TDL Energie

Treatment of landfill leachate by means of a mobile Reverse Osmosis plant

- Meece Landfill Site (Biffa) -

TDL Energie GmbH | Spreestrasse 3 | 24539 Neumuenster, Germany | Email: info@ps-nms.de

Contents

Page

1 General Information

1.1 Purpose

It is planned to concentrate the accumulated leachate (approx. 5 – 6 m³/h) at Meece landfill site by means of a containerized 2 or 3-stage Reverse Osmosis (RO) plant that is to be installed on site in order to ensure that the disposal of the cleaned permeate and the discharged material of the existing cleaning facility takes place in accordance with the relevant official requirements.

The new RO plant consists of a 40 ft container and a stripping tower (option) which is designed to increase the ph value of the permeate.

The container contains a 2 or 3-stage RO plant, including the relevant ancillary units which are required for the processing of water (pre-filter / adjustment of ph value), cleaning and secondary treatment (adjustment of ph value).

Photo: RO plant with CO_2 Stripping Tower

2 Description of the RO plant designed for leachate treatment

The Reverse Osmosis (RO) plant contains three stages which are arranged in series on the discharge (permeate) side of the plant.

TDL Energie GmbH uses spiral-wound membrane modules for the treatment of landfill leachate. Each membrane is wrapped around a pipe that is used for the transport of the permeate. The membranes are wrapped around the pipes in the form of flat layers. Plastic grids ('feedspacers') between the membrane layers serve as channels between each layer. Several spiral-wounded elements, connected through fittings on the discharge (permeate) side, are positioned one behind the other inside a pressure pipe.

The first stage of the membrane system consists of a high-pressure pump and four pressure pipes, a recirculation pump, including the corresponding fittings. The permeate in the first stage is pumped into the second stage of the RO plant which, basically, consists of a high-pressure rotary pump, a pressure pipe and the corresponding fittings. The third stage (option) is identical to the second stage regarding design and function. In the third stage, the permeate is led to a CO_2 stripping tower (option) for further treatment to achieve the required ph value. Instead of the CO2 stripping tower a caustic soda can be added to increase the ph value accordingly.

2.1 Design

It is assumed, that the leachate at Meece landfill site is contaminated with the following:

- COD: ≤ xx mg/l
- *BOD5:* ≤ xx mg/l
- NH4+-N: ≤ xx mg/l
- Temperature: ≤ 40 °C

The following reductions could be achieved by means of the RO plant (estimation):

- *COD: average reduction greater than 99%*
- *BOD5: average reduction greater than 99%*
- *NH4+-N: average reduction greater than 99 %*

2.2 Functional description

The osmosis and the reverse osmosis use the physical separation effect of a semi-permeable membrane.

Osmosis

If the concentrations of solutes are differently high on both sides of the membrane, the system is not in thermodynamic equilibrium and will try to achieve a concentration equilibrium. With the different concentration potentials as a "driving force“, the solvent permeates from the less concentrated side, through the membrane, onto the more concentrated side. On this occasion, the volume on the side with the higher concentration increases constantly.

This process continues until the same concentration is achieved on both sides of the membrane. At that time, the system is in a thermodynamic equilibrium between the dilution effort on the one hand and a hydrostatic positive pressure due to the increase in volume on the side of the concentrated solution, on the other hand.

Here, this hydrostatic positive pressure corresponds to the pressure difference of the osmotic pressures of the differently concentrated liquids.

Reverse osmosis

When applying a pressure exceeding the osmotic pressure difference on the higher concentrated liquid, the osmosis process can be reversed. The water (permeate) penetrates through the membrane, the concentrate remains behind.

A reverse osmosis plant consists in the essentials of a high-pressure pump, the membrane and a pressure control valve. The operating pressure achieves values of 20 to 80 bar during reverse osmosis.

The flow rate across the membrane is chosen so high that that a turbulent flow forms. This means that inflow and concentrate retained at the membranes blend continually. Without this mixing, a layer of concentrated solution (concentration polarisation) would form on the membrane surfaces, which would interfere with the retention performance.

2.2.1 Description of the Reverse Osmosis treatment plant

The reverse osmosis plant consists of three stages, which are connected in series on the permeate side.

TDL Energie GmbH uses membranes with a "spiral wound" design for leachate treatment. The membranes are wound around a permeate pipe in the form of flat envelopes. Between the individual layers, there is the so-called Feedspacer, a plastic grid that forms a duct between the membrane layers. Several winding elements are successively inserted into a pressure tube, coupled with sleeves on the permeate side.

At the inflow to the plant, the leachate passes through a bag filter and flows into the plant's internal storage tank.

Via a double pre-filtration, the leachate is fed from the storage tank to the so-called pre-compression pump. The pre-filtration consists of gravel filtration with a downstream fine filter station. With the high-pressure pump the leachate reaches the required system pressure of 25 to 80 bar. For pH adjustment 96% sulphuric acid is added to the raw leachate with a dosing pump. Thereby, the ammonia-ammonium-balance is shifted towards the ammoniums' side, i.e. only ammonium remains. This small-size molecule would be able to pass through the membrane. However, due to it being positively charged, the molecule is retained by the membranes which are also polar. In addition, an antiscalant is added that reduces carbonate and sulfate precipitation among other things.

The first stage of the membrane system consists of four pressure pipes, a recirculation pump, measurement equipment and the corresponding fittings.

The leachate is fed to the first stage at normal pressure of 25 to 80 bar. Here, it mixes with the circulatory flow and is fed through the recirculation pump to the winding elements. Inside these winding elements, some of the water is separated and referred to as permeate.

The remainder of the leachate is referred to as concentrate. A part of the concentrate will be fed to the regulation valve, while the rest is re-fed into the cycle and used for mixing with the inflow. This process is repeated in the subsequent units.

The concentrate forwarded by the first stage, flows through the flowmeter and the control valve into the concentrate tank. With the control valve the predetermined concentrate flow and thus the pressure in the stage is adjusted. The concentrate is disposed of externally, according to law.

The membrane for the ammonium-nitrogen parameter NH_4-N has a rejection of approx. 85 to 90%. Therefore, a second and subsequently a third stage are installed downstream from the first stage, on the permeate or clear water side.

Because these stages feature a similar rejection, a total rejection of 99% could be achieved. The permeate is collected and fed to stage 2 and finally stage 3 which operate similarly. The permeate of the first stage is acidic, and therefore no additional dosing of acid is necessary. Since the solids are already rejected in the first stage, and the scaling potential (risk of crystalline precipitations on the membrane) is lower in the second and third stage, membrane modules with higher packing density can be employed at those stages. At the same time, it is possible to do without recirculation pumps. The second and third stage consist only of a high-pressure pump (up to 30 bar second stage, third stage 22 bar), pressure pipes including membrane modules and a control valve. Measurement equipment and additional fittings are added.

By means of a centrifugal pump, the permeate is increased to normal pressure of between 15 to 30, and feed to the winding elements inside the pressure pipes of the respective stage. Inside the winding elements, some of the water is separated. Here, the yield, i.e. the permeate, represents 90 to 95% and is referred to as Permeate II or Permeate III respectively.

Following the third stage, the permeate is discharged by means of a CO2 stripping tower, which is installed on the outside of the container. The water inside the stripper runs from top to bottom, and countercurrent to air which is blown into the stripper from below by means of an air blower. The CO2 dissolved in the permeate passes into the air, and the pH value of the water increases. In addition, sodium hydroxide solution can be added with a dosing pump to achieve the pH value necessary for the discharge.

The process of reverse osmosis enables a simple and reliable monitoring of operations. The proper functioning of the plant, and therefore also the quality control of the output (“permeate”), is monitored by means of a continuous conductivity measurement.

A disturbance affecting the cleaning performance of the plant (e.g. by a leakage on a membrane) would be immediately noticeable by an increase in conductivity. This would be detected immediately and would in turn cause the shut-down of the plant.

3 Technical design of the RO container

The advantages of the containerized RO technology are the fast and easy installation on landfill sites, as well as the following:

- standardized technology
- efficient technique
- high reliability
- easy handling
- mobile system
- less time for installation and commissioning
- reduced space requirements

The 40’ RO container provides two compartments, the engine room and the control cabinet room. The rooms are separated from each other by means of a sheet metal wall.

The front end of the engine room consists of a fullsize door to enable the replacement of large plant units. This door has been closed with screws, and is equipped with a smaller access door for everyday use. The access doors that lead to the electrical control and to the engine room are equipped with panic locks.

The following devices are installed to the inside wall of the engine room.
The devices are arranged in the following order:

- Bag filter
- Buffer tank for raw leachate
- Two sand filters
- Dosing units (avíd & caustic soda (option))
- Cartridge filters
- CIP tank
- High-pressure pump set
- Reverse Osmosis stage
- Fan heater and ventilation appliances

The control cabinet room contains the electric cabinet, an air conditioning unit, an activated carbon supply air filter and a fire extinguisher.
The RO container is equipped with a frost protection facility (fan heater, 3 kW) and a ventilation unit.
Ventilation of the machinery room will be ensured by means of a blower and a supply air grille.
Ventilation of the control cabinet will be ensured by means of a ventilation unit and an activated carbon supply air filter.
The air in both rooms, machinery room and control room, will be monitored for hydrogen sulphide.

3.1 Storage Tanks

All storage tanks are made of chemical-resistant material.

Buffer tank for the storage of leachate (installed inside the RO container)

- Closed storage facility made of PE (polyethylene) material
- Volume: 1.1m³

2 Sand filters (installed inside the RO container)

- Closed storage facility made of GRP (glass-fibre reinforced plastic) with PE Inliner

CIP tank (installed inside the RO container)

- Closed storage facility made of PE (polyethylene) material
- Volume: 2.5m³

Stripping tower designed to increase the pH value (option)

- Position: positioned outside the RO container, approx. 10 m)
- Equipment: Blowers / Heating / Overfill protection device / Ventilation

3.2 Supply and distribution of water and electricity

The power supply of the RO plant is ensured by a power supply line which provides a power rating of approx. 80 kW.

The electric fuse protection of the entire RO plant is 200 A. The general power supply of the RO facility is ensured by means of the low-voltage main distribution board inside the control room.

3.3 Safety Technology

A fire extinguisher is provided for the RO container.

The low-voltage main distribution board inside the control room of the RO container plant is equipped with an overvoltage protection device.

All three doors are equipped with panic locks.

3.4 Process automation

The process control system of the RO plant will be operated by means of the control program *SIEMENS S 7*.

The visualisation program that will be used with this RO plant is the software program *WinCC flexible* by *SIEMENS*. The host computer is a Siemens Microbox-PC, including touch panel.

Data recording enables the collection of all important parameters, data and modifications that are required for the reliable operation of the RO plant. Such information include the recording of data required for starting/stopping the operation of pumps, valves, sliders, fittings etc.

All alarm signals and failures will be indicated on the display and shall not disappear from the display unless acknowledged and rectified accordingly.

Error messages are sent automatically to the operator by email and SMS.