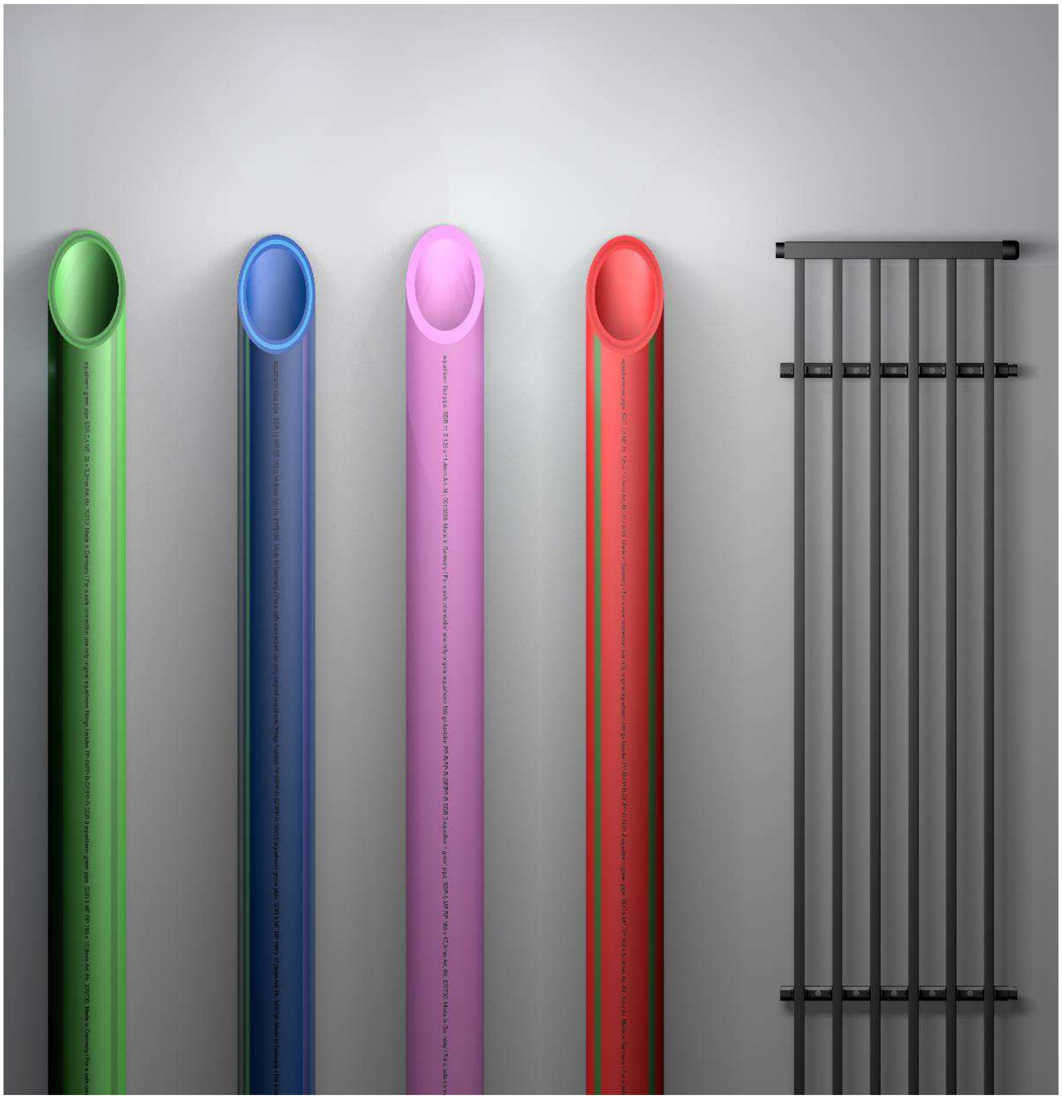
Environmental Product Declaration

Polpropylene (PP-R) Pressure Piping Systems
ENVIRONMENTAL PRODUCT DECLARATION



The declared, average piping system includes the following products:

- aquatherm green pipe, mechanical piping that is especially suited for potable water and food-grade applications;
- aquatherm blue pipe, mechanical piping that is especially suited for heating and chilled water, condenser water, and industrial and chemical process systems;
- aquatherm lilac pipe, mechanical piping that is specifically intended for non-potable, reclaimed or recycled water, rainwater catchment, and irrigation systems;
- aquatherm red pipe, mechanical piping that is specifically intended for light hazard fire suppression systems; and
- aquatherm black system, a radiant panel system that is used to provide energy-efficient radiant heating and cooling for any size building, from single-family homes to large high-rise commercial facilities

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SUSTAINABILITY CERTIFIED NSF Environmental Product Declaration

ENVIRONMENTAL PRODUCT DECLARATION VERIFICATION

EPD Information			
Program Operator		NSF International	
Declaration Holder		aquatherm GmbH	
Product Polypropylene (PP-R) Pressure Piping Systems	Date of Issue December 18, 2015	Period of Validity 5 Years	Declaration Number EPD10069
This EPD was independently verified by NSF International in accordance with ISO 14025: ☐ Internal ☒ External		Jenny Oorbeck joobeck@nsf.org	
This life cycle assessment was independently verified by in accordance with ISO 14044 and the reference PCR:		Paula Bernstein, PRé Bernstein@pre-sustainability.com	
LCA Information			
Basis LCA		Life Cycle Assessment of Polypropylene Pressure Piping Systems, September 10, 2015	
LCA Preparer		Takuma Ono thinkstep AG takuma.ono@thinkstep.com	
This life cycle assessment was critically reviewed in accordance with ISO 14044 by:		Paula Bernstein PRé Bernstein@pre-sustainability.com	
PCR Information			
Program Operator		NSF International	
Reference PCR		Piping systems for use for sewage and storm water (under gravity), The Norwegian EPD Foundation, with Addendum v2 by UL Environment	
Date of Issue		9/20/2012 (Addendum 6/10/2014)	
PCR review was conducted by:		The Norwegian EPD Foundation PB 5250 Majorstuen, 0303 Oslo	

Company Description

Aquatherm, a global manufacturer of polypropylene (PP-R) pressure piping systems is interested in demonstrating leadership in this industry through transparent communication of its products' environmental performance through an Environmental Product Declaration (EPD) in accordance with ISO 14025. This will enable purchasers of Aquatherm's PP-R pressure piping systems to be eligible for LEED points under the LEED v4 standard. Furthermore, the study will allow Aquatherm to identify key drivers of impacts as well as greatest opportunities for improvement throughout the supply chain.

Product Description

The Aquatherm piping system declared in this EPD represents an average of five different piping systems:

1. aquatherm green pipe, mechanical piping that is especially suited for potable water and food-grade applications;
2. aquatherm blue pipe, mechanical piping that is especially suited for heated and chilled water, condenser water, and industrial and chemical process systems;
3. aquatherm lilac pipe, mechanical piping that is specifically intended for non-potable, reclaimed or recycled water, rainwater catchment, and irrigation systems; and,
4. aquatherm black system, a radiant panel system that is used to provide energy-efficient radiant heating and cooling for any size building, from single-family homes to large high-rise commercial facilities;
5. aquatherm red pipe, mechanical piping that is specifically intended for light hazard occupancy fire suppression systems.

The amount and type of material of 1 m of piping system slightly differs among products. For example, the *standard dimension ratio* (SDR) offering differs among piping systems, as summarized in Table 1.

Table 1: Summary of baseline SDR, SDRs offered by piping systems, and calculated pipe wall thickness in mm

Material	Baseline SDR of ¾-in (25mm) pipe	Pipe wall thickness at ¾ (25mm) pipe diameter	SDR Offering for all pipe diameter
Black System	7.5*	3.33	7.5
Blue Pipe	7.4	3.5	7.4, 9, 11, 17.6
Green Pipe	7.4	3.5	7.4, 9, 11
Lilac Pipe	7.4	3.5	7.4, 11
Red Pipe	7.4	3.5	7.4
Average System		**3.47**	

* Pipes in the Black System is square; therefore, the perimeter of the square pipe was used to assume a hypothetical round pipe equivalent

The formula for calculating SDR is as follows: SDR = (pipe outside diameter) / (pipe wall thickness)

Note that higher values of SDR indicates thinner pipe walls. The average, representative piping system under analysis will have a pipe wall thickness of 3.47 mm.

Declared Unit

With a cradle-to-gate system boundary, a *declared unit* is considered. According to the PCR, the required declared unit is *one piece of pipe with a defined diameter and length*. The declared unit being evaluated, in accordance to the guiding PCR is:

"1 meter of piping system with a 25 mm outer diameter"

The reference flow of the declared unit is 0.2346 kg of piping system comprised of pipe and fittings. The 25mm outer diameter polypropylene pipe is equivalent to a ¾ inch copper pipe, because of the similarity between the pipes' flow cross sections. A 25mm outer diameter pipe has an internal diameter of 18 mm, which is the nearest to a ¾ inch copper pipe. Moreover, a ¾ inch nominal/equivalent diameter is offered in all five piping systems; therefore, it was selected as the defined size. The available *standard dimension ratio (SDR)*—the ratio between the pipe diameter and the pipe wall thickness—varies within and between systems.

System Boundary

The PCR requires, at minimum, that the EPD report environmental impacts of activities up to the factory "gate", with subsequent life cycle stages optionally reported. This is considered by the PCR to be the cradle-to-gate system boundary. According to the EN 15804 standard on the sustainability of construction works, cradle-to-gate activities, or product stage activities, can be grouped into three modules: raw material production, inbound transport, and manufacturing, which are categorized as *A1, A2,* and *A3*, respectively (Figure 1). Raw material production includes extraction of new materials, reuse of materials from previous systems, and processing of secondary materials. Manufacturing includes production of ancillary products (metal components, fasteners, supports, etc.), and manufacturing of products (pipes, fittings and valves), co-products, and packaging.

Product Stage			Construction Stage		Use Stage					End-of-Life Stage				Next Product System
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	C1	C2	C3	C4	D
Raw materials supply	Transport	Manufacturing	Transport	Installation	Use	Maintenance	Repair	Replacement	Refurbishment	De-construction	Transport	Waste processing	Disposal	Reuse, recovery or recycling potential

Figure 1: Life cycle stages of construction products according to EN 15804 standard

The EN 15804 stages included in the system boundary are A1-A3. Transport to the construction site and impacts from installation, use, and end-of-life are excluded due to lack of available data and wide variation in these phases globally. Thus, life cycle modules A4 and after are excluded from the study. Table 1 summarizes the included and excluded activities in this study.

Cut-off

No cut-off criteria are defined for this study. All relevant energy and material flow data have been included in the model. In cases where no matching life cycle inventories are available to represent a flow, proxy data have been applied based on conservative assumptions regarding environmental impacts.

Disposal

Wastes and potentially recyclable output flows were considered and treated appropriately by applying the relevant GaBi dataset. Non-hazardous flows were considered to be landfilled; hazardous flows were considered to be incinerated in appropriate facilities; plastic scrap was assumed to be sold to external recyclers; cardboard and paperboard, due to the high recycled content of the raw material input, has been cut off from the system per the GaBi modeling principles, available at http://www.gabi-software.com/support/gabi/gabi-modelling-principles/. By contrast, system expansion was used to model the displacement of primary plastic production from secondary plastic generated through plastic scrap recycling.

There were several wastes streams at the manufacturing facility where it was necessary to follow the European Union directive 91/689/EEC, Annex III:

- residue from substances employed as solvents—inks and solvents from pipe marking in the extrusion
- mineral oils and oily substances (e.g. cutting sludges, etc.)—hydraulic and gear oil from injection molding machines and extruders and tooling factory

Data Quality Requirements

The data used to create the inventory model were as precise, complete, consistent, and representative as possible. To cover these requirements and to ensure reliable results, site-specific Aquatherm primary data representing the year 2014 in combination with consistent background life cycle assessment (LCA) information from the GaBi 2015 database were used. The life cycle inventory (LCI) datasets from the GaBi 2015 database are widely distributed and used with the GaBi 6 Software. These datasets have been used in LCA models worldwide in industrial and scientific applications in internal as well as in many critically reviewed and published studies. In the process of providing these datasets they are cross-checked with other databases and values from industry and science.

Raw Material Extraction and Origin

Aquatherm piping system is primarily comprised of polypropylene random copolymers (PP-R). However, other polymers, accessory metals, additives, and fillers are also included in the product depending on the piping system. Table 2 shows the material composition by mass percentage, origin, and availability of the representative Aquatherm piping system product.

Table 2: Summary of % mass, origin, availability, and the backgroud LCI data

Material	Mass (%)	Origin	Availability	Background LCI data
PP-R Granulate	87.2%	Europe	Finite, Primary	2015 GaBi database
Filler	4.9%	Europe	Finite, Primary	2015 GaBi database
Brass Fitting	4.8%	Europe	Finite, Primary	2015 GaBi database
Oxygen barrier	1.3%	Europe	Finite, Primary	2015 GaBi database
Additive	1.1%	Europe	Finite, Primary	2015 GaBi database
Other polymers	0.4%	Europe	Finite, Primary	2015 GaBi database
Other Metals	0.3%	Europe	Finite, Primary	2015 GaBi database

Manufacture

Procured materials are compounded and extruded to desired width and length, while the pipe fittings are injection molded to the corresponding size. Electricity, fuel, and water are required to transform the materials into the desired piping system schematic. Figure 2 shows a simplified flow diagram of the Aquatherm production process.

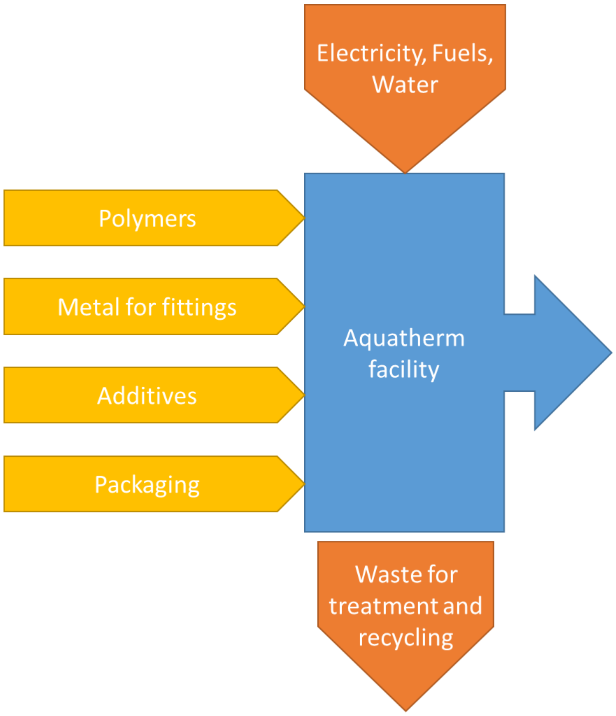

Figure 2: General flow diagram of Aquatherm production process

Declaration of Parameters in Accordance to PCR

PCR requires that resource use and waste to disposal parameters be reported in accordance to EN 15804.

Parameter	Unit	A1	A2	A3	Total
Use of renewable primary energy excluding renewable primary energy resources used as raw materials	MJ, net calorific value	0.730	1.22E-03	0.15	0.88
Use of renewable primary energy resources used as raw materials	MJ, net calorific value	0.130	0	0	0.130
Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials)	MJ, net calorific value	0.86	1.22E-03	0.15	1.01
Use of non renewable primary energy excluding non renewable primary energy resources used as raw materials	MJ, net calorific value	17.4	0.02	0.35	17.7
Use of non renewable primary energy resources used as raw materials	MJ, net calorific value	0	0	0	0
Total use of non renewable primary energy resources (primary energy and primary energy resources used as raw materials)	MJ, net calorific value	17.4	0.02	0.35	17.7
Use of secondary material	kg	0.0112	0	0	0.0112
Use of renewable secondary fuels	MJ, net calorific value	0	0	0	0
Use of non renewable secondary fuels	MJ, net calorific value	0	0	0	0
Net use of fresh water	m^3	0.00309	7.03E-07	7.51E-05	0.00317
Hazardous waste	kg	0	0	6.42E-05	6.42E-05
Non-Hazardous waste	kg	0	0	0.00184	0.00184
Radioactive waste	kg	0	0	0	0
Components for re-use	kg	0	0	0	0
Materials for recycling	kg	0	0	0.00406	0.00406
Materials for energy recovery	kg	0	0	0	0
Exported energy	MJ	0	0	0	0

According to the guiding PCR, the life cycle impact assessment (LCIA) is based on the CML 2001 (April 2013). Additionally, the addendum PCR by UL Environment optionally recommends that TRACI (version 2.1) be reported as well.

	Unit	A1	A2	A3	Total
CML2001 (April 2013)					
Global Warming Potential	$kgCO_2$-eq	0.567	0.0012	0.0156	0.584
Acidification Potential	$kgSO_2$-eq	1.60E-03	5.20E-06	2.90E-05	1.64E-03
Eutrophication Potential	$kgPO_4^{3-}$-eq	1.36E-04	1.41E-06	6.40E-06	1.43E-04
Ozone Depletion Potential	kgCFC11-eq	5.60E-11	1.44E-15	1.04E-12	5.70E-11
Photochemical Ozone Creation Potential	kgC_2H_4-eq	2.00E-04	-1.95E-06	4.00E-06	2.00E-04
Abiotic Depletion Potential, Elements	kgSb-eq	8.90E-05	6.00E-11	4.50E-09	8.90E-05
Abiotic Depletion Potential, Fossil	MJ	16.4	0.0159	0.33	16.8
TRACI 2.1					
Global Warming Potential	$kgCO_2$-eq	0.567	0.0012	0.0156	0.584
Acidification Potential	$kgSO_2$-eq	1.59E-03	6.90E-06	3.20E-05	1.62E-03
Eutrophication Potential	kgN-eq	8.80E-05	8.40E-07	5.20E-06	9.40E-05
Ozone Depletion Potential	kgCFC11-eq	5.90E-11	1.53E-15	1.11E-12	6.00E-11
Smog Formation Potential	kgO_3-eq	0.0197	0.000144	0.00052	0.02

Life Cycle Impact Conclusions

Polypropylene is the primary contributor to all LCIA categories as well as the primary energy parameters. However, note that according to the GaBi LCI dataset for polypropylene half of the non-renewable primary energy originate from the embodied energy of the feedstock rather than consumed energy. Additives, metal fittings, and energy production are significant contributors to all impacts. Depending on the piping system, there are glass fiber fillers, oxygen barriers, and other piping system-unique formulations that lead to high impact contributions, which is reflected in the average, representative piping system. Overall, raw materials (A1) were the most impactful module in the cradle-to-gate analysis.

An analysis of the individual raw material inputs shows that the impact contribution is largely correlated with mass. Polypropylene, brass, and glass fiber overall were the most impactful raw material inputs. Additives and accessories present in the representative system tended to be particularly impactful for Global Warming Potential and Primary Energy Demand. The flame retardant in the red system was particularly impactful for Acidification Potential.

The most significant raw materials are supported by material-specific GaBi LCI datasets; therefore, the reported results and conclusions are considered to be robust.

LCA Development

This EPD and corresponding LCA were prepared by thinkstep AG.

Comparability

This EPD meets the requirements for comparability with products evaluated in accordance to the guiding PCR document. EPDs from different programs may not be comparable.

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