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RPS DIVISION

Membrane Bioreactor (MBR) - ULTRAFOR[®] Package System



GENERAL PRESENTATION



CONTENTS

1. INTRODUCTION	3
2. PROCESS	4
2.1. TREATMENT STAGES.....	4
2.2. ZEEWEED 500 MEMBRANE MODULE.....	6
2.3. ULTRAFILTRATION SKID OPERATING CYCLES.....	7
3. ADVANTAGES.....	10
3.1. EXCELLENT WATER QUALITY	10
3.2. HIGH CAPACITY	10
3.3. A MODULAR AND INCREASABLE CAPACITY.....	10
3.4. OPERATION RELIABILITY	10
3.5. SKID-MOUNTING	10
3.6. ON-SITE INSTALLATION	10
4. INSTALLATION CONDITIONS	11
5. MEMBRANES SERVICE CONDITIONS.....	12
5.1. PH AND TEMPERATURE.....	12
5.2. CLEANING REAGENTS	12
5.3. UNCOMPATIBLE AND FORBIDDEN COMPOUNDS.....	13
5.4. ANTI-FOAM AGENTS.....	14
5.5. SLUDGE TREATMENT POLYMERS.....	15
5.6. COAGULANTS.....	15

1. INTRODUCTION

When disinfection and/or reuse of treated water are needed on wastewater plants, Degrémont has developed a range called :

ULTRAFOR® Package System

ULTRAFOR® process (Membrane Bioreactor) consists in filtrating with organic membranes the biological liquor of an urban or industrial wastewater treatment plant. Ultrafiltration membranes used in ULTRAFOR® process constitute a physical barrier stopping almost every suspended solids of the water going through.

Once pretreated, the effluent is treated in an aeration tank with sludge concentrations slightly superior to the ones of a classical system (6 to 8 g/L), what gives it higher compacity.

Then the effluent is « filtrated » on membranes which replace at the same time a clarification, a tertiary filtration and a partial disinfection. Membrane separation leads to excellent results in terms of suspended solids and bacteriological pollution removal.

ULTRAFOR® Package System (PS) is a range of standard solutions using ULTRAFOR® process for capacities up to 1370 m³/day at 20°C. Thanks to the modularity of these solutions, it is also possible to treat higher flows by a parallel installation.

For each ULTRAFOR® treatment stage, this range offers a **prefabricated compact solution**, fitted to your needs, giving you the possibility to quickly have a complete line of treatment.

The membrane ultrafiltration is here offered as a pre-mounted **skid**, allowing a rapid site set-up. The dimensions of the skids have been carefully chosen to conform to international quality standards and norms and they are readily transportable by land or sea.

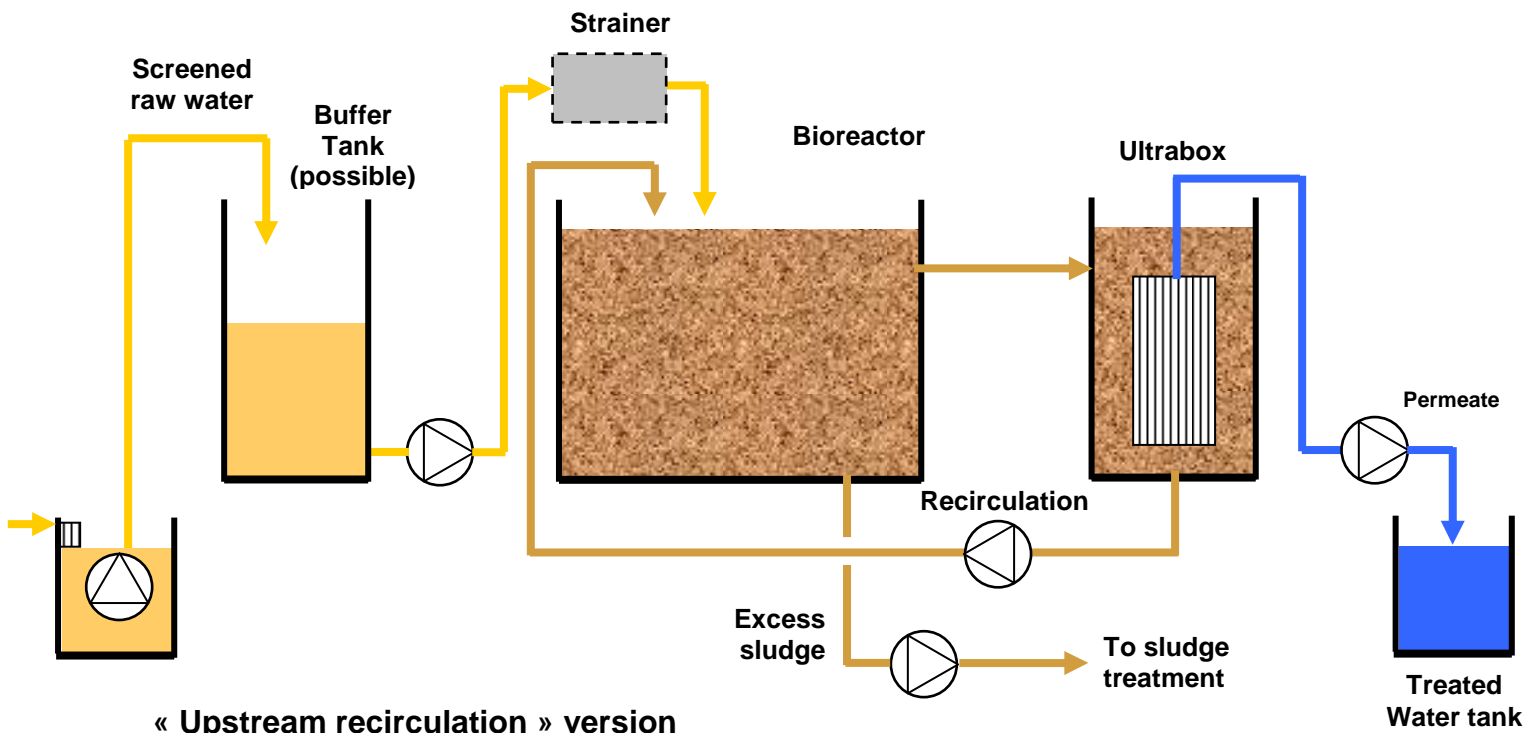
The range includes 8 models of ultrafiltration skid. These units are designed for **full-automatic operation** (delivered with control panel / PLC).



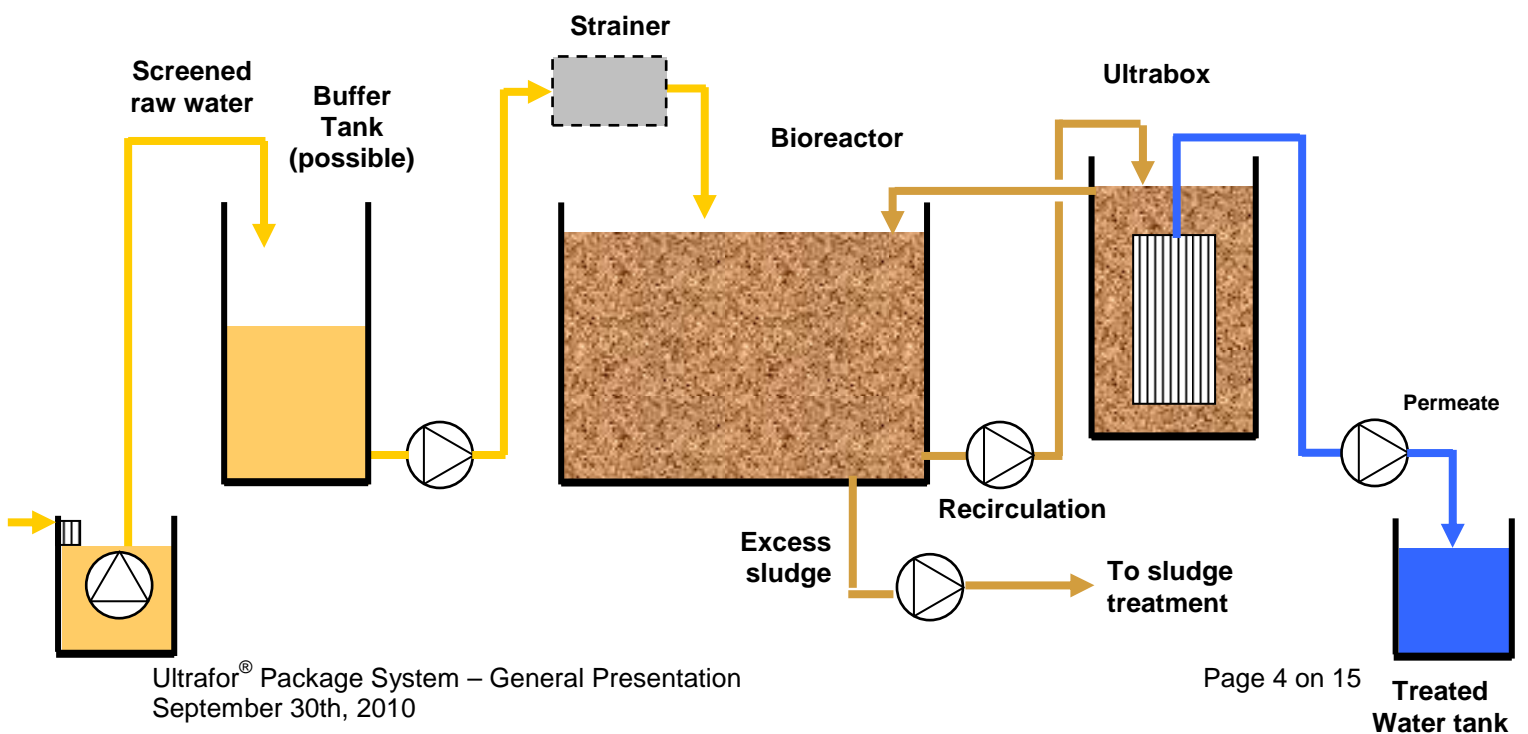
2. PROCESS

2.1. TREATMENT STAGES

« Downstream recirculation » version



« Upstream recirculation » version





2.1.1. Buffer tank (out of DEGREMONT standard scope of supply)

The buffer tank smoothes flow peaks and avoids a too large design of membrane separation. It is equipped with a level hydraulic gradient probe and a rotating strainer feeding pump.

2.1.2. Pretreatment on a rotating strainer (DEGREMONT possible supply)

The pretreatment on a fine rotating strainer is essential for the removal of fibers which could clog the membranes.

The strainer must be a metal sheet with **rounded holes of 0.8 mm diameter**. The use of slits or the by-pass of the strainer is forbidden. The design has to take peak flows into account.

2.1.3. Bioreactor (DEGREMONT possible supply)

The biological reactor or bioreactor is an activated sludge tank for wastewater biological treatment. Sequenced aeration ensures **the imperative total nitrification** which gives a good filtrability to the sludge.

2.1.4. Ultrafiltration (DEGREMONT standard scope of supply)

Ultrafiltration membranes are installed in a specific filtration tank called **ULTRABOX[®]**.

The mixed liquor coming from the Bioreactor feeds the ULTRABOX[®].

Separation between biomass and purified water is performed by the membranes.

Sludge concentration in the ULTRABOX[®] depends on the recirculation rate of the mixed liquor. The recirculation rate is contained between 300 and 500% to limit the concentration in the ULTRABOX[®] from 1.17 to 1.33 times the concentration in the Bioreactor.

Recirculation to the Bioreactor is performed by pumping from the ULTRABOX in the case of a **downstream recirculation**.

When the recirculation is ensured by pumping from the Bioreactor to the ULTRABOX, it is an **upstream recirculation**.

DEGREMONT can supply these ULTRAFOR[®] Package System ultrafiltration units in “downstream recirculation” or “upstream recirculation” version. The chosen version is précised, in that event, in the commercial proposal.

Ultrafiltration units can be equipped with a sodium hypochlorite dosing system, ensuring a minimum disinfecting rate in the distribution network according to the reuse type, notably in case of ultrafiltered water stocking.

Operating cycles of these ultrafiltration units are described at section 2.3.

2.2. ZEEWEED 500 MEMBRANE MODULE

ZENON ZEEWEED 500 is the membrane used for ULTRAFOR[®] process. It is a reinforced, outside-in hollow fiber membrane.

The nominal and absolute pore size is 0.04 micron meter.

The differential pressure applied makes the effluent flow through the membrane, from the outside to the inside.

Membrane modules (filtrating elements) are gathered in cassettes (support frame) submerged in the ULTRABOX[®].



Module example



Cassette example

The main physical characteristics of the ZW 500 membrane are given in the table here below.

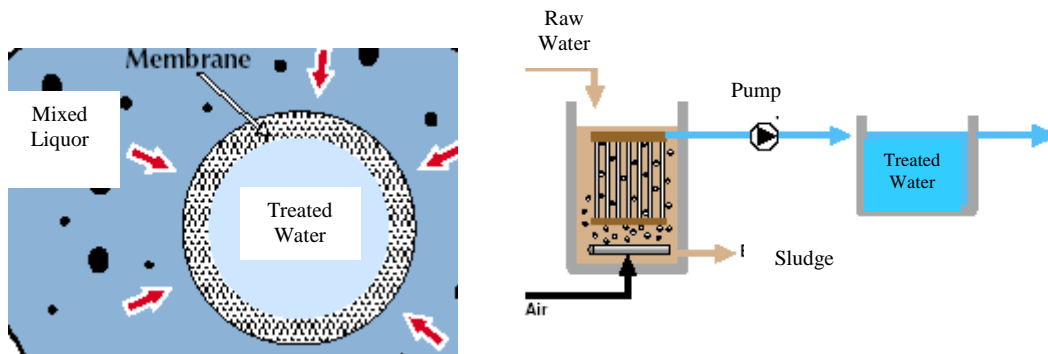
Configuration	Out-In hollow fiber with reinforced internal structure	
Fiber diameters	External diameter	1.9 mm
	Internal diameter	0.9 mm
Matériaux	Type	organic, non ionic, hydrophobic
	Nature	PVDF
Nominal and absolute pore size	0.04 microns measured according to norm ASTM E1294-89 (1999)	
TransMembrane Pressure	Usual during filtration	0.07-0.7 bar
	Maximum during filtration	0.83 bar
	Maximum during backwash	0.7 bar
Maximum Temperatures	Filtration	40°C (104°F)
	Cleanings	40°C (104°F)

2.3. ULTRAFILTRATION SKID OPERATING CYCLES

2.3.1. Filtration Cycle

Filtration is performed while the water flows through the membrane from the outside to the inside of the hollow fiber due to the **TransMembrane Pressure** (pressure difference between the outside and the inside of the fiber).

This TransMembrane Pressure is created by a suction pump which aspirates the filtrated water and repulses it toward a water tank.



Filtration leads to solids deposits on the external face of the membrane. This phenomenon generates a clogging of the membrane, thus a higher TMP is required to proceed to filtration.

Clogging control is ensured by three means :

- Sequenced aeration
- Backwashes
- Chemical cleanings

2.3.2. Aeration

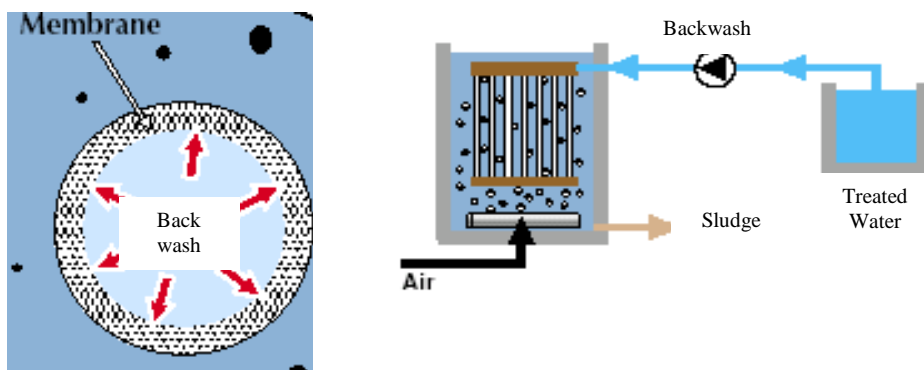
Air is injected to the bottom of the module, and prevents the unwished particulates to stick on the fibers by two means:

- by shaking them
- thanks to a water stream created by bubbles ascension, called “Spiral flow”.

This aeration is performed alternatively between 2 cassettes thanks to a set of automatic valves.

2.3.3. Backwash

Regularly, filtration cycle stops and backwash starts. Ultrafiltered water flows countercurrent, thus unsticks the impurities settled on the membrane surface.



These backwashes are performed without reagents every 10 minutes and are fully-automated. They last 30 seconds.



2.3.3. Chemical cleanings

In addition of aeration and backwashes are insufficient, chemical cleanings are necessary to maintain a good filtration capacity on long periods.

Two reagents are mainly used for cleanings:

- chlorine as sodium hypochlorite
- citric acid

These reagents are always used separately on different cleanings. They are injected in the membrane using a backwash flow.

Two types of cleanings are performed:

- **Maintenance cleaning**

This fully-automated cleaning is performed preventively one or several times a week while the ULTRABOX[®] is filled.

- **Regeneration cleaning**

This cleaning is performed one or several times a year (depending on clogging level) upon request of the operator. Contact times are longer and ULTRABOX[®] drainages and fillings are required. The process is semi-automatic.



3. ADVANTAGES

ULTRAFOR® Package System can be used for every type of urban wastewater and for most type of industrial wastewater. The advantages of this technology are the following:

3.1. EXCELLENT WATER QUALITY

Very low cut-off threshold leads to a very high quality of the treated water : very low turbidity, very low values of BOD5, COD, P, etc...due to the total removal of the part related to the SS.

3.2. HIGH COMPACITY

Footprint is reduced thanks to clarifiers suppression. In addition, ULTRAGREEN™ Package System can hold higher concentration of sludge in the bioreactor, then reduces its volume.

This last point allows capacity increase without increasing tanks size, only by adding membranes.

In addition, if there is no accurate objective for nitrogen treatment, the denitrification stage can be removed using membrane separation, that saves additional place.

3.3. A MODULAR AND INCREASABLE CAPACITY

It is possible and easy to install additional membranes in a second time to increase the capacity of treatment.

3.4. OPERATION RELIABILITY

- No disfunction due to clarifier (no filamentous bulking, unwished denitrification...)
- High level of automation

3.5. SKID-MOUNTING

The quality and reliability of the installations are ensured through shop manufacturing, inspection and testing before shipment.

3.6. ON-SITE INSTALLATION

Skid-mounting enables a **rapid site set-up** with a simple hydraulic and electrical connection.

According to the design, if necessary, the unit can be easily moved from one site to another.



4. INSTALLATION CONDITIONS

ULTRAFOR® Package System uses some fragile equipment:

- Membranes
- Electrical material, PLC
- Etc ...

To keep the equipment in good condition (the ambient temperature must be between 5°C and 40°C), installation in a building is recommended.

This building must be fitted with an opening in the roof to allow modules extraction.

For the drainage of the ULTRABOX® during regeneration cleanings, the drainage pumping unit must be able to evacuate a 50m³/h flow to the raw water inlet of the plant.

The customer has to install a potable water inlet (15 m³/h required flow) for the maintenance of the skid (regeneration chemical cleanings).

5. MEMBRANES SERVICE CONDITIONS

5.1. PH AND TEMPERATURE

The maximum temperature of the mixed liquor to be filtrated is 40°C and must not be exceeded.

This condition must be satisfied all the time, taking into account the heating of generated by biological treatment (this is the case for industrial wastewater).

The pH must remain between 5 and 9.5 for the fiber.

Nevertheless this range is larger than the one required for biological treatment (6.5 – 8.5) : membranes are not limiting .

5.2. CLEANING REAGENTS

Membrane materials have not an equal resistance to reagents used for membranes cleanings.

PVDF allows the use of sodium hypochlorite at high concentrations (up to 1000 or 2000 mg/L of NaClO). However, it does not allow to clean at high pH (for instance with soda).

Table 1 shows the concentrations of main cleaning reagents which can be used with ZW500 fiber.

pH	Production	5 – 9,5
	Cleanings	2 – 11 (< 30°C / 86°F) 2 – 10 (30 – 40°C / 86 – 104°F)
NaOCl *	Maximum exposure	1 000 000 ppm.h.
	Maximum concentration	2000 mg . L-1 (< 30°C) 1000 mg . L-1 (30 – 40°C)
Sodium bisulfite	Maximum concentration	1 % (masse)
Chlorine dioxyde	Maximum concentration	100 mg . L-1
	Maximum exposure	100 000 ppm.h.
Ozone	Occasional exposure	< 0,1 mg . L-1
	Continuous exposure	Non recommandée

Table 1 : chemical resistance of ZW500 fiber

* Nota : 1 mgL-1 de NaOCl is almost equivalent to 1mgL-1 de Cl₂ (1 mgL-1 de NaOCl = 1,05 mgL-1 de Cl₂)

5.3. UNCOMPATIBLE AND FORBIDDEN COMPOUNDS

Organic polymer composing the membranes can be damaged by the presence of incompatible molecules, especially solvents.

ZENON has performed tests whose results are shown in table 2:

Compounds	Compatibility	
Acetone		NO
Acetonitrile		NO
Benzene		NO
Butylacetate	YES	
Dibutylephtalate	YES	
Dichlorométhane		NO
Dicyclohexylamine	YES	
Diméthylacétamide		NO
N,N diméthylalanine	YES I	
Diméthylformamide		NO
Formaldéhyde	YES	
Formaline	YES	
Hexamethyldisiloxane	YES	
Alcool isopropylique		NO
Méthanol	YES	
N-methylpyrrolidine		NO
Silicone oil		NO
Sulfolane	YES	
Tetrahydrofuran	YES	
Toluene		NO
Triethylamine	YES	
P-xylene	YES	

Table 2 : compatibility of organic compounds with membrane Zenon ZW500

If a compound defined as incompatible has enough biodegradability, ULTRAFOR® may be used, but the treatability requires a validation from DEGREMONT experts. In any case, it is essential to have a good knowledge of the origin and the composition of the effluents.

5.4. ANTI-FOAM AGENTS

Anti-foam products contain surface agents which may modify the state of the membrane and deteriorates its performance. It is important to check the content of the product to be used.

Table 3 shows the products which must not be present in the anti-foam agent to be used:

Composés
Silicons
Hydrocarbures
Solvent from petroleum products (light parafines)
Additives containing polymer with molecular mass < 50 000
Additives containing polymer with molecular mass between 100 000 and 200 000
Polymer dissolved in light oil or from white oil

Table 3 : compounds which must not be present in anti-foam agents

A list of anti-foam agents approved by ZENON for a combined use with ZW500 membrane is shown in table 4 :

Approved Compounds
Nalco : IL08
Nalco : 7465
Air Products : Surfynol DF-110L
Air Productis : DF-110D
Pelron Corporation : P-463
Dow : Polyglycol 45-200
Dow : Polyglycol FR-530
Dow : Polyglycol P-1200
Dow : Polyglycol 112-2
Dow : Polyglycol P-1000TB
Dow : Polyglycol P-2000
Dow : Polyglycol P-4000
PPG : MAZU-DF-204

Table 4 : anti-foam agents approved by Zenon

5.5. SLUDGE TREATMENT POLYMERS

Polymers used for sludge treatment can clog the membrane quickly (back flow to plant inlet). It is recommended to use polymers less ionic as possible.

5.6. COAGULANTS

There is no specific recommendation for coagulant use with ULTRAFOR® Package System.