DRINK WATER TREATMENT

Ultrafiltration-Reverse Osmosis

CONTAINERIZED UNIT - 500 m^3/hour (12 000 m^3/day)

1. Design Basis

Proposal for the drink water treatment of the Mine water with membrane technologies utilizing Ultrafiltration and Reverse Osmosis processes to obtain high quality drink water.

Equipment proposed herein is based on the information that source mine water quality.

All main equipment will be installed inside 40-foot containers in quantity 9 (nine) pcs.

Containerized drink water station is delivered completely ready for use. The containers are insulated and have a special «winter-summer» cooling-heating system.

Plant is set to produce 12 000 m^3/day and would work 24 hours a day and 365 days a year.

2. Stages of the technological process

2.1 **Prefiltration** – filtering of large parts and fibrous (algae) inclusions on automatic disc filters up to 200 microns in size.

2.2 **Ultrafiltration –** membrane technology of deep water purification on ultrafiltration membranes. The degree of filtration is 0.02 microns. At this stage, the final purification of water from organic compounds, clarification of water, removal of microorganisms, bacteria and viruses.

2.3 **Reverse Osmosis -** desalination and decrease of hardness ultrafiltrate water.

3. Brief description of water treatment unit

3.1 Capacity – 12 00 m^3/day (500 m^3/hour).

3.2 Water use:

source water – 720 m^3/hour;

reject (UF, RO) –200 m^3/hour;

3.3 Main electricity consumers:

for source water temperature +14C^0 - 1,13 kW/m^3 ;

3.4 Quantity of containers:

40 foot –9 pcs. Size of container (HxLxW) – 2591-12192-2438 mm.

20 foot – 1 pcs. Size of container (HxLxW) – 2591-6058-2438 mm.

3.5 Feed Water Analysis/Guaranteed Outcome

№	Main Parameters	Feed Water	Clean Water	UA drink standard	Unit
1.	Total hardness	14	**1,0- 1,5**	< 7,0	mmol/L
2	Calcium, Ca	92			mg/L
3	Magnesium, Mg	78			mg/L
4	Sodium, Na	730	**< 150**		mg/L
5	Permanganate oxidizability	10	**< 0,5**	< 5,0	mg/L
6	Chloride, CL	400	**< 250**	< 250	mg/L
7	Sulphate, SO_4	961	**< 100**	< 250	mg/L
8	pH	7,4	**6,7**	6,5-8,5	
9	Hydrogen carbonate as, HCO_3	680	**<10**		mg/L
10	Temperature	10-25			C^0
11	Total Dissolved Solids (TDS)	2950	**300- 500**	< 1000	mg/L

3. Technology and process description

Inside the containers it will be treated by the following technological steps:

- **Prefiltration (automatic disc filters);**
- **UF (Ultrafiltration);**
- **RO (Reverse Osmosis, desalination)**

During **Prefiltrati**on stage on the automatic disc filter 200 micron and bigger particles rejected to protect membrane surface from sharp solid particles. This step immediately followed by the **UF.** Feed water enters disc filters made from polymers. Outside surface of the filter element appears in cylinder shape after disc compression. On each disc surface grooves are inflicted of the certain depth and width to achieve volumetric net structure, which is an actual filtration tool for smaller particles. During filtration phase discs are compressed by utilization of the spring. Compressed discs are creating the uniformed filtration structure. During disc filter backwash (BW), which starts after reception of the signal from the outside, pistons change direction of the water stream through the filter. Thus, disc packet expands. Under the skew stream that is created by special nozzles, discs start rotation and all particles from the surface are quickly and efficiently washed out into the drain under BW stream. At the end of the BW mode filter is rinsed by clean water. BW will be done for one filter at the time, while other filters would compensate for the lost flow.

After pre-filtration water entering **Ultrafiltration** membranes UF, under pressure of 2-5 bar. Main advantage of the UF system is to achieve high level of product quality without any change of high permeate (product) quality. Membranes have nominal and absolute pore sizes of 0.02 and 0.1 microns respectively. This ensures that particulate matter greater than 0.1 micron in size cannot enter the filtered water stream.

UF handling high turbidity not using additional steps of treatment and chemicals. For UF operation only 0.5-1 bar of the working pressure needed, therefore energy consumption of the process is low.

Permeate from each machine enters common pipe followed by the automatic valve that distribute water flow further to the RO machines. No intermediate tanks, transfer pumps and cartridge filter system is needed for this design. Small portion of the UF permeate would be used for the BW and Chemical Enhanced Backwash (CEB) of the UF membranes.

These processes would be done in a fully automatic mode either. To clean membrane surface from absorbed contamination designed BW process by clean product water.

BW implemented by specially consigned pump. BW process designed to bring water in opposite to a filtration mode direction – “out-in”. BW volume usually make up 3-5% of the feed water volume. Time duration – 30 secs, every 40-70 min.

To clean membrane even further, every 24 hours or so, CEB is held. During CEB chemicals (normally acid and caustic) are used.

Every module has 80 m² surface with capillary diameter of 0.9mm of the multibore membrane.

3.1 Table of comparative characteristics of ultrafiltration and multimedia (sand) filters.

№	Technological parameters	Ultrafiltration	Sand Filters
1.	The size of filtrated solids	All impurities larger than 0.02 μm in size. Retains colloidal parts	Solids up to 50 μm in size. Does not retain colloidal parts
2.	Removal of bacteria and viruses	**YES** Bacteria and viruses are retained by ultrafiltration membranes	**NO** Bacteria and viruses are not retained by Sand Filter Need a lot of more dosing of active chlorine are required for disinfection. The danger of creating toxic organochlorine compounds in the clean water.
3	Dependence of the quality of the filtrate on the amount of impurities in the incoming water	**INDEPENDENT** The quality of the filtrate does not change when the amount of impurities in the incoming water changes.	**IT DEPENDS** When the quality of the incoming water deteriorates, the quality of the filtrate also deteriorates.
4.	Design features	Compact, block-modular construction Does not require lifting mechanisms The quality and properties of the membranes do not change for a long time.	Bulky design. Requires additional lifting mechanisms for installation and maintenance. They have an internal filling of filter material - it needs periodic filling and replacement.

Description desalination – Reverse osmosis (RO)

The proposed 3 (three) RO units would produce total 12 000 m³/Day of desalinated water, which after existing post-treatment.

Operating RO is simple, especially in case of utilizing VFDs to control high pressure pumps, which we do. RO is operating in continuous mode, so programming of the RO portion of the system is basically control of the pressure drop to initiate timely cleanings in place (CIP) of the skids (each skid separately, when necessary)

Demanded variations of the product output will be additionally addressed by turning on/off skids based on a level in the product tank. Skid would have 3 enclosures: electrical, instrumentation, air-conditioned VFD enclosure. If necessary, information from the PLC, which would be displayed at local Panel View can be picked up by the main plant computer. Automatic valve actuator proposed to be electric. All flow, pressure, conductivity, and pH data would be shown on the Panel View screen.

Prior to the skid we'll have 3 chemical skids for Sodium metabisulfite (to avoid any possibility of oxidizers breakthrough, ORP analyzer would still be installed to check on this, RO membranes made from PA (polyamide), which is sensitive to oxidizing agents and will be destroyed overtime, if left unprotected and antiscalant to avoid any sulfate related fouling.

5. Main consumption of technological process

Consumers of electricity:

The main consumers of electricity of the technological process are:

- feed water pumps – work constantly;
- back wash pumps work periodically;
- dosing pumps work periodically;
- high pressure pump of reverse osmosis work constantly.

Variable Frequency drives (VFD) used for every pump, which helps to manage the process more effectively, reacting to requested flow and water temperature changes regardless of the nominal power of the pump

Power Consumption, while Producing Maximum Output, 12 000 m^3/Day

Name of position	Working time per day, hour	Power consumption per hour, kW	Power consumption per day, kW	kW per $м^3$ produced
Feed to UF	24	157,5	3 780	0,315
Back Wash UF	1,2	6,3	151	0,013
Chemical Wash UF	0,02	0,1	1,2	0,0001
High pressure pump RO	24	402	9 648	0,804
			Total:	**1,13**

Chemical Usage

For CEB process we are using acid and caustic.

Caustic (NaOH 40%) – used to achieve high pH (12-12.5) for effective cleaning from organics and microbiological fouling. It will be done few times a week and depends on how quickly pressure UF skid high drop appears. It will be done more often during the summer and less often during winter time.

Sulphuric Acid (H2SO4 44%) – used to achieve low pH (2-2.5) for effective cleaning from inorganic fouling. Acid CEB likely to be performed once in 36 hours or so.

CEB performed by dosing chemical by means of dosing pump directly into the pipeline, while UF permeate for the BW tank pumped into the skid. After completion of the CEB cleaning, which may also include several minutes soaking step skid is rinsing by clean permeate water before bringing back to service.

Water with chemicals is pumped out from the skid and after neutralization with either acid or caustic to neutral pH will be dumped into the sewage system. Our technology suggests usage of Sulphuric Acid (44%), which is within the requirements of using it without any restriction

Antiscalant dosing - to avoid any sulfate or calcium related fouling.

Chemicals Usage, while Producing Maximum Output – 17 500 m^3/Day

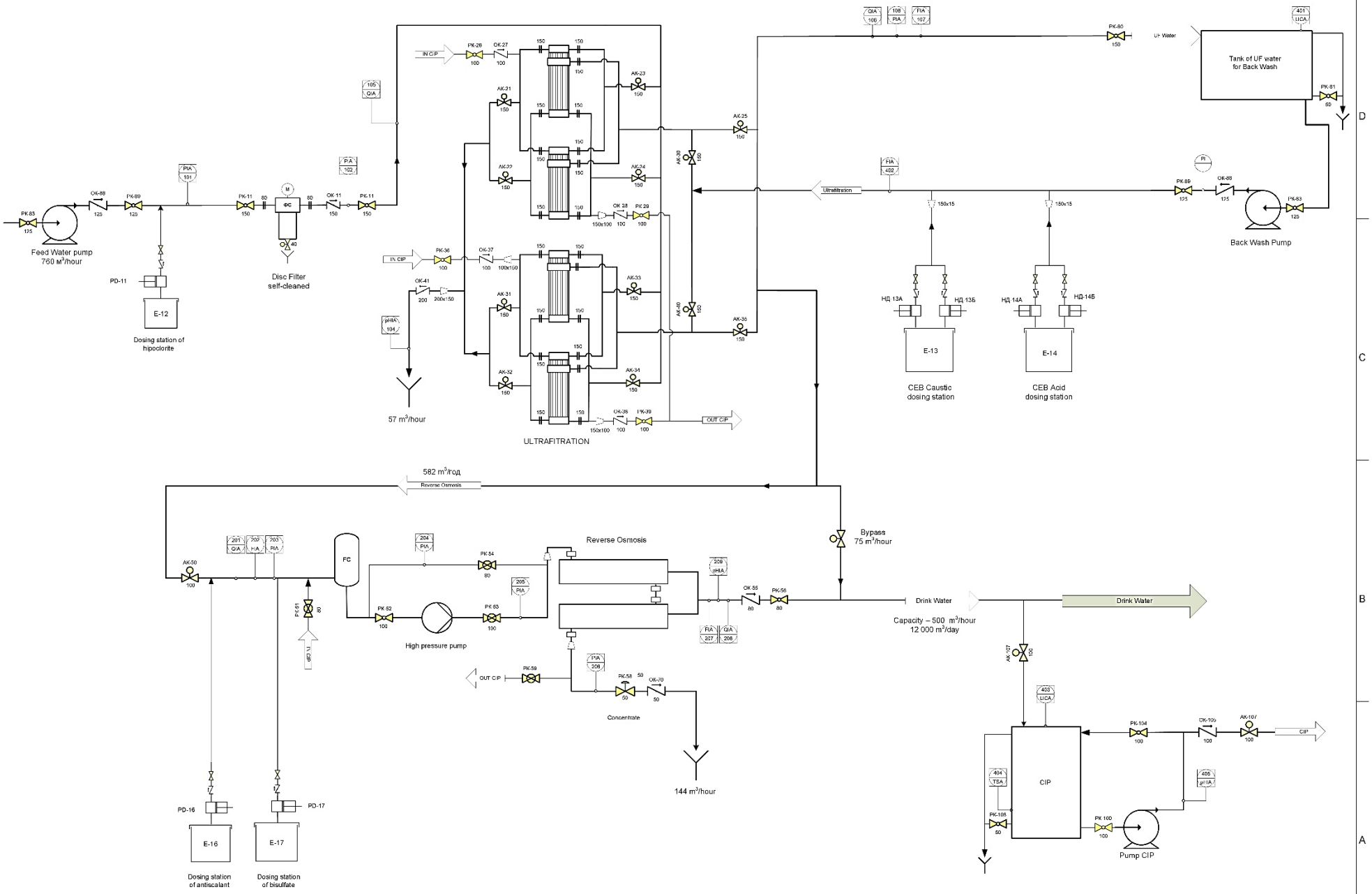
Chemical	Day Usage, kg	Usage per year, kg	Usage per 1 m^3 product produced	Note
Caustic, 40%	34	12 410	0,002	
Sulphuric acid, 44%	23	8 395	0,003	
Antiscalant 100%	12,5	4 563	0,001	

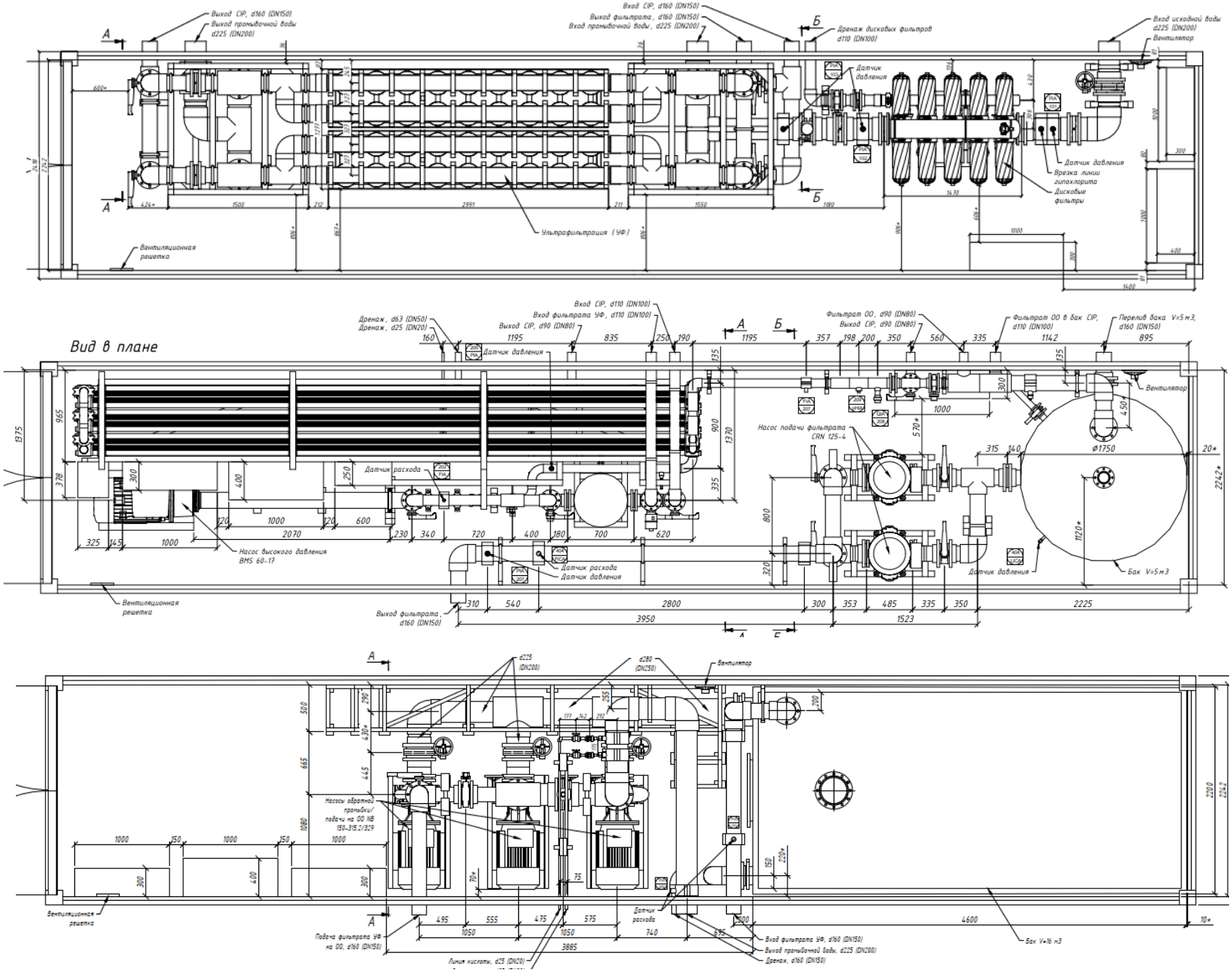
6. Specification of main equipment

№ п/п	Name	Description	Q-ty
	Feed source water		
1	Feed pumps	Q-760 m^3/hour, H-60 m, N -160 kW	2
2	Frequency converter	N-160 kW	2
3	Motor cabinet for Pumps	N-160 kW	1
4	Dosing station of hypochlorite	Q-5 L/hour, H-50v, N-0,3 kW	2
5	Tank of coagulant	V-1000 L	2
6	Automatic self-cleaned disc filter	Q-760 m^3/hour 2” Spin Klin, 200	2

	Ultrafiltration		
7	Ultrafiltration	MB 0,9-80	156
8	Automatic valves with electrical gearbox	Dn-150,250 mm	set
9	Pipe and hand valves of ultrafiltration	PVC	set
10	Automatic pressure sensors	0-10 bar	4
11	Flow transmitter	0-400 m^3/hor	4
12	Turbidity transmitter	0-10 NTU	3
13	Back wash pumps	Q-480 m^3/hour, H-30 m, N -55 kW	2
14	Frequency converter	N -55 kW	2
15	Motor cabinet for Pumps	N -55 kW	2
16	Tank for Back Wash UF	PP V-15,0 m^3	1
17	Acid dosing station	Q-400 L/hour, H-50m, N-0,6 kW	2
18	Caustic dosing station	Q-400 L/hour, H-50m, N-0,6 kW	2
19	PLC station	Siemens	3
	Reverse Osmosis		
20	High pressure pump	Q-195 m^3/год, H-210 m, N -200 kW	3
21	Frequency converter	N-200 kW	3
22	Motor cabinet for Pumps	N -200 kW	3
23	Membranes Housing	440	24
24	RO Membranes	BW 8040	144
25	Automatic pressure sensors	0-16 bar	9
26	Flow transmitter	0-300 m^3/hour	6
27	Conductometer	0-1000 ppm	6
28	Dosing station of antiscalant	Q-1 L/hour, H-50m, N-0,6 kW	3

29	Dosing station of bisulfite	Q-1 L/hour, H-50 m, N-0,6 kW	3
30	Container insulated	40 HQ	9
31	Climatic cooling/heating system of container equipment		9
32	Control panel of container		9
33	Container insulated	20 HQ	1
	CIP (Clean in Place) station for UF and RO		
34	Tank	PP V-15,0 m3	1
35	Pump of CIP	Q-570 m3/год, H-35 m, N -55 kW	1
36	Frequency converter	N-55 kW	1
37	Motor cabinet for Pump	N -55 Kw	1
38	Control panel		1


Feed Water pump
760 m³/hour
Dosing station of
hipoclorite
Disc Filter
self-cleaned
57 m³/hour
ULTRAFITRATION
Tank of UF water
for Back Wash
Back Wash Pump
CEB Caustic
dosing station
CEB Acid
dosing station
582 m³/год
Reverse Osmosis
Bypass
75 m³/hour
High pressure pump
Concentrate
144 m³/hour
Capacity – 500 m³/hour
12 000 m³/day
Drink Water
CIP
Pump CIP
Dosing station
of antiscalant
Dosing station
of bisulfate
Containerized drink water treatment station 12 000 m3/day
UF-RO
PID
Pages 1
Page 1


Вид в плане
Ультрафильтрация (УФ)
Дисковые фильтры
Насос высокого давления BMS 60-17
Насос подачи фильтрата CRN 125-4
Бак V=5 м3
Бак V=16 м3
Вентиляционная решетка
Датчик давления
Датчик расхода
Вентилятор


QIA-101
QIA-102
Model 56
24.88 NTU
0.018 NTU
SIEMENS
SIMATIC HMI
TOUCH
pHIA-104
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