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Treball Final de Grau

Closing of the plant's water cycle; using water from the wastewater treatment plant and wells for the osmosis process.

Tancament del cicle de l'aigua; us d'aigua provinent de la planta depuradora i de pous subterranis en la planta d'osmosi.

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El valor de l'educació universitària no és l'aprenentatge de moltes dades, sinó l'entrenament de la ment per pensar.

Albert Einstein

A la Dra. Esther Chamarro, tutora del treball de fi de grau, per guiar-me, aconsellar-me i ajudar-me durant la trajectòria del projecte. A tots els companys de l'empresa on he realitzat el projecte, en especial a Mònica Navarro, Kiko Romero i Xavier Tarrés per la seva confiança, ajuda, orientació i suggeriments. Per últim, però no menys important, als amics i la família pel seus ànims i recolzament en tot moment.

CONTENTS

SUMMARY

A company is using tap water previously demineralised for their productive process. Now, is considering the possibility of demineralize the water from the wastewater treatment plant (WWTP), that is currently spilt onto the sewage system (SS), and the water from two wells and use them in the process in order to reduce the consumption of tap water and the cost the use of it involves.

The aim of this project is to plan the closing of the water cycle (production-WWPT-production) and verify if it's profitable, which means, check if the initial investment will be amortized and, what's more if the project will suppose an economic saving in a long-term.

This project has been realised taking in account the only two premises that the company has imposed. The first one is the initial investment of the project has to be minimum and the second is the new installation has to require the minimum maintenance and attention of plant's operators.

According to these premises, the process designed for achieve the aim of the project consists on a vessel, a filter and a pump.

Finally, the initial investment of 25,000 € is returned in 2.5 years and the company will save 11,000 € per year.

Keywords: Waste Water Treatment Plant, osmosis plant, demineralize water, well's water.

RESUM

Una empresa està utilitzant aigua de xarxa prèviament osmotitzada pel seu procés productiu. Ara, està considerant la possibilitat d'osmotitzar l'aigua depurada, que actualment aboca a la claveguera, i l'aigua provinent d'uns pous subterranis i així utilitzar-les en el procés productiu per tal de disminuir el consum d'aigua de xarxa i conseqüentment els costos que el seu us comporta.

L'objectiu és planificar el tancament del cicle de l'aigua (producció-depuradora-producció) i comprovar si seria rentable, és a dir, comprovar si la inversió total del projecte es recuperarà i ,a més, suposarà un estalvi econòmic a llarg termini.

S'ha realitzat el disseny del projecte tenint en compte que les úniques premisses que ha imposat l'empresa són que la inversió inicial del projecte sigui mínima i que no requereixi molt manteniment ni atencions per part dels operaris de planta.

Tenint en compte aquestes premisses, el procés que s'ha dissenyat per dur a terme l'objectiu fixat consta únicament de un dipòsit, un filtre i una bomba.

Finalment, la inversió inicial de 25.000 € es recupera en 2,5 anys i l'empresa s'estalviarà 11.000 € l'any.

Paraules clau: Planta depuradora, osmosi, aigua desmineralitzada, aigua de pous.

1. INTRODUCTION

The plant has a small wastewater treatment plant (WWTP) that consists in a physic treatment system followed by a biologic treatment system. Nowadays, the purified water is spilt to the sewage system or, in case its quality is not the properly, to the physic system treatment again.

Inside the installations of the company, there are three wells. Nevertheless, before a study and a restoration only two of them could be operative.

The productive process that takes place in this plant require the use of demineralize water. In the past, they made advantage of the water from the wells, but since some years, due to the bad conditions of them and the shortage of extractive pumps the company uses only tap water for feed the osmosis plant and then the production.

1.1. JUSTIFICATION OF THE PROJECT

Currently, the osmosis plant is fed with an average flow of 5 m^3/h of tap water. Keeping in mind that the osmosis plant doesn't work continuously it's just that its functioning depend on the demand of the plant, to calculate the tap water's consume it has to be used the information of the last year. Approximately, the annual consume of tap water is 13,276 m^3. This consume means nearly 26,700 €/year wasted only in feed the osmosis plant.

The company thinks that this amount of money is too much and it wants to know if it's possible reduce it considering there are two another sources of water (purified water and well's water).

1.2. RANGE OF THE PROJECT

This Project includes send the water from the WWTP and the wells to a trench where they are going to be mixed and then send to the osmosis plant (OP). The range of the project starts on the WWTP's exit and finishes before the entrance to the OP.

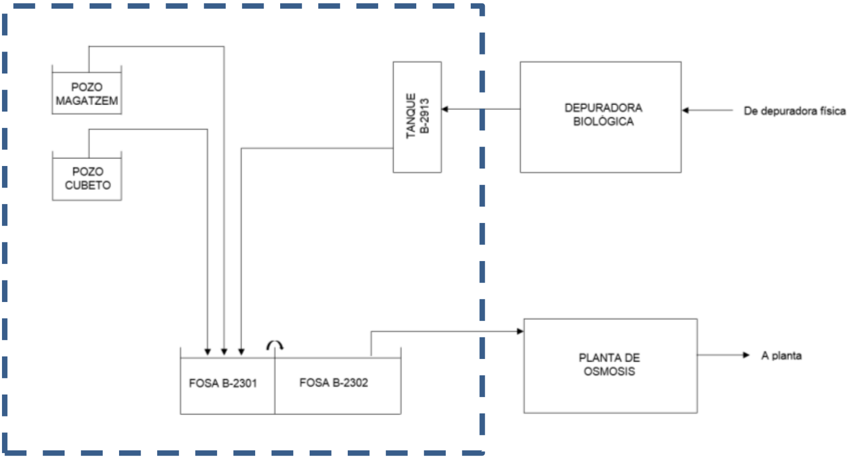

Figure 1. *Rang of the project*

2. OBJECTIVES

A company is using tap water previously demineralized for the productive process and it considers the fact of use the WWTP's and well's water.

The purpose of this project is reduce or eliminate the use of tap water and use instead of it water from own sources. For it, concrete aims have been fixed

- To select the necessary equipment, taking as a premise that the cost and the maintenance of the installation must be minimum. In order to this fact, it is going to try use, if it is possible, the equipment or instruments existent in the warehouse.
- To value the economic viability of the project.

3. PRODUCTION PROCESS

Closing the water cycle has three parts. The first one is the extraction of water of one of the wells that means set up a submersible pump in it. The second is do the same on the other well. Finally, redirect the spilt water to B-2301. The wells in these document are named as 1st well and 2nd well (See Figure 1).

An external company has done the design of the submersible pumps for the wells and the installation necessary to send the water from the wells to B-2301 is already existent.

3.1. DESIGN BASES

The design base of this project is the annual use of tap water for feed the OP. Based on this value it will estimate if the water from WWTP and wells is enough to feed the OP. If it is not enough it would be necessary, continue using tap water.

The annual volume of tap water used is 13,276 m^3.

3.1.1. MASS BALANCE

Based on these value, the mass balance has been solved and it would be possible eliminate the use of tap water, there will be enough water from own sources to feed the OP.

To continue a table with the volume with which each source is going to contribute until achieve the required volume is shown.

Table 1. Water's volume annual from each source.

Source	Volume annual (m^3)
WWTP	6,312
1st well	5,411
2nd well	1,553

3.2. WATER CHARACTERIZATION

An analysis of the water (J. Rodier, 1978) from the WWTP and the wells has been done in order to determinate approximately the characteristics of the water before the OP due to this water isn't going to have the same quality to tap water, and maybe is necessary do some changes in the OP. The parameters chosen for analyse have been selected by the responsible of the Environmental Department.

Table 2. Value of main parameters of water.

	WWTP	1st Well	2nd Well
pH	7.74	7.13	7.28
Conductivity	3,378	2,762	3,378
DQO	682	5.5	12
Chloride	186	722	995
Sulphate	93	403	445
Sulphide	0.02	0.02	0.01
N ammonia	4	3	2.5
Solids	92	0	0

The water that will feed the OP will be a mixt of those. To calculate the roughly value of each parameter for this water previously has to be calculated the percentage of water invested for each source. From the mass balance, the percentage has been calculated.

The water is going to feed the OP has the following characteristics:

Table 3. Approximately characterization of water will feed OP.

pH	Conductivity [µS/cm]	DQO [ppm]	Chloride [ppm]	Sulphate [ppm]	Sulphide [ppm]	N ammonia [ppm]	Solids [ppm]
7.15	2,979	35	814	405	0.02	3	9

Currently the water that feeds the OP is tap water, and its characteristics are:

Table 4. Characterization of tap water.

pH	Conductivity [µS/cm]	DQO [ppm]	Chloride [ppm]	Sulphate [ppm]	Sulphide [ppm]	N ammonia [ppm]	Solids [ppm]
7.36	1,093	4	187	93	0.003	0.02	0

There are some differences between the two water, so it implies changes have to be made into the OP. Unfortunately, this changes maybe means an extra cost for the company due to the responsible of the OP is an external company.

3.3. EQUIPMENT SELECTION

The aim is to plan a process for taking advantage of the water from the WWTP with the minimum number of equipment or what is the same doing the minimum investment possible.

Therefore, it has decided that will need:

- 1 vessel (B-2913)
- 1 pump (PB-2913)
- 1 filter (F-2911)

In the vessel, the spilled water from the WWTP is accumulated. In a nearly future, when the company analyses this water taking in account the microbiological parameters they might determinate it is required the addition of some substances. Thus, this addition will be done in this vessel.

The trench B-2301, where the different water will be mixt is located at the other site of the plant, relatively far from the WWTP, so for sending the water from the WWTP to B-2301 is needed a pump.

Finally, a filter will be necessary because the spilt water from the WWTP could contain filamentous microorganisms. It will be appropriate these microorganisms do not arrive to B-2301 because if it happens the trench will need a cleanliness and it is not usually cheap.

4. PROJECT'S DIAGRAMS

4.1. BLOCK DIAGRAM

It has done a block diagram of the project (See Figure 2).

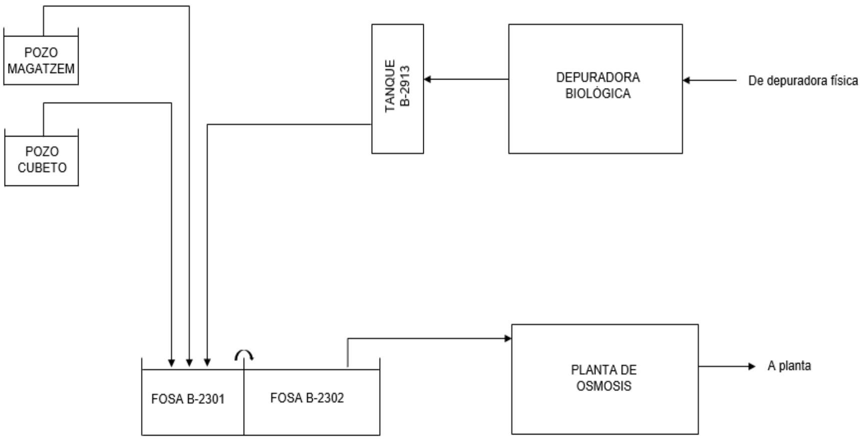

Figure 2. *Block diagram.*

4.2. PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Four are three Pipe and Instruments Diagrams; one is from the physic system, following one is from the biologic system of the WWTP, the third belongs to it project's proposal and the last belongs to the OP.

In these diagrams, all the equipment is shown, close to its main characteristics all the streams properly identified with the instrumentation and the basic control diagram (See Appendix 5.The pipes and instrumentation coloured in black are existent and the others, coloured in red, belong to the new project.

5. PROJECT SPECIFICATIONS

In this chapter, it will be detailed the design of the pipes, instrumentation and control. The specifications above-mentioned equipment will be explained too. It will talk about their size, materials and their auxiliary services if they are required.

5.1. PIPE DESIGN

The design of pipes has been done following the regulation established by the Company. The design of them could be seen in detail in Appendix 2 and in Appendix 4 there is a table with the list of the pipes.

5.2. EQUIPMENT

5.2.1. VESSEL B-2913

In this vessel, as it has said before, the water spilled of the WWTP is accumulated before send it to B-2301.

Design calculations of vessel could be seen in detail in the Appendix 2. However, the table 5 contains a summary of its characteristics.

Table 5. Vessel characteristics.

Diameter [m]	0.955
Section [m²]	0.716
Height [m]	1.350
Capacity [m³]	1
Material	PPH

Auxiliary services

For the maintenance of the vessel it will be required a source of tap water, a hose, nearly the vessel. Because it is, surely they will have to do a periodic cleaning.

Control parameters

The only parameter has to be controlled is the level. It is interesting control this parameter for two reasons. The first is because the work of the pump that follow the vessel depends on the vessel's level. The second one, but not less important, is for security items; controlling the level a spill over from the vessel could be avoid.

5.2.2. PUMP PB-2913

The pump's function is to send the water until B-2301. Design calculations of it could be seen in detail in the Appendix 2. To continue, it a table with its characteristics is shown.

Table 6. PB-2913 specifications

Average flow [m^3/h]	4.35
Head [m]	9
Motor power [W]	250
Permissible working temperature [ºC]	0-70
Permissible environment conditions [ºC]	0-40
Material	Polypropylene
Degree protection*	IP20

The degree protection IP20 includes protection in front of particles with a diameter smaller than 12.5 mm and dripping. But this pump requires more protection due to it's going to be installed outdoors, minimum a degree protection of IP55 that includes protection in front of the dust and streams of water. To achieve this degree of protection a little roof had to be set up.

5.2.3. FILTER F-2301

The filters chosen are the same that the company use in a process takes place in the plant and the company is very pleased with their efficiency. The filter works with filter bags, in the following table shows its characteristics:

Table 7. F-2301 specifications.

Average flow [m^3/h]	20
Diameter connection [cm]	5.08
Working pressure [bar]	10
Maximum pressure [bar]	16
Maximum temperature [ºC]	50
Filtration surface [cm^2]	1,250

Control parameters

The parameter that has to be controlled is the pressure, specifically the increase of pressure. This increase indicates the filter bag is empty, saturated and is necessary change it.

The type of filter chosen has a manometer incorporated, so is not required make a control bond of pressure.

5.2.4. TRENCHES B-2301 AND B-2302

Trenches B-2301 and B-2302 were built many years before and have not been used for many years. Trench B-2301 is where water from wells and WWTP flow into. It is small, only has a capacity of 20 m^3 and is connected to the other trench, B-2302. When B-2301 is empty the water falls into B-2302. This trench is bigger than the first one, has 100 m^3 of capacity. Once that water is in B-2302 is sent to OP.

Control parameters

In the past, when the company used well's water for feed the osmosis put up a control system in B-2302 that consists in a level control; when the level was low, insufficient to feed the OP, automatically tap water entered into B-2302.

This system control is adequate for our project, so we are going to get benefit from it.

5.2.5. PUMPS P-1101 AND P-2301

These pumps will be located into the wells and an external company has done their design, the same has done the study and restoration of the wells. Their function is to send the well's water to B-2301. Only have to choose the type and brand of the pumps, and their main characteristics are:

Table 8. P-1101 and P-2301 main characteristics.

Average flow [m^3/h]	2
Head [m]	35
Motor power [kW]	0.7
Material	Polyamide/stainless steel

5.3. INSTRUMENTATION AND STRATEGY OF CONTROL

In this section are defined the control's bonds to the security of the plant.

<u>Level control in vessel B-2913</u>

How it is said in the previous section we are interested in controlling the level of the vessel to avoid the water spill over it or the opposite case, the vessel was empty. Due to these alternatives will be set up three instruments of control.

One of these instruments will be a radar level sensor located on the top of it. Its objective will be measure the level in two points: when the vessel was at the 20% and 80% of its capacity. To this sensor will be connected to pump PB-2913; the pump would work when the capacity of the vessel was between 20% and 80%.

The other control instruments will be two vibrating level sensors. They have a security function. If the vessel achieves a 90% of its capacity will sound an alarm that would indicate that the control system or the pump PB-2913 do not work and it does not propel the water. Moreover, if the vessel achieves the 10% of its capacity will sound another alarm and this time it would indicate the pump does not stop and is propelling nothing, so it can be broken.

Flow control in exit's pipe of WWTP

Presently there are a flowmeter controlling the flow of water that is spill to sewage system. In this project this pipe has to be forked, so that, this flowmeter will continue measuring the flow if it goes to the sewage system. And other located in the pipe that flow into trench B-2301 is needed.

Level control in trench B-2302

As it's explained in the prior section there already are a control system in trench B-2302 and this system is going to be used in this project but is necessary do some changes.

It necessary that the control system measure the level of water in the trench in three points. These points will be:

- 10% of capacity: When the trench achieves this capacity, the pump that suctions water from the trench and send it to OP will stop.
- 50% of capacity: When the trench achieves this capacity, the submersible pumps that pull water out the wells will stop manually.
- 95% of its capacity: when the trench achieves this level it will mean that in spite of the well's water isn't been used the trenches are nearly full, so it's necessary stop sending water from the WWTP to trench B-2301, this water has to be send to SS or B-1901A.

6. OPERATION MANUAL

Once known in depth the process, it has made the election and the design of the equipment and it has been explained which task will be carried up each one, it's time to explain how all the installation will work.

Start-up

First, it has to be check that valve located in pipe 2910.9.2-100/10HA35F01B1 is closed and the valve located in pipe 2910.9.3-100/10HA35F01B1 is opened. In this way, the spilled water from the WWTP will be sent to vessel B-2913.

Right after, once the vessel B-2913 is at its optimal level (as it's indicated in the design) the pump PB-2913 will start working. In order to it all, the manual valves set between the vessel B–2913 and the trench B-2301 have to be opened.

The pumps P-1101 and P-2301 work apart from the process explain before. They have to work although the WWTP spilt water goes to the SS or B-1901A.

Operation

When the level of the vessel B-2913 achieves the properly value the pump PB-2913 will stop and it is not going to work again until the level of the vessel achieve the correct value, like in the start-up.

When the pump PB-2913 stops, automatically the valve set after the pump will be closed.

In trench B-2302 there are a continuous control of the level as it has been explained in other section. Therefore, if during the operation the level achieves a low value it's going to enter to the trench tap water. If the level achieves an intermediate value, the pumps P-1101 and P-2301 have to stop. In addition, if the trench is nearly full the WWTP spilt water has to be sent to the SS or B–1901A that means, close valve located in the pipe that connect the WWTP to vessel B-2913 and opened the one set in pipe that connect WWTP to the SS.

Shortstop

It is defined as a stop due to a breakdown, a small incident or maintenance tasks. Depending on the equipment or instrument where is the anomaly it will react in different ways:

Table 9. Anomalies and properly reactions in front of them.

Anomaly	Reaction
Change filter bag of F-2301	In case that the filter is saturated and the vessel is full first of all WWTP spilt water has to be sent to sewage system. Next, the manual valves set before and after the filter must be closed. Then, the filter bag can be changed. It's better do this change when the vessel is'nt full, because on this way the WWT spilled water doesn't has to be sent to the sewage system.
Avery in control valves	The process has manual valves located befor and after each control valve. Closing these manual valves the broken one will be isolated and the flow will be sent to a detour with another manual valve. When the control valve is repaired it has to be done the opposite procedure.
Leaks in pipes or vessel B-2913	Before the vessel: spilt water must be sent to sewage system. After the vessel: depending on the vessel's level, the leak can be repaired only closing the valve set on the vessel exit or if the vessel is nealy full, the spilt water has to be set to the sewage system.
Avery in pump PB-2913	Depending on the vessel's level maybe it's only necessary close the valve set on the vessel exit if this is not possible, and the vesseal is full, the water must be sent to the sewage system. The valves located before and after the pump must be closed before take away the pump for its reparation.
Avery in pumps P-1101 and P-2301	The valves located after these pumps must be closed. Then the pumps will be taken away and repared. Once they are repaired or replaced the valves have to be opened if the level of trench B-2302 is the properly.

Large stop

It is defined as a stop that implies the stop completely of the production. It can only happen when the company is not working that means it doesn't require demineralized water and the vessel B-2913 and the two trenches are full. The only solution is send the WWTP spilled water to the sewage system.

Emergency stop

In case of emergency it will be act as in case of large stop.

7. SECURITY

Usually all the chemistry plants do an analysis called HAZOP where they identify the possible risks or dangers that are in the plant due to the products or the process that takes place there. But this company doesn't do this analysis, they do another one more simply because the plant is not really dangerous. They call to this analysis Security Concept.

7.1. SECURITY CONCEPT

Table 10. Security sheet.

Number	Potential risk	Control measures
A.16	**Diagram No. D-2911**	
A.16.1	Overfilled of B-2913	Level meter with alarm LS±A± and close and spilled of WWTP water to sewage system/B-1901A. (Close valve HR29013 and open de HB29012)
A.16.2	Complete emptying of B-2913	Level meter with alarm LS±A± and close valve HR2913 and stop pump PB2913

8. ENVIRONMENTAL IMPACT

How has been explained throughout the document if this project is carried out the spilt of wastewater to the sewage system will be eliminated. Moreover, due to it and the fact the only residue produced will be the solids filtered the project is not going to damage the environment.

What's more, for the company carry through the project means improve its image because the industries do not spill wastewater to the SS are better seen.

9. FINANCIAL VIABILITY

In the present section, there tries to value the economic viability of the project by means of the calculation of the Net Present Value (NPV), the Internal Rate of Return (IRR) and the Payback Period (PP). To be able to determine them is necessary to do an estimation of the initial necessary investment of the project, the saves due to the same one and the operating cost (F. Jiménez, 2007).

9.1. ESTIMATION OF THE INITIAL INVESTMENT

Based on the information facilitated by companies of the sector that could provide us the equipment required and taking in account the cost of build the installation, the initial investment has been estimated in 25,000 €.

9.2. ANNUAL SAVINGS

According to the mass balance with this project, the use of tap water to feed the OP will be delete. In addition, since all the water from the WWTP will be used, the company will not spill water to the sewage system, so it does not have to pay the tax that this spilled imply.

Therefore, the company will save the money that now spends in tap water and the one, which waste paying the taxes. This amount raises to 28,142 €.

9.3. OPERATING COST

First, it is necessary do an estimation of the operating cost for then calculate the real viability of the project. To do this estimation it has been keeping in mind the following items.

Direct labour cost

It has supposed that an operation need at most an hour daily to do the entire tasks that this process requires.

Direct labour cost has estimated 25 €/h, an average value in this company that includes the brut salary more costs of National Health Service. Definitively, this process costs:

$$25\frac{€}{h}\times\frac{1\ h}{1\ day}\times\frac{350\ days}{1\ year}=8750\ {}^{€}/_{year} \qquad (1)$$

Energy cost

Regarding the energy cost, a cost value has been fixed by unit of time of each equipment during a year.

Table 11. Calculation of kWh.

Equipment	Power (kW)	Working h/day	kWh
Pump P-1101	0.7	8,760	6,132
Pump P-2309	0.7	8,760	6,132
Pump PB-2913	0.25	898	225
		TOTAL	**12,489**

The energy price is approximately 0.094 €/kWh, so the energy cost will be 1,174 €/year. To that quantity a little more is added, due to all the instruments (valves and flowmeters) are electric. Lastly, the energetic cost raise to 1,500 €/year.

Maintenance cost

Due to all the new equipment will be only used for this process, the maintenance cost has been considered as 5% of the initial investment, what's means, 1,250 €/year.

Cost of amortization

In the chemical industry and in agreement with Spanish Accounting Plan, it considers the period of useful life of the equipment is 10 years. Supposing a constant amortization and a residual value 10 years ago zero, the annual cost of amortization is 2,500 €/year.

Other costs

Other costs to have in mind are the material and the management of the generated residues. It has supposed that the filter bag has to be changed twice a month and the full bags has to be picked up by the external company head of the residues our plant produce.

Table 12. Other costs.

Cost filter bags [€/year]	188
Waste management [€/year]	1,500

These sum to nearly 1,600€/year.

Finally, the cost of operating raises to 15,688€/year.

Tax of water well's use

According to the law 3/2015 on 11 of March in taxes and public prices related to hydraulic public territory the company has to pay an annual tax due to the use of well's water. The ACA has given to the company permission to use an annual volume of 27,000 m^3 of water from the wells. Supposing the company makes use of the entire volume permitted, it has to pay an annual tax of 1,981.10 € (Generalitat de Catalunya).

9.4. PROFIT AND LOSSES STATEMENT (P&L)

Profit and losses statement is a summary of the income and the expenses incurred by the operation of the project during the period of one year. In this case, there aren't incomes, instead of it, there are saves.

Table 13. Profit and losses.

Due to the project	€
Saves	28,142
Operating costs	15,688
Gross margin	12,454
EBT	12,454
Taxes (30% of EBT)	3,736
Net Earnings	8,718

9.5. FINANCIAL INDICATORS

(Net Present Value, Internal Rate Return and Payback Period)

The basic financial indicators are calculated in this section of the chapter. These indicators are Discounted Cash Flow (DFC), Net Present Value (NPV), Internal Rate of Return (IRR) and Payback Period (PP).

For all the calculations it has supposed that the production is constant, not are inflationary effects, the Working Capital (WC) is constant and the initial investment is carried out with funds of the company.

Discount Cash Flow (DCF)

Table 14. Cash Flow.

Due to the project (€)	Year 0	Year 1-10
+ Savings	0	28,142
- Costs	0	15,688
EBT	0	12,454
-Taxes	0	3,736
Net benefit	0	8,718
+ Amortization	0	2,500
- Investment in FA	25,000	0
- ΔWC	0	0
Cash Flow (CF)	-25,000	11,218

Cash flows that occur uniformly over the project life should use a continuous discount rate. To calculate the continuous discount has been used the following equation:

$$DFC_i = \frac{(e^r - 1) \cdot e^{-rn}}{r} \quad (2)$$

Where DFCi is the discount factor for cash flow in year I, and r is the discount or interest rate. It has chosen a discount rate of 8%.

Table 15. Accumulated Discount Cash Flow.

Year	0	1	2	3	4	5	6	7	8	9	10
CF_i	25,000	11,218	11,218	11,218	11,218	11,218	11,218	11,218	11,218	11,218	11,218
DCF_i	25,000	10,387	9,617	8,905	8,245	7,634	7,069	6,545	6,061	5,612	5,196
DCF_i accumulated	25,000	14,613	4,996	3,909	12,154	19,789	26,857	33,403	39,463	45,075	50,271

Net Present Value (NPV)

The NPV is the sum of the discounted cash flow generated in all years the project is active. It indicates the total cash flow a project would generate if all the revenues and costs associated with the project were reduced to a single instant in time.

The equation to calculate the NPV that has been used is the following:

$$NPV_i = \sum_{1}^{i} DFC_i \tag{3}$$

Where *i* is the number of periods of evaluation.

The value of NPV can be positive or negative and each option has a different interpretation. If NPV is positive, means it expected to produce more savings than it costs. And if it is negative means it is expected to lose money, so the project should be avoiding.

For this project, the NPV_{10} obtained is 50,271€.

Internal Rate of Return (PP)

In order to measure, the profitability of the investments it is going to be calculated the value of the Internal Rate of Return. A discount rate makes the Net Present Value of all cash flow from the project equal to zero.

The value of IRR obtained is 44%.

Payback Period (PP)

The Payback Period (PP) is the length of time required to recover the cost of the investment. To calculate it, it's used a graphic method; it consists in represent the investment required and the accumulate discount cash flow and the point where the two lines cut each other indicated the PP.

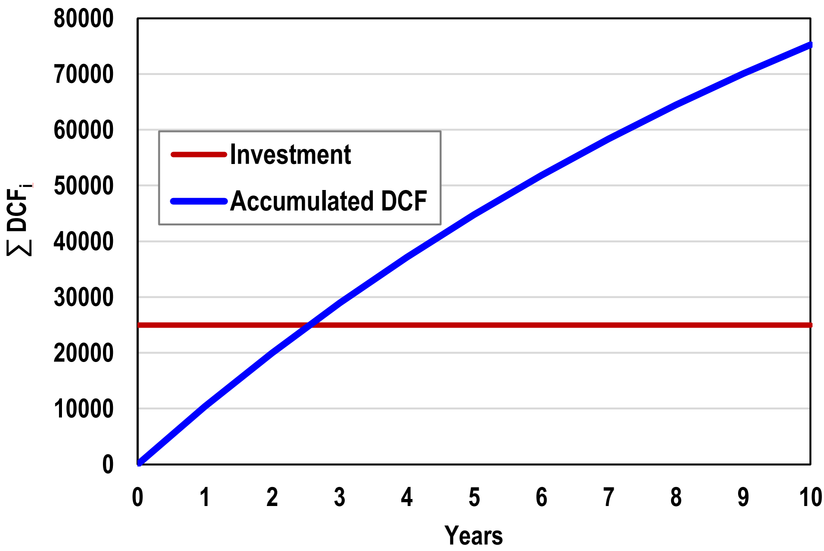

Figure 3. *Calculation of PP.*

As the graphic indicates, the PP is approximately 2.6, that is, 2 years and nearly 8 months. This value shows the project has a low PP considering that the usual PP in companies of the sector is between 3 and 5 years.

10. CONCLUSIONS

The main aim of this project is replace the use of tap water in the OP supply by water coming from own sources. These sources are, as it has explained before, two wells and water from the WWTP. Analysing the entire project, it is concluded that:

- It has been achieved accomplish the premises imposed by the company; the investment is not very huge and the equipment selected requires a minimum maintenance.
- According to the economic analysis the project is viable; the investment would be returned in a period of 2.5 years and once the investment is returned the company will save 11,000 € per year.

Considering that the project will benefit economically the company and will mean an improvement in the environmental issue, it is recommended the company carries out this project.

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ACRONYMS

ACA	Agencia Catalana d'Aigües (Catalan Water Agency)
CF	Cash Flow
DCF	Discounted Cash Flow
EBT	Earnings Before Taxes
F	Friction losses (J/kg)
FA	Fixed Assets
g	gravity (m/s^2)
g_c	Anglo-Saxon system conversion factor
IRR	Internal Rate of Return
NPV	Net Present Value
OP	Osmosis Plant
P&L	Profit and Losses
PP	Payback Period
PPH	Polypropylene Homopolymer
ρ	density (kg/m^3)
SS	Sewage System
v	velocity (m/s)
w_s	work (J/kg)
WC	Working Capital
WWTP	Wastewater Treatment Plant

INDEX OF FIGURES AND TABLES

FIGURES

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APPENDICES

APPENDIX 1: MASS BALANCE

To do the mass balance first has to be determinate the inlet and outlet flows of the trench B–2302. As has been explained trench B-2301 is connected to trench B-2302 and once B-2301 is full, the volume of water that enters in B-2301 is the same that enters in B-2302.

The following table shows the flow of inlet streams.

Table 16. Flow in inlet streams.

From	Flow [m^3/h]
WWTP	0.48
1st well	1.28
2nd well	1.06
TOTAL	2.82

And there is only one outlet stream, and the average flow of it is 1.64 m^3/h.

So, the mass balance:

$$W_{input} - W_{output} = 2.82\ m^3/h - 1.64\ m^3/h = 1.18\ m^3/h \qquad (4)$$

Given that the mass balance is positive theoretically will be enough with our own sources to feed the osmosis and the tap water won't be necessary.

APPENDIX 2: MANUAL OF CALCULATION

EQUIPMENT DESIGN

VESSEL B-2913

Due to one of the restrictions imposed by the Company implies a minimum investment the volume of the vessel must be the minimum possible because the more volume it has, the more cost it has. So, it has been considered that a vessel of $1m^3$ of capacity would be appropriate.

If it has this capacity, it will take 1.25 h to be full.

This vessel is going to contain wastewater from a biologic system, so this water will contain microorganisms. If it's wanted that the microorganisms don't proliferate the temperature of the water can't increase. For that is necessary the material of the vessel will be insulating. It's for this reason that the material selected is Polypropylene (PPH).

PPH is a resistant material that will make possible the temperature of the water will be constant. And in addition, is a cheap material.

PUMP PB-2913

To calculate the power required to send the water until the trench B-2301 it has been done the mechanic energy balance (O, Levenspiel, 1996):

$$\frac{g}{g_c}(z_2 - z_1) + \frac{1}{2g_c\alpha}(v_2^2 - v_1^2) + \int_1^2 \frac{dP}{\rho} + \sum F + W_S = 0 \qquad (5)$$

Solving this balance, it is determinate the pump is not really necessary because the fluid has to be elevate the same high that then it fall, the ascent and the descent of the fluid are equal. So, the pump is necessary only to elevate the flow nearly 8 meters, then the water flows on its own.

The pipe connected to the pump has a diameter of 32 mm.

Due to these facts, the pump must have the capacity of elevate the fluid and the flow it propels should have a velocity between 0.5 m/s and 1.5 m/s.

The Company have pumps available which accomplish all the requirement.

The pump selected would propel an average flow of 4.35 m^3/h. According to it and keeping in mind the dimensions of the vessel; the vessel will take a little more than 8 minutes to get empty, which means, the pump will be working during this period of time.

PUMPS P-1101 and P-2301

These pumps have been design and selected by an external company, the same has done the study of the wells.

PIPES DESIGN AND NOMENCLATURE

The diameter of each pipe has been calculated considering that the Speed recommended for water in pipelines is between 0.5 and 1.5 m/s.

Taking a velocity value of 1.5m/s and 4.2 m^3/h of flow, the diameter obtained is 31 mm. So, it has been chosen the normalized diameter immediately top to the calculated one, 32 mm.

The thickness will be chosen for the manufacturer.

All pipes have to be made of AISI 304 or 316.

Each pipe is named using the following code:

0000.0.0-00/00 XX00 X0 X0 X0

Where:

- First group: diagram number
- Second group: flowing fluid

Table 17. Number of flowing flow.

Number	Fluid	Number	Fluid
0	Air	**8**	Relief
1	Nitrogen	**9**	Product finished
2	Vapour	**10**	Hot water
3	Demineralized water	**11**	Natural gas
4	Condensates	**12**	Tap water
5	Refrigeration water	**13**	Dirty water
6	Suction	**14**	Cleaning water

7	Process	**15**	Wells water

- Third group: pipe order
- Fourth group: internal diameter
- Fifth group: maximum pressure
- sixth group: pipe material
    - BA10: iron
    - HA35: stainless steel
    - LE10: polypropylene
- Seventh group: type of gasket
    - F01: Aramid fiber with special NBR-adhesive
- Eighth group: type of end connection
    - B1: PN 40
- Ninth group: maximum temperature (only if the pipe is heated up)

VALVE SELECTION AND NOMENCLATURE

The type of valve that are used in this project is ball valve due to this kind of valve allows the direct flow in opened position with a minimum pressure loss.

They are named following the codes imposed by the company:

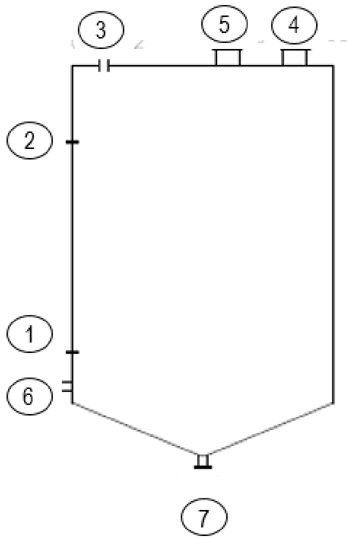
Table 18. Valves nomenclature.

Nomenclature	Specifications
H621Y	Manual opening. Thread ends.
H672B1	Manual opening. Ends with flanges.
HVK and H-Name equipment that it follows	Automatic opening. Ends with flanges.

APPENDIX 3: SPECIFICATION SHEETS

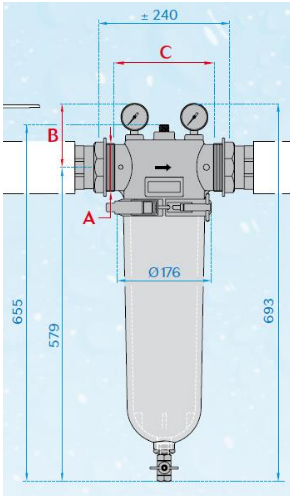
Table 19. B-2913 Specification sheet.

NUMBER OF EQUIPMENT: B-2913	
FUNCTION: Vessel (accumulation of water)	
FUNCTIONING OF THE UNIT	
Feed [kg]	600
Temperature of operation [ºC]	Ambient (≈25)
Pressure of operation [bar]	1.013
DESIGN SPECIFICATIONS	
Volume [m^3]	1
Wall thickness [mm]	6-8
Diameter [m]	0.955
Height [m]	1.355
SPECIFICATIONS	
Legs	Yes
Legs' high [m]	0.5
Diameter 1 and 2 [in]	½
Diameter 3 [in]	1 ½
Diameter 4 and 5 [mm]	100
Diameter 6 and 7 [mm]	32
Inputs, outputs and control	
Numbers 4	Input
Numbers 5, 6 and 7	output



(Company Manuel Romeu)

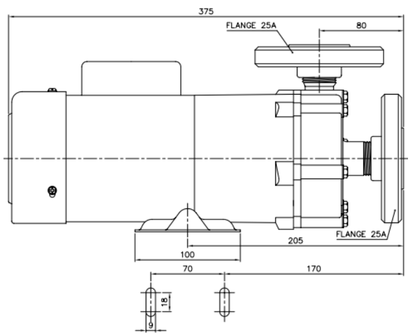
Table 20. F-2901 Specifications sheet.

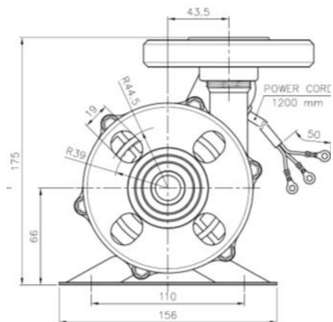
NUMBER OF EQUIPMENT: F-2901		
FUNCTION: Filter wastewater		
TYPE: With filter bags		
SPECIFICATIONS		
Connected diameter [in]	2	
Average flow [m³/h]	20	
Service pressure [bar]	10	
Maximum pressure [bar]	16	
Maximum temperature [ºC]	50	
Weight [kg]	3.2	
Filter area [cm²]	1,250	
A (Ø) [in]	2	
B [cm]	11.7	
C [cm]	18.7	

(Group TEC-FRED)

Table 21. PB-2913 Specifications sheet.

NUMBER OF EQUIPMENT: PB-2913	
FUNCTION: Send water to B-2301	
PUMP MODEL: NH-250PS	
Impeller diameter [mm]	100/85
Frequency [Hz]	50/60
PUMP SPECIFICATIONS	
Specified point	9m at 65L/min
	9m at 80L/min
Max head-Discharge flow	12.5 m-120 L/min
	14m-120L/min
Permissible working temp [ºC]	0-70
Permissible system pressure [MPa]	0.21
Permissible environment conditions	0-40ºC
	Upto 85%
Nominal speed [rpm]	2.700-3.300
Material	Polypropylene
MOTOR SPECIFICATIONS	
Nominal output*input [W]	250*390





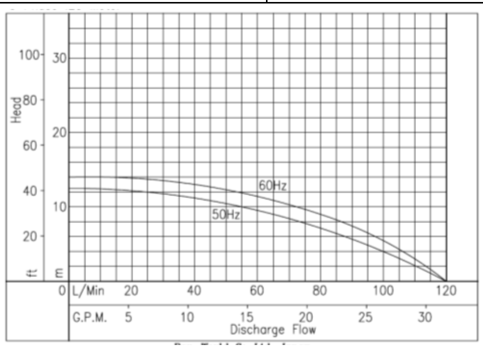


Table 22. P-1101 and P-2301 Specification sheet.

NUMBER OF EQUIPMENT: P-1101 and P-2301	
FUNCTION: Extract water from the wells	
TYPE: Submersible	
PUMP MODEL: SQ2-35	
PUMP SPECIFICATIONS	
Velocity [rpm]	10,700
Nominal flow [m³/h]	2
Nominal height [m]	35
Material	AISI 304
LIQUID SPECIFICATIONS	
Liquid	Water
Maximum temperature [ºC]	35
Working temperature [ºC]	20
MOTOR SPECIFICTIONS	
Entrance power-P1 [kW]	1.02
Nominal power-P2 [kW]	0.7
Feed frequency [Hz]	50
Protection degree	IP68

(Group Grundfos)

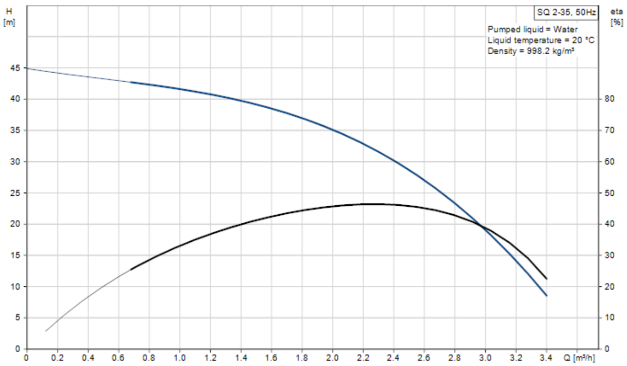
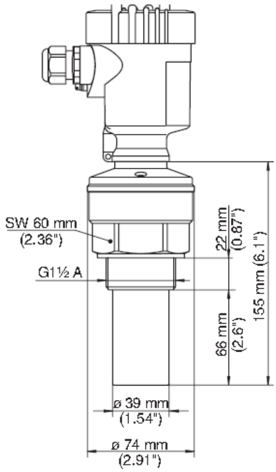
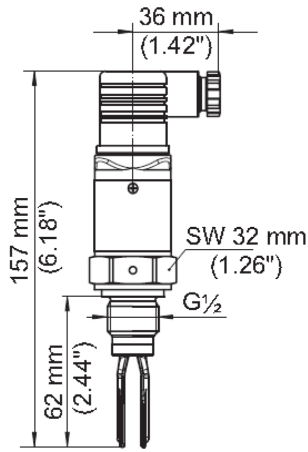


Table 23. L291301 Specification Sheet.

NUMBER OF EQUIPMENT: L291301		
FUNCTION: Control level		
TYPE: ultrasound (two thread)		
MODEL: VEGASON 61		**DIMENSIONS**
SPECIFICATIONS		
Measurement range [m±mm]	5±4	
Process pressure [bar]	-0,2 to +2	
Process temperature [ºC]	-40 to +80	
Material	PVDF	
		

(Group VEGA)

Table 24. L291302 and L291303 Specification Sheet.

<table>
<tr><td colspan="3">NUMBER OF EQUIPMENT: L291302/3</td></tr>
<tr><td colspan="3">FUNCTION: Control level</td></tr>
<tr><td colspan="3">TYPE: vibratory</td></tr>
<tr><td colspan="2">MODEL: VEGASWING 51</td><td>DIMENSIONS</td></tr>
<tr><td colspan="2">SPECIFICATIONS</td><td rowspan="6">
</td></tr>
<tr><td>Measurement range [m±mm]</td><td>5±4</td></tr>
<tr><td>Process pressure [bar]</td><td>-1 to +64</td></tr>
<tr><td>Process temperature [ºC]</td><td>-40 to +100</td></tr>
<tr><td>Material</td><td>AISI 316L</td></tr>
<tr><td colspan="2"></td></tr>
</table>

(Group VEGA)

APPENDIX 4: PIPES AND VALVES LISTS

PIPES

Table 25. Pipe list.

CODE	FLUID	DIAMETER [mm]	MATERIAL
2910.9.3-100/10HA35F01B1	Product finished*	100	AISI 304
2911.9.1-32/10HA35F01B1	Product finished*	32	AISI 304
2911.9.2-32/10HA35F01B1	Product finished*	32	AISI 304

*Product finished means, in this case, depurated water.

VALVES

Table 26. Valve list.

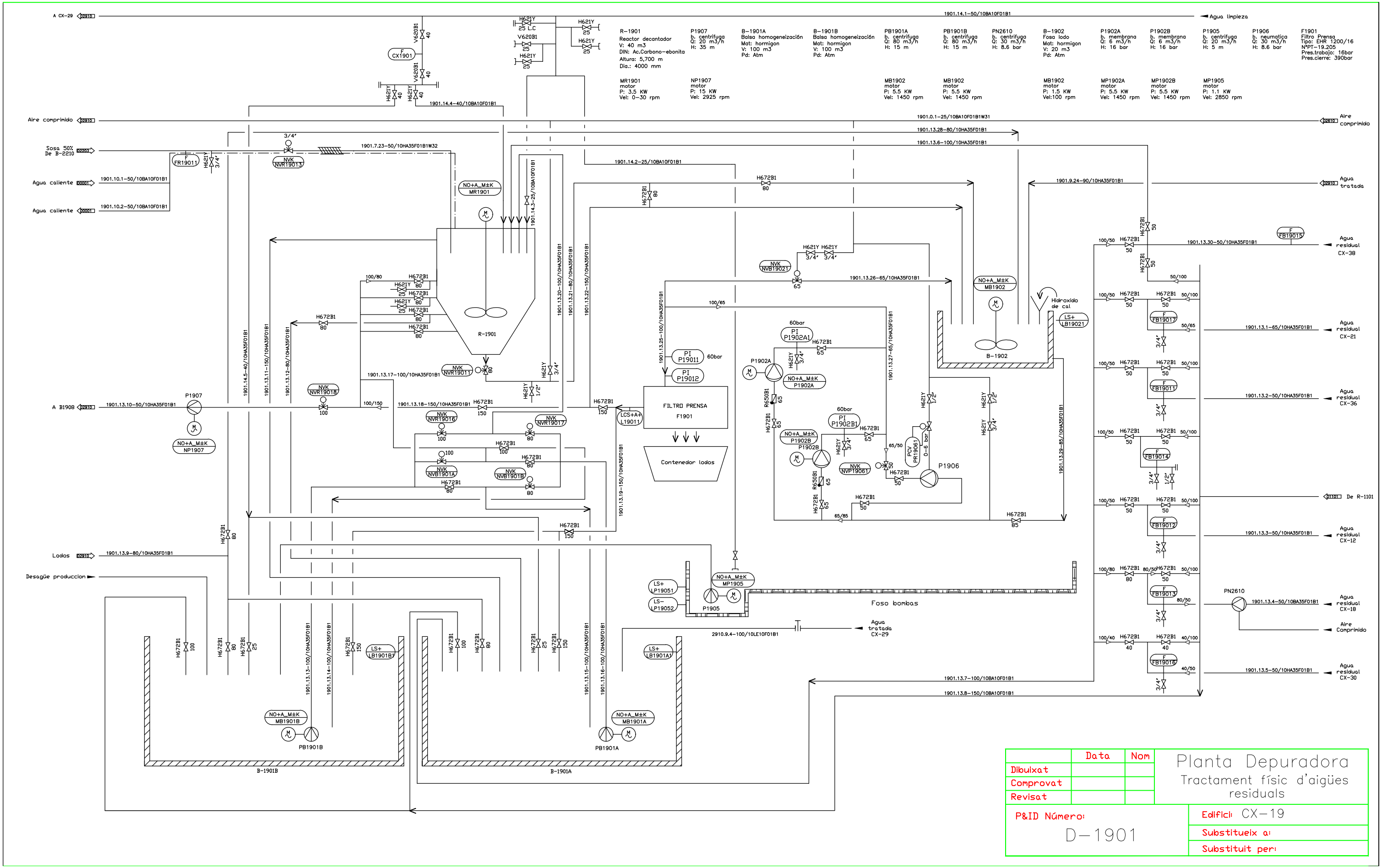
<table>
<tr><th>CODE</th><th>TYPE</th><th>OPENING</th><th>PIPE</th></tr>
<tr><td>HR29012</td><td>Ball valve</td><td>Automatic</td><td>2910.9.2-100/10BA10F01B1</td></tr>
<tr><td>HR29013</td><td>Ball valve</td><td>Automatic</td><td>2910.9.3-100/10HA35F01B1</td></tr>
<tr><td rowspan="2">H621Y</td><td rowspan="2">Ball valve</td><td rowspan="2">Manual</td><td>2910.9.2-100/10BA10F01B1</td></tr>
<tr><td>2910.9.3-100/10HA35F01B1</td></tr>
<tr><td>H672B1</td><td>Ball valve</td><td>Manual</td><td>2911.9.1-32/10HA35F01B1</td></tr>
<tr><td>H621Y</td><td>Ball valve</td><td>Manual</td><td>2911.9.1-32/10HA35F01B1</td></tr>
<tr><td>HR2913</td><td>Ball valve</td><td>Automatic</td><td>2911.9.1-32/10HA35F01B1</td></tr>
<tr><td>H621Y</td><td>Ball valve</td><td>Manual</td><td>2911.9.2-32/10HA35F01B1</td></tr>
</table>

APPENDIX 5: PIPING AND INSTRUMENTATION DIAGRAMS

This section shows all the P&ID. These are the followings:

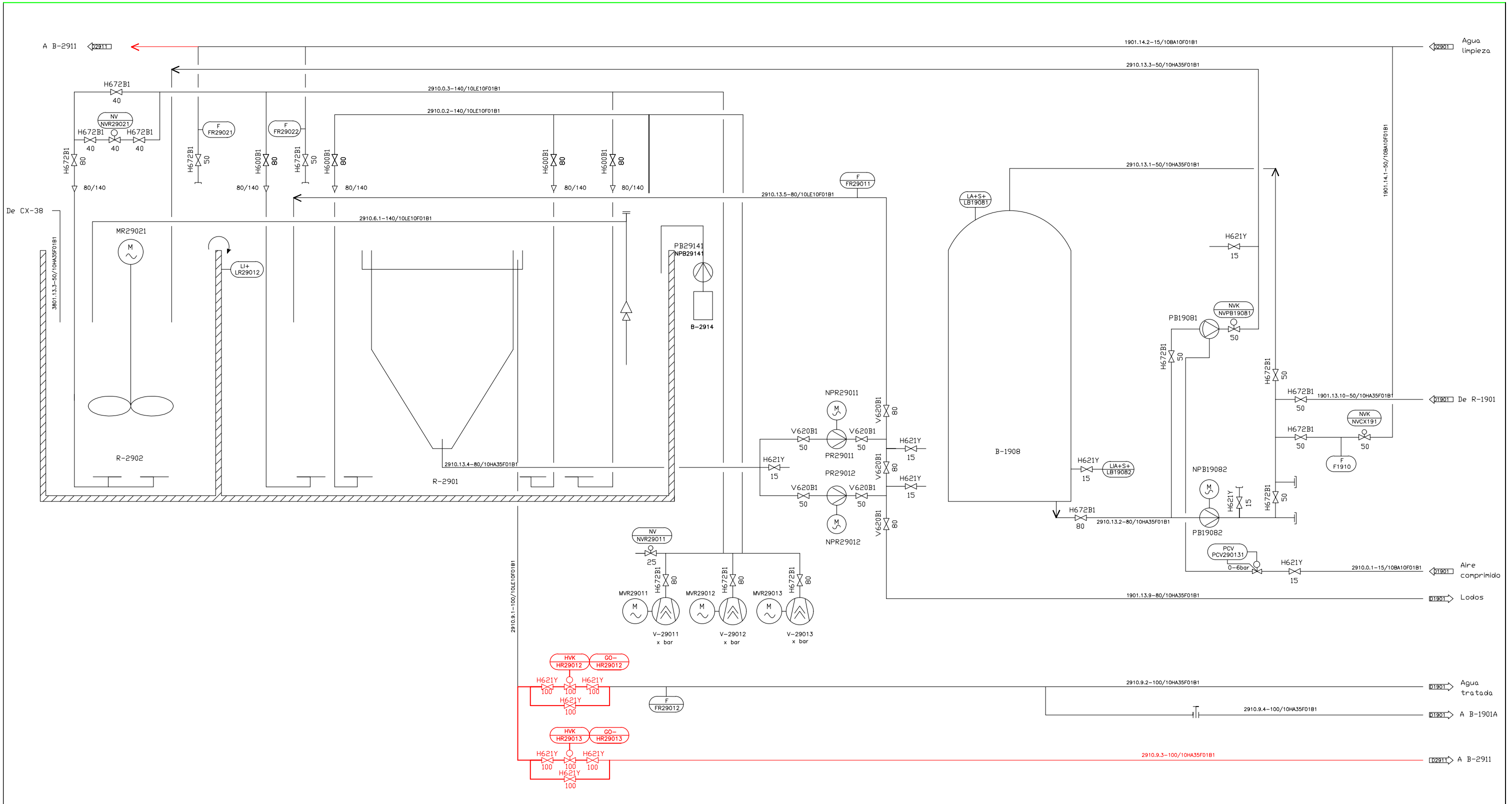
Table 27. P&IDs.

P&ID Number	Contents
D-1901	Physic part of WWTP
SK-2910.1	Biologic part of WWTP
SK-2911.1	Proposal process
SK-0005.1	Osmosis Plant



	Data	Nom	Planta Depuradora Tractament físic d'aigües residuals
Dibuixat			
Comprovat			
Revisat			

P&ID Número:	Edifici: CX-19
D-1901	Substitueix a:
	Substituït per:



R-2901
Reactor: 143,5 m3
DIN: Hormigón
Altura: 5200 mm
Long.: 9800 mm
Anch.: 4900 mm

R-2902
Reactor: 38 m3
DIN: Hormigón
Altura: 5200 mm
Long.: 1800 mm
Anch.: 4900 mm

MR29021
motor
P: 3.6 KW
Vel: 1435 rpm

V-29011
Compresor
Q: 300 m3/h
P.max 1.5 bar

MVR29011
motor
P: 7.5 KW
Vel: 2935 rpm

V-29012
Compresor
Q: 300 m3/h
P.max 1.5 bar

MVR29012
motor
P: 7.5 KW
Vel: 2935 rpm

V-29013
Compresor
Q: 300 m3/h
P.max 1.5 bar

MVR29013
motor
P: 7.5 KW
Vel: 2935 rpm

PB29141
b. centrifuga
Q: 10 m3/h
H: 12 bar

NPB29141
motor
P: 0,37 KW

B-2914
Depósito
V: 30 L
P: Polipropileno

PR29011
b. centrifuga
Q: 25 m3/h
H: X bar

NPR29011
motor
P: 1.5 KW
Vel: 1400 rpm

PR29012
b. centrifuga
Q: 25 m3/h
H: X bar

NPR29012
motor
P: 1.5 KW
Vel: 1400 rpm

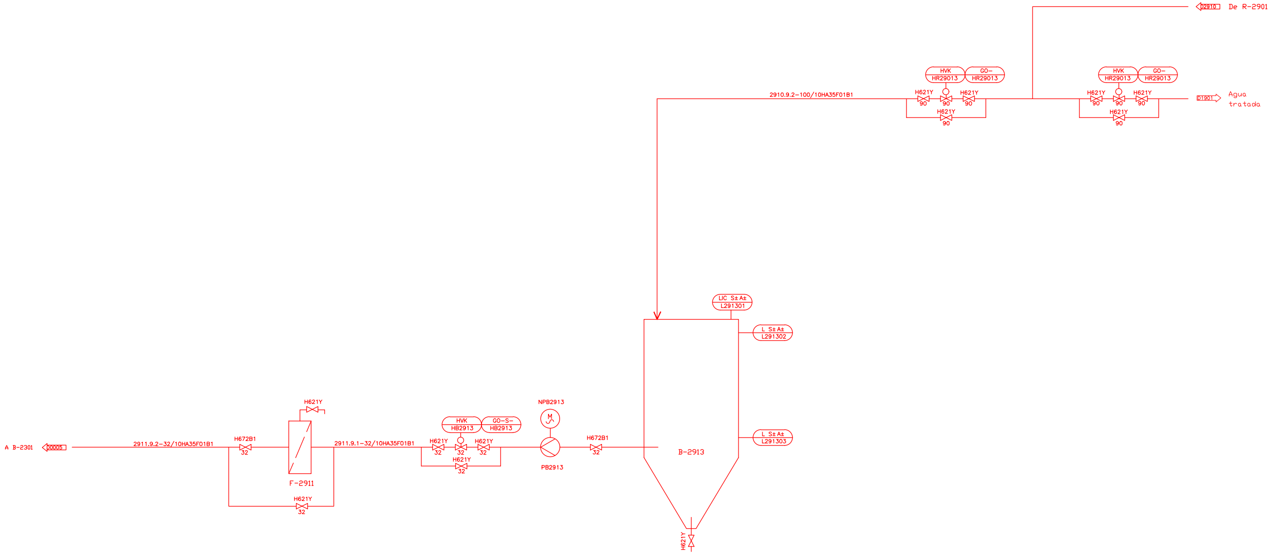
B-1908
deposito
V: 100 m3
Mat: Poilester-
fibra de vidrio
Pd. Atm.

PB19081
b. centrifuga
Q: 30 m3/h
H: 8.6 bar

PB19082
b. centrifuga
Q: 85 m3/h
H: x bar

NPB19082
motor
P: 17.3 KW
Vel: 2925 rpm

	Data	Nom	
Dibuixat			Planta Depuradora
Comprovat			Tractament biològic d'aigües residuals
Revisat			
P&ID Número: D-2910			Edifici: CX-29
			Substitueix a:
			Substituït per:



B-2913
Depósito
V: 1m3
Mat: Polipropileno

F-2913
Filtro
A. filtrante: 1,250 cm2
Pmáx: 16 bar

PB2913
b. centrifuga
Q: 3,9-4,8 m3/h
H: 9-15 bar

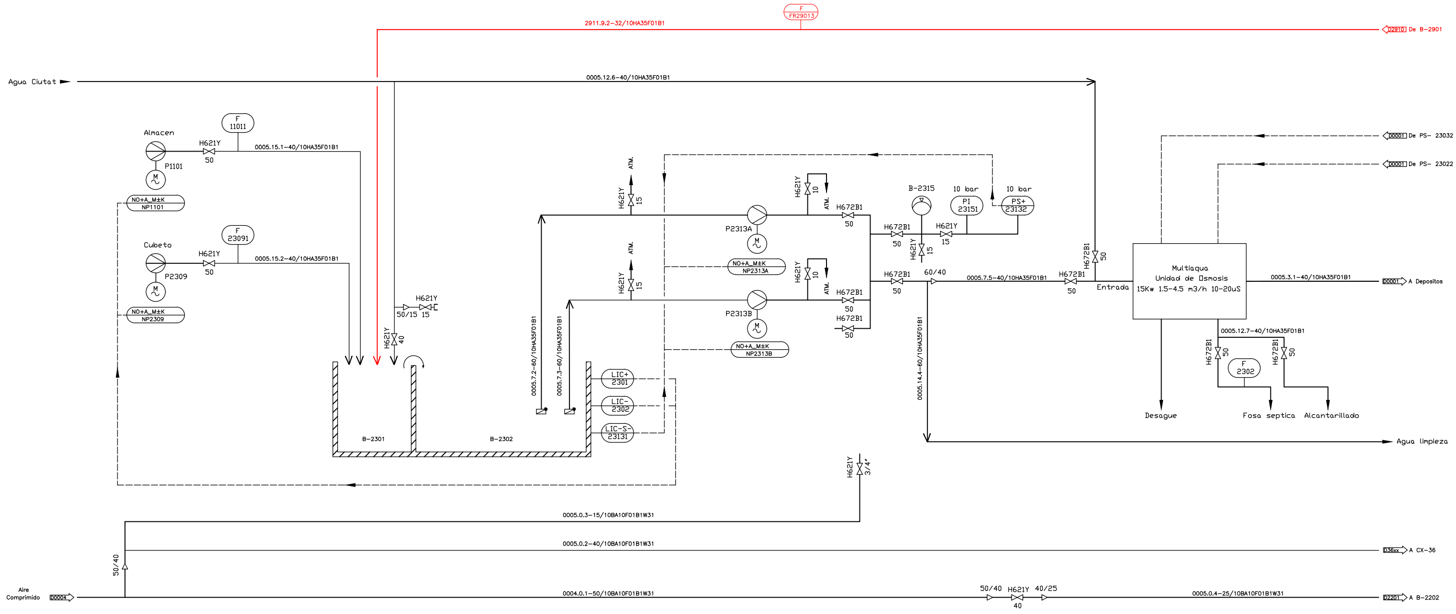
NPB2913
P: 0,25 kW

	Data	Nom
Dibuixat		
Comprovat		
Revisat		

Dipòsit acumulador d'aigua depurada

P&ID Número:
SK-2911.1

Edifici: CX-29
Substitueix a:
Substituit per:



P1101 b. centrifuga Q: 8-22 m3/h H: 52-22 bar	**P2913** b. centrifuga Q: 8-22 m3/h H: 52-22 bar	**P2309** b. centrifuga Q: 8-22 m3/h H: 52-22 bar	**P2313A** b. centrifuga Q: x m3/h H: x bar	**P2313B** b. centrifuga Q: x m3/h H: x bar	**B-2315** d.expansion Mat. Acero V. 0.5 m3 Pd. 8 bar	**B-2301** Fosa V: 20 m3	**B-2302** Fosa V: 100 m3
NP1101 motor 3 kW 2800 rpm	**NP2913** motor 3 kW 2800 rpm	**NP2309** motor 3 kW 2800 rpm	**NP2313A** motor 5.5 kW 2930 rpm	**NP2313B** motor 5.5 kW 2930 rpm			

	Data	Nom	Planta Osmosis
Dibuixat			
Comprovat			
Modificat			

P&ID Número: SK-0005.1	Edifici: CX-23
	Substitueix a:
	Substituit per: