TECHNICAL NOTE

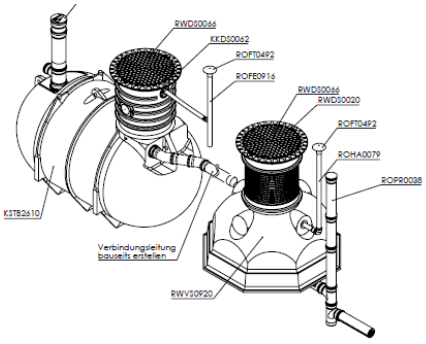
Ecoflo® Protection Filter (EPF)

Tertiary treatment unit for domestic wastewater according to EN 12566-7

EPF 900

EPF 3000

EPF 3650



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1 Introduction

An Ecoflo® Protection Filter (EPF) is a tertiary treatment system for domestic wastewater according to EN 12566-7 for treated effluent discharged by a secondary small wastewater treatment plant (WWTP) according to EN 12566-3.

EPF is providing additional passive and robust natural polishing. As all products of the Ecoflo family EPF is based on the unique filtering properties of the coconut-based husk fragments (100% organic material) ensuring by biological and physical means that another 50-80% of the remaining organic pollutants (being particulate or dissolved) will be retained and aerobically digested within the filtering bed - under nearly all circumstances without clogging of the filtering media. Coco is a highly porous and water-containing media (comparable to a sponge) that is ideal for biofilms to grow on. It also supports horizontal distribution of effluent within the media.

2 EPF concept

Modern small secondary WWTP plants (e.g. SBR-plants) are usually able to remove around 95 % of the organic pollution. But some conditions as “after desludging”, peak loads, wrong use, technical failures, etc. will have an impact on performance, reducing treatment efficiency temporarily down to 70-80% only. The addition of EPF downstream will compensate for times of temporary lower treatment efficiency and ensure proper protection of your environment (receiving water / groundwater and natural soil) by all means.

EPF approach can be applied in two different ways:

- As part of a HYBRID-system:
  WWTP Solido SMART (SBR secondary treatment) + EPF (tertiary treatment)
- As an additional (upgrade) solution downstream of any SBR WWTP (EN 12566-3)

HYBRID-system Solido SMART +P and EPF	EPF as upgrade / add-on solution
 Solido SMART is very effective and compact technical SBR-approach well acknowledged for advanced treatment efficiency. Adding EPF downstream results in a unique combination of the “best of two worlds” (technical secondary treatment and robust passive tertiary polishing by biofiltration).	

Figure 1: HYBRID-system vs. EPF upgrade

It is available as two different types of products:

- **Closed bottom**: as tertiary treatment unit (EN12566-7) with discharge into a receiving surface water (creek, ditch or the sea)
- **Open bottom:** as tertiary treatment + infiltration system for a safe and long-term direct discharge into the ground below

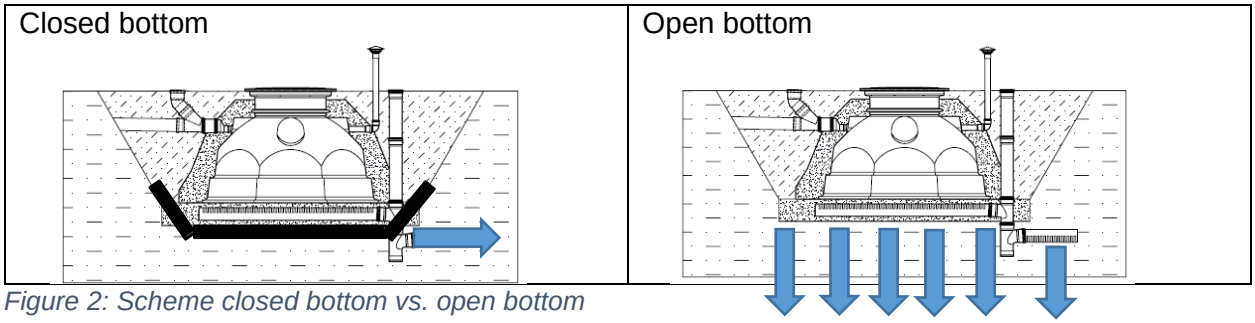


Figure 2: Scheme closed bottom vs. open bottom

EPF application for infiltration of treated wastewater

These are the three main functions when using EPF for infiltration:

1. **polishing** (tertiary treatment) of effluent
2. **proper distribution** of effluent before reaching soil
   - effective distribution through pipe system on top of coco
   - additional horizontal distribution within coco and gravel bed underneath
3. **permanent protection from clogging** of natural soil

When infiltrating treated effluent from small WWTP, it must be ensured to respect the known limits in terms of hydraulic and organic loading[1] rates (OLR) for every single m² of natural soil at any time. Ensuring that organic loading rate on the surface of natural soil will be both **below 1.5 g BOD5/m²/d and 1.5 g TSS/m²/d under all circumstances (worst case)** will provide for long-term safety and functionality of infiltration.

EPF with its unique combination of **polishing, distribution and protection** will guarantee that the limits of organic loading rates will be respected. Thus, natural soil will not be overloaded at any time preventing progressive clogging and thus preserving its long-term infiltration capacity. The protective layer of coco filtering media can easily be (partially) replaced at demand at regular maintenance. It will thus provide for **long-term-protection of your natural soil under all circumstances** (even in case of temporary accidental malfunctions or tough conditions regarding secondary treatment unit upstream).

[1] **Organic loading rate:** Daily amount of organic pollution (BOD5) and particles (TSS) in g per m² of natural soil.

EPF 900: filter shell with open bottom

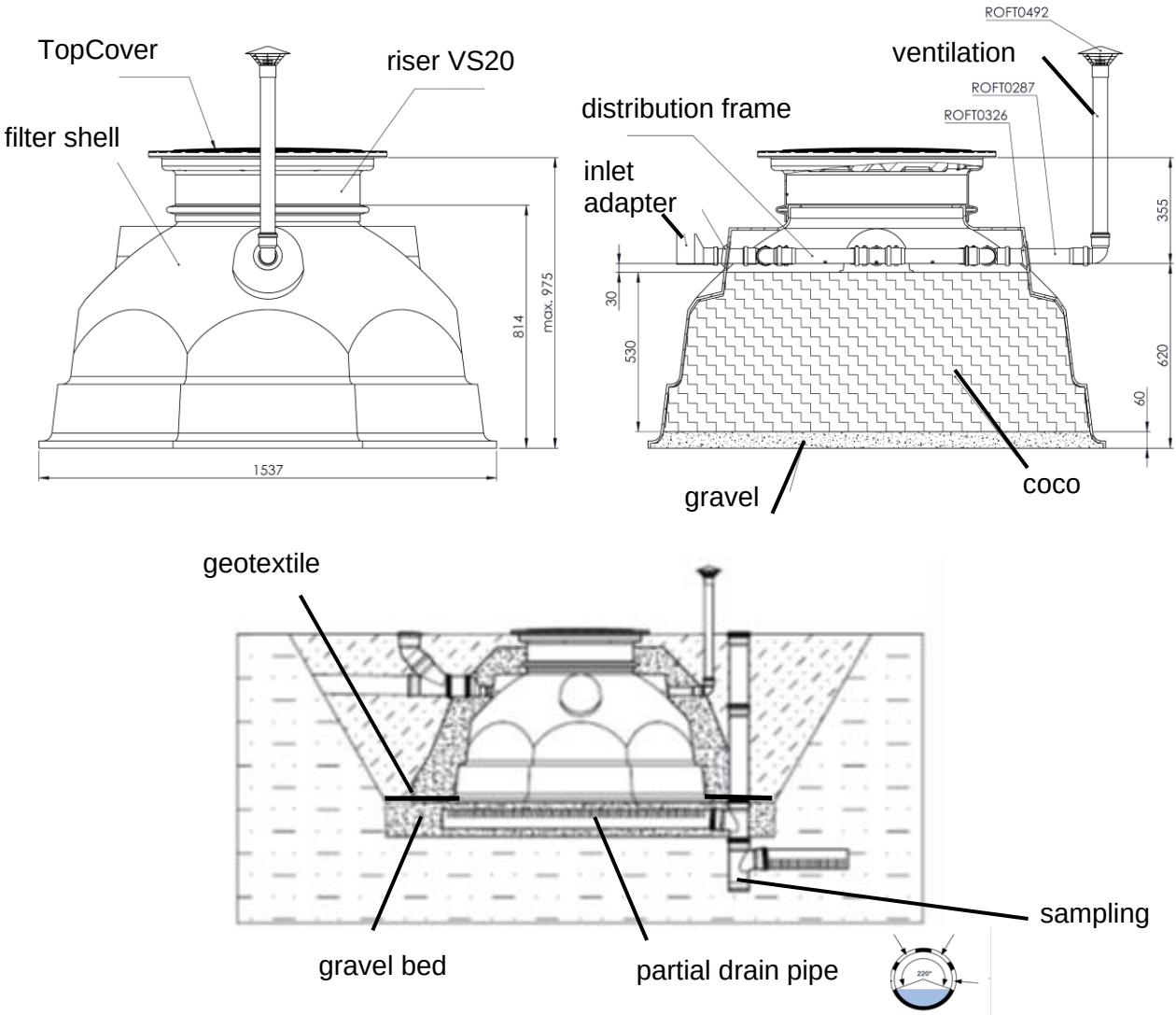


Figure 3: EPF 900 dimensions of part and scheme of installed system (open bottom)

EPF 900: filter shell with closed bottom
(non-permeable flexible sheet under gravel bed)

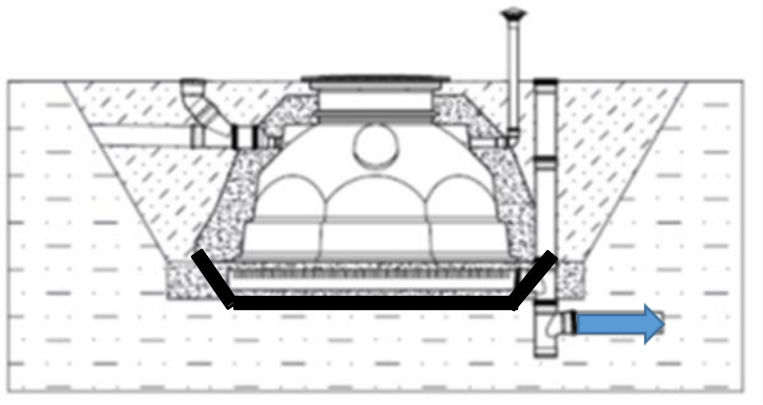
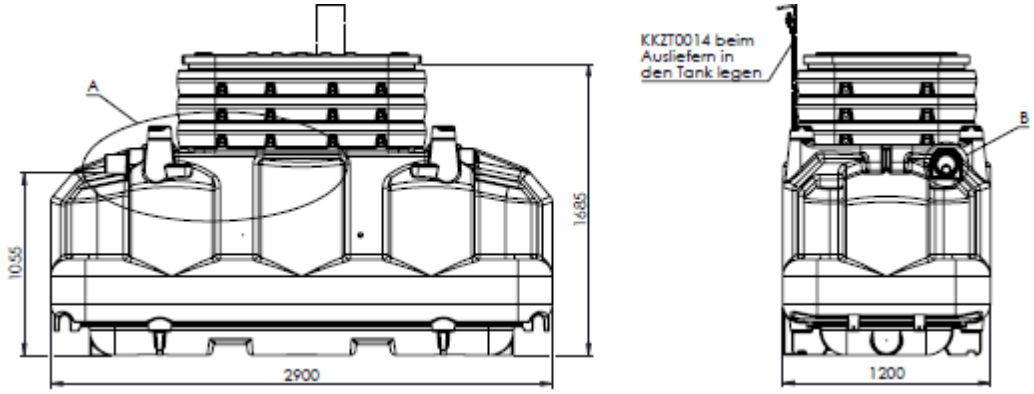
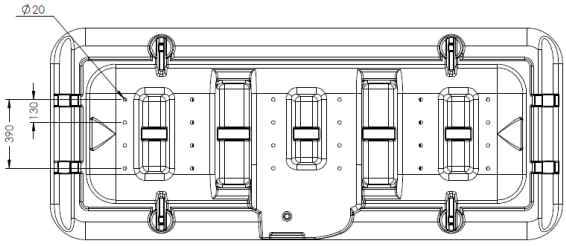


Figure 4: EPF 900 installed (closed bottom)

EPF 3000: closed bottom (can be opened on demand**)**



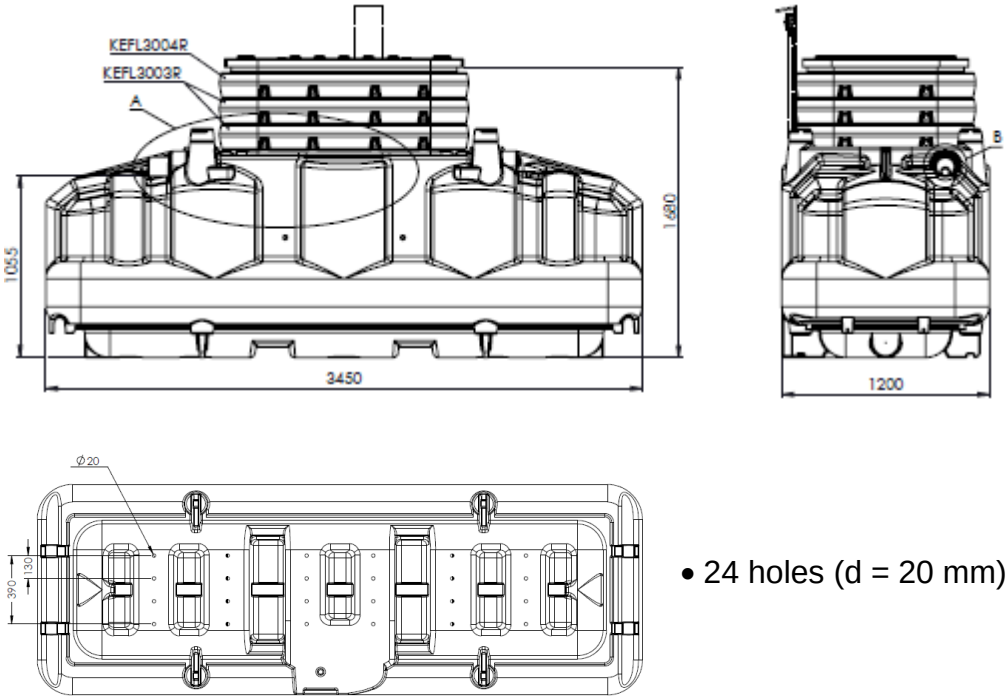
As infiltration system, the unit will be provided with infiltration holes at the bottom:



- 24 holes (d = 20 mm) on bottom

Figure 5: EPF 3000 dimensions (closed and open bottom)

EPF 3650: closed bottom (can be opened on demand)



- 24 holes (d = 20 mm) on bottom

Figure 6: EPF 3650 dimensions (closed and open bottom)

4 HYBRID plants

As mentioned above combining a Solido SMART / Solido SMART+P secondary small WWTP compliant to EN 12566-3 with EPF tertiary treatment unit compliant with EN 12566-7 will result in a highly sophisticated, high performant compact and at the same time robust HYBRID plant that is combining the “best of two worlds”. Solido SMART will take over the biggest part of treatment efficiency regarding BOD5, total-P and total-N while EPF is securing and improving this high level of performance (improving and securing TSS performance in the first place) by its natural passive and very robust approach that will be effective even in case of power failure, malfunctions or not properly desludged secondary treatment upstream protecting the discharge receiving environment (natural soil, ditch/creek). The total footprint of the HYBRID-plant including gravel bed for infiltration shown in figure below is **11.5 m² (L=5,10m, W=2.25m)** only.

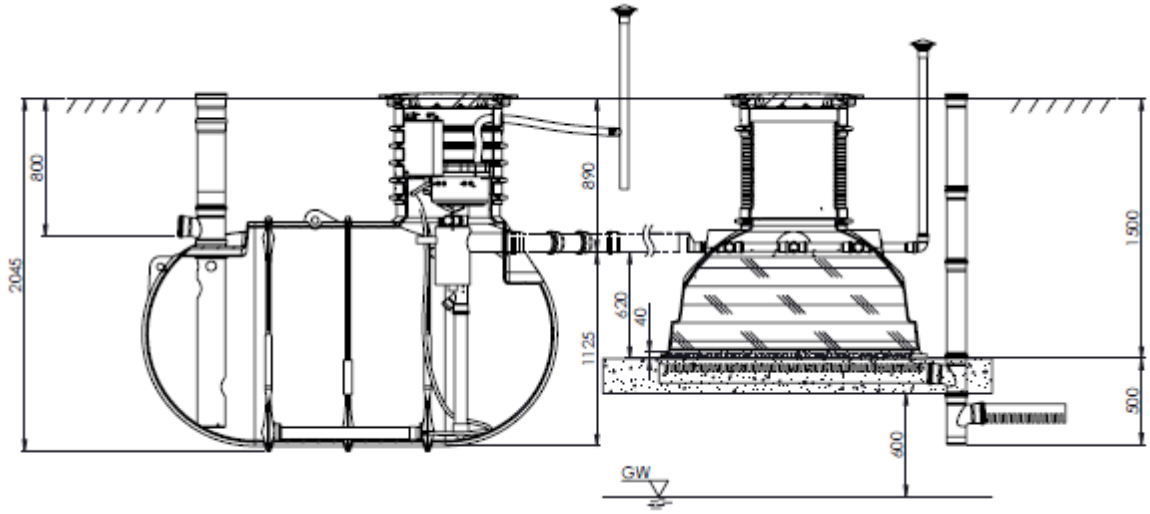


Figure 7: HYBRID-plant 5 PE: Solido SMART +P EBL-26P + EPF 900

4.1 Third Party test references

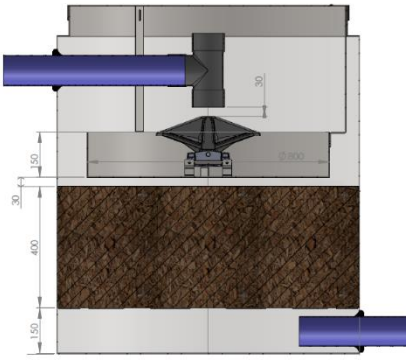
All claims on treatment efficiencies and sizing criteria for EPF that will be presented in detail in this technical note are based on and derived from different practical tests conducted by notified bodies like PIA Aachen (Germany), CSTB Nantes (France) or third parties like avizo.ca, Quebec (Canada).

A. EN-CAPE 18.9305 CSTB (France): EPF testing according to EN 12566-7 from 18.01.18 to 02.07.18 (number of samples: 13)
B. EN-CAPE 18.9949 CSTB (France): Additional internal EPF testing from 15.10.18 to 16.12.18 (number of samples: 22)
C. EN-CAPE 20.xxxx CSTB (France): currently ongoing internal test on HYBRID-system based on EN 12566-3 test protocol from Jun 2019 to summer 2020
D. STG-152-1A12 avizo.ca, (Canada): EPF demonstration program from Dec 2011 to Dec 2012 (number of samples: 111)
E. PIA 2016-276S22 (Germany): Solido SMART and EPF internal tests at PIA Aachen from 30.12.15 to 24.05.16 (number of samples: 15)
F. PIA2015-239B22e (Germany): Solido SMART testing according to EN 12566-3 from 22.12.14 to 13.09.15 (number of samples: 26)
G. PIA2017-300B22 (Germany): Solido SMART +P testing according to EN 12566-3 from 05.12.16 to 27.08.17 (number of samples: 26)
H. PIA2019-SB-365B23 (Germany): Solido SMART +P 6-week test based on EN 12566-3 test protocol for SINTEF approval from 01.04.19 to 12.05.19 (number of samples 13), voluntarily prolonged for internal research until 30.06.19

4.2 Tested treatment efficiency of EPF

All claims on treatment efficiency of EPF are mainly based on test A which is the official test made by PTA according to EN 12566-7 at CSTB in Nantes (France). Another important internal reference for EPF is test D which examined treatment efficiency of EPF for one year (Canada 2012) collecting 111 samples.

Test A



- test A was done with a prototype version of EPF (smaller than EPF 900)
- test A was done with a daily flow rate of 750 L/d (5 PE)
- less height of coco filtering media (40 cm vs. 50-65 cm)
- tested EPF had a closed bottom (for precise sampling)
- specific sizing criteria of tested EPF at CSTB are being used as reference to derive sizing of the 3 EPF models

Test D

Test D test was performed at full scale in real climate conditions in Quebec (Canada). The EPF was installed at the effluent of an attached growth aerobic treatment unit serving a rehabilitation centre (150 PE). The inlet and outlet of the EPF was sampled 30 days by a third party laboratory during a period of one year for system demonstration. The testing conditions were the following:

- Coco filter unit having 8.5 m² in surface fed at an average HLR of 1058 L/m²/d
- OLR=18 g BOD5/m²/d
- Filtering media height: 60 cm
- Distribution system: low pressure distribution system

Table 1: summary of the results of test A (EN 12566-7)

Parameter	Inlet	Effluent from EPF	Ø removal rate
TSS	43 ± 18 mg / L	8 ± 3 mg / L	81%
BOD_5	13 ± 7 mg / L	6 ± 4 mg / L	54%
COD	90 ± 25 mg / L	51 ± 11 mg / L	43%
TKN	20 ± 15 mg / L	10 ± 10 mg / L	50%

5 Claimed treatment efficiency of EPF and derivation of sizing criteria

Table 2: overview on claims for treatment efficiency EPF

	EPF 5 PE test EN 12566-7	EPF 900 8 PE	EPF 3000 16 PE	EPF 3650 20 PE
daily nominal flow Qd	0,75 m³/d	1,20 m³/d	2,40 m³/d	3,00 m³/d
fedding pattern	10x 38 L in 100min 2x daily	10x 60 L in 100min 2x daily	10x 120 L in 100min 2x daily	10x 150 L in 100min 2x daily
A Coco	0,80 m²	1,40 m²	2,70 m²	3,24 m²
H Coco	0,40 m	0,50 m	0,60 m	0,60 m
V Coco	320 L	740 L	1650 L	2050 L
spec. V Coco	64 L/PE	93 L/PE	103 L/PE	103 L/PE
daily HLR (Coco)	938 L/m²/d	857 L/m²/d	889 L/m²/d	926 L/m²/d
hourly HLR (Coco)	281 L/m²/h	257 L/m²/h	267 L/m²/h	278 L/m²/h
EPF at test EN12566-7 CSTB (test A)		**Claimed treatment efficiency for EPF**		
TSS reduction EPF	81% / 8 mg/L	**> 75% / < 10 mg/L**		
BOD_5 reduction EPF	54% / 6 mg/L	**> 50% / < 10 mg/L**		
COD reduction EPF	43% / 51 mg/L	**> 40% / < 70 mg/L**		
TKN reduction EPF	50% / 10 mg/L	**> 40% / < 30 mg/L**		
E. Coli reduction EPF	0.1 log	--		
Claimed treatment efficiency for HYBRID (SMART + EPF)				
TSS reduction		**> 98.5% / < 10 mg/L**		
BOD_5 reduction		**> 98% / < 10 mg/L**		
COD reduction		**> 95% / < 70 mg/L**		
TKN reduction		**> 70% / < 30 mg/L**		
E. Coli reduction		**> 3.5 log (99.97%)**		

Within this table specific sizing criteria are being defined. It is shown that for all 3 models of EPF the specific sizing criteria are even below the limits of the specific sizing criteria at test A at CSTB according to EN 12566-7. Claimed treatment efficiency is below tested treatment efficiency to allow for safety margin.

Treatment efficiency claims (removal rate in % and effluent level in mg/L) are being derived from test A for EPF as tertiary polishing unit. EPF can be placed downstream following any well-functioning secondary SBR-plant in the field if hourly hydraulic loading rates (HLR in L/m²/h) are being respected. Intermittent feeding of EPF (like in Solido SMART) is highly recommended.

Treatment efficiency claims (removal rate in % and effluent level in mg/L) for HYBRID-systems (SMART + EPF) are being derived by combining results from test A with those from tests B-H. Reduction of E. Coli by 3.5 log (99.97%) will be achieved by stand-alone Solido SMART systems. This was shown in test B, test C and test E.

6 EPF as infiltration system

When using EPF as infiltration unit it will be put on top of a gravel bed. As explained in chapter 2 it is essential to respect limits for hydraulic and organic loading rates regarding coco filtering media, gravel bed and natural soil to ensure long-term function of infiltration without clogging. As for any infiltration system a minimum vertical distance of 60 cm to the groundwater level must be respected.

Table 3: Required specific surface of gravel bed and hydraulic loading rates (HLR)

kf-value [1]	kf-value [1]	T [1]	A spec	max HLR per d	infiltr. rate Q spec [2]	Q cycl [3]	max HLR per h [4]	duration per cycl [3]
5,0E-04 m/s	4320 cm/d	0,3 min/cm	1,0 m²/PE	150 L/m²/d	900 L/h	75 L/PE/cycl	50 L/m²/h	0,08 h
1,0E-04 m/s	864 cm/d	1,7 min/cm	1,0 m²/PE	150 L/m²/d	180 L/h	75 L/PE/cycl	50 L/m²/h	0,42 h
5,0E-05 m/s	432 cm/d	3,3 min/cm	1,5 m²/PE	100 L/m²/d	135 L/h	75 L/PE/cycl	33 L/m²/h	0,56 h
1,0E-05 m/s	86 cm/d	16,7 min/cm	1,8 m²/PE	83 L/m²/d	32 L/h	75 L/PE/cycl	28 L/m²/h	2,31 h
5,0E-06 m/s	43 cm/d	33,3 min/cm	2,4 m²/PE	63 L/m²/d	22 L/h	75 L/PE/cycl	21 L/m²/h	3,47 h

1: fully saturated soil 2: Q spec = 0.5 x kf x A spec 3: 2 cycles / d (12 h) 4: intermittent discharge Solido SMART

Proper sizing of gravel bed is necessary in order to not overburden natural infiltration capacity of natural soil. In worst case conditions infiltration will need 3.5 h per 12h-cycle (Solido SMART). This represents a 30% utilization of soil infiltration capacity. It allows at least 8.5 h of rest and drying off for the natural soil.

The unique **polishing** properties of coco in combination with the EPF design providing for proper **distribution** and **long-lasting protection** of natural soil by accessible and easily replaceable protective layer of coco filtering media will **guarantee long-term full infiltration capacity.** When all sizing criteria including size of gravel bed are respected at installation the resulting organic loading rates in terms of TSS and BOD_5 will usually **NOT exceed 1.5 g/m²/d** at any time anywhere on top of the natural soil thus providing for long-term protection from clogging. Proper distribution and unique polishing of EPF allows for **reduction of specific organic loading rates by >98% for TSS and >95% for BOD5**.

Table 4: resulting organic loading rates for HYBRID 5 PE (corresponding to next figure below)

		BOD5 20 mg/L	BOD5 10 mg/L	BOD5 10 mg/L	TSS 50 mg/L	TSS 10 mg/L	TSS 10 mg/L
kf-value [1]	max HLR per d	BOD loading rate (5 PE at A1)	BOD loading rate (5 PE at A2)	BOD loading rate (5 PE at A3, soil)	TSS loading rate (5 PE at A1)	TSS loading rate (5 PE at A2)	TSS loading rate (5 PE at A3, soil)
5,0E-04 m/s	150 L/m²/d	30,0 g BOD/m²/d	5,0 g BOD/m²/d	1,5 g BOD/m²/d	75,0 g TSS/m²/d	5,0 g TSS/m²/d	1,5 g TSS/m²/d
1,0E-04 m/s	150 L/m²/d	30,0 g BOD/m²/d	5,0 g BOD/m²/d	1,5 g BOD/m²/d	75,0 g TSS/m²/d	5,0 g TSS/m²/d	1,5 g TSS/m²/d
5,0E-05 m/s	100 L/m²/d	30,0 g BOD/m²/d	5,0 g BOD/m²/d	1,0 g BOD/m²/d	75,0 g TSS/m²/d	5,0 g TSS/m²/d	1,0 g TSS/m²/d
1,0E-05 m/s	83 L/m²/d	30,0 g BOD/m²/d	5,0 g BOD/m²/d	0,8 g BOD/m²/d	75,0 g TSS/m²/d	5,0 g TSS/m²/d	0,8 g TSS/m²/d
5,0E-06 m/s	63 L/m²/d	30,0 g BOD/m²/d	5,0 g BOD/m²/d	0,6 g BOD/m²/d	75,0 g TSS/m²/d	5,0 g TSS/m²/d	0,6 g TSS/m²/d

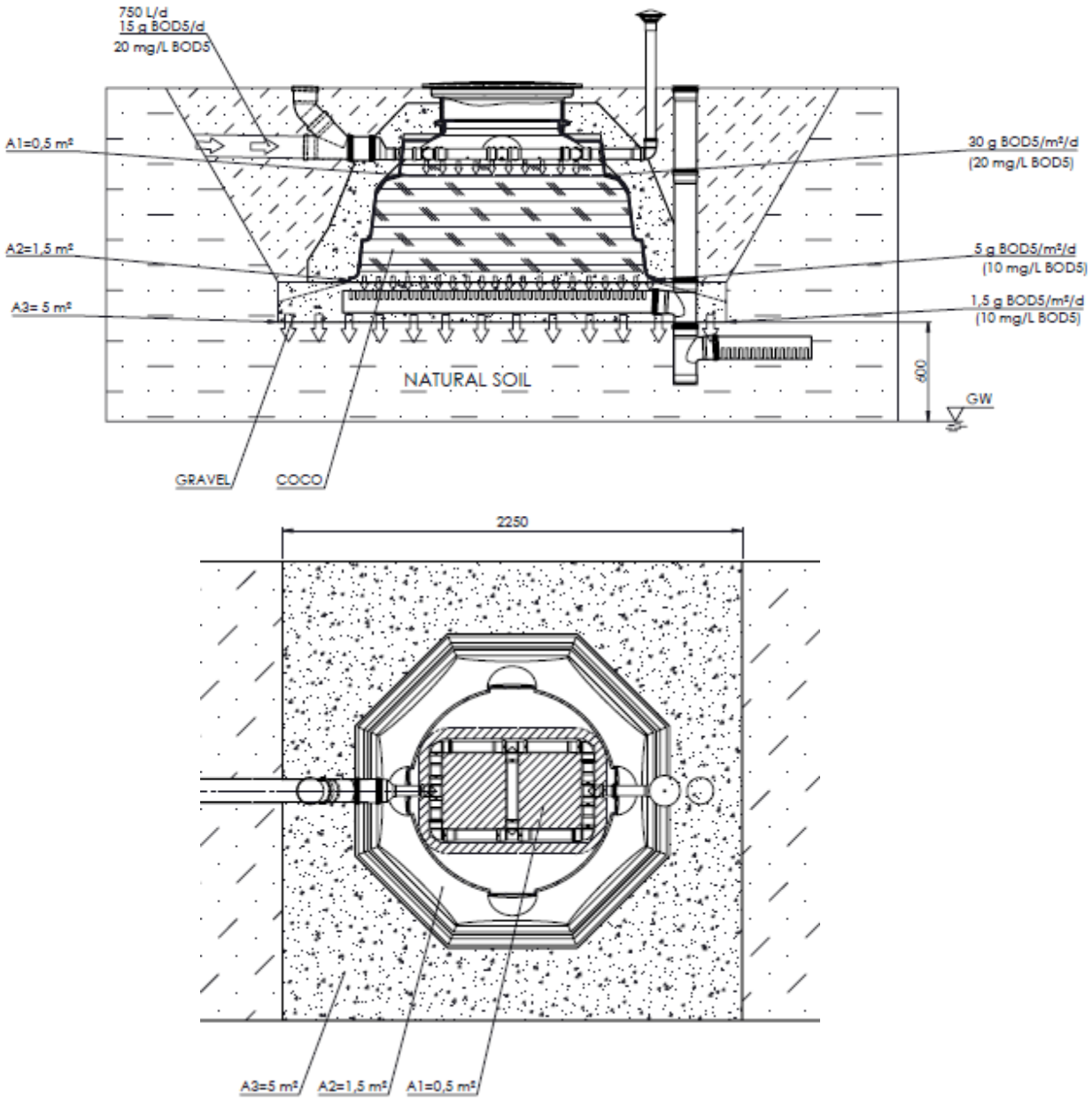


Figure 8: reduction of organic loading rates by EPF 900 / HYBRID 5 PE plant (side and top view)