1 OVERVIEW

TC Energy Keystone XL Pipeline Remote Workforce Housing Camps Wastewater Treatment Facilities

FilterBoxx will provide the design, fabrication, and supply of four (4) wastewater treatment (WWTP) units for the Keystone XL Pipeline Remote Workforce Housing Camps in Montana and South Dakota.

2 DESIGN BASIS

The four pipeline camps that these initial wastewater treatment plants are understood to be intended for are as follows:

- Montana:
  - Hinsdae
  - Glendive
- South Dakota:
  - Opal
  - Philip

This Scope of Work includes the design, fabrication, and supply of WWTP units for the four (4) above-noted camps only.

It is planned to use the same treatment system for each camp that requires a WWTP, for consistency of permitting, consistency of installation, and consistency of operations. The wastewater treatment system is known as the RemoteBoxx MBR 250 system. The following sections summarize the basis upon which the treatment system has been designed.

2.1 Design Treatment Capacity

The treatment plant is intended to treat wastewater generated by a total contributing population of up to twelve hundred (1,200) people. Based on a per-capita wastewater generation rate of 50 gallons / person / day (gpd), the nominal design flow is 60,000 gpd; as summarized in the following table.

Design Flows – 1,200-person Camp WWTP

Parameter	Value
Average Flow	48,000 gpd [2]
Maximum Day Flow	60,000 gpd [1]
Peak Flow (from collection system to WWTP EQ tank)	250 gpm
Peak Flow (from WWTP EQ tank to main WWTP system)	59 gpm

Notes:

1. Based on a population of 1,200 people and a per-capita wastewater generation rate of 50 gallons/person/day.
2. Based on an assumed average camp occupancy rate of 80%.

Note that the **minimum** operational capacity of the RemoteBoxx MBR 250 system is approximately 1,500 gpd.

2.2 Influent Wastewater Quality

The wastewater treatment systems have been designed on the wastewater quality provided by Target Logistics in April 2018 (with adjustments made for TSS, TKN, and TP), and summarized in the following table. This is the influent wastewater quality used by KLJ for permitting purposes.

Parameter	Value
BOD5	538 mg/L
TSS	544 mg/L
TKN	80 mg/L
NH_3-N	54 mg/L
TP	22 mg/L
Alkalinity	450 mg/L as $CaCO_3$
pH	6.5 – 8.5

2.3 Treated Effluent Water Quality

The following treated effluent water quality is anticipated following equipment start-up and stabilization of the biologic al treatment system, and depending on the influent wastewater flow and quality provided in the previous sections.

Parameter	Design Value	Typical Operating Value
BOD5	< 25 mg/L	< 10 mg/L
TSS	< 25 mg/L	< 10 mg/L
Ammonia	< 2 mg/L	< 1 mg/L

3 SCOPE OF SUPPLY BY FILTERBOXX – CAPITAL PURCHASE

3.1 Equipment – RemoteBoxx MBR 250 WWTP

The RemoteBoxx MBR 250 system consists of one treatment system building, mounted on a roll-off skid for ease of loading/unloading, that contains the majority of the tanks and equipment, with four external tanks. Dimensions of the treatment system are as follow s:

- One treatment system building, measuring 8' W x 40' L x 9.5' H
- Two equalization tanks, each measuring 8.5' W x 46' L x 10.5' H
- One aerobic bioreactor tank, measuring 8.5' W x 46' L x 10.5' H
- One sludge digestion tank, measuring 8.5' W x 46' L x 10.5' H
- One sludge transfer pump enclosure, measuring approximately 8' W x 8' L

The following equipment is pre-installed into the treatment system building: a 40-foot long modified ISO container building, with double doors on each end, three standard man doors, insulation, heating, lighting, and ventilation. All mechanical and electrical interconnections within the building are completed in the shop prior to shipping.

- 2-mm automatically-cleaned influent mechanical screen with compactor
- Influent tank with submersible influent transfer pump
- Antifoam chemical dosing system
- Membrane feed pumps and RAS pumps
- Ultrafiltration membrane systems, including two stainless steel side-loading membrane tanks, hollow fiber membranes,

permeate and backwash pumps, membrane aeration blowers, and sodium hypochlorite cleaning systems

- Treated effluent water storage tank (small volume, for in-plant use)
- Treated effluent discharge pump
- Treated effluent tubidimeter
- Surge arrestor
- RAS flow transmitters
- Cold weather package including building heating and pow er supply for external heat trace
- Eye wash and first aid kit
- Instrumentation and valves included with above systems
- Schedule 80 PVC piping for liquids; stainless steel and CPVC piping for air
- Central control panel with PLC, HMI, and required motor starters and VFD's
- Call-out / remote monitoring/access (Ethernet/internet connection by others)
- Building pow er distribution / lighting panel

Note: The screen/influent room is designed with a Class I, Division 2 area classification, and the remainder of the system is designed for a general-purpose area classification.

Additional scope of supply included by FilterBoxx associated with the four external tanks is as follow s:

- Tw o 21,000 gallon insulated carbon steel Equalization tanks with coarse bubble aeration system and level transmitter
- One 21,000 gallon insulated carbon steel Bioreactor tank with fine bubble aeration system and level transmitter
- One 21,000 gallon insulated carbon steel Sludge Digestion tank with coarse bubble aeration system and level transmitter
- Design/supply only of heat traced and insulated hose for connection of the liquid lines from the main building to the external tanks
- Design/supply only of electrical materials for connection between the main building and the external tanks Additional scope of supply included by FilterBoxx for winterization of the external tanks and equipment, to allow year round operation of the WWTP, is as follow s:
- Electric immersion heaters (2 heaters per external tank), flange mounted, Incoloy elements, NEMA 4 enclosure with high limit K thermocouple, 480V, 3-phase, 6.5 kW per heater, 60" immersion length
- Modifications to external storage tanks to allow installation of heaters and thermocouples, enabling the heaters to be removed/installed without draining the tanks
- Pow er distribution and control panels, NEMA 4X, heated panel intended for outdoor installation, separate process controls per tank, high limit controls for each heater
- Lot of electrical wiring for connection between the heaters/thermocouples and the pow er distribution/control panel (design/supply only; installation by others or per-diem)
- Lot of supplemental/upgraded heat trace and insulation scope for the FilterBoxx-supplied liquid lines between the main WWTP process building and the external storage tanks, and between the external sludge storage tank and the external sludge transfer pump (design/supply only; installation by others or per-diem)

Additional scope of supply included by FilterBoxx associated with the sludge transfer pump, to be used to transfer digested sludge from the Sludge Digestion tank to the sludge drying bed, is as follow s:

- One positive displacement sludge transfer pump
- Mounting on a dedicated base skid, along with piping, valves, flow transmitter, and high-pressure switch • Small outdoor-rated enclosure over the equipment, estimated footprint 8' x 8'
- Heat trace and insulation
- Design/supply of interconnecting piping/hose materials between the sludge tank and the sludge pump suction
- Design/supply of interconnection wiring materials between the WWTP main building and the sludge pump skid

In addition, the following ancillary equipment is included in FilterBoxx's scope of supply:

- One set of lab/testing equipment per WWTP

- One set of spare parts per state (two sets of spare parts total)

3.2 Remote Monitoring

Remote monitoring is available for each FilterBoxx system. Benefits include:

- Reduces the Operations Staff response times when there are process, mechanical and/or electrical issues
- Reduces FilterBoxx Process Services and Support response time when there are process, mechanical and/or electrical issues
- Reduces travel expenses if requiring system programming changes
- Provides additional security and support to the system Operations Staff
- Improves troubleshooting ability from Operations Staff and FilterBoxx Process Services and Support staff Note: Ethernet connection(s) and internet connection are to be provided by Purchaser.

3.3 On-Site Services

FilterBoxx can provide personnel for coordination and field project management of installation contractor, installation assistance and verification, start-up, commissioning, operator training, and/or performance testing on a per-diem basis. Time on site, travel time, and associated travel and living expenses will be charged at the rates given on the rate sheet included in Schedule B.

4 Process Description

The FilterBoxx treatment system to be used for these housing camps is known as the RemoteBoxx MBR 250 system.

Overall, the RemoteBoxx MBR 250 wastewater treatment plant (WWTP) is based on membrane bioreactor (MBR) technology, and consists of the following subsystems:

- Flow equalization
- Screening
- Aerobic biological treatment
- Membrane filtration
- Treated effluent discharge
- Sludge storage and aeration

The FilterBoxx RemoteBoxx MBR 250 WWTP is generally contained within a standard 40' ISO container building, with external tanks for flow equalization, biological treatment, and sludge storage. The ISO container main process building is customized for use in harsh environments, and is equipped with all required pumps, blowers, instruments , electrical equipment, process control equipment, heating, ventilation, and lighting equipment. The main process building is supplemented with three external tanks that provide the flow equalization, aerobic biological treatment, and sludge storage functions required for the proper operation of the system. Each external tank consists of a 500 - barrel (21,000 gallon) frac tank modified for use by the WWTP. The WWTP is designed to be mobile so that it can be demobilized and relocated to another camp in the future. The system does not require concrete foundations or any other permanent infrastructure for installation at a camp. A compacted gravel base or similar level foundation is adequate for the installation of the RemoteBoxx MBR 250 WWTP system.

During normal operating conditions, the WWTP will be operated automatically by the Programmable Logic Controller (PLC) located within the main control panel. All screening, aeration, pump and blower systems are monitored and controlled by the PLC. The operator is able to check operating conditions and make adjustments using the Human - Machine Interface (HMI), located on the front panel of the main control panel.

Shelf spare critical parts are proposed to manage potential system downtime. System downtime, as a result of critical equipment failure, would be minimized by having preventive maintenance programs in place, shelf spare equipment on hand in case of failure, adequate additional influent storage and/or temporary hauling of wastewater offsite.

Flow Equalization

The WWTP is equipped with one flow equalization tank that is used to attenuate influent flow and organic load fluctuations and provide a steady influent flow to the downstream treatment system. The tank is a modified 500-barrel (21,000 gallon) frac tank that is equipped with a level transmitter and a high level switch.

An EQ blower provides air for mixing of the equalization tank through a coarse bubble aeration grid installed in the tank.

An EQ transfer pump takes the raw sewage from the equalization tank and pumps it to the influent screen. The flow rate of the influent pumps is adjusted by the PLC through a VFD.

An influent flow transmitter installed downstream of the EQ transfer pump is used to display the instantaneous influent flow and to totalize daily volumes. The flow transmitter is also used to control the start/stop of the Influent Screen.

An automatic valve installed on the EQ transfer line is included to stop flow to the WWTP in the event of an alarm condition where the plant cannot receive any additional flow.

Influent Screening

The WWTP is equipped with an influent screen unit which is divided into two parts: a fine screen to separate solids from the influent wastewater, and a compactor to wash, press, and discharge solids out from the unit. The fine screen is a self-cleaning screen with 2-mm perforations. The compactor discharges the screenings into the bagging device provided. As the bag fills with screenings, the bag from the continuous bagger will need to be zip tied, cut off, and replaced with a new bag. This is a manual operation.

The wastewater from the equalization tank is pumped by the EQ transfer pump through an inlet automatic valve, influent flow transmitter, and to the influent screen. Screened wastewater, and pressate from the compaction zone of the screen, flow by gravity into an influent tank. From the influent tank, a submersible influent pump transfers the screened wastewater to the downstream aerobic bioreactor tank. The influent pump is controlled by three level switches included in the influent tank.

The influent screen and compactor are controlled by the PLC, using the instantaneous feed flow through the influent flow meter. The spray w ash for the screen and compactor is controlled by timers in the PLC and the w ash solenoid valve. The valve opens based on the operator adjustable frequency and duration to clean the buildup on the screen and compactor auger.

Aerobic Bioreactor (Aeration Tank)

The aeration tank is w here the majority of the biological treatment process takes place. The aeration tank uses microorganisms (biomass) to convert organics from the sew age into carbon dioxide and additional biomass. For optimal plant performance, this tank w ill be kept at an MLSS (Mixed Liquor Suspended Solids) concentration of between 8,000 – 12,000 mg/L. An MLSS above 12,000 mg/L can lead to membrane fouling issues.

The aeration tank receives screened wastewater pumped from the influent tank. Mixed liquor / activated sludge flow s through the tank and is pumped to the two membrane trains/tanks via one dedicated membrane feed pump for each membrane train/tank.

The aeration tank is equipped with a level transmitter and a high-level switch to control the operation of the membrane tanks and to prevent potential tank overflow s. The aeration tank has level control set points to start and stop the membrane trains as required. The goal of operations is to have steady permeate pump operation. This is achievable by adjusting the level set points in the aeration tank as well as the membrane permeate flow to achieve balanced operation. This steady operation avoids excessive starts and stops of the membrane train process equipment.

The aeration tank contains multiple fine bubble diffusers that provide an even fine bubble distribution of air throughout the tank.

Membrane Process Equipment

The WWTP is equipped with two separate membrane trains. Each train consists of one stainless steel membrane tank containing three membrane modules and the associated process equipment.

Each membrane train has one permeate pump and one backwash pump for filtration and backwash. Permeate pump operation is based on the level control set points of the aeration tank. The permeate pumps create a negative pressure on the permeate line which draws water into the membrane fibers, through the flow transmitter, the permeate pumps and into the effluent tank. The pressure in the line through the membrane is monitored by a pressure transmitter.

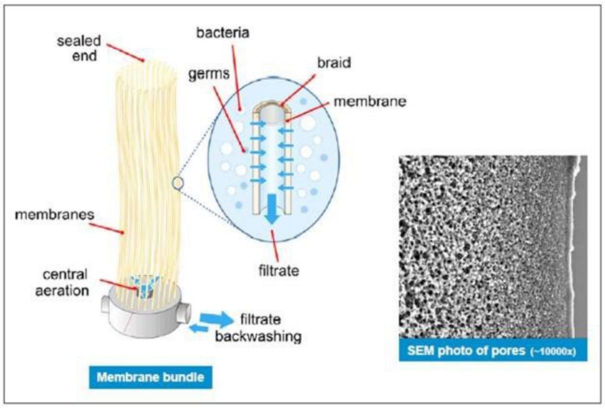
The membrane feed pumps transfer mixed liquor from the aeration tank to the membrane tanks. The pumps w ill run continuously at a flow rate proportional to the overall plant flow . The RAS pumps transfer mixed liquor from the membrane tanks back to the aeration tank. An optional flow transmitter is included on the discharge of each RAS pump to monitor the RAS flow rate. The RAS pump is also used to periodically direct WAS out of the treatment system; this is controlled automatically by an automatic 3-way valve that directs mixed liquor either back to the aeration tank (as RAS) or to the sludge storage tank (as WAS). The frequency and duration of WAS discharge is operator-adjustable on the HMI. The flow transmitter is also used to totalize the amount of WAS that is discharged from the treatment system.

During operation, the permeate pump speed ramps up or down proportionally to aeration tank level set points . The pump speed will reach a maximum value as the level in the aeration tank continues to rise. When the level decreases, the pump slows down.

During a backwash, the permeate pump stops and the backwash pump starts. Each backwash pump is equipped with a variable frequency drive (VFD) to control the speed of the pump. The PLC will control the speed of the pump to maintain the flow to the membranes based on a flow set point.

Ultrafiltration Membrane Modules and Tanks

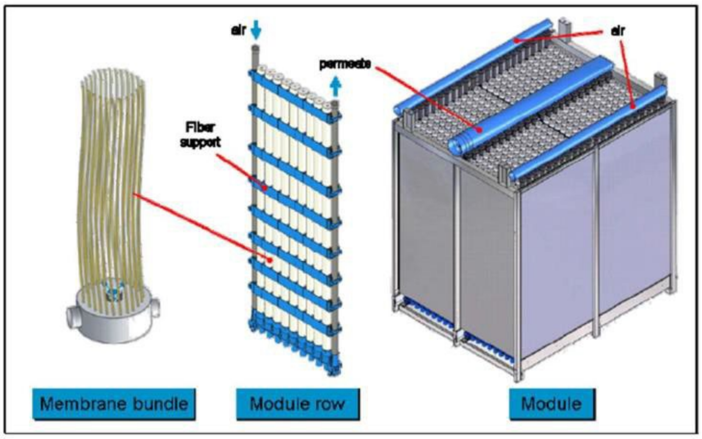
Six Ultrafiltration (UF) membrane modules, manufactured by Koch, are installed in each WWTP; three modules per membrane train. The three modules are submerged directly in mixed liquor inside each membrane tank. Each membrane train/tank is equipped with an aeration blower that provides scouring air to the surface of the membrane. This reduces the rate of fouling of the membrane and extends the time between chemical cleanings of the membranes.



The membrane module consists of bundles of hollow fibres with a nominal pore size of 0.03 µm. The membranes are an immersed negative pressure (vacuum) type membrane with a small nominal filtration pore size to separate most solids, pathogens , and unwanted constituents from wastewater.

The UF membranes are referred to as “outside in” filters; therefore, the solids that are filtered out of the wastewater are retained in the Membrane Tanks, and pumped to the aerobic digester system as WAS or recycled back to biological treatment process (aeration tank).

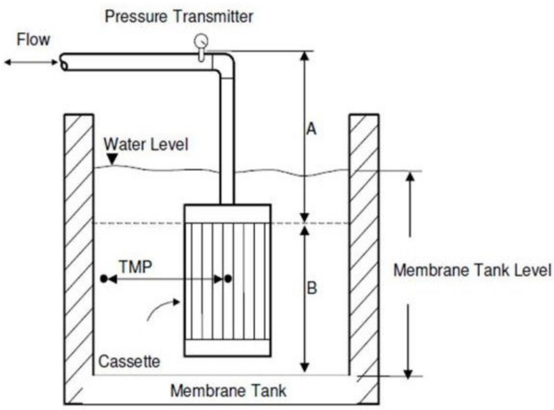
Transmembrane Pressure (TMP) is a measure of the differential pressure across the membrane surface. It is a calculated value that takes the measurement from the permeate pressure transmitter, and the relative heights of the membranes and the water level in the membrane tank, and calculates the differential pressure across the membrane fibers. This number, in conjunction with the flow (as the TMP is directly related to the flow) is useful in determining the permeability and condition of the membranes.



TMP is calculated by using the equation below:

TMP = Header Pressure + C x (A + B – Typical Operating Level)

Where:
A is the height of the pressure transmitter above the top of the membranes.
B is the height to the top of membranes in the membrane tank.
C is a conversion factor (water depth to pressure)



TMP is monitored by the pressure transmitter installed on each train permeate/backwash header and is always an absolute value. In production, if the membranes become fouled to a point w here the TMP is too high, the PLC w ill shut down the train.

Over time, the ultrafiltration membranes w ill foul, causing reduced flow s and/or increased pressures across the membranes. The four methods for cleaning the membranes in the WWTP are:

Air Scouring

Membrane aeration is the primary cleaning tool for the membranes. Vigorous aeration produced by the membrane blowers agitates the fibers and prevents solids buildup in between the fibers. Operating at a substantially reduced air flow or with no air flow will cause the membranes to foul.

The WWTP is equipped with membrane aeration blowers. Periodically, the aeration system will automatically open the pow er flush solenoid valve on each membrane aeration line when the aeration valve is closed and membrane is not aerating, allowing the membrane air scour header to fill with water. When the air is next supplied to the membrane aeration header it acts as a flush, cleaning the aerators with a surge of mixed liquor. The frequency and duration of the aerator flush is operator adjustable.

Backwash Cleaning
The WWTP automatically conducts backwash cleaning cycles based on time duration set points in the PLC. In backwash mode, treated water is pushed from the effluent tank back through the membranes fibers to remove any solids that have accumulated on the membrane fiber surface.

Maintenance Cleaning
A maintenance clean is an automatic cleaning procedure controlled by the PLC. The cleaning involves backwashing the membranes with chemicals at a set chemical dosage and flow rate. The clean is typically done at a much lower flow than the normal backwash to increase the concentration of chemical seen by the membranes. Chemical for the clean is injected downstream of the backwash pump. Permeate for the maintenance clean is drawn from the Effluent Tank. The membranes are not aerated during the cleaning process. At the end of the cleaning process the chemical will turn off and the backwash pump will flush the permeate lines of any residual chemicals before restarting production. These chemical cleanings help to restore some of the permeability that is inevitably lost over time with only backwash and aeration cleanings.

The cleaning chemical used in maintenance clean is either Sodium Hypochlorite or Citric Acid. Sodium Hypochlorite is used to remove organic contaminants from the membranes while Citric Acid is used to remove inorganic contaminants from the membranes. The set points for maintenance cleaning are operator adjustable.

The cleanings should be scheduled for a time of day with low influent flows as the plant will only be able to filter from a single train. Typical maintenance cleans last approximately 30 minutes. The operator should ensure chemical is being dosed by monitoring the chemical tank levels regularly.

Recovery Cleaning
The recovery cleaning process is used periodically to restore the membrane flux. Over time the membranes will continue to foul and lose permeability even with proper aeration, backwash and maintenance cleanings. When flows decrease or TMP rises by an unacceptable level the membranes will require a recovery cleaning procedure. During recovery clean, the membrane is soaked in a higher concentration chemical solution for a longer period of time. This is a manual process, and requires draining of the membrane tank and filling it with treated effluent to soak the membranes in with addition of chemical. The transfer of mixed liquor from the membrane tank is done via the RAS/WAS pump back to the aeration tanks. The effluent pump is used to fill the membrane tank with treated effluent while chemical pumps dose chemical directly into the tank to mix with the effluent.

It is recommended to perform a recovery clean at least every six (6) months. The choice of chemical for the recovery cleaning depends on the feed water characteristics. However, most cleanings will likely be with sodium hypochlorite. Occasional citric acid cleanings may also be required to remove any inorganic scaling that develops on the membrane fibers.

The following table provides a summary of the membrane design and associated operating fluxes.

Parameter	Value
Membrane Manufacturer	Koch Membrane Systems
Membrane Module	PSH-95
Type of Membrane	Inside-Out Hollow Fiber
Nominal Pore Size	0.03 µm
Number of Membrane Trains/Tanks	2

Number of Modules Installed per Train/Tank	3
Total Number of Membrane Modules Installed	6
Membrane Surface Area per Module	1,020 ft^2
Total Installed Membrane Surface Area	6,120 ft^2
Design Average Flow	45,520 gpd
Net Flux at Design Average Flow	7.6 gfd
Design Maximum Day Flow	56,900 gpd
Net Flux at Design Maximum Day Flow	9.5 gfd
Typical/Expected Transmembrane Pressure	1 – 2 psi
Maximum Transmembrane Pressure	9 psi

Treated Effluent Discharge

Permeate produced through the membranes is collected in the effluent tank. The effluent tank stores a small volume of treated water for in-plant use, including membrane cleaning and spray washing of the influent screen. Treated water from the effluent tank is pumped by the effluent pump in a recirculation loop through a pressure sustaining valve and back to the effluent tank.

When the level of the effluent tank is low , the recirculation valve is opened and the treated effluent is recycled to the effluent tank. When the level of the effluent tank reaches the high control level, the effluent discharge valve is opened. With the effluent discharge valve open, the effluent will be directed out of the system to the evaporation pond.

Waste Sludge Storage/Digestion

Sludge wasting from the WWTP is accomplished via the RAS/WAS pump and the WAS flow control valve from the bottom of each membrane tank to divert mixed liquor (WAS) to the sludge storage/digester tank. The frequency and duration of sludge wasting are operator adjustable and instantaneous flow is displayed on the flow meter provided in the RAS/WAS line. Sludge wasting is used to control the MLSS concentration in the aeration tank.

The sludge storage/digester tank is continuously aerated via a dedicated duty blow er and a grid of coarse bubble aerators. The aeration system should be on at all times to prevent the sludge from going septic. However, the blow er should be manually stopped prior to decanting to allow the solids to settle.

The WWTP is equipped with a manual decanting system to enable gravity thickening of the sludge. The decanting process is manually initiated by the operator. There is an automatic timer based shut-off (operator adjustable time and sludge holding tank level based) of the decant pump in case it is left on accidently. The sludge storage/digester tank consists of two different suction pipes installed at different levels in the tank. The two different suction lines allow for the decant pump to pull water from different heights in the tank and send it back to Aeration tank.

Following a sufficient residence time in the sludge storage/digestion tank, and following decant thickening as needed, the waste sludge will be discharged from the tank to the client-supplied sludge drying beds.

1 System Block Flow Diagram