EVALED™ PC F

Technical Report

PC F 0.7

Heat pump vacuum evaporator with forced circulation and external shell and tube heat exchanger

VEOLIA

1 Technical characteristics

Nominal production capacity of distillate with water:	700 [l/24h]
Available versions: *(selection dependent on corrosion resistance)*	**PC F 0.7 AA#** (austenitic stainless steel) **PC F 0.7 FF#** (superduplex stainless steel) **PC F 0.7 HH#** (nickel alloys) **PC F 0.7 FA#** (austenitic and superduplex stainless steel)
Electrical equipment:	PC F 0.7 --3 (400 [V] 50 [Hz] 3F) PC F 0.7 --4 (460 [V] 60 [Hz] 3F)
Construction:	pre-assembled single module on a stainless steel frame
Condensation heat exchanger:	internal coil
Heating exchanger:	external shell and tube with forced circulation
Evaporation conditions:	absolute pressure 6-8 kPa temperature 35-45 [°C]
Distillate temperature:	30-40 [°C]
Concentrate temperature:	35-45 [°C]
Drop separation:	perforated grill demister with packing elements
Feed filter:	cartridge filter 500 µm
Heating/cooling technology:	heat pump
Circulation pump:	centrifugal with fluxed mechanical seal
Heat pump compressor:	hermetic reciprocating piston type
Refrigerant:	R 134a (no impact on the ozone layer) Fluorinated greenhouse gas: 8 kg, equal to 11 t CO_2 equivalent
Vacuum system:	liquid ejector
Operating control:	automatic, continuous 24/24h 7/7d through PLC Siemens S7-1200; status information and consent to equipment operation remotable through digital signals
Operator panel:	Proface GP4000 touch screen
International Protection Rating:	IP 54
Noise:	< 75 [dB(A)]
Main reference legislation: *(CE marking)*	Machinery Directive (2006/42/EC) Electromagnetic compatibility (2004/108/EC) Electrical safety (EN 60204-1) Pressure Equipment Directive (PED) (97/23/EC)

2 Nominal performance

The data reported in the following table refer to the performances achieved during the FAT (Factory Acceptance Test) with clean machine fed with tap water under atmospheric pressure.

Version	**PC F 0.7--3**	**PC F 0.7--4**
Electrical power supply	400 [V] **50** [Hz] 3F	460 [V] **60** [Hz] 3F
Maximum production of distillate with water	790 [l/24h] ± 10%	790 [l/24h] ± 10%
Absorbed power under normal working conditions	6 [kW] ± 10%	6 [kW] ± 10%
Installed power	11 [kW]	12 [kW]
Power factor	[cosø] 0,9	[cosø] 0,9
Specific electrical consumption per litre of distillate	180 [Wh/l] ± 10%	180 [Wh/l] ± 10%
Heat generated by thermal dissipation	5 [kW] ± 10%	5 [kW] ± 10%
Maximum air flow of finned pack	7000 [Nm^3/h] ± 10%	8200 [Nm^3/h] ± 10%

3 Functional description

The PC F 0.7 machine is an evaporator for the treatment of water-based liquids. It uses the combined effect of vacuum and heat pump technology to achieve the boiling of liquids at low temperatures (35-45°C). The various components are identified in figure 1.

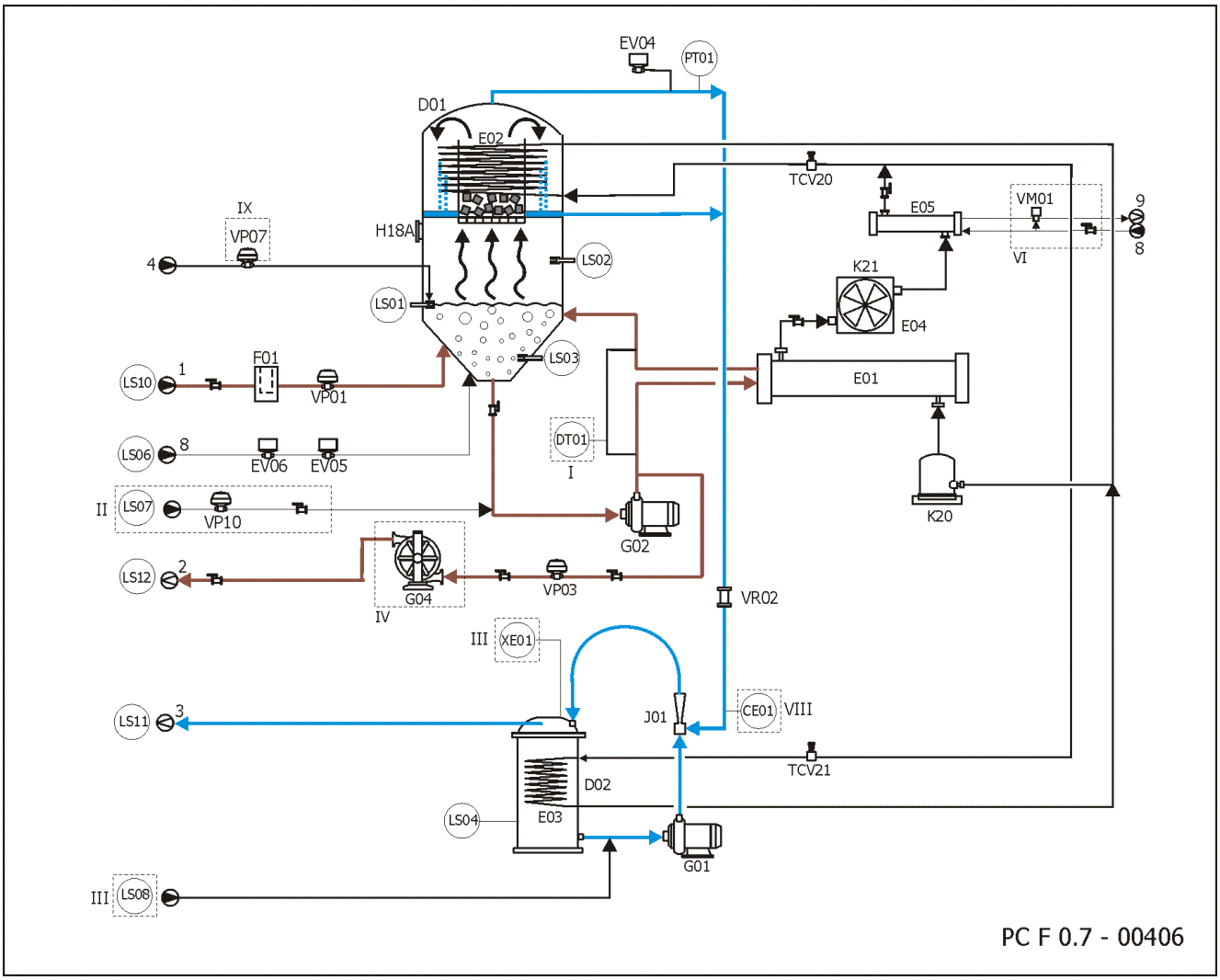


Figure 1

The circles with alphanumeric characters indicate the main sensors on the machine. The Roman numerals and dashed rectangles indicate the optional systems and accessories. The numbers next to the inlets and outlets indicate the various connections to the process lines.

3.1 Process liquid circuit

The liquid to be treated is sucked into the evaporation chamber **D01** as a result of the vacuum created inside it by the vacuum system, without using a feed pump. The feed is controlled by the level switch **LS01**, which controls the pneumatic valve **VP01**. The in-line filter **F01** removes any coarse material. The pump **G02** draws the liquid from the bottom of the evaporation chamber and pumps it through the heat exchanger **E01;** this heat exchanger supplies the heat necessary for evaporation. Once heated, the liquid is returned to the evaporation chamber **D01**. As a result of the vacuum in the chamber, a portion of the heated liquid immediately evaporates (flash evaporation). The generated water vapour rises through a separator in order to remove the liquid droplets. The vapour is then condensed against the heat exchanger **E02**.

The vacuum system extracts the distillate together with any incondensable gases and sends them to the tank **D02**. The distillate is continuously discharged by overflow and the incondensable gases are vented with the liquid. The concentrate is discharged automatically according to the equipment operating time through the opening of the pneumatic valve **VP03**. Internal washing of the LS01 level sensor in the evaporation chamber is carried out manually (automatically if the OW TW option is installed).

3.2 Vacuum system

The vacuum system consists of the centrifugal pump **G01** coupled with the ejector **J01**. The ejector uses the distillate produced by the evaporator as the driving fluid. The efficiency of the vacuum system depends on the temperature of the distillate.

The opening of solenoid valve **EV04** breaks the vacuum inside the evaporation chamber.

3.3 Heat pump circuit

The heat necessary to evaporate the liquid and the cooling necessary to condense the steam are both supplied by the heat pump circuit. The refrigerant, in the gaseous phase, is heated by the compressor **K20**. The liquid then passes through the heat exchanger **E01** and releases part of its heat to the liquid to be evaporated. In this way, the refrigerant cools and starts to condense. The finned heat exchanger **E04** completes the condensation of the refrigerant, and any excess heat is released into the environment. The refrigerant, in the liquid phase, is sent to the lamination valves **TCV20** and **TCV21**, which cause expansion and cooling. A branch of the circuit joins the exchanger **E02** in order to condense the water vapour produced by the boiling of the liquid in the boiler, while the other joins the exchanger **E03** to cool the distillate.

The cycle is completed with the joining of the two branches of the circuit and the suction of the refrigerant, in the vapour phase, by the compressor.

3.4 Auxiliary liquids

An antifoam agent supplied through the solenoid valves **EV06** and **EV05**.

Water for the internal washing of the evaporation chamber level sensor **LS01**.

An additive supplied through the opening of valve **VP10** if the optional system **OM AD F** is present.

Water for auxiliary cooling through the exchanger **E05** if the optional system **OC TP R** is present.

pH adjusting agent to adjust the pH of the distillate if the optional system **OC pH D** is present.

Bactericide for the distillate, if the accessory system **AM BT D** is present.

4 Options and accessories

(*1)	Code	Description	Standard/Opt
[-]	**OM AF F**	Antifoam agent dosing device	S
[-]	[-]	Provision for level control on external process liquid tanks	S
I	**OC DN C**	Concentrate density control and measuring device	O
II	**OM AD F**	Additive dosing device	O
III	**OC pH D**	Distillate pH adjustment device	O
IV	**OT DP C**	Concentrate transfer device	O
VI	**OC TP R**	Auxiliary cooling device	O
VIII	**OC CN D**	Distillate conductivity control device	O
IX	**OW TW**	Automatic washing of the level switch in the evaporation chamber	O
[-]	**OW CH (PC F)**	Automatic chemical washing system for series PC F evaporators *(*2)*	O
[-]	**OC PB**	Profibus interface device *(*2)*	O
[-]	**OC EN**	Ethernet interface device *(*2)*	O
[-]	**OI RC**	Remote control via ADSL/UMTS *(*2) (*3)*. Ethernet option “OC EN” required	O
[-]	**AM BT D**	Bactericide dosing device	O
[-]	**AT CP D**	Distillate transfer device (40 l/min – 2 bar)	O
[-]	**AT SP D**	Distillate pressurization device (tank not included)	O
[-]	**AC pH F**	Feed pH adjustment device	O

**1) See the diagram in figure 1. *2) To be considered when ordering. *3) Can be combined with remote control contract EVA-Link.*

As regards the automatic chemical washing system **OW CH (PC F)**, refer to the specific technical report.

5 Construction materials

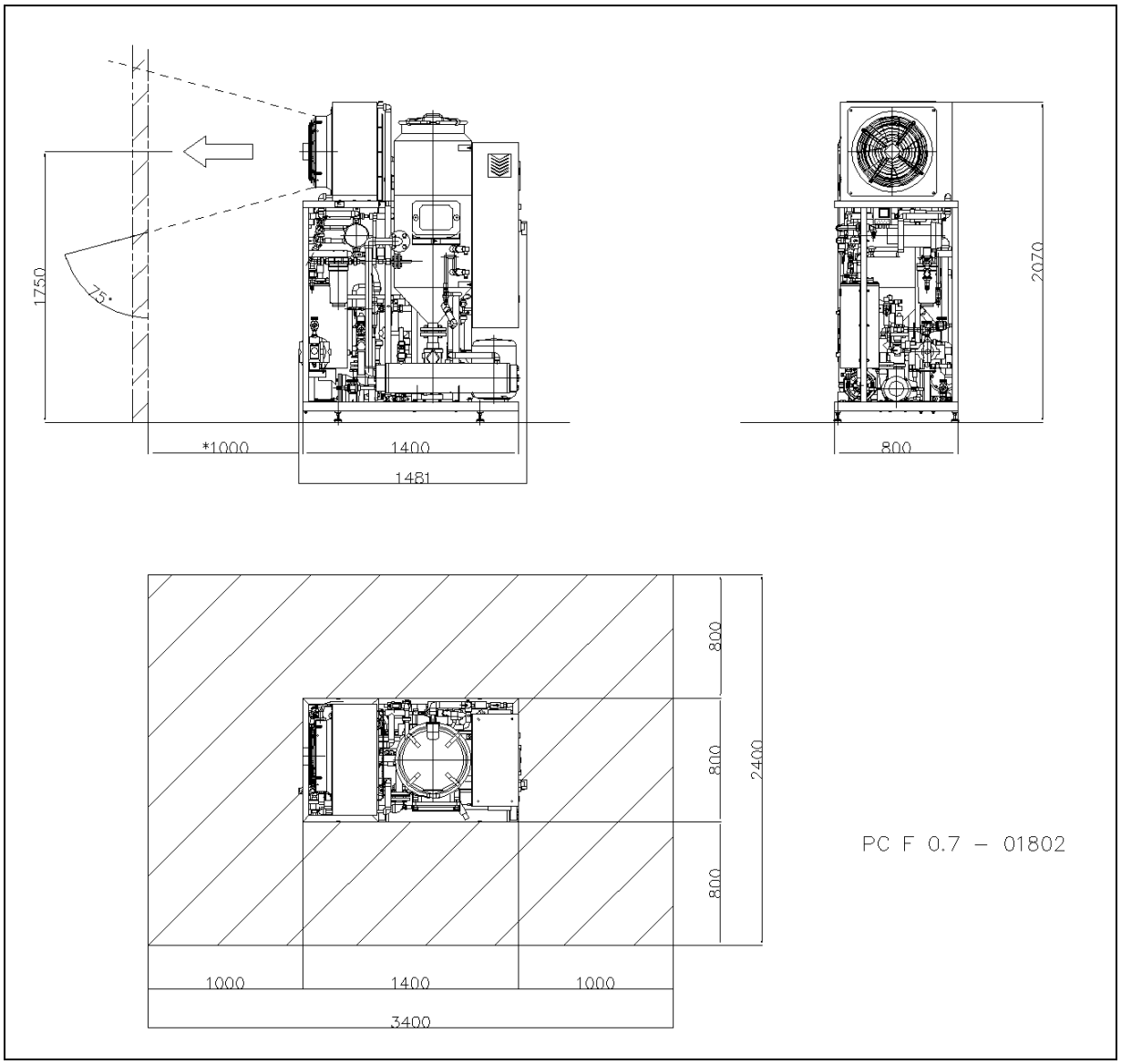
The main materials that come into contact with the process liquids are listed in the following tables.

Key:

INOX 304/L	austenitic stainless steel AISI 304 (EN 1.4301) / AISI 304L (EN 1.4307)
INOX 316/L	austenitic stainless steel AISI 316 (EN 1.4401) / AISI 316L (EN 1.4404)
DUPLEX	super duplex stainless steel UNS S32750 / UNS S32760 (EN 1.4410 / EN 1.4501)
IRON/INOX C	cast iron / carbon steel
PP	polypropylene
Cu	copper
Al	aluminium
ALLOY C22 / C4	nickel alloy UNS N06022 / UNS N06455
FPM	fluoropolymer
EPDM	ethylene Propylene Diene Monomer
PTFE	polytetrafluoroethylene

Component	ID	PC F NN AA#	PC F NN FA#	PC F NN FF#	PC F NN HH#
Lower wall of evaporation chamber	**D01**	INOX 316/L	INOX 316/L	DUPLEX	ALLOY C22
Dome of evaporation chamber	**D01**	INOX 316/L	INOX 316/L	INOX 316/L	INOX 316/L
Distillate collection tank	**D02**	INOX 316/L	INOX 316/L	INOX 316/L	INOX 316/L
Shell and tube heat exchanger	**E01**	INOX 316/L	DUPLEX	DUPLEX	ALLOY C22
Heat exchanger	**E02**	INOX 316/L	INOX 316/L	INOX 316/L	INOX 316/L
Coil heat exchanger	**E03**	INOX 316/L	INOX 316/L	INOX 316/L	INOX 316/L
Finned heat exchanger	**E04**	Cu/Al	Cu/Al	Cu/Al	Cu/Al
Shell and tube exchanger	**E05**	Cu –IRON/ INOX C	Cu –IRON/ INOX C	Cu –IRON/ INOX C	Cu –IRON/ INOX C
Vacuum pump	**G01**	INOX 316/L	INOX 316/L	INOX 316/L	INOX 316/L
Circulation pump	**G02**	INOX 316/L	INOX 316/L	DUPLEX	ALLOY C22
Concentrate discharge pump (option)	**G04**	PP	PP	PP	PP
Liquid ejector	**J01**	PP	PP	PP	PP
Evaporation chamber level sensors (blades)	**LS**	INOX 316/L	INOX 316/L	INOX 316/L	ALLOY C4
Structure and frame	-	INOX 304/L	INOX 304/L	INOX 304/L	INOX 304/L
Piping and line parts	-	INOX 316/L + PP	INOX 316/L + PP	INOX 316/L + PP	ALLOY C22 + PP
Heat pump piping	-	Cu	Cu	Cu	Cu
Gaskets	-	FPM+PTFE +EPDM	FPM+PTFE +EPDM	FPM+PTFE +EPDM	FPM+PTFE +EPDM

6 Dimensions and clearance zones



* Minimum distance from the wall in the absence of a suitable opening (800 x 800 mm) or adequate ducting.

A clearance height of at least 1000 mm is required above the machine for maintenance operations.

Figure 2

7 Dimensions, weight, packaging, storage and handling

Type	Dimensions [mm]	Weight [kg]
Standard packaging (pallet + nylon)	1550 x 800 x 2070 h	490
Wooden crate packaging (also with protection bag)	1700 x 1030 x 2250 h	650
Empty without packaging/under normal conditions with water	see Figure 2	480 / 600

If required, the equipment must be stored packaged and protected from the weather. In any case, the temperature of the storage area must be between **+5** and **+35**°C and the non-condensing relative humidity must be between 20% and 80%. The evaporator can be moved by pallet truck or forklift truck with forks of a suitable length or by a self-propelled crane or gantry crane using a harness and sling to balance the load.

8 Environmental conditions, ventilation and auxiliary cooling

The finned heat exchanger of the heat pump system produces warm air which should be discharged through an appropriate ventilation system to ensure the necessary air circulation. This system could be a simple direct opening to the outside or suitable conveying or forced ventilation systems. If there is no suitable opening in the wall, it is necessary to leave a minimum distance in front of the ventilator as shown in Figure 2.

Temp.	Working conditions
10÷40 [°C]	normal conditions
0÷10 [°C]	start-up allowed only with specific precautions
40÷45 [°C]	it is compulsory to use the optional auxiliary cooling system
>45 [°C]	contact VWT Italia

The machine is designed to be installed at a maximum altitude of 1000 metres a.s.l. (for installations at higher altitude contact VWT Italia).
The nominal performances stated in this document are guaranteed for a liquid feed temperature lower than 55°C.
The optional auxiliary cooling system has an output thermal capacity of **4** kW (**3450** kcal/h). The pressure drop produced by the system is ~ **25** kPa. The maximum pressure of input cooling water is **300** kPa. The output water temperature is ~**45**°C.
The cooling water used should be compatible with the E05 exchanger materials. Any use of the distillate is only permitted with prior authorization from the manufacturer.
Using tap water at **15**°C, the required flow rate of cold water will be ~**0.1** m^3/h; with cooling tower water at **28**°C, the required flow rate of cold water will be ~**0.2** m^3/h.

9 Installation requirements

The machine is designed to be installed indoors on a horizontal surface that can support the weights listed in section **7**. There must be clearance areas around the machine to enable users and maintenance staff to work unobstructed and to allow the passage of cooling air from the ventilator as specified in section **6**. The features of the hydraulic connections are listed below:

(*1)	Description	Type	Dext [mm]	Available outlet pressure [barg]	Required inlet pressure [barg]
1	Liquid to be treated inlet	Hose adapter	20	-	-0,6 <P< 1
2	Concentrate discharge	Hose adapter	20	~0,3	-
2	Concentrate discharge with pump (option IV)	Hose adapter	20	~3	-
3	Distillate discharge	Hose adapter	20	~0,25	-

**1) Ref. Figure 1*

Possible emissions of non-condensable gases are conveyed through the distillate discharge line (outlet 3 in Figure 1).

The following utilities are required to operate the machine, with the specified characteristics:

	Setup	Required pressure [barg]	Consumption [Nm^3/h]	Connection	Features
Compressed air	PC F 0.7 –3/4	6	1	PE tube (Dext 10 mm)	Water- and oil-free
Compressed air	PC F 0.7 –3/4 with IV option	6	10	PE tube (Dext 10 mm)	Water- and oil-free

	Setup	Frequency (Hz)	Voltage (V)	Nominal current (A)	Power supply
Electric energy	PC F 0.7 --3	50 (±2%)	400 (±4%)	23	3-PHASE + EARTH
Electric energy	PC F 0.7 --4	60 (±2%)	460 (±4%)	21	3-PHASE + EARTH

The power connection to the electricity network must be made according to the characteristics reported in the wiring diagrams.
An adequate electrical protection system must be put in place upstream of the machine by a qualified engineer, according to good practice.

10 Environmental Impact Reduction: CO_2 emissions

Below are the results of our Carbon Footprint study and a comparison with an extreme case of pollution:

$kgCO_{2eq}/m^3$ treated liquid waste	106,45
Percentage of emissions avoided with respect to incineration of the liquid waste	-91,4%

The first value represents an average between the various industrial uses considering machine usage of 24h/d, 330 d/y, for 10 years, road transport of the machinery 1000 km from the manufacturer's production site and road transport of the chemical products for a distance of 100 km from the customer's site. The data for comparison with incineration was weighted for machine efficiency, i.e. the ratio between the initial liquid waste to be treated and the residual concentrate to be disposed of.

11 Chemical products

Chemical products are required during the normal operation of the machine. In order to obtain the best performances together with minimum consumptions, the manufacturer recommends using "Hydrex" chemical products.

"Hydrex" is the VEOLIA brand that meets the chemical products requirements of the wastewater treatment and process water production.

Notes

- For details concerning machine safety and installation, refer to the use and maintenance manual.

- The data in this document are indicative. VWT Italia reserves the right to change any data without prior notice. The front-page photograph is not representative of all versions or all models.