EPD - ENVIRONMENTAL PRODUCT DECLARATION

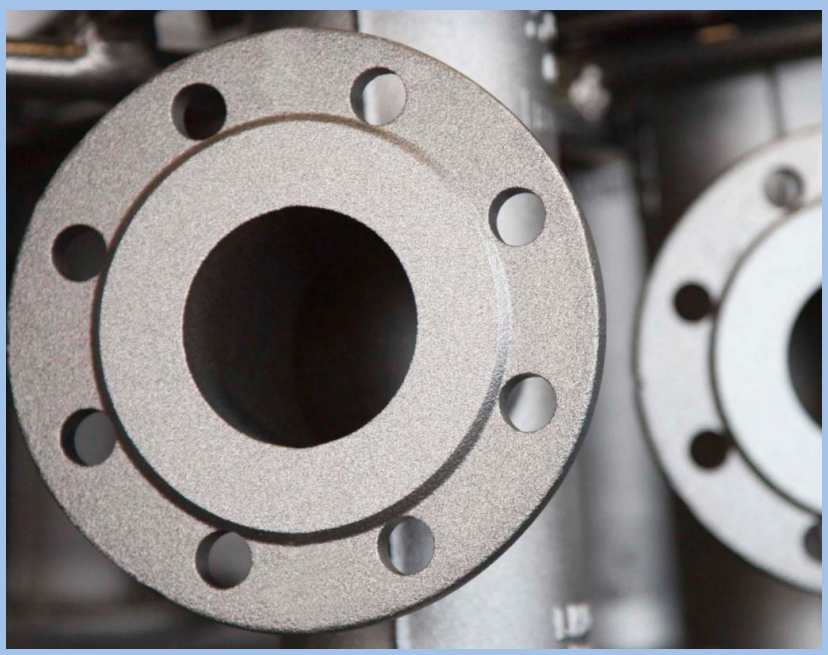
as per ISO 14025 and EN 15804+A2

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	**FRISCHHUT GmbH & Co. KG, D-84347 Pfarrkirchen, Franz-Stelzenberger-Str. 9-17**
DECLARATION NUMBER	**BAU-EPD-FRISCHHUT-2024-1-ECOINVENT-Cast iron fittings**
ISSUE DATE	**02.10.2024**
VALID TO	**02.10.2029**
NUMBER OF DATASETS	**4**
ENERGY MIX APPROACH	**MARKET BASED APPROACH**

Cast iron fittings

Fittings for plastic pipes - coated
Fittings for cast iron pipes with flange connections - coated
Special castings (high-quality, customised castings) - coated
Fittings for TRM pipe systems - uncoated

Frischhut GmbH & Co. KG



*FRISCHHUT

Content of the EPD

1 General information

Product name
Cast iron fittings

- Fittings for plastic pipes - coated
- Fittings for cast iron pipes with flange connections - coated
- Special castings (high-quality, customised castings) – coated
- Fittings for TRM pipe systems - uncoated

Declaration number
BAU-EPD-FRISCHHUT-2024-1-ECOINVENT-Cast iron fittings

Declaration data
☒ Specific data
☐ Average data

Declaration based on:
MS-HB Version 5.0.0 dated 20.09.2023 [1]:
Name of PCR: Cast iron products
PCR-Code: 2.16.8
Version 11.0 dated 20.09.2023 [2]
(PCR tested and approved by the independent expert committee = PKR-Gremium)

The holder 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 ton of average fittings for plastic pipes, fittings for cast iron pipes with flange connections and special castings, each with epoxy powder coating.
In the case of fittings for TRM pipe systems, 1 ton of the uncoated fitting from FRISCHHUT GmbH & Co. KG is declared because these are coated by the manufacturer of the pipe systems (Tiroler Rohre GmbH - TRM) itself.
Product variants of the analysed fittings and special castings can be scaled proportionally via the respective unit weight.

Number of datasets in EPD Document: 4

Range of validity
The EPD applies (only) to the cast fittings and special castings from the plants Neumarkt St. Veit and Pfarrkirchen of FRISCHHUT GmbH & Co KG.
The range of validity of the fittings for TRM pipes is appropriately limited because the coating required to fulfil the final function is not considered in this EPD (coating is applied by Tiroler Rohre GmbH - TRM).
Any additional components (seals, pipes, liners, etc.) required for the application of the products under consideration are not considered in this EPD.

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

Database, Software, Version
Database: ecoinvent 3.9.1
Version Characterisation Factors: Joint Research Center, EF 3.1

Author of the Life Cycle Assessment
floGeco GmbH
Hinteranger 61d
A-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: DI Therese Daxner, M.Sc., Daxner & Merl GmbH
Verifier 2: DI Roman Smutny, Independent Verifier

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Independent Verifier

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

2 Product

2.1 General product description

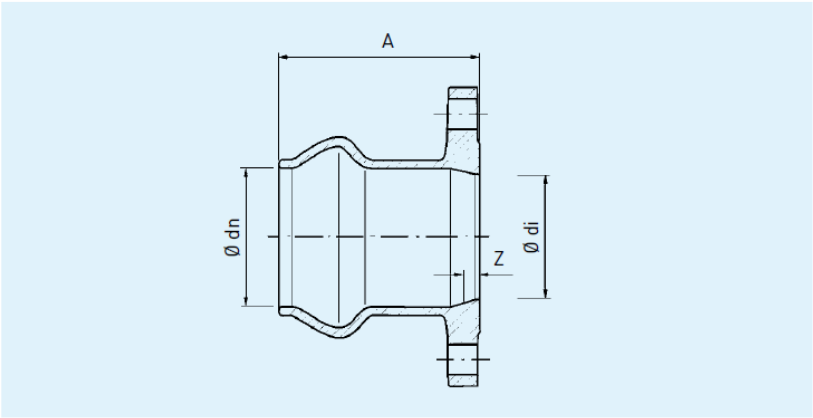
The declared products are average cast fittings and special castings (without sealing elements) of FRISCHHUT GmbH & Co. KG of the categories:

- Fittings for plastic pipes - coated
- Fittings for cast iron pipes with flange connections - coated
- Special castings (high-quality, customised castings) – coated
- Fittings for TRM pipe systems – uncoated

The products are cast at the plant Neumarkt St. Veit (semi-finished part) and mechanically processed, blasted and coated (epoxy powder coating) at the plant Pfarrkirchen. FRISCHHUT GmbH & Co. KG delivers the fittings for TRM pipe systems uncoated (as semi-finished part) to the manufacturer of the VRS-T pipe systems (Tiroler Rohre GmbH - TRM), who coats the fittings themselves. The range of validity of the fittings for TRM pipes is therefore limited appropriately because the coating required to fulfil the final function is not considered in this EPD. Special castings are produced in the same way as fittings for TRM pipes., i.e. further finishing is carried out by the respective customer.

Fittings for plastic pipes are applied to connect PE pipes and PVC-U pressure pipes. Figure 1 shows an excerpt from the FRISCHHUT GmbH & Co. KG product catalogue with corresponding technical specifications (including the unit weight for proportional evaluation of the specific fittings) for the flanged socket piece E-KS.

E-KS Flanschmuffenstück · DIN-EN 12842
E-KS Flanged socket · DIN-EN 12842

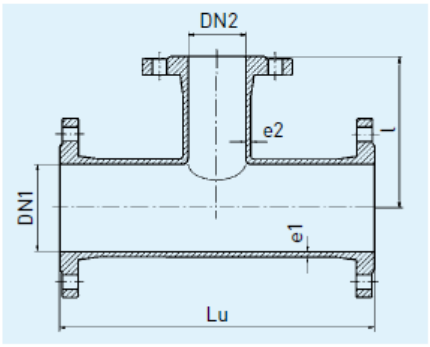


Maße in mm · dimensions in mm					kg/Stück kg/piece
DN	Ø dn	Ø di	A	Z	
50	63	50	100	4	3,0
60	75	65	110	9	3,8
65	75	65	110	9	3,8
80	75	80	120	14	4,3
80	90	80	120	14	4,6
100	110	100	130	15	6,2
125	125	110	145	19	7,5
125	140	125	145	19	7,7
150	160	145	135	15	7,9
200	200	178	192	34	17,2
200	225	210	164	16	12,5
250	250	223	220	41	25,6
250	280	265	178	17	16,7
300	315	300	251	58	35,0
350	355	325	265	45	50,0
400	400	354	295	71	71,0
400	450	400	310	84	72,3
500	500	470	340	76	98,0
600	630	600	425	90	136,1

Figure 1: Flanged socket piece E-KS – Excerpt from product catalogue FRISCHHUT GmbH & Co.KG

Fittings for cast iron pipes with flange connections are applied to form connections for pressure pipelines made of cast iron pipes. Figure 2 shows an excerpt from the FRISCHHUT GmbH & Co. KG product catalogue with corresponding technical specifications (including the unit weight for proportional evaluation of the specific fittings) for the flanged T-piece for cast iron pipes.

T-Stücke Flanschstücke mit Flanschstutzen PN 10/16 (25 und 40 auf Anfrage), nach FGR 73, DIN EN 545 Serie A bzw. Werksnorm
All-flanged-tee, PN 10/16 (25 and 40 upon request), according to FGR 73; DIN EN 545 series A or factory standard



Auch mit Nabe lieferbar (auf Anfrage)

Also available with boss (on request)

Maße in mm · dimensions in mm						kg/Stück kg/piece
DN1	DN2	Lu	l	e1	e2	
40	40	280	140	7,6	7,6	10,4
50	40	300	145	7,7	7,6	9,6
50	50	300	150	7,7	7,7	12,1
65	40	330	153	7,0	7,0	15,0
65	50	330	158	7,9	7,7	14,5
65	65	330	165	7,9	7,9	15,9
80	40	330	155	8,1	7,6	16,2
80	50	330	160	8,1	7,7	14,0
80	65	330	160	8,1	7,9	14,5
80	80	330	165	8,1	8,1	14,9
100	40	360	170	8,4	7,6	16,2
100	50	360	170	8,4	7,7	16,5
100	65	360	170	8,4	7,9	16,9
100	80	360	175	8,4	8,1	19,0
100	100	360	180	8,4	8,4	20,5
125	40	400	185	7,5	7,0	23,8
125	50	400	185	8,8	7,7	22,0
125	65	400	185	7,5	7,0	24,8
125	80	400	190	8,8	8,1	22,9
125	100	400	195	8,8	8,4	25,1
125	125	400	200	8,8	8,8	25,3
150	50	440	200	9,1	7,7	27,1
150	65	440	200	7,8	7,0	31,3
150	80	440	220	9,1	8,1	22,4
150	100	440	220	9,1	8,4	23,9
150	125	440	215	9,1	8,8	31,7
150	150	440	220	9,1	9,1	25,7
200	50	600	225	8,4	7,0	44,5
200	80	520	235	9,8	8,1	42,0
200	100	520	240	9,8	8,4	36,1
200	125	520	245	9,8	8,8	45,2
200	150	520	250	9,8	9,1	46,5
200	200	520	260	9,8	9,8	49,8
250	80	700	265	10,5	8,1	67,5
250	100	700	275	10,5	8,4	68,0
250	125	700	280	9,0	7,5	75,0
250	150	700	300	10,5	9,1	72,0
250	200	700	325	10,5	9,8	76,5
250	250	700	350	10,5	10,5	82,5
300	80	800	290	11,2	8,1	95,5
300	100	800	300	11,2	8,4	98,0
300	150	800	325	11,2	9,1	101,0
300	200	800	350	11,2	9,8	106,0
300	250	800	375	11,2	10,5	117,8

Figure 2: Flanged T-piece – Excerpt from product catalogue FRISCHHUT GmbH & Co.KG

Special castings manufactured by the FRISCHHUT GmbH & Co. KG are high-quality customer-specific castings, which are supplied exclusively to these customers. As a representative example the connector press ring of the “M-Connector” system of the “Primus Line” system from Rädlinger primus line GmbH can be named (Figure 3). The “Primus Line” system is used to transport liquid and gaseous media. The flexible liner reinforced with aramid fibres (not part of the EPD) and the specifically developed connectors (e.g. “M-Connector” - special casting from FRISCHHUT GmbH & Co. KG) form a high-performance system for the trenchless rehabilitation of pressure pipelines or for the construction of resistant unburied hose lines. A key component of “Primus Line” are the cast iron connectors. They are specifically developed for the system and form a force-fit, tight connection to the existing pipe or fittings. FRISCHHUT GmbH & Co. KG delivers the finished powder coated connector press rings to Rädlinger primus line GmbH. Figure 3 shows an exemplary system data excerpt of FRISCHHUT GmbH & Co. KG with corresponding technical specifications (including the unit weight for proportional assessment of the specific cast parts) for the “M-connector” press ring of Rädlinger primus line GmbH.

Rädlinger PrimusLine Pressringe für M-Verbinder ND System

Produktname	kg/Stück
M3-150-Pressring-PN10/PN16 E W S Blau	15,8
Verb.-Pressr.DN 150 AS4087 E W S	15,8
Verbinder-Pressr.200EWS 10 PRIMUS LINE	24,1
Verbinder-Pressr.200EWS 16 PRIMUS LINE	24,1
Verb.-Pressr.DN 200 AS4087 AS4087 E W S	24,1
Verb.-Pressr. DN 200 8inch ANSI E W S	24
Verbinder-Pressr.250EWS 10 PRIMUS LINE	32
Verbinder-Pressr.250EWS 16 Art. PRIMUS LINE	32
Verb.-Pressr.DN 250 AS4087 AS4087 E W S	32
Verb.-Pressr.DN 250 10inch ANSI E W S	31,3
Verbinder-Pressr.300EWS 10 PRIMUS LINE	38,9
Verbinder-Pressr.300EWS 16 PRIMUS LINE	38,9
Verb.-Pressr.DN 300 AS4087 AS4087 E W S	38,9

Figure 3: „M-Connector” press ring “Primus Line” system – system data excerpt FRISCHHUT GmbH & Co.KG

Fittings for TRM pipe systems are longitudinally force-locked connections for VRS-T cast iron pipes from Tiroler Rohre GmbH (TRM). FRISCHHUT GmbH & Co KG supplies the fittings for TRM pipe systems uncoated to the manufacturer of the VRS-T pipe systems (Tiroler Rohre GmbH), which coats the fittings itself. The range of validity of fittings for TRM pipes is therefore limited appropriately because the coating required to fulfil the final function is not considered in this EPD. Figure 4 shows an excerpt from the Tiroler Rohre GmbH product catalogue with corresponding technical specifications (including the unit weight for proportional assessment of the specific fittings) for the transfer joint “VRS-T U-piece (short)”.

VRS®-T U-Stück (kurz)

Überschubmuffe

Überschiebbares Doppelmuffenformstück für den Zusammenschluss einer Leitung aus duktilem Gusseisen nach ÖNORM EN 545 sowie Werksnorm. VRS®-T Verbindung nach ÖNORM B 2597. Epoxidharzbeschichtung nach ÖNORM EN 14 901 und RAL-GZ 662.

- ⚠ Zur leichteren Verschiebbarkeit bei der Montage TYTON® Dichtringe verwenden.
- ⚠ TYTON® Dichtringe werden mitgeliefert und dürfen nicht mit den VRS®-T Dichtringen verwechselt werden.
- ⚠ Die Einbauanleitung für Klemmring Verbindungen ist zu beachten!

DN	Artikel Nr.	Maße [mm]$_a$		PFA [bar]	Masse [kg]
		L	B		
80	106080650	161	415	100	12,5
100	106080651	160	430	100	17,0
125	106080652	174	460	100	22,5
150	106080653	180	480	100	30,5
200	106080654	180	500	100	42,5
250	106080655	190	520	100	65,0
300	106089656	200	540	85[1]	96,0
400$_b$	106081174	340	720	63	175,0
500$_b$	106081175	320	720	50	258,3

$_a$ nach EN 545 | B 2597 | Werksnorm

$_b$ HD-Muffe

[1] PFA 100 nach Rücksprache mit Anwendungstechnik möglich.

Figure 4: Transfer joint „U for VRS-T-pipe systems“ – Excerpt from product catalogue Tiroler Rohre GmbH

2.2 Application field

Fittings for plastic pipes are cast fittings in accordance with DIN EN 12842:2012 [4] and are applied to connect PE pipes and PVC-U pressure water pipelines (above or below ground, inside or outside buildings). The corrosion protection of the fittings is performed by an epoxy powder coating (EWS coating - Epoxy-Whirl-Sinter) in accordance with the GSK (Gütegemeinschaft Schwerer Korrosionsschutz – Quality Association for Heavy Duty Corrosion Protection) quality and test specifications RAL-GZ-662 [5].

Fittings for cast iron pipes with flange connections are so-called flanged fittings with flanged sockets in accordance with FGR standard 73 (Fachgemeinschaft Guss-Rohrsysteme – Trade association for cast iron pipe systems) [6] or DIN EN 545:2011 [7] and are applied to make connections for ductile iron pressure water pipelines. The corrosion protection of the fittings is performed by an epoxy powder coating (EWS coating - Epoxy-Whirl-Sinter) in accordance with the GSK (Gütegemeinschaft Schwerer Korrosionsschutz – Quality Association for Heavy Duty Corrosion Protection) quality and test specifications RAL-GZ-662 [5].

Special castings manufactured by the FRISCHHUT GmbH & Co. KG are high-quality customer-specific castings, which are supplied exclusively to these customers. As a representative example the connector press ring of the “M-Connector” system of the “Primus Line” system from Rädlinger primus line GmbH can be named (Figure 3). The “Primus Line” system is used to transport liquid and gaseous media. The flexible liner (not part of the EPD) and the specifically developed connectors (e.g. “M-Connector” - special casting from FRISCHHUT GmbH & Co. KG) form a high-performance system for the trenchless rehabilitation of pressure pipelines or for the construction of resistant unburied hose lines. The corrosion protection of the fittings is performed by an epoxy powder coating (EWS coating - Epoxy-Whirl-Sinter) in accordance with the GSK (Gütegemeinschaft Schwerer Korrosionsschutz – Quality Association for Heavy Duty Corrosion Protection) quality and test specifications RAL-GZ-662 [5]. The finished coated special castings are delivered pre-finished to the manufacturer (in this case Rädlinger primus line GmbH).

Fittings for TRM pipe systems are longitudinally force-locked connections for VRS-T cast iron pipes from Tiroler Rohre GmbH (TRM). FRISCHHUT GmbH & Co KG supplies the fittings for TRM pipe systems uncoated to the manufacturer of the VRS-T pipe systems (Tiroler Rohre GmbH), which coats the fittings itself. The range of validity of fittings for TRM pipes is therefore limited appropriately because the coating required to fulfil the final function is not considered in this EPD. The VRS-T cast iron pipe system is mainly used for drinking water supply and for fire extinguishing pipes, snow-making systems and turbine pipes.

2.3 Standards, guidelines and regulations relevant for the product

Table 1: Product specific standards

Standard	Titel
DIN EN 1563	Founding - Spheroidal graphite cast irons
DIN EN 545	Ductile iron pipes, fittings, accessories and their joints for water pipelines - Requirements and test methods
DIN EN 969	Ductile iron pipes, fittings, accessories and their joints for gas pipelines - Requirements and test methods
DIN EN 598	Ductile iron pipes, fittings, accessories and their joints for sewerage applications - Requirements and test methods
DIN EN 12842	Ductile iron fittings for PVC-U or PE piping systems - Requirements and test methods
DIN EN 14525	Ductile iron and steel wide tolerance couplings and flange adaptors for use with pipes of different materials: ductile iron, Grey iron, steel, PVC-U, PVC-O, PE, fibre-cement
EADIPS/ FGR 73	Double socket tees with flanged branch Ersatz and all flanged tees
EADIPS/ FGR 74	Packaging of ductile iron fittings and valves
RAL-GZ-662	Heavy Duty Corrosion Protection of Valves and Fittings with Powder Coating
DIN EN 1092-2	Flanges and their joints
AS4087	Metallic flanges for waterworks purposes
ASTM A395	Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures
UBA-KTW-BWGL	Evaluation basis for plastics and other organic materials in contact with drinking water
Customer-specific requirements	Data sheets, drawings, CAD data, etc.

2.4 Technical data

Table 2: Technical data for fittings and special castings from FRISCHHUT GmbH & Co.KG

Characterization	Value	Unit
Density cast iron	7100	kg/m³
Tensile strength	≥ 420	MPa
Proportional limit, 0.2% proof stress ($R_{p0,2}$)	≥ 300	MPa
Elongation at break	≥ 5	%
Brinell hardness	≤ 250	HB
Mean coefficient of linear thermal expansion	$12,5*10^{-6}$	m/m*K
Thermal conductivity	0,352	W/cm*K

Figure 1, Figure 2, Figure 3 and Figure 4 show exemplary technical data (dimensions and mass per piece) for fittings for plastic pipes (flanged socket pieces type E-KS), for fittings for cast iron pipes with flange connection (flanged T-pieces), for special castings (connector press ring of the "M-connector" system of the Primus Line system) and for (coated) fittings for TRM pipe systems (VRS-T U-piece (short) - in this EPD coating is not considered for fittings for TRM pipe systems - see 1, 2.1and 3.1).

The technical data (including the unit weight for proportional assessment of the specific fittings and castings) for the respective products can be found in the product catalogues of FRISCHHUT GmbH & Co KG (www.Frischhut.de) and of the respective customer (e.g. Tiroler Rohre GmbH or Rädlinger primus line GmbH).

2.5 Basic/auxiliary materials

Table 3: Basic materials in mass percentage

Fitting	Cast iron	EWS coating[1)]
Fittings for plastic pipes - coated	98,0%	2,0%
Fittings for cast iron pipes with flange connections - coated		
Special castings (high-quality, customised castings) – coated		
Fittings for TRM pipe systems – uncoated	100%	Coating is carried out by TRM – coating of fittings for TRM pipe systems is not considered in this EPD

[1)] Epoxy powder coating made from epoxy resin as well as hardeners, additives, fillers and pigments

Table 4: Basic materials semi-finished cast iron part in mass percentage

Components:	**Mass fraction in %**
Iron [1)]	approx. 94,1 %
Carbon [2)]	approx. 3,9 %
Silicon [3)]	approx. 1,5 %
Iron by-elements [4)]	approx.0,5 %

[1)] Iron from steel scrap (41 %), pig iron (35 %), recycled material or reject parts and swarf (24 %)

[2)] Carbon from carburising agents (electrode graphite)

[3)] Silicon is added in the form of SiC granulate (melting furnace) and ferrosilicon (treatment ladle). There is also a corresponding input from the recycled material and the scrap input.

[4)] Iron by-elements occur in varying, small quantities (<<1%) in applied the steel scrap and come from the magnesium and copper input in the treatment ladle (pre-treatment before the casting process)

The auxiliary materials applied in production are addressed in 2.6 in the respective production phases.

2.6 Production stage

The fittings and special castings are casted (semi-finished part) at the plant Neumarkt St. Veit. The fittings for plastic pipes, the fittings for cast iron pipes with flange connections and the special castings are mechanically processed, blasted or coated (epoxy powder coating) at the plant Pfarrkirchen. FRISCHHUT GmbH & Co. KG delivers the fittings for TRM pipe systems uncoated (as semi-finished part) from the plant Neumarkt St. Veit to the manufacturer of the VRS-T pipe systems (Tiroler Rohre GmbH), which coats the fittings itself. The range of validity of the fittings for TRM pipes is therefore limited appropriately because the coating required to fulfil the final function is not considered in this EPD.

Before melting, the moulds and cores for the cast components to be produced are shaped in the moulding systems (using auxiliary materials such as core and moulding sand – Figure 5, "Production of Moulds and Cores"). The basic materials for the cast iron (steel scrap, pig iron, recycled material, and SiC granulate including carburizing agents (electrode graphite) and inoculant alloys (ferrosilicon), which are then divided into the base materials iron, carbon, and silicon) are melted in two medium-frequency induction furnaces (2 x 5 tons) at the plant Neumarkt St. Veit (Figure 5, "Melting of Basic Materials"). The pre-treatment before the casting process (using propane gas (heat), magnesium, copper (both base materials – iron companion elements), ferrosilicon (base material), and slag binder (auxiliary material)) takes place in a treatment ladle (casting ladle) (not shown in Figure 5 – it is located between "Melting of Raw Materials" and "Pouring of Liquid Iron"). The casting of the analysed products is carried out at the plant Neumarkt St. Veit in two different moulding systems (using the previously created cores and moulds – Figure 5, "Pouring of Liquid Iron"). The fittings for plastic pipes and special castings are casted in moulding system 1, while the fittings for cast iron pipes with flange connections and the fittings for TRM pipe systems are casted in moulding system 2. During the emptying (Figure 5, "Emptying the Moulds") and knocking off (Figure 5, "Cleaning/ Knocking Off the Recycled Material"), a large portion of the cast material is returned to the melting furnaces as recycled material. Subsequently, the knocked-off fittings are blasted (using a blasting media mixture (auxiliary material) – Figure 5, "Blasting the Raw Fittings") and grounded (Figure 5, "Grinding the Raw Fittings").

The cast fittings and special castings are then delivered for further processing to the plant Pfarrkirchen or directly to the customer (uncoated fittings for TRM pipe systems – coating is not considered in this EPD for fittings for TRM pipe systems). The delivered semi-finished parts are first subjected to a leak test (Figure 5, "Leak Testing of Fittings") and then mechanically processed (using indexable inserts, twist drills, reamers, etc. – Figure 5, "Mechanical Processing of Fittings"). Subsequently, the fittings are blasted one more time (using blasting media (auxiliary material) – Figure 5, "Blasting the Fittings") and finally coated with epoxy powder (EWS coating – epoxy whirl sintering) – Figure 5, "Epoxy Coating of Fittings").

In the course of the manufacturing process, moulding and core sands as well as the blasting media utilised are reused or recycled as often as possible.

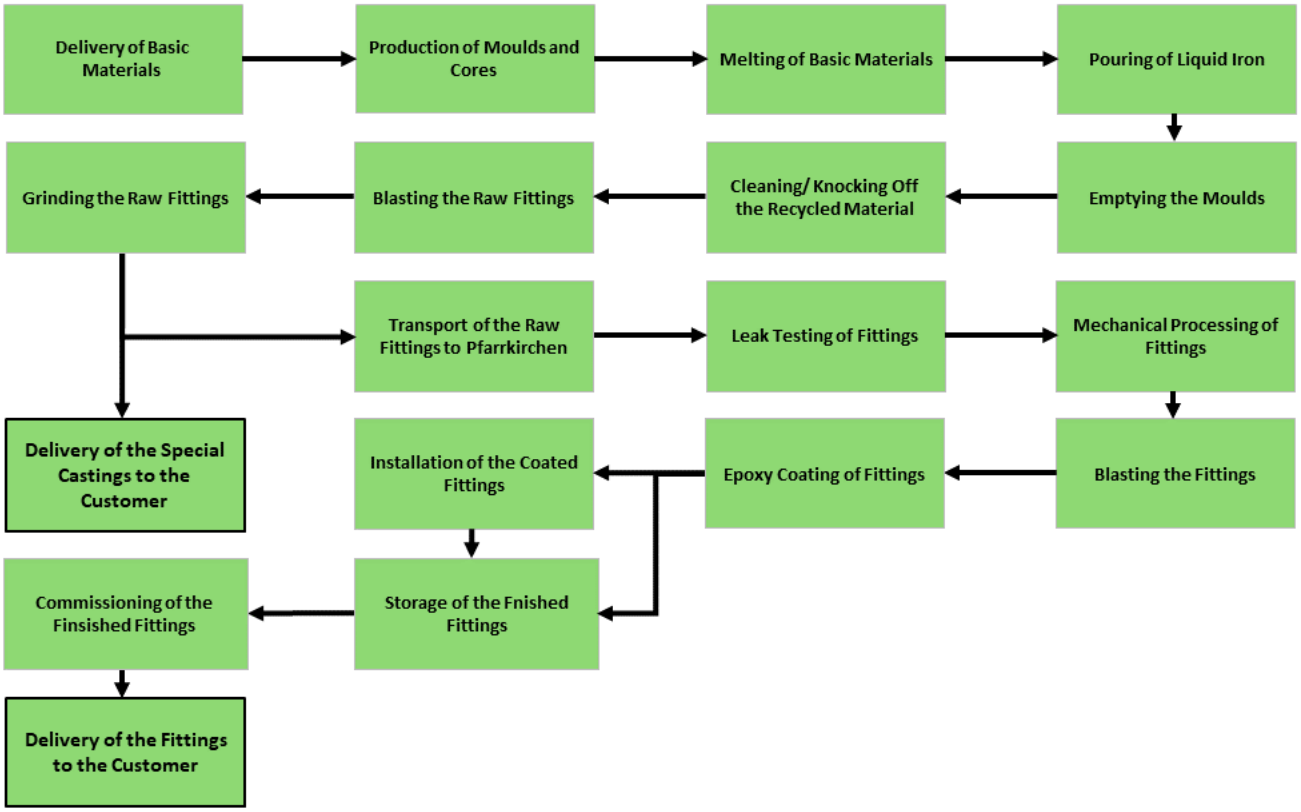


Figure 5: Flowchart of manufacturing processes

2.7 Packaging

Coated fittings and special castings from FRISCHHUT GmbH & Co. KG, with their highly varying shapes and sizes, are packaged, stored and/ or bundled for transport in different ways. Depending on their shape and dimensions, materials such as cardboard blanks, single-use wooden flat pallets, pressed wood pallets, square timber, wooden stacking frames, intermediate layers made of polypropylene (PP), as well as strapping bands, shrink covers, flat sacks, protective caps, end caps, and covers made of polyethylene (PE) are used.

Fittings for TRM pipe systems are simply placed in mesh boxes and delivered to customers without any additional packaging materials.

2.8 Conditions of delivery

The fittings and special castings are packaged, stored and/ or bundled for transport in various ways depending on their shape and dimensions. The fittings must be transported and stored with appropriate care. The storage regulations applicable at the place of use and the guidelines in the technical documentation must be observed.

2.9 Transport to site

The transport of the fittings to their destination within Europe is carried out by lorry and, for overseas destinations, additionally by ship.

2.10 Construction product stage

The considered fittings and special castings made of cast iron by FRISCHHUT GmbH & Co. KG are primarily used for pressure pipelines in water supply systems.

The installation of pressure pipelines made of ductile cast iron must comply with DIN EN 805:2000 [8] (Water supply - Requirements for systems and components outside buildings). When constructing a trench for the pipeline, sufficient working space for the installation of the pipeline must be provided, depending on the trench depth and the external diameter of the pipe. Corresponding safety regulations, as well as relevant standards and guidelines, must be observed accordingly.

The trench must be designed and excavated in such a way that all pipeline components are located at frost-free depths. The trench must be excavated to a depth that ensures the final covering height is at least 1.50 m. Generally, the existing soil is suitable for bedding ductile cast iron pipes. Therefore, a lower bedding layer can be omitted, and the trench bottom serves as the lower bedding.

The bedding of the pipeline and the backfilling of the trench must be carried out in such a way that the pipeline is securely fixed in its intended position, damage to the pipeline is avoided, and settlements occur only within permissible limits. Suitable material that does not damage the pipeline components or their coating must be used for bedding the pipeline. The backfill material should be applied in layers and sufficiently compacted.

The construction of a trench for the pressure water pipeline is considered to be a part of the construction process for the water pipeline itself. Fittings made of ductile cast iron complement the pipeline construction, which is why the trench construction is not considered in the EPD for the fittings.

In some cases, additional efforts, such as the possible application of sealing compounds, may be required for the installation of the fittings. However, in this EPD, only the fitting and special casting itself are considered due to the variety of possible applications and the minimal and infrequent use of additional efforts.

2.11 Use stage

For construction products made of cast iron, no changes in the material composition occur over the period of use, provided proper planning, correct and professional installation, and trouble-free operation.

2.12 Reference service life (RSL)

Table 5: Reference service life (RSL)

Characterization	value	unit
Product name	100	years

Based on the DVGW damage statistics (Deutscher Verein des Gas- und Wasserfaches – German Technical and Scientific Association for Gas and Water – https://www.dvgw.de/themen/sicherheit/gas-und-wasserstatistik/), it has been shown that in praxis a service life of over 100 years can be achieved.

2.13 Reuse and recycling

In urban areas, the main application field for water pressure pipelines, pipeline components are currently almost entirely dismantled. The fittings can then be fed into an appropriate recycling process, meaning the entire removed iron mass can be processed and reused as a raw material. Therefore, in the scenarios considered in this EPD, the dismantle and recycling rate has been set correspondingly high (see 3.2.4).

FRISCHHUT GmbH & Co. KG offers a service where dismantled cast products are reprocessed through collaborations with waste management companies and reintegrated into production, in order to create a closed-loop material cycle.

2.14 Disposal

In very rare cases, cast iron fittings are disposed of. The European Waste Catalogue (EWC) code for iron and steel from construction and demolition is 170405.

2.15 Further information

Further information on the fittings and special castings considered, as well as their possible applications, can be found on the website of the FRISCHHUT GmbH & Co.KG www.Frischhut.de.

3 LCA: Calculation rules

3.1 Declared unit/ Functional unit

The declared unit is 1 ton of the average fittings for plastic pipes, of the fittings for cast iron pipes with flange connections and of the special castings, each with epoxy powder coating.

For the fittings for TRM pipe systems, 1 ton of the uncoated fitting produced by the FRISCHHUT GmbH & Co. KG is declared, as these are coated by the pipe system manufacturer (Tiroler Rohre GmbH – TRM) itself. The range of validity of the fittings for TRM pipes is therefore appropriately limited, as the coating necessary to fulfil the final function is not considered in this EPD.

Any additional components (seals, pipes, liners, etc.) required for the application of the products under consideration are not considered in this EPD.

The performance tracking system of FRISCHHUT GmbH & Co. KG enables an average evaluation of the respective process steps (except for casting processes in the two different moulding systems (see 2.6)). The proportional scaling of the results based on the unit weight [kg/piece] for the assessment of specific fittings and casting parts (see, e.g., Figure 1, Figure 2, Figure 3, and Figure 4) is therefore subjected to slight deviations due to the average analysis of the production steps. However, FRISCHHUT GmbH & Co.KG states that the mass ratio of cast iron to coating involves very minor deviations (in the µ-range), because all products are generally calculated and produced with 2% (0.020 kg per ton) coating and 98% casting. This ratio is applied for each product via an automated process (coating robot).

The fittings for plastic pipes, fittings for cast iron pipes with flange connections, and the special castings are pre-coated (2% epoxy powder coating by mass) fittings made of ductile cast iron (98% by mass). The fittings for TRM pipe systems are delivered as pure cast iron products (100% by mass) to the manufacturer of the VRS-T pipes (Tiroler Rohre GmbH), who coats the fittings itself. The range of validity of the fittings for TRM pipes is therefore limited because the coating required to fulfiltheir final function is not considered in this EPD.

Table 6 shows the unit weight (kg/piece) as well as the multiplication factor (mass-related quantity – pieces/kg) exemplarily for one selected product from each of the four considered product categories (selected products are also shown in Figure 1, Figure 2, Figure 3, and Figure 4).

Table 6: Unit weight and multiplication factor

Product	Unit weight [kg/piece]	Multiplication factor [piece/kg]
Fittings for plastic pipes: E-KS DN 100	6,2	0,161290
Fittings for cast iron pipes with flange connections: T-DN 200/100	36,1	0,027701
Special castings: Connector press ring 150	15,8	0,063291
Fittings for TRM pipe systems: U 400 VRS-T (coated – coating for fittings for TRM pipe systems is not considered in this EPD)	175,0	0,005714

3.2 System boundary

The entire product life cycle is declared, i.e., this is a "cradle-to-grave" EPD (A+B+C+D). The fittings for TRM pipe systems are delivered uncoated as semi-finished products to the manufacturer of the VRS-T pipes (Tiroler Rohre GmbH), who coats the fittings itself. The range of validity of the fittings for TRM pipes is therefore limited because the coating required to fulfil the final function is not considered in this EPD.

Table 7: 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 Production stage:

The fittings and special castings are largely produced of the secondary material steel scrap. The steel scrap applied comes from Germany (Straubing) and Austria (Vienna). The pig iron is sourced from Germany (Duisburg). The system boundary for steel scrap is set when the processed steel scrap leaves the recycling plant, because then the end of waste status is reached (see 3.2.4 for regulations). The transport of the iron scrap to the plant in Neumarkt St. Veit is considered within the system boundaries of the declared cast iron products. The production phase includes the manufacturing steps in the plants, including energy supply (including upstream chains), the production of basic materials, auxiliary materials, packaging, transports to the plant, the infrastructure, and the disposal of waste generated during production.

Except for the casting in the two different moulding systems (see 2.6), the material and energy flows for cast iron production at the plant Neumarkt St. Veit are considered identical for all product categories, as the manufacturing process and material composition differ only slightly.

The fittings for plastic pipes, the fittings for cast iron pipes with flange connections, and the special castings are transported from the plant Neumarkt St. Veit to the plant Pfarrkirchen (distance: 36.6 km), where they are mechanically processed, blasted, and coated (epoxy powder coating). The material and energy flows for completing the fittings at the plant Pfarrkirchen are considered identical for the three product categories. Potential deviations (from the considered average) in the mass ratio of cast iron to coating for specific products are very minor (in the µ-range), because all products are generally calculated and produced with 2% (0.020 kg per ton) coating and 98% casting. This ratio is applied for each product via an automated process (coating robot).

The fittings for TRM pipe systems are delivered uncoated to the manufacturer of the VRS-T pipes (Tiroler Rohre GmbH), who coats the fittings itself. Therefore, coating is not considered in this EPD for these fittings. The range of validity of the fittings for TRM pipes is therefore limited because the coating required to fulfil their final function is not considered in this EPD.

Slag and filter dust generated during production can be disposed of in an inert waste landfill. During the manufacturing process, mould and core sand, as well as the blasting media applied, are reused as often as possible. Mould and core sand as well as blasting media (including filter dust) that can no longer be reused, are disposed of appropriately.

3.2.2 A4-A5 Construction process stage:

The fittings and special castings are transported to their destination by lorry within Europe and also by ship overseas. For the products delivered directly by FRISCHHUT GmbH & Co. KG (fittings for plastic pipes, fittings for cast iron pipes with flange connections and special castings), the client provided the information on transportation shown in Table 8.

Table 8: Average transportation distances

Country	Distribution	Average transportation distances lorry [km]	Average transportation distances ship [km]
Germany	69,698%	381	
Belgium	5,300%	842	
France	4,724%	893	
Austria	3,341%	290	
Croatia	2,309%	522	
Norway	2,274%	1 560	
Argentina	2,142%	1 368	13 050
Albania	1,582%	1 337	
Italy	1,287%	517	
Poland	1,209%	685	
Czech Republic	0,797%	302	
Luxembourg	0,714%	645	
Netherlands	0,642%	723	
Lithuania	0,568%	1 417	
Qatar	0,486%	920	12 945
Finland	0,483%	2 254	
Switzerland	0,428%	460	
Slovakia	0,308%	397	
Latvia	0,298%	1 166	
Slovenia	0,282%	423	
Spain	0,246%	1 507	
Bulgaria	0,180%	1 336	
Sweden	0,140%	1 382	
England	0,119%	1 422	
Sri Lanka	0,117%	1 050	13 235
Hungary	0,086%	563	
Bahrain	0,080%	950	12 925
Israel	0,057%	2 547	
Denmark	0,046%	1 138	
Dubai - UAE	0,045%	950	12 535
Bosnia and Herzegovina	0,005%	892	
Romania	0,004%	1 374	
Ireland	0,004%	1 864	
Total	**100,00%**		

For the assessment of the uncoated fittings of the TRM pipe systems, the transport to the Tiroler Rohre GmbH plant in Hall in Tirol (218 km) and the average delivery distances from the EPD for the VRS®-T pipe system from 2020 (reference year 2017) [9] were applied (lorry: 350.41 km, ship: 118.20 km).

The construction of a trench for pressure water pipelines is seen as part of the construction process for the water pipeline itself. Ductile iron fittings complement the pipeline construction, which is why the production of the trench is not considered. The cardboard blanks required for transportation are fed into a corresponding recycling process, which is why only transportation to the recycling plant is taken into account. Single-use wooden flat pallets, pressed wood pallets, square timber, wooden stacking frames, intermediate layers made of polypropylene (PP), strapping bands, shrink covers, flat sacks, protective caps, end caps, and covers made of polyethylene (PE) are thermally recycled.

3.2.3 B1-B7 Use stage:

In general, no LCA-relevant processes occur during the use stage of cast iron construction products.

3.2.4 C1-C4 End-of-life stage:

Like the construction of the trench for the pressure water pipeline, dismantling is seen as part of the construction process for the water pipeline itself. Ductile iron fittings complement the pipeline construction, which is why the dismantling processes are not taken into account for the EPD of the fittings.

In inner-city areas, the main area of application for pressure pipes for water supply, the installed pipe systems are usually dismantled because due to the limited space available and the usually high number of other installations it is not possible to leave the pipes in the ground. For this reason, a scenario with a 100 % dismantling rate is applied.

The dismantled fittings and special castings are fed into a recycling process and considered until they reach the end of waste status in the current product system. The system boundary is when the processed steel scrap leaves the recycling plants. From this point onwards, the fitting under consideration is part of a new product system.

The recycling scenario for the cast iron products under consideration was defined in cooperation with FRISCHHUT GmbH & Co. The manufacturer argues that due to their compactness (compared to the elongated pipes and piles), the fittings and special castings under consideration can be dismantled in an almost non-destructive way and can be fed into a recycling process (99%). 1 % must be sent to a landfill process due to breakage etc. The recycling scenario used is a manufacturer scenario that was determined based on the experience of FRISCHHUT GmbH & Co. KG and depicts a scenario in the future (after the end of life). It was taken into account that cast iron products will be dismantled as a whole in the future in order to avoid waste of secondary raw materials and will be completely recycled. The recycling scenario must be checked and adapted accordingly for the respective application of the EPD.

3.2.5 D Benefits and loads:

The recycling of the dismantled fittings and special castings results in a corresponding output of secondary raw materials in C3. The output flows are compared with the proportion of scrap in the production of the fittings (net output flow) in accordance with the net flow rule as per EN 15804 [3]. As mentioned, the recycling and net flow scenario applied in this EPD is a manufacturer scenario based on empirical values from FRISCHHUT GmbH & Co. KG, which must be checked and adjusted accordingly in the respective application of the EPD.

However, due to the multi-recycling potential of the fittings and special castings, these could replace primary raw materials to a gross extent in the next product system. The multi-recycling potential is shown as additional information in this EPD. This is a value that does not comply with the rules and specifications of EN 15804 [3]. The multi-recycling potential is therefore also explicitly shown in the results as additional information and as “not compliant with EN 15804”. As mentioned, the analysis of the multi-recycling potential is also a manufacturer scenario based on empirical values from FRISCHHUT GmbH & Co KG.

For the thermal recovery of transport aids and packaging, it is assumed that the energy recovery is divided into 1/3 electricity (with an efficiency of 17%) and 2/3 heat (with an efficiency of 75%).

3.3 Flow chart of processes/stages in the life cycle

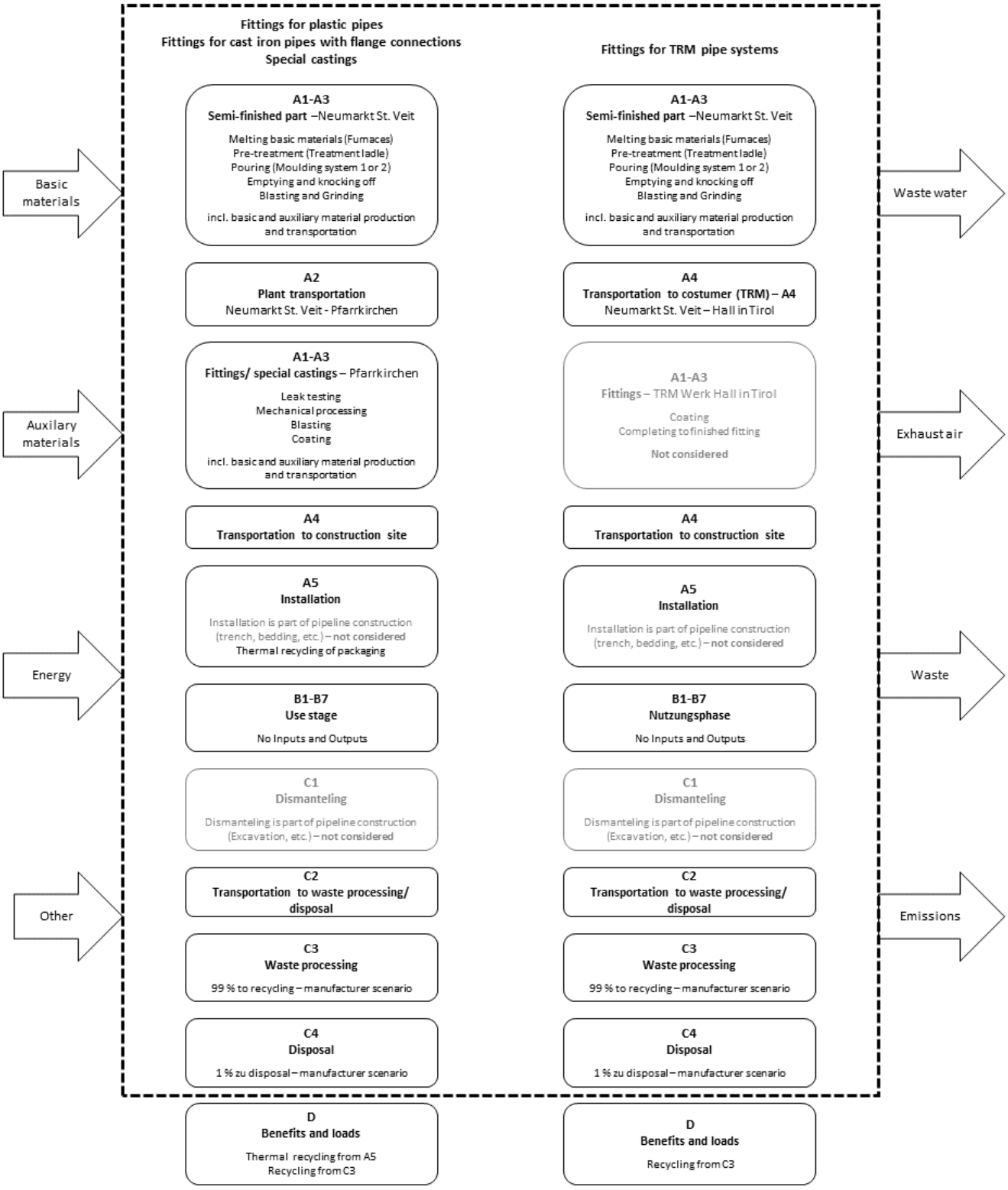


Figure 6: Flow chart life cycle

3.4 Estimations and assumptions

The manufacturer provided a data sheet with the material composition for the slag binder applied in the pre-treatment phase. Based on this information, a data set for the slag binder based on corresponding ecoinvent data sets was modelled.

The moulding sand applied in the moulding systems was modelled based on information from literature sources [10] and information from FRISCHHUT GmbH & Co.

As the infrastructure has a minor impact on the LCA results, the machines were only mapped with the main components steel and cast iron.

All transportation distances for basic material deliveries were recorded by the customer and taken into account in the life cycle assessment.

3.5 Cut-off criteria

The manufacturer has recorded and submitted the quantities of all materials applied, the energy required, the quantities of packaging materials, the quantities of waste produced and the method of disposal, as well as the infrastructure required (buildings and machinery for production). The measured values for emissions in accordance with the Foundry Ordinance were provided.

Auxiliary materials or waste whose material flows account for less than 1% by mass of all inputs in A1-A3 or all outputs in C1-C4 were disregarded. These are cutting wheels, grinding wheels, abrasive additives, coating waste, hydraulic fluid, lubricating oils, marking ink, etc. It can be assumed that the sum of the neglected processes accounts for less than 5% of the impact categories.

TRM pipe systems are delivered uncoated as semi-finished products to the manufacturer of the VRS-T pipes (Tiroler Rohre GmbH), who coats the fittings itself. The range of validity of the fittings for TRM pipes is therefore limited because the coating required to fulfil the final function is not considered in this EPD. The coating in the TRM factory and any transportation aids (cardboard, wood, etc. - including disposal) for the coated fittings of the TRM pipe systems are not considered in this EPD because no detailed information on the coating process (raw materials, energy, etc.) and the transportation characteristics (delivered together with the pipe system) was provided.

3.6 Background data

The background database applied was ecoinvent 3.9.1 with the “cut-off by classification” system model.

3.7 Data quality

The data for the production of the average fittings and special castings was collected at the plants Neumarkt St. Veit and Pfarrkirchen using the FRISCHHUT GmbH & Co KG performance tracking system. Measured values required by the Foundry Ordinance were applied for the emissions. The completeness and plausibility of the manufacturer's data was checked in several consultations with key personnel at the two plants.

The following quality requirements were taken into account when collecting foreground data (primary data) at the plants:

- The criteria of Bau EPD GmbH for data collection and the delimitation of material and energy flows are complied with.
- The data used corresponds to the annual average for the reference year 2022.
- All essential data such as energy and raw material requirements as well as transportation routes within the system boundary were provided by the manufacturer (using a data collection form).

According to the specifications of Bau EPD GmbH (MS-HB [1]), the electricity mix (product mix) actually used in the plants must be taken into account. In Germany, the Federal Environment Agency (only) registers Guarantees of Origin for the renewable share of electricity products. However, the electricity supplier of FRISCHHUT GmbH & Co. KG does not provide any guarantees of origin for the renewable shares for the electricity product supplied in 2022 (reference year), which is why the German residual mix is used for the assessment.

The data is representative for the fittings and special castings produced at the plants Neumarkt St. Veit and Pfarrkirchen in the production year 2022.

3.8 Reporting period

The data applied for the production of the fittings and special castings correspond to the annual average for the production year 2022.

3.9 Allocation

The system boundary for the steel scrap is set when the processed steel scrap leaves the recycling plants, as this is the end of waste status for the scrap. The transport of the iron scrap to the plant in Neumarkt St. Veit is considered within the system boundaries of the declared cast iron products.

In the liquid iron sector, an allocation by mass was carried out between the fittings and special castings considered in this EPD and the products not considered (referred to stock ingress). The same applies for the consideration of wastes.

The performance tracking system of FRISCHHUT GmbH & Co. KG enables an average evaluation of the respective process steps (except for casting processes in the two different moulding systems (see 2.6)). The proportional scaling of the results based on the unit weight [kg/piece] for the assessment of specific fittings and casting parts (see, e.g., Figure 1, Figure 2, Figure 3, and Figure 4) is therefore subjected to slight deviations due to the average analysis of the production steps. However, FRISCHHUT GmbH & Co.KG states that the mass ratio of cast iron to coating involves very minor deviations (in the µ-range), because all products are generally calculated and produced with 2% (0.020 kg per ton) coating and 98% casting. This ratio is applied for each product via an automated process (coating robot).

The fittings for plastic pipes and special castings are casted in moulding system 1, while the fittings for cast iron pipes with flange connections and the fittings for TRM pipe systems are casted in moulding system 2. The average consumption of core and moulding sand for the respective moulding system is taken into account here.

The fittings for plastic pipes, the fittings for cast iron pipes with flange connections, and the special castings are transported from the plant Neumarkt St. Veit to the plant Pfarrkirchen (distance: 36.6 km), where they are mechanically processed, blasted, and coated (epoxy powder coating). The material and energy flows for completing the fittings at the plant Pfarrkirchen are considered identical for the three product categories. Potential deviations (from the considered average) in the mass ratio of cast iron to coating for specific products are very minor (in the µ-range), because all products are generally calculated and produced with 2% (0.020 kg per ton) coating and 98% casting. This ratio is applied for each product via an automated process (coating robot).

The fittings for TRM pipe systems are delivered uncoated to the manufacturer of the VRS-T pipes (Tiroler Rohre GmbH), who coats the fittings itself. Therefore, coating is not considered in this EPD for these fittings. The range of validity of the fittings for TRM pipes is therefore limited because the coating required to fulfil their final function is not considered in this EPD.

The recycling of the dismantled fittings and special castings results in a corresponding output of secondary raw materials in C3. The output flows are compared with the proportion of scrap in the production of the fittings (net output flow) in accordance with the net flow rule as per EN 15804 [3]. The recycling and net flow scenario applied in this EPD is a manufacturer scenario based on empirical values from FRISCHHUT GmbH & Co. KG, which must be checked and adjusted accordingly in the respective application of the EPD.

3.10 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 [3], 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 EN 15804 [3], 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 production 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.

4.2 A4-A5 Construction process stage

The fittings and special castings are transported to their destination by lorry within Europe and also by ship overseas. For the products delivered directly by FRISCHHUT GmbH & Co. KG (fittings for plastic pipes, fittings for cast iron pipes with flange connections and special castings), the client provided information on transportation (Table 8).

For the assessment of the uncoated fittings of the TRM pipe systems, the transport to the Tiroler Rohre GmbH plant in Hall in Tirol (218 km) and the average delivery distances from the EPD for the VRS®-T pipe system from 2020 (reference year 2017) [9] were applied (lorry: 350.41 km, ship: 118.20 km). No transport aids (e.g. cardboard, wood, etc.) and their disposal are taken into account in this EPD for the delivery of the fittings from Tiroler Rohre GmbH to their destination.

Table 9 shows the general parameters for describing transportation to the building site.

Table 9: Description of the scenario „Transport to building site (A4)“

Parameters to describe the transport to the building site (A4)	Value	Unit
Average transport distance	see Table 8	km
vehicle type, Commission Directive 2007/37/EC (European Emission Standard)	Euro 6 and transoceanic cargo ship	-
Average fuel consumption, fuel type: Diesel or heavy fuel oil	25.3 and 9.000	l/100 km
Average transport mass	5.79 and 30,100	tons
Average capacity utilisation (including empty returns)	85 and 70	%
Average gross density of transported products	7,100	kg/m³
Volume capacity utilisation factor (factor: =1 or <1 or ≥ 1 for compressed or nested packaged products)	<1	-

The considered fittings and special castings made of cast iron by FRISCHHUT GmbH & Co. KG are primarily used for pressure pipelines in water supply systems. The construction of a trench for pressure water pipelines is seen as part of the construction process for the water pipeline itself. Ductile iron fittings complement the pipeline construction, which is why the production of the trench is not considered.

In some cases, additional efforts, such as the possible application of sealing compounds, may be required for the installation of the fittings. However, in this EPD, only the fitting and special casting itself are considered due to the variety of possible applications and the minimal and infrequent use of additional efforts.

The cardboard blanks required for transportation of the fittings for plastic pipes, the fittings for cast iron pipes with flange connections, and the special castings produced in Pfarrkirchen are fed into a corresponding recycling process, which is why only transportation to the recycling plant is taken into account. Single-use wooden flat pallets, pressed wood pallets, square timber, wooden stacking frames, intermediate layers made of polypropylene (PP), strapping bands, shrink covers, flat sacks, protective caps, end caps, and covers made of polyethylene (PE) are thermally recycled.

Table 10 shows the general parameters for describing the installation.

Table 10: 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);	Part of the pipeline construction	kg/t t/t l/t
Ancillary materials for installation (specified by type)		-
Water use		m3/t l/t
Other resource use		kg/t t/t l/t
Electricity demand		kWh or MJ/t
Other energy carrier(s): Diesel		kWh or MJ/t
Wastage of materials on the building site before waste processing, generated by the product's installation (specified by type)	-	kg/t
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)	Wood – 8.06, Polypropylene (PP) – 0.58, Polyethylene (PE) – 10.11	kg/t
Direct emissions to ambient air (such as dust, VOC), soil and water	-	tg/t

4.3 B1-B7 use stage

In the use phase, there are no material and energy flows relevant to the LCA for the fittings or special castings under consideration, which is why no activities were taken into account here.

4.4 C1-C4 End-of-Life stage

In inner-city areas, the main area of application for pressure pipes for water supply, the installed pipe systems are usually dismantled because due to the limited space available and the usually high number of other installations it is not possible to leave the pipes in the ground. For this reason, a scenario with a 100 % dismantling rate is applied. The dismantled fittings and special castings are fed into a recycling process and considered until they reach the end of waste status in the current product system. The system boundary is when the processed steel scrap leaves the recycling plants. From this point onwards, the fitting under consideration is part of a new product system. The recycling scenario for the cast iron products under consideration was defined in cooperation with FRISCHHUT GmbH & Co. The manufacturer argues that due to their compactness (compared to the elongated pipes and piles), the fittings and special castings under consideration can be dismantled in an almost non-destructive way and can be fed into a recycling process (99%). 1 % must be sent to a landfill process due to breakage etc. The recycling scenario used is a manufacturer scenario that was determined based on the experience of FRISCHHUT GmbH & Co. KG and depicts a scenario in the future (after the end of life). It was assumend that cast iron products will be dismantled as a whole in the future in order to avoid waste of secondary raw materials and will be completely recycled. The recycling scenario must be checked and adapted accordingly for the respective application of the EPD.

Like the construction of the trench for the pressure water pipeline, dismantling is seen as part of the construction process for the water pipeline itself. Ductile iron fittings complement the pipeline construction, which is why the dismantling processes are not taken into account for the EPD of the fittings.

Table 11: Description of the scenario "Dismantling (C1)"

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

The transport distance to the nearest recycling company (99 % of the fittings and special castings) and to the nearest inert material landfill (1 % of the fittings and special castings) was assumed to be 100 km, which results in a transport process of 100 ton-kilometres.

Table 12: 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	7,100	kg/m^3
Volume capacity utilisation factor (factor: =1 or <1 or ≥ 1 for compressed or nested package products)	<1	-

In C3, the recycling of fittings and special castings (99%), i.e., the processing of the dismantled products in a recycling plant (sorting and pressing) to a secondary raw material that can be used in cast iron and steel production, is taken into account. A new product system begins with the transportation of the processed scrap from the recycling plant to the production plant.

In C4, the landfilling of 1% of the mass of fittings and special castings at an inert material landfill is taken into account.

Table 13: Disposal processes (C3 and C4) per ton [t] Fitting/special casting

Product	Mass	Total mass to Recycling 99%	Total mass to disposal 1%
	[kg]	*[kg]*	*[kg]*
Fittings und Special castings	1000	990	10

Table 14: Description of the scenario „Disposal of the product (C1 to C4)"

Parameters for End-of-Life stage (C1-C4)	value	Quantity per m^3 insulation material
Collection process, separately	1000	kg collected separately
Recycling	990	kg for recycling
Disposal, inert material landfill	10	kg material for final deposition

4.5 D Potential of reuse and recycling

The recycling of the dismantled fittings and special castings (99%) results in a corresponding output of secondary raw materials in C3. The net flow rule in accordance with EN 15804 and the proportion of scrap in the production of fittings and special castings result in the net output flow shown in Table 15.

Table 15: Net flow steel scrap in C3

Product	Mass per product	Cast iron in product	Product to recycling	Cast iron to Recycling	Scrap input per t product	Net flow
	[kg]	*[kg]*	*[%]*	*[kg]*	*[kg]*	*[kg]*
Fittings for plastic pipes - coated	1000	980.4	99%	970.60	547.79	422.81
Fittings for cast iron pipes with flange connections - coated						
Special castings (high-quality, customised castings) – coated						
Fittings for TRM pipe systems – uncoated	1000	1000	99%	990.00	547.789	442.21

Due to the multi-recycling potential of the fittings and special castings, these could replace primary raw materials to a gross extent in the next product system. The multi-recycling potential is shown as additional information in this EPD. This is a value that does not comply with the rules and specifications of EN 15804 [3]. The multi-recycling potential is therefore also explicitly shown in the results as additional information and as “not compliant with EN 15804”. As mentioned, the analysis of the multi-recycling potential is also a manufacturer scenario based on empirical values from FRISCHHUT GmbH & Co KG.

Table 16: Multi-recycling potential (not compliant with the rules and specifications of EN 15804)

Product	Mass per product	Cast iron in product	Product to recycling	Multi-recycling potential
	[kg]	*[kg]*	*[%]*	*[kg]*
Fittings for plastic pipes - coated	1000	980.4	99%	970.60
Fittings for cast iron pipes with flange connections - coated				
Special castings (high-quality, customised castings) – coated				
Fittings for TRM pipe systems – uncoated	1000	1000	99%	990.00

For the calculation of D from A5 (for the thermal recycling of the transport aids of the fittings for plastic pipes, fittings for cast iron pipes with flange connections and special castings coated in Pfarrkirchen), the lower heat values are taken from the ecoinvent data sets for thermal recycling. For thermal recycling, it was assumed that the energy recovery is divided into 1/3 electricity (with an efficiency of 17%) and 2/3 heat (with an efficiency of 75%).

Table 17: Calculation D from A5

	Output	Lower heat value	Benefits electricity	Benefits heta
	[kg/t]	[MJ/kg]	[MJ/t]	[MJ/t]
Waste incineration (PP)	0.58	32.78	1.08	9.49
Waste incineration (Wood)	8.06	13.99	6.39	56.41
Waste incineration (PE)	1.01	42.47	2.43	21.47
D from A5			**9.90**	**87.38**

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	See Table 17, Column 2 (=Secondary fuels), Column 4 (=Energy recovery electricity), Column 5 (=Energy recovery heat)	MJ/t and kg/t
Materials for reuse, recovery or recycling from B2-B5		%
Energy recovery or secondary fuels from B2-B5		MJ/t and kg/t
Materials for reuse, recovery or recycling from C1-C4		%

5 LCA: results

5.1 Fittings for plastic pipes – coated

As the fittings for plastic pipes and the special cast elements both pass through moulding line 1 during production in Neumarkt St. Veit, both receive an average coating at the Pfarrkirchen plant and both have an identical further life cycle, the results for these two categories are congruent. The results for these product categories are nevertheless presented separately in 5.1 (fittings for plastic pipes) and 5.3 (special castings).

Table 19: Results parameters to describe the environmental impact per ton [t] fittings for plastic pipes

EN 15804 compliant results												Additional information on multi-recycling potential These values do not comply with the rules and specifications of EN 15804 (net flow rule)	Not EN 15804 compliant results
Parameter	**Unit**	**A1 - A3**	**A4**	**A5**	**B1 - B7**	**C1**	**C2**	**C3**	**C4**	**D fromA5**	**D from C3**		**Multi-Rec**
GWP total	kg CO2 eq.	2.69E+03	1.02E+02	4.61E+01	0.00E+00	0.00E+00	1.85E+01	2.52E+01	6.08E-02	4.62E+00	-6.87E+02		-1.58E+03
GWP fossil fuels	kg CO2 eq.	2.71E+03	1.02E+02	3.27E+01	0.00E+00	0.00E+00	1.85E+01	2.57E+01	6.08E-02	4.60E+00	-6.89E+02		-1.58E+03
GWP biogenic	kg CO2 eq.	2.57E+01	0.00E+00	-2.57E+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
GWP luluc	kg CO2 eq.	9.13E-01	5.15E-02	3.55E-04	0.00E+00	0.00E+00	9.12E-03	3.76E-02	3.67E-05	4.29E-03	-1.74E-01		-4.00E-01
ODP	kg CFC-11 eq.	6.20E-05	2.20E-06	2.07E-08	0.00E+00	0.00E+00	4.02E-07	4.08E-07	1.76E-09	9.90E-08	-1.66E-05		-3.82E-05
AP	mol H+ eq.	9.54E+00	3.28E-01	6.65E-03	0.00E+00	0.00E+00	4.04E-02	2.87E-01	4.58E-04	1.20E-02	-2.58E+00		-5.93E+00
EP freshwater	kg P eq.	1.00E+00	7.12E-03	1.36E-04	0.00E+00	0.00E+00	1.31E-03	1.51E-02	5.06E-06	9.24E-04	-2.81E-01		-6.44E-01
EP marine	kg N eq.	1.98E+00	8.25E-02	3.15E-03	0.00E+00	0.00E+00	1.02E-02	6.71E-02	1.76E-04	2.73E-03	-6.21E-01		-1.43E+00
EP terrestrial	mol N eq.	2.12E+01	8.64E-01	3.17E-02	0.00E+00	0.00E+00	1.04E-01	7.48E-01	1.88E-03	2.81E-02	-6.58E+00		-1.51E+01
POCP	kg NMVOC eq.	8.75E+00	4.18E-01	8.84E-03	0.00E+00	0.00E+00	6.27E-02	2.24E-01	6.56E-04	1.13E-02	-3.68E+00		-8.46E+00
ADPE	kg Sb eq.	1.83E-02	3.25E-04	2.41E-06	0.00E+00	0.00E+00	6.04E-05	1.58E-03	8.44E-08	2.64E-06	-3.54E-04		-8.13E-04
ADPF	MJ Hu	3.80E+04	1.44E+03	1.08E+01	0.00E+00	0.00E+00	2.62E+02	3.48E+02	1.51E+00	6.75E+01	-7.26E+03		-1.67E+04
WDP*	m3 Welt eq. entz.	2.86E+02	5.87E+00	9.54E-02	0.00E+00	0.00E+00	1.08E+00	4.22E+00	6.69E-02	4.39E-01	-3.57E+01		-8.19E+01
Legend		GWP = Global warming potential; luluc = Land use and land use change; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential; EP = Eutrophication potential; POCP = Formation potential of tropospheric ozone; ADP = Abiotic depletion potential; WDP = Water deprivation potential (users)											

*WDP: The results of this environmental impact indicator must be used with caution, as the uncertainties in these results are high.

“Multi-Rec” shows the multi-recycling potential without taking the net flow rule into account - value not compliant with EN 15804

Table 20: Results additional environmental impact indicators per ton [t] fittings for plastic pipes

EN 15804 compliant results												Additional information on multi-recycling potential These values do not comply with the rules and specifications of EN 15804	Not EN 15804 compliant results
Parameter	**Unit**	**A1 - A3**	**A4**	**A5**	**B1 - B7**	**C1**	**C2**	**C3**	**C4**	**D from A5**	**D from C3**		**Multi-Rec**
PM	Disease incidence	1.32E-04	7.45E-06	6.97E-08	0.00E+00	0.00E+00	1.38E-06	3.97E-06	1.00E-08	9.33E-08	-4.81E-05		-1.10E-04
IRP	kBq U235 equiv	3.02E+02	1.91E+00	1.38E-02	0.00E+00	0.00E+00	3.55E-01	2.77E+00	9.59E-04	2.84E-01	-8.89E+00		-2.04E+01
ETP-fw	CTUe	1.02E+04	7.14E+02	1.05E+01	0.00E+00	0.00E+00	1.30E+02	2.73E+02	7.11E-01	6.69E+00	-1.96E+03		-4.49E+03
HTP-c	CTUh	5.14E-06	4.65E-08	1.72E-09	0.00E+00	0.00E+00	8.42E-09	3.92E-08	2.59E-11	7.63E-10	-3.82E-06		-8.77E-06
HTP-nc	CTUh	2.86E-05	1.01E-06	7.15E-08	0.00E+00	0.00E+00	1.86E-07	1.76E-06	3.24E-10	1.95E-08	-2.60E-06		-5.96E-06
SQP	Points	8.65E+03	8.49E+02	5.16E+00	0.00E+00	0.00E+00	1.59E+02	6.18E+02	3.01E+00	4.39E+00	-1.36E+03		-3.12E+03
Legend		PM = Potential incidence of disease due to particulate matter emissions; IRP = Potential effect from human exposure to U235; ETP-fw = Potential toxicity comparison unit for ecosystems - freshwater; HTP-c = Potential toxicity comparison unit for humans - carcinogenic effect; HTP-nc = Potential toxicity comparison unit for humans - non-carcinogenic effect; SQP = Potential soil quality index											

“Multi-Rec” shows the multi-recycling potential without taking the net flow rule into account - value not compliant with EN 15804

Table 21: Results parameters describing resource use per ton [t] fittings for plastic pipes

EN 15804 compliant results												Additional information on multi-recycling potential These values do not comply with the rules and specifications of EN 15804	Not EN 15804 compliant results
Parameter	**Unit**	**A1 - A3**	**A4**	**A5**	**B1 - B7**	**C1**	**C2**	**C3**	**C4**	**D from A5**	**D from C3**		**Multi-Rec**
PERE	MJ H_u	8.99E+02	2.23E+01	1.13E+02	0.00E+00	0.00E+00	4.12E+00	5.39E+01	1.28E-02	3.16E+00	-1.47E+02		-3.37E+02
PERM	MJ H_u	1.13E+02	0.00E+00	-1.13E+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
PERT	MJ H_u	1.43E+03	2.23E+01	2.03E-01	0.00E+00	0.00E+00	4.12E+00	5.39E+01	1.28E-02	3.16E+00	-1.47E+02		-3.37E+02
PENRE	MJ H_u	1.03E+04	1.44E+03	7.27E+01	0.00E+00	0.00E+00	2.62E+02	3.48E+02	1.51E+00	6.75E+01	-7.26E+03		-1.67E+04
PENRM	MJ H_u	6.19E+01	0.00E+00	-6.19E+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	3.80E+04	1.44E+03	1.08E+01	0.00E+00	0.00E+00	2.62E+02	3.48E+02	1.51E+00	6.75E+01	-7.26E+03		-1.67E+04
SM	kg	5.37E+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	4.23E+02		0.00E+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	*ND	*ND	*ND	*ND	*ND	*ND	*ND	*ND	*ND	*ND		*ND
Legend		PERE = Renewable primary energy as energy carrier; PERM = Renewable primary energy resources as material utilisation; PERT = Total use of renewable primary energy resources; PENRE = Non-renewable primary energy as energy carrier; PENRM = Non-renewable primary energy as material utilisation; 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											

*ND: Indicator Not Declared: the ecoinvent datasets do not allow the use of freshwater resources to be fully recorded

“Multi-Rec” shows the multi-recycling potential without taking the net flow rule into account - value not compliant with EN 15804

Table 22: Results waste categories and output flows per ton [t] fittings for plastic pipes

EN 15804 compliant results												Additional information on multi-recycling potential These values do not comply with the rules and specifications of EN 15804	Not EN 15804 compliant results
Parameter	**Unit**	**A1 - A3**	**A4**	**A5**	**B1 - B7**	**C1**	**C2**	**C3**	**C4**	**D from A5**	**D from C3**		**Multi-Rec**
HWD	kg	3.21E-01	9.12E-03	8.86E-05	0.00E+00	0.00E+00	1.67E-03	1.93E-03	8.02E-06	2.35E-04	-8.11E-02		-1.86E-01
NHWD	kg	5.91E+02	6.96E+01	1.03E+00	0.00E+00	0.00E+00	1.30E+01	1.05E+01	1.00E+01	1.74E-01	-2.35E+01		-5.40E+01
RWD	kg	1.64E-01	8.46E-04	6.12E-06	0.00E+00	0.00E+00	1.57E-04	1.29E-03	4.01E-07	1.25E-04	-4.00E-03		-9.18E-03
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	1.30E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.90E+02	0.00E+00	0.00E+00	0.00E+00		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	3.27E+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
EET	MJ	0.00E+00	0.00E+00	2.88E+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
Legend		WD = 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											

“Multi-Rec” shows the multi-recycling potential without taking the net flow rule into account - value not compliant with EN 15804

Table 23: Results description of biogenic carbon content at the gate per ton [t] fittings for plastic pipes

EN 15804 compliant results											
Parameter	**Unit**	**A1 - A3**	**A4**	**A5**	**B1 - B7**	**C1**	**C2**	**C3**	**C4**	**D from A5**	**D from C3**
C content product	kg C	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
C content packaging	kg C	7,02E+00	0,00E+00	-7,02E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Legend		C content product = biogenic carbon content in the product; C content packaging = biogenic carbon content in the associated packaging									

5.2 Fittings for cast iron pipes with flange connections – coated

Table 24: Results parameters to describe the environmental impact per ton [t] fittings for cast iron pipes with flange connections

EN 15804 compliant results												Additional information on multi-recycling potential These values do not comply with the rules and specifications of EN 15804 (net flow rule)	Not EN 15804 compliant results
Parameter	**Unit**	**A1 - A3**	**A4**	**A5**	**B1 - B7**	**C1**	**C2**	**C3**	**C4**	**D fromA5**	**D from C3**		**Multi-Rec**
GWP total	kg CO2 eq.	2.91E+03	1.02E+02	4.61E+01	0.00E+00	0.00E+00	1.85E+01	2.52E+01	6.08E-02	4.62E+00	-6.87E+02		-1.58E+03
GWP fossil fuels	kg CO2 eq.	2.93E+03	1.02E+02	3.27E+01	0.00E+00	0.00E+00	1.85E+01	2.57E+01	6.08E-02	4.60E+00	-6.89E+02		-1.58E+03
GWP biogenic	kg CO2 eq.	2.57E+01	0.00E+00	-2.57E+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
GWP luluc	kg CO2 eq.	1.02E+00	5.15E-02	3.55E-04	0.00E+00	0.00E+00	9.12E-03	3.76E-02	3.67E-05	4.29E-03	-1.74E-01		-4.00E-01
ODP	kg CFC-11 eq.	6.58E-05	2.20E-06	2.07E-08	0.00E+00	0.00E+00	4.02E-07	4.08E-07	1.76E-09	9.90E-08	-1.66E-05		-3.82E-05
AP	mol H+ eq.	1.04E+01	3.28E-01	6.65E-03	0.00E+00	0.00E+00	4.04E-02	2.87E-01	4.58E-04	1.20E-02	-2.58E+00		-5.93E+00
EP freshwater	kg P eq.	1.04E+00	7.12E-03	1.36E-04	0.00E+00	0.00E+00	1.31E-03	1.51E-02	5.06E-06	9.24E-04	-2.81E-01		-6.44E-01
EP marine	kg N eq.	2.16E+00	8.25E-02	3.15E-03	0.00E+00	0.00E+00	1.02E-02	6.71E-02	1.76E-04	2.73E-03	-6.21E-01		-1.43E+00
EP terrestrial	mol N eq.	2.31E+01	8.64E-01	3.17E-02	0.00E+00	0.00E+00	1.04E-01	7.48E-01	1.88E-03	2.81E-02	-6.58E+00		-1.51E+01
POCP	kg NMVOC eq.	9.66E+00	4.18E-01	8.84E-03	0.00E+00	0.00E+00	6.27E-02	2.24E-01	6.56E-04	1.13E-02	-3.68E+00		-8.46E+00
ADPE	kg Sb eq.	1.93E-02	3.25E-04	2.41E-06	0.00E+00	0.00E+00	6.04E-05	1.58E-03	8.44E-08	2.64E-06	-3.54E-04		-8.13E-04
ADPF	MJ Hu	4.21E+04	1.44E+03	1.08E+01	0.00E+00	0.00E+00	2.62E+02	3.48E+02	1.51E+00	6.75E+01	-7.26E+03		-1.67E+04
WDP*	m3 Welt eq. entz.	3.97E+02	5.87E+00	9.54E-02	0.00E+00	0.00E+00	1.08E+00	4.22E+00	6.69E-02	4.39E-01	-3.57E+01		-8.19E+01
Legend		GWP = Global warming potential; luluc = Land use and land use change; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential; EP = Eutrophication potential; POCP = Formation potential of tropospheric ozone; ADP = Abiotic depletion potential; WDP = Water deprivation potential (users)											

*WDP: The results of this environmental impact indicator must be used with caution, as the uncertainties in these results are high.

“Multi-Rec” shows the multi-recycling potential without taking the net flow rule into account - value not compliant with EN 15804

Table 25: Results additional environmental impact indicators per ton [t] fittings for cast iron pipes with flange connections

EN 15804 compliant results												Additional information on multi-recycling potential These values do not comply with the rules and specifications of EN 15804	Not EN 15804 compliant results
Parameter	**Unit**	**A1 - A3**	**A4**	**A5**	**B1 - B7**	**C1**	**C2**	**C3**	**C4**	**D from A5**	**D from C3**		**Multi-Rec**
PM	Disease incidence	1.47E-04	7.45E-06	6.97E-08	0.00E+00	0.00E+00	1.38E-06	3.97E-06	1.00E-08	9.33E-08	-4.81E-05		-1.10E-04
IRP	kBq U235 equiv	3.11E+02	1.91E+00	1.38E-02	0.00E+00	0.00E+00	3.55E-01	2.77E+00	9.59E-04	2.84E-01	-8.89E+00		-2.04E+01
ETP-fw	CTUe	1.22E+04	7.14E+02	1.05E+01	0.00E+00	0.00E+00	1.30E+02	2.73E+02	7.11E-01	6.69E+00	-1.96E+03		-4.49E+03
HTP-c	CTUh	5.56E-06	4.65E-08	1.72E-09	0.00E+00	0.00E+00	8.42E-09	3.92E-08	2.59E-11	7.63E-10	-3.82E-06		-8.77E-06
HTP-nc	CTUh	3.06E-05	1.01E-06	7.15E-08	0.00E+00	0.00E+00	1.86E-07	1.76E-06	3.24E-10	1.95E-08	-2.60E-06		-5.96E-06
SQP	Points	1.10E+04	8.49E+02	5.16E+00	0.00E+00	0.00E+00	1.59E+02	6.18E+02	3.01E+00	4.39E+00	-1.36E+03		-3.12E+03
Legend		PM = Potential incidence of disease due to particulate matter emissions; IRP = Potential effect from human exposure to U235; ETP-fw = Potential toxicity comparison unit for ecosystems - freshwater; HTP-c = Potential toxicity comparison unit for humans - carcinogenic effect; HTP-nc = Potential toxicity comparison unit for humans - non-carcinogenic effect; SQP = Potential soil quality index											

“Multi-Rec” shows the multi-recycling potential without taking the net flow rule into account - value not compliant with EN 15804

Table 26: Results parameters describing resource use per ton [t] fittings for cast iron pipes with flange connections

EN 15804 compliant results												Additional information on multi-recycling potential These values do not comply with the rules and specifications of EN 15804	Not EN 15804 compliant results
Parameter	**Unit**	**A1 - A3**	**A4**	**A5**	**B1 - B7**	**C1**	**C2**	**C3**	**C4**	**D from A5**	**D from C3**		**Multi-Rec**
PERE	MJ H_u	1.01E+03	2.23E+01	1.13E+02	0.00E+00	0.00E+00	4.12E+00	5.39E+01	1.28E-02	3.16E+00	-1.47E+02		-3.37E+02
PERM	MJ H_u	1.13E+02	0.00E+00	-1.13E+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
PERT	MJ H_u	1.55E+03	2.23E+01	2.03E-01	0.00E+00	0.00E+00	4.12E+00	5.39E+01	1.28E-02	3.16E+00	-1.47E+02		-3.37E+02
PENRE	MJ H_u	1.44E+04	1.44E+03	7.27E+01	0.00E+00	0.00E+00	2.62E+02	3.48E+02	1.51E+00	6.75E+01	-7.26E+03		-1.67E+04
PENRM	MJ H_u	6.19E+01	0.00E+00	-6.19E+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	4.21E+04	1.44E+03	1.08E+01	0.00E+00	0.00E+00	2.62E+02	3.48E+02	1.51E+00	6.75E+01	-7.26E+03		-1.67E+04
SM	kg	5.37E+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	4.23E+02		0.00E+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	*ND	*ND	*ND	*ND	*ND	*ND	*ND	*ND	*ND	*ND		*ND
Legend		PERE = Renewable primary energy as energy carrier; PERM = Renewable primary energy resources as material utilisation; PERT = Total use of renewable primary energy resources; PENRE = Non-renewable primary energy as energy carrier; PENRM = Non-renewable primary energy as material utilisation; 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											

*ND: Indicator Not Declared: the ecoinvent datasets do not allow the use of freshwater resources to be fully recorded

“Multi-Rec” shows the multi-recycling potential without taking the net flow rule into account - value not compliant with EN 15804

Table 27: Results waste categories and output flows per ton [t] fittings for cast iron pipes with flange connections

EN 15804 compliant results												Additional information on multi-recycling potential These values do not comply with the rules and specifications of EN 15804	Not EN 15804 compliant results
Parameter	**Unit**	**A1 - A3**	**A4**	**A5**	**B1 - B7**	**C1**	**C2**	**C3**	**C4**	**D from A5**	**D from C3**		**Multi-Rec**
HWD	kg	3.34E-01	9.12E-03	8.86E-05	0.00E+00	0.00E+00	1.67E-03	1.93E-03	8.02E-06	2.35E-04	-8.11E-02		-1.86E-01
NHWD	kg	1.76E+03	6.96E+01	1.03E+00	0.00E+00	0.00E+00	1.30E+01	1.05E+01	1.00E+01	1.74E-01	-2.35E+01		-5.40E+01
RWD	kg	1.68E-01	8.46E-04	6.12E-06	0.00E+00	0.00E+00	1.57E-04	1.29E-03	4.01E-07	1.25E-04	-4.00E-03		-9.18E-03
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	1.30E+00	0.00E+00	5.44E+00	0.00E+00	0.00E+00	0.00E+00	9.90E+02	0.00E+00	0.00E+00	0.00E+00		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	3.27E+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
EET	MJ	0.00E+00	0.00E+00	2.88E+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
Legend		WD = 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											

“Multi-Rec” shows the multi-recycling potential without taking the net flow rule into account - value not compliant with EN 15804

Table 28: Results description of biogenic carbon content at the gate per ton [t] fittings for cast iron pipes with flange connections

EN 15804 compliant results											
Parameter	**Unit**	**A1 - A3**	**A4**	**A5**	**B1 - B7**	**C1**	**C2**	**C3**	**C4**	**D from A5**	**D from C3**
C content product	kg C	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
C content packaging	kg C	7.02E+00	0.00E+00	-7.02E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Legend		C content product = biogenic carbon content in the product; C content packaging = biogenic carbon content in the associated packaging									

5.3 Special castings – coated

Table 29: Results parameters to describe the environmental impact per ton [t] special castings

EN 15804 compliant results												Additional information on multi-recycling potential These values do not comply with the rules and specifications of EN 15804 (net flow rule)	Not EN 15804 compliant results
Parameter	**Unit**	**A1 - A3**	**A4**	**A5**	**B1 - B7**	**C1**	**C2**	**C3**	**C4**	**D fromA5**	**D from C3**		**Multi-Rec**
GWP total	kg CO2 eq.	2.69E+03	1.02E+02	4.61E+01	0.00E+00	0.00E+00	1.85E+01	2.52E+01	6.08E-02	4.62E+00	-6.87E+02		-1.58E+03
GWP fossil fuels	kg CO2 eq.	2.71E+03	1.02E+02	3.27E+01	0.00E+00	0.00E+00	1.85E+01	2.57E+01	6.08E-02	4.60E+00	-6.89E+02		-1.58E+03
GWP biogenic	kg CO2 eq.	2.57E+01	0.00E+00	-2.57E+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
GWP luluc	kg CO2 eq.	9.13E-01	5.15E-02	3.55E-04	0.00E+00	0.00E+00	9.12E-03	3.76E-02	3.67E-05	4.29E-03	-1.74E-01		-4.00E-01
ODP	kg CFC-11 eq.	6.20E-05	2.20E-06	2.07E-08	0.00E+00	0.00E+00	4.02E-07	4.08E-07	1.76E-09	9.90E-08	-1.66E-05		-3.82E-05
AP	mol H+ eq.	9.54E+00	3.28E-01	6.65E-03	0.00E+00	0.00E+00	4.04E-02	2.87E-01	4.58E-04	1.20E-02	-2.58E+00		-5.93E+00
EP freshwater	kg P eq.	1.00E+00	7.12E-03	1.36E-04	0.00E+00	0.00E+00	1.31E-03	1.51E-02	5.06E-06	9.24E-04	-2.81E-01		-6.44E-01
EP marine	kg N eq.	1.98E+00	8.25E-02	3.15E-03	0.00E+00	0.00E+00	1.02E-02	6.71E-02	1.76E-04	2.73E-03	-6.21E-01		-1.43E+00
EP terrestrial	mol N eq.	2.12E+01	8.64E-01	3.17E-02	0.00E+00	0.00E+00	1.04E-01	7.48E-01	1.88E-03	2.81E-02	-6.58E+00		-1.51E+01
POCP	kg NMVOC eq.	8.75E+00	4.18E-01	8.84E-03	0.00E+00	0.00E+00	6.27E-02	2.24E-01	6.56E-04	1.13E-02	-3.68E+00		-8.46E+00
ADPE	kg Sb eq.	1.83E-02	3.25E-04	2.41E-06	0.00E+00	0.00E+00	6.04E-05	1.58E-03	8.44E-08	2.64E-06	-3.54E-04		-8.13E-04
ADPF	MJ Hu	3.80E+04	1.44E+03	1.08E+01	0.00E+00	0.00E+00	2.62E+02	3.48E+02	1.51E+00	6.75E+01	-7.26E+03		-1.67E+04
WDP*	m3 Welt eq. entz.	2.86E+02	5.87E+00	9.54E-02	0.00E+00	0.00E+00	1.08E+00	4.22E+00	6.69E-02	4.39E-01	-3.57E+01		-8.19E+01
Legend		GWP = Global warming potential; luluc = Land use and land use change; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential; EP = Eutrophication potential; POCP = Formation potential of tropospheric ozone; ADP = Abiotic depletion potential; WDP = Water deprivation potential (users)											

*WDP: The results of this environmental impact indicator must be used with caution, as the uncertainties in these results are high.

“Multi-Rec” shows the multi-recycling potential without taking the net flow rule into account - value not compliant with EN 15804

Table 30: Results additional environmental impact indicators per ton [t] special castings

EN 15804 compliant results												Additional information on multi-recycling potential These values do not comply with the rules and specifications of EN 15804	Not EN 15804 compliant results
Parameter	**Unit**	**A1 - A3**	**A4**	**A5**	**B1 - B7**	**C1**	**C2**	**C3**	**C4**	**D from A5**	**D from C3**		**Multi-Rec**
PM	Disease incidence	1.32E-04	7.45E-06	6.97E-08	0.00E+00	0.00E+00	1.38E-06	3.97E-06	1.00E-08	9.33E-08	-4.81E-05		-1.10E-04
IRP	kBq U235 equiv	3.02E+02	1.91E+00	1.38E-02	0.00E+00	0.00E+00	3.55E-01	2.77E+00	9.59E-04	2.84E-01	-8.89E+00		-2.04E+01
ETP-fw	CTUe	1.02E+04	7.14E+02	1.05E+01	0.00E+00	0.00E+00	1.30E+02	2.73E+02	7.11E-01	6.69E+00	-1.96E+03		-4.49E+03
HTP-c	CTUh	5.14E-06	4.65E-08	1.72E-09	0.00E+00	0.00E+00	8.42E-09	3.92E-08	2.59E-11	7.63E-10	-3.82E-06		-8.77E-06
HTP-nc	CTUh	2.86E-05	1.01E-06	7.15E-08	0.00E+00	0.00E+00	1.86E-07	1.76E-06	3.24E-10	1.95E-08	-2.60E-06		-5.96E-06
SQP	Points	8.65E+03	8.49E+02	5.16E+00	0.00E+00	0.00E+00	1.59E+02	6.18E+02	3.01E+00	4.39E+00	-1.36E+03		-3.12E+03
Legend		PM = Potential incidence of disease due to particulate matter emissions; IRP = Potential effect from human exposure to U235; ETP-fw = Potential toxicity comparison unit for ecosystems - freshwater; HTP-c = Potential toxicity comparison unit for humans - carcinogenic effect; HTP-nc = Potential toxicity comparison unit for humans - non-carcinogenic effect; SQP = Potential soil quality index											

“Multi-Rec” shows the multi-recycling potential without taking the net flow rule into account - value not compliant with EN 15804

Table 31: Results parameters describing resource use per ton [t] special castings

EN 15804 compliant results												Additional information on multi-recycling potential These values do not comply with the rules and specifications of EN 15804	Not EN 15804 compliant results
Parameter	**Unit**	**A1 - A3**	**A4**	**A5**	**B1 - B7**	**C1**	**C2**	**C3**	**C4**	**D from A5**	**D from C3**		**Multi-Rec**
PERE	MJ H_u	8.99E+02	2.23E+01	1.13E+02	0.00E+00	0.00E+00	4.12E+00	5.39E+01	1.28E-02	3.16E+00	-1.47E+02		-3.37E+02
PERM	MJ H_u	1.13E+02	0.00E+00	-1.13E+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
PERT	MJ H_u	1.43E+03	2.23E+01	2.03E-01	0.00E+00	0.00E+00	4.12E+00	5.39E+01	1.28E-02	3.16E+00	-1.47E+02		-3.37E+02
PENRE	MJ H_u	1.03E+04	1.44E+03	7.27E+01	0.00E+00	0.00E+00	2.62E+02	3.48E+02	1.51E+00	6.75E+01	-7.26E+03		-1.67E+04
PENRM	MJ H_u	6.19E+01	0.00E+00	-6.19E+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	3.80E+04	1.44E+03	1.08E+01	0.00E+00	0.00E+00	2.62E+02	3.48E+02	1.51E+00	6.75E+01	-7.26E+03		-1.67E+04
SM	kg	5.37E+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	4.23E+02		0.00E+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	*ND	*ND	*ND	*ND	*ND	*ND	*ND	*ND	*ND	*ND		*ND
Legend		PERE = Renewable primary energy as energy carrier; PERM = Renewable primary energy resources as material utilisation; PERT = Total use of renewable primary energy resources; PENRE = Non-renewable primary energy as energy carrier; PENRM = Non-renewable primary energy as material utilisation; 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											

*ND: Indicator Not Declared: the ecoinvent datasets do not allow the use of freshwater resources to be fully recorded

“Multi-Rec” shows the multi-recycling potential without taking the net flow rule into account - value not compliant with EN 15804

Table 32: Results waste categories and output flows per ton [t] special castings

EN 15804 compliant results												Additional information on multi-recycling potential These values do not comply with the rules and specifications of EN 15804	Not EN 15804 compliant results
Parameter	**Unit**	**A1 - A3**	**A4**	**A5**	**B1 - B7**	**C1**	**C2**	**C3**	**C4**	**D from A5**	**D from C3**		**Multi-Rec**
HWD	kg	3.21E-01	9.12E-03	8.86E-05	0.00E+00	0.00E+00	1.67E-03	1.93E-03	8.02E-06	2.35E-04	-8.11E-02		-1.86E-01
NHWD	kg	5.91E+02	6.96E+01	1.03E+00	0.00E+00	0.00E+00	1.30E+01	1.05E+01	1.00E+01	1.74E-01	-2.35E+01		-5.40E+01
RWD	kg	1.64E-01	8.46E-04	6.12E-06	0.00E+00	0.00E+00	1.57E-04	1.29E-03	4.01E-07	1.25E-04	-4.00E-03		-9.18E-03
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	1.30E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.90E+02	0.00E+00	0.00E+00	0.00E+00		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	3.27E+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
EET	MJ	0.00E+00	0.00E+00	2.88E+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
Legend		WD = 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											

“Multi-Rec” shows the multi-recycling potential without taking the net flow rule into account - value not compliant with EN 15804

Table 33: Results description of biogenic carbon content at the gate per ton [t] special castings

EN 15804 compliant results											
Parameter	**Unit**	**A1 - A3**	**A4**	**A5**	**B1 - B7**	**C1**	**C2**	**C3**	**C4**	**D from A5**	**D from C3**
C content product	kg C	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
C content packaging	kg C	7.02E+00	0.00E+00	-7.02E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Legend		C content product = biogenic carbon content in the product; C content packaging = biogenic carbon content in the associated packaging									

5.4 Fittings for TRM pipe systems – uncoated

Table 34: Results parameters to describe the environmental impact per ton [t] fittings for TRM pipe systems

EN 15804 compliant results												Additional information on multi-recycling potential These values do not comply with the rules and specifications of EN 15804 (net flow rule)	Not EN 15804 compliant results
Parameter	**Unit**	**A1 - A3**	**A4**	**A5**	**B1 - B7**	**C1**	**C2**	**C3**	**C4**	**D fromA5**	**D from C3**		**Multi-Rec**
GWP total	kg CO2 eq.	2.60E+03	1.06E+02	0.00E+00	0.00E+00	0.00E+00	1.85E+01	2.52E+01	6.08E-02	0.00E+00	-7.18E+02		-1.61E+03
GWP fossil fuels	kg CO2 eq.	2.60E+03	1.06E+02	0.00E+00	0.00E+00	0.00E+00	1.85E+01	2.57E+01	6.08E-02	0.00E+00	-7.20E+02		-1.61E+03
GWP biogenic	kg CO2 eq.	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
GWP luluc	kg CO2 eq.	7.43E-01	5.28E-02	0.00E+00	0.00E+00	0.00E+00	9.12E-03	3.76E-02	3.67E-05	0.00E+00	-1.82E-01		-4.08E-01
ODP	kg CFC-11 eq.	5.31E-05	2.31E-06	0.00E+00	0.00E+00	0.00E+00	4.02E-07	4.08E-07	1.76E-09	0.00E+00	-1.74E-05		-3.89E-05
AP	mol H+ eq.	8.50E+00	2.65E-01	0.00E+00	0.00E+00	0.00E+00	4.04E-02	2.87E-01	4.58E-04	0.00E+00	-2.70E+00		-6.05E+00
EP freshwater	kg P eq.	9.31E-01	7.50E-03	0.00E+00	0.00E+00	0.00E+00	1.31E-03	1.51E-02	5.06E-06	0.00E+00	-2.93E-01		-6.57E-01
EP marine	kg N eq.	1.92E+00	6.69E-02	0.00E+00	0.00E+00	0.00E+00	1.02E-02	6.71E-02	1.76E-04	0.00E+00	-6.49E-01		-1.45E+00
EP terrestrial	mol N eq.	2.03E+01	6.87E-01	0.00E+00	0.00E+00	0.00E+00	1.04E-01	7.48E-01	1.88E-03	0.00E+00	-6.88E+00		-1.54E+01
POCP	kg NMVOC eq.	8.72E+00	3.83E-01	0.00E+00	0.00E+00	0.00E+00	6.27E-02	2.24E-01	6.56E-04	0.00E+00	-3.85E+00		-8.63E+00
ADPE	kg Sb eq.	1.69E-02	3.44E-04	0.00E+00	0.00E+00	0.00E+00	6.04E-05	1.58E-03	8.44E-08	0.00E+00	-3.70E-04		-8.29E-04
ADPF	MJ Hu	3.63E+04	1.51E+03	0.00E+00	0.00E+00	0.00E+00	2.62E+02	3.48E+02	1.51E+00	0.00E+00	-7.59E+03		-1.70E+04
WDP*	m3 Welt eq. entz.	2.67E+02	6.18E+00	0.00E+00	0.00E+00	0.00E+00	1.08E+00	4.22E+00	6.69E-02	0.00E+00	-3.73E+01		-8.35E+01
Legend		GWP = Global warming potential; luluc = Land use and land use change; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential; EP = Eutrophication potential; POCP = Formation potential of tropospheric ozone; ADP = Abiotic depletion potential; WDP = Water deprivation potential (users)											

*WDP: The results of this environmental impact indicator must be used with caution, as the uncertainties in these results are high.

“Multi-Rec” shows the multi-recycling potential without taking the net flow rule into account - value not compliant with EN 15804

Table 35: Results additional environmental impact indicators per ton [t] fittings for TRM pipe systems

EN 15804 compliant results												Additional information on multi-recycling potential These values do not comply with the rules and specifications of EN 15804	Not EN 15804 compliant results
Parameter	**Unit**	**A1 - A3**	**A4**	**A5**	**B1 - B7**	**C1**	**C2**	**C3**	**C4**	**D from A5**	**D from C3**		**Multi-Rec**
PM	Disease incidence	1.35E-04	7.86E-06	0.00E+00	0.00E+00	0.00E+00	1.38E-06	3.97E-06	1.00E-08	0.00E+00	-5.03E-05		-1.13E-04
IRP	kBq U235 equiv	2.61E+02	2.03E+00	0.00E+00	0.00E+00	0.00E+00	3.55E-01	2.77E+00	9.59E-04	0.00E+00	-9.30E+00		-2.08E+01
ETP-fw	CTUe	9.26E+03	7.45E+02	0.00E+00	0.00E+00	0.00E+00	1.30E+02	2.73E+02	7.11E-01	0.00E+00	-2.05E+03		-4.58E+03
HTP-c	CTUh	5.45E-06	4.84E-08	0.00E+00	0.00E+00	0.00E+00	8.42E-09	3.92E-08	2.59E-11	0.00E+00	-4.00E-06		-8.94E-06
HTP-nc	CTUh	2.67E-05	1.06E-06	0.00E+00	0.00E+00	0.00E+00	1.86E-07	1.76E-06	3.24E-10	0.00E+00	-2.71E-06		-6.08E-06
SQP	Points	7.16E+03	9.03E+02	0.00E+00	0.00E+00	0.00E+00	1.59E+02	6.18E+02	3.01E+00	0.00E+00	-1.42E+03		-3.18E+03
Legend		PM = Potential incidence of disease due to particulate matter emissions; IRP = Potential effect from human exposure to U235; ETP-fw = Potential toxicity comparison unit for ecosystems - freshwater; HTP-c = Potential toxicity comparison unit for humans - carcinogenic effect; HTP-nc = Potential toxicity comparison unit for humans - non-carcinogenic effect; SQP = Potential soil quality index											

“Multi-Rec” shows the multi-recycling potential without taking the net flow rule into account - value not compliant with EN 15804

Table 36: Results parameters describing resource use per ton [t] fittings for TRM pipe systems

EN 15804 compliant results												Additional information on multi-recycling potential These values do not comply with the rules and specifications of EN 15804	Not EN 15804 compliant results
Parameter	**Unit**	**A1 - A3**	**A4**	**A5**	**B1 - B7**	**C1**	**C2**	**C3**	**C4**	**D from A5**	**D from C3**		**Multi-Rec**
PERE	MJ H_u	2.87E+02	2.35E+01	0.00E+00	0.00E+00	0.00E+00	4.12E+00	5.39E+01	1.28E-02	0.00E+00	-1.54E+02		-3.44E+02
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	6.99E+02	2.35E+01	0.00E+00	0.00E+00	0.00E+00	4.12E+00	5.39E+01	1.28E-02	0.00E+00	-1.54E+02		-3.44E+02
PENRE	MJ H_u	1.02E+04	1.51E+03	0.00E+00	0.00E+00	0.00E+00	2.62E+02	3.48E+02	1.51E+00	0.00E+00	-7.59E+03		-1.70E+04
PENRM	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
PENRT	MJ H_u	3.63E+04	1.51E+03	0.00E+00	0.00E+00	0.00E+00	2.62E+02	3.48E+02	1.51E+00	0.00E+00	-7.59E+03		-1.70E+04
SM	kg	5.48E+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	4.23E+02		0.00E+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	*ND	*ND	*ND	*ND	*ND	*ND	*ND	*ND	*ND	*ND		*ND
Legend		PERE = Renewable primary energy as energy carrier; PERM = Renewable primary energy resources as material utilisation; PERT = Total use of renewable primary energy resources; PENRE = Non-renewable primary energy as energy carrier; PENRM = Non-renewable primary energy as material utilisation; 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											

*ND: Indicator Not Declared: the ecoinvent datasets do not allow the use of freshwater resources to be fully recorded

“Multi-Rec” shows the multi-recycling potential without taking the net flow rule into account - value not compliant with EN 15804

Table 37: Results waste categories and output flows per ton [t] fittings for TRM pipe systems

EN 15804 compliant results												Additional information on multi-recycling potential These values do not comply with the rules and specifications of EN 15804	Not EN 15804 compliant results
Parameter	**Unit**	**A1 - A3**	**A4**	**A5**	**B1 - B7**	**C1**	**C2**	**C3**	**C4**	**D from A5**	**D from C3**		**Multi-Rec**
HWD	kg	2.97E-01	9.56E-03	0.00E+00	0.00E+00	0.00E+00	1.67E-03	1.93E-03	8.02E-06	0.00E+00	-8.49E-02		-1.90E-01
NHWD	kg	1.71E+03	7.42E+01	0.00E+00	0.00E+00	0.00E+00	1.30E+01	1.05E+01	1.00E+01	0.00E+00	-2.46E+01		-5.50E+01
RWD	kg	1.42E-01	8.96E-04	0.00E+00	0.00E+00	0.00E+00	1.57E-04	1.29E-03	4.01E-07	0.00E+00	-4.18E-03		-9.36E-03
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	1.30E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.90E+02	0.00E+00	0.00E+00	0.00E+00		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	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
EET	MJ	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
Legend		WD = 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											

“Multi-Rec” shows the multi-recycling potential without taking the net flow rule into account - value not compliant with EN 15804

Table 38: Results description of biogenic carbon content at the gate per ton [t] fittings for TRM pipe systems

EN 15804 compliant results											
Parameter	**Unit**	**A1 - A3**	**A4**	**A5**	**B1 - B7**	**C1**	**C2**	**C3**	**C4**	**D from A5**	**D from C3**
C content product	kg C	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
C content packaging	kg C	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
Legend		C content product = biogenic carbon content in the product; C content packaging = biogenic carbon content in the associated packaging									

Table 39 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 39: 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.		

6 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.

In the dominance analyses of the entire life cycle of the fittings analysed, A1-A3 are shown to be the dominant modules for the majority of the indicators investigated. Therefore, the influence of the processes of modules A1-A3 is analysed in advance for the presentation of the life cycle dominance analyses (Figure 7 - for fittings for plastic pipes and special castings, Figure 8 - for fittings for cast iron pipes, Figure 9 - for fittings for TRM pipe systems). Production processes that take place at the plant in Neumarkt St. Veit are abbreviated with NSV and those at the plant in Pfarrkirchen with PAN.

Figure 7 to Figure 9 show the major influence of the melting furnace on the results of the production processes, which is primarily due to the production of pig iron, the electricity requirements and the electricity mix used. The influence of the treatment ladle, which is significant in some cases, is primarily associated with the magnesium used. The influence of the coating process is primarily caused by the powder coating, the required heat and the water requirement.

The fittings for plastic pipes and the special castings (Figure 7) are cast in moulding system 1 and the fittings for cast iron pipes with flange connections (Figure 8) and the fittings for TRM pipe systems (Figure 9) are cast in moulding system 2. This leads to different results for the respective products due to the different efforts in the two moulding lines (more moulding and core sand in moulding line 2).

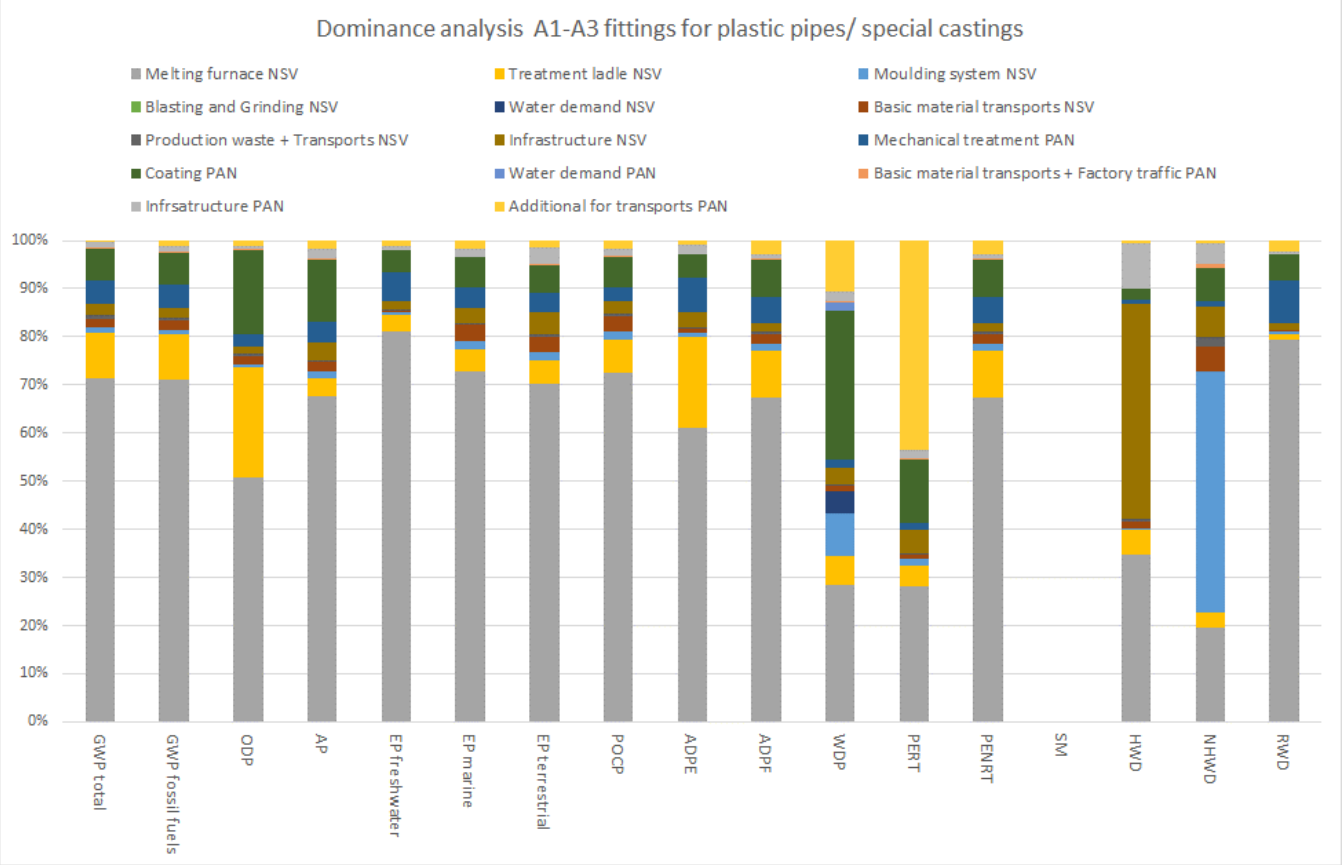


Figure 7: Dominance analysis A1-A3 fittings for plastic pipes/ special castings (Results 5.1 and 5.3)

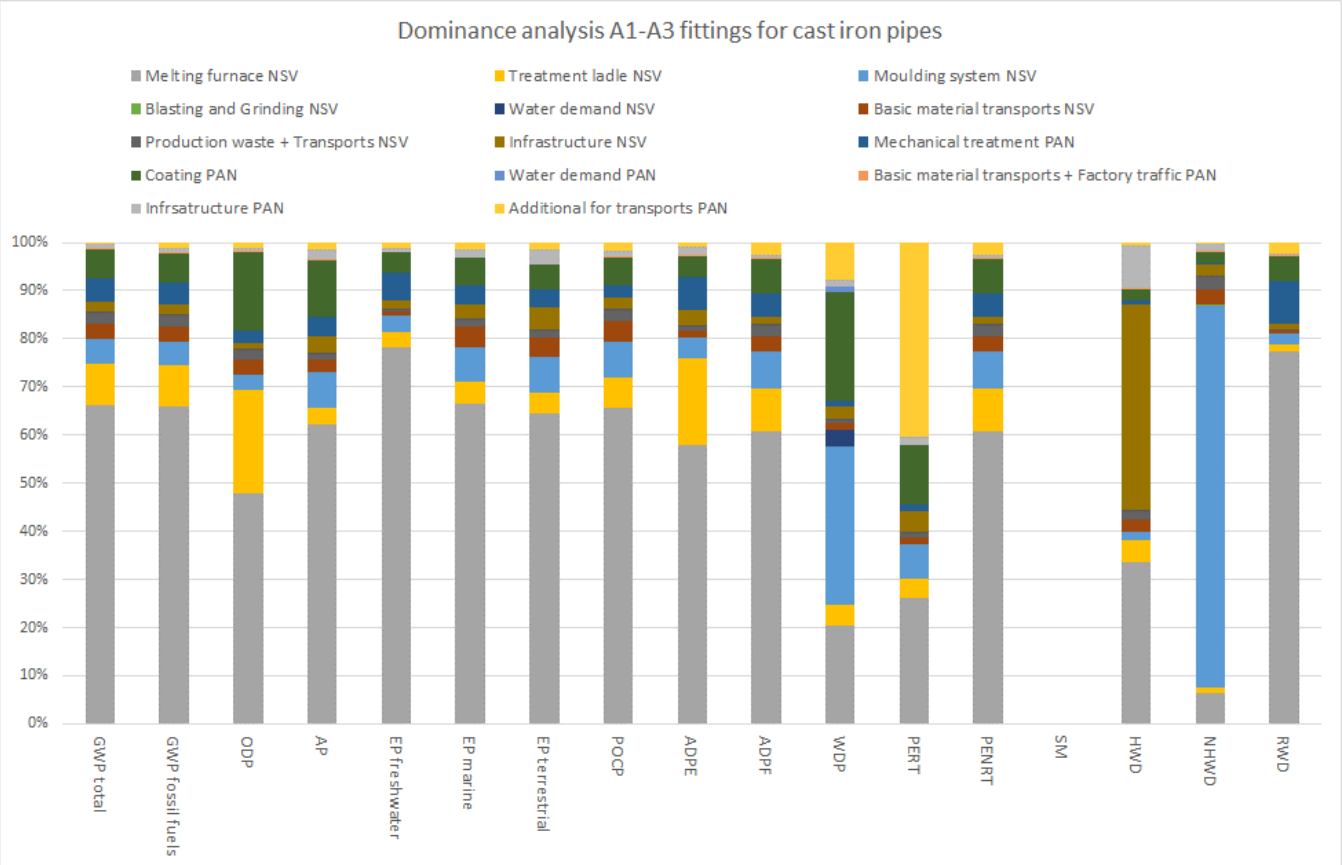


Figure 8: Dominance analysis A1-A3 fittings for cast iron pipes (Results 5.2)

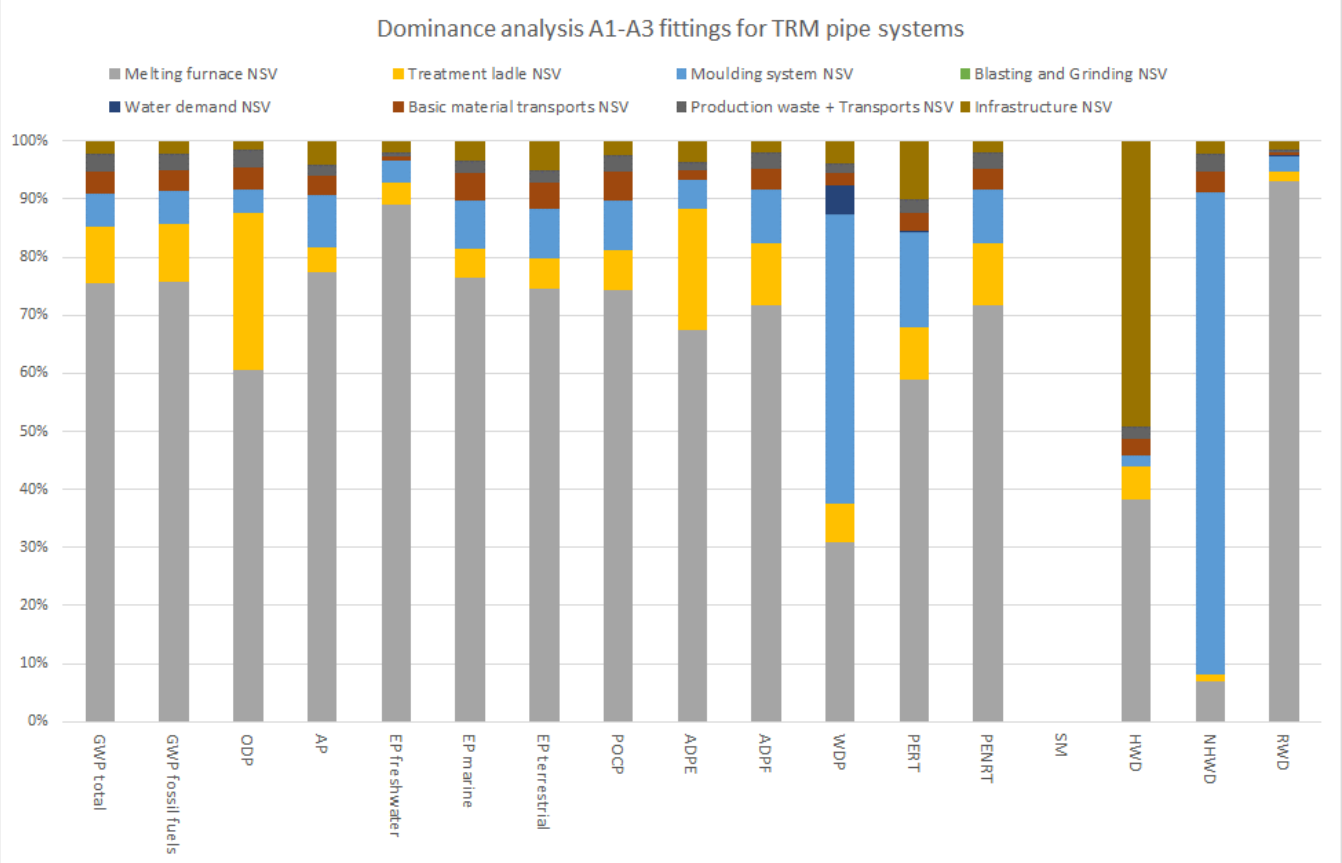


Figure 9: Dominance analysis A1-A3 fittings for TRM pipe systems (Results 5.4)

The life cycle dominance analyses of modules A1 to C4 (Figure 10 to Figure 12) show the dominant influence of the production phase A1-A3 of approx. 90 % and above. All other life cycle phases play a subordinate role, with transportation to the construction site (A4) emerging as the second most influential module.

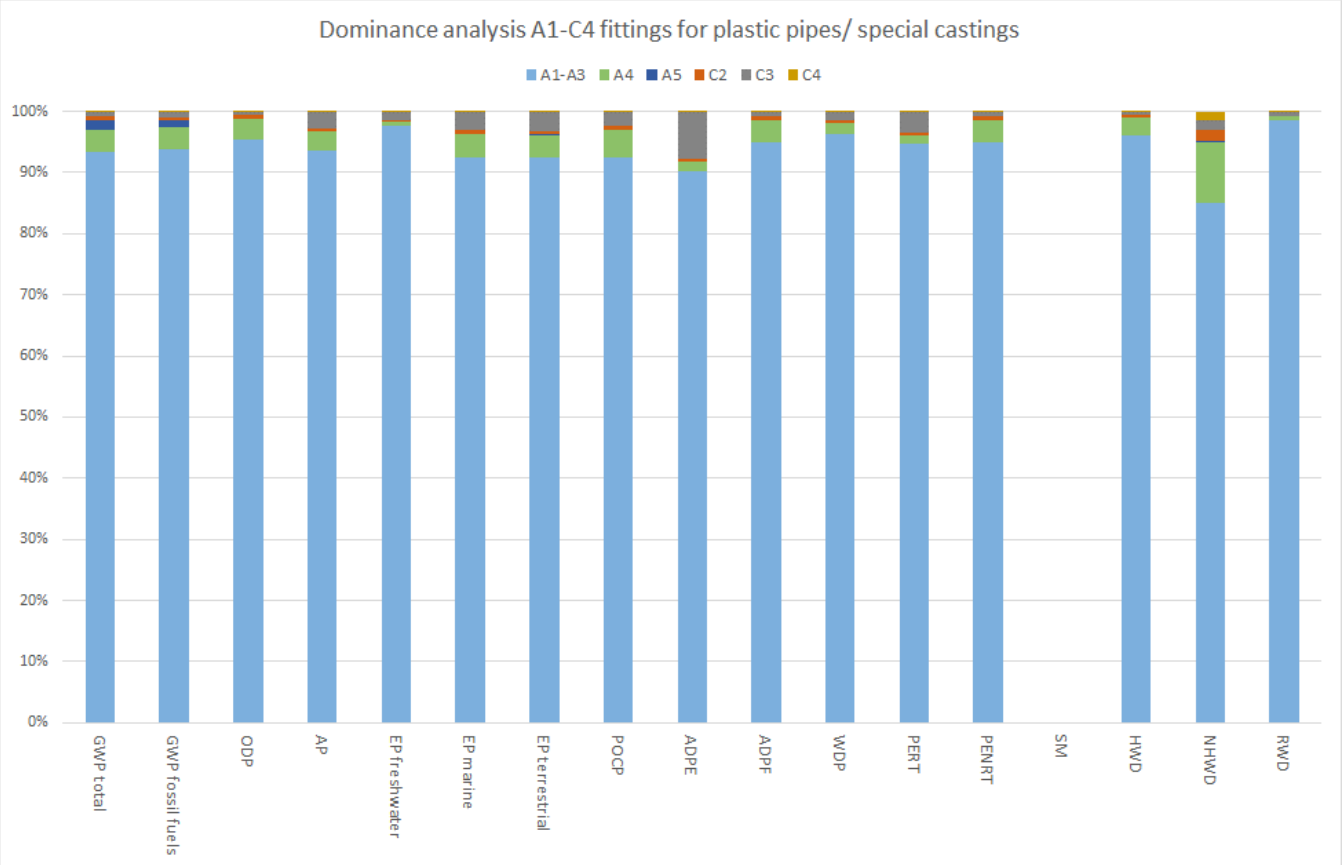


Figure 10: Dominance analysis A1-C4 fittings for plastic pipes/ special castings (Results 5.1 and 5.3)

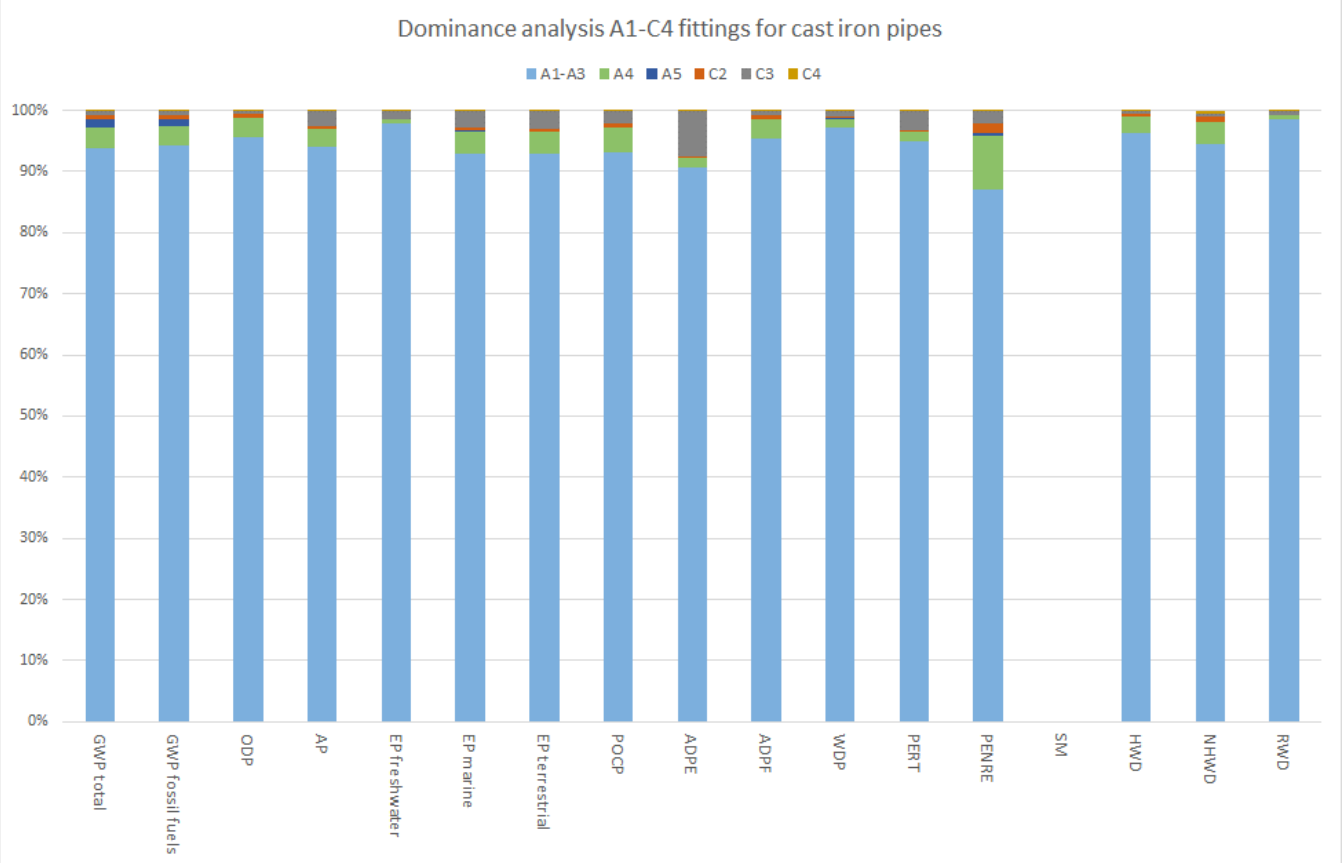


Figure 11: Dominance analysis A1-C4 fittings for cast iron pipes (Results 5.2)

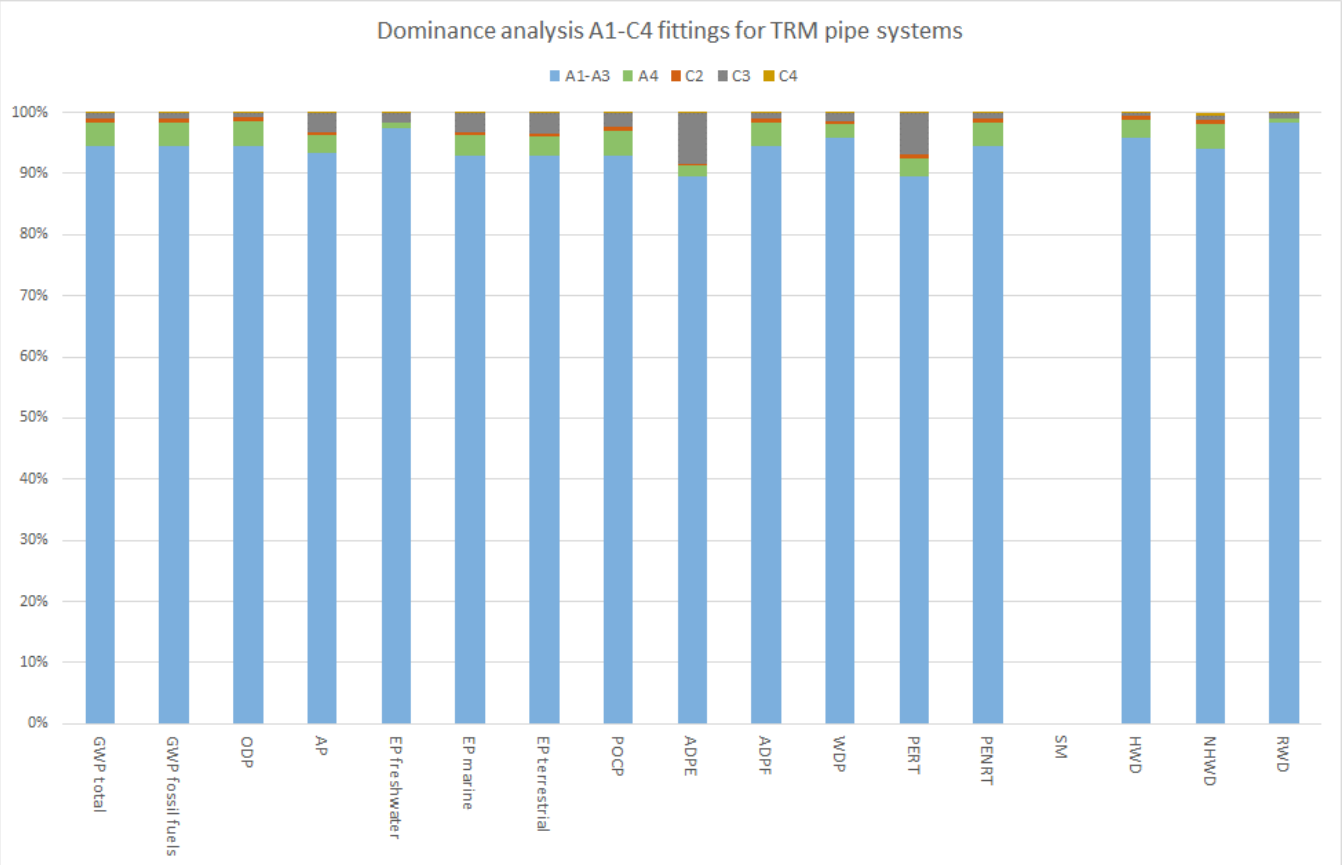


Figure 12: Dominance analysis A1-C4 fittings for TRM pipe systems (Results 5.4)

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8 Directory and Glossary

8.1 List of figures

8.2 List of tables

8.3 Abbreviations

8.3.1 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

8.3.2 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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