Description & Functioning of the St. Albans Smolt Systems

Appendix 2

Content

1. Introduction to recirculation

The system is designed for recirculation of the water.

The recirculation degree can be expressed on 2 different ways. Below the 2 different ways are shown based on data for the Smolt System. Data for the Smolt System are shown in table 1.

Parameters	Unit	Value
Water flow to tanks	m^3/h	1.890
Water volume in tanks	m^3	1.570
Water retention time in fish tanks	minutes	~50
Make up water (max.)	m^3/day	396
Biological filter capacity (max. feeding per day at 16 ^oC)	kg/day	1.130

Table 1 Data for Smolt System

The first way of describing the degree of recirculation is the "reuse degree". It is defined by the make up water added in relation to the flow in the system expressed in this equation:

Reuse degree - %

$$\text{Reuse degree} = \frac{\text{Water flow to tanks}}{\text{Make up water + Water flow to tanks}} \times 100$$

$$\text{Reuse degree} = \frac{1{,}890\ m^3/h}{16\ m^3/h + 1.890\ m^3/h} \times 100$$

Reuse degree = 99,2%

To give a more precise and unequivocal way of describing the degree of recirculationfor the efficiency and potential of a system it is necessary with a more cost- and technical related description of the recirculation degree. In this context the water exchange per amount of feed put into the system per day is much more precise.

Water exchange/kg feed

$$\text{Water exchange per kg feed} = \frac{\text{water exchange/day } (m^3/day)}{\text{Feeding/day (kg/day)}}$$

$$\text{Water exchange per kg feed} = \frac{396\ (m^3/day)}{1.130\ (kg/day)}$$

Water exchange per kg feed = 350 l/kg feed

2. The water flow through the system

Below a short description of the water flow in the system are given in relation to flow diagram on page 5 page.

- The water from the tanks (p1) runs by gravity to the mechanical filter (p2), where the excrements and uneaten feed pellets are removed from the water.

- After the mechanical filtration the water runs to reservoir 1 (p3). Reservoir 1 serves as a pump reservoir and also as a buffer for water in the system.

- From the pump sump the water is pump (p4) through a fixed bed biological filter (p6). Passing the fixed bed biological filter mainly organic matter in the water is transformed to carbon dioxide and water and further more small particles in the water is “captured” in the biofilm and thereby cleaning the water even further.

- After leaving the biological filter the whole water flow is disinfected by UV (p7) before it enters another biological filter called a moving bed filter (p8).

- In the moving bed filter the ammonia exceeded from the fish is transformed to nitrate and any rest of organic matter is transformed to carbon dioxide and water.

- After leaving the moving bed the water is distributed on top of a third biological filter called a trickling filter (p9). This type of filter act as a normal biological filters as described above, but in addition it removes undesired components in the water such as carbon dioxide and nitrogen gasses (if any). Furthermore the water is oxygenated to approx. 100% saturation by trickling down the filter. The filter is ventilated.

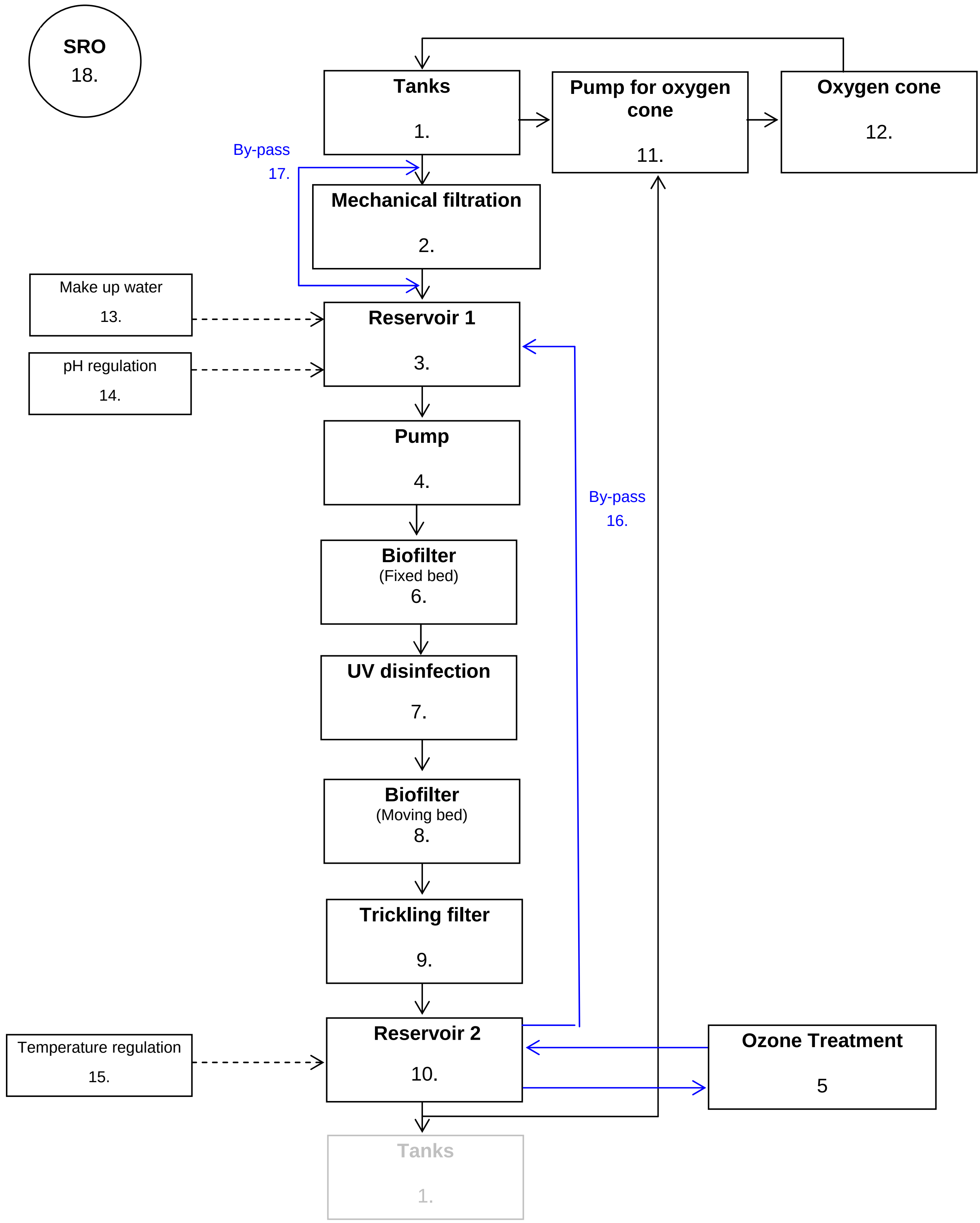
- From the trickling filter the water is trickling down into reservoir 2 (p10). From reservoir 2 the water is led to the fish tanks by gravity,

- For further disinfection and “brownish colour” removal a side loop is treated with ozone (p 5) taking water from reservoir 2 and re-introducing it to the reservoir 1.

- Before the water enter the fish tanks, part of the water is oxygenated by pumping the water (p11) through an oxygen cone (p12).

The function of the system will be specified further in the following chapters in relation to the flow diagram on page 5.

3. Flow diagram



4. Fish tanks (p1)

The design of the Smolt System is based on tanks with a circular flow pattern:

- 8 fish tanks with a diameter of 10 m and a water level of 2,5 m, equal a volume of 196 m^3 per tank. Total fish tank volume 1.570 m^3.

The total water flow to the fish tanks is 1.890 m^3/hour giving a retention time of 50 minutes and corresponding to a water exchange of approximately 1,2 times per hour.

The outlets of the tanks are split into a side drain and a central drain. Approx. 33% of the water leaves the tank through the central outlet consisting of a cylinder shape grid and approx. 67%through the side drain. The water goes to standpipes outside the tanks and further to the mechanical filter. On the stand pipes it is possible to regulate the level in the tank with 20 – 30 cm.

Example of stand pipes is given on the pictures below.

Picture 1 Example of a side drain

Picture 2 Example of a stand pipe

All tanks are equipment with a “Dead Fish Collector”, by use of this collector dead fish will easily be removed from the tank.

Picture 3 Example of a “Dead Fish Collector”.

Picture 4 Example of a “Dead Fish Collector”.

The mortality extraction pipe is made so that a fish pump can be connected and thereby be used for pumping the fish out of the fish tank.

Picture 5 Connection for fish pump

Picture 6 Pumping fish

5. Mechanical filtration (p2)

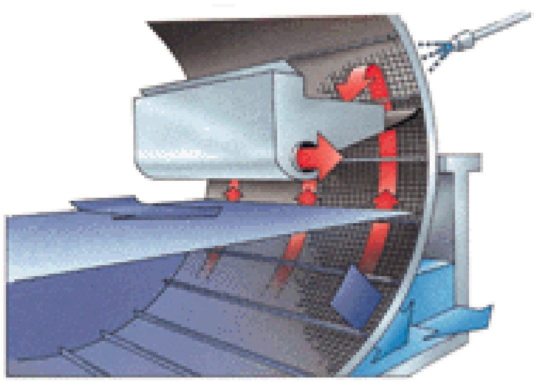
The mechanical filtering of the system water is done by 1 drum filter with a mesh size of 60 µm (p2). Example is shown in picture 7.

All the system water passes through the mechanical filtration.

Picture 7 Example of a drum filter

An ultra sound sensor (picture 8) registers when the mesh is clocked and the water level rises. The sensor is commanding the PLC so that the drum filter and the sluicing pump is turned on. The principles of a drum filter are illustrated on picture 9.

Picture 8 Ultra sensor by the drum filter



Picture 9 Principle of a drum filter

It is possible via the PLC to program the run time for the mechanical filter and the sluicing pump. When the filter is stopped for maintenance or reparation, the water can be by passed indicated with the red arrow on picture 10 (p16 in the flow diagram).

Picture 10 Example of a bypass (red arrow)
Manometer for pressure control (yellow arrow)

It is very important to check the nuzzles for clocking on the filter regularly and thereby insuring optimal cleaning of the mesh on mechanical filter. If this is not done the efficiency of the filter will be reduced and thereby cause higher volumes of sludge water. The sluicing pump must deliver a pressure of 8 bars to rinse the mesh properly.

6. ”Reservoir 1” (p3)

In the Reservoir 1 make up water is added (p13) and the lime is dosed in order to regulate the pH (p14).

The reservoir 1 is relatively big so it has a stabilizing effect on the water level in the system.

7. Pumps (p4)

The recirculation of the water in the system is only done by lifting the water one time. The water flow in the system has several functions, it must:

- *Remove waste products and uneaten feed pellets from fish tanks.*
- *Transport wastes products and uneaten feed pellet to the mechanical and biological filter.*
- *Transport oxygen to the fish and biological filter.*

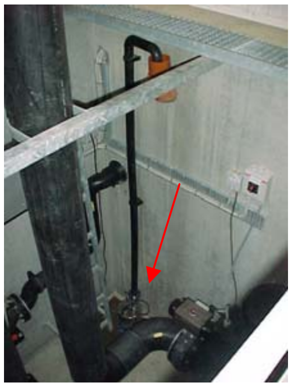
The max. recirculation flow in the system is approximately 1.890 m^3/h. To insure optimal flow 6 pumps are installed in the system.

An ultra sound level sensor (picture 11) is monitoring the level in reservoir 2 to insure that there is no over flow.

The pumps are Grundfos® pumps (picture 12). The pumps are places in a pump sump as shown on picture 12. In the pump sump a submergible pump is installed so if there are some water in the pump sump it is pumped out of the system (picture 13).

Picture 11 Ultra sound sensor

Picture 12 Centrifugal pumps in pump sump



Picture 13 Pump for empty the pump sump

8. Ozone (p5)

For further disinfection and “brownish colour” removal a side loop is treated with ozone (p 5) taking water from reservoir 2 and re-introducing it to the reservoir 1.The capacity of the ozone system is 440 g O_3/h. The system is consisting of ozone diffusers, ventilators and a reaction chamber (2 min. retention time).

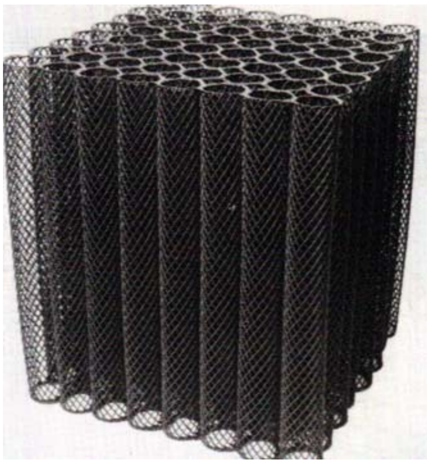
9. Biological filter 1 – ”Fixed bed” (p6)

In the submerged fixed bed biological filter the organic matter in the water is converted to carbon dioxide and water and the ammonia is converted to nitrate.

From the Reservoir 1 the water is pumped by 6 pumps through the biological filter which consist of 3 chambers (picture 10). The chambers are designed as submerged filter where the biological filtermedia is submerged under the water surface.

The amounts of bacteria in the filter are directly linked to the rinsing capacity. Therefore the requirement for a media is to have a big surface/volume ratio which gives a good contact surface between the water and the bacterial biofilm. The bio media used is the BIO-BLOK® 200 which in dry conditions has a specific surface volume ratio of approximately 200 m^2/m^3 (Picture 15). The dimensions of the blocks are 55 x 55 x 70 cm.

Picture 14 Example of ”fixed bed” biofilter.

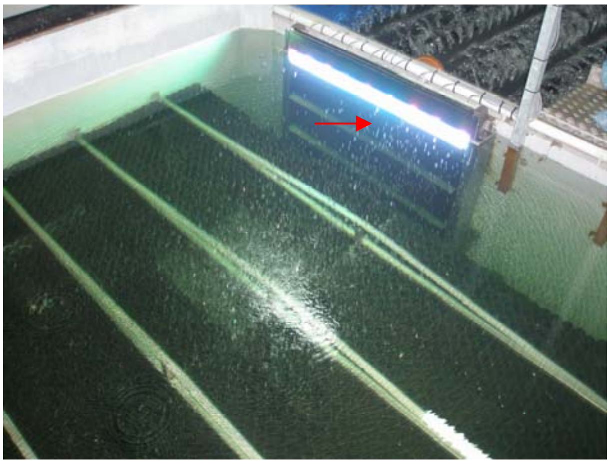


Picture 15 BIO-BLOK® 200

10. UV filtration (p7)

In the UV filter the water is exposed to power full UV radiation, and this is disinfecting the total water flow to the fish tanks.

After passing the fixed bed biological filter the total water flow is passing a UV disinfection before entering the moving bed biological filter. The UV is wall mounted and the UV radiation is equal to approximately 30 mWs/cm^2.

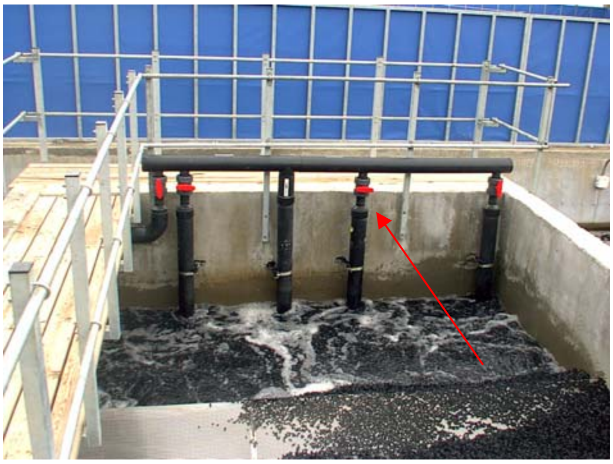


Picture 16 Example of UV radiation of the water

11. Biological filter 2 – ”Moving bed” (p8)

In the moving bed filter the organic matter in the water is converted to carbon dioxide and water and ammonia is converted to nitrate.

The filter consists of one chamber of 100 m^3 and is a submerged biological filter meaning that the media is submerged under the water surface. Due to the constant aeration with a blower (picture 18) the bio-media are in constant motion. Therefore the filter are called moving bed filter. In the filter valves are installed in order to regulate the aeration of the filter (picture 17).



Picture 17 Example of a moving bed filter. Red arrow indication the valves for regulation of air flow

Picture 18 Blower for the moving bed filter which keeps the bio media in motion

The amount of bacteria in the filter is directly linked to the rinsing capacity. Therefore the requirement for a media is to have a big surface/volume ratio which gives a good contact surface between the water and the bacterial bio film. The media use has a specific surface/volume ratio of 650 m^2/m^3.

A moving bed filter wear off the bio film all the time they are in motion, therefore cleaning of the biofilter is unnecessary.

12. Biological filter – "Trickling filter" (p9)

From the "Moving bed" biological filter the water runs to the top of the trickling filter. In the trickling filter 100% of the water flow is degassed from unwanted gasses such as CO_2 (g) and N_2 (g) and at the same time water is oxygenated to 100% saturation. Furthermore the organic matter is converted to carbon dioxide and water and ammonia is converted to nitrate.

On top of the trickling filter the water is distributed over the trickling filter by perforated pipes. The perforated distribution plate insures that the water is distributed over the whole trickling filter. A good distribution insures an optimal oxygenation, degassing of N_2 and CO_2 of the water that passes through the trickling filter.

The media used is the BIO-BLOK® 200 with a specific surface of 200 m^2/m^3. In the trickling filter blower are installed to ensure the correct air flow/water flow relation.

Picture 19 Example of a trickling filter

Picture 20 Example of perforated pipes red arrow

13. Reservoir 2 and water distribution to tanks (p10)

The water is now filtrated and gassed to 100% saturation of oxygen and is directed to the fish tank by pipes.

The inlet enters in a special designed (Billund Aquaculture) glass fibre inlet to insure that there is an optimal distribution in the fish tank and thereby creating a circular flow pattern with a minimum of vortex and giving the right swimming velocity for the smolt.

14. Oxygen cone and emergency oxygen injection (p11 & p12)

The inlet water from the filter has 100% oxygen saturation.

By each fish tank a pump and an oxygen cone are installed. If the fish need additional oxygen the pump starts automatically and thereby pumping water to the oxygen cone and here the oxygen is injected under 1 bar pressure.

The inlet pipe and outlet for the oxygen cone is welded in the matrix pipe to tank to insure an effective transport of oxygen to the tank without passing particles through the pump. During grading and treatments the cone can be run directly on the tank.

The pumps to each of the 8 fish tanks have a capacity of approximately 150 m^3/h. The principle is shown on the picture below.

Picture 21 Example of pump and cone connected to each tank

The adding of oxygen to the tanks is commanded from an OxyGuard oxygen sensor (picture 22) which gives signal to a solenoid valve (picture 23 – blue arrow). When the valve is open the oxygen is added to the cone. The amount of oxygen added to the cone can be regulated by use of flowmeters (picture 23 – red arrow).

The continuously monitoring and control of the oxygen in the tanks gives alarms for low or high oxygen, and if it is low the emergency oxygen diffusers will turn on. The amount of added emergency oxygen can be regulated on each tank.

Picture 22 Example of oxygen sensor

Picture 23 Example oxygen flowmeters

The continuously monitoring and control of the oxygen in the tanks gives alarms for low or high oxygen, and if it is low the emergency oxygen diffusers will turn on.

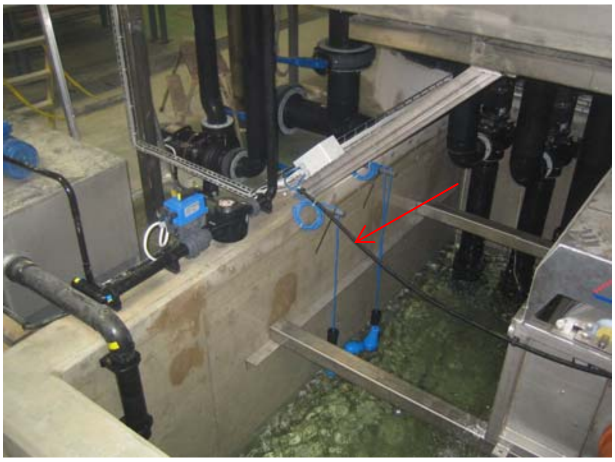
The emergency oxygen system will automatically turn on if the is a system failure.
The emergency oxygen system will be turn on in the following situations:

- Power failure
- Pump failure
- Low oxygen concentration in tanks

15. Adding of make up water (p13)

To compensate for the discharge water new water is add in reservoir 1.

The adding of fresh make up water is controlled by level sensor through the PLC that commands a motor valve and an inductive flow sensor which monitors the amount of makeup water.



Picture 24 Example of level and flow sensor

The total make up water is equal to the water led out of the system. The flow out of the system is controlled by a discharge water pump. This pump is control by the PLC so it is possible to get the desired volume of discharge water.

Picture 25 Example of discharge water pump

16. pH regulation (p14)

There are 3 parameters which has influence on the pH in the system:

1. *CO_2 production from the fish and the heterotrophic bacteria in the biological filters.*
2. *H^+ production from the nitrification in the biological filters.*
3. *OH^- production for a possible denitrification in the biological filters..*

For the pH regulation a base is added to:

1. *Increases the water pH*
2. *Increases the buffer capacity of the water*

For the pH regulation a base is added to the system water. As base can be used $Ca(OH)_2$. The $Ca(OH)_2$ is added by the lime dosing unit (picture 26), which is commanded by the pH sensor (picture 27).

Picture 26 Lime dosing

Picture 27 pH sensor

17. Temperature control of system water (p15)

The temperature regulation is depended of different factors:

- *The temperature of surroundings (summer/winter)*
- *The amount of make of water for the system*
- *The temperature of the make up water*
- *The degree of insulation of the whole system*
- *The total energy use in the system*

The temperature in the system is monitored by a temperature sensor placed in reservoir. The temperature sensor is connected to the PLC and depending on the set point temperature and the actual temperature in the system it opens a motor valve.

Incoming water is passed through a heat exchanger where the out coming water is pass contra vice and about 50% of the heat from the water is regained (Picture 28). This system can be bypassed if the system temperature is too high.

Picture 28 Heat exchanger

18. By-pass (p16, p17)

I relation to the daily operation of the system it is important that the system is flexible and all components are easily accessible so all maintenance is made without problems.

The system is designed so it is possible to by-pass the water in 2 places in the system:

1. By-pass – in-between reservoir 1 and 2 (by-pass 15)
2. By-pass – by pass for the drum filters (by-pass 16)

19. Control, regulation and monitoring (p18)

The whole system is controlled by a central PLC, but all equipment can be run in manual.

Selected parameters are monitored to insure a stable and efficient system.

The parameters:

- Low oxygen
- High oxygen
- Pump stops, pumps for the tanks
- Pump stop, pump for the trickling filter
- High water level
- Low water level
- Low temperature
- High temperature
- Thermal failure
- Low pH
- High pH
- High ozone in water
- High ozone in air

Parameters that visible in the monitor system:

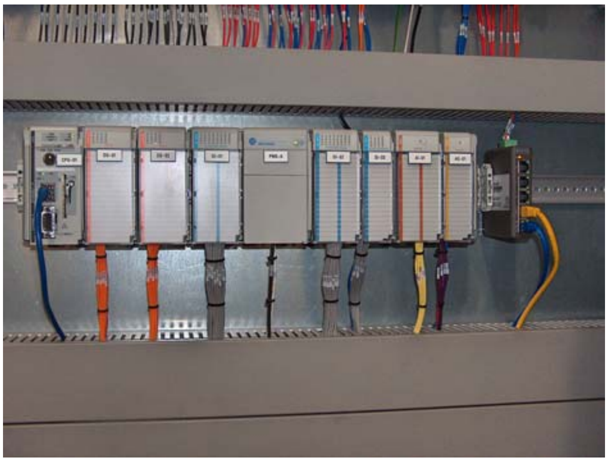
- oxygen
- pH
- Temperature
- Ozone in water
- Ozone in air
- Hour meter on pumps and running status man./auto or turned off
- On/off time on the pump that pumps water out of the system
- Alarm history

It is also possible to include sensors for salinity. This is not included in the quote.

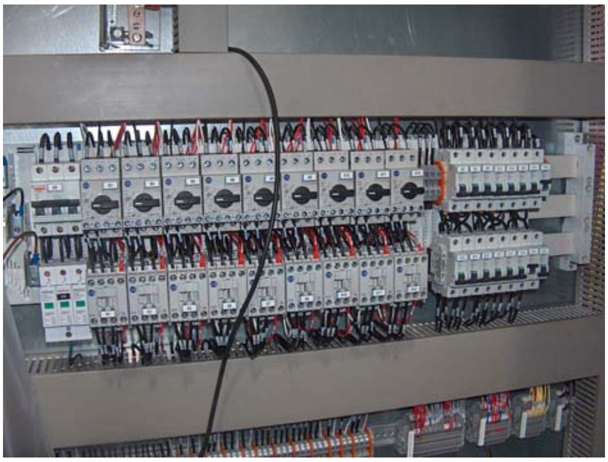
Below examples of power cabinet with PLC are shown. When a alarm is present and nobody is on the farm a SMS message will be generated and be send to the person in charge. This person can connected to the system thought a remote computer and look at the parameters in monitor system. If surveillance cameras are and submerged cameras in fish tanks is purchased from BA and connected to the monitoring system the images will also be visible for the user and the user will be able to control the surveillance cameras.

Picture 29 Power cabinet with PLC

Picture 30 Power cabinet with PLC and touch screen



Picture 31 Power cabinet with PLC



Picture 32 Power cabinet with PLC