March 25th, 2025

EMPEREST: A smart mobile solution to plan large-scale investments into advanced wastewater treatment

Interreg Baltic Sea Region

Co-funded by the European Union

SUSTAINABLE WATERS

EMPEREST

WATER-SMART SOCIETIES

What is in focus?

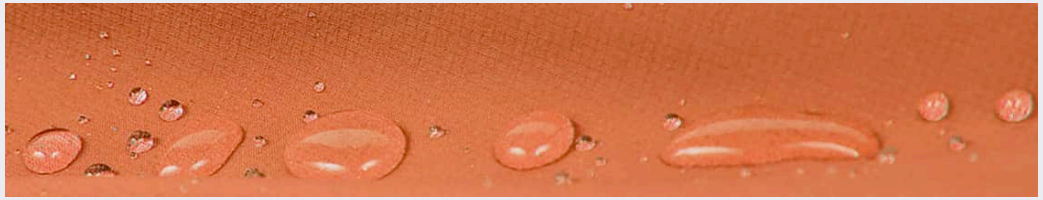
Micropollutants

Organic micropollutans

- **Pharmaceuticals**, hormones and other organic micropollutants
- Indicators defined in **EU UWD** 2024 (80%)
  - Category 1 – easily treated
    amisulprid, carbamazepine, citalopram, clarithromycin , diclofenac, hydrochlorothiazide, metoprolol, venlafaxine
  - Category 2 – easily disposed of
    benzotriazole, candesartan, irbesartan, methylbenzotriazole

Per- and polyfluoroalkyl substances

- A large group of mobile persistent man-made substances, also known as **“forever chemicals”** - extreme environmental persistency, and health hazards
- Not in EU UWD
- PFAS discharge management is becoming one of biggest **environmental challenges** in the BSR.

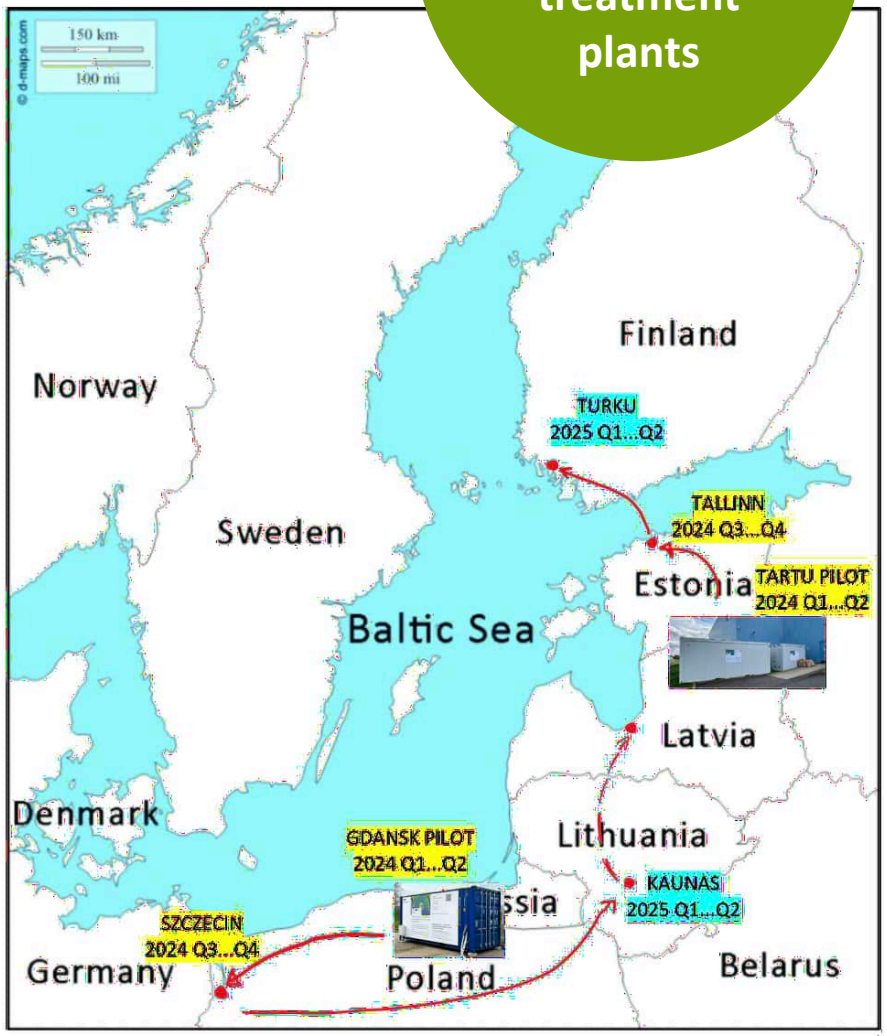


Strategies and technological means for

minimising organic micropollutant emissions from WWTPs

Piloting in 6 different wastewater treatment plants

- The project will assemble the necessary knowledge for wastewater treatment plants to be able to start planning their own investments into advanced effluent treatment.
- To achieve that, EMPEREST will set up two mobile pilots for advanced wastewater treatment.
- Two mobile containers were constructed for testing of 3-5 different technological solutions for quaternary wastewater treatment.



Coordinated by: **University of Tartu**

Todays presenters

Taavo Tenno

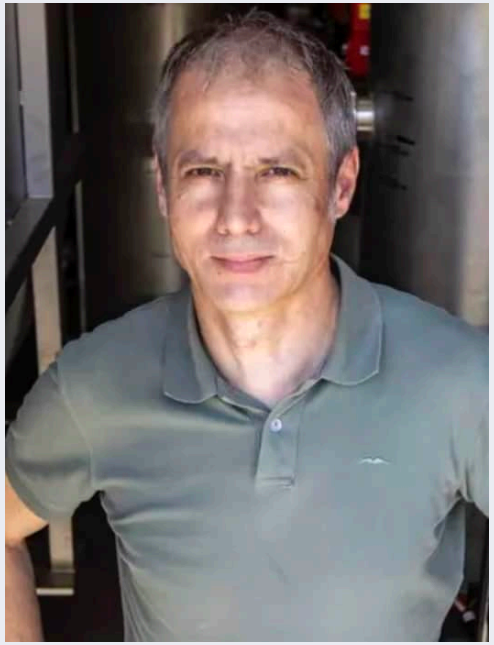
PhD, Associate Professor

University of Tartu

Marlen Taggu

Technologist

Tallinn Water Utilities



Marek Swinarski

PhD, Chief Technology

Gdansk Water Utilities

GIWK

Piotr Miakoto

WWTP manager Pomorzany

Szczecin Water Utilities

ZWiK

Technologies for quaternary wastewater treatment

Treatment Type	Technology Category	Technology
Sequestration Technologies	Sorption	Activated Carbon - Granular - GAC - Powder - PAC Anion Exchange Resin
	Membrane Filtration	Reverse Osmosis Nanofiltration
	Coagulation	Specialty Coagulants
Transformation or destruction technologies	Redox treatment	Electrochemical Ozone Plasma
	Other	Sonochemical Thermal Biological

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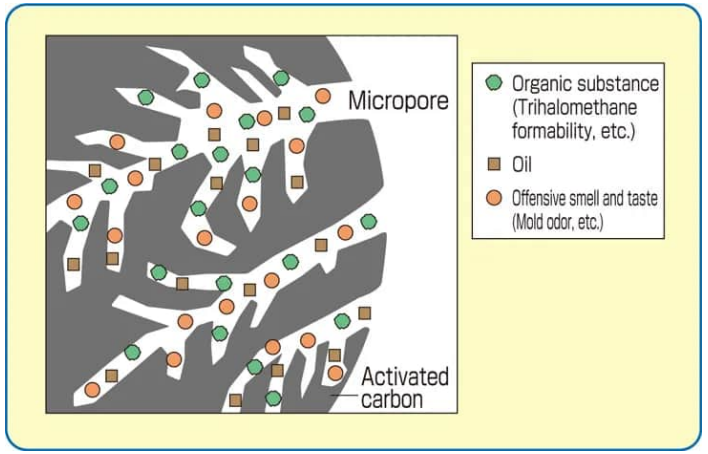

www.acarbons.com/activated-carbon-adsorption-mechanism

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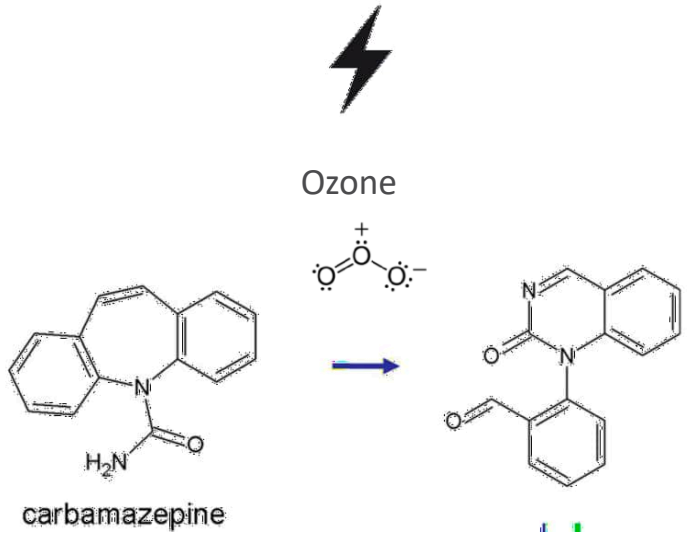

U. Hübner et al Water Research 2014

Technologies for quaternary wastewater treatment

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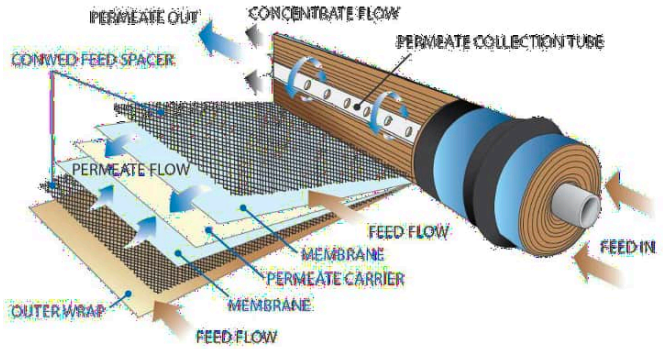
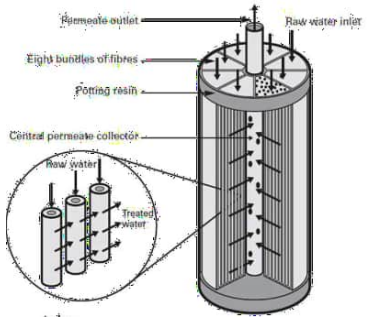




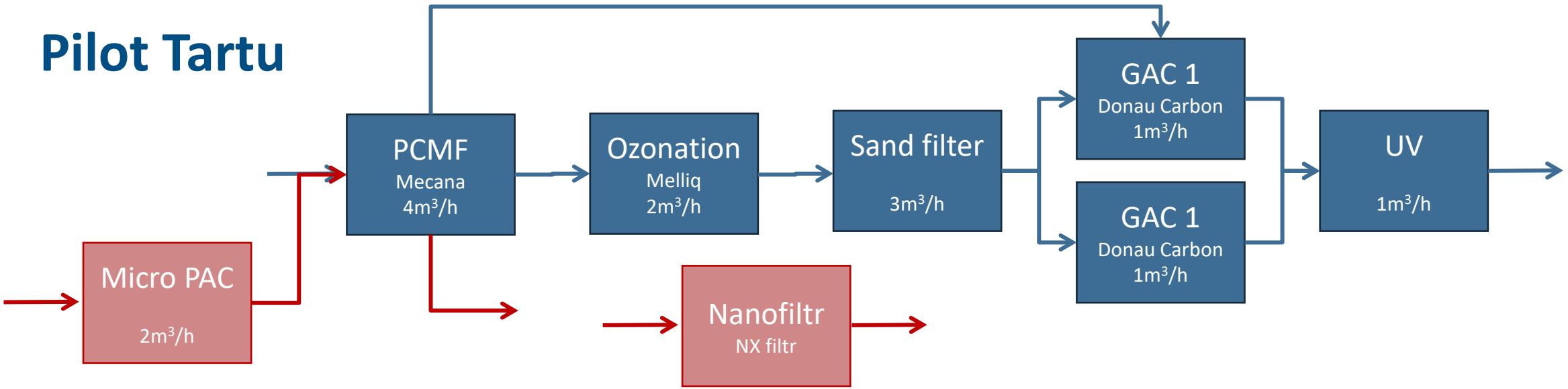
NX Filtration

Technologies for quaternary wastewater treatment

Treatment Type	Technology Category	Technology	P1 - Tartu	P2 - Gdansk
Sequestration Technologies	Sorption	Activated Carbon - Granular - GAC - Powder - PAC Anion Exchange Resin	✓ ✓ 0	✓ 0 ✓
	Membrane Filtration	Reverse Osmosis Nanofiltration	✓	0
	Coagulation	Specialty Coagulants		
Transformation or destruction technologies	Redox treatment	Electrochemical Ozone Plasma	✓	✓
	Other	Sonochemical Thermal Biological		

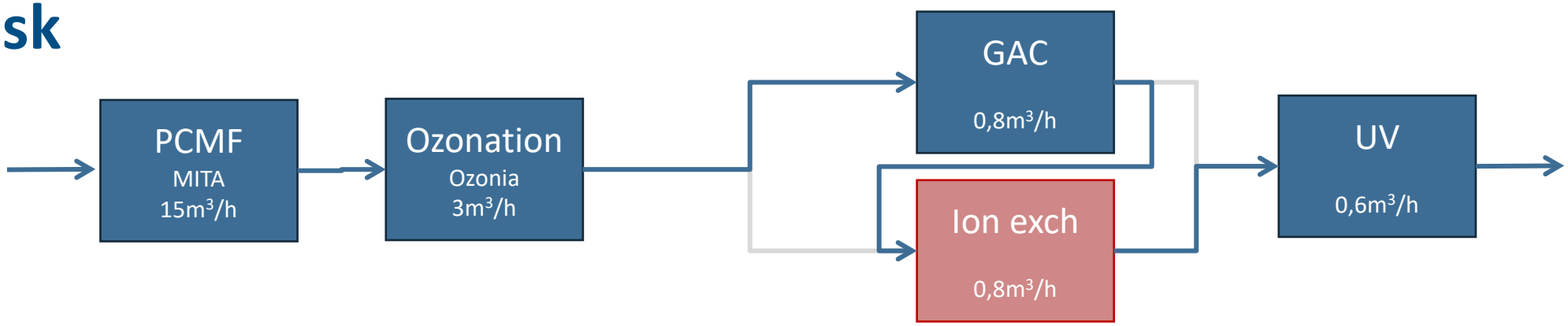
Design

Pilot Tartu

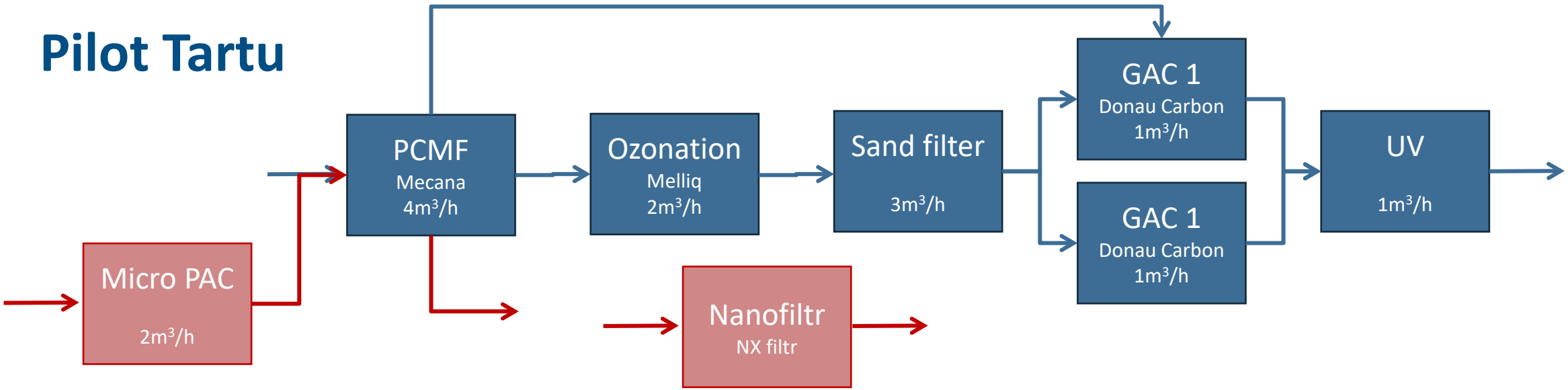


Design

Pilot Gdansk



Pilot Tartu



Pilot Tartu


MOBILE ADVANCED TECHNOLOGY
FOR MICROPOLLUTANT REMOVAL
FROM WATER

Pilot Tartu

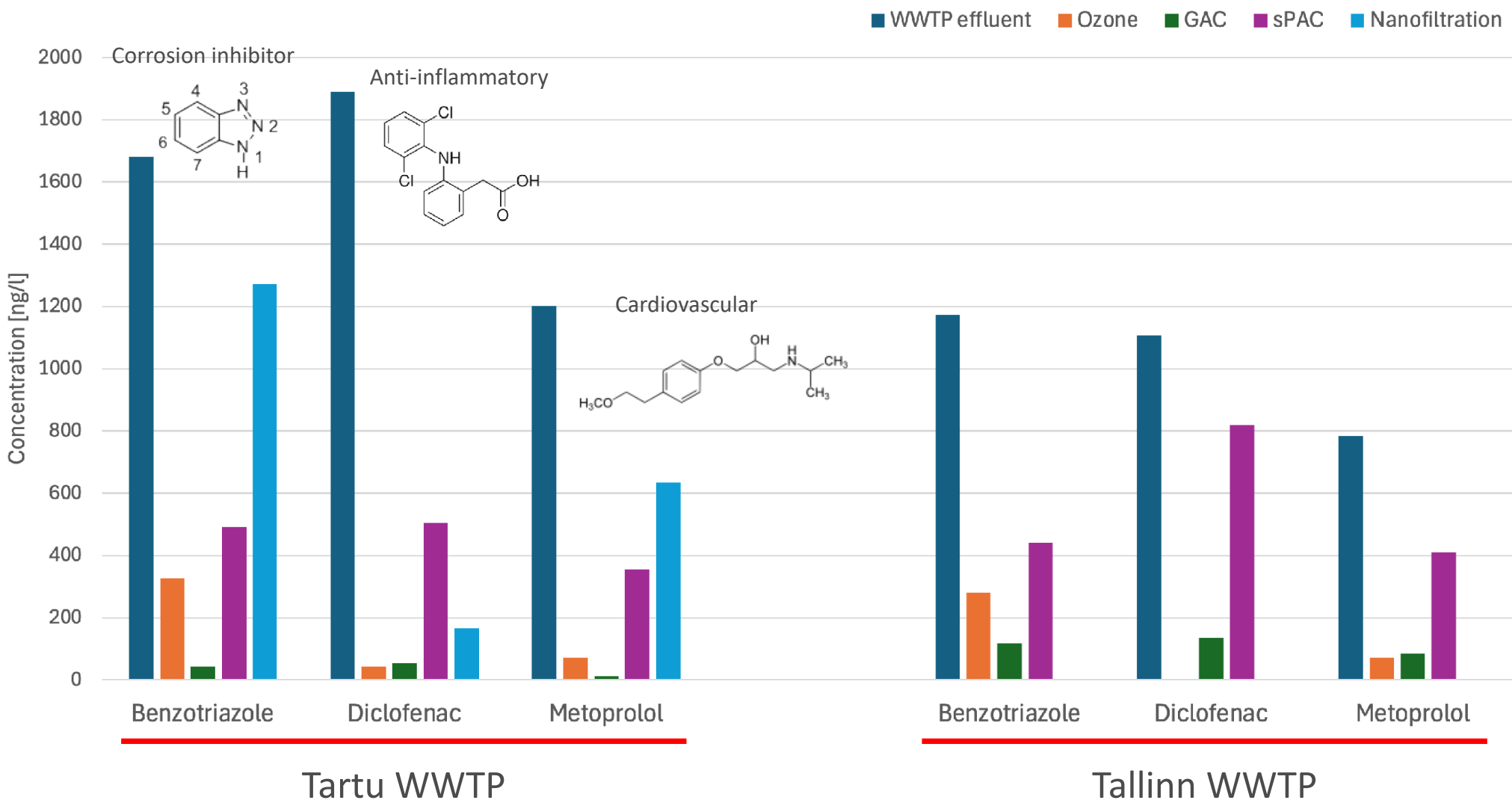
PCMF

Sand filter

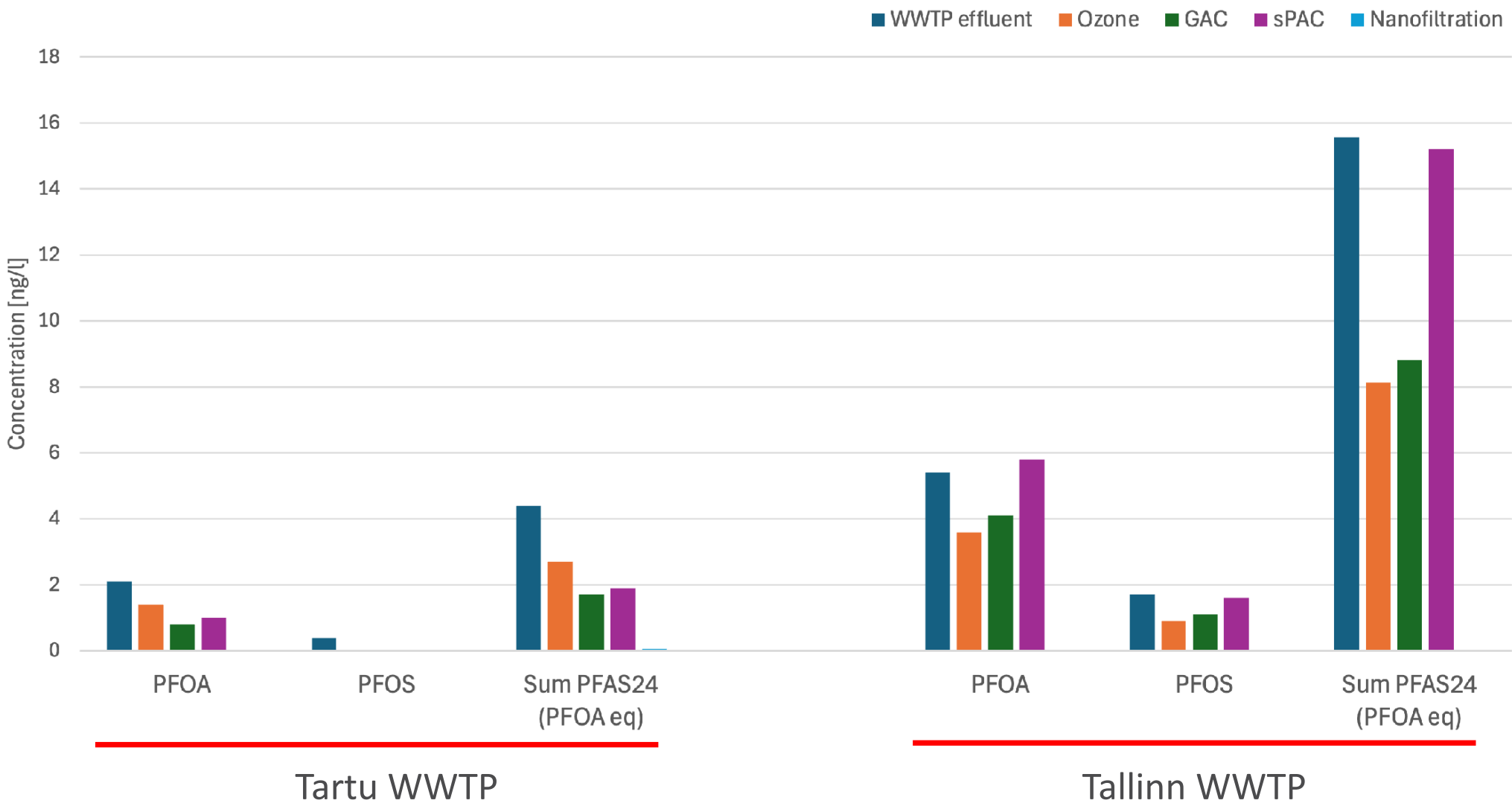
GAC

Ozone

Results - organic micropollutants



Results - PFAS



Conclusions

Feasibility studies are needed for Investment decisions

All technologies alone generally work with sufficient efficiency for removal of organic pollutants (not NF)

Sorption technologies (activated carbon) have a mild potential for PFAS removal

Long chain PFAS may partially degrade during ozonation and this should be considered in monitoring and assessment

Marlen Taggu
Tallinn
25.03.2025

Piloting experiences

Tallinn Water / ESTONIA

Interreg
Baltic Sea Region

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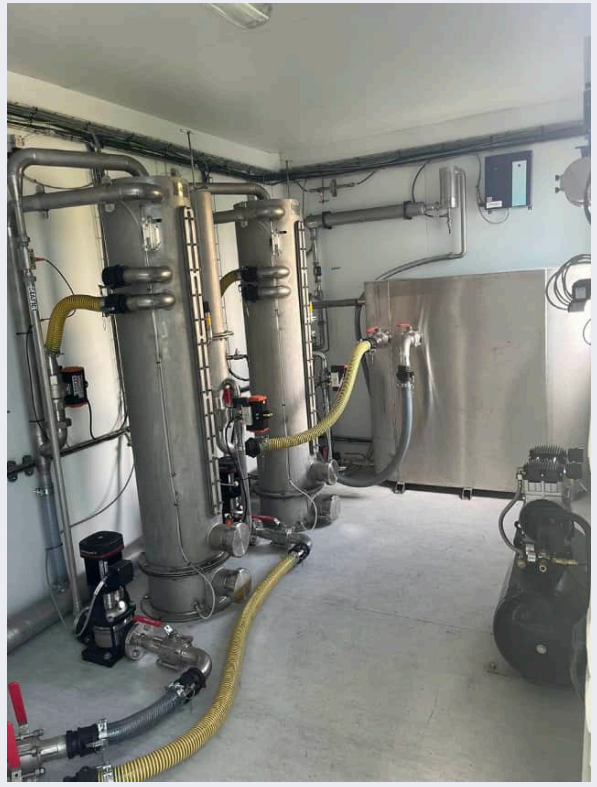
WATER-SMART SOCIETIES

Pilot Plant Operation in Tallinn WWTP

- Transport from Tartu WWTP to Tallinn WWTP
- Operation: 02.09.24 - 03.02.25
- Inflow from the biofilter (last biological treatment step)
  - Average inflow to pilot was about 1,2 m3/h

- Operation with two parallel lines
  - Biofilter -> Drum filter -> Ozone -> Sand filter -> GAC A -> UV
  - Biofilter -> Drum filter -> GAC B -> UV



sPAC addition

- In January addition of sPAC (super fine powdered activated carbon) treatment to the pilot plant
- Biofilter → sPAC → Drum Filter → …
- Prepared a chemical mixture for the test (water, powdered activated carbon, and coagulant)

Samples

- The pilot also has an on-site analyzer that takes samples from various cleaning stages every 15 minutes, allowing for continuous monitoring and quality control.
- PFAS and pharmaceutical analysis
  - Analyzed by Eurofins
  - Prior PFAS data from wastewater
- Pilot plant is now at Turku WWTP and sample collection has begun.

Interreg
Baltic Sea Region

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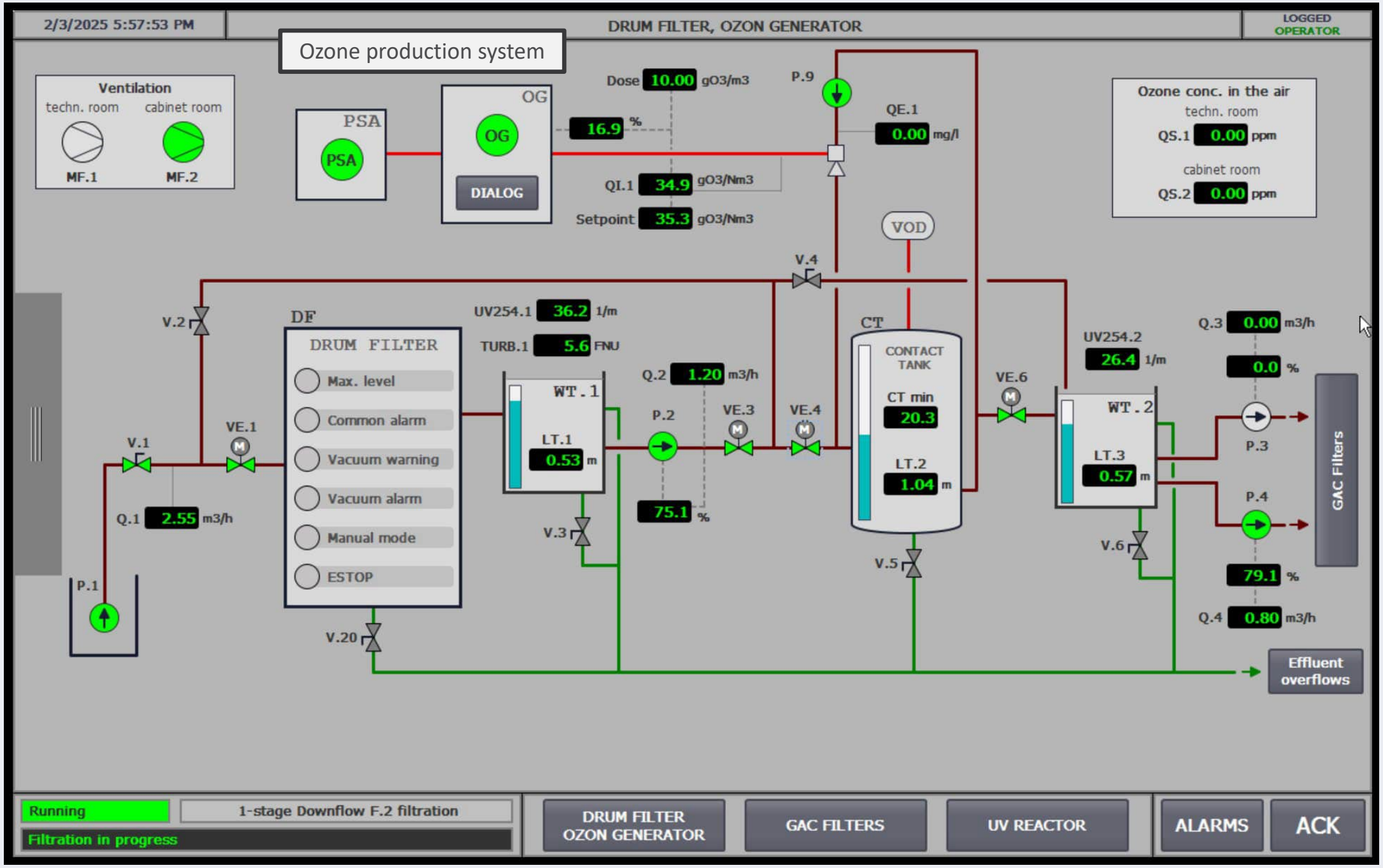
EMPEREST

Marek Swinarski
Gdańsk
March 25th, 2025

Mobile pilot plant for micropollutant removal

Gdańsk Water Utilities

Mobile plug-and-play pilot plant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DRUM FILTER, OZON GENERATOR
LOGGED OPERATOR
Ozone production system
Ventilation
techn. room
cabinet room
MF.1
MF.2
PSA
PSA
OG
OG
DIALOG
Dose 10.00 gO3/m3
16.9 %
QI.1 34.9 gO3/Nm3
Setpoint 35.3 gO3/Nm3
P.9
QE.1 0.00 mg/l
Ozone conc. in the air
techn. room
QS.1 0.00 ppm
cabinet room
QS.2 0.00 ppm
VOD
V.4
V.2
DF
DRUM FILTER
Max. level
Common alarm
Vacuum warning
Vacuum alarm
Manual mode
ESTOP
UV254.1 36.2 1/m
TURB.1 5.6 FNU
WT.1
LT.1 0.53 m
Q.2 1.20 m3/h
P.2
75.1 %
VE.3
VE.4
CT
CONTACT TANK
CT min 20.3
LT.2 1.04 m
VE.6
UV254.2 26.4 1/m
WT.2
LT.3 0.57 m
Q.3 0.00 m3/h
0.0 %
P.3
P.4
79.1 %
Q.4 0.80 m3/h
GAC Filters
V.1
VE.1
Q.1 2.55 m3/h
P.1
V.3
V.5
V.6
V.20
Effluent overflows
Running
1-stage Downflow F.2 filtration
Filtration in progress
DRUM FILTER OZON GENERATOR
GAC FILTERS
UV REACTOR
ALARMS
ACK

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DRUM FILTER, OZON GENERATOR

LOGGED OPERATOR

Ventilation
techn. room
cabinet room
MF.1
MF.2

PSA
PSA

OG
OG

Dose 10.00 gO3/m3
16.9 %
QI.1 34.9 gO3/Nm3

P.9
QE.1 0.00 mg/l

Ozone conc. in the air
techn. room
QS.1 0.00 ppm
cabinet room
QS.2 0.00 ppm

V.2

Drum filter

V.1
VE.1
Q.1 2.55 m3/h

P.1

DF
DRUM FILTER
Max. level
Common alarm
Vacuum warning
Vacuum alarm
Manual mode
ESTOP

V.20

Running
1-stage Downflow F.2 filtration
Filtration in progress

DRUM FILTER OZON GENERATOR
GAC FILTERS
UV REACTOR
ALARMS
ACK

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DRUM FILTER, OZON GENERATOR

LOGGED OPERATOR

Ozone production system

Ventilation
techn. room cabinet room
MF.1 MF.2

PSA
OG
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Dose 10.00 gO3/m3
16.9 %
QI.1 34.9 gO3/Nm3
Setpoint 35.3 gO3/Nm3

P.9
QE.1 0.00 mg/l
VOD

V.4
VE.4
V.5

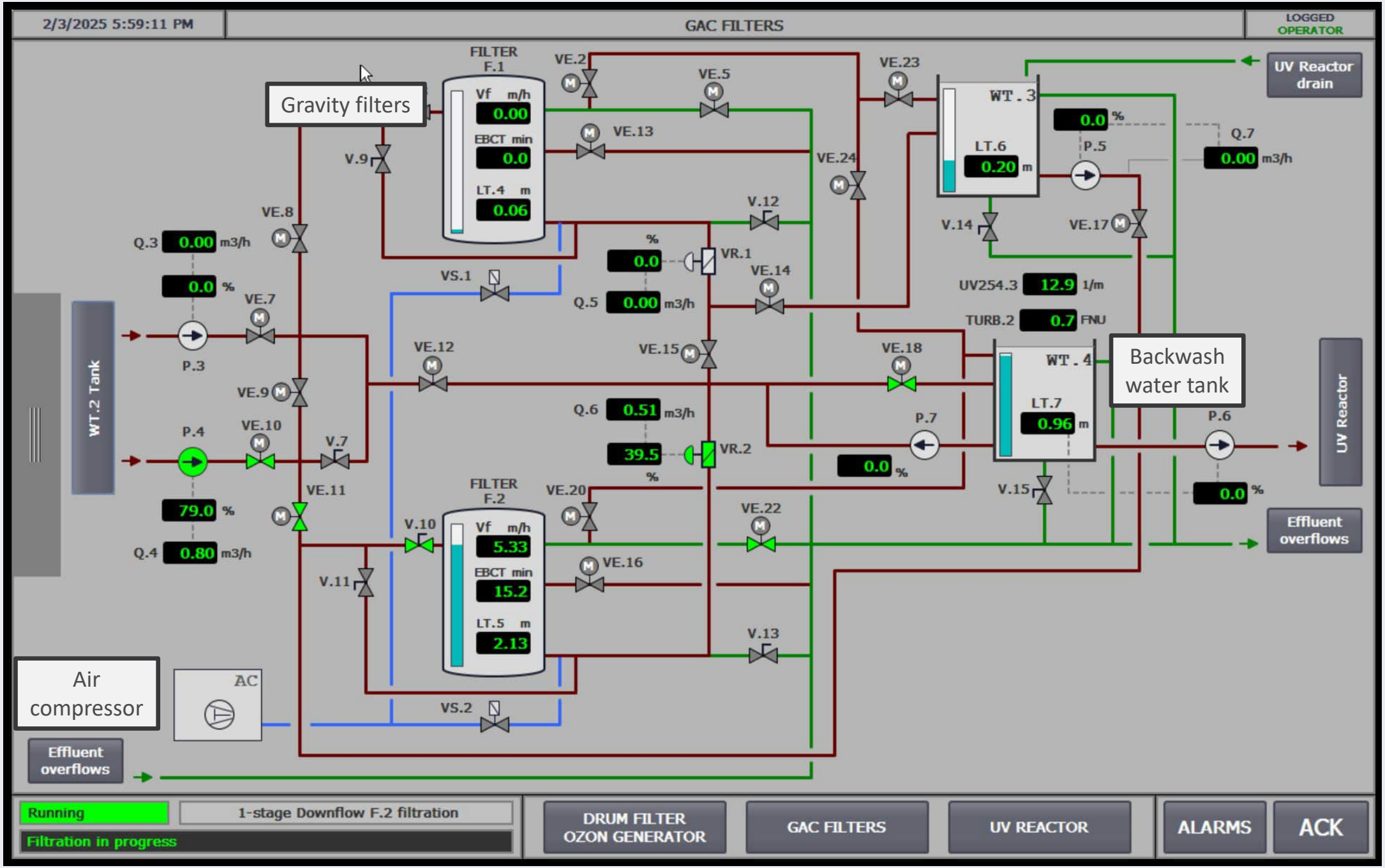
Ozon contact tank

CT
CONTACT TANK
CT min 20.3
LT.2 1.04 m

GAC Filters

Running
1-stage Downflow F.2 filtration
Filtration in progress

DRUM FILTER OZON GENERATOR
GAC FILTERS
UV REACTOR
ALARMS
ACK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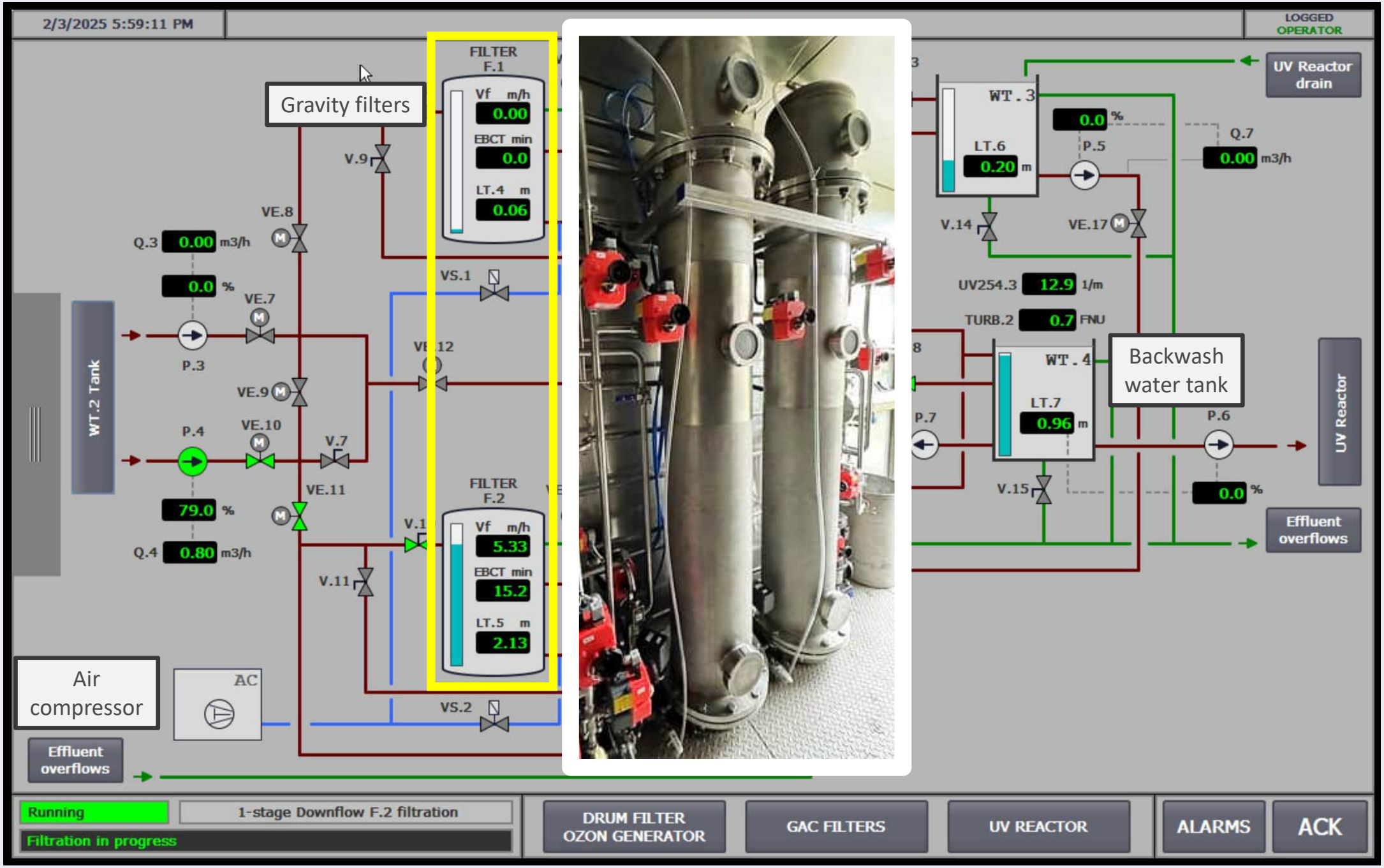
GAC FILTERS
LOGGED OPERATOR
Gravity filters
FILTER F.1
Vf m/h
0.00
EBCT min
0.0
LT.4 m
0.06
VE.2
VE.5
VE.13
V.9
VE.23
WT . 3
LT.6
0.20 m
0.0 %
P.5
Q.7
0.00 m3/h
UV Reactor drain
VE.24
V.12
V.14
VE.17
VE.8
Q.3 0.00 m3/h
0.0 %
VR.1
0.0 %
VS.1
VE.14
Q.5 0.00 m3/h
UV254.3 12.9 1/m
TURB.2 0.7 FNU
VE.7
P.3
VE.15
VE.18
VE.12
WT . 4
LT.7
0.96 m
Backwash water tank
VE.9
Q.6 0.51 m3/h
39.5 %
VR.2
P.7
0.0 %
P.6
0.0 %
WT.2 Tank
P.4
VE.10
V.7
VE.11
FILTER F.2
VE.20
VE.22
V.15
UV Reactor
Effluent overflows
79.0 %
Q.4 0.80 m3/h
V.10
Vf m/h
5.33
EBCT min
15.2
LT.5 m
2.13
VE.16
V.11
V.13
Air compressor
AC
VS.2
Effluent overflows
Running
1-stage Downflow F.2 filtration
Filtration in progress
DRUM FILTER OZON GENERATOR
GAC FILTERS
UV REACTOR
ALARMS
ACK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LOGGED
OPERATOR
Gravity filters
FILTER
F.1
Vf m/h
0.00
EBCT min
0.0
LT.4 m
0.06
V.9
VE.8
Q.3 0.00 m3/h
0.0 %
VE.7
P.3
VS.1
VE.12
VE.9
P.4
VE.10
V.7
79.0 %
Q.4 0.80 m3/h
VE.11
V.1
V.11
FILTER
F.2
Vf m/h
5.33
EBCT min
15.2
LT.5 m
2.13
VS.2
WT.2 Tank
Air
compressor
AC
Effluent
overflows
UV Reactor
drain
WT.3
LT.6
0.20 m
0.0 %
P.5
Q.7
0.00 m3/h
V.14
VE.17
UV254.3 12.9 1/m
TURB.2 0.7 FNU
WT.4
LT.7
0.96 m
Backwash
water tank
P.7
P.6
V.15
0.0 %
UV Reactor
Effluent
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OZON GENERATOR
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UV REACTOR
ALARMS
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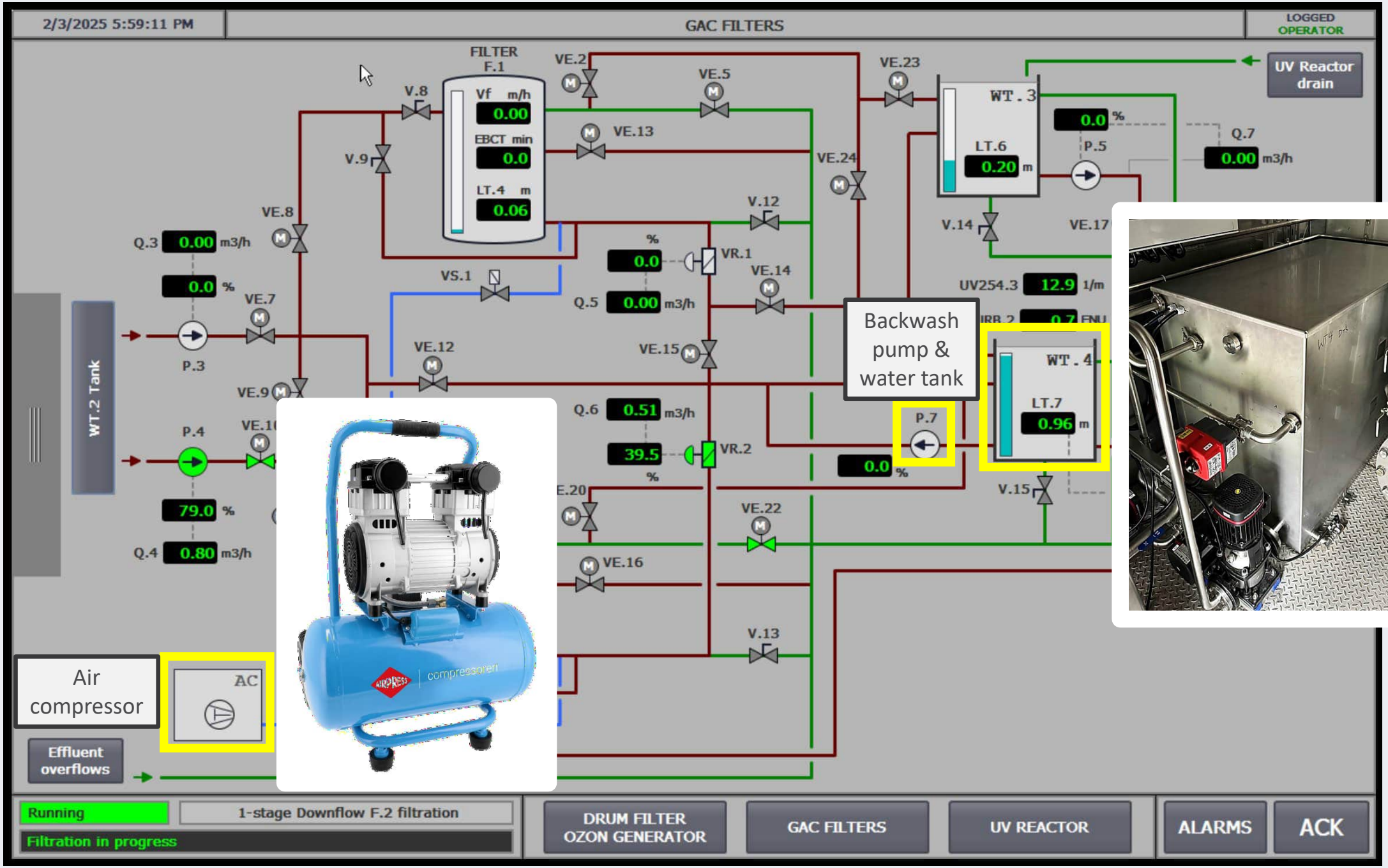
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GAC FILTERS
LOGGED OPERATOR
FILTER F.1
Vf m/h 0.00
EBCT min 0.0
LT.4 m 0.06
V.8
V.9
VE.2
VE.5
VE.13
VE.23
WT . 3
LT.6 0.20 m
0.0 %
P.5
Q.7 0.00 m3/h
UV Reactor drain
VE.24
V.12
V.14
VE.17
VE.8
Q.3 0.00 m3/h
0.0 %
VE.7
P.3
VS.1
% 0.0
VR.1
Q.5 0.00 m3/h
VE.14
UV254.3 12.9 1/m
VE.12
VE.15
WT.2 Tank
VE.9
Backwash pump & water tank
WT . 4
LT.7 0.96 m
P.7
0.0 %
Q.6 0.51 m3/h
39.5 %
VR.2
P.4
79.0 %
Q.4 0.80 m3/h
VE.20
VE.22
V.15
VE.16
V.13
Air compressor
AC
Effluent overflows
Running
1-stage Downflow F.2 filtration
Filtration in progress
DRUM FILTER OZON GENERATOR
GAC FILTERS
UV REACTOR
ALARMS
ACK

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UV REACTOR

LOGGED OPERATOR

Tank WT.3

UV lamp

V.16

GAC Filters

P.6

VE.19

UV RECTOR

CONTROL MODE Auto

RAD. DOSE 0.0 J/m2

UV INTENSITY 0.0 W/m2

FLOW 0.00 m3/h

TEMPERATURE 18.9 °C

100 %

CONTROLS

CLEANING SYSTEM

Stopped Manual

VE.21

R

Effluent overflows

WST

LT.8 0.18 m

V.17

P.8

V.18

MANHOLE

Running

1-stage Downflow F.2 filtration

Filtration in progress

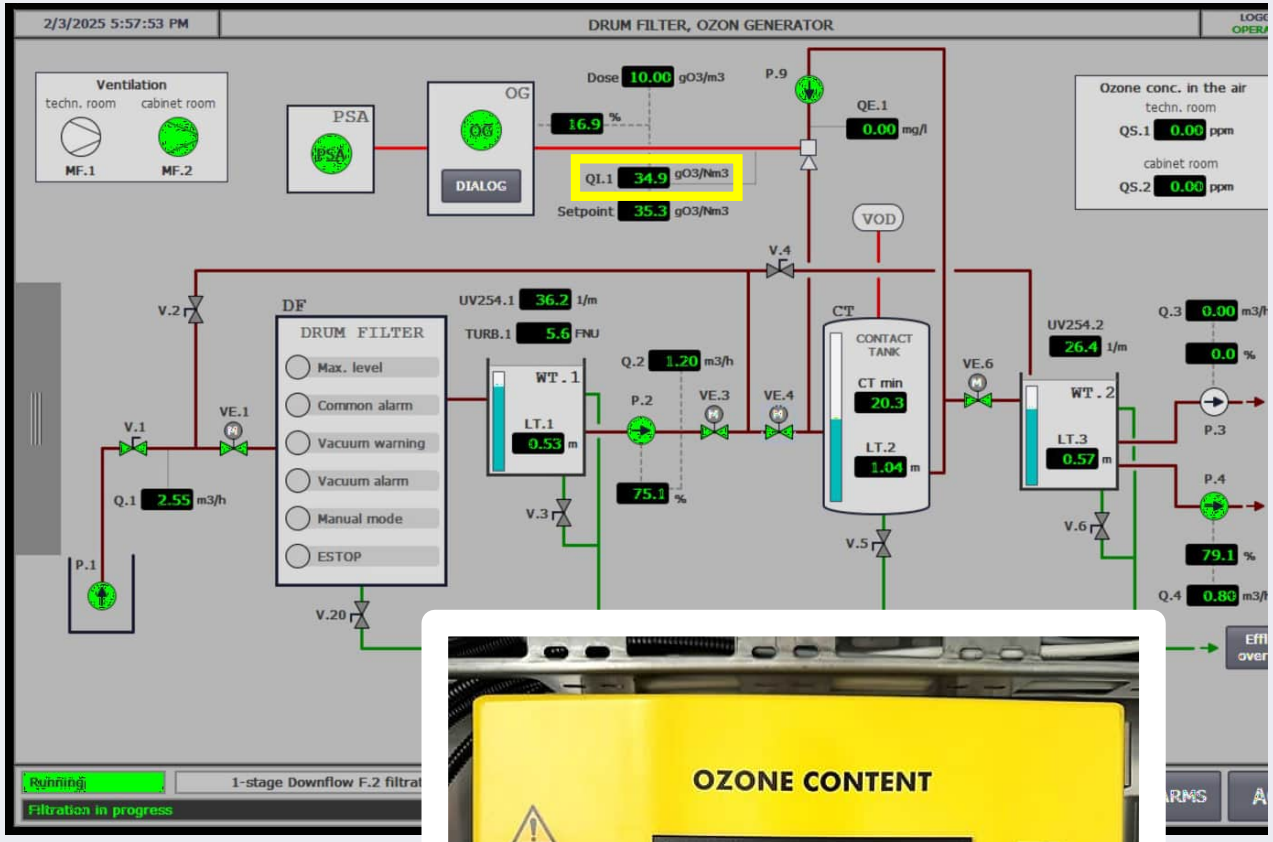
DRUM FILTER OZON GENERATOR

GAC FILTERS

UV REACTOR

ALARMS

ACK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DRUM FILTER, OZON GENERATOR
Ventilation
techn. room
cabinet room
MF.1
MF.2
PSA
OG
DIALOG
Dose 10.00 gO3/m3
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Max. level
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ESTOP
UV254.1 36.2 1/m
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WT.1
LT.1 0.53 m
Q.2 1.20 m3/h
P.2
75.1 %
VE.3
VE.4
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CONTACT TANK
CT min 20.3
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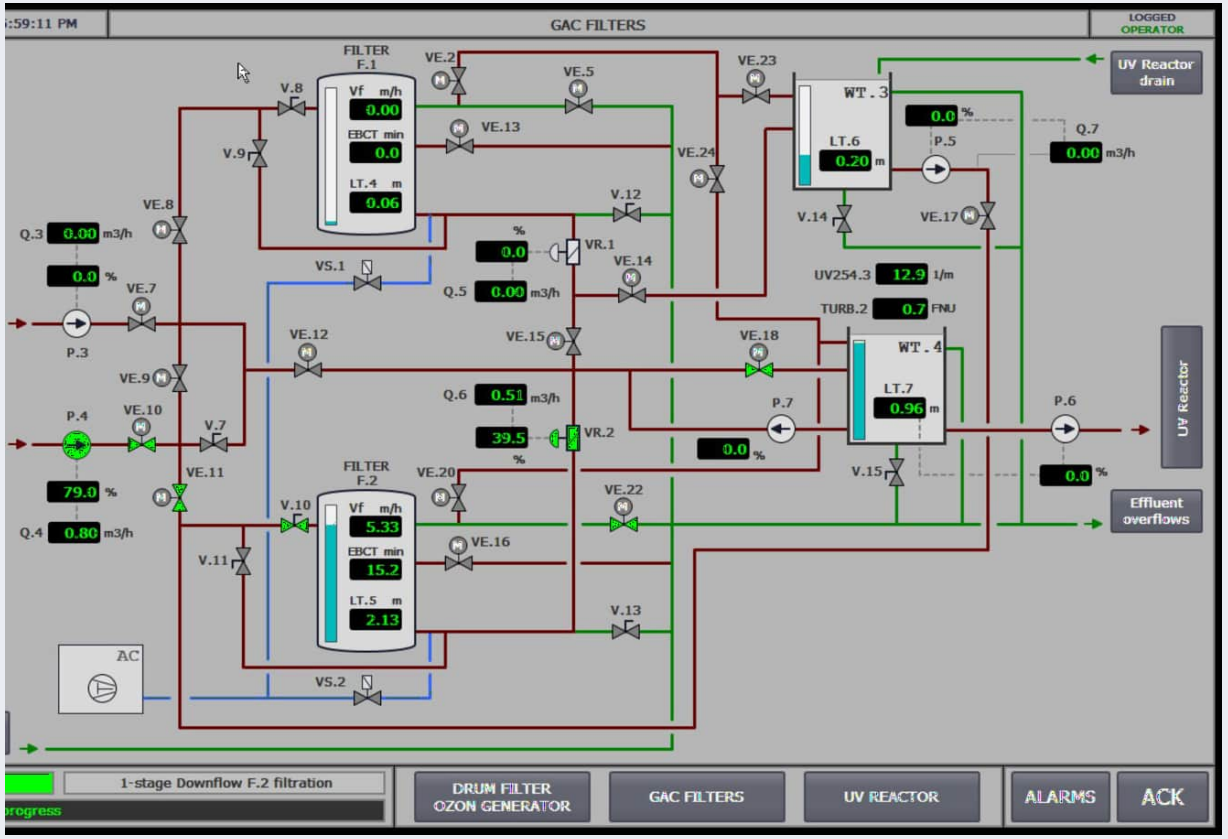
VE.6
UV254.2 26.4 1/m
WT.2
LT.3 0.57 m
Q.3 0.00 m3/h
0.0 %
P.3
P.4
79.1 %
Q.4 0.80 m3/h
V.1
VE.1
Q.1 2.55 m3/h
P.1
V.3
V.5
V.6
V.20
Running
1-stage Downflow F.2 filtrat
Filtration in progress
ARMS
A


OZONE CONTENT
OZONE ANALYZER BMT 965C
BMT MESSTECHNIK, BERLIN
OSTI, COLORADO
BMT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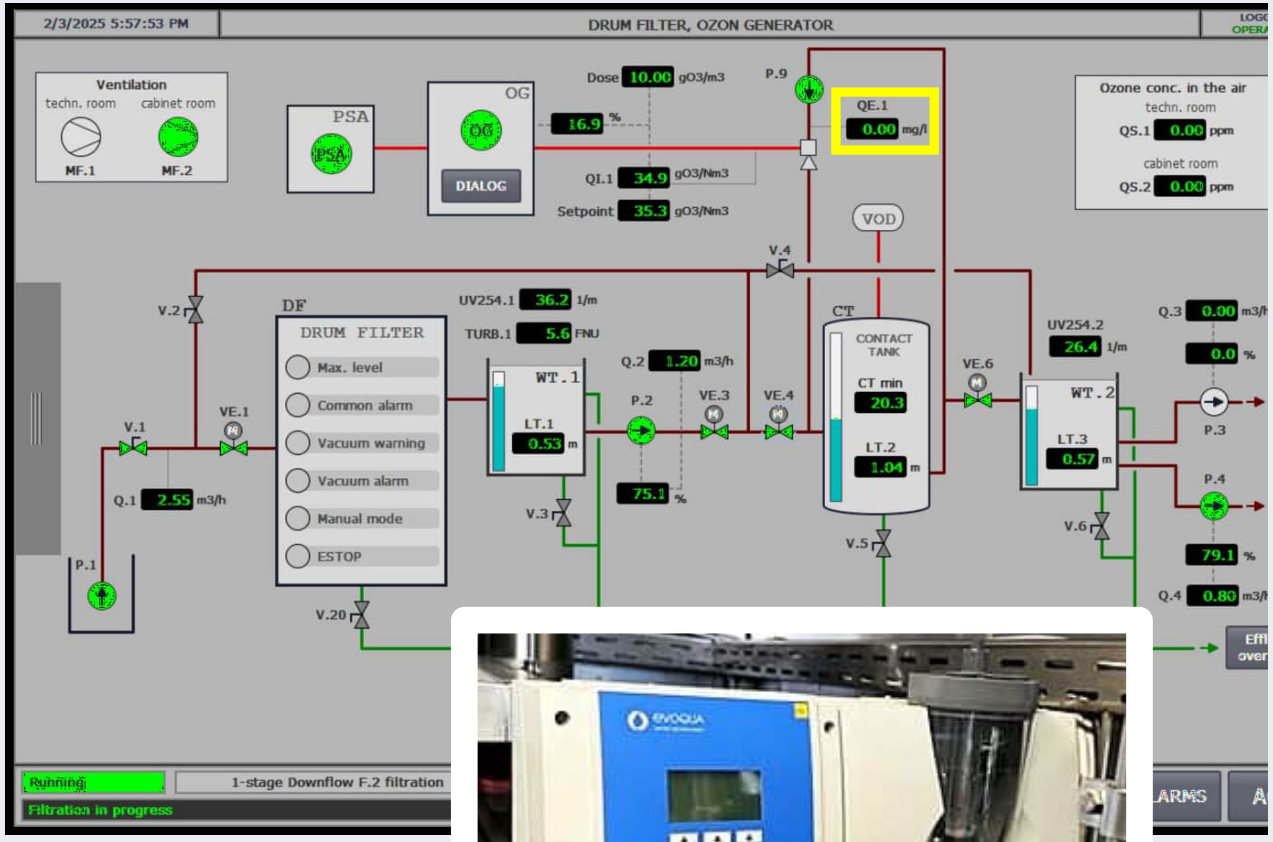
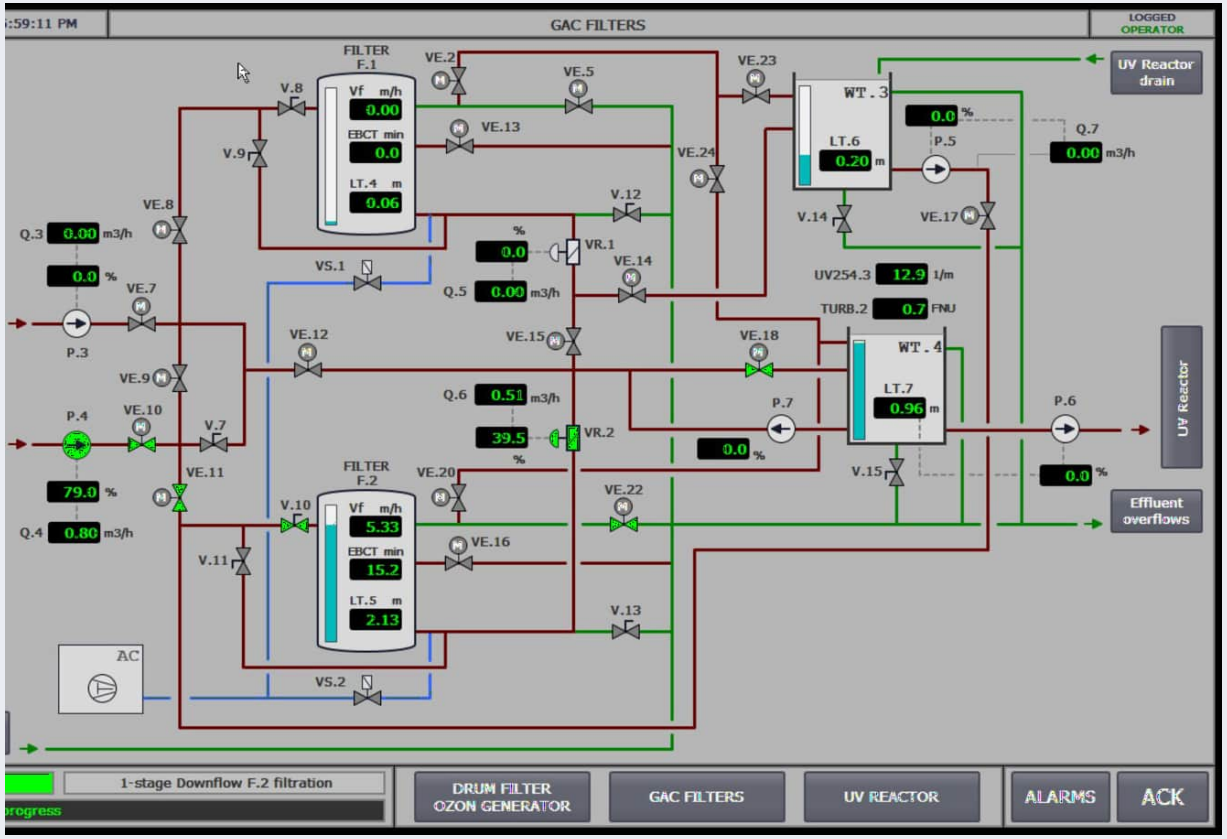
GAC FILTERS
LOGGED
OPERATOR
FILTER F.1
Vf m/h 0.00
EBCT min 0.0
LT.4 m 0.06
V.8
V.9
VE.2
VE.5
VE.13
VE.23
WT.3
LT.6 0.20 m
0.0 %
P.5
Q.7 0.00 m3/h
UV Reactor drain
V.12
V.14
VE.17
VE.24
VE.8
Q.3 0.00 m3/h
0.0 %
P.3
VE.7
VS.1
VR.1
VE.14
UV254.3 12.9 1/m
TURB.2 0.7 FNU
Q.5 0.00 m3/h
VE.12
VE.15
VE.18
WT.4
LT.7 0.96 m
VE.9
VE.10
P.4
79.0 %
Q.4 0.80 m3/h
V.7
VE.11
Q.6 0.51 m3/h
39.5 %
VR.2
P.7
0.0 %
P.6
0.0 %
UV Reactor
Effluent overflows
V.15
FILTER F.2
Vf m/h 5.33
EBCT min 15.2
LT.5 m 2.13
V.10
V.11
VE.20
VE.22
VE.16
V.13
AC
VS.2
1-stage Downflow F.2 filtration
DRUM FILTER OZON GENERATOR
GAC FILTERS
UV REACTOR
ALARMS
ACK


2/3/2025 5:57:53 PM
DRUM FILTER, OZON GENERATOR
Ventilation
techn. room
cabinet room
MF.1
MF.2
PSA
OG
DIALOG
Dose 10.00 gO3/m3
16.9 %
QI.1 34.9 gO3/Nm3
Setpoint 35.3 gO3/Nm3
P.9
QE.1 0.00 mg/l
VOD
Ozone conc. in the air
techn. room
QS.1 0.00 ppm
cabinet room
QS.2 0.00 ppm
V.4
V.2
DF
DRUM FILTER
Max. level
Common alarm
Vacuum warning
Vacuum alarm
Manual mode
ESTOP
UV254.1 36.2 1/m
TURB.1 5.6 FNU
WT.1
LT.1 0.53 m
Q.2 1.20 m3/h
P.2
75.1 %
VE.3
VE.4
CT
CONTACT TANK
CT min 20.3
LT.2 1.04 m
VE.6
UV254.2 26.4 1/m
WT.2
LT.3 0.57 m
Q.3 0.00 m3/h
0.0 %
P.3
P.4
79.1 %
Q.4 0.80 m3/h
V.1
VE.1
Q.1 2.55 m3/h
P.1
V.3
V.5
V.6
V.20
Running
1-stage Downflow F.2 filtration
Filtration in progress


EVOQUA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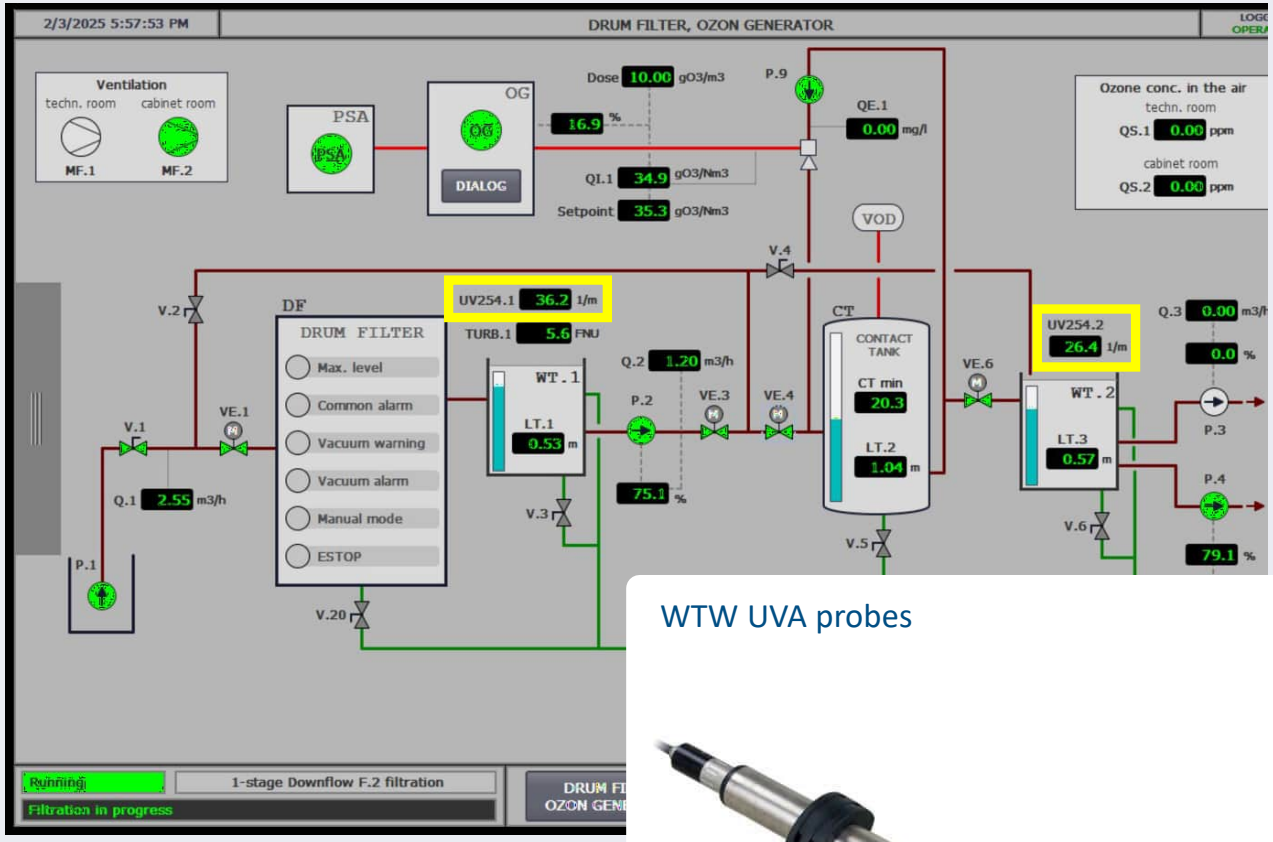
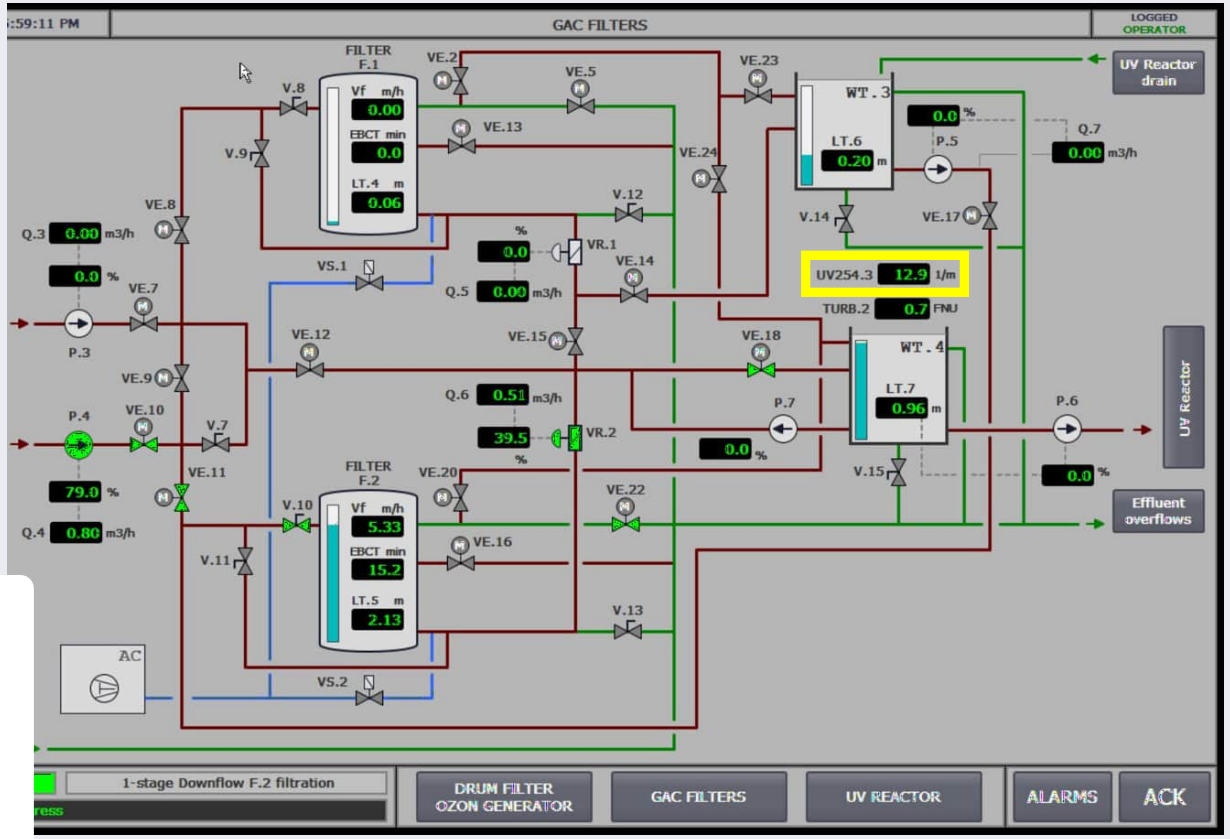
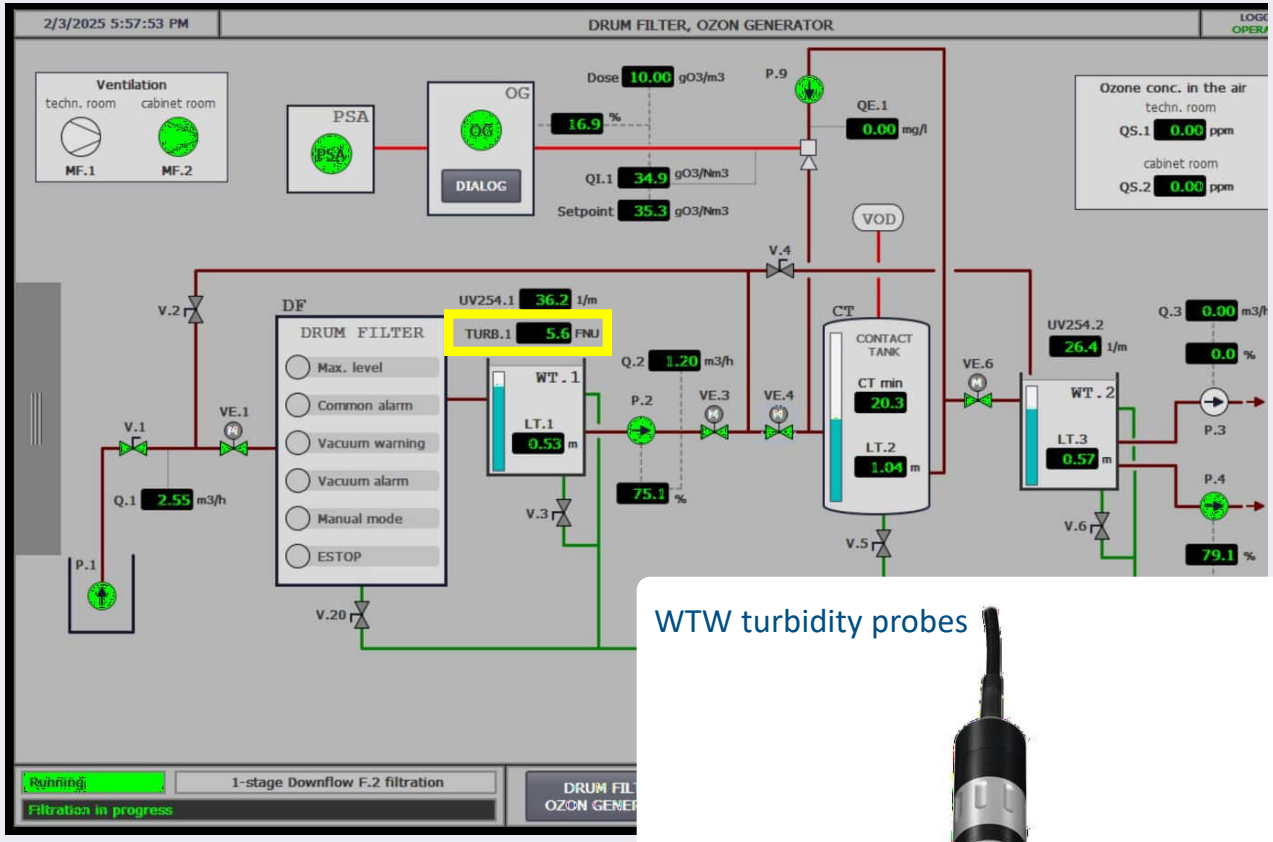
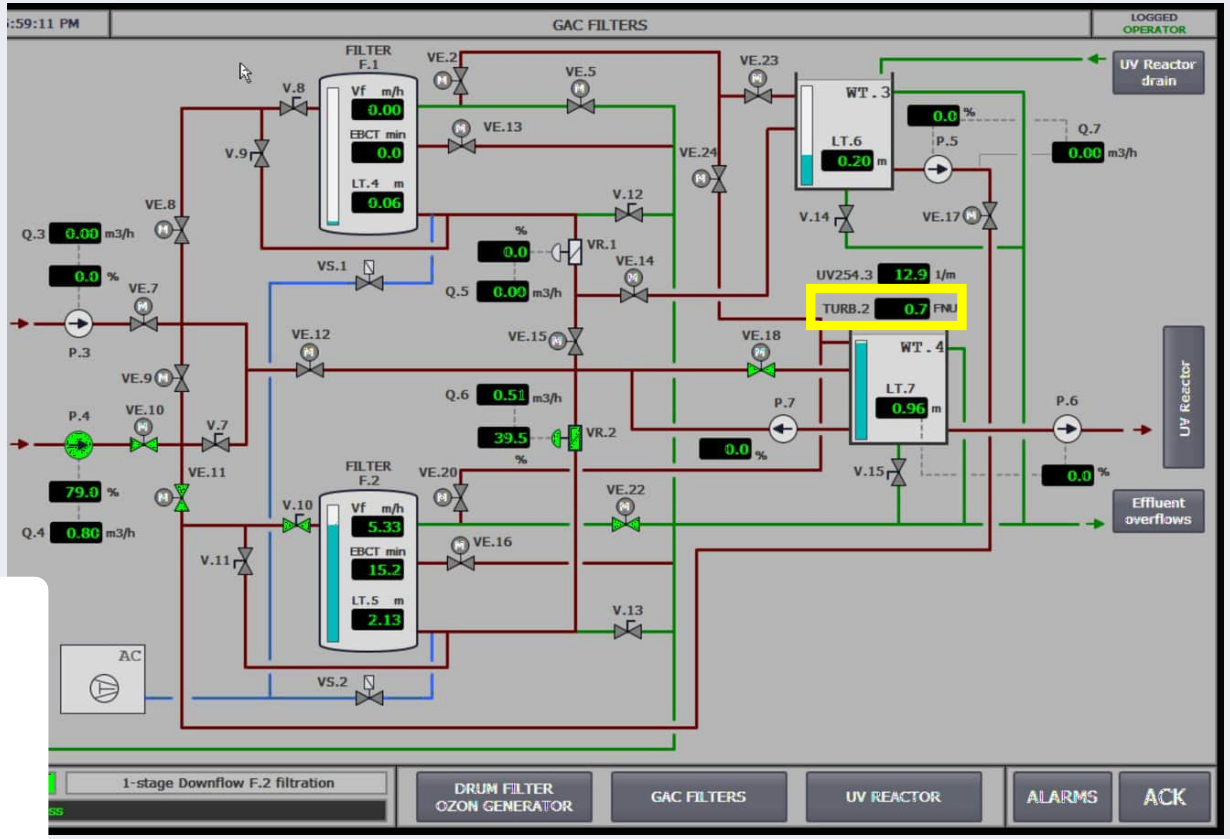
GAC FILTERS
LOGGED OPERATOR
FILTER F.1
Vf m/h 0.00
EBCT min 0.0
LT.4 m 0.06
FILTER F.2
Vf m/h 5.33
EBCT min 15.2
LT.5 m 2.13
V.8
V.9
V.10
V.11
VE.2
VE.5
VE.13
VE.8
VE.7
VE.12
VE.9
VE.10
VE.11
VE.20
VE.16
VE.22
V.12
V.13
VE.14
VE.15
VE.23
VE.24
VE.18
WT.3
LT.6 0.20 m
WT.4
LT.7 0.96 m
V.14
V.15
VE.17
P.5
P.6
P.7
Q.7 0.00 m3/h
UV Reactor drain
UV Reactor
Effluent overflows
Q.3 0.00 m3/h
0.0 %
P.3
Q.4 0.80 m3/h
79.0 %
P.4
Q.5 0.00 m3/h
VR.1
Q.6 0.51 m3/h
39.5 %
VR.2
UV254.3 12.9 1/m
TURB.2 0.7 FNU
VS.1
VS.2
AC
1-stage Downflow F.2 filtration
DRUM FILTER OZON GENERATOR
GAC FILTERS
UV REACTOR
ALARMS
ACK



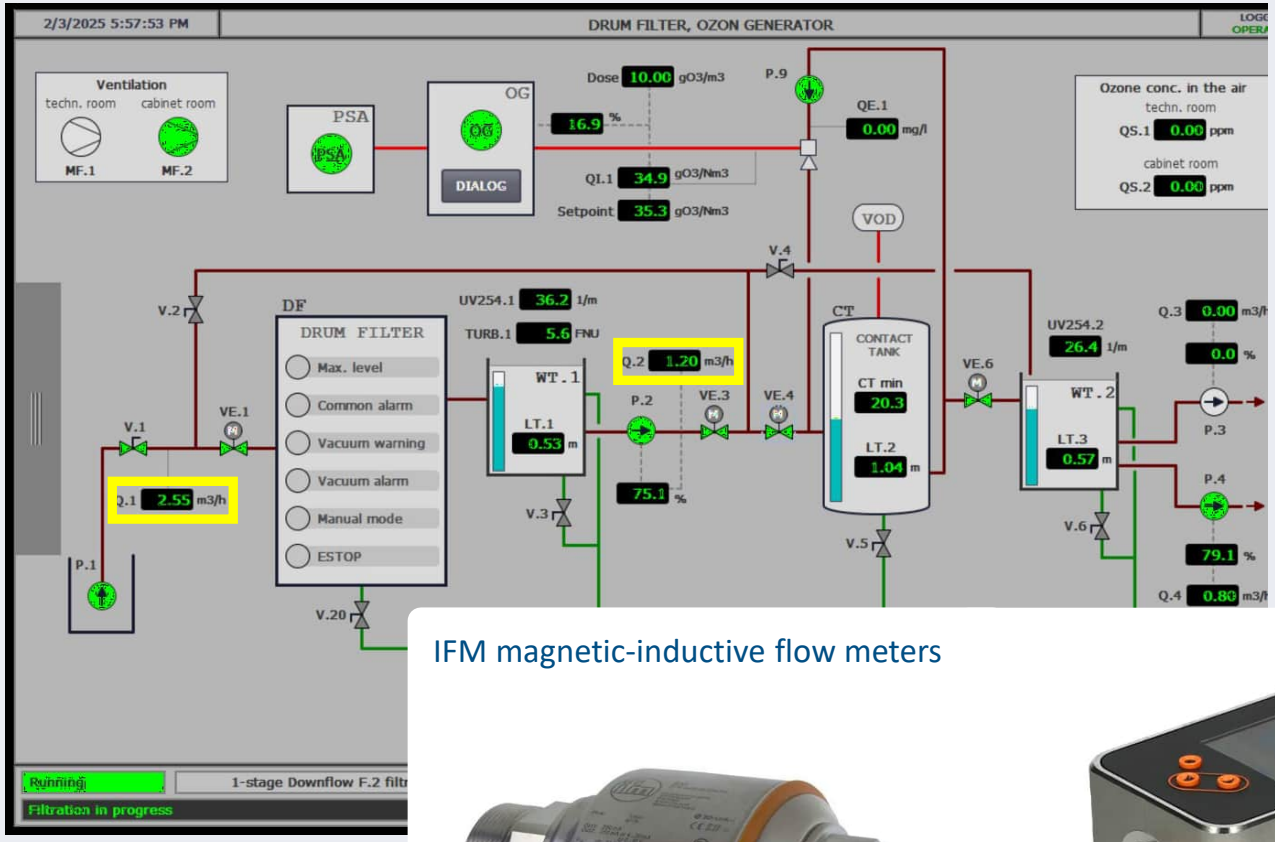


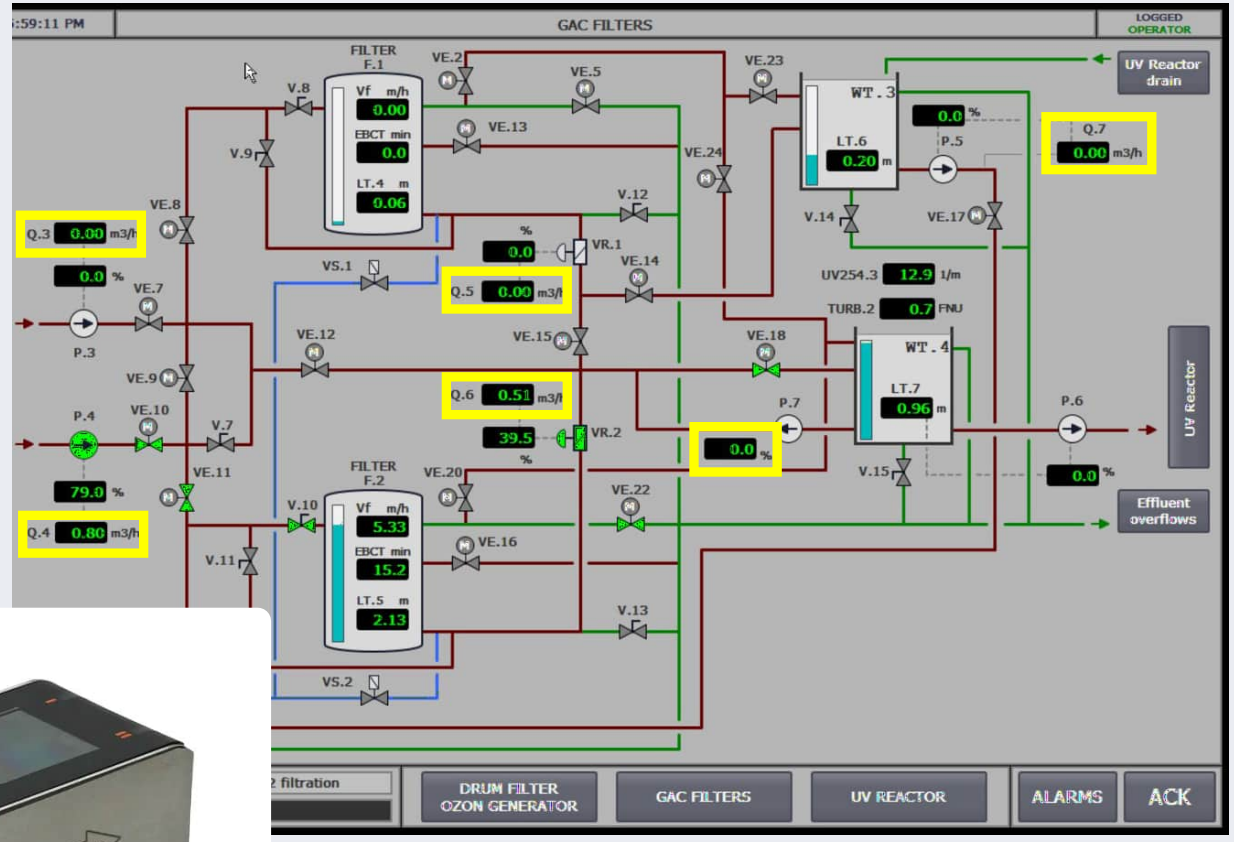
WTW UVA probes



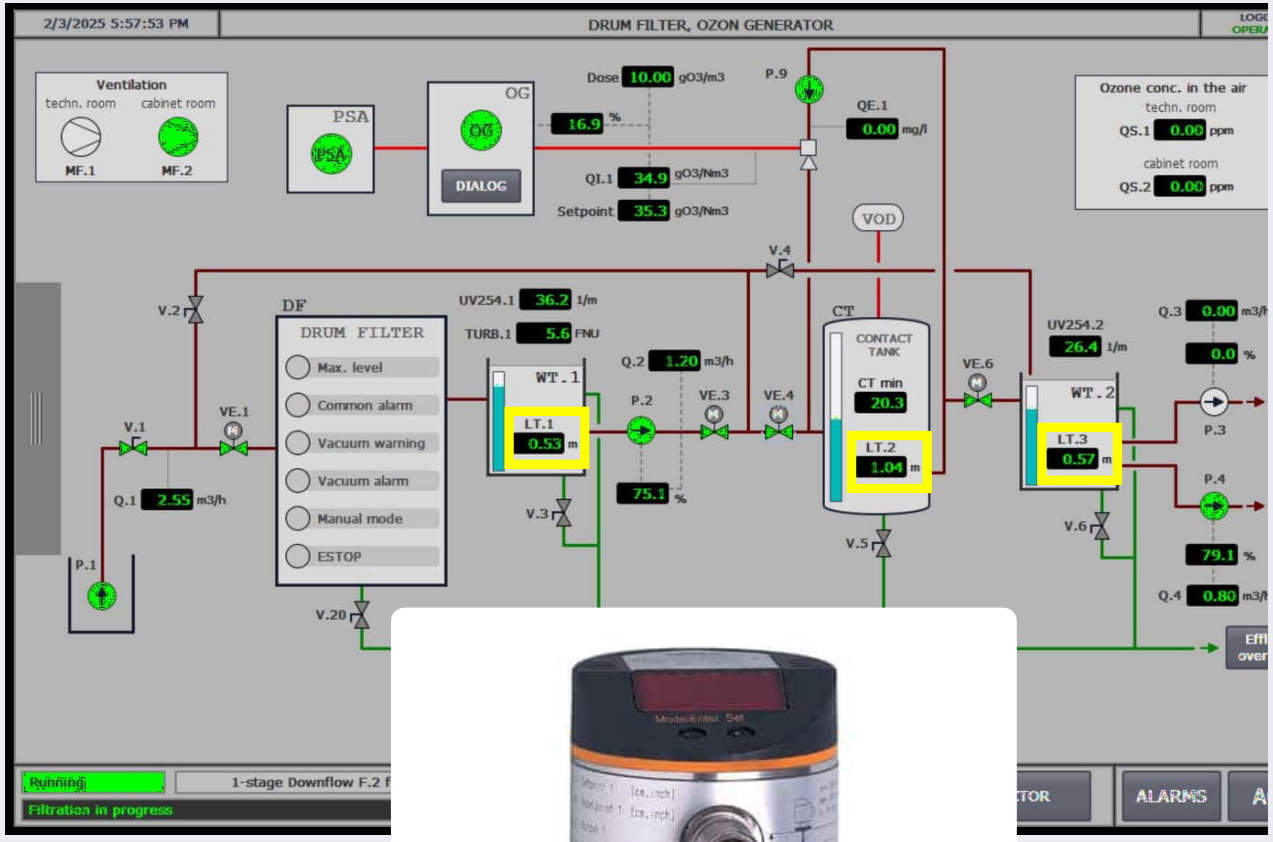


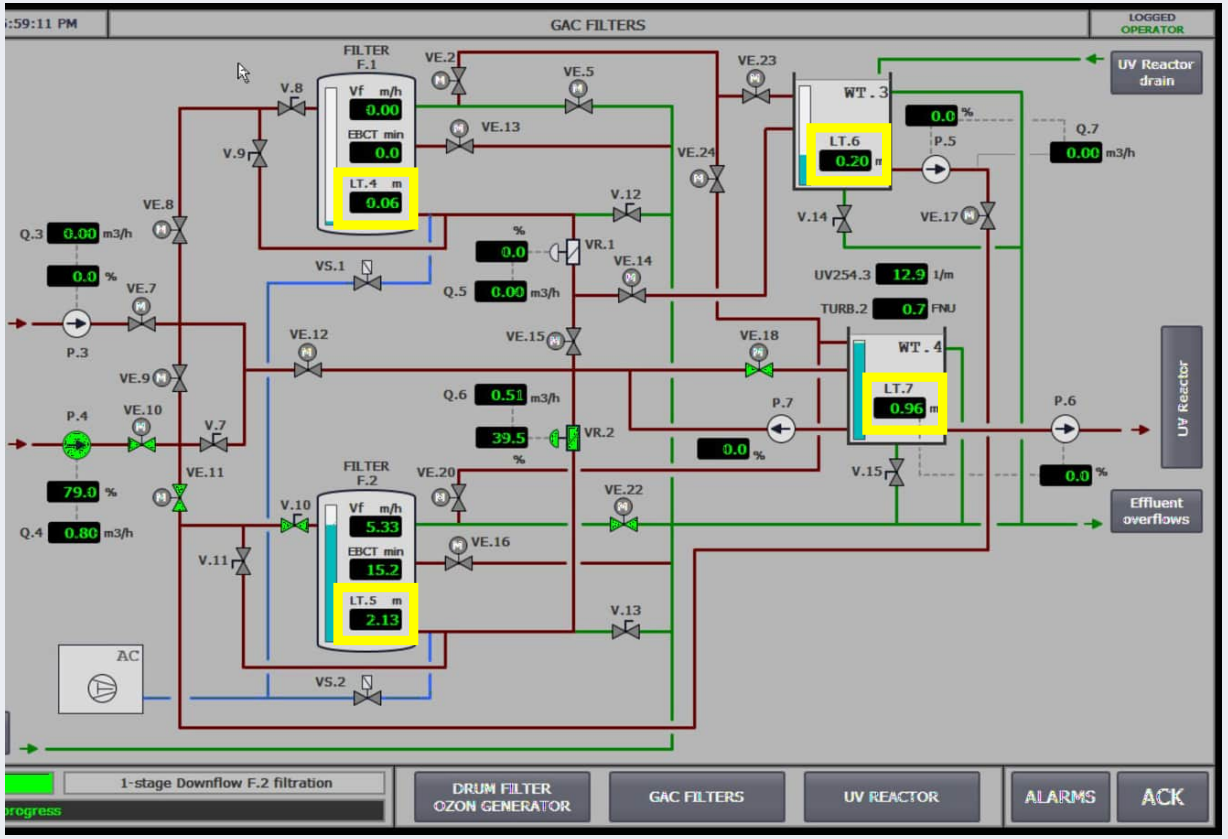
WTW turbidity probes





IFM magnetic-inductive flow meters


2/3/2025 5:57:53 PM
DRUM FILTER, OZON GENERATOR
Ventilation
techn. room
cabinet room
MF.1
MF.2
PSA
OG
DIALOG
Dose 10.00 gO3/m3
16.9 %
QI.1 34.9 gO3/Nm3
Setpoint 35.3 gO3/Nm3
P.9
QE.1 0.00 mg/l
VOD
Ozone conc. in the air
techn. room
QS.1 0.00 ppm
cabinet room
QS.2 0.00 ppm
V.4
V.2
DF
DRUM FILTER
Max. level
Common alarm
Vacuum warning
Vacuum alarm
Manual mode
ESTOP
UV254.1 36.2 1/m
TURB.1 5.6 FNU
WT.1
LT.1 0.53 m
Q.2 1.20 m3/h
P.2
75.1 %
VE.3
VE.4
CT
CONTACT TANK
CT min 20.3
LT.2 1.04 m
VE.6
UV254.2 26.4 1/m
WT.2
LT.3 0.57 m
Q.3 0.00 m3/h
0.0 %
P.3
P.4
79.1 %
Q.4 0.80 m3/h
V.1
VE.1
Q.1 2.55 m3/h
P.1
V.3
V.5
V.6
V.20
Running
1-stage Downflow F.2 f
Filtration in progress
ALARMS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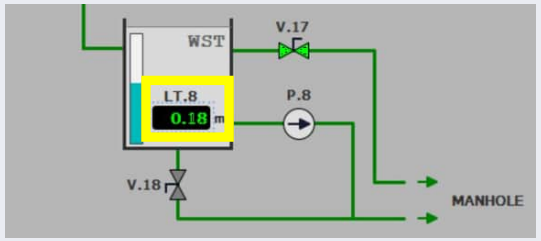
GAC FILTERS
LOGGED OPERATOR
FILTER F.1
Vf m/h 0.00
EBCT min 0.0
LT.4 m 0.06
V.8
V.9
VE.2
VE.5
VE.13
VE.23
WT.3
LT.6 0.20 m
0.0 %
P.5
Q.7 0.00 m3/h
UV Reactor drain
V.12
V.14
VE.17
VE.24
VE.8
Q.3 0.00 m3/h
0.0 %
P.3
VE.7
VS.1
VR.1
VE.14
UV254.3 12.9 1/m
TURB.2 0.7 FNU
Q.5 0.00 m3/h
VE.12
VE.15
VE.18
WT.4
LT.7 0.96 m
Q.6 0.51 m3/h
39.5 %
VR.2
P.7
0.0 %
P.6
0.0 %
UV Reactor
Effluent overflows
VE.9
VE.10
P.4
79.0 %
Q.4 0.80 m3/h
V.7
VE.11
FILTER F.2
Vf m/h 5.33
EBCT min 15.2
LT.5 m 2.13
V.10
V.11
VE.20
VE.22
VE.16
V.13
AC
VS.2
1-stage Downflow F.2 filtration
DRUM FILTER OZON GENERATOR
GAC FILTERS
UV REACTOR
ALARMS
ACK

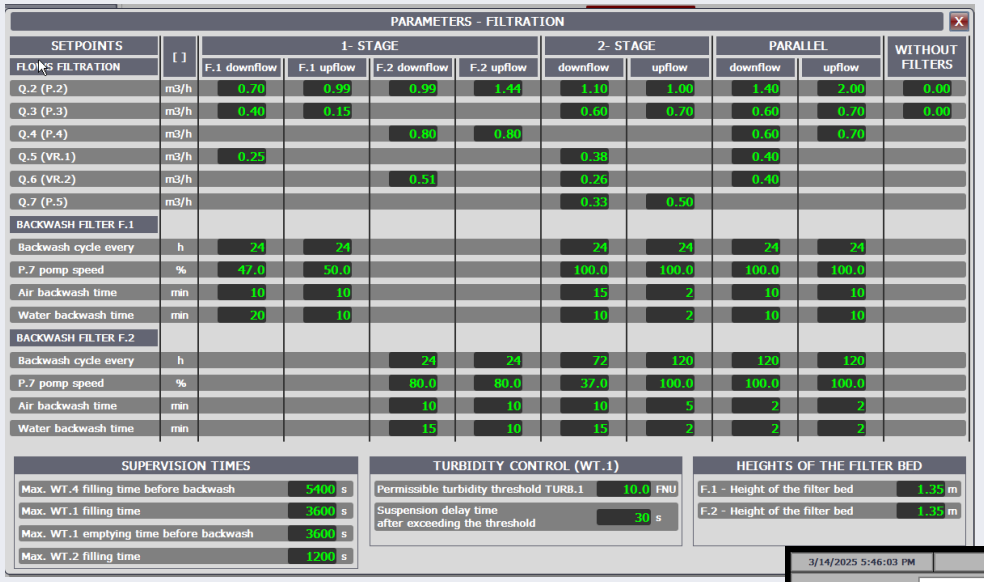

WST
LT.8 0.18 m
V.17
P.8
V.18
MANHOLE

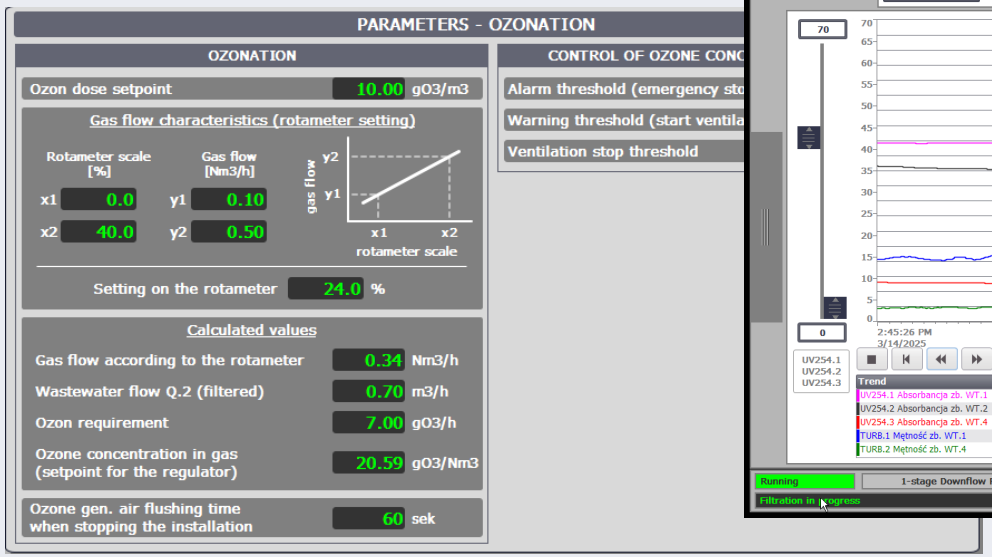
Advanced control system

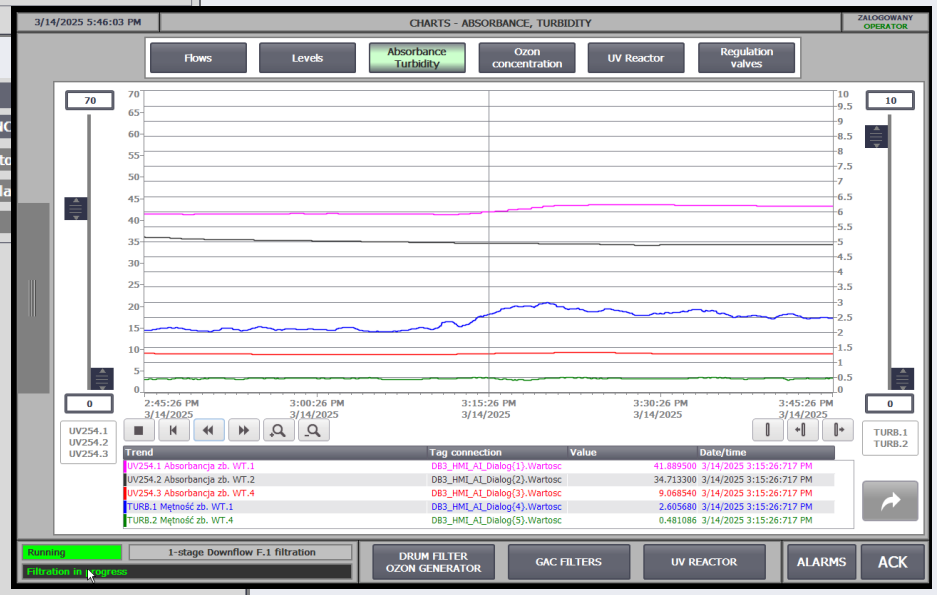
HMI

PLC

VPN router

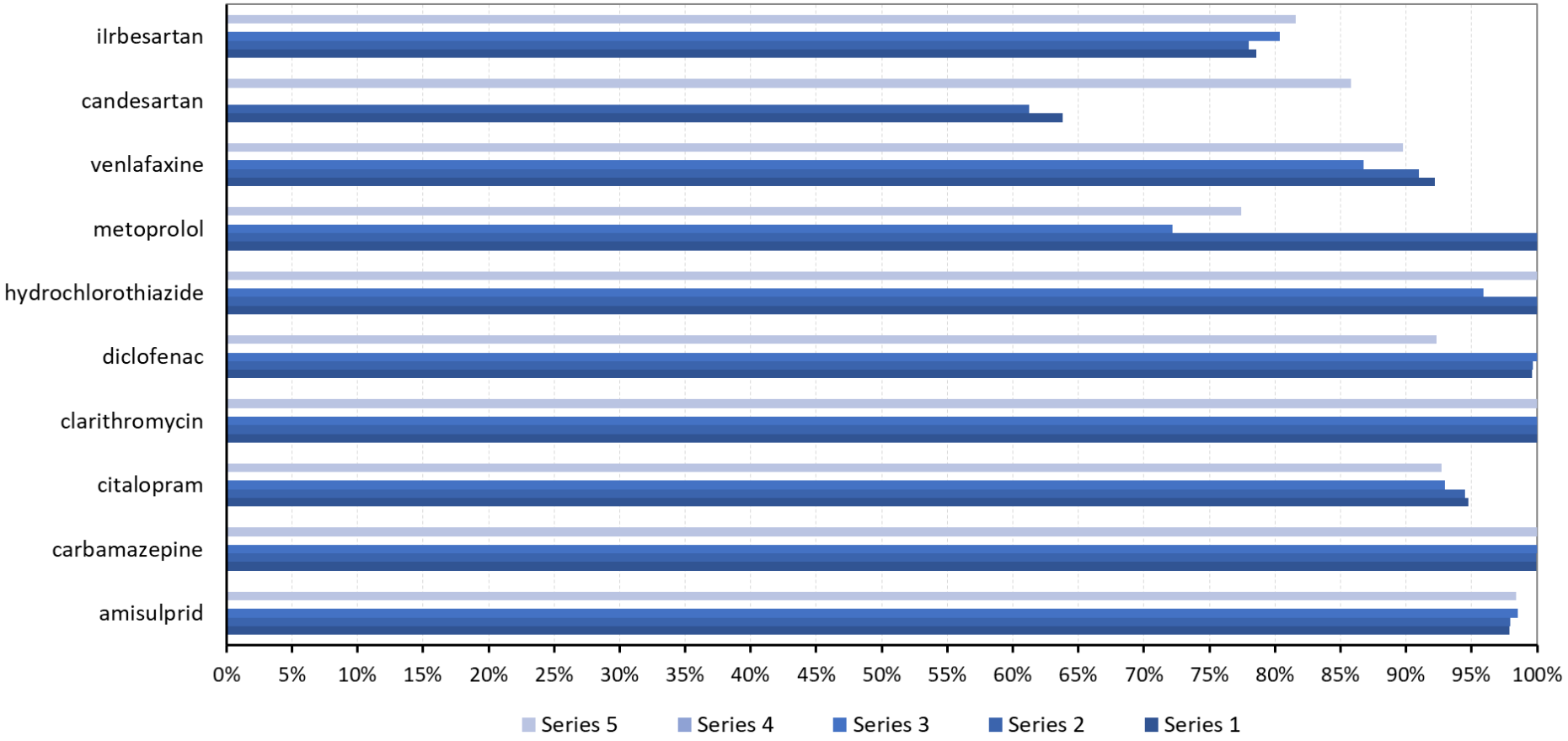






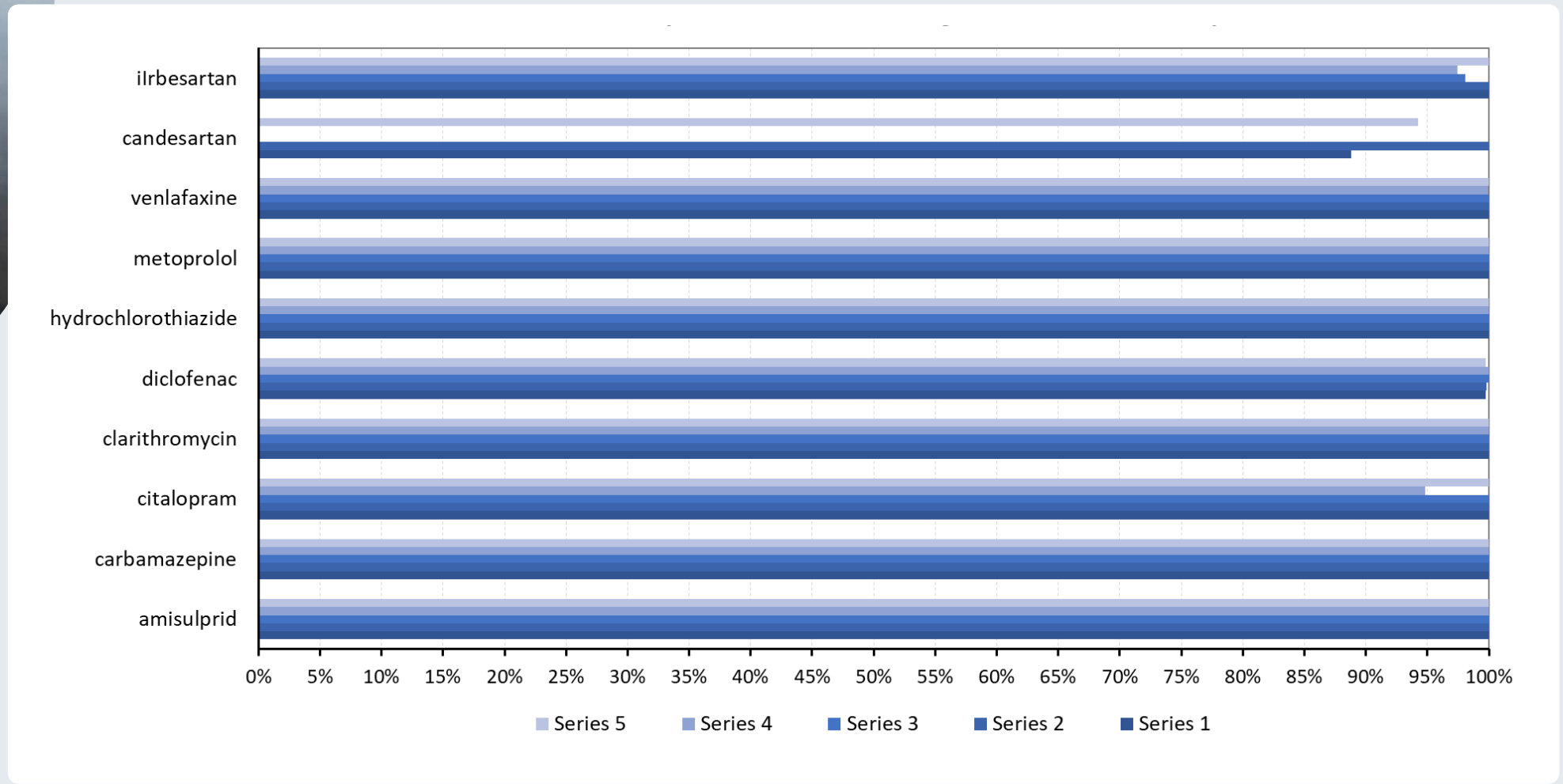
Removal efficiency of pharmaceuticals by ozonation

1,0 g O_3/g DOC, 30 min ozone contact time



Removal efficiency of pharmaceuticals by ozonation & GAC filtration

1,0 g O_3/g DOC, 30 min ozone contact time, 20 min EBCT of GAC filter



Thank you for your attention!

Marek Swinarski
Gdańsk Water Utilities
mswinarski@giwk.pl

#EMPEREST

The project EMPEREST co-financed by the Interreg Baltic Sea Region helps to drive the transition to a green and resilient Baltic Sea region.

Interreg Baltic Sea Region

Co-funded by the European Union

SUSTAINABLE WATERS EMPEREST

Piotr Miakoto
Szczecin
25.03.2025

Piloting experiences
WWTP „Pomorzany” Szczecin/POLAND

Interreg Baltic Sea Region
Co-funded by the European Union
SUSTAINABLE WATERS
EMPEREST

WATER-SMART SOCIETIES

Installation of the pilot station:

Piloting period:

September – December 2024

- **List of micropolutants measured as per EU Directive concerning urban and water treatment:**

AMI	Amisulprid
CAR	Carbamazepine
CIT	Citalopram
CLA	Clarithromycin
DIC	Diclofenac
HYD	Hydrochlorothiazide
MET	Metoprolol
VEN	Venlafaxine
BEN	Benzotriazole
CAN	Candesartan
IRB	Irbesartan
MBT	Mixture of 4-methylbenzotriazole and 6 -methylbenzotriazole

- **Tests schedule and setups for each serie**

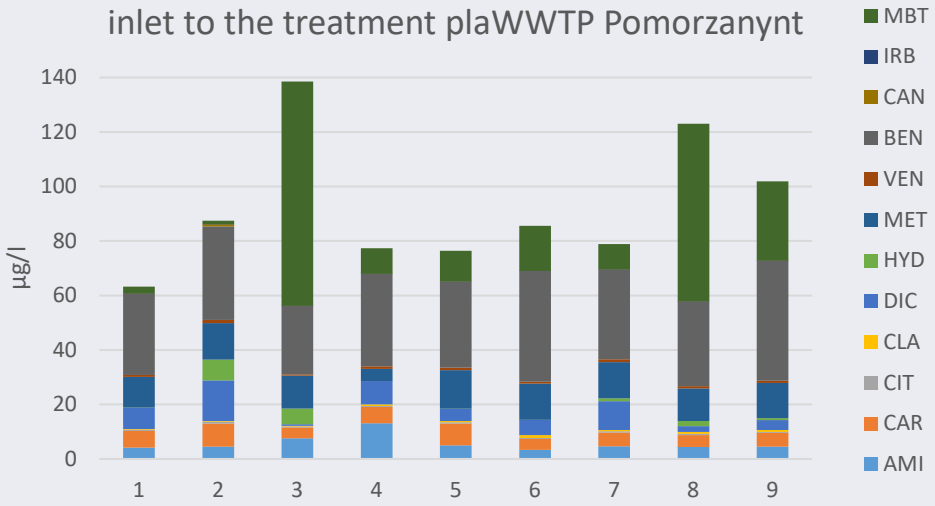
Activated carbon	Data		dose O3	CT O3	CT GAC
WG 12	**27.09.2024**	1 sample	6	20	30
	04.10.2024	2 sample	5	30	40
	11.10.2024	3 sample	6	40	20
	18.10.2024	4 sample	8	40	20
	25.10.2024	5 sample	10	40	20
	30.10.2024	6 sample	6	30	30
	08.11.2024	7 sample	8	30	20
WG 90	**22.11.2024**	8 sample	10	30	20
	27.11.2024	9 sample	8	30	20
	29.11.2024	extra sample	-	-	20
	04.12.2024	extra sample	3	30	20

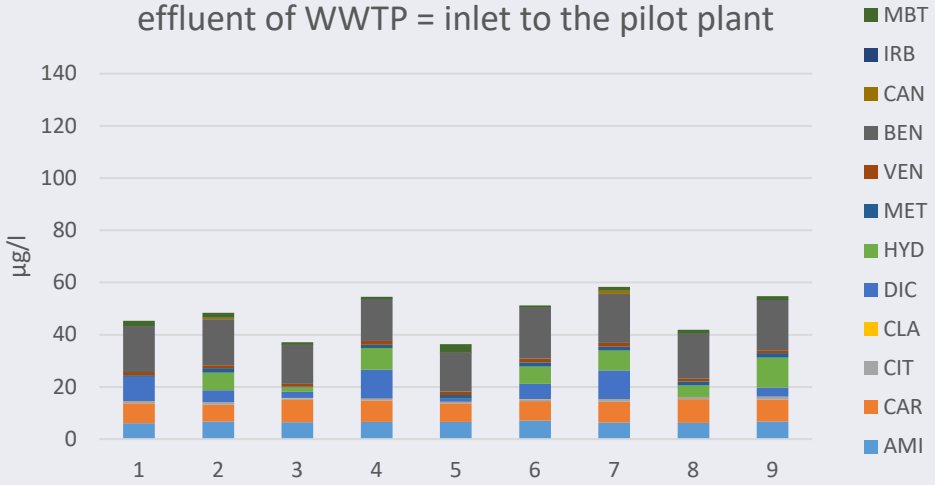
Pilot station:

Drum filter –> Ozone –> GAC

Results:

Raw sewage –> Treated = inlet to the pilot –> after pilot





Conclusions -> future:

- **The EMPEREST pilot** tests proved that we have a sound technology for fulfilling the requirements of the new EU urban wastewater Directive.
- **National implementation of EU Directive** along with the clarification of polluter-pays concept as well as organisation collecting and distributing money for 80% of quaternary development & exploitation costs.
- **Money and work force is needed** in order to do the investments. They include land purchase, development of tertiaty treatment stage, construction of a new quaternary stage and fulfilling the requirement of 100% energy neutrality.

Thank you for your attention!

Piotr Miakoto

Water and Sewage Company Ltd. of Szczecin

p.miakoto@zwik.szczecin.pl

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SUSTAINABLE WATERS EMPEREST