HB
Pipe length	5000	mm
Mean coefficient of linear thermal expansion	$10*10^{-6}$	m/m*K
Thermal conductivity	0,42	W/cm*K

Table 5: VRS®-T pipes DN 500 – nominal dimension-dependent technical data

DN	Wall thickness class K class	Minimum wall thickness [mm]	Mass per metre of pipe [kg/m]	Allowable operating pressure PFA [bar]	Permissible tensile force [kN]
500	K 9	7,2	142,4	25	860

2.5 Basic/auxiliary materials

Table 6: VRS®-T pipes DN 500 – basic materials in mass %

DN	Casting	Zinc	Cement stone	PUR
500	82,6%	0,4%	16,5%	0,5%

Table 7: Basic materials – casting in mass %

Ingredients:	**Mass %**
Iron [1)]	ca. 94 %
Carbon [2)]	ca. 3,5 %
Silicon [3)]	ca. 2 %
Ferric by-elements [4)]	ca.0,5 %

[1)] Iron consisting mainly of steel scrap and a very small proportion of pig iron and return iron from the casting process

[2)] Foundry coke carbon. The coke in the cupola furnace serves both as an energy supplier for the scrap melting and the adjusting of the desired carbon content

[3)] Silicon is added in the form of SiC pellets and/or ferro-silicon

[4)] Ferric by-elements are found in the steel scrap in different minor quantities (<<1%)

2.6 Production stage

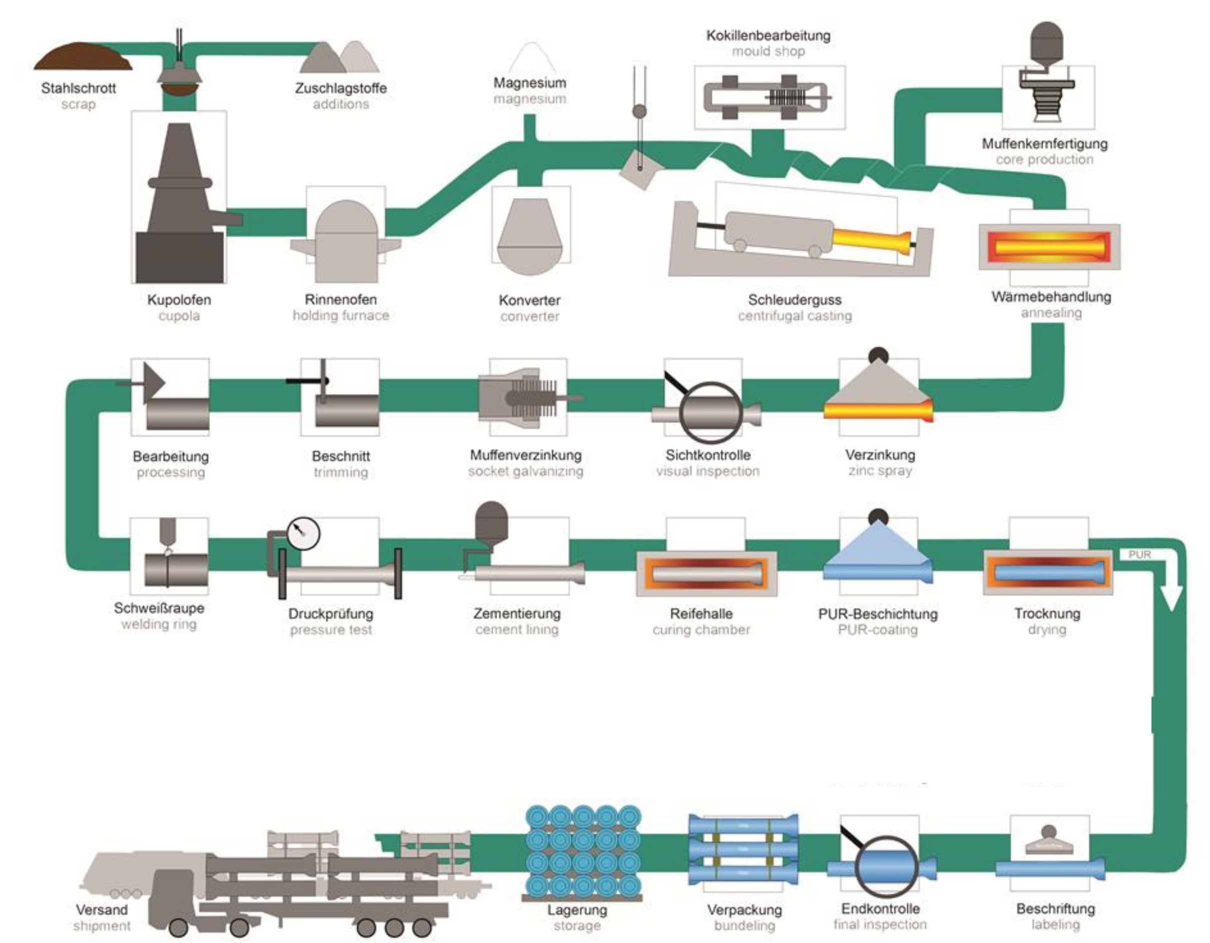


Figure 3: Flow chart of production process

For casting production, steel scrap and recycled material are smelted in the cupola furnace with the help of coke as a reaction and reduction agent. Silicon carbide is added as an alloying element. Added aggregates enhance slagging. The chemical composition of the smelted basic iron is then constantly monitored through spectral analysis. The smelted basic iron is kept warm in the holding furnace, a storage medium, and then treated with magnesium in the Georg Fischer converter, in order to reach the appropriate ductility. The liquid iron is then cast in a centrifuge machine with the De Lavaud procedure. In order to produce a specific pipe diameter, this machine is equipped with the corresponding mould (metal form that the liquid iron is poured into). The socket core made of quartz sand seals the inlet of the machine and forms the pipe socket. The glowing pipe is pulled out of the cast unit and placed in a furnace with the help of an automatic transport system. Here it undergoes annealing in order to achieve the desired mechanical properties.

The pipe is then galvanised using the electric arc spraying process and then cooled. The pipe is visually inspected in the pipe line. The spigot end and socket are machined if necessary. In the area of the welding ring, the zinc and annealing skin (tinder) are ground off and finally the welding ring is applied.

During the pressure test, each pipe is hydrostatically pressurised with a certain internal pressure and checked for leaks. The pipe is then lined with cement mortar using the centrifugal rotation process. The weld seam is galvanised and the pipes are visually inspected again. The cement stone hardens in the curing chamber. Finally, a solvent-free two-component polyurethane top coat is applied. All pipes are labelled according to the specifications, bundled and brought to the warehouse.

2.7 Packaging

The TRM pipes are sealed with protective caps and bundled using spacer rings as stacking aid and PET tapes. All packaging materials can be used for thermal recycling.

2.8 Conditions of delivery

The ductile cast iron pipes are bundled for transport and storage with the help of spacer rings as stacking aid as well as PET binding tapes.

2.9 Transport to site

The cast pipes are transported to their destination within Europe by lorry and, in rare cases, overseas by ship.

2.10 Construction product stage

The installation of pressure pipes made of ductile cast iron must comply with OENORM EN 805 (Water supply - Requirements for systems and components outside buildings) and OENORM B 2538 (Additional specifications concerning OENORM EN 805). When constructing the pipe trench, sufficient working space must be provided for the installation of the pipeline, depending on the trench depth and the outer diameter of the pipe. The Ordinance on Protection of Construction Workers (Bauarbeiterschutzverordnung) and other provisions as well as relevant standards and regulations must be complied with accordingly.

As this is a push-in joint, no additional work such as welding is required. The pipe trench must be constructed and excavated in such a way that all pipe sections are at frost-free depths. The trench must be excavated deep enough so that the final cover height is at least 1.50 m. In the case of ductile iron pipes, the existing soil is generally suitable for bedding the pipeline. This means there is no need for a lower bedding layer and the bottom of the trench becomes the lower bedding.

The pipeline must be embedded and the pipe trench refilled in such a way that the pipeline is securely fixed in its intended position and that damage to the pipeline is prevented and settlement can only occur to the permissible extent. Suitable material that does not damage the pipe components and the coating must be used for embedding the pipeline. The backfill material should be installed in layers and sufficiently compacted.

2.11 Use stage

If installed and designed professionally and if the phase of utilisation is not disturbed, no modification of the material composition of construction products made of ductile cast iron occur.

2.12 Reference service life (RSL)

Table 8: Reference service life (RSL)

Name	Value	Unit
Ductile cast iron pipes	50	Years

In practice, it has been shown that a service life of 100 years, based on the DVGW damage statistics (German Technical and Scientific Association for Gas and Water – https://www.dvgw.de/themen/sicherheit/gas-und-wasserstatistik/), is achieved.

2.13 End of life stage

In inner-city areas, the main area of application for the pipe systems, the installed pipes are currently almost entirely removed. These pipes can then be recycled accordingly. These pipes can then be sent to recycling. The removal and recycling rate was therefore set correspondingly high in the scenarios considered (see 4.4 - C1-C4 disposal phase). However, it should be noted that the 100% removal rate is a manufacturer's scenario, which must be checked and adjusted accordingly in each individual use case.

The pipes are disposed of in very rare cases. The EAK waste code number for iron and steel from construction and demolition is 170405.

2.14 Further information

For further information about the TRM pipe system and its possible applications, see the website http://trm.at/rohr.

3 LCA: Calculation rules

3.1 Declared unit/ Functional unit

The functional unit is 1 metre [m] of pipe. For conversion into kg, Table 9 can be used.

Table 9: Conversion factor to mass

Nominal diameter [mm]	Longitudinally related mass [kg/m]	Multiplication factor
500	142,4	0,00702

3.2 System boundary

The entire product life cycle and module D is declared. This is a “from cradle to grave with module D”-EPD (modules A+B+C+D).

Table 10: Declared life cycle stages

PRODUCT STAGE			CON-STRUCTION PROCESS STAGE		USE STAGE							END-OF-LIFE STAGE				BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARIES
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
Raw material supply	Transport	Manufacturing	Transport from the gate to the site	Construction, installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction, demolition	Transport	Waste processing	Disposal	Reuse- Recovery- Recycling- potential
x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

X = included in LCA; ND = Not declared

3.2.1 A1-A3 Product Stage:

The cast iron pipes (semi-finished parts) are almost exclusively made of the secondary material steel scrap and a very small proportion of pig iron and return iron from the casting process. The system boundary for the steel scrap is set when the processed steel scrap leaves the recycling plants, because the end of the waste properties of the steel scrap is reached here. This system is blamed for the transportation of the scrap to the TRM plant. The product stage includes the production steps in the plant along with the energy supply (including the upstream chains), the production of raw materials, auxiliary materials and packaging (including transport to the plant), the infrastructure and the disposal of the waste occurring during production. Module A1-A3 also includes the manufacture of the locks and gaskets required for assembling the pipe.

3.2.2 A4-A5 Construction stage:

The cast iron pipe can be installed in various ways. This EPD considers the standard case for installation, i.e. the conventional laying of the pipe:

- Excavation of trench
- Bedding of the pipe
- Backfilling with suitable material

The protective caps, squared lumber and binding tapes needed for transport are thermally recycled.

3.2.3 B1-B7 Use stage:

Generally, construction products made of ductile cast iron show no impact on the LCA during the use stage.

3.2.4 C1-C4 End-of-life stage:

In inner-city areas, the main area of application for the pipe systems, the installed pipes are currently almost entirely removed. For this reason, a 100% removal rate is applied as a scenario.

The removed pipes are sent to a recycling process and are considered until the end-of-waste state according to EN 15804 in the current product system. The system boundary is therefore set when the processed steel scrap leaves the recycling plants.

As a recycling scenario, due to the robustness of the pipe systems, it is assumed that 97% of the removed pipes are suitable for the recycling process and 3% have to be sent to landfill due to breakage, etc. The recycling scenario applied is a manufacturer's scenario based on the experience of Tiroler Rohre GmbH, which must be checked and adapted accordingly in each individual use case.

3.2.5 D Benefits and loads:

Due to the recycling of the removed pipes, there is a corresponding output of secondary raw materials in C3. The output flows are compared with the scrap share in the production of the cast iron pipes in accordance with the net flow rule according to EN 15804 and the net output flow is determined. The recycling and net flow scenario applied is a manufacturer's scenario based on the experience of Tiroler Rohre GmbH, which must be checked and adapted accordingly in each individual use case.

3.3 Flow chart of processes/stages in the life cycle

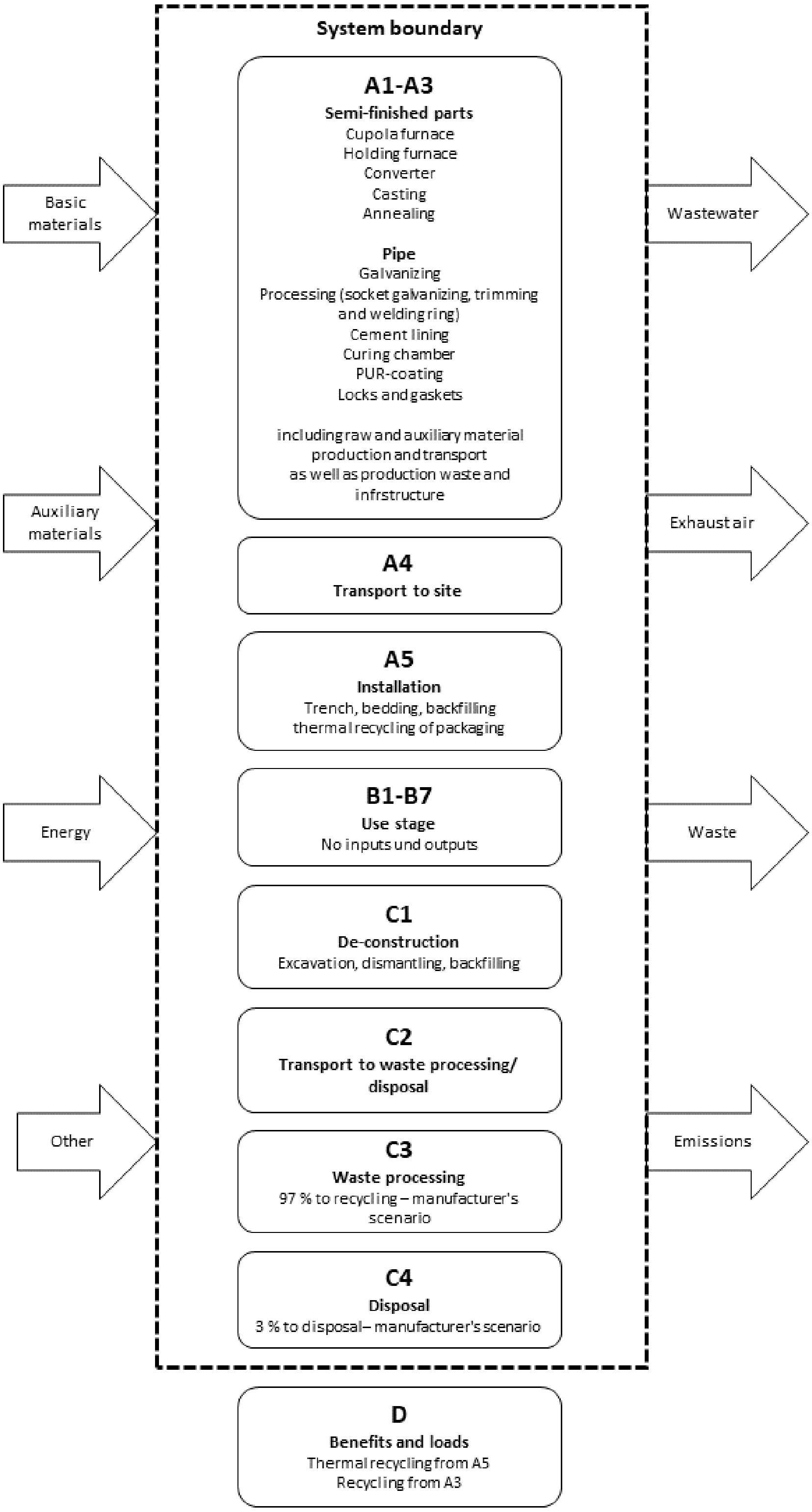


Figure 4: Life cycle flow chart

3.4 Estimations and assumptions

The SiC pellets used in casting production consist of various silicon components, Portland cement and water. In ecoinvent 3.10 there is only one data set for silicon carbide, which is typical of wafer production and has a very high SiC purity compared to the SiC component mixture used in casting production and therefore also a high energy intensity (information from the manufacturer of the pellets). According to the manufacturer of the SiC pellets, the energy required to produce the SiC components or silicon carbide is reflected in the respective prices per tonne. This allows an adjustment of the SiC purity (correction factor) of the data set available in ecoinvent based on an economic comparison (i.e. in the style of an economic allocation).

Cast steel is a special steel with no available data set. As the input is below 1 kg per t of ductile cast iron, the ecoinvent data set for chrome steel was applied.

For magnesium, which mainly comes from China, the global data set for magnesium was used ("market"-data set).

Since the infrastructure only makes a very small contribution to environmental impact, the machinery was modelled with its main components steel and casting.

For the use stage, it was assumed that no LCA-relevant material and energy flows occur.

All transport distances, with the exception of magnesium, were collected by the customer and taken into account in the LCA. For magnesium, the average transports are taken into account by the application of the global "market"-data set (which includes transport processes for the market under consideration).

3.5 Cut-off criteria

The producer calculated and submitted the amount of all applied materials, energy needed, the packaging material, the arising waste material and the way of disposal and the necessary infrastructure (buildings and machinery for the production). The measurement values for emissions according to the casting regulations were specified.

Auxiliary materials whose material flow is less than 1% were ignored as insignificant. Internal transport was negligible due to the short transport distances. It can be assumed that the total of insignificant processes is less than 5% of the impact categories.

During the production of the ductile pipes, slag (from cupola furnace) and coke dust are produced as by-products. Part of the waste heat is sold as district heating. However, these by-products contribute less than 1% to the operational income and can therefore be ignored according to the Management-System-Handbook (MS-HB) of the Bau EPD GmbH (MS-HB Version 6.0.0 dated 06.11.2024). The system limit for these two recyclable materials is set when they are collected from the plant by the future user.

The materials resulting from the production of semi-finished parts – foundry debris, fly-ash, filter cake from cupola furnace dust extraction and converter slag – are taken to a recycling plant for processing, whereby the system limit is set when the substances arrive at this plant, because no detailed information is available on the further treatment processes and the influence on the results of the impact categories is classified as negligible.

In C3, the recycling of the pipes (97%), i.e. the processing of the removed pipes in a recycling plant into a secondary raw material that can be used in cast iron and steel production, is taken into account. For this purpose, it is assumed that the pipe (including CML, etc.) is sent as a whole to the recycling plant, where any materials that cannot be used for cast iron and steel production are separated out. The treatment of these separated materials is excluded due to the expected minor influence.

3.6 Allocation

The system boundary for the steel scrap is set when the processed steel scrap leaves the recycling plants, because the end of the waste staus of the steel scrap is reached here. This system is blamed for the transportation of the scrap to the TRM plant.

In the liquid iron sector, an allocation by mass based on stock additions was carried out between the pipes considered in this EPD and the products not considered. The same applies to waste.

During the production of the ductile pipes, slag and coke dust are produced as by-products. Part of the waste heat is sold as district heating. However, these by-products contribute less than 1% to the operational income and can therefore be ignored according to the "Management-System-Handbook (MS-HB) of the Bau EPD GmbH (MS-HB Version 6.0.0 dated 06.11.2024).

For the annealing, the energy used was allocated according to the dwell times in the furnace.

Due to the recycling of the removed pipes, there is a corresponding output of secondary raw materials in C3. The output flows are compared with the scrap share in the production of the cast iron pipes in accordance with the net flow rule according to EN 15804 and the net output flow is determined.

3.7 Comparability

In principle, a comparison or evaluation of EPD data is only possible if all data sets to be compared have been created in accordance with EN 15804, the same programme-specific PCR/any additional rules and the same background database have been used, and the building context/product-specific performance characteristics are also taken into account.

4 LCA: Scenarios and additional technical information

4.1 A1-A3 Product stage

According to OENORM EN 15804, no technical scenario details are required for A1-A3 as the producer is responsible for the accounting of these modules, and this must not be changed by the user of the LCA.

Data collection for the product stage was carried out according to ISO 14044 Section 4.3.2. In accordance with the target definition, all relevant input and output flows that occur in connection with the product under consideration were identified and quantified in the life cycle inventory analysis.

Electricity generation is modelled according to the electricity mix supplied by Tiroler Wasserkraft AG (TIWAG) to Tiroler Rohre GmbH. In 2020, Tiroler Rohre GmbH purchased the TIWAG 2020 supplier mix (Versorgermix) from Tiroler Wasserkraft AG TIWAG (electricity mix contractually secured).

A part of the electricity consumption in the semi-finished parts production takes place at medium voltage level. The remaining electricity consumption takes place at low voltage level, with 5.75% coming from the in-house photovoltaic system.

Since photovoltaic electricity is generally fed into the grid and consumed at low voltage, and Tiroler Rohre GmbH purchases its electricity at medium voltage, the photovoltaic share is deducted when modelling the medium-voltage electricity supplied by TIWAG (see Table 11).

Table 11: Electricity mix

Source	**TIWAG Supplier mix general**	**Medium voltage without photovoltaics**
Hydro power	84,90%	86,32%
Norway	*20,23%*	*20,57%*
Tyrol	*64,67%*	*65,75%*
Wind power	10,37%	10,54%
Solid or liquid biomass	2,02%	2,05%
Photovoltaics	1,64%	0,00%
Biogas	1,05%	1,07%
Other eco-energy	0,02%	0,02%
Sum	**100,00%**	**100,00%**

The GWP total- result for the TIWAG electricity mix used is 57.3 g CO_2 eq/kWh at high voltage level, 60.5 g CO_2 eq/kWh at medium voltage level and 61.6 g CO_2 eq/kWh at low voltage level. The GWP total-result for low-voltage electricity from the photovoltaic system at the TRM plant is 104 g CO_2 eq/kWh.

4.2 A4-A5 Construction process stage

The pipes are transported to their destination by truck. The client provided relevant information on the transports, and based on this, an average transport distance of approximately 470 km was determined.

Table 12 shows the general parameters for describing transportation to the building site.

Table 12: Description of the scenario „Transport to building site (A4)“

Parameters to describe the transport to the building site (A4)	Value	Unit
Average transport distance	471	km
Vehicle type, Commission Directive 2007/37/EC (European Emission Standard)	Euro 6	-
Average fuel consumption, fuel type: Diesel or heavy fuel oil	25,3	l/100 km
Average transport mass	5,79	t
Average capacity utilisation (including empty returns)	85	%
Average gross density of transported products	142,4	kg/m
Volume capacity utilisation factor (factor: =1 or <1 or ≥ 1 for compressed or nested packaged products)	<1	-

Conventional laying was chosen as the installation method for the EPD, i.e. excavating a trench, bedding the pipe and backfilling with suitable material. A hydraulic excavator with an engine power of 150 kW, a scoop capacity of 2,2 m3 and a weight of 35 t was used for the excavation and backfilling of the pipe trench (including bedding).

Most of the excavation material is temporarily stored and reused for backfilling. However, a certain proportion of the excavation material (varying for the specific nominal diameters depending on the proportion of bedding) must be disposed of at a landfill 20 km away. The additional backfill material required for this is transported from a gravel pit 20 km away.

The spacer rings (PP), protective caps (PE), stacked wood and binding tape (PET) are thermally recycled in a waste incinerator 100 km away.

Table 13: Description of the scenario „Installation of the product in the building (A5)“

Parameters to describe the installation of the product in the building (A5)	Value	Unit
Ancillary materials for installation (specified by material);	Backfill material 722	kg/m
Ancillary materials for installation (specified by type)	Hydraulic excavator	-
Water use	0	m^3/m
Other resource use	0	kg/m
Electricity demand	0	kWh/m
Other energy carrier(s): Diesel	13,1	MJ/m
Wastage of materials on the building site before waste processing, generated by the product's installation (specified by type)	0	kg/m
Output materials (specified by type) as result of waste processing at the building site e.g. of collection for recycling, for energy recovery, disposal (specified by route)	Disposal Excavation: 722 Waste incineration PE: 0,280 PP: 0,060	kg/m
Direct emissions to ambient air (such as dust, VOC), soil and water	-	kg/m

4.3 B1-B7 Use stage

In the use stage, no material and energy flows relevant for the life cycle assessment take place for the VRS®-T pipe systems, wherefor no activities were taken into account.

4.4 C1-C4 End-of-Life stage

In inner-city areas, the main area of application for the pipe systems, the installed pipes are currently almost entirely removed. For this reason, a 100% removal rate is used as a scenario. The removed pipes are sent to a recycling process, being considered until the end-of-waste state in the current product system. The system limit is set when the processed steel scrap leaves the recycling plants. From this point on, the pipe is part of a new product system. As a recycling scenario it is assumed that 97% of the pipes are suitable for the recycling process and 3% have to be sent to disposal.

The pipes are removed with the same excavator that was used for the installation. The excavation volume for the removal corresponds to volume for the installation. The existing excavation material is reinstalled, but must be supplemented with additional backfill material (different for the specific DN). The distance to the gravel pit is estimated at 20 km.

Table 14: Description of the scenario “Dismantling (C1)”

Parameters to describe the dismantling (C1)	Value	Unit
Auxiliary materials for the dismantling	Backfill material 491,3	kg/m
Aids for the demolition	Hydraulic excavator	-
Water consumption	0	m^3/m
Other resource use	0	kg/m
Electricity consumption	0	kWh/m
Other energy carrier: Diesel	13,1	MJ/m
Material loss on the construction site before waste treatment, caused by the installation of the product	0	kg/m
Output materials due to waste treatment on the construction site, e.g. collection for recycling, for energy recovery or for disposal	0	kg/m
Direct emissions to ambient air (e.g. dust, VOC), soil and water	-	kg/m

The transport distance to the nearest recycling company (97% of the pipes) as well as to the nearest inert material landfill (3% of the pipes) or waste incineration plant (gaskets) was assumed to be 100 km.

Table 15: Description of the scenario "Transport for disposal (C2)"

Parameters to describe the transport for disposal (C2)	Value	Unit
Average transport distance	100	km
vehicle type, Commission Directive 2007/37/EC (European Emission Standard)	Euro 6	-
Average fuel consumption, fuel type: Diesel or heavy fuel oil	25,3	l/100 km
Average transport mass	5,79	t
Average capacity utilisation (including empty returns)	85	%
Average gross density of transported products	142,4	kg/m
Volume capacity utilisation factor (factor: =1 or <1 or ≥ 1 for compressed or nested package products)	<1	-

In C3, the recycling of the pipes (97%), i.e. the processing of the removed pipes in a recycling plant into a secondary raw material that can be used in cast iron and steel production, is taken into account. For this purpose, it is assumed that the pipe (including CML, etc.) is sent as a whole to the recycling plant, where any materials that cannot be used for cast iron and steel production are separated out. The treatment of these separated out materials is excluded due to the expected minor influence. A new product system begins with the transport of the processed scrap from the recycling plant to the production plant.

In C4, the disposal of 3% of the pipe mass in an inert material landfill and the disposal of the EPDM gasket material in a waste incinerator are considered. A 100% recycling rate is applied for the removed bolts, which are made of pure cast material.

Table 16: Disposal processes (C3 and C4) per m of pipe

DN	Mass per metre of pipe	Total pipe mass for recycling (97%)	Total pipe mass for disposal (3%)	Lock mass for recycling (100%)	Total mass (pipe and Lock) for recycling	Gasket mass for waste incineration
[mm]	*[kg/m]*	*[kg/m]*	*[kg/m]*	*[kg/m]*	*[kg/m]*	*[kg/m]*
500	142,40	138,128	4,272	1,100	139,228	0,2860

Table 17: Description of the scenario „Disposal of the product (C1 to C4)"

Parameters for end-of-life stage (C1-C4)	Value	Unit
Collection process, separately	see Table 16	kg collected separately
Recycling	see Table 16	kg for recycling
Disposal, inert material landfill	see Table 16	kg material for final deposition

4.5 D Potential of reuse and recycling

Due to the recycling of the removed pipes (97%), there is a corresponding output of secondary raw materials (D from C3). Due to the net flow rule according to EN 15804 and the high proportion of scrap in the production of cast iron pipes (988 kg per tonne of cast semi-finished part), there is a slightly negative net output flow here.

Table 18: Description of the scenario „re-use, recovery and recycling potential (module D)“

Parameters for module D	Value	Unit
Materials for reuse, recovery or recycling from A4-A5	-	%
Energy recovery or secondary fuels from A4-A5	Waste incineration PP: 0,060 PE: 0,280	kg/m
Materials for reuse, recovery or recycling from B2-B5	-	%
Energy recovery or secondary fuels from B2-B5	-	kg/m
Materials for reuse, recovery or recycling from C1-C4	97	%
Energy recovery or secondary fuels from C1-C4	Waste incineration Gasket: 0,2860	kg/m

Due to the multi-recycling potential of the pipes, they could again replace primary raw materials in the next product system. In this EPD, the multi-recycling potential is not shown as a life cycle assessment result (in the results tables) but as additional information (Appendix 1), because this value does not comply with the rules and specifications of EN 15804 (net flow rule). The additional information on multi-recycling potential is based on a manufacturer scenario based on the experience of Tiroler Rohre GmbH.

5 Information on data quality and data selection in accordance with EN 15941

5.1 Principles for the description of data quality

The following information on data quality is provided in accordance with the requirements of EN 15941 (EN 15941, section 7.3.4).

The data fulfils the following quality requirements:

The data is representative for the production year 2020 (annual average). The production year 2020 is considered based on the existing data for ductile cast iron production (semi-finished part production) of the EPD for ductile piles from Tiroler Rohre GmbH (published 2022).

For the data collection, generic data and the cut-off of material and energy flows the criteria of the Bau EPD GmbH were considered.

The manufacturer provided all essential data such as energy and raw material consumption, transport distances and vehicles as well as packaging within the system boundaries.

The applied background database ecoinvent 3.10 was published in 2024, but contains individual data sets whose collection or reference year dates back more than 10 years (requirement EN 15804 or Bau EPD GmbH). These data sets remained in the various ecoinvent database versions through the years, taking necessary adjustments for database updates into account. Nevertheless, these data sets are subject to a corresponding potential for fluctuation because some of the (technological) developments of recent years are not reflected.

The data is plausible, i.e. the deviations from comparable results are within a plausible range.

5.2 Description of the temporal, geographical and technological representativeness of the product data

Temporal representativeness:

- The data collection period corresponds to the year 2020. All specific data are from this year.
- There is no deviation from the reporting year 2020 in the collection of specific data.
- The applied background database ecoinvent 3.10 was published in 2024, but contains individual data sets whose collection or reference year dates back more than 10 years (requirement EN 15804 or Bau EPD GmbH).

Geographical representativeness:

- VRS®-T pipe systems are manufactured exclusively at the plant in Hall in Tirol. In the production year 2020, almost 50% of the products were delivered within Austria and a total of approx. 90% within Europe (with a focus on Germany and Italy in addition to Austria).
- The pipe systems are disposed of in an area close to where they were used.

Technological representativeness:

- The production technology at the plant in Hall in Tyrol is state-of-the-art. The facilities are regularly maintained and modernised.
- In addition to cast iron pipe systems, other products such as ductile piles (pure cast iron product corresponds to semi-finished parts) are also manufactured at the analysed plant.

Geographical and technological representativeness for EPDs covering an industry:

- Not relevant for this EPD.

5.3 Explanation of the averaging process

Not relevant for this EPD, as specific products from the plant in Hall in Tyrol of the Tiroler Rohre GmbH are considered.

5.4 Assessment of the data quality of the Life Cycle Inventory data

The validity (database/source, country/region, reference year, publication/update) and the geographical, technical and temporal representativeness (according to ÖNORM EN 15804 Annex E - Table E.1) of all data sets used are assessed in the project report for this EPD.

The manufacturer provided all essential data such as energy and raw material consumption, transport distances and vehicles, and packaging within the system boundaries (quality management system and SAP system).

6 LCA: results

Table 19: Parameters to describe the environmental impact per metre [m] VRS®-T DN 500

Parameters	Unit	A1-A3	A4	A5	B1-B7	C1	C2	C3	C4	C1-C4	A-C	D
GWP total	kg CO_2 eq	1,32E+02	1,29E+01	1,98E+01	0,00E+00	8,24E+00	2,73E+00	3,59E+00	9,30E-01	1,55E+01	1,80E+02	3,12E+00
GWP fossil fuels	kg CO_2 eq	1,32E+02	1,29E+01	1,98E+01	0,00E+00	8,22E+00	2,73E+00	3,64E+00	9,29E-01	1,55E+01	1,80E+02	3,13E+00
GWP biogenic	kg CO_2 eq	5,21E-01	8,94E-03	2,02E-02	0,00E+00	1,20E-02	1,89E-03	-4,72E-02	1,14E-04	-3,31E-02	5,17E-01	-1,39E-02
GWP luluc	kg CO_2 eq	7,32E-02	4,28E-03	1,11E-02	0,00E+00	5,38E-03	9,07E-04	5,14E-03	1,76E-05	1,14E-02	1,00E-01	3,76E-04
ODP	kg CFC-11 eq	1,51E-06	2,57E-07	3,20E-07	0,00E+00	9,80E-08	5,43E-08	5,01E-08	1,04E-09	2,03E-07	2,29E-06	5,19E-09
AP	mol H^+ eq	3,36E-01	2,69E-02	1,00E-01	0,00E+00	4,64E-02	5,69E-03	4,00E-02	3,14E-04	9,24E-02	5,56E-01	1,13E-02
EP freshwater	kg P eq	4,66E-02	8,74E-04	3,15E-03	0,00E+00	1,77E-03	1,85E-04	2,08E-03	4,56E-06	4,04E-03	5,46E-02	1,32E-03
EP marine	kg N eq	8,64E-02	6,45E-03	3,11E-02	0,00E+00	1,37E-02	1,37E-03	9,28E-03	1,22E-04	2,44E-02	1,48E-01	2,71E-03
EP terrestrial	mol N eq	8,89E-01	6,96E-02	3,52E-01	0,00E+00	1,57E-01	1,47E-02	1,04E-01	1,33E-03	2,78E-01	1,59E+00	2,94E-02
POCP	kg NMVOC eq	2,96E-01	4,46E-02	1,20E-01	0,00E+00	4,86E-02	9,46E-03	3,13E-02	4,23E-04	8,97E-02	5,51E-01	9,85E-03
ADPE	kg Sb eq	1,39E-03	4,20E-05	6,40E-05	0,00E+00	3,28E-05	8,89E-06	2,24E-04	7,74E-08	2,66E-04	1,76E-03	1,52E-06
ADPF	MJ H_u	9,06E+02	1,51E+01	6,35E+01	0,00E+00	3,66E+01	3,20E+00	1,57E+01	6,64E-02	5,56E+01	1,04E+03	3,00E+01
WDP	m3 World eq	3,55E+01	7,54E-01	1,59E+01	0,00E+00	7,41E+00	1,60E-01	6,09E-01	2,61E-02	8,20E+00	6,03E+01	1,82E-01
Legend		GWP = Global warming potential; luluc = land use and land use change; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential, Accumulated Exceedance; EP = Eutrophication potential; POCP = Formation potential of tropospheric ozone photochemical oxidants; ADPE = Abiotic depletion potential for non-fossil resources; ADPF = Abiotic depletion potential for fossil resources WDP = Water (user) deprivation potential, deprivation-weighted water consumption										

Table 20: Additional environmental impact indicators per metre [m] VRS®-T DN 500

Parameters	Unit	A1-A3	A4	A5	B1-B7	C1	C2	C3	C4	C1-C4	A-C	D
PM	Occurrence of diseases	1,59E-05	9,50E-07	2,14E-06	0,00E+00	9,34E-07	2,01E-07	5,60E-07	4,94E-09	1,70E-06	2,07E-05	2,40E-07
IRP	kBq U235 eq	5,98E+00	2,35E-01	9,00E-01	0,00E+00	5,33E-01	4,98E-02	3,67E-01	9,24E-04	9,50E-01	8,07E+00	8,57E-03
ETP-fw	CTUe	1,24E+03	4,94E+01	7,92E+01	0,00E+00	3,71E+01	1,05E+01	3,53E+01	1,60E+00	8,45E+01	1,45E+03	3,15E+02
HTP-c	CTUh	1,49E-06	9,16E-08	1,31E-07	0,00E+00	6,39E-08	1,94E-08	3,15E-08	2,12E-10	1,15E-07	1,83E-06	1,20E-06
HTP-nc	CTUh	1,22E-06	1,14E-07	1,29E-07	0,00E+00	5,82E-08	2,41E-08	1,95E-07	3,69E-10	2,77E-07	1,74E-06	1,08E-08
SQP	dimensionless	3,69E+02	1,10E+02	3,48E+02	0,00E+00	7,29E+01	2,32E+01	8,74E+01	1,33E+00	1,85E+02	1,01E+03	6,64E+00
Legend		PM = Potential incidence of disease due to Particulate Matter emissions; IRP = Potential Human exposure efficiency relative to U235; ETP-fw = Potential Comparative Toxic Unit for ecosystems; HTP-c = Potential Comparative Toxic Unit for humans – cancer effect; HTP-nc = Potential Comparative Toxic Unit for humans – non-cancer effect; SQP = Potential soil quality index										

Table 21: Parameters to describe the use of resources per metre [m] VRS®-T DN 500

Parameters	Unit	A1-A3	A4	A5	B1-B7	C1	C2	C3	C4	C1-C4	A-C	D
PERE	MJ H_u	2,19E+02	3,12E+00	1,13E+01	0,00E+00	6,54E+00	6,60E-01	7,97E+00	1,35E-02	1,52E+01	2,48E+02	4,00E-01
PERM	MJ H_u	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PERT	MJ H_u	2,19E+02	3,12E+00	1,13E+01	0,00E+00	6,54E+00	6,60E-01	7,97E+00	1,35E-02	1,52E+01	2,48E+02	4,00E-01
PENRE	MJ H_u	8,93E+02	1,51E+01	7,74E+01	0,00E+00	3,66E+01	3,20E+00	1,58E+01	6,64E-02	5,56E+01	1,04E+03	3,00E+01
PENRM	MJ H_u	1,38E+01	0,00E+00	-1,38E+01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PENRT	MJ H_u	9,07E+02	1,51E+01	6,36E+01	0,00E+00	3,66E+01	3,20E+00	1,58E+01	6,64E-02	5,56E+01	1,04E+03	3,00E+01
SM	kg	1,17E+02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,17E+02	-2,10E+00
RSF	MJ H_u	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
NRSF	MJ H_u	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
FW	m^3	1,38E+00	2,51E-02	3,89E-01	0,00E+00	1,83E-01	5,32E-03	2,40E-02	1,55E-03	2,14E-01	2,01E+00	4,88E-03
Legend		PERE = Renewable primary energy as energy carrier; PERM = Renewable primary energy resources as material utilization; PERT = Total use of renewable primary energy resources; PENRE = Non-renewable primary energy as energy carrier; PENRM = Non-renewable primary energy as material utilization; PENRT = Total use of non-renewable primary energy resources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of fresh water										

Table 22: Parameters describing LCA-output flows and waste categories per metre [m] VRS®-T DN 500

Parameters	Unit	A1-A3	A4	A5	B1-B7	C1	C2	C3	C4	C1-C4	A-C	D
HWD	kg	1,33E-02	1,22E-03	1,71E-03	0,00E+00	5,44E-04	2,59E-04	3,00E-04	6,56E-06	1,11E-03	1,73E-02	3,83E-04
NHWD	kg	1,10E+01	8,76E+00	7,27E+02	0,00E+00	2,09E+00	1,86E+00	1,28E+00	4,29E+00	9,52E+00	7,56E+02	7,85E-02
RWD	kg	2,78E-03	1,06E-04	3,96E-04	0,00E+00	2,34E-04	2,25E-05	1,71E-04	4,26E-07	4,28E-04	3,70E-03	4,33E-06
CRU	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
MFR	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,15E+02	0,00E+00	1,15E+02	1,15E+02	0,00E+00
MER	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
EEE	MJ	0,00E+00	0,00E+00	7,85E-01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	7,85E-01	0,00E+00
EET	MJ	0,00E+00	0,00E+00	6,93E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	6,93E+00	0,00E+00
Legend		HWD = Hazardous waste disposed; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed; CRU = Components for re-use; MFR = Materials for recycling; MER = Materials for energy recovery; EEE = Exported electric energy; EET = Exported thermal energy										

Table 23: Information describing the biogenic carbon content at the factory gate per metre [m] VRS®-T DN 500

Biogenic carbon content	Unit	A1-A3
Biogenic carbon content in product	kg C	0,00E+00
Biogenic carbon content in accompanying packaging	kg C	0,00E+00
NOTE: 1 kg biogenic carbon is equivalent to 44/12 kg of CO_2		

Table 24 presents disclaimers which shall be declared in the project report and in the EPD with regard to the declaration of relevant core and additional environmental impact indicators according to the following classification. That can be declared in a footnote in the EPD.

Table 24: Classification of disclaimers to the declaration of core and additional environmental impact indicators

ILCD-classification	Indicator	disclaimer
ILCD-Type 1	Global warming potential (GWP)	none
	Depletion potential of the stratospheric ozone layer (ODP)	none
	Potential incidence of disease due to PM emissions (PM)	none
ILCD-Type 2	Acidification potential, Accumulated Exceedance (AP)	none
	Eutrophication potential, Fraction of nutrients reaching freshwater end compartment (EP-freshwater)	none
	Eutrophication potential, Fraction of nutrients reaching marine end compartment (EP-marine)	none
	Eutrophication potential, Accumulated Exceedance (EP-terrestrial)	none
	Formation potential of tropospheric ozone (POCP)	none
	Potential Human exposure efficiency relative to U235 (IRP)	1
ILCD-Type 3	Abiotic depletion potential for non-fossil resources (ADP-minerals&metals)	2
	Abiotic depletion potential for fossil resources (ADP-fossil)	2
	Water (user) deprivation potential, deprivation-weighted water consumption (WDP)	2
	Potential Comparative Toxic Unit for ecosystems (ETP-fw)	2
	Potential Comparative Toxic Unit for humans (HTP-c)	2
	Potential Comparative Toxic Unit for humans (HTP-nc)	2
	Potential Soil quality index (SQP)	2
Disclaimer 1 – This impact category deals mainly with the eventual impact of low dose ionizing radiation on human health of the nuclear fuel cycle. It does not consider effects due to possible nuclear accidents, occupational exposure nor due to radioactive waste disposal in underground facilities. Potential ionizing radiation from the soil, from radon and from some construction materials is also not measured by this indicator.		
Disclaimer 2 – The results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experienced with the indicator.		

7 LCA: Interpretation

It should be noted that the impact assessment results are only relative statements that do not include any statements about "end-points" of the impact categories, exceeding of thresholds or risks.

Since the definition of basic materials (those substances that remain in the product) and auxiliary materials (those substances that do not remain in the product) are not applicable for this product, because small percentages of the energy source coke and the input materials ferrosilicon and silicon carbide remain in the product, a breakdown into A1-A3 was not carried out.

Figure 5 shows a dominance analysis of the percentage shares of modules A1-A3 (production), A4 (transport to construction site), A5 (installation), C1 (removal), C2 (transport) and C4 (waste treatment). The pipe production is the main contributor to all impact categories (except NHWD). The next largest impacts are the installation (A5) and the removal (C1) of the pipes and the transport to the construction site (A4).

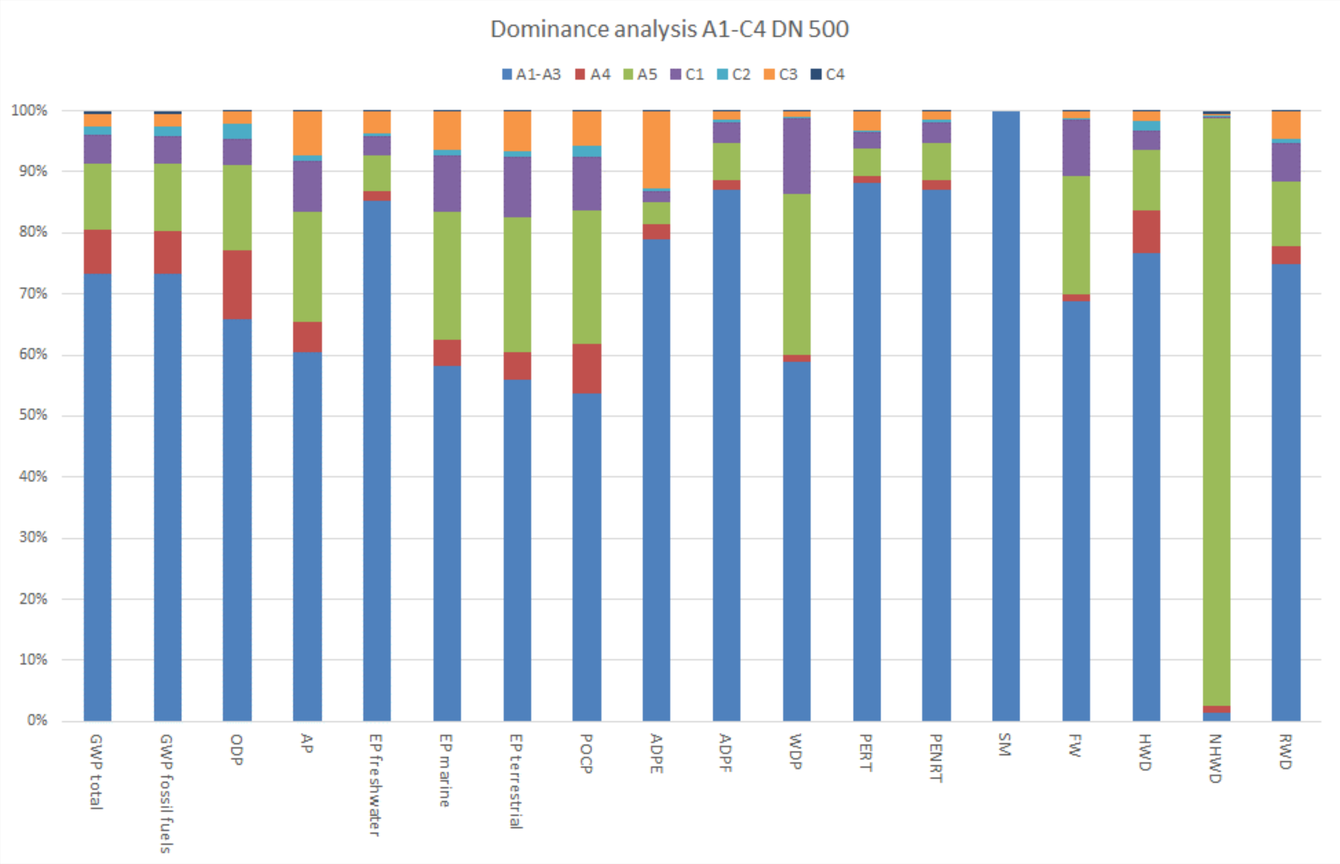


Figure 5: Dominance analysis DN 500

In the production phase (A1-A3), cast iron production has the greatest impact in terms of core indicators, with some impacts exceeding 80%. For individual indicators, galvanising has a high impact (e.g. ADPE >80%).

For the cast iron production, the cupola furnace, the annealing process and the converter have the greatest impact on the core indicators (together >90% in some cases). In the cupola furnace, CO_2 emissions from fuel use, SiC pellets and foundry coke have the greatest impact. The impact of the annealing process is determined by the natural gas used. In the converter, the magnesium and ferrosilicon applied have the greatest impact on the core indicators (in some cases >95%).

Pipe galvanisation is mainly dominated by the zinc applied (in some cases >99%).

The installation of the pipes (A5) is determined by the bedding material, the transport of the bedding material and the diesel consumption of the hydraulic excavator.

In C3, the upstream chain (wood input in the production of the scrap processing plant) of the data set used for recycling, "Iron scrap, sorted, pressed {RER}| sorting and pressing of iron scrap | Cut-off, U", causes a slightly negative value for GWP biogenic.

8 Literature

ÖNORM EN ISO 14025: 2010 Environmental labels and declarations — Type III environmental declarations — Principles and procedures

ÖNORM EN ISO 14040: 2021 Environmental management — Life cycle assessment — Principles and framework

ÖNORM EN ISO 14044: 2021 Environmental management — Life cycle assessment — Requirements and guidelines

ÖNORM 15804:2012+A2:2019+AC:2021 Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products

Bau EPD GmbH: Product category rules for building related products and services - Requirements on the EPD for cast iron products, PCR-Code 2.16.8, Version 12.0, dated 10.10.2024. Bau EPD Österreich, Vienna, 2024

Bau EPD GmbH: Management system handbook (EPD-MS-HB) of the EPD program, Version 6.0.0, dated 06.11.2024. Bau EPD Österreich, Vienna, 2024

9 Directory and Glossary

9.1 List of figures

9.2 List of tables

9.3 Abbreviations

9.3.1 Abbreviations as per EN 15804

EPD	environmental product declaration
PCR	product category rules
LCA	life cycle assessment
LCI	life cycle inventory analysis
LCIA	life cycle impact assessment
RSL	reference service life
ESL	estimated service life
EPBD	Energy Performance of Buildings Directive
GWP	global warming potential
ODP	depletion potential of the stratospheric ozone layer
AP	acidification potential of soil and water
EP	eutrophication potential
POCP	formation potential of tropospheric ozone
ADP	abiotic depletion potential

9.3.2 Abbreviations as per corresponding PCR

CE-mark	french: Communauté Européenne or Conformité Européenne = EC certificate of conformity
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals

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	Programme Operator Bau EPD GmbH Seidengasse 13/3 — Tel +43 664 2427429 1070 Wien — Mail office@bau-epd.at Austria — Web www.bau-epd.at
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	Holder of the declaration Tiroler Rohre GmbH — Tel +43 5223 503 0 Innsbruckerstraße 51 — Fax +43 5223 436 19 6060 Hall in Tyrol — Mail office@trm.at Austria — Web www.trm.at

EPD - ENVIRONMENTAL PRODUCT DECLARATION

as per ISO 14025 and EN 15804+A2

OWNER AND PUBLISHER	Bau EPD GmbH, A-1070 Wien, Seidengasse 13/3, www.bau-epd.at
PROGRAMME OPERATOR	Bau EPD GmbH, A-1070 Wien, Seidengasse 13/3, www.bau-epd.at
HOLDER OF THE DECLARATION	Tiroler Rohre GmbH
DECLARATION NUMBER	Bau EPD-TRM-2025-10-ECOINVENT-VRS-T-DN600
ISSUE DATE	10.08.2025
VALID TO	10.08.2030
NUMBER OF DATASETS	1
ENERGY MIX APPROACH	MARKET BASED APPROACH

VRS®-T ductile cast iron pipe system – DN 600
Tiroler Rohre GmbH

Content of the EPD

1 General information

Product name
VRS®-T ductile cast iron pipe system DN 600

Declaration number
Bau EPD-TRM-2025-10-ECOINVENT-VRS-T-DN600

Declaration data
☒ Specific data
☐ Average data

Declared Product / Declared Unit
1 m ductile cast iron pipe of the VRS®-T system DN 600 with Portland composite cement lining and zinc coating with PUR long-life coating with the nominal dimensions:

Table 1: Nominal dimensions

Nominal diameter [mm]	Longitudinally related mass [kg/m]
600	181,9

Number of datasets in EPD Document: 1

Declaration based on
MS-HB Version 6.0.0 dated 06.11.2024
Name of PCR: Cast iron products
PCR-Code 2.16.8, Version 12.0 dated 10.10.2024
(PCR tested and approved by the independent expert committee = PKR-Gremium)
Version of EPD-Format-Template M-Dok 14A2 dated 11.06.2024

The owner of the declaration is liable for the underlying information and evidence; Bau EPD GmbH is not liable with respect to manufacturer information, life cycle assessment data and evidence.

Range of validity
The EPD applies to the nominal diameter DN 600 of the VRS®-T ductile cast iron pipe system with the above-mentioned lining and duplex outer coating (zinc coating with PUR long-life coating) from the Hall in Tyrol plant of Tiroler Rohre GmbH (TRM).
The EPD and the production technologies assessed are representative for the production of pipes with a nominal diameter DN 600 at the Hall in Tyrol plant of Tiroler Rohre GmbH (TRM).

Type of Declaration as per EN 15804
From cradle to grave with module D (modules A+B+C+D)
LCA method: Cut-off by classification

Database, Software, Version
Ecoinvent 3.10, SimaPro 9.6.0.1
Version Characterisation Factors: Joint Research Center, EF 3.1

Author of the Life Cycle Assessment
floGeco GmbH
Hinteranger 61d
6161 Natters
Austria

The CEN standard EN 15804:2012+A2:2019+AC:2021 serves as the core-PCR.
Independent verification of the declaration according to ISO 14025:2010
☐ internally ☒ externally
Verifier 1: Dipl.-Ing. Therese Daxner M.sc.
Verifier 2: Dipl.-Ing. Roman Smutny

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Verifier

Dipl.-Ing. Roman Smutny
Verifier

Note: EPDs from similar product groups from different programme operators might not be comparable.

2 Product

2.1 2.1 General product description

The declared product is a ductile cast iron pipe of the VRS®-T system (restrained locking system) with cement mortar lining (CML) and zinc coating with PUR long-life coating with a nominal diameter DN 600 from Tiroler Rohre GmbH (TRM).

The TRM VRS®-T system consists of ductile, centrifugally cast pipes with a spigot end with a welding ring and a socket, which are joined together to form any length of pipe. The VRS®-T joint, consisting of a VRS®-T socket, VRS®-T sealing ring, spigot end with a welding ring and locking elements, is a highly resilient, flexible and restrained locking system. It is quick and easy to install and can be bent up to 5°. No welding and no weld-seam testing is necessary. The joint can be dismantled at any time.

The ductile cast iron pipes are manufactured in lengths of 5 m with nominal diameters from DN 80 to DN 600 and different wall thicknesses. The nominal dimensions of the declared ductile cast iron pipes with a nominal diameter DN 600 as well as the corresponding wall thickness classes, (normative) minimum wall thicknesses and masses per metre of pipe are shown in Table 2. To further illustrate the declared product, Figure 1 and Figure 2 show excerpts from the Tiroler Rohre GmbH product catalogue with technical and geometric specifications and corresponding mass data.

Table 2: VRS®-T ductile cast iron pipes DN 600 – nominal diameter, Wall thickness class, minimum wall thickness, mass per Meter

DN	Wall thickness class (K class)	Minimum wall thickness [mm]	Mass per m of pipe [kg/m]
600	K 9	8,0	181,9

DN	PFA a [bar]	Maße [mm]		zul. Zugkraft [kN]	Max. Abwinkelung [°]	Anzahl der Riegel	Gewicht Rohr 5m [kg] b
		s_1 Guss	s_2 ZMA				
80	100	4,7	4	115	5	2	81,6
100	75	4,7	4	150	5	2	100,0
125	63	4,8	4	225	5	2	128,2
150	63	4,7	4	240	5	2	157,3
200	40	4,8	4	350	4	2	204,5
250	40	5,2	4	375	4	2	268,9
300	40	5,6	4	380	4	4	339,5
400	30	6,4	5	650	3	4	519,9
500	25/30	7,2/8,2	5	860	3	4	711,8
600	35	8,0	5	1.525	2	9	909,5

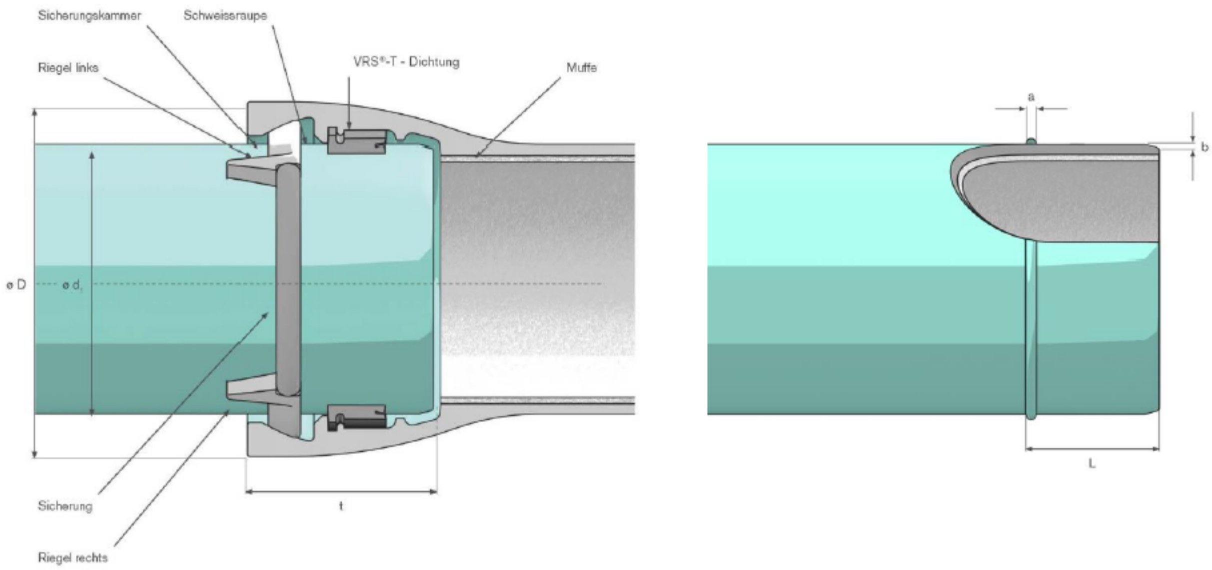
a PFA: zulässiger Bauteilbetriebsdruck | PMA = 1,2 x PFA | PEA = 1,2 x PFA + 5 | höhere PFA auf Anfrage | siehe Hinweise zum Einsatz von Klemmringen

b theoretische Masse pro Rohr für K9/10, inkl. ZMA, Zink, Deckbeschichtung

1 Mindestmaß - Toleranzen beachten | 2 Nennmaß - Toleranzen beachten

Figure 1: VRS®-T pipes – technical and geometric specifications

VRS®-T Verbindung DN 80 bis DN 600



DN	Maße [mm] a						
	Durchmesser Spitzende	Abweichungen	Durchmesser Muffe	Einstecktiefe	Schweißraupe		
	d1		D	t	L	a	b
80	98	+1,0 | -2,7	156	127	86 ±4	8 ±2	5 +0,5 | -1
100	118	+1,0 | -2,8	177	135	91 ±4	8 ±2	5 +0,5 | -1
125	144	+1,0 | -2,8	206	143	96 ±4	8 ±2	5 +0,5 | -1
150	170	+1,0 | -2,9	232	150	101 ±4	8 ±2	5 +0,5 | -1
200	222	+1,0 | -3,0	292	160	106 ±4	9 ±2	5,5 +0,5 | -1
250	274	+1,0 | -3,1	352	165	106 ±4	9 ±2	5,5 +0,5 | -1
300	326	+1,0 | -3,3	410	170	106 ±4	9 ±2	5,5 +0,5 | -1
400	429	+1,0 | -3,5	521	190	115 ±5	10 ±2	6 +0,5 | -1
500	532	+1,0 | -3,8	630	200	120 ±5	10 ±2	5 +0,5 | -1
600	635	+1,0 | -4,0	732	175	160 +0 | -2	9 ±1	5 +0,5 | -1

a Toleranzen sind möglich

Figure 2: Schematic illustration of a VRS®-T ductile cast iron pipe

The density of ductile cast iron is 7,050 kg/m³.

2.2 Application field

The VRS®-T cast iron pipe system with Portland composite cement lining is mainly used for drinking water supply and for fire extinguishing pipes, snow-making systems and turbine pipes. The cast iron pipe can be installed using various methods, such as:

- Conventional installation (trench)
- Trenchless installation
- Bridge pipes
- Interim pipes

- Floating

The usual installation method is conventional laying with the excavation of a trench, the creation of a bedding for the pipe and backfilling with suitable material.

2.3 Standards, guidelines and regulations relevant for the product

Table 3: Product specific standards

Regulation	Title
OENORM EN 545	Ductile iron pipes, fittings, accessories and their joints for water pipelines - Requirements and test methods
OENORM B 2599-1	Ductile iron pipes and fittings — Part 1: Use for water pipelines
OENORM B 2597	Ductile cast iron pipes and fittings for water, sewage and gas pipe lines - Restrained push-in-joints - Requirements and tests
OENORM B 2555	Coating of cast iron pipes - Thermal zinc spraying
OENORM B 2560	Ductile iron pipes - Finishing coating of polyurethane, epoxy or acrylic materials - Requirements and test methods
OENORM B 2562	Ductile cast iron pipes - Factory made lining with cement mortar - Requirements and test methods
OENORM EN 681-1	Elastomeric seals - Material requirements for pipe joint seals used in water and drainage applications - Part 1: Vulcanized rubber

2.4 Technical data

Mechanical properties are verified according to OENORM EN 545:2011, sections 6.3 and 6.4.

Table 4: Material parameters for ductile cast iron pipes of the VRS®-T system

Name	Value	Unit
Iron density	7050	kg/m³
Minimum tensile strength	≥ 420	MPa
Proportional limit, 0.2% yield strength ($R_{p0.2}$)	≥ 300	MPa
Minimum elongation at fracture	≥ 10	%
Maximum Brinell hardness	≤ 230	HB
Pipe length	5000	mm
Mean coefficient of linear thermal expansion	$10*10^{-6}$	m/m*K
Thermal conductivity	0,42	W/cm*K

Table 5: VRS®-T pipes DN 600 – nominal dimension-dependent technical data

DN	Wall thickness class K class	Minimum wall thickness [mm]	Mass per metre of pipe [kg/m]	Allowable operating pressure PFA [bar]	Permissible tensile force [kN]
600	K 9	8,0	181,9	35	1525

2.5 Basic/auxiliary materials

Table 6: VRS®-T pipes DN 600 – basic materials in mass %

DN	Casting	Zinc	Cement stone	PUR
600	85,2%	0,4%	14,0%	0,5%

Table 7: Basic materials – casting in mass %

Ingredients:	Mass %
Iron [1)]	ca. 94 %
Carbon [2)]	ca. 3,5 %
Silicon [3)]	ca. 2 %
Ferric by-elements [4)]	ca.0,5 %

[1)] Iron consisting mainly of steel scrap and a very small proportion of pig iron and return iron from the casting process

[2)] Foundry coke carbon. The coke in the cupola furnace serves both as an energy supplier for the scrap melting and the adjusting of the desired carbon content

[3)] Silicon is added in the form of SiC pellets and/or ferro-silicon

[4)] Ferric by-elements are found in the steel scrap in different minor quantities (<<1%)

2.6 Production stage

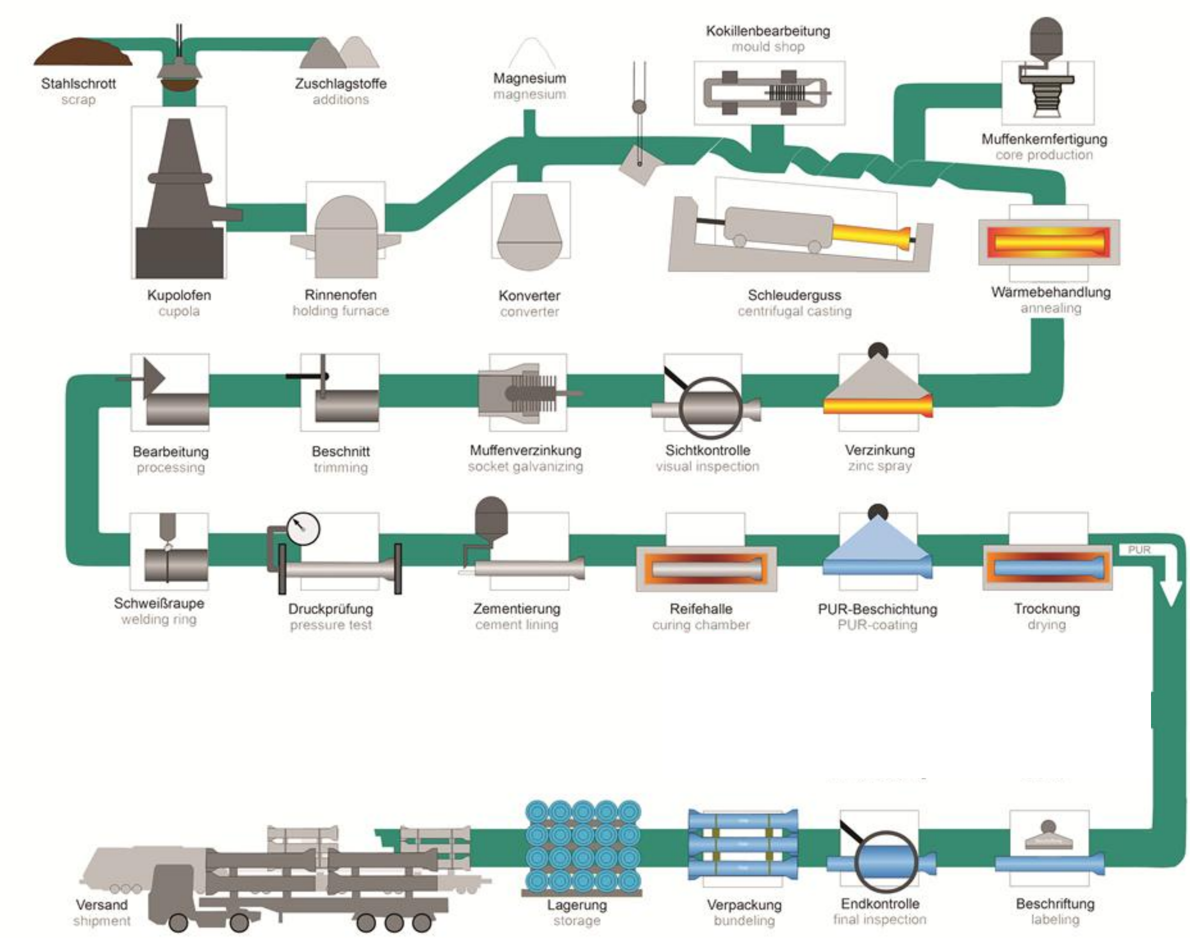


Figure 3: Flow chart of production process

For casting production, steel scrap and recycled material are smelted in the cupola furnace with the help of coke as a reaction and reduction agent. Silicon carbide is added as an alloying element. Added aggregates enhance slagging. The chemical composition of the smelted basic iron is then constantly monitored through spectral analysis. The smelted basic iron is kept warm in the holding furnace, a storage medium, and then treated with magnesium in the Georg Fischer converter, in order to reach the appropriate ductility. The liquid iron is then cast in a centrifuge machine with the De Lavaud procedure. In order to produce a specific pipe diameter, this machine is equipped with the corresponding mould (metal form that the liquid iron is poured into). The socket core made of quartz sand seals the inlet of the machine and forms the pipe socket. The glowing pipe is pulled out of the cast unit and placed in a furnace with the help of an automatic transport system. Here it undergoes annealing in order to achieve the desired mechanical properties.

The pipe is then galvanised using the electric arc spraying process and then cooled. The pipe is visually inspected in the pipe line. The spigot end and socket are machined if necessary. In the area of the welding ring, the zinc and annealing skin (tinder) are ground off and finally the welding ring is applied.

During the pressure test, each pipe is hydrostatically pressurised with a certain internal pressure and checked for leaks. The pipe is then lined with cement mortar using the centrifugal rotation process. The weld seam is galvanised and the pipes are visually inspected again. The cement stone hardens in the curing chamber. Finally, a solvent-free two-component polyurethane top coat is applied. All pipes are labelled according to the specifications, bundled and brought to the warehouse.

2.7 Packaging

The TRM pipes are sealed with protective caps and bundled using spacer rings as stacking aid and PET tapes. All packaging materials can be used for thermal recycling.

2.8 Conditions of delivery

The ductile cast iron pipes are bundled for transport and storage with the help of spacer rings as stacking aid as well as PET binding tapes.

2.9 Transport to site

The cast pipes are transported to their destination within Europe by lorry and, in rare cases, overseas by ship.

2.10 Construction product stage

The installation of pressure pipes made of ductile cast iron must comply with OENORM EN 805 (Water supply - Requirements for systems and components outside buildings) and OENORM B 2538 (Additional specifications concerning OENORM EN 805). When constructing the pipe trench, sufficient working space must be provided for the installation of the pipeline, depending on the trench depth and the outer diameter of the pipe. The Ordinance on Protection of Construction Workers (Bauarbeiterschutzverordnung) and other provisions as well as relevant standards and regulations must be complied with accordingly.

As this is a push-in joint, no additional work such as welding is required. The pipe trench must be constructed and excavated in such a way that all pipe sections are at frost-free depths. The trench must be excavated deep enough so that the final cover height is at least 1.50 m. In the case of ductile iron pipes, the existing soil is generally suitable for bedding the pipeline. This means there is no need for a lower bedding layer and the bottom of the trench becomes the lower bedding.

The pipeline must be embedded and the pipe trench refilled in such a way that the pipeline is securely fixed in its intended position and that damage to the pipeline is prevented and settlement can only occur to the permissible extent. Suitable material that does not damage the pipe components and the coating must be used for embedding the pipeline. The backfill material should be installed in layers and sufficiently compacted.

2.11 Use stage

If installed and designed professionally and if the phase of utilisation is not disturbed, no modification of the material composition of construction products made of ductile cast iron occur.

2.12 Reference service life (RSL)

Table 8: Reference service life (RSL)

Name	Value	Unit
Ductile cast iron pipes	50	Years

In practice, it has been shown that a service life of 100 years, based on the DVGW damage statistics (German Technical and Scientific Association for Gas and Water – https://www.dvgw.de/themen/sicherheit/gas-und-wasserstatistik/), is achieved.

2.13 End of life stage

In inner-city areas, the main area of application for the pipe systems, the installed pipes are currently almost entirely removed. These pipes can then be recycled accordingly. These pipes can then be sent to recycling. The removal and recycling rate was therefore set correspondingly high in the scenarios considered (see 4.4 - C1-C4 disposal phase). However, it should be noted that the 100% removal rate is a manufacturer's scenario, which must be checked and adjusted accordingly in each individual use case.

The pipes are disposed of in very rare cases. The EAK waste code number for iron and steel from construction and demolition is 170405.

2.14 Further information

For further information about the TRM pipe system and its possible applications, see the website http://trm.at/rohr.

3 LCA: Calculation rules

3.1 Declared unit/ Functional unit

The functional unit is 1 metre [m] of pipe. For conversion into kg, Table 9 can be used.

Table 9: Conversion factor to mass

Nominal diameter [mm]	Longitudinally related mass [kg/m]	Multiplication factor
600	181,9	0,00550

3.2 System boundary

The entire product life cycle and module D is declared. This is a "from cradle to grave with module D"-EPD (modules A+B+C+D).

Table 10: Declared life cycle stages

PRODUCT STAGE			CON-STRUCTION PROCESS STAGE		USE STAGE							END-OF-LIFE STAGE				BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARIES
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
Raw material supply	Transport	Manufacturing	Transport from the gate to the site	Construction, installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction, demolition	Transport	Waste processing	Disposal	Reuse-Recovery-Recycling-potential
x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

X = included in LCA; ND = Not declared

3.2.1 A1-A3 Product Stage:

The cast iron pipes (semi-finished parts) are almost exclusively made of the secondary material steel scrap and a very small proportion of pig iron and return iron from the casting process. The system boundary for the steel scrap is set when the processed steel scrap leaves the recycling plants, because the end of the waste properties of the steel scrap is reached here. This system is blamed for the transportation of the scrap to the TRM plant. The product stage includes the production steps in the plant along with the energy supply (including the upstream chains), the production of raw materials, auxiliary materials and packaging (including transport to the plant), the infrastructure and the disposal of the waste occurring during production. Module A1-A3 also includes the manufacture of the locks and gaskets required for assembling the pipe.

3.2.2 A4-A5 Construction stage:

The cast iron pipe can be installed in various ways. This EPD considers the standard case for installation, i.e. the conventional laying of the pipe:

- Excavation of trench
- Bedding of the pipe
- Backfilling with suitable material

The protective caps, squared lumber and binding tapes needed for transport are thermally recycled.

3.2.3 B1-B7 Use stage:

Generally, construction products made of ductile cast iron show no impact on the LCA during the use stage.

3.2.4 C1-C4 End-of-life stage:

In inner-city areas, the main area of application for the pipe systems, the installed pipes are currently almost entirely removed. For this reason, a 100% removal rate is applied as a scenario.

The removed pipes are sent to a recycling process and are considered until the end-of-waste state according to EN 15804 in the current product system. The system boundary is therefore set when the processed steel scrap leaves the recycling plants.

As a recycling scenario, due to the robustness of the pipe systems, it is assumed that 97% of the removed pipes are suitable for the recycling process and 3% have to be sent to landfill due to breakage, etc. The recycling scenario applied is a manufacturer's scenario based on the experience of Tiroler Rohre GmbH, which must be checked and adapted accordingly in each individual use case.

3.2.5 D Benefits and loads:

Due to the recycling of the removed pipes, there is a corresponding output of secondary raw materials in C3. The output flows are compared with the scrap share in the production of the cast iron pipes in accordance with the net flow rule according to EN 15804 and the net output flow is determined. The recycling and net flow scenario applied is a manufacturer's scenario based on the experience of Tiroler Rohre GmbH, which must be checked and adapted accordingly in each individual use case.

3.3 Flow chart of processes/stages in the life cycle

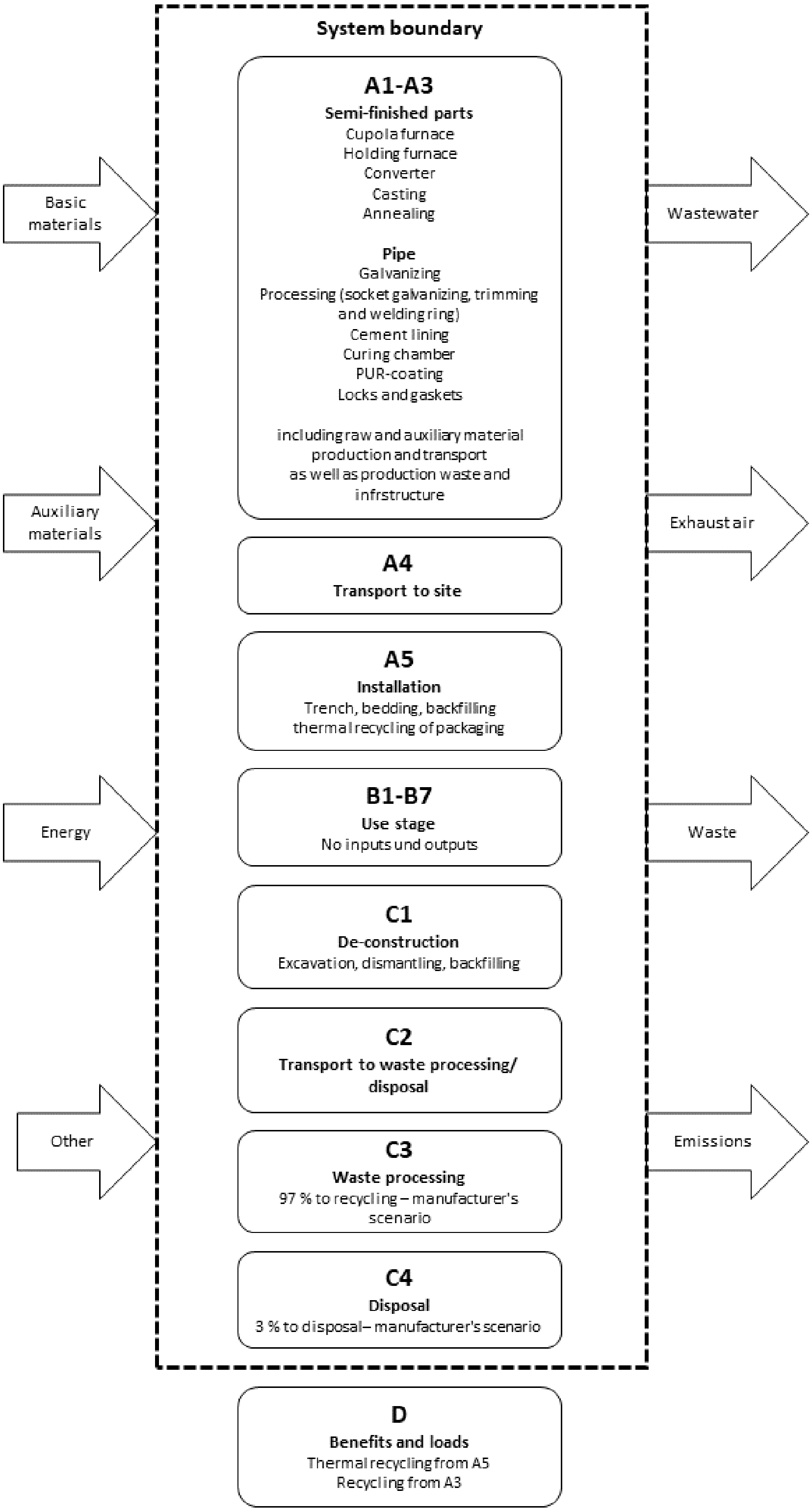


Figure 4: Life cycle flow chart

3.4 Estimations and assumptions

The SiC pellets used in casting production consist of various silicon components, Portland cement and water. In ecoinvent 3.10 there is only one data set for silicon carbide, which is typical of wafer production and has a very high SiC purity compared to the SiC component mixture used in casting production and therefore also a high energy intensity (information from the manufacturer of the pellets). According to the manufacturer of the SiC pellets, the energy required to produce the SiC components or silicon carbide is reflected in the respective prices per tonne. This allows an adjustment of the SiC purity (correction factor) of the data set available in ecoinvent based on an economic comparison (i.e. in the style of an economic allocation).

Cast steel is a special steel with no available data set. As the input is below 1 kg per t of ductile cast iron, the ecoinvent data set for chrome steel was applied.

For magnesium, which mainly comes from China, the global data set for magnesium was used ("market"-data set).

Since the infrastructure only makes a very small contribution to environmental impact, the machinery was modelled with its main components steel and casting.

For the use stage, it was assumed that no LCA-relevant material and energy flows occur.

All transport distances, with the exception of magnesium, were collected by the customer and taken into account in the LCA. For magnesium, the average transports are taken into account by the application of the global "market"-data set (which includes transport processes for the market under consideration).

3.5 Cut-off criteria

The producer calculated and submitted the amount of all applied materials, energy needed, the packaging material, the arising waste material and the way of disposal and the necessary infrastructure (buildings and machinery for the production). The measurement values for emissions according to the casting regulations were specified.

Auxiliary materials whose material flow is less than 1% were ignored as insignificant. Internal transport was negligible due to the short transport distances. It can be assumed that the total of insignificant processes is less than 5% of the impact categories.

During the production of the ductile pipes, slag (from cupola furnace) and coke dust are produced as by-products. Part of the waste heat is sold as district heating. However, these by-products contribute less than 1% to the operational income and can therefore be ignored according to the Management-System-Handbook (MS-HB) of the Bau EPD GmbH (MS-HB Version 6.0.0 dated 06.11.2024). The system limit for these two recyclable materials is set when they are collected from the plant by the future user.

The materials resulting from the production of semi-finished parts – foundry debris, fly-ash, filter cake from cupola furnace dust extraction and converter slag – are taken to a recycling plant for processing, whereby the system limit is set when the substances arrive at this plant, because no detailed information is available on the further treatment processes and the influence on the results of the impact categories is classified as negligible.

In C3, the recycling of the pipes (97%), i.e. the processing of the removed pipes in a recycling plant into a secondary raw material that can be used in cast iron and steel production, is taken into account. For this purpose, it is assumed that the pipe (including CML, etc.) is sent as a whole to the recycling plant, where any materials that cannot be used for cast iron and steel production are separated out. The treatment of these separated materials is excluded due to the expected minor influence.

3.6 Allocation

The system boundary for the steel scrap is set when the processed steel scrap leaves the recycling plants, because the end of the waste staus of the steel scrap is reached here. This system is blamed for the transportation of the scrap to the TRM plant.

In the liquid iron sector, an allocation by mass based on stock additions was carried out between the pipes considered in this EPD and the products not considered. The same applies to waste.

During the production of the ductile pipes, slag and coke dust are produced as by-products. Part of the waste heat is sold as district heating. However, these by-products contribute less than 1% to the operational income and can therefore be ignored according to the "Management-System-Handbook (MS-HB) of the Bau EPD GmbH (MS-HB Version 6.0.0 dated 06.11.2024).

For the annealing, the energy used was allocated according to the dwell times in the furnace.

Due to the recycling of the removed pipes, there is a corresponding output of secondary raw materials in C3. The output flows are compared with the scrap share in the production of the cast iron pipes in accordance with the net flow rule according to EN 15804 and the net output flow is determined.

3.7 Comparability

In principle, a comparison or evaluation of EPD data is only possible if all data sets to be compared have been created in accordance with EN 15804, the same programme-specific PCR/any additional rules and the same background database have been used, and the building context/product-specific performance characteristics are also taken into account.

4 LCA: Scenarios and additional technical information

4.1 A1-A3 Product stage

According to OENORM EN 15804, no technical scenario details are required for A1-A3 as the producer is responsible for the accounting of these modules, and this must not be changed by the user of the LCA.

Data collection for the product stage was carried out according to ISO 14044 Section 4.3.2. In accordance with the target definition, all relevant input and output flows that occur in connection with the product under consideration were identified and quantified in the life cycle inventory analysis.

Electricity generation is modelled according to the electricity mix supplied by Tiroler Wasserkraft AG (TIWAG) to Tiroler Rohre GmbH. In 2020, Tiroler Rohre GmbH purchased the TIWAG 2020 supplier mix (Versorgermix) from Tiroler Wasserkraft AG TIWAG (electricity mix contractually secured).

A part of the electricity consumption in the semi-finished parts production takes place at medium voltage level. The remaining electricity consumption takes place at low voltage level, with 5.75% coming from the in-house photovoltaic system.

Since photovoltaic electricity is generally fed into the grid and consumed at low voltage, and Tiroler Rohre GmbH purchases its electricity at medium voltage, the photovoltaic share is deducted when modelling the medium-voltage electricity supplied by TIWAG (see Table 11).

Table 11: Electricity mix

Source	**TIWAG Supplier mix general**	**Medium voltage without photovoltaics**
Hydro power	84,90%	86,32%
Norway	*20,23%*	*20,57%*
Tyrol	*64,67%*	*65,75%*
Wind power	10,37%	10,54%
Solid or liquid biomass	2,02%	2,05%
Photovoltaics	1,64%	0,00%
Biogas	1,05%	1,07%
Other eco-energy	0,02%	0,02%
Sum	**100,00%**	**100,00%**

The GWP total- result for the TIWAG electricity mix used is 57.3 g CO_2 eq/kWh at high voltage level, 60.5 g CO_2 eq/kWh at medium voltage level and 61.6 g CO_2 eq/kWh at low voltage level. The GWP total-result for low-voltage electricity from the photovoltaic system at the TRM plant is 104 g CO_2 eq/kWh.

4.2 A4-A5 Construction process stage

The pipes are transported to their destination by truck. The client provided relevant information on the transports, and based on this, an average transport distance of approximately 470 km was determined.

Table 12 shows the general parameters for describing transportation to the building site.

Table 12: Description of the scenario „Transport to building site (A4)“

Parameters to describe the transport to the building site (A4)	Value	Unit
Average transport distance	471	km
Vehicle type, Commission Directive 2007/37/EC (European Emission Standard)	Euro 6	-
Average fuel consumption, fuel type: Diesel or heavy fuel oil	25,3	l/100 km
Average transport mass	5,79	t
Average capacity utilisation (including empty returns)	85	%
Average gross density of transported products	181,9	kg/m
Volume capacity utilisation factor (factor: =1 or <1 or ≥ 1 for compressed or nested packaged products)	<1	-

Conventional laying was chosen as the installation method for the EPD, i.e. excavating a trench, bedding the pipe and backfilling with suitable material. A hydraulic excavator with an engine power of 150 kW, a scoop capacity of 2,2 m3 and a weight of 35 t was used for the excavation and backfilling of the pipe trench (including bedding).

Most of the excavation material is temporarily stored and reused for backfilling. However, a certain proportion of the excavation material (varying for the specific nominal diameters depending on the proportion of bedding) must be disposed of at a landfill 20 km away. The additional backfill material required for this is transported from a gravel pit 20 km away.

The spacer rings (PP), protective caps (PE), stacked wood and binding tape (PET) are thermally recycled in a waste incinerator 100 km away.

Table 13: Description of the scenario „Installation of the product in the building (A5)“

Parameters to describe the installation of the product in the building (A5)	Value	Unit
Ancillary materials for installation (specified by material);	Backfill material 893	kg/m
Ancillary materials for installation (specified by type)	Hydraulic excavator	-
Water use	0	m^3/m
Other resource use	0	kg/m
Electricity demand	0	kWh/m
Other energy carrier(s): Diesel	15,1	MJ/m
Wastage of materials on the building site before waste processing, generated by the product's installation (specified by type)	0	kg/m
Output materials (specified by type) as result of waste processing at the building site e.g. of collection for recycling, for energy recovery, disposal (specified by route)	Disposal Excavation: 893 Waste incineration PE: 0,353 PP: 0,060	kg/m
Direct emissions to ambient air (such as dust, VOC), soil and water	-	kg/m

4.3 B1-B7 Use stage

In the use stage, no material and energy flows relevant for the life cycle assessment take place for the VRS®-T pipe systems, wherefor no activities were taken into account.

4.4 C1-C4 End-of-Life stage

In inner-city areas, the main area of application for the pipe systems, the installed pipes are currently almost entirely removed. For this reason, a 100% removal rate is used as a scenario. The removed pipes are sent to a recycling process, being considered until the end-of-waste state in the current product system. The system limit is set when the processed steel scrap leaves the recycling plants. From this point on, the pipe is part of a new product system. As a recycling scenario it is assumed that 97% of the pipes are suitable for the recycling process and 3% have to be sent to disposal.

The pipes are removed with the same excavator that was used for the installation. The excavation volume for the removal corresponds to volume for the installation. The existing excavation material is reinstalled, but must be supplemented with additional backfill material (different for the specific DN). The distance to the gravel pit is estimated at 20 km.

Table 14: Description of the scenario "Dismantling (C1)"

Parameters to describe the dismantling (C1)	**Value**	**Unit**
Auxiliary materials for the dismantling	Backfill material 700	kg/m
Aids for the demolition	Hydraulic excavator	-
Water consumption	0	m^3/m
Other resource use	0	kg/m
Electricity consumption	0	kWh/m
Other energy carrier: Diesel	15,1	MJ/m
Material loss on the construction site before waste treatment, caused by the installation of the product	0	kg/m
Output materials due to waste treatment on the construction site, e.g. collection for recycling, for energy recovery or for disposal	0	kg/m
Direct emissions to ambient air (e.g. dust, VOC), soil and water	-	kg/m

The transport distance to the nearest recycling company (97% of the pipes) as well as to the nearest inert material landfill (3% of the pipes) or waste incineration plant (gaskets) was assumed to be 100 km.

Table 15: Description of the scenario "Transport for disposal (C2)"

Parameters to describe the transport for disposal (C2)	**Value**	**Unit**
Average transport distance	100	km
vehicle type, Commission Directive 2007/37/EC (European Emission Standard)	Euro 6	-
Average fuel consumption, fuel type: Diesel or heavy fuel oil	25,3	l/100 km
Average transport mass	5,79	t
Average capacity utilisation (including empty returns)	85	%
Average gross density of transported products	181,9	kg/m
Volume capacity utilisation factor (factor: =1 or <1 or ≥ 1 for compressed or nested package products)	<1	-

In C3, the recycling of the pipes (97%), i.e. the processing of the removed pipes in a recycling plant into a secondary raw material that can be used in cast iron and steel production, is taken into account. For this purpose, it is assumed that the pipe (including CML, etc.) is sent as a whole to the recycling plant, where any materials that cannot be used for cast iron and steel production are separated out. The treatment of these separated out materials is excluded due to the expected minor influence. A new product system begins with the transport of the processed scrap from the recycling plant to the production plant.

In C4, the disposal of 3% of the pipe mass in an inert material landfill and the disposal of the EPDM gasket material in a waste incinerator are considered. A 100% recycling rate is applied for the removed bolts, which are made of pure cast material.

Table 16: Disposal processes (C3 and C4) per m of pipe

DN	**Mass per metre of pipe**	**Total pipe mass for recycling (97%)**	**Total pipe mass for disposal (3%)**	**Lock mass for recycling (100%)**	**Total mass (pipe and Lock) for recycling**	**Gasket mass for waste incineration**
[mm]	*[kg/m]*	*[kg/m]*	*[kg/m]*	*[kg/m]*	*[kg/m]*	*[kg/m]*
600	181,90	176,443	5,457	1,840	178,283	0,4600

Table 17: Description of the scenario „Disposal of the product (C1 to C4)"

Parameters for end-of-life stage (C1-C4)	**Value**	**Unit**
Collection process, separately	see Table 16	kg collected separately
Recycling	see Table 16	kg for recycling
Disposal, inert material landfill	see Table 16	kg material for final deposition

4.5 D Potential of reuse and recycling

Due to the recycling of the removed pipes (97%), there is a corresponding output of secondary raw materials (D from C3). Due to the net flow rule according to EN 15804 and the high proportion of scrap in the production of cast iron pipes (988 kg per tonne of cast semi-finished part), there is a slightly negative net output flow here.

Table 18: Description of the scenario „re-use, recovery and recycling potential (module D)“

Parameters for module D	Value	Unit
Materials for reuse, recovery or recycling from A4-A5	-	%
Energy recovery or secondary fuels from A4-A5	Waste incineration PP: 0,060 PE: 0,353	kg/m
Materials for reuse, recovery or recycling from B2-B5	-	%
Energy recovery or secondary fuels from B2-B5	-	kg/m
Materials for reuse, recovery or recycling from C1-C4	97	%
Energy recovery or secondary fuels from C1-C4	Waste incineration Gasket: 0,4600	kg/m

Due to the multi-recycling potential of the pipes, they could again replace primary raw materials in the next product system. In this EPD, the multi-recycling potential is not shown as a life cycle assessment result (in the results tables) but as additional information (Appendix 1), because this value does not comply with the rules and specifications of EN 15804 (net flow rule). The additional information on multi-recycling potential is based on a manufacturer scenario based on the experience of Tiroler Rohre GmbH.

5 Information on data quality and data selection in accordance with EN 15941

5.1 Principles for the description of data quality

The following information on data quality is provided in accordance with the requirements of EN 15941 (EN 15941, section 7.3.4).

The data fulfils the following quality requirements:

The data is representative for the production year 2020 (annual average). The production year 2020 is considered based on the existing data for ductile cast iron production (semi-finished part production) of the EPD for ductile piles from Tiroler Rohre GmbH (published 2022).

For the data collection, generic data and the cut-off of material and energy flows the criteria of the Bau EPD GmbH were considered.

The manufacturer provided all essential data such as energy and raw material consumption, transport distances and vehicles as well as packaging within the system boundaries.

The applied background database ecoinvent 3.10 was published in 2024, but contains individual data sets whose collection or reference year dates back more than 10 years (requirement EN 15804 or Bau EPD GmbH). These data sets remained in the various ecoinvent database versions through the years, taking necessary adjustments for database updates into account. Nevertheless, these data sets are subject to a corresponding potential for fluctuation because some of the (technological) developments of recent years are not reflected.

The data is plausible, i.e. the deviations from comparable results are within a plausible range.

5.2 Description of the temporal, geographical and technological representativeness of the product data

Temporal representativeness:
- The data collection period corresponds to the year 2020. All specific data are from this year.
- There is no deviation from the reporting year 2020 in the collection of specific data.
- The applied background database ecoinvent 3.10 was published in 2024, but contains individual data sets whose collection or reference year dates back more than 10 years (requirement EN 15804 or Bau EPD GmbH).

Geographical representativeness:
- VRS®-T pipe systems are manufactured exclusively at the plant in Hall in Tirol. In the production year 2020, almost 50% of the products were delivered within Austria and a total of approx. 90% within Europe (with a focus on Germany and Italy in addition to Austria).
- The pipe systems are disposed of in an area close to where they were used.

Technological representativeness:
- The production technology at the plant in Hall in Tyrol is state-of-the-art. The facilities are regularly maintained and modernised.
- In addition to cast iron pipe systems, other products such as ductile piles (pure cast iron product corresponds to semi-finished parts) are also manufactured at the analysed plant.

Geographical and technological representativeness for EPDs covering an industry:
- Not relevant for this EPD.

5.3 Explanation of the averaging process

Not relevant for this EPD, as specific products from the plant in Hall in Tyrol of the Tiroler Rohre GmbH are considered.

5.4 Assessment of the data quality of the Life Cycle Inventory data

The validity (database/source, country/region, reference year, publication/update) and the geographical, technical and temporal representativeness (according to ÖNORM EN 15804 Annex E - Table E.1) of all data sets used are assessed in the project report for this EPD.

The manufacturer provided all essential data such as energy and raw material consumption, transport distances and vehicles, and packaging within the system boundaries (quality management system and SAP system).

6 LCA: results

Table 19: Parameters to describe the environmental impact per metre [m] VRS®-T DN 600

Parameters	Unit	A1-A3	A4	A5	B1-B7	C1	C2	C3	C4	C1-C4	A-C	D
GWP total	kg CO_2 eq	1,76E+02	1,65E+01	2,43E+01	0,00E+00	1,14E+01	3,50E+00	4,60E+00	1,49E+00	2,10E+01	2,38E+02	4,07E+00
GWP fossil fuels	kg CO_2 eq	1,75E+02	1,65E+01	2,43E+01	0,00E+00	1,14E+01	3,50E+00	4,66E+00	1,49E+00	2,10E+01	2,37E+02	4,09E+00
GWP biogenic	kg CO_2 eq	1,07E+00	1,14E-02	2,50E-02	0,00E+00	1,71E-02	2,42E-03	-6,04E-02	1,82E-04	-4,07E-02	1,07E+00	-1,83E-02
GWP luluc	kg CO_2 eq	6,98E-02	5,48E-03	1,37E-02	0,00E+00	7,63E-03	1,16E-03	6,58E-03	2,38E-05	1,54E-02	1,04E-01	4,78E-04
ODP	kg CFC-11 eq	1,89E-06	3,29E-07	3,94E-07	0,00E+00	1,34E-07	6,96E-08	6,41E-08	1,42E-09	2,69E-07	2,88E-06	6,37E-09
AP	mol H^+ eq	4,42E-01	3,44E-02	1,23E-01	0,00E+00	6,29E-02	7,29E-03	5,12E-02	4,43E-04	1,22E-01	7,22E-01	1,48E-02
EP freshwater	kg P eq	6,26E-02	1,12E-03	3,89E-03	0,00E+00	2,51E-03	2,37E-04	2,66E-03	6,60E-06	5,41E-03	7,30E-02	1,73E-03
EP marine	kg N eq	1,13E-01	8,27E-03	3,80E-02	0,00E+00	1,80E-02	1,75E-03	1,19E-02	1,72E-04	3,18E-02	1,91E-01	3,55E-03
EP terrestrial	mol N eq	1,17E+00	8,92E-02	4,30E-01	0,00E+00	2,08E-01	1,89E-02	1,34E-01	1,88E-03	3,62E-01	2,05E+00	3,85E-02
POCP	kg NMVOC eq	3,88E-01	5,72E-02	1,47E-01	0,00E+00	6,43E-02	1,21E-02	4,00E-02	5,86E-04	1,17E-01	7,10E-01	1,29E-02
ADPE	kg Sb eq	1,72E-03	5,38E-05	7,91E-05	0,00E+00	4,66E-05	1,14E-05	2,87E-04	1,11E-07	3,45E-04	2,19E-03	1,98E-06
ADPF	MJ H_u	1,23E+03	1,93E+01	7,85E+01	0,00E+00	5,20E+01	4,09E+00	2,02E+01	9,33E-02	7,63E+01	1,40E+03	3,94E+01
WDP	m3 World eq	4,68E+01	9,65E-01	1,96E+01	0,00E+00	1,05E+01	2,04E-01	7,80E-01	3,24E-02	1,16E+01	7,90E+01	2,37E-01
Legend		GWP = Global warming potential; luluc = land use and land use change; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential, Accumulated Exceedance; EP = Eutrophication potential; POCP = Formation potential of tropospheric ozone photochemical oxidants; ADPE = Abiotic depletion potential for non-fossil resources; ADPF = Abiotic depletion potential for fossil resources WDP = Water (user) deprivation potential, deprivation-weighted water consumption										

Table 20: Additional environmental impact indicators per metre [m] VRS®-T DN 600

Parameters	Unit	A1-A3	A4	A5	B1-B7	C1	C2	C3	C4	C1-C4	A-C	D
PM	Occurrence of diseases	2,17E-05	1,22E-06	2,62E-06	0,00E+00	1,24E-06	2,58E-07	7,16E-07	6,52E-09	2,22E-06	2,78E-05	3,15E-07
IRP	kBq U235 eq	7,70E+00	3,01E-01	1,11E+00	0,00E+00	7,57E-01	6,39E-02	4,70E-01	1,35E-03	1,29E+00	1,04E+01	9,68E-03
ETP-fw	CTUe	1,43E+03	6,32E+01	9,77E+01	0,00E+00	5,21E+01	1,34E+01	4,52E+01	2,55E+00	1,13E+02	1,70E+03	4,14E+02
HTP-c	CTUh	2,03E-06	1,17E-07	1,62E-07	0,00E+00	8,96E-08	2,48E-08	4,04E-08	3,02E-10	1,55E-07	2,46E-06	1,58E-06
HTP-nc	CTUh	1,58E-06	1,46E-07	1,59E-07	0,00E+00	8,24E-08	3,09E-08	2,49E-07	5,57E-10	3,63E-07	2,25E-06	1,41E-08
SQP	dimensionless	4,71E+02	1,40E+02	4,30E+02	0,00E+00	1,03E+02	2,97E+01	1,12E+02	1,72E+00	2,47E+02	1,29E+03	8,71E+00
Legend		PM = Potential incidence of disease due to Particulate Matter emissions; IRP = Potential Human exposure efficiency relative to U235; ETP-fw = Potential Comparative Toxic Unit for ecosystems; HTP-c = Potential Comparative Toxic Unit for humans – cancer effect; HTP-nc = Potential Comparative Toxic Unit for humans – non-cancer effect; SQP = Potential soil quality index										

Table 21: Parameters to describe the use of resources per metre [m] VRS®-T DN 600

Parameters	Unit	A1-A3	A4	A5	B1-B7	C1	C2	C3	C4	C1-C4	A-C	D
PERE	MJ H_u	2,87E+02	3,99E+00	1,39E+01	0,00E+00	9,29E+00	8,45E-01	1,02E+01	1,97E-02	2,04E+01	3,25E+02	5,08E-01
PERM	MJ H_u	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PERT	MJ H_u	2,87E+02	3,99E+00	1,39E+01	0,00E+00	9,29E+00	8,45E-01	1,02E+01	1,97E-02	2,04E+01	3,25E+02	5,08E-01
PENRE	MJ H_u	1,21E+03	1,93E+01	9,89E+01	0,00E+00	5,20E+01	4,09E+00	2,02E+01	9,34E-02	7,63E+01	1,40E+03	3,94E+01
PENRM	MJ H_u	2,03E+01	0,00E+00	-2,03E+01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PENRT	MJ H_u	1,23E+03	1,93E+01	7,86E+01	0,00E+00	5,20E+01	4,09E+00	2,02E+01	9,34E-02	7,63E+01	1,40E+03	3,94E+01
SM	kg	1,55E+02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,55E+02	-2,77E+00
RSF	MJ H_u	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
NRSF	MJ H_u	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
FW	m^3	1,84E+00	3,22E-02	4,82E-01	0,00E+00	2,61E-01	6,82E-03	3,07E-02	2,27E-03	3,00E-01	2,65E+00	6,32E-03
Legend		PERE = Renewable primary energy as energy carrier; PERM = Renewable primary energy resources as material utilization; PERT = Total use of renewable primary energy resources; PENRE = Non-renewable primary energy as energy carrier; PENRM = Non-renewable primary energy as material utilization; PENRT = Total use of non-renewable primary energy resources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of fresh water										

Table 22: Parameters describing LCA-output flows and waste categories per metre [m] VRS®-T DN 600

Parameters	Unit	A1-A3	A4	A5	B1-B7	C1	C2	C3	C4	C1-C4	A-C	D
HWD	kg	1,52E-02	1,57E-03	2,10E-03	0,00E+00	7,43E-04	3,32E-04	3,84E-04	9,18E-06	1,47E-03	2,04E-02	5,03E-04
NHWD	kg	1,44E+01	1,12E+01	8,99E+02	0,00E+00	2,98E+00	2,38E+00	1,64E+00	5,48E+00	1,25E+01	9,37E+02	1,03E-01
RWD	kg	3,57E-03	1,36E-04	4,89E-04	0,00E+00	3,32E-04	2,89E-05	2,19E-04	6,24E-07	5,81E-04	4,77E-03	4,99E-06
CRU	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
MFR	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,52E+02	0,00E+00	1,52E+02	1,52E+02	0,00E+00
MER	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
EEE	MJ	0,00E+00	0,00E+00	9,61E-01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	9,61E-01	0,00E+00
EET	MJ	0,00E+00	0,00E+00	8,48E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	8,48E+00	0,00E+00
Legend		HWD = Hazardous waste disposed; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed; CRU = Components for re-use; MFR = Materials for recycling; MER = Materials for energy recovery; EEE = Exported electric energy; EET = Exported thermal energy										

Table 23: Information describing the biogenic carbon content at the factory gate per metre [m] VRS®-T DN 600

Biogenic carbon content	Unit	A1-A3
Biogenic carbon content in product	kg C	0,00E+00
Biogenic carbon content in accompanying packaging	kg C	0,00E+00
NOTE: 1 kg biogenic carbon is equivalent to 44/12 kg of CO_2		

Table 24 presents disclaimers which shall be declared in the project report and in the EPD with regard to the declaration of relevant core and additional environmental impact indicators according to the following classification. That can be declared in a footnote in the EPD.

Table 24: Classification of disclaimers to the declaration of core and additional environmental impact indicators

ILCD-classification	Indicator	disclaimer
ILCD-Type 1	Global warming potential (GWP)	none
	Depletion potential of the stratospheric ozone layer (ODP)	none
	Potential incidence of disease due to PM emissions (PM)	none
ILCD-Type 2	Acidification potential, Accumulated Exceedance (AP)	none
	Eutrophication potential, Fraction of nutrients reaching freshwater end compartment (EP-freshwater)	none
	Eutrophication potential, Fraction of nutrients reaching marine end compartment (EP-marine)	none
	Eutrophication potential, Accumulated Exceedance (EP-terrestrial)	none
	Formation potential of tropospheric ozone (POCP)	none
	Potential Human exposure efficiency relative to U235 (IRP)	1
ILCD-Type 3	Abiotic depletion potential for non-fossil resources (ADP-minerals&metals)	2
	Abiotic depletion potential for fossil resources (ADP-fossil)	2
	Water (user) deprivation potential, deprivation-weighted water consumption (WDP)	2
	Potential Comparative Toxic Unit for ecosystems (ETP-fw)	2
	Potential Comparative Toxic Unit for humans (HTP-c)	2
	Potential Comparative Toxic Unit for humans (HTP-nc)	2
	Potential Soil quality index (SQP)	2
Disclaimer 1 – This impact category deals mainly with the eventual impact of low dose ionizing radiation on human health of the nuclear fuel cycle. It does not consider effects due to possible nuclear accidents, occupational exposure nor due to radioactive waste disposal in underground facilities. Potential ionizing radiation from the soil, from radon and from some construction materials is also not measured by this indicator.		
Disclaimer 2 – The results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experienced with the indicator.		

7 LCA: Interpretation

It should be noted that the impact assessment results are only relative statements that do not include any statements about "end-points" of the impact categories, exceeding of thresholds or risks.

Since the definition of basic materials (those substances that remain in the product) and auxiliary materials (those substances that do not remain in the product) are not applicable for this product, because small percentages of the energy source coke and the input materials ferrosilicon and silicon carbide remain in the product, a breakdown into A1-A3 was not carried out.

Figure 5 shows a dominance analysis of the percentage shares of modules A1-A3 (production), A4 (transport to construction site), A5 (installation), C1 (removal), C2 (transport) and C4 (waste treatment). The pipe production is the main contributor to all impact categories (except NHWD). The next largest impacts are the installation (A5) and the removal (C1) of the pipes and the transport to the construction site (A4).

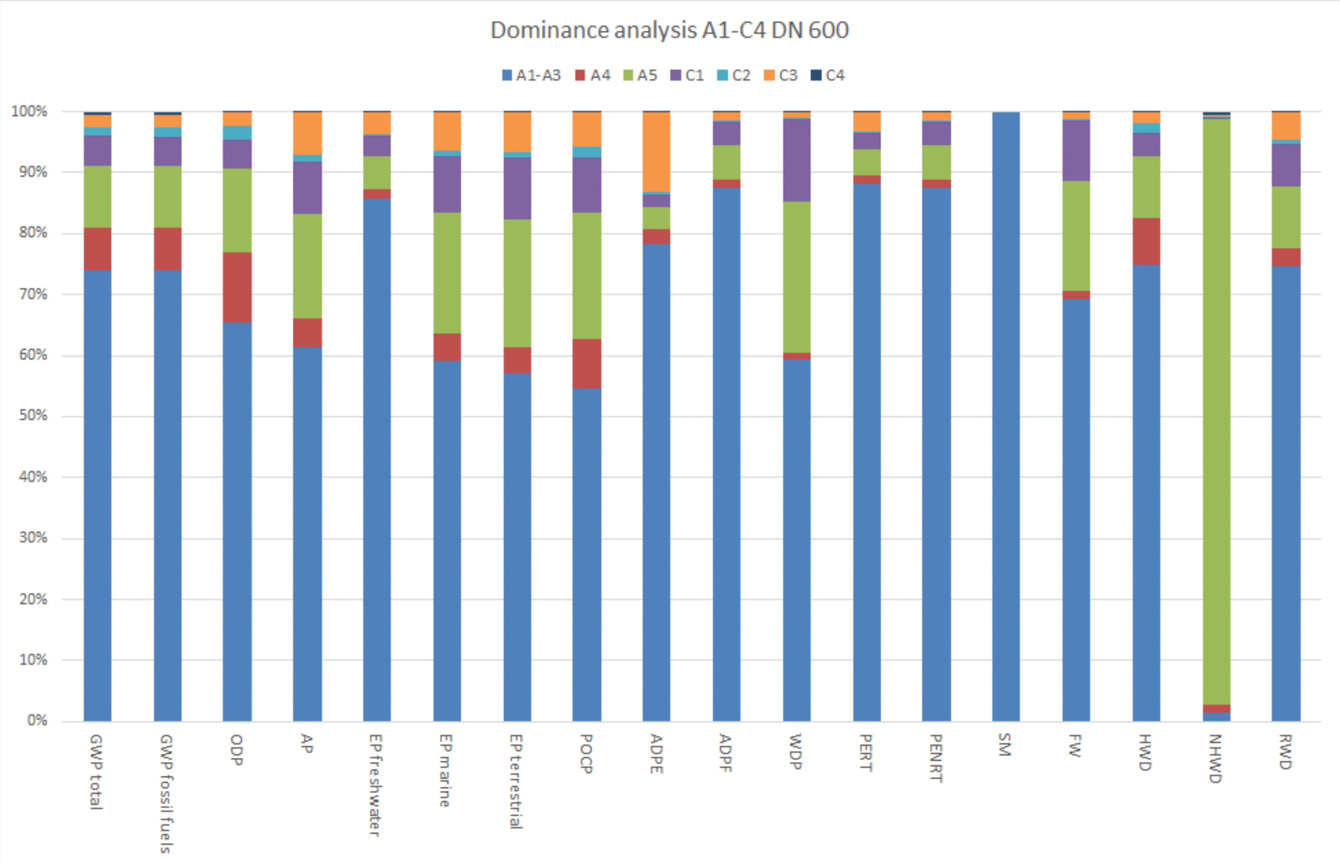


Figure 5: Dominance analysis DN 600

In the production phase (A1-A3), cast iron production has the greatest impact in terms of core indicators, with some impacts exceeding 80%. For individual indicators, galvanising has a high impact (e.g. ADPE >80%).

For the cast iron production, the cupola furnace, the annealing process and the converter have the greatest impact on the core indicators (together >90% in some cases). In the cupola furnace, CO_2 emissions from fuel use, SiC pellets and foundry coke have the greatest impact. The impact of the annealing process is determined by the natural gas used. In the converter, the magnesium and ferrosilicon applied have the greatest impact on the core indicators (in some cases >95%).

Pipe galvanisation is mainly dominated by the zinc applied (in some cases >99%).

The installation of the pipes (A5) is determined by the bedding material, the transport of the bedding material and the diesel consumption of the hydraulic excavator.

In C3, the upstream chain (wood input in the production of the scrap processing plant) of the data set used for recycling, "Iron scrap, sorted, pressed {RER}| sorting and pressing of iron scrap | Cut-off, U", causes a slightly negative value for GWP biogenic.

8 Literature

ÖNORM EN ISO 14025: 2010 Environmental labels and declarations — Type III environmental declarations — Principles and procedures

ÖNORM EN ISO 14040: 2021 Environmental management — Life cycle assessment — Principles and framework

ÖNORM EN ISO 14044: 2021 Environmental management — Life cycle assessment — Requirements and guidelines

ÖNORM 15804:2012+A2:2019+AC:2021 Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products

Bau EPD GmbH: Product category rules for building related products and services - Requirements on the EPD for cast iron products, PCR-Code 2.16.8, Version 12.0, dated 10.10.2024. Bau EPD Österreich, Vienna, 2024

Bau EPD GmbH: Management system handbook (EPD-MS-HB) of the EPD program, Version 6.0.0, dated 06.11.2024. Bau EPD Österreich, Vienna, 2024

9 Directory and Glossary

9.1 List of figures

9.2 List of tables

9.3 Abbreviations

9.3.1 Abbreviations as per EN 15804

EPD environmental product declaration
PCR product category rules
LCA life cycle assessment
LCI life cycle inventory analysis
LCIA life cycle impact assessment
RSL reference service life
ESL estimated service life
EPBD Energy Performance of Buildings Directive
GWP global warming potential
ODP depletion potential of the stratospheric ozone layer
AP acidification potential of soil and water
EP eutrophication potential
POCP formation potential of tropospheric ozone
ADP abiotic depletion potential

9.3.2 Abbreviations as per corresponding PCR

CE-mark french: Communauté Européenne or Conformité Européenne = EC certificate of conformity
REACH Registration, Evaluation, Authorisation and Restriction of Chemicals

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